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Crandon Mining Company

Environmental Impact Report

Section 3.7

Surface Water and Bottom Sediments

SUPERSEDED

Crandon Mining Company
Environmental Impact Report

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3.7 Surface Water and Bottom Sediments

Data collection and technical studies for the project's surface water monitoring program have been completed for three purposes, 1) to provide data which would be used for the development of WPDES effluent limits, 2) to provide background surface water quality and quantity information, and 3) to provide background surface water sediments information. A discussion of this work is contained in this section of the EIR.

3.7.1 Field and Laboratory Methods

A considerable amount of data has been collected over the past 15 years for the surface waters and sediments within the study area. The historical data collected during these previous studies are presented throughout the text for comparison purposes. Many methodological and analytical advances have occurred since the time of the collection of these data. In particular, the use of "clean techniques" has only been available during the latest 1993-1995 studies. Coupled with analytical advances, these clean techniques should allow greater resolution and sample integrity than previously observed. While changes in methodology and analytical techniques have occurred since the existing water and sediment chemistry data was collected, the historical data has value because it provides a good reference point as to conditions that existed at the time of collection.

Accepted flow monitoring methods have not changed in the past 20 years. As a result, existing data will be used for environmental studies and as part of the project permit applications. Since the time that the original permitting efforts ceased, additional monitoring of lake levels has been conducted on a regular basis by both CMC and Foth & Van Dyke employees. This information is also included in the data base.

A detailed surface water sampling and quality assurance plan (Foth & Van Dyke, 1993) was prepared for the project and submitted to WDNR in December 1993. This plan was also appended to CMC's February 1994 NOI/SOS (Foth & Van Dyke, 1994). In March of 1995 an update to the December 1993 surface water sampling and quality assurance plan was submitted to the WDNR and USCOE (Foth & Van Dyke, 1995). This update, which is included in Appendix 3.7-1, incorporated and supplemented the December 1993 plan.

3.7.1.1 Monitoring Locations

Surface waters in the project area were selected for water quality monitoring and for stream flow and lake level monitoring to establish regional baseline data and to support the evaluation of project design alternatives. Table 3.7-1 provides a listing of the surface water sampling points selected for the project. Figures 3.7-1 and 3.7-2 show the location of these surface water monitoring sites.

The original surface water monitoring program presented in the NOI/SOS included four additional sites not identified in Table 3.7-1. These were SG-23 (Creek 12-9), LG-30A (Martin Spring), LG-31 (Hoffman Springs) and LG-14 (Rice Lake). Sites SG-23 and LG-14 were not monitored because access was unavailable. Sites LG-30A and LG-31 were not monitored for levels since their outlet streams were monitored for flow. In addition, a single surface water quality monitoring event was performed at SG-PR, SG-HC, SG-NC, SG-MG, SG-WR-1, SG-WR-2 and SG-WR-3 as part of the evaluation of alternative discharge sites. This monitoring was not part of the original program outlined in the NOI/SOS.

In order to establish baseline conditions, a sediment monitoring program was established. The surface water sediments collected for this purpose were sampled from the sites identified in Table 3.7-2. Figures 3.7-1 and 3.7-2 also show the location of all sediment collection sites.

Table 3.7-1

Surface Water Monitoring Frequency

Surface Water	Site ID	Water Quality				
		Monthly Monitoring	Quarterly Monitoring	Single Monitoring Event	Peak Flow Monitoring Event	Flow/Lake Level Monitoring
Swamp Creek	SG-2	X[1]				X[2]
Swamp Creek	SG-2A					X[2]
Swamp Creek	SG-3	X[1]				X[2]
Swamp Creek	SG-5A		X			X[3]
Swamp Creek	SG-AB	X[1]			X	X[2]
Swamp Creek	SG-AA					X[2]
Swamp Creek	SG-V	X[1]			X	X[2]
Wolf River	SG-Y	X[1]			X	X[2]
Wolf River	SG-CC	X[1]			X	X[2]
Pickerel Creek	SG-19	X[1]				X[2]
Pickerel Creek	SG-19A					X[2]
Hemlock Creek	SG-6	X[1]				X[2]
Hemlock Creek	SG-6A					X[2]
Creek 11-4	SG-30	X[1]				X[2]
Hoffman Creek	SG-E	X[1]				X[2]
Outlet Creek	SG-4		X			X[3]
Skunk Lake	LG-15	X[1]				X[4]
Duck Lake	LG-12	X[1]				X[4]
Deep Hole Lake	LG-13	X[1]				X[4]
Little Sand Lake	LG-7	X[1]				X[4]
Oak Lake	LG-11	X[1]				X[4]
Rolling Stone Lake	LG-9		X			
Pelican River	SG-PR			X		
Haymeadow Creek	SG-HC			X		
Neptune Creek	SG-NC			X		
Monico Creek	SG-MC			X		
Wisconsin River	WR-HR-01			X		
Wisconsin River	WR-HR-02			X		
Wolf River	SG-WR-3			X		

[1] Low level metal analyses performed.
[2] Monthly flow monitoring.
[3] Quarterly flow monitoring.
[4] Lake level monitoring during ice-free periods.

Prepared by: GJB1
Checked by: JJA

Table 3.7-2

Surface Water Sediment Sampling Sites

Surface Water	Sampling Station
Swamp Creek	D
Swamp Creek	E
Hemlock Creek	A-1
Oak Lake	G
11-4 Creek (Martin Springs)	M-3
Pickerel Creek	M-5
Rolling Stone Lake	M-2
Rolling Stone Lake	M-4
Deep Hole Lake	L
Duck Lake	K
Little Sand Lake	H
Little Sand Lake	I
Wolf River	Y
Wolf River	Z

Prepared by: GJB1
Checked by: JJA

3.7.1.2 Methodology

Table 3.7-1 identifies the type and frequency of surface water monitoring performed at the listed sites. Water quality monitoring was performed either on a monthly, quarterly or single event basis. Peak flow water monitoring was performed on two occasions during major runoff events. Flow monitoring was performed either monthly or quarterly. Lake level monitoring was performed during ice-free periods.

Analytical parameters for stream and lake water quality monitoring are listed in Table 3.7-3. Stream flow monitoring procedures, sample collection procedures, analytical methods, detection limits, quality control targets; etc., are outlined in the Updated Surface Water Quality Assurance Plan (Foth & Van Dyke, 1995) included in Appendix 3.7-1. Surface water samples collected from selected sites identified in Table 3.7-1 were analyzed for low level metals to define background conditions in the event that treated effluent from the project would be directed to them for discharge or for mitigation. The selected sites are within the drainage basin of the Wolf River which has been classified as an Outstanding Resource Water (ORW). As a result, advanced analytical techniques, which have detection limits lower than the standard techniques, were used to quantify aluminum, cadmium, chromium, copper, lead, mercury, and zinc for samples collected from these sites. The parameters measured with the advanced analytical techniques are referred to as "low level metals." The list of parameters for the SG-PR, SG-HC, SG-NC, SG-MC and SG-WR-3 single event water quality monitoring sites was different than that for the other water quality monitoring sites. The parameters for these five sites are listed in Table 3.7-4. Samples WR-HR-01 and 02 from the single event water quality site were analyzed for most of the parameters listed in Table 3.7-3. A summary of the data associated with the single sampling events is included in Appendix 3.7-8. Laboratory data sheets are included in Appendix 3.7-9.

Regarding lake sampling, it should be noted that in contrast to the procedures outlined in Appendix 3.7-1, from April 1994 through July 1994 a non-metallic canoe was used exclusively as a work area for the sample collection team. Based on comments received from WDNR in August 1994, the sampling team subsequently used a plastic drop cloth to prepare a work surface in the bottom of the canoe. This procedure modification was one of the additions included in the update found in Appendix 3.7-1.

Analytical parameters for the sediment sampling program are shown in Table 3.7-5. The table also lists analytical methods, detection limits, and quality control targets used for the program.

Sediment samples from aquatic substrates were collected in October 1994. Core samples were collected using a Wildco 2" Hand Corer. The lexan corer tube was equipped with a lexan nosepiece and PVC flapper and liners. The core tube handle was constructed of 3/16-inch stainless steel and made to receive 5, 10 and 15 foot extension handles. Liners were fitted with plastic eggshell core catchers designed to capture the core while extracting it from the substrate. River sediment samples were collected using the corer with the five foot extension handle. Lake samples were collected from a canoe using the corer with the ten foot extension handle.

For each site, a new core liner was installed in the core sampler. Liners were inserted from the nosepiece end of the sampler. Once the liner was installed, an eggshell core catcher was inserted into the liner end followed by capping of the corer with the tapered nosepiece. Cores were obtained by applying pressure on the handle.

Table 3.7-3

Surface Water Quality Monitoring Parameters

Parameters		
Alkalinity	Turbidity	Molybdenum
Bicarbonate	Phosphorus (Soluble)	Selenium
Biological Oxygen Demand (5 day)	Phosphorus (Total)	Silver
	Modified SAR	Beryllium
Carbonate	Sulfate	Thallium
Chemical Oxygen Demand	Cations (Sum)	Nickel
Chloride	Anions (Sum)	Antimony
Cyanide	Cation Anion Balance	Magnesium
Fluoride	Total Dissolved Solids	Potassium
Hardness	Total Suspended Solids	Sodium
Nitrogen-Ammonia	Boron	Aluminum
Nitrogen-Nitrate	Calcium	Cadmium
Nitrogen, Kjeldahl	Arsenic	Copper
Oil and Grease	Barium	Lead
pH	Iron	Mercury
Conductivity	Iron (Total)	Zinc
Temperature	Manganese	Chromium (Total)
Dissolved Oxygen	Manganese (Total)	

Prepared by: JJA
Checked by: JWS

Table 3.7-4

Single Event Surface Water Quality Monitoring Parameters

Parameters		
Chloride	Arsenic	Aluminum
Cyanide	Selenium	Cadmium
Nitrogen-Ammonia	Silver	Chromium
pH	Beryllium	Copper
Conductivity	Thallium	Lead
Temperature	Nickel	Mercury
Dissolved Oxygen	Antimony	Zinc

Prepared by: JJA
Checked by: JWS

Table 3.7-5

Parameter and Quality Assurance Targets for Bottom Sediment Monitoring

Parameter	Method Reference	Matrix	Precision Targets	Accuracy Targets	TDL (mg/kg)
Chloride	EPA 9252	SW Sed.	25	80-120	1
Cyanide	EPA 9010	SW Sed.	25	80-120	0.5
Fluoride	EPA 340.2	SW Sed.	25	80-120	0.5
Nitrogen-Organic	EPA 350.2	SW Sed.	25	80-120	50
Nitrogen-Kjeldahl	EPA 351.3	SW Sed.	25	80-120	50
Oil and Grease	EPA 413.2	SW Sed.	25	75-125	50
pH	EPA 150.1	SW Sed.	25	N/A	0.1 SU
Phosphorous (total)	EPA 365.3	SW Sed.	25	80-120	5
Total Solids	SM 209F	SW Sed.	25	N/A	1
Total Volatile Solids	SM 209F	SW Sed.	25	N/A	10
Boron	EPA 6010	SW Sed.	25	75-125	10
Calcium	EPA 6010	SW Sed.	25	75-125	100
Aluminum	EPA 6010	SW Sed.	25	75-125	20
Arsenic	EPA 7060	SW Sed.	25	75-125	5
Barium	EPA 6010	SW Sed.	25	75-125	4
Cadmium	EPA 6010	SW Sed.	25	75-125	1
Copper	EPA 6010	SW Sed.	25	75-125	3
Iron (total)	EPA 6010	SW Sed.	25	75-125	5
Lead	EPA 7421	SW Sed.	25	75-125	0.1
Manganese	EPA 6010	SW Sed.	25	75-125	1
Manganese (total)	EPA 6010	SW Sed.	25	75-125	1
Mercury	EPA 7471	SW Sed.	25	75-125	1
Molybdenum	EPA 6010	SW Sed.	25	75-125	0.1
Selenium	EPA 7740	SW Sed.	25	75-125	2
Silver	EPA 6010	SW Sed.	25	75-125	5
Zinc	EPA 6010	SW Sed.	25	75-125	1
Chromium (total)	EPA 6010	SW Sed.	25	75-125	2
Beryllium	EPA 6010	SW Sed.	25	75-125	3
Thallium	EPA 7841	SW Sed.	25	75-125	1
Nickel	EPA 6010	SW Sed.	25	75-125	7.5

Table 3.7-5 *(Continued)*

Parameter	Method Reference	Matrix	Precision Targets	Accuracy Targets	TDL (mg/kg)
Antimony	EPA 6010	SW Sed.	25	75-125	3
Magnesium	EPA 6010	SW Sed.	25	75-125	5
Potassium	EPA 6010	SW Sed.	25	75-125	100
Sodium	EPA 6010	SW Sed.	25	75-125	100

SW Sed. = Surface Water Sediment.

TDL = Target Detection Limit.

SU = Standard Units.

SM references the *Standard Methods for the Examination of Water and Wastewater,* 1989.

EPA references either *Methods for Chemical Analysis of Water and Wastes*, USEPA 600/4-79-020, Revised March 1983, or *Test Methods for Evaluating Solid Waste* (SW846) USEPA, September, 1986.

Prepared by: GJB1
Checked by: JJA

The NOI/SOS (Foth & Van Dyke, February 1994), described a plan to collect sediment samples from the upper one foot of substrate. Most of the sites contained a substrate of firm composition. This firm composition prevented the collection of a 12-inch sediment sample in a single core effort. One to six-inch core increments were the average core capable of being extracted. Therefore, additional cores were taken until a total of 12 inches of cored material was obtained for a sample. Details of the specific composite core collected at each site are provided in Table 3.7-6.

As each core was extracted, it was transferred to a one-liter plastic bottle. Liquid volumes captured during sample collection were discarded from the top of the sampler. Cores were removed from the liner by dissembling the core sampler at the nosepiece. Because of the force required to obtain the sample, the liners were wedged onto the nosepiece. Therefore, by removing the nosepiece, the nosepiece and liner with sample intact could be removed as a unit. Cores were removed from the liner by inverting the liner and shaking the core into the plastic bottle. Once filled, the plastic bottles were capped, labelled, and stored in a cooler filled with ice. Samples were hand delivered to the lab within 24 hours of collection.

Documentation of surface water monitoring sampling procedures, sample preservation, sample handling and shipping, etc., was performed in accordance with the procedures outlined in Appendix 3.7-1. In addition, representatives of the WDNR were informed in advance of the schedule of sample collection so that they were able to observe procedures and/or split samples. With the exception of the December 1994 sampling event, WDNR personnel were present during portions of all monthly sampling events from November 1993 through October 1994.

The current surface water data collection for the project occurred between November 1993 and April 1995. This section of the EIR includes all data collected and reported as part of the 1993-1995 surface water sampling program, in addition to pertinent data collected in the 1970s and 1980s. The statistical analyses performed on the 1993/1995 database were completed using a value of zero for all results below method detection levels. Alternative methods of addressing non-detects when calculating arithmetic means are available and in some instances may be appropriate to use. Future evaluations may incorporate the use of alternate methods for making this calculation.

The information in the current project's data base has undergone several levels of review during the course of this project. As a result of these reviews, the laboratory was asked to verify certain laboratory results. In most cases, the laboratory verified the results as originally reported, however, in a limited number of cases, the reported results were corrected. The data base in Appendix 3.7-8 contains the verified and corrected laboratory results, while the laboratory results sheets in Appendix 3.7-9 do not. Corrections included in the data base are documented in the form of a table and in correspondence from the laboratory, both of which are included at the beginning of Appendix 3.7-9.

Table 3.7-6

Sediment Core Extraction Increments by Site for October 1994 Sampling

Sampling Location	Sampling Station	Collection Increments (Total Inches/Total Number of Core)
Swamp Creek (Swampy Lane)	D	1" per core/12 cores
Swamp Creek (Upstream of Hwy. 55)	E	6" per core/2 cores
Hemlock Creek (Deep Hole Road Bridge)	A-1	6" per core/2 cores
Oak Lake (East end)	G	1" per core/12 cores
11-4 Creek (Martin Springs) (North Rolling Stone Lake Road)	M3	3" per core/3 cores
Pickerel Creek (North Rolling Stone Lake Road)	M5	2" per core/3 cores
Rolling Stone Lake (North end)	M2	4" per core/3 cores
Rolling Stone Lake (South end)	M4	3" per core/2 cores
Deep Hole Lake (South end)	L	4" per core/3 cores
Duck Lake (South end)	K	2" per core/6 cores
Little Sand Lake (North end)	H	1" per core/12 cores
Little Sand Lake (South end)	I	6" per core/2 cores
Wolf River (Downstream of Lower Post Lake)	Y	2" per core/5 cores
Wolf River (Cty. T)	Z	6" per core/2 cores

Prepared by: WMW
Checked by: JJA

3.7.2 Regional Hydrologic Characterizations

3.7.2.1 Drainage Basins

The study area lies within the area of northeast Wisconsin that is drained by the Wisconsin, Wolf, Fox, Peshtigo, Oconto, and Menominee Rivers. The area is entirely within the northern headwaters of the Wolf River drainage basin as shown on Figure 3.7-3. The Wolf River originates approximately 20 miles northwest of the site area and flows south to Lake Poygan in Winnebago County (WDNR, 1977), which is approximately 100 miles south of the study area. The Fox River drains the Lake Poygan-Winnebago system in a northeasterly direction to Green Bay. The Wolf River basin is bordered on the west by the Wisconsin River basin. The Wisconsin River flows south and then west to the Mississippi River. To the north and east of the Wolf River basin, drainage is provided by the Menominee, Peshtigo, and Oconto rivers, which all flow southeast to Green Bay. In the upper Wolf River basin, the relatively slow-flowing streams frequently pass through lakes and wetlands. Stream gradients were determined from topographic maps and are generally in the range of 7.7 to 10 feet/mile (EMC, 1985).

3.7.2.2 Regional Precipitation

Average annual precipitation in the regional study area is 30.36 inches as reported in Section 3.4.2, Climatology-Meteorology. Precipitation is greatest from May through September and least during mid-winter when it generally occurs as snow. The mean annual accumulation of snow ranges from 40 to 60 inches. Precipitation records measured at the North Pelican at Pelican Lake meteorological station, approximately 15 miles west of the site, are assumed to be representative of the region. Average monthly precipitation values for the period 1961 through 1990 inclusive are given in Table 3.7-7. On the average, the wettest month is June with almost fourteen percent of the annual precipitation and the driest is February with only 2.7 percent.

3.7.2.3 Regional Runoff

Total annual surface water runoff in the drainage basins in the regional study area ranges from 11 to 13 inches (Hindall, 1976). For the Wolf River basin the annual stream discharges range from 10 to 13 inches of surface water runoff per year (Hindall, 1976). The nearest long-term stream gaging station to the site area is the USGS station on the Wolf River at Langlade as shown in Figure 3.7-4. The surface drainage area upstream from this gage encompasses 463 square miles and includes the site area. Mean annual discharge at the Langlade station for the periods of March 1966 through September 1979 and October 1980 through September 1993 is approximately 455 cubic feet/second (USGS, 1994). This discharge rate corresponds to an average surface water runoff depth of 13.35 inches from the surface drainage area of the Wolf River measured by this gage. Statistical monthly stream flow data for the Wolf River at Langlade are given in Table 3.7-8. January and February are typically the months of lowest stream runoff, because most precipitation is retained on the ground surface as snow and ice.

Review of the Wolf River stream discharges data presented in Table 3.7-8 indicates that the 1988 water year had the lowest annual mean flow measured during the 27 year period of record. The annual mean flow for 1988 was 326 cubic feet per second. The highest annual mean flow was measured in 1973 at 666 cubic feet per second. These flow rates can be compared with an annual mean flow rate of 455 cubic feet per second over the same 28 year period (USGS, 1994).

Table 3.7-7

Historic Meteorological Data

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Temperature Data (°F)[1]													
Average High	20.1	25.8	36.9	51.9	66.2	73.2	77.2	73.6	64.4	54.0	37.8	24.1	50.4
Average Low	0.1	2.6	15.0	28.8	40.1	49.7	54.9	53.0	45.4	35.3	23.2	6.9	29.6
Precipitation (in)[1]	1.08	0.82	1.62	2.35	3.18	3.58	3.73	4.14	3.99	2.46	1.96	1.45	30.36

Note: [1] Monthly averages for 30 year period (1961-1990) as measured at North Pelican at Pelican Lake meteorological station.

Source: State Climatologist (Anderson, 1995).

Prepared by: JJA
Checked by: JWS

Table 3.7-8

USGS Statistical Monthly Stream Discharge Record for Water Years 1966-1993 Wolf River at Langlade, WI USGS Station Number 04074950

	October	November	December	January	February	March	April	May	June	July	August	September
Mean	440	453	377	317	317	482	831	621	502	364	321	409
Max	813	788	578	548	482	1227	1330	1312	1013	874	632	813
(Wy)	1986	1986	1986	1969	1984	1973	1976	1973	1991	1968	1972	1968
MIN	196	203	226	193	213	278	263	319	173	183	188	171
(Wy)	1977	1977	1977	1977	1982	1982	1990	1987	1988	1989	1989	1989

Summary Statistics	**For 1992 Calendar Year**		**For 1993 Water Year**		**Water Years 1966 - 1993**	
Annual Total	177222		202505		N.A.	
Annual Mean	484		555		455	
Highest Annual Mean					666	1973
Lowest Annual Mean					326	1988
Highest Daily Mean	1520	April 21	1730	June 21	2200	March 15 1973
Lowest Daily Mean	229	July 29	(a)270	(b)February 20	137	July 7 1988
Annual Seven -Day Minimum	246	July 26	271	February 19	142	September 28 1989
Instantaneous Peak Flow			(c)1780	June 20	(d)2200	March 15 1973
Instantaneous Peak Stage			(a)9.95	December 28	(a)10.18	March 16 1990
Instantaneous Low Flow					119	November 8 1976
Annual Runoff (CFSM)	1.05		1.20		.98	
Annual Runoff (Inches)	14.24		16.27		13.35	

Table 3.7-18 *(Continued)*

Summary Statistics	For 1992 Calendar Year	For 1993 Water Year	Water Years 1966 - 1993
10 percent exceeds	781	918	792
50 percent exceeds	439	466	370
90 percent exceeds	268	300	240

Notes:

(a) Ice affected.
(b) Also occurred on Feb. 21-25, 27, 28 (ice affected).
(c) Gage Height, 9.84 feet.
(d) Gage height, 9.48 feet.

N.A. = Not applicable.
Drainage Area 463 square miles.

Source: USGS, 1994.

Prepared by: GJB1
Checked by: JJA

3.7.2.4 Regional Evapotranspiration

Evapotranspiration is defined as the movement of water through vegetation and from a free surface to the atmosphere. Evapotranspiration (E) is generally computed as the difference between precipitation (P) and stream discharge (Q), assuming that there is no net flux of ground water from the regional area (Freeze and Cherry, 1979), and that the amount of water held in storage in both the ground water (S_G) and surface water (S_s) reservoirs remains constant. That is, the average annual amount of ground water that flows from the aquifer is equal to the amount of recharge to the aquifer within the designated watershed or drainage basin, regardless of the porosity/permeability of the aquifer(s), and that the average annual amount of surface water lost from storage in the surface water system (i.e., in lakes and ponds) is replaced by precipitation. These assumptions have been proven to be generally accurate by empirical studies. Thus, this concept is expressed in the equation (Freeze and Cherry, 1979, p. 205):

$$P = Q + E + \Delta S_s + \Delta S_G$$

where $\Delta S_s = \Delta S_G = 0$ for a given drainage basin. Therefore, the general equation for evapotranspiration becomes:

$$E = P - Q$$

Each unit of this equation has several components that can be evaluated in detail for a specific stream flow rate analysis; however, for a general description of a regional system, such as that described in this subsection, the general equation is sufficient. On this basis, average annual evapotranspiration for the Wolf River surface drainage basin measured by the USGS station at Langlade, in conjunction with the precipitation records from the North Pelican at Pelican Lake meteorological station, is approximately 17.3 inches.

3.7.2.5 Surface Water Use

Water law in Wisconsin is essentially riparian, which means that water rights are acquired with the land adjacent to surface waters. In Wisconsin, permits for diversion of surface water are required for irrigation or agricultural purposes. In the Wolf River basin in Forest and Langlade counties, there are three diversions of surface water for irrigation registered with the WDNR (Table 3.7-9), all of which are outside the study area. There are no known diversions of surface water for domestic or industrial use in Forest or Langlade Counties, although such diversions may exist on the lower Wolf River.

3.7.3 Hydrologic Characterizations of the Study Area

Surface topography is used to define watersheds or drainage basins. The project area is within the Wolf River drainage basin which is part of the larger Fox River Basin, as illustrated in Figure 3.7-4. Drainage basins are typically separated by defining the high points between the drainage basins. The drainage basins discussed in this section are delineated by the channelized flow in a surface stream and are tributaries to the Wolf River Basin which in turn can be subdivided into numerous smaller drainage basins. The Crandon Project site is near three drainage basins, the Swamp Creek Basin, Hemlock Creek Basin and the Pickerel Creek Basin as shown on Figure 3.7-4. The Hemlock Creek Basin is contained within the Swamp Creek Basin.

Table 3.7-9

Irrigation Diversion Permits for the Wolf River Drainage Basin in Forest and Langlade Counties

Permittee	Stream	County	Location			Maximum Rate (cfs)	Docket Number
			Section	TWP.	Range		
1. William Koehler & John Witman	Lily River	Langlade	11, 14, 15	31N 32N	13E	2.22	2-WP-1076
2. Bula Potato Farms	Wolf River	Langlade	12, 13	34N	11E	2.00	2-WP-1092
3. Schroeder Brothers	Pollack Creek	Langlade	3, 4, 10	34N	11E	1.50	2-WP-1120

Source: Lang, 1995.

Prepared by: GJB1
Checked by: JJA

These drainage basins are characterized by forested land, lakes, wetland areas and perennial streams that provide drainage paths.

The topographic features of the environmental study area are a reflection of its glacial origin. The drainage basins are underlain by glacial drift, including fine grain materials as well as sand and gravel. The surface waters in the drainage basins interact with groundwater in various ways. While some streams such as Swamp Creek, are fed by groundwater movement into them, others provide a source of water to the groundwater system. The rate of interaction between surface waters and groundwater is governed by the porosity of the soil type, stream or lake bed characteristics and the gradients of the groundwater/surface water systems.

The wetlands and the forested lands located within the study area are described in detail under Terrestrial Ecology, Section 3.9, and the topographic features, geology, and glacial drift are described in Section 3.5, Geology. Groundwater characteristics are presented in Section 3.6, Groundwater.

The rate of stream flow is generally dependent on the drainage basin characteristics. Size, surface gradients, vegetation and soil types will impact the stream flow rates. Each surface water system is unique and will exhibit it's own characteristics.

Peak stream flow rates are usually associated with spring time snow melt and rain events. Major rain events at other times of the year may also result in peak flow conditions. Flooding conditions will often result in an increase in erosion in the drainage basin. Therefore, peak flow rates will often be associated with maximum sediment transport. The sampling events associated with these studies attempted to capture peak flow conditions on Swamp Creek and the Wolf River.

Low stream flow conditions are usually associated with the winter season and prolonged periods of dry weather during the summer. For example, while precipitation may be available in the winter, no runoff occurs because the moisture is stored as snow. Low flow conditions may also be associated with higher dissolved solids in streams. This condition is typically attributed to a lack of dilution. Routine monthly sampling was conducted to provide data for both high and low flow conditions.

The regional study area lies within the physiographic province known as the Northern Highlands (Hindall, 1976). The Northern Highlands encompasses all or part of 16 Wisconsin counties. Average annual sediment yields from the Northern Highlands region, based on USGS records, are generally less than 10 tons/square mile, and average annual values recorded at 12 stations in the Northern Highlands ranged from 3.1 to 31 tons/square mile (Hindall, 1976). This annual area sediment yield of 10 tons/square mile corresponds to an annual average surface water runoff of 13 inches, which produces an average concentration of approximately 11 mg/L (Hindall, 1976). This suspended sediment concentration is used herein as a standard for comparison to surface water sediment yields within the regional study area.

Rivers and lakes are dynamic entities and therefore will react to major rain events, spring runoff and dry periods. The impact of these flows on lakes is measured by a change in the lakes' water elevations. Although the impact of changes in precipitation on lakes is not typically of the same magnitude as streams, the characteristics as with streams of a lake's structure and drainage basin will influence the lakes reaction to excessive precipitation or prolonged dry periods. A lake with

a small drainage basin which is not fed by groundwater, will typically exhibit the greatest change in elevation due to excessive precipitation or prolonged dry periods. These lakes are in contrast to those which have large drainage basins and are also fed by groundwater. Such lakes will tend to have outlet structures which provide relief to an increase in water input. Groundwater can also provide a stable source of water to a lake and therefore lessen the impacts of changes in input such as prolonged periods of dry weather.

Natural lakes in Wisconsin frequently are classified by the source of water supply. Based on water source and outflows, four categories of lakes as described below have been identified in the 1995 WDNR publication titled, *Wisconsin Lakes* (WDNR, 1995).

- "Drainage lakes - Lakes [that] have both an inlet and outlet where the main water source is stream drainage. Most major rivers in Wisconsin have drainage lakes along their course. Drainage lakes owing one-half of their maximum depth to a dam are considered to be artificial lakes or impoundments."

- "Seepage lakes - These lakes do not have an inlet or an outlet, and only occasionally overflow. As landlocked waterbodies, the principal source of water is precipitation or runoff, supplemented by groundwater from the immediate drainage area. Since seepage lakes commonly reflect groundwater levels and rainfall patterns, water levels may fluctuate seasonally. Seepage lakes are the most common lake type in Wisconsin."

- "Spring lakes - These lakes have no inlet, but do have an outlet. The primary source of water for spring lakes is groundwater flowing into the bottom of the lake from inside and outside the immediate surface drainage area. Spring lakes are the headwaters of many streams and are a fairly common type of lake in northern Wisconsin."

- "Drained lakes - These lakes have no inlet, but like spring lakes, have a continuously flowing outlet. Drained lakes are not groundwater-fed. Their primary source of water is from precipitation and direct drainage from the surrounding land. Frequently, the water levels in drained lakes will fluctuate depending on the supply of water. Under severe conditions, the outlets from drained lakes may become intermittent. Drained lakes are the least common lake type found in Wisconsin."

Of the five lakes in the immediate vicinity of the project, Skunk Lake generally falls into the "seepage lake" category. Oak, Duck, and Deep Hole Lakes generally fall into the "drained lake" category since they do not have continuous flowing inlets, have outlets, and are not groundwater-fed lakes. Little Sand Lake generally falls into the "drainage lake" category since it has both an intermittent inlet and outlet and its main source of water comes from surface water runoff and stream drainage.

These five lakes can be further divided into two subcategories, "perched" and "groundwater head dependent" lakes based on their interaction with the groundwater table. Oak Lake is a perched lake. The bottom of this lake's silty clay lake bed is above the groundwater table. Therefore, the level of the lake is not dependent on the groundwater elevation. While the lake recharges the groundwater in the area, the lake bed restricts the amount of water leaving the lake. A very limited amount of water leaves the lake through percolation.

Duck, Deep Hole, Skunk and Little Sand Lakes can be classified as "groundwater head dependent" lakes. While the elevation of these lake surfaces are above the groundwater system, the bottom of the lake beds are connected to the groundwater system. The elevations of the lakes are influenced by the elevation of the groundwater system. The lake beds in these lakes limit percolation from the lakes to the groundwater system, thus maintaining a higher water elevation in the lakes than the surrounding groundwater system. Further discussion on the relationship between groundwater elevations and surface water elevations can be found in Section 3.6.

Ordinary high water mark elevations, determined and surveyed by the WDNR in July 1983, are shown in Table 3.7-10. Information relating to the determination of ordinary high water mark elevations is included in Appendix 3.7-2. The ordinary high water mark is the point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark, either by erosion, destruction of terrestrial vegetation, or other easily recognized characteristic. The table also includes statistical information regarding lake levels that have been recorded as part of project activities since the 1970s.

Table 3.7-10

Water Level Summary for Lakes in the Study Area

Location	Gage	Ordinary High Water Mark	Historical Water Level Statistics[1]		
			Maximum	Minimum	Mean
Oak Lake	LG-11	1633.17	1634.42	1632.12	1633.21
Little Sand Lake	LG-7	1591.96	1593.47	1590.81	1592.07
Rolling Stone Lake	LG-9	1535.35	1535.92	1534.94	1535.28
Duck Lake	LG-12	1611.09	1612.88	1610.24	1611.74
Deep Hole Lake	LG-13	1605.83	1607.09	1604.86	1605.64
Skunk Lake	LG-15	1598.09	1599.85	1595.18	1597.66

[1]Statistics through October 1994.

Prepared by: JJA
Checked by: SVD1

3.7.4 Swamp Creek Drainage Basin

A portion of the project area lies within the Swamp Creek drainage basin as shown on Figure 3.7-4. The Swamp Creek drainage basin is located in the northcentral portion of the Wolf River drainage basin as shown on the figure. Headwater streams of the Swamp Creek drainage basin above Rice Lake include upper Swamp Creek which originates from Lake Lucerne, Hemlock Creek which originates from Ground Hemlock Lake, Outlet Creek which originates from Lake Metonga, and Hoffman Creek whose headwater is Hoffman Springs. Swamp Creek flows westerly to Rice Lake and then southerly to its confluence with the Wolf River. Water bodies included in the discussion of the Swamp Creek drainage basin are Rice Lake; Hemlock, Swamp, Outlet, and Hoffman creeks; Hoffman Springs; Ground Hemlock Lake; and Oak Lake.

3.7.4.1 Rice Lake

The data presented for Rice lake is taken from previous project studies completed in the 1970s and 1980s (EMC, 1985). Unsuccessful attempts were made in 1994 to obtain access to Rice Lake from the Mole Lake Sokaogon Chippewa Community. Because of this, additional current data is unavailable.

Rice Lake is located approximately 2.7 miles northwest of the ore body. As shown in Table 3.7-11, it has a total area of 208 acres and a maximum depth of six feet (EMC, 1985). Over much of the lake, depths are typically four feet or less. The shoreline vegetation consists of conifer, shrub, and marsh wetland. The predominant lake substrate is muck. The lake itself has five inlets, the largest being Swamp Creek, which is navigable by small craft. The outlet, lower Swamp Creek, is navigable by small craft and flows to the Wolf River. The lake is entirely within the Swamp Creek drainage basin.

Table 3.7-11

Summary of Water Body Characteristics for the Portion of the Swamp Creek Drainage Basin Within the Study Area[a]

Seepage Water Category/ Water Body	Distance and Direction From Ore Body (mi)	Drainage Basin Area (sq. mi)	Length (mi)	Average Width (ft)	Average Depth (ft)	Maximum Depth (ft)	Surface Area (acres)	Gradient[b] (ft/mi)	Adjoining Wetlands (acres)	Predominant Shoreline Vegetation[c]	Substrate Classification
Lakes and Associated Streams											
Rice Lake	2.7 Northwest	--[d]	--	--	--	6	208	--	225	Sedge Meadow (Emergent wetland)	muck
Hemlock Creek	1.6 East	4.3	2.4	14	1.0	--	4.1	2.5	180	Wet-mesic or Wet Northern Forest	muck, sand, gravel
Swamp Creek	1.0 North	151.3	15.5	23.1	1.0	--	8.1	8.1	3,479	Wet-mesic or Wet Northern Forest	muck, sand, gravel and rubble
Outlet Creek	1.2 North	11.4	1.8	13	1.0	--	2.8	15	520	Dry-mesic or Mesic Northern Hardwoods and Wet-mesic or Wet Northern Forest	sand, gravel, muck
Hoffman Creek	1.8 West	1.7	0.5	8.0	0.5	--	0.5	8.1	20	Wet-mesic or Wet Northern Forest	sand, gravel, muck
Ground Hemlock Lake	2.4 East	--	--	--	--	42	88	--	8	Dry-mesic or Mesic Northern Hardwoods	sand, gravel, muck, rubble, boulders
Oak Lake	0.9 Southwest	--	--	--	--	47	51	--	15	Dry-mesic or Mesic Northern Hardwoods	muck, sand, gravel

[a] Steuck and Andrews, 1976; Steuck, et. al., 1977, Andrews and Theinen, 1966.
[b] Calculated from topographic maps.
[c] See Terrestrial Biology, Section 3.9.
[d] Not applicable.

Source: EMC, 1985
Checked by: SVD1

A staff gage (LG 14) was established in Rice Lake on May 26, 1977 and monitored through October 11, 1980 to measure surface water levels. Appendix 3.7-3 provides a record of gage readings at this location. The lake gage fluctuated in response to the groundwater inflow, incident precipitation, and the flow pattern of its tributary streams. During the period from October, 1977 to July, 1980, a 2.18-foot water level fluctuation was observed. The highest water level during the study period occurred on April 21, 1979, during the 1979 high snowmelt runoff period; however, no reading was taken because the gage was submerged. A measured high water level of 1,535.16 feet MSL was recorded in October 1977. The lowest water level of 1,532.98 feet MSL occurred on July 12, 1980.

Samples for water chemistry analyses were collected at two locations in Rice Lake: Station N, centrally situated in the lake at a depth of approximately three feet, and Station F, located in the southern portion of the lake within the channel of Swamp Creek that meanders through Rice Lake. The depth at Station F was approximately 3.6 feet. Water chemistry samples were collected monthly at both locations from March 1977 through March 1978. Additional samples were collected at Station N in May, August, and October 1978. Unsafe ice conditions were common on this lake in the winter; consequently, no samples were collected from either station in April 1977, and from Station N in December 1977 and January 1978. The maximum, minimum and mean values for the parameters measured are presented in Appendix 3.7-4.

Water chemistry data indicated that Rice Lake was a moderately hard, light brown-stained, neutral pH lake. Mean values for hardness, alkalinity, and specific conductance were 102 and 108 mg/L $CaCO_3$, <81 and 98 mg/L $CaCO_3$, and 197 and 194 μmhos/cm at Stations N and F, respectively. Mean pH values calculated for Stations N and F were 7.3 and 7.1, respectively. Secchi disc transparency was consistently recorded at or near the bottom at both sampling locations. Mean true color determined for Stations N and F were <40 and <24 color units, respectively.

Low dissolved oxygen concentrations were occasionally recorded at both stations in the winter and summer as documented in Appendix 3.7-4. Dissolved oxygen concentrations below 5.0 mg/L were found at Station N in March, July and September 1977. Similarly, concentrations below 5.0 mg/L were found in July, August and September 1977, and January 1978 at Station F.

Depth profiles of water chemistry parameters such as temperature, dissolved oxygen, pH, and conductivity indicated that Rice Lake at these sampling locations was generally well mixed.

Concentrations of metals measured in Rice Lake were either below detection limits or measured at very low levels. Mercury values were consistently below the detection limit of 0.1 μg/L at both stations, with the exception of a concentration of 0.1 μg/L reported for Station N in November 1977. Iron was detected in all samples from Rice Lake. Except for January 1978, in which a concentration of 4.34 mg/L was detected at Station F, concentrations ranged from 0.12 to 0.60 mg/L with a mean of 0.27 mg/L at Station F and from 0.10 to 0.35 mg/L with a mean of 0.20 mg/L at Station N. The anomalously high iron concentration in the water sample collected from Station F in January 1978 also had the highest suspended solids concentration, 28 mg/L, and therefore may reflect inadequate filtration and/or the presence of unfilterable colloidal iron oxides. Lead was below detection limits at both stations on Rice Lake on all sampling dates except July 1977 when a concentration of 0.03 mg/L was recorded at Station N.

Station N was sampled seasonally during 1979 and 1980. The results reported from these analyses generally were similar to those of 1977-1978 and are presented in Appendix 3.7-4. However, neither lead nor mercury were measured in the 1979-1980 samples. Also, lower levels of nitrate and organic nitrogen with mean concentrations both at <0.05 mg/L and dissolved and total solids with mean concentrations of 117 mg/L and 124 mg/L, respectively were reported in the 1979-1980 analytical results.

Bottom sediments were collected in March 1978 for chemical analyses at Station F and N. The analytical results are presented in Appendix 3.7-4.

3.7.4.2 Hemlock Creek (SG-6)

Hemlock Creek is a perennial stream that originates from the northwest shore of Ground Hemlock Lake, approximately 2.5 miles southeast of the ore body, and flows 2.4 miles north to its confluence with Swamp Creek (Figure 3.7-2). The stream is adjoined by 180 acres of wetlands, has a drainage area of 4.3 square miles, a total surface area of 4.1 acres, an average width of 14 feet, and an average depth of one foot (Table 3.7-11). Hemlock Creek has a well defined channel that flows through a wooded, flat drainage basin while receiving inputs from two unnamed tributaries originating in adjacent wetlands to the east.

A stream gage (SG-6) was established on Hemlock Creek during the 1977-1980 study and its location is shown on Figure 3.7-2. Flow readings obtained from October 1993 through March 1995 at this location are given in Appendix 3.7-5. Historical flow readings obtained from 1977 through 1980 are provided in Appendix 3.7-6. Because the area surrounding Hemlock Creek is of low relief and highly vegetated, stream flow is relatively constant across its width. Maximum and minimum flows observed on Hemlock Creek were 30.9 cubic feet per second (cfs) and 0.8 cfs in August 1977 and July 1977 respectively. Flows measured at this site during the 1994 study were within the range observed historically (min=3.11 cfs, max=8.56 cfs). In order to address groundwater input into the Hemlock Creek system, flow data was also collected at station SG-6A during the 1993-1995 study. This station was located approximately 0.1 miles downstream of Ground Hemlock Lake and 0.7 miles upstream of Station SG-6. Flow readings obtained at SG-6A ranged from 2.61 cfs to 6.72 cfs between April 1994 and March 1995 and are given in Appendix 3.7-5. In any year, the minimum seven-day average flow rate of Hemlock Creek has a 50-percent chance of being less than 2.0 cfs and a 10-percent chance of being less than 1.4 cfs (Table 3.7-12).

Samples for water chemistry analyses were collected from Hemlock Creek monthly from April 1994 through March 1995 at Station SG-6. Water quality data obtained from analyses of samples collected at the site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-13 which compares them to similar statistics derived from samples obtained during the 1977-1980 study. Historical data and current laboratory data reports supporting this table can be found in Appendices 3.7-4 and 3.7-9.

In general, the results reported from analyses of samples collected from Hemlock Creek in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Water chemistry data collected in 1994 indicated that Hemlock Creek was a moderately hard, neutral pH stream according to the classification system contained in Table 3.7-14. Mean values recorded for hardness, alkalinity

Table 3.7-12

Summary of Stream Water Body Discharges in the Study Area

Stream Gaging Location	1978 Water Year		Maximum Recorded Discharge[a]	Minimum Recorded Discharge[a]	1984 Estimated	
	Average Flow	Average Base Flow			Q7,2	Q7,10
Wolf River (at Langlade-USCS)	N/C	N/C	1,840	175	N/C	N/C
Swamp Creek						
S-1	74.4	50.1	274	25.3	24	18
USGS below Rice Lake @ Hwy M	47.9	N/C	209	17	19	15
USGS above Rice Lake @ Hwy 55	33.5	23.6	151	8	11	8
SC-3	N/C	N/C	138	10.3	6.7	4.7
SC-5A	N/C	N/C	N/C	N/C	1.4	1
Outlet Creek (SG 4)	N/C	N/C	206	<0.1	0.8	0.6
Hemlock Creek (SG 6)	3.6	2.3	30.9	0.8	2.0	1.4
Pickerel Creek (SG 19)	3	1.8	23.4	0.1	0.6	0.4
Creek 12-9						
SG-23	N/C	N/C	42.2	1.2	1.5	1.1
SG-8	0.7	0.55	10.1	0.4	0	0

Source: Krug, 1984, Appendix 3.7-6

[a] During periods of record prior to November, 1980.

Notes: N/C = Not Calculated.
All values in cubic feet per second.

Prepared by: JJA
Checked by: SVD1

Table 3.7-13

Water Quality Data, SG-6 (Hemlock Creek)
Summary of Monthly Means and Ranges

Station: A-1/SG-6	Units	1977-1978 Min.	1977-1978 Max.	1977-1978 Mean	1994-1995 Min.	1994-1995 Max.	1994-1995 Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	3.36	58.20	20.40
Arsenic, Total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	2	<1	<.003	.008	.002
Copper, Total	µg/L	<1	17	<5	.101	.430	.229
Iron, Total	mg/L	.02	.37	.11	<.050	.300	.129
Lead, Total	µg/L	<10	<10	<10	.023	.159	.082
Manganese, Total	mg/L	.005	.196	.028	<.010	.126	.028
Mercury, Total	ng/L	<100	200	<100	.50	3.12	1.66
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	<1	14	<5	<.64	3.94	1.70
Phosphorus							
Phosphorus, Total	mg/L	<.01	.04	<.02	<.050	.048	.011
Nitrogen							
Nitrogen, Ammonia	mg/L	<.05	.94	<.29	<.10	.17	.03
Nitrogen, Nitrate	mg/L	<.01	.48	<.18	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	9	<4	4.00	16.00	6.95
Solids							
Solids, Dissolved	mg/L	58	384	153	90	190	126
Solids, Suspended	mg/L	1	50	9	<5	6	1
General Parameters							
Alkalinity, Total	mg/L	55	130	101	76	130	102
Biological Oxygen Demand	mg/L	1	5	2	<2	7	1
Chemical Oxygen Demand	mg/L	3	14	9	14	22	18
Chloride	mg/L	<1	2	<2	<1	2	1
Conductivity	µmhos/cm	85	161	136	98	248	185
Cyanide	mg/L	<.001	.005	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	3.2	14.4	9.3	5.8	14.5	9.3
Hardness	mg/L	74	138	107	<5	130	97
pH	SU	5.8	8.1	7.4	6.83	8.05	7.54
Temperature	°C	0	22.0	8.3	.5	22.5	9.8
Turbidity[a]	NTU	.6	5.7	2.8	<.50	3.30	1.40

[a] Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-14

Hardness, pH and Color Classification System

Hardness[a] (mg/L as $CaCO_3$)	pH[b] (standard units)	Color[c] (color units)
0-60 = soft	0-2 = very acidic	0-20 = clear
61-120 = moderately hard	2-4 = acidic	20-50 = light brown
121-180 = hard	4-6 = slightly acidic	50-100 = medium brown
180+ = very hard	6-8 = neutral	100+ = dark brown
	8-10 = slightly basic	
	10-12 = basic	
	12-14 = very basic	

[a] (USGS, 1985).
[b] This classification is based on narrative text by Steuck and Andrews (1976).
[c] This classification system was developed specifically for the 1985 Crandon Project study (EMC, 1985).

Prepared by: JJA
Checked by: SDJ

and specific conductance at Station SG-6 were 97 mg/L as $CaCO_3$, 102 mg/L as $CaCO_3$ and 185 μmhos/cm, respectively. The mean pH value measured in field was 7.54. The concentration of dissolved oxygen in Hemlock Creek was above 5 mg/L during all samplings and ranged from 5.8 mg/L to 14.5 mg/L throughout the sampling period.

All metals analyzed from samples collected at SG-6 during the 1994-1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Hemlock Creek. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, aluminum was detected at a level higher than those observed during the 1977-1980 study (mean value = 58.2 μg/L vs <10 μg/L).

In October 1994 a sediment sample was collected from Hemlock Creek at station A-1. A sample was also collected at this site in March 1978 as part of the previous work that was completed (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-15. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

Surface water sediment composition has a considerable amount of variability. This is most evident in streams where scouring and deposition of sediments can take place within inches of each other. Samples collected from a stream or lake may have variable compositions and represent the variability of the sediments for that surface water. This is evident when comparing the two sets of sampling data for Hemlock Creek. The 1994 data is indicative of inorganic sediments with relatively high calcium, aluminum, iron and magnesium concentrations as well as relatively low volatile solids concentrations, 7,000 mg/kg or 0.7%. This sample was collected from a scoured area of the stream. The data collected in 1978 demonstrated a predominantly organic composition with only an 18.29% solids concentration and a freon extractables (Oil and Grease) concentration of 1,181 mg/kg. This sample was likely collected from an area of deposition in the stream. The sampling devices may also have impacted the nature of the sample. The 1994 sample was collected with a core type sampler while the 1978 sample was collected with an Ekman dredge.

The concentrations of some metals and inorganic parameters demonstrated fairly good correlation between the 1994 data and the 1978 data. This is likely reflective of the water chemistry within the stream.

3.7.4.3 Swamp Creek

Swamp Creek is a perennial stream that originates at Lake Lucerne, approximately 4.5 miles northeast of the ore body, and joins the Wolf River approximately 7.8 miles downstream and southwest of the ore body as shown in Figure 3.7-2. Swamp Creek has a drainage area of 151.3 square miles, a total surface area of 8.1 acres and a total length of 15.5 miles when measured to its confluence with the Wolf River (Table 3.7-11). Wooded land, wetlands, and undeveloped lands dominate the watershed of the river, and approximately 10 percent of the area surrounding it is used for agricultural purposes (EMC, 1985). The creek's channel is well defined and flows

Table 3.7-15

Sediment Sampling Data, Hemlock Creek (Station A-1)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	7.5	NDA
Solids, Total	%	86.6	18.29
Solids, Total Volatile	mg/kg	7000	NDA
Ammonia, N	mg/kg	33	NDA
Total Kjeldahl Nitrogen	mg/kg	260	NDA
Total Organic Nitrogen	mg/kg	230	NDA
Chloride	mg/kg	20	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	240	1181
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	2000	NDA
Arsenic, Total	mg/kg	1.4	1.3
Barium, Total	mg/kg	12	NDA
Iron, Total	mg/kg	6200	4026
Manganese, Total	mg/kg	56	179
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	15	66.2
Cobalt, Total	mg/kg	1.8	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	3.9	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	1900	NDA
Phosphorus, Total	mg/kg	170	NDA
Potassium, Total	mg/kg	180	NDA
Sodium, Total	mg/kg	28	NDA
Aluminum, Total	mg/kg	2700	NDA
Cadmium, Total	mg/kg	<0.50	1.0
Copper, Total	mg/kg	6.4	6.7
Lead, Total	mg/kg	4.4	7

Table 3.7-15 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	59	46
Vanadium	mg/kg	9.9	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

through a relatively flat drainage basin. Swamp Creek flows west along the northern edge of the site area, and through both Rice Lake and a broad wetland before connecting with the Wolf River (Figures 3.7-1 and 3.7-2). Its major tributaries in the study area are Hemlock, Hoffman, and Outlet creeks, each of which is discussed individually in this section.

An additional unnamed tributary to Swamp Creek, designated Creek 24-15, is located in Sections 13 and 24, T35N, R12E. Three unnamed tributaries that contribute flow to Creek 24-15 are Creeks 24-4, 24-13 and 24-14. No stream gage measurements were taken in this stream system during these studies. Historically, Creek 24-15 has been described by Steuck (1981) as a medium hard water trout stream (Class IB) with slightly alkaline, light brown water. Other major tributaries to Swamp Creek not included in this investigation are Squaw Creek and Creeks 6-10, 7-5, and 7-9.

Two USGS stream gages and five other stream gages were established by earlier studies and used to monitor stream flow rates in the Swamp Creek system during the 1970s and 1980s. Historical records of gage readings and flow rates for these locations are presented in Appendix 3.7-6. Table 3.7-11 lists some descriptive characteristics for Swamp Creek and other water bodies located within its drainage basin.

Samples for water chemistry analysis and flow rate transect data were collected from five locations (Figures 3.7-1 and 3.7-2) on Swamp Creek during the 1993-1995 study. The furthest upstream of these, Station SG-5A, was located approximately 2.9 miles northeast of the ore body, and approximately two miles upstream from the confluence of Swamp Creek with Hemlock Creek. Station SG-3 was established two miles downstream from Station SG-5A, about 0.2 mile below the confluence with Outlet Creek, and SG-2 was located 2.1 miles downstream from SG-3, in an area approximately 0.9 mile upstream from Rice Lake. Bottom substrates at the three Swamp Creek sites upstream of Rice Lake were variable. SG-3 was located in a riffle section of the creek containing boulders, rubble, and substrate consisting of gravel and coarse sand. The other stations were located on reaches of the creek with typically slower current velocities and predominantly less coarse substrates. Downstream from Rice Lake, two stations were established: Station SG-AB, approximately 0.3 mile upstream from the Squaw Creek confluence,

and SG-V, which was positioned approximately 1.4 miles upstream from the confluence with the Wolf River.

Samples for water chemistry analyses were collected at stations SG-2 and SG-3 monthly from April 1994 through January 1995. Samples were also collected at Stations SG-5A in April, July, and October 1994. Station SG-AB was sampled monthly from December 1993 through October 1994; and samples from Station SG-V were collected monthly from November 1993 through October 1994.

Flow readings were obtained at sites SG-5A, SG-3, SG-2 and SG-V periodically from November 1993 to March 1995 during the time of their respective water chemistry sampling events. River flow was also monitored at SG-AA at the USGS gaging station located at the County Highway M crossing of Swamp Creek during this time. An additional flow measurement station was established on Swamp Creek (SG-2A) in order to address the effect of groundwater input into the Swamp Creek system. Station SG-2A was established above Rice Lake approximately 1.2 miles upstream of Station SG-2. This station was monitored from March 1994 to October 1994, and April 1994 to March 1995, respectively. Stream flow data collected during these time periods is included in Appendix 3.7-5.

Because the area surrounding Swamp Creek is of low relief and highly vegetated, stream flow is relatively constant across its width. Maximum and minimum flows observed during the 1993-1995 study in Swamp Creek ranged from 3.28 cfs and 4.45 cfs at the furthest upstream station, SG-5A, to 36.19 cfs and 171.09 cfs at SG-V, the furthest downstream station. During earlier studies, similar flow measurements were observed within the Swamp Creek system. Measurements conducted during the 1970s and 1980s yielded similar values for SG-5A (minimum = 2.3 cfs, maximum 2.4 cfs) to those measured during the 1993-1995 study period.

Although maximum values observed at SG-3 during earlier studies were higher than those seen in the 1993-1995 study (138.3 cfs versus 38.93 cfs), there is general agreement in the two data sets for flows measured at the furthest mutual downstream station (1994-1995 average flow = 28.07, 1977-1980 average flow = 35.95). Historical flow information and supporting data are given in Appendices 3.7-5 and 3.7-6.

Water quality data obtained from analyses of samples collected during the current study are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Tables 3.7-16 through 20 which compare them to similar statistics derived from samples obtained during the 1977-1980 study.

In general, the results reported from analyses of samples collected from Swamp Creek in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Water chemistry data indicated that Swamp Creek was a moderately hard, neutral pH stream (Table 3.7-14). Mean values for hardness, alkalinity, and specific conductance at the five sampling stations ranged from 91 to 113 mg/L as $CaCO_3$, 87 to 105 mg/L as $CaCO_3$, and 188 to 207 μmhos/cm, respectively. Mean pH values ranged from 7.10 to 7.47. Dissolved oxygen was measured in concentrations below 5 mg/L at SG-5A in July, and at Stations SG-AB and SG-V during the months of January and February of 1994.

Table 3.7-16

Water Quality Data, SG-V (Swamp Creek)
Summary of Monthly Means and Ranges

Station: V/SG-V	Units	1977-1978 Min.	1977-1978 Max.	1977-1978 Mean	1993-1994 Min.	1993-1994 Max.	1993-1994 Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	18.30	99.50	40.16
Arsenic, Total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	3	<1	<.004	.070	.012
Copper, Total	µg/L	<1	15	<3	.179	1.550	.410
Iron, Total	mg/L	.26	2.54	.80	.260	.830	.492
Lead, Total	µg/L	<10	<10	<10	.093	.316	.193
Manganese, Total	mg/L	.016	.156	.062	.025	.117	.060
Mercury, Total	ng/L	<100	<100	<100	1.00	7.16	2.43
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	<1	13	<5	.80	3.67	1.78
Phosphorus							
Phosphorus, Total	mg/L	<.01	.04	<.03	<.05	1.11	.11
Nitrogen							
Nitrogen, Ammonia	mg/L	.32	1.60	.95	<.10	.48	.13
Nitrogen, Nitrate	mg/L	<.01	.54	<.21	<.04	.73	.15
Sulfur							
Sulfate	mg/L	<1	8	<5	4.15	26.00	8.33
Solids							
Solids, Dissolved	mg/L	85	161	126	79	154	115
Solids, Suspended	mg/L	1	16	5	<5	8	2
General Parameters							
Alkalinity, Total	mg/L	64	112	81	35	122	87
Biological Oxygen Demand	mg/L	1	3	2	<1	9	3
Chemical Oxygen Demand	mg/L	69	69	69	<20	34	17
Chloride	mg/L	<1	4	<3	2	4	3
Conductivity	µmhos/cm	.60	145	110	106	262	188
Cyanide	mg/L	<.001	.001	<.001	<.010	<.020	Note 1
Dissolved Oxygen	mg/L	3.8	11.6	6.7	2.8	10.6	7.3
Hardness	mg/L	76	124	95	61	140	101
pH	SU	5.8	7.6	6.8	6.60	7.70	7.10
Temperature	°C	0	22.0	8.5	0	20.2	9.3
Turbidity[a]	NTU	1.4	2.9	2.1	<.50	3.30	1.84

[a] = Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-17

Water Quality Data, SG-2 (Swamp Creek)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: E/SG-2	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	22.10	60.60	34.62
Arsenic, Total	mg/L	<.001	.001	<.001	<.005	.006	.001
Cadmium, Total	µg/L	<1	4	<2	<.003	.051	.006
Copper, Total	µg/L	<1	10	<4	.154	6.990	.952
Iron, Total	mg/L	.11	.36	.23	.212	.439	.324
Lead, Total	µg/L	<10	<10	<10	.053	.227	.124
Manganese, Total	mg/L	.023	.085	.043	.037	.142	.059
Mercury, Total	ng/L	<100	<100	<100	.98	4.66	2.25
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	<1	17	<5	.75	3.47	1.58
Phosphorus							
Phosphorus, Total	mg/L	<.01	.06	<.03	<.050	.046	.011
Nitrogen							
Nitrogen, Ammonia	mg/L	.06	1.00	.39	<.10	.20	.06
Nitrogen, Nitrate	mg/L	<.01	.48	<.19	<.50	.72	.18
Sulfur							
Sulfate	mg/L	<1	12	<5	4	13	7.19
Solids							
Solids, Dissolved	mg/L	78	372	167	90	190	135
Solids, Suspended	mg/L	<1	12	<4	<5	10	3
Bacteria							
Fecal Coliform Bacteria	ORG/100 ml	2	145	48	<1	<1	Note 1
General Parameters							
Alkalinity, Total	mg/L	55	132	94	70	120	95
Biological Oxygen Demand	mg/L	1	9	2	<2	8	2
Chemical Oxygen Demand	mg/L	3	17	10	10	27	21
Chloride	mg/L	<1	5	<2	2	3	3
Conductivity	µmhos/cm	90	165	132	158	259	196
Cyanide	mg/L	<.001	.003	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	6.2	12.4	8.9	6.3	13.2	9.9
Hardness	mg/L	66	130	99	78	130	104
pH	SU	5.8	8.1	7.3	6.46	7.89	7.24
Temperature	°C	0	21.0	8.0	.2	19.2	8.1
Turbidity[a]	NTU	1.4	4.5	2.2	.90	5.10	2.29

[a] = Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-18

Water Quality Data, SG-3 (Swamp Creek)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: D/SG-3	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	11.90	49.9	27.20
Arsenic, Total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	4	<1	<.004	.024	.004
Copper, Total	µg/L	<1	14	<4	.154	1.48	.471
Iron, Total	mg/L	.11	.41	.25	.228	.379	.312
Lead, Total	µg/L	<10	<10	<10	.053	.208	.111
Manganese, Total	mg/L	.020	.091	.050	.037	.076	.059
Mercury, Total	ng/L	<100	<100	<100	.90	3.36	1.85
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	<1	20	<5	.827	5.38	1.98
Phosphorus							
Phosphorus, Total	mg/L	<.01	.04	<.03	<.050	.035	.009
Nitrogen							
Nitrogen, Ammonia	mg/L	<.05	.91	<.34	<.10	.28	.04
Nitrogen, Nitrate	mg/L	<.01	.24	<.13	<.05	<.05	Note 1
Sulfur							
Sulfate	mg/L	<1	12	<5	4.00	12.00	6.99
Solids							
Solids, Dissolved	mg/L	65	434	169	68	190	125
Solids, Suspended	mg/L	2	16	6	<5	7	2.9
General Parameters							
Alkalinity, Total	mg/L	61	128	95	75	130	96
Biological Oxygen Demand	mg/L	1	8	3	<2	12	3
Chemical Oxygen Demand	mg/L	3	24	13	12	23	18
Chloride	mg/L	<1	6	<2	1	3	3
Conductivity	µmhos/cm	90	165	138	175	262	207
Cyanide	mg/L	<.001	.006	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	6.7	15.0	10.4	7.5	12	9.6
Hardness	mg/L	72	130	101	<5	120	91
pH	SU	5.9	7.8	7.3	6.93	7.96	7.47
Temperature	°C	0	21.0	8.0	.6	19.3	9.0
Turbidity[a]	NTU	1.2	2.6	1.8	.65	2.3	1.39

[a] = Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-19

Water Quality Data, SG-5A (Swamp Creek)
Summary of Monthly Means and Ranges

Parameter	Units	Minimum	Maximum	Mean
pH	SU	7.06	7.32	7.16
Conductivity	μmhos	183	208	195
Temperature	°C	2.3	19.3	9.7
Dissolved Oxygen	mg/L	4.8	8.9	7.2
Alkalinity, total	mg/L	94	122	105
Hardness	mg/L	101	129	113
Total Dissolved Solids	mg/L	97	149	119
Total Suspended Solids	mg/L	<5	<5	Note 1
Biological Oxygen Demand	mg/L	<3	5	2
Chemical Oxygen Demand	mg/L	<10	12	6
Ammonia	mg/L	<.10	<.10	Note 1
Nitrate	mg/L	<.50	<.50	Note 1
Nitrogen, Total Kjeldahl	mg/L	.39	.48	.42
Chloride	mg/L	1	2	2
Fluoride	mg/L	<.1	<.1	Note 1
Sulfate	mg/L	<1.00	14.00	6.43
Cyanide, total	mg/L	<.020	<.020	Note 1
Oil & Grease	mg/L	<1.0	6.2	2.1
Turbidity, Lab	NTU	.80	1.10	.95
Cations	Meq/L	2.10	2.66	2.32
Anions	Meq/L	1.69	2.15	1.91
Cation and Anion Balance	%	5.33	13.20	9.68
Boron, Total	mg/L	<.100	<.100	Note 1
Calcium, total	mg/L	22.0	29.7	25.2
Arsenic, total	mg/L	<.005	<.005	Note 1
Barium, total	mg/L	<.010	.017	.009
Iron, dissolved	mg/L	.111	.173	.141
Iron, total	mg/L	.173	.274	.226
Manganese, dissolved	mg/L	.015	.028	.023
Manganese, total	mg/L	.067	.114	.095
Molybdenum, total	mg/L	<.020	<.020	Note 1
Selenium, total	mg/L	<.005	<.005	Note 1
Silver, total	mg/L	<.010	<.010	Note 1
Chromium, total	mg/L	<.005	<.020	Note 1
Beryllium, total	mg/L	<.005	<.010	Note 1
Thallium, total	mg/L	<.005	<.005	Note 1

Table 3.7-19 *(Continued)*

Parameter	Units	Minimum	Maximum	Mean
Nickel, total	mg/L	<.003	<.003	Note 1
Antimony, total	mg/L	<.005	<.005	Note 1
Magnesium, total	mg/L	11.0	13.3	11.8
Phosphorus, dissolved	mg/L	<.050	.018	.006
Phosphorus, total	mg/L	<.050	.037	.012
Potassium, total	mg/L	<.600	.800	.267
Sodium, total	mg/L	1.70	1.83	1.78
Sodium Absorption Ratio	std	.070	.078	.073
Aluminum, total	µg/L	<50	<200	Note 1
Cadmium, total	µg/L	<5	<5	Note 1
Copper, total	µg/L	<30	<30	Note 1
Lead, total	µg/L	<50	<50	Note 1
Mercury, total	ng/L	<200	<200	Note 1
Zinc, total	µg/L	<20	<20	Note 1

Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Table 3.7-20

Water Quality Data, SG-AB (Swamp Creek)
Summary of Monthly Means and Ranges

Parameter	Units	Minimum	Maximum	Mean
pH	SU	6.87	7.71	7.31
Conductivity	μmhos	151	275	203
Temperature	°C	0	20.8	10.6
Dissolved Oxygen	mg/L	3.2	11.1	7.6
Fecal Coliform	org/100mL	<1	<1	Note 1
Alkalinity, total	mg/L	59	124	96
Hardness	mg/L	65	129	103
Total Dissolved Solids	mg/L	79	153	118
Total Suspended Solids	mg/L	<5	12	1
Biological Oxygen Demand	mg/L	<1	8	3
Chemical Oxygen Demand	mg/L	<20	29	14
Ammonia	mg/L	<.10	.57	.11
Nitrate	mg/L	.04	.79	.38
Nitrogen, Total Kjeldahl	mg/L	.25	4.48	1.02
Chloride	mg/L	2	4	3
Fluoride	mg/L	<.1	.5	0
Sulfate	mg/L	4.77	18.00	7.68
Cyanide, total	mg/L	<.010	<.020	Note 1
Oil & Grease	mg/L	<1.0	6.5	.94
Turbidity, Lab	NTU	<.50	7.00	1.92
Cations	Meq/L	1.42	2.72	2.11
Anions	Meq/L	.09	2.27	1.70
Cation and Anion Balance	%	.73	92.73	14.69
Boron, total	mg/L	<.099	<.200	Note 1
Calcium, total	mg/L	15.0	29.0	22.5
Arsenic, total	mg/L	<.005	<.005	Note 1
Barium, total	mg/L	<.010	.013	.008
Iron, dissolved	mg/L	.100	.266	.127
Iron, total	mg/L	.160	.508	.287
Manganese, dissolved	mg/L	<.010	.051	.017
Manganese, total	mg/L	.025	.098	.056
Molybdenum, total	mg/L	<.020	<.020	Note 1
Selenium, total	mg/L	<.005	<.005	Note 1
Silver, total	mg/L	<.010	<.010	Note 1
Chromium, total[1]	μg/L	.300	.817	.533

Table 3.7-20 *(Continued)*

Parameter	Units	Minimum	Maximum	Mean
Chromium, total	mg/L	<.020	<.020	Note 1
Beryllium, total	mg/L	<.001	<.010	Note 1
Thallium, total	mg/L	<.005	<.005	Note 1
Nickel, total	mg/L	<.030	<.030	Note 1
Antimony, total	mg/L	<.005	<.005	Note 1
Magnesium, total	mg/L	7.0	13.6	10.9
Phosphorus, dissolved	mg/L	<.050	.025	.004
Phosphorus, total	mg/L	<.050	.039	.010
Potassium, total	mg/L	<.600	1.100	.493
Sodium, total	mg/L	1.60	3.09	2.52
Sodium, Absorption Ratio	std	.086	.148	.110
Aluminum, total	µg/L	4.5	77.1	21.7
Cadmium, total	µg/L	<.006	.011	.004
Copper, total	µg/L	.135	2.910	.543
Lead, total	µg/L	.052	.374	.137
Mercury, total	ng/L	.90	4.37	2.00
Zinc, total	µg/L	.11	2.18	1.23

[1]Chromium analyzed using low level techniques.
Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

All metals analyzed from samples collected at Swamp Creek during the 1993-1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Swamp Creek. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. As consistent with the results from Hemlock Creek only aluminum was detected at a level significantly higher than those observed during the 1977-1980 study (range of means = 21.7 μg/L - 40.16 μg/L vs <10 μg/L).

In October 1994 sediment samples were collected from Swamp Creek at stations D and E. Samples were also collected at these sites in March 1978 as part of the previous project work (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-21 and Table 3.7-22. Information pertaining to the analysis of sediment samples are included in Appendices 3.7-4 and 3.7-10.

As stated previously, surface water sediment composition has a considerable amount of variability. This is most evident in streams where scouring and deposition of sediments can take place within inches of each other. Samples collected from a stream or lake may have variable compositions and represent the variability of the sediments for that surface water. This is evident when comparing the two sets of sampling data from Swamp Creek. The total solids in the 1994 samples were 81.8% and 22.1% as compared to 1.02% and 16.13% in the samples collected in 1978 for sites D and E respectively.

The 1994 data for sampling site D is indicative of inorganic sediments with relatively high calcium, aluminum, iron and magnesium concentrations as well as relatively low volatile solids concentrations, 3000 mg/kg or 0.3%. This sample was collected from a scoured area of the stream. The data collected in 1978 demonstrated a predominantly organic composition with only a 1.02% solids concentration and a freon extractables (Oil and Grease) concentration of 4,412 mg/kg. This sample was likely collected from an area of deposition in the stream. The 1978 data for site D also had very high concentrations of cadmium, chromium, copper, iron, and manganese which indicate that the sampling devices may also have impacted the nature of the sample. The 1994 sample was collected with a core type sampler while the 1978 sample was collected with an Ekman dredge sampler.

The 1994 data for sampling site E indicated that this site had a higher level of organic material in the sample. The total solids concentration was 22.1%, and of that, the volatile solids concentration was 261,000 mg/kg or 26.1% of the total solids. The Nitrogen concentrations were also elevated at this site, which again indicates the presence of higher levels of organic material. This site is likely associated with an area of stream deposition.

The 1978 data for site E had a percent solids level of 16.13 which is a higher than average level for the data collected in 1978. The average percent solids level in 1978 was 8.04 for the Swamp Creek and Pickerel Creek drainage basins. This site also had a lower Freon extractables (oil and grease) level with only 477 mg/kg being observed. This is indicative of an inorganic substrate. This sample was likely collected from an area of stream scouring. Metals measured in Swamp Creek sediments were found either in low concentrations or below detection limits.

Table 3.7-21

Sediment Sampling Data, Swamp Creek (Station D)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	7.5	NDA
Solids, Total	%	81.8	1.02
Solids, Total Volatile	mg/kg	3000	NDA
Ammonia, N	mg/kg	23	NDA
Total Kjeldahl Nitrogen	mg/kg	120	NDA
Total Organic Nitrogen	mg/kg	97	NDA
Chloride	mg/kg	<10	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	210	4412
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	540	NDA
Arsenic, Total	mg/kg	1.8	2.0
Barium, Total	mg/kg	13	NDA
Iron, Total	mg/kg	2700	19894
Manganese, Total	mg/kg	290	3696
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	3.3	180.8
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	410	NDA
Phosphorus, Total	mg/kg	140	NDA
Potassium, Total	mg/kg	60	NDA
Sodium, Total	mg/kg	28	NDA
Aluminum, Total	mg/kg	950	NDA
Cadmium, Total	mg/kg	<0.50	4.4
Copper, Total	mg/kg	0.56	51.7
Lead, Total	mg/kg	1.1	<1
Mercury, Total	mg/kg	<0.02	<0.01

Table 3.7-21 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Zinc, Total	mg/kg	8.5	66
Vanadium	mg/kg	3.8	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Table 3.7-22

Sediment Sampling Data, Swamp Creek (Station E)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.8	NDA
Solids, Total	%	22.1	16.13
Solids, Total Volatile	mg/kg	261000	NDA
Ammonia, N	mg/kg	<20	NDA
Total Kjeldahl Nitrogen	mg/kg	1600	NDA
Total Organic Nitrogen	mg/kg	1600	NDA
Chloride	mg/kg	25	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	460	477
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	1800	NDA
Arsenic, Total	mg/kg	1.4	6.3
Barium, Total	mg/kg	10	NDA
Iron, Total	mg/kg	2100	8815
Manganese, Total	mg/kg	130	1084
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	1.2	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	4.5	57.9
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	450	NDA
Phosphorus, Total	mg/kg	820	NDA
Potassium, Total	mg/kg	<60	NDA
Sodium, Total	mg/kg	18	NDA
Aluminum, Total	mg/kg	710	NDA
Cadmium, Total	mg/kg	<0.50	1.1
Copper, Total	mg/kg	2.1	13.3
Lead, Total	mg/kg	2.3	12
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	15	74
Vanadium	mg/kg	3.5	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

3.7.4.4 Outlet (Metonga) Creek

Outlet Creek originates approximately 2.8 miles north of the ore body at the south shore of Lake Metonga and flows southward 1.8 miles to its confluence with Swamp Creek (Figure 3.7-2). The creek has a drainage area of 11.4 square miles, is adjoined by 520 acres of wetlands, has a total surface area of 2.8 acres, and an average width and depth of 13 feet and 1 foot, respectively. It has a well defined channel that flows through a relatively flat drainage basin and has no major tributaries.

A stream gage (SG-4) was established on Outlet Creek during the 1977-1980 study and its location is shown on Figure 3.7-2. This station was located immediately upstream of Keith Siding road which is approximately 0.9 mile upstream from the confluence with Swamp Creek. Flow readings obtained from April 1994 through October 1994 at this location are given in Appendix 3.7-5. Historical readings from 1977 through 1980 are provided in Appendix 3.7-6. Maximum and minimum flows observed in Outlet Creek were <0.1 cubic feet per second (cfs) and 34.0 cfs respectively. Flows measured at this site during the 1993-1995 study were within the range observed historically (min=5.57 cfs, max = 14.64 cfs).

Samples for water chemistry analyses were collected from Outlet Creek in April, July, and October of 1994 at Station SG-4. Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics for the 1994 study period, including maximum, minimum and mean values for these parameters are given in Table 3.7-23 which compares them to similar statistics derived from samples obtained during the 1977-1980 study (Appendix 3.7-4). In general, the results reported from analyses of samples collected from Outlet Creek in 1994 were similar to those obtained during the 1977-1980 effort. Water chemistry data indicated that Outlet Creek was a moderately hard, neutral pH stream. Mean values recorded in 1994 for hardness, alkalinity and specific conductance at Station SG-4 were 100 mg/L as $CaCO_3$, 92 mg/L as $CaCO_3$ and 187 μmhos/cm, respectively. The mean pH value measured in field was 7.26. Dissolved oxygen concentrations measured during the study were consistently high, ranging from 8.0 mg/L to 10.3 mg/L. All metals analyzed from samples collected at SG-4 during the 1994 study were either below detection limits or were found in low concentrations.

3.7.4.5 Hoffman Creek and Springs

Hoffman Creek originates from Hoffman Spring Pond, which is located approximately 1.8 miles west of the ore body. It has a drainage area of 1.7 square miles and flows north approximately 0.5 mile to its confluence with Swamp Creek (Figure 3.7-2). The stream has a total surface area of 0.5 acre, and its watershed is predominantly wetland, wooded, and undeveloped land (Table 3.7-11). It is a stream with a poorly defined channel that derives its water flow from a large, poorly drained wetland area above Hoffman Spring Pond. Oak Lake discharges intermittently to this wetland and, thus, to Hoffman Creek.

A stream gage (SG-E) was established on Hoffman Creek during the 1977-1980 study and its location is shown on Figure 3.7-2. This station was located approximately 125 feet downstream from Hoffman Spring Pond. Flow readings obtained from April 1994 through March 1995 at this location are given in Appendix 3.7-5. Historical readings from 1978 through 1979 are provided in Appendix 3.7-6. Minimum and Maximum flows observed in Hoffman Creek were 0.22 cubic feet per second (cfs) and 11.9 cfs, respectively. Flows measured at this site during the 1993-1995 study were similar to those observed during previous studies (min = 0.22 cfs, max = 5.04 cfs).

Table 3.7-23

Water Quality Data, SG-4 (Outlet Creek)
Summary of Monthly Means and Ranges

		1977-1978			1994		
Station: C/SG-4	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	<50	<200	Note 1
Arsenic, Total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	4	<1	<5	<5	Note 1
Copper, Total	µg/L	<1	16	<5	<30	<30	Note 1
Iron, Total	mg/L	.04	.34	.12	.093	.274	.192
Lead, Total	µg/L	<10	<10	<10	<50	<50	Note 1
Manganese, Total	mg/L	.006	.110	.025	.018	.054	.030
Mercury, Total	ng/L	<100	200	<100	<200	300	100
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	<1	11	<5	<20	<20	Note 1
Phosphorus							
Phosphorus, Total	mg/L	<.01	.06	<.02	<.050	.018	.006
Nitrogen							
Nitrogen, Ammonia	mg/L	<.05	.20	<.14	<.1	<.10	Note 1
Nitrogen, Nitrate	mg/L	<.01	.84	<.34	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	1	8	6	5.29	9.10	6.70
Solids							
Solids, Dissolved	mg/L	29	388	163	88	117	104
Solids, Suspended	mg/L	1	16	5	<5	8	3
General Parameters							
Alkalinity, Total	mg/L	65	110	88	90	96	92
Biological Oxygen Demand	mg/L	1	6	2	<3	7	2
Chloride	mg/L	<1	5	<3	5	5	5
Conductivity	µmhos/cm	90	165	132	181	194	187
Cyanide	mg/L	<.001	.002	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	3.0	9.0	5.9	8	10.3	9.2

Table 3.7-23 *(Continued)*

Station: C/SG-4	Units	1977-1978			1994		
		Min.	Max.	Mean	Min.	Max.	Mean
pH	SU	5.8	8.0	7.6	6.68	8.03	7.26
Hardness	mg/L	69	118	93	92	110	100
Temperature	°C	0	21.0	8.2	5.8	20.6	13.2
Turbidity[a]	NTU	.5	6.0	1.7	1.70	3.20	2.45

[a] Turbidity was measured in FTU during the 1978-1978 study.
Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Samples for water chemistry analysis were collected monthly from April 1994 through March 1995 from sampling Station SG-E which was located in a well mixed region of the stream approximately 100 feet downstream from Hoffman Spring Pond. Water quality data obtained from analyses of samples collected in 1994 and 1995 at this site are presented in Appendix 3.7-8. Summary statistics, including maximum, minimum and mean values for these parameters are given in Table 3.7-24. Collections of samples for water chemistry analysis were not conducted in Hoffman Creek during the 1977-1980 study.

Available water chemistry information derived from samples obtained at SG-E indicate that Hoffman Creek is a hard, neutral pH stream. Mean values recorded for hardness, alkalinity and specific conductance were 144 mg/L as $CaCO_3$, 140 mg/L as $CaCO_3$, and 263 μmhos/cm respectively. Dissolved oxygen concentrations measured in Hoffman Creek ranged from 5.5 to 10.8 and averaged 8.8 mg/L. The mean pH recorded was 7.33.

All metals analyzed from samples collected at Hoffman Creek during the 1994-1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Hoffman Creek. The lower detection limits associated with these techniques allowed for trace level detections of all these metals.

3.7.4.6 Ground Hemlock Lake

The data presented for Ground Hemlock Lake is taken from previous studies completed in the 1970s and 1980s. The time period in which this data was collected was before the laboratory certification program NR 149 was enacted. The water quality for Ground Hemlock Lake is reflected in the data submitted for Hemlock Creek, Site SG-6 which is fed by Ground Hemlock Lake.

Table 3.7-24

Water Quality Data, SG-E (Hoffman Creek)
Summary of Monthly Means and Ranges

Parameter	Units	Minimum	Maximum	Mean
pH	SU	6.70	7.86	7.33
Conductivity	μmhos	227	297	263
Temperature	°C	4.1	20.6	9.6
Dissolved Oxygen	mg/L	5.5	10.8	8.8
Alkalinity	mg/L	129	150	140
Alkalinity, Bicarbonate	mg/L	129	150	140
Hardness	mg/L	129	150	144
Total Dissolved Solids	mg/L	110	230	163
Total Suspended Solids	mg/L	<5	5	1
Biological Oxygen Demand	mg/L	<2	9	1
Chemical Oxygen Demand	mg/L	<10	<10	Note 1
Ammonia	mg/L	<.10	<.10	Note 1
Nitrate	mg/L	<.50	.76	.27
Nitrogen, total Kjeldahl	mg/L	<.20	.50	.27
Chloride	mg/L	1	2	2
Fluoride	mg/L	<.1	.8	.1
Sulfate	mg/L	6.88	11.00	8.32
Cyanide, total	mg/L	<.020	<.020	Note 1
Oil Grease	mg/L	<1.0	14.0	1.67
Turbidity, Lab	NTU	<.50	1.42	.75
Cations	Meq/L	2.76	3.34	3.02
Anions	Meq/L	.37	2.71	2.33
Cation and Anion Balance	%	7.04	78.17	15.02
Boron, total	mg/L	<.099	<.200	Note 1
Calcium, total	mg/L	29.2	36.0	32.3
Arsenic, total	mg/L	<.005	<.005	Note 1
Barium, total	mg/L	<.010	<.010	Note 1
Iron, dissolved	mg/L	<.050	.227	.024
Iron, total	mg/L	<.050	.087	.013
Manganese, dissolved	mg/L	<.010	<.010	Note 1
Manganese, total	mg/L	<.010	.016	.003
Molybdenum, total	mg/L	<.020	<.020	Note 1
Selenium, total	mg/L	<.005	<.005	Note 1
Silver, total	mg/L	<.010	<.010	Note 1
Chromium, total	mg/L	<.020	<.020	Note 1
Chromium, total[1]	μg/L	300	1.920	1.22

Table 3.7-24 *(Continued)*

Parameter	Units	Minimum	Maximum	Mean
Beryllium, total	mg/L	<.005	<.010	Note 1
Thallium, total	mg/L	<.005	<.005	Note 1
Nickel, total	mg/L	<.030	<.030	Note 1
Antimony, total	mg/L	<.005	<.005	Note 1
Magnesium, total	mg/L	14.6	17	15.8
Phosphorus, dissolved	mg/L	<.050	.017	.004
Phosphorus, total	mg/L	<.050	.030	.007
Potassium, total	mg/L	<.600	1.100	.272
Sodium, total	mg/L	2.27	2.70	2.41
Sodium Absorption Ratio	std	.080	.090	.086
Aluminum, total	µg/L	10.7	73.3	28.4
Cadmium, total	µg/L	<.003	.014	.002
Copper, total	µg/L	.107	.649	.283
Lead, total	µg/L	.022	.192	.078
Mercury, total	ng/L	.54	2.93	1.18
Zinc, total	µg/L	.57	6.66	1.67

(1) = Chromium analyzed utilizing low level techniques.

Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Ground Hemlock Lake is located 2.4 miles east of the ore body (Figure 3.7-2). It has a total surface area of 85 acres and a maximum depth of 42 feet. The predominant lake substrate is sand, gravel, rubble boulders, and muck (Table 3.7-11). The lake has no defined inlets and is the headwaters of Hemlock Creek.

The shoreline vegetation is predominantly upland hardwoods with the remainder being a coniferous wetland. The effects of associated wetlands on lake levels of spring lakes such as Ground Hemlock vary depending upon the hydrologic characteristics of the wetland. In a spring-fed lake the primary source of water supply to the lake is groundwater. If the wetland associated with the lake is also groundwater fed, then the level of water in both should fluctuate similarly, although there would be a delayed yield of water to the lake from the wetland that would tend to stabilize the lake level. If, however, the wetlands surrounding the lake are perched, as many in the study area are, then the wetland discharge to the lake could also have a stabilizing effect on the level of the lake.

Surface water levels in Ground Hemlock Lake were measured at LG-24 during the 1970s and 1980s. Appendix 3.7-3 provides a record of gage readings at this location. Lake levels fluctuated in response to groundwater inflow, incident precipitation, and local runoff from rainfall. During the period of study, a 0.58-foot water level fluctuation was observed, reflecting maintenance of a fairly constant water level within the system. The high water level of 1,579.10 feet MSL during the study period occurred on May 13, 1980, whereas the low lake level reading of 1,578.52 feet MSL was recorded on July 16, 1980 (EMC, 1985).

The water chemistry sampling station at Ground Hemlock Lake was centrally located at approximately the 36.1-foot depth contour. Samples were collected at this location from two separate levels: 3.3 feet (GH-1) and 19.7 to 32.8 feet (GH-2). Samples at GH-2 were always collected in the hypolimnion, when present. Water chemistry collections for Ground Hemlock Lake continued monthly from November 1979 through October 1980 and from May 1979 through October 1980 at GH-1 and GH-2, respectively. Maximum, minimum, and mean values calculated from the results of the analyses of the water samples are presented in Appendix 3.7-4.

The results of the water chemistry data indicated that Ground Hemlock Lake was a moderately hard, clear, neutral to slightly basic pH lake. Mean values for hardness, alkalinity, and specific conductance were 112 and 128 mg/L as $CaCO_3$, 110 and 129 mg/L as $CaCO_3$, and 213 and 257 μmhos/cm at GH-1 and GH-2, respectively. Mean hardness and pH values indicated that the deeper waters were somewhat harder and closer to a neutral pH (GH-2: 128 mg/L as $CaCO_3$ and pH 7.7) than the near surface waters (GH-1: 112 mg/L as $CaCO_3$ and pH 8.2).

Temperature and dissolved oxygen concentration profiles indicated that Ground Hemlock Lake stratified during the summer (Appendix 3.7-11). A rapid temperature decrease with depth (metalimnion) was recorded in June between 13.1 and 26.2 feet, and maximum dissolved oxygen (12.0 mg/L) was measured concurrently at 16.4 feet. The metalimnion and oxygen maximum became more pronounced in July and August, respectively. In July, the metalimnion exhibited its most extreme temperature change, a 29°F drop between 9.8 and 23 feet. In August, the dissolved oxygen concentration at 16.4 feet within the metalimnion was so high (>20 mg/L) that it was not measurable with standard field measures.

Metalimnetic oxygen maxima as observed in Ground Hemlock Lake during June, July, and August are common phenomena that occur in clear, thermally stratified lakes and, typically, are

generated by a bloom of blue-green algae (Eberly, 1959; Reynolds and Walsby, 1975). Observations made by a scuba equipped diver in August confirmed the presence of a sharply defined, dense growth of phytoplankton within the metalimnion (EMC, 1985).

Very low dissolved oxygen concentrations (typically <1 mg/L) were recorded from June through September at or below the metalimnion. This region of low dissolved oxygen concentration rose from a depth of 26.2 feet in June to 19.7 feet by September. By October, the autumn overturn had occurred, as indicated by the uniform vertical temperature distribution and the diminished dissolved oxygen gradient.

In general, the concentrations of metals in Ground Hemlock Lake were either below detection limits or at very low levels. Lead was below detection limits at both sampling levels throughout this study except at GH-1 in December 1979 and April 1980 when concentrations of 0.02 mg/L and 0.03 mg/L were recorded, respectively.

3.7.4.7 Oak Lake

Oak Lake is located approximately 0.9 mile southwest of the ore body (Figure 3.7-2). It has a total surface area of 51 acres and a maximum depth of 47 feet. The shoreline vegetation surrounding it is predominantly upland hardwoods with the remainder being composed of bog, meadow, and shrub wetlands. The lake substrate is predominantly muck, sand and gravel (Table 3.7-11). The lake has no defined inlets and provides an intermittent headwater source of water to Hoffman Creek.

Oak Lake receives water directly from precipitation and from runoff within its drainage basin. During most of the year it appears to have no surface water connection to the remainder of the Hoffman Creek drainage basin; however, when a sufficient amount of water is delivered to the lake by thunderstorms or during snowmelt, it discharges surface water to Hoffman Creek (EMC, 1985). At those times, surface water enters Oak Lake around its edges and from the north through a culvert under Sand Lake Road. Surface water leaves Oak Lake and flows into a broad wetland area via a poorly defined, intermittent outlet on the lake's southwest margin. Water flow in this outlet proceeds southwest and then north through a wetland area via a second culvert under Sand Lake Road.

A stream gage (SG-10) located on the outlet stream of Oak Lake was monitored during the 1977-1978 study. Staff gage readings recorded at SG-10 are given in Dames & Moore, 1985. Flow measurements made by these earlier studies indicated that the area immediately surrounding Oak Lake was a groundwater aquifer recharge area, which contributes to the discharge area at Hoffman Springs.

Staff gage LG-11 was established on Oak Lake during the 1977-1980 study. Lake levels calculated from data obtained at this location between April 1977-October 1994 are given in Appendix 3.7-3. During this time period, the level in Oak Lake varied from a low of 1632.12 to a high of 1634.42, and averaged 1633.21.

The water chemistry sampling station designated LG-11 was positioned in the northcentral portion of Oak Lake. Collections of samples for water chemistry analysis were conducted monthly at this location from April 1994 through March 1995. Throughout the majority of this period at those times when the lake was determined to be well mixed, these samples were collected from the approximate center of the water column (LG-11). At the request of the WDNR, during the winter of 1995 when the lake was stratified, as indicated by the presence of a chemocline or thermocline, water samples were generally collected from both the hypolimnion (LG-11-H) and epilimnion (LG-11-E) portions of the lake. Analyses on these latter samples were completed for the same list of parameters as for other lake samples with the exception of metals. Water quality data obtained from analyses of samples collected during this time period at this site are presented in

Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Tables 3.7-25 through 3.7-25B which compares them to similar statistics derived from samples obtained during the 1977-1980 study.

In general, the results reported from analysis of water samples collected from LG-11 in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Results of water chemistry analysis indicated that Oak Lake was a soft, slightly acidic to neutral pH lake. As shown in Table 3.7-25 the average hardness, alkalinity, and specific conductance values in Oak Lake were 7 mg/L as $CaCO_3$, 1 mg/L as $CaCO_3$ and 22 μmhos/cm respectively. Surface water pH values ranged from 5.34 to 6.76 and averaged 6.29 throughout the period of study.

As shown in Table 3.7-25 the average dissolved solids levels recorded in the 1994-1995 samples were much lower than those recorded in the 1978 work. A review of the data indicates that the monthly results from the 1994-1995 work were consistent throughout the year, while the results from the 1978 work contained a wider range of values. The wide range of values recorded in 1978 could be the result of natural lake variations or variations in sampling and testing procedures.

Monthly dissolved oxygen concentration profiles indicated that Oak Lake showed signs of stratification during the summer of 1994 (Figure 3.7-5). This is consistent with historical data collected during the late 1970s, which indicated that Oak Lake was in the stratified state in July and August of 1977 and August of 1978. In 1994 a rapid decrease in both water temperature and dissolved oxygen level with depth (metalimnion) was evident in August between 22 and 31 feet. By September the metalimnion had ascended to between 19 and 29 feet. Finally in October temperatures were similar throughout the water column, indicating that the fall mixing cycle had occurred. At that time dissolved oxygen concentrations ranged from 9.4 at the surface to 8.2 at one foot from the bottom, and were consistent throughout the majority of the water column. A metalimnetic oxygen maxima such as that recorded in Oak Lake in July of 1977 was not observed during the summer of 1994. Dissolved oxygen data collected in Oak Lake during the 1977-1980 study can be found in Appendix 3.7-11.

Profiles of oxygen conducted during the winter of 1994-1995 indicated that Oak Lake was also stratified during February and March of 1995. Although the temperature throughout the water column was uniform throughout this period, a distinct chemocline (change in chemical composition with depth) was observed between 21 and 28 and 23 and 29 feet, respectively, during these months (Figures 3.7-5 and 3.7-6).

All metals analyzed from samples collected at LG-11 during the 1994-1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Oak Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. Only aluminum was detected at a level substantially higher than those observed during the 1977-1980 study (mean value = 20.07 mg/L vs <10 mg/L).

In October 1994 a sediment sample was collected from Oak Lake at station G. A sample was also collected at this site in March 1978 for the previous work that was completed (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-26.

The data from 1994 indicates that the substrate for Oak lake is predominantly inorganic. Relatively low levels of metals, calcium and magnesium were observed. It is likely that silica materials such as quartz dominate the composition of the sediments in Oak Lake, although the organic content of the sediments can vary dependant upon the position within the lake. In general, a relatively small layer of organic sediment can typically be found in the deeper waters of lakes with predominantly inorganic substrate.

Table 3.7-25

Water Quality Data, LG-11 (Oak Lake)
Summary of Monthly Means and Ranges[a]

		1978			1994-1995		
Station: G-1/G-2/LG-11	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	11.70	31.40	20.05
Arsenic, Total	mg/L	<.001	<.001	<.001	<.005	.006	.001
Cadmium, Total	µg/L	<1	4	<1	.004	.025	.013
Copper, Total	µg/L	<1	<19	<5	.287	.764	.414
Iron, Total	mg/L	.01	.15	.05	<.050	.490	.067
Lead, Total	µg/L	<10	<10	<10	.077	.262	.142
Manganese, Total	mg/L	.007	.061	.023	<.010	.120	.023
Mercury, Total	ng/L	<100	200	<100	.84	2.35	1.26
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	1	36	11	2.33	4.78	3.23
Phosphorus							
Phosphorus, Total	mg/L	<.01	.03	<.02	<.050	.019	.005
Nitrogen							
Nitrogen, Ammonia	mg/L	.11	.22	.16	<.10	.15	.03
Nitrogen, Nitrate	mg/L	<.01	.16	<.07	<.50	.71	.07
Sulfur							
Sulfate	mg/L	2	9	6	3.6	9.0	5.2
Solids							
Solids, Dissolved	mg/L	2	216	53	<5	44	22
Solids, Suspended	mg/L	1	10	3	<5	7	1
General Parameters							
Alkalinity, Total	mg/L	<1	8	<4	<5	5	1
Biological Oxygen Demand	mg/L	1	6	2	<2	10	1
Chemical Oxygen Demand	mg/L	7	7	7	<10	16	10
Chloride	mg/L	<1	6	<2	<1	1	0

Table 3.7-25 *(Continued)*

		1978			1994-1995		
Station: G-1/G-2/LG-11	Units	Min.	Max.	Mean	Min.	Max.	Mean
Conductivity	µmhos/cm	11	32	23	17	27	22
Cyanide	mg/L	<.001	.002	<.001	<20	<20	Note 1
Hardness	mg/L	1	24	11	<5	10	7
pH	SU	5.8	7.5	6.2	5.34	6.76	6.29
Temperature	°C	1.0	25.1	10.7	1	22.9	13.3
Turbidity[b]	NTU	.7	2.5	1.3	21	2.40	1.02

[a] This table includes a summary of all data collected for Oak Lake. For statistical comparison purposes, data was collected from the epilimnion (LG-11-E) and the hypolimnion (LG-11-H) on the same date. This data was first averaged together to obtain one composite value for each parameter for that date. This value was then used in the calculations for the statistics included in Table 3.7-25.

[b] Turbidity was measured in FTU during the 1977-1978 study.

Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Table 3.7-25A

Water Quality Data, LG-11-H (Oak Lake)
Summary of Means and Ranges for Hypolimnetic Water

		1978			1995		
Station: G-2/LG-11-H	Units	Min.	Max.	Mean	Min.	Max.	Mean
Phosphorus							
Phosphorus, Total	mg/L	.04	.04	.04	<.050	<.050	Note 1
Nitrogen							
Nitrogen, Ammonia	mg/L	.18	.18	.18	<.10	.20	.10
Nitrogen, Nitrate	mg/L	.15	.15	.15	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	7	8	8	4.6	4.7	4.7
Solids							
Solids, dissolved	mg/L	40	46	43	11	39	25
Solids, suspended	mg/L	1	2	2	<5	<5	Note 1
General Parameters							
Alkalinity, Total	mg/L	2	2	2	<5	5	3
Biological Oxygen Demand	mg/L	2	2	2	<3	<3	Note 1
Chemical Oxygen Demand	mg/L	ND	ND	ND	13	14	14
Chloride	mg/L	<1	<1	<1	<1	<1	Note 1
Conductivity	µmhos/cm	ND	ND	ND	29.6	63.2	46.4
Cyanide	mg/L	<.001	<.001	<.001	<.020	<.020	Note 1
Hardness	mg/L	8	12	10	6	7	7
pH[Lb]	SU	5.3	6.0	5.7	5.30	5.50	5.40
Turbidity[a]	NTU	.8	1.3	1.1	.60	.60	.60

[a] Turbidity was measured in FTU during the 1977-1978 study.

[Lb] = Laboratory pH Value.
ND = No Data

Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Table 3.7-25B

Water Quality Data, LG-11-E (Oak Lake)
Summary of Means and Ranges for Epilimnetic Water

		1978			1995		
Station: G-1/LG-11-E	Units	Min.	Max.	Mean	Min.	Max.	Mean
Phosphorus							
Phosphorus, Total	mg/L	<.01	<.01	<.01	<.050	<.050	Note 1
Nitrogen							
Nitrogen, Ammonia	mg/L	.20	.20	.20	<.10	.20	.10
Nitrogen, Nitrate	mg/L	<.01	<.01	.07	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	8	8	8	4.50	4.60	4.55
Solids							
Solids, dissolved	mg/L	32	36	34	28	46	37
Solids, suspended	mg/L	1	2	2	<5	<5	Note 1
General Parameters							
Alkalinity, Total	mg/L	<1	2	1	<5	5	3
Biological Oxygen Demand	mg/L	1	1	1	<3	<3	Note 1
Chemical Oxygen Demand	mg/L	7	7	7	13	17	15
Chloride	mg/L	<1	2	1	<1	<1	Note 1
Conductivity	µmhos/cm	11	32	23	26.3	74.3	50.3
Cyanide	mg/L	<.001	<.001	<.001	<.020	<.020	Note 1
Hardness	mg/L	8	12	10	6	8	7
pH[Lb]	SU	5.8	6.0	5.9	5.10	5.20	5.15
Turbidity[a]	NTU	.8	2.4	1.6	.60	.70	.65

[a] Turbidity was measured in FTU during the 1977-1978 study.

[Lb] = Laboratory pH Value.

Note 1: All data reported as less than detection, therefore no mean value is calculated.
SU = Standard Units.

Prepared by: JJA
Checked by: BDH

Table 3.7-26

Sediment Sampling Data, Oak Lake (Station G)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.0	NDA
Solids, Total	%	78.7	6.53
Solids, Total Volatile	mg/kg	7000	NDA
Ammonia, N	mg/kg	30	NDA
Total Kjeldahl Nitrogen	mg/kg	200	NDA
Total Organic Nitrogen	mg/kg	170	NDA
Chloride	mg/kg	<10	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	950	3951
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	84	NDA
Arsenic, Total	mg/kg	<0.40	1.5
Barium, Total	mg/kg	3.5	NDA
Iron, Total	mg/kg	550	4388
Manganese, Total	mg/kg	52	91
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	<0.50	16.8
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	85	NDA
Phosphorus, Total	mg/kg	<100	NDA
Potassium, Total	mg/kg	<60	NDA
Sodium, Total	mg/kg	11	NDA
Aluminum, Total	mg/kg	400	NDA
Cadmium, Total	mg/kg	<0.50	2.9
Copper, Total	mg/kg	<0.50	11.0
Lead, Total	mg/kg	2.8	60

Table 3.7-26 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	5.5	205
Vanadium	mg/kg	1.2	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

The variability of the data between 1994 and 1978 may have resulted from the collection of samples from different locations within the lake. In addition to the variability in sampling locations, the method used to collect samples was also different. The core sampler used in 1994 may have collected a greater proportion of the inorganic sediments than the Ekman dredge sampler used in 1978. In either case, the data provides background information and illustrates the potential variability in the measurement of sediment characteristics.

3.7.5 Pickerel Creek Drainage Basin

The portion of the study area that resides within the Pickerel Creek drainage basin is shown on Figures 3.7-1 and 3.7-2. The Pickerel Creek drainage basin has ground and surface water features that are characteristic of the study area, as was described previously. The Pickerel Creek drainage basin is located approximately in the center of the Wolf River drainage basin (Figure 3.7-4). Surface water drainage within it flows to the southwest via Pickerel Creek to its confluence with the Wolf River. Specific key basin characteristics are given in Table 3.7-27. Selected surface water features included in the discussion of the Pickerel Creek drainage basin are Rolling Stone Lake; Pickerel Creek and Creeks 12-9 and 11-4; and Little Sand, Duck, Deep Hole, and Skunk Lakes. These features are described individually below.

3.7.5.1 Rolling Stone Lake

Rolling Stone Lake is located 3.5 miles south of the ore body as shown on Figures 3.7-1 and 3.7-2. It has a surface area of 672 acres with a reported maximum depth of 12 feet. The lake substrates are primarily composed of sand, gravel, muck, detritus and rubble (Table 3.7-27). The lake has two primary inlets, which are Pickerel Creek and Creek 12-9, both located along its north shore. The lake has a simple man-made outlet structure at its southeast end that serves to partially control water levels (EMC, 1985).

The shoreline of Rolling Stone Lake is approximately 60 percent woodland and 40 percent wetland. As previously discussed, the influence of a wetland on water level fluctuations in associated lakes is dependent upon the individual hydrologic characteristics such as the source of water and the lakes relative position with respect to the groundwater aquifer as well as the interrelationship between the wetland and the lake. Because the main source of water for the lake is stream discharge, fluctuations within the two water bodies generally occurs only if the surrounding wetlands are also fed predominantly by stream discharge. If the wetland water source is groundwater, limited correlation in water level fluctuations would be expected. The wetland would be expected to increase the attenuation influence of the lake on stream discharge by increasing the storage capacity. Surrounding wetlands may also provide a source of water during drought periods.

Surface water levels in Rolling Stone Lake were measured at LG-9 during the 1977-1978 study. Data located in Appendix 3.7-3 provides a historical record of gage readings at this location. During the period of study, a 0.98-foot water level fluctuation was observed. The high water level during the study period was 1535.92 feet MSL. The lowest water level recorded was 1534.94 feet MSL.

Table 3.7-27

Summary of Water Body Characteristics for the Portions of the Pickerel Creek and Wolf River Drainage Basins Within the Study Area[a]

Pickerel Creek Drainage Basin

Surface Water Category/ Water Body	Distance and Direction from Ore Body (mi)	Drainage Basin Area (sq mi)	Length (mi)	Average Width (ft)	Average Depth (ft)	Maximum Depth (ft)	Surface Area (acres)	Gradient[b] (ft/mi)	Adjoining Wetlands (acre)	Predominant Shoreline Vegetation[c]	Substrate Classification
Lakes and Associated Streams											
Rolling Stone Lake	3.5 South	—[d]	—	—	—	12	672	---	1,067	Dry-mesic or Mesic Northern Hardwoods	sand, gravel, muck, detritus, rubble
Pickerel Creek	2.9 Southwest	44.3	9.2	45	1.75	--	50	4.3	1,164	Wet-mesic or Wet Northern Forest	muck
Creek 12-9	1.4 South	6.0[e]	1.6	9.0	1.0	--	1.7	35	23	Wet-mesic or Wet Northern Forest	muck, sand, gravel
Creek 11-4	2.8 Southwest	0.4	0.5	5.0	0.3	--	0.3	31	53	Wet-mesic or Wet Northern Forest	muck, sand, gravel
Little Sand Lake	0.4 South	--	--	--	--	21	248	--	20	Dry-mesic or Mesic Northern Hardwoods	sand, gravel, muck
Duck Lake	1.1 Southeast	--	--	--	--	10	26	--	22	Bog (Scrub/Shrub Wetland)	muck
Deep Hole Lake	1.5 Southeast	--	--	--	--	10	97	--	35	Dry-mesic or Mesic Northern Hardwoods	muck, sand, gravel, rubble
Skunk Lake	0.4 East	--	--	--	--	6	6	--	5	Dry-mesic or Mesic Northern Hardwoods	muck

Table 3.7-27 *(Continued)*

Surface Water Category/ Water Body	Distance and Direction from Ore Body (mi)	Drainage Basin Area (sq mi)	Length (mi)	Average Width (ft)	Average Depth (ft)	Maximum Depth (ft)	Surface Area (acres)	Gradient[b] (ft/mi)	Adjoining Wetlands (acre)	Predominant Shoreline Vegetation[c]	Substrate Classification
Pickerel Creek Drainage Basin											
Wolf River Drainage Basin											
Wolf River											
Above Langlade Co	7.6 Southwest	460[f]	61.50[g]	149	1.9	--	185.9	6.4[h]	8,156	Wet-mesic and Wet Northern Forest and Aspen	sand, gravel, silt, detritus, peat

[a] Steuck and Andrews, 1976; Steuck, et. al., 1977; Andrews and Threinen, 1966.
[b] Calculated from topographic maps.
[c] EMC, 1985.
[d] Not applicable.
[e] Calculated from data generated in the 1985 study.
[f] USGS, 1978.
[g] Northwestern Wisconsin Regional Planning Commission, 1970.
[h] Measured between Pine Lake and Langlade, Wisconsin.

Source: EMC, 1985.

Prepared by: JJA
Checked by: SDJ

The 1994 study on Rolling Stone Lake concentrated on the systems water chemistry. Samples for water chemistry analyses were collected in April, July and October 1994 at Rolling Stone Lake at Station LG-9 which was located in the east central portion of the lake (Figure 3.7-1).

Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-28 which compares them to similar statistics derived from samples obtained during the 1977-1978 study (Appendix 3.7-4).

In general, the results reported from analyses of water samples collected from LG-9 in 1994 and 1995 were similar to those obtained during the 1977-1979 effort. Results of water chemistry analysis indicated that Rolling Stone was a moderately hard, neutral pH lake. Mean hardness, alkalinity, and specific conductance values at Station LG-9 were 77 mg/L as $CaCO_3$, 81 mg/L as $CaCO_3$ and 121 μmhos/cm. Surface water pH values ranged from 7.36 to 7.94 and averaged 7.71 throughout the period of study.

In April of 1994 the total phosphorus concentration within the water column of Rolling Stone Lake was measured at 0.417 mg/L, an unexpectedly high value compared to the 1977-1978 mean of 0.03 mg/L. Subsequent samplings in July and October of 1994 revealed levels of phosphorus closer to those observed historically (0.019 and <0.05 mg/L, respectively).

The mean dissolved oxygen concentration measured in 1994 in surface water at LG-9 was 7.4, although the lake was not sampled during the months it was ice covered. Dissolved oxygen data collected in 1994 on Rolling Stone Lake can be found in Appendix 3.7-8.

Previous studies conducted during the 1970s and 1980s observed dissolved oxygen (D.O.) concentrations below 5.0 mg/L (EMC, 1985) in Rolling Stone Lake during February, March and April and noted low D.O. readings in the near bottom waters in January and July 1978 suggesting that it experiences high decomposition and productivity which are characteristics of a lake in eutrophy. This situation was verified by the WDNR who classified Rolling Stone Lake as eutrophic in a 1978 report (WDNR, 1978). The report indicated that at that time there had been little change in the water quality of Rolling Stone Lake over the past fifteen years; and that the present trophic status of Rolling Stone Lake was part of its natural maturation process.

Metals measured in water samples collected from Rolling Stone Lake during 1994 were generally either below detection limits or found in low concentrations.

In October 1994 sediment samples were collected from Rolling Stone lake at stations M-2 and M-4 (Figure 3.7-1). Samples were also collected at these sites in March 1978 for the previous project work (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-29 and Table 3.7-30 below. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

The 1994 data shows the variability of sediment composition within Rolling Stone Lake. Sampling site M-2 is indicative of a lake that receives predominantly organic deposition. It has a lower total solids concentration (3.0 percent), coupled with a higher concentration of volatile solids (259,000 mg/kg, 25.9 percent of the total solids), as well as higher levels of nitrogen and phosphorus which are reflective of organic sediments.

Table 3.7-28

Water Quality Data, LG-9 (Rolling Stone Lake)
Summary of Monthly Means and Ranges

Station Period: M-4/LG-9	Units	1977-1978 Min.	1977-1978 Max.	1977-1978 Mean	1994 Min.	1994 Max.	1994 Mean
Metals							
Aluminum, total	µg/L	<10	<10	<10	<50	314	104.67
Arsenic, total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, total	µg/L	<1	3	<1	<5	<5	Note 1
Copper, total	µg/L	<1	1	<1	<30	<30	Note 1
Iron, Total	mg/L	.03	.46	.14	<.1	.129	.083
Lead, total	µg/L	<10	10	<10	<50	<50	Note 1
Manganese, total	mg/L	.004	.199	.052	<.010	.017	.011
Mercury, total	ng/L	<100	<100	<100	<200	300	100
Molybdenum, total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, total	µg/L	3	18	8	<20	<20	Note 1
Phosphorus							
Phosphorus, total	mg/L	.02	.05	.03	<.050	.417	.145
Nitrogen							
Nitrogen, Ammonia	mg/L	.34	1.09	.55	<.10	10	.03
Nitrogen, Nitrate	mg/L	<.01	.34	<.18	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	5	8	7	4.06	11	6.72
Solids							
Solids, Dissolved	mg/L	83	157	116	92	105	97
Solids, Suspended	mg/L	2	12	5	<5	<5	Note 1
General Parameters							
Alkalinity, total	mg/L	70	114	87	77	87	81
Biological Oxygen Demand	mg/L	2	5	3	<3	8	3
Chemical Oxygen Demand	mg/L	31	31	31	15	23	19
Chloride	mg/L	<1	4	<2	<1	1	1
Conductivity	µmhos/cm	25	165	118	17	182	121
Cyanide	mg/L	<.001	<.001	<.001	<.020	<.020	Note 1
Dissolved Oxygen[b]	mg/L	1.1	13.0	7.8	6.2	8.5	7.4
Hardness	mg/L	72	124	93	68	82	77
pH	SU	5.7	9.0	7.7	7.36	7.94	7.71
Temperature	°C	1.0	22.0	9.9	8.0	23.3	14.1
Turbidity[a]	NTU	.9	4.5	2.1	.6	1.5	1.1

[a] Turbidity was measured in FTU during the 1977-1978 study.
[b] Measured at 0.5 feet.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-29

Sediment Sampling Data, Rolling Stone Lake (Station M-2)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.8	NDA
Solids, Total	%	3.0	4.48
Solids, Total Volatile	mg/kg	259,000	NDA
Ammonia, as N	mg/kg	60	NDA
Total Kjeldahl Nitrogen	mg/kg	900	NDA
Total Organic Nitrogen	mg/kg	840	NDA
Chloride	mg/kg	<10	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	540	3304
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	280	NDA
Arsenic, Total	mg/kg	<0.40	2.9
Barium, Total	mg/kg	1.1	NDA
Iron, Total	mg/kg	130	605
Manganese, Total	mg/kg	3.6	112
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	0.63	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	0.59	6.6
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	52	NDA
Phosphorus, Total	mg/kg	750	NDA
Potassium, Total	mg/kg	<60	NDA
Sodium, Total	mg/kg	8.0	NDA
Aluminum, Total	mg/kg	110	NDA
Cadmium, Total	mg/kg	<0.50	0.7
Copper, Total	mg/kg	<0.50	4.8
Lead, Total	mg/kg	0.41	11
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	3.2	79
Vanadium	mg/kg	<1.0	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Table 3.7-30

Sediment Sampling Data, Rolling Stone Lake (Station M-4)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	7.4	NDA
Solids, Total	%	71.4	4.20
Solids, Total Volatile	mg/kg	5000	NDA
Ammonia, N	mg/kg	38	NDA
Total Kjeldahl Nitrogen	mg/kg	260	NDA
Total Organic Nitrogen	mg/kg	220	NDA
Chloride	mg/kg	<10	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	460	2381
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	450	NDA
Arsenic, Total	mg/kg	<0.40	2.6
Barium, Total	mg/kg	3.3	NDA
Iron, Total	mg/kg	1600	4377
Manganese, Total	mg/kg	14	138
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	1.2	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	3.1	21.9
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	380	NDA
Phosphorus, Total	mg/kg	250	NDA
Potassium, Total	mg/kg	91	NDA
Sodium, Total	mg/kg	17	NDA
Aluminum, Total	mg/kg	750	NDA
Cadmium, Total	mg/kg	<0.50	0.9
Copper, Total	mg/kg	0.96	7.2
Lead, Total	mg/kg	1.1	33
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	5.1	76
Vanadium	mg/kg	3.2	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

The 1994 data for site M-4 is representative of an inorganic substrate. The total solids concentration of 71.4 percent and total volatile solids level of 5000 mg/kg (0.5 percent of the total solids) present in the sample are indicative of an inorganic substrate.

Nitrogen and phosphorus levels were somewhat elevated at both sampling sites in 1994. The total Kjeldahl Nitrogen (TKN) concentrations for M-2 and M-4 were 900 mg/kg and 260 mg/kg, respectively. These corresponded to phosphorus concentrations of 750 mg/kg and 250 mg/kg. This is typical for a eutrophic lake such as Rolling Stone.

The variability of the data between 1994 and 1978 may have resulted from the collection of samples from different locations within the lake. In addition to the variability in sampling locations, the method used to collect samples was also different. The core sampler used in 1994 may have collected a greater proportion of the inorganic sediments than the Ekman dredge sampler used in 1978. In either case, the data provides background information and illustrates the potential variability in the measurement of sediment characteristics.

3.7.5.2 Pickerel Creek

Pickerel Creek has a surface area of 50 acres and a total length of 9.2 miles. It is a perennial stream with a drainage area of 44.3 square miles that originates in a large wetland area north-northwest of Rolling Stone Lake (Table 3.7-27). The drainage basin of Pickerel Creek is predominantly wooded and undeveloped and includes large tracts of adjoining wetlands in the headwaters. The stream originates in the wetlands south of Mole Lake, approximately 2.9 miles west of the ore body, and intermittently flows south to Rolling Stone Lake, through a flat drainage basin (Figure 3.7-2). Pickerel Creek emerges from the southern most bay in Rolling Stone Lake and flows west to its eventual confluence with the Wolf River.

A stream gage SG-19 was established on Pickerel Creek during the 1977-1980 study. Its location is shown on Figure 3.7-2. Flow readings obtained from April 1994 through March 1995 at this location are given in Appendix 3.7-5. Historical readings from 1977 through 1980 are provided in Appendix 3.7-6. Maximum and minimum flows observed on Pickerel Creek were 23.4 cubic feet per second (cfs) and <0.1 cfs in April 1979 and June 1978 respectively. Flows measured at this site during the 1993-1995 study were within the range observed historically (min=0.93 cfs, max=5.58 cfs). Flow data was also collected at station SG-19A during the 1993-1995 study. This station was located approximately 1.5 miles upstream of Rolling Stone Lake and 1.4 miles upstream of Station SG-19 (Figure 3.7-2). Flow readings obtained at SG-19A ranged from 0.43 cfs to 1.12 cfs between May 1994 and March 1995 and are given in Appendix 3.7-5. In any year, the minimum seven-day average flow rate of Pickerel Creek has a 50-percent chance of being less than 0.6 cubic cfs, and a 10-percent chance of being less than 0.4 cfs (Table 3.7-12).

Samples for water chemistry analyses were collected from Pickerel Creek monthly from April 1994 through March 1995 at Station SG-19. Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-31 which compares them to similar statistics derived from samples obtained during the 1977-1978 study.

Table 3.7-31

Water Quality Data, SG-19 (Pickerel Creek)
Summary of Monthly Means and Ranges

Station: M-5/SG-19	Units	1977-1978 Min.	1977-1978 Max.	1977-1978 Mean	1994-1995 Min.	1994-1995 Max.	1994-1995 Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	9.12	68.40	34.75
Arsenic, Total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	4	<1	<.003	.014	.005
Copper, Total	µg/L	<1	28	<4	.093	.613	.295
Iron, Total	mg/L	.09	.59	.31	.110	.770	.400
Lead, Total	µg/L	<10	<10	<10	.073	.315	.149
Manganese, Total	mg/L	.006	.073	.038	.013	.100	.043
Mercury, Total	ng/L	<100	200	<100	.81	7.95	3.59
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.03	<.03	Note 1
Zinc, Total	µg/L	1	12	6	.71	6.58	2.74
Phosphorus							
Phosphorus, Total	mg/L	.02	.12	.06	<.050	.060	.023
Nitrogen							
Nitrogen, Ammonia	mg/L	.05	1.47	.70	<.10	.20	.05
Nitrogen, Nitrate	mg/L	<.01	.34	<.22	<.50	.72	.23
Sulfur							
Sulfate	mg/L	<1	9	<5	5	28	11
Solids							
Solids, Dissolved	mg/L	86	152	122	58	190	119
Solids, Suspended	mg/L	<1	11	<4	<5	19	6
General Parameters							
Alkalinity, Total	mg/L	42	110	73	42	120	72
Biological Oxygen Demand	mg/L	1	4	2	<2	9	2
Chemical Oxygen Demand	mg/L	69	69	69	23	45	32
Chloride	mg/L	<1	4	<2	<1	2	1
Conductivity	µmhos/cm	20	125	92	94	241	157
Cyanide	mg/L	<.001	<.001	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	5.5	12.2	9.0	8.1	13.4	10.0
Hardness	mg/L	60	116	83	46	120	81
pH	SU	5.8	7.5	6.9	6.37	8.13	7.33
Temperature	°C	0	14.8	4.8	1.1	14.8	7.8
Turbidity[a]	NTU	.8	2.8	1.5	<.5	9.9	2.78

[a] Turbidity was measured in FTU during the 1977-1978 study.

SU = Standard Units.

Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA

Checked by: BDH

In general, the results reported from analyses of samples collected from Pickerel Creek in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Water chemistry data indicated that Pickerel Creek was a moderately hard, neutral pH stream. Mean values recorded in 1994 for hardness, alkalinity and specific conductance at Station SG-19 were 81 mg/L as $CaCO_3$, 72 mg/L as $CaCO_3$ and 157 μmhos/cm, respectively. The mean pH value measured in field was 7.33. The concentration of dissolved oxygen in Pickerel Creek was above five mg/L during all samplings and ranged from 8.1 mg/L to 13.4 mg/L throughout the sampling period.

All metals analyzed from samples collected at SG-19 during the 1994 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Pickerel Creek. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, aluminum was detected at a level higher than those observed during the 1977-1980 study (mean value = 34.75 mg/L vs <10 mg/L).

In October 1994 two sediment samples were collected from Pickerel Creek at station M-5 (Figure 3.7-2). The samples were collected within a few feet of each other to demonstrate the variability of sediments within the stream. A sample was also collected at this site in March 1978 (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-32. Information pertaining to the analyses of sediment samples is included in Appendices 3.7-4 and 3.7-10.

Surface water sediment composition has a considerable amount of variability. This is most evident in streams where scouring and deposition of sediments can take place within inches of each other. Samples collected from a stream or lake may have variable compositions and represent the variability of the sediments for that surface water. This is demonstrated in both samples collected in 1994 and can also be seen when comparing the data from the two sampling events.

The 1994 data for M-5 and the duplicate for the same site show characteristics of organic and inorganic substrates. The volatile solids content, which is equivalent to the organic portion of the sediment, for M-5 was 37.9 percent of the total solids content (379,000 mg/kg). In contrast to this, the duplicate sample taken at M-5 had a volatile solids content of 0.57 percent (5,700 mg/kg) and appears to be composed primarily of inorganic substrate. Data also indicated higher levels of other analytical parameters including: manganese, calcium, phosphorous, and nitrogen within the sample composed primarily of organic substrate.

The total solids content of samples collected in 1994 was consistently higher than in the sample collected in 1978 (16.9% and 65.0% versus 11.28%). This further illustrates the variability that exists within the sediment composition of an aquatic system.

Table 3.7-32

Sediment Sampling Data, Pickerel Creek (Station M-5)

Parameter	Units	October 1994 Data	October 1994 Dup. Data	March 1978 Data
pH, Lab	SU	6.6	6.7	NDA
Solids, Total	%	16.9	65.0	11.28
Solids, Total Volatile	mg/kg	379000	5700	NDA
Ammonia, N	mg/kg	82	61	NDA
Total Kjeldahl Nitrogen	mg/kg	1300	430	NDA
Total Organic Nitrogen	mg/kg	1200	370	NDA
Chloride	mg/kg	24	23	NDA
Fluoride	mg/kg	<0.5	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	600	340	1445
Boron, Total	mg/kg	<10	<10	NDA
Calcium, Total	mg/kg	2500	1900	NDA
Arsenic, Total	mg/kg	1.4	1.3	2.3
Barium, Total	mg/kg	15	11	NDA
Iron, Total	mg/kg	2300	2100	7079
Manganese, Total	mg/kg	82	56	635
Molybdenum, Total	mg/kg	<2.0	<2.0	NDA
Selenium, Total	mg/kg	<0.50	0.82	NDA
Silver, Total	mg/kg	<0.50	<0.50	NDA
Chromium, Total	mg/kg	3.0	2.7	33
Cobalt, Total	mg/kg	<1.0	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	<1.0	NDA
Nickel, Total	mg/kg	<2.0	<2.0	NDA
Antimony, Total	mg/kg	<5.0	<5.0	NDA
Magnesium, Total	mg/kg	440	510	NDA
Phosphorus, Total	mg/kg	530	180	NDA
Potassium, Total	mg/kg	72	<60	NDA
Sodium, Total	mg/kg	20	15	NDA
Aluminum, Total	mg/kg	630	730	NDA
Cadmium, Total	mg/kg	<0.50	<0.50	0.8
Copper, Total	mg/kg	1.2	1.2	6.6
Lead, Total	mg/kg	1.2	0.81	8
Mercury, Total	mg/kg	<0.02	<0.02	<0.01

Table 3.7-32 *(Continued)*

Parameter	Units	October 1994 Data	October 1994 Dup. Data	March 1978 Data
Zinc, Total	mg/kg	11	9.8	62
Vanadium	mg/kg	3.4	3.1	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

3.7.5.3 Creek 12-9

The data presented for Creek 12-9 is taken from the previous project studies completed in the 1970s and 1980s. As of March 1995, attempts to gain access to Creek 12-9 from private parties were unsuccessful. Because of this, additional current data is unavailable.

Creek 12-9 originates in a wetland area adjacent to the southern shore of Little Sand Lake; however, stream flow directly from the lake is intermittent (Figure 3.7-2). The stream has a drainage area of 6.0 square miles, a total surface area of 1.7 acres, and flows southward 1.6 miles prior to its entrance into Rolling Stone Lake, which serves as it's confluence with Pickerel Creek. Creek 12-9 has an average width of nine feet, an average depth of one foot, and is adjoined by 23 acres of wetlands (Table 3.7-27). Its drainage basin primarily contains lakes and wetlands, and is wooded. Duck and Deep Hole lakes contribute surface water drainage intermittently to Little Sand Lake, which is the headwater of Creek 12-9 (EMC, 1985).

Extensive adjoining wetlands provide a source of base flow to Creek 12-9. They tend to maintain the flow in the stream under drought conditions longer than would be expected in their absence. These wetlands also dampen changes in both high and low flows. This dampening is proportional to their surface area and hydraulic connection to the stream.

Two stream gages were established on Creek 12-9 during earlier studies (SG-8 and SG-23) to monitor surface water levels. Appendix 3.7-3 provides the record of gage readings at these locations. Creek 12-9 has essentially no base flow as measured 0.1 mile downstream of Little Sand Lake. Although the Creek 12-9 drainage basin is very steep, it consists of about 50 percent wetlands and lakes. Discharge measured at SG-A, which is located on the primary surface water stream flowing into Little Sand Lake, and those lower surface water discharges measured at SG-8, reflect the storage effect of Little Sand Lake. The difference between flows measured and the time lag between SG-8 and SG-23 is primarily attributable to local runoff and wetland contribution flowing into Creek 12-9 as well as discharge from the stream to the groundwater between Little Sand Lake and SG-23.

From August 15 through 17, 1978, intensive monitoring of storm water runoff was conducted for the Creek 12-9 drainage (Dames & Moore 1985). A large increase in discharge rate measured at SG-23 indicated that storm runoff was reaching SG-23 by several routes. During periods of rapid storm runoff, the flow at SG-23 was a combination of groundwater and local surface water runoff that had passed directly through Little Sand Lake to Stream 12-9 (EMC, 1985,

Section 2.3). During the study period, the highest flow rate of 42.2 cfs was recorded at SG-23 on April 20, 1979. A low flow rate of 1.2 cfs occurred on October 2, 1978 at the same site.

Samples for water chemistry analyses were collected monthly from March 1977 through September 1978 at Station M-1, which was located approximately 328 feet upstream from Rolling Stone Lake. Maximum, minimum, and mean values calculated from data collected at this location are presented in Appendix 3.7-4.

Results of water chemistry analyses indicated that Creek 12-9 was a moderately hard, neutral pH stream. Mean values for hardness, alkalinity, and specific conductance were 108 mg/L as $CaCO_3$, 110 mg/L as $CaCO_3$, and 197 μmhos/cm, respectively. Mean pH was 7.4. Dissolved oxygen concentrations were greater than 5.0 mg/L throughout the study. The lowest value recorded was 5.2 mg/L in March 1977. Metals measured in water samples from Creek 12-9 were generally below detection limits. Mercury was however, detected at Station M-1 in December 1977 at a concentration of 0.1 μg/L.

No sediment samples were collected from Creek 12-9 during the current study period because access to the stream was unavailable. Data was collected in 1978 for previous project work (EMC, 1985). This data is presented in Table 3.7-33.

Table 3.7-33

Sediment Sampling Data, Creek 12-9 (Station M-1)

Parameter	Units	March 1978 Data
Solids, Total	%	17.81
Oil & Grease (Freon Extractables)	mg/kg	1275
Arsenic, Total	mg/kg	3.0
Iron, Total	mg/kg	11243
Manganese, Total	mg/kg	1796
Chromium, Total	mg/kg	92.1
Cadmium, Total	mg/kg	1.7
Copper, Total	mg/kg	8.3
Lead, Total	mg/kg	12
Mercury, Total	mg/kg	<0.01
Zinc, Total	mg/kg	152

Prepared by: GJB1
Checked by: GJB

Historical data indicate that the substrate at sampling point M-1 on Creek 12-9 was primarily inorganic. In addition to this, high percent solids, iron, chromium, and manganese were also indicated within the sample. As with the other sites, it is anticipated that considerable variability in sediment composition exists within Creek 12-9.

Suspended sediment samples were collected at SG-8 and SG-23 in 1978 and the respective results are presented in Appendix 3.7-4. The average total suspended solids was 8.1 mg/L, which is less than the average 11 mg/L for the Northern Highlands region (Hindall, 1976), indicating that Creek 12-9 is essentially free of suspended sediments. The volatile portion of the suspended solids acts as an indicator of the organic content of sediment carried by Creek 12-9; the remainder is clastic sediment. In Creek 12-9, volatile solids averaged <4.8 mg/L.

3.7.5.4 Creek 11-4

The headwaters for Creek 11-4 begin in a beaver pond (Martin Springs) located north of Rolling Stone Lake (Figure 3.7-2). This creek has a watershed of 0.4 square miles, a total surface area of 0.3 acre, and flows a distance of approximately 0.5 miles south/southwest prior to its entrance into Rolling Stone Lake. Creek 11-4 has an average width of 5 feet, an average depth of 0.3 foot, and is adjoined by 53 acres of wetlands (Table 3.7-27) (1985 EIR).

Samples for water chemistry analysis and measurements of stream flow were obtained from Creek 11-4 at Station SG-30, which was located 0.3 miles upstream form Rolling Stone Lake. Water samples and on site measurements were collected from this location monthly from April 1994 through March 1995. The maximum and minimum flows observed at SG-30 were 1.49 cubic feet per second (cfs) and 0.55 cfs in March 1995 and February 1995 respectively. The average flow measured at SG-30 throughout the study period was 0.96 cfs (Appendix 3.7-5).

Water quality data obtained from analyses of samples collected during the current study at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-34 which compares them to similar statistics derived from samples obtained during the 1977-1980 study. In general, the results reported from analyses of samples collected from Creek 11-4 in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Water chemistry data obtained from analysis of samples collected in 1994 indicated that Creek 11-4 was a moderately hard, neutral pH stream. Mean values recorded for hardness, alkalinity, and specific conductance were 122 mg/L as $CaCO_3$, 116 mg/L as $CaCO_3$, and 232 μmhos/cm, respectively. Mean pH at this station was 7.58 standard units. Dissolved oxygen concentrations ranged from 5.1 to 13.1 mg/L (mean: 9.2 mg/L).

All metals analyzed from samples collected at SG-30 during the 1994 and 1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Creek 11-4. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, aluminum was detected at levels higher than those observed during the 1977 - 1980 study (mean value = 78.27 μg/L vs. <10 μg/L). In October 1994 a sediment sample was collected from Creek 11-4 at station M-3. A sample was also collected at this site in March 1978 for previous project work (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-35. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

Table 3.7-34

Water Quality Data, SG-30 (Creek 11-4)
Summary of Monthly Means and Ranges

Station: M-3/SG-30	Units	1977-1978 Min.	1977-1978 Max.	1977-1978 Mean	1994-1995 Min.	1994-1995 Max.	1994-1995 Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	7.71	182.00	78.27
Arsenic, Total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	4	<1	<.006	.024	.010
Copper, Total	µg/L	<1	10	<2	.229	1.130	.452
Iron, Total	mg/L	.11	.40	.26	<.050	.300	.096
Lead, Total	µg/L	<10	20	<10	.037	.465	.202
Manganese, Total	mg/L	.006	.201	.069	.011	.057	.023
Mercury, Total	ng/L	<100	<100	<100	.59	5.58	2.36
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.03	<.03	Note 1
Zinc, Total	µg/L	<1	10	<5	.817	7.350	2.98
Phosphorus							
Phosphorus, Total	mg/L	.02	.09	.06	<.050	.100	.032
Nitrogen							
Nitrogen, Ammonia	mg/L	.60	1.35	.90	<.10	.20	.05
Nitrogen, Nitrate	mg/L	<.01	.19	<.10	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	9	<4	6.00	19.00	9.31
Solids							
Solids, Dissolved	mg/L	84	210	141	104	200	150
Solids, Suspended	mg/L	1	13	5	<5	13	3
General Parameters							
Alkalinity, Total	mg/L	46	138	84	84	150	116
Biological Oxygen Demand	mg/L	1	4	2	<2	10	3
Chemical Oxygen Demand	mg/L	69	69	69	17	36	26
Chloride	mg/L	<1	2	<2	<1	1	1
Conductivity	µmhos/cm	80	185	123	129	307	232
Cyanide	mg/L	<.001	<.001	<.001	<.020	<.020	Note 1
Dissolved Oxygen	mg/L	3.0	9.0	5.9	5.1	13.1	9.2
Hardness	mg/L	60	138	93	94	160	122
pH	SU	5.8	7.3	6.9	7.16	7.98	7.58
Temperature	°C	0	23.0	10.0	.5	24.2	11.0
Turbidity[a]	NTU	.8	5.7	1.8	<.50	9.50	1.81

[a] Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-35

Sediment Sampling Data, Creek 11-4 (Station M-3)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.7	NDA
Solids, Total	%	63.6	7.31
Solids, Total Volatile	mg/kg	61000	NDA
Ammonia, N	mg/kg	54	NDA
Total Kjeldahl Nitrogen	mg/kg	700	NDA
Total Organic Nitrogen	mg/kg	650	NDA
Chloride	mg/kg	14	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	550	1560
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	1600	NDA
Arsenic, Total	mg/kg	1.8	0.1
Barium, Total	mg/kg	14	NDA
Iron, Total	mg/kg	3500	4715
Manganese, Total	mg/kg	99	558
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	0.68	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	3.4	15.8
Cobalt, Total	mg/kg	1.5	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	860	NDA
Phosphorus, Total	mg/kg	150	NDA
Potassium, Total	mg/kg	170	NDA
Sodium, Total	mg/kg	23	NDA
Aluminum, Total	mg/kg	1500	NDA
Cadmium, Total	mg/kg	<0.50	0.7
Copper, Total	mg/kg	3.1	6.6
Lead, Total	mg/kg	1.7	3
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	13	80
Vanadium	mg/kg	5.6	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared: GJB1
Checked by: GJB

The data collected in 1994 indicates that a mixture of organic and inorganic sediments are found in Creek 11-4. The total solids content of 63.6 percent that was observed is indicative of inorganic materials. The sediments also contained 61,000 mg/kg of volatile solids which is equivalent to 6.1 percent organic matter. The 1978 data also indicated a near average total solids content, 7.31 percent as compared to an average solids content in 1978 of 8.04 percent. In addition, the 1978 data had a freon extractables content of 1,560 mg/kg which is slightly below the average concentration of 2,753 mg/kg, which indicates that a moderate amount of organic matter is present.

As stated previously, surface water sediment composition can have a considerable amount of variability due to deposition. Samples collected from a stream or lake may have variable compositions and represent the variability of the sediments for that surface water. It appears that the data from 1994 and 1978 have shown some degree of correlation. The variability that exists is likely the result of the particular sampling location and/or the nature of the different sampling methods.

3.7.5.5 Little Sand Lake

Little Sand Lake is located 0.4 mile south of the ore body (Figure 3.7-2). It has a surface area of 248 acres and a maximum depth of 21 feet. Eighty-six percent of the lake has a depth of 10 feet or less (EMC, 1985). The shoreline vegetation is predominantly upland hardwoods with some wetland. The lake substrate consists primarily of sand, gravel and muck (Table 3.7-27). Little Sand Lake has a single intermittent inlet stream on its east side and a single intermittent outlet stream to the south. It receives water intermittently from the lakes upstream of it, namely Duck and Deep Hole (EMC, 1985).

A staff gage (LG-7) was established on Little Sand Lake during the 1977-1980 study. Lake levels calculated from data obtained at this location between April 1977 and October 1994 are given in Appendix 3.7-3. Throughout this time a 2.66 ft. low to high water level difference was observed with minimum (1590.81 MSL) and maximum (1593.47 MSL) measurements occurring in July 1977 and February 1986 respectively. Lake level readings calculated from measurements made during the 1993-1995 study were within the range observed historically (min=1592.01, max=1592.76).

The water quality sampling station for Little Sand (LG-7) was located in the south central portion of the lake. The depth measured at LG-7 was 15-18 feet. Collections of samples for water quality analysis were conducted monthly at this location from April 1994 through March 1995.

Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-36 which compares them to similar statistics derived from samples obtained during the 1977-1980 study. In general, the results reported from analyses of samples collected from Little Sand Lake in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Results from water chemistry analysis indicated that Little Sand Lake was a soft, slightly acidic pH lake. Mean hardness, alkalinity and specific conductance values at Station LG-7 were 4 mg/L as $CaCO_3$, 4 mg/L as $CaCO_3$ and 22 μmhos/cm, respectively. Surface water pH values ranged from 5.42 to 6.75 and averaged 6.29 throughout the period of study.

Table 3.7-36

Water Quality Data, LG-7 (Little Sand Lake)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: H/LG-7	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, total	µg/L	<10	<10	<10	33.50	122	72.15
Arsenic, total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, total	µg/L	<1	3	<1	.030	.071	.054
Copper, total	µg/L	<1	43	<7	.345	.975	.575
Iron, Total	mg/L	.01	.13	.04	<.100	.114	.042
Lead, total	µg/L	<10	30	<10	196	.445	.304
Manganese, total	mg/L	.018	.108	.050	<.010	.037	.011
Mercury, total	ng/L	<100	<100	<100	1.69	2.27	1.94
Molybdenum, total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, total	µg/L	7	35	17	7.94	21.70	11.53
Phosphorus							
Phosphorus, total	mg/L	<.01	.17	<.04	<.050	.014	.004
Nitrogen							
Nitrogen, Ammonia	mg/L	.08	.35	.23	<.10	.10	.03
Nitrogen, Nitrate	mg/L	<.01	.34	<.13	<.50	.72	.07
Sulfur							
Sulfate	mg/L	3	14	9	3.05	7.80	5.14
Solids							
Solids, Dissolved	mg/L	2	173	40	5	51	29
Solids, Suspended	mg/L	<1	12	<4	<5	5	1
General Parameters							
Alkalinity, total	mg/L	<1	6	<2	<5	35	4
Biological Oxygen Demand	mg/L	1	7	2	<2	7	1
Chemical Oxygen Demand	mg/L	7	7	7	10	27	18
Chloride	mg/L	<1	6	<2	<1	1	0
Conductivity	µmhos/cm	11	59	29	13	47	22
Cyanide	mg/L	<.001	.004	<.001	<.020	<.020	Note 1
Hardness	mg/L	6	24	12	<5	8	4
Dissolved Oxygen[b]	mg/L	2.8	11.8	9.1	5.2	12.3	9.0
pH	SU	4.8	6.1	5.4	5.42	6.75	6.29
Temperature	°C	1.5	24.9	10.9	1.1	25.3	13.8
Turbidity[a]	NTU	.7	1.4	1.0	<.50	2.00	.80

[a] Turbidity was measured in FTU during the 1977-1978 study.
[b] Dissolved oxygen measured at 3 feet below surface.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Monthly dissolved oxygen profiles showed that Little Sand Lake remained well mixed and oxygenated throughout the 1993-1995 sampling period (Figure 3.7-7 and 3.7-8). This is consistent with results from studies conducted in the 1970s and 1980s (Appendix 3.7-4). During the 1993-1995 study a mean dissolved oxygen concentration of 9.0 mg/L was recorded from a three-foot depth at LG-7. Concentrations ranged from 5.2 mg/L to 12.3 mg/L at the surface and 5.2 mg/L to 10.6 mg/L near the lake bottom (15-18 feet). Oxygen levels below 5 mg/L were not observed within the water column of Little Sand Lake (Appendix 3.7-8). Dissolved oxygen and temperature data collected in Little Sand Lake during previous studies can be found in Dames & Moore (1985).

All metals analyzed from samples collected at LG-7 during the current study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc, and chromium in water samples collected in Little Sand Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. Only aluminum was detected at a level significantly higher than those observed during the 1977-1980 study (mean value = 72.15 mg/L vs <10 mg/L).

In October 1994 sediment samples were collected from Little Sand Lake at Stations H and I. A duplicate sample was also collected at station H which will be referred to as H-Duplicate. Samples were also collected at these sites in March 1978 for the previous project work (EMC, 1985). A comparison of the results from these two sampling events is shown in Tables 3.7-37 and 3.7-38. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

The 1994 data illustrates the variability in sediment composition within Little Sand Lake. Sampling site I is indicative of a higher level of organic deposition. The lower total solids concentration, 33.7 percent, coupled with a higher concentration of volatile solids, 109,000 mg/kg (10.9 percent of the total solids) as well as higher levels of nitrogen and phosphorus are reflective of the greater amount of organic material that is present in the sediments.

The 1994 data for site H, from both the first sample, H, and the second sample, H-Duplicate, are representative of an inorganic substrate. Total solids concentrations of 65.6 and 74.8 percent, coupled with total volatile solids concentrations of only 19,000 mg/kg (1.9 percent of the total solids) and 7,000 mg/kg (0.7 percent of the total solids), are indicative of inorganic substrates.

The metals concentrations in H and H-Duplicate compare very closely. This shows consistency in sampling techniques, analytical methods and the substrate at this site. Except for mercury, the metals data for site I in the 1978 sampling event are considerably higher than those from 1994. This may be a result of variability in the sampling location, sampling methods or analytical techniques. It is likely that the variability in sediments may be reflected in this data. The arsenic, chromium, copper, lead and zinc data in 1978 for site I were on the upper end of the concentrations for that data set. Because of the uniformity in sampling and analytical techniques used during the 1978 study period, the variation in present data is likely attributable to actual variability within the composition of the sediments. Therefore, the sediment sample collected at site I in 1978 likely did contain higher than average concentration of metals.

Table 3.7-37

Sediment Sampling Data, Little Sand Lake (Station H)

Parameter	Units	October 1994 Data	October 1994 Dup. Data	March 1978 Data
pH, Lab	SU	5.5	5.5	NDA
Solids, Total	%	65.6	74.8	7.34
Solids, Total Volatile	mg/kg	19000	7000	NDA
Ammonia, N	mg/kg	38	23	NDA
Total Kjeldahl Nitrogen	mg/kg	290	180	NDA
Total Organic Nitrogen	mg/kg	250	160	NDA
Chloride	mg/kg	22	25	NDA
Fluoride	mg/kg	<0.5	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	390	360	2548
Boron, Total	mg/kg	<10	<10	NDA
Calcium, Total	mg/kg	250	160	NDA
Arsenic, Total	mg/kg	0.74	0.95	0.3
Barium, Total	mg/kg	7.9	4.3	NDA
Iron, Total	mg/kg	2300	1800	6014
Manganese, Total	mg/kg	61	42	119
Molybdenum, Total	mg/kg	<2.0	<2.0	NDA
Selenium, Total	mg/kg	0.80	0.60	NDA
Silver, Total	mg/kg	<0.50	<0.50	NDA
Chromium, Total	mg/kg	3.7	2.8	18.4
Cobalt, Total	mg/kg	1.9	1.4	NDA
Beryllium, Total	mg/kg	<0.50	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	<1.0	NDA
Nickel, Total	mg/kg	2.4	2.1	NDA
Antimony, Total	mg/kg	<5.0	<5.0	NDA
Magnesium, Total	mg/kg	420	340	NDA
Phosphorus, Total	mg/kg	<100	<100	NDA
Potassium, Total	mg/kg	170	110	NDA
Sodium, Total	mg/kg	30	12	NDA
Aluminum, Total	mg/kg	2900	1900	NDA
Cadmium, Total	mg/kg	<0.50	<0.50	2.3
Copper, Total	mg/kg	1.6	0.82	10.5
Lead, Total	mg/kg	3.2	2.5	38
Mercury, Total	mg/kg	<0.02	<0.02	<0.01
Zinc, Total	mg/kg	32	30	150
Vanadium	mg/kg	5.5	4.4	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Table 3.7-38

Sediment Sampling Data, Little Sand Lake (Station I)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	5.2	NDA
Solids, Total	%	33.7	4.23
Solids, Total Volatile	mg/kg	109000	NDA
Ammonia, N	mg/kg	88	NDA
Total Kjeldahl Nitrogen	mg/kg	690	NDA
Total Organic Nitrogen	mg/kg	600	NDA
Chloride	mg/kg	35	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	590	3972
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	160	NDA
Arsenic, Total	mg/kg	0.76	5.0
Barium, Total	mg/kg	8.2	NDA
Iron, Total	mg/kg	1100	9265
Manganese, Total	mg/kg	20	1079
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	1.2	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	2.8	22.3
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	2.1	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	250	NDA
Phosphorus, Total	mg/kg	350	NDA
Potassium, Total	mg/kg	230	NDA
Sodium, Total	mg/kg	20	NDA
Aluminum, Total	mg/kg	2100	NDA
Cadmium, Total	mg/kg	<0.50	4.1
Copper, Total	mg/kg	1.6	20.9
Lead, Total	mg/kg	2.6	156
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	10	218
Vanadium	mg/kg	4.5	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

3.7.5.6 Duck Lake

Duck Lake is located approximately 1.1 miles southeast of the ore body (Figure 3.7-2). It has a surface area of 26 acres and a maximum depth of 10 feet. The shoreline is characterized by swamp conifer or bog vegetation with mixed hardwoods in the upland areas. The lake sediments are primarily muck (Table 3.7-27). The lake has no clearly defined inlet stream and an intermittent outlet stream, which flows through a major wetland before discharging into Little Sand Lake (EMC, 1985).

Staff Gage LG-12 was established on Duck Lake during the 1977-1980 study. Lake levels calculated from data obtained at this location between April 1977 and October 1994 are given in Appendix 3.7-3. During this time period, a 2.64-foot fluctuation was recorded. Lake levels throughout the period varied from a high of 1612.88 MSL to a low of 1610.24, and averaged 1611.74 MSL through the study period.

The water chemistry sampling location designated LG-12 was positioned in the south central portion of Duck Lake. Collection of samples for water chemistry analysis were conducted monthly at this location from April 1994 through March 1995. Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are provided in Table 3.7-39 which compares them to similar statistics derived from samples obtained during the 1977-1980 study.

In general, the results reported from analysis of water samples collected from LG-12 in 1994 and 1995 were similar to those obtained during the 1977-1978 effort. Results of water chemistry analysis indicated that Duck Lake is a soft, slightly acidic pH lake. Mean hardness, alkalinity and specific conductance values were 7 mg/L as $CaCO_3$, 1 mg/L as $CaCO_3$, and 19 μmhos/cm, respectively. The pH values for the surface water at Duck Lake ranged from 4.91 to 6.37, and averaged 5.62 throughout the duration of the study.

Dissolved oxygen concentrations measured in the surface water of Duck Lake ranged from 6.4 mg/L to 13.6 mg/L. Concentrations were above 5 mg/L throughout the water column during all samplings except in those regions within two feet of the lake bottom where lower concentrations were measured in September 1994, January 1995 and March 1995. Depth profiles of water temperature indicated that Duck Lake was generally well mixed throughout the year. Periods when the lower level of the lake had low oxygen content indicated that mixing may be limited at times. This mixing is not restricted because of temperature related density factors however.

All metals analyzed from samples collected at LG-12 during the 1994 and 1995 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Duck Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, aluminum was detected at a level higher than those observed during the 1977-1980 study (mean value = 91.86 μg/L vs <10 μg/L).

Table 3.7-39

Water Quality Data, LG-12 (Duck Lake)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: K/LG-12	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	62.30	154.00	91.86
Arsenic, Total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	6	<2	<.006	.039	.020
Copper, Total	µg/L	<1	38	<5	.447	3.490	.902
Iron, Total	mg/L	.02	1.01	.26	.100	.170	.130
Lead, Total	µg/L	<10	<10	<10	.413	2.18	.997
Manganese, Total	mg/L	.036	.500	.077	.010	.040	.022
Mercury, Total	ng/L	<100	<100	<100	2.30	3.95	3.10
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	6	63	19	4.68	10.10	6.41
Phosphorus							
Phosphorus, Total	mg/L	<.01	.05	<.03	<.050	.028	.009
Nitrogen							
Nitrogen, Ammonia	mg/L	.47	2.44	1.28	<.10	.67	.08
Nitrogen, Nitrate	mg/L	<.01	1.27	<.24	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	14	<10	2.35	10.00	6.56
Solids							
Solids, Dissolved	mg/L	1	85	46	8	54	29
Solids, Suspended	mg/L	1	17	7	<5	<5	Note 1
General Parameters							
Alkalinity, Total	mg/L	<1	18	<3	<5	4	1
Biological Oxygen Demand	mg/L	1	10	4	<2	10	2
Chemical Oxygen Demand	mg/L	7	34	20	21	36	31
Chloride	mg/L	<1	6	<2	<1	1	0
Conductivity	µmhos/cm	22	40	30	13	39	19
Cyanide	mg/L	<.001	.002	<.001	<.020	<.020	Note 1
Dissolved Oxygen[b]	mg/L	.5	13.9	7.7	6.4	13.6	9.3
Hardness	mg/L	4	26	15	<5	12	7
pH	SU	4.5	6.0	5.0	4.91	6.37	5.62
Temperature	°C	.5	27.5	11.7	2.4	25.3	14.1
Turbidity[a]	NTU	.9	5.6	2.0	<.5	2.4	1.1

[a] Turbidity was measured in FTU during the 1977-1978 study.
[b] Measured at 0.5 feet below surface.
SU = Standard Units.
Note 1: All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

In October 1994 a sediment sample was collected from Duck Lake at Station K. A sample was also collected at this site in March 1978 for the previous work that was completed (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-40. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

The sediment sample collected from Duck Lake in 1994 is representative of a predominantly inorganic substrate. The volatile solids portion, a measure of the organic content, measured within the sample was 7.5 percent (75,000 mg/kg) of the total solids present. The nitrogen and phosphorus levels were however high, which confirms that a portion of the sample is of organic origin.

The 1978 sample also showed some indications of organic material being present. The freon extractables level was the highest concentration for the 1978 sediment data set. This parameter is also an indicator of organic matter in a sediment sample.

The other parameters had mixed correlations between 1994 and 1978. This may be attributable to sampling methods, analytical methods, or, more likely, variability in the sediments in Duck Lake.

3.7.5.7 Deep Hole Lake

Deep Hole Lake is located approximately 1.5 miles southeast of the ore body (Figure 3.7-2). It has a surface area of 97 acres and a maximum depth of 10 feet. The shoreline vegetation there is characteristically upland hardwood and wooded, shrub-meadow wetland. The major components of the lake littoral sediments are sand, muck, gravel and rubble (Table 3.7-27).

Although the lake has no clearly defined inlet or outlet, an intermittent inlet is present through the wetlands to the east, and two intermittent outlets exist. During periods of high water levels, surface water discharge can occur from the main outlet of Deep Hole Lake through a shallow marsh located in the west central portion of the lake. A secondary outlet is located on the southwest side in the lake (EMC, 1985).

Staff gage LG-13 was established on Deep Hole Lake during the 1977-1980 study (Figure 3.7-2). Lake levels calculated from data obtained at this location between June 1977 and October 1994 are given in Appendix 3.7-3. During this time period a 2.23-foot fluctuation was recorded. Lake levels throughout this period varied from a high of 1607.09 MSL on April 21, 1979, to a low of 1604.86 MSL on October 12, 1987.

The water chemistry sampling location designated LG-13 was positioned in the central portion of Deep Hole Lake. Collections of samples for water chemistry analysis were conducted monthly at this location from April 1994 through March 1995. Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-41 which compares them to similar statistics derived from samples obtained during the 1977-1980 study.

Table 3.7-40

Sediment Sampling Data, Duck Lake (Station K)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.1	NDA
Solids, Total	%	63.2	4.96
Solids, Total Volatile	mg/kg	75000	NDA
Ammonia, N	mg/kg	86	NDA
Total Kjeldahl Nitrogen	mg/kg	1000	NDA
Total Organic Nitrogen	mg/kg	910	NDA
Chloride	mg/kg	64	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	690	5504
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	340	NDA
Arsenic, Total	mg/kg	<0.40	<0.1
Barium, Total	mg/kg	9.2	NDA
Iron, Total	mg/kg	210	2152
Manganese, Total	mg/kg	4.3	83
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	1.3	8.8
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	93	NDA
Phosphorus, Total	mg/kg	100	NDA
Potassium, Total	mg/kg	75	NDA
Sodium, Total	mg/kg	11	NDA
Aluminum, Total	mg/kg	840	NDA
Cadmium, Total	mg/kg	<0.50	1.5
Copper, Total	mg/kg	0.82	12
Lead, Total	mg/kg	1.2	4

Table 3.7-40 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	12	64
Vanadium	mg/kg	1.4	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Table 3.7-41

Water Quality Data, LG-13 (Deep Hole Lake)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: L/LG-13	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, total	µg/L	<10	<10	<10	90.40	248.0	145.90
Arsenic, total	mg/L	<.001	.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	7	<2	.009	.151	.033
Copper, total	µg/L	<1	11	<3	.493	1.070	.719
Iron, total	mg/L	.05	.42	.14	.146	.410	.198
Lead, total	µg/L	<10	<10	<10	.421	1.620	.805
Manganese, total	mg/L	.014	.086	.029	.018	.075	.029
Mercury, total	ng/L	<100	<100	<100	2.39	3.01	2.73
Molybdenum, total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<0.1	<.01	<0.1	<.030	.070	.006
Zinc, total	µg/L	6	20	12	6.03	14.90	8.37
Phosphorus							
Phosphorus, total	mg/L	<.01	.12	<.04	<.05	.097	.019
Nitrogen							
Nitrogen, Ammonia	mg/L	.33	.77	.48	<.10	.34	.05
Nitrogen, Nitrate	mg/L	<.01	.39	<.11	<.50	.71	.08
Sulfur							
Sulfate	mg/L	4	13	9	3.94	12.0	7.89
Solids							
Solids, Dissolved	mg/L	8	196	53	15	78	40
Solids, Suspended	mg/L	1	17	5	<5	<5	Note 1
General Parameters							
Alkalinity, Total	mg/L	<1	28	<5	<2	5	2
Biological Oxygen Demand	mg/L	1	9	3	<2	6	1
Chemical Oxygen Demand	mg/L	3	21	12	15	29	23
Chloride	mg/L	<1	4	<2	<1	<1	Note 1
Conductivity	µmhos/cm	18	85	30	21	40	28
Cyanide	mg/L	<.001	.004	<.001	<.020	<.020	Note 1
Dissolved Oxygen[b]	mg/L	1.3	14.8	8.4	8.2	12.8	10.4
Hardness	mg/L	8	36	16	<5	13	8
pH	SU	5.4	6.6	6.0	5.31	6.63	5.95
Temperature	°C	.6	24.0	11.9	2.8	24.6	14.0
Turbidity[a]	NTU	.6	2.7	1.4	.90	2.98	1.51

[a] Turbidity was measured in FTU during the 1977-1978 study.
[b] Measured at 0.5 feet below surface.
SU = Standard Units.
Note 1 = All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

In general, the results reported from analysis of water samples collected from LG-13 in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Results of water chemistry analysis indicated that Deep Hole Lake was a soft, slightly acidic pH lake. Mean hardness, alkalinity and specific conductance values at Deep Hole Lake were 8 mg/L as $CaCO_3$, 2 mg/L as $CaCO_3$, and 28 μmhos/cm, respectively. The pH values measured in surface waters at Deep Hole Lake ranged from 5.31 to 6.63 and averaged 5.95 throughout the duration of the study.

Dissolved oxygen concentrations measured in the surface water of Deep Hole Lake ranged from 8.2 to 12.8 mg/L. Concentrations of dissolved oxygen were above 5 mg/L during all samplings except in the region within one foot of the bottom sediment where a concentration of 2.2 mg/L was measured in September 1994.

All metals analyzed from samples collected at LG-13 during the 1994 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected from Deep Hole Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, only aluminum was detected at a level higher than those observed during the 1977-1980 study (mean value = 145.9 μg/L vs <10 μg/L).

In October 1994 a sediment sample was collected from Deep Hole lake at Station L (Figure 3.7-2). A sample was also collected at this site in March 1978 for the previous work that was completed (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-42. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

The sediment sample collected from Deep Hole Lake in 1994 is representative of a predominantly inorganic substrate. The volatile solids portion, a measure of the organic content, measured within the sample was 4.9 percent (49,000) of the total solids present. Nitrogen and phosphorus levels were however high, which confirms that a portion of the sample is of organic origin.

The 1978 sample also showed some indications of organic material being present. The freon extractables level, another indicator of organic constituents, was above the average for the sediment concentrations reported in the 1978 data set. The 1978 concentration data was considerably higher than the 1994 data for parameters other than mercury. This may be attributable to sampling methods, analytical methods, or, more likely, variability in the sediments in Deep Hole lake.

3.7.5.8 Skunk Lake

Skunk Lake is located 0.4 mile east of the ore body in the uppermost portion of the Pickerel Creek drainage basin (Figure 3.7-2). It has a surface area of six acres and a maximum depth of six feet; however, depths in most of the lake are <3.0 feet (Table 3.2-27). The shoreline of Skunk Lake is predominantly upland hardwoods with the remainder being marsh wetland. The bottom substrate consists primarily of muck. Skunk Lake is located in a topographic depression and appears to have neither a surface water inlet nor outlet.

Table 3.7-42

Sediment Sampling Data, Deep Hole Lake (Station L)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	5.8	NDA
Solids, Total	%	59.6	6.47
Solids, Total Volatile	mg/kg	49000	NDA
Ammonia, N	mg/kg	45	NDA
Total Kjeldahl Nitrogen	mg/kg	610	NDA
Total Organic Nitrogen	mg/kg	560	NDA
Chloride	mg/kg	22	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	490	3818
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	210	NDA
Arsenic, Total	mg/kg	<0.40	4
Barium, Total	mg/kg	8.0	NDA
Iron, Total	mg/kg	660	2507
Manganese, Total	mg/kg	14	92
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	1.2	14.7
Cobalt, Total	mg/kg	<1.0	NDA
Beryllium, Total	mg/kg	<0.5	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	<2.0	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	150	NDA
Phosphorus, Total	mg/kg	150	NDA
Potassium, Total	mg/kg	66	NDA
Sodium, Total	mg/kg	12	NDA
Aluminum, Total	mg/kg	970	NDA
Cadmium, Total	mg/kg	<0.5	1.4
Copper, Total	mg/kg	1.1	15
Lead, Total	mg/kg	3.7	12
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	8.9	83
Vanadium	mg/kg	2.1	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Staff gage LG-15 was established on Skunk Lake during the 1977-1980 study. Lake levels calculated from data obtained at this location between May 1977 and October 1994 are given in Appendix 3.7-3. During this time period a 4.67 foot fluctuation was recorded in the water level in Skunk Lake. Lake levels throughout this time varied from a high of 1599.85 MSL on June 17, 1991, to a low of 1595.18 MLS on February 15, 1986.

The water chemistry sampling station designated LG-15 was positioned in the eastern portion of Skunk Lake. Samples were collected from this location monthly from April 1994 through March 1995. Water quality data obtained from analyses of samples collected during this time period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Table 3.7-43 which compares them to similar statistics derived from samples obtained during the 1977-1980 study.

In general, the results reported from analysis of samples collected from LG-15 in 1994 and 1995 were similar to those obtained during the 1977-1980 effort. Results of water chemistry analysis indicated that Skunk Lake is a soft, slightly acidic pH lake. Mean hardness, alkalinity and specific conductance values were 7 mg/L as $CaCO_3$, 5 mg/L as $CaCO_3$ and 23 μmhos/cm, respectively. The pH values measured in surface waters at Skunk Lake ranged from 4.81 to 5.96 and average 5.42 throughout the duration of study.

Dissolved oxygen levels were consistently low throughout the study duration in Skunk Lake. Measurements made at a depth of three feet ranged from 0.9 mg/L to 8.0 mg/L. Dissolved oxygen concentrations within the top foot of water in Skunk Lake were generally higher than those made at three feet and ranged from a high of 8.0 mg/L in April 1994 to a low of 0.9 in February of 1995.

All metals analyzed from samples collected at LG-15 during the 1994 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected in Skunk Lake. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. However, aluminum was detected at a level higher than those observed during the 1977-1980 study (mean value = 74.23 μg/L vs <10 μg/L).

3.7.6 Wolf River Drainage Basin

The portion of the Wolf River studied is included in the area shown on Figure 3.7-4. Characteristics of the drainage basin upstream from Langlade are summarized in Table 3.7-27. Two of its major drainage sub-basins, the Swamp Creek basin and the Pickerel Creek basin, are described specifically in subsections 3.7.4 and 3.7.5, respectively. Swamp Creek and Pickerel Creek have drainage areas of 151 square miles (Table 3.7-11) and 44.3 square miles (Table 3.7-27), respectively, and the Wolf River at Langlade has a drainage area of 460 square miles.

The Wolf River originates in Hiles Mill Pond in Forest County and flows south approximately 223 miles to Lake Poygan in Winnebago County (WDNR, 1977). Its course of flow meanders along the western margin of the study area. Principal tributaries to the Wolf located upstream

Table 3.7-43

Water Quality Data, LG-15 (Skunk Lake)
Summary of Monthly Means and Ranges

		1977-1978			1994-1995		
Station: J/LG-15	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, Total	µg/L	<10	<10	<10	36.90	182.0	74.23
Arsenic, Total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, Total	µg/L	<1	<5	<2	<.006	.011	.005
Copper, Total	µg/L	<1	92	<11	.250	.907	.462
Iron, Total	mg/L	.08	1.30	.45	.106	.740	.242
Lead, Total	µg/L	<10	20	<10	.120	.289	.199
Manganese, Total	mg/L	.018	.724	.221	.040	.280	.119
Mercury, Total	ng/L	<100	<100	<100	1.26	3.29	2.09
Molybdenum, Total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, Total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, Total	µg/L	4	25	9	3.32	6.64	4.95
Phosphorus							
Phosphorus, Total	mg/L	.07	.54	.20	<.050	.301	.060
Nitrogen							
Nitrogen, Ammonia	mg/L	.61	3.06	1.57	<.10	.34	.13
Nitrogen, Nitrate	mg/L	<.01	.63	<.17	<.50	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	1	<1	<1.00	11.00	5.65
Solids							
Solids, Dissolved	mg/L	5	310	67	15	62	40
Solids, Suspended	mg/L	1	56	12	<5	11	1.1
General Parameters							
Alkalinity, Total	mg/L	4	30	10	<5	15	5
Biological Oxygen Demand	mg/L	2	13	8	<2	15	5
Chemical Oxygen Demand	mg/L	*	*	*	33	50	40
Chloride	mg/L	<1	2	<2	<1	2	0
Conductivity	µmhos/cm	16	45	27	11	59	23
Cyanide	mg/L	<.001	.006	<.002	<.020	<.020	Note 1
Dissolved Oxygen[b]	mg/L	.4	10.5	5.1	.9	8.0	4.9
Hardness	mg/L	4	32	15	<5	14	7
pH	SU	5.2	6.6	5.8	4.81	5.96	5.42
Temperature	°C	.8	26.0	8.7	1.6	24.1	12.3
Turbidity[a]	NTU	.9	8.7	2.9	.85	8.2	2.53

[a] Turbidity was measured in FTU during the 1977-1978 study.
[b] Measured at 0.5 feet.
SU = Standard Units.
Note 1 = All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

from the town of Langlade are Swamp Creek, Pickerel Creek, Hunting River, Lily River, and Nine Mile Creek. Ninety-five percent of the Wolf River drainage basin is wooded and undeveloped, whereas the remaining five percent is farmland (Steuck, et. al., 1977). Table 3.7-8 presents stream discharge data for the Wolf River at Langlade. Above the community of Lily the river has a flat gradient, reflecting the large areas of lakes and wetlands through which it flows. Below Pearson the character of the river begins to change as it exhibits a steeper gradient. As calculated from USGS topographic maps, the gradient above Pearson averages 3.7 feet/mile, while below this area the gradient increases to 9.8 feet/mile (EMC, 1985).

River flow data and samples for water chemistry analyses were collected from the Wolf River monthly from November 1993 through October 1994 at Station SG-Y located approximately 1.2 miles upstream from the confluence with Swamp Creek, and at SG-CC, located approximately 2.1 miles upstream of the confluence with Pickerel Creek (Figure 3.7-1). River flow was monitored on the Wolf River at both SG-Y and SG-CC at the respective times that samples for water chemistry analyses were collected at those sites. The data associated with flow monitoring on the Wolf River is given in Appendices 3.7-5 and 3.7-6. Maximum and minimum flows measured at the upstream Wolf River site SG-Y were 135 cfs and 39 cfs (mean = 80 cfs). Flows measured at the downstream site SG-CC were consistently higher (min=75 cfs, max=218 cfs) than those measured at SG-Y (mean = 129 cfs). The flows averaged 129 cfs between November 1993 and September 1994. Samples were also collected from these sites during storm flow events. Peak flows were not obtained at these times because of unsafe conditions.

Water quality data obtained from analyses of samples collected during the current study period at this site are presented in Appendix 3.7-8. Summary statistics including maximum, minimum and mean values for these parameters are given in Tables 3.7-44 and 3.7-45 which compare them to similar statistics derived from samples obtained during the 1977-1980 study. In general, the results reported from analyses of samples collected from the Wolf River in 1993 and 1994 were similar to those obtained during the 1977-1980 effort. Water chemistry information indicated that the Wolf River is a moderately hard, neutral pH stream. Mean hardness, alkalinity and conductivity values were 61 and 78 mg/L as $CaCO_3$, 55 and 69 mg/L as $CaCO_3$, and 138 and 154 μmhos/cm at Stations SG-Y and SG-CC, respectively. The mean pH values recorded on the Wolf River ranged from 7.35 at SG-Y to 7.01 at SG-CC. Maximum and minimum dissolved oxygen values measured on the Wolf River were 10.9 mg/L and 2.8 mg/L at SG-CC and 11.4 and 6.2 mg/L at SG-Y.

All metals analyzed from samples collected at sites SG-Y and SG-CC during the 1993-1994 study were either below detection limits or were found in low concentrations. During this recent study, low level analyses techniques were used to monitor concentrations of aluminum, cadmium, copper, lead, mercury, zinc and chromium in water samples collected from the Wolf River. The lower detection limits associated with these techniques allowed for trace level detections of all these metals. Aluminum was detected at levels higher than those observed during the 1977-1980 study (range of means = 27.7 - 42.2 vs 10 μg/L).

In October 1994 sediment samples were collected from the Wolf River at stations Y and Z. Samples were also collected at these sites in March 1978 for the previous work that was completed (EMC, 1985). A comparison of the results from these two sampling events is shown in Table 3.7-46 and Table 3.7-47. Information pertaining to the analysis of sediment samples is included in Appendices 3.7-4 and 3.7-10.

Table 3.7-44

Water Quality Data, SG-CC[a] (Wolf River)
Summary of Monthly Means and Ranges

		1977-1978			1993-1994		
Station: Z/SG-CC	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, total	µg/L	<10	<10	<10	20.40	98.40	42.15
Arsenic, total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, total	µg/L	<1	3	<2	<.004	.032	.009
Copper, total	µg/L	<1	4	<1	.163	1.100	.428
Iron, total	mg/L	.31	1.45	.61	.358	.780	.500
Lead, total	µg/L	<10	10	<10	.131	.557	.237
Manganese, total	mg/L	.016	.160	.068	.035	.139	.071
Mercury, total	ng/L	<100	900	<200	1.00	7.18	2.63
Molybdenum, total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, total	µg/L	<1	23	<9	.97	6.48	2.02
Phosphorus							
Phosphorus, total	mg/L	<.01	.04	<.03	<.050	.046	.012
Nitrogen							
Nitrogen, Ammonia	mg/L	.51	1.51	1.00	<.10	1.47	.19
Nitrogen, Nitrate	mg/L	<.01	.54	<.27	<.04	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	8	<5	4.12	24.00	8.65
Solids							
Solids, Dissolved	mg/L	72	174	122	6	125	89
Solids, Suspended	mg/L	1	11	4	<5	7	2
General Parameters							
Alkalinity, Total	mg/L	46	90	63	40	97	69
Biological Oxygen Demand	mg/L	1	2	2	<2	8	3
Chemical Oxygen Demand	mg/L	7	55	31	17	32	23
Chloride	mg/L	<1	4	<3	2	3	3
Conductivity	µmhos/cm	75	135	99	111	213	154
Cyanide	mg/L	<.001	<.001	<.001	<.010	<.020	Note 1
Dissolved Oxygen	mg/L	1.4	12.6	6.8	2.8	10.9	7.8
Hardness	mg/L	56	104	73	52	104	78
pH	SU	6.4	7.5	7.0	5.96	7.64	7.01
Temperature	°C	0	22.0	9.3	0	20	10
Turbidity[b]	NTU	1.2	3.3	2.0	1.60	2.80	2.13

[a] Station SG-CC was positioned approximately three miles upstream of Station Z.
[b] Turbidity was measured in FTU during the 1977-1978 study.
SU = Standard Units.
Note 1 = All data reported as less than detection, therefore no mean value is calculated.

Prepared by: JJA
Checked by: BDH

Table 3.7-45

Water Quality Data, SG-Y (Wolf River)
Summary of Monthly Means and Ranges

		1977-1978			1993-1994		
Station: Y/SG-Y	Units	Min.	Max.	Mean	Min.	Max.	Mean
Metals							
Aluminum, total	µg/L	<10	<10	<10	13.40	60.70	27.70
Arsenic, total	mg/L	<.001	<.001	<.001	<.005	<.005	Note 1
Cadmium, total	µg/L	<1	5	<2	<.006	.039	.008
Copper, total	µg/L	<1	5	<2	.137	4.090	.652
Iron, total	mg/L	.34	.71	.47	.270	.820	.409
Lead, total	µg/L	<10	10	<10	.098	.307	.193
Manganese, total	mg/L	.014	.179	.069	.026	.219	.072
Mercury, total	ng/L	<100	<100	<100	1.00	4.55	2.27
Molybdenum, total	mg/L	<.01	<.01	<.01	<.020	<.020	Note 1
Nickel, total	mg/L	<.01	<.01	<.01	<.030	<.030	Note 1
Zinc, total	µg/L	<1	21	<9	1.04	3.73	1.76
Phosphorus							
Phosphorus, total	mg/L	<.01	.12	<.04	<.050	.767	.077
Nitrogen							
Nitrogen, Ammonia	mg/L	.39	1.36	1.01	<.10	.81	.15
Nitrogen, Nitrate	mg/L	<.01	.59	<.15	<.04	<.50	Note 1
Sulfur							
Sulfate	mg/L	<1	9	<6	3.47	21.00	7.16
Solids							
Solids, Dissolved	mg/L	57	166	110	50	135	86
Solids, Suspended	mg/L	1	13	4	<5	5	0
General Parameters							
Alkalinity, total	mg/L	36	80	52	41	88	55
Biological Oxygen Demand	mg/L	1	3	2	<1	9	3
Chemical Oxygen Demand	mg/L	10	52	31	20	36	28
Chloride	mg/L	<1	4	<2	2	4	3
Conductivity	µmhos/cm	50	120	84	92	197	138
Cyanide	mg/L	<.001	<.001	<.001	<.010	<.020	Note 1
Dissolved Oxygen	mg/L	6.1	16.1	9.2	6.2	11.4	8.6
Hardness	mg/L	42	92	60	39	93	61
pH	SU	5.8	7.6	6.9	6.44	10.87	7.35
Temperature	°C	1.0	22.0	10.2	1.1	21.9	11.2
Turbidity[a]	NTU	1.1	3.0	2.1	1.70	4.10	2.90

[a] Turbidity was measured in FTU during the 1977-1978 study.

SU = Standard Units. Prepared by: JJA

Note 1 = All data reported as less than detection, therefore no mean value is calculated. Checked by: BDH

Table 3.7-46

Sediment Sampling Data, Wolf River (Station Y)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.3	NDA
Solids, Total	%	74.4	45.78
Solids, Total Volatile	mg/kg	104000	NDA
Ammonia, N	mg/kg	<20	NDA
Total Kjeldahl Nitrogen	mg/kg	150	NDA
Total Organic Nitrogen	mg/kg	150	NDA
Chloride	mg/kg	<10	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	250	229
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	410	NDA
Arsenic, Total	mg/kg	0.69	0.3
Barium, Total	mg/kg	7.2	NDA
Iron, Total	mg/kg	3500	2571
Manganese, Total	mg/kg	28	102
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	<0.50	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	4.8	14.5
Cobalt, Total	mg/kg	1.6	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	3.4	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	620	NDA
Phosphorus, Total	mg/kg	170	NDA
Potassium, Total	mg/kg	150	NDA
Sodium, Total	mg/kg	15	NDA
Aluminum, Total	mg/kg	1900	NDA
Cadmium, Total	mg/kg	<0.50	0.1
Copper, Total	mg/kg	3.2	2.8
Lead, Total	mg/kg	18	4

Table 3.7-46 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	8.9	11
Vanadium	mg/kg	11	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

Table 3.7-47

Sediment Sampling Data, Wolf River (Station Z)

Parameter	Units	October 1994 Data	March 1978 Data
pH, Lab	SU	6.5	NDA
Solids, Total	%	46.0	67.66
Solids, Total Volatile	mg/kg	66000	NDA
Ammonia, N	mg/kg	81	NDA
Total Kjeldahl Nitrogen	mg/kg	790	NDA
Total Organic Nitrogen	mg/kg	710	NDA
Chloride	mg/kg	29	NDA
Fluoride	mg/kg	<0.5	NDA
Cyanide, Total	mg/kg	<0.5	NDA
Oil & Grease (Freon Extractables)	mg/kg	350	74
Boron, Total	mg/kg	<10	NDA
Calcium, Total	mg/kg	1100	NDA
Arsenic, Total	mg/kg	0.89	0.4
Barium, Total	mg/kg	14	NDA
Iron, Total	mg/kg	3500	2601
Manganese, Total	mg/kg	82	144
Molybdenum, Total	mg/kg	<2.0	NDA
Selenium, Total	mg/kg	0.76	NDA
Silver, Total	mg/kg	<0.50	NDA
Chromium, Total	mg/kg	4.8	33.1
Cobalt, Total	mg/kg	1.6	NDA
Beryllium, Total	mg/kg	<0.50	NDA
Thallium, Trace ICP	mg/kg	<1.0	NDA
Nickel, Total	mg/kg	1.9	NDA
Antimony, Total	mg/kg	<5.0	NDA
Magnesium, Total	mg/kg	780	NDA
Phosphorus, Total	mg/kg	530	NDA
Potassium, Total	mg/kg	120	NDA
Sodium, Total	mg/kg	30	NDA
Aluminum, Total	mg/kg	2200	NDA
Cadmium, Total	mg/kg	<0.50	0.1
Copper, Total	mg/kg	2.5	2.8
Lead, Total	mg/kg	2.2	1

Table 3.7-47 *(Continued)*

Parameter	Units	October 1994 Data	March 1978 Data
Mercury, Total	mg/kg	<0.02	<0.01
Zinc, Total	mg/kg	17	11
Vanadium	mg/kg	8.0	NDA

SU = Standard Units.
NDA = No Data Available.

Prepared by: GJB1
Checked by: GJB

The analytical results for sediment collections made on the Wolf River in 1994 were similar to those derived from collections made in 1978. This is illustrated by comparison of metals concentration results between the two sampling periods, which are in general agreement.

The 1994 data for sampling both sites are indicative of a mixture of organic and inorganic sediments. there are moderate levels of volatile solids found in both. Site Y had a volatile solids content of 10.4 percent (104,000 mg/kg) while site Z had a volatile solids content of 6.6 percent, (66,000 mg/kg).

3.7.7 Hydrological Relationships

3.7.7.1 Surface Water/Groundwater

Geography and climate have combined to provide a water surplus in northern Wisconsin. The excess of rainfall over evapotranspiration is reflected in the abundant groundwater resources, and the numerous lakes, wetlands, and perennial streams within the area. The streams of the study area share very similar characteristics. They are small, often not well defined, have varying surface water runoff characteristics, act as groundwater collectors with base water flow derived largely from groundwater, and, as a result, have similar water chemistry.

Groundwater and surface water in the study area are interrelated. In some cases, groundwater contributes to surface water flows, while in other cases surface water primarily contributes to the groundwater system.

When groundwater is a significant component of the input to a surface water system, the water chemistry of the surface water reflects the chemistry of the groundwater. In the study area, this correlation is seen in the hardness of the surface water. Using the classification system presented in Table 3.7-14, the groundwater in the study area is classified as moderately hard to very hard. The average hardness reported in Section 3.6.5 of the EIR is approximately 150 mg/L as $CaCO_3$. Those surface waters within the area which are fed by groundwater via direct connection to the water table or by groundwater-fed tributaries also exhibit a moderate hardness. In contrast, when a surface water in the study area is fed primarily by precipitation and surface water runoff, the water is characteristically soft.

To illustrate the correlation between water chemistry and the interaction of groundwater and surface water, Table 3.7-48 was prepared. The table compares alkalinity, hardness, pH, field conductivity, total solids, etc. for the various lakes, streams and rivers within the study area. Of the lakes, Little Sand, Oak, Duck, Skunk, and Deep Hole all have soft water. The hardness concentrations found in these lakes are less than 10 mg/L as $CaCO_3$ on the average. The maximum mean hardness recorded for these lakes was 8 mg/L in Deep Hole Lake. The hardness and other water chemistry data indicate that these lakes receive all or most of their water from surface water sources. In contrast, based on the 1994-1995 data, Rolling Stone Lake had an average hardness of approximately 77 mg/L as $CaCO_3$. This is an indication that groundwater is an important factor in the water balance for this lake. The groundwater component for Rolling Stone Lake is not just a result of the direct discharge of groundwater to the lake. Creeks 11-4 and 12-9 and Pickerel Creek have moderate hardness levels and contribute groundwater to

Table 3.7-48

Summary of Water Chemistry Data to Identify Similar Water Bodies in the Study Area

		Mean of 1993-1995 Values						
Water Body	Sampling Station[a]	Alkalinity mg/L as $CaCO_3$	Hardness mg/L as $CaCO_3$	pH	Field Conductivity mhos/cm	Total Dissolved Solids mg/L	Hardness Classification[b]	pH Classification[b]
Little Sand Lake	LG-7	4	4	6.29	22	29	Soft	Slightly Acidic
Oak Lake	LG-11	1	7	6.29	22	22	Soft	Slightly Acidic
Duck Lake	LG-12	1	7	5.62	19	29	Soft	Slightly Acidic
Skunk Lake	LG-15	5	7	5.42	23	40	Soft	Slightly Acidic
Deep Hole Lake	LG-13	2	8	5.95	28	40	Soft	Slightly Acidic
Rolling Stone Lake	LG-9	81	77	7.71	121	97	Moderately Hard	Neutral
Hemlock Creek	SG-6	102	97	7.54	185	126	Moderately Hard	Neutral
Outlet Creek	SG-4	92	100	7.26	187	104	Moderately Hard	Slightly Acidic
Swamp Creek	SG-5A	105	113	7.16	195	119	Moderately Hard	Neutral
Swamp Creek	SG-3	96	91	7.47	207	125	Moderately Hard	Neutral
Swamp Creek	SG-2	95	104	7.24	196	135	Moderately Hard	Neutral
Swamp Creek	SG-AB	96	103	7.31	203	118	Moderately Hard	Neutral
Swamp Creek	SG-V	87	101	7.10	188	115	Moderately Hard	Neutral
Creek 11-4	SG-30	116	122	7.58	232	150	Moderately Hard	Neutral
Pickerel Creek	SG-19	72	81	7.33	157	119	Moderately Hard	Neutral
Wolf River	SG-Y	55	61	7.35	138	86	Moderately Hard	Neutral
Wolf River	SG-CC	69	78	7.01	154	89	Moderately Hard	Neutral
Hoffman Creek	SG-E	140	144	7.33	263	163	Hard	Neutral
Groundwater[c]	----	147.4	149.8	7.25	390.2	202.2	Hard	Neutral

[a] See Figures 3.7-1 and 3.7-2.
[b] See Table 3.7-14.
[c] See Table 3.6-25 (May 1994 through May 1995 Data).

Prepared by: JJA
Checked by: BDH

Rolling Stone Lake through their tributarial relationship. The average 1994-1995 water hardness data for Creek 11-4 and Pickerel Creek were 122 and 81 mg/L as $CaCO_3$, respectively. The 1977 and 1978 data for Creek 12-9 indicated an average hardness of 108 mg/L as $CaCO_3$. These tributaries are a factor in determining the water chemistry of Rolling Stone Lake. Given the chemistry of these creeks, most of their water is from groundwater discharge also.

In general, the streams in the study area contain moderately hard to hard water. Based on the 1993-1995 data, the average hardness of the streams ranged from a low of approximately 61 mg/L as $CaCO_3$ for the Wolf River at sampling site SG-Y to a high of 144 mg/L as $CaCO_3$ for Hoffman Creek. This is an indication that the groundwater component of these streams varies from moderate to high. Since the water in the Wolf River is softer, it would seem that groundwater flow plays a smaller role in the Wolf River's hydrological system than in Hoffman Creek where an average hardness of 144 mg/L as $CaCO_3$ was observed, indicating that it is primarily groundwater fed.

3.7.7.2 Wetlands

In order to optimize the design of the proposed Crandon Project so that wetland impacts could be minimized, an evaluation of the existing wetland hydrology was performed. Initial efforts to model existing wetland conditions with typical hydrologic forecasting methods (such as USGS, SCS TR-55) showed that under general rainfall events, very little runoff would be generated from the drainage basin tributaries to the various wetlands. The full canopy wooded vegetation cover and generally permeable soils of study area upland drainage areas result in very little surface runoff moving downslope into the wetlands. This effort showed that single-event hydrologic modeling would not provide the information needed for the evaluation of hydrologic impacts. It also highlighted the fact that the high infiltration/percolation potential of the upland drainage areas under study have an effect on the overall wetland hydrology which needs to be evaluated accordingly.

The method ultimately used for evaluation of the wetland hydrology is a general water balance analysis. This method was chosen to address the need to model spring snowmelt/runoff which is the primary source of upland drainage area runoff to the wetlands. The analysis focuses on monthly water budgets based on monthly averages of climatological data from the nearby North Pelican at Pelican Lake meteorological station. Details regarding the methodology used to complete the analysis are contained in Appendix 3.7-12.

Using the selected methodology, the hydrologic water balance was determined for selected wetlands which could potentially be affected by construction and operations of the Crandon Project. These wetlands and their tributary drainage basins are shown in Figures 1 and 2 (Appendix 3.7-12) for existing conditions in the area of the proposed plant site and TMA, respectively. With the use of the water balance program, runoff was calculated for each basin. The results are shown in Tables 3.7-49 and 3.7-50 where 3.7-49 lists existing conditions in the area of the proposed plant site, and Table 3.7-50 lists existing conditions in the area of the proposed TMA.

The model calculated the upland area runoff first, and then calculated the wetland runoff pertaining to the upland area. These runoff values were then accumulated to give total basin runoff. For example, TMA basin F15 in Table 3.7-50 had an upland area basin annual runoff of

Table 3.7-49

Annual Existing Conditions Draining Basin Water Balance Runoff Calculations for Plant Site

Drainage Basin I.D	Upland Area (acres)	Wetland Area (acres)	Runoff in AC-FT	
			Basin	Cumulative
P2	174.47	20.90	47.70[a] 5.59[b]	53.29
O3	48.67	1.84	13.31[a] 0.49[b]	13.80
O11	7.35	0.73	2.01[a] 0.20[b]	2.21
O12	3.67	0.18	1.00[a] 0.05[b]	1.05
F116	12.75	0.66	3.49[a] 0.18[b]	3.67
6	3.20	0.44	0.87[a] 0.12[b]	0.99
8	6.34	0.29	1.73[a] 0.08[b]	1.81
9	9.01	0.22	2.46[a] 0.06[b]	2.52
10	7.33	1.54	2.00[a] 0.41[b]	2.41
F11	79.49	18.37	21.73[a] 4.92[b]	26.65
F119	16.57	0.92	4.53[a] 0.25[b]	4.78
R7A	63.53	3.93	17.37[a] 1.05[b]	18.42

[a] Upland Area Basin.
[b] Wetland Area Basin.

Prepared by: SRB
Checked by: MDL

Table 3.7-50

Annual Existing Conditions Drainage Basin Water Balance Runoff Calculations for TMA

Drainage Basin I.D	Upland Area (acres)	Wetland Area (acres)	Runoff in AC-FT	
			Basin	Cumulative
F31	60.95	6.43	16.30[a]	
			1.68[b]	17.98
F29	81.97	3.27	21.92[a]	39.9
			0.86[b]	40.76[c]
F15	119	36.21	31.83[a]	
			9.49[b]	41.32
F66	64.23	16.70	17.18[a]	
			4.38[b]	21.56
M3	48.97	5.62	13.10[a]	
			1.47[b]	14.57
M1	49.90	0.92	19.68[a]	34.25
			0.24[b]	34.49[c]

Prepared by: SRB
Checked by: MDL

[a] Upland Area Basin.
[b] Wetland Area Basin.
[c] Cumulative runoff for F29 and M1 includes outflow from F31 and M3, respectively.

31.83 ac-ft. The wetland of basin F15 had a runoff of 9.49 ac-ft. Therefore, the accumulated runoff for existing conditions of basin F15 is 41.32 ac-ft.

3.7.7.3 Flood Potential

The streams in both the Swamp Creek and Pickerel Creek drainage basins have the potential to experience flooding as a result of rainfall, snowmelt, or a combination of rainfall and snowmelt. In these relatively small basins, peak stream water flows are most commonly caused by rainfall events. The flood potential is low along these streams, however, in comparison to basins of similar size in other regions because of the relatively high permeability of the surficial soils, which allows water to infiltrate into the groundwater system (Section 3.6, Groundwater). In addition, the extensive areas of lakes and wetlands associated with the drainage basins, along with the highly vegetated woodland topography facilitate the storage of relatively large volumes of water, thereby keeping flood peaks low. No significant floods, as such, have occurred during the study period.

All the streams studied in both the Swamp Creek and Pickerel Creek drainage basins are subject to localized flooding caused by beaver dams. Historical data indicates that during the summer of

1979, the level of Ground Hemlock Lake was raised in this manner (EMC, 1985). Historically, flooding caused by beaver activity has also been observed in Hemlock Creek near water chemistry sampling Station A-1, on Swamp Creek near sampling Station E, in Hoffman Spring Pond, on Hoffman Creek, in Creek 11-4 downstream from water chemistry sampling Station M-3, and in Creek 12-9 near SG-23 (EMC, 1985). Flooding of this nature is unpredictable and somewhat independent of precipitation events.

Portions of Hemlock, Swamp, Outlet and Hoffman Creeks have all been mapped or partially mapped by the Federal Emergency Management Agency (FEMA) for flood hazards. Neither Pickerel Creek, Creek 12-9, nor Creek 11-4 have been mapped by FEMA. No other published information is known to exist on flooding for these streams. However, because there are no residences or other structures with a potential for flood damage along any of these creeks in either basin, historic flooding could have occurred and remained unrecorded.

Flooding in the lakes in the study area consists of temporary rises in lake level due to increased inflow. There is little potential for hazard to human life or structures on these lakes from flooding however, because the drainage areas are small and the lake level fluctuations are minor.

Besides localized flooding caused by excessive precipitation events, there is no potential for flooding associated with lakes and streams in the immediate vicinity of the proposed plant and TMA sites. Both sites are situated at the high end of drainage basins, above any location where any stream has formed. As such, there is no floodplain infringement at the proposed plant and TMA sites.

Various mapped or unmapped floodplains will be crossed by portions of the various corridors associated with the proposed mining activity. These floodplain interactions, such as the access road crossing of Swamp Creek, will require specific design features to assure full compliance with floodplain zoning and regulatory requirements.

3.7.8 Summary and Conclusions

The project study area primarily lies within the Swamp and Pickerel Creek drainage basins, which reside within the Wolf River drainage basin. The study area is characterized by forested lands, wetland areas, and small perennial streams, and contains two basic lake types: drainage (recharge) and seepage (discharge).

For the Wolf River drainage basin at Langlade, the highest average monthly stream discharge occurs in May and June when snowmelt runoff is highest and the lowest in the months of January, February and March when precipitation is retained on the ground surface as snow and ice.

The streams in the study area transport small quantities of sediment. This appears to be a result of the factor that land in the study area is forested, soils are granular, slopes are moderate, stream velocities are low, and the many lakes and wetlands in the area serve as sediment traps.

A correlation exists between surface water and groundwater chemistry and hydrologic flow. Soft water lakes are generally upland in nature and receive most if not all their water from surface water flows. Hard water lakes are associated with groundwater discharge areas and have water chemistry that more closely resembles that of the groundwater.

The characteristics of the surface water bodies as indicated by water chemistry measurements appear to be consistent over time as shown by comparing the data collected from the current study to that collected previously. Noted variations in sediment data is attributable to the variability of sediment deposition.

Flood potential in the study area is low in comparison to basins of similar size in other regions due to the extensive areas of lakes and wetlands associated with the drainage basins, along with the highly vegetated woodland topography, which facilitates the storage of relatively large volumes of water, thereby keeping flood peaks low. Neither the plant site nor TMA are located in areas where flooding associated with lakes and streams will occur.

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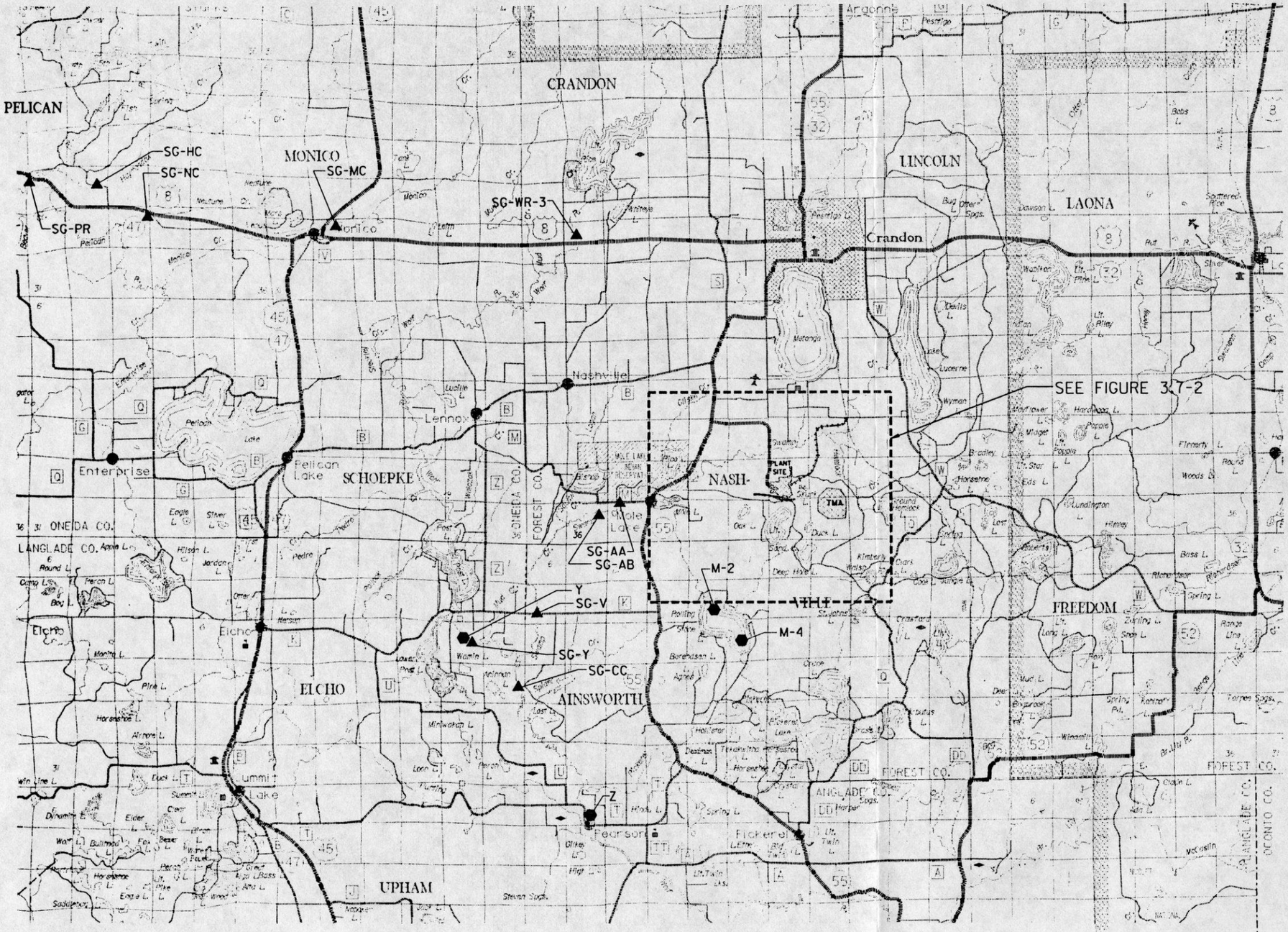
FIGURES FOR SECTION 3.7



LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- (W) COUNTY HIGHWAY LETTER
- NATIONAL & STATE FOREST BOUNDARY
- CORPORATE LIMITS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- SG-AB — SURFACE WATER MONITORING STATION
- M-2 — SURFACE WATER SEDIMENT SAMPLING STATION

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. SURFACE WATER STATIONS ARE APPROXIMATE LOCATIONS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	GJBI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.7-1

SURFACE WATER AND SEDIMENT MONITORING STATION LOCATION MAP 1

Scale: 0 7500' 15,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: KMP

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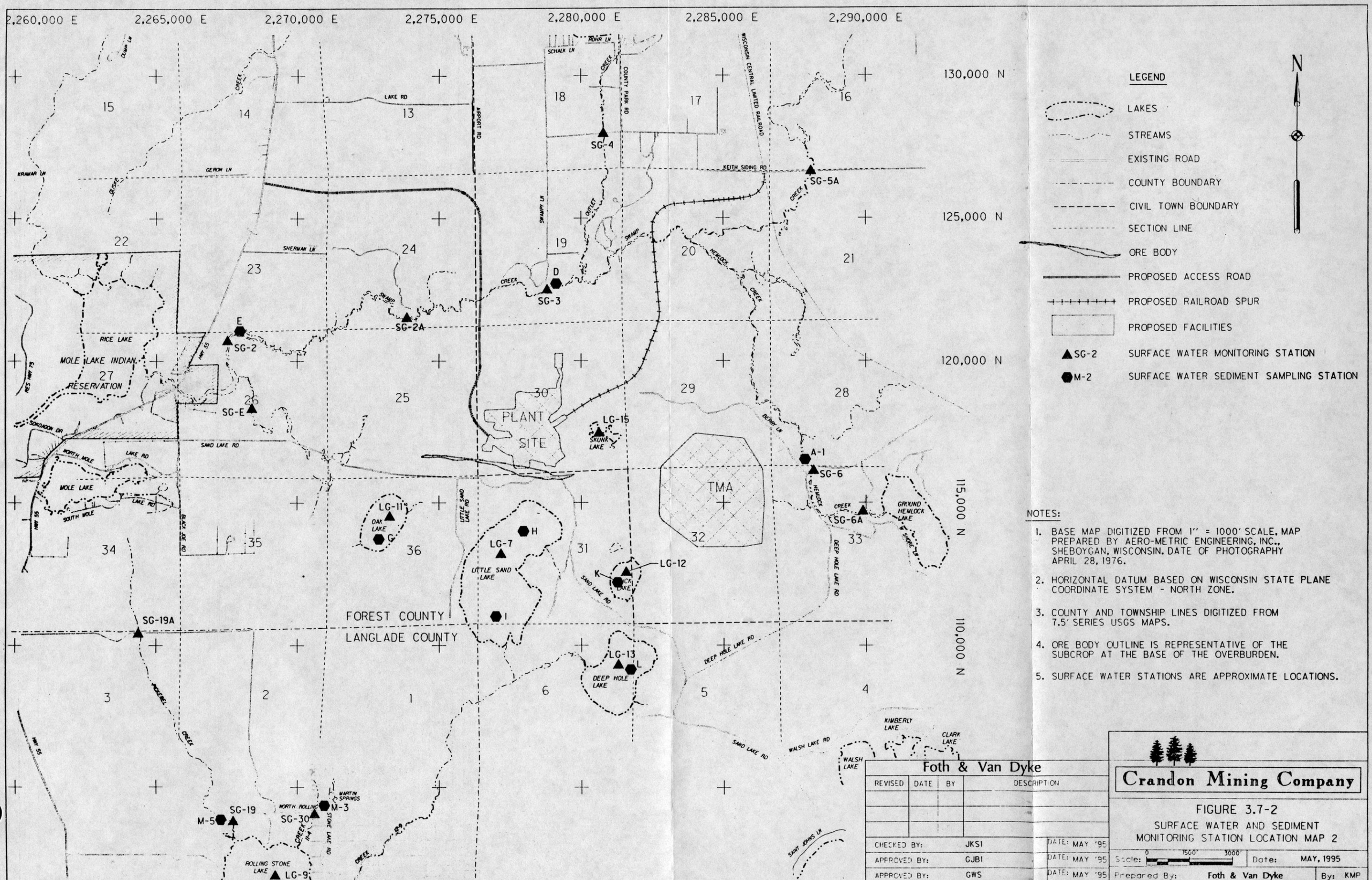

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
5. SURFACE WATER STATIONS ARE APPROXIMATE LOCATIONS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	GJB1	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.7-2

SURFACE WATER AND SEDIMENT MONITORING STATION LOCATION MAP 2

Scale: 0 1500' 3000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: KMP

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SOURCE: 1985, ENVIRONMENTAL IMPACT REPORT.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	GJBI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.7-3

MAJOR DRAINAGE BASINS IN NORTHEASTERN WISCONSIN

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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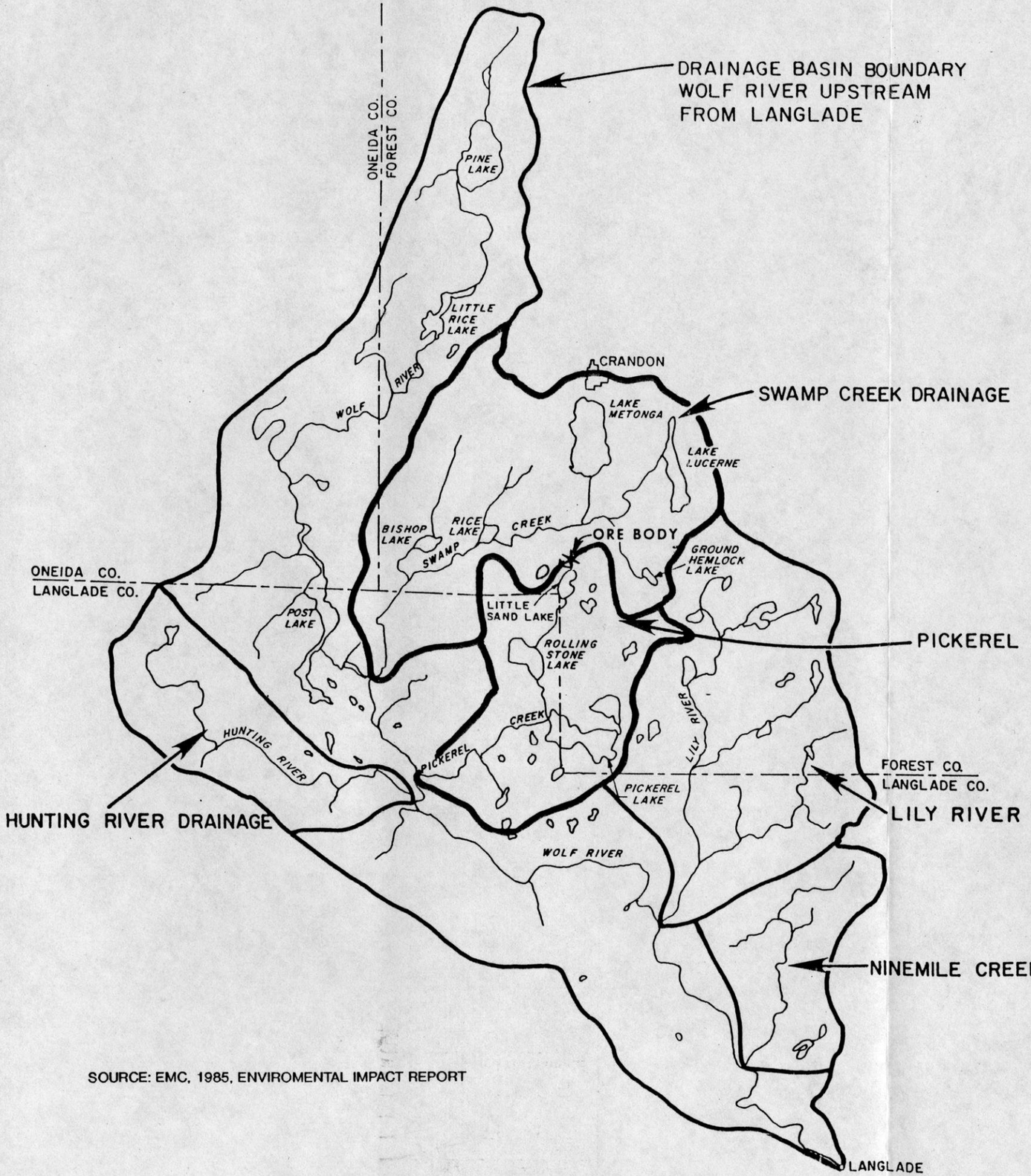
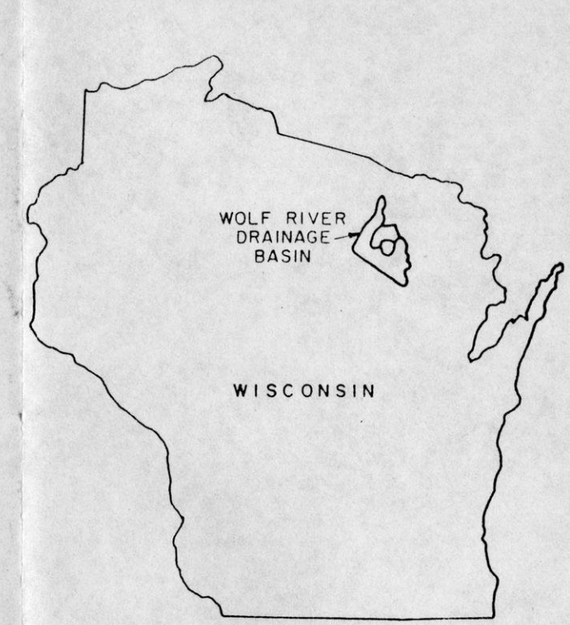


SOURCE: EMC, 1985, ENVIROMENTAL IMPACT REPORT



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	GJBI	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.7-4
DRAINAGE BASINS OF THE WOLF RIVER UPSTREAM FROM LANGLADE

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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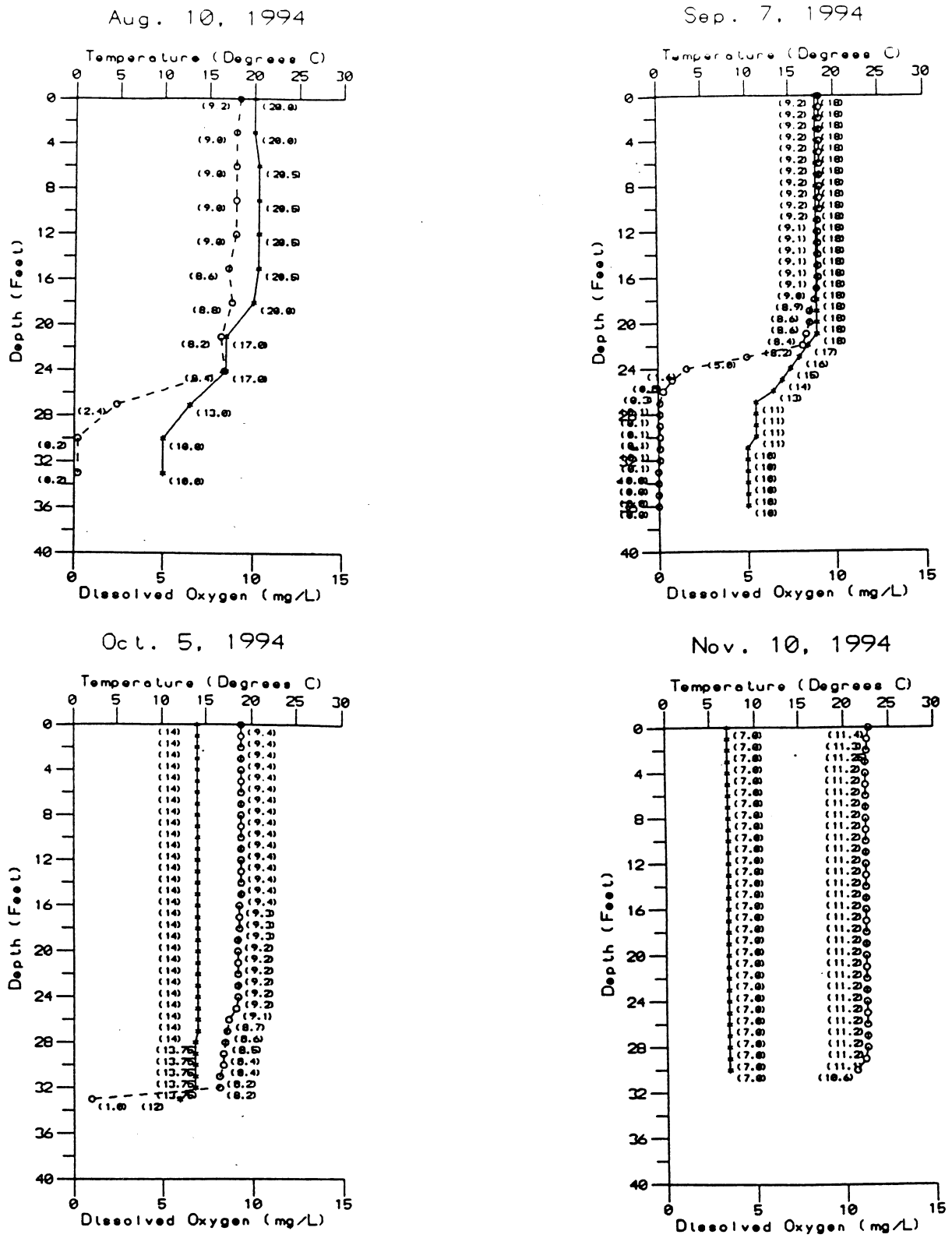

KEY:

-o- - - - -● Dissolved Oxygen

-✱———✱ Temperature

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: NOV. '95
APPROVED BY:	GJB1	DATE: NOV '95
APPROVED BY:	GWS	DATE: NOV '95

Crandon Mining Company

FIGURE 3.7-5

DISSOLVED OXYGEN/TEMPERATURE PROFILES FOR OAK LAKE LG-11 AUG. 1994-NOV. 1994

Scale:	NONE	Date:	NOVEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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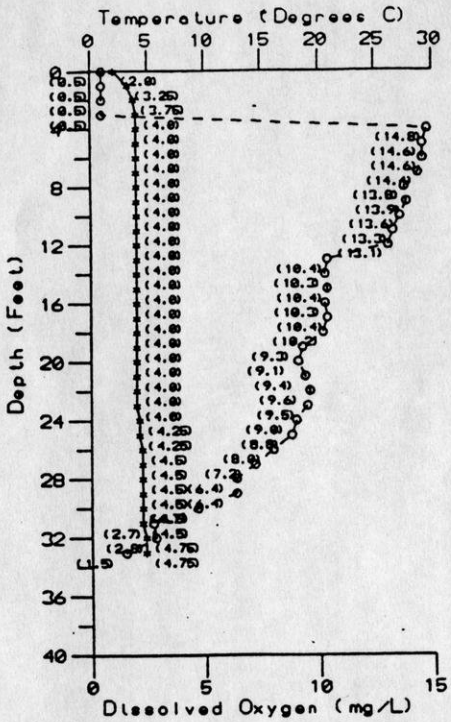

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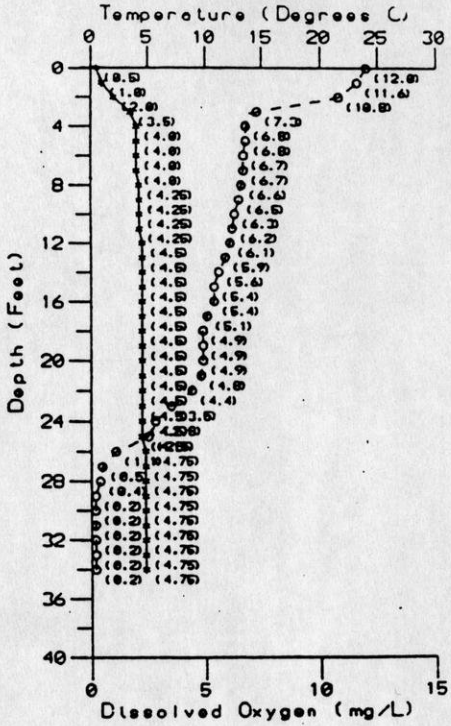
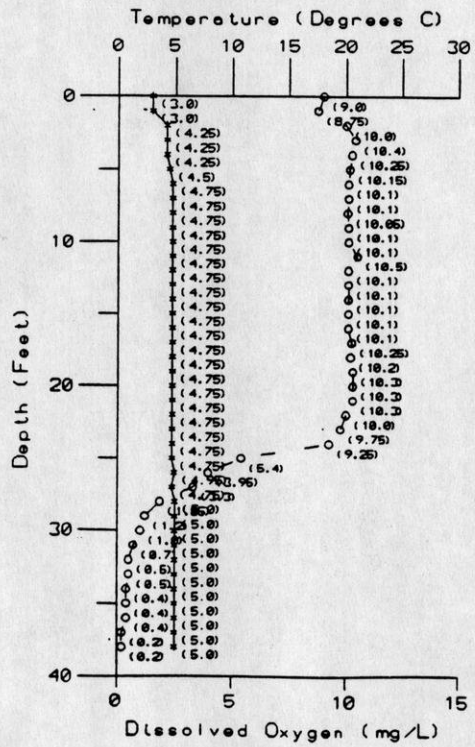


Mar. 20, 1995



KEY:

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Temperature

Foth & Van Dyke			
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CHECKED BY:	JKS1	DATE: NOV '95
APPROVED BY:	GJB1	DATE: NOV '95
APPROVED BY:	GWS	DATE: NOV '95

Crandon Mining Company

FIGURE 3.7-6

DISSOLVED OXYGEN/TEMPERATURE PROFILES FOR OAK LAKE LG-11 JAN. 1995-MARCH. 1995

Scale:	NONE	Date:	NOVEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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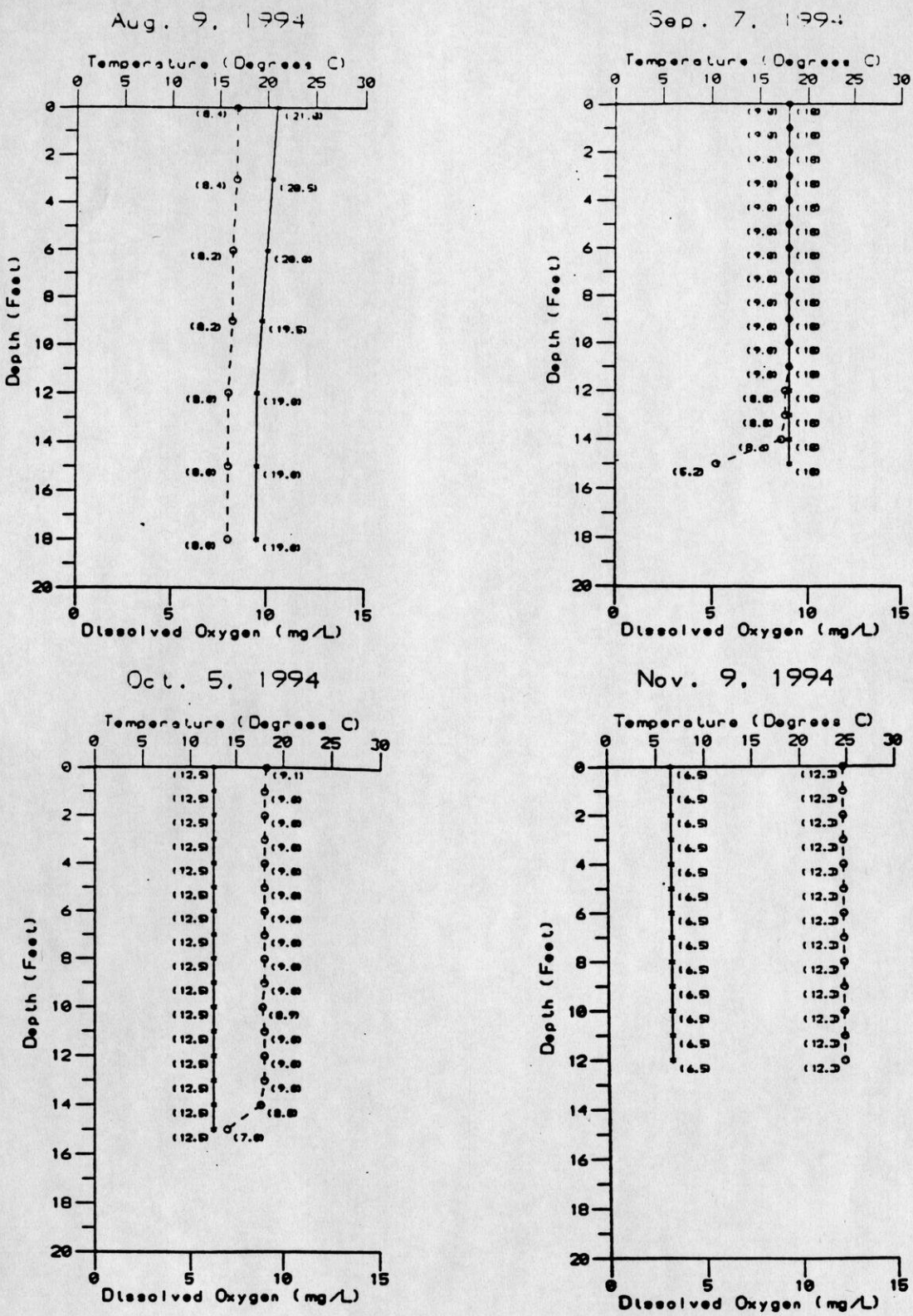

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Temperature

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APPROVED BY:	GJB1	DATE: FEB. '96	
APPROVED BY:	GWS	DATE: FEB. '96	

Crandon Mining Company

FIGURE 3.7-7

DISSOLVED OXYGEN/TEMPERATURE PROFILES FOR LITTLE SAND LAKE LG-7 AUG. 1994 - NOV. 1994

Scale: NONE	Date: FEBRUARY, 1996
Prepared By: Foth & Van Dyke	By: JOW

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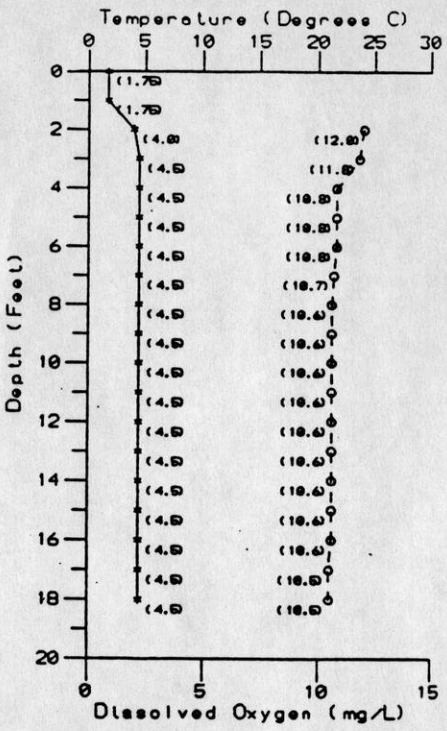
Jan. 4, 1995



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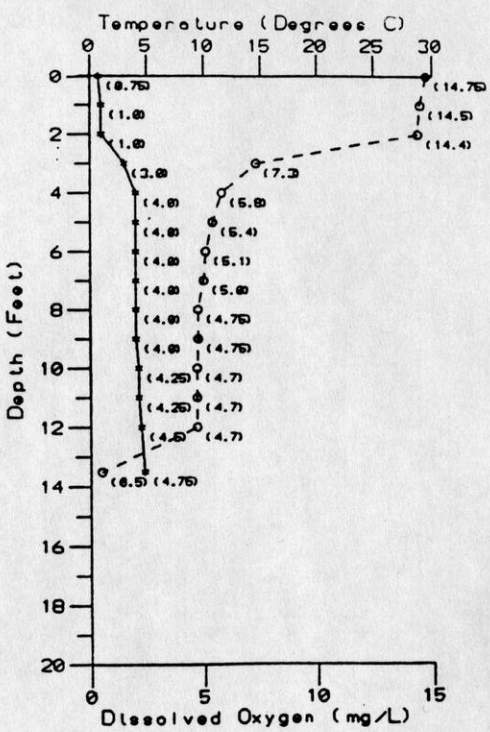

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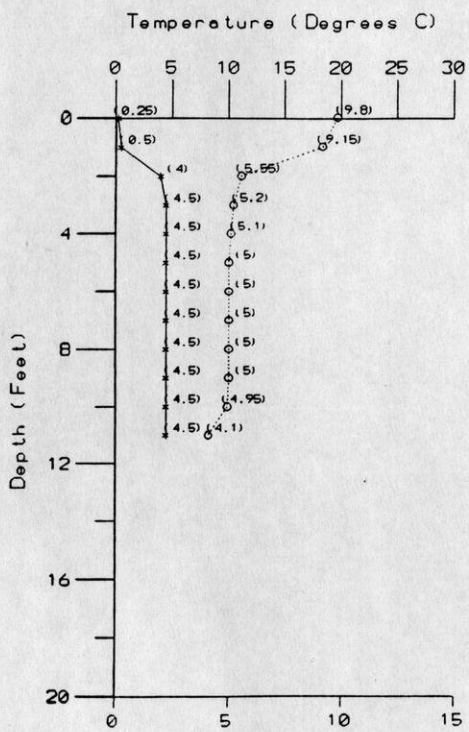

KEY:

Dissolved Oxygen

Temperature

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: FEB. '96
APPROVED BY:	GJBI	DATE: FEB. '96
APPROVED BY:	GWS	DATE: FEB. '96

Crandon Mining Company

FIGURE 3.7-8
DISSOLVED OXYGEN/TEMPERATURE PROFILES
FOR LITTLE SAND LAKE LG-7
JAN. 1995 - MAR. 1995

Scale:	NONE	Date:	FEBRUARY, 1996
Prepared By:	Foth & Van Dyke	By:	JOW

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Crandon Mining Company

Environmental Impact Report

Section 3.8

Aquatic Biology

Crandon Mining Company
Environmental Impact Report

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3.8 Aquatic Biology

The purpose of this study was to survey surface waters around the project area for the presence of aquatic threatened, endangered and special concern species included on the Wisconsin Heritage Inventory List.

Biological studies relative to the Crandon Project were first completed in the late 1970s and early 1980s. These early studies provide a basic biological database for the study area. Recent studies have added to the database by providing additional information, with an emphasis on threatened, endangered, and special-concern species.

This section of the EIR provides the basic methodology for the collection of aquatic biological specimens, including quality control for handling of samples; the results of the findings of both the 1970s and 1980s studies and the recent 1993 and 1994 studies; and finally, a discussion of the significance of the findings.

3.8.1 Field Methodology

Aquatic biology studies on water bodies within the study area were undertaken from the mid 1970s to mid 1980s, and November 1993 through September 1994. The study area for the aquatic biology program includes those locations of sampling stations selected for monitoring as shown on Figure 3.8-1 (1970s and 1980s) and Figure 3.8-2 (1993 and 1994). Locations identified in Figure 3.8-2 were established based on review of project objectives and site reconnaissance with WDNR (October 1993). The objective of the investigations was to provide aquatic biological population studies (1970s and 1980s data) and actual field data on federal or state listed threatened, endangered, or special concern species, i.e., species "listed" by the Wisconsin Heritage Inventory. Work conducted in 1993 and 1994 differs from previous field studies conducted in 1977 and 1978 by Ecological Analysts (Dames & Moore, 1982) because the emphasis was on listed species. The Dames & Moore work generally identified organisms to order or family while the 1993 and 1994 studies of listed species provided identifications to species. In addition, since target species were identified prior to initiation of 1993-94 field studies, sampling locations and time windows were selected to coincide with the life cycle and habitats of the target species.

Studies included an investigation of the Swamp Creek and Upper Pickerel Creek drainage basins and the Wolf River upstream and downstream of the confluence with Swamp Creek. A list of all monitoring locations used in 1977-78 is provided in Table 3.8-1.

3.8.1.1 1993/1994 Sampling Location Selection

The purpose of the studies conducted in 1993-94 was to supplement previous studies conducted in the late 1970s and early 1980s by providing information relative to the abundance and distribution of aquatic threatened, endangered or special concern species in lakes and streams within the study area. As described in Section 3.8.1, the study area is entirely within the Wolf River drainage basin and is characterized by forested lands, lakes, wetland areas, and perennial and intermittent streams that provide drainage routes. The proposed mine facilities lie on a watershed divide (a line defining locations where water flows perpendicularly away from the line) that separates the Swamp Creek basin and the Pickerel Creek basin, both of which are part of the larger Wolf Rover drainage basin (Figure 3.8-1).

Table 3.8-1

Sampling Stations for Aquatic Biology Studies in the Study Area 1977-1978

Water Body	Stations
Swamp Creek Drainage Basin	
Rice Lake	F, N
Hemlock Creek	A-1, A-2
Hoffman Creek	E-1
Swamp Creek	B, D, E
Oak Lake	G
Pond 25-11*	25-11
Hoffman Springs	E-2
Hoffman Pond	E-3
Pickerel Creek Drainage Basin	
Rolling Stone Lake	M-2, M-4
Pickerel Creek	M-5
Creek 12-9*	M-1
Creek 11-4*	M-3
Little Sand Lake	H, I
Duck Lake	K
Deep Hole Lake	L
Skunk Lake	J
Pond 31-13*	31-13
Pond 6-8*	6-8
Pond 35-7*	35-7
Pond 34-1*	34-1
Wolf River	Y, Z

* WDNR Identification Code for unnamed streams and lakes.

Source: Dames & Moore, 1982
Checked by: WMW

Lakes in the study area that were investigated can be characterized as seepage or discharge.

Seepage lakes included in this study are situated above the groundwater system, that is, the lake surface elevation is above the elevation of the groundwater system with water levels apparently maintained by a low-permeability soil layer. Groundwater is recharged by seepage from these lakes through the lake bed. In contrast, groundwater flows into the discharge lakes included in this study.

Seepage lakes in the study area are characteristically low in pH and have soft water that is low in alkalinity. Seepage lakes include Oak, Duck, Skunk, Little Sand, and Deep Hole Lakes. Discharge lakes within the study area have water slightly basic in pH and are moderately hard with moderate alkalinity. Examples of discharge lakes are Rolling Stone and Ground Hemlock. Streams in the study area have similar characteristics to discharge lakes. They are generally small, often not well defined, and have a base flow derived largely from the groundwater system. Typically, pH of the water is neutral and hardness and alkalinity values are similar to those in discharge lakes.

Streams and lakes receive nutrients from their watersheds through the active transport of vegetation and soil minerals via surface runoff. The water quality and sediment quality of water bodies is directly influenced by the volume and quality of inputs from terrestrial portions of their watersheds.

The selection of sampling locations for 1993 and 1994 work was based on two criteria. The first criterion deals with the spatial relationship of organisms or populations of organisms with respect to proposed mining activities. In this respect, sampling locations proximal to the mining activities were chosen to evaluate species in the near vicinity of the project area and TMA. In addition, distal sampling locations were chosen to evaluate species distribution peripheral to the mining activity including downstream Swamp Creek and Wolf River environs.

The second criterion for selection of sampling locations deals with the need to include as many types of habitats as possible. The study area includes many lentic and lotic environments. A total of six lakes were studied as well as a cold water spring (Hoffman Springs) and Popple Pond. Small streams (Hemlock Creek, Swamp Creek above Rice Lake, Martin Springs, Creek 12-9, Pickerel Creek, Hoffman Creek) and larger streams (Swamp Creek below Rice Lake, Wolf River) provided a diverse habitat from which to select representative sampling locations. Within these habitats, substrates which were sampled included sand, cobble, gravel, rock, and muck. Submerged and emergent vegetation were sampled including overhanging vegetation and submerged detritus. Sampling from areas with distinctive vegetative types included alder swamp, bog, marsh, sedge meadow, and hardwood.

A description of each sampling site follows. A characterization of habitats and habitat descriptions were provided in the 1977-78 data collection effort. These characterizations are discussed in Section 3.8.1.6 below. For a review of sampling locations, refer to Figures 3.8-1 and 3.8-2. Sample locations for data collected in 1993 and 1994 use an identification code of a CMC-AB- prefix followed by a five digit site identifier. In most cases site locations duplicated those of samples collected in the 1970s and 1980s. Therefore in the following site description the 1993/94 identifier will be followed with the 1977/78 identifier in parenthesis, e.g. CMC-AB-HL-200 (A-1). The former is found on Figure 3.8-2, while the latter can be cross-referenced on Figure 3.8-1.

CMC-AB-HL-100 Hemlock Creek at West Lake Road crossing. Upstream of the road consists of a pool with muck bottom surrounded by hardwoods. Downstream of the road the creek meanders through an open meadow bordered by alder, birch, and spruce. The substrate is mostly muck though some washed sand was observed. Intermittent flooding because of beaver activity prevents thorough washing of substrates even during periods of high water. Fish surveys were conducted at this site.

CMC-AB-HL-200 Hemlock Creek at Berry Lane crossing, also known as Deep Hole Road Crossing (A-1). The bottom consists of hard sand covered with six to 12 inches of organic detritus. Banks are lined with sedge meadow interspersed with alder, birch, black ash, and spruce/balsam. Beaver activity is a major factor in the amount of debris located in pools. Fish and mussel surveys and light trapping activities were conducted at this location. Adult Odonata were also collected here as well as other biological studies in 1977/78.

CMC-AB-SC-200 Swamp Creek at Keith Siding Road. This site is a fully canopied hardwood reach with muck bottom. Organic debris exists including leaf litter and fallen timber. Fish surveys and light trapping activities were conducted at this location.

CMC-AB-SC-250 Swamp Creek at confluence with Hemlock Creek. This site is an open sedge meadow with erodible banks. Muck bottom along banks gives way to sand bottom in middle covered with detritus. Submerged vegetation (*Elodea*) is common growing on sand bars throughout area. Numerous small mollusks (fingernail clams) were observed in areas of washed gravel below beaver dams. Macroinvertebrate collections, mussel midden collections, and Odonata exuviae collections were conducted at this location.

CMC-AB-SC-300 Swamp Creek south of Swampy Lane access (D). This is a true riffle area with many large rocks throughout the area. This heavily timbered, closed canopy segment contained many large trees downed across the stream. Macroinvertebrate, fish, adult Odonata, Odonata exuviae, and mussel collections were completed in this stream segment. Light trapping was also conducted along the stream at this location as well as biological studies conducted in 1977/78.

CMC-AB-SC-301 Swamp Creek about 1/4 mile downstream of Swampy Lane Access. This true riffle area contained fewer boulders than SC-300, with more cobble and gravel. There is a slightly more open canopy here than at site SC-300. Macroinvertebrate, fish, adult Odonata, Odonata exuviae, and mussel collections were completed in this stream segment.

CMC-AB-SC-400 Swamp Creek at Highway 55 crossing. Substrate at this site consists of muck bottom. Some beds of wild rice occur immediately upstream along with pockets of water lily. Open canopy dominates with scattered hardwoods. Swamp Creek upstream from this site is almost pondlike. Fish collections were conducted at this location.

CMC-AB-SC-500 Swamp Creek downstream of County M. This segment is a meandering stream averaging about three feet in depth. Several sand bars exist with dense beds of *Elodea*. Up to one foot of muck is deposited between sand bars. Birch and alder are common along erodible sandy banks. Adult Odonata, mussel, and fish collections were conducted at this location. Light trapping was also conducted at this location.

CMC-AB-SC-501 Swamp Creek from Schallock's Bridge downstream to SC-500. Bottom substrate and vegetation are similar to SC-500. Banks of the meandering stream are typically sedge meadow with alder/birch mix. One area of rock/cobble occurs in a deeper hole (four to five feet) about 1/2 mile upstream of SC-500. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location.

CMC-AB-SC-502 Swamp Creek from SC-500 downstream about 1/2 mile. For macroinvertebrate and mussel collections, this reach included about 1/2 mile. For fish collections, this area was expanded to include the distance down to the forest road crossing, about an additional 3/4 mile. Substrate and habitat in this segment are similar to SC-501. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location.

CMC-AB-SC-700 Swamp Creek at Highway K crossing. Samples were taken downstream of this crossing. Bottom center consists of sand, fairly firm, while sides of the stream were of muck bottom. Culverts create distinct back current up to 20 yards downstream depositing detritus along side wings of stream. Overhead canopy is hardwood. Mussel collections were conducted at this location.

CMC-AB-WR-200 Wolf River at Lower Post Lake outfall (Y). Substrate at the outfall is made up of riprap. The pool downstream of the outfall is of sand bottom. Some muck occurs along shore near the outfall. The river at this point is wide (open) with hardwood shore. Fish and mussel collections were conducted at this location as well as biological studies conducted in 1977/78.

CMC-AB-WR-301 Wolf River immediately upstream of confluence with Swamp Creek. The stream is fairly flat, with pools in excess of four feet in depth. Most of the substrate is sand. One area of cobble/rock is located along the west bank about four feet in depth. Large sand bars are common. River segment up to 1/4 mile upstream of the confluence with Swamp Creek is wide, 30 to 60 feet, with hardwood canopy. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location.

CMC-AB-SGI-CC Wolf River at Lost Lake Road access. Substrate at this access point is covered with some boulder and many smaller rocks. River stage through this point is greater than three feet except where sand bars occur upstream and downstream of this point. The access point is generally of hardwood canopy while upstream and downstream bank vegetation is characteristically sedge meadow. Substrate is devoid of muck bottom except in areas of backwater. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location. Light trapping was also conducted at this location.

CMC-AB-PK-200 Pickerel Creek at North Rolling Stone Lake Road access (M-5). Substrate is generally muck bottom. Stream is narrow with alder/birch canopy. Fish collections were collected at this location as well as biological studies conducted in 1977/78.

CMC-AB-MS-100 Martin Springs at North Rolling Stone Lake Road access (M-3). Stream near the access road is similar to PK-200. Stream upstream of access road about 30 yards meanders through a sedge meadow including a drawn down beaver pond before

entering the wooded canopy. The center of the stream in the meadow is of firm sand while edges are of muck. Macroinvertebrate, adult Odonata, and Odonata exuviae collections were conducted at this location. Light trapping was also conducted at this location as well as biological studies conducted in 1977/78. This stream is WDNR Creek 11-4.

CMC-AB-SC-12-9 Creek 12-9 at entrance to Rolling Stone Lake (M-1). Substrate is mostly of muck bottom. Creek meanders through dense alder just prior to entering Rolling Stone Lake. Much detritus carried by 12-9 (mostly conifer needles) are deposited at the mouth. Macroinvertebrate collections were conducted at this location in 1993 and 1994 as well as biological studies conducted in 1977/78.

CMC-AB-PK-300 Pickerel Creek at outfall from Rolling Stone Lake. The outfall is made up of a rock spillway. Rock continues several yards downstream of outfall. Fish, crayfish, and mussel collections were conducted at this location.

CMC-AB-HS-005 Hoffman Springs (E-3). This is a shallow pond which is spring fed. Substrate is of muck bottom containing one or more feet of organic detritus, much of the litter is conifer needles. Macroinvertebrate, adult Odonata, and Odonata exuviae collections were conducted at this location in 1993 and 1994. Light trapping was also conducted at this location in 1994 as well as minnow trapping in 1978.

CMC-AB-HC-100 Hoffman Creek beginning at farm lane between Hoffman Creek and Hoffman Springs and continuing about 1/4 mile downstream (E-1 and E-2). This is a shallow stream with a washed sand bottom in the center and detritus along banks. Undercut banks are prevalent. Beds of watercress are common from the farm lane downstream. This segment of stream is a noted brook trout spawning area. Macroinvertebrate, adult Odonata, and Odonata exuviae collections were completed at this location in 1993 and 1994 as well as minnow trapping and trout redd surveys in 1977 and 1978.

CMC-AB-SK-005 Skunk Lake (J). A soft bottom lake located immediately east of the project area. The lake is overgrown with submerged and emergent vegetation, apparently in an advanced stage of succession. The lake is bordered on the south, west, and east by hardwoods, with marsh in various portions of north edges. Macroinvertebrate, adult Odonata, and Odonata exuviae collections were conducted at this location in 1993 and 1994. Light trapping was also conducted at this location in 1994. General biological collections were conducted in 1977 and 1978.

CMC-AB-DL-005 Duck Lake. The west and north end of this lake are characteristic of bog habitat, while the south and east sides of the lake are bordered in hardwood. Scant emergent vegetation exists, while stained water reduces the ability to observe submerged vegetation. The bottom is soft and muck occurs along bog edges, while firm bottom with some rock occurs along the south and east shorelines. The lake drains to Little Sand Lake. The lake is located southeast of the mining site in fairly close proximity to the proposed tailings management area. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location.

CMC-AB-OL-005 Oak Lake (G). Substrate is of sand throughout entire periphery. Scant emergent and submergent vegetation exists. The lake is bordered by hardwoods throughout entirety except for a sedge meadow along east shore south of boat landing. When discharge occurs, the lake drains north to Swamp Creek watershed. The lake is located southwest of the project area. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location in 1993 and 1994. General biological collections were conducted in 1977 and 1978.

CMC-AB-SL-005 Little Sand Lake (H and I). Substrate is sand along north and east end, some cobble on east end, with softer bottom toward south end. Some larger boulder and rock are located near the outfall at the south end of the lake. Emergent and submerged vegetation are not abundant. Lake drains south to Pickerel chain. The lake is located immediately south of the project area. Macroinvertebrate, fish, mussel, adult Odonata, and Odonata exuviae collections were conducted at this location in 1993 and 1994. Light trapping was also conducted at this location in 1994. General biological collections were conducted in 1977 and 1978.

CMC-AB-DH-005 Deep Hole Lake (L). Substrate is sand around most of lake. Scattered boulder/rock occur along the south shore. Emergent and submerged vegetation are scattered throughout the lake. Deep Hole drains northwest to Little Sand Lake. Hardwoods border most of the lake except the outfall where succession creates more of a marshy habitat. Macroinvertebrate, fish, mussel, and Odonata exuviae collections were conducted at this location in 1993 and 1994. General biological collections were conducted in 1977 and 1978.

CMC-AB-RS-005 Rolling Stone Lake (M-2 and M-4). This lake receives drainage from Little Sand Lake and Pickerel Creek (Mole Lake). This is a true discharge lake with abundant emergent and submergent vegetation. Substrate is sandy, firm throughout most of the lake, an exception being the north end where three inlets create areas of soft muck bottom. Some rock shoreline is prevalent. Macroinvertebrate, fish, mussel, and Odonata exuviae collections were conducted at this location in 1993 and 1994. General biological collections were conducted in 1977 and 1978.

CMC-AB-PP-005 Popple Pond (25-11). This pond is located east of Hoffman Springs and west of the mining site. The pond drains to the Swamp Creek drainage basin. The pond is bordered on the east and south by hardwoods while north and west edges are marshy and open. Substrate is of muck. Emergent and submerged vegetation is prolific. Macroinvertebrate, adult Odonata, and Odonata exuviae collections were conducted at this location in 1994. Aquatic macrophyte collections and minnow trapping were conducted in 1977.

CMC-AB-OC-200 Outlet Creek at Keith Siding Road crossing. Substrate is of sand with scant debris. Undercut banks are present. The stream is fully canopied with hardwood. This stream is the outlet from Lake Metonga and joins Swamp Creek to the south at about the area where the riffle on Swamp Creek begins. A beaver dam is present on Swamp Creek at about the same point where Outlet Creek enters. Creek stage levels may be controlled by a low head spillway at the outlet of Lake Metonga. Light trapping was conducted at this location.

CMC-AB-RR-100 Railroad North from Hemlock Road about 1/2 mile. This segment of terrestrial habitat is interspersed with ponds, marshes and bog-type habitat. This segment was investigated for presence of adult dragonflies.

3.8.1.2 Methods for Phytoplankton

At each phytoplankton sampling station, duplicate samples were collected with water pumps (Schwoerbel, 1972). Two calibrated centrifugal pumps were deployed in tandem and equipped with a pair of intake hoses of 19-mm (0.75-inch) inside diameter. Water was pumped from 1-m (3.3-foot) intervals in the water column. Two pumps in tandem were utilized in the collection to increase volume in order to minimize sampling time. In Rice and Skunk lakes, which are shallow (depth <2.0m [6.6 feet]), the entire volume was withdrawn from mid-depth. For each replicate, an integrated sample of 50 liters (13.2 gallons) of water was collected in a large container. After thorough mixing of the sample, a minimum subsample of one liter (0.26 gallon) was obtained. Each phytoplankton sample was preserved in the field with three percent buffered formalin, shipped to the laboratory, and stored. Although Weber (1973) recommends preservation of phytoplankton with 5 percent buffered formalin, experience has demonstrated that a three percent solution is more desirable in that it reduces cellular distortion and provides adequate preservation.

Each sample was analyzed in the laboratory using a Sedgewick-Rafter counting cell for the identification and enumeration of species present (Weber, 1973; American Public Health Association [APHA] et. al., 1976). All planktonic algae were identified to the lowest possible taxon, generally species. Individuals enumerated were expressed as units/mL where a "unit" is equivalent to a filament, colony, partial colony, mass, or one complete diatom cell (two valves). A minimum of 400 individuals was counted to facilitate an accurate estimate of the density (number/liter) and relative abundance of algal taxa. Less than 400 individuals were enumerated if, on the basis of four strips traversed, the densities were very sparse or were at a level that would excessively exceed the 400 minimum if a fifth strip was enumerated. The majority of the samples were analyzed within three months of the date of collection. Algae were identified using taxonomic keys presented in Collins (1909), Smith (1920, 1924, 1950), Lackey (1938), Patrick (1959), Thompson (1959), Prescott (1962, 1970), Patrick and Reimer (1966), Weber (1966), Whitford and Schumacher (1969), and Taft and Taft (1971). Identifications and enumerations were verified by reanalysis of approximately 10 percent of the samples by either Dr. Theodore S. Roeder, Associate Professor, University of Wisconsin at Stevens Point or Mr. Mason G. Fenwick, Assistant Professor, Northern Illinois University at DeKalb, Illinois. Consultation for identification was also provided by Dr. Gary B. Collins and Mr. Benjamin H. MacFarland, Aquatic Biologists, U.S. EPA, Cincinnati, Ohio.

Diversity was calculated using the formula presented in Shannon and Weaver (1949) and numbers of organisms identified to the lowest possible taxa (based on $\log_{10}$). Samples for chlorophyll a analysis were obtained from lake stations where phytoplankton was collected (Table 3.8-2 and Table 3.8-3), except in March 1977. Samples were filtered on site, and the filters were placed in vials containing aqueous acetone solution (Weber, 1973). Approximately 500 mL (0.13 gallons) of sample was filtered utilizing 0.45 micron membrane filters. The sample vials were wrapped in aluminum foil, packed in ice, and shipped in insulated containers via air freight on the day of collection to Aqualab, Inc. for analysis. The analysis was conducted in accordance with Section 602c, "Determination of Chlorophyll a in the Presence of Pheophytin a" in Standard Methods for the Examination of Water and Wastewater (APHA et. al., 1971). The chlorophyll a data reported present pheophytin a corrected data.

Table 3.8-2

Schedule of Seasonal Biological Sampling in the Swamp Creek Drainage Basin During 1977 and 1978

		1977								1978				
Water Body	Sample/Station(s)	Mar	May	June	July	August	September	October	November	March	April	May	August	October
Rice Lake	Phytoplankton/ Zooplankton													
	F	X	X	X	X	X	X	X	--	--	--	--	--	--
	N	X	X	X	X	X	X	X	--	X	X	X	X	--
	Chlorophyll a													
	F	--	X	X	X	X	X	X	--	X	--	--	--	--
	N	--	X	X	X	X	X	X	--	X	--	X	X	--
	Periphyton													
	F	--	X	X	X	X[a]	X	X	--	--	--	--	--	--
	N	--	X	--	X	X[a]	X	X	--	--	--	X	X	--
	Aquatic Macrophytes -													
	Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--
	Benthos													
	F	X	X	--	--	X[a]	--	X	--	X[b]	--	--	--	--
	N	X	X	--	--	X[a]	--	X	--	X[b]	--	X	X	--
	Fish - Lake Survey													
	Electroshocking	--	X	--	--	X[a]	--	X	--	--	--	X	X[a]	--
	Gill Net	--	--	--	--	--	--	--	--	--	--	X	--	--
	Fyke Net	--	X	--	--	X[a]	--	X	--	--	--	X	X	--
	Minnow Trap	--	--	--	--	--	--	--	--	--	--	X	X	--
	Tissue Chemistry -													
	Lake Survey													
	Aquatic Macrophytes	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	Benthos	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	Fish	--	--	--	--	X[a]	--	--	--	--	--	--	X[a]	--

Table 3.8-2 *(Continued)*

Water Body	Sample/Station(s)	1977 Mar	May	June	July	August	September	October	November	1978 March	April	May	August	October
Hemlock Creek	Periphyton													
	A-1	--	--	--	--	--	--	X	--	--	--	X	X	--
	Benthos													
	A-1	--	--	X	--	X[a]	--	X	--	X	--	X	X	--
	Fish													
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	X	X	--	--	--	--	--
	Electroshocking													
	A-1	--	X	--	--	X[a]	--	X	--	--	--	X	X	--
	A-2	--	X	--	--	X[a]	--	X	--	--	--	--	--	--
	Tissue Chemistry													
	Fish													
	A-1	--	--	--	--	--	--	--	--	--	--	--	X	--
	A-2	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
Hoffman Creek	Fish													
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	--	X	--	--	--	--	--
	Electroshocking													
	E-1	--	--	X	--	X[a]	--	X	--	--	--	--	--	--
Swamp Creek	Periphyton													
	D	X	X	X	X	X[a]	X	X	--	--	--	X	X[a]	--
	E	X	X	X	--	X[a]	X	X	--	--	--	X	X[a]	--
	Benthos													
	D	X	X	--	--	X[a]	--	X	--	X	--	X	X[a]	--
	E	X	X	--	--	X[a]	--	X	--	X[b]	--	X	X[a]	--

Table 3.8-2 *(Continued)*

Water Body	Sample/Station(s)	1977 Mar	May	June	July	August	September	October	November	1978 March	April	May	August	October
	Fish													
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	X	X	--	--	--	--	--
	Electroshocking													
	B	--	X	--	--	X[a]	--	X	--	--	--	--	--	--
	D	--	X	--	--	X[a]	--	X	--	--	--	X	X[a]	--
	Tissue Chemistry													
	Aquatic Macrophytes													
	E	--	--	--	--	X[A]	--	--	--	--	--	--	--	--
	Benthos													
	D	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	E	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	Fish													
	B	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	D	--	--	--	--	X[a]	--	--	--	--	--	--	X[a]	--
Outlet Creek and Tributaries of Hemlock Creek	Fish													
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	--	X	--	--	--	--	--
Oak Lake	Phytoplankton/Zooplankton													
	B	X	X	X	X	X	X	X	--	X	--	X	X	--
	Chlorophyll a													
	G	--	X	X	X	X	X	X	--	X	--	X	X	--
	Periphyton													
	G (near shore)	-	X	X	X	X[a]	X	X	--	--	--	X	--	--
	Aquatic Macrophytes - Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--

Table 3.8-2 *(Continued)*

Water Body	Sample/Station(s)	1977 Mar	May	June	July	August	September	October	November	1978 March	April	May	August	October
	Benthos													
	G	X[b]	X	--	--	X[a]	--	X	--	X	--	X	X[a]	--
	Fish - Lake Survey													
	Metered Larval Net	--	X	X	X	--	--	--	--	--	--	--	--	--
	Electroshocking	--	--	--	--	X	--	--	--	--	--	X	X[a]	--
	Bill Net	--	X	--	--	X[a]	--	X	--	--	--	X	X[a]	--
	Seining	--	X	--	--	X[a]	--	--	--	--	--	X	X	--
	Tissue Chemistry -													
	Lake Survey													
	Aquatic Macrophytes	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	Benthos	--	--	--	--	X[a]	--	--	--	--	--	--	--	--
	Fish	--	--	--	--	X[a]	--	--	--	X	--	--	X[a]	--
Pond 25-11[c]	Aquatic Macrophytes -													
	Pond Survey													
	Fish	--	--	--	--	X	--	--	--	--	--	--	--	--
	Minnow Trap													
	25-11	--	--	--	--	--	--	X	--	--	--	--	--	--
Hoffman Springs	Aquatic Macrophytes -													
	Spring Survey	--	--	--	--	X	--	--	--	--	--	--	--	--
	Fish													
	Minnow Trap													
	E-2	--	--	--	--	--	--	--	--	--	--	--	--	X
Hoffman Pond	Fish													
	Minnow Trap													
	E-3	--	--	--	--	--	--	--	--	--	--	--	--	X

Notes: Additional sampling was conducted on Swamp Creek downstream form Rice Lake. For this information, see report by Ecological Analysts, Inc. (1983, 1984a,b).
-- indicates no sample collected.
[a]Sample collected in late July.
[b]Sample collected in late February.
[c]WDNR identification code.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-3

Schedule of Seasonal Biological Sampling in the Pickerel Creek Drainage Basin During 1977 and 1978

Water Body	Sample/Station(s)	1977 March	May	June	July	August	September	October	1978 March	May	June	July	August	September	October
Pickerel Creek	Periphyton														
	M-5	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	Benthos														
	M-5	--	--	--	--	--	--	X	X[b]	X	--	--	X[a]	--	--
	Fish														
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	--	--	--	--	--	--	--	X
	Electroshocking														
	M-5	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	Tissue Chemistry Fish														
	M-5	--	--	--	--	--	--	--	--	--	--	--	X[a]	--	--
Creek 12-9	Periphyton														
	M-1	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	Benthos														
	M-1	--	--	--	--	--	--	X	X[b]	X	--	--	X[a]	--	--
	Fish														
	Trout Redd Reconnaissance - Creek Survey	--	--	--	--	--	--	--	--	--	--	--	--	--	X
	Electroshocking														
	M-1	--	--	--	--	--	--	X	--	X	--	--	X	--	--
	Minnow Trap														
	M-1	--	--	--	--	--	--	--	--	X	--	--	--	--	--
	Tissue Chemistry														
	Fish														
	M-1	--	--	--	--	--	--	--	--	--	--	--	X	--	--
Creek 11-4	Periphyton														
	M-3	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--

Table 3.8-3 *(Continued)*

Water Body	Sample/Station(s)	1977 March	May	June	July	August	September	October	1978 March	May	June	July	August	September	October
	Benthos														
	M-3	--	--	--	--	--	--	X	X[b]	X	--	--	X[a]	--	--
	Fish														
	Electroshocking														
	M-3	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	Minnow Trap														
	M-3	--	--	--	--	--	--	--	--	X	--	--	--	--	--
	Tissue Chemistry														
	Fish														
	M-3	--	--	--	--	--	--	--	--	--	--	--	X[a]	--	--
Rolling Stone Lake	Phytoplankton/Zooplankton														
	M-2	--	--	--	--	--	--	X	X	X	--	--	X	--	--
	M-4	--	--	--	--	--	--	X	X	X	--	--	X	--	--
	Chlorophyll a														
	M-2	--	--	--	--	--	--	X	X	X	--	--	X	--	--
	M-4	--	--	--	--	--	--	X	X	X	--	--	X	--	--
	Periphyton														
	M-2	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	M-4	--	--	--	--	--	--	X	--	X	--	--	X[a]	--	--
	Aquatic Macrophytes - Lake Survey	--	--	--	--	--	--	--	--	--	--	--	X[a]	--	--
	Benthos														
	M-2	--	--	--	--	--	--	X	X	X	--	--	X[a]	--	--
	M-4	--	--	--	--	--	--	X	X	X	--	--	X[a]	--	--
	Fish - Lake Survey														
	Electroshocking	--	--	--	--	--	--	--	--	X	--	--	X[a]	--	--
	Gill Net	--	--	--	--	--	--	X	--	X	--	--	--	--	--
	Fyke Net	--	--	--	--	--	--	--	--	X	--	--	X[a]	--	--
	Minnow Trap	--	--	--	--	--	--	--	--	X	--	--	--	--	--
	Tissue Chemistry - Lake Survey														
	Fish	--	--	--	--	--	--	--	--	X	--	--	X	--	--

Table 3.8-3 *(Continued)*

Water Body	Sample/Station(s)	1977 March	May	June	July	August	September	October	1978 March	May	June	July	August	September	October
Deep Hole Lake	Phytoplankton/Zooplankton L	--	--	--	--	--	--	X	X	X	X	X	X	X	X
	Chlorophyll a L	--	--	--	--	--	--	X	X	X	X	X	X	X	X
	Periphyton L (near shore)	--	--	--	--	--	--	X	--	X	X	X	X[a]	X	X
	Aquatic Macrophytes - Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Benthos L	--	X	--	--	X[a]	--	X	X	X	--	--	X[a]	--	--
	Fish - Lake Survey Electroshocking	--	--	--	--	--	--	--	--	X	--	--	X[a]	--	--
	Gill Net	--	X	--	--	X[a]	--	X	--	X	--	--	X[a]	--	--
	Minnow Trap	--	--	--	--	--	--	--	--	X	--	--	--	--	--
	Tissue Chemistry - Lake Survey Fish	--	--	--	--	X[a]	--	--	--	--	--	--	X[a]	--	--
Duck Lake	Phytoplankton/Zooplankton K	--	--	--	--	--	--	X	X	X	X	X	X	X	X
	Chlorophyll a K	--	--	--	--	--	--	X	X	X	X	X	X	X	X
	Periphyton K (near shore)	--	--	--	--	--	--	X	--	X	X	X	X	X	X
	Aquatic Macrophytes - Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Benthos K	--	X	--	--	X[a]	--	X	X[b]	X	--	--	X	--	--
	Fish - Lake Survey Electroshocking	--	--	--	--	--	--	--	--	--	--	--	X[a]	--	--
	Bill Net	--	X	--	--	X[a]	--	X	--	X	--	--	X	--	--
	Minnow Trap	--	--	--	--	--	--	--	--	X	--	--	--	--	--

Table 3.8-3 *(Continued)*

Water Body	Sample/Station(s)	1977 March	May	June	July	August	September	October	1978 March	May	June	July	August	September	October
	Tissue Chemistry -														
	Lake Survey														
	Fish	--	--	--	--	--	--	--	--	X	--	--	X[a]	--	--
Little Sand Lake	Phytoplankton/Zooplankton														
	H	X	X	X	X	X	X	X	X	X	--	--	X	--	--
	I	X	X	X	X	X	X	X	X	X	--	--	X	--	--
	Chlorophyll a														
	H	--	X	X	X	X	X	X	X	X	--	--	X	--	--
	I	--	X	X	X	X	X	X	X	X	--	--	X	--	--
	Periphyton														
	H (near shore)	--	X	X	X	X[a]	X	X	--	X	--	--	X	--	--
	I (near shore)	--	X	X	X	X[a]	X	X	--	X	--	--	X	--	--
	Benthos														
	H	X[b]	X	--	--	X[a]	--	X	X[b]	X	--	--	X	--	--
	I	X[b]	X	--	--	X[a]	--	X	X[b]	X	--	--	X	--	--
	Aquatic Macrophytes -														
	Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Fish - Lake Survey														
	Metered Larval Net	--	X	X	X	--	--	--	--	--	--	--	--	--	--
	Electroshocking	--	--	--	--	X[a]	--	--	--	X	--	--	X	--	--
Skunk Lake	Phytoplankton/Zooplankton														
	J	--	--	X	X	X	X	X	--	--	--	--	--	--	--
	Chlorophyll a														
	J	--	--	X	X	X	X	X	X	--	--	--	--	--	--
	Periphyton														
	J	--	--	X	X	X[a]	X	X	--	--	--	--	--	--	--
	Aquatic Macrophytes -														
	Lake Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Benthos														
	J	--	X	--	--	X[a]	--	--	--	--	--	--	--	--	--

Table 3.8-3 *(Continued)*

Water Body	Sample/Station(s)	1977 March	May	June	July	August	September	October	1978 March	May	June	July	August	September	October
	Fish - Lake Survey														
	Electroshocking	--	--	--	--	--	--	--	--	X	--	--	--	--	--
	Minnow Trap	--	--	--	--	--	--	--	--	X	--	--	--	--	--
Pond 6-8[c]	Aquatic Macrophytes -														
	Pond Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Fish														
	Minnow Trap 6-8	--	--	--	--	--	--	X	--	--	--	--	--	--	--
Pond 31-13[c]	Aquatic Macrophytes -														
	pond Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Fish														
	Minnow Trap 31-13	--	--	--	--	--	--	X	--	--	--	--	--	--	--
Pond 34-1[c]	Aquatic Macrophytes -														
	Pond Survey	--	--	--	--	X	--	--	--	--	--	---	--	--	--
	Fish														
	Minnow Trap 34-1	--	--	--	--	--	--	X	--	--	--	--	--	--	--
Pond 35-7[c]	Aquatic Macrophytes -														
	Pond Survey	--	--	--	--	X	--	--	--	--	--	--	--	--	--
	Fish														
	Minnow Trap 35-7	--	--	--	--	--	--	X	--	--	--	--	--	--	--

Note: -- Indicates no sample collected.
[a]Sample collected in late July.
[b]Sample collected in February.
[c]WDNR identification code.

Source: Dames & Moore, 1982
Checked by: WMW

No additional phytoplankton studies were conducted in the 1993-1994 study effort because no phytoplankton species are listed as endangered or threatened on the Wisconsin Heritage Inventory.

3.8.1.3 Methods for Zooplankton

At each zooplankton sampling station, duplicate samples were collected with water pumps (Schwoerbel, 1972). Two calibrated centrifugal pumps were deployed in tandem and equipped with a pair of intake hoses of 19-mm (0.75-inch) inside diameter. For each sample, the intake hoses were lowered to a position immediately above the substrate and then raised at approximately 152-mm (six inch) intervals to obtain an integrated sample of the water column. Each sample consisted of a minimum of 250 liters (66 gallons) of water pumped through a No. 20 mesh net, 76 micron meter (0.003 inch). To reduce the potential of forcing zooplankton through the mesh, the net was suspended in water. The samples were concentrated into prelabeled containers and preserved with a five percent buffered formalin (Weber, 1973).

Enumeration by subsampling was conducted by the open grid method (Weber, 1973). To facilitate counting organisms in the subsample, a brass grid was used to subdivide an 80 x 100 x 5-mm (3.15 x 4 x 0.2-inch) chamber. All organisms for the entire subsample, usually two to five mL, or a minimum of 300 organisms were enumerated and identified to the lowest possible taxon, generally species.

Taxonomic keys used for zooplankton identifications were Ahlstrom (1940, 1943), Edmondson (1959), and Ruttner-Kolisko (1974) for rotifera; Brooks (1957, 1959) and Deevey and Deevey (1971) for cladocera; Yeatman (1959) and Torke (1976) for cyclopoid copepods; and Wilson (1959) for calanoid copepods.

Cyclopoid and calanoid copepodites and nauplii were reported as such. Identifications were verified by Dr. Byron G. Torke, Assistant Professor, Ball State University, Muncie, Indiana, through review of reference slide mounts of the voucher specimens.

Individuals enumerated were expressed in number per liter. Diversity was calculated on all mature individuals identified to be lowest positive taxon using the formula presented in Shannon and Weaver (1949) (based on $\log_{10}$). The relative abundance was calculated and expressed as the percent of all organisms collected. No additional zooplankton studies were conducted during the 1993-1994 collection effort.

3.8.1.4 Methods for Periphyton

Qualitative samples of periphytic algae were collected from commonly occurring natural substrates found at near-shore areas in the vicinity of the sampling stations. Entire substrates such as plants or rocks, along with material scraped from larger substrates, such as logs or boulders, were preserved in five percent formalin (Weber, 1973) and transported to the laboratory for analysis.

In the laboratory, algae were scraped from the collected substrates and two aliquots were withdrawn from the well mixed sample. One aliquot was transferred to a Sedgewick-Rafter counting cell for enumeration and non-diatom identification (APHA et. al., 1976). Strips of the counting cell were examined until a minimum of 250 diatom cells were enumerated. Diatoms were identified from the other aliquot using standard diatom mounts (APHA et. al., 1976) after

centrifugation and mounting with Cover Bond. Raw counts of diatoms were extrapolated to whole samples through Diatom Species Proportional Counts (Weber, 1973). Periphyton were identified to lowest possible taxon, generally species, and counts were expressed as relative abundance.

Verification of identification and enumerations was completed by reanalysis of 10 percent of the samples by Mr. Keith E. Kamburn, Phytologist, Kentucky Nature Preserves Commission, Frankfort. No additional periphyton studies were conducted during the 1993-1994 collection effort.

3.8.1.5 Methods for Aquatic Macrophytes

The survey consisted of the observation of macrophyte beds during a systematic reconnaissance of each water body. The extent of growth was visually estimated and described as "dense" when coverage was continuous, "moderate" when growths were common, or "sparse" when the growth was rarely encountered (Weber, 1973). Representative specimens were collected, dried in a plant press, and mounted for identification. Species were identified using taxonomic keys presented in Gleason and Cronquist (1963). An estimation of the relative composition was made, and a general map outlining the macrophyte beds was subsequently prepared. A reference collection of pressed and dried specimens of each species was prepared. Identifications were verified through review of mounted specimens by Dr. Hugh H. Iltis, Professor of Botany and Director of the Herbarium, University of Wisconsin, Madison, Wisconsin.

In addition to the survey of aquatic macrophytes in study area lakes and ponds (Tables 3.8-2 and 3.8-3), an inventory to determine the relative abundance of aquatic macrophytes in Swamp Creek and the Wolf River was completed in June 1983. The inventory was initiated 0.4km (0.25 mile) upstream of the previously proposed discharge site on Swamp Creek and terminated on the Wolf River approximately 1.2 km (0.75 mile) downstream from the confluence with Swamp Creek at the bend in Lost Lake Road. The relative abundance of aquatic macrophyte species was determined by visual estimates.

An inventory of aquatic macrophytes was also conducted in 1994. The results of this inventory are provided in Section 3.9 in conjunction with the 1994 plant inventory.

3.8.1.6 Methods for Benthic Macroinvertebrates Collected in 1977 and 1978

Quantitative sampling consisted of two, three, or five replicate samples in 1977, and three replicate samples in 1978. Samples were collected utilizing an Ekman sampler, except at Station D on Swamp Creek, where a Surber sampler was used. Sampler selection was based on predominant substrate type, which was visually determined at each station. The substrates encountered were visually characterized according to the classification system presented in Weber (1973) and in Table 3.8-4. Samples were screened in the field through a No. 30 U.S. Standard sieve and preserved in 10 percent buffered formalin with rose bengal stain added to facilitate subsequent sorting (APHA et al., 1976).

Qualitative sampling, consisting of hand-picked or dip-net samples of miscellaneous substrates near each sampling station, was conducted in 1977 and 1978 (Table 3.8-5). Typically, shoreline areas were investigated for suitable substrates such as rocks or sticks that might provide benthic

Table 3.8-4

Categories for the Field Classification of the General Substrate Characteristics* of the Water Bodies in the Study Area

Type	Size or Characteristic
Inorganic Components	
Bedrock or solid rock	
Boulders	>256 mm (10 inches) in diameter
Rubble	64 to 256 mm (2-1/2 to 10 inches) in diameter
Gravel	2 to 64 mm (1/12 to 2-1/2 inches) in diameter
Sand	0.06 to 2.0 mm in diameter; gritty texture when rubbed between fingers
Silt	0.004 to 0.06 mm in diameter
Clay	<0.004 mm in diameter; smooth slick feeling when rubbed between fingers
Marl	Calcium carbonate; usually gray; often contains fragments of mollusc shells or Chara; effervesces freely with hydrochloric acid
Organic Components	
Detritus	Accumulated wood, sticks, and other undecayed coarse plant materials
Fibrous peat	Partially decomposed plant remains; parts of plants readily distinguishable
Pulpy peat	Very finely divided plant remains; parts of plants not distinguishable; varies in color from green to brown; varies greatly in consistency, often being semi-fluid
Muck	Black, finely divided organic matter; completely decomposed

*Weber, 1973

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-5

Substrate Types Sampled for the Collection of Qualitative Benthic Macroinvertebrates

Location	Sampling Station	Substrate
Swamp Creek Drainage Basin		
Rice Lake	F	Aquatic vegetation, peat, muck, detritus
Rice Lake	N	Aquatic vegetation, peat, muck, detritus
Hemlock Creek	A-1	Silt, sand, detritus, sticks
Swamp Creek	D	Rocks, gravel, sticks, shoreline vegetation
Swamp Creek	E	Shoreline vegetation, aquatic vegetation, sticks, detritus
Oak Lake	G	Squatic macrophytes, sticks, sand
Pickerel Creek Drainage Basin		
Rolling Stone Lake	M-2	Aquatic macrophytes, detritus, sticks
Rolling Stone Lake	M-4	Aquatic macrephytes, rocks, gravel, muck
Pickerel Creek	M-5	Shoreline vegetation, detritus, sticks
Creek 12-9	M-1	Shoreline vegetation, detritus, sticks
Creek 11-4	M-3	Shoreline vegetation, detritus, sand, sticks
Little Sand Lake	H	Shoreline vegetation, detritus, sticks
Little Sand Lake	I	Aquatic macrophytes, rocks, sand, sticks
Duck Lake	K	Aquatic macrophytes, muck, peat, detritus, sticks
Deep Hole Lake	L	Aquatic macrophytes, rubble, sand, gravel, muck, detritus
Skunk Lake	J	Aquatic macrophytes, muck
Wolf River	Y	Sand, detritus, sticks
Wolf River	Z	Aquatic macrophytes, rocks, gravel, sand, detritus

Source: Dames & Moore, 1982
Checked by: WMW

habitat. Also, a dip-net was swept through aquatic macrophytes and overhanging terrestrial vegetation, if present, as well as surficial sediments. Organisms were preserved in 10 percent buffered formalin.

In the laboratory, benthic organisms were sorted manually from the substrate materials and placed in vials containing 70 percent ethanol (APHA et. al., 1976). Chironomidae and Oligochaeta were subsequently mounted in CMC-10 medium on glass slides. All organisms were identified to the lowest possible taxon and enumerated. Enumeration and identification were verified by review of samples and reference specimens by an investigator other than the original analyst. Taxonomic keys used for identification of invertebrates were Ross (1944), Roback (1957), Saether (1971), Brown (1972), Bryce and Hobart (1972), Mason (1973), Stewart and Loch (1973), Hilsenhoff (1975), Wiggins (1977), Oliver (1978), and Pennak (1978) for insects; Brousefield (1958), Hobbs (1972), Holsinger (1972), Williams (1972), and Pennak (1978) for crustacea; Brinkhurst (1964), Hiltunen (1967, 1973), and Brinkhurst and Jamieson (1971) for Oligochaeta; Klem (1972) and Pennak (1978) for Hirudinea; and Baker (1928), Eddy and Hodson (1961), and Pennak (1978) for Mollusca.

Numbers of individuals collected in quantitative samples were expressed as number per square meter of substrate. Diversity was calculated using Brillouin's formula (based on $\log_{10}$) (Pielou, 1966) and the number of organisms identified in the sample:

$$H = \left(\frac{1}{N}\right) ln \frac{N!}{N_1!N_2!...N_s!}$$

where: H = Diversity;
N = The total number of individuals in the sample;
N_1N_2,... = The number of individuals in taxa 1, 2..., and
S = The total number of taxa in the collection.

The taxa level used to calculate diversity was the lowest possible taxon to which each organism was identified. In general, this was as follows:

Coelenterata: genus
Platyhelminthes: order
Nematoda: phylum
Oligochaeta
Naididae: species
Tubificidae: species (except immatures)
Enchytraeidae: family
Lumbriculicae: family
Branchiobdellida: family
Hirudinea: family, genus, species
Crustacea: genus, species
Hydracarina: order
Insecta: genus, species
Mollusca: genus

The relative abundance of taxa collected in quantitative samples was calculated and expressed as the percent of all organisms collected.

3.8.1.7 Methods for Aquatic Macroinvertebrates Collected in 1993 and 1994

Aquatic macroinvertebrate collections occurred three times, once in November 1993 and twice in 1994 (May and August). During each sampling event, sites identified in Figure 3.8-2 were sampled. Some sites were not accessible in 1993 due to ice conditions while other sites were not available in 1994 because of restrictions to private access. Areas which were targeted for field investigation included lakes and streams local to proposed mining activities as well as streams which may be impacted by mining. Table 3.8-6 lists the sample sites and collection dates.

In general, three collection techniques were used for aquatic macroinvertebrates, including kick seining with an 8 x 18 inch, 800 to 900 micron mesh rectangular net, surber sampler, and Ekman dredge. The rectangular net was used in all habitats to search bottom substrate, undercut banks, and sweep aquatic vegetation. The rectangular net was supplemented in riffle areas with the surber sampler and in soft bottom habitat with the Ekman dredge. Where the surber sampler and Ekman dredge were used, triplicate samples were collected, washed in a 600 to 800 micron filter, and preserved in formalin. Each microhabitat was sampled by two biologists for a minimum of one hour or until a five minute period produced no new species, whichever was the longer period.

Some organisms, such as the nymphs of Ephemeroptera and Plecoptera and larvae of Trichoptera and Coleoptera are difficult to identify to species. Where genera of these groups were found in the fall 1993 aquatic collections and contained potentially listed species, light trapping for adult specimens was conducted in the vicinity of the sampling station during June, July, and August 1994. Light trapping sites are identified on Figure 3.8-3.

A special effort to collect riffle beetles was expended in June 1994. The only true riffle area in the project area on Swamp Creek is south of Swampy Lane (encompassed by site designations CMC-AB-SC-300 and CMC-AB-SC-301 shown on Figure 3.8-2). This area was sampled by two people hand picking beetles off of submerged vegetation for one hour.

All macroinvertebrate samples were preserved on site with 10 percent formalin. A chain of custody form was completed for samples. Preserved samples were shipped to Dr. Ken Tennessen in Florence, Alabama for identification. General macroinvertebrate specimens were identified by Dr. Tennessen. For light trapping collections, Ephemeraptera were identified by Dr. Bob Waltz of the Indiana Department of Natural Resources, while Trichoptera were identified by Dr. Brian Armitage of Ohio Biological Survey. Specimens of *Alloperla* sp., a stone fly, were identified by Dr. Bill Stark of Mississippi College. Voucher specimens of all threatened, endangered, or species of concern were sent to Bill Smith, WDNR for documentation.

Members of the Trichoptera (caddisfly group), Plecoptera (stonefly group), Coleoptera (beetle group) and Ephemeroptera (mayfly group) can be difficult to identify to species in the nymph or larval stage. Therefore, efforts were expended to collect members of these groups in the adult stage using light traps.

Common camping type lanterns were used as light traps. Each lantern contained two ultraviolet lights powered by eight size D batteries that were replaced with fresh batteries prior to each night of sampling.

Table 3.8-6

1993/1994 Aquatic Species Work Effort

	Location and Type of Sampling Performed								
Date	CMC-AB-HL-100	CMC-AB-HL-200	CMC-AB-SC-200	CMC-AB-SC-250	CMC-AB-SC-300	CMC-AB-SC-301	CMC-AB-SC-400	CMC-AB-SC-500	CMC-AB-SC-501
11-08-93									I
11-09-93					I				
11-10-93									
11-11-93									
05-09-94									
05-10-94								F	F
05-11-94	F	F	F			I,F	F		I
05-12-94				I					
05-13-94									
05-14-94									
06-01-94				E					
06-02-94									
06-03-94						E			
06-04-94									
06-05-94									E
06-14-94									
06-15-94									
06-16-94						E			
06-27-94		A			E,A				
06-28-94					T				
06-29-94		T	T					T	E,A
06-30-94					E,A				
07-01-94		A							
07-28-94		M							
07-29-94									
07-30-94									
07-31-94					M	M			
08-01-94				I					
08-02-94									I,M
08-03-94						I			
08-04-94		M							
08-05-94									
09-28-94								T	
09-29-94		T							

Table 3.8-6 *(Continued)*

Date	Location and Type of Sampling Performed									
	CMC-AB-SC-502	CMC-AB-SC-700	CMC-AB-WR-200	CMC-AB-WR-301	CMC-AB-SGI-CC	CMC-AB-SK-005	CMC-AB-DL-005	CMC-AB-SL-005	CMC-AB-OL-005	CMC-AB-RS-005
11-08-93	I				I					
11-09-93				I,M						
11-10-93								I	I	
11-11-93										
05-09-94				F	F					
05-10-94	F			I	I				I	
05-11-94	I					I		F		
05-12-94								I	F	F
05-13-94							I			I
05-14-94										
06-01-94								E		
06-02-94						E				E
06-03-94							E			
06-04-94				E	E				E	
06-05-94	E									
06-14-94				F	F				F	
06-15-94										
06-16-94					E			F		
06-27-94										
06-28-94					T					
06-29-94	E,A			E,A	E,A					
06-30-94						T		T,A		
07-01-94						A			A	
07-28-94					M					
07-29-94										
07-30-94			M	M	M					
07-31-94										
08-01-94	M			I	I					
08-02-94	I									M,I
08-03-94						I	I	I		
08-04-94							M		I	
08-05-94										M
09-28-94					T					
09-29-94		M			M	T				

Table 3.8-6 *(Continued)*

Date	Location and Type of Sampling Performed								
	CMC-AB-DH-005	CMC-AB-PP-005	CMC-AB-HS-005	CMC-AB-HC-100	CMC-AB-MS-100	CMC-AB-12/9-100	CMC-AB-OC-200	CMC-AB-PK-200	CMC-AB-PK-300
11-08-93									
11-09-93					I				
11-10-93						I			
11-11-93			I						
05-09-94									
05-10-94									
05-11-94								F	
05-12-94	I								
05-13-94	F	I			I	I			
05-14-94			I	I					
06-01-94		E							
06-02-94					E				
06-03-94	E		E	E					
06-04-94									
06-05-94									
06-14-94									
06-15-94	F								
06-16-94									
06-27-94									
06-28-94					T				
06-29-94							T		
06-30-94			T,E,A	E,A	E,A				
07-01-94									
07-28-94									
07-29-94									
07-30-94									
07-31-94									
08-01-94					I				
08-02-94	I								
08-03-94	M	I							
08-04-94			I	I					
08-05-94									
09-28-94					T				M
09-29-94			T						

F = Fish
M = Mussel
I = Invertebrate
A = Adult Odonata
E = Odonata Exuviae
N = Odonata Nymph
T = Light trapping

Prepared by: JCP
Checked by: WMW

Each light was positioned over a collecting pan. The pan was filled with 70 percent alcohol to a depth of approximately ¾ inch. Light trapping commenced at dusk and continued for a minimum of two hours at each site. Light trap locations are shown on Figure 3.8-3. Four lanterns were used for trapping per night of effort during the week of June 27, 1994 to July 1, 1994.

After the collection period, all specimens captured in the alcohol were transferred in the field to labeled four ounce or eight ounce jars. Jars were transferred to the lab where they were emptied into a sorting pan. All Trichoptera, Plecoptera, Coleoptera and Ephemeroptera were saved for identification by Dr. Tennessen. At the request of Bill Smith, Ephemeroptera were sent to the WDNR for further handling. To expedite identification of samples, Ephemeroptera were subsequently returned to Dr. Tennessen and identifications were completed by Dr. Bob Waltz.

3.8.1.8 Methods for Odonata Collection

Collection efforts for Odonata (dragonflies and damselflies) included searches for nymphs (aquatic), adults (terrestrial), and the exuviae (casings left after emergence of nymphs from aquatic environment). Nymphs were collected during the general macroinvertebrate collection time periods described above - November 1993, May 1994, and August 1994. Exuviae were collected from shoreline locations throughout June 1994. Adult Odonata were collected or identified on the wing from late June into August, 1994. Collection methods and locations of Odonata nymph sampling are described above in Section 3.8.1.6.

Exuviae collections were conducted in June with the greatest level of effort being expended from June 1, 1994 through June 5, 1994 because this was the peak emergence period for adults. Additional sampling was conducted on June 16, 1994, and again from June 27, 1994 to July 1, 1994 to provide back-up collections and allow thorough coverage of the emergence period. Sites were selected which represented preferred habitat of adults of the targeted group.

Stations at all streams and lakes as shown on Figure 3.8-2 were sampled from June 1, 1994 through June 5, 1994. Two people either in a canoe or wading conducted the sampling. At each site all exuviae observed in an approximate 100 meter distance of shoreline were collected. In small streams both left and right banks (facing downstream) were sampled and specimens were composited. Small stream sites for exuviae collection were located on Hemlock Creek, Swamp Creek downstream to County Highway M, Creek 12-9, Martin Springs (Creek 11-4), and Hoffman Springs. For larger streams (Swamp Creek downstream of County Highway M and sampling sites on the Wolf River) 100 meter sections were sampled on both right and left banks and collections were kept separate at each bank. Sample segregation on larger streams permitted evaluation of habitat preferences by species (qualitative and quantitative) which may be due to substrate, exposed shore, shoreline vegetation, or possibly time of day.

At each lake, a minimum of 100 meters of shoreline was sampled. In small lakes an effort was made to cover as much of the shoreline as possible. On larger lakes three to four tracts covering 25 to 33 meters in length were sampled. An effort was made to sample all major shoreline habitats available at a particular lake (emergent vegetation such as cattails, exposed shoreline, bog habitats, timbered shoreline including downed timber, branches, and stumps in the water, rock shores and embankment).

Exuviae were hand-picked within a minimum three foot strip from the water's edge landward at all collection sites. The sampling width increased if flat shoreline allowed emerging Odonata to penetrate further. Likewise, where steep banks occurred, the search area was more vertical than horizontal.

All samples were placed in plastic containers and preserved in 70 percent alcohol. Identifications were completed by Dr. Ken Tennessen, with assistance from Bill West of Foth and Van Dyke. Voucher specimens were hand delivered to Bill Smith of the WDNR for documentation.

On June 16, 1994, Foth & Van Dyke accompanied Bill Smith of the WDNR for a one-day site collection effort on the Wolf River at the Lost Lake Road access and on Swamp Creek downstream of the Swampy Lane access. These locations are identified on Figure 3.8-4. Collections were not limited by time or distance of shoreline. Specimens were retained by Bill Smith for identification.

From June 27, 1994 to July 1, 1994, Foth & Van Dyke, accompanied by Dr. Tennessen, completed the last exuviae collections. Sites on the Wolf River, Swamp Creek upstream and downstream of the previously proposed discharge site, and two sites at and downstream of Swampy Lane were sampled. These sites are shown of Figure 3.8-5. This activity essentially duplicated the sampling area of June 1, 1994 to June 5, 1994, efforts at these sites. This second effort collected specimens which could emerge later than the late May/early June time period. Specimens were placed in plastic containers and preserved in 70 percent alcohol. All exuviae were identified by Dr. Tennessen with assistance by Bill West, (Foth & Van Dyke). Voucher specimens were hand delivered to Bill Smith for documentation.

3.8.1.9 Methods for Adult Odonata

Many Odonata can be located and identified by collecting exuviae or specimens in the nymph stages. However, for some species and in some instances, collection techniques discussed above for these stages could result in little or no success. Therefore, to provide a more complete collection effort, adults were sampled from June 27, 1994 through July 1, 1994. Dr. Tennessen, accompanied by Bill West, collected adult Odonata specimens from most of the same stream, river and lake sites as previously identified, as well as several access roads, meadows, woodland swamps and other stream access locations throughout the general project area. These collection sites are shown on Figure 3.8-6.

In general, all adult collections used long handled (four to six feet) sweep nets. Most specimens could be readily collected on the wing. Common species were collected, identified, the sex identified, recorded, and released. Special concern species were collected, identified, sexed, recorded and saved in plastic envelopes in the field. These specimens were placed in acetone in the lab. Voucher specimens were hand delivered to Bill Smith for documentation.

Dr. Tennessen identified some specimens on the wing which were either common and not worth the effort to collect or which were out of reach, and therefore unable to collect. Tentative identifications of visual observations were compared with other collection data (nymph and exuviae collections).

Final adult Odonata collection activities were conducted by Bill West (Foth & Van Dyke) from July 28, 1994, through August 4, 1994. All specimens collected were placed in plastic envelopes

in the field, placed in acetone in the lab, and sent to Dr. Tennessen for identification. Voucher specimens were sent to Bill Smith, WDNR for documentation. Figure 3.8-7 shows the collection sites of this effort.

3.8.1.10 Methods for Collection of Fish in 1977 and 1978

Fish surveys were conducted in the study area during ice-free sampling periods (Table 3.8-2) by Ecological Analysts, Inc., Deerfield, Illinois. A variety of fish sampling techniques were utilized to overcome the selectivity inherent in each type of fish sampling gear. Sampling techniques included gill and fyke netting, beach haul or minnow seining, electroshocking, and minnow trapping. Sampling stations where these techniques were used are shown on Figure 3.8-8. In addition, larval fish were sampled at stations located in Oak and Little Sand Lakes and a trout redd reconnaissance was conducted in several creeks (Figure 3.8-9).

Experimental monofilament gill nets, each 24.4 m (80 feet) in length, were fished along the bottom for two consecutive 12-hour periods at selected lake areas. The nets were 1.8 m (six feet) deep and consisted of eight 3.0-m (10-foot) panels. Each panel has an individual mesh size, with the panels arranged so mesh size increased in approximately 12.7-mm (0.5-inch) increments from 12.7 mm (0.5-inch) to 101.6 mm (four inches) bar measure. Care was taken to avoid areas of potentially low dissolved oxygen.

Modified fyke nets with a rectangular entrance 0.9 m (three feet) high and 1.8 m (six feet) wide were utilized. The remainder of the net assembly included four hoops, 0.8 m (2.5 feet) in diameter with a single Crowfoot-style throat and a 18.3 m (60-foot) lead. The entire net was composed of 1.3 cm (0.5 inch) mesh netting. The nets were set for a 24-hour period in shallow areas at depths less than 1.2 m (four feet) with the lead attached to a shoreline stake and the remaining lead and trap extended perpendicularly offshore. A double lead net was utilized in Rice Lake.

Seining was conducted during daylight with a beach haul seine or a minnow seine to obtain qualitative samples along suitable shoreline areas at depth of 1.2 m (four feet) or less. The beach haul seine had dimensions of 36.6 x 1.8 m (120 x 6 feet), a mesh size of 12.7 mm (0.5 inch) bar measure, and contained a 1.8 x 1.8 m (6 x 6 foot) back of 6.4 mm (0.25 inch) mesh. The minnow seine had dimensions of 7.6 x 1.2 m (25 x 4 feet) and a mesh size of 6.4 mm (0.25 inch). Two to four hauls were collected depending on the quantity of fish collected.

Electrofishing was conducted in selected areas (Figure 3.8-8) with either a Coffelt VPP-2C stream electroshocker unit, a Smith-Root Type VII backpack unit, or a boat-mounted boom electroshocker unit. The Coffelt and Smith-Root units were utilized primarily for stream sampling, and the boom electroshocker for lakes and the Wolf River. Because of inaccessibility or motorboat usage constraints, the Coffelt unit was mounted in a row boat for use in Rice, Duck, and Skunk Lakes. Both AC and DC currents were utilized in the water bodies studied depending on the conductivity of the water and the specific electrofishing equipment employed for sampling.

Stream electrofishing at Swamp Creek (Stations B and D) and Hemlock Creek (Station A-2) was conducted over a distance of approximately 305 m (1,000 feet). In areas where the streams were greatly obstructed, Creek 11-4 (M-3), Pickerel Creek (M-5), Creek 12-9 (M-1), and Hemlock Creek (A-1), electrofishing was conducted over a distance of approximately 100 m (328 feet). In

Hoffman Creek (Station E), which was also greatly obstructed, the distance was 85 m (279 feet). All stream electrofishing was conducted during daylight in an upstream direction. Daytime electrofishing on the Wolf River was conducted for 30 minute intervals along shoreline areas with the boom electroshocker unit. For all stream electrofishing with the Coffelt unit and the Smith-Root unit, a pulsed current of 250 to 300 volts DC (at two to three amps for the Coffelt unit and one amp for the Smith-Root unit) was utilized. A pulsed current for 250 to 300 volts AC (two to three amps) was used in the Wolf River.

Except for Rice Lake, lake electrofishing was conducted at night (1900 to 2330 hours) along selected shoreline areas for 30 minute intervals. In Rice Lake, sampling was conducted during the daylight within the Swamp Creek channel area of the lake for a 30 minute interval. A pulsed current of 250 to 300 volts DC (two to three amps) was utilized for Rice Lake and Rolling Stone Lake, and a pulsed current of 250 to 300 volts AC (two to three amps) was utilized for all other lake sampling. Minnow traps baited with bread were set for two consecutive 12 hour periods in several small ponds in the study area and in Deep Hole, Duck, Skunk, Rice, and Rolling Stone Lakes, and Creeks 11-4 and 12-9 (Figure 3.8-8).

Fish collected were identified, enumerated, measured (mm, total length), and weighed (g) on a spring scale. Identifications were made using taxonomic keys presented in Hubbs and Lagler (1958) and Becker and Johnson (1970). If catches were large, approximately 100 or more fish, the total number for each species was recorded, lengths were obtained from as many fish as practical, and a representative sample, approximating the size frequency of captured fish, was weighed. All fish were examined externally for incidence of parasitism, fungal growths, or apparent disease. Obvious external characterization of gonadal conditions were also recorded. Except for fish preserved for later identification, enumeration, to serve as voucher specimens or utilized for tissue chemistry, all fish were returned to the water.

Relative abundance of species caught by the various collection techniques and condition factors for the processed fish were calculated. Relative abundance was expressed as the percent that a species contributed to the catch for a particular collection technique. The condition factor is an expression of the relative well-being of fish (Carlander, 1969). The heavier a fish is at a given length, the larger the factor, and, by implication, the better the "condition" of the fish. The factor is expressed in the form $K = W \times 10^5/L^3$ where W is the weight of the fish in grams, L is the total length of the fish in millimeters, and 10^5 is a factor to bring the value of K near unity.

Because Oak or Little Sand lakes were considered as potential water sources, larval fish were sampled at 1 month intervals during May, June, and July 1977. Duplicate samples were collected in two areas in Little Sand Lake and one in Oak Lake (Figure 3.8-8) with a 0.6 m (two foot) diameter metered (TSK type) flow net, constructed of 00 mesh, 752 mm (0.3 inch), with a terminal oceanographic bucket. The net was towed at a low constant speed 0.5 m (1.6 feet) below the surface for five minutes for each replicate.

Potential brook trout spawning areas were located by traversing Swamp Creek upstream of Rice Lake, Hemlock Creek, Outlet Creek, and Hoffman Creek during October and November 1977 and segments of Creek 12-9 and Pickerel Creek during October 1978 (Figure 3.8-9). A fisheries biologist either walked or canoed each creek. Mr. Ronald A. Theis, Fisheries Biologist WDNR, participated in the survey along Swamp Creek upstream of Keith Siding Road, portions of Hemlock Creek, and Creek 26-14. Potential spawning areas were characterized as riffles or the downstream edges of pools that contained sand and gravel substrate with indication of

groundwater discharge, such as seeps and springs (Latta, 1965). Potential reeds were considered to be in areas where brook trout were observed to be congregated in suitable riffle areas.

Fish identifications were verified by Mr. Donald M. Fago, Fishery Biologist, WDNR, Madison; Dr. George E. Becker, Professor, University of Wisconsin at Stevens Point; or Dr. Lawrence M. Page, Associated Taxonomist, Illinois Natural History Survey, Urbana.

3.8.1.11 Methods for Fish Collected in 1993 and 1994

Sampling for target fish species that were listed by the WDNR and could potentially occur in the study area was conducted in May and June of 1994 by EA Engineering, Deerfield, Illinois. May is the period of time when spring activity for these species in the study area is high. The second period of activity occurred in the middle of June.

Three methods were used for fish collection including boat mounted electroshocking, pram mounted electroshocking, and seining. Application of these methods at particular sites depended on access, water depth, and size of water body. Many times seining was used to supplement shocking efforts at the same site. At all locations, habitats likely to harbor the targeted species were noted, and specific sampling efforts were expended to maximize the potential of collecting these species if they were present.

Boat electrofishing was used on Rolling Stone, Deep Hole, and Little Sand Lakes, on the Wolf River, and on Swamp Creek from Shallock's bridge to the Firelane bridge. Lakes were sampled at night while streams were shocked during the day. A Coffelt Model VVP15 controller and a 4000 watt generator were used to produce pulsed DC current. One to three hours were expended electroshocking each lake. The larger the lake, the greater effort was expanded. Approximately three hours were spent shocking the Wolf River while about two hours were spent shocking Swamp Creek downstream of County Highway M.

A pram mounted shocking device was used on Swamp Creek in the riffle area immediately downstream of the Swampy Lane access, Pickerel Creek, Creek 11-9, and Hemlock Creek. The pram operates similar to the boat electroshocking system except the pram is used in shallow water or narrow streams where the boat cannot navigate. Output by the pram was controlled by a Coffelt Model VVP2C powered by a 1500 watt generator. Pulsed DC was used at all stations. Slightly more than one hour was expended pram shocking the riffle area of Swamp Creek. One hour was spent pram shocking on Hemlock Creek with about one half hour each expended at Pickerel Creek (upstream of Rolling Stone Lake) and Creek 11-4 (Martin Springs).

Seining was conducted at Oak, Duck, Rolling Stone, and Deep Hole Lakes. Depending on conditions, a 30 foot long seine with 1/8 inch mesh, or a ten foot long straight seine with 1/8 inch mesh was used. Seining was used at stream locations with the exception of Pickerel Creek, Hemlock Creek off West Hemlock Road, Wolf River below the confluence with Swamp Creek and Swamp Creek below the access at Swampy Lane. Slightly more than five hours was expended two hours of which included seining in Rolling Stone and Deep Hole Lakes. Additional seining was conducted in Oak and Duck Lakes, with about two hours expended in other streams.

Figure 3.8-10 shows the location of fish collection activities. No threatened, endangered, or species of concern were captured, therefore, none were saved as voucher specimens.

3.8.1.12 Methods for Tissue Chemistry of Specimens Collected in 1977 and 1978

Trace metal analyses were performed on the tissues of selected aquatic species. Aquatic macrophytes, benthos, and fish were collected during 1977 from water bodies in the Swamp Creek drainage basin (Swamp and Hemlock Creeks and Oak and Rice Lakes) and the Pickerel Creek drainage basin (Deep Hole and Little Sand Lakes). During 1978, fish samples were again collected from these same water bodies and from additional location in the Pickerel Creek drainage basin (Duck and Rolling Stone lakes, Pickerel Creek, and Creeks 11-4 and 12-9).

Common aquatic macrophytes were collected from the shoreline. The lower portions of the main stalks of larger species (i.e., bur reed cattail, water lily) and the entire plant above the substrate of smaller species (i.e., pipewort, spike rush, wild rice) were collected and used in the analyses. At least a 30 g sample (wet weight) of tissue was obtained. Samples were rinsed in distilled water in the field to remove sediment particles attached to the plants (Mathis and Kevern, 1973). Except for wild rice from Rice Lake, macrophytes were placed in a separate plastic bag and analyzed as a composite sample of the aquatic macrophyte community at each sampling station. Wild rice plants from Rice Lake were analyzed separately.

Benthic macroinvertebrate organisms were collected for tissue analysis in conjunction with qualitative benthos collections, which consisted of hand-picked or dip-net sampling of miscellaneous substrates near each sampling station. Two or more grams of tissue were collected. In the field, organisms were rinsed in distilled water to remove sediment particles (Copeland and Ayers, 1972). Except for crayfish from Rice Lake, benthic organisms were placed whole in a separate plastic bag for each station and analyzed as a composite sample of the benthic community at each sampling station. Muscle tissue from crayfish tails was analyzed separately.

Fish for tissue analysis were collected by electroshocking, gill nets, and fyke nets. All fish were measured and weighed prior to dissection in the field. Dissections were performed with a stainless steel knife (Copeland, et. al., 1973), which was cleaned after each dissection with distilled water. Tissues were gently rinsed in distilled water (Mathis and Kevern, 1973) and placed in a plastic bag. Two fish types were utilized in 1977: muscle (skinless fillet), because it is the most commonly consumed portion, and liver, because the presence of some trace metals in low concentrations is better detected in this tissue (Hannerz, 1967).

In 1978, tissue from a commonly occurring fish species was selected for analysis. Generally, samples consisted of muscle tissues composited from 25 yellow perch that were similar in size from each body of water. However, black bullhead, white sucker, redbelly dace, and mottled sculpin comprised the samples from Hemlock Creek, Swamp Creek, Rice Lake, and Creek 11-4 because yellow perch were not found. For small fish such as redbelly dace, mottled sculpin, and young white sucker, whole fish were used for analysis (Table 3.8-7). For composite samples, care was taken to select fish of similar size and to excise tissue samples of similar size. In addition to the composite sample from each water body, an additional 23 yellow perch of a wide range of lengths from Little Sand Lake were analyzed individually to document intraspecies variation of metal concentrations. Immediately after collection, all tissue samples were placed on ice in an insulated container and frozen within eight hours of collection. In the laboratory, the tissues were homogenized in an electric blender, food processor, or manual grinding depending on amount and consistency of tissue.

Table 3.8-7

Determination of Trace Metals in Fish Tissues Collected From Water Bodies in the Study Area in 1978

Location Station	Month of Collection	Number of Individuals that Comprised the Sample	Species	Tissue Analyzed
Swamp Creek Drainage Basin				
Rice Lake	August	25	Black bullhead	muscle
Hemlock Creek Station A-1	August	24	White sucker	muscle
Swamp Creek Station D	May	21	White sucker	whole fish
Station D	August	7	Mottled sculpin	whole fish
Oak Lake	August	25	Yellow perch	muscle
Pickerel Creek Drainage Basin				
Rolling Stone Lake	May	20	Yellow perch	muscle
	August	26	Yellow perch	muscle
Pickerel Creek M-5	August	25	Yellow perch	muscle
Creek 12-9 M-1	August	5	Yellow perch	muscle
Creek 11-4 M-3	August	25	Redbelly dace	whole fish
Little Sand Lake	August	20	Yellow perch	muscle
Little Sand Lake	August	1*	Yellow perch	muscle
Duck Lake	May	20	Yellow perch	muscle
	August	25	Yellow perch	muscle
Deep Hole Lake	August	25	Yellow perch	muscle

*23 yellow perch were analyzed individually.

Source: Dames & Moore, 1982
Checked by: WMW

In preparation for analysis, the homogenized tissue samples were separated into subsamples for analysis for the specific parameters as follows:

Subsample	Parameters
1	cadmium, chromium, cobalt, copper, lead, manganese, zinc, and percent moisture
2	arsenic
3	mercury

Subsample 1 was weighed to determine wet weight, dried to constant weight at 135 - 150° C (275 - 302° F) and the final dry weight determined. The relationship between wet and dry tissue weights was expressed as percent moisture and was used to convert metal concentrations based on dry weight to concentrations based on weight. The sample was ashed at 450° C (842° F) and subsequently dissolved in hydrochloric acid and analyzed by atomic absorption (AA) spectroscopy using direct aspiration (Horowitz, 1975).

Subsample 2 was weighed wet, dissolved in 1 + 1 sulfuric and concentrated nitric acids and analyzed for arsenic using AA and the hydride generation technique (U.S. EPA, 1974). The percent moisture was used to convert arsenic concentrations based on dry weight to concentrations based on wet weight.

Subsample 3 was weighed wet, dissolved in concentrated sulfuric and nitric acids, potassium permanganate, and potassium persulfate. Sodium chloride hydroxylamine hydrochloride solutions was then added and the sample analyzed for mercury using AA and the conventional cold vapor technique (U.S. EPA, 1974). The percent moisture was used to convert mercury concentrations based on dry weight to concentrations based on wet weight. All analyses were performed using a Perkin-Elmer model 306 atomic absorption spectrophotometer.

3.8.1.13 Methods for Tissue Chemistry of Fish and Crayfish Collected in 1994

As part of the 1994 macroinvertebrate investigation, crayfish were collected for tissue analysis. Five sites were selected for crayfish collection including the Wolf River upstream and downstream of the confluence with Swamp Creek, Swamp Creek upstream and downstream of the previously proposed treated wastewater discharge location, and Little Sand Lake. These locations were extended or changed during collections due to lack of specimens (Figure 3.8-11).

Crayfish were collected in May 1994 using 8 x 18 inch, 800 to 900 micron mesh rectangular net. In deeper water, the net was used with kick-seining techniques. In shallow water, two feet or less, kick-seining was supplemented with hand picking.

Upon collection, crayfish were transferred to a ziplock bag. A minimum of ten specimens were collected per site. All crayfish from one site were composited into a single sample, iced in the field and frozen at the field station. Samples were shipped to the lab in a frozen condition. Parameters included in the tissue analysis included arsenic, cadmium, chromium, cobalt, copper, lead, mercury, manganese, and zinc.

As part of the 1994 fish investigation, fish were collected for tissue analysis. Five sites were selected for fish collection including the Wolf River upstream and downstream of the confluence with Swamp Creek, Swamp Creek upstream and downstream of the previously proposed discharge location, and Little Sand Lake. Figure 3.8-12 shows the locations of the fish collection efforts.

At each station, ten perch six inches or larger were to be collected using shocking or seining techniques. If ten perch of the size limit were not available, smaller size perch or other fish species were substituted. At each location, all captured fish were scaled and filleted so that the skin was left intact. All fish livers from an individual site were composited into a single sample for metals analysis. Tissue samples were analyzed for arsenic, cadmium, chromium, copper, colbalt, manganese, lead, and zinc. Paired fillets were individually analyzed for mercury.

All collections of fish and processing of fillets and livers of fish were conducted by EA Associates, Deerfield, IL. Once processed, fillets and composite liver samples were frozen and delivered to Foth & Van Dyke. Foth & Van Dyke completed the chain of custody forms and shipped frozen samples to the laboratory for analysis.

3.8.1.14 Methods for Mussel Collection

Mussel collections were conducted on lakes and streams in the study area from July 27, 1994 to August 7, 1994. Three methods which were utilized for collection of specimens included diving, snorkeling, and wading using a water "telescope".

Diving was used in waters greater than two feet deep. This included all lakes, the Wolf River, and Swamp Creek excluding the riffle area downstream of the access at Swampy Lane. Some snorkeling was conducted in lakes (restricted to shallow water), Swamp Creek in the riffle area, and in Hemlock Creek. The water telescope was used in the riffle area of Swamp Creek. Sampling sites are shown on Figure 3.8-13.

At each sampling site mussels were located by a team of divers or snorkelers or a combination of these. At good locations, mussels were found in high numbers. At Wolf River sites and Swamp Creek downstream of County Highway M., one diver plus a spotter worked to collect specimens. These were placed in a mesh bag. One replicate would include 20 specimens. As a bag was filled, a third person transferred the specimens to an onshore location for identification. This process continued until no new specimens were identified for six consecutive replicates. In most cases this effort took a minimum of four hours for the diver to collect and return all identified specimens.

Identifications were completed by Don Helms of Helms & Associates. Voucher specimens of threatened, endangered, or species of concern were saved for WDNR documentation. Live specimens were returned to the stream where found. Many of the streams and lakes did not have sufficient mussels to fulfill the criteria described above, i.e., fewer than 20 mussels were found to complete one replicate. In these sites a minimum of four hours each for up to four personnel was expended in the search for mussels. In areas where middens (shells found on shore or in shallow water) were located, these were collected to supplement live specimen findings. Fairly good midden collections were located along the Wolf River and Swamp Creek. Scant midden collections were found elsewhere (Hemlock Creek).

On September 29, 1994, Foth & Van Dyke accompanied Dave Heath of WDNR in an effort to conduct additional mussel collection activities. Mussels were collected from the Wolf River (Site CMC-AB-SGI-CC) and Swamp Creek (Site CMC-AB-SC-700). The purpose of the collection was threefold: 1) verify specimen identifications provided by Don Helms; 2) search for possible threatened species collected earlier by Great Lakes Indian Fish and Wildlife Commission (GLIFWC) representatives; and 3) search for an additional listed species known as the salamander mussel.

The collection effort at the Wolf River site included 1.5 manhours of diving, while the effort at Swamp Creek was approximately one manhour. Since the Wolf River site had been searched intensively by Don Helms and GLIFWC in July and August 1994, Dave Heath did not use the methodology of collecting six replicate samples of 20 specimens each. Rather, he searched the area identifying specimens as he searched. Voucher specimens of questionable species were retained.

Approximately 190 specimens were collected at the Swamp Creek site. These were identified, enumerated and sexed (where possible) on site and returned to the water. Voucher specimens of questionable species were retained.

3.8.1.15 Methods for Quality Control

Field and laboratory quality control procedures were utilized during the aquatic biology studies as a means of assuring that they were completed according to currently accepted standards of practice for ecological investigations.

3.8.1.15.1 Field Procedures

A daily log of field activities was maintained by the field team leader who signed and dated the entries. These entries were supplemented by information from the daily logs of individual field personnel. Daily logs were completed during 1977-78 as well as 1993-94 field activities.

Two types of field data sheets were used for aquatic ecology field work which was conducted in 1977 and 1978. One data sheet was used for recording data pertaining to plankton, periphyton, benthos, and larval fish. The second data sheet was used to record data on juvenile and adult fish captured. Data regarding sample station number (or location), date, time, weather conditions, and sampling equipment used were entered on both types of sheets. A separate data sheet was utilized by Helms & Associates and Dave Heath (WDNR) to record the results of mussel field investigations.

Plankton pumps were calibrated daily by recording the time that elapsed for a known volume of water to pass through the pump. This was done at least four separate times prior to each sampling to calculate an average time per unit volume. This calibration was utilized to determine the pumping intervals for zooplankton and phytoplankton sampling so that equal volumes of water were withdrawn at each depth interval.

The meter on the larval fish net was calibrated prior to each use in the field. Calibration was performed by making subsurface (depth 0.5-m [1.6-foot]) tows over a measured distance. Meter values, for tows made with the complete device and tows made with the terminal bucket removed, were compared with the manufacturers' standards and recorded in the daily field log. If more than five percent difference was recovered, the meter was returned to the manufacturer for maintenance.

3.8.1.15.2 Laboratory Procedures

Chemical analyses for chlorophyll a and tissue trace metals for samples collected in 1977-78 were conducted by Aqualab, Inc. For the analysis of biological samples collected in 1977-78, a continuous daily log was maintained at the Environmental Laboratory in the Dames & Moore Park Ridge, Illinois office, and all log entries were signed and dated. Each set of biological samples brought into the laboratory was accompanied by a copy of the field sampling notes and data sheets. The field notes were placed in the project files following their review and the transfer of pertinent data to laboratory data sheets. Upon receipt in the laboratory, all samples were arranged in order of station and depth at which each was collected to verify that all samples were present. Permanent tags with assigned laboratory numbers were attached to each sample container. Field identification tags or labels were retained until sample processing was completed. A continuous master list of all laboratory sample numbers with brief sample descriptions was maintained. The assigned laboratory numbers were used in all data records and on labels for preserved and mounted specimens.

Pertinent sample history and analytical data for each biological sample were recorded on pre-prepared laboratory data sheets. Completion of laboratory analysis for biological samples was verified by checking against the master list. All original data were filed by month and segment of the biological sampling program. Release of any samples for quality control analysis was accompanied by a transmittal sheet. Information on transmittal of samples was documented in the laboratory log.

All preserved and identified biological specimens were labeled, where applicable, with names of organisms, job number, and laboratory number. Upon completion of laboratory analysis, each voucher sample was carefully examined for correct label information, sufficient volume of preservative, and proper sealing for storage. The samples were then organized and stored in a container labeled with description of contents, date of samples, job number, and location.

A master file was maintained with a list of all the laboratory equipment subject to calibration and the information on:

1. Calibration requirements;

2. Sources of calibration standards (for example, National Bureau of Standards, equipment vendor specifications, recognized natural physical constants); and

3. Location of individual equipment maintenance and calibration logs.

Individual equipment logs contained the dates of calibration and the next date of calibration (or a statement that calibration was not required). Where appropriate, tags or stickers for recording dates of calibration were affixed to the piece of equipment. Mandatory recall requirements and acceptance criteria, where applicable, were recorded in the equipment log.

For verification of specimen identifications, every tenth sample was reanalyzed by another professional employee with comparable technical expertise or by an outside expert. For the Crandon Project, independent verification was undertaken by the following outside experts:

Fish	Mr. D. Fago, WDNR, Madison Dr. L. Page, Illinois Natural History Survey, Urbana Dr. G. Becker, University of Wisconsin at Stevens Point
Phytoplankton	Dr. T. Roeder, University of Wisconsin at Stevens Point Mr. M. Fenwick, Northern Illinois University, DeKalb
Periphyton	Mr. K. Kamburn, Kentucky Nature Preserves Commission, Frankfort
Zooplankton	Dr. B. Torke, Ball State University, Muncie, Indiana
Aquatic Macrophytes	Dr. H. Iltis, University of Wisconsin at Madison

Outside consultation for phytoplankton identifications was also provided by Dr. Gary B. Collins and Mr. Benjamin H. MacFarland, U.S. EPA, Cincinnati. Benthos identifications and enumerations were reviewed by a Dames & Moore analyst other than the original investigator.

3.8.1.15.3 Data Analyses

All data collected in 1977-1978 were rechecked by a Dames & Moore employee other than the original investigator. This review included proofing all scientific names and checking calculations where applicable and signing and dating the document reviewed. Any discrepancies were reviewed by the originator of the document before changes were made.

All data and scientific names were transcribed onto computer code forms and checked for accuracy by a second individual who made corrections where needed and signed and dated the coding forms.

The transmittal of these materials to the keypunch and computer service was documented and entered into the laboratory log. The completed computer printouts underwent a final documented review upon return from the computer services to check for misspellings and incorrect data calculations. Calculations were performed with a formally verified computer program.

3.8.1.15.4 QA/QC Laboratory Procedures

On June 21 and 22, 1994, Hazelton Environmental Services (HES), acting as a subcontractor for Environmental Testing and Certification Corporation (ETC), received fish and crayfish samples for analysis from Foth & Van Dyke. These samples included crayfish from five site locations, each location consisted of at least ten specimens, 50 fish livers, 50 pairs of fish filets, and applicable QC for inorganic analysis. The samples were received frozen in a cooler and in good condition. Each sample was documented by a chain of custody form.

3.8.1.15.5 Sample Preparation

The samples were prepared for digestion in a room used exclusively for the preparation of samples. The samples were thawed slightly, chopped into pieces, and homogenized in an industrial blender under liquid nitrogen. All samples were stored frozen until extraction. The extraction for metals analysis was performed according to the EPA 6010/7000 method. One blender blank was prepared for the purpose of detecting possible laboratory contamination.

3.8.1.15.6 Inorganic Analysis

The inorganic results were reported on wet and dry weight basis. The data packages, chain of custodies and correspondence are attached in Appendix 3.8-1.

3.8.2 Results of Biological Data Collection Including Endangered, Threatened or Special Concern Species

3.8.2.1 Results of Phytoplankton Collections (1977-78)

3.8.2.1.1 Rice Lake

Phytoplankton samples were collected from Rice Lake at Stations F and N. Sampling was conducted at both stations during March 1977, monthly from May through October 1977, and at Station N during March, May, and August 1978. Density and relative abundance of the eight major taxa identified and enumerated during the study are presented in Table 3.8-8.

Phytoplankton was generally similar at both stations in Rice Lake. Densities in March 1977 were considerably higher at Station N (2,040 units/mL), than at Station F, (262 units/mL). However, during May, June, and October densities were similar at both stations, ranging from 1,441 to 2,166 units/mL at Station F and from 1,765 to 2,372 units/mL at Station N. Peak density was recorded in August at Station N (8,708 units/mL) and in September at Station F (8,234 units/mL).

The number of phytoplankton at Station N was considerably lower in March 1978 (375 units/mL) than in March 1977, but was similar to the number collected at Station F during March 1977. Numbers collected in May and August of 1977 and 1978 were similar.

Golden-brown algae (Chrysophyceae), diatoms (Bacillariophyceae), and blue-green algae (Cyanophyceae) were the major algal families collected in Rice Lake. Golden-brown algae comprised from 55 to 97 percent of the collections from May through October at both stations. During March 1977 diatoms predominated at both stations, and during March 1978 blue-green algae predominated at Station N.

Golden-brown algae primarily consisted of an unidentified *Chrysococcus*-like alga[1] and common diatom species *Fragilaria construens*, *F. crotonensis*, and *F. intermedia*. The blue-green algal species, *Oscillatoria agardhi*, was the most common alga collected in March 1978.

Diversity values varied from 0.1 to 1.0. A low diversity value indicates that most of the individuals observed in the phytoplankton community were taken from only a few taxa. A high diversity value indicates that a number of individuals were broadly distributed over several taxa. Diversity values could theoretically go to infinity depending on the total number of taxa present (Fager, 1972).

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[1]Mr. Benjamin MacFarland of the Environmental Monitoring and Support Laboratory, U.S. EPA, Cincinnati, suggested that organisms tentatively identified as *Chrysococcus rufescens*, *C. hemisphaerica*, *C. cylindrica*, and *C. ovalis* be referred to as unidentified *Chrysococcus*-like algae, based on their size and quality of preservation.

Table 3.8-8

Mean Density[a] (units/mL), Relative Abundance (%) and Diversity[b] of Phytoplankton Collected at Rice Lake - Stations F and N March 1977, May through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Bacillariophyceae																				
F	177	67	76	5	762	35	225	17	122	3	143	2	55	3	--c	--	--	--	--	--
N	2,010	99	65	4	82	4	176	5	493	6	57	2	66	3	26	7	330	29	74	1
Chlorophyceae																				
F	2	1	104	7	139	6	0	0	8	<1	78	1	4	<1	--	--	--	--	--	--
N	11	1	7	<1	18	1	32	1	92	1	19	1	5	<1	1	<1	40	4	763	8
Chrysophyceae																				
F	2	1	1,208	84	1,200	55	1,067	82	3,636	96	7,978	97	1,988	97	--	--	--	--	--	--
N	0	0	1,590	90	1,853	94	3,444	91	7,878	90	2,823	96	2,295	97	76	20	754	66	7,364	77
Cryptophyceae																				
F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	--	--	--	--	--	--
N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,298	14
Cyanophyceae																				
F	82	31	45	3	8	<1	0	0	3	<1	0	0	3	<1	--	--	--	--	--	--
N	18	1	93	5	10	<1	0	0	0	0	3	<1	3	<1	272	72	15	1	11	<1

Table 3.8-8 *(Continued)*

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Dinophyceae																				
F	0	0	0	0	14	1	0	0	0	0	0	0	0	0	--	--	--	--	--	--
N	0	0	2	<1	0	0	0	0	12	<1	0	0	0	0	0	0	1	<1	0	0
Euglenophyceae																				
F	0	0	8	1	17	1	10	1	5	<1	34	<1	0	0	--	--	--	--	--	--
N	0	0	8	<1	3	<1	144	4	233	3	25	1	3	<1	0	0	7	1	36	<1
Xanthophyceae																				
F	0	0	0	0	28	1	0	0	0	0	0	0	0	0	--	--	--	--	--	--
N	0	0	0	0	6	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total																				
F	262		1,441		2,166		1,302		3,774		8,234		2,049		--	--	--	--	--	--
N	2,040		1,765		1,971		3,795		8,708		2,927		2,372		375		1,147		9,548	
Diversity																				
F	1.0		0.3		0.8		0.3		0.1		0.1		0.1		--		--		--	
N	0.6		0.2		0.2		0.3		0.2		0.1		0.1		0.5		0.7		0.4	

[a]Density is the mean of two replicates rounded to the nearest whole number.
[b]Calculated by Shannon-Weaver formula ($\log_{10}$) using numbers of organisms.
-- No sample collected.

Source: Dames & Moore, 1982
Checked by: WMW

The highest diversity value of 1.0 at Station F in October 1977 (Table 3.8-8) was associated with a relatively balanced phytoplankton community. Low values (0.1 to 0.2) corresponded to the high ($\geq$90 percent) relative abundance of Chrysophyceae, which was almost exclusively represented by the unidentified *Chrysococcus*-like alga.

The mean chlorophyll a concentration recorded from stations in Rice Lake was $\leq$11 µg/L and ranged from $\leq$1 to 49 µg/L. The highest value at each of the two stations was reported in July 1977.

3.8.2.1.2 Oak Lake

Phytoplankton were collected from Oak Lake in March 1977, monthly from May through October 1977 and in March, May, and August 1978. Density and relative abundance of the seven major taxa identified and enumerated are presented in Table 3.8-9.

In 1977 total phytoplankton density was lowest in March, 493 units/mL, ranged from 828 units/mL to 1,516 units/mL in May, June, July and October and peaked in August (13,464 units/mL) and September (9,817 units/mL). In 1978, lowest density was again observed in March (339 units/mL). The density in May (2,548 units/mL) was higher than the previous May, and density in August 3,420 units/mL) did not reach the high level observed the previous year.

In 1977 golden-brown algae predominated in March, May, August, and September. Blue-green algae predominated in June and July. In 1978 golden-brown algae predominated in March whereas blue-green algae were most abundant in May and August.

Unidentified *Chrysococcus*-like algae generally were the common golden-brown algae but *Diachros* sp. predominated in March 1977. *Chroococcus dispersus* var. *minor* was the dominant blue-green alga in June and July 1977, *Aphanotheca clathrata* predominated in May 1978 and *Chroococcus minimus* in August 1978.

The average phytoplankton diversity, calculated from the data presented in Table 3.8-9, was 0.6 for Oak Lake. Minimum diversities of 0.3 and 0.4 occurred in March 1977 and March 1978, respectively, whereas a maximum diversity of 0.9 occurred in October 1977.

The mean chlorophyll a concentration recorded from Oak Lake was less than 16 µg/L, ranging from <1 to 53 µg/L. Peak concentrations occurred in July and September 1977 from both sampling depths.

3.8.2.1.3 Rolling Stone Lake

Phytoplankton samples were collected from Rolling Stone Lake at Stations M-2 and M-4 in October 1977 and March, May, and August 1978. Density and relative abundance of the six major taxa identified and enumerated during the study are presented in Table 3.8-10.

Densities of phytoplankton were similar at the two Rolling Stone Lake stations. Density per sampling period at Stations M-2 and M-4 ranged from 3,630 units/mL and 3,468 units/mL in May 1978 to 37,323 units/mL and 32,735 units/mL in March 1978, respectively.

Table 3.8-9

Mean Density[a] (units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected at Oak Lake - Station G March 1977, May Through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	Units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%
Bacillariophyceae	51	10	100	12	47	4	12	1	1,164	9	251	3	125	8	53	15	90	11	21	1
Chlorophyceae	42	8	182	22	221	17	279	23	3,723	28	2,181	22	486	32	10	3	0	0	112	3
Chrysophyceae	400	81	487	59	245	19	426	35	7.064	52	6,575	67	856	56	277	82	761	30	1,356	40
Cyanophyceae	0	0	58	7	767	60	500	41	1,380	10	154	2	44	3	0	0	1,476	58	1,918	56
Dinophyceae	0	0	1	<1	1	<1	4	<1	83	1	0	0	5	<1	0	0	0	0	0	0
Euglenophyceae	0	0	0	0	0	0	1	<1	17	<1	654	7	0	0	0	0	21	1	13	<1
Xanthophyceae	0	0	0	0	0	0	0	0	33	<1	1	<1	0	0	0	0	0	0	0	0
Total	493	100	828	100	1,281	100	1,222	100	13,464	100	9,817	100	1,516	100	339	100	2,548	100	3,420	100
Diversity	0.3		0.7		0.7		0.8		0.8		0.6		0.9		0.4		0.7		0.5	

[a]Density is the mean of two replicate samples rounded to the nearest whole number.
[b]Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-10

Mean Density[a](units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected from Rolling Stone Lake - Stations M-2 and M-4 October 1977, March, May and August 1978

	1977		1978					
	October		March		May		August	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Bacillariophyceae								
M-2	51	<1	0	0	327	9	680	3
M-4	170	2	66	<1	453	13	287	1
Chlorophyceae								
M-2	49	<1	0	0	45	1	9,687	42
M-4	30	<1	44	<1	82	2	12,057	47
Chrysophyceae								
M-2	13,509	97	26,640	71	2,761	76	9,462	41
M-4	7,112	81	22,152	68	2,383	69	9,380	37
Cyanophyceaee								
M-2	360	3	10,638	28	363	10	2,790	12
M-4	248	3	10,472	32	3,504	14	3,504	14
Dinophyceae								
M-2	0	0	0	0	24	1	0	0
M-4	0	0	0	0	82	2	0	0
Euglenophyceae								
M-2	0	0	44	<1	111	3	328	1
M-4	1,169	13	0	0	46	1	278	1
Total								
M-2	13,969		37,323		3,630		22,946	
M-4	8,727		32,735		3,468		25,515	
Diversity								
M-2	0.1		0.3		0.6		0.8	
M-4	0.3		0.3		0.7		0.8	

[a]Density is the mean of two replicate samples rounded to the nearest whole number.
[b]Calculated by Shannon-Weaver formula ($\log_{10}$) using total number of organisms presented.

Source: Dames & Moore, 1982
Checked by: WMW

Golden-brown algae were the most abundant phytoplankton collected during each sampling period except August 1978 when green algae were dominant. Golden-brown algae comprised over 41 percent of the phytoplankton in all samples at Station M-2 and over 37 percent in all samples at Station M-4. Unidentified *Chrysococcus*-like algae were the most abundant forms.

Green algae and blue-green algae were commonly collected but their peak abundances occurred at different times. Blue-green algae were most abundant in March 1978 and comprised from three to 32 percent of the phytoplankton. With the exception of August 1978, green algae comprised less than two percent of any collection.

Individual species of green algae and blue-green algae occurred sporadically and none were common. Organisms that comprised the majority of the green algal maximum in August 1978 were, in decreasing order of abundance, an unidentified green coccoid, *Ankistrodesmus falcatus*, and *Oocystis submarina*. During other months no species comprised more than two percent of any collections. *Spirulina laxa* was the only blue-green alga that was identified in March 1978; it comprised 28 and 32 percent of the phytoplankton at Stations M-2 and M-4, respectively, and was not found in other collections. Diatoms comprised from zero to nine percent of the phytoplankton at Station M-2 and from <1 to 13 percent at Station M-4. *Asterionella formosa*, *Cocconeis placentula*, and *Fragilaria* sp. were the only diatoms that comprised more than one percent of any collection.

Phytoplankton diversity ranged from 0.1 at Station M-2 in October 1977 to 0.8 at both stations in August 1978. In October, when diversity was lowest, golden-brown algae comprised 97 percent of the sample. In August 1978, diversity was highest and no taxon comprised more than 50 percent of the samples.

Mean chlorophyll a concentration in Rolling Stone Lake was 20 µg/L and ranged from 10 to 45 µg/L. Highest values were reported for March 1978 and August 1978 at Stations M-2 and M-4, respectively.

3.8.2.1.4 Little Sand Lake

Phytoplankton samples were collected from Stations H and I in Little Sand Lake in March 1977, monthly from May through October 1977, and in March, May, and August 1978. An additional grab sample was collected in July 1977 from the western shoreline when a red coloration of the water occurred. Density and relative abundance of the seven major taxa identified and enumerated during the study are presented in Table 3.8-11.

In 1977 density at Station H ranged from 10 units/mL in March to 4,665 units/mL in September and at Station I from 10 units/mL to 5,871 units/mL in the same months. With the exception of August 1977, densities were generally similar between stations.

In 1978 densities were considerably higher than during corresponding months in 1977. At Station H density ranged from 363 units/mL in March to 30,025 units/mL in August and at Station I from 110 to 33,321 units/mL in the same months.

Table 3.8-11

Mean Density[a] (units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected at Little Sand Lake - Station H and I March 1977, May Through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	units/mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%
Bacillariophyceae																				
H	1	8	25	2	1	<1	11	<1	2	<1	15	<1	27	8	2	1	47	1	0	0
I	1	11	5	<1	3	1	0	0	2	2	14	<1	13	2	1	1	59	1	38	<1
Chlorophyceae																				
H	<1	1	27	2	207	59	870	27	174	18	433	9	167	49	1	<1	0	0	494	2
I	<1	1	28	2	262	52	613	30	51	61	430	7	181	29	1	1	0	0	570	2
Chrysophyceae																				
H	<1	<1	1,556	93	60	17	412	13	720	76	362	8	128	37	354	97	4,160	88	1,729	6
I	0	0	1,475	95	81	16	261	13	8	10	136	2	421	68	108	98	5,144	87	2,166	6
Cyanophyceae																				
H	0	0	52	3	77	22	1,931	60	39	4	3,844	82	17	5	0	0	0	0	27,802	93
I	0	0	32	2	141	28	1,133	56	20	24	5,279	90	6	1	0	0	378	6	30,517	92
Dinophyceae																				
H	9	90	8	<1	9	3	0	0	8	1	5	<1	1	<1	6	2	0	0	0	0
I	9	88	7	<1	15	3	8	<1	2	3	0	0	2	<1	0	0	15	<1	0	0
Euglenophyceae																				
H	0	0	0	0	0	0	0	0	0	0	6	<1	0	0	0	0	495	11	0	0
I	0	0	0	0	1	<1	0	0	<1	<1	0	0	0	0	0	0	294	5	0	0

Table 3.8-11 *(Continued)*

	1977																1978			
	March		May		June		July		August		September		October		March		May		August	
	units/mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%	units/ mL	%
Xanthophyceae																				
H	0	0	0	0	0	0	0	0	2	<1	0	0	1	<1	0	0	0	0	0	0
I	0	0	0	0	0	0	0	0	0	0	13	<1	0	0	0	0	15	<1	0	0
Total																				
H	10	100	1,668	100	353	100	3,223	100	944	100	4,665	100	342	100	363	100	4,702	100	30,025	100
I	10	100	1,517	100	504	100	2,015	100	84	100	5,871	100	622	100	110	100	5,905	100	33,321	100
Diversity																				
H	0.5		0.5		1.0		0.6		0.5		0.4		1.0		0.1		0.5		0.2	
I	0.3		0.4		0.9		0.6		1.0		0.3		0.6		0.1		0.5		0.2	

[a]Density is the mean of two replicate samples rounded to the nearest whole number.
[b]Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms.

Source: Dames & Moore, 1982
Checked by: WMW

Overall, golden-brown algae, blue-green algae, and green algae were most abundant. Golden-brown algae were dominant (>85 percent of the collection) in May 1977 and March and May 1978 at both stations. In August 1977 they comprised 76 percent of the community at Station H but only 10 percent at Station I. In October 1977 they comprised 68 percent of the community at Station I, but only 37 percent at Station H in October 1977. Unidentified *Chrysococcus*-like algae were the dominant forms. Other commonly occurring forms were *Dinobyron sertularia*, *D. divergens*, and *D. bavaricum*.

Blue-green algae exhibited exceptionally high density in August 1978 (>30,000 units/mL), which was five to six times higher than densities enumerated in other sampling periods. Blue-green algae were the most abundant phytoplankton in July and September 1977 and August 1978 at both stations when they comprised 56 to 93 percent of the samples. In other sampling periods they comprised 24 percent or less of the collections. *Merismopedia tenuissima* was the most abundant blue-green algal species.

Green algae were the most abundant group in June 1977 at both stations, at Station I in August 1977, and Station H in October 1977. An unidentified coccoid was the most abundant of the green algae and *Selenastrum minutum* was commonly present.

An additional whole water sample was collected from a near-shore area in July 1977 where local residents noted a red coloration in the water. A single euglenoid member, *Phacus pyrum*, was identified from this sample. The algae occurred in the shallow water area along the northwestern shoreline and appeared to be responsible for the red coloration noted in that area.

The lowest diversity (0.1) occurred at both stations in March 1978 when the unidentified *Chrysococcus*-like algae comprised most of the sample (Table 3.8-11). The highest diversity (1.0) occurred at Station H in June and October 1977 and at Station I in August 1977 when no single taxon comprised more than 61 percent of the collection. The mean chlorphylll a concentration calculated from all samples taken in Little Sand Lake was <11 and 10 μg/L at Stations H and I, respectively.

3.8.2.1.5 Duck Lake

Phytoplankton samples were collected from Duck Lake in October 1977, March 1978, and monthly from May through October 1978. Density and relative abundance of the seven major taxa identified and enumerated during the study are presented in Table 3.8-12.

In 1978 numbers of phytoplankton were lowest in March, 983 units/mL, progressively increased to 23,918 units/mL in July, then declined to 2,830 units/mL in October. Density in October 1978 (2,830 units/mL) was considerably lower than the number collected in October 1977 (16,922 units/mL).

Golden-brown algae dominated the phytoplankton collections. Members of this class were the most abundant forms in every sampling period except May 1978 when blue-green algae were the most abundant. Unidentified *Chrysococcus*-like algae were dominant and comprised 95 percent of the golden-brown algae collection.

Table 3.8-12

Mean Density[a] (units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected at Duck Lake - Station K October 1977, March 1978 and May Through October 1978

	1977		1978													
	October		March		May		June		July		August		September		October	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Bacillariophyceae	38	4	0	0	12	<1	0	0	0	0	0	0	0	<0	16	1
Chlorophyceae	5	<1	60	6	0	0	3,324	29	10,511	44	2,194	10	496	3	93	3
Chrysophyceae	16,408	97	852	87	1,869	38	8,243	71	13,322	56	20,080	89	14,388	93	2,537	90
Cyanophyceae	0	0	5	<1	2,446	50	0	0	0	0	33	<1	89	1	101	4
Dinophyceae	465	3	0	0	390	8	0	0	86	<1	166	1	97	1	43	2
Euglenophyceae	0	0	66	7	150	3	43	<1	0	0	0	0	344	2	40	1
Xanthophyceae	5	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	16,922		983		4,867		11,610		23,918		22,473		15,413		2,830	
Diversity	0.2		0.3		0.5		0.4		0.4		0.2		0.3		0.3	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms.

Source: Dames & Moore, 1982
Checked by: WMW

Green algae were collected in every sampling period except May 1978 and comprised up to a maximum of 44 percent (July 1978). Commonly occurring green algal species were *Oocystis submarina* and *Selenasturm minutum* and unidentified members of the family Spondylomoraceae.

Blue-green algae comprised 50 percent of the organisms enumerated in May 1978 but were four percent or less during the other sampling periods. The only blue-green algae in May were genera of the family Chroococcaceae. Diversity values were low and ranged from 0.2 in October 1977 and August 1978 to 0.5 in May 1978 (Table 3.8-12).

The mean chlorophyll a concentration calculated for all Duck Lake samples was nine μg/L and ranged from two μg/L in June 1977 to 19 μg/L in October 1978. Values exhibited a bimodal distribution with high values in spring and late summer/autumn and low mid-summer levels.

3.8.2.1.6 Deep Hole Lake

Phytoplankton samples were collected from Deep Hole Lake in October 1977, March 1978, and monthly from May through October 1978. Density and relative abundance of the seven major taxa identified and enumerated during the study are presented in Table 3.8-13.

In 1978, phytoplankton density was lowest in March, 768 units/mL, increased to 16,194 units/mL in May, then progressively decreased to 4,758 units/mL in August. In September density increased to 11,710 units/mL then decreased to 9,102 units/mL in October. Density in October 1978 was considerably higher than in October 1977 (1,205 units/mL).

Golden-brown algae was the most abundant class of algae in all sampling periods ($\geq$72 percent) except March, May, and June 1978 when green algae or blue-green algae predominated. Golden-brown algae were represented primarily by unidentified *Chrysococcus*-like forms. Other common golden-brown algae were *Dinobyron sertularia*, *Chrysococcus major*, and *Mallomonas acaroides*.

Green algae was the most numerous class in March and June 1978, when it comprised 75 and 90 percent, respectively, of the collections. Common green algae were *Oocystis submarina*, *Selenastrum minutum*, and *Ankistrodesmus folcatus* var. *acicularis*.

Blue-green algae was the most abundant algal class in May 1978 when it constituted 60 percent of the sample. Blue-green algae were dominated by unidentified members of the family Chroococcaceae and *Merismopedia tenuissima*.

The minimum diversity of 0.1 occurred in October 1977 when the unidentified *Chrysococcus*-like algae comprised 93 percent of the sample (Table 3.8-13). The maximum diversity of 0.6 occurred in July 1978, when no class comprised more than 44 percent of the sample.

The mean chlorophyll a concentration recorded from Deep Hole Lake was $\leq$4 μg/L, and ranged from <1 to 10 μg/L. The highest mean concentration of 6.5 μg/L (mean of two replicates) occurred in October 1978.

Table 3.8-13

Mean Density[a] (units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected at Deep Hole Lake - Station L October 1977, March 1978 and May Through October 1978

	1977				1978											
	October		March		May		June		July		August		September		October	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Bacillariophyceae	7	1	1	<1	40	<1	0	0	43	1	27	1	15	<1	11	◁
Chlorophyceae	74	6	577	75	16	<1	13,992	90	1,309	16	428	9	2,649	23	608	7
Chrysophyceae	1,124	93	184	24	5,995	37	1,375	9	3,602	44	4,199	88	8,392	72	8,440	93
Cyanophyceae	0	0	2	<1	9,739	60	38	<1	3,295	40	93	2	59	<1	0	0
Dinophyceae	0	0	0	0	0	0	0	0	11	<1	3	<1	43	<1	0	0
Euglenophyceae	0	0	4	<1	404	2	120	1	0	0	8	<1	552	5	43	◁
Total	1,205		768		16,194		15,525		8,258		4,758		11,710		9,102	
Diversity	0.1		0.3		0.5		0.3		0.6		0.3		0.5		0.5	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms.

Source: Dames & Moore, 1982
Checked by: WM

3.8.2.1.7 Skunk Lake

Phytoplankton samples were collected from Station J in Skunk Lake monthly from June to October 1977. Density and relative abundance of the six major taxa identified and enumerated during the study are presented in Table 3.8-14.

Phytoplankton density in Skunk Lake ranged from 571 units/mL in October to 15,727 units/mL in September 1977.

Golden-brown algae comprised 75 percent or more of each sample. The most abundant golden-brown algal species were unidentified *Chrysococcus*-like algae.

Green algae was second in abundance, comprising from one to 25 percent of the phytoplankton collected. *Ankistrodesmus falcatus* was the most common green alga in June and July (92 and 97 percent of the assemblage, respectively) but was uncommon in subsequent collections. *Dictyosphaerium pulchellum, Elakatothrix gelatinosa* and *Scenedesmus brasiliensis* were common green algal species in various periods from August through October 1977.

Primarily because of the dominance of the unidentified golden-brown *Chrysococcus*-like algae, diversity values were low, ranging from 0.1 to 0.3. The highest diversity value occurred in July 1977 when golden-brown algae were lowest in abundance (75 percent of the collection).

The mean chlorophyll a level calculated from all samples was <81 µg/L. Values ranged from <1 µg/L in June 1977 to 395 µg/L in March 1978. During March 1978 when the highest chlorophyll a level was recorded, the phytoplankton samples were collected at a depth of approximately 0.5 m (1.6 feet). The ice cover at the sampling location was approximately 30.5 cm (12 inches) in thickness. There was patchy snow cover, which varied across the lake.

3.8.2.2 Results of Zooplankton Collections (1977-78)

3.8.2.2.1 Rice Lake

The studies conducted on Rice Lake included collection of zooplankton samples at Stations F and N during March and monthly from May to October 1977. Collections also were made at Station N in March, May, and August 1978. Zooplankton were classified into the orders Copepoda and Cladocera or the phylum Rotatoria; the density and relative abundance of these three major taxa are presented in Table 3.8-15.

The zooplankton community was generally similar at the stations in Rice Lake. In 1977, densities were lower than 50/L at both stations in March, May, and October. Peak densities of 342/L were observed in June at Station F and of 297/L at Station N. During July, August, and September densities at Station F decreased from 77 to 15/L, but at Station N densities increased from 17 to 169/L. During 1978, densities were considerably lower ($\leq$10/L) than in corresponding sampling periods in 1977 collections and were not greater than 10/L.

Table 3.8-14

Mean Density[a] (units/mL), Relative Abundance (%), and Diversity[b] of Phytoplankton Collected at Skunk Lake - Station J June Through October 1977

	1977									
	June		July		August		September		October	
	units/mL	%	units/mL	%	units/mL	%	units/mL	%	units/mL	%
Bacillariophyceae	37	<1	14	<1	60	1	48	<1	7	1
Chlorophyceae	1,177	16	1,456	25	729	7	125	1	25	4
Chrysophyceae	6,210	84	4,341	75	9,176	91	15,478	98	532	93
Cyanophyceae	12	<1	0	0	96	1	76	<1	4	1
Euglenophyceae	0	0	0	0	0	0	0	0	1	<1
Xanthophyceae	0	0	0	0	0	0	0	0	1	<1
Total	7,436		5,811		10,060		15,727		571	
Diversity	0.2		0.3		0.2		0.1		0.2	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated by Shannon-Weaver formula ($\log_{10}$) using total number of organisms presented.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-15

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Rice Lake - Stations F and N March 1977, May Through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera																				
F	<1	1	2	4	150	44	19	25	1	5	<1	4	<1	5	--	--	--	--	--	--
N	<1	2	3	14	219	74	1	6	19	14	3	2	<1	2	<1	3	3	28	1	13
Copepoda																				
F	4	39	4	8	102	30	52	68	12	55	7	48	<1	14	--	--	--	--	--	--
N	42	88	3	15	56	19	9	51	73	53	104	61	<1	5	5	78	3	36	4	43
Rotatoria																				
F	5	60	36	87	89	26	6	8	9	40	7	47	5	82	--	--	--	--	--	--
N	5	10	15	70	22	8	7	42	45	33	63	37	17	93	1	19	3	36	4	44
Total																				
F	9		42		342		77		22		15		6		--		--		--	
N	47		21		297		17		137		169		18		6		10		9	
Diversity							1.2													
F	0.9		0.9		1.0		1.2		0.9		1.0		0.5		--		--		--	
N	0.9		1.0		0.9				1.0		0.7		0.4		0.7		0.9		0.9	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated using the Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented.
-- No sample collected.

Source: Dames & Moore, 1982
Checked by: WMW

Community composition at Rice Lake fluctuated throughout the year. In 1977 rotifers were most abundant in March, May, and October at both stations, except at Station N in March when copepods were most common. In June, when highest total numbers were observed, cladocerans were most common, comprising 44 percent of the collection at Station F and 24 percent at Station N. Copepods were most abundant at both stations during July, August, and September, comprising 48 percent or more of the zooplankton collections.

In 1978 at Station N, Copepoda were abundant in March and were codominant with Rotatoria during May and August.

Nauplii were the most abundant copepod forms and cyclopoid copepodites occurred commonly. Common rotifer forms included *Trichocera longiseta*, *Ploesoma* sp., and *Synchaeta* sp. The most abundant cladoceran species were *Acroperus harpae*, *Chydorus sphaericus*, *Diaphanosoma brachyurum*, and *Eubosmina tubicen*. Diversity values during the period of investigation ranged from 0.4 at Station N in October 1977 to 1.2 at both stations in July 1977. The low value of 0.4 corresponded to an abundance of Rotatoria, which were represented primarily by *Synchaeta* sp. (67 percent of the zooplankton community).

3.8.2.2.2 Oak Lake

Zooplankton samples were collected from Oak Lake in March 1977; monthly from May through October 1977; and during March, May, and August 1978. Zooplankton enumerated from these samples were classified into two crustacean orders, Copepoda and Cladocera, or the phylum Rotatoria, and the mean density and relative abundance of these three major taxa are presented in Table 3.8-16.

In 1977 zooplankton density ranged from 164/L in June to 518/L in September. In 1978, density in March, 494/L, was higher than the previous year, 182/L, whereas densities in May, 194/L, and August, 89/L, were lower than corresponding collections in 1977, 307 and 247/L, respectively.

Copepods dominated the collections in March and May through August 1977 and August 1978 comprising 68 to 84 percent of the collections. Rotifers predominated the collections in September and October 1977 and March 1978, comprising 70 to 84 percent of the collections, and were codominant with copepods in May 1978. Common components of the copepod group were the immature naupliar and copepodite life stages and the adult calanoid *Diaptomus minutus*. *Kellicottia bostoniensis*, *K. longispina*, and *Keratella taurocephala* were commonly collected rotifer species.

Zooplankton diversity ranged from 0.3 in March 1978 to 0.9 in May 1977. The monthly values for samples collected in March and May 1978 were lower than for comparable months sampled in 1977.

3.8.2.2.3 Rolling Stone Lake

Zooplankton samples were collected from Rolling Stone Lake at Stations M-2 and M-4 in October 1977 and March, May and August 1978. Density and relative abundance of the major taxa identified and enumerated during the study are presented in Table 3.8-17.

Table 3.8-16

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Oak Lake - Station G March 1977, May Through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera	4	2	23	8	8	5	8	3	8	3	6	1	15	3	11	2	2	1	11	12
Copepoda	142	78	227	74	125	76	223	84	167	68	77	15	66	14	139	28	95	49	70	79
Rotatoria	37	20	56	18	31	19	34	13	72	29	435	84	378	82	344	70	96	50	9	10
Total	182		307		164		264		247		518		459		494		194		89	
Diversity	0.8		0.9		0.6		0.7		0.7		0.6		0.5		0.3		0.5		0.7	

[a]Density is the mean of two replicate samples rounded to the nearest whole number.
[b]Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-17

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected from Rolling Stone Lake - Stations M-2 and M-4 October 1977, March, May, and August 1978

	1977		1978					
	October		March		May		August	
	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera								
M-2	341	70	<1	2	2	<1	4	1
M-4	71	31	<1	2	1	<1	13	3
Copepoda								
M-2	110	22	<1	38	54	12	371	99
M-4	83	37	1	30	240	50	373	95
Rotatoria								
M-2	37	8	1	60	379	87	1	<1
M-4	72	32	1	68	236	49	4	1
Total								
M-2	488		1		434		376	
M-4	226		2		477		390	
Diversity								
M-2	0.4		0.9		0.4		0.6	
M-4	1.0		0.8		0.4		0.8	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated by Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented. Immature life stages were not included in the calculations.

Source: Dames & Moore, 1982
Checked by: WMW

Total zooplankton density per sampling period ranged from 1/L in March 1978 to 488/L in October 1977 at Station M-2, and from 2/L in March 1978 to 477/L in May 1978 at Station M-4. Densities were similar at both stations except in October 1977 when over twice as many organisms were collected at Station M-2 (488/L) than at Station M-4 (266/L).

Copepoda were the most numerous zooplankton enumerated during the investigation ranging from 12 to 99 percent at Station M-2 to 30 to 95 percent at Station M-4. The immature nauplii and cyclopoid copepodites were the most commonly collected copepod life stages. The adult *Diacyclops thomasi* and *Tropocyclops prasinus mexicanus* were the most commonly collected species. Rotatoria were second in abundance in the zooplanton collections. Rotifers comprised from <1 to 87 percent of the zooplankton at Station M-2 and from one to 68 percent at M-4. *Synchaeta* sp., *Keratella quadrata*, and *Polyarthra* sp. were the most commonly collected organisms. Cladocerans were most abundant in October 1977 when they comprised 70 (341/L) and 31 (71/L) percent of the respective collections at Stations M-2 and M-4. During other collections, they comprised ≤ three percent of the samples. *Eubosmina tubicen* and *Chydorus sphaericus* were the most common species encountered. Zooplankton diversity was lowest (0.4) in October 1977 at Station M-2 and at both stations in May 1978 (Table 3.8-17). Diversity was highest (1.0) at Station M-4 in October 1977.

3.8.2.2.4 Little Sand Lake

Zooplankton samples were collected from Little Sands Lake (Stations H and I) during March 1977, and monthly from May through October 1977 and March, May, and August 1978. Density and relative abundance of the three major taxa are presented in Table 3.8-18.

The lowest density of zooplankton occurred in March 1978 at both stations, 66/L at Station H and 75/L at Station I. The highest density was observed in June 1977 at Station H (419/L) and in May 1977 at Station I (293/L). Generally, collections in corresponding periods in 1977 and 1978 were similar.

Copepods were the most numerous zooplankton at both stations. This subclass comprised 47 percent or more of each collection. The copepods were primarily comprised of immature nauplii and calanoid copepodites, and adult *Diaptomus minutus*. Other adult species included *Diacyclops thomasi* and *Mesocyclops edax*. Rotifers were the second most abundant group at Little Sand Lake and comprised from 18 to 47 percent of the monthly samples. *Keratella taurocephala* was the primary rotifer identified.

Except for June 1977, cladocera never comprised more than 15 percent of the zooplankton community. In June, cladocerans represented 20 percent of the zooplankton sample at Station I, with their highest density (44/L). Cladocerans commonly found in the sample were *Diaphanosoma leuchtenbergianum*, *Eubosmina tubicen*, and *Daphnia dubia*. Zooplankton diversity was similar at Stations H and I and ranged from 0.4 in August 1977 at both locations and in July at Station H to 0.8 in May at Station I (Table 3.8-18).

Table 3.8-18

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Little Sand Lake - Stations H and I March 1977, May Through October 1977, and March, May and August 1978

	1977														1978					
	March		May		June		July		August		September		October		March		May		August	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera																				
H	<1	<1	0	0	40	9	15	7	7	2	39	12	13	8	1	1	5	2	13	9
I	<1	<1	2	1	44	20	14	8	13	6	22	9	9	4	1	1	2	1	25	15
Copepoda																				
H	73	82	225	59	195	47	148	72	162	57	159	47	100	59	37	56	196	60	104	72
I	102	64	209	71	123	54	120	65	132	57	128	55	100	49	39	52	132	69	100	61
Rotatoria																				
H	16	18	156	41	184	44	42	21	118	41	139	41	55	33	28	43	127	39	28	19
I	57	36	82	28	59	26	50	27	87	38	84	36	95	47	35	46	57	30	40	24
Total																				
H	90		381		419		205		287		338		168		66		329		145	
I	159		293		226		185		233		234		205		75		192		164	
Diversity																				
H	0.5		0.5		0.7		0.4		0.4		0.5		0.5		0.6		0.5		0.6	
I	0.6		0.8		0.7		0.5		0.4		0.5		0.6		0.7		0.6		0.6	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated using the Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented. Immature life stages were not included in the calculations.

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.2.5 Duck Lake

Zooplankton samples were collected from Duck Lake (Station K) during October 1977, March 1978, and monthly from May through October 1978. Density and relative abundance of the three major taxa are presented in Table 3.8-19.

In 1978, zooplankton density ranged from 25/L in May to 419/L in August. Density in October 1978 was considerably less than in October 1977. Rotifers were the most abundant organisms in all sampling periods except July and August 1978 when copepods were dominant. Rotifer abundance ranged from 12 percent in July 1978 to 99 percent in March 1978. *Keratella taurocephala* was the most abundant species. Individuals from the genera *Polyarthra* and *Synchaeta* were also common.

Copepods were highest in density in July (187/L) and August 1978 (283/L) when they comprised 65 and 68 percent of the respective collections. The greatest abundance of cladocerans was observed in June 1978 when they comprised 43 percent (116/L) of the sample. Among the copepods, the nauplii were the most common forms and the most abundant adult form was the cyclopoid *Mesocyclops edax*. *Eubosmina tubicen*, *Holopedium gibberum* and *Diaphanosoma leuchtenbergianum* were the most common cladoceran species.

Zooplankton diversity ranged from a low of 0.1 in September to a high of 0.7 recorded for both May and August (Table 3.8-19).

3.8.2.2.6 Deep Hole Lake

Zooplankton samples were collected from Deep Hole Lake (Station L) in October 1977, March 1978, and monthly from May through October 1978. Density and relative abundance of the three major taxa are presented in Table 3.8-20.

In 1978, density ranged from 68/L in March to 512/L in September. Density in October 1978 (234/L) was less than in October 1977 (693/L).

Rotifers were the most numerous of all zooplankton in October 1977, and June, August, September and October 1978 comprising from 59 to 84 percent of the collection. *Keratella cochlearis* and *K. taurocephala* were the most common rotifers collected.

Table 3.8-19

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Duck Lake - Station L October 1977, March 1978 and May Through October 1978

	1977		1978													
	Oct		March		May		June		July		Aug		Sept		Oct	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera	14	2	1	1	4	16	116	43	65	23	73	17	4	4	13	11
Copepoda	3	<1	1	1	1	6	22	8	187	65	283	68	4	4	9	8
Rotatoria	772	98	143	99	19	79	133	49	36	12	63	15	86	92	88	80
Total	789		145		25		272		288		419		94		110	
Diversity	0.2		0.3		0.7		0.6		0.5		0.7		0.1		0.3	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated using the Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented. Immature life stages were not included in the calculations.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-20

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Deep Hole Lake - Station L October 1977, March 1978 and May Through October 1978

	1977		1978													
	Oct		March		May		June		July		Aug		Sept		Oct	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera	110	16	<1	<1	8	7	20	16	44	40	15	5	61	12	61	26
Copepoda	51	7	49	72	73	62	31	25	40	35	30	11	58	11	19	8
Rotatoria	532	77	19	28	37	31	73	59	28	25	231	84	394	77	154	66
Total	693		68		118		124		112		275		512		234	
Diversity	0.7		0.6		1.0		0.9		0.8		0.6		0.6		0.9	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated using the Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented. Immature life stages were not included in the calculations.

Source: Dames & Moore, 1982
Checked by: WMW

Copepods were the most abundant organisms in March (72 percent) and May (62 percent) 1978 but comprised no more than 35 percent of any sample during the other sampling periods. Of the copepods, the immature naupliar form was the most abundant, and the cyclopoid and calanoid copepodites and the adult calanoid *Diaptomus minutus* were frequently identified but were never abundant. Cladocera were most abundant in July 1978 (40 percent) but generally did not comprise more than 26 percent of any sample. Although no single cladoceran species occurred in all of the samples, *Eubosmina tubicen*, *Daphnia dubia*, and *Holopedium gibberum* were the most common species.

Zooplankton diversity ranged from a low of 0.6 in March to a high of 1.0 in May (Table 3.8-20). From the maximum in May, diversity decreased through the summer months to 0.6 in September before increasing to 0.9 in October 1978.

3.8.2.2.7 Skunk Lake

Monthly zooplankton samples were collected from Skunk Lake (Station J) from June through October 1977. Density and relative abundance of the three major taxa identified are presented in Table 3.8-21.

The density of zooplankton was highest in July 1977 (1,293/L) but declined in subsequent months to a low of 35/L in October 1977.

Rotifers were the most abundant organisms in all samples and comprised from 47 to 88 percent of the organisms enumerated. *Conochilus unicornis* was the most numerous rotifer identified and represented 90 percent of the total rotifers during the study. Other rotifers identified were *Keratella quadrata* and *K. taurocephala*. The density of copepods was highest in June when 434/L (43 percent) were enumerated and lowest in October when 3/L (eight percent) were collected. Immature nauplii were the major component of Copepoda present. Other commonly collected copepods were calanoid copepodites and the adult calanoid *Diaptomus leptopus*.

The temporal distribution of cladocerans was irregular. This group comprised two percent or less (9/L) of the population in June, July and August but 24 percent (26/L) and 46 percent (16/L) in September and October, respectively. *Chydorus sphaericus* and *Daphnia* sp. were the numerically important cladocerans. Zooplankton diversity ranged from a low of <0.1 in July 1977 to a high of 0.8 in October 1977 (Table 3.8-21).

3.8.2.3 Results of Periphyton Collections (1977-78)

3.8.2.3.1 Rice Lake

Periphytic algae samples were collected from Rice Lake in the vicinity of Station F monthly from May through October 1977 and from Station N in May and monthly from July through October 1977, and May and August 1978. The relative abundances of the five major taxa identified during the study are presented in Table 3.8-22.

Table 3.8-21

Mean Density[a] (No./L), Relative Abundance (%), and Diversity[b] of Zooplankton Collected at Skunk Lake - Station J June Through October 1977

	June		July		August		September		October	
	No./L	%	No./L	%	No./L	%	No./L	%	No./L	%
Cladocera	7	1	9	1	6	2	26	24	16	46
Copepoda	434	43	150	12	88	28	17	16	3	8
Rotatoria	569	56	1,134	88	218	70	68	61	16	47
Total	1,010		1,293		311		112		35	
Diversity	0.5		<0.1		0.1		0.7		0.8	

[a] Density is the mean of two replicate samples rounded to the nearest whole number.
[b] Calculated using the Shannon-Weaver formula ($\log_{10}$) using total numbers of organisms presented. Immature life stages were not included in the calculations.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-22

Relative Abundance (%) of Major Taxa of Periphyton Collected From Water Bodies in the Swamp Creek Drainage Basin March, May Through October 1977 and May and August 1978

	1977							1978	
Location/Taxa	March	May	June	July	Aug	Sept	Oct	May	Aug
Rice Lake (F and N)									
Bacillariophyceae									
F	--	97	100	97	72	95	86	--	--
N	--	93	--	87	97	69	98	100	47
Chlorophyceae									
F	--	<1	<1	2	2	4	2	--	--
N	--	6	--	1	1	17	2	<1	2
Chrysophyceae								--	
F	--	0	0	0	19	0	0	0	--
N	--	0	--	0	0	0	0		16
Cyanophyceae									
F	--	2	0	1	6	1	12	--	--
N	--	1	--	12	2	8	0	0	35
Xanthophyceae									
F	--	0	0	0	0	0	0	--	--
N	--	0	--	0	0	6	0	0	0
Hemlock Creek (A-l)									
Bacillariophyceae	--	--	--	--	--	--	99	99	98
Chlorophyceae	--	--	--	--	--	--	0	<1	2
Chrysophyceae	--	--	--	--	--	--	0	<1	0
Cyanophyceae	--	--	--	--	--	--	1	<1	<1
Swamp Creek (D and E)									
Bacillariophyceae									
D	72	62	86	100	48	99	100	100	97
E	98	94	99	--	67	100	100	100	96
Chlorophyceae									
D	0	<1	0	0	<1	0	0	<1	3
E	0	2	1	--	<1	0	<1	0	3
Chrysophyceae									
D	1	34	0	0	52	0	0	0	0
E	1	0	0	--	33	0	0	0	0
Cyanophyceae									
D	27	3	14	0	<1	1	0	0	<1
E	1	4	0	--	0	0	0	0	<1

Table 3.8-22 *(Continued)*

Location/Taxa	1977 March	1977 May	1977 June	1977 July	1977 Aug	1977 Sept	1977 Oct	1978 May	1978 Aug
Rice Lake (F and N)									
Xanthophyceae									
D	0	0	0	0	0	0	0	0	0
E	0	0	0	--	<1	0	0	0	0
Euglenophyceae									
D	0	0	0	0	0	0	0	0	0
E	0	<1	0	--	0	0	0	0	0

-- Indicates no sample collected.

Source: Dames & Moore, 1982
Checked by: WMW

Diatoms comprised over 85 percent of the collections except during August or September. During August 1977 at Station F diatoms comprised 72 percent of the collections and during September 1977 and August 1978 at Station N diatoms made up 69 and 47 percent of the respective collections. The most abundant diatom enumerated from Rice Lake was *Cocconeis placentula*. The largest relative abundance (35 percent) of algae other than diatoms was recorded for the blue-green algae at Station N in August 1978 when *Chroococcus minor* was the most abundant blue-green algae species.

3.8.2.3.2 Hemlock Creek

Periphytic algae samples were collected from Station A-1 in October 1977 and May and August of 1978. The relative abundances of the four major taxa identified during the study are presented in Table 3.8-22. The periphyton community at Station A-1 consisted primarily of diatoms ($\leq$98 percent) and *Achnanthes minutissima* was most abundant. Other diatoms never comprised more than 10 percent of the periphyton community, except for *Fragilaria pinnata*, 16 percent in August 1978, and *A. microcephala*, 15 percent in May 1978.

3.8.2.3.3 Swamp Creek

Periphytic algae samples were collected at two locations in Swamp Creek upstream of Rice Lake, Stations D and E. Station D was sampled in March and monthly from May through October 1977 and May and July 1978, and Station E was sampled in March and monthly from May through July 1978, and Station E was sampled in March and monthly from May through July, September, and October 1977 and May and August 1978. The relative abundance of the six major taxa identified during the study are presented in Table 3.8-22.

Diatoms were the most abundant algae collected at both stations. This group comprised from 48 to 100 percent of the periphyton community at Station D and from 67 to 100 percent at Station E. The two most abundant diatom species encountered at both stations were *Cocconeis placentula* and *Achnanthes minutissima*.

Except for golden-brown algae, other major taxa did not comprise more than 27 percent of any one collection. Golden-brown algae, represented entirely by an unidentified *Chrysococcus*-like alga, accounted for 34 and 52 percent of the total periphyton at Station D in May and August 1977, respectively. The group accounted for 33 percent of the periphyton at Station E in August and were not found in May 1977. This motile algal form probably originated in an upstream, still water area. During the sampling period, there was a large beaver pond upstream of Station D that may have been the source of this algae.

3.8.2.3.4 Oak Lake

Periphyton samples were collected from Oak Lake monthly from May through October 1977 and May and August 1978. The relative abundances of the five major taxa identified are presented in Table 3.8-23.

Diatoms, green algae and golden-brown algae were most abundant in the collections. The relative abundance of diatoms exceeded 40 percent in all months sampled, except May 1977 and August 1978, and reached a maximum of 85 percent in October 1977. Abundant species of

Table 3.8-23

Relative Abundance (Percent Composition) of Major Taxa of Periphyton Collected from Oak Lake - Station G May Through October 1977, and May and August 1978

	1977						1978	
Taxa	May	June	July	August	September	October	May	August
Bacillariophyceae	22	56	52	49	55	85	44	13
Chlorophyceae	30	30	35	15	43	15	26	50
Chrysophyceae	46	0	0	32	0	0	2	30
Cyanophyceae	1	14	12	5	2	0	<1	6
Euglenophyceae	0	0	0	0	0	0	28	<1

Source: Dames & Moore, 1982
Checked by: WMW

diatoms throughout the study were *Tabellaria flocculosa*, *T. fenestrata*, and *Frustulia rhomboides* var. *crussinevira*.

The highest relative abundances for the green algae were recorded in September 1977 (43 percent) and August 1978 (50 percent). During the other months sampled, the relative abundances for the green algae ranged from 15 percent in both August and October 1977 to 35 percent in July 1977. Species of *Oedogonium* were the most abundant green algae during the study. Golden-brown algae comprised up to 46 percent of the periphyton in May 1977, exhibited similar abundance in August 1977 (32 percent) and 1978 (30 percent) and were absent or found in low abundances in other collections. The unidentified *Chrysococcus*-like algae were the most abundant golden-brown algae.

3.8.2.3.5 Rolling Stone Lake

Periphyite algae samples were collected from Rolling Stone Lake at Stations M-2 and M-4 during October 1977, and May and August 1978. The relative abundances of the four major taxa are presented in Table 3.8-24. Diatoms accounted for 78 percent or more of the periphyton community at both stations during the study. August 1978 was the only month of the study in which the average relative abundance of diatoms was less than 90 percent. Although 30 of the total 72 diatoms enumerated were common to both sampling locations, only *Cocconeis placentula* was abundant at both. *Fragilaria pinorata* was abundant at Station M-2, and *Cybella cistula*, *Achnanthes minutissima*, and *Rhoicospenia curvata* were abundant at Station M-4.

Unidentified *Chrysococcus*-like algae were the only golden-brown algae enumerated at Stations M-2 and M-4. These algae were collected only in August 1978 and comprised 21 and seven percent of the periphyton at Stations M-4 and M-2, respectively.

3.8.2.3.6 Streams Feeding Rolling Stone Lake

Periphytic algae samples were collected from Pickerel Creek at Station M-5 in October 1977 and May and August 1978. The relative abundances of the four major taxa identified during the study are presented in Table 3.8-24.

Diatoms accounted for 75 percent or more of the periphyton community. Golden-brown algae, blue-green algae and green algae comprised the remaining periphyton. the highest relative abundance for algae other than diatoms was 22 percent for the golden-brown algae in August 1978. Commonly occurring diatoms were *Eunotia curvata*, *Navicula minima*, and *Achnanthes lanceolata* and *A. minutissima*. The only golden-brown algae enumerated were unidentified *Chrysococcus*-like algae, which were encountered only in the August 1978 sample.

Periphytic algae samples were collected at Creek 12-9 (Station M-1) during October 1977 and May and August 1978. The relative abundances of the three major taxa identified during the investigation are presented in Table 3.8-24. Diatoms were the most common algae constituting 100 percent of the sample in October 1977 and subsequently decreasing to a relative abundance of 54 percent of the sample in August 1978. *Achnanthes minutissima* and *Cocconeis placentuala* were the most abundant diatoms.

Golden-brown algae were encountered only in August 1978 when the unidentified *Chrysococcus*-like algae and *Chrysococcus major* comprised 45 percent of the sample.

Table 3.8-24

Relative Abundance (%) of Major Taxa of Periphyton Collected from Creek 12-9, Creek 11-4, Pickerel Creek and Rolling Stone Lake October 1977, May and August 1978

	1977	1978	
Location/Taxa	October	May	August
Rolling Stone Lake (M-2)			
Bacillariophyceae	93	99	88
Chlorophyceae	0	0	3
Chrysophyceae	0	0	7
Cyanophyceae	7	1	1
Rolling Stone Lake (M-4)			
Bacillariophyceae	99	97	78
Chlorophyceae	0	3	<1
Chrysophyceae	0	0	21
Cyanophyceae	1	0	1
Pickerel Creek (M-5)			
Bacillariophyceae	99	98	75
Chlorophyceae	0	0	1
Chrysophyceae	0	0	22
Cyanophyceae	1	2	2
Creek 12-9 (M-1)			
Bacillariophyceae	100	92	54
Chlorophyceae	0	7	1
Chrysophyceae	0	0	45
Creek 11-4 (M-3)			
Bacillariophyceae	100	94	54
Chlorophyceae	0	6	0
Chrysophyceae	0	0	40
Cyanophyceae	0	0	6

Source: Dames & Moore, 1982
Checked by: WMW

Periphytic algae samples were collected at Creek 11-4 (Station M-3) during October 1977, and May and August 1978. The relative abundances of the four major taxa identified during the investigation are presented in Table 3.8-24. During the study, diatoms were the most abundant component of the periphyton. The lowest relative abundance (54 percent) of the diatoms occurred in August 1978, and was associated with a golden-brown algae relative abundance of 40 percent. No diatom was particularly dominant. The most abundant species that were found in every sampling period were *Achnanthes lanceolata, A. minutissima, Nitzschia palea,* and *Cocconeis placentula.*

The only golden-brown algae enumerated were the unidentified *Chrysococcus*-like forms. These algae exhibited a relative density of 40 percent of the periphyton during August 1978, and were not collected in October 1977 and May 1978.

3.8.2.3.7 Little Sand Lake

Periphytic algae samples were collected from Little Sand Lake (Stations H and I) monthly from May through October 1977 and May and August 1978. The relative abundances of the six major taxa identified during the study are presented in Table 3.8-25.

Diatoms were generally the dominant periphytic algal forms collected at Little Sand Lake. Diatoms comprised 53 percent or more of the periphytic algae except during summer and fall when diatoms decreased at times to seven to 32 percent of the samples at Stations H and I, respectively. Only one diatom, *Tabellaria flocculosa,* was consistently abundant at Little Sand Lake. Other common forms found at both stations were *T. fenestrata, Frustulia rhomboides* var. *saxonica,* and *Eunotia curvata.*

Green algae were commonly collected in the periphytic community at both stations. Green algae were most abundant at Station H in June 1977 (41 percent) and at Station I in October 1977 (66 percent). Abundant green algal forms were *Oedogonium* sp. and *Mougeotia* sp.

Golden-brown algae typically ranged from 0 to 17 percent but on three occasions (Station H in July 1977 and both stations in August 1978) their abundance increased to 58 to 72 percent of the community. The most common golden-brown algae were the unidentified *Chrysococcus*- like algae and *Chrysococcus major.*

Blue-green algae were found in all collections except May 1978. With the exception of September 1977, when 61 percent of the sample at Station H was composed of blue-green algae, this group comprised 12 percent or less of the collections.

Table 3.8-25

Relative Abundance (%) of Major Taxa of Periphyton Collected at Deep Hole, Duck, Little Sand and Skunk Lake May Through October 1977 and May Through October 1978

	1977						1978					
Location/Taxa	May	June	July	Aug	Sept	Oct	May	June	July	Aug	Sept	Oct
Little Sand Lake (H)												
Bacillariophyceae	53	55	8	60	22	63	62	--	--	7	--	--
Chlorophyceae	29	41	27	38	15	29	34	--	--	13	--	--
Chrysophyceae	17	0	61	1	2	0	4	--	--	72	--	--
Cyanophyceae	1	4	4	1	61	6	0	--	--	7	--	--
Euglenophyceae	0	0	0	0	0	0	0	--	--	1	--	--
Xanthophyceae	0	0	0	0	0	3	0	--	--	0	--	--
Little Sand Lake (I)												
Bacillariophyceae	61	73	56	52	77	32	68	--	--	18	--	--
Chlorophyceae	11	21	25	43	13	66	20	--	--	22	--	--
Chrysophyceae	16	0	7	3	1	2	13	--	--	58	--	--
Cyanophyceae	12	6	11	2	9	<1	0	--	--	3	--	--
Duck Lake (K)												
Bacillariophyceae	--	--	--	--	--	22	51	70	34	37	32	64
Chlorophyceae	--	--	--	--	--	50	49	20	11	15	20	28
Chrysophyceae	--	--	--	--	--	0	<1	8	14	37	28	2
Cyanophyceae	--	--	--	--	--	1	0	2	40	8	7	1
Euglenophyceae	--	--	--	--	--	0	0	<1	0	<1	13	5

Table 3.8-25 (*Continued*)

Location/Taxa	1977 May	1977 June	1977 July	1977 Aug	1977 Sept	1977 Oct	1978 May	1978 June	1978 July	1978 Aug	1978 Sept	1978 Oct
Little Sand Lake (H)												
Xanthophyceae	--	--	--	--	--	0	0	0	0	2	0	0
Dinophyceae	--	--	--	--	--	27	0	0	0	0	0	0
Deep Hole Lake (L)												
Bacillariophyceae	--	--	--	--	--	69	60	66	42	34	43	51
Chlorophyceae	--	--	--	--	--	31	9	16	48	29	36	32
Chrysophyceae	--	--	--	--	--	<1	30	17	4	33	9	5
Cyanophyceae	--	--	--	--	--	0	<1	1	6	4	2	11
Euglenophyceae	--	--	--	--	--	0	0	0	0	0	10	2
Dinophyceae	--	--	--	--	--	0	0	0	0	<1	0	0
Skunk Lake (J)												
Bacillariophyceae	--	83	25	28	98	87	--	--	--	--	--	--
Chlorophyceae	--	14	3	17	2	9	--	--	--	--	--	--
Chrysophyceae	--	0	72	56	0	0	--	--	--	--	--	--
Cyanophyceae	--	3	1	<1	<1	4	--	--	--	--	--	--

-- Indicates no sample collected.

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.3.8 Duck Lake

Periphytic algae samples were collected from Duck Lake during October 1977 and monthly from May through October 1978. The relative abundances of the seven major taxa are presented in Table 3.8-25.

Diatoms dominated the periphytic algal community in June and October 1978 comprising 70 and 64 percent of the collections, respectively. Diatom abundance was similar to that of green algae in May 1978, and blue-green algae in August and September 1978. *Tabellaria fenestrata* was the most abundant diatom and *T. flocculosa* was commonly collected but in low abundance.

Green algae were most abundant in October 1977 (50 percent) and May 1978 (49 percent). At other times their relative abundance did not exceed 28 percent of the collections. *Oedogonium* sp. and *Ulothrix* sp. were the most abundant green algal forms. Golden-brown algae comprised 37 and 28 percent of the community in August and September 1978, respectively, but other times did not exceed 14 percent. Blue-green algae comprised 40 percent of the collection in July 1978 but did not exceed 8 percent during any other sampling periods. Common golden-brown algae included an unidentified *Chrysococcus*-like algae and *Chrysococcus major*. *Hapalosiphon flexuosus* was the most common blue-green algal species.

3.8.2.3.9 Deep Hole Lake

Periphytic algae samples were collected from Deep Hole Lake during October 1977 and monthly from May through October 1978. The relative abundance of the six major taxa identified during the study is presented in Table 3.8-25.

Diatoms, green algae, and golden-brown algae were the predominant groups of periphytic algae. Diatoms were most abundant (43 to 69 percent) in spring and autumn. However, they were similar in abundance to green algae in July 1978 and to green algae and blue-green algae in August 1978. The most abundant diatom species was *Tabellaria flocculosa*, and *T. fenestrata* was commonly collected. Green algae generally were second in abundance to diatoms throughout the study. The most common green algal form encountered was the genus *Oedogonium*. The primary forms of golden-brown algae were the unidentified *Chrysococcus*-like algae.

3.8.2.3.10 Skunk Lake

Periphytic algae samples were collected from Skunk Lake monthly from June through October 1977. The relative abundances of the four major taxa identified during the investigation are presented in Table 3.8-25.

Diatoms were the most abundant periphytic algal class collected in June, September and October 1977 comprising over 80 percent of these samples. However, their abundance decreased to <30 percent of the July and August collections. The most abundant diatom was *Nitzschia palea*. Other common forms were *Frustulia rhomboides* var. *saxonica*, *Tabellaria flocculosa* and *T. fenestrata*.

Golden-brown algae comprised 72 and 56 percent of the July and August samples, respectively. The collections primarily consisted of unidentified *Chrysococcus*-like algae.

3.8.2.3.11 Wolf River

A summary of characteristics of the Wolf River is presented in Table 3.8-26. From its source to the Town of Pearson, the river has a generally flat gradient, 0.7 m/km (3.7 feet/mile), reflecting the large areas of lakes and wetlands through which it flows. Below Pearson the character of the river begins to change and the gradient becomes steeper, 1.9 m/km (9.8 feet/mile), and several rapids are found in this stretch of river.

Samples were collected at the Wolf River at Station Y, located upstream from the confluence with Swamp Creek, and Station Z, located downstream of the confluence with Pickerel Creek (Figure 3.8-1). Periphytic algae samples were collected from the Wolf River, Stations Y and Z, during October 1977 and May, July, and October 1978. The relative abundances of the four major taxa identified during the study are presented in Table 3.8-26.

Periphytic algal communities were generally similar at the two Wolf River stations. Diatoms accounted for 94 to 100 percent of each sample except in August 1978 when their relative abundance decreased to 17 and 37 percent at Stations Y and Z, respectively. *Cocconeis placentula*, *Fragilaria pinnata*, and *Achnanthes minutissima* were the most abundant diatoms at both stations.

In August 1978, golden-brown algae, which generally accounted for five percent or less of any collection, comprised 58 and 62 percent of the samples at Stations Y and Z, respectively. The unidentified *Chrysococcus*-like algae were the only golden-brown algae collected.

3.8.2.4 Results of Aquatic Macrophytic Collections (1977-78)

3.8.2.4.1 Rice Lake

Dames & Moore (1982) described the aquatic macrophyte community of Rice Lake as dense and consisting mainly of emergent species with some submersed and floating species (Figure 3.8-14). Most of the emergent vegetation in the central portion of the lake was wild rice *Zizania aquatica* interspersed with sparse beds of yellow water lily *Nuphar variegatum* and arrowhead *Sagittaria latifolia*. Moderate to dense beds of water marigold *Megalodonta beckii*, flatstem pondweed *Potamogeton zosteriformis*, and pondweed *P. friesii* were also observed.

The channel area where Swamp Creek meanders through Rice Lake was characterized by dense submerged vegetation, primarily coontail *Ceratophyllum demersum* and water weed *Elodea canadensis*, with moderate occurrences of the previously listed emergent species.

The Swamp Creek inlet area of Rice Lake was characterized by a dense emergent growth of bulrush *Scirpus fluviatilis* and bur reed *Sparganium eurycarpum*. The vegetation in the shallow area adjacent to the south shore of the lake was composed of sparse to moderate beds of arrowhead, yellow water lily, water weed, and water lily (*Nymphaea tuberosa*).

Floating vegetation, observed throughout the lake, consisted primarily of big duckweed (*Spirodela polyrhiza*) and star duckweed(*Lemna trisulca*). The common emergent shoreline vegetation included moderate stands of cattail (*Typha latifolia*), sedge (*Scirpus validus*), and water hemlock (*Cicuta bulbifera*). Results of aquatic macrophyte investigation completed in 1994 are included in Section 3.9 where a complete inventory of plants is provided.

Table 3.8-26

Relative Abundance (Percent Composition) of Major Taxa of Periphyton Collected from the Wolf River, Stations Y and Z October 1977 Though October 1978

	1977	1978		
Taxa	October	May	August	October
Bacillariophyceae				
Y	96	98	17	100
Z	99	100	37	94
Chlorophyceae				
Y	0	0	19	0
Z	1	0	1	<1
Chrysophyceae				
Y	0	1	58	0
Z	0	0	62	5
Cyanophyceae				
Y	4	0	6	0
Z	0	0	<1	<1

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.4.2 Oak Lake

Aquatic vegetation was present along the northern, eastern, and southwestern shorelines of Oak Lake in the littoral zone in water ≤ m (3.3 feet) in depth (Figure 3.8-14). Stands were sparse and were comprised primarily of spike rush (*Eleocharis smallii*). Water lobelia (*Lobelia dortmann*), pipewort (*Eriocaulon septangulare*), bur reed (*Sparganium angustifolium*), and rush (*Juncus pelocarpus*) were also identified but collectively occupied less than 50 percent of all aquatic macrophytes encountered. The WDNR also found dwarf milfoil (*Myriophyllum tenellum*), waterwort (*Elatine minima*), three-way sedge (*Dulichium arundinaceum*), and marsh purselane (*Ludwigia palustris*) (Ramharter, 1982).

3.8.2.4.3 Pond 25-11

Dense growths of yellow water lily were observed throughout the pond (Figure 3.8-14). The two predominant plant types located in moderate growths along the mud banks of the pond were spike rush (*Eleocharis obtusa*) and carex (*Carex rostrata*). Other incidental shoreline vegetation included St. John's-wort (*Hypericum majus*), beggar's tick (*Bidens cernua*), manna grass (*Glyceria boeralis*), and smartweed (*Polygonum pensylvanicum*).

3.8.2.4.4 Hoffman Springs

The aquatic vegetation was very sparse throughout the pond. The vegetation that was observed in shoreline areas was bitter cress (*Cardamine pensylvanica*) and muskgrass (*Chara* sp.).

3.8.2.4.5 Rolling Stone Lake

Submersed aquatic vegetation in Rolling Stone Lake was dense, floating vegetation was moderate, and emergent vegetation was sparse (Figure 3.8-14).

The submersed vegetation throughout the lake consisted predominantly of water milfoil (*Myriophyllum exalbenscens*), flatstem pondweed and whitestem pondweed (*Potamogeton praelongus*) (WDNR, 1978). Additional observations in the northern littoral area of the lake between Pickerel Creek and Creek 12-9 (Figure 3.8-14) indicated that these same macrophytes were predominant although coontail and water weed were also common. Vegetation beds near Pickerel Creek included sparse stands of sedge (*Carex* sp.), whereas shoreline areas adjacent to Creek 12-9 included moderate beds of white water lily (*Nymphaea* sp.) and yellow water lily (*Nuphar* sp.). Interspersed within these beds in moderate to sparse occurrence were the floating species star duckweed, big duckweed, and duckweed (*Lemna minor*). Additional shoreline vegetation between Creeks 11-4 and 12-9 included sparse stands of bulrush (*Scirpus* sp.). In addition, the WDNR found wild celery (*Vallisneria americana*), sago pondweed (*Potamogeton pectinatus*) and bur reed (*Sparganium* sp.) in Rolling Stone Lake (Ramharter, 1982).

3.8.2.4.6 Little Sand Lake

Aquatic macrophyte vegetation in Little sand Lake was located primarily along shoreline areas in water depths to one m (3.3 feet) (Figure 3.8-14). The pondweed *Potamogeton epihydrus*, which occurred sparsely throughout the lake, was typically found at depths less than one m (3.3 feet).

Aquatic macrophyte beds in the shallow ares along the northern, eastern and southwestern shore areas, characterized primarily by sandy substrates, were dominated by spike rush. This spike rush comprised approximately 75 percent of the vegetative cover in these areas. Other species common in these areas were: yellow water lily (*Nuphar variegatum* and *N. rubrodiscum*), waterwort (*Elatine triandra*), narrow-leaved bur reed (*Sparganium angustifolium*), mud rush (*Juncus pelocarpus*), water lobelia, and bulrush (*Scirpus torreyi*). Vegetation along the northeastern shoreline area that had primarily silt-organic substrate was characterized by yellow water lily (*Nuphar rubrodiscum*), bur reed (*Sparganium fluctuans*), and pondweed (*Potamogeton epihydrus*). Common species in the southeastern portion of the lake were watershield (*Brasenia schreberi*), arrowhead (*Sagittaria graminea*), yellow water lily (*N. rubrodiscum*), pipewort, and fluctuating bur reed (*Sparganium fluctuans*). Sparsely occurring macrophytes, including the white water lily (*Nymphaea tuberosa*) and bur reed (*Sparganium angustifolium*), were observed in the southwestern area of the lake at a water depth of 1.2 m (four feet).

Additional species found by the WDNR were spike rush (*Eleocharis smallii*), quillwort (*Isoete* spp.), three-way sedge, water hemlock (*Cicuta bulbifera*), and dwarf milfoil (Ramharter, 1982).

3.8.2.4.7 Deep Hole Lake

The primary areas of vegetation in the littoral zone of Deep Hole Lake extended from the shoreline to a depth of one m (3.3 feet) (Figure 3.8-14). Common aquatic macrophyte species, in order of apparent relative abundance, were arrowhead (*Sagittaria latifolia*), spike rush (*Eleocharis smallii*), yellow water lily (*Nuphar variegatum*), and pondweed (*P. epihydrus*). These species were observed in moderate stands in all areas along the northern, western, southwestern and eastern shorelines. Bur reed (*Sparganium fluctuans*) and cattail were observed in sparse stands along parts of the southern and eastern lake shoreline areas. The only aquatic macrophyte found at depths less than one m (>3.3 feet) was the pondweed, which occurred infrequently.

Nonwoody vegetation found in shoreline wetland areas was commonly comprised of cut grass (*Leersia oryzoides*), manna grass (*Glyceria canadensis*), and sedges (*Scirpus cyperinus, Carex rostrata*, and *Dulichium arundinaceum*). Less common species in these areas included beggar's tick and marsh St. John's wort (*Triadenum fraseri*).

Additional species found by the WDNR were arrowhead (*Sagittaria* sp.), bladderwort (*Utricularia vulgaris*), water arum (*Calla palustris*), water lobelia, pipewort, rush, *Juncus pelocarpus*, waterwort (*Elatine minima*) and quillwort (*Isoette echinospora*) (Ramharter, 1982).

3.8.2.4.8 Duck Lake

Aquatic macrophytes are primarily limited to sparse growths in southern and northwestern areas of Duck Lake (Figure 3.8-14). Species that were found in these areas and that comprised approximately 75 percent of the macrophyte community were yellow water lily (*Nuphar variegatum*) and bur reed (*Sparganium fluctuans*). Water arum was also observed but was limited in abundance.

Other species occurring in sparse stands were pipewort and water lily (*Nymphaea* sp.). Pipewort was observed along the southern portions of the lake shore, and the water lily primarily along the

northwestern shore. A moss mat composed of *Drepanocladus exannulatus* overlaid the sediment over most of the lake.

Uprooted vegetation that consisted primarily of pondweed (*Potamogeton confervoides*), a species listed as threatened in Wisconsin, was found along the east and southeast shoreline in July 1980. The identification of this species was made by Dr. H. Iltis of Madison, Wisconsin, from several intact specimens. In addition to the lake vegetation survey in 1978, littoral areas of the lake were searched in July and October 1980 from a canoe and the deep portions in October 1980 utilizing snorkel and scuba gear, specifically to locate this rooted aquatic plant. No rooted specimens were found.

Additional species found by the WDNR in verification studies were white water lily (*Nymphaea tuberosa*), pipewort, pondweed (*Potamogeton epihydrus*), manna grass (*Glyceria canadensis*), three-way sedge (*Carex limosa*), pitcher plant (*Sarracenia purpurea*), bog cinquefoil (*Potentilla palustris*). iris (*Iris versicolor*), small bur reed (*Sparganium minima*), quillwort (*Isoeste* sp.), *Nitella* sp., and arrowhead (*Sagittaria* sp.) (Ramharter, 1982).

3.8.2.4.9 Skunk Lake

Generally, aquatic vegetation occurred in moderate stands throughout the lake but was most abundant along shoreline areas (Figure 3.8-14). The vegetation was primarily pondweed (*Potamogeton* sp.) and yellow water lily (*Nuphar variegatum*). Shoreline areas were characterized by moderate growths of spike rush.

Additional species reported by the WDNR in Skunk Lake were three-way sedge (*Dulichium arundinaceum*), Robbin's pondweed (*Potamogeton robbinsii*), bulrush (*Scirpus* sp.), cattail (*Typha latifolia*), bladderwort (*Utricularia* sp.), sphagnum moss (*Sphagnum* sp.), leatherleaf (*Chamaedaphne calyculata*), and water moss (*Drepnocladus* sp.) (Druckenmiller, 1983).

3.8.2.4.10 Pond 31-13

Moderate to sparse vegetation growths in Pond 31-13 included bladderwort and yellow water lily (*Nuphar variegatum*) (Figure 3.8-14). Other sparsely occurring shoreline and wetland vegetation included sedges (*Carex oligosperma* and *C. limosa*) and pitcher plant (*Sarracenia* sp.).

3.8.2.4.11 Pond 6-8

Aquatic macrophytes observed in moderate stands in Pond 6-8 were yellow water lily (*Nuphar variegatum*) throughout the pond and water arum along the shoreline and adjacent wetland areas (Figure 3.8-14). Other vegetation occurring in moderate to sparse stands along the shoreline included white water lily, and the sedges *Dulichium arundinaceum* and *Carex limosa*. Common nonwoody, riparian vegetation, which contained a variety of plant types associated with bog areas, included primrose (*Lysimaehia terrestris*), beggar's tick (*Bidens comosa*), marsh cinquefoil, iris, marsh St. John's-wort, sundew (*Drosera* sp.), and pitcher plant.

3.8.2.4.12 Pond 35-7

Yellow water lily (*Nuphar variegatum*) was observed in moderate to dense growths throughout Pond 35-7 (Figure 3.8-14). Other macrophytes occurring moderately to sparsely in limited areas

along shoreline or marginal wetland areas were as follows: cattail, water arum, pondweed (*Potamogeton epihydrus*), the sedges *Carex lacustris, C. crawfordii* and *C. comosa*, and the grass *Muhlenbergia glomerata*. Additional species found by the WDNR in verification studies were muskgrass, (*Chara* sp.), water hemlock, and pitcher plant (*Sarracenia purpurea*) (Ramharter, 1982).

3.8.2.4.13 Pond 34-1

The aquatic vegetation located within and along the shoreline of Pond 34-1 included sparse growths of bladderwort (*Utricularia vulgaris* var. *americana*), coontail, water arum, bulrush (*Scirpus cyperinus*), and duckweed (*Lemna* ef. *minor*) (Figure 3.8-14). Wetland vegetation occurring in moderate abundance included marsh bluebell (*Campanula aparinoides* var. *grandiflora*) and water hemlock. Additional species found by the WDNR in verification studies were pitcher plant (*Sarracenia purpurea*), yellow water lily (*Nuphar variegatum*), and water hemlock (Ramharter, 1982).

Aquatic macrophytes and vascular plants along the adjacent stream banks were inventoried in Swamp Creek and the Wolf River in June 1983. The relative abundance of rooted aquatic vegetation was higher in the upstream portion of Swamp Creek and was reduced in the downstream segment and in the Wolf River (Table 3.8-27). The most abundant species throughout Swamp Creek and the Wolf River were water-weed (*Anacharis canadensis*), arrowhead (*Sagittaria* sp.), bur reed (*Sparganium* sp.), and pondweed (*Potamogeton epihydrus* and *P. praelongus*). Several small scattered patches of northern manna grass (*Glyceria borealis*) were also present in the lower portion of Swamp Creek in the floating leaf form. No wild rice beds were identified.

Total areal coverage of the bottom by rooted vascular plants ranged from approximately 80 percent in some areas upstream of County Trunk Highway K to 20 percent in portions of the downstream segment of Swamp Creek. Plant species composition of the bottom and adjacent bank of Swamp Creek and the Wolf River was typical for the existing substrate and flow conditions.

3.8.2.5 Results of Benthic Macroinvertebrate Collections conducted in 1977 and 1978.

3.8.2.5.1 Rice Lake

Benthic macroinvertebrate samples were collected from Rice Lake at Stations F and N in March, May, August, and October 1977 and March 1978, and from Station N in May and August 1978. The eight major taxa collected in quantitative sampling and their relative abundance are presented in Table 3.8-28. A total of 103 and 114 taxa were identified during quantitative sampling conducted at Stations F and N, respectively, and an additional eight taxa were collected in qualitative samples from Rice Lake.

Table 3.8-27

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Wolf River - Stations Y and Z March, May, August, and October 1978

	March		May		August		October	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta								
Y	273	1	2,644	31	101	2	29	2
Z	72	1	1,149	13	3,664	28	1,394	26
Isopoda								
Y	0	0	29	<1	0	0	0	0
Z	0	0	0	0	0	0	0	0
Amphipoda								
Y	675	4	1,552	18	0	0	0	0
Z	0	0	646	8	72	1	101	2
Ephemeroptera								
Y	58	<1	14	<1	14	<1	0	0
Z	0	0	29	<1	503	4	0	0
Trichoptera								
Y	302	2	72	1	43	1	0	0
Z	29	<1	460	5	560	4	58	1
Chironomidae								
Y	2,126	11	2,126	25	2,471	37	0	0
Z	503	8	2,399	28	2,313	18	43	1
Gastropoda								
Y	9,180	48	1,135	13	1,437	22	345	18
Z	3,692	58	1,135	13	1,940	15	1,925	36
Pelecypoda								
Y	1,034	5	388	5	2,284	34	1,078	57
Z	1,623	26	129	2	1,451	11	359	7
All Others[c]								
Y	5,387	28	618	7	287	4	445	24
Z	445	7	2,644	21	2,457	19	1,494	28
Total								
Y	19,036	100	8,577	100	6,637	100	1,896	100
Z	6,364	100	8,591	100	12,959	100	5,373	100
Diversity								
Y	0.6		1.0		0.7		0.6	
Z	0.6		1.0		1.1		0.9	

[a] Density is the mean of three or five replicate samples.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the numbers of organisms.
[c] Includes Coelenterata, Tricladida, Alloeocoela, Nemertea, Nematoda, Hirudinea, Hydracarina, Anisoptera, Zygoptera, Hemiptera, Lepidoptera, Coleoptera and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-28

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Rice Lake - Stations F and N March, May, August and October 1977, and March, May and August 1978

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta														
F	1,905	9	3,267	16	5,034	30	10,146	31	3,477	15	--	--	--	--
N	60	1	1,052	4	11,947	21	1,060	6	603	1	144	1	1,250	12
Isopoda														
F	0	0	0	0	0	0	0	0	29	<1	--	--	--	--
N	9	<1	0	0	0	0	0	0	0	0	0	0	29	<1
Amphipoda														
F	9,051	44	3,534	17	4,681	28	2,724	8	3,276	14	--	--	--	--
N	2,095	34	3,026	11	11,534	20	4,431	27	8,347	18	3,189	18	3,592	33
Ephemeroptera														
F	43	<1	34	<1	172	1	17	<1	29	<1	--	--	--	--
N	60	1	17	<1	78	<1	60	<1	0	0	0	0	0	0
Trichoptera														
F	69	<1	69	<1	9	<1	34	<1	72	<1	--	--	--	--
N	60	1	328	1	60	<1	43	<1	58	<1	101	1	115	1
Chironomidae														
F	5,413	26	6,603	32	1,965	12	7,439	23	6,882	30	--	--	--	--
N	2,465	40	17,024	62	23,162	40	3,569	22	9,108	20	3,132	17	2,399	22
Gastropoda														
F	3,017	15	2,957	14	2,345	14	8,008	24	7,614	33	--	--	--	--
N	595	10	3,526	13	3,198	6	4,888	30	25,041	54	9,051	50	1,911	18

Table 3.8-28 (*Continued*)

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Pelecypoda														
F	379	2	3,120	15	948	6	1,940	6	216	1	--	--	--	--
N	491	8	129	<1	52	<1	466	3	474	1	330	2	431	4
All Others[c]														
F	552	3	1,328	6	1,465	9	2,604	8	1,250	5	--	--	--	--
N	310	5	2,146	7	7,956	14	2,008	12	3002	6	2,212	12	1,006	9
Total														
F	20,429	100	20,912	100	16,691	100	32,911	100	22,843	100	--	--	--	--
N	6,146	100	27,248	100	57,987	100	16,524	100	46,635	100	18,160	100	10,732	100
Number of Replicates	5		5		5		5		3		3		3	
Diversity														
F	0.9		1.3		1.1		1.1		1.0		--		--	
N	0.8		1.3		1.1		1.0		1.1		0.9		1.0	

[a] Density is the mean of three or five replicate samples, as indicated above, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total numbers of organisms presented.
[c] Includes Hydracarina, Coelenterata, Tricladida, Lepidoptera, Coleoptera, Alloeocoela, Hirudinea, Ostracoda, Odonata, Hemiptera, Nematoda, and Diptera other than Chironomidae.

-- No sample collected.

Source: Dames & Moore, 1982
Checked by: WMW

In 1977, considerably greater fluctuations in density of benthic macroinvertebrates occurred at Station N than at Station F. At Station F density ranged from 16,691/m^2 in August to 32,911/m^2 in October, and at Station N from 6,146/m^2 in March to 57,987/m^2 in August. In 1978 at Station N densities in March, May, and August differed up to seven fold (March) from corresponding months in 1977 but were within the range observed throughout 1977. The four most commonly collected groups at Rice Lake were Chironomidae (midges), Amphipoda (amphipods), Oligochaeta (worms), and Gastropoda (snails) (Table 3.8-28). The common midges at both sampling locations were *Dicrotendipes* sp., *Chironomus* sp., *Procladius* sp., and *Tanytarsus* sp.

The amphipod most commonly found in the benthic samples from the two Rice Lake sampling locations was *Hyalella azteca*; other amphipods identified were *Cragonyx* sp. and *Gammarus pseudolimnaeus*. Enumerations of worms from the two Rice Lake sampling locations indicated that naidid species, *Nais* sp. and *Dero digitata*. were most abundant, although immature tubificid forms were occasionally collected in moderate to high densities. *Amnicola* sp. was the most numerous snail collected.

Mean benthic diversity values were similar for these two sampling locations and ranged from 0.8 at Station N in March 1977 to 1.3 at both Stations N and F in May 1977 (Table 3.8-28).

3.8.2.5.2 Hemlock Creek

Macroinvertebrate samples were collected from Hemlock Creek at Station A-1 in June, August, and October 1977, and March, May, and August 1978. The nine major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-29.

In 1977, total density of benthic forms ranged from 2,069/m^2 in June to 23,877/m^2 in October. In 1978 density ranged from 14,166/m^2 in March to 28,388/m^2 in May. The community was dominated by midges, which comprised from 57 to 92 percent of numbers collected. *Tanytarsus* sp. and *Procladius* sp. were the most abundant genera.

Benthic organisms from other major taxonomic groups, mayflies and worms, were commonly collected but comprised not more than 16 percent of any sample. Members of the genus *Caenis* were the most abundant mayfly, and the immature tubificid form with hair setae was the most abundant worm enumerated during the study.

Pelecypods (clams) enumerated from Hemlock Creek were typically from the family Sphaeriidae, although one specimen from the family Unionidae was recorded. The mature spaeriids enumerated were *Pisidium* sp. and *Sphaerium* sg. The benthic diversity values at Hemlock Creek were relatively consistent. They ranged from 0.6 in June 1977 and May 1978 to 1.0 in October 1977 and August 1978 and averaged 0.8 (Table 3.8-29).

Taxa collected by the WDNR during verification studies were collected from Swamp Creek at Stations D and E in March, May, August, and October 1977 and March, May, and August 1978. The eight major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-30. A total of 126 and 106 taxa were identified in quantitative samples and an additional nine and 16 taxa were identified in qualitative samples from Stations D and E, respectively.

Table 3.8-29

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Hemlock Creek - Station A-1 June, August and October 1977, and March, May and August 1978

	1977						1978					
	June		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta	216	10	724	3	974	4	101	1	445	2	761	4
Isopoda	0	0	0	0	0	0	0	0	14	<1	0	0
Amphipoda	17	1	0	0	34	<1	29	<1	43	<1	115	1
Ephemeroptera	0	0	95	<1	3,414	14	216	2	302	1	3,060	16
Trichoptera	9	<1	0	0	60	<1	58	<1	101	<1	618	3
Chironomidae	1,172	57	18,300	85	13,326	56	11,809	83	26,205	92	12,140	65
Gastropoda	60	3	0	0	2,612	11	747	5	201	1	58	<1
Pelecypoda	284	14	86	<1	1,155	5	690	5	359	1	230	1
All Others[c]	310	15	2,440	11	2,302	10	517	4	718	3	1,710	9
Total	2,069	100	21,645	100	23,877	100	14,166	100	28,388	100	18,691	100
Number of Replicates	5		5		5		3		3		3	
Diversity	0.6		0.7		1.0		0.9		0.6		1.0	

[a] Density is the mean of three or five replicate samples, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Hirudinea, Ostracoda, Hydracarina, Anisoptera, Hemiptera, Megaloptera, Lepidoptera, Coleoptera and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-30

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Swamp Creek - Stations D and E March, May, August and October 1977, and March, May and August 1978

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta														
D	0	0	3	<1	9	2	11	<1	4	<1	0	0	18	1
E	1,207	13	2,474	20	716	10	1,146	12	273	6	216	3	819	7
Amphipoda														
D	0	0	0	0	0	0	0	0	0	0	4	1	0	0
E	1,319	15	698	6	34	<1	138	1	115	2	86	1	345	3
Ephemeroptera														
D	93	8	100	8	179	5	213	6	166	14	68	11	32	2
E	172	2	233	2	716	10	2,000	21	704	14	1,853	22	488	4
Trichoptera														
D	404	34	575	44	460	12	1,363	35	148	12	65	11	274	14
E	78	1	43	<1	17	<1	9	<1	0	0	0	0	158	1
Chironomidae														
D	378	32	189	14	1,955	52	1,151	30	551	46	180	29	540	28
E	3,776	42	5,586	44	2,655	37	2,569	26	1,379	28	2,715	32	3,663	30
Gastropoda														
D	76	6	86	7	166	4	408	11	79	7	32	5	194	10
E	750	8	1,836	15	612	9	560	6	359	7	1,537	18	230	2
Pelecypoda														
D	11	1	35	3	302	8	175	5	25	2	112	18	392	20
E	1,310	14	974	8	1,336	19	1,776	18	1,825	38	1,552	18	2,572	21

Table 3.8-30 *(Continued)*

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
All Others[d]														
D	222	18	319	24	687	18	525	14	234	20	151	25	475	25
E	439	5	793	6	1,103	15	1,526	16	201	4	489	6	4,023	33
Total														
D	1,173		1,307		3,758		3,864		1,206		612		1,926	
E	9,051		12,637		7,189		9,723		4,856		8,448		12,298	
Number of Replicates	5		5		5		5		3		3		3	
Diversity														
D	1.0		1.1		1.1		1.1		0.9		1.0		1.0	
E	1.2		1.2		1.0		1.9		0.8		1.0		1.0	

[a] Density is the mean of three or five replicate samples, as indicated above, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Plecoptera, Megaloptera, Coelenterata, Alloeocoela, Hirudinea, Anisoptera, Tricladida, Nematoda, Ostracoda, Zygoptera, Coleoptera, Hydracarina, Hemiptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Density as consistently higher at Station E than at Station D. In 1977 density at Station D ranged from 1,173/m^2 in March to 3,864/m^2 in October and at Station E from 7,189/m^2 in August to 9,723/m^2 in October. In 1978 density at Station D ranged from 612/m^2 in May to 1,926/m^2 in August and at Station E from 4,856/m^2 in March to 12,298/m^2 in August.

Although midges were the most abundant organisms in the benthic communities at both stations, more were consistently collected at Station E than at Station D. *Micropsectra* sp. and *Rheotanytarsus* sp. were the most abundant genera at Station D, whereas *Procladius* sp., *Tanytarsus* sp., and *Cladotanytarsus*. were most abundant at Station E.

Caddisflies comprised from 11 to 44 percent of the total benthos enumerated at Station D during the study, but were ≤ 1 percent at Station E. Twenty-three caddisfly genera were identified in quantitative samples from Station D, whereas only seven genera were identified from Station E. Caddisflies from only two of these genera were identified from both locations. For Station D, the most common and abundant caddisflies were generally *Leucotrichia pictipes*, *Glossosoma* sp., and various *Hydropsyche* species. At Station E, the most common caddisflies were *Platycentropus* sp. and *Phylocentropus* sp.

Mayflies also comprised similar percentages of the total benthos at the two sampling locations, from two to 14 percent at Station D, and from two to 22 percent at Station E. However, the numbers of organisms and the individual genera of mayflies occurring at the two locations were generally quite different. Density of mayflies ranged from 32 to 231/m^2 at Station D and from 172 to 2,000/m^2 at Station E. Only four of the 13 total genera identified in quantitative samples occurred at both sampling locations. At Station D mayflies from the general *Ephemerella* sp., *Baetis* sp., *Paraleptophlebia* sp., and *Stenonema*. sp. were common. The most abundant mayflies at Station E were from the general *Hexagenia* sp. and *Caenis* sp., although *Baetis* sp. and *Ephemerella* sp. also occurred at this station.

At Station D, worms typically occurred in densities of less than 20/m^2 and typically comprised less than one percent of the benthos enumerated during each sample period. However, at Station E, worms ranged from 216 to 2,474/m^2 in mean densities and comprised from three to 20 percent of the benthic macroinvertebrate community (Table 3.8-30).

Snails comprised from 4 to 11 percent of the benthos at Station D and from two to 18 percent at Station E. The major snail at Station D was the freshwater limpet, *Ferrissia* sp.. which comprised most of the gastropods identified. At Station E, the snail *Amnicola* sp. comprised most of the snails identified.

Clams comprised from one to 20 percent of the benthos identified at Station D and from eight to 38 percent at Station E. The clams identified from both sampling locations were exclusively from the family Sphaeriidae; mature specimens were identified to the genera *Sphaerium* and *Pisidium*. Plecopterans (stonefiles) were collected in low numbers (<80/m^2) in all months at Station D and were found at Station E in March 1977 only.

Although differences were observed in the species composition of the benthic communities at Stations D and E, diversity values were similar. Values at Station D ranged from 0.9 in March 1978 to 1.1 in May, August, and October 1977. At Station E, values ranged from 0.8 in March 1978 to 1.2 in March and May 1977. Mean diversity at both stations was 1.0.

Information on the composition and density of benthic macroinvertebrates in Swamp Creek downstream in Swamp Creek downstream from County Trunk Highway M is presented in Ecological Analysts, Inc. (1983, 1984a). These results are from qualitative and quantitative sampling of macroinvertebrate communities during 1982 and 1983 in the vicinity of the proposed water discharge site.

Taxa were collected by the WDNR during verification sampling. The samples were obtained with a kick net during October 1979 downstream of Route 55, approximately 1.1 km (0.7 miles) downstream of Station E (Ramharter, 1982).

Quantitative benthic macroinvertebrate samples were collected from one location in Oak Lake (Station G), and qualitative collections were undertaken during March, May, August, and October 1977 and March, May, and August 1978. The major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-31.

In 1977 total numbers of benthic organisms collected at Oak Lake ranged from 1,172/m^2 in August to 7,741/m^2 in March. In 1978 densities in March (2,256/m^2) and August (819/m^2) were lower than in corresponding collections in 1977, 7,741 and 1,172/m^2, respectively. Density in May was higher in 1978 (7,226/m^2) than in 1977 (4,956/m^2).

Midges were the predominant benthic organisms collected from Oak Lake during the study. Midges comprised from 63 to 94 percent of the benthic macroinvertebrates collected. Midges from the genera *Tanytarsus* and *Procladius* were most common.

In general, other benthic invertebrates individually comprised less than seven percent of the total invertebrates collected during any sampling period. The only exception was the Nematoda (roundworms), which comprised 11 (560/m^2), 15 (172/m^2), and 26 (784/m^2) percent of the total benthos in May, August, and October 1977, respectively.

The benthic diversity for Oak Lake varied little with a range of 0.5 in August 1978 to 0.7 in March and May 1977 and 1978 (Table 3.8-31). Taxa collected by the WDNR during verification sampling were obtained with an Ekman sampler during December 1980 in deep and shallow areas of the lake (Ramharter, 1982).

3.8.2.5.3 Rolling Stone Lake

Quantitative benthic macroinvertebrate samples were collected from two locations, Stations M-2 and M-4. Qualitative collections were obtained from Rolling Stone Lake in October 1977 and March, May and August 1978. The seven major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-32.

Table 3.8-31

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Oak Lake - Station G March, May, August and October 1977, and March, May and August 1978

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta	52	1	119	2	78	7	164	5	0	0	259	4	43	5
Trichoptera	17	<1	32	1	0	0	0	0	0	0	14	<1	29	4
Chironomidae	7,292	94	4,073	82	879	75	1,896	63	1,968	87	5,862	81	646	79
Gastropoda	0	0	11	<1	0	0	0	0	0	0	14	<1	0	0
Pelecypoda	0	0	0	0	17	1	0	0	0	0	230	3	29	4
All Others[c]	379	5	722	15	198	17	974	32	287	13	848	12	72	9
Total	7,741		4,956		1,172		3,034		2,256		7,226		819	
Number of Replicates	5		5		5		5		3		3		3	
Diversity	0.7		0.7		0.6		0.6		0.7		0.7		0.5	

[a] Density is the mean of three or five replicate samples, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Hydracarina, Nematoda, Ostracoda, Megaloptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-32

Mean Density[a] (No./m^2), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Rolling Stone Lake - Stations M-2 and M-4 October 1977 and March, May and August 1978

	1977		1978					
	October		March		May		August	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta								
M-2	3,419	15	29	1	172	1	2,572	15
M-4	5,976	14	115	1	0	0	5,488	24
Amphipoda								
M-2	2,054	9	0	0	29	<1	0	0
M-4	1,494	3	1,020	10	0	0	72	<1
Ephemeroptera								
M-2	86	<1	0	0	0	0	0	0
M-4	474	1	14	<1	0	0	0	0
Trichoptera								
M-2	589	3	144	3	675	6	388	2
M-4	7,787	18	216	2	158	1	43	<1
Chironomidae								
M-2	6,254	28	790	17	2,471	21	5,244	31
M-4	13,634	31	747	7	5,646	39	5,632	24
Gastropoda								
M-2	7,945	35	3,347	71	7,442	65	5,129	30
M-4	10,574	24	7,614	74	7,873	54	9,180	39
Pelecypoda								
M-2	72	<1	58	1	115	1	489	3
M-4	216	<1	115	1	503	3	158	1
All Others[c]								
M-2	2,241	10	330	7	632	5	3,247	19
M-4	3,520	8	488	5	417	3	3,017	13
Total								
M-2	22,656		4,698		11,536		17,068	
M-4	43,675		10,330		14,596		23,590	
Diversity								
M-2	1.1		0.7		0.7		1.0	
M-4	1.2		0.6		0.9		0.9	

[a] Density is the mean of three or five replicate samples, as indicated above, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Hydracarina, Coelenterata, Tricladida, Coleoptera, Alloeocoela, Hirudinea, Ostracoda, Odonata, Nematoda, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

There were 75 and 89 individual taxa identified in quantitative sampling at Stations M-2 and M-4, respectively, and the additional 15 taxa identified in qualitative sampling. Numbers of benthic organisms collected were consistently higher at Station M-4 than at M-2. At Station M-2 density ranged from 4,698/m^2 in March 1978 to 22,656/m^2 in October 1977 and at Station M-4 from 10,330 to 43,675/m^2 during the collecting periods. Snails were the dominant benthic organisms, constituting 30 to 71 percent of the benthic organisms collected at Station M-2 and from 24 to 74 percent at Station M-4. The most abundant snails at both locations were *Amnicola* sp. and *Valvata tricarinata*. Midges were the second most numerous benthic organisms comprising from 17 to 31 percent of the organisms collected at Stations M-2 and from seven to 39 percent at Station M-4. *Glyptotendipes* sp., *Chironomus* sp., *Dicrotendipes* sp., and *Endochironomus* sp. were the most common genera. Worms were abundant only in October 1977 and August 1978 when they comprised from 16 to 27 percent of the benthos. During other sampling periods they did not exceed one percent of the benthos. The naidids, *Dero digitata*, *Stylaria lacustris*, *Nais* sp., and *Pristina leidgi*, were the most common worms encountered.

Although densities differed at the two stations, diversity values were similar. Values ranged from 1.1 to 1.2 at Stations M-2 and M-4, respectively, in October 1977 and 0.7 and 0.6 in March 1978 (Table 3.8-32). Taxa collected by the WDNR during verification studies were obtained with an Ekman sampler during December 1980 (Ramharter, 1982).

3.8.2.5.4 Pickerel Creek

Quantitative and qualitative benthos collections were obtained from Pickerel Creek (Station M-5) in October 1977 and March, May, and August 1978. The major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-33. There were 67 taxa identified in quantitative sampling and the additional 15 taxa identified in qualitative sampling. Density of organisms ranged from 5,316/m^2 in March 1978 to 9,338/m^2 in May 1978.

Midges were the most abundant benthic organisms in each collection comprising from 34 to 66 percent of the total. Midges from the genera *Procladius*, *Micropsectra*, *Chironomus*, and *Tanytarsus* were most common. Worms were the next most abundant organisms and comprised from 9 to 27 percent of the organisms collected. In general, the most commonly collected worms were the immature tubificid forms with or without hair setae. Additional worms enumerated from these samples included the tubificids *Aulodrilus pigueti*, *Ilyodrilus templetoni*, *Limnodrilus hoffmeisteri*, and *L. cervix* and the naidids *Slavina appendiculata*, *Mais* sp., *Dero digitata*, and *Pristina leidgi*.

Isopods constituted from seven to 22 percent of the benthos. Mature specimens that could be identified to the species level were *Asellus racovitzai racovitzai*. Clams comprised from seven to 18 percent of the benthos and all specimens were from the family Sphaeriidae. Mature specimens were identified to the genera *Pisidium* and *Sphaerium*. The benthic diversity was consistent during the investigation with values ranging from 0.9 in October 1977 to 1.0 for the remaining three collection periods (Table 3.8-33).

3.8.2.5.5 Creek 12-9

Quantitative and qualitative benthos collections were obtained from Creek 12-9 (Station M-1) in October 1977 and March, May and August 1978. The major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-34.

Table 3.8-33

Mean Density[a] (No./m^2), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Pickerel Creek - Station M-5 October 1977 and March, May and August 1978

	1977		1978					
	October		March		May		August	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta	1,997	27	1,063	20	819	9	1,465	16
Isopoda	977	13	1,063	20	646	7	1,983	22
Amphipoda	86	1	359	7	244	3	460	5
Trichoptera	14	<1	0	0	14	<1	115	1
Chironomidae	2,543	34	2,241	42	6,192	66	3,965	45
Gastropoda	14	<1	158	3	72	1	43	<1
Pelecypoda	1,336	18	388	7	905	10	690	8
All Others[c]	474	6	43	1	446	5	187	2
Total	7,442		5,316		9,338		8,907	
Diversity	0.9		1.0		1.0		1.0	

[a] Density is the mean of three replicate samples, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Hirudinea, Ostracoda, Megaloptera, Hydracarina, Coelenterata, Alloeocoela, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-34

Mean Density[a] (No./m^2), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Creek 12-9 - Station M-1 October 1977 and March, May and August 1978

	1977		1978					
	October		March		May		August	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta	201	1	144	1	29	<1	345	3
Isopoda	991	7	316	3	129	0	345	3
Amphipoda	158	1	0	0	0	0	0	0
Ephemeroptera	259	2	0	0	0	0	14	<1
Trichoptera	244	2	101	1	14	<1	158	2
Chironomidae	8,433	59	9,554	83	8,706	65	1,408	13
Gastropoda	0	0	0	0	29	<1	43	<1
Pelecypoda	1,192	8	905	8	3.,850	29	7,902	75
All Others[c]	2,830	20	517	4	560	4	302	3
Total	14,309		11,536		13,318		10,516	
Diversity	1.1		0.6		0.9		0.8	

[a] Density is the mean of three replicate samples rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Hirudinea, Ostracoda, Plecoptera, Megaloptera, Hydracarina, Lepidoptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

There were 75 taxa identified in quantitative sampling and the additional six taxa identified in qualitative sampling. The numbers of organisms enumerated during each sampling period were similar throughout the investigation. Density ranged from 10,516/m^2 in August 1978 to 14,309/m^2 in October 1977. The most abundant benthic organisms were midges and clams. Midges comprised from 13 to 83 percent of the collections. *Micropsectra* sp. was the most abundant midge during the study. *Tanytarsus* sp., *Polypedilum* sp., *Conchapelopia* sp., and *Trichocladius* sp. also occurred commonly. All clams collected in the benthic samples from Creek 12-9 were in the family Sphaeriidae; mature specimens were identified to the genera *Pisidium* and *Sphaerium*. Clams ranged from eight to 75 percent of the benthos. The benthic diversity ranged from 0.6 in March 1978 when midges comprised over 83 percent of the sample to 1.1 in October 1977 when no taxa comprised more than 59 percent of the sample (Table 3.8-34).

3.8.2.5.6 Creek 11-4

Quantitative and qualitative benthos collections were obtained from Creek 11-4 (Station M-3) in October 1977 and March, May and August 1978. The major taxa collected in quantitative sampling along with their density and relative abundance are presented in Table 3.8-35.

There were 76 taxa identified in quantitative sampling and the additional six taxa identified in qualitative sampling. Subsequent to an exceptionally high density of 86,214/m^2 in October 1977, densities were relatively similar in 1978 ranging from 14,424/m^2 in August to 20,731/m^2 in May. The three most abundant benthic groups were worms, isopods, and clams.

Worms comprised from 37 to 69 percent of the benthos enumerated at Creek 11-4. Most of the worms were from the family Tubificidae of which the immature forms with or without hair setae and *Tubifex tubifex* were most common. Isopods constituted from five to 40 percent of the total benthos enumerated from Creek 11-4. All isopods enumerated were from the genus *Asellus* and adults were identified to *A. racovitzai racovitzai*. Clams, represented exclusively by the family Sphaeriidae, comprised from seven to 25 percent of the benthos collected. Mature specimens were identified to the genera *Sphaerium* and *Pisidium*. Benthic diversity for Creek 11-4 ranged from 0.6 in October 1977 to 0.9 in May 1978 (Table 3.8-35).

3.8.2.5.7 Little Sand Lake

Benthic macroinvertebrates were collected at two locations, Stations H and I, in Little Sand Lake during March, May, August and October 1977 and March, May and August 1978. The seven major taxa collected in quantitative sampling and their density and relative abundance are presented Table 3.8-36. There were 67 taxa identified in quantitative sampling from Station H and 73 from Station I as well as the additional 14 taxa identified in qualitative sampling. Density of benthic organisms in 1977 ranged from 12,266/m^2 in March to 39,962/m^2 in October at Station H and from 8,603/m^2 in August to 38,411/m^2 in October at Station I. In May and October density at both stations was similar but considerable variation occurred in March and August.

In 1978 density ranged from 6,479/m^2 in August to 28,417/m^2 in May at Station H and from 6,828/m^2 in August to 14,870/m^2 in March at Station I. Densities in 1978 generally corresponded to densities observed in 1977.

Table 3.8-35

Mean Density[a] (No./m^2), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Creek 11-4 - Station M-3 October 1977 and March, May and August 1978

	1977		1978					
	October		March		May		August	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Oligochaeta	59,866	69	6,336	37	11,091	54	8,692	60
Isopoda	14,223	16	6,810	40	4,741	23	704	5
Amphipoda	158	<1	560	3	115	1	14	<1
Ephemeroptera	14	<1	0	0	115	1	0	0
Trichoptera	29	<1	0	0	14	<1	0	0
Chironomidae	718	1	1,537	9	2,873	14	1,020	7
Gastropoda	172	<1	72	<1	14	<1	14	<1
Pelecypoda	9,295	11	1,437	8	1,465	7	3,606	25
All Others[c]	1,738	2	216	1	302	1	374	3
Total	86,214		16,967		20,731		14,424	
Diversity	0.6		0.8		0.9		0.7	

[a] Density is the mean of three replicate samples rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Hirudinea, Ostracoda, Plecoptera, Megaloptera, Hydracarina, Lepidoptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-36

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Little Sand Lake - Stations H and I March, May, August and October 1977, and March, May and August 1978

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta														
H	207	2	940	6	241	1	940	2	86	<1	1,020	4	747	12
I	293	1	302	2	207	2	681	2	345	2	158	1	431	6
Amphipoda														
H	103	1	0	0	9	<1	9	<1	0	0	0	0	14	<1
I	26	<1	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera														
H	9	<1	17	<1	0	0	181	<1	0	0	14	<1	0	0
I	34	<1	0	0	0	0	17	<1	0	0	0	0	0	0
Trichoptera														
H	681	6	431	3	578	3	733	2	402	2	618	2	460	7
I	1,388	6	621	4	724	8	940	2	776	5	718	6	517	8
Chironomidae														
H	11,154	91	12,896	86	12,913	77	36,411	91	21,895	93	24,854	87	4,597	71
I	22,119	91	13,327	91	6,232	72	27,774	72	13,418	90	9,582	77	5,057	74

Table 3.8-36 *(Continued)*

	1977								1978					
	March		May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Gastropoda														
H	0	0	0	0	0	0	0	0	0	0	0	0	158	2
I	0	0	0	0	0	0	0	0	14	<1	0	0	0	0
Pelecypoda														
H	17	<1	172	1	216	1	0	0	0	0	0	0	0	0
I	0	0	86	1	52	1	95	<1	29	<1	58	<1	287	4
All Others[c]														
H	95	1	534	4	2,741	16	1,690	4	1,221	5	1,911	7	503	8
I	517	2	353	2	1,388	16	8,904	23	287	2	1,968	16	546	8
Total														
H	12,266		14,990		16,697		39,962		23,604		28,417	100	6,479	
I	24,377		14,688		8,603		38,411		14,870		12,485	100	6,838	
Number of Replicates	5		5		5		5		3		3		3	
Diversity														
H	0.8		0.9		1.1		1.0		1.0		1.0			1.0
I	1.0		0.9		1.1		1.0		1.0		1.1			0.8

[a] Density is the mean of three or five replicate samples, as indicated above, rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using total number of organisms presented.
[c] Includes Tricladida, Hirudinea, Hydracarina, Zygoptera, Coelenterata, Nematoda, Anisoptera, Neuroptera, Ostracoda and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Midges were the most abundant benthic macroinvertebrates collected at both sampling locations, comprising over 70 percent of the benthos collected during each sampling period. Common and abundant midges were *Pseudochironomus* sp., *Tanytarsus* sp., and *Procladius* sp.

Other organisms what were common but never exceeded 12 percent of the benthos community were worms and caddisflies. Of the worms enumerated, no single species exceeded 4 percent of the total benthos during any one period. At both sampling locations, the common naidids were *Mais* sp. and *Dero digitata*. Less common and irregularly occurring naidid forms included *Stylaria fossularis, Slavina appendiculata* and *Vejdovskyella comata*. Immature forms were the most common tubificids recorded throughout the study. No caddisfly species exceeded eight percent of the total benthos identified at any location for any collection period. This group was composed primarily of *Polycentropus* sp., which comprised from 75 to 95 percent of the caddisflies collected from both sampling locations during any sampling period.

Benthic diversity ranged from 0.8 at Station H in March 1977 and Station I in August 1978 to 1.1 at Station H in August 1977 and Station I in August 1977 and May 1978 (Table 3.8-36). Taxa collected by the WDNR during verification studies were obtained with an Ekman grab in deep and shallow portions of the lake during October 1979 (Ramharter, 1982).

3.8.2.5.8 Duck Lake

Benthic macroinvertebrates were identified from quantitative samples and qualitative collections from Duck Lake during May, August, and October 1977 and March, May and August 1978. The five major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-37. There were 53 taxa identified in quantitative sampling and the additional 12 taxa identified in qualitative sampling. In 1977, benthic density was highest in May, 20,192/m^2, and subsequently decreased to 3,879/m^2 in October. In 1978, the previous year's trend of high spring density was not observed and density ranged from 3,549/m^2 in August to 6,609/m^2 in May.

Worms dominated in August and October 1977 and August 1978 comprising 45 to 75 percent of the collections. During the other sampling periods worms comprised from 18 to 41 percent. Naidid worms, including *Nais* sp., *Vejdovskyella comata*, and *Dero digitata*, were generally abundant but immature tubificid forms, as well as *Aulodrilus pigueti* occurred regularly at low densities. Midges were the most abundant organisms in May 1977 and 1978 comprising 48 and 44 percent of the respective collections. Midges were co-dominant with worms in March 1978 comprising 37 percent of the collections. During the remaining sampling periods midges comprised from eight to 21 percent of the collections. *Tanytarsus* sp. was the most abundant midge and *Polypedilum* sp., *Chironomus* sp., and *Conchapelopia* sp. were also commonly collected.

Other benthic groups that occurred throughout the study were caddisflies and mayflies that comprised up to 16 and eight percent, respectively, of the benthic community. The two most common caddisflies were *Polycentropus* sp. and *Oxyethira* sp., while *Caenis* sp. was the most abundant mayfly. Individual diversity values ranged from 0.8 in March and August 1978 to 1.1 in May 1978. Taxa collected by the WDNR during verification studies were obtained with an Ekman grab in deep and shallow portions of the lake during October 1979 (Ramharter, 1982).

Table 3.8-37

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Duck Lake - Station K May, August and October 1977 and March, May, and August 1978

	1977						1978					
	May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%	No/m²	%	No./m²	%
Oligochaeta	8,340	41	9,568	65	1,738	45	1,695	37	1,221	18	2,672	75
Amphipoda	0	0	0	0	0	0	0	0	0	0	14	<1
Ephemeroptera	43	<1	86	1	316	8	101	2	532	8	29	1
Trichoptera	690	3	690	5	216	6	718	16	934	14	273	8
Chironomidae	9,633	48	3,146	21	1,293	33	1,695	37	2,916	44	287	8
All Others[c]	1,487	7	1,250	8	316	8	359	8	1,006	15	273	8
Total	20,192		14,740		3,879		4,569		6,609		3,549	
Number of Replicates	2		2		3		3		3		3	
Diversity	1.0		0.9		0.9		0.8		1.1		0.8	

[a] Density is the mean of three replicate samples rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Anisoptera, Hydracarina, Ostracoda, Zygoptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.5.9 Deep Hole Lake

Quantitative and qualitative benthic macroinvertebrate samples were collected from Deep Hole Lake in May, August and October 1977 and March, May and August 1978. The six major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-38. There were 69 taxa identified in quantitative sampling and the 21 additional taxa identified in qualitative sampling. In 1977, density ranged from 11,235/m^2 in May to 23,173/m^2 in October. In 1978, density was lowest in August (6,005/m^2) and highest in May (14,252/m^2).

Midges were the most abundant benthic macroinvertebrates enumerated, comprising 42 to 89 percent of the benthos collected. Overall, the most common and abundant midge was *Tanytarsus* sp., which was recorded in all sampling periods. *Microtendipes* sp., *Procladius* sp., and *Pseudochironomus* sp. also were found regularly. Other groups that were collected in moderate densities included worms, caddisflies and clams. Worms comprised five percent or less of the benthos during all sampling periods except August 1978, when worms comprised 18 percent of the total benthos. Common forms were immature tubificids with hair setae, *Nais* sp., and *Stylaria fossularis*.

Monthly values of benthic diversity ranged from 0.8 in May 1977 to 1.1 in August 1978 (Table 3.8-38). Taxa collected by the WDNR during verification studies were obtained with an Ekman grab in deep and shallow portions of the lake during October 1979 (Ramharter, 1982).

3.8.2.5.10 Skunk Lake

Benthic macroinvertebrates were collected from Skunk Lake in May and August 1977. The three major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-39.

There were 20 taxa identified from quantitative sampling and an additional two taxa identified in qualitative sampling. Densities of organisms were considerably higher in August (16,615/m^2) than in May (1,940/m^2). The increase in density was largely from an abundance of midge flies and worms. The dominant midge in May was *Psectrocladius* sp., which comprised 21 percent of the sample. In August *Chironomus* sp. was the dominant midge, comprising 81 percent of the sample. *Dero digitata* was the dominant worm in both collections.

Diversity was higher in May (0.6), when no single taxon comprised more than 25 percent of the sample (Table 3.8-39). The low value, 0.3, corresponded to the dominance (86 percent of the sample) of one taxon, Chironomidae.

3.8.2.5.11 Wolf River

Benthic macroinvertebrates were collected at two locations, Stations Y and Z in March, May, August and October 1978. The eight major taxa collected in quantitative sampling and their density and relative abundance are presented in Table 3.8-40.

Table 3.8-38

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Deep Hole Lake - Station L May, August and October 1977 and March, May, and August 1978

	1977						1978					
	May		August		October		March		May		August	
	No./m²	%	No./m²	%	No./m²	%	No/m²	%	No./m²	%	No./m²	%
Oligochaeta	101	1	776	5	589	3	58	1	431	3	1,078	18
Amphipoda	29	<1	0	0	0	0	0	0	0	0	14	<1
Ephemeroptera	0	0	0	0	0	0	14	<1	29	<1	0	0
Trichoptera	144	1	1,013	7	991	4	101	2	273	2	675	11
Chironomidae	9,726	87	11,422	74	19,079	82	9,367	77	11,034	77	2,543	42
Pelecypoda	761	7	991	6	675	3	330	7	991	7	675	11
All Others[c]	474	4	1,142	7	1,839	8	632	10	1,494	10	1,020	17
Total	11,235		15,344		23,173		10,502		14,252		6,005	
Number of Replicates	3		2		3		3		3		3	
Diversity	0.8		1.0		1.0		0.9		1.0		1.1	

[a] Density is the mean of three replicate samples rounded to the nearest whole number.
[b] Calculated using Brillouin's formula ($\log_{10}$) using the total number of organisms presented.
[c] Includes Nematoda, Hirudinea, Ostracoda, Plecoptera, Megaloptera, Hydracarina, Lepidoptera, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-39

Mean Density[a] (No./m^2), Relative Abundance (%), and Diversity[b] of Benthic Macroinvertebrates Collected from Skunk Lake - Station J May and August 1977

	May		August	
	No./m^2	%	No./m^2	%
Oligochaeta	560	29	2,263	14
Chironomidae	733	38	14,223	86
Pelecypoda	108	6	22	<1
All Others[c]	539	28	108	1
Total	1,940		16,615	
Diversity	0.6		0.3	

[a]Density is the mean of two replicate samples, rounded to the nearest whole number.
[b]Calculated by Brillouin's formula ($\log_{10}$) using total number of organisms presented.
[c]Includes Hydracarina, Nematoda, and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-40

Mean Density[a] (No./m²), Relative Abundance (%), and Diversity[b] of Bethnic Macroinvertebrates Collected from Wolf River - Stations Y and Z March, May, August, and October 1978

	March		May		August		October	
	No./m²	%	No./m²	%	No./m²	%	No./m²	%
Oligochaeta								
Y	273	1	2,644	31	101	2	29	2
Z	72	1	1,149	13	3,664	28	1,394	26
Isopoda								
Y	0	0	29	<1	0	0	0	0
Z	0	0	0	0	0	0	0	0
Amphipoda								
Y	675	4	1,552	18	0	0	0	0
Z	0	0	646	8	72	1	101	2
Ephemeroptera								
Y	58	<1	14	<1	14	<1	0	0
Z	0	0	29	<1	503	4	0	0
Trichoptera								
Y	302	2	72	1	43	1	0	0
Z	29	<1	460	5	560	4	58	1
Chironomidae								
Y	2,126	11	2,126	25	2,471	37	0	0
Z	503	8	2,399	28	2,313	18	43	1
Gastropoda								
Y	9,180	48	1,135	13	1,437	22	345	18
Z	3,692	58	1,135	13	1,940	15	1,925	36
Pelecypoda								
Y	1,034	5	388	5	2,284	34	1,078	57
Z	1,623	26	129	2	1,451	11	359	7
All Others[c]								
Y	5,387	28	618	7	287	4	445	24
Z	445	7	2,644	21	2,457	19	1,494	28
Total								
Y	19,036	100	8,577	100	6,637	100	1,896	100
Z	6,364	100	8,591	100	12,959	100	5,373	100
Diversity								
Y	0.6		1.0		0.7		0.6	
Z	0.6		1.0		1.1		0.9	

a Density is the mean of three or five replicate samples.
[b] Calculated using Brillouin's formula ($\log_{10}$) using total number of organisms presented.
[c] Includes Coelenterata, Tricladida, Alloeocoela, Nemertea, Nematoda, Hirudinea, Hydracarina, Anisoptera, Zygoptera, Hemiptera, Lepidoptera, Coleoptera and Diptera other than Chironomidae.

Source: Dames & Moore, 1982
Checked by: WMW

There were 81 and 100 taxa obtained in quantitative sampling and the additional 9 and 13 taxa obtained in qualitative sampling at Stations Y and Z, respectively. Densities of benthic organisms ranged from 1,896 to 19,036/m^2 at Station Y and 5,373 to 12,959/m^2 at Station Z. Benthic macroinvertebrates from several different groups were irregular in abundance, although they were common throughout the study. These groups included snails, midges, worms and clams.

Snails accounted for 13 to 48 percent of the benthos at Station Y and from 13 to 58 percent at Station Z. All of the 13 taxa identified, except *Promenetus exacuous*, which was collected only at Station Y, were collected at both sampling stations on the Wolf River. *Amnicola* sp. was the most common and abundant snail collected at both stations.

Midges comprised 0 to 37 percent of the total benthos enumerated from Station Y and from one to 28 percent at Station Z. Densities of midges at Station Y ranged from 0 in October 1978 to 2,471/m^2 in August 1978, and densities at Station Z ranged from 43/m^2 in October 1978 to 2,399/m^2 in May 1978. Individual genera of midges varied in abundance and occurrence throughout the period of investigation. Organisms that comprised five percent or more of a collection were *Cladotanytarsus* sp., *Polypedilum* sp., and *Trissocladius* sp. at Station Y and *Rheotanytarsus* sp., *Tanytarsus* sp., and *Stictochironomus* sp. at Station Z.

Worms comprised from one to 31 percent of the total benthos enumerated at Station Y and from one to 28 percent at Station Z. The immature tubificid form without hair setae was the most abundant worm at both stations during the study except May and July at Station Z. The naidids *Nais* sp. and *Slavina appendiculata* were most abundant in May whereas the naidid *Uncinais uncinata* was most abundant in July.

Clams comprised from five to 57 percent of the benthos collected at Station Y and from two to 26 percent at Station Z. All pelecypods collected from both Stations Y and Z were from the family Sphaeriidae; mature specimens were identified to the genera *Sphaerium* and *Pisidium*. Diversity values ranged from 0.6 at both stations in March and at Station Y in October to 1.1 at Station Z in August (Table 3.8-40).

3.8.2.6 Results of Aquatic Macroinvertebrate Collection Activities Conducted in 1993 and 1994

Aquatic macroinvertebrate were sampled in November, 1993, and May and August, 1994. Light trapping for adult specimens of members of the insect orders Trichoptera, Ephemeroptera, Coleoptera, and Plecoptera was conducted in June, July and August 1994. A general list of specimens collected with site location is provided in Appendix 3.8-2. Only immature (larvae or nymphs) specimens which were in families containing a threatened, endangered, or species of concern were keyed to genus and, where possible, species. Appendix 3.8-3 provides the data summary for adult Trichoptera and Ephemeroptera which were captured during light trapping collection efforts in late June and early July 1994. Table 3.8-41 provides a site location key by Town/Range, and should be used as a reference for all location identifications utilized in this section. Macroinvertebrate collection identification data are provided in Appendix 3.8-4.

Table 3.8-41

Key to Site Sampling Locations
1993-1994 Aquatic Sampling Program

Site ID	County	Section	Town/Range
CMC-AB-HL-100	Forest	33	35N13E
CMC-AB-HL-200	Forest	28/33	"
CMC-AB-SC-200	Forest	6/21	"
CMC-AB-SC-250	Forest	20	"
CMC-AB-SC-300	Forest	19	"
CMC-AB-SC-301	Forest	19	"
CMC-AB-SC-400	Forest	27	35N12E
CMC-AB-SC-500	Forest	32	"
CMC-AB-SC-501	Forest	32	"
CMC-AB-SC-502	Forest	32	"
CMC-AB-SC-700	Langlade	7	34N12E
CMC-AB-WR-200	Langlade	14	34N11E
CMC-AB-WR-301	Langlade	13	"
CMC-AB-SGI-CC	Langlade	24	"
CMC-AB-SK-005	Forest	30	35N13E
CMC-AB-DL-005	Forest	31/32	"
CMC-AB-SL-005	Forest	31/36/6	35N13E 35N12E 34N13E
CMC-AB-OL-005	Forest	36	35N12E
CMC-AB-RS-005	Langlade	11/12/13/14	34N12E
CMC-AB-DH-005	Forest	5/6	34N13E
CMC-AB-PP-005	Forest	26	35N12E
CMC-AB-HS-005	Forest	26	"
CMC-AB-HC-100	Forest	26	"
CMC-AB-12-9	Langlade	12	34N12E
CMC-AB-OC-200	Forest	18	35N13E
CMC-AB-PK-200	Langlade	11	34N12E
CMC-AB-PK-300	Langlade	13	"
CMC-AB-MS-100	Langlade	11	"
CMC-AB-RR-100	Forest	27/28	35N13E

Prepared by: WMW
Checked by: JJA

Rice Lake was not sampled in 1993-94 because the Mole Lake Sakoagan Chippewa would not grant access to project personnel.

No threatened or endangered species of macroinvertebrates were collected or observed in the study area. With the exception of the Odonata (discussed below in Section 3.8.2.7), two special concern species were observed in the study area, including a caddisfly (*Triaenodes dipsius*) and a mayfly (*Caenis youngi*). Larval specimens of the genus *Triaenodes* were first collected in November 1993 at the Wolf River (Site CMC-AB-WR-301). Follow-up light trapping activities for adult specimens in June 1994 yielded a total of six species of *Triaenodes* with *Triaenodes dipsius* being discovered at four stations (CMC-AB-SC-200, CMC-AB-SC-500, CMC-AB-HL-200, and CMC-AB-HS-005). These locations, Hoffman Springs, Swamp Creek at Keith Siding Road, Swamp Creek downstream of County Highway M, and Hemlock Creek, essentially surround the mining site and indicate a wide distribution of the species in the study area. Several specimens of the genus *Triaenodes* were collected in 1977 and 1978 at Stations L, M-1, A-1, Y and Z, however, none of these specimens were keyed to species. Therefore, it is unknown if *T. dipsius* was collected in 1977 and 1978. *Caenis youngi* was found in two locations during light trapping. These locations include site CMC-AB-SC-100 and site CMC-AB-SGI-CC.

One species of stonefly in the genus *Alloperla* was collected in November 1993 as an immature nymph. This genus has not been previously reported for the state of Wisconsin. The nymph was collected at the riffle area of Swamp Creek (CMC-AB-SC-300). A single adult female *Alloperla sp.* was collected in June 1994 during light trapping activities at the same location which is north of the mine site. This specimen could not be identified to species as only males of this genus can be identified reliably.

Crayfish were collected for tissue analysis in May 1994. A total of 13 specimens were collected from the Wolf River Site CMC-AB-SGI-CC. Only two specimens were captured from the Wolf River immediately upstream of the confluence with Swamp Creek. Since the objective was to obtain a minimum of ten specimens, these two were returned to the river. An alternative sampling site above Swamp Creek on the Wolf River was located. This site was at the outfall of Lower Post Lake (Site CMC-AB-WR-200). A total of 12 specimens were collected for tissue analysis below Lower Post Lake. Crayfish were collected from two sites on Swamp Creek, CMC-AB-SC-501 and CMC-AB-SC-502. A total of 11 and 13 specimens were collected from these sites respectively. The collection of crayfish at Little Sand Lake was fruitless as neither specimens nor skeletons were observed anywhere along the periphery of the lake. The lack of crayfish probably has a lot to do with the chemistry of the waters in Little Sand Lake. The first downstream location on the Pickerel Chain where significant numbers of crayfish were observed was at the outfall of Rolling Stone Lake. A total of 12 crayfish were collected at this location (CMC-AB-PK-300) for tissue analysis. Data from the analysis of crayfish tissue is presented in Table 3.8-42.

3.8.2.7 Results of Odonata Collection Activities (Nymph, Exuviae, and Adult) During 1993 and 1994

Efforts were made to conduct comprehensive collections of each of the life forms of Odonata species, i.e., nymph, final instar exuviae, and adult. Odonata nymphs were collected in November, 1993, and May and August, 1994. Odonata exuviae (final instar shed by emerging adults) were collected throughout June 1994 with the greatest effort being expended during the first week of June. Adult Odonata were collected in June, July, and August 1994. Results of the 1993-94 Odonata collection activities are provided in Appendix 3.8-5. Odonata identification data is provided in Appendix 3.8-4.

Table 3.9-42

Tissue Analysis of Crayfish from Selected Locations
May 1994 - Results in mg/kg

Location	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Mercury	Zinc
CMC-AB-SC-501	2.10	<0.13	1.80	<1.50	42.3	0.56	1090	0.21	68.1
CMC-AB-SC-502	2.90	<0.14	2.30	<1.50	45.4	0.38	989	0.23	80.5
CMC-AB-PK-300	1.90	<0.11	1.40	<1.20	34.9	0.25	182	0.14	80.2
CMC-AB-WR-200	1.70	<0.12	<1.20	<1.30	55.9	2.50	740	0.31	80.0
CMC-AB-SGI-CC	1.50	<0.12	2.30	<1.30	41.8	0.34	1080	0.21	93.8

Prepared by: WMW
Checked by: JJA

It was not always possible to identify some life forms to species. This is especially true of nymphs and exuviae of some species. At times it is necessary to also collect the adult of a species for positive identification. Examples of species keyed to genus only include *Aeshna sp.*, *Gomphus (Gomphus) sp.*, *Gomphus (Gomphurus) sp.*, and *Somatochlora sp.* Some species of these genera may have also been collected as adult, properly identified to species, and listed elsewhere on the table. Other specimens collected as adults and identified to species may not be a listed species.

In general, members of the Odonata enjoy a wide distribution throughout the study area. No threatened or endangered species of Odonata were collected or observed in the study area. Eleven special concern species were collected from the study area. An additional three species, which may be listed species, were keyed to genus. A single adult damselfly, seen but not collected, may have been a special concern species: *Lestes eurinus.*

Several of the special concern species were found to occur only in the downstream portions of Swamp Creek and the Wolf River. Downstream portions of Swamp Creek include areas downstream of County Highway M. These two areas were particularly populated with gomphids including *Gomphus lineatifrons, G. viridifrons, G.(Gomphus) sp.*, and *G.(Gomphurus) sp.* Two other areas which produced characteristic populations of targeted Odonata included the riffle area of Swamp Creek (Sites CMC-AB-SC-300 and CMC-AB-SC-301) and the area of Hemlock Creek in the vicinity of Deep Hole Road bridge (Site CMC-AB-HL-200). Scattered collections and sightings of special concern species were obtained at Hoffman Springs/Hoffman Creek, Popple Pond, Oak Lake, Skunk Lake, Deep Hole Lake, and Duck Lake.

As indicated earlier, these findings indicate Odonata are fairly well distributed throughout the study area both in the vicinity of the mine proper as well as in the vicinity of the lower Swamp Creek and Wolf River.

3.8.2.8 Results of Fish Studies Completed in 1977 and 1978

3.8.2.8.1 Rice Lake

Fish were collected from Rice Lake during May, August, and October 1977 and May and August 1978 by Ecological Analysts, Deerfield, Illinois. Numbers and relative abundance of the species collected are presented in Table 3.8-43.

Fish samples in Rice Lake were numerically dominated by black bullhead. This species was collected in all sampling periods, and it comprised from seven to 96 percent of the fyke net catches and from 12 to 86 percent of the electrofishing samples. Other common species in the collections included pumpkinseed and white sucker. Pumpkinseed comprised up to 88 percent of fyke net and from four to 25 percent of the electrofishing samples. No fish were caught in minnow traps set in May and August 1978.

Table 3.8-43

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Fyke Net (FN), Gill Net (GN), and Electroshocking (ES) - Rice Lake May, August, October 1977 and May, August 1978

	1977												1978									
	May				August				October				May						August			
	FN		ES		FN		ES		FN		ES		FN		GN		ES		FN		ES	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No	%	No.	%	No	%	No	%	No.	%	No.	%
Catostomidae																						
White sucker	1	1	6	25	0	0	1	3	0	0	4	9	2	2	6	40	1	1	5	3	0	0
Shorthead redhorse	0	0	2	8	0	0	0	0	0	0	0	0	1	1	1	7	0	0	0	0	0	0
Centrarchidae																						
Bluegill	0	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	1	1	0	0	0	0
Rock Bass	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	6	25	52	88	3	10	0	0	3	7	1	1	0	0	3	4	0	0	1	14
Cyprinidae																						
Golden shiner	0	0	0	0	0	0	0	0	0	0	5	11	0	0	0	0	0	0	0	0	0	0
Common shiner	0	0	0	0	1	2	0	0	2	7	0	0	0	0	0	0	6	9	0	0	0	0
Blackchin shiner	0	0	0	0	0	0	1	3	0	0	2	4	0	0	0	0	0	0	0	0	0	0
Blacknose shiner	0	0	0	0	0	0	7	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Esocidae																						
Northern Pike	2	2	0	0	0	0	0	0	2	7	0	0	1	1	4	27	0	0	1	<1	0	0
Ictaluridae																						
Black bullhead	92	96	3	12	4	7	15	52	16	57	28	62	104	95	4	27	58	84	177	95	6	86
Yellow bullhead	1	1	0	0	2	3	0	0	7	25	0	0	0	0	0	0	0	0	4	2	0	0
Percidae																						
Yellow perch	0	0	7	29	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
Salmonidae																						
Brook trout	0	0	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.8-43 *(Continued)*

	1977												1978									
	May				August				October				May						August			
	FN		ES		FN		ES		FN		ES		FN		GN		ES		FN		ES	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No	%	No.	%	No	%	No	%	No.	%	No.	%
Umbridae																						
Mudminnow	0	0	0	0	0	0	2	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	96		24		59		29		28		45		110		15		69		187		7	

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.8.2 Hemlock Creek

Fish were collected from Stations A-1 and A-2 in Hemlock Creek in May, August and October 1977 and from Station A-1 during May and August 1978. Numbers and relative abundance of the species collected are presented in Table 3.8-44.

Most fish collected at both stations were representatives of the family *Cyprinidae* (minnows). Common shiner and northern redbelly dace, collected in all sampling periods, were the most common species. In 1977 common shiner comprised from 12 to 36 percent of the samples at Station A-1 and from three to 29 percent of the samples at Station A-2. In 1978 common shiner and northern redbelly dace comprised 14 to 56 percent and 10 to 25 percent of the respective samples at A-1. Other common minnow species included creek chub and fathead minnow.

Except for small sunfish (*Centrarchidae*) and yellow perch, species generally sought by anglers that occurred in the collections included brook trout and white sucker. In addition, longnose dace and northern pike were collected by the WDNR in verification studies (Ramharter, 1982).

3.8.2.8.3 Hoffman Creek

Fish were collected from Hoffman Creek during June, August and October 1977. Numbers and relative abundance of the species collected are presented in Table 3.8-45.

Brook trout and mottled sculpin were the numerically dominant fish species collected. Both species were captured in all sampling periods. Brook trout constituted from 38 to 57 percent of numbers of fish collected, and mottled sculpin comprised from 11 to 34 percent of the catches.

3.8.2.8.4 Swamp Creek

Fish were collected from Stations B and D during May, August and October 1977 and at Station D during May and August 1978. Numbers and relative abundance of the species collected are presented in Table 3.8-46.

Table 3.8-44

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking (ES) - Hemlock Creek - Stations A-1 and A-2 May, August, October 1977 and May, August 1978

	1977												1978			
	May				August				October				May		August	
	A-1		A-2		A-1		A-2		A-1		A-2		A-1		A-1	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae																
White sucker	3	3	3	2	9	3	12	2	8	3	0	0	2	1	28	13
Centrarchidae																
Rock Bass	0	0	0	0	1	<1	0	0	0	0	0	0	0	0	0	0
Pumpkinseed	0	0	0	0	3	1	0	0	1	<1	0	0	0	0	1	<1
Bluegill	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0
Cottidae																
Mottled sculpin	7	7	1	<1	0	0	1	<1	6	2	0	0	3	2	1	<1
Cyprinidae																
Brassy minnow	0	0	0	0	0	0	0	0	15	6	0	0	4	3	36	17
Hornyhead chub	1	1	0	0	0	0	0	0	0	0	0	0	1	<1	1	<1
Golden shiner	0	0	0	0	0	0	0	0	8	3	1	1	0	0	0	0
Common shiner	12	12	4	3	79	28	76	14	97	36	26	29	78	56	30	14
Blackchin shiner	0	0	0	0	0	0	0	0	1	<1	0	0	0	0	0	0
Blacknose shiner	0	0	2	1	18	6	1	<1	1	<1	1	1	2	1	0	0
Northern redbelly dace	11	11	53	34	54	19	299	54	6	2	30	33	14	10	54	25
Fathead minnow	4	4	17	11	11	4	6	1	69	26	0	0	1	<1	5	2
Bluntnose minnow	0	0	2	1	0	0	2	<1	2	1	1	1	1	<1	1	<1
Blacknose dace	7	7	0	0	24	9	0	0	6	2	0	0	3	2	9	4
Creek chub	16	16	5	3	18	6	12	2	27	10	5	6	15	11	26	12
Pearl dace	1	1	0	0	34	12	5	<1	4	2	0	0	0	0	10	5
Cyprinidae (unid. sp.)	4	4	2	1	14	5	87	16	0	0	0	0	0	0	0	0
Gasterosteidae																
Brook stickleback	22	23	51	32	0	0	12	2	1	<1	11	12	8	6	8	4

Table 3.8-44 (*Continued*)

	1977												1978			
	May				August				October				May		August	
	A-1		A-2		A-1		A-2		A-1		A-2		A-1		A-1	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ictaluridae																
Black bullhead	0	0	3	2	0	0	15	3	1	<1	2	2	0	0	2	<1
Percidae																
Johnny darter	3	3	11	7	1	<1	6	1	4	2	5	6	5	4	0	0
Yellow perch	5	5	0	0	9	3	1	<1	2	<1	4	4	0	0	1	<1
Salmonidae																
Brook trout	0	0	0	0	0	0	0	0	7	3	0	0	3	2	0	0
Umbridae																
Mudminnow	1	1	4	3	0	0	21	4	0	0	4	4	0	0	0	0
Total	97		158		279		558		266		90		140		213	

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-45

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking Hoffman Creek - Station E-1 June, August, October 1977

	1977					
	June		August		October	
Fish	No.	%	No.	%	No.	%
Catostomidae White sucker	0	0	1	3	5	18
Centrarchidae Bluegill	0	0	0	0	1	4
Cottidae Mottle sculpin	23	34	6	19	3	11
Cyprinidae						
Common Shiner	0	0	0	0	1	4
Blacknose dace	4	6	11	34	0	0
Creek chub	--	0	1	3	2	7
Esocidae Northern pike	2	3	0	0	0	0
Salmonidae Brook trout	39	57	12	38	16	57
Umbridae Mudminnow	0	0	1	3	0	0
Total	68		32		28	

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-46

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking (ES) - Swamp Creek - Stations B and D May, August, October 1977 and May, August 1978

	1977												1978			
	May				August				October				May		August	
	B		D		B		D		B		D		D		D	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae																
White sucker	29	17	117	37	35	17	9	5	21	14	12	5	31	10	2	1
Centrarchidae																
Pumpkinseed	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0
Largemouth bass	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Cottidae																
Mottled sculpin	41	24	4	1	1	<1	13	7	5	3	9	4	0	0	7	4
Cyprinidae																
Brassy minnow	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0
Hornyhead chub	3	2	1	<1	7	3	2	1	9	6	24	11	9	3	0	0
Golden shiner	1	<1	0	0	0	0	0	0	0	0	0	0	0	0	2	1
Common shiner	46	27	68	21	60	28	8	4	102	66	20	9	75	23	8	5
N redbelly dace	0	0	2	<1	0	0	0	0	0	0	3	1	0	0	0	0
Fathead minnow	1	<1	2	<1	0	0	0	0	0	0	0	0	0	0	0	0
Bluntnose minnow	0	0	1	<1	0	0	2	1	0	0	0	0	0	0	0	0
Blacknose dace	3	2	30	9	0	0	33	18	1	<1	30	13	42	13	50	29
Longnose dace	0	0	41	13	0	0	98	52	0	0	112	50	72	22	68	40
Creek chub	18	11	11	3	3	1	16	9	9	6	3	1	16	5	24	14
Pearl dace	0	0	1	<1	0	0	0	0	0	0	0	0	1	<1	0	0
Cyprinidae (unid. sp.)	2	1	1	<1	0	0	3	2	0	0	0	0	0	0	0	0
Gasterosteidae																
Brook stickleback	8	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3.8-46 (*Continued*)

Fish	1977												1978			
	May				August				October				May		August	
	B		D		B		D		B		D		D		D	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ictaluridae																
Black bullhead	1	<1	0	0	80	38	0	0	1	<1	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	0	0	0	0	0	0	1	<1	0	0	0	0
Percidae																
Johnny darter	13	8	0	0	4	2	0	0	2	1	1	<1	1	<1	7	4
Yellow perch	2	1	0	0	1	<1	0	0	1	<1	1	<1	0	0	0	0
Salmonidae																
Brook trout	1	<1	39	12	0	0	0	0	0	0	10	5	78	24	4	2
Umbridae																
Mudminnow	0	0	0	0	16	8	4	2	0	0	0	0	0	0	0	0
Total	169		318		211		188		154		226		325		172	

Source: Dames & Moore, 1982
Checked by: WMW

Minnow species generally numerically dominated the catches at both Stations B and D. Common shiner and creek chub were the most common species and were collected during each sampling period. In 1977 the common shiner comprised from 27 to 66 percent of the samples at Station B and from four to 21 percent of the samples at Station D. Creek chub comprised from six to 11 percent of the samples at Station B and from one to nine percent at Station D. In 1978 common shiner comprised 23 and five percent of the samples in May and August, respectively, and creek chub five and 14 percent of the samples in May and August, respectively, at Station D. Blacknose dace and longnose dace were also abundant minnows at Station D but few were caught at Station B.

White sucker was another commonly collected species. It occurred in all collections, in 1977 and comprised from 14 to 17 percent of the collections at Station B and from one to 37 percent at Station D. Black bullhead was the most abundant species at Station B in August 1977 but were uncommon during other sampling periods. Additional species collected by the WDNR in verification sampling were shorthead redhorse, Iowa darter, bluegill, and rockbass (Ramharter, 1982).

Information on species composition and relative abundance of fish in Swamp Creek downstream of County Trunk Highway M is presented in Ecological Analysts, Inc. (1983, 1984a). These results are from field sampling of fish populations in the vicinity of the proposed water discharge site during 1982 and 1983. The results of chemical analyses of muscle tissue from fish collected in Swamp Creek downstream from County Trunk Highway M are presented in Ecological Analysts, Inc. (1984b). Metal concentrations in four northern pike, six rock bass, and five white suckers collected downstream of County Trunk Highway M are presented in this 1984 report.

3.8.2.8.5 Fish Parasites

The occurrence of external parasites was periodically observed on various fish species. Blackspot (the metacercaria of larval flatworms known as strigeids) was the most commonly observed parasite. Frequently, heavy infestations of blackspot were found on yellow perch, brassy minnow, common shiner, fathead minnow, blacknose dace, and northern creek chub from Station A-1 on Hemlock Creek. Blackspot was observed infrequently on northern pike from Rolling Stone Lake and redbelly dace from Creek 11-4. In addition, the metacercaria of the trematode *Clinostomum marginatum* was observed in yellow perch musculature when tissue was being obtained for chemical analysis. Lesser levels of parasitism were observed on blacknose dace from Hoffman Creek, and longnose dace and mudminnow from Swamp Creek.

Other parasites or deformities observed on fish included the copepod *Salmincola edwardsii* (gill lice) on brook trout from Hoffman Creek, and deformed or abbreviated opercula on brook trout from Swamp Creek were observed. Deformities of yellow perch such as deformed spines and jaw tumors were also observed.

3.8.2.8.6 Brook Trout Redd Survey

In the autumn, brook trout dig redds (nests) in gravel beds of headwater streams, with areas of groundwater flow particularly favored (Benson, 1953; Latta, 1965; Webster and Eiriksdottir, 1976). Because brook trout support a popular and intensive sport fishery in Wisconsin (Brasch et al., 1973), areas important to spawning brook trout were sought in October and November

1977 in Swamp Creek and its tributaries upstream of Rice Lake. Six potential spawning areas were observed, and their locations are depicted on Figure 3.8-9.

A relatively large potential spawning area was observed in Hoffman Creek approximately 210 m (689 feet) upstream of Station E-1 and extended for approximately 50 m (164 feet). This portion of the creek was characterized as having a sand and gravel bottom and observations of seeps and springs suggested a groundwater discharge. The area generally consisted of riffles, but small pools formed by in-stream obstructions such as fallen branches were also found. Aquatic vegetation was composed of *Nasturtium officinale* (watercress), which occurred in moderately sized clumps.

Brook trout typically disperse to downstream areas during their first summer of life (Hunt, 1965). The collection of trout less than 50 mm (two inches) at Station E-1 in June 1977 indicates that spawning probably occurred in Hoffman Creek in autumn 1976. Four other areas bearing qualities similar to those observed in Hoffman Creek were observed in the Swamp Creek drainage basin (Figure 3.8-14). However, these potential spawning areas were small, less than approximately 5 m (10 feet), and isolated by reaches, characterized by soft, silty, muck bottom, that are typically not suitable as trout spawning habitat. The generally low reproductive potential of brook trout in Swamp Creek is supplemented by the WDNR's stocking of 1,000 legal-sized 152-mm (six-inch) trout in spring in Swamp Creek at the Keith Siding Road bridge (Theis, 1978).

Areas that appeared suitable for spawning brook trout were sought in the three northern tributary streams of Rolling Stone Lake in October 1978. One marginally suitable spawning area was located in Creek 12-9. The substrate in this reach of the creek was characterized by sand, gravel and rubble with some indication of groundwater discharge such as seeps and springs. The creek in this area flowed through uplands into a lowland area and the stream character was primarily riffles. One brook trout was collected during the investigation by electrofishing, which suggests that brook trout production in Creek 12-9 is minimal.

3.8.2.8.7 Oak Lake

Fish were collected from Oak Lake during May, August and October 1977, and May and August 1978 by seine, gill net, or electroshocking. Numbers and relative abundances of the species collected are presented in Table 3.8-47.

Yellow perch was the most abundant species in Oak Lake in gill net and electroshocking catches. This species comprised from 78 to 100 percent of the gill net catches and from 90 to 95 percent of the electroshocking catches, excluding the October 1977 catch. Electroshocking was conducted around the entire lake in association with WDNR staff in October 1977, and although more fish (235) were collected than in other electroshocking collections (70 to 193), yellow perch comprised a similar portion of the catch (96 percent) as in other electroshocking samples (90 to 95 percent). In addition to yellow perch, seven golden shiner and two largemouth bass were collected in October 1977 using the WDNR electrofishing gear.

Yellow perch comprised more than 60 percent of the beach seine catches except for August 1978. In that period, golden shiner comprised 80 percent of the fish collected and yellow perch made up only 17 percent. Generally, golden shiner did not comprise more than seven percent of the catches.

Table 3.8-47

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Gill Net (GN)[a], Seine (BS)[b] and Electroshocking (ES) - Oak Lake - Station G May, August, October 1977 and May, August 1978

	1977														1978									
	May				August				October				May						August					
	(BS)		(GN)		(BS)		(GN)		(ES)		(GN)		(BS)		(GN)		(ES)		(BS)		(GN)		(ES)	
Species	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Centrarchidae																								
Bluegill	1	1	0	0	0	0	0	0	3	2	0	0	10	7	1	1	0	0	7	1	0	0	1	1
Pumpkinseed	3	3	0	0	2	4	0	0	1	<1	0	0	2	1	2	2	5	3	16	2	0	0	0	0
Largemouth bass	28	31	5	11	8	16	0	0	5	3	1	1	6	4	8	6	5	3	1	<1	0	0	6	8
Cyprinidae																								
Golden shiner	1	1	3	7	0	0	0	0	1	<1	0	0	0	0	1	1	5	3	531	80	0	0	1	1
Longnose dace	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Ictaluridae																								
Black bullhead	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Percidae																								
Yellow perch	58	64	35	78	39	80	48	100	173	95	84	98	131	88	113	90	163	92	110	17	34	100	70	90
Total	91		45		49		48		183		86		149		125		178		665		34		78	

[a]One gill net fished in May, August, October 1977; two fished in May August 1978; numbers expressed as catch per set.
[b]Minnow seine was used in May 1977, beach haul seine was used at all other times.

Source: Dames & Moore, 1982
Checked by: WMW

Largemouth bass was the second most abundant species in the catches. It comprised from zero to six percent of the gill net, from three to eight percent of the electroshocking catches, and from <1 to 31 percent of the beach seine catches. In addition, white sucker was collected by the WDNR in verification sampling conducted during September and October 1979 and October 1980 (Ramharter, 1982). Sampling gear was minnow seine, gill nets, fyke nets, minnow traps, and boom shocker.

3.8.2.8.8 Pond 25-11

No fish were collected from minnow traps.

3.8.2.8.9 Hoffman Springs

Two finescale dace were the only fish collected in minnow traps from Hoffman Springs, Station E-2, in October 1978. Fish sampling in Hoffman Springs by the WDNR in October 1983 yielded the following species and numbers: brook trout (230), pearl dace (85), creek chub (14), common shiner (10), white sucker (9), brassy minnow (4), finescale dace (4), golden shiner (3), mottled sculpin (2), and pumpkinseed (1). Most of the brook trout that were captured had been stocked by the landowner three days prior to the WDNR investigation (Steuck, 1983).

3.8.2.8.10 Hoffman Pond

A total of 328 northern redbelly dace and 53 finescale dace were collected from Hoffman Pond, Station E-3, in October 1978. In addition, mudminnow and brook stickleback were observed in a minnow trap tended by the landowner. In October 1983, the WDNR sampled Hoffman Pond and collected 35 finescale dace, 27 creek chubs, 15 bluegill, eight brook stickleback, and seven central mudminnows (Steuck, 1983).

3.8.2.8.11 Rolling Stone Lake

Fish were collected from Rolling Stone Lake (Stations M-2 and M-4) during October 1977 and May and August 1978. Numbers and relative abundance of the species collected are presented in Table 3.8-48.

Yellow perch was the most abundant species collected in all samples, except in the fyke net catch of May 1978. It comprised 59 percent or more of the electrofishing catches in May and August 1978, was co-dominant with golden shiner in the October 1977 gill net catch, and was the only species collected in minnow traps in May 1978.

Other commonly occurring fish species were white sucker, black bullhead and members of the centrarchid (sunfish) family, particularly bluegill, pumpkinseed, and black crappie. Fish species characterized as "game fish" such as largemouth bass, northern pike and walleye were captured in low numbers in most sampling periods.

3.8.2.8.12 Pickerel Creek

Fish were collected from Pickerel Creek (Station M-5) during October 1977 and May and August 1978. Numbers and relative abundance of the six species collected are presented in Table 3.8-49.

Table 3.8-48

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Fyke Net (FN)[a], Gill Net (GN), Minnow Trapping (M) and Electroshocking (ES) Rolling Stone Lake - Stations M-2 and M-4 October 1977 and May and August 1978

	1977		1978													
	October		May										August			
	(GN)		(FN)		(GN)		(ES)		(MT)		(ES)[b]		(FN)		(ES)	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae																
White sucker	1	3	3	30	1	25	3	3	0	0	3	17	2	3	2	2
Centrachidae																
Pumpkinseed	0	0	0	0	0	0	1	1	0	0	0	0	11	19	11	11
Bluegill	0	0	4	40	0	0	15	15	0	0	7	39	5	9	8	8
Largemouth bass	0	0	0	0	0	0	1	1	0	0	0	0	0	0	3	3
Black Crappie	0	0	1	10	0	0	1	1	0	0	3	17	2	3	1	1
Cyprinidae																
Golden shiner	15	38	0	0	0	0	0	0	0	0	0	0	2	3	5	5
Common shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Esocidae																
Northern pike	7	18	0	0	2	50	0	0	0	0	1	6	0	0	2	[illegible]
Ictaluridae																
Black bullhead	1	3	2	20	0	0	0	0	0	0	1	6	24	41	4	4
Percidae																
Yellow perch	15	38	0	0	1	25	78	79	7	100	0	0	12	21	59	59
Walleye	0	0	0	0	0	0	0	0	0	0	3	17	0	0	2	2
Total	39		10		4		99		7		18		58		100	

[a]One fyke net was fished in May 1978; two were fished in August 1978.
[b]Supplemental electroshocking collection along western shoreline; yellow perch were selectively not collected.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-49

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking Pickerel Creek - Station M-5 October 1977 and May and August 1978

	1977		1978			
	October		May		August	
	No.	%	No.	%	No.	%
Catostomidae						
White Sucker	0	0	0	0	5	12
Centrarchidae						
Largemouth bass	1	50	0	0	0	0
Cottidae						
Mottled sculpin*	0	0	6	75	1	2
Percidae						
Yellow perch	0	0	0	0	28	70
Salmonidae						
Brook trout	1	50	1	12	6	15
Umbridae						
Mudminnow	0	0	1	12	0	0
Total	2		8		40	

*Three additional mottled sculpin were collected in supplemental electroshocking in May.

Source: Dames & Moore, 1982
Checked by: RFS

Brook trout and mottled sculpin were the most abundant species and each comprised an average 26 percent of the catches. Brook trout were collected in all three sampling periods but no more than six individuals were captured in any one collection. Mottled sculpin were collected in May and August 1978, and no more than six individuals were captured in any one collection. No fish were collected in the minnow trap set in May 1978.

3.8.2.8.13 Creek 12-9

Fish were collected from Creek 12-9 (Station M-1) during October 1977 and May and August 1978. Numbers and relative abundance of the seven species collected are presented in Table 3.8-50.

Mottle sculpin was the most abundant species comprising from 17 to 86 percent of the catches and was the only species collected during each sampling period. Game fish collected at this station included largemouth bass, black bullhead, yellow perch and brook trout. In addition, mudminnow was collected by the WDNR in verification sampling (Ramharter, 1982).

3.8.2.8.14 Creek 11-4

Fish were collected from Creek 11-4 (Station M-3) during October 1977 and May and August 1978. Numbers and relative abundance of the 15 species collected are presented in Table 3.8-51.

Cyprinids were dominant in the electrofishing and minnow trap catches. Seven species of cyprinids were collected, and the northern redbelly dace, which comprised from 11 to 88 percent of electrofishing samples, was the most abundant species in all collecting periods. Fathead minnow, which comprised from seven to 12 percent of the electrofishing catches, was the only other species collected in every sampling period. Game fish included bluegill, largemouth bass and yellow perch. Additional species collected by the WDNR in verification sampling were yellow perch, black crappie, and mottled sculpin (Ramharter, 1982).

3.8.2.8.15 Little Sand Lake

Ten species of fish, representing the families Catostomidae, Centrarchidae, Esocidae, Ictaluridae, and Percidae, were collected in Little Sand Lake during May, August and October 1977 and May and August 1978.

Yellow perch, yellow bullhead, and bluegill were collected in all months sampled and generally were the most abundant species in Little Sand Lake (Table 3.8-52). Yellow perch were the most abundant species in the gill net catches, except in October 1977, comprising 67 to 100 percent of the samples and in electroshocking samples comprising 42 to 87 percent. Yellow bullhead comprised two to 49 percent, and bluegill one to 72 percent (16 per net set) of the fyke net catches. Other species collected were black crappie, largemouth bass, walleye, and northern pike. Although black crappie and largemouth bass comprised small percentages ($\leq$14 percent) of any collection, they were collected in most sampling periods. With the exception of October 1977, where walleye made up the entire gill net catch, walleye and northern pike occurred infrequently and made up five percent or less of the catches.

Table 3.8-50

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking Creek 12-9 - Station M-1 October 1977 and May and August 1978

Species	1977		1978			
	October		May		August	
	No.	%	No.	%	No.	%
Centrarchidae						
Largemouth bass	2	33	0	0	0	0
Cottidae						
Mottle sculpin	1	17	6	86	2	22
Cyprinidae						
Blacknose shiner	1	17	0	0	0	0
Ictaluridae						
Black bullhead	0	0	1	14	0	0
Percidae						
Iowa darter	0	0	0	0	1	11
Yellow perch	2	33	0	0	5	56
Salmonidae						
Brook trout	0	0	0	0	1	11
Total	6		7		9	

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-51

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Minnow Trap (MT) and Electroshocking (ES) Creek 11-4 - Station M-3 October 1977 and May and August 1978

	1977		1978					
	October		May				August	
	(ES)		(ES)		(MT)		(ES)	
Species	No.	%	No.	%	No.	%	No.	%
Centrarchidae								
Bluegill	3	11	0	0	0	0	0	0
Largemouth bass	4	15	0	0	0	0	0	0
Cyprinidae								
Brassy minnow	1	4	59	4	40	17	0	0
Blacknose shiner	0	0	37	3	4	2	0	0
Northern redbelly dace	3	11	1030	78	164	71	105	88
Finescale dace	0	0	1	<1	0	0	0	0
Fathead minnow	2	7	156	12	12	5	9	8
Northern creek chub	11	41	0	0	0	0	0	0
Pearl dace	0	0	3	<1	0	0	0	0
Gasterosteidae								
Brook stickleback	0	0	32	2	11	5	1	1
Percidae								
Iowa darter	0	0	0	0	0	0	2	2
Johnny darter	1	4	0	0	0	0	0	0
Yellow perch	2	7	0	0	0	0	0	0
Umbridae								
Mudminnow	0	0	6	<1	0	0	3	2
Total	27		1324		231		120	

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-52

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Gill Net (GN)[a], Fyke Net (FN)[b], Seining (BS)[c] and Electroshocking (ES) - Little Sand Lake - Stations H and I May, August, October 1977 and May and August 1978

	1977																			
	May						August								October					
	(BS)		(GN)		(FN)		(BS)		(GN)		(FN)		(ES)		(BS)		(GN)		(FN)	
Fish	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae																				
White Sucker	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Centrarchidea																				
Bluegill	2	4	0	0	10	12	20	21	0	0	78	72	1	4	1	100	0	0	3	4
Pumpkinseed	25	44	0	0	3	4	35	36	0	0	23	21	1	4	0	0	0	0	1	1
Black Crappie	0	0	0	0	9	11	0	0	0	0	0	0	2	7	0	0	0	0	29	41
Largemouth bass	4	7	0	0	0	0	12	12	0	0	5	5	0	0	0	0	0	0	0	0
Esocidae																				
Northern pike	0	0	0	0	0	0	0	0	1	5	0	0	0	0	0	0	0	0	0	0
Ictaluridae																				
Black bullhead	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	0	0	0	1	1
Yellow bullhead	0	0	0	0	15	18	0	0	1	5	2	2	5	19	0	0	0	0	34	49
Percidae																				
Walleye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	100	0	0
Yellow perch	26	46	170	100	44	54	29	30	18	90	1	<1	17	63	0	0	0	0	2	3
Total	57		170		82		96		20		109		27		1		2		70	

Table 3.8-52 *(Continued)*

Fish	1978															
	May								August							
	(BS)		(GN)		(FN)		(ES)		(BS)		(GN)		(FN)		(ES)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae																
White sucker	0	0	0	0	0	0	0	0	0	0	1	33	0	0	0	0
Centrarchidae																
Bluegill	0	0	0	0	1	1	0	0	13	30	0	0	34	45	14	10
Pumpkinseed	0	0	0	0	0	0	3	5	21	48	0	0	7	9	39	29
Black crappie	0	0	0	0	14	20	2	3	0	0	0	0	0	0	0	0
Largemouth bass	0	0	0	0	0	0	0	0	4	9	0	0	5	7	9	7
Esocidae																
Northern pike	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0
Ictaluridae																
Black bullhead	0	0	0	0	2	3	1	2	0	0	0	0	0	0	0	0
Yellow bullhead	0	0	0	0	51	73	2	3	0	0	0	0	26	35	16	12
Percidae																
Walleye	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0
Yellow perch	4	100	25	96	0	0	54	87	6	14	2	67	3	4	56	42
Total	4		26		70		62		44		3		75		134	

[a]Two gill nets were fished.
[b]One fyke net was fished in May and August 1977; two were fished in October 1977 and May and August 1978.
[c]Minnow net was used May 1977; beach haul seine was used other times.

Source: Dames & Moore, 1982
Checked by: WMW

Electrofishing in October 1977 by the WDNR (Theis, 1978) yielded higher numbers of fish (217) than electrofishing samples for the baseline studies (27 to 134). However, the WDNR sampled the entire lake perimeter, whereas baseline sampling was conducted for approximately 0.5 hour, which encompassed approximately one-half of the lake perimeter. The assemblage of fish collected by the WDNR was similar to other baseline electrofishing samples. Fish collected and their percent of catch were: bluegill, 8; pumpkinseed, 4; black crappie, 4; largemouth bass, <1; northern pike, <1; black bullhead, <1; yellow bullhead, 12; and yellow perch, 71. Additional fish species collected by the WDNR in verification sampling were mudminnow, northern pike, and Iowa darter (Ramharter, 1982). Samples were obtained with fyke nets, minnow seines, and boom electrofisher in May, September and October 1979 and October 1980.

3.8.2.8.16 Duck Lake

Yellow perch, black bullhead, and mudminnow were collected from Duck Lake in May, August and October 1977 and May and August 1978 surveys (Table 3.8-53). Yellow perch, which comprised 73 percent or more of the gill net catches, was the only species caught in minnow traps and it comprised 87 percent of the electroshocking samples. Black bullheads were a minor portion of the catches in 1977 (two to 27 percent) and none were collected in 1978. Mudminnows were collected in low numbers in October 1977 and August 1978.

No additional fish species were collected by the WDNR in verification sampling (Ramharter, 1982). Fish sampling consisted of gill netting and fyke netting in October 1979 and 1981.

3.8.2.8.17 Deep Hole Lake

Walleye, yellow perch, white sucker and golden shiner were the only species collected in Deep Hole Lake during May, August and October 1977 and May and August 1978 surveys (Table 3.8-54). Yellow perch, the most abundant species in all collections, comprised 75 percent or more of the gill net catches, and 67 percent or more of the eletroshocking samples. Walleye comprised minor portions of the electroshocking and gill net catches. No fish were caught in minnow traps fished in May 1978.

Additional fish species collected by the WDNR in verification sampling were mudminnow and bluegill (Ramharter, 1982). Fish sampling was conducted in September and October 1979 utilizing minnow seine, fyke nets, gill nets and boom shocker.

Table 3.8-53

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Gill Net (GN)[a], Minnow Trap (MT)[b] and Electroshocking (ES) - Duck Lake - Station K May, August, October 1977 and May and August 1978

	1977						1978							
	May		August		October		May				August			
	(GN)		(GN)		(GN)		(GN)		(MT)		(GN)		(ES)	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Ictaluridae														
Black bullhead	12	27	1	2	1	2	0	0	0	0	0	0	0	0
Percidae														
Yellow perch	32	73	53	98	45	96	453	100	528	100	61	100	26	87
Umbridae														
Mudminnow	0	0	0	0	1	2	0	0	0	0	0	0	4	13
Total	44		54		47		453		528		61		30	

[a]One gill net was fished in May and August 1977 and May 1978; two nets were fished in October 1977 and August 1978.
[b]Three minnow traps were fished.

Source: Dames & Moore, 1982
Checked by: WMW

Table 3.8-54

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Gill Net (GN)*, and Electroshocking (ES) - Deep Hole Lake - Station L May, August, October 1977 and May and August 1978

	1977						1978							
	May		August		October		May				August			
	(GN)		(GN)		(GN)		(ES)		(GN)		(ES)		(GN)	
Species	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae														
White sucker	0	0	0	0	0	0	0	0	1	6	0	0	0	0
Cyprinidae														
Golden shiner	0	0	0	0	0	0	0	0	0	0	2	4	0	0
Percidae														
Walleye	0	0	2	3	1	5	9	33	3	19	1	2	3	4
Yellow perch	13	100	62	97	19	95	18	67	12	75	51	94	65	96
Total	13		64		20		27		16		54		68	

*One gill net was fished in May and August 1977; two nets were fished in October 1977 and May and August 1978.

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.8.18 Skunk Lake

No fish were collected by minnow trapping (May 1977) or modified streamside electroshocking (May 1978) in Skunk Lake. Also no fish were collected by the WDNR in verification sampling in September 1979 (Ramharter, 1982).

3.8.2.8.19 Pond 31-13

No fish were collected in minnow traps set in Pond 31-13.

3.8.2.8.20 Pond 6-8

Two mudminnows were the only fish collected by minnow trapping in Pond 6-8 in 1977.

3.8.2.8.21 Pond 35-7

Fish collected from Pond 35-7 in 1977, along with the number collected, and the percent of the catch are: finescale dace, 344 (75 percent); fathead minnow, 59 (13 percent); bluntnose minnow, 55 (12 percent); and brook stickleback, 1 (<1 percent).

3.8.2.8.22 Pond 34-1

One brook stickleback was the only fish collected from minnow traps set in Pond 34-1 in 1977.

3.8.2.8.23 Wolf River

Fish were collected by electroshocking at both Stations Y and Z in May, August and October 1978 (Table 3.8-55).

Common species were white sucker, shorthead redhorse, and common shiner, which comprised up to 27 percent of the fish collected and occurred in every sampling period except August at Station Z. Black bullheads were also common but were not found in the August sampling at either station.

In August at Station Z no fish were captured during electroshocking collections and only small minnows, creek chub, hornyhead chub, common shiner, and an unidentified shiner were collected along the shore by dip net. White sucker, shorthead redhorse, common shiner, rock bass, yellow perch, black crappie, and hornyhead chub were collected by electroshocking conducted at the mouth of the Hunting River, which is located approximately 200 m (656 feet) downstream from Station Z. At the time of sampling, fish apparently avoided this area of the Wolf River for a more suitable area because dissolved oxygen concentrations, measured concurrently with fish sampling, were low, 1.4 mg/L at Station Z, and higher, 5.6 mg/L, at the mouth of the Hunting River. No additional fish species were collected by the WDNR in verification sampling (Ramharter, 1982).

Table 3.8-55

Numbers and Relative Abundance (Percent of Total Catch) of Fish Collected by Electroshocking, Wolf River - Stations Y and Z May, August and October 1978

	May				August*		October			
	(Y)		(Z)		(Y)		(Y)		(Z)	
Species	No.	%	No.	%	No.	%	No.	%	No.	%
Catostomidae										
White sucker	7	21	10	10	1	12	7	7	18	27
Northern Hog sucker	0	0	2	2	0	0	0	0	0	0
Shorehead redhorse	3	9	6	6	2	25	2	2	1	1
Centrarchidae										
Rock bass	0	0	13	13	0	0	0	0	9	13
Pumpkinseed	0	0	0	0	0	0	3	3	1	1
Bluegill	0	0	1	1	0	0	0	0	0	0
Smallmouth bass	1	3	0	0	0	0	2	2	1	1
Black crappie	1	3	8	8	0	0	0	29	0	0
Cyprinidae										
Brassy minnow	1	3	0	0	0	0	0	0	0	0
Hornyhead chub	0	0	17	17	0	0	3	3	3	4
Golden shiner	0	0	0	0	0	0	1	<1	0	0
Common shiner	1	3	22	22	3	38	2	2	9	13
Blacknose shiner	0	0	0	0	0	0	1	<1	0	0
Bluntnose minnow	0	0	0	0	2	25	2	12	0	0
Creek chub	0	0	1	1	0	0	0	0	0	0
Esocidae										
Northern pike	0	0	0	0	0	0	1	<1	1	1
Ictaluridae										
Black bullhead	14	41	7	7	0	0	5	15	17	25
Yellow bullhead	5	15	1	1	0	0	6	6	2	3
Tadpole madtom	0	0	2	2	0	0	1	<1	1	1
Percidae										
Johnny darter	0	0	0	0	0	0	2	2	0	0
Yellow perch	1	3	9	9	0	0	4	14	4	6
Total	34		99		8		102		67	

*No fish were collected in sampling at Station Z.

Source: Dames & Moore, 1982
Checked by: WMW

3.8.2.9 Results of Fish Collection Activities Conducted in 1994.

Fish were collected in May and June 1994 by EA Associates, Deerfield, Illinois. Records of findings are provided in Appendix 3.8-6. Fish collection activities conducted in 1994 were not for the purpose of completing a general population survey. The survey targeted threatened, endangered, or species of concern. No threatened, endangered, or species of concern were collected during these efforts. Data regarding fish collections are provided in Appendix 3.8-7.

Fish were collected for tissue analysis in May and June 1994. Two sites on Swamp Creek, CMC-AB-SC-501 and CMC-AB-SC-502 and one site at Little Sand Lake yielded the requisite ten perch in May. Insufficient perch were collected from either of two Wolf River sampling locations in May. Therefore during a second site visit additional effort was expended to collect perch in the Wolf River. This occurred in June 1994. Because the additional collection effort failed to obtain sufficient numbers of perch for the study, white sucker was substituted for perch for the tissue analysis. Table 3.8-56 provides the data for the tissue and liver analysis.

3.8.2.10 Results of Mussel Collection Activities Completed in 1993 and 1994

Mussel collections were conducted the last week of July and first week of August 1994. Results of mussel identification are provided in Table 3.8-57. Raw data, including field sheets, are provided in Appendix 3.8-8. No threatened or endangered species of mussels were collected from the lakes, streams, or rivers in the Crandon Project study area. A total of three special concern species were collected from the study area. These include the elktoe (*Alasmidonta marginata*, three specimens all from the Wolf River), the creek heelsplitter (*Lasmigona compressa*, 17 specimens all from Swamp Creek), and the round pigtoe (*Pleurobema coccineum*, 103 specimens from the Wolf River and Swamp Creek). The round pigtoe was the second most abundant species collected in two of the sample locations (CMC-AB-SGI-CC and CMC-AB-SC-502). Most specimens of the creek heelsplitter were found in Swamp Creek at site CMC-AB-SC-501).

While the investigation of the Pickerel Creek drainage was limited upstream of Rolling Stone Lake and 100 feet of the discharge from Rolling Stone Lake (Pickerel Creek), no special concern species were collected from these bodies or upstream locations on this chain. An extensive search for the salamander mussel (*Simpsonaias ambigua*) was conducted in two areas of the Wolf River were there was thought to be suitable habitat. These areas included the river immediately below the Post Lake Dam (Site CMC-AB-WR-200) and the river at the Lost Lake Road access (Site CMC-AB-SGI-CC). Substrate in both of these locations contained large rocks and small boulder. The search for this species involved moving the large rocks/boulders and searching beneath for the target mussel. The cylindrical papershell (*Anodontoides ferussacianus*) a species very similar to the salamander mussel was collected and properly identified in the same habitat from which the salamander mussel might be located. Supplemental studies conducted by the WDNR (July 1991 and September 1994, unpublished report) have also failed to locate the salamander mussel in this area.

Table 3.8-56

Concentrations (mg/kg) of Metals in Fish Tissue and Mercury in Fish Livers May/June 1994

	Perch			White Sucker	
	CMC-AB-SC-501	CMC-AB-SC-502	CMC-AB-SL-005	CMC-AB-WR-301	CMC-AB-SGI-CC
Metals					
Arsenic	<0.13	<0.13	0.14	<0.13	<0.16
Cadmium	<0.19	<0.20	3.20	<0.40	<0.31
Chromium	0.95	1.10	0.84	1.30	1.20
Cobalt	0.22	0.34	0.33	<0.43	<0.33
Copper	28.0	17.0	13.1	5.2	6.6
Lead	0.58	0.23	0.35	0.60	0.16
Manganese	8.4	10.6	4.2	9.3	13.7
Zinc	90.2	87.5	68.2	56.4	66.3
Mercury					
1	0.96	0.70	2.80	0.74	1.20
2	0.68	1.00	3.60	1.90	1.10
3	1.50	0.88	2.20	1.30	1.80
4	0.69	0.85	2.40	0.73	0.62
5	0.37	1.10	4.70	0.63	1.10
6	0.90	0.92	0.69	1.90	0.86

Table 3.8-56 *(Continued)*

	Perch				White Sucker
	CMC-AB-SC-501	CMC-AB-SC-502	CMC-AB-SL-005	CMC-AB-WR-301	CMC-AB-SGI-CC
7	0.79	0.79	3.10	1.90	1.90
8	1.20	1.20	2.80	0.75	1.00
9	0.62	0.36	2.50	0.80	1.10
10	0.71	0.94	3.60	0.64	2.20

Prepared by: WMW
Checked by: JJA

Table 3.8-57

1994 Mussel Inventory

Organism	Site	Date	Status
Alasmodonta marginata	CMC-AB-SGI-CC	7/30/94 9/29/94	Special Concern
Anodonta grandis	CMC-AB-SGI-CC	7/30/94 9/29/94	None
	CMC-AB-WR-301	5/10/94	
	CMC-AB-WR-200	7/30/94	
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
	CMC-AB-PK-300	8/05/94	
	CMC-AB-RS-005	8/02/94 8/05/94	
Anodontoides ferussacianus	CMC-AB-SGI-CC	7/30/94 9/29/94	None
	CMC-AB-SC-250	9/30/93	
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
	CMC-AB-SC-700	9/29/94	
	CMC-AB-HL-200	8/04/94	

Table 3.8-57 *(Continued)*

Organism	Site	Date	Status
Fusconia flava	CMC-AB-WR-301	5/10/94	None
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SGI-CC	9/29/94	
	CMC-AB-SC-700	9/29/94	
Lampsilis cardium	CMC-AB-WR-200	7/30/94	None
	CMC-AB-WR-301	5/10/94	
	CMC-AB-SGI-CC	7/30/94 9/29/94	
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
	CMC-AB-SC-700	9/29/94	
Lampsilis siliquoidea	CMC-AB-WR-200	7/30/94	None
	CMC-AB-WR-301	5/10/94	
	CMC-AB-SGI-CC	7/30/94 9/29/94	
	CMC-AB-SC-250	9/30/93	
	CMC-AB-SC-300	7/31/94	
	CMC-AB-SC-301	7/31/94	
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
	CMC-AB-HL-200	7/29/94 8/04/94	
	CMC-AB-SC-700	9/29/94	

Table 3.8-57 *(Continued)*

Organism	Site	Date	Status
Lampsilis siliquoidea	CMC-AB-RS-005	8/05/94	None
Lasmigona costata	CMC-AB-WR-200	7/30/94	None
	CMC-AB-WR-301	5/10/94	
	CMC-AB-SGI-CC	7/30/94 9/29/94	
Lasmigona compressa	CMC-AB-SC-301	7/31/94	Special Concern
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
	CMC-AB-SGI-CC	9/29/94	
Pleurobema coccineum	CMC-AB-SC-700	9/29/94	Special Concern
	CMC-AB-SGI-CC	9/29/94	
	CMC-AB-WR-200	7/30/94	
	CMC-AB-WR-301	5/10/94	
	CMC-AB-SGI-CC	7/30/94	
	CMC-AB-SC-501	8/02/94	
	CMC-AB-SC-502	8/01/94	
Strophitus undulatus	CMC-AB-SGI-CC	7/30/94	None
	CMC-AB-PK-300	8/05/94	
	CMC-AB-SC-700	9/29/94	

Prepared by: WMW
Checked by: JJA

In late July 1994 there was a reported collection of a state threatened species (slippershell, *Alasmidonta viridis*) by Glen Miller of GLIFWC in the same area as Site CMC-AB-SGI-CC. Specimen verification is still pending. During follow-up field work conducted in September 1994 by Dave Heath of WDNR, specimens of the squawfoot (*Strophitis undulatus*) were collected. The squawfoot is morphologically similar to the slippershell. It is believed that the squawfoot, which is not a species of concern, is the likely identification of the GLIFWC specimen. Several specimens of the squawfoot were collected and identified as such by Helms & Associates in the same location during the first week of August 1994.

3.8.3 Ecological Significance of Findings

The Crandon Project study area is surrounded by two watersheds, the Swamp Creek and Pickerel Creek chains, both of which are within the Wolf River drainage basin. Some of the lakes located within the Crandon Project study area are connected directly via surface flow to one or the other chains, while other lakes are indirectly connected via subsurface flow or are isolated. Hemlock Creek which borders the project study area to the east, is directly connected to the Swamp Creek chain. Some lakes such as Duck Lake, Little Sand Lake, and Deep Hole Lake are at times directly connected to the Pickerel Creek chain via Creek 12-9, however, only during periods of extremely high water is this a direct connection. In most cases, the outlet of Little Sand Lake is no more than recharge to adjacent wetlands. These physical connections are important from the standpoint of species distribution and migration up the Pickerel Chain, especially for species of fish and mussels. Other lakes which appear to have similar isolated conditions include Skunk Lake which indirectly drains toward the Pickerel Chain, and Oak Lake and Popple Pond which drain toward Swamp Creek. Another factor which restricts the migration of fish and mussels includes natural barriers such as beaver dams. This is especially true along Hemlock Creek and Swamp Creek above Rice Lake.

Biologically, the Swamp Creek watershed is connected only with the Wolf River watershed. There are no other surface water connections with any other watersheds via lakes or streams that would allow movements of fish, macroinvertebrates, or other forms of aquatic biota between watersheds. Aquatic insects, most of which are capable of dispersal flight in the adult stage, could conceivably colonize any suitable habitat within the project area, as physical/geographical barriers here are extremely slight. This is especially true for the Odonata. Differences in insect species composition at the different sample sites is much more dependant on specific habitat requirements.

The flow rate of tributary streams to Swamp Creek and Rice Lake is sufficient to support biological populations that could serve as sources for colonization of downstream water bodies. There is no linkage for aquatic species between the Pickerel Creek watershed and any adjacent watersheds except the Wolf River. No surface water connections exist with any other watersheds via lakes or streams that would allow movements of fish, macroinvertebrates, or other forms of aquatic biota between watersheds. The flow rate in tributary streams to Rolling Stone Lake is sufficient to support biological populations that could serve as sources for colonization of downstream water bodies.

Streams of the study area generally share similar physical characteristics. The streams are small, often not well defined, and of low gradient. Generally, the creeks have surface water drainage from and through wetland areas and the creek bottoms are composed of soft muck. However, small areas of firm sand and gravel substrate also exits in portions of most creeks. The Wolf

River also drains wetlands but the bottom composition is generally more firm than the creeks. The extent of riffle habitat is minor in most of the streams with the only significant riffle area being found in Swamp Creek north of the project area. This is important for survey purposes, as riffles can support high biological diversity and a relatively high number of "sensitive species".

Previous studies conducted in the 1970s and 1980s (Dames & Moore, 1982; Ecological Analysts, Inc., 1983) reported no threatened, endangered, or special concern species in the fish, mussel, macroinvertebrate, or Odonata groups. With the exception of fish, the lack of such findings in earlier studies is attributable to differences in method of collection, degree of taxonomy required and study objectives.

3.8.3.1 Summary of 1977-1978 Biological Findings

The analysis of periphytic algal samples suggests that communities were generally similar in the running waters. Diatoms comprised the major portions of the collections, and *Cocconeis placentula* or *Achnanthes minutissima* were the most abundant species. Notable exceptions occurred in Pickerel Creek where *Eunotia curvata* and *Navicula minima* were most abundant, and Creek 11-4 where *A. lanceolata* was the most abundant.

Benthic macroinvertebrate data indicate that benthos composition and abundance was primarily dependent on the habitats present; that is, substrate type, current velocity, and dissolved oxygen content. In the creeks, numbers of organisms were highest (consistently >14,000/m^2) in samples from areas of soft silty substrate such as Creek 11-4 and Hemlock Creek. Densities were lowest (<4,000/m^2) in samples from areas of highest current velocity with sand and gravel substrates, such as Station D at Swamp Creek. Midges, which occur over a wide range of substrates (Curry, 1965), were the most abundant benthic taxa at all stations except Creek 11-4 and the Wolf River. In Creek 11-4, worms from the family Tubificidae were abundant in the organic sediment. Brinkhurst (1966) and Brinkhurst and Jamieson (1971) have indicated that most tubificids are generally dominant in soft sediments. The largest densities of clams were typically found in substrates composed of silt with some sand such as occurred at Station E on Swamp Creek, Creek 12-9, and both stations on the Wolf River. DeMarch (1976) reported that the clam *Sphaerium* sp. was very common in substrates composed of sand overlain with silt. Caddisflies, specifically *Leucotrichia pictipes* and *Glossosoma* sp., which were subdominant at Station D in Swamp Creek, are typical of such fast-flowing areas of streams (Wiggins, 1977).

Information on the spatial and temporal relationships of benthic macroinvertebrates in Swamp Creek downstream from County Trunk Highway M is presented in reports by Ecological Analysts, Inc. (1983, 1984a). These reports contain biotic index values for macroinvertebrates and identification of dominant taxa in the vicinity of the previously proposed water discharge site.

Based on electrofishing data, three general fish associations were apparent in streams of the study area. In the smaller, headwater streams such as Hoffman and Pickerel creeks and Creek 12-9, numbers of species were low (five to nine) and brook trout and mottled sculpin were dominant. Station D in Swamp Creek had intermediate characteristics. Swamp Creek is a large stream providing more habitats for varied fish species (15), but because of the steep gradient, it has characteristics of a headwater stream, such as an abundance of brook trout, mottle sculpin, and other trout indicator species, specifically blacknose and longnose dace (Becker, 1976). In the larger sluggish streams (>4.0 m [>13 feet] mean width), including portions of Hemlock

Creek, Swamp Creek, and Creek 11-4 (because of its pond-like characteristics), numbers of species were relatively high (15 to 21) and generally dominated by minnows.

Information on fish communities in Swamp Creek downstream from County Trunk Highway M is presented in reports by Ecological Analysts, Inc. (1983, 1984a). These reports contain documentation on the spatial and temporal characteristics of fish species in the vicinity of the proposed water discharge site and a comparison of the species found in Swamp Creek in relation to those reported in the Wolf River and Rice Lake and in Swamp Creek upstream from Rice Lake.

With few exceptions, phytoplankton densities in the lakes were lowest in samples collected during winter and with improving light conditions and increasing temperature during spring, phytoplanton densities increased and peaked in July, August or September then decreased in the fall. Nitrate, an important nutrient for phytoplankton, was generally highest during winter when phytoplankton levels were lowest, and decreased throughout the year to levels below detection limits in the autumn. Exceptions to the general pattern of summer phytoplankton maxima were observed in samples from Deep Hole and Rolling Stone lakes where phytoplankton exhibited two peaks in abundance: May and September 1978 in Deep Hole, and March and August 1978 in Rolling Stone Lake.

Golden-brown algae were abundant in samples from all lakes, and green algae and blue-green algae were also common. Diatoms, in contrast to their abundance in periphyton, were common only in phytoplankton samples from Rice Lake.

Zooplankton densities were typically lowest in samples collected in March, and spring or autumn pulses were observed. Both spring and autumn pulses were recorded in samples from all lakes except Duck, Deep Hole, and Skunk. Autumn maxima only were observed at Duck and Deep Hole lakes. Skunk Lake, sampled from June through October, exhibited highest density in July and low densities during subsequent months. Densities were typically <400/L in all lakes except when high numbers of rotifers were collected. Rotifers were most abundant in Skunk (up to 1,200/L), Duck, and Deep Hole Lakes. Copepods dominated in Little Sand and Oak Lakes, lakes with the clearest water. Copepods and rotifers were generally co-dominant in Rice and Rolling Stone Lakes, the hard water lakes.

Diatoms comprised the major portion of the periphytic algae samples from the lakes which also was observed in the creeks. Most diatoms are sessile and are associated with littoral substrates (Hutchinson, 1967). Diatom dominance generally was greatest in samples collected during spring and autumn and least during summer. Diatoms were less dominant in the samples from seepage than discharge lakes possibly because the levels of silica were lower in the mineral-poor waters of the seepage lakes. *Cocconeis placentula*, a dominant or sub-dominant in most creeks, was the dominant species in the discharge lakes. *Tabellaria fenestrata* or *T. flocculosa* were the dominant diatoms in the seepage lakes, except Skunk Lake. In Skunk Lake, *Nitzschia palea* was most abundant. Water chemistry data indicate that nutrient levels were highest in Skunk Lake, which is consistent with the abundance of *N. palea*, an indicator of organic enrichment (Palmer, 1969).

Density of benthic organisms was lowest in samples collected from the uniform muck substrate in Oak Lake (<8,000/m^2) and tended to be highest in the dense vegetation at Rice and Rolling Stone lakes (up to 58,000/m). Midges predominated in samples from all seepage lakes except Duck Lake. Snails, midges and worms were prominent in the discharge lakes. *Tanytarsus* sp. was

the most common midge at all lakes except Skunk and Rolling Stone, where *Chironomus* sp. was most common. *Chironomus* sp. is typically predominant in the benthos of eutrophic lakes or areas subject to oxygen depletion (Brundin, 1956). *Tanytarsus* sp. is more sensitive to oxygen depletion and is typically found in less enriched areas (Brundin, 1956).

The seepage lakes of the study area have very low intermittent inflow or outflow, which severely restricts opportunity for interlake fish movements. In general, the fish fauna was characterized as consisting of a few species with yellow perch as the dominant. No fish were found in Skunk Lake. Periodically low dissolved oxygen concentrations apparently make the lake uninhabitable for fish. Based on total species counts from all sampling gear, species richness was highest in lakes that contained varied habitat such as Oak Lake (8 species), and Little Sand Lake (10 species), where sand, gravel, muck and vegetation were present. In Duck Lake, where the bottom substrate primarily consisted of soft muck, only three species were collected. Sunfish, which prefer a firm sand or gravel substrate for spawning, occurred only in Oak and Little Sand lakes.

The data indicate that the fish communities were generally similar in the two discharge lakes. Fifteen species were collected in Rice Lake and twelve in Rolling Stone Lake. Black bullhead, white sucker, and sunfish species were common in samples from both lakes. However, walleye and black crappie were found in Rolling Stone Lake, but not Rice Lake. Both species prefer water bodies with firm bottoms (Becker, 1976). Although extensive areas of Rolling Stone Lake contain soft sediments, sand and gravel areas exist along the near-shore areas, particularly along the eastern and western shore, whereas no firm substrate was found in Rice Lake. In the Wolf River, 21 species of fish were collected. The collections were generally dominated by suckers, minnow species and black bullhead.

3.8.3.2 Significance of Macroinvertebrate Findings from 1993-1994 Studies

Aquatic macroinvertebrates were collected from November 1993 through August 1994. Most of the collections were instream life stages of macroinvertebrates, such as annelids, leeches, insects, crustaceans and mollusks. However, to help identify some specimens to species, some groups were collected in the adult stages. Adult insect collections were conducted using light trapping techniques. Groups targeted for light trapping included members of the orders Ephemeroptera, Trichoptera, Plecoptera, and Coleoptera.

This discussion will not address Odonata, which will be addressed in a following section. No threatened or endangered aquatic macroinvertebrate species were collected or observed from the study area during the period of study. Some Trichoptera larvae were collected which were of a genus (*Triaenoides*) which could contain a listed species; however, larvae of this genus cannot be identified to species. Subsequent light trapping for adults of the aquatic forms resulted in the finding of a species of concern (*T. dipsius*) at several locations throughout the study area. Two of the four sites where *Triaenoides dipsius* was collected were sites where streams are flowing toward the mine site (Outlet Creek and Hemlock Creek). Additional sightings occurred at Hoffman Springs and Swamp Creek both west of the mine site.

Though not a listed species, a single stone fly of the genus *Alloperla* was collected from the riffle area of Swamp Creek. This finding is of a genus which has not been recorded previously from the state of Wisconsin. A female *Alloperla* was collected also at Swamp Creek 300, but only males can be identified to species. The Ephemeropteran *Caenis youngi* was collected from two

sites in the study area (Martin Springs and Wolf River). This special concern specie has few sightings in the state.

The results of light trapping illustrate the diversity of the study area as some 65 species of Trichoptera were collected during one week in early summer. Some of the species collected are uncommon and were collected in low numbers, but were widely distributed throughout the study area. Most of the 65 Trichopteran species collected from the ten sites are indicators of good to excellent water quality (Tennessen, June 1994 personal communication).

Distribution of macroinvertebrates and richness of taxa suggests that local populations have colonized available habitat. The finding of several uncommon species in low numbers or where no record has been recorded in the state is not surprising considering the level of effort afforded this study was much more intensive that any prior work in the area. As a result, it is suggested that many species are likely more common, at least in Northern Wisconsin, than previously thought.

3.8.3.2.1 Significance of Tissue Analysis of Crayfish Collected in 1994

The purpose of collecting information regarding the amount of metals in crayfish tissue was to establish a background for the project. Based on local watershed chemistries, it is known that in general, waters of the study area are soft with hardness values ranging from 10 to 100 mg/L. Soft waters generally have more available metals which in turn are often times accumulated in the food chain. Metals data for crayfish taken in the study area fall within the range of similar data for soft water lakes.

3.8.3.3 Significance of 1993 and 1994 Odonata Findings

Dragonflies represent a group of insects which are extremely mobile and have the ability to colonize suitable habitat fairly rapidly, i.e., they do not depend on other organisms or continuous aquatic habitat with which to disperse upstream or downstream, in contrast to fish and mussels which require continuous habitat to disperse. The Odonata are also very opportunistic. It would not be unreasonable to find populations of individual species in marginal habitat for short periods of time. Because of the mosaic of aquatic habitat in the area, the mobility of Odonata, and the fact that no intensive study of Odonata has ever been conducted in the study area previously, it is reasonable to expect to find numerous species including some listed species in the study area.

A total of 57 species of Odonata were identified from the study area. No species of Odonata categorized by the State of Wisconsin as threatened or endangered were observed or collected in the study area. A total of twelve species listed as special concern species in Wisconsin were observed or collected from the study area. An additional five genera listed as possible special concern species were collected and identified to genus, but species identifications were not possible either because the life form collected did not provide positive species identification or the adult was only observed on the wing and positive identification was impossible. Genera which included unidentified species included *Aeshna sp.*, *Calopteryx sp.*, *Enallagma sp.*, *Epitheca sp.*, *Gomphus sp.*, *Gomphus (Gomphus) sp.*, *Gomphus (Gomphurus) sp.*, *Leucorrhinia sp.*, and *Somatochlora sp.* A third category of specimens which did not receive species identification included genera for which there are no known listed species. Examples of specimens occurring in this category include *Calopteryx sp.*, *Epitheca sp.*, and *Leucorrhinia sp.*

The most frequent taxon collected and identified only to genus was *Aeshna sp.* This genus was collected in the nymph stage 15 times at 11 locations, exuviae were collected five times at five different locations. These specimens were collected from a variety of habitats including ponds, lakes, large streams and some smaller streams which do not have a closed canopy, i.e., are bordered by open sedge meadow. Based on adults, four species of *Aeshna* were identified, including *A. canadensis, A. umbrosa, A. eremita,* and *A. tuberculifera,* the latter two being special concern species.

In general, aeshnids are commonly seen cruising open water, which includes lakes and ponds and open areas over land. Wider rivers and streams are also common areas to find aeshnids as well as smaller streams if broad expanses of open meadow exist (Tennessen, June 1994, personal communication). Emergent vegetation and other plant materials are favored by the adult, and also are essential for deposition of eggs. The habitat described can be found throughout the study area, including edges of lakes proximal to the plant site (Skunk, Oak, Little Sand, Popple Pond) and lakes and rivers more distal to the plant site (Hemlock Creek, Wolf River, Martin Springs, Swamp Creek). This survey found no indication that any species of aeshnid resident in northern Wisconsin is restricted by lack of habitat in the vicinity (proximal or distal) of the mine site.

Several gomphids were collected from the study area three of which were special concern species. These included *Ophiogomphus carolus, Gomphus lineatifrons* and *G. viridifrons.* Other gomphids which were found as nymphs and therefore only identifiable to genus included *G.(Gomphus) sp.* and *G. (Gomphurus) sp. G.(Gomphus) sp.* was thought to be *G. spicatus* which was observed at numerous sites. The *G. (Gomphurus) sp.* specimen was a small nymph which was thought to be *G. ventricosus* (Tennessen, June 1994, personal communication).

G. lineatifrons is a listed species, but is fairly common in northern Wisconsin where suitable stream habitat exists. This species has a preference for medium-sized streams (15 to 20 feet wide), and was found in fairly good number in both the Wolf River and Swamp Creek. *G. lineatifrons* nymphs can tolerate some degree of silt and muck in the substrate, but need a mix of sand and gravel. This microhabitat is common along Swamp Creek and the Wolf River. *G. viridifrons* requires much the same habitat as *G. lineatifrons* and the two species often occur together. *G. viridifrons* appears to prefer slightly larger streams, however (Tennessen, June 1994, personal communication).

These two special concern species appear to be restricted in distribution within the project area based on stream size. Both were found commonly on Swamp Creek downstream of County Highway M and on the Wolf River. Other common, widespread gomphid species (*G. exilis, G. lividus, G. spicatus*) were located throughout the study area including small streams and lakes. These species do not appear to be restricted by stream size and appear to be well distributed throughout the study area.

Three species of *Ophiogomphus* were collected from the study area, including *O. rupinsulensis, O. colubrinus,* and *O. carolus,* the latter a special concern species. The identification of *O. carolus* was based on the nymph stage, and is therefore uncertain. All three species were found in the riffle area of Swamp Creek (CMC-AB-SC-300 and CMC-AB-SC-301).

Six species of *Somatochlora* were collected from the study area. Three species, *S. elongata, S. forcipata*, and *S. kennedyi* are special concern species. In general, members of this genus are difficult to collect as nymphs or exuviae because they usually occur in bog, swamp, and marsh habitat. Although several of the specimens collected were of the nymph and exuviae form, species presence is best assessed using adult collection methods. Most of the adults captured were taken along sandy or dirt roads sometimes well away from an obvious water source. While this is a typical location for finding adult specimens, road habitat does nothing to pinpoint the microhabitat or exact location of the specimen origination.

The only known North American species of *Stylogomphus (S. albistylus)*, a special concern species in Wisconsin, was collected in the riffle area of Swamp Creek. This specie inhabits areas of gentle riffle with rock and gravel substrate (Tennessen, June 1994, personal communication). Suitable habitat may occur upstream and downstream of the riffle area on Swamp Creek.

Two special concern species of the genus *Stylurus* were collected from the Wolf River, one of which was collected only from the riffle area of Swamp Creek. *S. amnicola* is somewhat restricted to larger streams and was only found in the Wolf River. *S. scudderi* which can tolerate a mix of sand and muck was found in both the Wolf River and Swamp Creek (riffle area).

Lestes eurinus, a damselfly special concern species, was possibly sighted at Skunk Lake, as a single adult male was perched on emergent vegetation. No positive identification could be made at the time because the adult specimen was not captured. This species needs fishless habitat such as that which occurs in Skunk Lake (Tennessen, June 1994, personal communication). Several pond habitats similar to Skunk Lake occur in the study area though not all are fishless. Some similar pond habitat such as Popple Pond and Upper Hoffman Springs have had in the past minnows introduced to them and their status as "fishless" is questionable (Ray Hoffman, personal communication).

Another damselfly special concern species, *Chromagrion conditum*, was collected at Hoffman Springs, in both the nymph and adult stages. Its habitat is primarily shallow, spring-fed runs or small pools in shaded areas. The species is likely to occur in other locations within the study area, but its preferred habitat among the sampling locations chosen was found only at Hoffman Springs.

In general, most habitats which contain Odonata special concern species are replicated throughout the study area as well as outside of the study area. Two areas which are not well duplicated throughout the study area but which are found outside of the study area include the riffle area of Swamp Creek north of the mine site and the large stream complex represented by the lower Swamp Creek/Wolf River study area segments.

Lower Swamp Creek (downstream of County Highway M) and the Wolf River are large enough to supply habitat for several gomphids which require a larger stream. Similar habitat in the study area includes the Wolf River both upstream and downstream of the confluence with Swamp Creek and possibly other peripheral streams such as Squaw Creek, Pickerel Creek below Rolling Stone Lake and Spider Creek.

3.8.3.4 Significance of Fish Findings 1994

No threatened, endangered, or special concern species were observed during the 1994 collection effort. This is consistent with the findings of previous studies as discussed above.

The six species of fish targeted for this study (river redhorse, greater redhorse, pugnose shiner, pugnose minnow, least darter, and weed shiner) are all fish which have been found in the lower Wolf River drainage and have the potential for distribution in the study area. In general, with the exception of Rolling Stone Lake, other lakes within the study area are isolated from the Wolf River drainage system and have little or no opportunity for recruitment. If the target species are present, the best opportunity for observing them would be in the Wolf River. Since none of the areas studied produced target species, it is concluded that there is a high probability that these species do not exist in the study area.

3.8.3.4.1 Significance of Tissue Analysis of Fish Collected in 1994

Metals analysis of fish fillets and livers was conducted at selected locations within the study area. The purpose of the analysis was to provide a certain degree of continuity of data from reports generated in the 1970s and 1980s. This information also serves to establish a background for pre-mining data of the study area.

In comparison to data reported in 1983 by EA Associates (EMI-SW-BA-5), concentrations of metals in white sucker have, in general, decreased slightly by 1994. Some of this may be due to lower detection levels achieved for some metals, however, because of the migratory nature of white sucker, it is impossible to say that a collection of specimens at a certain location on the Wolf River can be duplicated year to year. This data should be used to help establish a range of concentrations observed by the species sampled.

Based on review of the data, it appears as though the perch in Little Sand Lake have a higher average concentration of mercury in their tissue than either perch from the Swamp Creek or white sucker from the Wolf River. Concentrations of arsenic and cadmium in fish liver were also higher in perch from Little Sand Lake than in Swamp Creek and the Wolf River though other metal concentrations appeared about the same in all fish. The chemistry of Little Sand Lake may promote metal uptake in Little Sand Lake over the other sites and the differences may be somewhat related to the difference between lentic and lotic environments in conjunction with stream and lake chemistries.

3.8.3.5 Significance of Mussel Findings

Studies conducted in 1994 represent the first comprehensive mussel surveys conducted in the Crandon Project study area. Previous collection efforts conducted by Dames & Moore in 1977 and 1978 were generally unsuccessful in finding significant populations of any mussels outside of the common fingernail clams. More recent studies conducted by Dave Heath of the Wisconsin Department of Natural Resources (June 1991, unpublished data) concentrated efforts on the Wolf River particularly in the vicinity of Lower Post Lake and the adjacent outfall. The present study included the Wolf River from Lower Post Lake downstream to the Lost Lake Road access, major portions of Swamp Creek, Hemlock Creek, and lakes around the mine site, and the Pickerel Creek drainage basin at Rolling Stone Lake including Pickerel Creek at the outfall from Rolling Stone Lake.

Because few species of mussels had been reported from the study area in the 1970s, the initial premise for the 1994 study was to look for recruitment from the major drainage systems, i.e., the Swamp and Pickerel Creek drainage systems via the Wolf River. The highest probability for success in finding listed species was expected to come from the Wolf River. If listed species are found in the Wolf River, then it would be possible to find similar species closer to the mine by following the Swamp and Pickerel Creek chains. Based on knowledge of the drainage systems, it would be possible to migrate up Swamp Creek somewhat above Rice Lake before a series of beaver dams obstructs upstream movement. Likewise, upstream mobility seems unimpeded in the Pickerel chain until Rolling Stone Lake. Upstream mobility beyond Rolling Stone Lake may be possible via Pickerel Creek, Martin Springs, and Creek 12-9, however, these streams generally originate from groundwater sources and upstream migration from Rolling Stone Lake seems improbable.

Eleven species of mussels were collected and identified from the study area. All of the species collected were collected from the Wolf River many of which were also collected from lower Swamp Creek. No threatened or endangered species were collected during the 1994 collection efforts. Three special concern species were collected and identified from the study area. All three were collected in the Wolf River and Swamp Creek drainage system (Swamp Creek below County Highway M).

The elktoe (*Alasmodonta marginata*) was found in the Wolf River. One living specimen and two complete dead shells (from middens) were collected from the site downstream of the mouth of Swamp Creek. None were found at the upstream site on the Wolf River and none were found at any of the other sampling locations. Host fish species include white sucker, northern hog sucker, shorthead redhorse, rock bass and warmouth, some of which are quite common in the Wolf River in the study area.

The creek heelsplitter (*Lasmigona compressa*) was found at three of the four locations sampled in Swamp Creek. Ten were found in Swamp Creek below County Highway M (CMC-AB-SC-501), one was found at CMC-AB-SC-502, and six were collected one half mile downstream from Swampy Lane (lower portion of riffle area of Swamp Creek). In addition, a survey by the WDNR in 1991 produced one specimen in a collection of 494 individuals in the Wolf River downstream of the Post Lake dam. The only known host for the creek heelsplitter is carp. Habitat reported by Cummings and Mayer (1992) is creeks and the headwaters of small to medium rivers in fine gravel or sand. It is rarely found on large rivers.

The round pigtoe (*Pleurobema coccineum*) was encountered at both collection sites in the Wolf River and the two sites on Swamp Creek. The species was relatively common in these areas. Its host is unknown. Habitat reported by Cummings and Mayer (1992) is medium to large rivers in mud, sand, or gravel.

Some threatened and endangered species are not expected to be found in the study area because they are generally limited to the Mississippi and Ohio drainage basins (winged maple leaf [Vaughan, 1993], purple warty back, bullhead, monkeyface, buckhorn, and scaleshell [Cummings and Mayer, 1992]). Listed mussel species that occur in the lower Wolf River include snuffbox (*Epioblasma triquetra*), salamander mussel (*Simpsonaias ambigua*), slippershell (*Alasmidonta viridis*), and buckhorn (*Tritogonia verrucosa*) (WDNR, 1995).

It is apparent from this survey that the Wolf River is the dominant factor determining the mussel community in the vicinity of the Crandon Project site. The Wolf River carries the most abundant and diverse population of unionid mollusks. The more remote from the Wolf River, the fewer individuals and less diverse the mussel community became. This is true of both streams and lakes in the area. The three target species encountered in this survey, all listed as special concern, also tended to be found either in the Wolf River or close to it. The reason for this phenomenon may be linked to accessibility of host species, however, chemical and physical factors may contribute as well. The condition of some of the specimens examined certainly indicate a harsh environment that is not conducive to the well being of mollusks. The primary indicator of this is the extreme erosion and pitting observed on many of the specimens.

3.8.3.6 Summary

Overall, within the study area no habitat was noted that is unique to northern Wisconsin. Given this fact, the list of species found was typical of what would be expected within the habitat of the study area. The finding of some uncommon species, for example, *Alloperla* sp. found during nymph collection and light trapping and *Caenis youngi* found at several locations during light trapping was not due to the uniqueness of the habitat, but rather to the thoroughness of the study. It is likely that success in finding uncommon species can be achieved in similar habitats outside the study area using methods based on insect's activity patterns.

Aquatic habitats are colonized by diverse populations of flora and fauna. These populations are dynamic and change from time to time depending on a variety of environmental conditions. Some groups of organisms such as fish and mussels depend on continuous water resources for distribution. In addition, mussels are dependent on host species such as fish and amphibians for dispersal. Many aquatic insects, on the other hand, have terrestrial life stages and are capable of dispersion and distribution without the need for continuous water resources. Because of these diverse biological requirements, the occurrence of natural phenomena such as the drought of 1988-1989 and the location and/or relocations of beaver dams could affect fish and mussel populations more than insect populations.

Throughout this section of the EIR there have been discussions relative to the aquatic habitats found throughout the project study area. It was noted that limiting factors for aquatic faunal distribution include water depth, water quality, spatial distribution of stream impediments such as beaver dams, water temperature, and harshness of the environment such as the scouring effect of riffle areas. Considering these environmental conditions, it would appear that mussels are and will be one of the most limited populations. While mussels are common in the Wolf River downstream of Lower Post Lake, the colonization of streams and lakes on the Swamp Creek and Pickerel Creek chains is limited. Therefore, their functional role within the Crandon Project area is expected to be limited.

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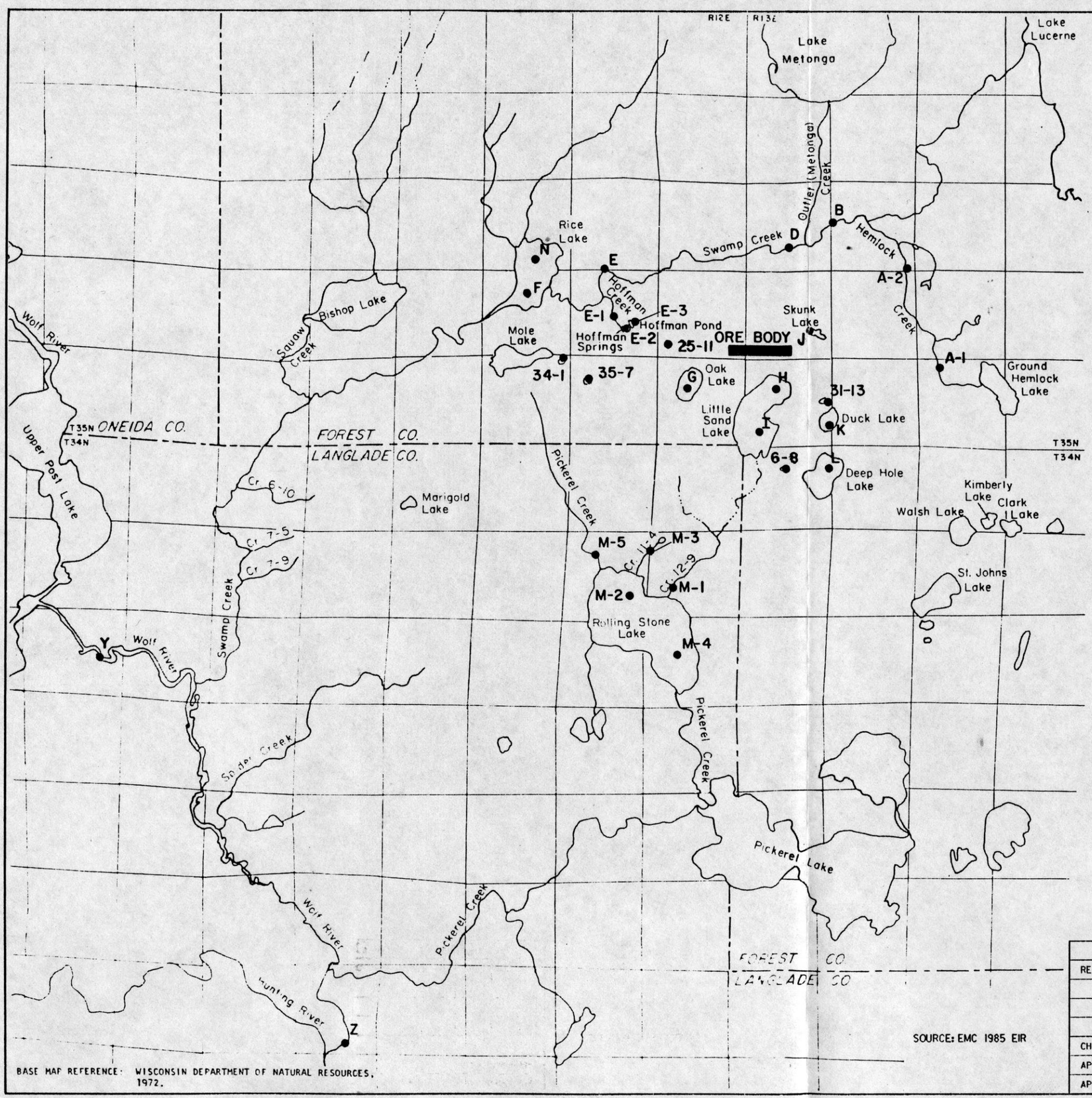
FIGURES FOR SECTION 3.8



KEY:

STREAM

25-11 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED LAKES

Cr. 11-4 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED STREAMS

● — AQUATIC ECOLOGY SAMPLING STATION

Note: Additional sampling was conducted in Swamp Creek downstream from Rice Lake. The results of this sampling program are presented in Ecological Analysts, Inc. (1983, 1984a,b).

1 .5 0 1 MILE

SOURCE: EMC 1985 EIR

BASE MAP REFERENCE: WISCONSIN DEPARTMENT OF NATURAL RESOURCES, 1972.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-1

AQUATIC ECOLOGY SAMPLING LOCATIONS (PRE 1993/94 WORK)

Scale:	AS SHOWN	Date:	MAY 1995
Prepared By:	Foth & Van Dyke	By:	JPR

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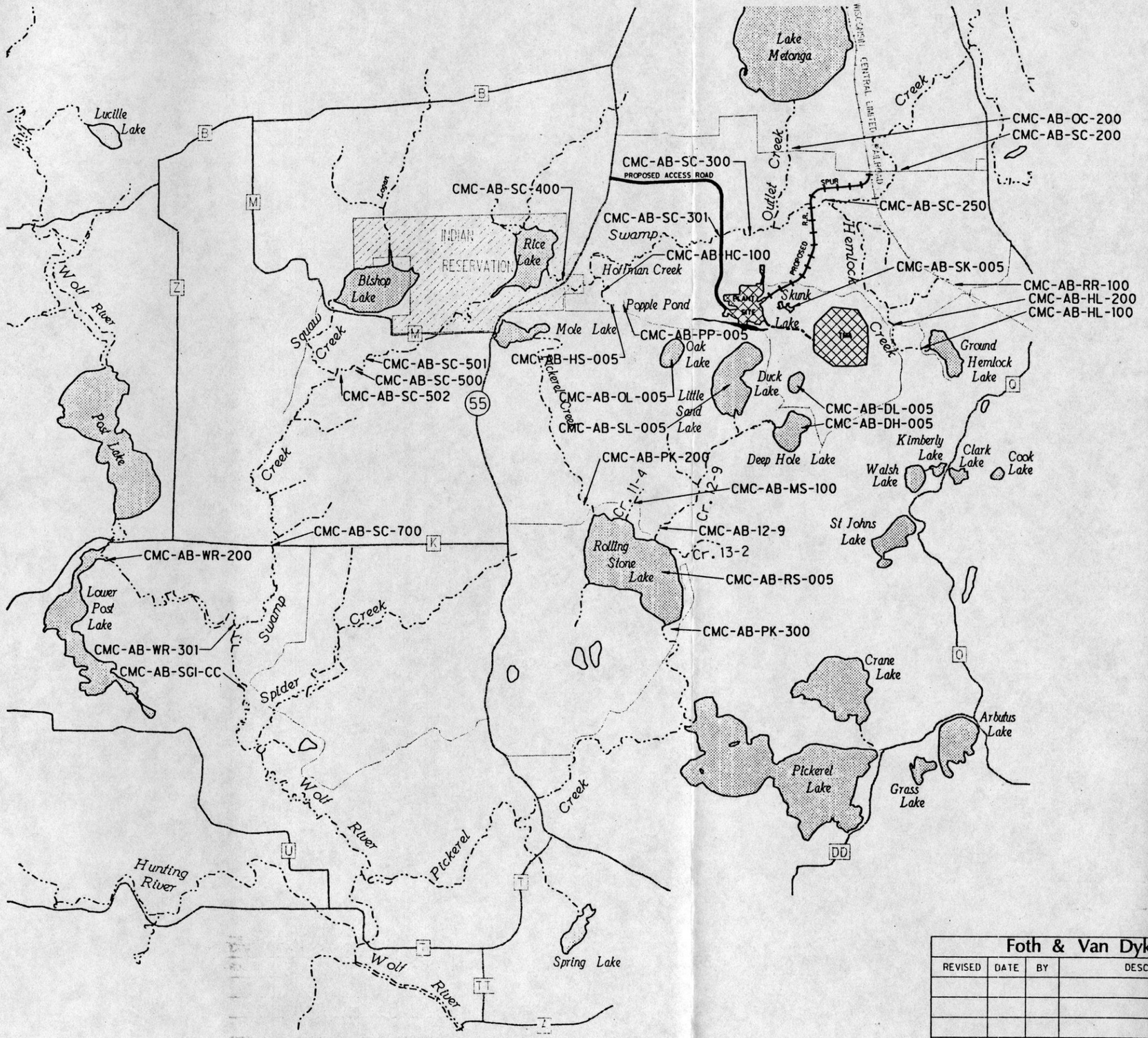


NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

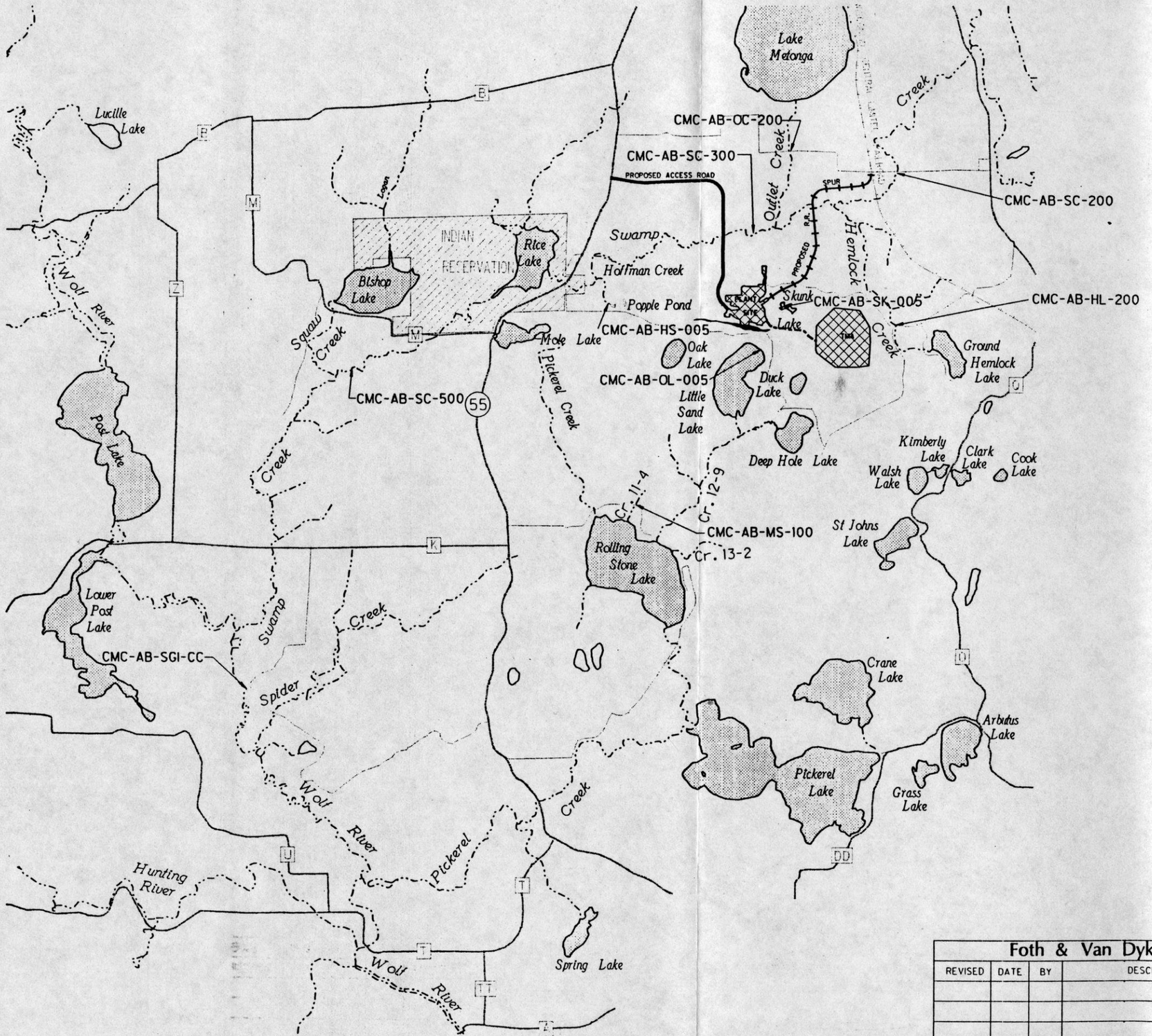
Crandon Mining Company

FIGURE 3.8-2
1993/1994 GENERAL
AQUATIC SAMPLE LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

930049



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-HL-200 SAMPLING LOCATION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-3

1994 LIGHT TRAPPING STATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

93C049

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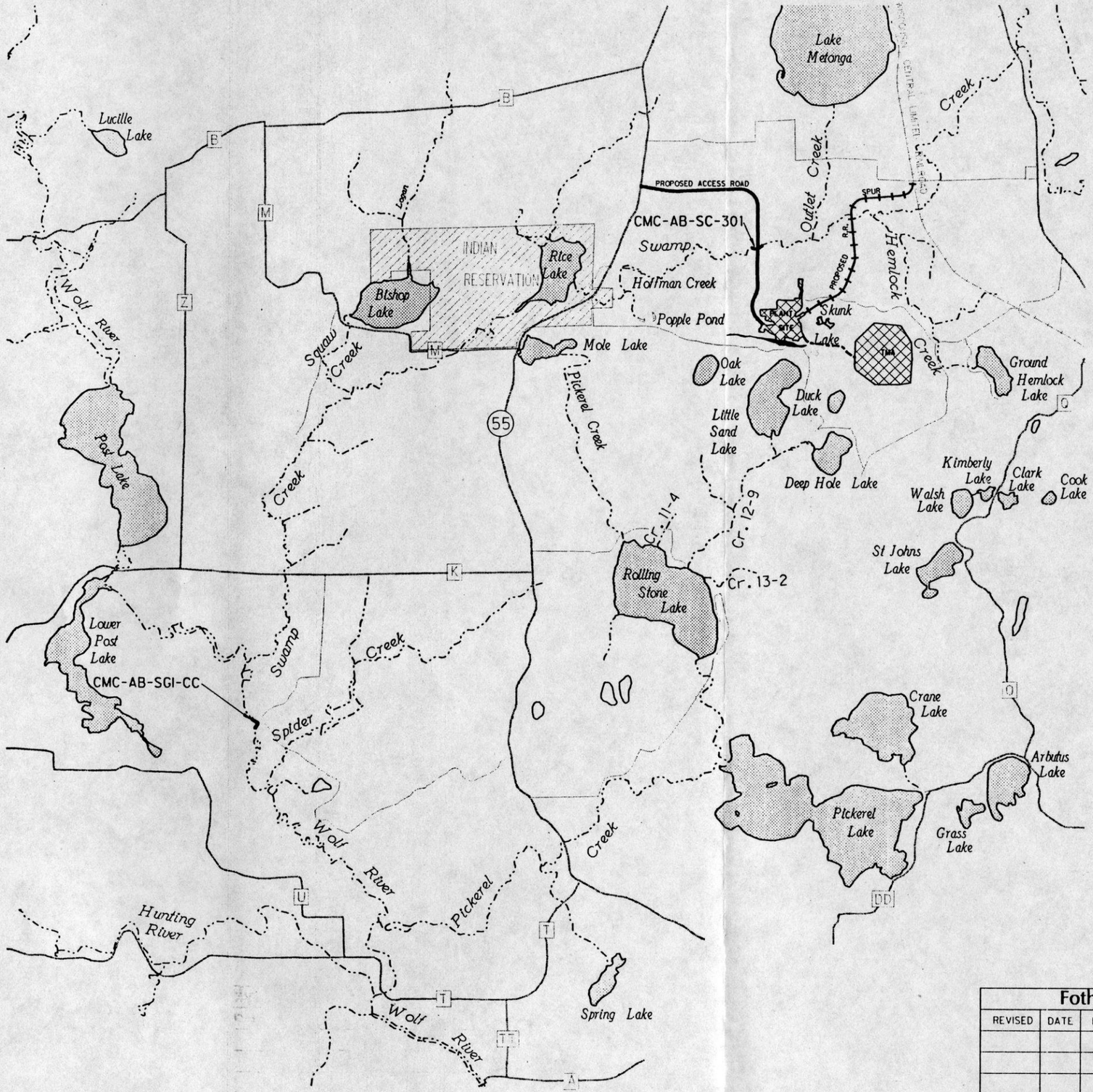

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SGI-CC SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

N

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-4
JUNE 1994 WDNR/FOTH & VAN DYKE
EXUVIAE COLLECTION SITES

Scale: 0 3750' 7500' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPR

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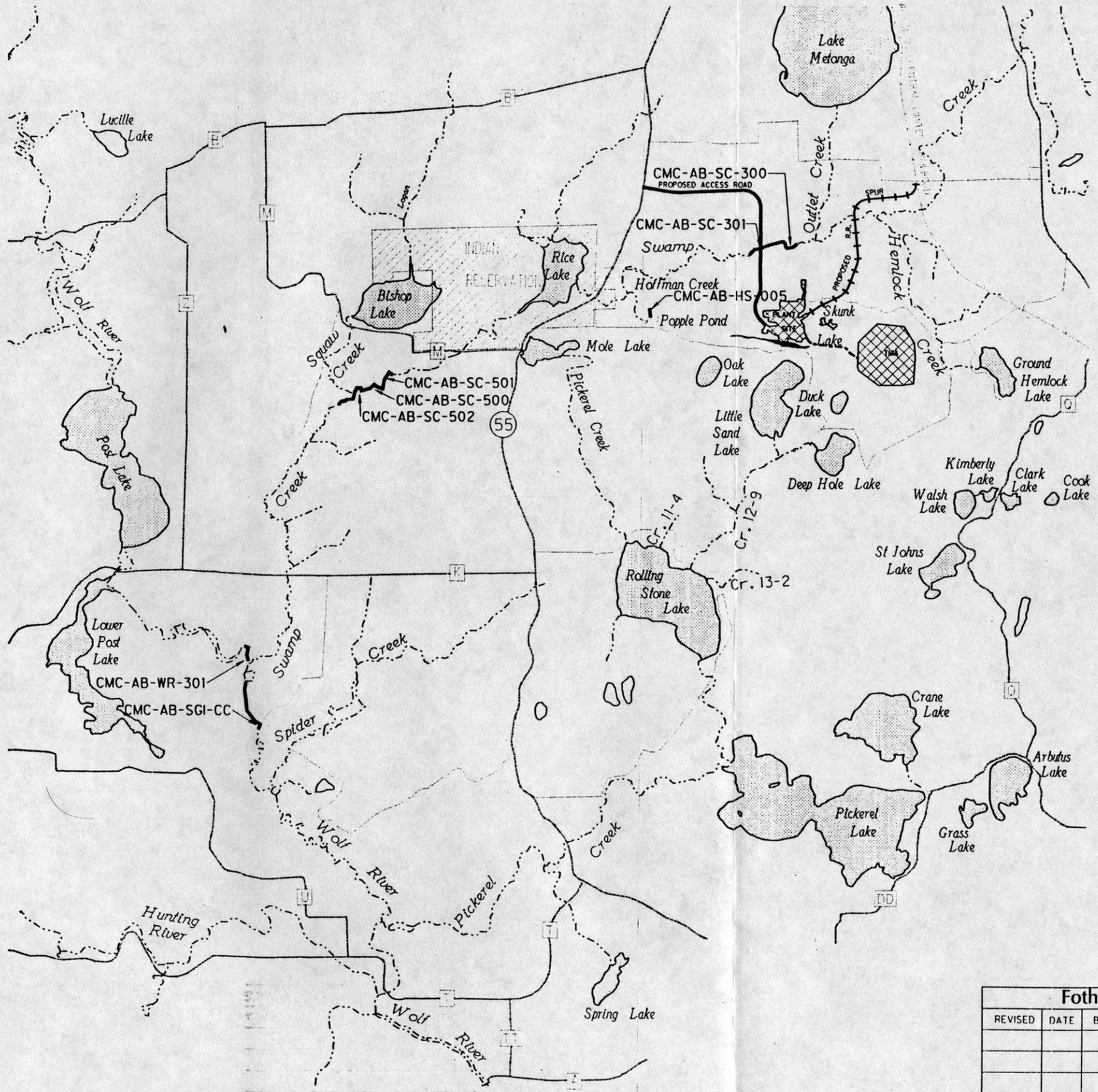
93C049



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-5

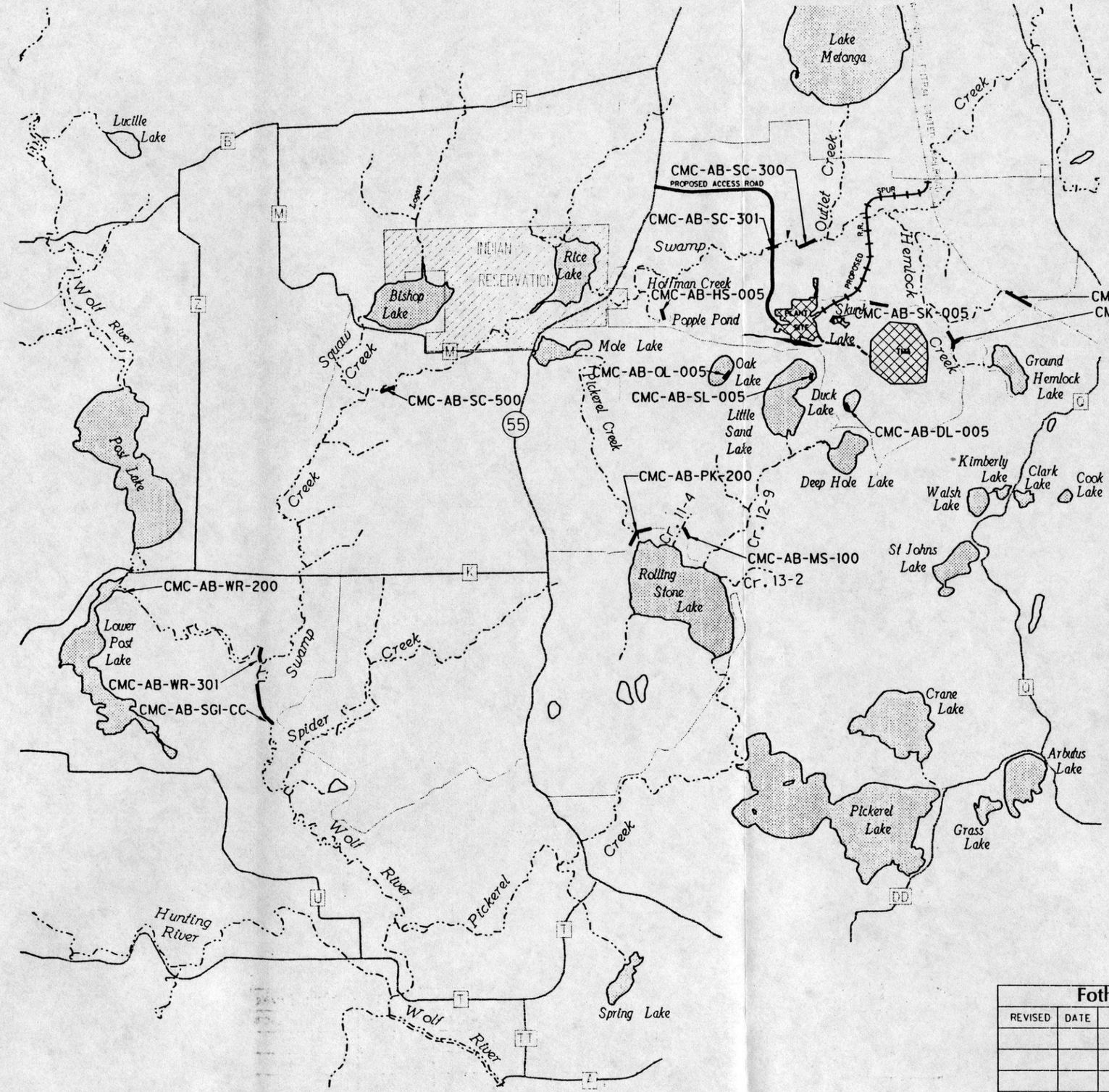
JUNE 27 - JULY, 1994

ODONATA EXUVIAE COLLECTION LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

93C048



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-6
JUNE 27 - JULY 1, 1994
ADULT ODONATA COLLECTION LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

93C049

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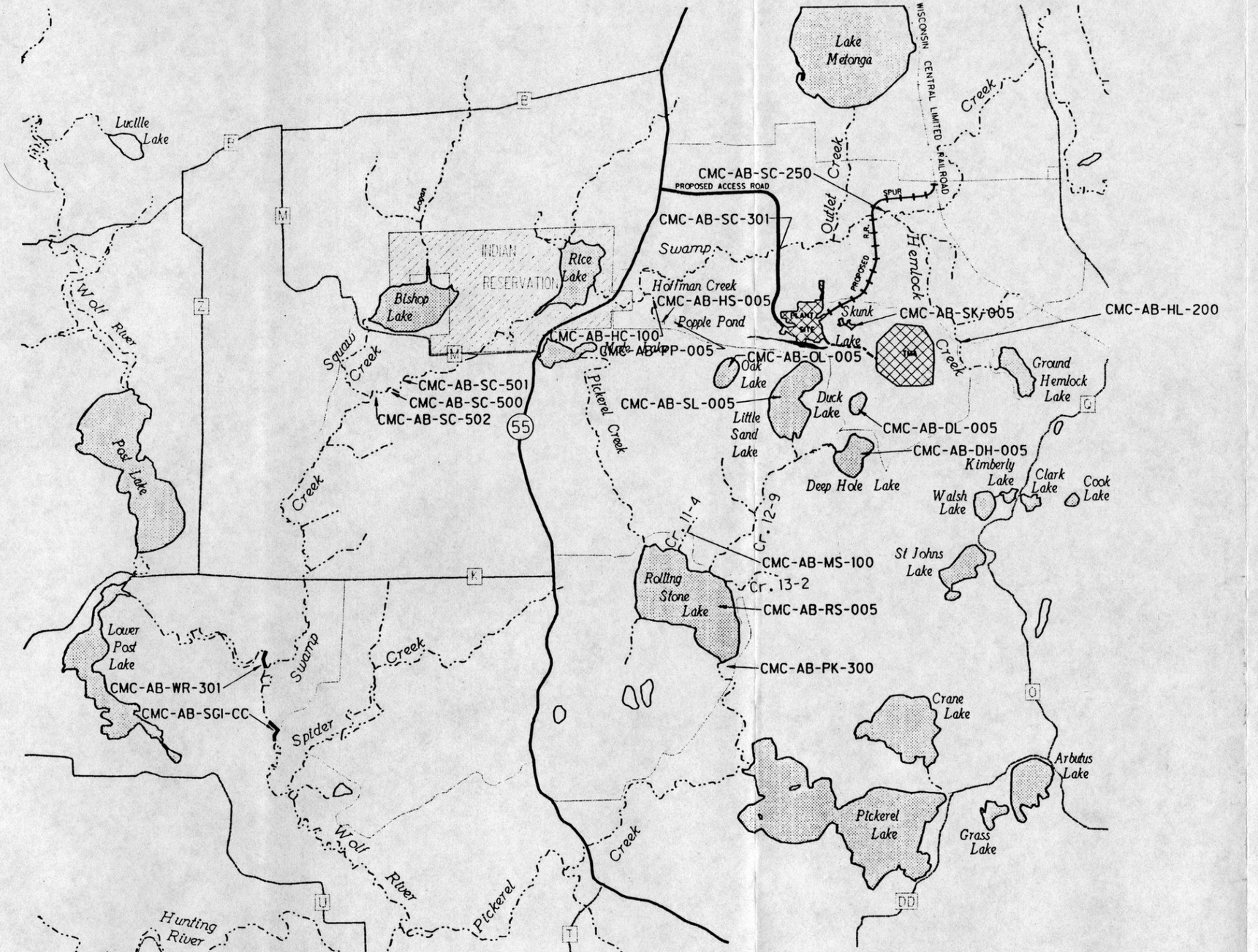

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.8-7

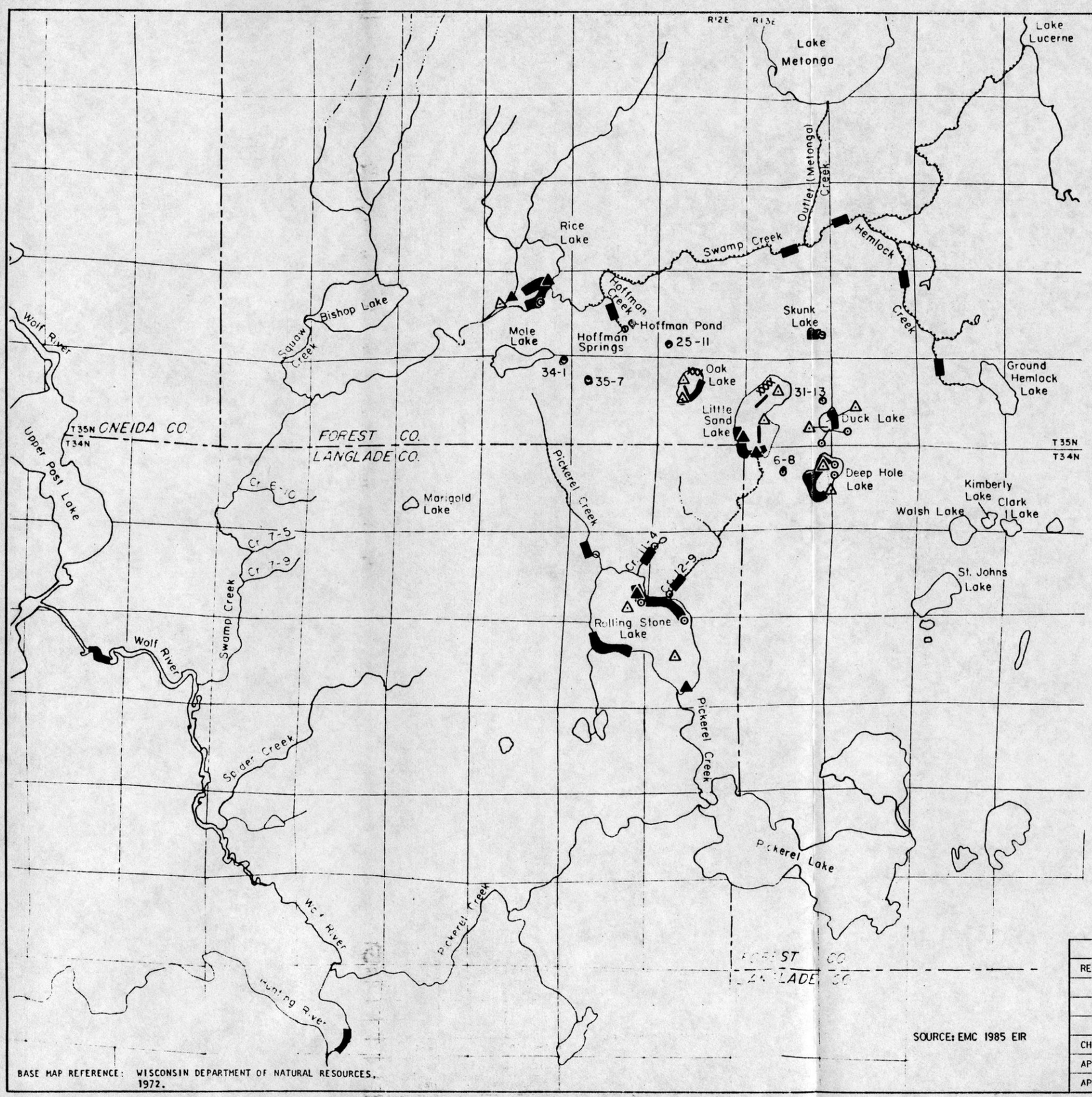
JULY 28 - AUGUST 4, 1994
ADULT ODONATA COLLECTION LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

93C049

/d3/dl/users/jpr1/4c57f30.dgn



SOURCE: EMC 1985 EIR

BASE MAP REFERENCE: WISCONSIN DEPARTMENT OF NATURAL RESOURCES, 1972.

/d3/dl/users/jpr1/4c57f42.dgn

Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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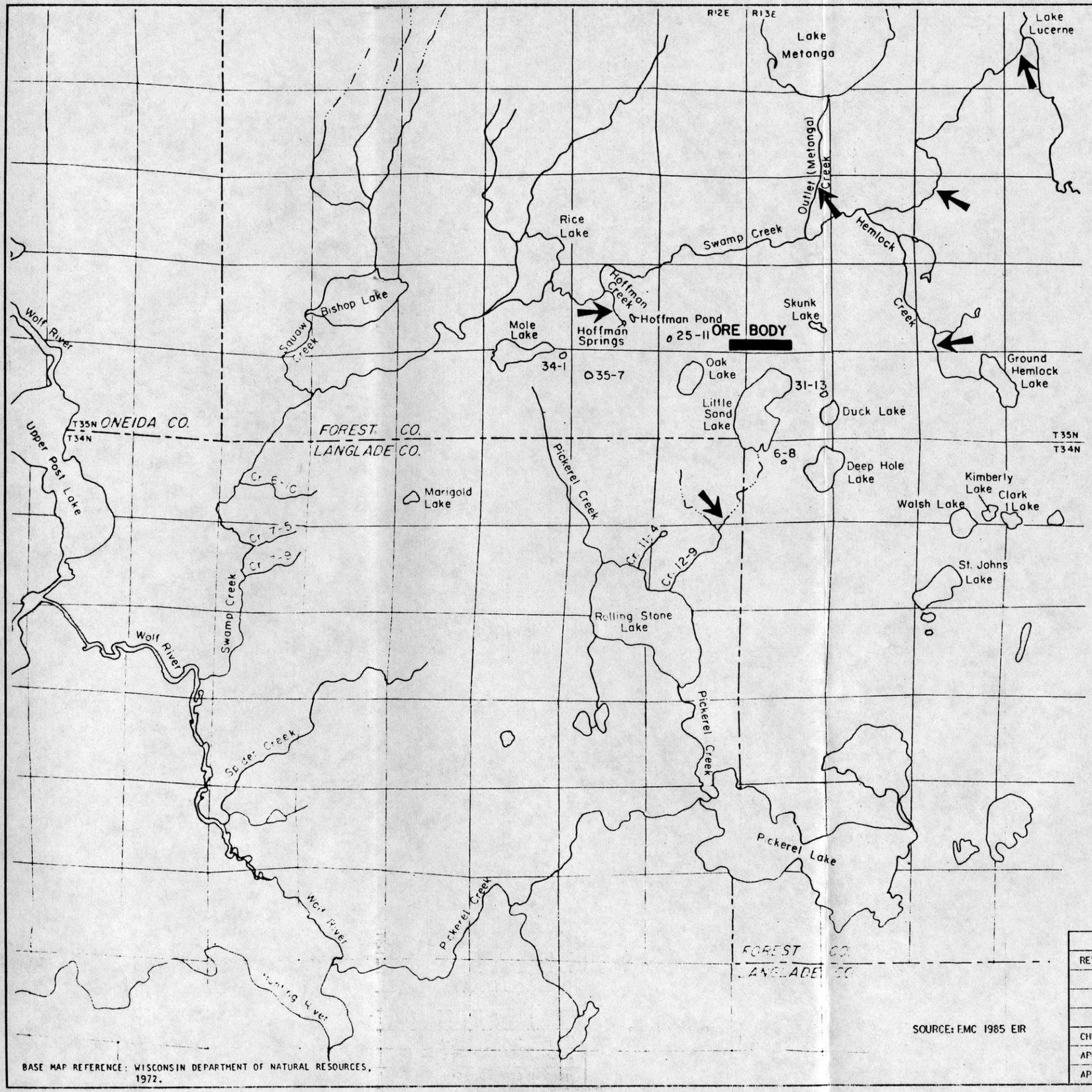
FIGURE 3.8-8

FISH SAMPLING TECHNIQUES AND LOCATIONS (PRE 1993/94 WORK)

Scale:	AS SHOWN	Date:	MAY 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049





KEY:

STREAM

25-11 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED LAKES

Cr. 11-4 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED STREAMS

LOCATION OF POTENTIAL BROOK TROUT SPAWNING AREAS

1 .5 0 1 MILE

BASE MAP REFERENCE: WISCONSIN DEPARTMENT OF NATURAL RESOURCES, 1972.

SOURCE: EMC 1985 EIR

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:	JKSI		DATE: MAY '95	
APPROVED BY:	RFS		DATE: MAY '95	
APPROVED BY:	GWS		DATE: MAY '95	

Crandon Mining Company

FIGURE 3.8-9

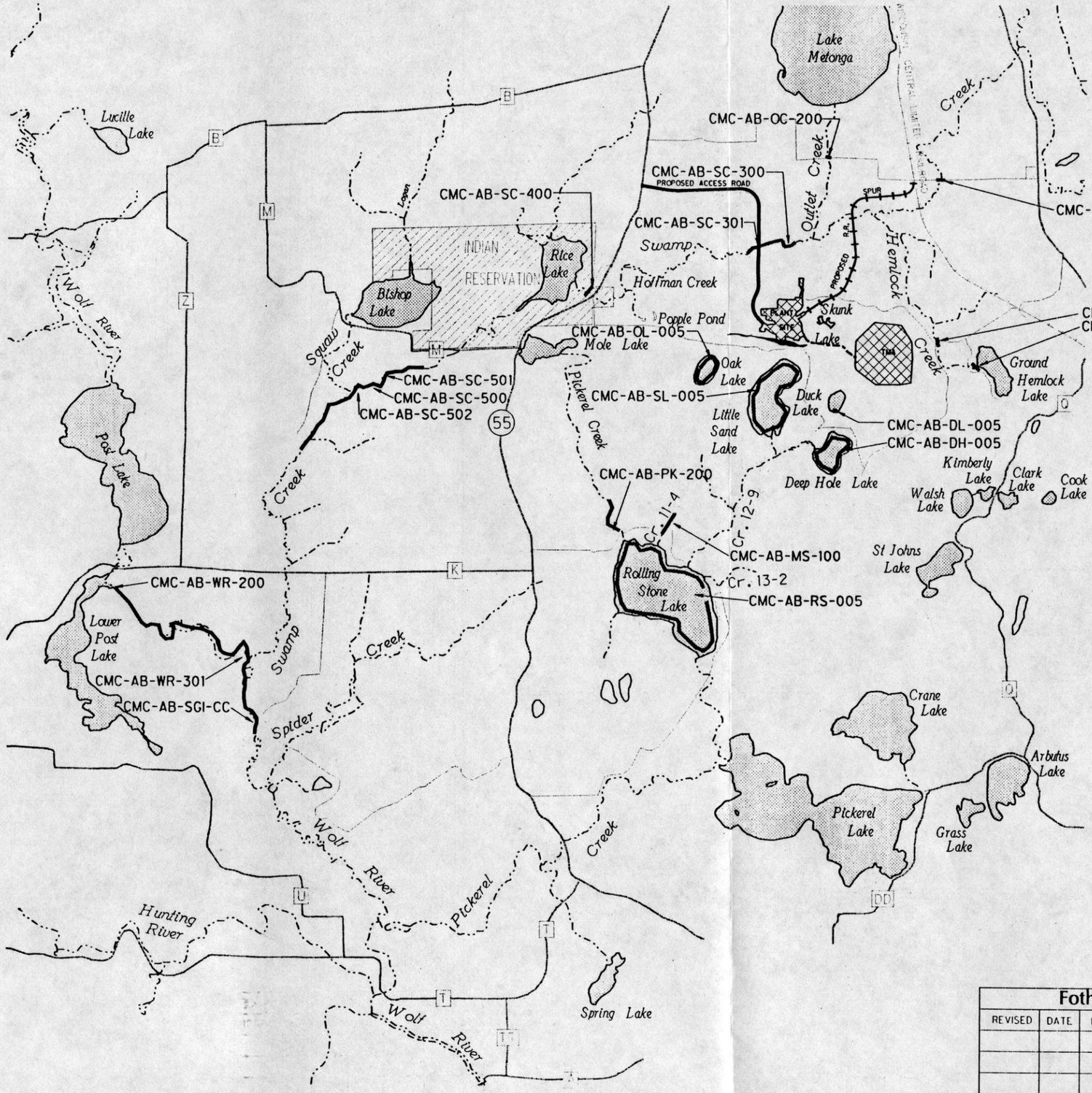
POTENTIAL BROOK TROUT SPAWNING AREAS
(PRE 1993/94 WORK)

Scale: AS SHOWN | Date: MAY 1995

Prepared By: Foth & Van Dyke | By: JPR

93C049

/d3/dl/users/jpr1/4c57f42.dgn



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-10

1994 FISH COLLECTION LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

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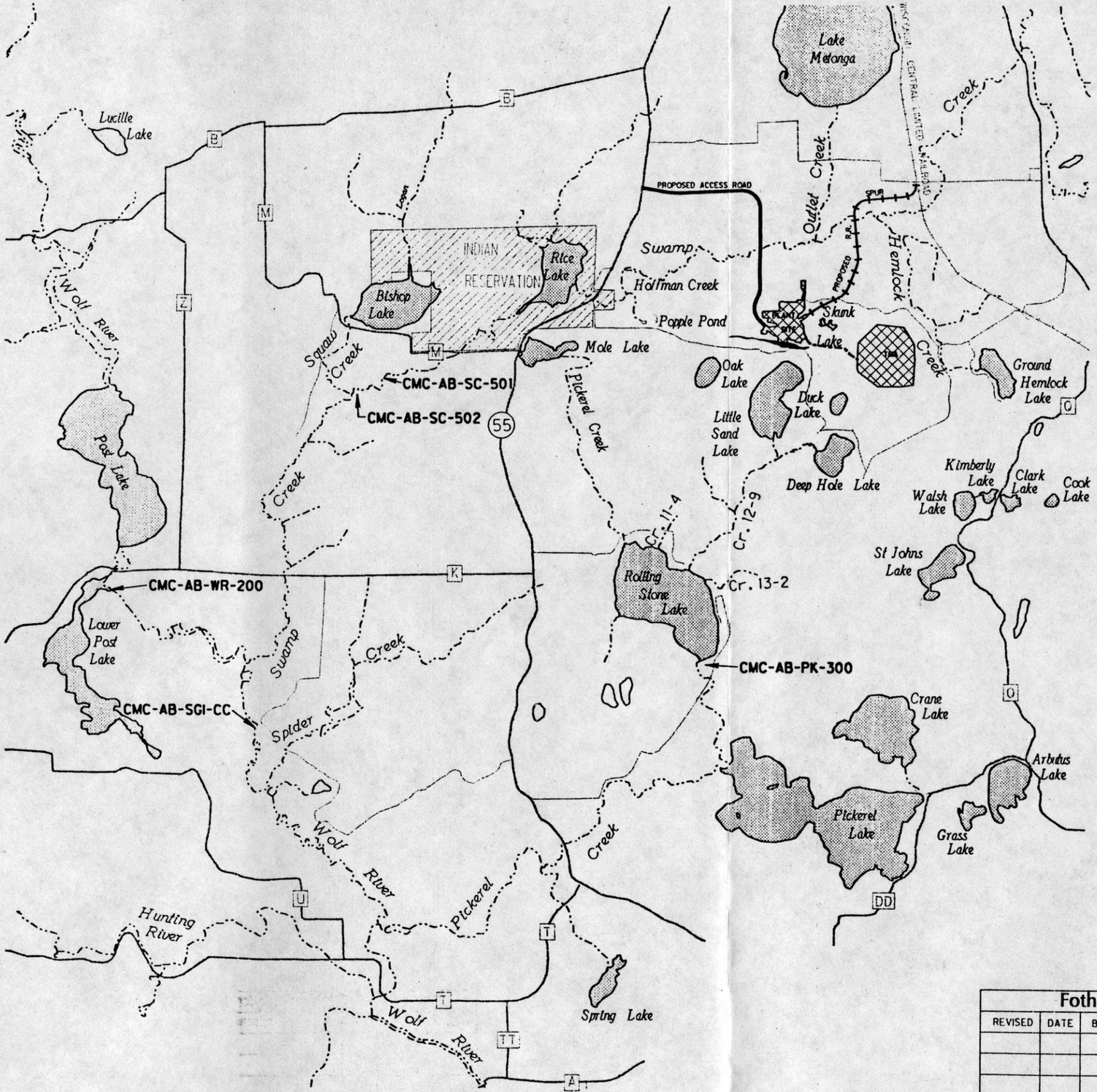
93C049



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-11
LOCATION FOR CRAYFISH COLLECTION FOR TISSUE ANALYSIS - MAY 1994

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

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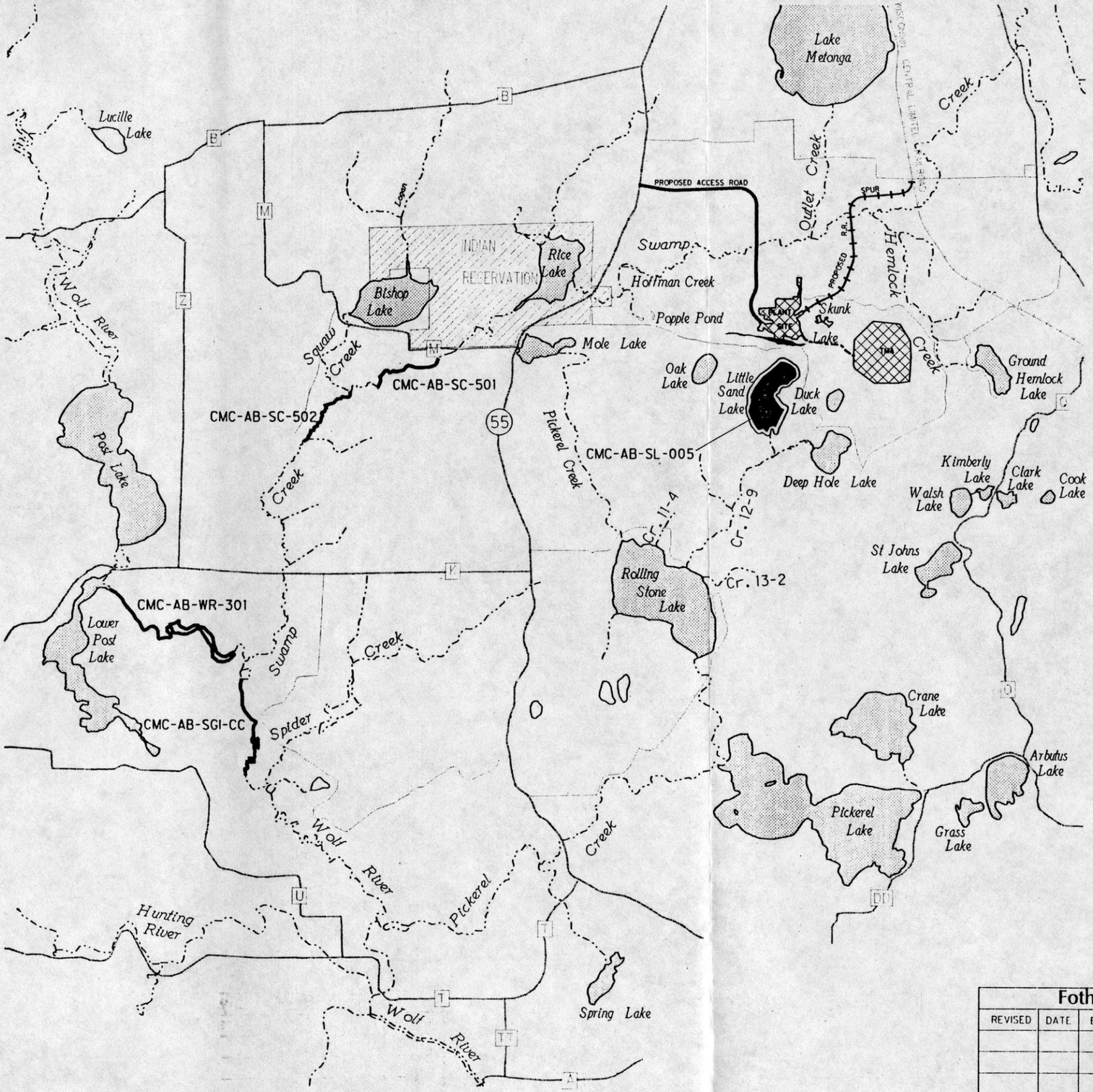
93C049



N

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SC-301 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-12
LOCATION FOR FISH COLLECTION FOR TISSUE ANALYSIS - MAY 1994

Scale: 0 3750' 7500' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JPR

/d3/d1/users/jpr1/4c57f5.dgn

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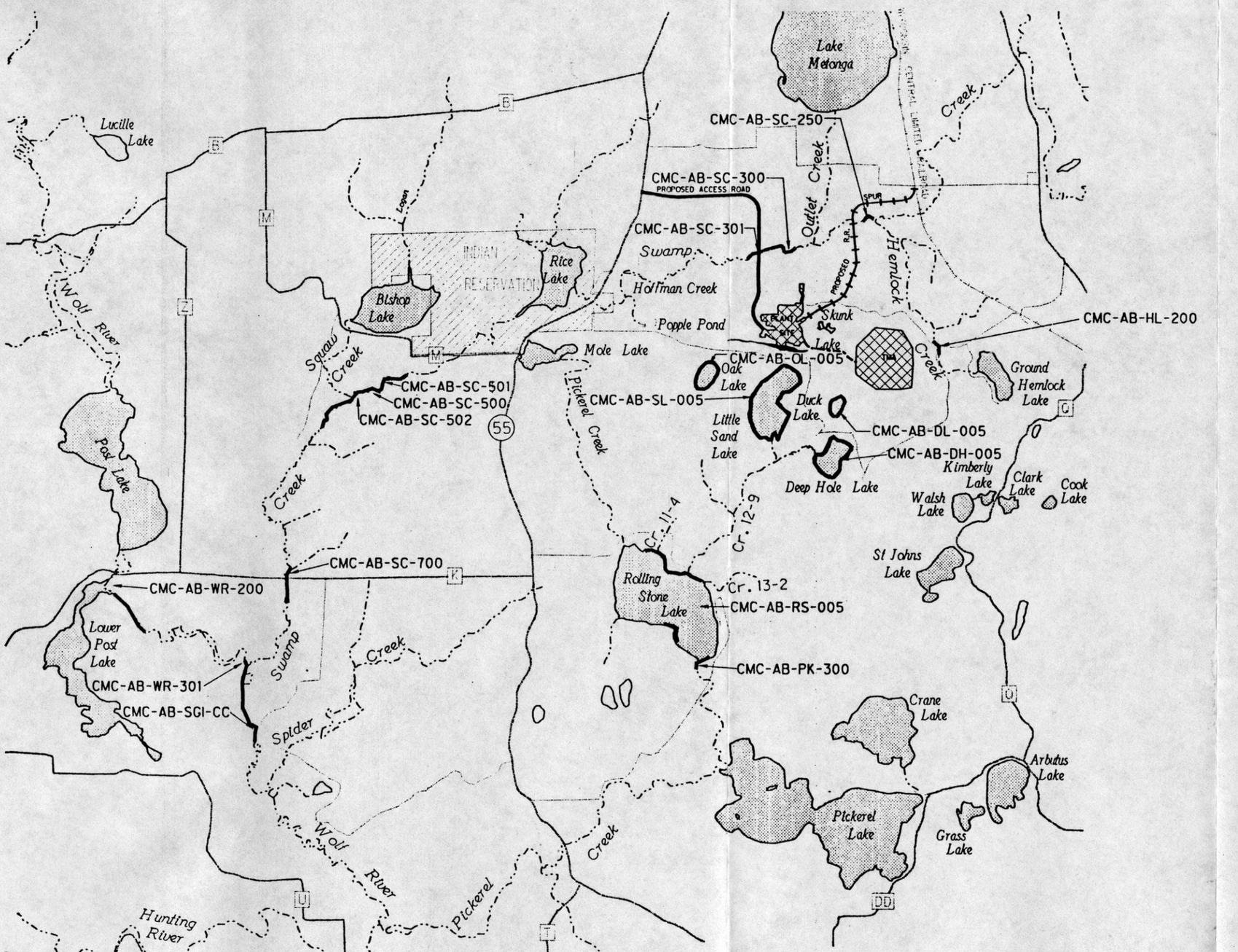

LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- LAKES
- STREAMS
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

CMC-AB-SL-005 SAMPLING LOCATION

AREA OF SAMPLE COLLECTION

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.8-13

1994 MUSSEL COLLECTION LOCATIONS

Scale: 0 3750' 7500' | Date: FEBRUARY, 1995

Prepared By: Foth & Van Dyke | By: JPR

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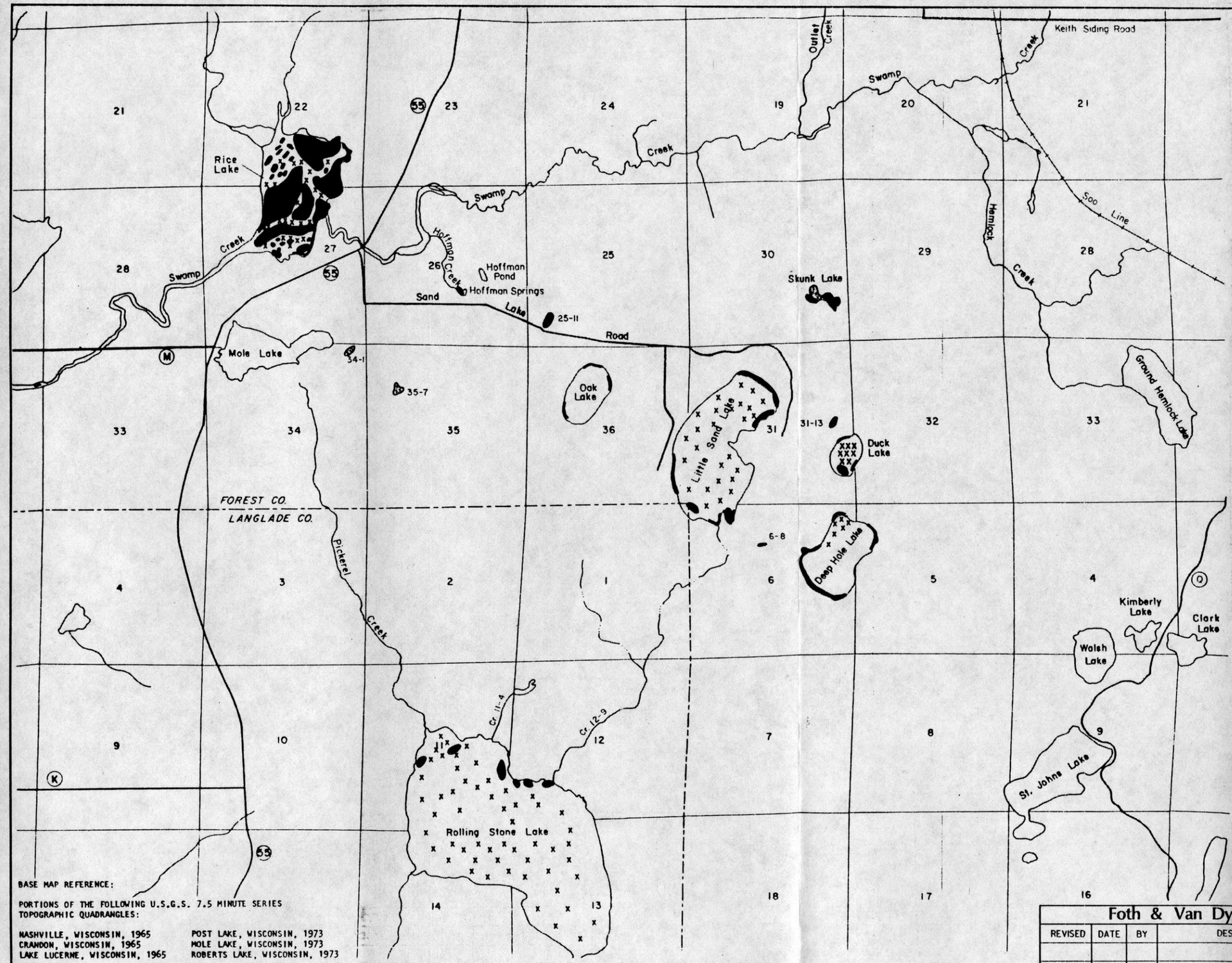
93C049



KEY:

- STREAM
- 25-11 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED LAKES
- Cr. 11-4 — WISCONSIN DNR IDENTIFICATION CODE FOR UNNAMED STREAMS
- (55) — BLACKTOP ROAD
- EMERGENT AQUATIC MACROPHYTES
- x x — SUBMERGENT AQUATIC MACROPHYTES

NOTE: BASED ON FIELD OBSERVATIONS MADE IN AUGUST, 1977 & 1978.

.5 0 1 MILE

BASE MAP REFERENCE:

PORTIONS OF THE FOLLOWING U.S.G.S. 7.5 MINUTE SERIES TOPOGRAPHIC QUADRANGLES:

NASHVILLE, WISCONSIN, 1965
CRANDON, WISCONSIN, 1965
LAKE LUCERNE, WISCONSIN, 1965
POST LAKE, WISCONSIN, 1973
MOLE LAKE, WISCONSIN, 1973
ROBERTS LAKE, WISCONSIN, 1973

SOURCE: EMC 1985 EIR

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.8-14

DISTRIBUTION OF AQUATIC MACROPHYTES IN SELECTED LAKES AND PONDS (PRE 1993/1994 WORK)

Scale:	AS SHOWN	Date:	MAY 1995
Prepared By:	Foth & Van Dyke	By:	JPR

/d3/dl/users/jpr1/4c57f42.dgn

93C049

Crandon Mining Company

Environmental Impact Report

Section 3.9

Terrestrial Biology

Crandon Mining Company
Environmental Impact Report

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3.9 Terrestrial Biology

The purpose of this study was to identify terrestrial threatened, endangered and special concern species that live in and around the project area. Studies conducted in the 1970s and 1980s during the initial effort to permit the Crandon Project provided an inventory of the major plant and animal communities found in the area.

The Crandon Project terrestrial biology program involved a comprehensive inventory of the flora and fauna existing in the study area. Reptiles and amphibians, birds, mammals, butterflies, and plants were all considered. The greatest majority of the field work was conducted in 1994. Limited additional field work related to owls, butterflies, water birds, and plants was conducted in 1995. In addition, an extensive field survey for goblin fern (*Botrychium mormo*) was conducted in 1995. Observation records of all species encountered were maintained; however, the focus of this program was on those species considered to be rare endangered, or threatened species as listed by state or federal agencies. The 1986 Final Environmental Impact Report (Dames & Moore, 1985) and *Final Environmental Impact Statement*, Exxon Minerals Company Zinc-Copper Mine (WDNR, 1986) provide a comprehensive background on the common plant and animal communities existing in the area.

The following sections provide a description of the field and laboratory methods; regional ecology; study area vegetation, study area wildlife; rare, endangered and threatened species; and natural and scientific areas associated with the terrestrial and wetland habitats of the study area. The study area for the terrestrial biology program included an approximate 25 square mile area shown in Figure 3.9-1 as well as a corridor along Swamp Creek and its riparian environs from CTH M downstream to the Wolf River, and the Wolf River from Post Lake downstream to Spider Creek. The discussions in this section focus on the entire data base collected for the project from 1977 through 1995.

3.9.1 Field and Laboratory Methods

The 1994/95 terrestrial biology field and laboratory program was developed based on a review of the previous studies (Dames & Moore, 1981; Dames & Moore, 1979; Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc., 1982a; Interdisciplinary Environmental Planning, Inc., 1983), site reconnaissance visits conducted August through October, 1993, and coordination with the WDNR and U.S. Fish and Wildlife Service. The primary objective was to determine the status of endangered, threatened and other species of concern (targeted species), as listed by state and federal agencies, in the study area. A list of targeted species potentially occurring in the vicinity of the study area was provided by the WDNR (letter dated September 2, 1993, included in Appendix 3.9-1). A similar list was provided by the U.S. Fish and Wildlife Service (letter dated August 20, 1993, included in Appendix 3.9-1). These lists were reviewed and a number of species of plants and animals were added based upon the experience of the study team. Individual work plans were then developed for each of the study disciplines: plants, mammals, birds, butterflies, and reptiles and amphibians. In many cases, due to the unique habit requirements or characteristics of the target species, specific work plans were developed for individual species (Foth & Van Dyke, 1993). Although the focus of the work conducted in 1994 and 1995 was on State or Federally listed species, observation records for all species encountered were maintained. Summaries of the field and laboratory methods for the surveys are presented separately below. It should be noted that in the spring of 1996 CMC obtained an update of the Wisconsin Natural Heritage Working List. This list (included in Appendix 3.9-1) contains nine birds and one butterfly previously identified in the study area that are now considered of special concern in Wisconsin. A discussion of these additional species has been added to the text of this section of the EIR.

3.9.1.1 Plants

A target list of plants was developed based on input from the WDNR and the study team. Prior to the commencement of field work the phenology for all 71 target species was assessed to maximize efficiency of searches of each habitat type and increase the probability of encountering them if they were present. The botanical crews identified all species encountered at each site not just known rare species. Vouchers of any unknown species encountered were either collected, or the sites were flagged for further examination if populations were too small to justify taking a voucher or if they had not matured enough to allow positive identification. Lists of species noted at each site were recorded. Seven people worked a total of approximately 3,000 hours on the plant surveys and support functions.

Methods varied to accommodate the targeted species and their known habitats. For the most part, conifer swamps were searched with larger numbers of botanists than other cover types because these areas are more difficult to survey. The preferred technique was to arrange four to six people abreast and "sweep" through each area so the group could more easily maintain its orientation and provide more thorough searches. Because most swamps in this study were associated with streams and were linear in shape, the sweep method was directed along the long axis of the area. It was also necessary to search the swamps intensely for short periods because some species, such as the Calypso orchid (*Calypso bulbosa*) have a relatively short flowering period. The larger crew size and the sweep method described above helped to complete these searches in the minimum time. The sweep technique was also the preferred methodology for very "fine-grained" searches, such as that employed for the tiny goblin fern (*Botrychium mormo*). Alternatively, stream searches were more effective using two or more smaller crews working different sections of a stream at the same time. The same procedures were used for other linear features such as the access road route.

Surveys of aquatic plant species were conducted from canoe and by wading. Surveys for some plants, such as the small, bottom dwelling species plantain shoreweed (*Littorella americana*), resupinate bladderwort (*Utricularia resupinata*) and waterwort (*Elatine triandra*) required snorkeling in some cases. When botanists snorkeling in Duck Lake found that algal-leaved pondweed (*Potamogeton confervoides*) was restricted to deeper levels, scuba divers were employed to assist in mapping their distribution in that lake. The scuba divers also searched Oak, Little Sand and Deep Hole Lakes for algal-leaved pondweed and collected samples of other species encountered on the lake bottom.

3.9.1.1.1 Heavy Metals in Vegetation

Terrestrial Vegetation

Three plant species, one from each of the three major taxonomic groups of vascular plants (gymnosperms, monocotyledons, and dicotyledons) were collected in June 1978 at 28 locations in the study area for analysis of manganese, zinc, cadmium, copper, arsenic, lead, mercury, cobalt, and total chromium. The purpose of this work was to establish a baseline for heavy metals in vegetation as part of the environmental studies completed to support the previous project permitting work. The three plant species included balsam fir, red raspberry, and Pennsylvania sedge. Balsam fir (*Abies balsamea*) was selected as the gymnosperm because it is a widely distributed conifer in the environmental study area. Red raspberry (*Rubus idaeus*), the dicotyledon selected, grows commonly throughout the environmental study area. Pennsylvania

sedge (*Carex pennsylvanica*) was selected as the monocotyledon because it is also common in the area. For each species, samples were collected at six locations for separate analysis. As shown in Figure 3.9-2, the study area was divided into three sectors: north, south, and west, with respect to the predominant wind directions. Composite samples of each of the three species, from each of the sample locations within each of the sectors, were then analyzed.

Samples of terrestrial vegetation were collected in the vicinity of the proposed Crandon Project site on June 29, 1994 for the same heavy metal analyses. The purpose of the 1994 sampling was to verify and update the previous data base. A subset of the previous 28 sample sites were selected. The subset included three sites from each of the three sectors as shown on Figure 3.9-2 and in Table 3.9-1. New growth of balsam fir, red raspberry and Pennsylvania sedge were collected at each site, placed into two-gallon Ziploc bags, marked appropriately, and placed in a cooler of ice. The samples were then transported to the office where they were composited into same species bags from each of the three sectors. The samples were then placed in a cooler of ice with the appropriate chain of custody form, sealed, and sent to Hazelton Environmental Services (HES).

HES prepared the samples for digestion by thawing them slightly, chopping them into pieces, and homogenizing them in an industrial blender under liquid nitrogen. The extraction for metals analysis was performed according to the EPA 6010/7000 method. One blender blank was prepared for the purpose of detecting possible laboratory contamination.

Aquatic Vegetation

Trace metal analyses (i.e., manganese, zinc, cadmium, copper, arsenic, lead, mercury, cobalt, and total chromium) on the tissues of selected aquatic macrophytes were performed in 1977 (EMC, 1985a). Aquatic macrophytes sampled included bur reed, cattail, water lily, pipewort, spike rush, and wild rice. Composite samples were collected along the shorelines of Rice Lake, Swamp Creek, Oak Lake, and Little Sand Lake. A wild rice sample was also collected from Rice Lake and analyzed separately.

To update and verify the above described previous work, samples of aquatic macrophytes were collected in the vicinity of the proposed Crandon Project site on July 20, 1994 for the same heavy metal analyses. A total of six sites were sampled, as shown in Figure 3.9-3 and Table 3.9-2, five for white water lily including upstream and downstream Swamp Creek, upstream and downstream Wolf River, and Little Sand Lake. Swamp Creek west of Highway 55 was sampled for wild rice. Rice Lake was not sampled due to limitation of access. The samples were collected, composited, sent to the lab, and analyzed in the same manner as the terrestrial plant samples.

Table 3.9-1

Terrestrial Plant Tissue Sample Site Locations

Sample Site	Sector	Location
1	North	T35N R13E NE 1/4 NW 1/4 Section 17 East Shore Lane adjacent to Wisconsin Central Railroad line at south end of Lake Metonga
24	North	T35N R13E NE 1/4 NW 1/4 Section 33 Intersection of Hemlock Lake Road and Berry Lane
26	North	T35N R13E SW 1/4 NE 1/4 Section 33 West Shore Lane to the west of Ground Hemlock Lake Road
20	South	T34N R13E SW 1/4 NW 1/4 Section 3 County Trunk Q ½ mile south of Wisconsin Central Railroad line
19	South	T34N R13E NW 1/4 SW 1/4 Section 5 Sand Lake Road at intersection with snowmobile trail and access to Deep Hole Lake
18	South	T34N R13E SW 1/4 SE 1/4 Section 9 County Trunk Q South West of St Johns Lake
16	West	T34N R12E SW 1/4 NW 1/4 Section 12 North Rolling Stone Lake Road
12	West	T35N R12E NW 1/4 SW 1/4 Section 35 Black Joe Road
10	West	T35N R12E NE 1/4 NW 1/4 Section 26 State Trunk Highway 55 east of Indian Settlement Road

Prepared by: BDH
Checked by: AWZ

Table 3.9-2

Aquatic Macrophyte Tissue Sampling Locations

Sample Site	Sample Location
CMC-AB-SC-501	T35N R12E SE 1/4 NW 1/4 Section 32 Swamp Creek, Upstream of CTH M
CMC-AB-SC-502	T35N R12E SW 1/4 NW 1/4 Section 32 Swamp Creek, Downstream of CTH M
CMC-AB-WR-301	T24N R12E SW 1/4 NE 1/4 Section 14 Wolf River, Upstream of Swamp Creek Confluence
CMC-AB-WR-302	T24N R12E SE 1/4 NW 1/4 Section 24 Wolf River, Upstream of Swamp Creek Confluence
CMC-AB-SC55	T35N R12E SE 1/4 SW 1/4 Section 26 Swamp Creek, West of STH 55
CMC-AB-SC	T35N R13E SE 1/4 SW 1/4 Section 32 East Shore of Little Sand Lake

Prepared by: BDH
Checked by: AWZ

3.9.1.2 Mammals

Normandeau Associates, Inc. (1982) trapped small and medium-sized mammals at two representative areas of each of the wetland habitat types (except marsh and aquatic bed). In each area, trap stations were located at approximate 50 foot (15 m) intervals along transects totaling approximately 344 feet. An "assessment line", 295 feet in length, was established at a 45-degree angle to these transects to determine the effective width of the transects. One Sherman live-trap (3 x 3.5 x 9 inches) was placed at each station for a total of eight traps along the transects and six along the assessment lines. Larger Tomahawk live-traps (6 x 6 x 24 inches) were placed at 148 feet intervals along the transect lines for a total of two per area. The smaller traps were baited with dry rolled oats and the larger ones with eared sweet corn. Traps were set for four consecutive days from June 17-20, 1981.

Dames & Moore (1985) relied on the WDNR for regional data on white-tailed deer (*Odocoileus virginianus*), black bear (*Ursus americanus*), and medium-sized mammals such as beaver (*Castor canadensis*), otter (*Lutra canadensis*), bobcat (*Lynx rufus*), marten (*Martes americana*), and squirrel (*Sciurus carolinenis*). White-tailed deer, however, were given special consideration. During the spring and autumn of 1977 deer were censused using the deer trail count method. Small mammals were sampled using snap traps during August of 1977 and 1978. Four traplines were set in each of the three major plant communities (northern hardwoods, lowland conifer, shrub swamp) consisting of 15 stations approximately 30 feet (10m) apart with two mouse traps and one rat trap at each station. Traps were baited with a mixture of peanut butter and dry rolled oats, set for three consecutive days and checked every 24 hours.

Mammal surveys in 1994 were planned and supervised by Dr. Robert Howe, Thomas Erdman and Ronald F. Steg. Eleven additional field assistants took part in the research, all with at least undergraduate degrees in biology or field experience in the study of mammals. Specimens collected in the course of this investigation have been catalogued and deposited in the Richter Natural History Museum at the University of Wisconsin-Green Bay.

The mammal surveys focused on nine target species (Table 3.9-3). Again, as with the previous investigations, the WDNR will be relied upon for white tailed deer and other common game species. Seven of these mammals are listed by the WDNR Bureau of Endangered Resources as endangered, threatened, or special concern status. In addition to these target species, correspondence with WDNR mammalogist Adrian Wydeven and published accounts by Jackson (1961) identified another two species as rare or poorly known in Wisconsin: water shrew (*Sorex palustris*), and woodland jumping mouse (*Napaeozapus hudsonius*). Although all mammal species encountered in the study area were recorded, efforts were focused specifically on the target species.

The mammal program included a snow tracking survey, small mammal trapping, and a live trapping survey for pine marten. The breadth of methods and number of samples for each method is comparatively a very intensive mammal field study for an area of this size in Wisconsin. Each of the above listed program elements is described in the following paragraphs.

Table 3.9-3

Target Mammal Species

Common Name	Scientific Name	Wisconsin Status
Timber Wolf	*Canis lupus*	Endangered
Lynx	*Lynx canadensis*	Endangered
Bobcat	*Lynx rufus*	Special Concern
Pine Marten	*Martes americana*	Endangered
Woodland Vole	*Microtus pinetorum*	Special Concern
Arctic Shrew	*Sorex arcticus*	Special Concern
Thompson's Pygmy Shrew	*Sorex hoyi thompsoni*	Special Concern
Water Shrew	*Sorex palustris*	None
Woodland Jumping Mouse	*Napaeozapus insignis*	None

Prepared by: RWH
Checked by: RFS

3.9.1.2.1 Snow Tracking Surveys

Tracking surveys were made on transects of 1,640 feet (0.5 km) located in selected habitats within or near the potential impact area as shown on Figure 3.9-4. Routes were located primarily but not exclusively along accessible roads and trails. All major habitats in the study area were surveyed. Lowland conifers were part of at least one-third of the surveyed routes, exceeding the representation of this habitat in the study area as a whole (Table 3.9-4) because this habitat was more likely to be used by the targeted species. Twelve road transects ranging from 0.5 to 2.8 miles were surveyed separately, providing additional geographic coverage of the study area. Notable tracks along trails on the way to/from the appointed transect locations also were recorded, providing a mechanism for documenting significant observations anywhere in the study area.

Observers used metric "hip-chains" to standardize transect length. All mammal tracks which crossed the transect line were recorded, in addition to mammal signs such as scat, browse, etc. within approximately 16.4 feet (5 m) of the line. Data were entered on standardized forms included in Appendix 3.9-2 and designed to make the track identification as objective as possible. The tracking forms instructed the observer(s) to record standard quantitative information on each set of carnivore tracks; tracks of white-tailed deer, lagomorphs, and rodents were simply tallied in columns representing each 164 feet (50 m) interval. Snow tracking transects were selected in early February based on earlier site visits and air photo analysis of the study area.

Table 3.9-4

Mammal Tracking Summary

Site	Month	Day	Year	Habitat
1	2	27	94	Northern Hardwoods
1	3	19	94	Northern Hardwoods
2A	2	27	94	Aspen/Northern Hardwoods
2A	3	19	94	Aspen/Northern Hardwoods
2B	2	27	94	Lowland Conifers
3	2	27	94	Lowland Conifers
3	3	19	94	Lowland Conifers
4	2	15	94	Aspen
4	3	19	94	Aspen
5	2	27	94	Aspen/Lowland Conifers
5	3	2	94	Aspen/Lowland Conifers
6	2	1	94	Northern Hardwoods
6	2	27	94	Northern Hardwoods
6	3	19	94	Northern Hardwoods
7	2	1	94	Northern Hardwoods
7	3	19	94	Northern Hardwoods
8	2	1	94	Northern Hardwoods
8	3	27	94	Northern Hardwoods
9	2	1	94	Northern Hardwoods
9	3	19	94	Northern Hardwoods
10	2	26	94	Lowland Conifers
10	3	19	94	Lowland Conifers
11A	3	2	94	Aspen/Northern Hardwoods
11A	3	29	94	Aspen/Northern Hardwoods
11B	2	27	94	Aspen/Northern Hardwoods
12	3	2	94	Aspen/Lowland Conifers/Northern Hardwoods
12	3	29	94	Aspen/Lowland Conifers/Northern Hardwoods
13	2	14	94	Northern Hardwoods/Spruce
13	3	29	94	Northern Hardwoods/Spruce
14	2	15	94	Aspen
15	2	15	94	Lowland Conifers/Aspen/Northern Hardwoods
15	3	19	94	Lowland Conifers/Aspen/Northern Hardwoods
16	2	25	94	Lowland Conifers/Aspen
16	3	29	94	Lowland Conifers/Aspen
18	2	25	94	Northern Hardwoods
18	3	19	94	Northern Hardwoods

Table 3.9-4 *(Continued)*

Site	Month	Day	Year	Habitat
19	2	14	94	Northern Hardwoods/Lowland Conifers
19	3	19	94	Northern Hardwoods/Lowland Conifers
22	3	29	94	Northern Hardwoods
23	2	14	94	Northern Hardwoods/Lowland Conifers
24	2	14	94	Northern Hardwoods/Lowland Conifers
25	2	14	94	Northern Hardwoods/Spruce
26	2	26	94	Northern Hardwoods
26	3	29	94	Northern Hardwoods
27	2	26	94	Northern Hardwoods/Lowland Conifers
28	2	26	94	Lowland Conifers/Northern Hardwoods/Spruce
29	2	26	94	Northern Hardwoods
30	2	26	94	Northern Hardwoods/Lowland Conifers
30	3	29	94	Northern Hardwoods/Lowland Conifers
31	2	26	94	Lowland Conifers
31	3	30	94	Lowland Conifers
32	2	14	94	Northern Hardwoods/Lowland Conifers
32	2	26	94	Northern Hardwoods/Lowland Conifers
32	3	30	94	Northern Hardwoods/Lowland Conifers
33	3	19	94	Northern Hardwoods
34	3	30	94	Northern Hardwoods
36	2	14	94	Northern Hardwoods/Aspen
36	3	29	94	Northern Hardwoods/Aspen
37	2	27	94	Upland Conifers/Aspen
38	2	14	94	Northern Hardwoods
38	2	26	94	Northern Hardwoods
38	3	30	94	Northern Hardwoods
39	2	26	94	Aspen
39	3	30	94	Aspen
40	3	19	94	Northern Hardwoods/Lowland Conifers
41	3	19	94	Lowland Conifers

Prepared by: AWZ
Checked by: RFS

Plastic reference markers were placed at starting points of the tracking routes to facilitate navigation. Between February 1 and March 30, 44 transects were sampled, as listed in Table 3.9-4. All but five of these were surveyed at least twice. Surveys were conducted during all times of the day but were restricted to periods of new snow, usually within two days of a significant snowfall (≥0.5 in.). Snow depths ranged from approximately 25 cm (10 in.) within forest transects on February 1 to approximately 1.5 cm (0.5 in.) within road transects on March 30.

Multivariate analysis of measurements for each carnivore track was followed by a classification procedure using known track dimensions for reference. This procedure provides to the best possible identification of species even though the field observers might not have been sure of a species' identity. Errors in identification are minimized by this objective technique.

3.9.1.2.2 Pitfall Traps

Pitfall traps are effective for shrews and small rodents (Williams and Brown, 1983), including three of the target species, pygmy shrew (*Sorex hoyi*), arctic shrew (*Sorex arcticus*), and pine vole (*Microtus pinetorum).* In early June, eight pitfall trap units were set in representative habitats, as listed on Table 3.9-5 and shown on Figure 3.9-5. Each trap unit included 10 metal, 3.18 quart cans arranged in a standard configuration, as shown on Figure 3.9-6. Two or three nail-sized holes were pounded into the side of each can approximately two inches from the bottom to provide drainage of rain water. Each can was set in the ground so the open margin was flush or slightly below the ground surface. A solution of ethylene glycol (automobile anti-freeze) mixed approximately 50 percent with water was poured in each can to a depth of one and one-half to two inches. Four of the cans were positioned at ends of a 10 foot long drift fence consisting of 10-inch high galvanized aluminum flashing (Figure 3.9-6) embedded one to three inches in the ground and held in place by wooden supports. The other six cans were located individually, 16.4 to 32.8 feet (5 to 10 m) from either drift fence. None of the pitfall traps were baited. Trap units were monitored every two to three days. All mammals, reptiles, amphibians, and selected insect species were collected. The observer recorded whether each specimen was captured in the drift fence traps or the individual traps. Collections were labeled and frozen in zip-lock plastic bags for later analysis. In most cases, skulls of the mammal specimens will be kept for documentation; in a few cases, entire specimens will be prepared as study skins or fluid-preserved specimens. A ninth pitfall trap unit was installed on June 28th in lowland conifers north of Swamp Creek. Three of the original trap units (numbers 5, 6, and 8) were removed on August 1, 1994, and three new sites were established. During August 2 and August 3, 1994, six additional trap units were set, and a single trap unit was installed on August 17, 1994. Monitoring of all active trap sites continued until the week of August 18-24, 1994, as listed on Table 3.9-3. In total, 18 pitfall trap were monitored over a total period of 11 weeks. If each metal can is considered as a separate trap, this effort amounted to 7,430 trap nights.

3.9.1.2.3 Snap Traps and Sherman Live Traps

In order to provide a more complete survey and a baseline for comparisons with previous studies, two small mammal trapping transects were established in the area of the plant site and the TMA as listed on Table 3.9-6 and shown on Figure 3.9-5. Each transect consisted of 33 stations located 82 feet apart along a linear route. At each station, three snap traps were baited with rolled oats and peanut butter and placed within a radius of several meters. Four traps were

Table 3.9-5

Pitfall Trapping Summary

Site Number	Location					Habitat	Begin	End	Total Trap Nights
	Township	Range	Section	1/4	1/4				
1	T35N	R13E	30	SE	SE	lowland spruce/fir w/sphagnum mat(wetland F11)	6/7	8/7	770
2	T35N	R13E	30	NE	SE	white pine/jack pine(near F12)	6/7	8/18	720
3	T35N	R13E	32	SE	SE	border of wet opening and mesic forest(near wetland F65)	6/9	8/23	750
4	T35N	R13E	32	NE	NW	wet depression in rich mesic forest	6/9	8/18	700
5	T34N	R12E	1	SE	NE	(dry)sedge meadow(wetland F7)	6/7	8/01	550
6	T34N	R13E	6	NW	NW	lowland hardwoods near stream edge(wetland F2)	6/7	8/01	550
7	T35N	R13E	31	SE	SE	mixed forest of black spruce/lowland hwds.(near mesic forest)	6/7	8/18	720
8	T35N	R13E	30	SE	NE	mesic hardwood-hemlock forest	6/7	8/01	550
9	T35N	R12E	24	SW	SE	(Wetland W1) conifer swamp w/sphagnum mate	6/28	8/18	510
10	T35N	R13E	30	NE	SW	(Wetland P2) conifer swamp	8/1	8/18	170
11	T35N	R12E	25	SE	SE	(Wetland R7A) alder swamp w/sphagnum	8/1	8/24	230
12	T35N	R12E	23	NE	NE	Drainage between wetland Z1 and Z2/sedge meadow/bog	8/1	8/18	170
13	T35N	R13E	29	NW	NW	conifer swamp (wetland O1/cedar-spruce)	8/2	8/19	170
14	T35N	R13E	29	NW	SW	oak savanna/dry sedge meadow (wetland F15)	8/2	8/18	160
15	T35N	R12E	34	SE	SE	open cedar swamp (blueberry-alder-tamarack-sphagnum)	8/3	8/19	160
16	T34N	R12E	3	NE	NE	cedar swamp w/sphagnum	8/3	8/19	160
17	T35N	R12E	35	NE	NE	upland hardwoods (s.maple/birch)	8/2	8/24	220
18	T35N	R12E	26	SE	NE	lowland conifer	8/2	8/19	170
Total									**7,430**

Prepared by: AWZ
Checked by: RFS

Table 3.9-6

Snap and Live Trap Summary

Site Number	Location					Habitat	Begin	End	Total Trap Nights
	Township	Range	Section	1/4	1/4				
3	T35N	R13E	32	SE	SE	border of wet opening and mesic forest (near Wetland F65)	8/8	8/23	240
11	T35N	R12E	25	SE	SE	(Wetland R7A) alder swamp w/sphagnum	8/8	8/24	256
17	T35N	R12E	35	NE	NE	upland hardwoods (s.maple/birch)	8/8	8/24	256
Transect A	T35N	R13E	30			mixed northern hardwoods	8/3	8/18	1,500
Transect B	T35N	R13E	32			mixed northern hardwoods/lowland conifer	8/4	8/19	1,500
Total									**3,752**

Prepared by: AWZ
Checked by: RFS

placed at the last station, giving a total sampling effort of 100 traps/transect. Two of the traps at each station were standard, commercially available Victor mouse traps, while the other was a *Museum Special* trap manufactured and sold by Woodstream Corporation. All traps in the two transects were checked daily between August 3-4 and August 18-19, 1994. Whenever necessary, baits were replaced and captured specimens were bagged and frozen for later analysis. Altogether, this trapping effort resulted in 2,800 trap nights. Beginning August 8-9, 1994, an additional 12 snap traps (10 Victor mouse traps, two *Museum Specials*) and four Sherman live traps (3 x 3 x 9 inch) were placed in a standard arrangement, as shown on Figure 3.9-6, near pitfall trap units 1, 3, 11, and 17. This arrangement allowed comparison of the effectiveness of pitfall traps versus snap traps and introduced another sampling method, live traps, to the field program.

3.9.1.2.4 Water Shrew Traps

In order to search effectively for water shrews, a species poorly known from much of its range and a state special concern species in Wisconsin, 10 galvanized metal minnow traps (approximately 24 inch long x 9 inch diameter) were placed in open water at the edge of streams and ponds (Figure 3.9-5). Traps were baited with sardines or other fish wired to the middle of the trap and monitored every three to four days from June 1 through June 17, 1994. Subsequently several of these were moved to different locations, as listed on Table 3.9-7. The new trap locations, together with four of the original trap sites, were monitored from June 17 through July 21, 1994, after which all of the minnow traps were removed. This effort resulted in a total of 575 trap nights.

3.9.1.2.5 Carnivore Trapping

During late October an intensive trapping effort was carried out to detect the presence of Pine Marten (*Martes americana*) which had not been observed during earlier investigations. John Wright, a researcher from the University of Wisconsin-Stevens Point, and Ron Eckstein from the WDNR in Rhinelander met with Howe, Steg, Erdman, and field assistants to help design the sampling effort. Twenty-seven trapping localities were chosen, as shown on Figure 3.9-7, in habitats ranging from upland northern hardwoods to alder swamps, with special emphasis on sites dominated by conifers (hemlock, pine, and spruce/fir). A single Tomahawk wire trap (9 x 9 x 32 inch) was baited and placed at each locality. The traps were baited with approximately one-half pound of beaver meat and scented with commercially purchased fisher/marten call (scent). The trap was carefully covered with bark, conifer boughs, and logs, leaving only the opening exposed. A strip of deer hide was suspended above the trap opening and painted with skunk gel, another commercially available scent.

The traps were monitored daily for 14 days between October 19 and November 1, 1994. One of the traps was moved on October 20, 1994, and four others were moved on October 24, 1994, as listed in Table 3.9-8. Captured animals were marked, photographed, and released unharmed. In order to recognize previous captures, a small portion of fur on the tail of the captured animal was cut before each animal was released. A total of 377 trap nights were expended in carnivore trapping targeting the pine marten.

Table 3.9-7

Water Shrew Trapping Summary

Trap Number	Location					Habitat	Begin	End	Total Trap Nights
	Township	Range	Section	1/4	1/4				
A	T34N	R12E	1	NE	NE	sedge meadow (aspen/willow)	6/2	6/29	27
C	T34N	R13E	6	NW	NW	shrub carr (stream edge)	5/28	7/21	54
D	T34N	R13E	6	SW	NW	riparian edge (grass/sedge)	5/29	7/21	53
K	T35N	R13E	28	SE	SW	pond edge (shrubs)	5/28	7/21	54
L	T35N	R13E	33	NW	NW	riparian edge (sedge/alder)	5/28	7/21	54
M	T35N	R13E	33	NW	NW	riparian edge (sedge/alder)	5/28	7/21	54
N	T35N	R13E	30	SE	SE	lake edge (grass/sedge)	5/28	7/3	36
O	T35N	R13E	30	NE	SE	lake edge (grass/sedge)	5/28	7/3	36
P	T35N	R13E	31	NE	SW	riparian edge (grass/sedge)	5/28	7/21	54
Q	T35N	R13E	31	NE	SW	riparian edge (grass/sedge)	5/28	7/21	54
R	T35N	R12E	25	SE	SE	(*Typha spp*) wetland	5/28	6/29	32
S	T35N	R13E	33	NW	NW	riparian edge (grass/sedge)	6/17	7/21	34
T	T35N	R12E	24	SW	SE	riparian edge (alder)	6/17	7/20	33
Total									**575**

Prepared by: AWZ
Checked by: RFS

Table 3.9-8

Pine Marten Trapping Summary

Trap Number	Location					Habitat	Trapping Dates	Trap Nights
	Township	Range	Section	1/4	1/4			
1	T35N	R13E	28	SW	SE	Pole Timber (spruce/aspen)	10/18-10/22 10/23-11/1	13
2	T35N	R13E	30	NE	NE	Saw Timber (hemlock/cedar)	10/18-10/24	6
2a	T35N	R13E	30	NE	NE	Saw Timber (hemlock/cedar)	10/24-11/1	8
3	T35N	R13E	32	SW	SE	Pole Timber (maple/birch)	10/18-11/1	14
4	T35N	R13E	30	NW	SE	Pole Timber (balsam/w.birch)	10/18-11/1	14
5	T35N	R12E	24	NE	NW	Saw Timber (aspen/w.pine)	10/18-10/19	1
5a	T35N	R12E	26	NW	SE	Pole Timber (balsam/aspen)	10/20-11/1	12
6	T35N	R12E	34	SW	SE	Pole Timber (balsam/maple/aspen)	10/18-10/22	4
6a	T34N	R12E	12	NW	SW	Pole Timber (lowland conifer)	10/23-10/24	1
6b	T35N	R12E	24	NW	NW	Saw Timber (aspen/balsam/w.pine)	10/24-10/25	1
6c	T34N	R13E	6	SW	NW	Pole Timber (sugar maple/w.birch)	10/25-11/1	14
7	T35N	R13E	30	NW	SW	Pole Timber (sugar maple/aspen)	10/18-11/1	14
8	T35N	R13E	32	SW	SW	Saw Timber (hemlock/sugar maple)	10/18-11/1	14
9	T34N	R12E	3	NE	NE	Saw Timber (white cedar)	10/18-11/1	14
10	T35N	R12E	35	NE	NE	Pole Timber (w.spruce)/ Sapling (aspen)	10/18-11/1	14
11	T35N	R12E	36	SE	NW	Saw Timber (red oak)	10/18-10/20	2
11A	T35N	R12E	36	NE	SW	Saw Timber (red oak)	10/20-11/1	14
12	T35N	R12E	25	SE	SE	Pole Timber (r.oak/aspen/b.fir)	10/18-11/1	14
13	T35N	R12E	24	SE	SE	Pole Timber (balsam fir)/ Sapling (aspen)	10/18-11/1	14
14	T35E	R13E	19	SW	SW	Sapling (aspen)/Pole Timber (b.fir)	10/18-11/1	14
15	T35E	R13E	19	SW	SE	Saw Timber (w.cedar/w.spruce)	10/18-11/1	14

Table 3.9-8 *(Continued)*

Trap Number	Location					Habitat	Trapping Dates	Trap Nights
	Township	Range	Section	1/4	1/4			
16	T35E	R13E	30	NW	SE	Pole Timber (sugar maple)	10/18-11/1	14
17	T35N	R13E	31	NE	NE	Pole Timber (balsam fir/aspen)	10/18-11/1	14
18	T35	R13E	31	SW	SE	Sapling (aspen)/ Saw Timber (w.cedar)	10/18-11/1	14
19	T35N	R13E	32	NE	NW	Pole Timber (sugar maple)	10/18-11/1	14
20	T35N	R13E	32	NE	NE	Saw Timber (hemlock)/ Pole Timber (birch)	10/18-11/1	14
21	T35N	R13E	28	NW	SE	Pole Timber (sugar maple)	10/18-10/24	6
21A	T35N	R13E	28	NE	NE	Pole Timber (balsam fir)/ Sapling (aspen)	10/24-11/1	8
22	T35N	R13E	21	SW	SW	Saw Timber (hemlock/w.spruce/y.birch)	10/18-10/24	6
22A	T35N	R13E	28	SW	NE	Saw Timber (w.cedar/spruce)	10/24-11/1	8
23	T35N	R13E	28	SW	NE	Pole Timber (hemlock)	10/18-11/1	14
24	T35N	R13E	28	SW	NW	Saw Timber (spruce)/ Sapling (aspen)	10/18-11/1	14
25	T35N	R13E	33	NW	NW	Pole Timber (sugar maple)	10/18-10/24	6
25a	T35N	R13E	32	SE	SE	Sapling (aspen)/ Pole Timber (r.maple)	10/24-11/1	8
26	T34N	R13E	4	NW	NW	Sapling (aspen)/ Pole Timber (r.maple)	10/18-11/1	14
27	T34N	R13E	5	SE	NW	Sapling (aspen)/ Saw Timber (spruce)	10/18-11/1	14
Total								**377**

Prepared by: AWZ
Checked by: RFS

3.9.1.2.6 Habitat Descriptions

All of the pitfall trap units, small mammal transects, carnivore trapping localities, and most of the water shrew trapping sites were photographed for reference. Habitat descriptions were recorded at each of these sites to provide at least general comparisons of dominant plant species, vegetation cover, ground cover, and other conspicuous features such as proximity to water. Habitat descriptions for the tracking, small mammal trapping, and carnivore trapping efforts are presented in Tables 3.9-4 through 3.9-8.

3.9.1.3 Birds

Two representative areas of each wetland type (e.g., bog, conifer swamp, etc.) were selected for bird censuses by Normandeau Associates, Inc. (1982). Line transects, ranging in length between 328 and 1,312 feet (100 and 400 m), and listening stations were established. All bird species heard or seen were recorded along with their number and perpendicular distance to the transect. At the listening stations, the distance to each bird from the center point was recorded. All surveys were conducted between 5:00 a.m. and 6:15 p.m. on May 11-15, 1981 and again on June 16-19, 1981.

Dames & Moore (1985) conducted bird censuses seasonally during 1977 and 1978. A special focus was placed on waterfowl and upland game birds. Drumming ruffed grouse counts were conducted from April 27-29, 1977 and from April 26-28, 1978. Migrating waterfowl were surveyed for one-half hour on each of three days during late evening or early morning on Skunk, Duck, Little Sand, Rice, Ground Hemlock, Walsh, Oak, Deep Hole, and Rolling Stone Lakes. These surveys were conducted between April 26 and 29, 1977, September 26 and 28, 1977, and April 26 and 28, 1978. Waterfowl brood counts were made at the same locations between June 13 and 16, 1978. Songbirds were surveyed using two different methods (i.e., transects censuses and variable width strip censuses) during the winter, spring, and summer of 1977 and 1978. Bird surveys in 1994 and 1995 were designed and supervised by Dr. Robert Howe and Thomas Erdman. The methods focused on the target species list presented in Table 3.9-9, but also provided an update on the common species existing in the study area.

Field surveys began in April 1994 with searches by Erdman for nesting goshawks and red-shouldered hawks at the locations shown on Figure 3.9-8. Red-shouldered hawk surveys were conducted in the study area between April 20 and May 24, 1994 utilizing amplified, broadcast conspecific (i.e., of the same species) calls. Broadcast equipment consisted of a portable cassette tape recorder with a Realistic brand, 20 watt amplifier and two eight inch power horn, 30 watt, eight ohm speakers. Vocalizations were broadcast simultaneously to both sides of the road by mounting the two speakers on the top of the vehicle facing in opposite directions approximately six feet above the ground. Broadcast volume was measured and standardized using a decibel meter. Broadcasts could be heard one-half mile away on a calm day but only one-quarter mile in densely forested, hilly areas after total leafout. Sound intensity nine feet in front of the speaker was 93-105dB. To survey areas which were not accessible by auto, Realistic brand mini amplified speakers with a one watt power output were used. These could be heard approximately 650 feet (.2km) away and were used at 22 of the 112 survey stops in the area.

Table 3.9-9

Target Bird Species

Common Name	Scientific Name	**Wisconsin Status**
Northern Goshawk	*Accipiter gentilis*	Rule
LeConte's Sparrow	*Ammodramus leconteii*	Rule
American Black Duck	*Anas rubripes*	Rule
Long-eared Owl	*Asio otus*	Rule
American Bittern	*Botaurus lentiginosus*	Rule
Common Goldeneye	*Bucephala clangula*	Rule
Red-shouldered Hawk	*Buteo lineatus*	Threatened
Pine Siskin	*Carduelis pinus*	Rule
Swainson's Thrush	*Catharus ustulatus*	Rule
Black Tern	*Chlidonias niger*	Rule
Northern Harrier	*Circus cyaneus*	Rule
Sedge Wren	*Cistothorus platensis*	Rule
Evening Grosbeak	*Coccothraustes vespertinus*	Rule
Yellow Rail	*Coturnicops noveboracensis*	Rule
Spruce Grouse	*Dendragapus canadensis*	Rule
Cerulean Warbler	*Dendroica cerulea*	Threatened
Blackburnian Warbler	*Dendroica fusca*	Rule
Cape May Warbler	*Dendroica tigrina*	Rule
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Rule
Merlin	*Falco columbarius*	Rule
Bald Eagle	*Haliaeetus leucocephalus*	Threatened
Black-crowned Night Heron	*Nycticorax nycticorax*	Rule
Connecticut Warbler	*Oporornis agilis*	Rule
Osprey	*Pandion haliaetus*	Threatened
Boreal Chickadee	*Parus hudsonicus*	Rule
Gray Jay	*Perisoreus canadensis*	Rule
Black-backed Woodpecker	*Picoides arcticus*	Rule
Prothonotary Warbler	*Protonotaria citrea*	Rule

Table 3.9-9 *(Continued)*

Common Name	Scientific Name	**Wisconsin Status**
Ruby-crowned Kinglet	*Regulus calendula*	Rule
Forster's Tern	*Sterna forsteri*	Endangered
Great Gray Owl	*Strix nebulosa*	Rule
Tennessee Warbler	*Vermivora peregrina*	Rule

Prepared by: RWH
Checked by: RFS

The broadcast tape was a 10 minute loop cassette which replicated the defense call of a red-shouldered hawk. Experience has shown that most of the territorial/defense calls are the "KEE-AAH" call. This is usually performed five to 12 times, followed by a 10-20 second interval of silence, another five to 12 calls, and then two to seven minutes of silence. The playback tape of red-shouldered hawk calls had seven "KEE-AAH" calls followed by 10 seconds of silence. This series was repeated for seven minutes followed by three minutes of silence for a total of 10 minutes at each survey site. Observations were recorded at an average of 164 feet (50 m) from the parked vehicle. Surveys were not made during rain or winds greater than 15 mph.

During early May 1994 a crew of eight researchers conducted surveys for owls by playing standard recordings of boreal owl, long-eared owl, and great gray owl, respectively, as recommended by similar studies in northern forests (Shepherd, 1992). Calls of each species were played approximately three minutes, followed by a five minute listening period. Responses were recorded on standardized forms, included as Appendix 3.9-2. Surveys were conducted on seven calm evenings between May 5 through May 26, 1994 at 38 stations (Figure 3.9-9). In order to avoid confusion of tape recordings with owl responses, observers synchronized their watches before leaving to their appointed sites and recorded the time of all recordings and responses on standardized forms. Again, virtually all of the project area and most of the study area were covered at least once.

Similar methods were used later during May and during early June 1994 to search for rails and bitterns. Recordings includes calls of the following species: yellow rail, king rail, black rail, least bittern, and American bittern. After each three minute playback, the observer(s) listened for five minutes to detect a response. Results were recorded on standardized forms, included as Appendix 3.9-2. If a response from a target species was detected, the site was visited later by other observers for verification. Rail/bittern surveys were completed at 14 sites representing the major wetland areas in the study area (Figure 3.9-10).

During late May, June and July, 1994, standardized point counts were conducted at 111 localities scattered throughout the study area, as shown on Figure 3.9-11. Observers Howe, Broetzman, Cleerman, Friedrick, Henrickson, Goltz, and Zovnic all were skilled at identifying bird vocalizations and possessed at least several years' field experience sampling and banding breeding birds in northern Wisconsin. Methods followed the standardized 10 minute unlimited-radius

point count used in the Nicolet National Forest Bird Survey (Howe, et. al., 1995) and are consistent with recommended methods for North American breeding bird censuses (Ralph, et. al., 1993).

All birds seen or heard were mapped on standardized forms for two successive five minute periods. Where possible, standard codes distinguished the sex and behavior of each bird observed, as shown on standard forms included in Appendix 3.9-2. All counts were conducted between daybreak and approximately 9:00 a.m. Localities of the point counts were established to provide a broad coverage of the study area and representation of all habitat types, as listed on Table 3.9-10. Assuming that each point count covers approximately 15 acres (Wolf, et. al., 1995), the counts collectively covered approximately 1,665 acres, or more than 10 percent of the study area. This can be compared with the 1.3 percent coverage of the Nicolet National Forest Bird Survey (500 points in an area of approximately 670,000 acres) and the less than 0.1 percent coverage of the North American Breeding Bird Survey in Wisconsin (Howe, et. al., 1995).

Records of target species or uncertain identifications during the point counts were followed by later visits to the same site for verification. In addition to the systematic point counts observations of birds throughout the study area were recorded by observers engaged in other inventory activities. Erdman, Howe, Steg, and the point count observers mentioned above contributed hundreds of additional field hours during mammal trapping, butterfly surveys, and turtle trapping. Botanists Gary Fewless, Mark Jaunzems, Steve Janke, and Pat Robinson have participated in bird surveys in Wisconsin and added several important bird observations during their plant inventories.

In addition to the 1994 field surveys, supplemental work was completed in 1995. The purpose of the 1995 work was to conduct field investigations within the environmental study area and nearby regions for rare or special concern owls and nocturnal water birds. Additional studies were warranted because the 1994 owl studies had yielded suggestive but inconclusive results, and because water birds (notably rails and bitterns) had been observed on isolated occasions but resident status was not established. Investigators completed 16 trips covering 26 dates between April 1 and August 25, 1995.

The 1995 investigations focused on six water birds (common goldeneye, American black duck, black tern, black-crowned night-heron, yellow rail, LeConte's sparrow) and two owls (great gray owl, and long-eared owl) that had been listed as target species prior to the 1994 field work. In addition, the red-breasted merganser, common merganser, lesser scaup, American bittern, sedge wren and Boreal owl were added as target species for 1995. The general methodology utilized during the 1994 field investigations were followed during the supplemental 1995 surveys. Owls and nocturnal water birds were sampled by playing tape recordings and listening for responses of target species in appropriate habitats shortly after dusk or before dawn. Daytime surveys of wetlands were also conducted, often in association with butterfly surveys.

3.9.1.4 Butterflies

Butterflies were sampled during inventories of suitable habitats during the known flight periods of the target species (Figure 3.9-12). Butterfly surveys focused on the target species listed in Table 3.9-11.

Early surveys for the West Virginia white (*Pieris virginiensis*) began on May 12, 1994, and continued through the end of the month. Bogs and wooded wetlands were visited for jutta arctic and *Boloria* spp. during late May and early June of that year. During June, July, and early August 1994, butterflies were surveyed from all habitat types, including roadsides and the margins of watercourses. Because most of the study area is wooded, the number of open habitats (favored by all but one of the target species, West Virginia white) could be surveyed quite thoroughly. The distribution of butterflies collected during this study (Figure 3.9-13) shows the extent of these surveys, although many other localities were searched without yielding specimens.

Table 3.9-10

1994 Bird Point-Count Habitats and Dates Surveyed

Point-Count Sites	Habitat										Date
	N	F	C	S	B	M	P	DW	W	A	
1	X										05/26/94
2	X	X						X			05/26/94
3	X							X			05/26/94
4	X	X									05/26/94
5	X				X	X		X			05/27/94
6	X										05/26/94
7	X	X		X							05/26/94
8	X										05/26/94
9			X	X							06/27/94
10	X										05/26/94
11	X		X								05/26/94
12	X										05/26/94
13			X	X							06/27/94
14			X	X							06/27/94
15	X		X	X							05/26/94
16	X							X			07/05/94
17	X							X			05/26/94
18	X		X	X				X			07/05/94
19	X										05/26/94
20	X			X	X						07/05/94
21	X							X			07/05/94
22	X		X					X			05/26/94
23	X		X								05/26/94
24	X							X			05/26/94
25	X										05/26/94
26	X							X			

Table 3.9-10 *(Continued)*

Point-Count Sites	Habitat										Date
	N	F	C	S	B	M	P	DW	W	A	
27	X										05/26/94
28	X		X								05/26/94
29	X		X			X		X			05/26/94
30	X				X						05/26/94
31	X		X	X				X			05/26/94
32	X		X	X				X			05/26/94
33	X		X	X							05/26/94
34	X		X	X							05/26/94
35	X		X	X					X		05/26/94
36	X		X	X					X		05/26/94
37	X		X								05/26/94
38	X			X							05/26/94
39	X					X		X			05/27/94
40	X	X									05/26/94
41	X					X					05/26/94
42	X	X									06/27/94
43	X										05/27/94
44	X		X			X					05/27/94
45	X		X			X					05/27/94
46	X										05/27/94
47	X						X	X	X		05/27/94
48					X					X	05/27/94
49	X		X			X		X			05/27/94
50	X										05/27/94
51	X				X			X			06/07/94
52	X			X		X			X		05/27/94
53	X		X			X					06/07/94

Table 3.9-10 *(Continued)*

Point-Count Sites	Habitat										Date
	N	F	C	S	B	M	P	DW	W	A	
54	X		X			X					06/07/94
55	X		X								06/07/94
56	X		X								06/07/94
57	X	X	X	X							06/07/94
58	X		X	X							06/07/94
59	X		X								06/07/94
60	X				X			X			05/27/94
61	X					X			X		05/26/94
62	X					X		X	X		06/10/94
63	X				X			X			07/05/94
64	X		X		X				X		07/05/94
65	X		X		X				X		07/05/94
66	X		X						X		06/10/94
67	X			X					X		06/10/94
68	X		X		X			X			07/05/94
69	X					X			X		06/10/94
70	X					X		X			06/10/94
71	X	X									05/27/94
72	X										05/27/94
73	X		X								05/27/94
74	X		X								06/09/94
75	X	X									06/09/94
76	X										06/09/94
77			X	X							05/27/94
78	X		X								06/09/94
79			X								06/09/94
80	X		X								06/09/94

Table 3.9-10 *(Continued)*

Point-Count Sites	Habitat										Date
	N	F	C	S	B	M	P	DW	W	A	
81			X			X					06/21/94
82	X		X								06/21/94
83	X										06/21/94
84	X										06/21/94
85	X										06/21/94
86	X										06/21/9
87	X		X								06/21/94
88	X										06/21/94
89	X										06/21/94
90	X										06/21/94
91	X		X	X							05/26/94
92	X			X							06/21/94
93	X			X							06/21/94
94	X			X							06/21/94
95	X			X							06/21/94
96	X		X	X							06/20/94
97	X										06/23/94
98	X		X								06/23/94
99	X		X								06/23/94
100	X		X	X				X			06/07/94
101	X										06/22/94
102	X										06/22/94
103	X										06/22/94
104	X							X			06/22/94
105	X					X		X			06/22/94
106	X				X	X					06/22/94
107	X										06/22/94

Table 3.9-10 *(Continued)*

Point-Count Sites	Habitat										Date
	N	F	C	S	B	M	P	DW	W	A	
108	X										06/22/94
109	X										06/22/94
110	X										06/22/94
111	X	X	X								06/27/94

N = northern hardwood forest
F = fields and upland openings
C = swamp conifer
S = shrub swamp
B = bogs
M = marshes
P = pine plantations
DW = deciduous forested wetlands
W = open water
A = agricultural lands

X = habitat type in which census points were conducted
Point-Count Sites = see Figure 3.9-11 for locations

Prepared by: AWZ
Checked by: RFS

Table 3.9-11

1994 Target Butterfly Species

Species	Habitat (Host Plant)	Flight
Boloria eunomia	bogs, tundra (*Viola palustris* + *salix spp.*)	July - Early August
Boloria freija	bogs (*Vaccinium, Arctostaphylos*)	Late May - Early July
Boloria frigga	shrub/willow bogs (*Salix, Betula*)	June - July
Coenonympha tullia	woodland, meadows (grasses)	June - July
Erebia discoidalis	open sphagnum bogs (grasses)	May - June
Euphyes dion	sedge meadows (*Scirpus, Carex*)	July - Early August
Lycaena dorcas	bogs, marshes (*Potentilla*)	July - Early August
Lycaena epixanthe	cranberry bogs (*Vaccinium*)	Late June - August
Oeneis jutta ascerta	spruce bogs, tamarack bogs (*Carex, Eriophorm* +)	June - July[1]
Pieris virginiensis	deciduous woods (*Dentaria* + others)	May
Calephelis mutica	bogs, wet meadows (*Cirsium muticum*)	Mid July - August

[1]This species is biennial and primarily flies in odd years; surveys were conducted in 1995.

Prepared by: RWH
Checked by: RFS

Butterfly surveys were carried out on 20 dates between May 12 and August 3, 1994, distributed rather evenly over the period, as listed on Table 3.9-12. All habitats known to be used by the target species were visited regularly. Individuals conducting the plant, bird, and mammal surveys also participated in the butterfly surveys, so butterflies were being "surveyed" during virtually every day that field observers were present. The northern blue butterfly and inornate ringlet were first collected during bird survey efforts. Numerous species were collected by the botanists, including Bate's checkerspot. Other important observations were also made along roadsides between field sites by other research teams. Absences of certain species (e.g., *Euphyes* spp.) were documented during inventories of wetlands and other habitats for plants or animals other than butterflies.

Butterflies with contracted flight periods and/or (in the case of *Oeneis jutta*) biennial emergence patterns suggest that several special concern species could have been overlooked in 1994. As a result, additional butterfly surveys were conducted on 22 occasions between May 29 and August 25, 1995.

Six species (*Boloria eunomia, Boloria freija, Boloria frigga, Erebia discoidalis, Euphyes dion, Oeneis jutta*) originally targeted for the 1994 survey and one additional species (*Boloria titania*) were the focus of the 1995 field investigation. Butterflies were sampled by carefully searching habitats which contained documented host plants or which are known to be appropriate or potential habitats based on published results from elsewhere.

3.9.1.5 Reptiles and Amphibians

Normandeau Associates, Inc. (1982) noted all amphibians and reptiles seen or heard during all phases of their wetland field work from April through June 1981. Field time spent during this effort was approximately 30 ten-hour days. In addition, an intense sampling effort for spotted salamanders, which were formerly a state threatened species that has since been delisted, occurred in April and early May 1981. "Drift fences" made of plastic sheeting approximately 12 inches wide by 40-50 feet long were erected parallel to open water breeding areas to intercept adults migrating to or from the pools. Pitfall traps consisting of 32 ounce plastic cups were buried along both sides of each fence to capture the salamanders. Each trap was checked once every 24-hours and the species and number of individuals caught were recorded.

Dames & Moore (1985) also studied amphibians and reptiles in the vicinity of the proposed mine. Qualitative surveys were conducted during May and August 1977 and April, May and August 1978. Numerous habitats were searched including pond banks, beneath logs, pieces of bark, debris, and leaf litter. During the spring surveys, singing amphibians were identified and their presence recorded. These surveys focused on those areas believed to be directly affected by the proposed project and adjacent ponds or wetlands.

The amphibian and reptile (herptile) surveys conducted in 1994 focused on seven target species, as listed on Table 3.9-13. Herptile surveys were designed and supervised by Gary S. Casper, a herpetologist with the Milwaukee Public Museum since 1984. Ronald F. Steg, a senior biologist with Foth & Van Dyke coordinated the effort and accompanied Casper on many occasions. Bradley D. Helmandollar and Andrew W. Zovnic, both Foth & Van Dyke biologists, also assisted in the effort. Significant numbers of amphibians also were collected during mammal inventories using pitfall traps and water shrew traps. All specimens collected through this effort have been catalogued and deposited in the Milwaukee Public Museum.

A variety of survey techniques were employed, including; visual encounter surveys, dipnetting, audio surveys, road cruising, quadrant sampling, turtle trapping, and miscellaneous other trapping techniques. Each of these techniques are described in the following paragraphs.

Table 3.9-12

Butterfly Survey Locations and Dates

Location No.	T	R	Section	County	Date
1	34N	12E	10	Langlade	02-Jun-94
2	34N	12E	11	Langlade	02-Jun-94
3	34N	12E	11	Langlade	20-Jun-94
3	34N	12E	11	Langlade	13-Jul-94
4	34N	12E	12	Langlade	01-Jun-94
5	34N	12E	12	Langlade	06-Jun-94
6	34N	12E	12	Langlade	20-Jun-94
7	34N	12E	3	Langlade	06-Jul-94
8	35N	12E	34	Forest	05-Jul-94
8	34N	12E	3	Langlade	06-Jul-94
9	34N	13E	5	Forest	14-Jun-94
10	34N	13E	6	Forest	28-Jun-94
11	34N	13E	6	Forest	04-Jun-94
12	34N	13E	6	Forest	28-Jun-94
13	35N	12E	23	Forest	20-Jun-94
13	35N	12E	23	Forest	20-Jul-94
14	35N	12E	24	Forest	21-Jul-94
15	35N	12E	24	Forest	29-Jun-94
16	35N	12E	24	Forest	01-Aug-94
17	35N	12E	24	Forest	20-Jul-94
18	35N	12E	25	Forest	08-Jun-94
19	35N	12E	25	Forest	20-Jun-94
20	35N	12E	25	Forest	
20	35N	12E	25	Forest	02-Aug-94
21	35N	12E	26	Forest	27-Jun-94
22	35N	12E	26	Forest	20-Jun-94
23	35N	12E	26	Forest	27-Jun-94
24	35N	12E	26	Forest	20-Jun-94
25	35N	12E	34	Forest	06-Jul-94
26	35N	12E	34	Forest	05-Jul-94
27	35N	12E	35	Forest	06-Jul-94
27	35N	12E	35	Forest	09-Aug-94
28	35N	13E	19	Forest	20-Jul-94
29	35N	13E	20	Forest	13-Jun-94
30	35N	13E	28	Forest	24-May-94
31	35N	13E	28	Forest	09-Jun-94

Table 3.9-12 *(Continued)*

Location No.	T	R	Section	County	Date
31	35N	13E	28	Forest	17-Jun-94
32	35N	13E	29	Forest	15-Jun-94
32	35N	13E	29	Forest	02-Aug-94
33	35N	13E	29	Forest	28-Jun-94
33	35N	13E	29	Forest	30-Jun-94
33	35N	13E	29	Forest	05-Jul-94
33	35N	13E	29	Forest	06-Jul-94
34	35N	13E	29	Forest	02-Jun-94
34	35N	13E	29	Forest	14-Jun-94
34	35N	13E	29	Forest	05-Jul-94
34	35N	13E	29	Forest	06-Jul-94
35	35N	13E	29	Forest	12-May-94
36	35N	13E	30	Forest	13-May-94
37	35N	13E	30	Forest	09-Jun-94
38	35N	13E	31	Forest	12-May-94
39	35N	12E	36	Forest	20-Jun-94
40	35N	13E	31	Forest	20-May-94
40	35N	13E	31	Forest	23-May-94
40	35N	13E	31	Forest	06-Jul-94
41	35N	13E	32	Forest	12-May-94
41	35N	13E	31	Forest	20-Jun-94
41	35N	13E	31	Forest	21-Jun-94
42	35N	13E	32	Forest	20-May-94
42	35N	13E	32	Forest	20-Jun-94
42	35N	13E	32	Forest	06-Jul-94
43	35N	13E	32	Forest	13-May-94
44	35N	13E	33	Forest	22-Jun-94
44	35N	13E	33	Forest	27-Jun-94
44	35N	13E	33	Forest	02-Aug-94
45	35N	13E	33	Forest	15-Jun-94
45	35N	13E	33	Forest	30-Jun-94
46	34N	13E	4	Forest	06-Jul-94
47	35N	12E	34	Forest	29-Jun-94
48	35N	13E	30	Forest	06-Jul-94
49	35N	13E	31	Forest	06-Jul-94
50	35N	13E	31	Forest	06-Jul-94
51	35N	13E	31	Forest	06-Jul-94
52	35N	13E	32	Forest	19-May-94

Table 3.9-12 *(Continued)*

Location No.	T	R	Section	County	Date
53	36N	16E	14	Forest	30-May-94
54	34N	12E	34	Langlade	07-Jun-94
55	34N	12E	18	Langlade	16-Aug-94

Location No. - see Figure 3.9-13

Prepared by: AWZ
Checked by: RFS

Table 3.9-13

Herptile Target Species

Common Name	Scientific Name	Wisconsin Status
Wood Turtle	*Clemmys insculpta*	Threatened
Blanding's Turtle	*Emydoidia blandingii*	Threatened
Northern Ringneck Snake	*Diadophis punctatus edwardsii*	Special Concern
Northern Ribbon Snake	*Thamnophis sauritus*	Endangered
Bullfrog	*Rana catesbeiana*	Rule
Pickerel Frog	*Rana palustris*	Special Concern
Four-toed Salamander	*Hemidactylium scutatum*	Proposed Special Concern

Prepared by: RFS
Checked by: AWZ

3.9.1.5.1 Visual Encounter Surveys (VES)

In this method field personnel search visually for animals in appropriate habitats. VES can be used quantitatively, with prescribed time periods and search methods (Heyer, et al., 1994), to compare abundance over time. Such time constrained VES often fail to pick up rare species. In this study, VES were used without quantitative protocols, in order to optimize for species presence/absence. Personnel walked through habitats searching the ground for active animals (snakes, anurans, turtles), and turned cover items to expose sheltered animals (mainly snakes and salamanders). Cover items were returned to their original positions. Additionally, binoculars and a spotting scope were used for VES along lakes, ponds and streams to target basking turtles. In the latter surveys, travel was often by canoe with 9.5 miles of stream covered twice, as shown on Figure 3.9-14, or automobile, with approximately 55 miles of roads covered multiple times. Cover items turned included logs, bark, stones, and litter. Nine boards and metal sheets were placed on May 16, 1994 at the plant site to provide cover items to attract snakes. An additional four boards were placed in the meadow on the northeast corner of wetland F15 on 14 June 1994.

Snake board placement is mapped on Figure 3.9-15. Approximately 20 percent of rotting logs, and five percent of rotting stumps encountered on VES were opened to some degree, to reveal salamanders within. These items were then returned as best as possible to their original positions. Weather, soil moisture and time of year can significantly influence the success of VES surveys and cover object use (Heyer, et al., 1994; Karns, 1986). Weather conditions were noted on all surveys. VES were conducted from April 27, 1994 through June 30, 1994, as listed on Table 3.9-14. Thirty VES routes are mapped on Figure 3.9-15.

3.9.1.5.2 Dipnetting

Dipnetting is an effective technique for assessing presence/absence for many species of amphibian larvae (Heyer, et. al., 1994). A 50 cm x 50 cm landing net with four millimeter mesh was used to sample at 34 sites between May 17, 1994, and June 30, 1994. Dipnetting was performed in shallow water (usually shorelines) where aquatic vegetation was present, as shown on Figure 3.9-15.

3.9.1.5.3 Audio Surveys

Audio surveys have been used for long-term monitoring and presence/absence surveys of anurans for a decade (Mossman & Hine, 1984, 1985; Heyer, et. al., 1994; Karns, 1986). Audio surveys were performed at 59 sites, as shown on Figure 3.9-15, and included on 19 miles of canoe surveys, during the period April 27, 1994, through June 30, 1994. Call index values (Mossman & Hine, 1984, 1985) were recorded for each species heard.

3.9.1.5.4 Road Cruising

Slowly driving roads, usually at night and/or after rains, is a standard technique for herptiles surveys (Heyer, et. al., 1994; Karns, 1986). This technique is most effective for snakes, turtles (especially during the nesting season) and frogs, and to a lesser degree salamanders. Animals encountered on the road were recorded and sometimes photographed or collected (road kills). Road cruises were performed on routes covering approximately 55 miles, with most sections surveyed multiple times during the period May 3, 1994, through June 30, 1994, as shown on Figure 3.9-14.

3.9.1.5.5 Quadrant Sampling

Fourteen square feet (1.5 square meter) quadrants were sampled by raking surface litter in a mature cedar swamp and on a maple-birch slope (Figure 3.9-15). This technique can uncover salamanders, frogs and fossorial snakes that hide in surface litter.

Table 3.9-14

Herptile Survey Method Timetable

Method	April	May			June			July			August			September		
	20-30	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31	1-10	11-20	21-30
Visual Encounter	■	■	■	■	■	■	■									
Canoe Surveys		■			■											
Dipnetting	■	■	■	■	■	■	■									
Quadrant Samples			■													
Road Cruising		■	■	■	■	■	■									
Audio Surveys	■	■	■	■	■	■	■									
Turtle Trapping	■	■	■	■	■	■	■					8/15-24				
Pitfall Traps					6/7-8/24											

- shading indicates active survey dates

Prepared by: GC
Checked by: RFS

3.9.1.5.6 Turtle Trapping

Hoop net trapping is the method of choice for detecting the blanding's turtle (*Emydoidea blandingii*) (Karns, 1986; Ross & Anderson, 1990; Rowe & Moll, 1991). Trapping success is highest in June, and drops off precipitously in July (Rowe & Moll, 1991). Trap sites were chosen by Casper, near areas of emergent vegetation and weak currents, where the best potential turtle habitat was present. Turtle trapping for this study was conducted by Andrew Zovnic and Brad Helmandollar, under the direction of Casper. Twenty baited 24 inch diameter hoop net traps were utilized at 13 sites, as shown on Figure 3.9-15. All captured turtles were marked (Cagle, 1939) and aged (Zug, 1991). A standardized turtle trapping form was used to record all data (Appendix 3.9-2). A total of 342 trap days were accumulated from May 31, 1994 through June 23, 1994. An additional 10 trap days were conducted at one site in mid-August, 1994.

3.9.1.5.7 Drift Fences and Pitfall Traps; Minnow Traps

These techniques are very effective for trapping terrestrial amphibians and small mammals, and to a lesser extent, small snakes (Heyer, et. al., 1994; Karns, 1986). The small mammal team accumulated 7,430 pit fall trap nights (Table 3.9-5) and 575 mammal trap nights (Table 3.9-7). All herptiles collected in the small mammal traps were verified by Casper and deposited at the Milwaukee Public Museum. A total of 1,932 specimens of 16 species were thus collected. A description of personnel, trapping protocol and trap sites is included in Section 3.9.1.2.

Casper spent a total of 22 days conducting surveys. On any given excursion a variety of methods were used to optimize species detection. Surveys on foot, utilizing VES, dipnetting, audio calling, and quadrant sampling techniques, were utilized on 22 days, totalling 137 hours field time. Surveys by canoe occupied 12.5 hours on four days. Road cruising was performed on 20 days totalling 134 hours over approximately 55 miles of roads. Additionally, Zovnic and Helmandollar spent 30 field days accumulating 352 turtle trap days, and the small mammal team spent 82 days accumulating 7,430 pitfall trap days and 575 minnow trap days. A survey method timetable is presented in Table 3.9-14.

3.9.2 Regional Ecology

To provide a general perspective for the project location in northeastern Wisconsin, the regional study area has been defined as the land within a 25 mile radius of the site. The study region includes portions of Forest, Langlade, Oconto, Marinette, Oneida, and Florence counties. Approximately 40 percent of this is Nicolet National Forest, while the rest is comprised of private land, county forest, and Native American reservations. This region is drained by the upper Wisconsin, Menominee-Oconto-Peshtigo, central Wisconsin, and Fox-Wolf river basins. The weather patterns of this region are typical of Great Lakes states. The summers are warm, but short, and the winters are very cold. Snow usually blankets the region from late fall until early spring (USDA, 1986). Glacial activity has greatly influenced the landscape of the region. The irregular, hilly topography of the area is a direct result of this glacial activity (Ziolkowski, 1987). The glacial activity also carved many irregular sized and shaped lakes which are prevalent throughout the region. Wetlands are also prevalent in the region.

Logging has had a significant impact on the landscape. Nearly 100 percent of the original forest has been logged at least once. Only a small percentage of the land in this region is suitable for agriculture because of the marshlands, sandy soil, and the hilly topography (Martin, 1982).

A vegetational transition zone crosses Wisconsin from the northwest to the southeast, separating two major vegetational provinces (Curtis, 1959). The study area is located in the northern zone. This area is typically characterized by a mixture of coniferous and deciduous trees in upland areas, and conifer swamps in forested wetland areas (Curtis, 1959). The two most abundant vegetation types are Northern Hardwood (including Aspen-Birch), and Swamp Conifer (EMC, 1985). The northern hardwood element is the most dominant, and is generally composed of maple, aspen, and birch. The swamp conifer is the minor element, and is generally composed of spruce, tamarack and cedar. The remainder of the region is comprised of shrub swamp, bog, marsh, urban or developed areas, old field and clear cut, and agriculture.

Three hundred eighty nine species of higher vertebrates spend some or all of their life in the upper Great Lakes region (Benyus, et. al., 1992). The distribution and abundance of species found in an area will vary greatly depending on habitat types, as well as forest age class, canopy cover, ground cover, moisture, and time of the year.

Fifty-four species of amphibians and reptiles are known to be indigenous to Wisconsin (Vogt, 1981; Collins, 1990). Of these, 32 species could be expected to occur in the general region (Casper, 1995). There are six species of salamanders, 11 frogs and toads, five species of turtles, nine snakes, and one lizard. The majority of these are associated with wetlands. They tend to take advantage of any cover ranging from leaf litter to hollowed out rotten logs.

Over 75 species of wild mammals range throughout the Great Lakes region (Kurta, 1995). Of these, 55 species of mammals would be expected to be found in the general region. The list of potential species includes some mammals (e.g., moose, pine marten) which are represented by only occasional sightings or very local populations.

Glacial ice covered most of Canada and the upper midwestern United States, including the study area, between 18,000 to approximately 10,000 years B.P. (Paull and Paull, 1977). The biotas that had previously occupied these areas were displaced by the ice; today's fauna consisted of species that have recolonized the region during geologically recent times. With the exception of highly mobile organisms such as birds, the diversity of mammals, herptiles, fishes and probably most groups of invertebrates is significantly lower in glaciated regions of North America than it is in southern regions which were not annihilated by glacial advances (Howe, 1984). Species ranges and ecological assemblages in the upper midwest probably are still in a state of flux as the ranges of different species expand and contract at different rates. Removal of important species (e.g., beaver, pine marten, fisher) by 18th and 19th century trappers (Jackson, 1961), deforestation and subsequent growth of secondary forest during the early 1900s, and the elimination or near elimination of top predators (gray wolf, wolverine) has imposed additional dramatic changes in the fauna of the study area and nearby regions. As a result, today's assemblages of animals and plants in northern Wisconsin cannot realistically be viewed as highly integrated, ecologically distinct communities.

3.9.3 Study Area Vegetation

Vegetation of the study area is essentially the same as that described in the 1986 *Environmental Impact Report*, although additional logging has taken place in the past decade (Figure 3.9-16). Vegetation cover types from previous work have been retained with the addition of "pine plantations". Cover types within the study area are described below. A study area plant list is included in Appendix 3.9-3.

3.9.3.1 Northern Hardwoods

Northern hardwood is the most common vegetation type in the study area. It has all been logged or cleared at least once and is represented by various stages of succession. Characteristic tree species include sugar maple (*Acer saccharum*), yellow birch *(Betula allegheniensis),* hemlock *(Tsuga canadensis),* white pine *(Pinus strobus),* quaking aspen *(Populus tremuloides)* basswood *(Tilia americana),* paper birch *(Betula papyrifera),* red oak *(Quercus rubra),* American elm *(Ulmus americana),* red maple *(Acer rubrum)* and ironwood *(Ostrya virginiana).*

Northern hardwood forests vary considerably in prominence of individual species and in degree of canopy closure. Differences within this type are primarily due to the frequency and severity of disturbance. The more mature and least disturbed areas are heavily dominated by sugar maple with full or nearly full canopy. All other tree species in these areas are of minor importance. The best example of this particular type is found in T35N R13E Section 32 and parts of adjacent sections. The soil is rich with a conspicuous layer of decomposing leaves on the surface.

Shrubs are generally sparse in these full canopy sites and the most common species found are leatherwood *(Dirca palustris)* and Canada honeysuckle (*Lonicera canadensis).* The ground layer is typically sparse but includes wild sarsaparilla (*Aralia nudicaulis*), lady fern (*Athyrium filix-femina*), Pennsylvania sedge (*Carex pennsylvanica*), Canada mayflower (*Maianthemum canadense*), bland sweet cicely (*Osmorhiza claytoni*), Solomans's seal (*Polygonatum pubescens*), twisted stalk (*Streptopus roseus*), starflower (*Trientalis borealis*), and yellow forest violet (*Viola pubescens*). Also worthy of note are the goblin fern (*Botrychium mormo*), a Wisconsin endangered species, lance-leaved grape fern (*B. lanceolatum*), little grape fern (*B. simplex*), Assiniboine sedge (*Carex assiniboinensis*), and ginseng (*Panax quinquefolia*), all four of which are Wisconsin special concern species, and good populations of two-leaved toothwort (*Dentaria diphylla*) and cut-leaved toothwort (*D. laciniata*). The *Dentaria* species represent the food plant for the larvae of a large population of the West Virginia white butterfly *(Pieris virginiensis),* a Wisconsin special concern species.

Most of the northern hardwood vegetation on the study area is less mature than described above. These sites have been logged more recently, more frequently, or more intensely. The diversity of canopy species, the biomass of the understory, and the number of shrubs and seedling and sapling trees increases in these areas. As the canopy becomes conspicuously open, the understory becomes "brushy" and white birch and quaking aspen become more prominent. At the extreme cases of "clear-cutting" species composition is converted to nearly pure stands of quaking aspen with bracken fern *(Pteridium aquilinum)* prominent in the understory. In the shrub layer, red-berried elder (*Sambucus pubens*) appears more frequently as the canopy becomes more open and beaked hazel (*Corylus cornuta*) also becomes conspicuous. Ginseng and the *Botrychium* species noted for closed canopy sites appear to be absent from the vegetation at sites with more open canopy.

3.9.3.2 Swamp Conifers

The number of prominent tree species in the swamp conifer vegetation type is small. The most important are white cedar *(Thuja occidentalis),* black spruce *(Picea mariana),* tamarack *(Larix laricina),* balsam fir *(Abies balsamea),* black ash *(Fraxinus nigra),* red maple (*Acer rubrum*) and paper birch (*Betula papyrifera*). Hemlock (*Tsuga canadensis*) is sometimes conspicuous at the edges of swamp conifer stands, but is seldom an important species of the interior portions.

Balsam fir, red maple, yellow birch (*Betula allegheniensis)*, paper birch, black ash, hemlock and American elm (*Ulmus americana*) are also characteristic of small, wet depressions within the larger matrix of upland forest.

Shrubs of the swamp conifer vegetation are usually sparse except in canopy openings. Common shrub species include mountain maple (*Acer spicatum*), black chokeberry (*Aronia melanocarpa),* leather leaf (*Chamaedaphne calyculata,)* laborador tea (*Ledum groenlandicum*), mountain holly (*Nemopanthus mucronatus*), skunk currant (*Ribes glandulosum*), swamp red currant (*Ribes triste*) and velvet leaved blueberry (*Vaccinium myrtilloides*). Dwarf birch (*Betula pumila*), honeysuckle (*Lonicera villosa*), alder leaved buckhorn (*Rhamnus alnifolius*) and northern black currant (*Ribes hudsonianum*) are less frequently encountered, but are widely distributed.

Sphagnum moss is common and often abundant in the ground layer, although not uniformly present. Common ground layer species include *Carex disperma, Carex leptalea,* bluebead-lily (*Clintonia borealis*), goldthread (*Coptis trifolia*), bunchberry (*Cornus canadensis*), wintergreen (*Gaultheria procumbens*), Canada mayflower (*Maianthemum canadense*), dwarf raspberry (*Rubus pubescens*), Solomon's seal (*Smilacina trifolia*) and starflower (*Trientalis borealis*).

The composition of the swamp conifer vegetation is not uniform and certain general types can be distinguished. Some sites are clearly dominated by white cedar, often with balsam fir. Other sites, especially the wettest, are dominated by black spruce and tamarack. Seedlings and saplings of balsam fir are common in many swamp conifer stands.

No large deciduous swamps were found in the study area, although black ash, red maple and American elm are locally prominent within swamp conifer stands and in transition areas to the uplands. Wetland F15 is unique for the presence of bur oaks (*Quercus macrocarpa)* growing with common wetland species, including American elm, black ash, green ash and red maple. The understory is also largely of typical wetland species, including blue joint grass (*Calamagrostis canadensis*) *Carex crinita, Carex tuckermannii,* spotted touch-me-not (*Impatiens biflora*), northern blue iris (*Iris versicolor*), woolgrass (*Scirpus cyperinus*) and marsh skullcap (*Scutellaria galericulata*). Open areas within this forest are dominated by sedges, including *Carex lacustris.* This site became rather dry during the summer of 1994, which was not a particularly dry year.

3.9.3.3 Shrub Swamp

Shrub swamp vegetation as used in the 1986 *Environmental Impact Report* included the Wisconsin plant communities commonly known as alder thicket and shrub carr. This type of vegetation was usually present along the border of streams or lakes, or as small openings within swamp conifers. Speckled alder was usually the most prominent species, but willows (*Salix petiolaris, S. bebbiana,* and *S. discolor),* red-osier dogwood (*Cornus stolonifera*), and bog birch (*Betula pumila*) are also significant on some sites. The groundlayer is commonly of blue-joint grass and sedges (*Carex rostrata, C. stricta,* and others) with a variety of other herbaceous species typical of moist soil habitats.

3.9.3.4 Bog

Plant species composition of the bogs in the study area is typical of bogs of northeastern Wisconsin and is characterized by abundant *Sphagnum* moss and ericaceous shrubs of which leatherleaf (*Chamaedaphne calyculata*) and Labrador tea (*Ledum groenlandicum*) are most

conspicuous. When sedges are prominent in the bogs, *Carex rostrata* and *Carex lasiocarpa* are usually the most common species.

Some of the wetter and more open conifer swamps are "boggy" in the character of the understory and groundlayer vegetation, and "boggy" marshes are another common intermediate type. There are actually very few "pure" bogs on the study area. A large bog is found around the north, west and south edges of Duck Lake, with good floating mats, large areas of transition into which large numbers of tamarack and black spruce seedlings and saplings have become established, and a well developed "moat" around the outside edge. Several areas of bog are also conspicuous around the shoreline of Deep Hole Lake.

The best example of bog vegetation not associated with a lake is in wetland F16 along Berry Lane. The vegetation of F16 included the only population of grass pink (*Calopogon tuberosus*) found on the study area. Wetland F64 also contains a diversity of bog vegetation with well developed transition into swamp conifers.

3.9.3.5 Marsh

There is very little emergent marsh in the study area, although the shoreline of several lakes and portions of the streams support small stands of emergent species such as softstem bulrush *(Scirpus validus),* burreed *(Sparganium chlorocarpum, S. eurycarpum)* and arrowhead *(Sagittaria latifolia).* Most of the areas which appear to be emergent marsh are closer to bog or to sedge meadow. *Carex rostrata* is common in such areas and often forms dense stands. The stands of *Calamagrostis canadensis* within alder thicket or in canopy openings in some swamps are often small and if separated from the larger surrounding vegetation should probably be considered as sedge meadow.

Submergent and floating leaved aquatic plants grow abundantly in Rolling Stone Lake, Mole Lake, Skunk Lake and Deep Hole Lake and moderately in Little Sand Lake, Hemlock Creek, and portions of Swamp Creek. Common species included ribbon-leaved pondweed (*Potamogeton epihydrus,*), floating pondweed (*P. natans*), sago pondweed (*P. pectinatus*), flatstem pondweed (*P. zosteriformis*), coontail (*Ceratophyllum demersum*), northern water nymph (*Najas flexilis*), burreed (*Sparganium angustifolium*) and common bladderwort (*Utricularia vulgaris*).

Oak Lake and Duck Lake supported remarkably little submergent vegetation, although Duck Lake did provide the only population of algal-leaved pondweed (*Potamogeton confervoides*). Oak Lake had virtually none of the common submergents, but supported an abundant growth of the small, inconspicuous bottom dwelling species such as waterwort (*Elatine minima, E. triandra*), resupinate bladderwort (*Utriculatia resupinata*), water lobelia (*Lobelia dortmanna*), pipewort (*Eriocaulon septangulare*) and rush (*Juncus pelocarpus*).

3.9.3.6 Urban or Developed

Urban and developed areas, as expected, were vegetated primarily by cultivated plants and by weedy naturalized species. Bluegrass *(Poa pratensis, Poa annua)* and dandelions *(Taraxacum officinale)* are common in maintained lawns. More neglected areas tend to produce a variety of alien weed species which varies depending on soil moisture and level of use of the area. Rights-of-way of roads and power lines typically reflect early successional stages of the major surrounding vegetation. Bracken fern *(Pteridium aquilinum),* large leafed aster *(Aster Macrophyl-*

lus) and sprouts, seedlings and saplings of the adjacent woody species are prominent in rights-of-way through forested areas and "old field" weeds such as goldenrods and naturalized grasses dominate in right-of-ways through farms or residential areas.

3.9.3.7 Old Field and Clearcut

"Old field" vegetation colonizes fields after they are abandoned for agriculture or following major disturbance in which the native vegetation is totally removed. Ultimately, succession will convert these areas into forest, but many such sites persist in primarily herbaceous vegetation for several decades.

In the early stages of abandonment these sites are dominated by the primarily annual species of agricultural weeds. Within a few years clonal grasses and other herbaceous perennials replace the annual species. Typical species include quack grass *(Agropyron repens),* brome grass *(Bromus inermis,* bluegrass *(Poa pratensis),* goldenrods *(Solidago canadensis, S. graminifolia),* asters *(Aster laevis)* and numerous other familiar weedy species, along with some seedlings of early successional tree and shrub species.

On the sandy soils typical of the study area, some of the well-drained sites with especially low organic content, and therefore with low nutrient content and low pH, will produce a less productive vegetation comprised of such species as Canada bluegrass (*Poa compressa*), poverty grass (*Danthonia spicata*), little bluestem (*Andropogon scoparius*), *Carex rugosperma,* gray goldenrod (*Solidago nemoralis*), early goldenrod (*S. juncea*), etc.

"Clearcut" areas within the study area are largely occupied by dense stands of quaking aspen sprouts with bracken fern (*Pteridium aquilinum*) and often common blackberry (*Rubus allegheniensis*). Seedlings of balsam fir are also common. The understory is often somewhat weedy in the first few years following cutting and large-leaved aster (*Aster macrophyllus*) is often prominent. Some of the ground layer species from the previous vegetation will persist, such as Canada mayflower, clubmoss (*Lycopodium* spp.), pennsylvania sedge, etc. Some of the clearcut areas have obviously been cut since the Dames & Moore study.

3.9.3.8 Agriculture

Agricultural sites obviously produce primarily crop plants, but also support vigorous growth of weeds at their edges, within the ranks of the crops, and in small in-holdings which are difficult to cultivate. The weeds are predictable, primarily introduced species such as pigweed (*Chenopodium album*), green amatranth (*Amaranthus retroflexus*), foxtail (*Setaria spp.*), etc. Conspicuous crop species seen in the area include potatoes and various hay plantings in addition to the vegetable gardens of individual households.

3.9.3.9 Pine Plantations

Several conspicuous pine plantations of red pine *(Pinus resinosa)* and jack pine *(Pinus banksiana)* were noted in the study area. These areas are generally chosen for pine plantations because of sandy soil which is largely unsuited for other crops or other forest types. The pine plantations in the study area had somewhat open canopy and produced a ground layer similar to that noted for old fields on poor, sandy soils, with canada bluegrass, poverty grass, gray goldenrod, and

bluestem. This area also produced notable growth of blackberries *(Rubus allegheniensis)*, and sweet fern *(Comptonia peregrina)* in openings among the trees.

3.9.3.10 Heavy Metals in Vegetation

3.9.3.10.1 Terrestrial

As described in Section 3.9.1.1.1, samples of the above-ground, new growth portions of Pennsylvania sedge, red raspberry, and balsam fir were collected in 1994 from three locations in each of three sectors within the study area (i.e., north sector, south sector, and west sector as shown on Figure 3.9-2). The purpose of this analysis was to validate similar work conducted in 1977. Species specific composites were analyzed for each sector (i.e., all of the Pennsylvania sedge collected from the three locations in the north sector were combined for a north sector Pennsylvania sedge composite sample). The results of the 1977 and 1994 sampling events analysis are presented in Table 3.9-15. All results are presented in dry weight. Laboratory data sheets are presented in Appendix 3.9-4.

Upon comparison of the previous data to the 1994 data, there do not appear to be any noticeable trends in heavy metal concentrations related to the sample location. At most sample locations, arsenic and cadmium results for 1994 were slightly higher than data collected in 1977. Cobalt, copper, lead, and zinc show slightly lower results for 1994 when compared to 1977 data. The remaining metals concentrations are nearly the same as reported previously.

As shown in Table 3.9-15a, with the exception of lead and cobalt, all of the reported 1994 values fall within the range of concentrations reported in the literature (DiLabio, Rencz and Egginton, 1982; Rogers and Dunn, 1993; Smith, 1973; Heinrichs and Mayer, 1980; Gerloff et al., 1966). Lead and cobalt results from the project area are below those reported in the literature. In general, the concentrations of the listed metals in plant tissue are variable and not solely dependant on soil metal concentrations, but may vary due to the plant's uptake rate. The rate at which plants uptake metals is dependant upon both the condition of the plant as well as the characteristics of the soil and may vary seasonally as well as on a long-term basis as plant communities change over time.

3.9.3.10.2 Aquatic Macrophytes

The 1977 sampling effort was directed at collecting several species of plants and compositing them for analysis. For the 1994 effort, a composite of a single species, as listed in Table 3.9-16, was collected and analyzed. Due to limited access to the Sokaogon Chippewa Reservation at Mole Lake there were no samples taken at Rice or Oak Lakes. Oak Lake was not sampled due to the presence of sweat lodges. The data collected in 1977 and 1994 are presented in Table 3.9-16. Laboratory data sheets are presented in Appendix 3.9-4. All data is measured in dry weight. The data present a range of values likely resulting from the analysis of a variety of plants.

Table 3.9-15

Terrestrial Plant Tissue Results from 1977 and 1994 (in mg/kg)

Species	Sample/Year	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Mercury	Zinc
Pennsylvania Sedge	North Composite									
	1977	<0.01	0.32	0.49	1.2	6.7	1.4	253	<0.01	48
	1994	0.09	0.55	0.83	<.130	6.9	0.56	224	<.110	28.8
	South Composite									
	1977	<0.01	2.13	0.35	1.0	6.1	1.2	207	<0.01	41
	1994	<.080	0.65	0.79	<.140	5.4	0.35	201	<.140	32.4
	West Composite									
	1977	<0.01	0.25	0.31	0.6	7.0	1.0	258	<0.01	32
	1994	<.400	0.67	0.69	<.130	13.3	0.89	265	<.110	30.5
Red Raspberry	North Composite									
	1977	<0.01	0.43	1.31	1.3	11.7	2.0	429	<0.01	69
	1994	<.090	0.56	0.81	<.140	6.2	1.1	185	<.120	39.7
	South Composite									
	1977	<0.01	0.38	2.89	1.4	10.9	2.2	260	<0.01	59
	1994	0.45	0.62	0.74	<.140	9.1	0.55	296	<.130	40
	West Composite									
	1977	<0.01	0.38	0.61	0.6	18.3	1.8	429	<0.01	44
	1994	0.080	0.69	0.72	<.130	5.4	0.35	513	<.120	43.3
Balsam Fir	North Composite									
	1977	<0.01	0.31	0.32	0.7	7.2	1.2	337	<0.01	58
	1994	<.080	0.66	0.73	<.140	3.6	0.23	270	<.120	39.1
	South Composite									
	1977	<0.01	0.26	0.68	0.7	7.7	1.5	512	<0.01	62
	1994	0.11	0.64	0.68	0.16	7.3	0.35	349	<.130	38.2
	West Composite									
	1977	<0.01	0.39	0.24	0.7	7.4	2.0	528	<0.01	59
	1994	0.65	0.61	0.63	0.14	5.2	0.46	422	<.120	38.7

Prepared by: BDH
Checked by: RFS

Table 3.9-15a

Comparison of 1977 and 1994 Terrestrial Plant Tissue Results with Those Reported in the Literature

Metal	1997 Mean[1]	1994 Mean[2]	Dilabio, Renez and Egginton, 1982[3]	Rogers and Dunn, 1993[4]	Smith, 1973[5]	Heinrichs and Mayer, 1980[6]	Heinrichs and Mayer, 1980[7]	Gerloff et al., 1966[8]	Range Reported by Other Authors
Manganese	357	303	—	—	113-599	260-1800	160-1650	38-1225	38-1800
Zinc	52	36	25-62	—	49-351	10-94	21-178	15-86	10-351
Cadmium	0.54	0.62	0.06-0.11	—	0.7-2.3	0.064-0.66	0.27-1.45	—	0.06-2.3
Copper	9.2	6.9	—	—	6-16	24-41	24-48	2.7-8.5	2.7-48
Arsenic	<0.01	1.19	—	0.12-3.6	—	—	—	—	0.12-3.6
Lead	1.6	0.53	—	—	64-315	3-73	5.4-80	—	3-315
Mercury	<0.01	not detected	—	—	—	—	—	—	—
Cobalt	0.9	0.08	—	—	—	0.5-0.7	0.6-0.9	—	0.5-0.9
Chromium	0.80	0.73	—	0.12-3.6	1.6-6.0	8.5-12	9.3-14	—	0.12-14

[1]Mean of all 1977 composite analyses irrespective of plant species or sector, N=9.
[2]Mean of all 1994 composite analyses irrespective of plant species or sector, N=9.
[3]Balsam fir from Ontario, Canada.
[4]Balsam fir from Nova Scotia, Canada.
[5]Range reported for sugar maple, pin oak, norway maple, eastern hemlock, yew and norway spruce.
[6]Beech.
[7]Spruce.
[8]Values listed are from various species sampled throughout Wisconsin.

Prepared by: RFS
Checked by: JWS

Table 3.9-16

Aquatic Macrophyte Tissue Sample Results from 1977 and 1994 (in mg/kg)

Location	Tissue	Year	Arsenic	Cadmium	Chromium	Cobalt	Copper	Lead	Manganese	Mercury	Zinc
Swamp Creek Upstream	White Water Lilly	1994	0.72	<.370	1.1	<.400	8.1	1.1	918	<.350	20.8
Swamp Creek Downstream	White Water Lilly	1994	2.9	<.290	0.81	<.310	2.1	0.34	924	<.290	25.1
Wolf River Upstream	White Water Lilly	1994	0.22	<.280	0.84	<.300	24.4	1.3	396	<.280	27.2
Wolf River Downstream	White Water Lilly	1994	0.51	<.370	1.3	<.400	4.4	0.57	1230	<.380	30.8
Little Sand Lake	White Water Lilly	1994	<.140	0.83	0.48	<.240	5.9	1.3	128	<.220	36.3
Little Sand Lake	Composite A[1]	1977	0.12	1.1	1.3	<0.1	9.8	7.3	228	<0.05	45
Swamp Creek Hwy 55	Wild Rice	1994	0.77	<.330	1.3	<.360	3.7	0.78	721	<.320	15.7
Rice Lake	Composite B[2]	1977	4.68	<0.1	<0.1	<0.1	9.2	2.6	193	0.05	30
Rice Lake	Wild Rice	1977	8.58	1.8	4.9	<0.1	16	12	751	<0.05	40
Swamp Creek Station E	Composite C[3]	1977	0.84	<0.1	11	<0.1	105	11	1120	<0.05	155
Oak Lake	Composite D[4]	1977	2.28	0.4	0.1	<0.1	13	1.5	21.1	<0.05	50

1. Composite A - spike rush and pipewort
2. Composite B - yellow water lilly, cattail and burreed
3. Composite C - cattail and burreed
4. Composite D - spike rush, pipewort and water lobelia

Prepared by: BDH
Checked by: RFS

3.9.4 Study Area Wildlife

3.9.4.1 Mammals

According to Kurta (1995), the current ranges of 54 native mammal species encompass the study area. Seven of these are bats, a taxonomic group that includes no threatened or endangered species in northern Wisconsin and was not a target of this or previous investigations. Of the remaining 47, lynx, mountain lion, and moose are large-ranging mammals which generally were once considered to be extirpated from Wisconsin and now occur as transients or a few scattered individuals. gray wolf, another wide-ranging species, has established populations in Wisconsin but packs are rare and very locally distributed (see individual species accounts). Fox squirrels are characteristic of open woodlands and savannas; their range barely reaches Forest County and the study area. This leaves only three species which reasonably might be expected to occur in the study area but which were not observed by field investigators: gray fox, pine marten, and northern flying squirrel. A list of the mammal species documented in the study area is presented in Table 3.9-17.

Numerous tracks of foxes were recorded during the winter tracking analysis. Some of these might have been made by gray foxes, but there is no means of distinguishing the two species. In other words, gray foxes likely occur in the study area even though none was directly observed. Kurta (1995) notes that gray foxes are less common than red foxes in northern Wisconsin and the possibility also exists that they simply were not present in the study area.

The ranges of northern flying squirrels and southern flying squirrels overlap in northern Wisconsin (Kurta, 1995). Northern flying squirrels are known recently as far south as Kewaunee County, whereas southern flying squirrels occur as far north as Forest and Oneida Counties. Previous researchers (Dames & Moore, 1981) collected a southern flying squirrel at the study area. During summer 1994 two individuals were collected, again southern flying squirrels. Ecological relationships between the two species of flying squirrels are not well known, but apparently the northern species does not coexist with southern flying squirrels in the study area.

As a result of overharvesting and habitat deterioration, pine martens were extirpated from Wisconsin by the early 1900s. Re-introduction by the WDNR during the 1970s has led to the successful establishment of populations in several local areas, including portions of the Nicolet National Forest within 30 miles of the study area. Pine martens were the object of an intensive trapping effort during October 1994 (see species accounts). Despite 377 trap nights, using guidance of WDNR-sponsored pine marten researchers, no pine martens were captured. Tracking surveys likewise revealed no unambiguous evidence of pine martens, although similarity of this species' tracks with fisher, a species that appears to be quite common in the study area, does not rule out the possibility that pine marten tracks were observed but not distinguished. If pine martens are present in the study area, however, they certainly are rare.

Even if gray fox, pine marten, and northern flying squirrel are absent, the diversity of the documented mammals in the study area is comparable to most Wisconsin counties (Jackson, 1961). Particularly notable are eight species of mustelids (including badger, river otter, fisher, mink, striped skunk, and all three species of native Wisconsin weasels) and a rich assemblage of small mammals, including five species of shrews, three tree squirrels, two chipmunks, and seven other small rodents (Table 3.9-17).

Table 3.9-17

Mammal Species Documented From the Study Area

Species	Method[1]	Status[2]	Habitat[3]	Observed in:		
				Region[4]	SA[5]	PA[6]
Virginia Opossum *(Didelphis virginiana)*	O	R	Confined to wooded areas along streams, around lakes, and in swamps.	X	+	NO
Masked Shrew *(Sorex cinereus)*	C	VC	Moist wetlands, including coniferous and deciduous forests; occasionally bogs, marshes, spruce-alder swamps, and alder thickets; rarely dry woods or fields.	+	X	X
Arctic Shrew *(Sorex arcticus)*	C	U	Chiefly wet spruce or tamarack swamps or alder and willow marshes; rarely bogs.	+	+	+
Water Shrew *(Sorex palustris)*	C	R	Wooded wetlands, including marshes, bogs, and wet areas near borders of streams, lakes, or water holes.	+	+	+
Pygmy Shrew *(Sorex hoyi)*	C	U	Moist woods, spruce and tamarack bogs, sweet fern environments on dry slopes, high grassy openings.	+	X	X
Short-tailed Shrew *(Blarina brevicauda)*	C	U	Generally unrestricted, including forests, marshes, grasslands and bushy areas.	X	X	X
Star-nosed Mole *(Condylura cristata)*	C	U	Moist ground near water, swamps or marshes; wooded and brush land areas or open areas; soils or muck, humus or light sandy loams.	X	+	+
Coyote *(Canis latrans)*	T,O	C	Wooded borders and bushy areas, particularly second-growth hardwood; rarely in meadows or cultivated fields.	X	X	X
Gray Wolf *(Canis lupus)*		R/A	Large areas of dense forests.	+	NO	NO
Red Fox *(Vulpes vulpes)*	T,O	C	Hilly farmland, woodlots, brush land, lakes or streams bottoms.	X	+	+
Gray Fox *(Urocyon cinereoargenteus)**		R	Hardwood or mixed hardwood-coniferous forests, particularly in rough, hilly terrain; favors vicinity of streams and lakes.	X	NO	NO

Table 3.9-17 *(Continued)*

Species	Method[1]	Status[2]	Habitat[3]	Observed in:		
				Region[4]	SA[5]	PA[6]
Black Bear *(Ursus americanus)*	T,O	C	Heavily wooded areas and dense brush land, prefers mixed forest type.	X	X	X
Raccoon *(Procyon lotor)*	T,O	C	Forests and old wooded areas with hollow trees and nearby water.	X	X	X
Ermine *(Mustela erminea)*	T,C	C	Brush lands or wooded areas; occasionally in open country near stone walls and old buildings.	X	+	+
Least Weasel *(Mustela nivalis)*	T,C	U	Meadows, fields, and possibly woodlands.	+	+	+
Long-tailed Weasel *(Mustela frenata)*	T,C	U	Woodlands, brushed, bushy field borders and prairies near creeks and other water	+	+	+
Mink *(Mustela vison)*	T,O	C	Banks of lakes, rivers, and other waterways, particularly if forested.	X	X	X
Fisher *(Martes pennanti)*	T,C	C	Heavy lowland forests of mixed hardwoods and conifers.	X	X	+
Badger *(Taxidea taxus)*	C,O	R	Grasslands, sandy fields and pastures, also sparse brush land and open woodlots; open farmland.	X	+	NO
Striped Skunk *(Mephitis mephitis)*	T,O	U	Brush lands, sparse woods and grasslands; woodpiles, rock piles and buildings; bushy borders of lakes and streams.	+	+	NO
River Otter *(Lutra canadensis)*	T,O	C	Along rivers, large creeks, sloughs and lakes.	X	X	*
Bobcat *(Lynx rufus)*	T	U	Remote bushy and woodlands country, particularly in swamps and rocky areas.	X	X	X
White-tailed Deer *(Odocoileus virginianus)*	T,O	VC	Variable; young woodland borders and agricultural areas; winter yards in tamarack and spruce swamps.	X	X	X
Eastern Cottontail *(Sylvilagus floridanus)*	T	R	Abandoned homesteads, farms, open country.	X	+	NO
Snowshoe Hare *(Lepus americanus)*	T,O	C	Bushy woodlands and heavy forests; bogs and swamps; old barns and cut over land; rarely in pure hardwoods.	X	X	X

Table 3.9-17 *(Continued)*

Species	Method[1]	Status[2]	Habitat[3]	Observed in:		
				Region[4]	SA[5]	PA[6]
Porcupine *(Erethizon dorsatum)*	T,C	C	Forests of almost any kind, preferably with some conifers.	X	X	X
Beaver *(Castor canadensis)*	T,O	C	Remote lakes and streams in wooded areas.	X	X	X
Eastern Chipmunk *(Tamias striatus)*	C,O	C	Deciduous forests, bushy areas, near rocky outcrops.	X	X	X
Least Chipmunk *(Tamias minimus)*	O	R	Mixed coniferous and hardwood forests; burns and slash; lakeshores and roadsides; rarely in wet areas.	X	X	X
Woodchuck *(Marmota monax)*	O	R	Bushy woodlands edges; clearings; and rock outcrops.	X	X	X
Thirteen-lined Ground Squirrel	O	R	Grassy fields, dry meadows and abandoned fields, fencerows, pastures; parks; woodland openings; rarely in dense forest.	X	X	*
Red Squirrel *(Tamiasciurus hudsonicus)*	O,T	C	Coniferous and mixed hardwood forests; deciduous stands in wet terrain.	X	X	X
S. Flying Squirrel *(Glaucomys volans)*	C	U	Forests, groves of deciduous trees, old orchards, woods of mixed hardwoods and conifers; particularly where hardwoods predominate.	+	X	X
Woodland Deer Mouse *(Peromyscus maniculatus gracilis)*	T,C	C	Coniferous, deciduous, or mixed woodlands; occasionally spruce-cedar swamps and abandoned buildings.	X	X	X
White-footed Mouse *(Peromyscus leucopus)*	T,C	VC	Forests, bushy fence lines, woodland edges; prefers deciduous woods.	X	X	X
S. Red-backed Vole *(Clethrionomys gapperi)*	C	VC	Hardwood forests and conifer swamps, especially where there are decaying logs and stumps.	X	X	X
Muskrat *(Ondatra zibethicus)*	O	C	Marshes, lakes, ponds, and streams.	X	X	*
Meadow Vole *(Microtus pennsylvanicus)*	C	C	Low, moist areas or grasslands, near water; open grassy orchards and woodlands; agricultural fields; occasionally in bogs.	X	X	X
S. Bog Lemming *(Synaptomys cooperi)*	C	C	Damp meadows or low bogs; occasionally in hemlock or wet deciduous woods; prefers a moderately grassy environment.	+	+	+

Table 3.9-17 *(Continued)*

Species	Method[1]	Status[2]	Habitat[3]	Observed in: Region[4]	SA[5]	PA[6]
Meadow Jumping Mouse *(Zapus hudsonicus)*	C	VC	Low meadows, brush land near water, woods edge.	X	X	X
Woodland Jumping Mouse *(Napaeozapus insignis)*	C	U	Along creeks, small damp openings, usually in brush land or second growth; never far from woodlands.	+	X	X

[1] Methods: O = Observed
C = Captured
T = Tracks

[2] Status: Qualitative assessment of population in the study area based on observations in 1994 and experience of the authors.
VC = abundant in appropriate habitat
C = present in appropriate habitat
U = present but in low numbers or scattered populations
R = in very low numbers
A = absent
NO = not observed

[3] Habitat information obtained from Dames & Moore, 1985.
[4] Region = Northeastern Wisconsin
[5] SA = Study Area
[6] PA = Project Area

+ = 1994 survey only

X = Previous surveys and 1994 survey

* = Previous surveys only

Prepared by: AWZ
Checked by: RFS

Trapping studies show that many species are widely distributed among habitats in the study area. Tracks or direct observations of larger mammals such as coyote, red fox, and black bear were found at numerous localities in both open and forested habitats. Abundant species like masked shrew, red-backed vole, and meadow jumping mouse were present in virtually all major habitat types. In addition to the species described separately (see species accounts), other mammals showed clear habitat preferences (Table 3.9-17). Meadow voles were common in open and wet habitats, but were rare in upland forests, a result consistent with published habitat preferences for this species (Kurta, 1995, et. al.). White-footed mouse and woodland deer mouse, both caught mainly in snap traps or live traps, were characteristic of upland forest. The latter species (woodland deer mouse) was less abundant than the widespread white-footed mouse, but was not uncommon in the mammal trapping transects. Star-nosed moles were collected at five localities, all associated with moist habitats. Appendix 3.9-6 contains a summary of the small mammal trapping results.

The abundance of weasels in the study area is notable. Although only one least weasel was collected, short-tailed weasels (ermines) were found in live traps at four pitfall stations, and two others were caught during the pine marten trapping effort. A single long-tailed weasel was trapped, photographed, and released in the project area. Numerous weasel tracks were recorded during the winter tracking surveys; some of these were least weasels, but again short-tailed weasels appear to be the most abundant of the three weasels in the study area. A single badger was trapped and released near Oak Lake during the October pine marten trapping analysis; no evidence of this species was previously observed. Other species encountered rarely during this investigation include least chipmunk, observed several times (independently) in the vicinity of the Swamp Creek Cedars; river otter, observed in Swamp Creek and (tracks) at the road crossing of Hemlock Creek; mink, observed by several observers along Swamp and Hemlock Creeks and (tracks) at the Hemlock Creek crossing; and open country species like woodchuck, thirteen-lined ground squirrel, and eastern cottontail.

Habitat types in the study area occur in a complex mosaic, and the home ranges of many if not most of the resident mammals incorporate several of these habitats. The presence of woodland ponds, bogs, lowland conifer swamps, lakes, and streams, together with extensive forested habitats, provide a favorable mix of wet and upland habitats which undoubtedly contribute to a varied assemblage of mammals in the study area. Note that the site is inhabited by species of upland grasslands (thirteen-lined ground squirrel, woodchuck) as well as aquatic species like water shrew, muskrat, mink, and river otter. This diversity of habitats is partly responsible for the observed diversity of mammals in the study area. Also notable, however, is the fact that few (if any) areas in Wisconsin have been studied as intensively as the study area. Many regions in northern Wisconsin are characterized by a similar mix of wet and upland habitats and likely support a comparable diversity of mammals.

3.9.4.2 Birds

As a consequence of three quantitative field studies (Dames & Moore, 1981; Normandeau Associates, 1982; and this investigation), birds at the proposed mine site are well known. Results obtained during 1994 and 1995 are consistent with the findings of previous investigators, as well as with data from the Nicolet National Forest Bird Survey, North American Breeding Bird Surveys, and published regional surveys (e.g., Vanderschagen, 1981; Hoffman and Mossman, 1990; Mossman, et. al., 1990).

In general, breeding birds at the study area are typical of heterogeneous landscapes in northern Wisconsin. Altogether at least 132 species were recorded during the 1994 breeding season as listed in Table 3.9-18. Several of these birds undoubtedly represent transients, but the observed species richness compares favorably with the 170 species recorded during eight years of the Nicolet National Forest Bird Survey (Howe, et. al., 1994). Of the 15 most frequently recorded species in the study area, 13 (all but song sparrow and common yellowthroat) are among the 15 most frequently recorded species in the Nicolet National Forest. During 1992, 89 species were recorded at 90 random roadside points in the northern half of the Forest; during 1993, 107 species were recorded at 101 random points in the southern half; and during 1994, 77 species were recorded at 100 random points in the northern half. CMC's 1994 investigation at the study area yielded 98 species at 111 points. These data suggest that the diversity and composition of birds at the study area is comparable to the avifauna of the Nicolet National Forest.

Each of the survey points was assigned to a habitat category (Table 3.9-10) based on a map of the study area vegetation (Figure 3.9-16). If two or more habitats were present within 450 feet of the sample point (the area within which birds are to be detected), the site was assigned to a category which combines the major nearby habitat types. Different numbers of points were sampled for each habitat category; habitat categories represented by many survey points would be expected to yield higher species richness than categories represented by only a few points. In order to remove sampling effects, the species richess (number of species) accumulated for each habitat category must be compared against the best-fit relationship between bird species richness and number of sampling points (Table 3.9-19).

Taking the relationship between species richness and sample size into account, four habitat categories (conifer/shrub, northern hardwoods/mixed forest, northern hardwoods/wetlands, and northern hardwoods/conifer/shrub) showed highest levels of species richness. Northern hardwoods, northern hardwoods/conifers, and northern hardwoods/deciduous forests showed comparatively lower bird diversities.

Neotropical migrant songbird densities are comparable to those in the Nicolet National Forest, where annual production is high for many species that are declining elsewhere in their range (Zovnic, 1995). Of the 15 most common breeding species in the study area, ovenbird, red-eyed vireo, rose-breasted grosbeak, black-throated green warbler, mourning warbler, Nashville warbler, veery, chestnut-sided warbler, and least flycatcher are long-distance Neotropical migrants. Although these species are believed to be vulnerable to long term population decline, they are well represented elsewhere in northern Wisconsin.

Other migratory songbirds in the study area deserve mention. Black-and-white warbler is particularly widespread in the study area, where individuals were documented at 16 point counts representing all habitat categories. Golden-winged warbler, a species considered by most to be seriously declining (Thompson, et. al., 1992), was found at 12 sites, again widely distributed across habitat types. These birds are typical of shrub swamps, open tamarack bogs, and aspen parklands (Morse, 1989); they also are fairly common in the Nicolet National Forest. Northern parula was found at nine points, especially in lowland forests of both conifers and hardwoods. Canada warbler, one of northern Wisconsin's uncommon songbirds, was found breeding along the margin of Swamp Creek. Other notable records of Neotropical migrant songbirds include veery

Table 3.9-18

Bird Species Observed at the Crandon Study Area During 1994 and 1995

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Common Loon (*Gavia immer*)	U	Inland lakes, flowages.	X	X	X
Pied-billed Grebe (*Podilymbus podiceps*)	R	Inland lakes, flowages, ponds, stream, shallow marsh.	X	X	*
Great Blue Heron (*Ardea herodias*)	R	Shallow marsh, wooded swamps, ponds, streams, inland lakes, and flowages.	X	X	X
Green-backed Heron (*Butorides striatus*)	R	Shallow marsh, wooded swamps, ponds, streams, inland lakes, and flowages.	X	X	*
American Bittern (*Botaurus lentiginosus*)	R	Sedge meadows, shallow marsh, and woodland swamps.	X	X	*
Mallard (*Anas platyrhynchos*)	U	Perennial forage, sedge meadows, shallow marsh, wooded swamp, ponds, streams, inland lakes, flowages.	X	X	*
American Black Duck (*Anus rubripes*)	R	Shallow marsh, ponds, streams, inland lakes, and flowages.	X	X	*
Canada Goose (*Branta canadensis*)	M	Shallow marsh, ponds, streams, inland lakes, and flowages.	X	X	*
Blue-winged Teal (*Anas discors*)	U	Perennial forage, sedge meadows, shallow marsh, wooded swamps, ponds, streams, inland lakes, flowages.	X	X	X
Green-winged Teal (*Anas crecca*)	M	Shallow marshes, ponds, and streams.	X	NO	NO
Northern Shoveler (*Anas clypeata*)	M	Shallow marshes, ponds, and streams.		+	
Ring-necked Duck (*Aythya collaris*)	R	Lowland deciduous forests, shallow marsh, wooded swamps, ponds, streams, inland lakes, and flowages.	X	X	*
Wood Duck (*Aix sponsa*)	C	Shallow marsh, wooded swamps, ponds, streams.	X	X	X
Common Merganser (*Mergus merganser*)	M	Ponds, streams, inland lakes, flowages.	X	X	X
Red Head (*Aythya americana*)	M	Shallow marsh, inland lakes, flowages.	X	X	*

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Hooded Merganser (*Lophodytes cucullatus*)	R	Wooded swamps, ponds, streams.	X	X	*
Turkey Vulture (*Cathartes aura*)	R	Open grassland, sand, gravel.	+	+	
Northern Goshawk *(Accipiter gintilis)*	R	Mesic deciduous, pioneer deciduous.			
Cooper's Hawk (*Accipiter cooperii*)	R	Mesic deciduous, pioneer deciduous.	+	+	NO
Sharp-shinned Hawk (*Accipiter striatus*)	R	Mesic conifer-hardwoods, upland mesic boreal.	+	+	+
Red-tailed Hawk (*Buteo jamaicensis*)	U	Mesic deciduous, pioneer deciduous, annual crops, perennial forage, old fields.	+	+	NO
Red-shouldered Hawk (*Buteo lineatus*)	R	Mesic deciduous.	+	+	NO
Broad-winged Hawk (*Buteo platypterus*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood.	X	X	X
Northern Harrier (*Circus cyaneus*)	R	Northern lowland carr, annual crops, perennial forage, old field, sedge meadow.	X	X	+
Bald Eagle (*Haliaeetus leucocephalus*)	UC	Mesic conifer-hardwoods, woodland swamps, ponds, streams, inland lakes, flowages.	X	X	X
Osprey (*Pandion haliaetus*)	UC	Wooded swamps, ponds, streams, inland lakes, flowages.	X	X	*
Northern Shrike (*Lanius excubitor*)	M or W	Savanna, deciduous shrub, open crop, grassland, residential, farmyard.	X	+	NO
American Kestrel (*Falco sparverius*)	UC	Deciduous forest savanna, reforestation lands, perennial forage, old fields, sand, gravel, farmsteads, commercial.	X	X	*
Ruffed Grouse (*Bonasa umbellus*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood.	X	X	X
Wild Turkey (*Meleagris gallopavo*)	R	Dry deciduous.	+	+	NO
Solitary Sandpiper (*Tringa solitaria*)	M	Wetlands, lakes, streams.			
Black Tern (*Chlidonias niger*)	R	Shallow marsh, ponds, streams, inland lakes, flowages.			

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Spotted Sandpiper (*Actitis macularia*)	UC	Ponds streams, inland lakes, flowages.			
Common Snipe (*Gallinago gallinago*)	UC	Northern lowland carr, annual crops, sedge meadows.			
American Woodcock (*Scolopax minor*)	C	Savanna shrub, wooded swamps.			
Yellow Rail (*Coturnicops noveboracensis*)	R	Shallow Marsh.	+		
Virginia Rail (*Rallus limicola*)	UC	Shallow Marsh.	+	+	+
Killdeer (*Charadrius vociferus*)	UC	Annual crops and perennial forage, old fields, sand, gravel, ponds, streams, inland lakes, flowages.	X	X	*
Sora (*Porzana carolina*)	UC	Shallow marsh.	X	X	X
American Coot (*Fulica americana*)	M	Shallow marsh, wooded swamps, ponds, streams.	X	X	*
Sandhill Crane (*Grus canadensis*)	R	Annual crops, perennial forage, old fields, sedge meadows, shallow marsh.	+	+	+
Rock Dove (*Columba livia*)	UC	Annual crops, ponds, streams, farmyards, commercial.	X	X	*
Mourning Dove (*Zenaida macroura*)	C	Dry sandy northern forest, conifer plantations, annual crops, perennial forage, old field, sand, gravel, ponds, streams, farmyards, residential(trees).	X	X	*
Black-billed Cuckoo (*Coccyzus erythropthalmus*)	UC	Mesic deciduous, pioneer deciduous.	X	X	X
Great Grey Owl (*Strix nebulosa*)	R	Mesic deciduous, mesic conifer-hardwood.	+	+	NO
Great Horned Owl (*Bubo virginianus*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood, conifer plantations, wooded swamps.	+	+	NO
Barred Owl (*Strix varia*)	R	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood, wooded swamps.	+	+	+
Northern Saw-whet Owl (*Aegolius acadicus*)	UC	Mesic conifer-hardwood, upland mesic boreal, conifer swamp.	+	+	

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Whip-poor-will (*Caprimulgus vociferus*)	C	Mesic deciduous.	X	X	*
Common Nighthawk (*Chordeiles minor*)	UC	Shallow marsh, sand, gravel, residential(tree)(shrubs), commercial.	X	X	*
Chimney Swift (*Chaetura pelagica*)	UC	Mesic deciduous, mesic conifer-hardwood, farmsteads, residential (trees) (shrub), commercial.	X	X	*
Ruby-throated Hummingbird (*Archilochus colubris*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood, farmsteads, residential (trees).	X	X	*
Belted Kingfisher (*Ceryle alcyon*)	UC	Shallow marsh, wooded swamps, ponds, streams, inland lakes, flowages.	X	X	*
Northern Flicker (*Colaptes auratus*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, old fields, farmsteads, residential(Trees).	X	X	X
Pileated Woodpecker (*Dryocopus pileatus*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, upland mesic, wooded swamps.	X	X	X
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	R	Mesic deciduous, pioneer deciduous, farmsteads, residential(Trees).	X	X	*
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods.	X	X	X
Hairy Woodpecker (*Picoides villosus*)	C	Northern forest, northern lowland carr, wooded swamps, farmsteads, residential(Trees).	X	X	X
Downy Woodpecker (*Picoides pubescens*)	UC	Northern forest, northern lowland carr, wooded swamps, farmsteads, residential(Trees).	X	X	*
Black-backed Woodpecker (*Picoides arcticus*)	R	Upload mesic boreal, conifer swamp.	X	+	NO
Eastern Kingbird (*Tyrannus tyrannus*)	C	Dry and sandy northern forest, savanna shrub, old fields, shallow marsh, wooded swamp, ponds, streams, inland lakes, flowages.	X	X	X

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Great Crested Flycatcher (*Myiarchus crinitus*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods.	X	X	X
Eastern Phoebe (*Sayornis phoebe*)	UC	Mesic deciduous, pioneer deciduous, northern lowland carr, wooded swamps, ponds, streams, farmsteads, residential(Trees).	X	X	X
Alder Flycatcher (*Empidonax alnorum*)	C/UC	Northern lowland carr, shallow swamps.	X	X	*
Willow Flycatcher (*Empidonax traillii*)	R	Shallow swamps.	X	X	*
Least Flycatcher (*Empidonax minimus*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods.	X	X	X
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	R	Mesic deciduous, mesic conifer-hardwoods, upland mesic, boreal.	X	X	*
Eastern Wood-Pewee (*Contopus virens*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, farmstead, residential (Trees).	X	X	X
Olive-sided Flycatcher (*Contopus borealis*)	R	Conifer swamps, reforestation lands.	X	X	*
Barn Swallow (*Hirundo rustica*)	UC	Northern lowland carr, perennial forage, old fields, sedge meadow, waterscapes, farmsteads.	X	X	*
Cliff Swallow (*Hirundo pyrrhonota*)	R	Perennial forage, old field, sedge meadows, waterscapes, farmstead.	X	X	NO
Tree Swallow (*Tachycineta icolor*)	C	Deciduous forested savanna, northern lowland carr, waterscapes, farmsteads, residential(Trees).	X	X	X?
Bank Swallow (*Riparia riparia*)	R	Shallow marsh, ponds, streams, inland lakes, flowages.	X	X	*
N. Rough-winged Swallow (*Stelgidopteryx serripennis*)	R	Shallow marsh, ponds, streams, inland lakes, flowages.	X	X	*
Purple Martin (*Progne subis*)	R	Shallow marsh, ponds, streams, inland lakes, flowages, Farmsteads, Residential(Trees)(Shrubs).	X	X	NO
Blue Jay (*Cyanocitta cristata*)	C	Northern forest, northern lowland carr, farmsteads, residential(Trees).	X	X	X

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in:		
			Region[3]	SA[4]	PA[5]
Gray Jay (*Perisoreus canadensis*)	UC	Upland mesic boreal, conifer swamp.	X	X	*
Common Raven (*Corvus corax*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, upland mesic boreal.	X	X	X
American Crow (*Corvus brachyrhychos*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer plantation, annual crops, perennial forage.	X	X	X
Black-capped Chickadee (*Parus atricapillus*)	VC	Northern forest, savanna shrub, settled areas.	X	X	X
Boreal Chickadee (*Parus hudsonicus*)	R	Upland mesic boreal, conifer swamp.	X	X	*
Red-breasted Nuthatch (*Sitta canadensis*)	C	Mesic conifer-hardwood, upland mesic boreal, conifer swamp, conifer plantation, residential.	X	X	X
White-breasted Nuthatch (*Sitta carolinensis*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, farmsteads, residential.	X	X	X
Brown Creeper (*Certhia americana*)	C	Mesic conifer-hardwood, upland mesic boreal.	X	X	X
House Wren (*Troglodytes aedon*)	UC	Pioneer deciduous, deciduous forest savanna, settled areas.	X	X	*
Winter Wren (*Troglodytes troglodytes*)	C	Upland mesic boreal, conifer swamp, ponds, streams.	X	X	X
Gray Catbird (*Dumetella carolinensis*)	UC	Pioneer deciduous, northern upland carr, settled areas.	X	X	X
Brown Thrasher (*Toxostoma rufum*)	R	Pioneer deciduous, deciduous forest savanna, reforestation lands, farmsteads.	X	X	*
American Robin (*Turdus migratorius*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer plantations, savanna shrub, annual crops, perennial forage, ponds, streams, settled areas.	X	X	X
Wood Thrush (*Hylocichla mustelina*)	U	Mesic deciduous, residential.	X	X	*
Hermit Thrush (*Catharus guttatus*)	VC	Mesic conifer-hardwood, upland mesic boreal, conifer swamp.	X	X	X

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Veery (*Catharus fuscescens*)	VC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer swamp, northern lowland carr, wooded swamp.	X	X	X
Eastern Bluebird (*Sialia sialis*)	U	Deciduous forested savanna, reforestation lands, farmsteads.	X	X	
Golden-crowned Kinglet (*Regulus satrapa*)	U	Upland mesic boreal, conifer plantation.	X	X	X
Cedar Waxwing (*Bombycilla cedrorum*)	U	Mesic conifer-hardwood, conifer swamp, savanna shrub, ponds, streams, farmsteads, residential.	X	X	X
European Starling (*Sturnus vulgaris*)	C	Mesic deciduous, pioneer deciduous, deciduous forest savanna, reforestation lands, annual crops, perennial forage, ponds, streams, settled areas.	X	X	*
Solitary Vireo (*Vireo solitarius*)	R	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer plantation.	X	X	*
Yellow-throated Vireo (*Vireo flavifrons*)	R	Mesic deciduous, pioneer deciduous, desiduous forest savanna.	X	X	*
Red-eyed Vireo (*Vireo olivaceus*)	UC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, desiduous forest savanna.	X	X	X
Black-and-white Warbler (*Mniotilta varia*)	U	Mesic desiduous, mesic conifer-hardwood, upland mesic boreal, conifer swamp.	X	X	X
Golden-winged Warbler (*Vermivora chrysoptera*)	U	Pioneer desiduous, northern lowland carr.	X	X	X
Nashville Warbler (*Vermivora ruficapilla*)	UC	Upland mesic boreal, conifer swamp, conifer plantation.	X	X	X
Northern Parula (*Parula americana*)	U	Upland mesic boreal, conifer swamp.	X	X	*
Magnolia Warbler (*Dendroica magnolia*)	R	Upland mesic boreal, conifer swamp.	X	X	*
Yellow-rumped Warbler (*Dendroica coronata*)	C	Upland mesic boreal, conifer swamp, conifer plantation.	X	X	X
Black-throated Green Warbler (*Dendroica virens*)	VC	Mesic deciduous, mesic conifer-hardwood, upland mesic boreal.	X	X	X
Black-throated Blue Warbler (*Dendroica caerulescens*)	R	Upland mesic boreal, conifer swamp.	X	X	*

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Blackburnian Warbler (*Dendroica fusca*)	W/R	Mesic conifer-hardwood, upland mesic boreal.	X	X	X
Chestnut-sided Warbler (*Dendroica pensylvanica*)	VC	Pioneer desiduous, northern lowland carr, reforestation lands.	X	X	X
Pine Warbler (*Dendroica pinus*)	R	Upland mesic boreal, conifer plantation.	X	X	*
Yellow Warbler (*Dendroica petechia*)	R	Northern lowland carr, shallow marsh, farmstead, residential.	X	X	*
Ovenbird (*Seiurus aurocapillus*)	VC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods.	X	X	X
Northern Waterthrush (*Seiurus noveboracensis*)	R	Conifer swamp, northern lowland carr, wooded swamp.	X	X	*
Common Yellowthroat (*Geothlypis trichas*)	VC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer swamp, northern lowland carr, reforestation lands, shallow marsh, wooded swamp, ponds, stream.	X	X	X
Connecticut Warbler (*Oporornis agilis*)	R	Conifer swamp, reforestation lands.	X	X	*
Mourning Warbler (*Oporornis philadelphia*)	C	Pioneer desiduous, mesic conifer-hardwood, northern lowland carr, reforestation lands.	X	X	X
Canada Warbler (*Wilsonia canadensis*)	R/U	Mesic conifer-hardwood, upland mesic boreal, conifer swamp.	X	X	*
American Redstart (*Setophaga ruticilla*)	U	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, northern lowland carr, reforestation lands, wooded swamps, ponds, streams, inland lakes, flowages.	X	X	X
Bobolink (*Dolichonyx oryzivorus*)	R	Northern lowland carr, perennial forage, old fields, sedge meadow.	X	X	X
Eastern Meadowlark (*Sturnella magna*)	U	Annual crops, perennial forage, old fields.	X	X	X
Red-winged Blackbird (*Agelaius phoeniceus*)	VC	Savanna shrub, open grassland, waterscapes, farmsteads.	X	X	X
Brewer's Blackbird (*Euphagus cyanocephalus*)	R	Northern lowland carr, open grasslands.	X	X	*
Common Grackle (*Quiscalus quiscula*)	C	Conifer plantation, savanna shrub, annual crops, perennial forage, waterscapes, farmstead, residential.	X	X	X

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Brown-headed Cowbird (*Molothrus ater*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, conifer plantation, savanna shrub, annual crops, perennial forage, old field, farmstead, residential.	X	X	*
Northern Oriole (*Icterus galbula*)	U	Mesic deciduous, pioneer deciduous, desiduous forest savanna, ponds, streams, inland lakes, flowages, farmsteads, residential.	X	X	*, X?
Scarlet Tanager (*Piranga olivacea*)	U	Mesic deciduous, pioneer deciduous.	X	X	X
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	VC	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods.	X	X	X
Evening Grosbeak (*Coccothraustes vespertinus*)	U	Northern desiduous forest, northern coniferous forest, desiduous shrub, residential, farmstead.	X	X	X
Indigo Bunting (*Passerina cyanea*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwoods, desiduous forested savanna, reforestation.	X	X	X
Purple Finch (*Carpodacus purpureus*)	U	Mesic conifer-hardwood, upland mesic boreal, conifer swamp.	X	X	*, X?
House Finch (*Carpodacus mexicanus*)	R	Residential.	+	+	
Red Crossbill (*Loxia curvirostra*)	R	Conifer plantation.	X	X	X
Pine Grosbeak (*Pinicola enucleator*)	M or W	Northern deciduous forest, northern conifer forest, residential.	+	+	NO
Pine Siskin (*Carduelis pinus*)	M or W	Upland mesic boreal.	X	X	*
American Goldfinch (*Carduelis tristis*)	C	Savanna shrub, old fields, farmsteads, residential.	X	X	X
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	R	Pioneer desiduous, reforestation lands.	X	X	*
Savannah Sparrow (*Passerculus sandwichensis*)	C	Open grassland.	X	X	*
Vesper Sparrow (*Pooecetes gramineus*)	R	Annual crops, perennial forage, old fields.	X	X	*
Chipping Sparrow (*Spizella passerina*)	C	Mesic deciduous, pioneer deciduous, mesic conifer-hardwood, conifer plantation, deciduous forest savanna, reforestation lands, old fields, settled areas.	X	X	X

Table 3.9-18 *(Continued)*

Species	Status[1]	Habitat[2]	Observed in: Region[3]	SA[4]	PA[5]
Clay-colored Sparrow (*Spizella pallida*)	R	Conifer plantations, reforestation lands, old fields, residential.	X	X	NO
White-throated Sparrow (*Zonotrichia albicollis*)	VC	Conifer plantations, reforestation lands, old fields	X	X	X
Swamp Sparrow (*Meloospiza georgiana*)	C	Northern lowland carr, sedge meadow, shallow marsh, wooded swamps.	X	X	X
Song Sparrow (*Melospiza melodia*)	VC	Savanna shrub, old field, waterscapes, settled areas.	X	X	X
House Sparrow (*Passer domesticus*)	R	Annual crops, perennial forage, settled areas.	X	X	*

[1] Status: Qualitative assessment of population in the study area based on observations in 1994 and experience of the authors.
VC = abundant in appropriate habitat
C = present in appropriate habitat
U = present but in low numbers or scattered populations
R = in very low numbers
A = absent
M = migrant
W = wintering
NO = not observed

[2] Habitat information obtained from Robbins, 1991.
[3] Region = Northeastern Wisconsin
[4] SA = Study Area
[5] PA = Project Area

\+ = 1994 survey only
X = Previous surveys and 1994 survey
* = Previous surveys only

Prepared by: AWZ
Checked by: RFS

Table 3.9-19

1994 Bird Habitat Relationships

Species Name	Location		Habitat[1]						
	SA%[2]	PA%[3]	Northern Hardwood	Conifer & Shrub	N. Hardwood & Conifer	N. Hardwood & Deciduous Wetlands	N. Hardwood & Mixed	N. Hardwood & Wetlands	N. Hardwood & Conifer/Shrub
	n=111	n=11	n=28	n=6	n=15	n=6	n=27	n=17	n=12
Alder Flycatcher	4.50	9.09	0.00	0.00	6.67	0.00	3.70	0.00	25.00
American Crow	22.52	0.00	25.00	50.00	26.67	16.67	18.52	29.41	0.00
American Goldfinch	16.22	9.09	10.71	16.67	6.67	16.67	22.22	17.65	25.00
American Robin	40.54	18.18	46.43	83.33	33.33	33.33	29.63	35.29	50.00
American Woodcock	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
Bald Eagle	1.80	0.00	0.00	0.00	0.00	0.00	7.41	0.00	0.00
Northern Oriole (Baltimore)	5.41	0.00	3.57	0.00	0.00	16.67	0.00	17.65	8.33
Barred Owl	1.80	0.00	0.00	0.00	0.00	0.00	3.70	5.88	0.00
Black-and-white Warbler	14.41	0.00	3.57	33.33	13.33	16.67	14.81	17.65	25.00
Black-capped Chickadee	35.14	36.36	42.86	66.67	33.33	16.67	33.33	35.29	16.67
Belted Kingfisher	2.70	0.00	0.00	0.00	0.00	0.00	3.70	5.88	8.33
Blackburnian Warbler	3.60	0.00	0.00	16.67	13.33	0.00	0.00	0.00	8.33
Blue Jay	37.84	18.18	35.71	50.00	46.67	0.00	37.04	29.41	58.33
Brown-headed Cowbird	3.60	0.00	0.00	0.00	0.00	0.00	11.11	0.00	8.33
Brown Creeper	6.31	9.09	0.00	0.00	0.00	0.00	14.81	17.65	0.00
Black-throated Blue Warbler	2.70	0.00	3.57	0.00	0.00	0.00	3.70	0.00	8.33
Black-throated Green Warbler	25.23	54.55	35.71	0.00	33.33	50.00	18.52	23.53	8.33
Broad-winged Hawk	4.50	0.00	3.57	0.00	0.00	0.00	3.70	11.76	8.33
Canada Warbler	1.80	0.00	0.00	16.67	6.67	0.00	0.00	0.00	0.00
Clay-colored Sparrow	0.90	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00
Cedar Waxwing	7.21	0.00	7.14	0.00	0.00	16.67	7.41	5.88	16.67
Chipping Sparrow	5.41	0.00	3.57	16.67	0.00	0.00	7.41	11.76	0.00
Common Grackle	4.50	0.00	0.00	33.33	0.00	0.00	7.41	0.00	8.33
Common Loon	4.50	0.00	0.00	0.00	6.67	0.00	11.11	0.00	8.33
Common Merganser	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
Connecticut Warbler	0.90	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Common Raven	2.70	0.00	0.00	0.00	6.67	0.00	7.41	0.00	0.00
Common Yellowthroat	24.32	0.00	3.57	66.67	13.33	0.00	33.33	29.41	50.00
Chestnut-sided Warbler	35.14	18.18	39.29	16.67	33.33	33.33	33.33	47.06	25.00
Downy Woodpecker	2.70	0.00	7.14	0.00	0.00	0.00	0.00	0.00	8.33
Eastern Kingbird	4.50	0.00	0.00	0.00	0.00	0.00	7.41	11.76	8.33
Eastern Meadowlark	0.90	9.09	0.00	0.00	0.00	0.00	3.70	0.00	0.00
Eastern Phoebe	0.90	9.09	0.00	0.00	0.00	0.00	3.70	0.00	0.00
Eastern Wood-Pewee	13.51	9.09	21.43	0.00	6.67	0.00	3.70	35.29	8.33
European Starling	0.90	9.09	0.00	0.00	0.00	0.00	3.70	0.00	0.00

Table 3.9-19 *(Continued)*

Species Name	Location		Habitat[1]						
	SA%[2]	PA%[3]	Northern Hardwood	Conifer & Shrub	N. Hardwood & Conifer	N. Hardwood & Deciduous Wetlands	N. Hardwood & Mixed	N. Hardwood & Wetlands	N. Hardwood & Conifer/Shrub
Evening Grosbeak	1.80	0.00	0.00	0.00	0.00	0.00	3.70	0.00	8.33
Great-crested Flycatcher	19.82	0.00	10.71	33.33	13.33	0.00	25.93	35.29	16.67
Golden-crowned Kinglet	3.60	0.00	0.00	33.33	0.00	0.00	3.70	0.00	8.33
Gray Jay	1.80	0.00	0.00	16.67	0.00	0.00	3.70	0.00	0.00
Gray Catbird	3.60	0.00	0.00	33.33	0.00	0.00	3.70	5.88	0.00
Great Blue Heron	1.80	0.00	0.00	0.00	0.00	0.00	0.00	11.76	0.00
Golden-winged Warbler	10.81	0.00	3.57	0.00	20.00	50.00	11.11	11.76	0.00
Hairy Woodpecker	4.50	9.09	7.14	0.00	0.00	16.67	0.00	5.88	8.33
Hermit Thrush	22.52	9.09	28.57	16.67	20.00	16.67	22.22	23.53	16.67
House Sparrow	0.90	9.09	0.00	0.00	0.00	0.00	3.70	0.00	0.00
House Wren	1.80	0.00	0.00	0.00	0.00	0.00	3.70	5.88	0.00
Indigo Bunting	13.51	9.09	21.43	0.00	13.33	33.33	7.41	11.76	8.33
Killdeer	1.80	9.09	0.00	0.00	0.00	0.00	7.41	0.00	0.00
Least Flycatcher	26.13	9.09	42.86	0.00	13.33	33.33	14.81	41.18	16.67
Mallard	1.80	0.00	0.00	0.00	0.00	0.00	0.00	5.88	8.33
Mourning Dove	4.50	9.09	3.57	33.33	0.00	0.00	3.70	5.88	0.00
Mourning Warbler	19.82	18.18	25.00	0.00	33.33	16.67	14.81	29.41	0.00
Nashville Warbler	46.85	18.18	21.43	100.00	40.00	50.00	51.00	58.82	58.33
Northern Goshawk	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
Northern Parula	8.11	0.00	0.00	16.67	20.00	0.00	11.11	0.00	16.67
Northern Waterthrush	1.80	0.00	0.00	16.67	0.00	0.00	3.70	0.00	0.00
Olive-sided Flycatcher	0.90	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00
Osprey	1.80	0.00	0.00	0.00	0.00	0.00	3.70	5.88	0.00
Ovenbird	80.18	90.91	96.43	16.67	86.67	83.33	81.48	76.47	66.67
Pied-billed Grebe	1.80	9.09	0.00	0.00	0.00	0.00	3.70	5.88	0.00
Pileated Woodpecker	2.70	0.00	0.00	0.00	6.67	0.00	7.41	0.00	0.00
Purple Finch	7.21	9.09	0.00	0.00	20.00	0.00	0.00	11.76	25.00
Rose-breasted Grosbeak	40.54	54.55	39.29	16.67	53.33	33.33	40.74	35.29	50.00
Red-breasted Nuthatch	6.31	9.09	7.14	16.67	0.00	0.00	7.41	0.00	16.67
Red-eyed Vireo	74.77	81.82	89.29	33.33	86.67	100.00	66.67	76.47	50.00
Rufous-sided Towhee	0.90	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00
Red-tailed Hawk	0.90	0.00	3.57	0.00	0.00	0.00	0.00	0.00	0.00
Ruffed Grouse	14.41	18.18	10.71	16.67	20.00	16.67	14.81	11.76	16.67
Red-winged Blackbird	15.32	0.00	3.57	16.67	0.00	0.00	18.52	29.41	41.67
Scarlet Tanager	12.61	0.00	10.71	16.67	13.33	16.67	11.11	11.76	16.67
Sora	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
Song Sparrow	29.73	9.09	7.14	33.33	13.33	0.00	37.04	52.94	66.67
Solitary Vireo	1.80	0.00	3.57	0.00	0.00	0.00	0.00	0.00	8.33
Swamp Sparrow	14.41	0.00	0.00	33.33	6.67	0.00	11.11	17.65	58.33
Tree Swallow	7.21	9.09	0.00	0.00	0.00	0.00	11.11	23.53	8.33
Turkey Vulture	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00

Table 3.9-19 *(Continued)*

Species Name	Location		Habitat[1]						
	SA%[2]	PA%[3]	Northern Hardwood	Conifer & Shrub	N. Hardwood & Conifer	N. Hardwood & Deciduous Wetlands	N. Hardwood & Mixed	N. Hardwood & Wetlands	N. Hardwood & Conifer/Shrub
Unidentified Duck	0.90	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00
Unidentified Swallow	0.90	9.09	0.00	0.00	0.00	0.00	0.00	0.00	8.33
Unidentified Thrush	0.90	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00
Unidentified Warbler	0.90	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00
Unidentified Woodpecker	6.31	9.09	3.57	0.00	0.00	0.00	18.52	5.88	0.00
Veery	21.62	18.18	25.00	33.33	20.00	50.00	14.81	17.65	16.67
Vesper Sparrow	0.90	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00
White-breasted Nuthatch	5.41	9.09	10.71	0.00	0.00	0.00	3.70	11.76	0.00
Willow Flycatcher	1.80	0.00	0.00	33.33	0.00	0.00	0.00	0.00	0.00
Winter Wren	12.61	0.00	10.71	33.33	6.67	16.67	14.81	5.88	16.67
Wood Duck	2.70	0.00	0.00	16.67	0.00	0.00	0.00	11.76	0.00
Wood Thrush	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.33
White-throated Sparrow	43.24	18.18	21.43	100.00	46.67	33.33	48.15	35.29	66.67
Yellow-bellied Flycatcher	0.90	0.00	0.00	0.00	6.67	0.00	0.00	0.00	0.00
Yellow-bellied Sapsucker	10.81	0.00	14.29	0.00	6.67	33.33	3.70	17.65	8.33
Myrtle Warbler	11.71	0.00	7.14	33.33	6.67	0.00	18.52	11.76	8.33
Yellow-shafted Flicker	2.70	0.00	0.00	0.00	0.00	0.00	11.11	0.00	0.00
Yellow-throated Vireo	5.41	9.09	10.71	0.00	0.00	0.00	3.70	5.88	8.33

1 Values indicate the frequency of birds (F) among the census points within each category, where F = [(Number of points in which a bird species occurred in a particular category/total number of all points sampled in a category)X100]

2 Percent of observations within the study area for a given species, out of the total number of point counts in the study area.

3 Percent of observation within the project area for a given species, out of the total number of point counts in the project area.

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(common in the study area), olive-sided flycatcher (rare but resident along Hemlock Creek), and solitary vireo (nesting along Pickerel Creek north of Rolling Stone Lake and observed at two point counts). Several neotropical migrants (Connecticut warbler, yellow-bellied flycatcher) are discussed separately under individual species accounts.

The abundance and diversity of wetland birds is not high in the study area. The single record of yellow rail probably represents a late migrant. Green-backed heron and American bittern were not regularly encountered, although one or two individuals were seen during this investigation. Sora and Virginia rails were found in the larger wetlands, but these are not particularly rare species (Robbins, 1991). Uncommon species of northern Wisconsin's muskeg and bogs (Lincoln's sparrow, LeConte's sparrow, palm warbler) were not observed during this investigation or during previous studies. Waterfowl production is low in the lakes and ponds of the study area, an observation that is consistent with conclusions of previous workers (Dames & Moore, 1981; Normandeau and Associates, 1982). Perhaps the most significant wetland birds are those of riparian habitats at the margins of Swamp and Hemlock Creeks. Hooded merganser, black-backed woodpecker, olive-sided flycatcher, magnolia warbler, and purple finch were observed in this habitat, although all are considered to be uncommon or rare.

Finally, the study area is inhabited by a fairly diverse assemblage of boreal forest birds which are near the southern limits of their geographic ranges. Gray jay and boreal chickadee, both considered to be uncommon and locally distributed in northern Wisconsin, appear to be well established in the study area. Other northern species include black-backed woodpecker, olive-sided flycatcher, yellow-bellied flycatcher, golden-crowned kinglet, and evening grosbeak.

3.9.4.3 Butterflies

Although certainly not the most diverse group of insects, butterflies are well known and represent convenient ecological indicators for other, less familiar terrestrial invertebrates. Historic distributions of Wisconsin's butterflies are reviewed by Ebner (1970). More recent information is incorporated into an annotated checklist by Ferge (1990), who identifies 154 species or recognized subspecies that have been documented in Wisconsin. At least 17 of these are strays or transients that are not known to breed within the state.

Prior to the start of this study, the WDNR's Bureau of Endangered Resources identified 11 butterfly species of "Special Concern" which may occur at or near the proposed mine site (Table 3.9-11). Three species pepper and salt skipper (*Amblyscirtes hegon*), purple lesser fritillary (*Boloria titania*), and greenish blue (*Plebejus saepiolus*) were added as a result of a May 10, 1994 memo from Charles Pils, Director of the WDNR Bureau of Endangered Resources. Given the presence of its host plant (*Cirsium muticum*), the state threatened swamp metalmark (*Calephelis mutica*) also could be present at the proposed mine site, although populations have never been documented in northern Wisconsin. Although not part of this study's original list of "target species", the mustard white (*Pieris napi*) was collected during the 1994 survey and has subsequently been added to the Wisconsin Natural Heritage Inventory list as a species of special concern.

Between the 1994 and 1995 surveys, a total of 50 species of butterflies were recorded within the study area (Table 3.9-20), and at least two others, monarch (*Danaus plexippus*) and mourning cloak (*Nymphalis antiopa*) were observed but were not collected. One additional species, the dusky wing (*Erynnis brizo*), might be added pending taxonomic verification of specimens. Nevertheless, four of the original 14 target species were documented, all with well-established populations within the study area. Perhaps most significantly, an unexpected population of the state endangered northern blue butterfly (*Lycaeides idas nabakovi*) was

Table 3.9-20

Butterflies Species Documented in the Study Area

Species	Habitat	Observed in: Region[1]	SA[2]	PA[3]
Milbert's Tortoise Shell (*Aglais milberti*)	Open forest	X	X	NO
Pepper and Salt Skipper (*Amblyscirtes hegon*)	Forest	X	X	NO
Banded Purple (*Basilarchia arthemis rubrofasciata*)	Forest	X	X	X
Arctic Skipper (*Carterocephalus palaemon*)	Moist woods	X	X	NO
Spring Azure (*Celastrini ladon*)	Forest	X	X	NO
Common Wood Nymph (*Cercyonis pegala*)	Open areas	X	X	NO
Silvery Checkerspot (*Charidryas nycteis*)	Damp openings	X	X	NO
Meadow Fritillary (*Clossiana bellona*)	Open areas	X	X	NO
Silver-bordered Fritillary (*Clossiana selene*)	Wetlands	X	X	NO
Inornate Ringlet (*Coenonympha inornata*)	Grassy openings	X	X	NO
Alfalfa Butterfly (*Colias eurytheme*)	Open areas	X	X	NO
Clouded Sulpher (*Colias philodice*)	Open areas	X	X	NO
Monarch *(Danaus plexippus)*	Open areas	X	X	NO
Northern Pearly Eye (*Enodia anthedon*)	Forest	X	X	X
Dorcas Copper (*Epidemia dorcas*)	Bog lake edge	X	X	NO
Bog Copper (*Epidemia epixanthe*)	Bog lake edge	X	X	X
Sleepy Dusky Wing (*Erynnis brizo*)	Open woods	X	X	NO
Dreamy Dusky Wing (*Erynnis icelus*)	Open woods	X	X	NO
Dusky Wing (*Erynnis icelus or brizo*)	Open woods	X	X	NO
Dun Skipper (*Euphyes vestris metacomet*)	Moist openings	X	X	NO
Harvester (*Feniseca tarquinius*)	Stream banks	X	X	NO
Brown Elfin (*Incisalia augustinus*)	Barrens; bogs	X	X	X
Northern Blue Butterfly (*Lycaeides idas nabokovi*)	Dry openings	X	X	NO
Little Wood Satyr (*Megisto cymela*)	Forest	X	X	NO
Mourning Cloak *(Nymphalis antiopa)*	Forest	X	X	NO
Compton Tortoise Shell (*Nymphalis j-album*)	Forest	X	X	NO
Tiger Swallowtail (*Papilio glaucus*)	Forest openings	X	X	NO
Tawny Crescent (*Phyciodes batesii*)	Damp openings	X	X	NO
Pearl Crescent (*Phyciodes tharos*)	Open areas	X	X	NO

Table 3.9-20 *(Continued)*

Species	Habitat	Observed in: Region[1]	SA[2]	PA[3]
Mustard White (*Pieris napi*)	Forest	X	X	X
Cabbage Butterfly (*Pieris rapae*)	Open areas	X	X	NO
West Virginia White (*Pieris virginiensis*)	Damp forest	X	X	X
Greenish Blue (*Plebejus saepiolus*)	Open areas	X	X	NO
Hobomok Skipper (*Poanes hobomok*)	Forest	X	X	NO
Long Dash (*Polites mystic*)	Moist openings	X	X	NO
Tawny-edged Skipper (*Polites themistocles*)	Open areas	X	X	NO
Gray Comma (*Polygonia progne*)	Forest	X	X	NO
Appalachian Eyed Brown (*Satyrodes appalachia*)	Wet forest	X	X	NO
Eyed Brown (*Satyrodes eurydice*)	Sedge meadow	X	X	NO
Atlantis Fritillary (*Speyeria atlantis*)	Forest openings	X	X	NO
Great Spangled Fritillary (*Speyeria cybele*)	Moist openings	X	X	NO
Gray Hairstreak (*Strymon melinus*)	Open areas	X	X	NO
European Skipper (*Thymelicus lineola*)	Weedy openings	X	X	X
Red Admiral (*Vanessa atalanta*)	Forest openings	X	X	NO
American Painted Lady (*Vanessa virginiensis*)	Open areas	X	X	X
Bog Fritillary (*Boloria eunomia*)	Bog	X	X	NO
Freija Fritillary (*Boloria freija*)	Bog	?	NO	NO
Frigga Fritillary (*Boloria frigga*)	Fens	X	X	NO
Purple Lesser Fritillary (*Boloria titania*)	Bog	X	X	NO
Red-disked Alpine (*Erebia discoidalis*)	Bog	?	NO	NO
Common Branded Skipper (*Hesperia comma*)	Open areas/barrens	X	X	NO
Leonard's Skipper (*Hesperia leonardus leonardus*)	Open areas	X	NO	NO
Jutta Arctic (*Oeneis jutta*)	Bog	X	X	NO
Viceroy (*Limenitis archippus*)	Shrub/carr	?	?	?
Chryxus Arctic (*Oeneis chryxus*)	Meadows	X	NO	NO
Hoary Elfin (*Incisalia polia*)	Barren	X	NO	NO

1 Species listed for Wisconsin in "Checklist of Wisconsin Butterflies". Ferge, Leslie A. 1990.
2 SA = Study Area
3 PA = Project Area

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Checked by: RFS/BDH

discovered along the Langlade-Forest County line (2.5 miles from the plant site) in association with its recently documented host plant, the state endangered dwarf bilberry (*Vaccinium caespitosum*).

In approximately 10 years of survey work west of the project area and east of Mole Lake, Tom Rocheleau (1994) with the University of Wisconsin-Madison, Department of Entomology, has recorded approximately 450 species of moths and butterflies (i.e., approximately 10 percent butterflies and 90 percent moths). A copy of Rocheleau's list is provided in Appendix 3.9-1. The number of species recorded by the North American Butterfly Association's Fourth of July Butterfly Counts in Wisconsin ranged from 8 to 31 species during 1993 (Opler and Swengel, 1994). These surveys, each covering a maximum 15 square mile radius, are conducted during a single day. During the CMC surveys, more than 20 butterfly species were recorded at the study area during late June and July. Due to the tendency of certain butterflies to fluctuate in abundance from year to year (Opler and Krizek, 1986), the species list reported here (Table 3.9-20) may be incomplete.

Of the 14 original target species, 10 are characteristic of bogs or wetland habitats. Important wetlands for butterflies include the extensive bog/tamarack swamp around Duck Lake, where both dorcas copper (*Epidemia dorcas*) and bog copper (*E. epixanthe*) were found. Meadows along Pickerel Creek also are rich in butterflies, including dorcas copper. A small bog in the northeastern part of the study area (Wetland F16) supports bog copper. Upland habitats in the study area were inhabited by several important butterfly species. In addition to the northern blue butterfly site along County Line Road (see Section 3.9.5.4), the pine plantation and associated openings in Sections 25 and 26, T35N R12E, yielded target butterfly species, including inornate ringlet (*Coenonympha inornata*), greenish blue *(Plebejus saepiolus)*, and pepper and salt skipper (*Amblyscirtes hegon*). Investigations in the woods surrounding Duck and Skunk Lakes led to the collection of the mustard white (*Pieris napi*). A more detailed analysis of butterfly habitats is given in the individual species accounts.

Identifications of difficult specimens were verified by Susan Borkin of the Milwaukee Public Museum and Les Ferge of the USDA Forest Products Laboratory in Madison. All specimens currently are stored at the Richter Museum of Natural History, University of Wisconsin-Green Bay.

3.9.4.4 Herptiles

Surveys were successful in recording 20 herptile species in the project area, of which two were target species. Specimens collected totalled 1,932 individuals representing 16 species. The majority of these (1,889 specimens) were collected in pitfall and minnow traps set for small mammal surveys. Two ubiquitous species (American toad and wood frog) accounted for 80.2 percent of all specimens collected. A breakdown of specimens collected is presented in Table 3.9-21. All specimens have been deposited in the Milwaukee Public Museum herpetology collection.

Records are available from other sources for another 12 herptile species in Forest and adjacent counties, including five target species. The prior study by Dames & Moore (1985) recorded 15 species, none of which were target species. Table 3.9-22 provides a master herptile list for the study area. Table 3.9-23 includes an estimation of species relative abundance. The following terms are applied, based on the professional opinion of the investigator.

Table 3.9-21

Herptile Collection List

Species		
Common Name	Scientific Name	Number Collected
Blue-spotted Salamander	*Ambystoma laterale*	88
Spotted Salamander	*Ambystoma maculatum*	5
Central Newt	*Notophthalmus viridescens louisianensis*	5
Four-toed Salamander	*Hemidactylium scutatum*	4
Redback Salamander	*Plethodon cinereus*	22
American Toad	*Bufo americanus*	633
Spring Peeper	*Pseudacris crucifer*	57
Eastern Gray Treefrog	*Hyla versicolor*	6
Green Frog	*Rana clamitans*	169
Leopard Frog	*Rana pipiens*	1
Mink Frog	*Rana septentrionalis*	5
Wood Frog	*Rana sylvatica*	917
Unidentifiable Anurans		9
Ringneck Snake	*Diadophis punctatus*	2
Fox Snake	*Elaphe vulpina*	1
Common Garter Snake	*Thamnophis sirtalis*	6
Redbelly Snake	*Storeria occipitomaculata*	2

Prepared by: GC
Checked by: RFS

Table 3.9-22

Master Herptile Species List

Vernacular	Scientific Name	Source		
Salamanders		1	2	3
Blue-spotted Salamander	*Ambystoma laterale*	X	X	X
Spotted Salamander	*Ambystoma maculatum*	X	X	X
Central Newt	*Notophthalmus viridescens louisianensis*	X	X	
Four-toed Salamander[TS]	*Hemidactylium scutatum*	X	X	
Redback Salamander	*Plethodon cinereus*	X	X	X
Mudpuppy	*Necturus maculosus*		X	
Frogs and Toads				
American Toad	*Bufo americanus*	X	X	X
Chorus Frog	*Pseudacris triseriata*	X	X	X
Spring Peeper	*Pseudacris crucifer*	X	X	X
Eastern Gray Treefrog	*Hyla versicolor*	X	X	X
Cope's Gray Treefrog	*Hyla chrysoscelis*		X	
Green Frog	*Rana clamitans*	X	X	X
Bullfrog[TS]	*Rana catesbeiana*		X	
Leopard Frog	*Rana pipiens*	X	X	X
Pickerel Frog[TS]	*Rana palustris*		X	
Mink Frog	*Rana septentrionalis*	X	X	X
Wood Frog	*Rana sylvatica*	X	X	X
Turtles				
Snapping Turtle	*Chelydra serpentina*	X	X	X
Painted Turtle	*Chrysemys picta*	X	X	X
Wood Turtle[TS]	*Clemmys insculpta*		X	
Blanding's Turtle[TS]	*Emydoidea blandingii*		X	
Spiny Softshell Turtle	*Apalone spinifera*		X	
Lizards				
Five-lined Skink	*Eumeces fasciatus*		X	
Snakes				
Northern Ringneck Snake[TS]	*Diadophis punctatus edwardsii*	X	X	
Eastern Hognose Snake	*Heterodon platyrhinos*		X	
Smooth Green Snake	*Opheodrys vernalis*	X	X	
Fox Snake	*Elaphe vulpina*	X	X	X
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	X	X
Northern Ribbon Snake[TS]	*Thamnophis sauritus septentrionalis*		X	
Brown Snake	*Storeria dekayi*		X	
Redbelly Snake	*Storeria occipitomaculata*	X	X	
Water Snake	*Nerodia sipedon*		X	

Source: 1 - recorded this study, in study area.
2 - other records for Forest or adjacent counties (see species accounts).
3 - recorded by Dames & Moore, 1985.
[TS] - target species.

Prepared by: GC
Checked by: RFS

Table 3.9-23

Estimated Herptile Abundance

Vernacular	Scientific Name	Relative Abundance[1]				
Salamanders		**VC**	**C**	**U**	**R**	**A**
Blue-spotted Salamander	*Ambystoma laterale*	X				
Spotted Salamander	*Ambystoma maculatum*		X			
Central Newt	*Notophthalmus viridescens louisianensis*		X	X		
Four-toed Salamander[TS]	*Hemidactylium scutatum*			X		
Redback Salamander	*Plethodon cinereus*	X				
Mudpuppy	*Necturus maculosus*			X	X	X
Frogs and Toads						
American Toad	*Bufo americanus*	X				
Chorus Frog	*Pseudacris triseriata*				X	
Spring Peeper	*Pseudacris crucifer*	X				
Eastern Gray Treefrog	*Hyla versicolor*	X				
Cope's Gray Treefrog	*Hyla chrysoscelis*					X
Green Frog	*Rana clamitans*	X				
Bullfrog[TS]	*Rana catesbeiana*			X	X	X
Leopard Frog	*Rana pipiens*			X		
Pickerel Frog[TS]	*Rana palustris*			X	X	X
Mink Frog	*Rana septentrionalis*			X		
Wood Frog	*Rana sylvatica*	X				
Turtles						
Snapping Turtle	*Chelydra serpentina*	X				
Painted Turtle	*Chrysemys picta*	X				
Wood Turtle[TS]	*Clemmys insculpta*			X	X	X
Blanding's Turtle[TS]	*Emydoidea blandingii*			X	X	X
Spiny Softshell Turtle	*Apalone spinifera*			X	X	X
Lizards						
Five-lined Skink	*Eumeces fasciatus*			X	X	X
Snakes						
Northern Ringneck Snake[TS]	*Diadophis punctatus edwardsii*		X	X		
Eastern Hognose Snake	*Heterodon platirhinos*			X	X	X
Smooth Green Snake	*Opheodrys vernalis*		X			
Fox Snake	*Elaphe vulpina*		X	X		
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X				
Northern Ribbon Snake[TS]	*Thamnophis sauritus septentrionalis*				X	X
Brown Snake	*Storeria dekayi*			X	X	X
Redbelly Snake	*Storeria occipitomaculata*	X				
Water Snake	*Nerodia sipedon*			X	X	X

[1] Relative Abundance: two or more categories marked means species abundance is thought to be within the indicated range.
VC - abundant in appropriate habitat.
C - present in appropriate habitat.
U - present but in low numbers and/or scattered small populations.
R - in very low numbers and/or transitory.
A - absent.
[TS] - target species.

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Checked by: RFS

very common: abundant in appropriate habitat.
common: present in appropriate habitat.
uncommon: present but in low numbers and/or scattered small populations.
rare: in very low numbers and/or transitory.

Quantitative studies on relative abundance were not performed. Brief species accounts are given for each non-target species in the following paragraphs. Target species are discussed in more detail in Section 3.9.5.5.

3.9.4.4.1 Salamanders

Blue-spotted salamander (*Ambystoma laterale*)

Very common in mixed or deciduous forest with appropriate wetlands (usually ephemeral) for breeding. Found throughout the study area in such habitat. This species was the most abundant salamander in the study area in visual encounter surveys, dipnet surveys, road cruising, and pitfall trapping.

Spotted salamander (*Ambystoma maculatum*)

Common in mixed or deciduous forest with appropriate wetlands (usually ephemeral) for breeding. Found throughout the study area in such habitat. This species was found within the study area in visual encounter surveys, egg surveys and pitfall trapping. Breeding was noted in many wetlands. Dames & Moore (1979) also surveyed the project area for this species, recording them at nine locations.

Central newt (*Notophthalmus viridescens louisianensis*)

Newts are found in a variety of forested habitats (mixed and deciduous) in Wisconsin, associated with permanent and ephemeral wetlands (Vogt, 1981). Newts have an impressive ability to alternate their physical body form between a gilled aquatic form and an air-breathing terrestrial form. Seven newts were found in the study area by dipnetting (W.M. West; Skunk L.), minnow trap (D. Goltz, wetland F7) and pitfall traps (Erdman & Howe, wetlands F12 & Z1). This indicates that the terrestrial form is common to uncommon in upland hardwoods and mixed forest in the project area, and the aquatic form is uncommon in permanent lakes. Additional records for the study area exist from Forest, Langlade, Marinette, Menominee, and Oconto Counties (Casper, 1995; Vogt, 1981). This species was not detected in the project area by Dames & Moore (1985).

Redback salamander (*Plethodon cinereus*)

This terrestrial, lungless salamander is associated with northern mesic and boreal forests in Wisconsin (Vogt, 1981). In favorable habitat in New Hampshire, the biomass of salamanders has been calculated at twice that of birds, with redback salamanders accounting for 94 percent of all salamanders (Burton & Likens, 1975). In the study area it is considered very common in mixed and deciduous forest. It was the second most abundant salamander in the project area in visual encounter surveys and pitfall trapping.

Mudpuppy (*Necturus maculosus*)

This aquatic salamander was not found in this study, but is recorded from the study area, with records available from Forest, Oneida, Marinette, and Shawano Counties (Casper, 1995; Vogt, 1981). They may be absent from the study area. If they occur in the study area, they would likely be uncommon to rare in permanent waters with some gravel or cobble bottoms, such as portions of Swamp and Hemlock Creeks, and the east shore of Duck Lake.

3.9.4.4.2 Frogs and Toads

American toad (*Bufo americanus*)

This ubiquitous species was very common throughout the study area in all habitats. Toads were very abundant on visual encounter surveys, audio surveys, dipnet surveys and pitfall trapping.

Chorus frog (*Pseudacris triseriata*)

Chorus frogs are common in habitats of almost all wetland types throughout the southern two thirds of Wisconsin (Casper, 1995; Vogt, 1981). Northeastern Wisconsin represents the northern limit of their range. Chorus frogs were rare in the study area in shallow, open wetlands, typically sedge meadows and shrub-carr. This species was the rarest frog in the study area on calling surveys. They were reported calling within the project area by Dames & Moore (1985) as well. Andrew Zovnic recorded an audio tape of this species on the east end of Mole Lake on May 12, 1994, which represents the first documented record for Forest County (Casper, 1995). Chorus frogs have also been reported from five sites on a Laona (Forest County) frog and toad survey route, and eight sites from two Oneida County frog and toad survey routes (Mossman & Hine, 1985). Chorus frogs were first documented in Langlade County in 1992 (Casper, 1995), and records exist for Oneida County as well (Casper, 1995).

Spring peeper (*Pseudacris crucifer*)

Spring peepers are a common frog throughout Wisconsin in nearly all wetland types (Casper, 1995; Vogt, 1981). Peepers were very common throughout the study area in all wetland habitats. They were very abundant in the study area on calling surveys, and also well represented on dipnet surveys, road cruising and pitfall trapping.

Eastern gray treefrog (*Hyla versicolor*)

Treefrogs (eastern gray and Cope's gray) occur statewide in deciduous forests associated with wetlands (Casper, 1995; Mossman & Hine, 1985; Vogt, 1981). Results of the Wisconsin Frog and Toad Survey data (Mossman & Hine, 1984, 1985) indicate that both species occur statewide, with eastern gray more associated with closed canopy forest, and Cope's gray more associated with open, savannah habitats. Surveys found eastern gray to be very common throughout the project area in all forested wetland habitats. This species was well represented in the study area on calling surveys, and road cruises. A few were also obtained in pitfall traps.

Cope's gray treefrog (*Hyla chrysoscelis*)

Cope's gray is apparently absent from the study area. None were recorded on calling surveys. There are records from Marinette and Oconto Counties (Vogt, 1981), and the species was reported from one site on a Laona (Forest County) frog and toad survey route in 1984 (Mossman & Hine, 1985). However, they were absent from three Oneida County frog and toad survey routes (Mossman & Hine, 1985). Appropriate habitat is savannah-like, open canopied regions without continuous forest cover.

Green frog (*Rana clamitans*)

This ubiquitous frog is common throughout Wisconsin in all permanent wetlands (Casper, 1995; Vogt, 1981). It is very common throughout the study area in permanent wetlands. This species was well represented in the study area on calling surveys, visual encounter surveys, dipnet surveys, road cruises and pitfall trapping.

Leopard frog (*Rana pipiens*)

Leopard frogs may be found in or near any permanent wetlands in Wisconsin, most commonly associated with wet prairies and sedge meadows (Vogt, 1981). They were uncommon in the study area in permanent wetlands. Leopard frogs were found in the study area only on calling surveys, but they are well represented in the study area from numerous sources (Casper, 1995; Vogt, 1981). Leopard frogs were also recorded in the project area by Dames & Moore (1985).

Mink frog (*Rana septentrionalis*)

Mink frogs are associated with bogs, and recorded throughout the northern third of Wisconsin (Vogt, 1981). In the study area, surveys indicate they are uncommon in permanent wetlands with a bog component. This species was not detected on dedicated calling surveys, but a few were collected in minnow and pitfall traps. However, mink frogs were commonly heard calling along Hemlock Creek and near hoopnet site 14 (Figure 3.9-15) during the bird censusing activities in June 1994. Mink frogs were also recorded in the study area by Dames & Moore (1985).

Wood frog (*Rana sylvatica*)

Wood frogs are very common throughout all but the southern quarter of Wisconsin, in most forested habitats (Casper, 1995; Vogt, 1981). They were very common throughout the study area in forested habitat, and utilized most shallow and ephemeral wetlands for breeding. Wood frogs were very abundant in the project area in calling surveys, egg surveys, larval surveys, visual encounter surveys, and pitfall trapping. They are probably a major prey item for most mammalian and avian predators in the study area.

3.9.4.4.3 Turtles

Snapping turtle (*Chelydra serpentina*)

This ubiquitous turtle is found statewide in almost all wetlands (Casper, 1995; Vogt, 1981). Snapping turtles were very common throughout the study area in permanent wetlands. This

species was the second most abundant turtle in the study area in trapping surveys and visual encounter surveys. A total of 18 snapping turtles were trapped (Appendix 3.9-5).

Painted turtle (*Chrysemys picta*)

Painted turtles are also found statewide in almost all wetlands (Casper, 1995; Vogt, 1981). They were found to be very common throughout the study area in permanent wetlands. They were the most abundant turtle in the project area in trapping surveys and visual encounter surveys. A total of 66 painted turtles were trapped (Appendix 3.9-5).

Spiny softshell turtle (*Apalone spinifera*)

Spiny softshell turtles are strongly associated with rivers and large lakes in the southern two thirds of Wisconsin, and are most common in such habitats with sandy substrates (Casper, 1995; Vogt, 1981). They are probably uncommon to absent from the study area. None were recorded in this study, however, records exist for southeastern Oneida County (Casper, 1995; Vogt, 1981) near Pelican Lake. The study area is at the northern limit of the range for this species in Wisconsin. It may or may not be present in any sand bottomed permanent waters within the project area.

3.9.4.4.4 Lizards

Five-lined skink (*Eumeces fasciatus*)

This small lizard is found in forests, barrens and savannah in Wisconsin, and is most abundant in the central sand counties (Vogt, 1981). They are probably uncommon to absent in the study area. None were recorded in this study, however they are found within the region. Vogt (1981), gives records from eastern Marinette County and southern Langlade County. The Wisconsin Herptile Atlas (Casper, 1995) has additional records for Marinette, Oconto and Shawano Counties. Appropriate habitat is uplands with sand soils in sparsely forested or disturbed habitat.

3.9.4.4.5 Snakes

Eastern hognose snake (*Heterodon platirhinos*)

This harmless snake is widely distributed in Wisconsin, and strongly associated with sand soils (Casper, 1995; Vogt, 1981). It is probably uncommon to absent from the study area. None were recorded in this study. However, they are found within the study area, with records from Florence, Langlade, Marinette, Menominee, Oconto and Shawano Counties (Casper, 1995; Vogt, 1981). They prey heavily on American toads. Sand soils are scarce in the project area. Sandy outwash plains associated with Swamp Creek and Wolf River offer the best potential habitat for hognose snakes.

Smooth green snake (*Opheodrys vernalis*)

This colorful snake is associated with grassy and forest edge habitats in Wisconsin (Casper, 1995; Vogt, 1981). They are common in the study area in open field and disturbed habitats, with numerous records from Forest and surrounding counties (Casper, 1995; Vogt, 1981). This species was the third most abundant snake in the study area in visual encounter surveys, and

undoubtedly occurs within the project area in areas with open fields, such as the railroad corridor, roadsides and agricultural fields. Smooth green snakes were not recorded in the project area by Dames & Moore (1985).

Fox snake (*Elaphe vulpina*)

This large constrictor preys heavily on small rodents throughout Wisconsin, with spotty distribution in the southeastern and northcentral portions of the state (Casper, 1995; Vogt, 1981). It is considered uncommon to common in the study area, in mixed forest, agricultural and disturbed habitats. Fox snakes were the least abundant snake in the project area in all surveys, with one specimen found dead on the road, and another possible cast skin found at the plant site. Fox snakes are well documented from Forest and surrounding counties (Casper, 1995; Vogt, 1981). A Fox snake was also discovered in the study area by Dames & Moore (1985).

Eastern garter snake (*Thamnophis sirtalis sirtalis*)

This ubiquitous animal is found in every county in the state, in almost any habitat associated with wetlands of any type (Casper, 1995; Vogt, 1981). Eastern garter snakes were very common in the study area, in and near almost all wetland habitats. This species was the most abundant snake in the study area in all surveys (53 encounters). It was also recorded in the study area by Dames & Moore (1985).

Brown snake (*Storeria dekayi*)

Brown snakes are common in the southern two thirds of Wisconsin (Casper, 1995; Vogt, 1981), in a wide variety of habitats. They are probably uncommon to absent in the study area. None were recorded in this study, however records from Marinette, Oconto, Oneida and Shawano Counties (Casper, 1995; Vogt, 1981) warrant the inclusion of this species. It may eventually be discovered in the study area.

Redbelly snake (*Storeria occipitomaculata*)

This ubiquitous snake is found statewide, in almost any forested habitat (Casper, 1995; Vogt, 1981). They are very common in the project area, in mixed forest and disturbed habitats. This species was the second most abundant snake in the study area in all surveys (32 encounters). It was not recorded by Dames & Moore (1985).

Northern water snake (*Nerodia sipedon sipedon*)

Water snakes are found statewide, in a wide variety of permanent waters (Casper, 1995; Vogt, 1981). They are probably uncommon to absent from the study area. None were recorded in this study, however they are expected to occur in the study area, most likely along Swamp Creek or Hemlock Creek. There are numerous records for Forest and most surrounding counties (Casper, 1995; Vogt, 1981).

3.9.5 Rare, Endangered, or Threatened Species

Biological field survey work conducted in 1994 and 1995 focused on the rare, endangered and threatened species of plants and animals potentially occurring in the northeast region of

Wisconsin. An area covering approximately 25 square miles surrounding the proposed Crandon Project site was surveyed intensively for a period of greater than one year by a team of up to 18 biologists. This survey is perhaps one of the most comprehensive biological surveys focusing on endangered and threatened species in Wisconsin. As a result of this intense scrutiny, a total of five endangered, five threatened, and 61 special concern species of terrestrial plants and animals were observed in the study area.

General location information, habitat descriptions, ecological relationships, and study area population estimates are provided for each of these species in the following paragraphs. Specific location information is not included in this document, but has been submitted to the WDNR Bureau of Endangered Resources (Steg, 1995).

3.9.5.1 Plants

During the course of the 1994 and 1995 field surveys, 23 species of vascular plants of the Wisconsin Natural Heritage Working Lists were found. They included four endangered, two threatened, and 17 special concern species as listed in Table 3.9-24. Of these, only goblin fern, lance-leaved grape fern, little grape fern, assiniboine sedge, variegated scouring rush, and ginseng were observed in the project area. The remaining species were observed in the area and/or surrounding area.

Three of the 17 special concern species (dragon's mouth (Arethusa bulbosa), marsh willow-herb (Epilobium palustre), and blunt-lobe grape-fern (Botrychium oneidense)) were thought to exist within the study area, but were not verified during the 1994 field effort. However, a follow-up survey of likely habitat types was conducted in 1995, and these species were located. The state special concern species Hooker's orchid (Platanthera hookeri) was thought to be represented by a two senescent plants in 1994. The site was again searched in 1995, but no plants of Hooker's orchid were found. In addition, the special concern showy lady's-slipper (Cypripedium reginae) was reported west of the plant site (T34N R12E Section 3) in 1952. That location corresponds with the conifer swamp along Pickerel Creek between Mole Lake and Rolling Stone Lake. No individuals of showy lady's-slipper were found in this or any other areas during the 1994 and 1995 studies.

Table 3.9-24

Endangered, Threatened and Special Concern Plants Observed in the Study Area

Common Name	Scientific Name	State Status
Goblin fern	*Botrychium mormo*	Endangered
Yellow water crowfoot	*Ranunculus gmelinii*	Endangered
Dwarf bilberry	*Vaccinium caespitosum*	Endangered
Mountain cranberry	*Vaccinium vitis-idaea*	Endangered
Calypso orchid	*Calypso bulbosa*	Threatened
Algal-leaved pondweed	*Potamogeton confervoides*	Threatened
Dragon's mouth	*Arethusa bulbosa*	Special Concern
Lance-leaved grape fern	*Botrychium lanceolatum var angustisegmentum*	Special Concern
Blunt-lobe grape fern	*Botrychium oneidense*	Special Concern
Little grape fern	*Botrychium simplex*	Special Concern
Assiniboine sedge	*Carex assiniboinensis*	Special Concern
Northern bog sedge	*Carex gynocrates*	Special Concern
Sparse-flowered sedge	*Carex tenuiflora*	Special Concern
Sheathed sedge	*Carex vaginata*	Special Concern
Waterwort	*Elatine triandra*	Special Concern
Marsh willow-herb	*Epilobium palustre*	Special Concern
Marsh horsetail	*Equisetum palustre*	Special Concern
Variegated scouring rush	*Equisetum variegatum*	Special Concern
Ginseng	*Panax quinquefolius*	Special Concern
Northern black currant	*Ribes hudsonianum*	Special Concern
Torrey's bulrush	*Scirpus torreyi*	Special Concern
American yew	*Taxus canadensis*	Special Concern
Resupinate bladderwort	*Utricularia resupinata*	Special Concern

Prepared by: RFS
Checked by: AWZ

3.9.5.1.1 Endangered Species

Goblin fern (*Botrychium mormo*)

The goblin fern is a very small and inconspicuous plant and went largely unnoticed until the second half of the twentieth century. The goblin fern was not officially published as a valid species until 1981 (Wagner & Wagner, 1981). Preferred habitat for the goblin fern is rich mesic forest dominated by sugar maple, basswood and sometimes beech (Wagner & Wagner, 1981). Most plants reach maximum size and are most detectable in August and September, although plants at known sites have been observed by early June.

The goblin fern is known only from Wisconsin, Minnesota and Michigan and published accounts of frequency and abundance are limited. Prior to the 1994 survey it was known from five counties in Wisconsin, of which only three sites in two counties were known to be active with a total of 27 individual plants (Trick, 1994). In 1994 and 1995, three additional sites for *B. mormo* in Taylor County were reported by Chequamegon National Forest botanists (Tans, 1996). Other than the Wisconsin populations, *B. mormo* was known from seven counties (Beltrami, St. Louis, Itaska, Cass, Polk, Clearwater, and Mahnomem Counties) in Minnesota, with 53 separate "colonies" or populations according to John Casson of the Chippewa National Forest (Tans, 1996), and from eight sites in seven counties in Michigan of which the current status was largely unknown (Tans, 1994).

Dames & Moore and the WDNR spent a number of field days in the 1980s in the study area surrounding the proposed Crandon Project site. Although these prior surveys were not focused specifically on the goblin fern, none were observed in the study area. The goblin fern is a very small and inconspicuous plant, often barely protruding above the leaf litter. As described by Tans (1994) in Appendix 3.9-1, this species' small size, late emergence and recent description may all contribute to the lack of observation records. Tans (1994) further states: "In my opinion, it is likely that goblin fern is often overlooked and may be undercollected. Certainly this was true in the project site prior to 1994. Only a handful of botanists in Wisconsin have ever seen and searched for goblin fern."

CMC conducted searches for the goblin fern in 1994 and 1995. A complete summary of these surveys is presented in Appendix 3.9-7. Based on the results of CMC's surveys in 1994 and 1995, the goblin fern is more widespread than previously thought. In 1994, the surveys on and near the Crandon site discovered 16 new populations of goblin fern in eight sections and in two counties, Forest and Langlade. A total of 116 individual plants were noted. In 1995, approximately 160 sites with high potential for goblin fern in six counties in Wisconsin and two counties in the upper peninsula of Michigan were identified. Ninety-three of those sites were searched and goblin fern was found at 27 new sites, including the first county records for Marinette, Oconto and Florence Counties in Wisconsin and Gogebic County in Michigan. A total of 480 plants were noted at the new sites. All told, between 1994 and 1995, the CMC surveys resulted in the observation of 596 individual plants.

Small yellow water crowfoot (*Ranunculus gmelinii*)

One small population of small yellow water crowfoot was found near the mouth of a small, cold stream at the north end of Rolling Stone Lake. This stream flowed through a partly open, wet woods containing speckled alder and few a tamarack and white cedar, with Canada blue-joint, sedge red osier dogwood and willow species.

Small yellow water crowfoot grew in several small subpopulations near the edges of the stream in very shallow water over a mucky bottom. Extensive surveys of this stream and of other similarly cold, spring fed streams did not discover any additional plants. Because this species is clearly northern in distribution, it is likely that the remarkably cold water is a significant factor in its presence at this location. Small yellow water crowfoot is inconspicuous and could easily be overlooked, even in flower. This population does not appear to be in any immediate danger, however the habitat could be easily disrupted and the plants could be susceptible to damage from wading or even canoeing in the stream.

Dwarf bilberry (*Vaccinium cespitosum*)

One population of dwarf bilberry was found on the western edge of the study area during this survey. The site is at the north end of a series of "barrens" openings marked by a scattering of red pines *(Pinus resinosa)* and jack pines *(P. banksiana)* and by typical species of dry open sites in this area: bracken fern (*Pteridium aquilinum),* blackberries (*Rubus* sp.), sweet fern (*Comptonia peregrina),* common lowbush-blueberry *(Vaccinium angustifolium),* wild bergamot *(Monarda fistulosa),* hawkweed species (*Hieracium* spp.), early goldenrod *(Solidago juncea),* upland willow *(Salix humilis),* etc.

Dwarf bilberry grows near the northern edge of a clearing which adjoins a regrowth stand of small diameter quaking aspen. The population of this clonal bilberry is scattered over a roughly "L" shaped area with the long axis extending approximately 100 feet along an east/west axis, 25 feet wide, and bending north along the west end for approximately 30 feet. Although the general nature of the series of barrens openings is dry, the particular site occupied by dwarf bilberry is a bit lower and some species of clearly moist soil affinity are growing within 20 feet of this population [e.g., wool grass *(Scirpus cyperinus)*]. No immediate threats to this population were noted, although a small population of this type in a "clearing" could be destroyed inadvertently by heavy equipment used in forestry, etc.

Mountain cranberry (*Vaccinium vitis-idaea)*

One population of mountain cranberry was found in the study area during the 1994 field survey. This species was known in Wisconsin from collections made in Douglas County before 1930, but was believed to be extirpated in Wisconsin prior to this find in 1994. Mountain cranberry is otherwise currently found in the U. S. only in northern Minnesota and in northern New England. A historical nineteenth century collection from Michigan has not been reverified.

The study area population was found in a cold coniferous swamp along Swamp Creek dominated by black spruce (*Picea mariana*) and tamarack with a thoroughly wet *Sphagnum* base. The canopy was generally patchy with small openings. The mountain cranberry population was found within a small canopy opening within which speckled alder (*Alnus rugosa*), mountain holly *(Nemopanthus mucronatus),* and labrador tea *(Ledum groenlandicum)* were prominent. There

were several thousand ramets of mountain cranberry over a roughly triangular area approximately 100 feet on each side. Adjacent similar habitats were searched several times for additional plants without success.

The mountain cranberry plants flowered abundantly and mature fruit were observed in August, but did not reach the full red color until after mid-August. At this time they were highly visible and those that were not eaten by animals remained so until the end of the growing season. Other appropriate habitats were searched again during this ripe fruit stage, without success.

3.9.5.1.2 Threatened Species

Calypso orchid (*Calypso bulbosa*)

Calypso orchid was found at three locations in the study area. The largest population was found in the Swamp Creek Cedars to the northeast of the proposed plant site. A total of 26 individuals were noted there, of which 13 were fertile. Most of the plants were found in the interior of the swamp, although two plants were also found near the extreme western edge. A population of *Calypso* was previously noted for this area in the WDNR database records. Another small population of three *Calypso* plants was found in the conifer swamp along the stream which runs from Little Sand Lake to Rolling Stone Lake. A third population was represented by a single individual found in the swamp along Pickerel Creek.

All three sites were typical of recent reports for *Calypso* in Wisconsin. The canopy was full and was usually comprised of relatively mature white cedar (*Thuja occidentalis*) with a mossy floor. Although these swamps frequently supported dense growths of *Sphagnum* moss, the specific sites occupied by *Calypso* plants were covered by other mosses. *Calypso bulbosa* is notorious in the Great Lakes area for persisting in small populations and for relatively short periods. All three sites identified in this survey contained large, unoccupied areas of what appeared to be good habitat for *Calypso*, and other swamps which seemed to have appropriate habitat were searched without producing any additional plants.

In general the three swamps occupied by *Calypso* were conspicuously cold. The closed cedar canopy provided deep shade and the thick moss floor appeared to insulate the soil and retard its warming until well into the growing season. Ice could be dug out from under moss in the low spots until the last week in June. The swamps in which *Calypso* was found also tended to support populations of the concern species sheathed sedge (*Carex vaginata),* northern bog sedge (*C. gynocrates),* Canadian black currant *(Ribes hudsonianum)* and American yew *(Taxus canadensis).* The biggest threat to *Calypso* on these sites would probably be logging. Opening the canopy would alter the cool climate immediately and would ultimately change the species composition of the swamp trees. Recent logging on Forest County land in the Swamp Creek conifers in Section 30 has opened up the canopy there and appears to threaten the densest concentration of *Calypso* plants found in this survey.

Algal-leaved pondweed (*Potamogeton confervoides*)

Algal-leaved pondweed was found only in Duck Lake. It was not conspicuous and could be reliably located only by snorkeling or scuba, except for a few stem fragments which had washed to the windward shore. Plants were uniformly sterile, as they appear to have been at all previous observations in this lake, and stayed close to the bottom in four or more feet of water.

Algal-leaved pondweed appears to be firmly established in Duck Lake, despite the lack of flowers or fruit. The best growth was noted at the northeast end of the lake where numerous small "colonies" were found, and at the south end of the lake where a large colony 50 to 60 feet in length and several smaller colonies were reported by scuba divers. There was no apparent special character to Duck Lake which distinguished it from numerous other bog-margined lakes in northern Wisconsin. Other submergent species were not prominent and productivity of aquatic macrophytes was low.

3.9.5.1.3 Special Concern Species

Dragon's mouth (*Arethusa bulbosa*)

The late season remains of an orchid which appeared to be *Arethusa bulbosa* were discovered east of the mine site in 1994. This site was checked again in 1995 and the presence of *Arethusa* was confirmed. Fifty-eight flowering plants were seen in a walking survey of this boggy site on June 15, 1995. A thorough survey to establish the total number of individual plants was not conducted. A second population of at least 30 plants of *Arethusa bulbosa* was reported by Dr. Robert Howe in 1995 during field work east of Ground Hemlock Lake. Vouchers were obtained from both populations.

Arethusa bulbosa is a special concern species in Wisconsin. Neither of the populations found in 1995 is within the area of proposed development for the mine.

Lance-leaved grape fern (*Botrychium lanceolatum* var *angustisegmentum)*

Lance-leaved grape fern was found both within the project area in the area planned for the TMA and the study area, and was typically associated with daisy leaf grape fern *(B. matricariaefolium)* in rich leaf mold soil under a full canopied mesic forest of mostly sugar maple, habitat similar to that noted for goblin fern. Lance-leaved grape fern was widely distributed in this habitat type, but the number of plants seen in 1994 was not large. Commonly one or a few plants would be found at any specific site.

Blunt-nose grape fern (*Botrychium oneidense*)

Blunt-lobed grape fern was noted for the study area in Robert Read's WDNR 1979 list. This species was not found in 1994. However, *B. oneidense* was found in two sites within the study area in 1995. Both sites were mesic forests dominated by *Acer saccharum* with full canopies and rich leaf mold soils. These sites often supported other *Botrychium* species, including *B. dissectum, B. matticariae-folium, B. lanceolatum,* and in one case, *B multifidum.*

Little grape fern (*Botrychium simplex*)

This species was found in the mesic forest habitats noted for goblin fern and lance-leaved grape fern, and also occasionally in white cedar swamps, both within the project area and study areas. As in all the *Botrychium* species, distribution is irregular. The number of individuals in the study area is not precisely known, but this species is less common than are the other *Botrychium* species noted, except for goblin fern.

Assiniboine sedge *(Carex assiniboinensis)*

Carex assiniboinensis was found in four locations, three in the study area and one location in the Nicolet National Forest. This plant is located both within the proposed TMA and plant site. The habitat within the proposed location for the TMA was in a rich, moist, gentle depression within a typical mesic woods of mostly sugar maple. Approximately 1,000 fertile ramets were seen on this site which also extended up into the adjacent drier woods. Prominent associates were *Laportea canadensis* (reflecting the wetter nature of this site) and Lady fern *(Athyrium filix-femina).*

The population within the plant site was totally sterile and included several thousand ramets. The habitat was northern mesic forest of mostly sugar maple, and a mostly closed canopy. This site is well drained. The other site in the study area was also located in well-drained northern mesic forest with vegetation similar to the first site. The Nicolet National forest site is composed of similar habitat at a location approximately 10 miles northeast of the study area.

Northern bog sedge *(Carex gynocrates)*

C. gynocrates was found in the larger coniferous swamps along Swamp Creek, along Pickerel Creek and along stream 12-9. No specimens were observed in the project area. Populations were very localized in full canopy stands of white cedar for the most part and ranged from a few stems to a few hundred stems at any site. All three of these swamps provide extensive areas of full canopy, cool habitats. The biggest threat to *C. gynocrates* is probably logging, as noted for *Calypso orchid.* As is the case with several other species associated with these swamps (sparse-flowered sedge, black currant and American yew), it is reasonable to consider these individual locations as part of one large population due to their close proximity and the connecting streams and associated swamps.

Sparse-flowered sedge *(Carex tenuiflora)*

Carex tenuiflora also occurs in large conifer swamps in the study area, but tends to prefer partially open canopies and is more often associated with black spruce and tamarack swamps or at least more mixed canopies. It is largely restricted to the Pickerel Creek Swamp north of the Forest/Langlade county line and to the conifer swamp on both sides of Swamp Creek. A few plants were also found in the swamp along stream 12-9.

Sheathed sedge *(Carex vaginata)*

Carex vaginata occupied many of the same swamps as *C. gynocrates* although they did not always occur at exactly the same sites. These swamps were dominated by white cedar, but *C. vaginata* appeared to flourish best at edges between the dense cedar stands and adjacent swamps or Alder thickets, or under partial canopy. Fertile plants were prominent in the edge populations, but less numerous under full canopy. Most populations seemed stable and often included 100 or more stems, with a few ranging up to several thousand stems. The largest populations occurred along Swamp Creek. Other populations were noted in the swamp along Pickerel Creek and in the swamp along stream 12-9. As noted for *C. gynocrates,* these various locations may be considered part of a single population on the study area.

Waterwort (*Elatine triandra*)

Waterwort was found only in Oak Lake on sandy bottom beneath a few inches to about two feet of water. Associated species include *Elatine minima,* Pipewort *(Eriocaulon septangulare),* Water Lobelia *(Lobelia dortmanna)* and *Utricularia resupinata. Elatine triandra* is very small and without magnification is essentially identical to the more common *E. minima.* It is virtually impossible to estimate the population size in Oak Lake and it is possible and perhaps likely that the area occupied by this species is larger than that revealed by our collections on the northeast shoreline.

Previous investigations in the 1970s and 1980s reported waterwort in Little Sand Lake. Surveys conducted in 1994 in Little Sand Lake found only *Elatine minima*. Although it is possible that *E. triandra* did previously exist in Little Sand Lake, it is also very possible that it was confused with the taxonomically similar *E. minima*.

It appears that waterwort has been present in Oak Lake since it was first collected during the previous study of this area in 1977, which suggests that the population is stable. There was no evidence of significant recent changes to Oak Lake that would affect waterwort. Increased use of the shallow water area by swimmers, etc. would likely be a negative impact and nutrient enrichment of the water (e.g., fertilizer runoff into the lake) would also probably be detrimental.

Marsh willow-herb (*Epilobium palustre*)

Epilobium palustre, a Wisconsin special concern species, has been reported in Wisconsin primarily from bogs. No plants were found in bogs within the study area in 1994, however, plants resembling *Epilobium palustre* were found in several swamps. In each case only sterile plants were found. In 1995 the most prominent population, in the cedar swamp south of County Line Road, was revisted. All plants were again sterile.

E. palustre is very similar to *E. leptophyllum* which also grows in swamps and was found within the study area. The critical character separating the two species involves the nature of pubsecence on the leaves (Voss, 1985; Gleason and Cronquist, 1991). The pubescence characteristics of numerous specimens examined in 1995 and the several vouchers collected in 1994 indicate that these plants are in fact *E. palustre*, regardless of the non-flowering condition of the plants in the study area.

Bogs and swamps support many species in common and it is likely that species which thrive (and therefore flower regularly) in the full sun of bogs might persist, but not thrive in swamps where they are fully or partially shaded. People are less likely to collect sterile plants, and the number of vouchers of such plants is likely to be small. The UWGB herbarium record for such species is likely to overlook their occurrence in habitats in which they most often occur in the sterile condition, thereby limiting knowledge concerning the habitats in which they might be expected.

Based on the sterile plants examined in this study, *E. palustre* is present in the swamp associated with Pickerel Creek and at several locations in swamps along Creek 12-9. These locations are outside of the area proposed for development of the mine.

Marsh horsetail (*Equisetum palustre)*

Equisetum palustre was found in one site along the west edge of the large conifer swamp along Swamp Creek. Habitat was white cedar swamp with small openings in the canopy. All plants found were growing in shade and were sterile and small and therefore not conspicuous. The population size is conservatively estimated at 50+. This species when sterile is similar in general appearance to the common *E. arvense* and it is possible that other sterile *Equisetum* plants seen in this swamp represented *E. palustre* as well.

Variegated scouring rush (*Equisetum variegatum)*

Variegated scouring rush was also represented by one small population within the study area. The location is a small, disturbed opening at a well site in the TMA. Several hundred ramets grew on sandy soil over an area of approximately 150 square feet. The site was at the transition from mesic forest into mixed wet forest. The site is being invaded by seedlings of various trees and shrubs and will likely become unsuitable for variegated scouring rush within a few years, in the absence of disturbance.

Ginseng (*Panax quinquefolius)*

Ginseng was found in rich mesic woods in an area covering and extending beyond the TMA. The population is very sparse with one or a few plants found in each instance, widely spread over the area indicated. A few plants were also found immediately to the north of the plant site. Habitat appears to be similar to that of goblin fern and lance-leaved grape fern. Ginseng probably prefers a full canopy, although perhaps not necessarily mature trees, and would probably be negatively impacted by forestry which opened the canopy and by collecting of the roots by people.

Northern black currant (*Ribes hudsonianum)*

Northern black currant was encountered in numerous locations in the conifer swamps along Swamp Creek, Pickerel Creek, stream 12-9, Hemlock Creek and in the swamp extending from the middle of the northern half of Section 4 T34N R13E, into the middle of the southern half of section 33 T35N R13E. This species appears to prefer small canopy openings and wetter sites within these swamps and is generally represented by one or a few small shrubs at each site. As noted for *Carex gynocrates,* these numerous small local populations are best considered as a single meta-population. Although northern black currant is seldom prominent it appears to be well established and no threats to this population were noted.

Torrey's bulrush (*Scirpus torreyi)*

Torrey's bulrush was found only in Little Sand Lake where it was firmly established. Torrey's bulrush occurred sporadically all around the shoreline of the lake in water from about four to 24 inches deep, and mostly in the 12 to 18 inch range. The plants seemed healthy and fertile plants were common. Associated species included *Eriocaulon septangulare, Juncus pelocarpus, Elatine minima,* and resupinate bladderwort (*Utricularia resupinata).* Torrey's bulrush is known from only a few current sites in northeastern Wisconsin and this may represent the largest population currently known there.

American yew (*Taxus canadensis)*

The distribution of American yew is very similar to that of northern black currant. It is found in small numbers in most of the larger swamps, including those along Swamp Creek , Pickerel Creek, stream 12-9, Hemlock Creek and in the swamp extending from the middle of the northern half of Section 4 T34N R13E, into the middle of the southern half of Section 33 T35N R13E.

The number of individual sites found was relatively large, but American yew was usually present at any given site as a few very short stems under fallen trees or in low areas next to a log. This

is consistent with the common conception that this species is heavily browsed by whitetail deer and persists only where it is protected from browsing by fallen branches, or in low areas in which it is hidden by fallen snow during the winter. As noted for *Carex gynocrates,* these numerous small local populations are best considered as a single meta-population. No large plants of American yew of the type seen in Door County were found on the study area, and only a few flowering branches were seen. However, a few large plants were seen at the edge of the Highway 55 right-of-way just south of Crandon, several mile north of the study area.

Resupinate bladderwort (*Utricularia resupinata*)

Resupinate bladderwort was found in Oak Lake and in Little Sand Lake. This species grows in the bottom of clear, soft water lakes. It is very small and the leaves are often at least partially covered by sediment making it very difficult to find. It apparently rarely flowers in northern Wisconsin and usually does so only in very shallow water or on exposed lake bottom following a drop in water level. Sterile plants are readily identified if found, however.

Resupinate bladderwort was common around the north end of both Oak and Little Sand Lakes in clear water over a sandy bottom. It appears to be thriving in the vegetative state, although only a few flowering stems were seen. Common published descriptions of this species indicate its habitat as limited to very shallow water, but in these two lakes it appears to be more abundant in the sterile condition in water of 12 to 48 inches, and the scuba divers collected sterile plants from depths of over nine feet in Little Sand Lake.

Resupinate bladderwort appears to be firmly established and although it is not producing large numbers of fertile plants it appears to be well adapted to both lakes. No immediate threats to this species were noted in either lake although it is obvious that anything which reduced water clarity, including nutrient enrichment of the water, would affect many of the submergent species including resupinate bladderwort.

3.9.5.2 Mammals

No endangered or threatened species of mammals were observed in the study area. Five special concern species were observed directly or indirectly: bobcat, arctic shrew, pygmy shrew, water shrew, and woodland jumping mouse. In addition, the southern bog lemming was found. Although it is not on the Natural Heritage Inventory Working List, it is rare or poorly known in Wisconsin.

3.9.5.2.1 Endangered Species

The study area is within the potential range of three state endangered mammals; timber wolf (*Canis lupus*), lynx (*Lynx canadensis*), and pine marten (*Martes americana*). Tracking surveys, as well as a trapping effort focusing on pine marten, were carried out to determine the presence or absence of these species in the study area. No direct evidence (i.e., observation of live animals, roadkills, trapped animals, etc.) was obtained.

Timber wolf (*Canis lupus*)

Based on conversations with Adrian Wydeven, WDNR Wolf Biologist, the nearest wolf observation record to the Crandon Project was approximately eight miles to the southeast

(Wydeven, 1995). Tracks of two animals were observed at that location on February 19, 1995 and a single individual was observed on February 21, 1995. The WDNR has not been able to confirm these observation records to date. Breeding populations of wolves are not known to exist in Forest or Langlade Counties. Likely, any observations are associated with single animals moving through the area.

Lynx (*Lynx canadinsis*)

There has not been any documented evidence of lynx breeding activity in the state for many years (Wydeven, 1995). Occasionally, however, lynx are observed. Tracks were observed in northern Forest County in 1995 and 1993. No observation records were reported for the area in 1994 (Wydeven, 1995). No evidence of lynx was observed in the study area.

Pine marten (*Martes americana*)

Potential evidence of pine marten activity in the study area was observed in the form of tracks during the winter of 1994. A total of 309 carnivore tracks were encountered during the 1994 tracking surveys. However, due to the similarity in pine marten tracks to other mid-sized mustelids (e.g., fisher, mink), it is not possible to positively identify a marten by tracks alone. A trapping survey for pine marten, as described in Section 3.9.1.2.5, was carried out in October and November 1994 to confirm the presence or absence of marten in the study area. Although this trapping effort resulted in the capture of seven fishers, six purcupines, one badger, one short-tailed weasel, and one long-tailed weasel, no marten were captured in 376 trap nights, indicating that either marten are not present in the study area or the population density is very low.

From 1975-1983, 172 pine marten were released in the Nicolet National Forest in an area designated as the Fisher Management Unit. Pine marten are now considered common throughout the Fisher Management Unit which is located approximately 25 miles to the north by northwest of the project site (Ashbrenner, 1994). However, WDNR track counts indicate that marten range expansion to the south, towards the project site, has been minimal (Ashbrenner, 1994).

3.9.5.2.2 Threatened Species

No threatened species of mammals are known to range in the vicinity of the proposed Crandon Project.

3.9.5.2.3 Special Concern Species

Bobcat (*Lynx rufus*)

Bobcat populations in Wisconsin have ranged from 1,400 to 1,750 animals between 1980 and 1993 (Kohn and Ashbrenner, 1993). WDNR population analyses indicate that the population has been on the increase since 1988 (Kohn and Ashbrenner, 1993). As described in Section 3.9.1.2.1, greater than 20 miles were surveyed for tracks during the winter of 1994. Bobcat tracks were observed on six occasions during the formal tracking surveys. Evidence of bobcat, in the form of tracks, was observed also on several occasions during other phases of study within some of the larger coniferous swamps in the study area. Tracks of an adult with a juvenile were observed in the mud along County Line Road which bisects a large conifer swamp along the headwaters of Pickerel Creek. Tracks were also observed north of Swamp Creek and west of Swampy Lane, as well as along the Wisconsin Central Limited Railroad lines northwest of Hemlock Road.

Arctic shrew (*Sorex arcticus*)

The Arctic Shrew is a medium-sized shrew of boreal regions which reaches the southern limits of its range in Wisconsin. According to Kurta (1995) it can be locally common in moist habitats, but its life history is poorly known. Jackson (1961) notes that in Wisconsin it is found chiefly in wet spruce and tamarack swamps and in shrub swamps of alder or willow. Although most records in Wisconsin are from the northern part of the state, specimens have been collected as far south as Dane and Dodge County. Peterson (1979), for example, trapped 98 Arctic Shrews during a study of raptor food habits in Jefferson and Dodge Counties.

Neither Dames & Moore (1981) nor Normandeau Associates (1982) recorded arctic shrews in the study area. During the 1994 surveys, however, 32 specimens were collected, all but one in pitfall traps. A complete summary of the 1994 trapping survey results is presented in Appendix 3.9-6. Captures were widespread (11 of 18 stations) and included a variety of habitat types, as shown on Table 3.9-5, both within and outside the project area. Highest numbers were captured at Stations 11 and 15, an alder swamp with sphagnum, very close to the project area as shown on Figure 3.9-5, and an open cedar swamp with alder, tamarack, blueberry and sphagnum, respectively. Other arctic shrew localities in the study area share a characteristically moist substrate. A single arctic shrew was captured in a snap strap along Transect B; together with specimens taken at Pit Trap Stations 10 and 4, these records document the presence of arctic shrews within the project area.

Pygmy shrew (*Sorex hoyi*)

Long (1972, 1974) in his revision of the genus *Microsorex* listed two species, *M. hoyi* and *M. thompsoni*. The latter, based on single specimens from the Milwaukee and Madison area, was said to be smaller, in having a short skull, minute teeth and a flattened cranium. However, van Zyll de Jong (1976) using multivariate analyses questioned the existence of two species, and recommended that *M. thompsoni* be regarded as a subspecies of *M. hoyi*. An extensive review of the "subgenus" *Microsorex* by Diersing (1980) which utilized univariate and multivariate analyses found that the subgenus was monotypic, contained only one species, with five recognized subspecies. He also found that the Wisconsin specimens and an additional one from northern Illinois (Palatine) were comparable in size to northern and central Wisconsin shrews, and are all referable to *Sorex hoyi hoyi*. Range maps for *S. h. thompsoni* no longer include Wisconsin, Illinois or Lower Michigan. It is therefore questionable that it be retained on the Wisconsin Natural Heritage Inventory.

Jackson (1961), Wisconsin has probably 25 masked shrews to every one arctic shrew, but possibly as many as five arctic shrews to every one pygmy shrew or water shrew. Pygmy shrews have a wide distribution across northern North America and are known from a wide range of habitats. According to Kurta, pygmy shrews typically occur in "moist boreal habitats with extensive ground cover." Even in these habitats, however, pygmy shrews seem to be scarce (e.g., Pasitschniak-Arts and Gibson 1989; Etnier, 1989).

Normandeau Associates (1982) captured one pygmy shrew near a sphagnum bog in the NE ¼ of the SW ¼ of Section 29, T35N R13E, while surveying salamanders. In 1994 this species was collected at 11 pitfall trap localities and at both snap trap transects. A complete summary of the 1994 trapping survey results is presented in Appendix 3.9-6. Like other investigators, however, few individuals were found at each site. Highest numbers were recorded at Pit Trap Stations 2 (white pine/jack pine near Wetland F12), 3 (wet opening in mesic forest), 11 (alder swamp), and 12 (open meadow/bog). Pygmy shrews apparently occur in low, moist habitats

throughout the study area, including the project area itself. Several subspecies of pygmy shrew are recognized by mammalogists. Specimens from the study area will be compared to shrews from elsewhere in the state to determine the taxonomic status of these animals.

Water shrew (*Sorex palustris*)

Like the above two species, water shrews are poorly known and seldom collected in Wisconsin. Previous records are mainly from far northern counties, where it occurs in marshes, bogs, and margins of streams, lakes or ponds, usually in a forested landscape (Jackson, 1961). Its distribution covers a broad range across Canada, extending southward into the Appalachians and western mountain ranges. Water shrews are amphibious, and feed on aquatic insects, such as snails, and leeches as well as earthworms, crickets, and slugs (Beneski and Stinson, 1987). They are also known to feed on small minnows, fish eggs, and larval salamanders. Water shrews were not collected during previous research at the study area. In 1994, five specimens were collected: four of these in pitfall traps and the other in a baited minnow trap at the edge of Hemlock Creek. Two specimens were collected at the edge of a bog/meadow near the proposed access road (Pit Trap Station 12). Another was collected at Station 1 south of Skunk Lake. These results suggest that water shrews occur throughout the study area in moist habitats.

Woodland jumping mouse (*Napaeozapus insignis*)

The range of woodland jumping mouse is restricted to northeastern North America, extending southward into the Appalachians. According to Kurta (1995), this species inhabits cool, moist forests of spruce-fir, hemlock-hardwood, and pure deciduous trees. It prefers lush undergrowth and is never far from a woodland stream or pond. Previous Wisconsin records are restricted to the northern half of the state (Jackson, 1961). Dames & Moore (1981) and Normandeau Associates (1982) both collected woodland jumping mice in the study area. In 1994 this species was found to be fairly common in densely wooded areas, but it was significantly outnumbered by the meadow jumping mouse at all but Pit Trap Station 17 and Snap Trap Transect B. In total 52 specimens were collected, 39 of these within the project area at the two Snap Trap Transects.

Southern bog lemming (*Synaptomys cooperi*)

No previous records existed for southern bog lemmings in the study area. During 1994, however, 40 specimens were collected, all from pitfall traps. High abundances occurred at Stations 3 (border of wet opening and mesic forest), 4 (wet depression in mesic forest) and 7 (wet forest near Duck Lake bog). Apparently southern bog lemmings are present throughout the study area, including the project area. Wisconsin lies near the (western) center of the range of the southern bog lemming. Long (1990) reviews the distribution of this species in Wisconsin, noting that few records are available from the southern third of the state. Bog lemmings occur in a wide variety of both disturbed and undisturbed habitats (Parker, 1989; Etnier, 1989). Kurta (1995) suggests that its spotty distribution might be due to competition from the more aggressive meadow vole.

Woodland vole (*Microtus pinetorum*)

The woodland vole, also known as pine vole, has a more southern range than the other target small mammals of this investigation. It inhabits a variety of forest types but prefers oak, maple, and other hardwood forests where soils are covered by thick leaf litter (Kurta, 1995; Smolen, 1981). Woodland voles are semifossorial, spending most of their time in burrows underground or

beneath the leaf litter. Primary foods include roots, tubers, and rhizomes (Kurta 1995). Long (1990) describes the distribution and taxonomic variation of woodland voles in Wisconsin. Northernmost records include four specimens from Clark County and a single specimen from Brown County examined by Jackson (1961). Neither the 1994 studies nor those of previous investigators were able to document woodland voles in the study area. Based on the high success in capturing other small mammal species, coupled with lack of evidence of runways or other signs in the site's mesic forests, it is concluded that woodland voles are absent in the study area.

3.9.5.3 Birds

During the course of the 1994 field studies, 1995 follow-up work, and previous investigations (Normandeau Associates, Inc., 1982; Dames & Moore, 1985) 27 species of birds listed on the Wisconsin Natural Heritage Working List were found. These included three threatened and 24 special concern species as listed in Table 3.9-25.

No state or federally endangered bird species were found in the study area. Several other species listed by the WDNR during the planning of this inventory are potentially present in the study area but were not found.

The ruby-crowned kinglet, for example, is a common migrant through the study area, but no evidence of this special concern bird's presence during the breeding season was found. This is consistent with findings from the Nicolet National Forest Bird Survey, where the species is known from only six sites, all but one of these in the northern half of Nicolet National Forest. Habitats associated with these records are lowland conifers or white spruce plantations. Neither of the previous investigations at the proposed mine site reported ruby-crowned kinglets during the breeding season (Dames & Moore, 1981; Normandeau Associates, 1982). Robbins (1991) considers ruby-crowned kinglets to be an uncommon summer resident in spruce and tamarack bogs of northern Wisconsin. During the Michigan Breeding Bird Atlas survey (Brewer, et. al., 1991) this species was recorded in 29 percent of survey blocks of the Upper Peninsula. Mossman, et. al., (1990) did not report ruby-crowned kinglets at any of their boreal forest remnants in northern Wisconsin. Presence of suitable habitat in the study area leaves open the possibility that a small number of ruby-crowned kinglets might be present in the study area, although the failure of all field studies (this and previous investigations) to find them argues that its occurrence is unlikely.

Swainson's thrush is another special concern species potentially present in the study area but was not observed. The study area lies near the southernmost range limit of the Swainson's thrush in Wisconsin. A north-south gradient is shown by results from the Nicolet National Forest Bird Survey: individuals were recorded at 5.6 percent of 266 sites in the northern half of the Forest, but only 3.5 percent of 254 sites in the southern half. Breeding records are scattered but widespread in Michigan's Upper Peninsula (Brewer, et. al., 1991). Although most of this species' range lies in the coniferous belt of Canada and high altitudes, Swainson's thrushes occur locally in both hardwood and conifer forests in the Great Lakes region. Its range-wide status is not believed to be seriously jeopardized (Thompson, et. al., 1992). No Swainson's thrushes were observed during the breeding season surveys. Previous work by Dames & Moore (1981) reported the presence of at least one Swainson's thrush but did not provide details. The absence of Swainson's thrushes in systematic transects (Dames & Moore, 1981) suggests that the bird(s) might have been observed during the migration period only. None was recorded by the

Table 3.9-25

Threatened and Special Concern Species Observed in the Study Area

Common Name	Scientific Name	State Status
Osprey	*Pandion haliaetus*	Threatened
Bald Eagle	*Haliaetus leucocephalus*	Threatened
Red-shouldered Hawk	*Buteo lineatus*	Threatened
Common Merganser	*Mergus merganser*	Special Concern
American Black Duck	*Anas rubripes*	Special Concern
Black Tern	*Chlidonias niger circus cyaneus*	Special Concern
American Bittern	*Botaurus lentiginosus*	Special Concern
Spruce Grouse	*Dendragapus canadensis*	Special Concern
Black-backed Woodpecker	*Picoides arcticus*	Special Concern
Yellow-bellied Flycatcher	*Empidonax flaviventris*	Special Concern
Sedge Wren	*Cistothorus platensis*	Special Concern
Boreal Chickadee	*Parus hudsonicus*	Special Concern
Gray Jay	*Perisoreus canadensis*	Special Concern
Blackburnian Warbler	*Dendroica fusca*	Special Concern
Connecticut Warbler	*Oporonis agilis*	Special Concern
Tennessee Warbler	*Vermivora peregrina*	Special Concern
Evening Grosbeak	*Coccothraustes respertinus*	Special Concern
Pine Siskin	*Carduelis pinus*	Special Concern
Cooper's Hawk	*Accipiter cooperii*	Special Concern
Blue-winged Teal	*Anas discors*	Special Concern
Veery	*Catharus fuscescens*	Special Concern
Black-throated Blue Warbler	*Dendroica caerulescens*	Special Concern
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Special Concern
Vesper Sparrow	*Pooecetes gramineus*	Special Concern
Eastern Meadowlark	*Sturnella magna*	Special Concern
Golden-winged Warbler	*Vermivora chrysoptera*	Special Concern
Nashville Warbler	*Vermivora ruficapilla*	Special Concern

Prepared by: RWH
Checked by: RFS/BDH

Normandeau Associates, Inc. (1982) Wetlands Assessments. Singing males or even pairs might occur occasionally, but no well established local population of Swainson's thrushes appears to inhabit the study area.

The Cerulean warbler, a state threatened species, is widely recognized as one of North America's most threatened species of migratory songbirds (Robbins, et. al., 1992). Breeding Bird Surveys show a continuing population decline. Not only is the species' nesting habitat declining, but its wintering habitat is undergoing large scale destruction. Few breeding records are reported for Wisconsin, although Robbins (1991) considers it an uncommon resident in southern and central Wisconsin whose range has expanded northward. Scattered records are available for northern Wisconsin. Erdman notes that Cerulean warblers occur along the Wolf River near New London, and Howe (personal observation) recorded a singing male along the Wolf River near Big Smoky Falls in Menominee County during summer 1994. Cerulean warblers have been recorded at only two of the 520 points in the Nicolet National Forest Bird Survey. This species was a major target of the inventory efforts. In addition to points along watercourses, numerous sites were selected in extensive hardwoods, particularly in the hardwood dominated ridges east and south of Oak Lake (Points 101-105, 82-90) and in the northeast of the study area (92-94). Howe, Erdman, and others also searched potential habitats in addition to the formal point counts. Efforts failed to yield any Cerulean warblers in the study area. Although singing males might occur occasionally in the study area, the inventory results show that a persistent breeding population of Cerulean warblers is not likely to occur in the study area. This conclusion is supported by the lack of records from previous studies and the scarcity of records from other studies in northern Wisconsin.

LeConte's sparrow (a special concern species) is considered to be an uncommon summer resident in northern and central Wisconsin (Robbins, 1991). It breeds in peatlands (Niemi and Hanowski, 1984), sedge meadows, and extensive grasslands. Mossman and Sample (1990) considered LeConte's sparrows to be common in natural sedge meadows and fairly common in moss-dominated bogs within the State Natural Areas System. Potential habitats in the study area include the open bogs around Duck Lake and riparian meadows along Hemlock/Swamp Creek. Lack of extensive openings in the study area suggests that LeConte's sparrows are not regular breeders in the study area. No records of this species exist in the study area during the breeding season or migration periods.

Cape May warbler is a special concern species, known from only a few nesting records in Wisconsin. Included in these accounts, however, is the observation of a pair carrying food to the top of a 45 foot balsam fir in Forest County (Robbins, 1991). Virtually all Wisconsin breeding records have come from spruce or fir habitats in the extreme northern part of the state. Other studies (Morse, 1989) show that Cape May warblers undergo local movements or irruptions in response to spruce budworm outbreaks. This species has been recorded at eight of the habitat-based Nicolet National Forest Bird Survey points, five in the northern half of Nicolet National Forest. Mossman, et. al. (1990) found Cape May warblers at only one of seven sites in their analysis of boreal forest natural areas in Wisconsin. Robbins (1991) reports that Cape May warblers breed "in small numbers" in far northern Wisconsin, a conclusion that is supported by recent evidence. Neither the 1994 surveys nor those of previous investigators have found evidence of Cape May warblers breeding within the study area. Although appropriate habitat is available in small patches (e.g., west of railroad tracks north of Ground Hemlock Lake and along Hemlock Creek), it is unlikely that Cape May warblers are resident there. Several other special concern species, including merlin, red-breasted merganser, common goldeneye, northern pintail,

lesser scaup, black-crowned night-heron and long-eared owl, were not observed in the study area, similar to the findings of Dames & Moore (1981) and Normandeau Associates (1982). Because their significance to the proposed mine project is probably very low, a species by species account is not included of regional status and habitat requirements. Individual accounts of the listed bird species observed in the study area during the breeding season are presented in the following paragraphs beginning with the threatened species.

3.9.5.3.1 Endangered Species

No endangered bird species were observed in the study area.

3.9.5.3.2 Threatened Species

Bald eagle (*Haliaetus leucocephalus*)

The distribution of bald eagles in Wisconsin is closely monitored by WDNR, U.S. Forest Service, and U.S. Fish and Wildlife Service biologists. Eagle nests are known to occur in the study area, and individuals were observed regularly by field observers during this investigation. The status of bald eagles in North America is well documented and reported elsewhere (Robbins, 1991). In general, populations have increased dramatically since the banning of DDT in the 1960s (Postupalsky 1978; Robbins, 1991). The WDNR eagle survey of Wisconsin has shown a steady increase in eagle territories, from approximately 100 in 1973, to 533 in 1994 (Eckstein, 1994a). More than 25 birds now overwinter along the heavily industrialized Fox River in northeastern Wisconsin (Howe, et. al., 1993). In addition, the bald eagle is under consideration to be removed from the threatened category in Wisconsin.

Figure 3.9-17 shows the environmental study area. In this area in 1994, WDNR aerial surveys identified nine occupied bald eagle territories (Eckstein, 1994a). Each territory may have one or more former nest sites and one or more alternate nest sites. The results of the 1994 WDNR aerial survey are summarized in Table 3.9-25a and are shown on Figure 3.9-17.

Bald eagles were observed hunting or flying over much of the study area, including the project area itself. On August 9, 1994 an eagle was heard while field observers were checking Small Mammal Transect B. Other localities include Hemlock Creek (May 9, 1994 - an adult hunting from a log overhanging the water), Swamp Creek (August 2, 1994 - adult perching in a tall white pine), Little Sand Lake (July 18, 1994 - sub-adult flying on east side of lake), south of Little Sand Lake (May 26, 1994 - perched near top of tall white pine), north of Rolling Stone Lake (July 13, 1994 - recently-fledged juvenile soaring overhead), west of Duck Lake (May 19, 1994 - adult flying overhead), and County Line Road near Reference Marker 19 (May 9, 1994 - adult flying low over trees). Two bald eagle nests were observed during CMC's biological monitoring study. The first was found east of STH 55 on a county line road bordering Langlade and Forest Counties on February 2, 1994. The second nest was observed north of Rolling Stone Lake on April 12, 1994 near Marten Springs. By the continuing presence of an adult bald eagle in this area, the first nest appeared to be active through the summer. An inspection of the area around the nest north of Rolling Stone Lake revealed that this nest produced no young in 1994. The relative importance of the study area to these birds is not known, but clearly the lakes and streams are used regularly during the breeding season.

Table 3.9-25a

WDNR 1994 Aerial Bald Eagle Survey Results

Nest	Name	April Check	June Check
LA02A	Spider Creek Flow.	Occupied	Failed
LA02B	Spider Creek Flow. SE	Empty, unrepaired	—
LA03A	Rolling Stone Lake	Gone many years	—
LA03B	Rolling Stone Lake	Incubating	Failed
LA03C	Rolling Stone Lake	—	New empty nest
LA05C	Pickerel Lake	Incubating	Failed
LA12	Hunting River	Empty, unrepaired	—
LA12A	Wolf River Pond	Incubating	Failed
ON56	Lucille Lake	Incubating	1 young
FO01A	Rice Lake	Gone many years	—
FO01B		Gone many years	—
FO01C		Gone many years	—
FO01D		Gone many years	—
FO01E		Incubating	1 young
FO13B	Lake Lucerne	Incubating	2 young
FO16B	Bishop Lake	Occupied	Failed
FO19	Copper Mine	Gone many years	—
FO23	Arbutus Lake	Empty, unrepaired	—
FO23A	Crane Lake	Gone, blowout	—
FO23B	Crane Lake	Incubating	Failed

Source: WDNR

Prepared by: MLD2
Checked by: JWS

Osprey (*Pandion haliaetus*)

Like the bald eagle, osprey are monitored in Wisconsin by state and federal agencies. Also like the bald eagle, numbers have recovered from serious declines during the DDT era. WDNR surveys found 90 active osprey territories in 1973. This has increased to 390 in 1994 (Eckstein, 1994b). Both osprey and bald eagles are primarily fish-eaters, osprey preferring open, clear, and shallow waters (Brewer, et. al., 1991a). Nest sites include dead trees along the edges of streams or lakes, tall trees in conifer swamps, and artificial nest platforms.

Figure 3.7-17 shows the environmental study area. In this area in 1994, WDNR aerial surveys identified five active osprey territories (Eckstein, 1994b) as listed in Table 3.9-25b and as shown on Figure 3.9-17. One territory, FO01, has two nest sites.

Osprey nesting was documented during this investigation in the northeastern corner of the study area. A bird was observed on a nest platform near the confluence of Swamp Creek and Hemlock Creek in Section 20, T35N, R13E. Later, (June 7, 1994), two adults were observed, including one carrying food. Botanist Mark Jaunzems located a potentially active nest in a tall pine near the point of this observation (SW ¼ SW ¼ Section 21). The area around this nest represents an old growth forest remnant surrounded by open and forested wetlands. Other osprey observations were recorded at the southern end of Little Sand Lake, near Pickerel Creek northeast of Rolling Stone Lake, near Turtle Traps 5 and 6 along Swamp Creek, and elsewhere along Swamp Creek. Based on results from this study and previous investigations (Dames & Moore, 1981), the study area is clearly used for nesting Ospreys, although critical areas tend to lie peripheral to the proposed Crandon Project.

Red-shouldered hawk (*Buteo lineatus*)

Significant declines in red-shouldered hawks (*Buteo lineatus*) throughout Wisconsin have resulted in it being listed as "threatened" by the WDNR and as a "sensitive" species on the nearby Nicolet National Forest. In southern and central Wisconsin it is usually considered a riparian species nesting in heavily wooded bottomlands along streams and rivers. In northeastern Wisconsin it is most likely to occur in mature stands of hardwood near palustrine wetlands or riparian areas. Habitat destruction by draining of swamps and wetlands, forest fragmentation and large clear-cuts which increase competition by red-tailed hawks and predation by great-horned owls has adversely affected the population. The recent dramatic increase in the reintroduced fisher population has resulted in increased nest losses and adult mortality.

Only one nesting territory was located in the study area (Township 34N, Range 12 East, Section 2). This site had already failed when found on April 24. The nest tree had been climbed by a mammal, either raccoon or fisher. The presence of two olds nests in the same stand indicate that this territory had been used previously. This stand was one of the few throughout the study area which has not been either selectively cut or clearcut. This territory was not present in the Dames & Moore Study. The only documented territory noted then was near St. Johns Lake (D.F. Brinker, personal communication 1994). The only other red-shouldered hawk observation for the area was an adult hunting on the north side of Duck Lake on August 23.

Table 3.9-25b

WDNR 1994 Aerial Osprey Survey Results

Nest	Name	May Check	July Check
LA02A	Miniwakin Snag	Inactive, nest present	—
LA04A	Spider Flowage Platform	Incubating	Failed
LA06	Pickerel Lake Platform	Used by Great blue herons	—
LA11A	Spider Flowage Platform	Inactive	—
LA12B	Rolling Stone L. Platform	Incubating	2 young
FO01A	Swamp Creek Platform	Empty, nest unrepaired	—
FO01B	Swamp Creek Pole	Incubating	Failed
FO02A	Ground Hemlock Lake	Gone many years	—
FO05	Mole Lake Platform	Incubating	2 young
ON91	Bishop Lake Trust Land	Incubating	1 young

Source: WDNR

Prepared by: MLD2
Checked by: JWS

Red-shouldered hawks decline in number northward in Wisconsin. A recent survey on Nicolet National Forest estimated that a sizeable population of 200-250 pair were present on the 656,000 acres of forest. However 90 percent of that population was located on the southernmost Lakewood District (Erdman and Jacobs, 1994).

3.9.5.3.3 Special Concern Species

Northern goshawk (*Accipiter gentilis*)

The northern goshawk (*Accipiter gentilis*) is a regular but rare breeder across northern Wisconsin. Generally the population in Wisconsin has increased since the 1960s as northern forests continue to recover and mature from the slash and burn period at the turn of the century. This positive trend however stopped in the early 1980s as forest management practices began to negatively effect goshawks. Large clearcuts, forest fragmentation, and monoculture stands have destroyed many nest sites. The dramatic increase in the reintroduced fisher has also resulted in additional nest loss and increased adult mortality.

No goshawk nests were found in the study area in 1994. All suitable habitat was walked and conspecific calls were broadcast at three sites. No old previously used nests attributable to goshawk were found. Two observations were made of flying individuals. The first during mammal track survey in March at transect 6. The second was a bird seen flying over the Gum Bottoms area in May. In winter, goshawks often move considerable distances from their nesting territories. In Wisconsin, movements as great as 15 miles have been documented. Breeding adults in May and June also have extensive territories for hunting which may take upwards to five km from the nest. Undoubtedly parts of the study area was utilized by foraging goshawks.

The goshawk nest reported in the Dames & Moore study persisted in the same stand from 1977 through 1982. Logging has resulted in the site becoming inactive since. The adult male from that site banded in the summer of 1979 was recovered in the winter of 1992 near Whiteye Lake, about nine miles northwest.

Northern harrier (*Circus cyaneus*)

Like many birds of grasslands and open wetlands, Northern harriers have disappeared from much of their original range. Populations seem to have held their own in northern regions, however, and Breeding Bird Censuses (Robbins, et. al., 1986) and the Wisconsin Checklist Project (Rolley, 1994) indicate increases in Wisconsin during recent years. Northern harriers are characteristic of wet meadows, prairies, uncultivated fields (Apfelbaum and Seelbach, 1983), and other open or semi-open habitats (Hamerstrom and Kopeny, 1981). In the Nicolet National Forest Bird Survey, harriers have been recorded from shrub swamps and open conifer swamps. Territories of nesting harriers are in the order of one square mile (Craighead and Craighead, 1956), suggesting that the mainly forested study area is not likely to sustain a resident population. Although few extensive open habitats exist in the study area, Northern harriers were observed several times in open fields near Mole Lake. Both a male and female, on different occasions, were observed hunting in agricultural fields near the junction of Sand Lake Road and Black Joe Road during June, July, and early August, 1994. Apparently the pair nested in this area. No birds were reported from the primary study area, however. This result is similar to the findings of Dames &

Moore (1981), who reported Northern harrier (marsh hawk) from the "environmental study area", but not the "site area".

Great gray owl (*Strix nebulosa*)

Great gray owls are considered a rare summer resident in northern Wisconsin (Robbins, 1991). Documented nesting has only occurred in the northwestern portion of the state. Recent observations reported in the seasonal field notes for the Wisconsin Society for Ornithology indicate summer observations across northern Wisconsin including Florence and Oneida Counties. Distribution of this species is limited by adequate microtine populations and the presence of an existing stick nest structure. Most often this old hawk or raven nest in spruce or tamarack habitat. Often this is adjacent to stands of hardwood, sparse woodland (shrub/carr) and semi-open areas needed for hunting. Clear cuts appear to be avoided (Shepherd, 1992). Owls may well move with changing microtine densities. Foraging distances for telemetry monitored nesting males in Oregon was 0.4 miles with a range of up to two miles (Bull, et. al., 1988). They also recorded a home range for five males averaging 2.8 miles (range = 0.8-4 miles^2). Post breeding movements can be extensive up to 375 miles immediately after nesting, apparently dependant on vole cycles (Shepherd, 1992).

Great gray owl responses were obtained from two survey stops (37 and 3) on May 19, 1994 (Figure 3.9-9). Responses were probably made by the same bird working the Pickerel Creek swamp north of Rolling Stone Lake. At site 3, the owl called twice and it responded only once at site 37. Subsequent survey at site 3 on May 24, 1994 obtained no response. Additional great gray owl surveys were conducted in May 1995. On May 6, 1995, two responses to tape recordings were heard north of Rolling Stone Lake near Martin Springs in the vicinity of a lowland conifer swamp. A single response was heard on May 15, 1995, and nine responses were heard on May 17, 1995, near the Pickerel Creek road crossing north of Rolling Stone Lake. On May 3, 1995, the WDNR recovered a dead great gray owl on CTH G in Oneida County west of Pelican Lake, approximately 17 miles northwest of the Crandon site. The observed vocalizations and nearby road kill suggest that great gray owls occur in or near the study area.

Common merganser (*Mergus merganser*)

Common mergansers are uncommon summer residents in northern Wisconsin (Robbins, 1991) and were reported previously in the study area only during migration (Dames & Moore, 1981). During this investigation, a flock of common mergansers was observed during November 1993 on Deep Hole Lake, but we have no evidence of this species breeding in the study area. According to Brewer, et. al. (1991), common mergansers nest in "secluded wooded streams and inland lakes bordered by forest." Females nest in tree cavities or small cavities in rocks or cliffs. Absence of large, dead trees in the vicinity of the local lakes and streams probably represents the major reason for the absence of common mergansers in the study area.

American black duck (*Anas rubripes*)

Black ducks are widely recognized as declining across their range in northeastern North American (Rusch, et. al., 1989). Robbins (1981) reports that numbers in Wisconsin are highest in forested lakes of northeastern counties, but "nowhere in the state is this bird a common breeder." Dames & Moore researchers found an adult with five young on Ground Hemlock Lake during summer of 1978. Normandeau and Associates (1982) found black ducks at one of their marsh transects during June 1981. Only a single record of black ducks was reported during this investigation. Botanists observed five birds in Pickerel Creek approximately 50 feet north of Rolling Stone Lake on August 9, 1994.

The taxonomic status of black ducks is controversial (Ankney, et. al., 1986), and hybridization with mallards is well known. Presence of numerous mallards in the study area could be responsible for disappearance of black ducks in much of their former range, including many areas in northeastern Wisconsin. Although a few black duck pairs might occur today in lakes of the study area, numbers certainly are very small.

Black tern (*Chlidonias niger*)

Trends shown by the North American Breeding Bird Survey show significant declines between 1966 and 1987 in the north-central U.S. and even greater declines of black terns elsewhere (Hands, et. al., 1989). Mossman (1983) carried out an extensive survey of black terns in Wisconsin and found individuals at more than 40 percent of roadside stops along suitable habitat. Robbins (1991) considers it a fairly common summer resident in northern Wisconsin.

Black terns breed in freshwater marshes and shallow ponds or lakes surrounded by significant areas of emergent aquatic vegetation, usually cattails, pond-lilies, bulrushes, or bur-reed (Bergman, et. al., 1970). In Iowa, Brown and Dinsmore (1986) found them nesting only in wetlands larger than 12 acres. Large cattail marshes are generally absent from the study area, but potential habitat exists near Duck Lake, in open wetlands in the northeastern corner of the study area, and perhaps in small ponds in the western half of the study area. Dames & Moore (1981) reported black terns from the study area, apparently during migration. The only observation of black terns during this investigation occurred on August 2, 1994, when botanists observed two individuals in flight over a small pond east of Mole Lake in the NW ¼ of Section 35, T35N R12E. Subsequent visits to the site in 1994 as well as 1995 yielded no additional observations of these birds. Black terns are known to nest at Rice Lake, and it is likely that the August 2, 1994 observation represented birds from that local population. Perhaps small wetlands in the study area are used occasionally by black terns for feeding, but there is no evidence of nesting.

American bittern (*Botaurus lentiginosus*)

Populations of American bittern have declined throughout most of its range, particularly in agricultural regions. In the north-central United States numbers have declined by approximately four percent per year from 1966 to 1987 (Hands, et. al., 1989a). Robbins (1991) points out that this is the only heron that is more numerous and widespread in northern Wisconsin than in the southern part of the state. It has been recorded from scattered localities in the Nicolet National Forest, including five of 201 randomly selected roadside points. Habitats of American bitterns include marshes, sedge meadows, lake edges, bogs, and shrub swamps.

Dames & Moore (1981) reported American bitterns in both the study area and in the project area, but no evidence is given about the date of observations. During this investigation individuals were heard at none of the nocturnal census localities. Only two American bitterns were observed during this investigation. One was seen flying over the road near Pickerel Creek north of Rolling Stone Lake on June 20, 1994. The second was observed on August 17, 1994 west of the study area in sedge meadow/shrub carr along Squaw Creek between Bishop Lake and Swamp Creek. Normandeau Associates (1982) failed to find American bitterns during June 1994, although individuals were recorded at a transect in shrub swamps during May 1981. Presence of at least one bird during June 1994 suggests that American bitterns breed within or near the study area, but their numbers must be very low. The failure of nocturnal surveys with tape recordings to reveal any American bitterns in potentially suitable habitat is consistent with

the characterization of American bitterns as a species which is rare or absent in the study area. This result is consistent with the findings of Hoffman and Mossman (1993), Hoffman (1989), and others, who report American bitterns only sporadically from bogs and other wetlands like those in the study area.

Yellow rail (*Coturnicops noveboracensis*)

The yellow rail is currently on the State Special Concern list. It has been recommended that its status be changed to threatened. Documenting nesting of this species has been restricted to the west Green Bay shore wetlands (Grimm, 1991), mainly documented by C.H. Richter, who collected over 60 egg set between 1926 and 1966. The WDNR has indicated regular occurrence at three inland site, tow in Burnett County and one in Vilas County. Unpublished records from UWGB also indicate an inland record for central Oconto County and recent observations from Door County and the Lake Noquebay area of Marinette County (Pleyte, 1994). Yellow rails are difficult to detect without using playback calls and extensive surveys of northern Wisconsin have not been done. Coastal populations are known to shift and move being dependant on fluctuant water levels of the Great Lakes. Actual distribution of the yellow rail is poorly known.

A single response to the yellow rail tape was noted at a small wetland along the outlet of Little Sand Lake (survey site 10) on May 26, 1994. Subsequent checks on the site on June 8 and July 5, 1994 produced no response. No response was obtained at any other survey site (Figure 3.9-10).

Spruce grouse (*Dendragapus canadensis*)

Spruce grouse are not listed as endangered in Wisconsin, although ornithologists and wildlife managers have argued that they deserve this status (Robbins, 1991). Recent records indicate that the proposed Crandon Project lies at the southern edge of the species' Wisconsin range. Even within this range, however, spruce grouse are very scarce and difficult to find. None has been recorded at census points of the Nicolet National Forest Bird Survey, although birds have been occasionally seen during the survey period. According to WDNR spruce grouse specialist Larry Gregg, a spruce grouse was reported two miles west of the study area in 1981, but "records are scarce" in this area and "it's likely that birds are too."

No evidence of spruce grouse was found in the study area. Dames & Moore (1981) reported the presence of spruce grouse in their "environmental study area", but no details or dates are available. Spruce grouse are conspicuous where they occur. Given the numerous visits to lowland conifers during this investigation, the probability that an established spruce grouse population could have been overlooked in the study area is very low.

Black-backed woodpecker (*Picoides arcticus*)

Black-backed woodpeckers occur very locally in northern Wisconsin during the breeding season, where Robbins (1991) considers them regular breeders in tamarack bogs and recently burned jack pines. This species has never been reported from census points in the Nicolet National Forest, although it is regularly seen elsewhere in the Forest and was not reported by previous investigators at the study area. Mossman, et. al. (1990) did not find this species in surveys of seven remnant boreal forest stands in Wisconsin Natural Areas. Evidence of this species is present along Swamp Creek, where large patches of bark have been removed from dead spruce

and tamaracks. On June 8, 1994 three members of the botany team observed an individual near the crossing of Berry Lane and Hemlock Creek (T35N R13E, Section 33, NE ¼). The status of this species in the study area is not known, although breeding is possible, if not likely.

Yellow-bellied flycatcher (*Empidonax flaviventris*)

Despite few nest records, yellow-bellied flycatchers are not rare in appropriate habitat (lowland conifers and spruce bogs) of northern Wisconsin. In the Nicolet National Forest, observers have recorded yellow-bellied flycatchers at 23 of 48 lowland conifer census points. In Michigan's Upper Peninsula, participants in the Michigan Breeding Bird Atlas found them in one-quarter of all townships (Brewer, et. al., 1991). During this investigation yellow-bellied flycatchers were found at Point 78 and along Swamp Creek. Previous researchers observed this species during May 1977 in swamp conifers (Dames & Moore 1981) and during June 1981 in coniferous wetlands (Normandeau Associates 1982). These records together suggest that yellow-bellied flycatchers are established summer residents in extensive conifer swamps in the study area. No records exist from the project area itself.

Sedge wren (*Cistothorus platensis*)

Sedge wrens have disappeared from much of their range as wet meadows and grasslands have been replaced by intensive agriculture. Ornithologists consider this species to be sporadically distributed and irregular even within its breeding range (Brewer, et. al., 1991). Sedge wrens are particularly important for conservation in this state because Wisconsin lies at the center of its geographic distribution. Robbins (1991) considers it to be a common summer resident, with abundance increasing toward the northern and western parts of the state. Observers in the Nicolet National Forest have recorded sedge wrens at nine sites, seven in the northern half of the Forest. Habitats include sedge meadows, open shrub swamps, and wetlands at the edges of lakes. Mossman and Sample (1990) found sedge wrens at more than 75 percent of their samples of sedge meadows and bogs in northern Wisconsin. Hoffman (1989) considered sedge wrens to be abundant at the Thunder Lake State Wildlife Area, approximately 23 miles north of the study area.

Dames & Moore (1981) report the presence of sedge (short-billed marsh) wren in their "environmental study area". This record probably represents a migrant, although no details are given. No other evidence exists for the occurrence of sedge wrens in the study area, including the 1994 investigation and the work by Normandeau Associates (1982) and Dames & Moore (1981). Lack of extensive open, sedge-dominated wetlands or meadows is consistent with the lack of breeding season records. Sedge wrens probably occur occasionally in the open wetlands near Duck Lake and in the northeastern corner of the study area, but evidence of their presence is lacking for the period of this investigation.

Boreal chickadee (*Parus hudsonicus*)

Boreal chickadees have always been rare in Wisconsin (Robbins, 1991). Only a few breeding records are available, but at least two of these come from Forest County. This certainly must be considered a peripheral species in this state, with its primary range extending through the boreal forest belt from Alaska to the North Atlantic. In Michigan, it is restricted to scattered localities in the Upper Peninsula. Observers in the Nicolet National Forest Bird Survey have found it at three sites, all lowland conifers in the northern half of Nicolet National Forest. Hoffman and

Mossman (1993) reported it as uncommon in muskeg habitats and rare in forested bogs in Wisconsin Natural Areas.

Boreal chickadees were recorded in the study area by Dames & Moore (1981) and by observers during this study. None was found during the formal point counts, but several sightings were reported in the study area. Broetzman observed a pair in the Pickerel Creek Swamp near County Line Road on July 5, 1994. The botany team reported three boreal chickadees near Swamp Creek in Section 26 (T35N R12E) on August 1, 1994. Howe and others observed at least two birds the following day in the same vicinity, near Bird Survey Points 9 and 14. Although black-capped chickadees far outnumber them in the study area, boreal chickadees apparently are resident in small numbers, undoubtedly fewer than five to 10 pairs, and possibly only one or two. Consistent with findings of other studies, we found this species in association with dense lowland conifers.

Gray jay (*Perisoreus canadensis*)

Gray jays, like boreal chickadees, ruby-crowned kinglets, and other species of northern conifer forests, reach the southern limits of their geographic ranges in northern Wisconsin. Numerous confirmed breeding records were reported for Michigan's Upper Peninsula (Brewer, et. al., 1991), but none were reported for the Lower Peninsula during the Michigan Breeding Bird Atlas. Records from the Nicolet National Forest include 21 points in the northern half of the Forest, but only eight points in the southern half. Gray jays were observed here near County Line Road and at Points 14 and 111 during the breeding season point counts. Individuals also were recorded at numerous other localities in spring and late summer. Adults with young were observed in Section 26 (T35N R12E) and near the Pickerel Creek Swamp (T35N R12E Section 34). Dames & Moore (1981) also reported this bird to be present in the study area. None of these records lie within the project area, although individuals at the western edge of Duck Lake are within a mile of the proposed plant site.

Blackburnian warbler (*Dendroica fusca*)

Blackburnian warblers are long-distance migratory birds characteristic of mature conifer and mixed hardwood-conifer forests in eastern North America. Although forest dominated by hemlock or white pine are favored, blackburnian warblers also occur in mixed hardwood-conifer forests and lowland conifers (Dawson, 1979). Individuals generally forage and nest in tall conifers (Hoffman and Mossman, 1990); males often are observed singing from the tallest branches (Morse, 1967). Because of the species' predilection for mature, uneven-aged conifer forests, the Nicolet and Chequamegon National Forests have designated blackburnian warblers as Sensitive Species and as Management Indicator Species (USDA, 1986). Blackburnian warblers winter in tropical forests from Costa Rica to Peru and Bolivia (Ehrlich, et. al., 1988). Thompson, et. al. (1992) note threats to wintering grounds of this species are severe. Recent North American Breeding Bird Surveys, however, show significant positive trends both on the short term (1982-1991) and longer term (1966-1991).

Blackburnian warblers are common in the Upper Peninsula of Michigan, occurring in over 450 of 1,613 survey blocks in the Michigan Breeding Bird Atlas (Brewer, et. al., 1991). Robbins (1991) considers it a "fairly common summer resident" in the northern third of Wisconsin. This species is uncommon and local in the Nicolet National Forest Bird Survey (Howe, et. al., 1994), occurring in 16 percent of random points in the northern half of the Forest, but at only six

percent of the random points in the southern half. In habitat-centered points, this species occurs at 71 percent of points dominated by hemlock or white pine, 13 percent of sites dominated by lowland conifers, and 26 percent of sites dominated by northern hardwoods.

Blackburnian warblers were observed at four points (9, 15, 37, and 73) within the study area, all associated with swamp conifers (Figure 3.9-11). None of these sites lies in the project area, although one (Point 15) is less than 600 feet east of the boundary. Blackburnian warblers also were observed during summer by previous investigators (Dames & Moore, 1981). This species must be considered uncommon and local in the study area. Documented populations occur along Swamp/Hemlock Creek, with scattered individuals or pairs elsewhere. Based on information from the Nicolet National Forest Bird Survey, blackburnian warblers can be expected most consistently in forests dominated by hemlock and white pine. Only local areas of this type of forest occur in the study area.

Connecticut warbler (*Oporornis agilis*)

Connecticut warbler is among the top 12 neotropical migratory bird species of management concern in the Midwest (Thompson, et. al., 1992). Across its range in the Great Lakes region this species occurs along the edges of bogs (Niemi and Hanowski, 1984), in jack pine barrens (Hoffman and Mossman, 1990; Robbins, 1991) and in aspen-fir parklands (Walkinshaw and Dyer, 1961). Michael Grimm (1994) found individuals at the edges of jack pine islands in extensive spruce bogs of the Headwaters Wilderness in the Nicolet National Forest during 1993. Robbins (1991) calls this species an uncommon summer resident in northern Wisconsin. Connecticut warblers have been reported from seven of the 319 habitat-based census points and none of the 201 random roadside points in the Nicolet National Forest Bird Survey. Vegetation at the inhabited points is varied, including aspen, lowland conifers, red pine, and white spruce. Mossman, et. al. (1990) recorded Connecticut warblers at two of seven remnant boreal forest stands in northern Wisconsin.

Previous inventories (Dames & Moore, 1981) reported at least three Connecticut warblers during the breeding season at a transect in the eastern part of the study area. These observations would represent an unusual concentration of Connecticut warblers. Presence of several other species characteristic of moist, shrubby habitats (Nashville warbler, golden-singed warbler, common yellowthroat) suggests that the habitat along at least part of the transect is potentially suitable for Connecticut warblers. Two points (19 and 27) were located directly along the transect and several others (18, 31, 32, and 100) were in close proximity. None of them yielded Connecticut warblers or any species that might have been confused with this species.

James Broetzman heard what he believed was a Connecticut warbler at the margin of young aspen and swamp conifers near Point 99. Howe investigated the site several days later and heard (presumably) the same bird. The habitat was dense and neither Howe or Broetzman were able to verify the record with a visual observation. Songs of Connecticut warblers are similar to those of the common yellowthroat, and it is possible that these observations, as well as those of the previous study, represent aberrant individuals of this more common species. On the other hand, presence of appropriate habitat and proximity of observations (Point 99) to the site of previous reports argues that an established local population of Connecticut warblers in the eastern part of the study area is likely.

Tennessee warbler (*Vermivora peregrina*)

The Tennessee warbler is a rare breeding species in Wisconsin, with only a single reported nest record in the Apostle Islands (Robbins, 1991). Despite its scarcity during the breeding season it is an abundant migrant, persisting into late May and occasionally into the first week of June, 1994. Only three confirmed breeding records were reported during the Michigan Breeding Bird Atlas (Brewer, et. al., 1991). Habitat in Michigan and Canada (Peck and James, 1987) consists of coniferous bog with scattered trees (usually black spruce) and shrubs. Habitat of this description occurs along the margin of Duck Lake and in the northeastern corner of the study area. Despite numerous visits to these areas we found no evidence of this species, similar to the results of the Dames & Moore (1981) study. The Wetlands Assessment Report by Normandeau Associates (1982), however, reported at least one Tennessee warbler during June 1981 at their Transect #2, located in a coniferous wetland. No detailed information is available about that observation, which might represent a late migrant. Tennessee warblers have been reported from only three sites in the Nicolet National Forest Bird Survey, one of these, in a northern hardwoods forest, almost certainly representing a late migrant. Chances are slim that this species breeds in the study area.

Evening grosbeak (*Coccothraustes espertinus*)

Evening grosbeaks are irregular and local breeders in northern Wisconsin (Robbins, 1991), where they occur mainly in conifer forests or mixed in hardwood/conifer landscapes. They are recorded regularly during the Nicolet National Forest Bird Survey in both the northern and southern half of the forests, but the number of documented localities is small (five percent of all sites). The study area contains a mosaic of hardwood/conifer forest that is typical habitat for this species.

Evening grosbeaks were observed during all times of the year. Steg, Howe, and Erdman observed flocks of birds in conifer swamps of Sections 29 and 30 (T35N, R13E) during March 1994 and at numerous localities, including the project area, during late August 1994. Previous workers (Dames & Moore, 1981) recorded evening grosbeaks during their spring transects, but not during the summer. Although adults feeding young were observed at Crandon to the north. We recorded individuals at two breeding season point counts (Sites 34 and 35). Although no nests were discovered, evening grosbeaks undoubtedly breed in the vicinity of these points (T35N, R13E, Section 28) or elsewhere in the study area.

Pine siskin (*Carduelis pinus*)

The breeding of pine siskins in Wisconsin is irregular and poorly known, although it is consistently reported from northern Wisconsin during summer. In the Nicolet National Forest Bird Survey it is most consistently recorded at sites located in rural towns; apparently bird feeders have helped establish centers of breeding. Mossman, et. al. (1990) consider pine siskins to be rare in native boreal forest stands in northern Wisconsin. Their survey revealed pine siskins in only one of seven remnant stands. Hoffman and Mossman (1993) recorded siskins rarely in small bogs and lakes and not at all in other types of northern swamps. Hoffman and Mossman (1990) found them only in mature jack pines during their survey of remnant pine stands in State Natural Areas. Pine siskins have been reported from only two of 49 pine-dominated forest sites in the Nicolet National Forest Bird Survey. Erdman observed pine siskins during March 1994, but neither the 1994 study nor the results of previous researchers (Dames & Moore 1981; Normandeau Associates 1982) provides any evidence of nesting by this species in

the study area. If nesting does occur, it is very unlikely within the hardwood-dominated project area.

Black-throated Blue Warbler (*Dendroica caerulescens*)

Black-throated blue warblers are uncommon in northeastern Wisconsin, however its numbers are increasing toward the north (Davis, 1996). Their numbers have increased slightly in Wisconsin between 1966 and 1991 according to the North American Breeding Bird Survey (Robbins, et al, 1996), but decreased between 1982 and 1991. On a continental scale, this species has declined slightly since 1984 (Price, et al., 1995).

Black-throated blue warblers were observed at four widely scattered sites (30, 71, 84, and 94) during the summer of 1994. Although not abundant, black-throated blue warblers occur locally in second-growth hardwoods throughout the study area.

Eastern Meadowlark (*Sturnella magna*)

Eastern Meadowlarks are open country birds that have been the subject of much concern on a statewide and national level. According to the North American Breeding Bird Survey, their numbers have declined 46 percent since 1966. In Wisconsin, a corresponding annual decrease of 2.2 percent has been documented between 1966 and 1991 (Robbins, et al., 1996). Eastern Meadowlarks were observed only once, at the intersection of Keith Siding Road and the Wisconsin Central Railroad tracks (Point 48).

Golden-winged Warbler (*Vermivora chrysoptera*)

Northern Wisconsin might be one of North America's most important strongholds for Golden-winged Warbler, a species that has experienced dramatic declines since 1966 (44 percent in North America; 3.9 percent average annual decline in Wisconsin). Declines of this species might be due to habitat destruction on wintering grounds (Rappole, 1995), but breeding habitat also plays an important role in the population dynamics of such long-distance migrants (Sherry and Holmes, 1995). Golden-winged Warblers favor shrubby habitats, including alder swamps, shrubby forest edges, and tamarack swamps. Beyond its general preference for forest "edge" habitats, specific habitat preferences of this species are not well known. During 1994, this species was observed at 13 census points, including several (3, 4, 17, and 23) in or near the project area.

Veery (*Catharus fuscescens*)

Veeries are characteristic of moist forests, ranging from shrubby riparian woodland to relatively mature upland forests. This species is still relatively common and widespread in northern Wisconsin, but their numbers in the state have declined steadily (2.5 percent annually) since 1966. This decline parallels a continent-wide trend.

Veeries were recorded at 27 census points (30 individual counts) during 1994, making it the 15th most abundant bird species observed during the investigation. Individuals were observed through much of the proposed project area.

Vesper Sparrow (*Pooecetes gramineus*)

Vesper sparrow is an open country bird that occurs more commonly in southern Wisconsin than in northern Wisconsin. Like many grassland species, its numbers have declined during the past several decades (4.7 percent annually in Wisconsin according to Robbins, et al. (1996)).

The vesper sparrow was recorded in the pine plantation south of Swamp Creek and at Census Point 111. Both of these sites offer appropriate habitat and the species probably breeds there (as well as in other open, sparsely wooded fields in the vicinity of the study area).

Nashville Warbler (*Vermivora ruficapilla*)

Nashville Warblers are among the most widespread and common bird species in northeastern Wisconsin forests. In the Nicolet National Forest, it ranks as the sixth most abundant species. Statewide, Nashville Warblers have declined nearly 6 percent between 1982 and 1991 (Robbins, et al., 1996). A 21.5 percent decline has been documented since 1984 across North America.

The Nashville Warbler was observed at 54 bird census points, including the area around Duck Lake and Skunk Lake. Nashville Warblers favor moist, swampy forests, but they also occur in upland forests imbedded with wetlands or moist openings.

Red-headed Woodpecker (*Melanerpes erythrocephalus*)

Although no Red-headed Woodpeckers were recorded during the formal point counts, individuals were observed in the vicinity of Duck Lake and Sand Lake. The status of these birds is unknown, but oak dominated woodlands around the lakes might provide suitable breeding habitat for pairs of Red-headed Woodpeckers. This is not a deep forest species, and changes in the forest landscape, especially if oak woodlands were created, could in fact favor Red-headed Woodpeckers, a species that has declined dramatically during recent years both in Wisconsin and elsewhere in North America (Robbins, et al., 1996).

Cooper's Hawk (*Accipiter cooperii*)

Cooper's Hawks are resident in the study area, and breeding has been documented by Erdman's discovery of a nest during 1994. Observations were concentrated in the heavily wooded areas west and south of Oak Lake. Fragmentation of the forest resulting from mine construction will reduce feeding habitat for this raptor. On the other had, Cooper's Hawks seem to be recovering from a mid-century decline, and are becoming more common in residential and other highly disturbed environments.

Blue-winged Teal (*Anas discors*)

Next to Mallards, Blue-winged Teal are among Wisconsin's most widespread breeding ducks. This species was encountered at wetland Z2 during June, suggesting that a small number of pairs might breed in the study area. No teal were encountered at other wetlands or lakes, however, so Blue-winged Teal cannot be considered to be an important element of the area's avifauna. Even during migration, teal were not commonly observed anywhere in the study area. According to Robbins (1991), Blue-winged Teal are less common in northeastern Wisconsin than elsewhere in the state, an observation that is consistent with the study findings.

3.9.5.4 Butterflies

3.9.5.4.1 Endangered and Special Concern Species

A total of 50 species of butterflies were observed in the study area. Of these one state endangered and 13 state special concern species were encountered. Individual species accounts of each of these are presented in the following paragraphs. Tom Rocheleau (1994), through his surveys over the last ten years west of the project area and east of Mole Lake, has recorded seven special concern species, one species (inornate ringlet) which was in 1995 reported to be under consideration for deletion from the Special Concern List, and one species (saepiolus [greenish] blue) which was in 1995 reported to be under consideration for addition to the Special Concern List in 1995. This list is presented in Appendix 3.9-1 with a WDNR internal memorandum from Chuck Pils, dated April 18, 1995. A review of the April/May 1995 Wisconsin Natural Heritage Working List shows that the inornate ringlet is still on the list and that the greenish blue has been added to the list.

West Virginia white (*Pieris virginiensis*)

The West Virginia white occurs in moist deciduous woods from north-central Wisconsin to Massachusetts, and south through the Appalachians to Georgia and Alabama (Opler and Krizek, 1986). Adults are present during a single flight period in the spring, from late April to mid-June in the northern parts of its range. The only known larval host plants are toothworts *(Dentaria* spp.). It is similar in appearance but genetically distinct from the more common mustard white *(Pieris napi)*, with which it differs in several respects; West Virginia white has 26 rather than 25 chromosomes (Scott, 1986) and has only one rather than two flight periods. This species was not known from Wisconsin until it was collected in 1967 in a rich maple forest of Vilas County (Ebner, 1970). Ferge (1990) considers it to be rare and local in the state.

West Virginia white was conspicuous in the study area in mesic woods of mostly sugar maple, where the larval food plants, *Denteria diphylla* and *D. laciniata,* were found. The first flying individuals were seen in early May; maximum presence occurred during May 12-20, with numbers rapidly declining thereafter. The flight effectively ended by May 25, except for a very few stragglers seen over the next few days. During the peak flight period individuals were seen in other habitat types, including the open bog around Duck Lake, the edges of conifer swamps, and along roads near the mesic woods. Overall, several thousand individuals were seen in the study area.

Northern blue butterfly (*Lycaeides idas nabokovi*)

Northern blue is found in northern parts of North America, extending south through western mountain ranges into California and Colorado. The subspecies northern blue is restricted to the Great Lakes region (Scott, 1986), where it occurs in very local populations associated primarily or exclusively with its larval host plant, dwarf bilberry (*Vaccinium caespitosum*). Wolf (1993) identified eight localities in Wisconsin and approximately 12 (including historical records) in Minnesota, Ontario, and Michigan's Upper Peninsula. The specialization of this subspecies on a single host plant suggests that it might represent a distinct species.

This species was discovered incidentally by one of the bird researchers *en route* to a census point. Subsequent investigations revealed a small local population along county line road in a dry

"barrens" clearing on dry, sandy soil with scattered red pine and jack pine, bracken fern, blueberry and other typical "barrens" species. A small population of dwarf bilberry was located by botanists in this habitat. Northern blue butterflies were found near the host plants and scattered over at least ¼ mile within a strip of barrens. A few individuals also were found along a narrow sandy road for nearly ¼ mile to the west. No additional colonies of dwarf bilberry were found in this area. Population size of the butterflies was not easy to assess from our limited visits.

Wolf (1993) reports an historical record (UW-Madison entomological collection) from Langlade County, but she failed to re-locate the species there. Our finding appears to represent a separate locality. The number of extant Wisconsin localities for northern blue now totals nine.

Inornate ringlet (*Coenonympha tullia inornata*)

Inornate ringlet is a widespread species with significant geographic variation. The subspecies inornate ringlet occurs in Wisconsin, northeastern Minnesota, eastern Canada, and south into New England (Scott, 1986). This form intergrades with other subspecies in western North America. A variety of host plants are used in the western U.S., mainly grasses, but larval hosts for the eastern subspecies are not documented (Opler and Krizek, 1986). Habitat includes open grassy fields, marsh edges, and openings along the edge of forests. Opler and Krizek (1986) note that individuals occasionally occur within young second-growth woods. Ebner (1970) reports a single record from Wisconsin (Burnett County), suggesting that the species might invade Wisconsin irregularly from the north during certain years. More recent records have been documented in northeastern Wisconsin (Howe, personal observation); Ferge (1990) lists its status as unknown.

Inornate ringlets were found at two locations in the study area. The first was on dry sandy soil in a plantation of young pines. The vegetation of openings in the plantation is typical for sandy "barrens" in northeastern Wisconsin, including poverty oatgrass *(Danthonia spicata)*, *Carex rugosperma*, Canada bluegrass (*Poa compressa*), Kentucky bluegrass *(Poa pratensis)*, orange hawkweed (*Hieracium aurantiacum*), yellow hawkweed (*H. florentinum*), sweet fern *(Comptonia peregrina)*, and blackberry *(rubus spp.)*. Approximately 10-15 individuals were observed, suggesting that the population is small but probably well established.

The second locality for ringlets in the study area was a small bog, where a single individual was caught on July 5, 1994. This individual probably wandered into the bog from adjacent grassy roadsides; no additional individuals were found in this vicinity.

Dorcas copper (*Epidemia dorcas*)

Ebner (1970) reported that little is known about the dorcas copper in Wisconsin, noting also that its life history is "a mystery at this time." The first state records were collected in "the wilderness area at Argonne in Forest County" in 1933 (Ebner, 1970). Ferge (1990) lists this species as resident in northern Wisconsin but rare or local in occurrence. Opler and Krizek (1986) identify shrubby cinquefoil (*Potentilla fruticosa*) as its only documented host plant in eastern North America, but they suggest that other plants (primarily cinquefoils) are used elsewhere in the species' range. Dorcas coppers have a single flight period and are very closely related to the more southern, multiple-brooded purplish copper (*E. helloides*), from which it probably separated during the Ice Ages (Opler and Krizek, 1986).

Shrubby cinquefoil is rare in northern Wisconsin and has not been found in the study area. Nevertheless, we collected dorcas coppers at two localities, one a typical bog and the other a boggy wetland near a lake. It seems likely that the host plant here is marsh-potentilla (*Potentilla palustris*), which is common in local bogs. Individuals were collected during a very short flight period in early July.

Bog copper (*Epidemia epixanthe*)

The range of the bog copper is even more restricted than that of the dorcas copper. It's primary habitat is cranberry bogs in northeastern North America, from Newfoundland and the Maritime Provinces through Quebec and Ontaria to Minnesota, then south through Wisconsin, Michigan, and east to New Jersey (Opler and Krizek, 1986; Scott, 1986). Its host plants are cranberries, small cranberry (*Vaccinium oxycoccus*) and cranberry (*V. macrocarpa*). Like other rare butterflies, the bog copper has a single flight period, typically during early July in Wisconsin (Ferge, 1990). Only a few colonies are known from Wisconsin; Ebner (1970) mentions records from Door, Burnett, Chippewa, and Forest Counties. Bog coppers were collected from three bogs within the study area. Flight times were brief (early July), but sizeable populations seem to be present.

Greenish blue (*Plebejus saepiolus*)

The greenish blue is associated with open sites, on both moist and dry soils. Opler and Krizek (1986) list bogs, moist open fields, and roadsides as habitats, and Scott (1986) refers to "moist meadows and stream sides." It is likely that roadsides are important habitats in forested regions like northern Wisconsin, because the larval food plant is generally considered to be clover, especially alsike clover (*Trifolium hybridum*). All clovers in northern Wisconsin generally do not occur under forest canopies and would rarely be found anywhere except along roadsides or in artificial clearings of relatively recent disturbance. In Wisconsin the greenish blue is found mainly in the northern counties where Ebner (1970) considers it to be "relatively plentiful." According to Ebner, "fields of flowers and dry hillsides are suitable collecting spots, but it also flies at the very edge of roadsides and forests." This is an abundant species in the Rocky Mountains of western North America (Ebner, 1970).

During this investigation a single specimen was collected in the pine plantation where the inornate ringlet also was found (see above). The population size is unknown, but appears to be very small. No other individuals were identified or collected during the study period.

Pepper and salt skipper (*Amblyscirtes hegon*)

The preferred habitat for the pepper and salt skipper appears to be forest edges and openings and the margins of bogs or boggy streams (Opler and Krizek, 1986). Larval food plants include a variety of grasses (Opler and Krizek, 1986; Scott, 1986), of which the only species that seems likely for the study area is Kentucky bluegrass. The geographic range of this species encompasses much of eastern North America, although it is not evenly distributed (Opler and Krizek, 1986) and is more common in northern states. Ferge (1990) considers its status to be unknown in Wisconsin, where it is known from the northern and eastern regions. Ebner (1970) reports that it was once a common resident in the Milwaukee and Racine areas, but now (in 1970) is known only from Shawano and Marinette Counties. A single individual was collected on

June 8, 1994 in a forest opening in the study area. The status of this species here is unknown, but a local population probably persists nearby.

Tawny crescent (*Phyciodes batesii*)

Although not included in our preliminary list of target species, the tawny crescent is considered to be an extremely localized species that has disappeared from much of its former range (Opler and Krizek, 1986) which extends from southeastern Canada to New England, Nebraska, and Minnesota. Studies of captive individuals (Oliver, 1979) showed tawny crescents to be reproductively isolated from the abundant pearl crescent (*Phyciodes tharos*), which it closely resembles. Host plants appear to be asters (*Aster* spp.). Ferge (1990) lists the status of tawny crescent as unknown in Wisconsin, where it occurs in damp openings of the northern and central parts of the state. Ebner (1970) identifies three records from Wisconsin in Marinette, Forest, and Burnett Counties.

Descriptions of habitat for the tawny crescent include moist openings and "drier sites such as slopes with little vegetation" (Scott, 1986). In this survey the tawny crescent was found during late June and early July at two localities. One was on a dry, sandy barrens with blackberry (*Rubus allegheniensis*), bracken fern (*Pteridium aquilinum*), sweet fern (*Comptonia peregrina*), and blueberry (*Vaccinium angustifolium*). The second collection came from a dry sandy forest road with both wet and dry habitats adjacent. Only two specimens have been verified, and size of these local populations is unknown.

Mustard White (*Pieris napi*)

The mustard white occurs generally in deciduous woods, bogs, and open fields from New England across the Great Lakes area to the Rocky Mountains and central California (Opler and Krizek, 1986). Ferge (1990) reported that the mustard white is found in forested locations in the northern and southeastern portions of Wisconsin. Its flight time ranges from early May to July.

The mustard white was collected on the site, but was not seen in abundance. Two specimens were collected within the study area. One was collected in the woods surrounding Duck Lake, and the other was collected just south of Skunk Lake. The population size of the mustard white is unknown and appears to be very small.

Bog Fritillary (*Boloria eunomia*)

The habitat for bog fritillary is very wet *Spagnum* bog with abundant *Sarracenia* and *Drosera*. Based on surveys conducted in 1994 and 1995, this type of bog was found to be relatively uncommon in northeastern Wisconsin. This species was only found within a narrow range from Laona to Summit Lake. Of seven sites in which this species was observed, three were in the study area.

Freija Fritillary (*Boloria freija*)

The freija fritillary flies during late May (Ferge, 1990) or early June (Masters, 1968). From analysis of sites where it is known to occur in Oneida and Douglas Counties, it appears that this species prefers somewhat dry *Spagnum* bogs with tall growths of heaths. Despite extensive searches of bogs in the study area in both 1994 and 1995, no individuals were found.

Frigga Fritillary (*Boloria frigga*)

The frigga fritillary is very rare and appears restricted in northeastern Wisconsin to poor fens containing *Betula pumila* and *Salix pedicellaris*. This species was observed in 1995 by the study team at two locations in the region. No appropriate habitat is known in the project area and only one potential site is known in the study area. Neither the 1994 or 1995 surveys resulted in any observations in the study area or project area.

Red-disked Alpine (*Erebia discoidalis*)

It appears that this species prefers large bogs with abundant *Carex oligosperma*. No suitable habitat exists in the project area and only one site in the study area appears to have the potential to support this species. Neither the 1994 or 1995 surveys resulted in any observations in the study area or project area. However, the red-disked alpine has been collected in the region in an open bog along Highway 17, about 5 miles north of Rhinelander (Ebner, 1970).

Jutta Arctic (*Oeneis jutta*)

The habitat for jutta arctic is open spruce bogs with abundant growth of *Eriophorum spissum*, the main host plant for this species. This species is markedly biennial, with most individuals appearing in odd-numbered years. In 1995, this species was observed in the majority of the suitable sites inventoried, including six sites within the study area. No individuals were observed in the project area.

3.9.5.5 Herptiles

Of the seven targeted herptile species potentially existing in the study area only two were observed; the four-toed salamander and the ringneck snake, both are state special concern species. Individual species accounts are presented in the following paragraphs for each of the targeted species.

3.9.5.5.1 Salamanders

Four-toed salamander (*Hemidactylium scutatum*)

Four-toed salamanders are an extremely secretive species for which no adequate survey methods exist. They were first discovered in Minnesota in 1994 (Moriarty, 1994). There are widely scattered, isolated records throughout Wisconsin (Casper, 1993; Vogt, 1981). Habitat descriptions are varied (see summary in Casper, 1993), but most have a common factor of mossy wetlands in hardwood forest.

Four-toed salamanders were found in the study area on visual encounter surveys and by pitfall trapping near Duck Lake and in the TMA. This represents the first recorded observation for Forest County (Casper, 1995). One specimen was found underneath a rock in a maple (*Acer* sp.) dominated upland approximately 100 meters from the Duck Lake bog. Other specimens were collected in a pitfall trap situated in a moss hummock in a shrub-carr wetland dominated by white ash (*Fraxinus pennsylvanica*), spiraea (*Spiraea latifolia*), and willows, and surrounded by maple dominated uplands. These habitats are typical of the study area, and four-toed salamanders should be considered uncommon in the project area in any wetlands with a strong moss component adjacent to hardwood or mixed forest.

The Wisconsin Herptile Atlas (Casper, 1995) also has undocumented Forest County records from the 1950s. Additional records are available from Oconto County in 1949, central Oneida County in 1993 and 1994, and Vilas County in 1964, 1976, and 1986. Vogt (1981) reported them from Forest and Oconto Counties. Four-toed salamanders were not found by Dames & Moore (1985).

3.9.5.5.2 Frogs and Toads

Bullfrog (*Rana catesbeiana*)

Bullfrogs have been recorded statewide from a wide variety of permanent wetlands (Casper, 1995; Vogt, 1981). They are apparently absent from the study area, but there are numerous records for the region. Vogt (1981) gives records for all counties bordering Forest County except Langlade. Other records are available for Oneida and Marinette County (Casper, 1995). Bullfrogs were absent from a Laona (Forest County) and two Oneida County frog and toad survey routes, but present at five stops on a McNaughton (Oneida County) frog and toad survey route in 1984 (Mossman & Hine, 1985). Bullfrogs could potentially be uncommon to rare in any permanent waters within the study area.

Pickerel frog (*Rana palustris*)

Pickerel frogs have been recorded statewide, and are associated with wet meadows and springs (Casper, 1995; Vogt, 1981). They are apparently absent from the project area, but there are records for the study area. Vogt (1981) gives records for Marinette and Langlade Counties. They were absent from a Laona (Forest County) and three Oneida County frog and toad survey routes in 1984 (Mossman & Hine, 1985). Pickerel frogs could potentially be uncommon to rare in any permanent waters within the study area, especially those associated with wet meadows.

3.9.5.5.3 Turtles

Wood turtle (*Clemmys insculpta*)

Wood turtles are protected as a threatened species in Wisconsin, where they occupy streams and rivers in forested habitat throughout the northern three quarters of the state (Casper, 1995; Vogt, 1981). Availability of sandy, sun-exposed slopes for nesting may be a limiting factor in their distribution. They are easy targets for illegal collection by the pet trade. This species was not recorded during this study, but there are numerous records for the adjacent counties and appropriate habitat exists within the study area. Vogt (1981) gives records for Forest, Marinette, Menominee, Oconto and Oneida Counties. The Wisconsin Herptile Atlas (Casper, 1995) has additional records for Forest, Florence, Menominee, Oconto, Oneida, Shawano and Vilas Counties. There are records for the Wolf River in southern Menominee and southern Shawano Counties from 1987, 1989 and 1990 (Casper, 1995). Given this pervasive presence in the region and the watershed, wood turtles may very well occupy Swamp Creek and/or Hemlock Creek within the study area. If present, they are probably uncommon to rare in the study area, with a low population density.

Blanding's turtle (*Emydoidea blandingii*)

Blanding's turtles are protected as a threatened species in Wisconsin, where they are most abundant in shallow to deep marsh or shallow bog (Congdon, et. al, 1983; Gibbons, 1968; Graham & Doyle, 1977; Kofron & Schreiber, 1985; Lincke, et. al, 1989; MacCulloch & Weller, 1988; Ross, 1985; Ross & Anderson, 1990; Rowe, 1987; Rowe & Moll, 1991), habitat which is rare within the study area. They are found throughout Wisconsin, but are uncommon in the northcentral and northeast regions (Casper, 1995; Vogt, 1981). This species was not recorded during this study. Blanding's turtles were once considered absent from the region (Vogt, 1981), but records for the region are accumulating fast (Casper, 1995), and it is now considered rare and local in northeastern Wisconsin. The Wisconsin Herptile Atlas (Casper, 1995) has recent records for Florence, Forest, Marinette, Menominee, Oconto, Oneida, and Shawano Counties. Based on habitat availability and the absence of this species during 1994 turtle trapping and visual encounter surveys, it is considered unlikely to occur within the study area, but its presence cannot be ruled out. If present, Blanding's turtles should be uncommon to rare within the study area.

3.9.5.5.4 Snakes

Northern ringneck snake (*Diadophis punctatus edwardsii*)

This target species is known throughout the region in moist deciduous forests (Casper, 1995; Vogt, 1981). There are records from Florence, Forest, Langlade, Marinette, Oconto, Oneida and Shawano Counties. An extremely secretive, fossorial species, they often appear to be absent in areas where they are in fact common. Two specimens were encountered in this study. One was crossing a road on a rainy evening in a region of cutover, mixed and deciduous forest with scattered housing. The other specimen was found in a grassy field in mixed, cutover forest, within 50 meters of a coniferous swamp and 50 meters of a shallow to deep marsh, within the project area. Northern ringneck snakes are associated with mixed and deciduous forest in northern Wisconsin, and the typical maple-birch dominated uplands within the project area are good habitat. Based on the two individuals found during 1994 surveys, this species is expected to be uncommon to common throughout the study area in mixed and deciduous woods. There has been some concern over the impact of logging to this species, which is thought to prefer mature deciduous stands (Vogt, 1981). Habitat fragmentation due to clearcutting may impact this species in the study area. Northern ringneck snakes were not recorded by Dames & Moore (1985).

Northern ribbon snake (*Thamnophis sauritus septentrionalis*)

This rare snake is known from only a few records in Wisconsin, where it is protected as an endangered species (Casper, 1995; Vogt, 1981). All records for northern ribbon snakes in Wisconsin are from open bogs with floating sphagnum mats and tamarack, a habitat much more common than is the snake. Records from Marinette and Oconto Counties warranted surveys for this species in the project area, but no northern ribbon snakes were found. Bog mats searched included wetlands F28, F66, and F16. It is considered rare or absent from the study area.

3.9.6 Natural Areas

State Natural Areas are tracts of land and water containing remnants of presettlement native biotic communities, unique biotic features, or significant geologic or archaeological sites. State Natural Areas are natural areas of statewide significance designated or dedicated under the provisions of Chapters 23.27 and 23.29, Wis. Stats. There are no designated or dedicated State Natural Areas within the study area. Past project inventories identified four areas having some county or local interest. None of these areas are currently being pursued for inclusion in the State Natural Areas program. The following comments describe the current status of these four areas based on the biological studies conducted in 1994.

3.9.6.1 Oak Lake (Forest County, T35N R12E NW/4 Section 36).

As noted in the 1986 *Environmental Impact Statement*, this is a "deep, clear, soft water seepage lake with high transparency". Aquatic macrophyte productivity is generally low as may be expected for this type of lake. The most notable biological feature is the well developed community of small bottom-dwelling species, including waterwort *(Elatine minima, E. triandra),* pipewort *(Eriocaulon septangulare),* spiny-spored quillwort *(Isoetes echinospora),* deep-water quillwort *(Isoetes macrospora), Juncus pelocarpus,* water lobelia *(Lobelia dortmanna), Myriophyllum tenellum,* and resupinate bladderwort *(Utricularia resupinata).* Resupinate

bladderwort, a Wisconsin Special Concern Species, was not noted for Oak Lake in the previous surveys (Dames & Moore, 1985). The best development of these species is along the north and west edges of the lake. Other aquatic plants are conspicuously sparse.

Another notable feature of Oak Lake is the abrupt sandy beach ridge with adjacent swale which extends prominently along the shoreline from the northeast corner counterclockwise to the south end of the lake, with a few interruptions. The top of the ridge is dry and supports some large bur oaks and a few pines. The swale (only one is obvious, but it is broken into several different units by local contour) varies from areas heavily dominated by dense growth of sedge species to seasonal pools which are dry in mid-summer and support sparse ruderal species. No rare species were found in association with either the ridge or swale.

3.9.6.2 Swamp Creek Cedars (Forest County, T35N R13E Sections 19, 20, 29, and 30)

This is a good quality conifer swamp of mostly white cedar, black spruce, balsam fir, and tamarack, with some speckled alder, black ash and hemlock. There is a population of calypso orchid (Wisconsin Threatened Species) in the more mature stands of white cedar in Section 30 and probably ranging north into Section 19. The diverse ground layer also includes the Wisconsin special concern species northern bog sedge, sheathed sedge, marsh horsetail, *C. vaginata,* Canadian black currant and American yew. The area is an important corridor for breeding bird species, including neotropical migrants such as Canada warbler, black-and-white warbler, norther parula, and olive-sided flycatcher. Recent logging on Forest County land in Section 30 appears to threaten the calypso orchid population, which requires relatively mature white cedar trees and full canopy.

3.9.6.3 Burr Oak Swamp (Forest County, T35N R13 SW/4 Section 29)

The area called "Burr Oak Swamp" is difficult to place in a conventional community type. The field studies indicated that this area did not appear to provide habitat for any listed plant species. The area is a sparse, patchy forest of bur oak, red maple, black ash, green ash, and american elm with a ground layer of herbaceous species typical of wetlands. Large sedges dominate the canopy openings and include *Carex lacustris* and probably *C. rostrata.* Virtually all of these large sedge plants were sterile in 1994. Other conspicuous species include red-berried elder *(Sambucus pubens),* prickly gooseberry *(Ribes cynosbati),* winterberry *(Ilex verticillata),* northern blueflag *(Iris versicolor),* orange touch-me-not *(Impatiens biflora),* hispid hedgenettle *(Stachys hispida),* marsh skullcap *(Scutellata galericulata), Sium suave, Carex crinita,* wool grass *(Scirpus cyperinus),* blue-joint grass, cinnamon fern *(Osmunda cinnamomea)* and wild red raspberry *(Rubus strigosus).*

3.9.6.4 Upper Pickerel Creek (Langlade County, T34N R12E W/2 Section 2 and E/2 Section 3)

Some parts of the upland portion of this complex have apparently been logged since the previous studies. Scattered pines are still present, but this forest is somewhat disturbed and no listed plant species were noted during 1994.

The conifer swamp along Pickerel Creek is still relatively intact and supports a diverse flora, including the Wisconsin threatened *Calypso bulbosa* and the special concern species northern bog sedge, sheathed sedge, Canadian black currant and American yew. In addition, the lower portion of Pickerel Creek near its mouth at Rolling Stone Lake in the NW/4 of Section 11 (within

approximately 1/4 mile of the area described above) also supports a population of the Wisconsin Endangered Species small yellow water crowfoot *(Ranunculus gmelinii)*. The area is inhabited by bobcat and numerous neotropical migrant bird species.

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FIGURES FOR SECTION 3.9

2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N 125,000 N 120,000 N 115,000 N 110,000 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- APPROXIMATE TERRESTRIAL ECOLOGY STUDY BOUNDARY

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY: JKSI DATE: MAY '95
APPROVED BY: RFS DATE: MAY '95
APPROVED BY: GWS DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-1
TERRESTRIAL ECOLOGY STUDY AREA

Scale: 0 1500' 3000' Date: MAY, 1995
Prepared By: Foth & Van Dyke By: BSH

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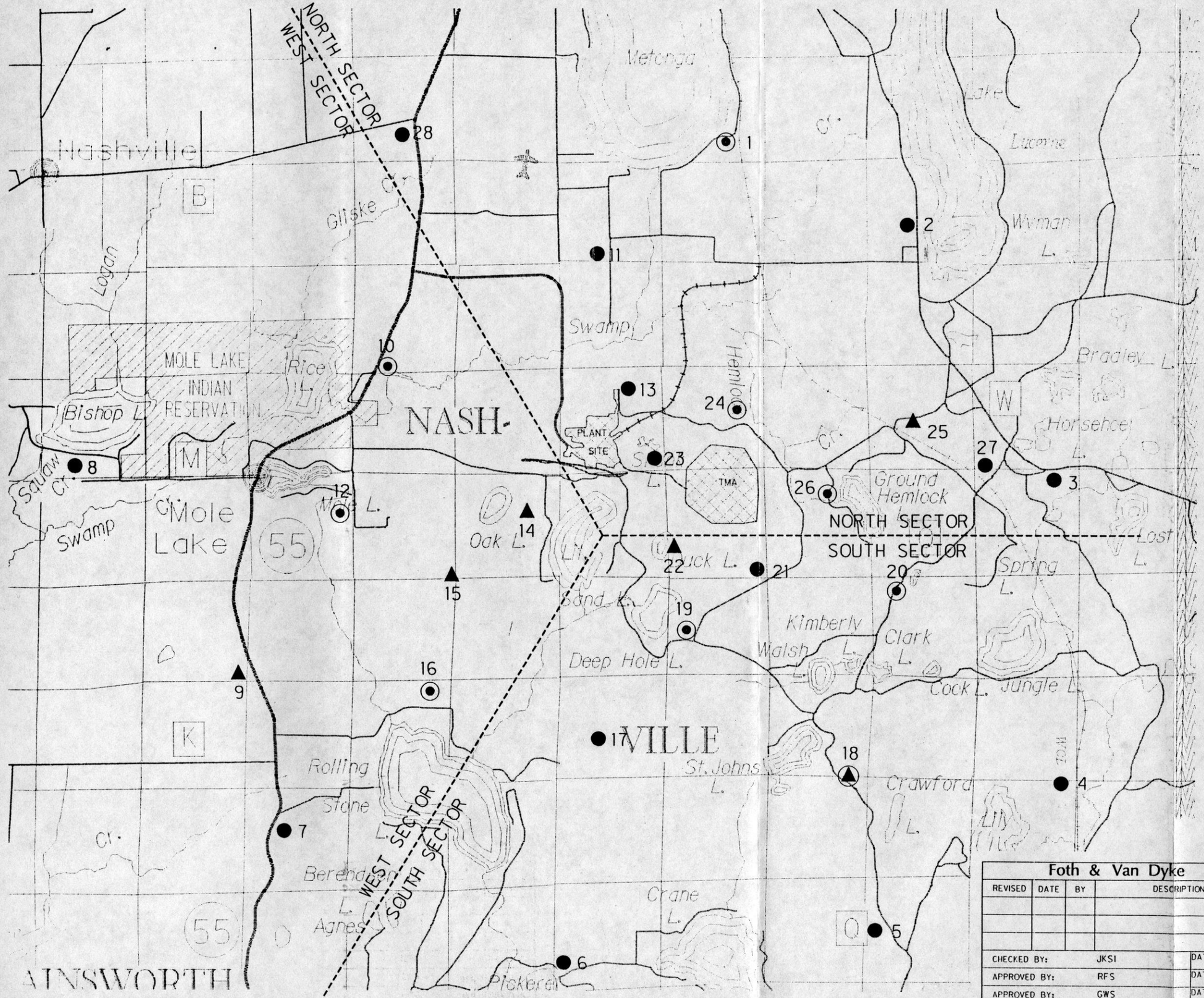
93C049



LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- (M) COUNTY HIGHWAY LETTER
- NATIONAL & STATE FOREST BOUNDARY
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CIRCLED SITES AS SHOWN ARE THOSE SAMPLED IN 1994 AND 1978
- MATERIAL COLLECTED IN 1978 USED FOR COMPOSITE SAMPLE
- MATERIAL COLLECTED IN 1978 USED FOR INDIVIDUAL AND COMPOSITE SAMPLE
- COMPOSITE SECTOR BOUNDARY

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. NO SAMPLES WERE COLLECTED AT LOCATION 17 DUE TO INACCESSABILITY.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

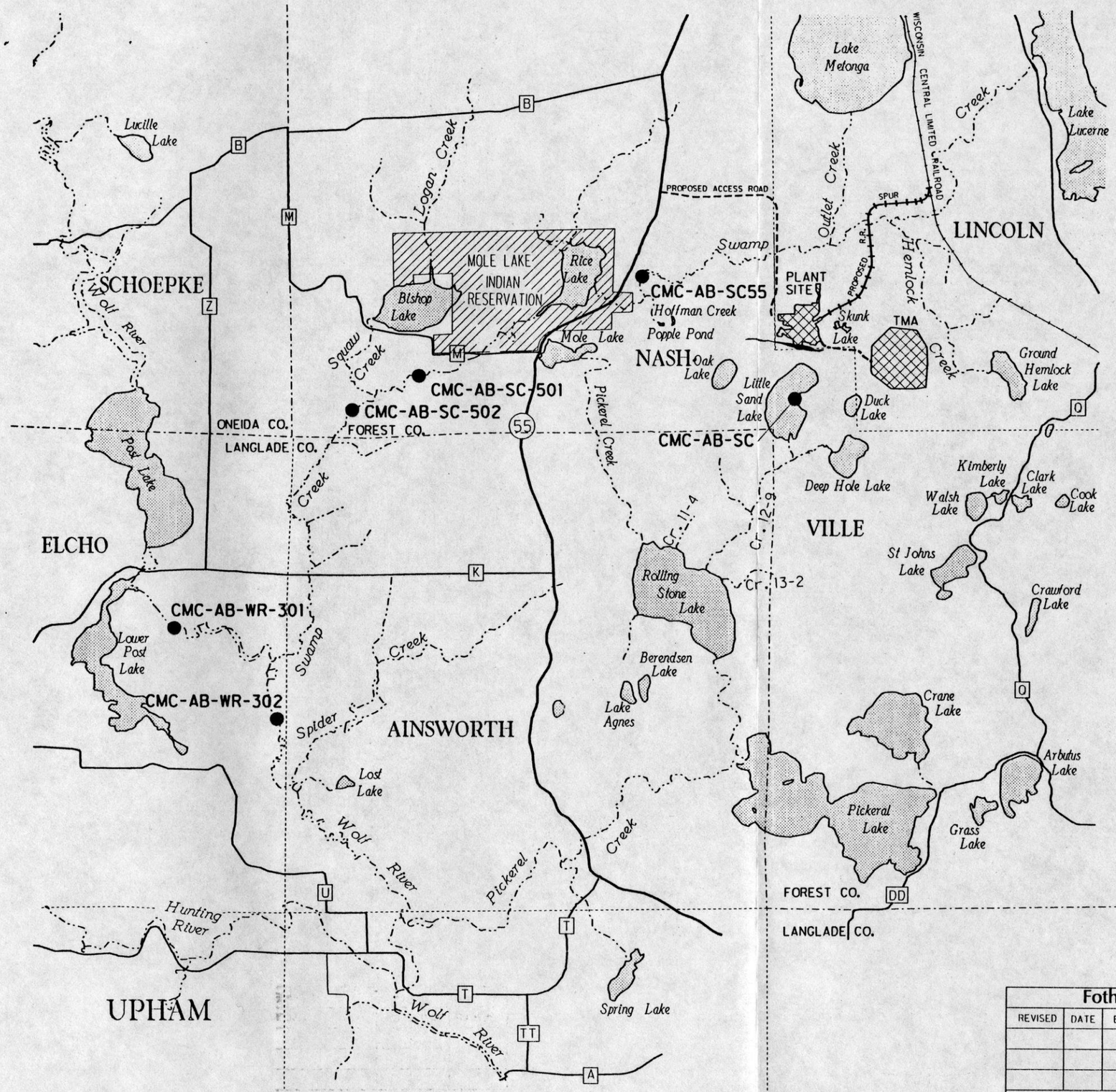
Crandon Mining Company

FIGURE 3.9-2
VEGETATION SAMPLING LOCATIONS FOR HEAVY METAL ANALYSIS

Scale: 0 2500' 5000' | Date: APRIL, 1995

Prepared By: Foth & Van Dyke | By: BSH

93C049



N

LEGEND

- STATE HWY (47)
- COUNTY TRUNK HWY (W)
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- LAKES
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- CMC-AB-WR — SAMPLING LOCATION

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:		JKSI		DATE: MAY '95
APPROVED BY:		RFS		DATE: MAY '95
APPROVED BY:		GWS		DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-3

AQUATIC MACROPHYTE SAMPLING LOCATIONS FOR HEAVY METAL ANALYSIS

Scale: 0 3750' 7500' | Date: APRIL, 1995

Prepared By: Foth & Van Dyke | By: JRB2

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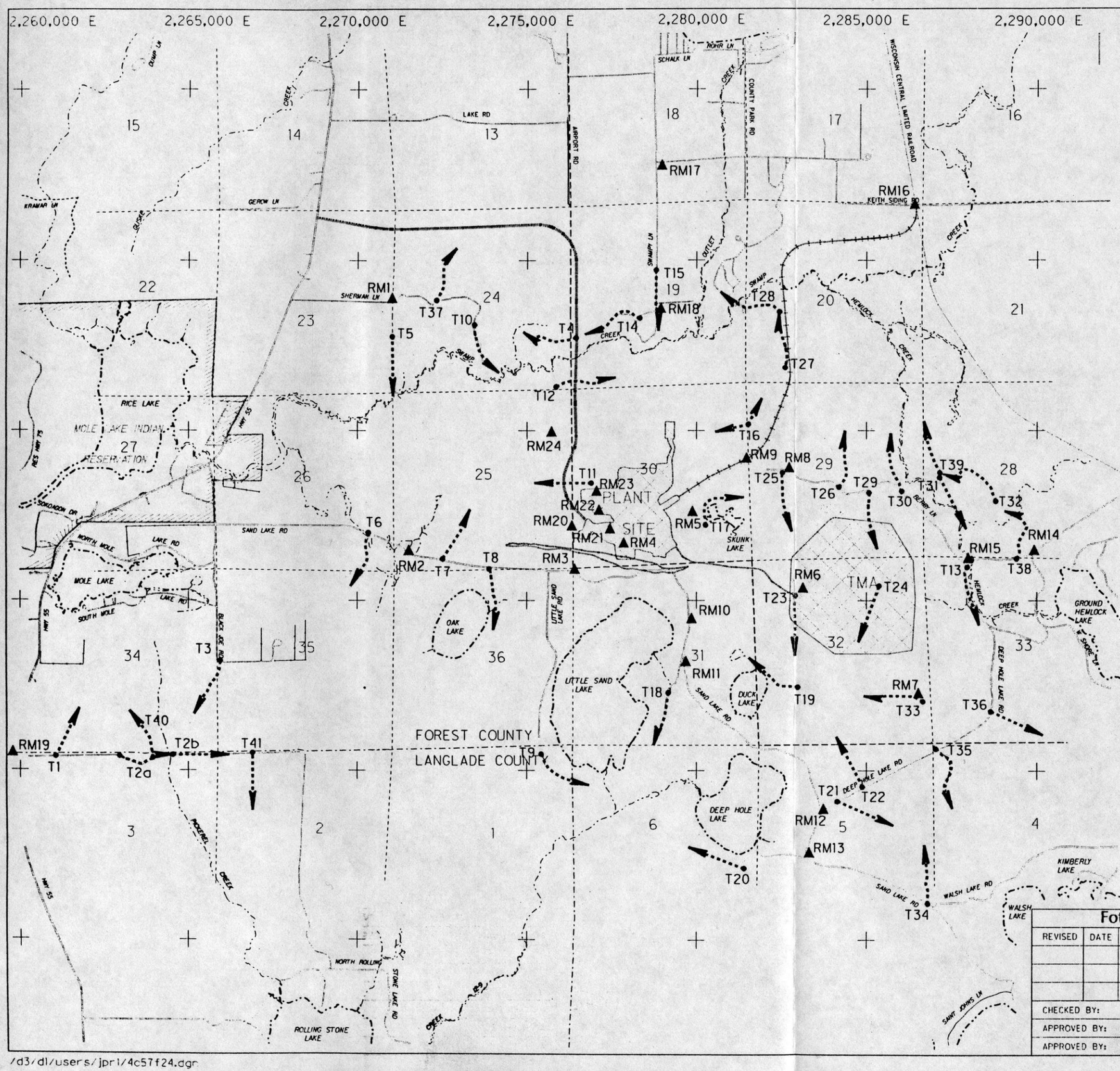
93C049



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- T1 MAMMAL TRACKING TRANSECTS
- RM24 REFERENCE MARKERS

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-4

MAMMAL TRACKING ROUTES

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: BSH

/d3/dl/users/jpr1/4c57f24.dgn

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2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 10 PITFALL TRAP
- 17 SNAP TRAPS AND LIVE TRAPS IN ASSOCIATION WITH PITFALL TRAPS
- SNAP TRAP TRANSECTS
- L WATER SHREW TRAPS

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-5
SMALL MAMMAL
TRAPPING LOCATIONS

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: BSH

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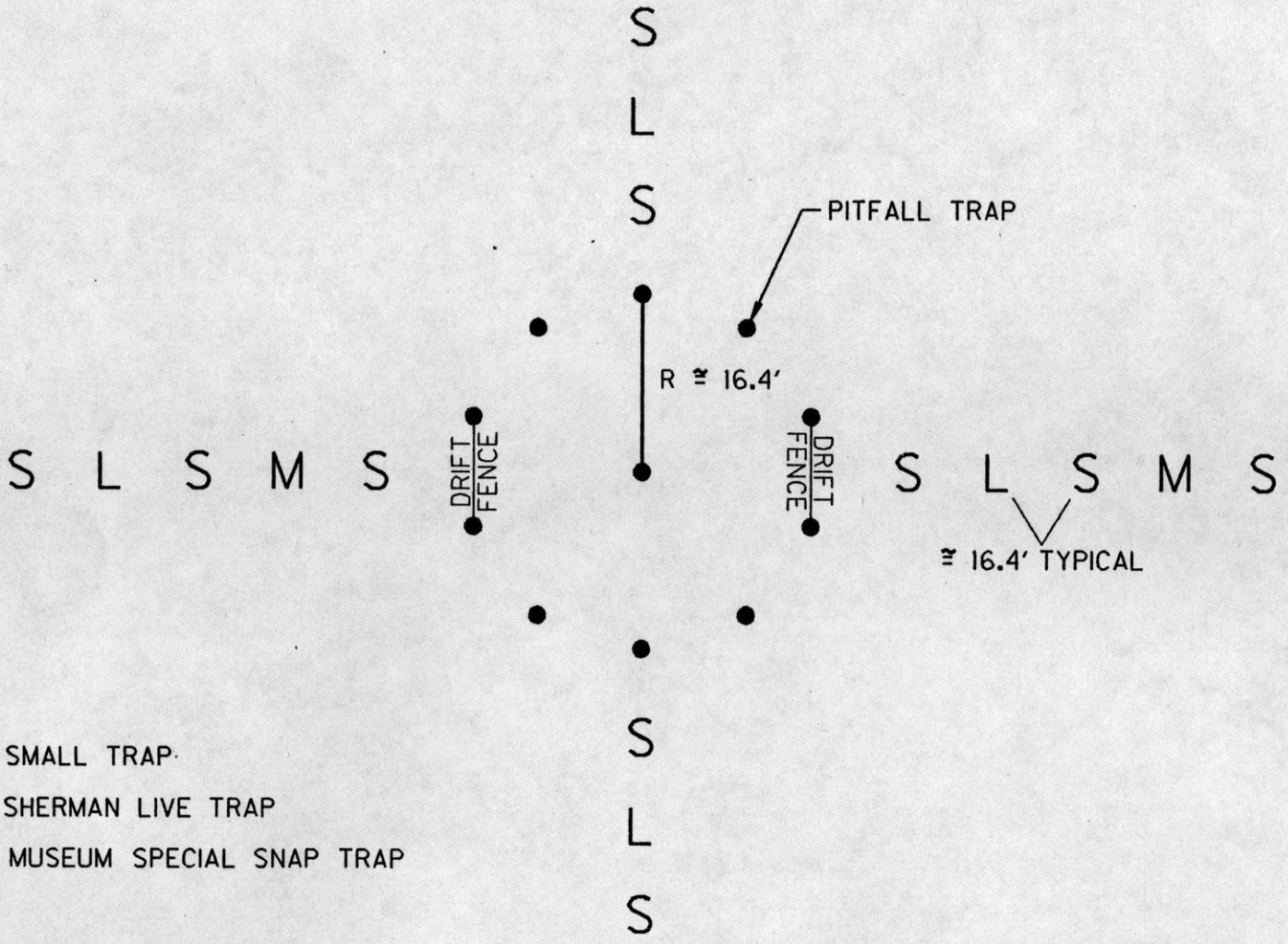

S = SMALL TRAP

L = SHERMAN LIVE TRAP

M = MUSEUM SPECIAL SNAP TRAP

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-6

MAMMAL TRAPPING STATION LAYOUT

Scale:	NOT TO SCALE	Date:	APRIL, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C049

2,260,000 E | 2,265,000 E | 2,270,000 E | 2,275,000 E | 2,280,000 E | 2,285,000 E | 2,290,000 E

130,000 N | 125,000 N | 120,000 N | 115,000 N | 110,000 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 26 PINE MARTEN TRAPPING LOCATION

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

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APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-7

PINE MARTEN TRAPPING LOCATIONS

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: BSH

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2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- (50) SURVEY POINT AND NUMBER

N

NOTES:

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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-8

RED-SHOULDERED HAWK SURVEY LOCATIONS

Scale: 0 1500' 3000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

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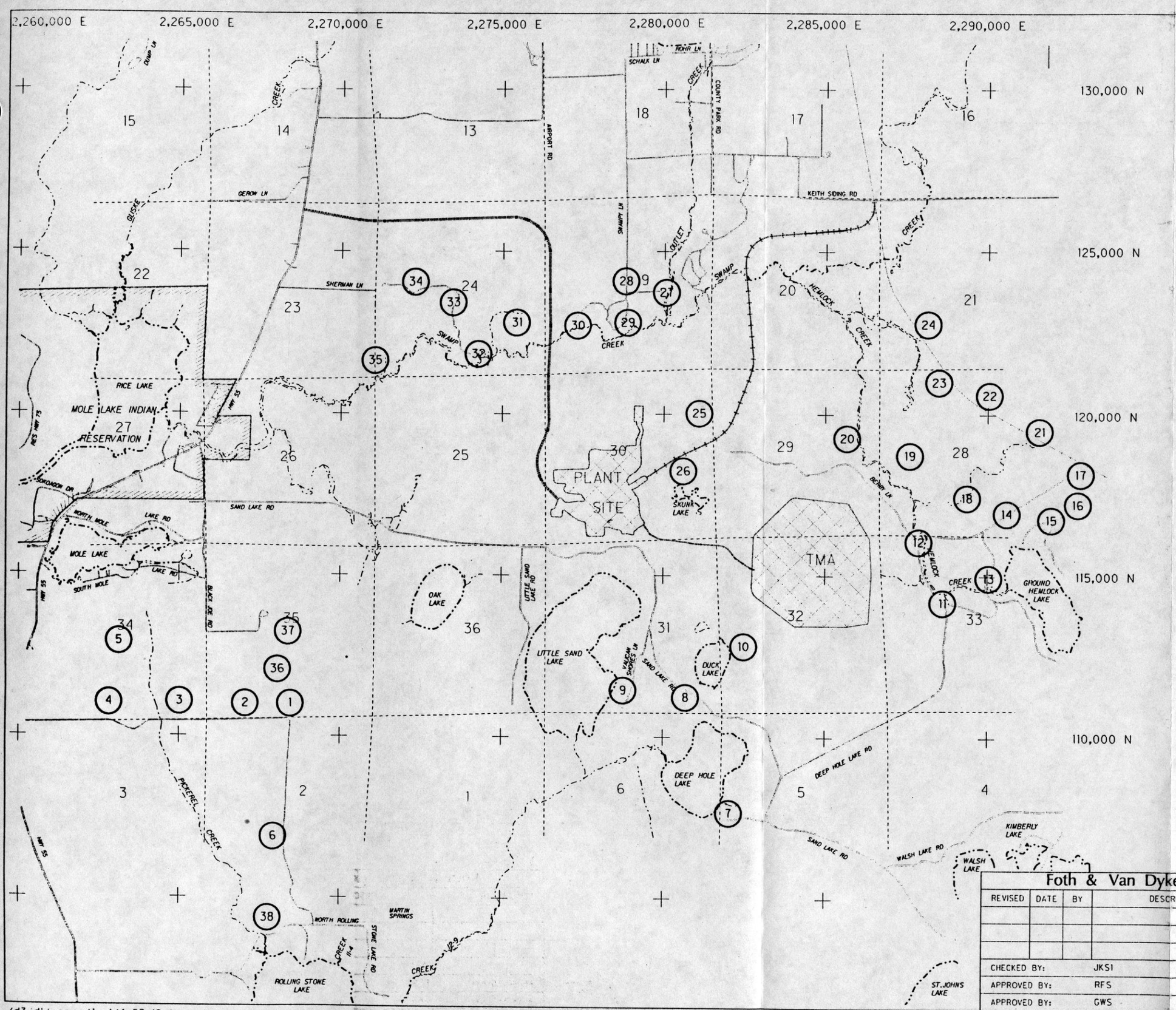

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- (22) SURVEY POINT AND NUMBER

N

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-9

OWL SURVEY LOCATIONS

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: BSH

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2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- (12) SURVEY POINT AND NUMBER

N

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

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APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-10

RAIL SURVEY LOCATIONS

Scale: 0 1500' 3000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: BSH

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93C049

2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N 125,000 N 120,000 N 115,000 N 110,000 N

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- PROPOSED TMA ACCESS ROAD AND PIPELINE ROUTE
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- (50) SURVEY POINT AND NUMBER

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-11

BIRD POINT - COUNT SITES

Scale: 0 1500' 3000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JRB2

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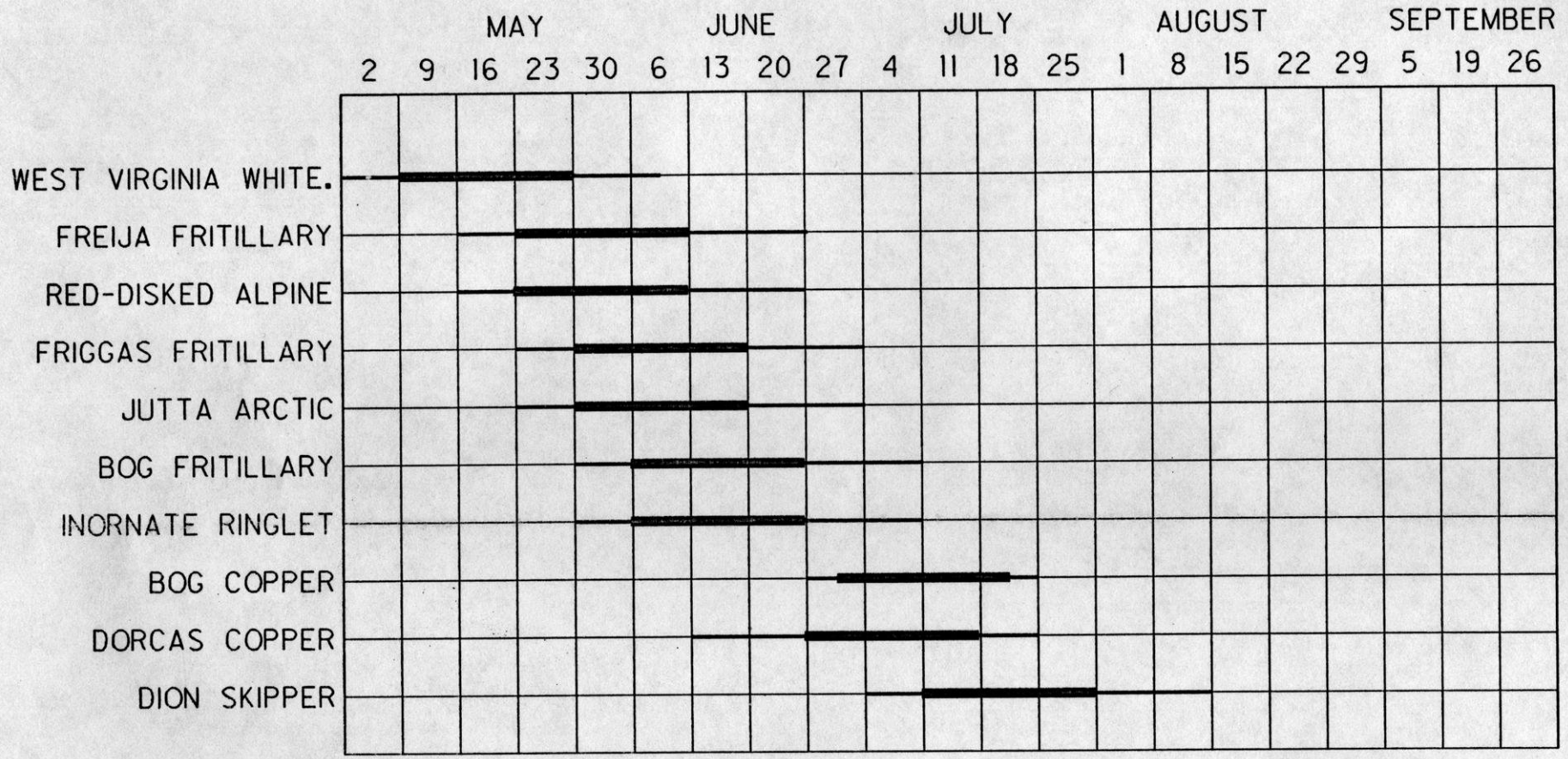

LEGEND

——— POSSIBLE OCCURENCE

▬▬▬ MOST LIKELY OCCURENCE

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY: JKSI			DATE: MAY '95
APPROVED BY: RFS			DATE: MAY '95
APPROVED BY: GWS			DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-12

BUTTERFLY PHENOLOGY CHART

Scale: NOT TO SCALE | Date: APRIL, 1995

Prepared By: Foth & Van Dyke | By: BSH

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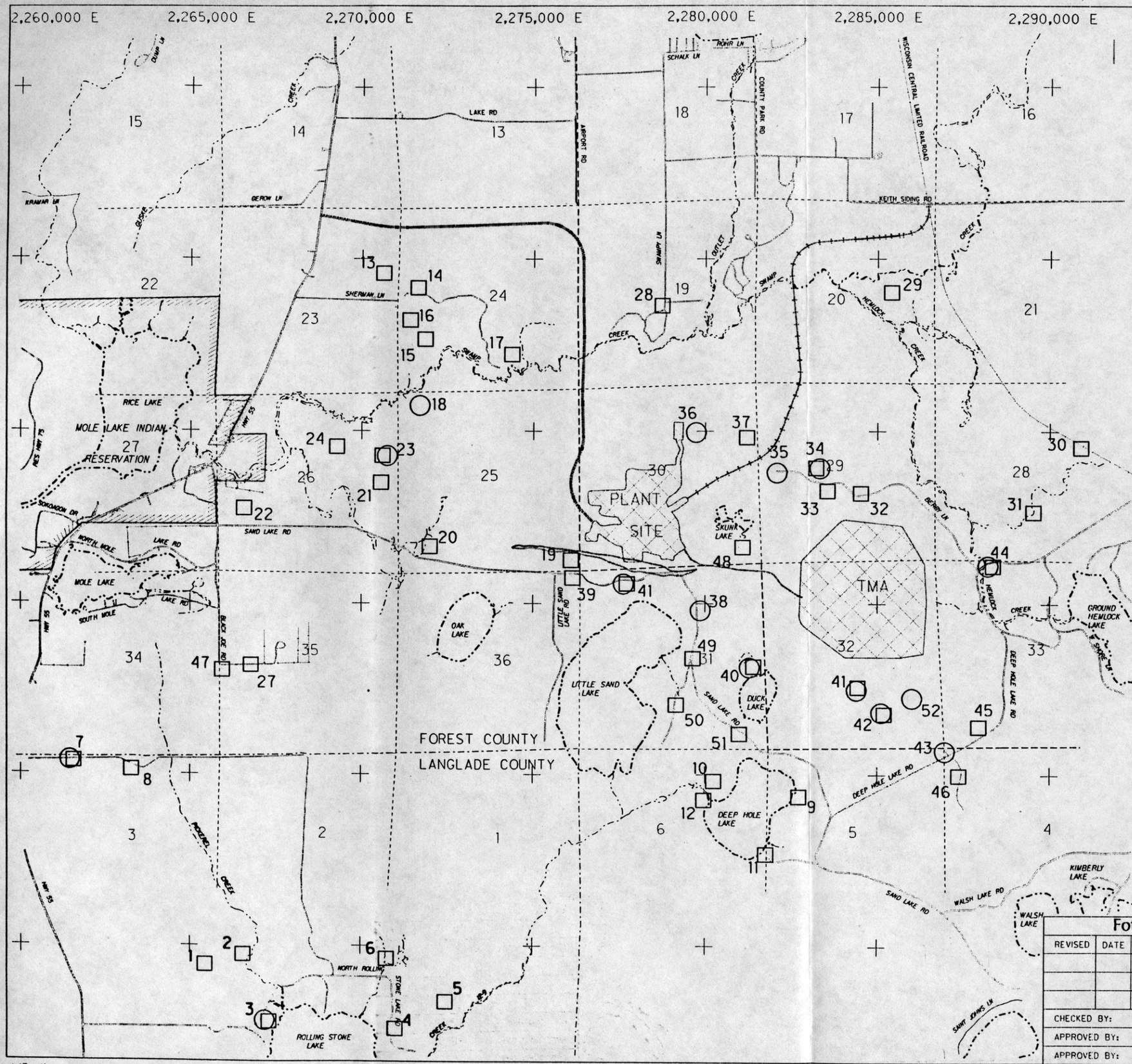

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- △1 ENDANGERED SPECIES (LOCATION AVAILABLE FROM WDNR)
- □2 NON-LISTED SPECIES
- ○3 SPECIAL CONCERN

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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Foth & Van Dyke

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APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-13

OBSERVED BUTTERFLY LOCATIONS

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: BSH

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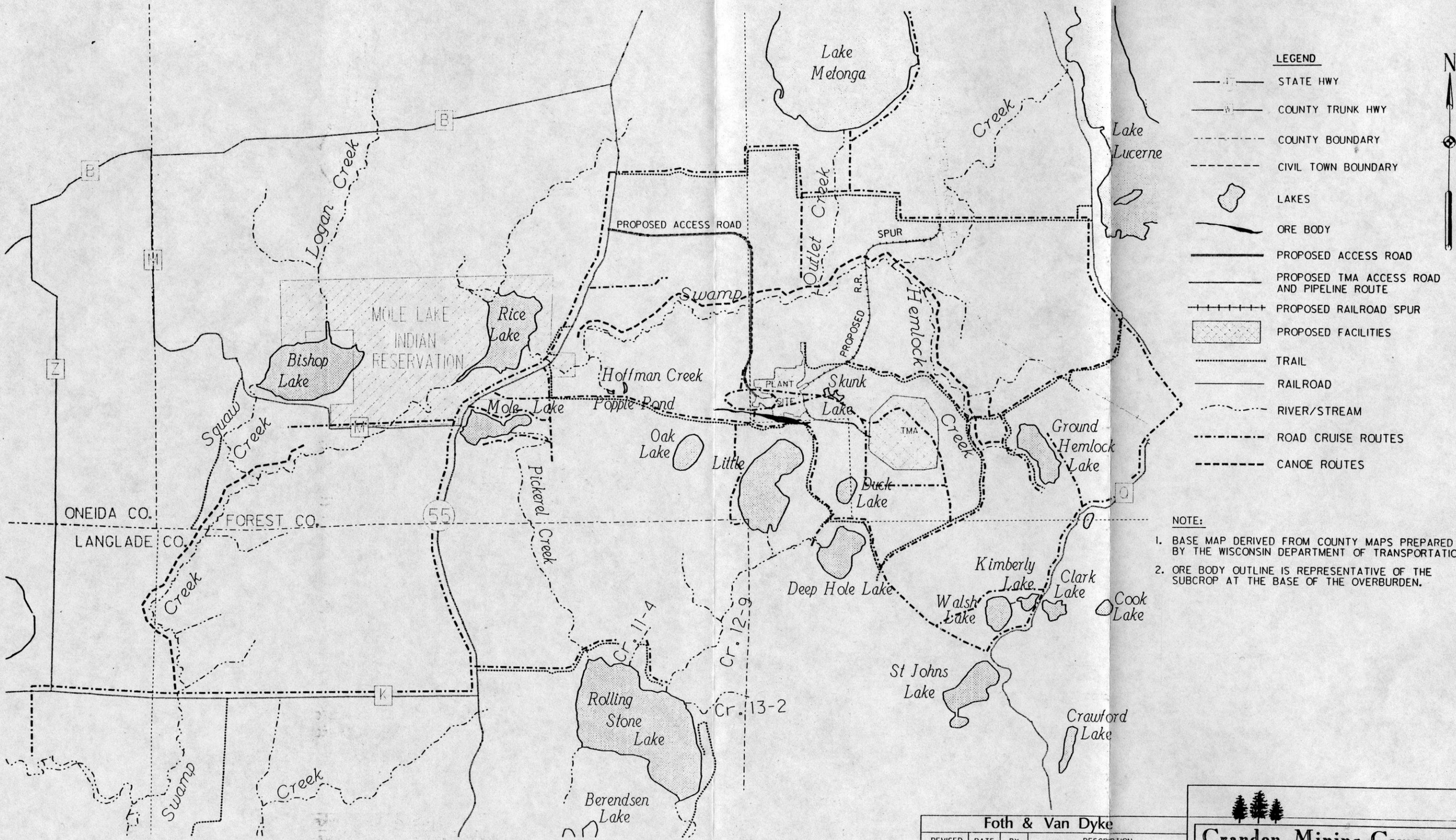

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

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APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-14

REPTILE AND AMPHIBIAN SURVEYS
ROADWAY AND CANOE ROUTES

Scale: 0 2500' 5000' | Date: APRIL, 1995

Prepared By: Foth & Van Dyke | By: JRB2

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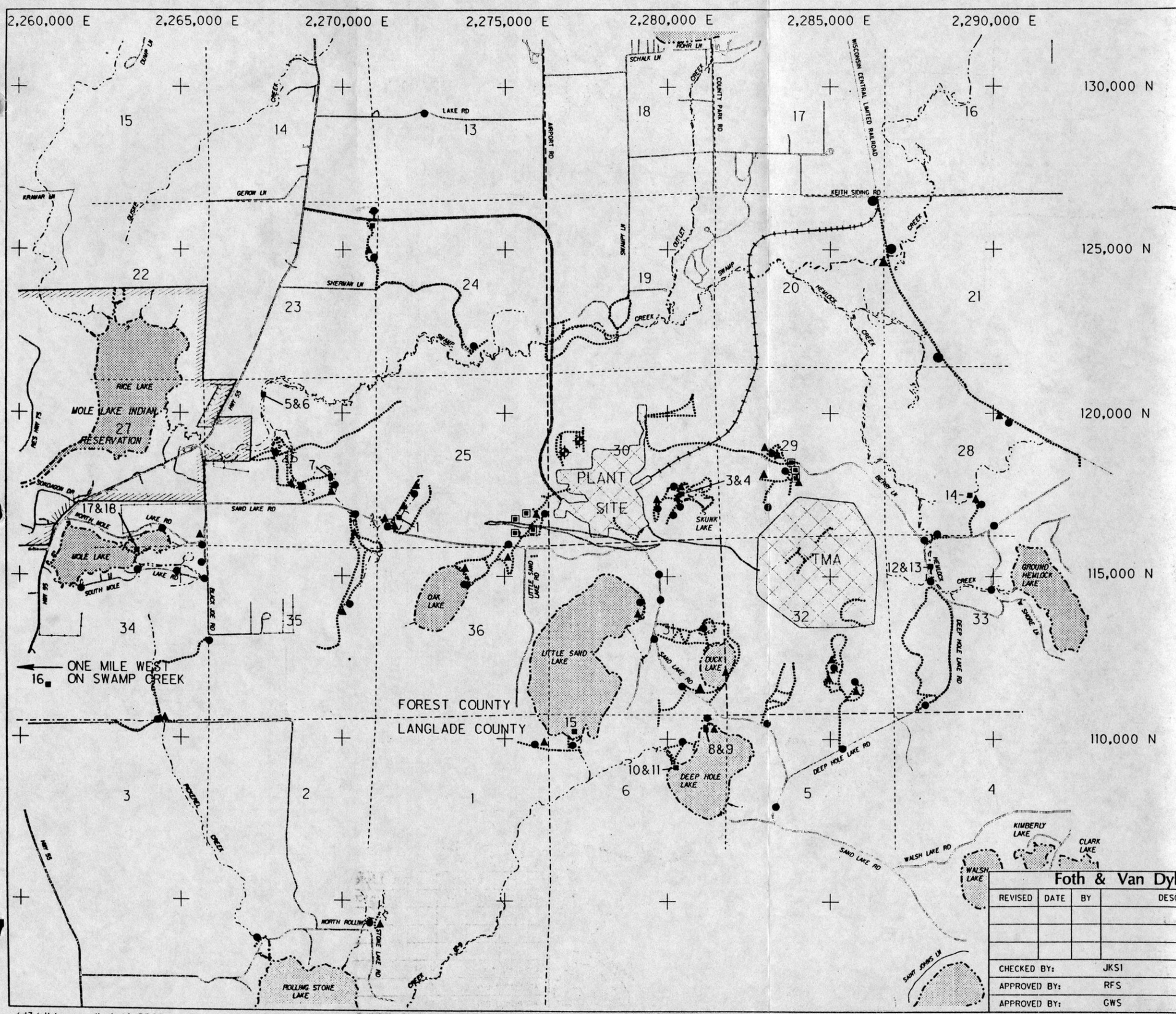

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA HAUL ROAD AND PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- SNAKE BOARDS
- VES ROUTES
- DIPNET SITES
- 13- HOOPNET SITES
- AUDIO SURVEYS
- QUADRAT SITES

N

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
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APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

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FIGURE 3.9-15
REPTILE AND AMPHIBIAN SURVEY LOCATIONS

Scale: 0 1500' 3000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JRB2

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2,260,000 E 2,265,000 E 2,270,000 E 2,275,000 E 2,280,000 E 2,285,000 E 2,290,000 E

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

105,000 N

100,000 N



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

VEGETATION CLASSIFICATIONS

- B = BOGS
- C = SWAMP CONIFERS
- DW = DECIDUOUS FORESTED WETLANDS
- M = MARSHES
- S = SHRUB WETLANDS
- F = FIELDS AND UPLAND OPENINGS (INCLUDING TREES < 10' IN HEIGHT)
- A = AGRICULTURAL LANDS
- P = PINE PLANTATIONS
- N = NORTHERN HARDWOOD FORESTS (INCLUDING > 10' IN HEIGHT)

OTHER LAND CLASSIFICATIONS

- W = OPEN WATER
- U = URBAN, RESIDENTIAL OR DEVELOPED AREAS

NOTES:

1. BASE MAP DIGITIZED FROM 1'' = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

Foth & Van Dyke

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CHECKED BY:	JKS1	DATE: MAY '95	
APPROVED BY:	RFS	DATE: MAY '95	
APPROVED BY:	GWS	DATE: MAY '95	

Crandon Mining Company

FIGURE 3.9-16

STUDY AREA VEGETATION MAP

Scale: 0 1750' 3500' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JPRI

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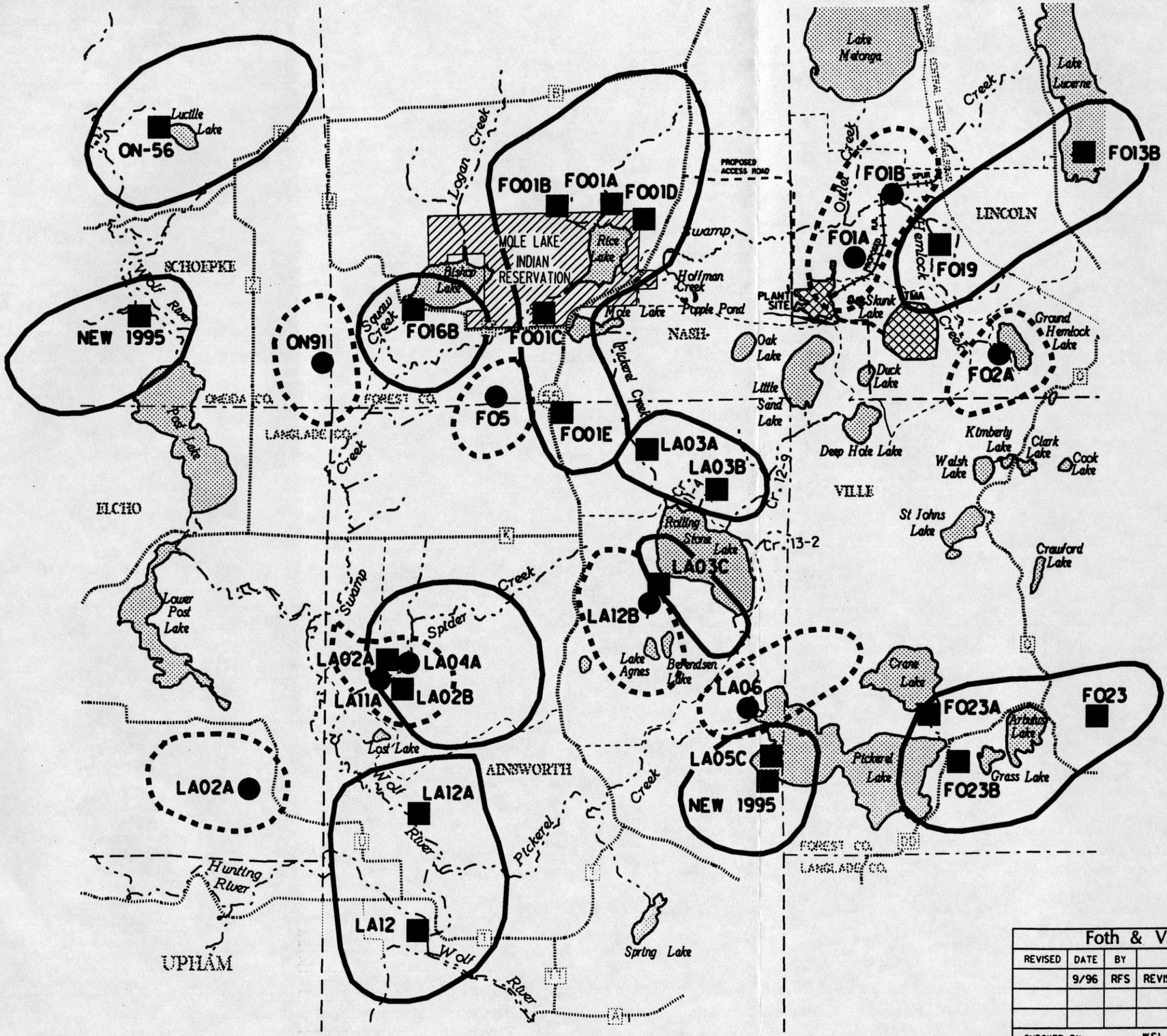
93C049



LEGEND

- STATE HWY
- COUNTY TRUNK HWY
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- LAKES
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA HAUL ROAD AND PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- OSPREY NEST
- TERRITORIAL OSPREY PAIRS
- EAGLE NEST
- TERRITORIAL EAGLE PAIRS

N

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
	9/96	RFS	REVISED NEST DATA

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.9-17

BALD EAGLE AND OSPREY NEST SITES IN THE ENVIRONMENTAL STUDY AREA

Scale: 0 3750' 7500' | Date: APRIL, 1995

Prepared By: Foth & Van Dyke | By: JRB2

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Crandon Mining Company

Environmental Impact Report

Section 3.10

Wetlands

Crandon Mining Company
Environmental Impact Report

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Table 3.10-4 Study Area Wetland Vegetation Types and Sizes 6
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Figures

(Note: Figures for Section 3.10 are located at the end of the text, following page 3.10-14.)

Figure 3.10-1 Study Area Wetlands
Figure 3.10-2 Fox-Wolf River Watershed

Appendices

Appendix 3.10-1 Relevant Technical Memoranda and Correspondence
Appendix 3.10-2 Functional Values Assessment Methods
Appendix 3.10-3 1994 Wetland Verification Delineation
Appendix 3.10-4 Normalized Results of 10 Functional Models for Wetlands in the Study Area

3.10 Wetlands

The purpose of this section of the EIR is to present data regarding the current condition of wetlands in the area surrounding the proposed Crandon Project site. The wetland studies were conducted to satisfy the requirements of NR 132 and Section 404 of the Clean Water Act. The field and laboratory methods are described in Section 3.10.1, followed by a summary of the wetland types identified in Section 3.10.2, Ecological Relationships between the study area wetlands and wetlands existing in the region in Section 3.10.3 and hydrological relationships in Section 3.10.4.

3.10.1 Field and Laboratory Methods

Beginning in the early 1980s and continuing through 1995, a number of wetland studies have been conducted regarding the proposed Crandon Project. A list of the documents produced and a brief summary of their contents is provided in Table 3.10-1. These studies form the basis for the data presented in this EIR. The methods employed for these studies are described below. Methods are divided into two categories: 1) wetland mapping, delineation, characterization, and 2) wetland functional analyses. Table 3.10-2 contains a numerical summary of all wetlands surveyed for the project.

3.10.1.1 Wetland Mapping, Characterization, Delineation

In 1982, assessments were conducted on 127 wetlands existing on the CMC property that were larger than 0.25 acres. The assessments included wetlands in an approximate 9.4 square mile area encompassing the plant site, two alternative TMA sites, the access road corridor, and the railroad spur corridor (Normandeau Associates, Inc. and IEP, 1982a,b,c,d). IEP evaluated 31 additional wetlands in 1983 in an expanded study area (IEP, 1983). In total, the two assessments mapped and characterized all of the wetlands larger than approximately 0.25 acres in an approximate 18.3 square mile study area (Figure 3.10-1).

Wetlands were mapped in the early 1980s at a scale of 1 inch = 400 feet by stereoscopic interpretation of 1976 to 1981 aerial photography. Each mapped wetland was then visited during field surveys. When discrepancies were noted, the aerial photography was stereoscopically reviewed in the field and corrections were made to the map (Normandeau Associates, Inc. and IEP, 1982a,d).

As part of the wetland mapping and characterization work conducted in the early 1980s, Normandeau Associates Inc. and IEP also conducted quantitative studies of plants and wildlife communities in wetlands representative of the different types existing in the study area (e.g., scrub/shrub, emergent/wet meadow, bog, etc.). Plant communities were sampled during the spring at three representative areas within each wetland type. Vegetation was sampled on points at fixed intervals along transects. Each plot was divided into three vertical strata (i.e., overstory, intermediate strata, herbaceous layer). A relative importance index was computed for each species in each strata (Normandeau Associates, Inc. and IEP, 1982a).

Also, as part of the work conducted in the early 1980s, herptofauna, mammals and avifauna were inventoried in representative wetlands. In general, the survey for reptiles and amphibians noted all individuals seen or heard during each phase of the field work from April to June. Spotted salamanders were intensively sampled using pitfall traps and drift fences. Two representative areas of each wetland type were selected for bird census.

Table 3.10-1

Chronological Summary of Wetland Studies Conducted for the Proposed Crandon Project

Wetland Document Title	Summary of Contents
Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. (1982a). Wetland Assessment Report.	Characteristics and functional values of 127 wetlands larger than 0.25 acres in a 9.4 square mile study area.
Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. (1982b). Wetland Assessment Inventory Report.	Presents data sheets for each of the 127 wetlands providing basic characteristic information for each of 10 wetland functional values.
Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. (1982c). Wetland Assessment Appendices.	Provides technical back-up for assessment of the 127 wetlands.
Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. (1982d). Wetland Assessment Maps.	Provides a series of maps showing the 127 wetlands in the 9.4 square mile study area.
Interdisciplinary Environmental Planning, Inc. (1983). Supplemental Wetland Assessment Report.	Characteristics and functional values of an additional 31 wetlands larger than 0.25 acres in an 8.9 square mile study area immediately to the west and north of the previous wetland study area.
Hollands, Garrett. November 3, 1992. Letter to Ronald Landers, Exxon Coal & Minerals Company, Inc.	Results and maps of 21 wetlands generally smaller than 0.25 acres in the vicinity of the plant site and TMA.
Moe, Don. March 22, 1995. Letter to David Ballman, U.S. Army Corps of Engineers.	Foth & Van Dyke delineated wetlands 5, P2, F64, F65, F66, and M3 in accordance with 1987 Corps of Engineers Wetland Delineation Manual. Results were compared to previous mapping of these wetlands.
Moe, Don. January 9, 1995. Letter to Dave Siebert, Wisconsin Department of Natural Resources	Foth & Van Dyke delineation report regarding one additional wetland (wetland 22).

Prepared by: RFS
Checked by: JWS

Table 3.10-2

Summary of Wetlands Surveyed

Study	Number of Wetlands Surveyed
Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc. (1982a, b, c, & d)	127
Interdisciplinary Environmental Planning, Inc. (1983).	31
Hollands (1992).	21[1]
Foth & Van Dyke (1995).	1
Total	180

[1]Includes additions to two existing wetlands.

Prepared by: RFS
Checked by: JWS

A line transect and one listening station were established. All bird species seen or heard were recorded. Two representative areas in each of the wetland types were trapped for small and medium-sized mammals. Captures in each area were summarized by species and expressed in numbers caught per 100 trap nights (Normandeau Associates, Inc. and IEP, 1982a).

Subsequent to the completion of wetland work conducted in the early 1980s, Fugro-McClelland, Inc. (Hollands, 1992) mapped 21 additional wetlands, typically less than 0.25 acres in size, in the plant site and TMA areas in 1992. Of the 21 wetlands, two were additions to existing mapped wetlands (e.g., wetland 3 was added to wetland R7A and wetland 4 was added to wetland R8). Field investigations were conducted in the area of the ore body, plant site, and TMA. Wetlands were delineated in accordance with the 1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands (USCOE, USEPA, et al., 1989). A summary of the results is presented in Appendix 3.10-1.

In August 1994, Foth & Van Dyke delineated wetlands 5, P2, F64, F65, F66 and M3 in accordance with the 1987 *U.S. Corps of Engineers Wetland Delineation Manual* (USCOE, 1987). The purpose of this delineation was to select a subsample to validate the work, conducted by Normandeau Associates, Inc. and IEP Inc. in the early 1980s, for consistency with the 1987 Corps of Engineers' Manual mapping methods. These wetlands, totaling approximately 25 percent of previously delineated wetlands within the plant site and TMA configuration current in the 1980s, were delineated, flagged, and a horizontal control survey was conducted to allow for the production of a wetland boundary map which could be directly compared with the wetland map prepared by the previous investigators. The results of this verification evaluation are described in Section 3.10-2.

In November 1994 as part of investigating alternative sites for wastewater discharge absorption ponds, Foth & Van Dyke delineated a 0.26 acre wetland located to the northwest of the plant site. This wetland, referred to as Wetland 22, is located in an area that was clear-cut by a third

party since the previous wetland studies were conducted in the early 1980s. Wetland 22 is situated upgradient of a logging road that appears to have impeded the natural flow through a drainage swale, thereby creating conditions suitable for the formation of this small wetland. A letter discussing the delineation of this wetland is provided in Appendix 3.10-1 (Moe, 1995).

3.10.1.2 Wetland Functional Assessment Methods

The functional values of 158 named wetlands were assessed by Normandeau Associates Inc. and Interdisciplinary Environmental Planning, Inc. in the early 1980s (Normandeau Associates, Inc. and IEP, 1982 a through d; IEP, 1983). An additional 20 named wetlands were assessed by Fugro-McClelland in 1995. For the analysis, wetlands 3 and 4 are included in the assessment completed for wetlands R7A and R8, respectively. The wetland functions considered, as required by NR 132, included the following:

1. Biological
2. Hydrologic Support
3. Groundwater
4. Storm and Floodwater Storage
5. Shoreline Protection
6. Water Quality Maintenance
7. Cultural/Economic
8. Recreational
9. Aesthetics
10. Educational

A separate model, representing each of the above wetland functions, was used to provide a score for each of the ten functions for each modeled wetland. The individual scores from each model were then weighted and summed to provide an overall wetland functional value ranking for each wetland. The biological and hydrological functions (i.e., hydrologic support, groundwater, storm and flood water storage, shoreline protection, and water quality maintenance) were considered of equal importance and each was weighted 40 percent. The remaining 20 percent was divided equally among the cultural/economic, recreational, aesthetics and educational function. The final ranking was based on a scale of 0 to 100, with 100 the highest possible ranking. Assessment methodology is described in detail in Appendix 3.10-2.

3.10.2 Wetland Characterization/Classification

As shown on Figure 3.10-1, 256 individual wetlands are mapped within an approximate 18.3 square mile area surrounding the proposed mine facility. This figure includes the 180 surveyed wetlands discussed in Section 3.10.1 above and 76 unnamed wetlands that are typically very small forested depressions that may or may not meet the USCOE and WDNR jurisdictional criteria for wetlands. The mapped wetlands total approximately 2,621 acres.

Wetlands were habitat typed (Figure 3.9-16). A functional values assessment was conducted for each of the 180 mapped wetlands (i.e., the named wetlands [eg., W1] shown on Figure 3.10-1). The named wetlands generally include wetlands greater than 0.25 acres and all wetlands existing in areas where potential impacts are expected to occur.

Table 3.10-3 provides a summary of the wetlands existing in the study area by wetland habitat type using current updated information. Table 3.10-4 presents a comprehensive listing of named wetlands in the study area, including dominant wetland habitat type and acreage. The results of the wetland functional analysis are presented in Appendix 3.10-4. Tables 1, 2, and 3 of Appendix 3.10-4 contain the results of the wetland functional analyses for the 127 and 31 wetlands characterized by Normandeau Associates, Inc. and IEP in the early 1980s, for 19 of the

wetlands characterized by Fugro-McClelland in 1992; and the wetland characterized by Foth & Van Dyke in 1995. The functional values of two of the wetlands (3 and 4) characterized by Fugro-McClelland in 1992 were assessed as part of the assessment completed for wetlands R7A and R8 shown on Table 1 of Appendix 3.10-4. Thus, the three tables include individual or consolidated assessment information for each of the 180 surveyed wetlands.

Table 3.10-3

Summary of Wetlands Existing Within the Study Area and Limits of Project Facilities

Wetland Habitat Type	Study Area[1] (acres)
Aquatic Bed	<1
Emergent/Wet Meadow	226
Shrub Swamp	61
Conifer Swamp	1,928
Deciduous Swamp	196
Bog	152
Streamside	5
Various small wetlands	53
Total	2,621

[1]Within the 18.3-square mile study area.

Prepared by: RFS
Checked by: JWS

In a WDNR correspondence/memorandum dated September 15, 1994 from Dave Siebert, it was indicated that WDNR staff field evaluated the wetland work completed in the 1980's and were satisfied with the mapped wetland boundaries (Siebert, 1994). A copy of this memorandum is included in Appendix 3.10-1. Further, based on the 1994 Foth & Van Dyke validation of the previous wetland mapping, it is concluded that the wetland mapping/characterization work performed by Normandeau and Associates, Inc. and IEP (1982 a through d and 1983) is an accurate representation of the wetlands in the entire study area and may have overestimated the acreage by up to 13 percent (Appendix 3.10-3).

Table 3.10-4

Study Area Wetland Vegetation Types and Sizes

Wetland ID	Dominant Vegetation Type (1)	Total Acres
A1	SM	0.74
A2	CS	2.15
A3	DS	1.11
B1	SW	0.01
B2	CS	5.19
B3	DS	1.5
B4	CS	20.54
B5	CS	0.55
B8	DS	0.48
D1	CS	4.39
D2	SW	0.09
D3	DS	1.61
D4	CS	17.15
D4A	DS	1.84
D5	B	0.9
D8	DS	0.78
D18	DS	0.94
F1	SW	3.9
F2	SM	20.3
F4	CS	3.81
F5	CS	3.32
F6	SW	0.02
F7	SM	20.46
F8	DS	0.9
F9	CS	7.74
F10	CS	9.02
F11	CS	18.37
F12	SM	7.8
F13	CS	1.35
F15	DS	36.47
F16	B	8.81
F17	DS	1.75
F18	CS	56.34
F19	SM	9.21
F21	SM	1.35
F22	DS	2.21

Table 3.10-4 *(Continued)*

Wetland ID	Dominant Vegetation Type (1)	Total Acres
F23	SM	4.46
F24	SW	0.01
F25	DS	4.08
F26	SW	0.12
F27	DS	3.44
F28	B	63.0
F29	SS	3.16
F30	SW	0.02
F31	CS	6.45
F32	DS	0.68
F33	DS	1.82
F34	DS	0.45
F35	CS	2.17
F36	DS	1.36
F37	SM	15.72
F38	SW	0.09
F39	SS	5.92
F40	SM	7.9
F42	SS	0.44
F43	B	1.33
F45	B	0.65
F46	DS	3.36
F48	CS	0.53
F50	DS	0.59
F51	DS	0.45
F52	B	2.91
F53	CS	13.93
F54	B	0.93
F55	DS	0.52
F57	DS	6.22
F58	SM	0.4
F60	DS	31.76
F61	DS	2.03
F62	DS	8.27
F63	CS	9.68
F64	B	4.5
F65	SS	2.4
F66	CS	16.1
F69	DS	1.38

Table 3.10-4 *(Continued)*

Wetland ID	Dominant Vegetation Type (1)	Total Acres
F70	DS	2.44
F72	DS	4.29
F81	SM	0.33
F86	DS	0.46
F87	DS	0.74
F90	AB	0.23
F114	SM	0.52
F116	CS	0.6
F119	CS	1.11
F121	CS	0.48
F122	DS	0.61
F122A	SS	0.46
F125	SS	0.87
F126	SM	1.45
F127	DS	1
G1	DS	0.37
H1	CS	18.62
I1	DS	0.64
J1	DS	0.52
K1	SW	0.13
K2	DS	5.17
K3	CS	12.52
K4	SS	0.8
K5	B	1.3
M1	SS	1.09
M2	SW	0.3
M3	DS	4.51
M4	DS	1.37
M5	CS	1.83
M6	DS	0.62
N1	SS	0.71
O1	CS	113.85
O3	DS	2.22
P1	DS	2.75
P2	CS	18.09
R1	DS	4.93
R1A	DS	7.15
R3	SM	19.08
R5	CS	10.43

Table 3.10-4 *(Continued)*

Wetland ID	Dominant Vegetation Type (1)	Total Acres
R7	DS	1.52
R7A	SS	2.72
R8	SS	1.92
T1	B	1.66
T2	B	1.74
T3	SS	0.32
T4	CS	199.02
T5	CS	1.64
X2	DS	0.65
X3	CS	38.1
X4	SM	0.75
Z1	SM	7.38
Z2	SM	15.6
Z3	SM	2.04
Z4	SM	1.45
Z5	SM	19.34
Z6	CS	44.68
Z7	DS	3.89
Z8	DS	2.78
Z9	CS	9.54
Z10	DS	20.93
Z11	CS	26.18
Z12	SS	6.9
Z13	SS	4.08
Z14	CS	75.28
Z15	CS	9.89
Z16	CS	33.79
Z17	SM	3.35
Z18	DS	6.2
Z19	CS	3.53
Z20	SM	42.36
Z21	CS	3.54
Z22	SM	22.7
Z23	CS	226.96
Z24	CS	4.02
Z25	SS	16.26
Z26	B	2.86
Z27	SS	2.88
Z28	B	16.26

Table 3.10-4 *(Continued)*

Wetland ID	Dominant Vegetation Type (1)	Total Acres
Z29	B	45.65
Z30	CS	290.90
Z31	SS	7.30
W1	CS	503.1
W2	CS	78.47
1	SS	0.67
2	DS	0.65
3 (part of wetland R7A)	SM	0.71
4 (part of wetland R8)	SS	1.98
5	SM	0.01
6	SM	0.16
7	CS	0.2
8	CS	0.27
9	SM	0.19
10	CS	1.41
11	DS	0.72
12	DS	0.11
13	DS	0.07
14	DS	0.06
15	DS	0.14
16	DS	0.1
17	DS	0.54
18	CS	1.51
19	DS	0.13
20	DS	1.85
21	SM	0.07
22	SM	0.26
Other Mapped Wetlands in Study Area	Various	52.52

(1) SM = Emergent marsh/wet meadow.
CS = Coniferous Swamp.
DS = Deciduous Swamp.
B = Bog.
SS = Shrub Swamp.
AB = Aquatic Bed.
SW = Streamside Wetland. These may contain components of each of the above listed vegetation types.

Prepared by: RFS
Checked by: JWS

3.10.3 Ecological Relationships

To assess the significance of the wetland types occurring in the study area surrounding the proposed Crandon Project site, a comparison was drawn between the frequency of occurrence of each wetland type in the study area with the frequency of occurrence of wetland types in the region (Normandeau Associates, Inc. and IEP, 1982 a through d; IEP, 1983). The larger evaluated region is defined as the Fox-Wolf River Watershed above the town of Langlade as shown in Figure 3.10-2. Regional wetland acreage and habitat interpretations were based on stereoscopic analysis of aerial photographs dated July 1979 obtained from the WDNR (Normandeau Associates, Inc. and IEP, 1983). The results of this comparison are presented in Table 3.10-5. The representation of a given wetland type in the study area versus the total wetland area for the region provides an indication of the regional scarcity of the wetland types identified.

Wetlands are a common landscape feature in the region. Based on the results of Normandeau Associates Inc. and IEP work (1982 a through d and 1983), wetlands comprise approximately 20 percent of the total land area of the larger region. Conifer swamp is the most common wetland type in the region followed by deciduous swamp, shrub swamp, bog, marsh and finally, aquatic bed.

The relationship between the frequency of wetland occurrence in the study area and that of the region is proportional to the relationship between the overall size of the study area and the size of the region (Table 3.10-5). The study area comprises approximately 3.9 percent of the region while the study area wetlands comprise approximately 4.2 percent of the regional wetlands. In other words, the study area contains an average quantity of wetland for the region in which it is located.

3.10.4 Hydrological Relationships

The proposed Crandon Project site and surrounding study area are located in the Fox-Wolf River watershed which is part of the Lake Michigan drainage basin. Surface water hydrology is controlled by an average annual rainfall of 30.36 inches (see Section 3.4). It is also controlled by the surface soils, topography, vegetation, land use, and seasonal temperature variations.

There are numerous wetlands located in upland areas of the study area situated in small isolated basins with no defined surface water inlet or outlet. The exception to this are the riparian wetlands along Swamp Creek, Pickerel Creek, Hemlock Creek and those surrounding and feeding the five wetland study area lakes.

In general, relatively permeable surface soils in the contributing watersheds to the wetlands result in very little runoff reaching the wetlands except during snowmelt and during above average rainfall events. The surface water budgets of selected wetlands in the vicinity of the proposed TMA and plant site are discussed in Section 3.7.7.2 of the EIR. Detailed water budget calculations for the wetlands discussed in that section are contained in Appendix 3.7-12.

From a groundwater perspective, wetlands have been classified as either discharge or recharge wetlands based on their relationship with the groundwater system. A detailed discussion of the classification of wetlands in the study area is presented in Section 3.6 of this EIR.

Table 3.10-5

Frequency of Occurrence of Wetland Types in the Study Area Versus the Region

Wetland Type	Estimated Area of Wetlands in the Region[1]	Area of Wetlands as a Percentage of the Total Regional Area	Acreage of Wetlands in the Study Area[2]	Study Area Wetlands as a Percentage of the Total Study Area	Study Area Wetlands as a Percentage of the Regional Area Wetlands
Shrub Swamp	10,083	3.3	61	<1	<1
Bog	4,800	1.6	152	1.3	3.2
Aquatic Bed	785	0.3	<1	<1	<1
Deciduous Swamp	15,940	5.3	196	1.7	1.2
Conifer Swamp	25,873	8.6	1928	16.4	7.4
Emergent Marsh/Wet Meadow	3,174	1.0	226	1.9	7.1
Total	60,655	20.1	2563	21.9	4.2

[1] Total land area of the region: 301,900 acres.

[2] Total land area of the study area: 11,711 acres. Acreage total does not include 58 acres for the small unnamed and streamside wetlands which represent various habitat types.

Source: *Adapted from Table 6.5-1 in Normandeau Associates Inc. and IEP, 1982a and Table 5.4-1 in IEP, 1983.*

Prepared by: RFS
Checked by: JWS

3.10.5 Bibliography

Hollands, Garrett, November 1992. Correspondence to Ronald Landers, Exxon Coal and Minerals Company, Inc.

Interdisciplinary Environmental Planning, Inc., 1983. Supplemental Wetland Assessment Report. CMC-NOI-164.

Moe, Don, September 1994. Correspondence to James Bauer, WDNR.

Moe, Don, January 1995. Correspondence to Dave Siebert, WDNR.

Moe, Don, March 1995. Correspondence to David Ballman, USCOE.

Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc., 1982a. *Wetlands Assessment Report.* CMC-NOI-160.

Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc., 1982b. *Wetlands Assessment Inventory Reports.* CMC-NOI-161.

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Normandeau Associates, Inc. and Interdisciplinary Environmental Planning, Inc., 1982d. *Wetlands Assessment Maps.* CMC-NOI-163.

Siebert, Dave, WDNR Correspondence Memorandum to Bill Tans dated September 15, 1994.

USCOE, 1987. *Corps of Engineers Wetlands Delineation Manual.*

USCOE, USEPA, USFWS, and USDA-SCS, 1989. *Federal Manual for Identifying and Delineating Jurisdictional Wetlands.*

FIGURES FOR SECTION 3.10

2,262,000 E 2,267,000 E 2,272,000 E 2,277,000 E 2,282,000 E 2,287,000 E 2,292,000 E

N

130,000 N

125,000 N

120,000 N

115,000 N

110,000 N

105,000 N

100,000 N

LAKE METONGA

RICE LAKE

MOLE LAKE

OAK LAKE

LITTLE SAND LAKE

DUCK LAKE

DEEP HOLE LAKE

SKUNK LAKE

GROUND HEMLOCK LAKE

KIMBERLY LAKE

WALSH LAKE

ST JOHNS LAKE

ROLLING STONE LAKE

PLANT SITE

SWAMP

CREEK

PICKEREL CREEK

MARTIN SPRINGS

HEMLOCK CREEK

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- 1692.0 X SPOT ELEVATION
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- F16 WETLAND IDENTIFICATION
- WETLAND DIVIDER
- WETLAND STUDY BOUNDARY

WETLANDS WITHIN THIS BOUNDARY BASED ON NORMANDEAU ASSOCIATES, INC., AND INTERDISCIPLINARY ENVIRONMENTAL PLANNING, INC. 1983. WETLANDS OUTSIDE THIS BOUNDARY BASED ON AERIAL PHOTOGRAPHIC INTERPRETATION BY FOTH & VAN DYKE IN 1995.

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.

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11/05/96 jrb2

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	10-24-96	GWS	CHANGED F116 WETLAND DELINEATION
2	10-24-96	GWS	MODIFIED LAKE DISCHARGE

CHECKED BY:	JKS1	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

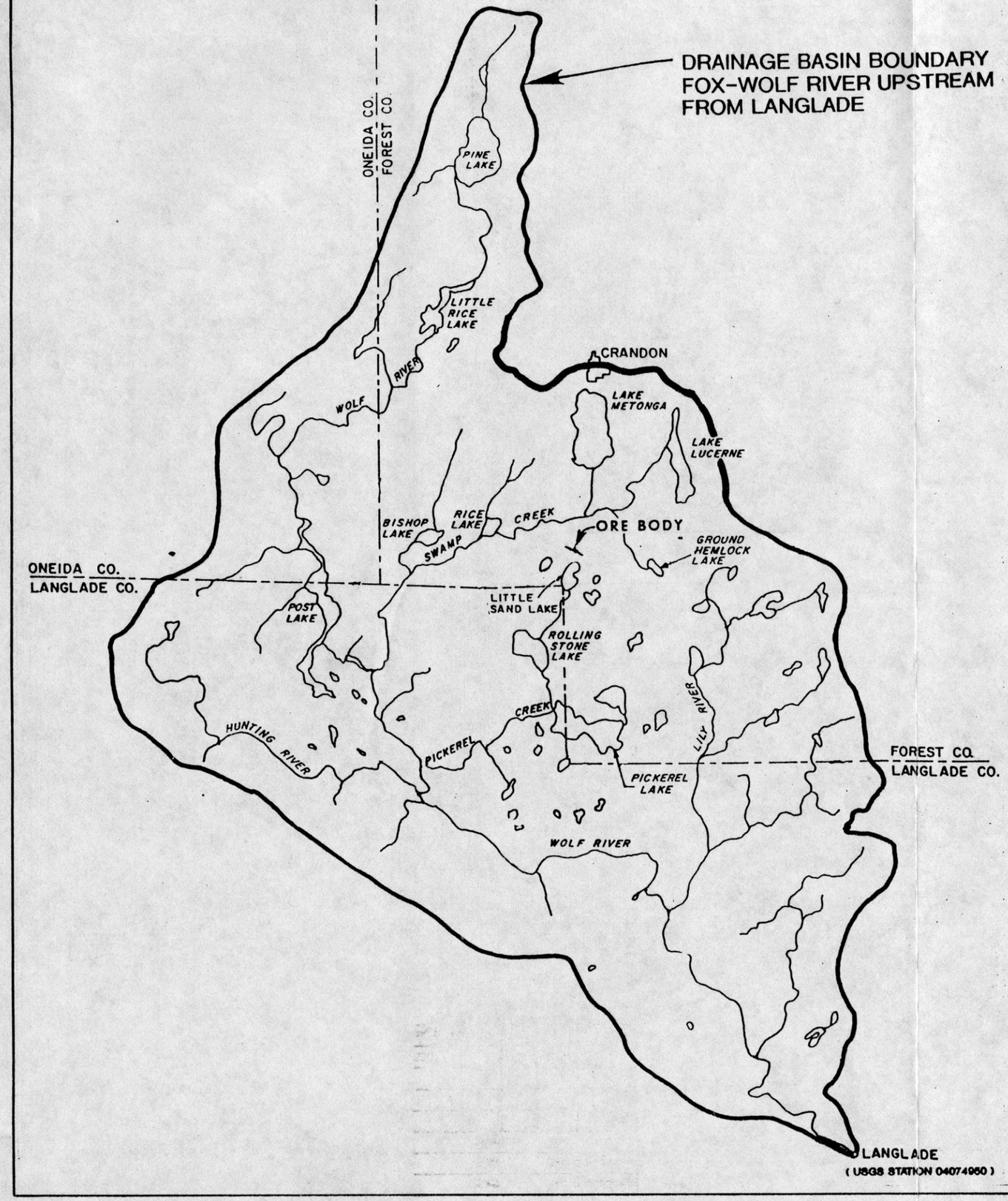
Crandon Mining Company

FIGURE 3.10-1
STUDY AREA WETLANDS

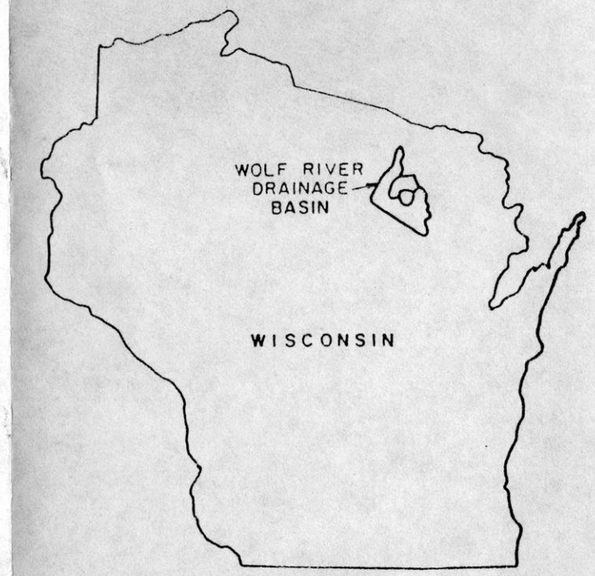
Scale: 0 1000' 2000' Date: MAY, 1995

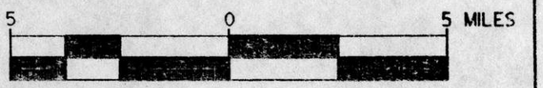
Prepared By: Foth & Van Dyke By: BSH

93C049









SCALE

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:		JKSI	DATE:	MAY'95
APPROVED BY:		RFS	DATE:	MAY'95
APPROVED BY:		GWS	DATE:	MAY'95

Crandon Mining Company

FIGURE 3.10-2

FOX-WOLF RIVER WATERSHED

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

93C049

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Appendix 3.10-1

Relevant Technical Memoranda and Correspondence

FUGRO ◘ McClelland

FUGRO-McCLELLAND (EAST), INC.

6 Maple Street
P.O. Box 1130
Northborough, MA 01532
Tel: (508) 393-6779
FAX: (508) 393-8647

November 3, 1992

Mr. Ronald Landers
Exxon Coal and Minerals Company, Inc.
2077 S. Gessner
Houston, TX 77063

Re: Supplemental Wetlands
Contract No. ECMC 92-MCM-0183

Dear Mr. Landers:

The following letter report describes the work completed by Fugro-McClelland (East), Inc. (FM-East) to conduct field investigations of the ore body area, the mine/mill site, the water reclaim ponds and the mine waste disposal facility, in order to locate any additional wetlands not observed in 1982. The field investigations were conducted on July 28, 29 and 30, 1992, by Mitchell Strain, Senior Soil Scientist, Stephen Ellsworth, Senior Biologist and Garrett Hollands, Senior Geologist.

Methods

Existing documents were first reviewed. These included the following:

- Topographic map, scale 1" = 1,000', 5 foot contour interval, prepared by Aero-metric Engineering, Inc., C-TM-0113.
- Topographic map, scale 1" = 100 meters, 1 meter contour interval, illustrating mine/mill site, water reclaim ponds and waste disposal ponds. This map is attached as Figure 1.
- Orthophoto map, plates 5 and 6, scale 1" - 400', 5 foot contour interval, prepared by Aero-metric Engineering, Inc., illustrating wetlands as mapped by the August 1982 Wetland Assessment Report.
- Aerial photographs of the ore body, mine/mill site, true color, dated April 22, 1977, 15260 047710.

The above listed documents were reviewed to observe any areas not shown in 1982 as wetlands, which possibly could be wetland, no matter how small. Such areas were identified and the documents were carried into the field.

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Key WETLANDS MAPPING FUGRO-McCLELLAND

Twenty-five offices nationwide in the United States
International operating companies in Australia, Belgium, Brunei, Canada, Germany, Hong Kong, Indonesia, Japan, Malaysia, The Netherlands, Saudi Arabia, Singapore, United Kingdom, and United Arab Emirates

In the field, the three person field team, walked east-west transverse lines across the site. The team spaced themselves approximately 150 feet apart in order to maintain visual contact with each other in the woods. This spacing decreased in dense cover and increased in more open cover. The team set compass courses and used terrain features observable on maps and aerial photographs to land navigate. When a team member encountered an area which contained wetland features, all three team members inspected the area in questions to determine if:

1. It was an area already mapped in 1982 as wetland.
2. The area was a new unmapped wetland.
3. The area was not a wetland.

The site was investigated for the occurrence of wetlands using the standards for wetland identification per the 1989 Unified Federal Delineation Method, (USCOE, USEPA, USFWS and USDA-SCS, 1989, Federal Manual for Identifying and Delineating Jurisdictional Wetlands). The three parameter tests of mandatory criterion for wetland hydrology, wetland soils and wetland vegetation were applied by the team members. All of the area of the ore body, mine/mill site and waste disposal ponds was visually inspected.

A total of 21 new wetland areas not mapped as wetland in 1982 were located. All, but two of these areas are isolated depressional wetlands or isolated hillside wetlands that are not connected to a stream system. Most are small, less than one acre in size. The two exceptions are Area 2 which connects to Wetland R7 and Area 3 which is connected to Wetland R7A. Wetlands R7 and R7A are part of a raparian system draining to Oak Lake.

Results

The location of the additional wetlands are shown on the attached Figure 1. The general locations are accurate to the scale of the map. The boundaries shown are approximate, that is they were sketched onto Figure 1, without using any accurate land survey methods. Their shape and size accuracy is appropriate for project planning purposes, but detailed field delineation and land survey is needed before their accurate location and boundaries can be shown on a large scale map.

Area 1

This small wetland is west of the ore body and north of Little Sand Lake Road, above Wetland R3. It is triangular in shape with two small valleys flowing into it from the northwest and northeast. It has no outlet steam. The southernmost portion is the most wet, containing seasonal flooding of approximately two feet in depth. No standing water was observed. The soils are mineral hydric soils. The vegetation is predominantly facultative wet species dominated by saplings, red maple, black alder and willow. Herbs include Scripus sp. and crested fern.

It is hydrologically isolated and occurs within a small depression on dense lodgment till and is believed to be a perched water table situation.

Area 2

This wetland occurs to the west of a north-south trending construction road, west of Wetland R-7. It is connected by a small cross culvert to Wetland R7. It contains pit and pond topography, mineral hydric soil, evidence of hydrology (water stained and matted leaves), floods seasonally with approximately one foot of water, occurs on dense lodgment till, and is believed to be a perched water table situation. No standing water was observed. A section of this wetland occurs north of an east-west trending construction road where water is trapped behind the road fill. Predominant vegetation is that of a deciduous wooded swamp. Trees observed included red maple and sugar maple. Shrubs/Saplings observed included poplar, sugar maple,red maple, green ash and hemlock, American elm. Herbs observed included lady fern, cleaves sp., ostrich fern, Jack-in-the-pulpit and jewelweed, carex sp.

Area 3

This wetland is part of previously mapped Wetland R7A and is included in this report for completeness. The northeastern arm of Wetland R7A extends more northeasterly than previously shown. This area contains shrub swamp and cattail marsh, hydric mineral and hydric organic soils and certain small areas of standing water. It floods seasonally along with the rest of Wetland R7A. Construction road fill has partially blocked its drainage to Wetland R7A.

Area 4

This wetland occurs north of a construction road which blocked drainage and created the wetland. There is no culvert under the road to drain the depression caused by the road fill. No standing water was observed, but evidence of seasonal flood occurs in the form of water-stained and matted leaves. The area contains soils which have hydric characteristics, but have been modified by human activity. No herbaceous vegetation was observed. Woody species include red maple and arrowwood.

Approximately 50 to 100 meters south of Wetland Area 4 are three depressions in ablation till. Each was investigated and none had the required criteria to be a wetland.

Area 5

This area is a wetland and was indicated as a wetland in the August 1982 Wetlands Assessment Report, but was not inventoried nor assessed because it was to small. It is a combination of wooded swamp, shrub swamp and wet meadow. A small area of open water (less than 10 square feet) occurred in the center and lowest portion of the site. Evidence of seasonal flooding of approximately two feet occurs as water-stained and matted leaves. The dominant vegetation is red maple, willow and Scripus sp. Hydric mineral soils occur along the edges with a histosol (organic soil) in the middle. It appears to be a perched water table on ablation till. The eastern portion has been filled, but a Scripus sp. community covers the fill. The area has no inlet nor outlet.

Area 6

This area is a dammed depression. A small approximately three foot high dam occurs at its southeastern end. All of the vegetation in this area is dead with the exception of a small clump of cattail in the northeast corner. Dead vegetation includes spruce, fir, black ash, and gray birch. There were two small puddles of standing water which was an opaque green. These puddles were being heavily used by deer for drinking water, as evidenced by numerous recent deer tracks. The area can fill seasonally with standing water to an approximate depth of two and a half to three feet. Evidence of flooding occurs as water-stained and matted leaves and red silt staining on stems and leaves. The wetland has positive indicators of wetland hydrology, soils, and vegetation. It appears to be a perched wetland on ablation till and drains southeastward to Area 7.

Area 7

This wetland is downstream of Wetland Area 6. It is primarily a shrub swamp containing black ash, black alder, red maple, Scripus sp., blue flag, and dead hemlock. The organic soil is a histosol and evidence of seasonal flooding to approximately one foot occurs as water-stained and matted leaves. This wetland appears to be a perched water table wetland on ablation till. This wetland has no outlet.

Area 8

This area is east of Wetland Area 7 and west of Wetland F11 of 1982. It consists of two directly different areas, an eastern and a western portion. The western portion is the most unaltered section containing poplar, red maple, willow, fir and Scripus sp. Soils are hydric mineral soils and seasonal flooding evidenced by water-stained and matted leaves appears to occur to a depth of one and a half feet. It consists primarily of Scripus sp. growing on fill. Willow, fir and birch seedlings and saplings occur in this area. Red colored sediment occurs in this wetland, which appears to be a perched water table wetland on ablation till. No inlet nor outlet was observed.

Area 9

This wetland is primarily a wet meadow-marsh with cattail and Scripus sp. being dominant species. No trees are present and the edge contains scrub willow and spruce saplings. The wetland seasonally floods as evidenced by water-stained and matted leaves. A culvert under the road allows eastward drainage to Wetland Area 10 which drains to Wetland F11, but has no inlet. Wetland Area 9 appears to be a depression partially blocked by the road fill where a perched water table seasonally occurs on ablation till.

Area 10

This wetland is primarily a forested wetland and contains mixed coniferous and deciduous trees including hemlock, larch, fir, spruce and red maple. Shrub/saplings include black spruce, willow, and yellow birch. Herbs include Scripus sp., cinnamon fern, blue flag, jewelweed and cow slip. Sphagnum moss is found throughout the wetland. Both hydric mineral and organic histosol soils were found. Seasonal flooding of approximately one foot was evidenced by water-stained and matted leaves. Pit and pool microtopography occurs in the wetter and lower portions of this area. Stream flow passes in a small (less than two foot wide) discontinuous channel from Wetland Area 10 through Wetland Area 11 and into Wetland F11. No standing water was observed in Wetland Area 10, which appears to be a perched seasonal water table on ablation till within a series of interconnected depressions.

Area 11

This wetland area is located in the northern portion of the mine/mill site. It consists of a sapling wooded swamp, containing red maple, black ash and yellow birch saplings of three feet to five inches BHD. Shrubs/saplings include yellow birch, black spruce and red maple. Herbs include jewelweed, Lycopus sp., black ash seedlings, carex sp., viola spp., sphagnum moss, cinnamon fern, blue flag, and Scripus sp. It occupies in a northeast-southwest trending steeply sided valley cut by melt water into dense lodgment till. The bottom of the valley (wetland) is lined with a veneer of boulders. Soils within these boulders are hydric mineral soils. Because the valley has a slight gradient little seasonal flooding occurs. No standing water was observed. Seasonal discharge may occur to Wetland Area 12, but no defined outlet stream channel was observed.

Area 12

These two small wetland areas occur within the same valley as does Wetland Area 11, but are further to the northeast (down gradient). The first of these small areas is approximately 45 feet x 35 feet and the second is 75 feet x 50 feet. The bottoms of both areas are covered with small boulders. Mineral hydric soils occur between the boulders. Evidence of seasonal flooding (less than one foot) in the form of water-stained and matted leaves occur in both areas. The vegetation is primarily a wooded swamp community including herbs such as mad dog skullcap, bedstraw, carex sp., and

sphagnum moss. Shrubs/saplings include red maple, yellow birch and black ash. Trees include red maple and poplar. No outlet stream was observed.

To the east of this area, approximately 50 to 100 meters occur three kettle depressions in ablation till. None of these areas contain wetland hydrology, vegetation nor soils.

Areas 13, 14 and 15

These three wetland areas are west of water reclaim pond Cell A. They are northeast of the woods road and consist of three small depressions where seasonal perched water tables produce approximately one to two feet of flooding. Wetland Areas 13 and 15 are deciduous wooded swamps containing red maple, black ash and American elm. Shrubs include black alder and willow. Sphagnum moss occurs in both depressions. Wetland Area 14 has been impacted by a logging road and is less of a depression. It consists of a wet meadow to shrub swamp community containing carex sp. and Scripus sp., plus willow. All three areas have mineral hydric soils. No standing water was observed and none have an inlet nor outlet.

Area 16

This small depression in the northeastern portion of water reclaim pond B is an abandoned burrow pit dug into lodgment till for logging road construction materials. No significant vegetation occurs within the depression. Evidence of seasonal (approximately one foot deep) flooding occurs as water-stained and matted leaves. Hydric mineral soils have developed in this pit. No standing water was observed and no inlet nor outlet occurs.

Area 17

This wetland area north of water disposal pond T3. It is primarily a wet meadow containing Scripus sp. and a shrub swamp with willow and red maple saplings. It contains mineral hydric soil and seasonally floods with approximately one foot of water. It occurs in a slight valley and is believed to be a perched water table on dense lodgment till. No standing water was observed and no inlet nor outlet occurs.

Area 18

The area is between waste disposal ponds T2 and T4 and occurs in a flat portion of a topographic saddle. It is a mixed coniferous-deciduous forested wetland. Dominant trees include spruce, red maple and hemlock. Shrubs include black alder, sapling red maple and spruce. Sphagnum moss occurs in the pools of the pit and mound microtopography. No standing water was observed, and evidence of approximately one foot of seasonal flooding exist in the form of water-stained and matted leaves. The soil consists of predominantly mineral hydric soil. In some portions a histic ephipedon (<18 inches of organics) overlies the mineral soils. No inlet nor outlet stream was observed. The wetland appears to have formed on a flat area of dense lodgment till where runoff from surrounding slopes accumulates as a perched water table.

Area 19

This is a small wetland area formed when logging road construction blocked the drainage of a small valley, allowing seasonally perched water to flood to an approximate depth of one foot or less. It occurs in the west-central area of pond T2. Soils are mineral hydric soils. Vegetation includes red maple, sugar maple, American elm, Scripus sp., carex sp. and sphagnum moss. It has no inlet nor outlet and is hydrologically isolated.

Area 20

This wetland area is draped on a hillside, partially within a valley in the western portion of pond T2. Runoff from the surrounding slopes of dense lodgment till accumulates seasonally in this valley (flooding less than one foot) creating mineral hydric soils and a wetland vegetative community, which is little different from surrounding upland. Trees include red maple, yellow birch, poplar and American elm. Shrubs include red maple saplings, beaked hazelnut, bush honey suckle and elm saplings. The herbs include wood fern, viola, wood sorrel and blue beadlilly. When viewed in 1982, this area was not considered a wetland, but using the soil and hydrology criteria of the 1989 Unified Federal Delineation Manual, the area is a wetland. No standing water was observed and no inlet nor outlet streams were found.

Area 21

This area is an excavated burrow pit dug for logging road construction fill many years ago. It occurs just beyond the southeast corner of pond T4. Approximately two feet of seasonal water floods this pit dug into dense till. Hydric mineral soils have formed in the pit bottom. Sparse vegetation occurs and includes horsetail. No standing water was observed, but water-stained and matted leaves indicate seasonal flooding.

Please call me if you have any questions.

Yours very truly,

Fugro-McClelland (East), Inc.

Garrett G. Hollands
Vice President

GGH:Jlr

Attachment

Appendix 3.10-4 Table 1

Normalized Results of 10 Functional Models for 127 Wetlands in the Study Area

	FUNCTIONAL MODELS										
Wetland No.	Biological Function	Hydrologic Support Function	Groundwater Function	Storm and Floodwater Storage Function	Shoreline Protection Function	Water Quality Maintenance Function	Cultural and Economic Function	Recreational Function	Aesthetics Function	Education Function	Total
R8*	14.00	0.64	2.00	5.92	0.00	5.28	2.85	1.70	1.85	2.35	36.59
T1*	13.20	0.64	4.64	5.28	0.00	4.24	2.85	1.50	3.15	2.35	37.85
T2*	20.00	0.64	4.64	5.60	0.00	4.56	2.85	1.70	2.90	3.25	46.14
T3*	16.00	0.24	4.24	5.28	0.00	4.64	1.95	1.40	1.60	2.35	37.70
T4*	27.60	6.40	5.88	5.44	3.04	5.90	4.65	3.70	2.45	2.05	67.11
T5	15.20	0.64	2.96	5.36	0.00	4.32	3.50	1.65	1.95	0.00	35.58
W1*	22.40	5.32	6.16	5.68	3.68	5.44	4.35	2.60	1.95	0.90	58.48
W2*	22.80	5.52	5.04	5.44	3.68	5.44	4.35	2.30	1.95	0.90	57.42
X2	12.00	0.24	1.28	4.88	0.00	3.92	2.15	1.05	2.10	0.00	27.62
X3	20.00	4.56	1.84	5.68	0.00	4.48	4.35	2.30	2.20	0.90	46.31
X4	10.80	0.24	1.28	5.36	0.00	4.96	1.75	1.55	2.30	0.00	28.24

*wetlands of special interest

Prepared by: MDJ
Checked by: GGH

Appendix 3.10-4 Table 2

Normalized Results of 10 Functional Models for 31 Wetlands

		FUNCTIONAL MODELS										
Wetland No.	Wetland Type	Biological Function	Hydrologic Support Function	Groundwater Function	Storm and Floodwater Storage Function	Shoreline Protection Function	Water Quality Maintenance Function	Cultural and Economic Function	Recreational Function	Aesthetics Function	Education Function	Total
Z1	SM	53	14	70	77	0	70	70	54	46	18	472
Z2	SM	47	14	70	77	0	70	70	49	46	0	443
Z3	SM	23	8	65	70	0	61	35	13	18	0	293
Z4	SM	33	8	65	70	0	61	35	18	18	0	308
Z5	SM	49	68	63	76	0	68	83	62	51	47	567
Z6	CS	51	68	61	71	0	56	100	57	44	65	573
Z7	DS	39	49	63	44	0	37	17	25	18	0	292
Z8	DS	37	55	56	50	0	43	17	25	18	0	301
Z9	CS	57	65	68	67	46	58	87	51	33	18	550
Z10	DS	56	57	63	76	0	59	91	52	49	82	585
Z11	CS	46	55	63	69	0	52	100	52	39	47	523
Z12	SS	48	19	70	79	0	70	74	41	32	47	480
Z13	SS	41	8	65	74	0	66	57	34	32	47	424
Z14	CS	62	81	70	62	38	58	100	57	49	65	642
Z15	CS	47	14	70	72	0	58	100	46	39	47	493
Z16	CS	59	14	70	77	0	61	100	51	49	65	546
Z17	SM	71	62	59	65	13	59	96	69	86	18	575
Z18	DS	47	81	68	68	38	63	91	48	44	65	613
Z19	CS	46	73	65	69	0	64	70	39	39	18	483
Z20	SM	60	16	56	71	0	77	126	70	77	65	640
Z21	CS	34	8	51	68	0	53	83	39	49	65	469
Z22	SM	64	24	54	77	0	70	126	70	82	82	670
Z23	CS	50	81	68	71	38	61	87	66	39	0	561
Z24	SS	90	40	59	94	0	70	37	31	33	18	472
Z25	B	108	62	64	102	22	78	45	47	48	18	594
Z26	B	81	12	57	94	0	66	31	27	42	10	420
Z27	SS	96	16	55	101	0	78	37	31	33	18	465
Z28	B	106	47	56	99	0	68	39	31	45	13	504
Z29	B	97	52	56	101	0	71	39	35	39	10	500
Z30	CS	109	57	59	100	0	78	51	38	34	13	539
Z31	SS	98	63	58	103	19	86	51	47	36	23	584

SM-shallow marsh, SS-shrub swamp, DS-deciduous swamp, CS-conifer swamp, B - Bog

Prepared by: MDJ
Checked by: GGH

Crandon Mining Company

Environmental Impact Report

Section 3.11

Ambient Noise and Vibration

Crandon Mining Company
Environmental Impact Report

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Figure 3.11-3 Monitoring Locations Ambient Ground Vibration

Appendices

Appendix 3.11-1 24-Hour Sound Level Measurement Data
Appendix 3.11-2 Ambient Ground Vibration Data

3.11 Ambient Noise and Vibration

Historical background noise data was collected for the study area (Figure 3.11-1) in 1977, 1983, 1994 and 1995. The data collected in the 1970s and 1980s was used as input information for noise impact evaluations included in the 1985 Environmental Impact Report (EMC, 1985). With the reinitiation of permitting work, updated data was collected. Section 3.11.1 of the EIR discusses data collection methodologies and presents a discussion of existing project area noise levels based on an evaluation of the data.

Crandon Mining Company has developed a blasting plan for the project to comply with Wisconsin Department of Industry, Labor and Human Relations (DILHR) SubChapter VII Blasting Resultants at a half mile radius of the mine. DILHR has established regulations pertaining to blasting resultants. The purpose of these regulations is to establish uniform limits on permissible levels of blasting resultants to reasonable assure that the resultants do not cause injury, damage or unreasonable annoyance to persons or property outside any controlled blasting area. To assess blasting effects CMC desired to obtain general information regarding pre-project ground vibrations in the vicinity of the ore body. Section 3.11.2 discusses the work that was performed to obtain this information and the results of that work.

3.11.1 Ambient Noise

3.11.1.1 Noise Descriptors

Noise is usually defined as sound that is undesirable because it interferes with speech communication and hearing, or is intense enough to damage hearing, or is otherwise annoying. The characteristics of sound include parameters such as amplitude, frequency, and duration.

Sound can vary over an extremely large range of amplitudes. The decibel (dB) is the accepted standard unit for measuring the amplitude of sound because it accounts for these large variations in amplitude and reflects the way people perceive changes in sound amplitude. Figure 3.11-2 illustrates sound pressure levels in dB of various sound sources between 0 dB (threshold of hearing) and 140 dB (threshold of pain) as adapted from Peterson and Gross (1980), Beranek (1971), and EPA (1971). Different sounds may have different frequency content. When describing sound and its effect on a human population, A-weighted (dBA) sound levels are typically used to account for the response of the human ear. The term "A-weighted" refers to a filtering of the noise signal to emphasize frequencies in the middle of the audible spectrum and to deemphasize low and high frequencies in a manner corresponding to the way the human ear perceives sound. This filtering network has been established by the American National Standards Institute (ANSI, 1984). The A-weighted noise level has been found to correlate well with peoples' judgements of the noisiness of different sounds and has been used for many years as a measure of community noise.

Community noise levels usually change continuously during the day. However, community noise exhibits a daily, weekly, and yearly pattern. To compare noise levels over different time periods, several descriptors have been developed. One descriptor is the equivalent sound level (L_{eq}). The L_{eq} is the equivalent steady-state A-weighted sound level that would contain the same acoustical energy as the time-varying A-weighted sound level during the same time interval. The hourly L_{eq} is often used to describe peak-hour noise.

Another descriptor for noise is the statistical A-weighted noise level exceeded a given percentage of the time (L_n). These L_n values provide an indication of the quietness and noisiness of the area. For example, the L50 is the level exceeded 50 percent of the time representing the typical noise level, the L10 is the level exceeded 10 percent of the time representing the noisier periods, and L90 is the level exceeded 90 percent of the time representing the quieter periods.

Another descriptor, the day-night average sound level (L_{dn}), was developed to evaluate the total daily community noise environment. The L_{dn} is the time average of all A-weighted levels for a 24-hour period with a 10 dB upward adjustment added to the nighttime levels (2200 to 0700). This adjustment is an effort to account for the increased sensitivity to nighttime noise events. L_{dn} has been adopted by federal agencies including the Environmental Protection Agency (EPA), Federal Aviation Administration (FAA), and Housing and Urban Development (HUD) as the accepted unit for quantifying human annoyance to general environmental noise.

3.11.1.2 Field and Laboratory Methods

Historical background sound level data was collected in 1977 and 1983 based upon "16- to 21-minute data samples." Some of these samples were reportedly impacted by "short duration, high sound pressure level events" and were "modified by comparing the data to that obtained at the same or similar locations during other sampling periods" to eliminate these intrusive sounds.

Additional baseline noise data were collected in April and August of 1994 by Foth & Van Dyke. Samples collected in April were 16 to 21 minutes in duration. Samples collected in August were 30 minutes in duration. Three of the sites were augmented with a one hour long sample. Data were collected using a Bruel & Kjaer (B&K) Type 2230 integrating sound level meter. Consequently, these data represent the L_{eq} values.

Table 3.11-1 and Figure 3.11-1 present a description of the 10 original 1977 and 1983 noise survey locations and three new 1994 locations, denoted by A, that replaced some of the older locations due to access considerations. The noise survey locations define the extent of the project's noise study area.

During the period of March 14-15, 1995, long-term (24-hour) noise measurements were made at four locations in the surrounding project area to obtain additional information relative to the existing noise environment. These four include noise sampling locations 2A, 3, 8 and 9. The data was collected by Acentech, Inc.

Table 3.11-1

Noise Survey Locations

Location	Description
1	Playground at the Mole Lake School yard near County Road M and State Highway 55.
2	In parking lot of the former community center at a subdivision near State Highway 55 and Sand Lake Road.
2A	Residential backyards along State Highway 55.
3	At the Mihalko residence on Airport Road.
4	In the driveway of residence No. 3712 on County Road W and Keith Siding Road.
4A	Southeast of location 4.
5	CMC Field Office on Sand Lake Road across from the proposed plant site.
6	Across from the C. F. Webb residence on Little Sand Lake Road.
7	South shore of Lake Metonga in parking lot of Forest County Veterans Memorial Park.
8	North shore of Rolling Stone Lake on the Simonson property.
9	Northwest shore of Ground Hemlock Lake on the Solper property.
9A	Northeast shore of Ground Hemlock Lake.
10	North of St. John's Lake on Sand Lake Road.

Prepared by: SJL
Checked by: REN

Larson Davis Model 870 and Digital Acoustics Model 607 precision environmental noise monitors were used to measure and calculate the A-weighted sound levels. These instruments meet and exceed the American National Standards Institute (ANSI) 1.4-1983 Type I precision sound level meter standards. The monitor system was calibrated before and after data collection using an acoustical calibrator traceable to the National Bureau of Standards, Washington, D.C.

The hourly L_{eq} and daily L_{dn} values were determined at each 24-hour monitor location. The L90, L50, and L10 values were also determined at all measurement locations.

3.11.1.3 Existing Noise Levels

Table 3.11-2 and Table 3.11-3 present the data collected by EMC in 1977 and 1983 and the data collected by Foth & Van Dyke in 1994. The results of the 24-hour measurements collected by Acentech, Inc. are included in Appendix 3.11-1. These measurements are presented for each 15 minute interval during the 24-hour monitoring periods thereby providing an indication of the variability of sound levels throughout the monitoring period. Table 3.11-4 summarizes the measured L_{eq} and L_{dn} for the existing ambient environment during the March 14-15, 1995 period. The noise environment of the area is controlled mainly by birds, animals, and nearby and distant traffic on the local roads. Locations 2A and 3 are indicative of backyards of residential lots near more heavily traveled roadways. The L_{dn} is between 53 and 57 dBA for residential areas along the more heavily traveled roadways. Based on the 24-hour measurements the 15-minute L_{eq} varies from 34 to almost 70 dBA at location 3 and from 42 to 54 dBA at location 2A during the daytime hours. The nighttime 15-minute L_{eq} values ranged from 25 to 58 at location 3 and from 28 to 52 at location 3.

Location 9 is a partially developed rural area in the woods next to Ground Hemlock Lake. Location 8 is more secluded with no development in the area. The L_{dn} measured at location 8 of 37 is typical for undeveloped rural areas. The L_{dn} at location 9 was 48 dB, over 11 dB higher than at location 8. Although average daytime levels were about the same at the two locations, the average nighttime level at location 9 was over 10 dB higher than that measured at location 8 during nighttime hours.

The L_{eq} values reported in the prior study work and by Foth & Van Dyke fell mostly within the range of values measured over the 24-hour period. Discrepancies may be attributed to some seasonal variations, weather conditions, and changes that have occurred since the original data were collected in 1977 and 1983. Based upon the range of 15-minute L_{eq}'s observed at four monitor locations, the L_{dn} values in Table 3.11-2 reported by EMC are comparable. For purposes of developing an average sound level for the project area, the current 1995 24-hour measurements were used.

Based upon the types of land uses in the area and measured values at locations 2A, 3, 8, and 9, typical L_{dn} ranges can be assigned based on the description of the area (National Research Council, 1977). Table 3.11-5 presents typical L_{dn} ranges based upon the description of the area.

Table 3.11-2

Summary of 1977 and 1983 A-Weighted Background Sound Level[a], dB

Location	Winter			Summer		
	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)
1 - Mole Lake School	3/5/77-1155	3/5/77-2030	3/6/77-0025	7/16/77-1015	7/16/77-2015	7/17/77-0050
L90	38	26	24	43	29	24
L50	40	29	26	46	33	27
L10	43	31	31	49	43	40
L_{eq}	44.1	30.9	29.8	47.2	44.6	42.7
L_d		42.8			46.6	
L_n		29.8			42.7	
L_{dn}		41.9			49.9	
2 - Community Center	3/5/77-1230	3/5/77-2000	3/6/77-0055	7/16/77-0930	7/16/77-1930	7/16/77-2345
L90	33	23	26	36	27	26
L50	35	28	27	39	32	32
L10	41	37	31	46	42	45
L_{eq}	37.9	38.1	28.5	43.0	38.0	39.7
L_d		37.9			42.1	
L_n		28.5			39.7	
L_{dn}		38.1			46.5	

Table 3.11-2 *(Continued)*

Location	Winter			Summer		
	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)
3 - Mihalko Residence	3/5/77-1312	3/5/77-1930	3/5/77-2250	7/16/77-1525	7/16/77-1905	7/17/77-0130
L90	34	21	20	36	31	39
L50	36	39	22	39	33	43
L10	40	46	26	44	40	47
L_{eq}	37.8	41.9	23.9	45.3	50.1(39.7)[c]	44.1
L_d		39.3			47.1 (44.4)[c]	
L_n		23.9			44.1	
L_{dn}		37.9			51.0 (50.5)[c]	
4 - Residence 3712	3/5/77-1455	3/5/77-1900	3/5/77-2215	7/16/77-1445	7/16/77-1810	7/17/77-0205
L90	35	21	21	40	31	23
L50	38	22	24	46	38	30
L10	48	28	33	63	52	44
L_{eq}	44.6	39.8 (33.3)[c]	35.1	65.1	54.1	47.0
L_d		43.7 (43.4)[c]			63.8	
L_n		35.1			47.0	
L_{dn}		44.2 (44.1)[c]			62.2	

Table 3.11-2 *(Continued)*

Location	Winter			Summer		
	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)
5 - Exxon Field Office	3/5/77-1555	3/5/77-2130	3/5/77-2350	7/16/77-1600	7/16/77-2130	7/17/77-0020
L90	31	25	22	35	21	25
L50	37	27	24	41	23	26
L10	45	30	29	53	26	28
L_{eq}	43.8	28.4	50.5 (37.7)[c]	58.2	42.7 (36.8)[c]	26.5
L_d		42.4			56.8	
L_n		50.5 (37.7)[c]			26.5	
L_{dn}		56.4 (45.2)[c]			54.7	
6 - Webb Residence	3/5/77-1617	3/5/77-2100	3/6/77-2320	7/16/77-1140	7/16/77-2050	7/16/77-2215
L90	23	18	18	31	21	19
L50	25	19	29	35	24	21
L10	37	22	20	39	34	35
L_{eq}	53 (43.4)[c]	22.6	19.0	38.4	36.8	38.6
L_d		51.6 (42.1)[c]			38.0	
L_n		19.0			38.6	
L_{dn}		49.5 (40.2)[c]			44.9	

Table 3.11-2 *(Continued)*

Location	Winter			Summer		
	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)
7 - Lake Metonga	3/30/83 1225 - 1300	3/29/83-2100	3/30-31/83 2340 - 0010	7/12/83 1500 - 1530	7/11/83 1910 - 1937	7/11-12/83 2350 - 0020
L90 L50 L10	41 - 41 42 - 41 43 - 42	43 44 45	41 - 41 42 - 42 42 - 42	41 - 41 44 - 44 48 - 51	41 - 39 44 - 42 50 - 47	39 - 38 41 - 39 46 - 39
L_{eq} L_{eq} (Ave)[d]	46.9 - 41.4 (44.2)	44.3 (44.3)	41.9 - 41.7 (41.8)	46.4 - 48.8 (47.6)	47.7 - 44.5 (46.1)	42.9 - 38.9 (40.9
L_d L_n L_{dn}		44.8 41.8 48.8			47.5 41.3 49.3	
8 - Rolling Stone Lake	3/30/83 1345 - 1413	3/30/83 2045 - 2115	3/31/83 0100 - 0125	7/12/83 1530 - 1555	7/11/83 2036 - 2110	7/11/83 2230 - 2300
L90 L50 L10	31 - 32 33 - 33 36 - 38	31 - 30 32 - 31 34 - 31	30 - 30 31 - 31 31 - 31	38 - 35 42 - 40 44 - 43	34 - 33 37 - 34 43 - 40	36 - 34 39 - 38 43 - 42
L_{eq} L_{eq} (Ave)[d]	33.7 - 35.5 (34.6)	32.1 - 30.7 (31.4)	30.8 - 30.8 (30.8)	42.1 - 40.6 (41.4)	39.3 - 36.2 (37.8)	40.2 - 38.9 (39.6)
L_d L_n L_{dn}		34.2 30.8 37.9			40.7 39.6 46.2	

Table 3.11-2 *(Continued)*

Location	Winter			Summer		
	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)	Daytime[b] (Date-Time)	Evening[b] (Date-Time)	Nighttime[b] (Date-Time)
9 - Ground Hemlock Lake	3/30/83 1008 - 1027	3/30/83 1910 - 1940	3/29/83 2245 - 2310	7/13/83 1205 - 1230	7/12/83 1825 - 1847	7/12/83 2200 - 2230
L90	30 - 31	30 - 30	30 - 29	37 - 37	31 - 28	26 - 25
L50	31 - 33	30 - 30	30 - 29	42 - 39	33 - 32	26 - 26
L10	34 - 35	31 - 31	31 - 30	47 - 42	39 - 35	28 - 29
L_{eq})	32.1 - 33.4	30.5 - 36.8	30.3 - 29.6	44.2 - 39.6	46.0 - 32.5	26.8 - 28.0
L_{eq}) (Avg)[d]	(32.8)	(33.7)	(30.0)	(41.9)	(39.2)	(27.4)
L_d		33.4			42.7	
L_n		30.0			27.4	
L_{dn}		37.1			41.4	
10 - St. John's Lake	3/30/83 1118 - 1143	3/30/83 1800 - 1827	3/30/83 2225 - 2250	7/13/83 1655 - 1725	7/12/83 2025 - 2055	7/12/83 2315 - 2345
L90	31 - 33	30 - 30	31 - 31	34 - 33	26 - 26	25 - 24
L50	33 - 34	31 - 31	31 - 31	38 - 37	28 - 29	25 - 25
L10	35 - 36	32 - 32	31 - 31	42 - 43	36 - 40	27 - 26
L_{eq})	33.4 - 34.5	30.9 - 31.6	31.0 - 31.0	38.9 - 39.6	32.6 - 37.3	28.0 - 28.1
L_{eq}) (Avg)[d]	(34.0)	(31.3)	(31.0)	(39.3)	(35.0)	(28.1)
L_d		33.4			38.6	
L_n		31.0			28.1	
L_{dn}		37.8			38.4	

[a]EMC, 1985.
[b]The times shown for the daytime, evening, and nighttime periods signify the start time of recorded 16- to 21-minute data samples.
[c]Values were adjusted to reduce the contribution from short duration, high sound pressure level sources.
[d]Numbers in parentheses are average L_{eq} values for each time period.

Prepared by: SJL
Checked by: REN

Table 3.11-3

Sound Level Monitoring Results
April and August 1994 Baseline Conditions[1]

Monitoring Site	April 1994 Daytime	August 1994 Daytime	April 1994 Evening	August 1994 Evening	April 1994 Night	August 1994 Night
1	--	--	--	--	--	--
2A	(52.7)46.5	48.6	50.1	47.8	42	40.8
3	52.3	50.3	50.9	50.8	--	28.7
4A	49	48.9	45.2	42.2	30.8	42
5	42	24.8	45.1	26.6	43.5	36.8
6	30	25.9	40.9	--	36.1	39.5
7	46.1	43.7	42	38.7	42.4	32.7
8	(43.4)32.6	44.3	39.8	--	36.7	32.3
9	(46.0)49.9	42.4	32.2	26.8	42	21.8
9A	--	39	--	--	--	--
10	47.6	40	34.7	27.8	29.2	22.3

Notes: (52.7) = results from 1-hour-long monitoring.
-- = no data available.

[1]L_{eq} values collected by Foth & Van Dyke. Daytime = 0700-1800, Evening = 1800-2200, and Night 2200-0700. Sampling period equal to 16 to 21 minutes for April and 30 minutes for August, unless otherwise noted.

Prepared by: REN
Checked by: RFS

Table 3.11-4

Measured L_{dn} and L_{eq}

	Location 3	Location 2A	Location 8	Location 9
24-Hour Measurements (March 14-15, 1995)				
L_{dn}	57 (52)[1]	53	37	48
Daytime Maximum L_{eq}	71	54	46	47
Daytime Average L_{eq}	57 (46)[1]	49	35	37
Daytime Minimum L_{eq}	34	42	27	22
Nighttime Maximum L_{eq}	58	52	36	51
Nighttime Average L_{eq}	46	46	30	42
Nighttime Minimum L_{eq}	25	28	27	34
Short-Term Measurements from 1986 FEIS				
Daytime Maximum L_{eq}	50	43	42	46
Daytime Minimum L_{eq}	38	38	30	32
Nighttime Maximum L_{eq}	44	40	40	30
Nighttime Minimum L_{eq}	24	29	31	27
Short-Term Measurements from Foth & Van Dyke				
Daytime Maximum L_{eq}	52	53	44	50
Daytime Minimum L_{eq}	50	47	33	27
Nighttime Maximum L_{eq}	29	42	37	42
Nighttime Minimum L_{eq}	29	41	32	22

[1]Local truck maintenance, e.g. impact wrenches and steam cleaning, were observed near the monitor locations. ( ) average L_{eq} and L_{dn} were computed by eliminating daytime data between 1515 and 1800.

Prepared by: SJL
Checked by: REN

Table 3.11-5

Typical L_{dn} Based on the Land Uses in the Area[1]

Land Uses	L_{dn}
Near busy roadways	45 - 55 dBA
Quiet residential areas	40 - 50 dBA
Partially developed rural areas	35 - 45 dBA
Undeveloped rural areas	30 - 40 dBA

Note: All areas would be less than the EPA criteria of 55 dB and compatible for a wide range of land uses.

[1]Based on National Research Council, 1977.

Prepared by: SJL
Checked by: REN

3.11.2 Ambient Vibration

Baseline data pertaining to ambient vibrations were obtained at four locations on September 27 and 28, 1994. Selection of these sites was made on the basis of both nearby residential locations and the nearby communities following a reconnaissance of the project area. Figure 3.11-3 shows the monitoring locations.

The equipment used to monitor ambient vibrations consisted of a Slope Indicator Company S-6 Vibration Monitor and two triaxial transducer packages. At each location, continuous recording of ambient ground vibrations was conducted for durations of three to four hours. Two transducers were used, one set at an extremely small threshold velocity value of 0.003 inches per second, and the other at a threshold value of 0.03 inches per second. Recordings were made in the frequency and peak mode such that in addition to the peaks in the three mutually perpendicular directions (longitudinal, transverse and vertical) and peaks of the vector sum for both transducers, information on the distribution of energy in different frequency bands, and the peak frequencies within those bands was also obtained.

At two of the four locations, no ambient ground vibration was recorded. At the remaining two sites located adjacent to Highway 55 and near the public access boat ramp to Little Sand Lake, a few records were obtained as listed in Table 3.11-6. Copies of strip charts containing the raw data from the monitors is included in Appendix 3.11-2.

Table 3.11-6

Ambient Ground Vibrations

Location	Event No.	Date	Time	Peak Particle Velocity, in/sec				Predominant Frequency Band H_z
				Long	Trans	Vertical	Vector	
2[a]	1	9/27/94	12:38	--	.0035	--	.0047	19-39
	2	9/27/97	14:58	.0106	--	.0076	.0129	19-53
	3	9/27/94	15:11	.0041	--	--	.0047	28-75
	4	9/27/94	16:24	.0059	--	.0035	.0065	40-75
4[b]	5	9/28/94	12:17	.0035	--	--	.0035	28-58;76-107
	6	9/28/94	12:33	.0025	.0047	--	.0047	No Data
	7	9/28/94	12:34	--	.0035	--	.0035	19-27
	8	9/28/94	12:35	--	.0041	--	.0041	5-10;15-18

-- Not over threshold.
a. Continuous recording from 12•30 hours to 16•30 hours on 9/27/94.
b. Continuous recording from 12•00 hours to 3•20 hours on 9/28/94.

Prepared by: NXP
Checked by: JWS

Based on the field work completed, only eight events were recorded during the approximately 14 hour recording period distributed at four locations surrounding the proposed Crandon Project site. At location 2, the maximum recorded particle velocity was 0.0129 in/sec. At location 4 peak recorded particle velocity was .0047 in/sec from the four records.

3.11.3 Bibliography

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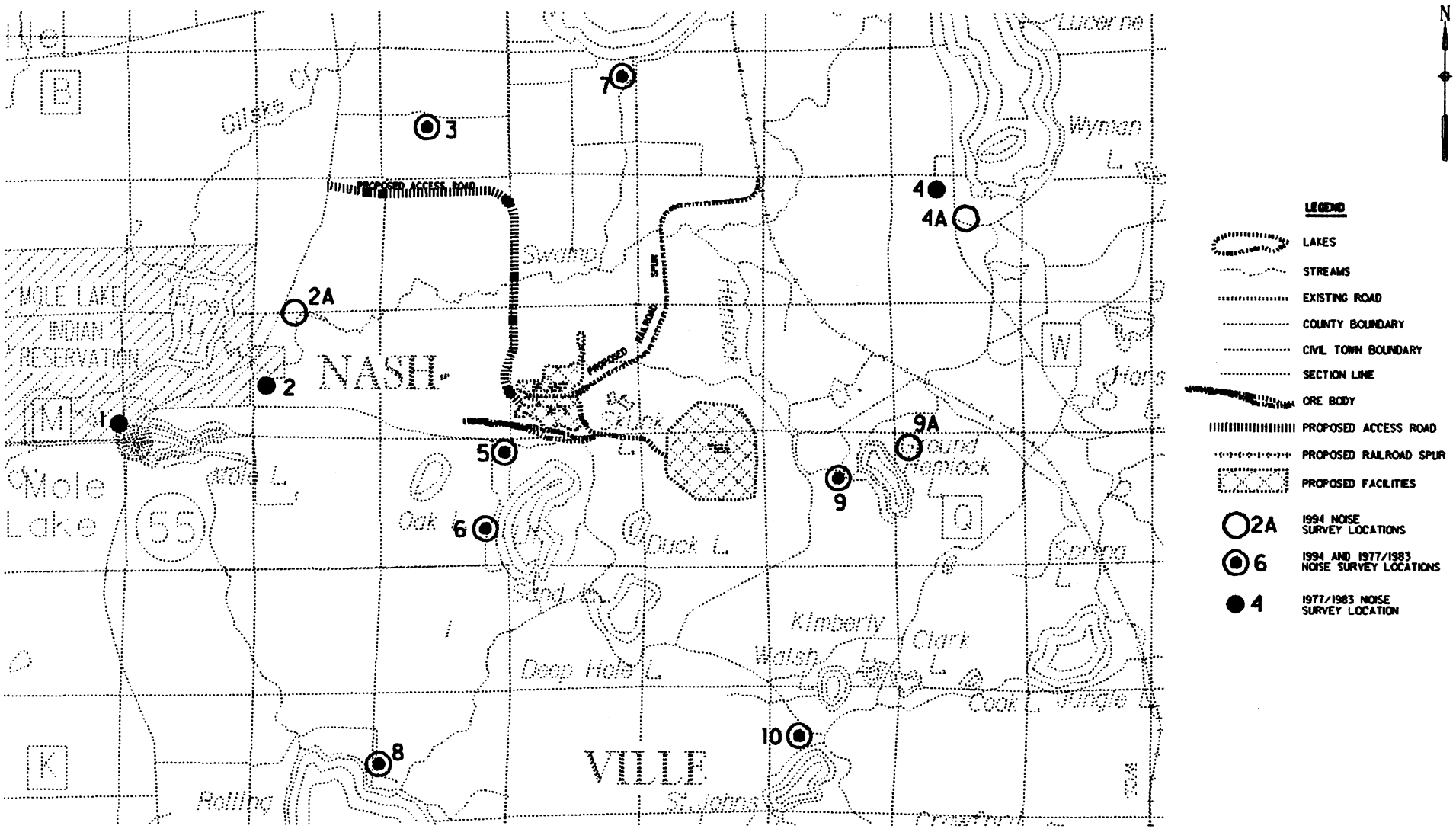
Wisconsin Department of Natural Resources, 1986. *Final Environmental Impact Statement*, Exxon Coal and Mineral Co., Zinc-Copper Mine, Crandon, Wisconsin.

FIGURES FOR SECTION 3.11



NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

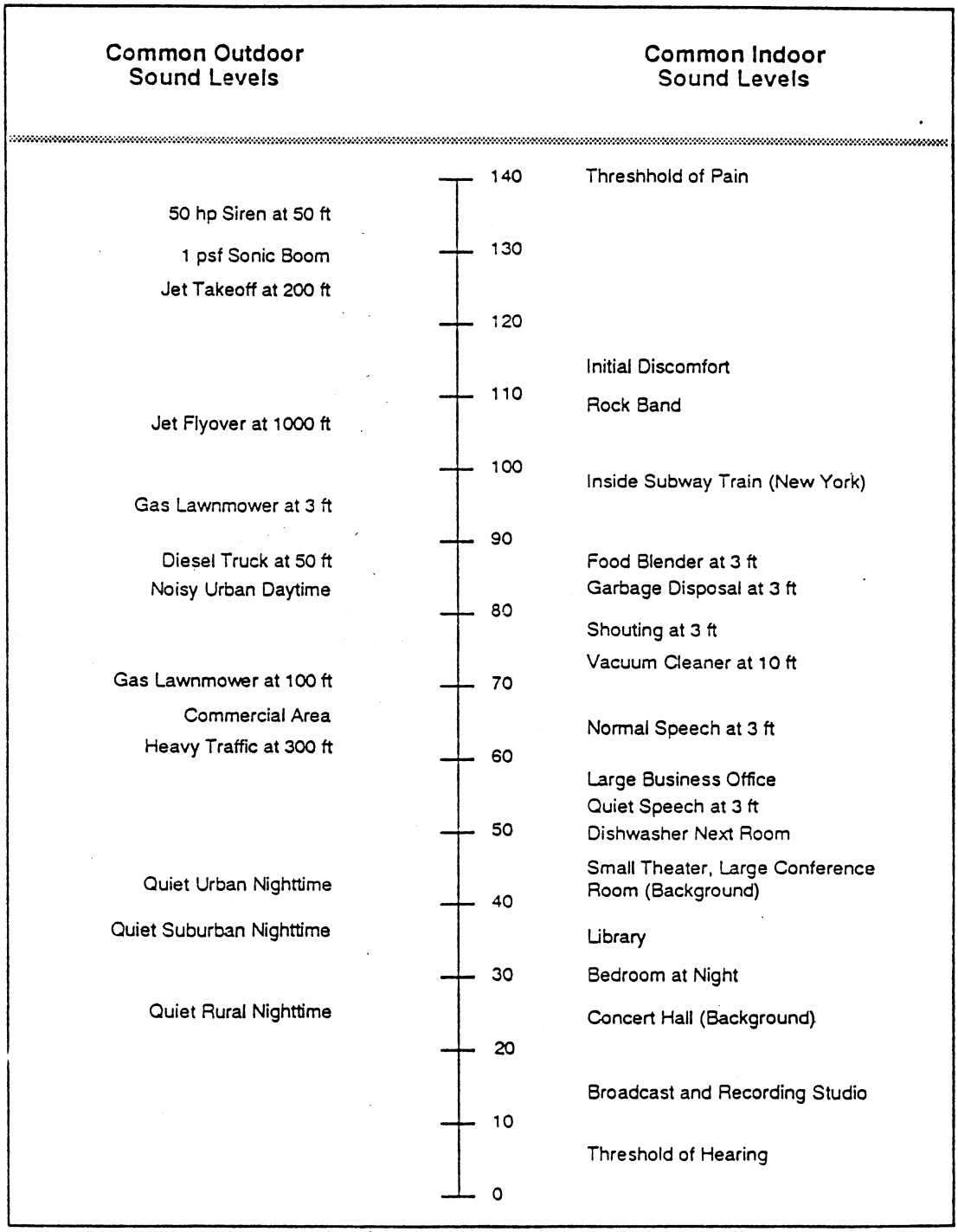
Crandon Mining Company

FIGURE 3.11-1
LOCATION OF
NOISE SAMPLING SITES

Scale: 0 3000' 6000'
Date: MAY, 1995
Prepared By: Foth & Van Dyke
By: JRB

c:\cadwork\4c60f15.dgn

93C049



SOURCE: PETERSON AND GROSS (1980), BERANEK (1971), EPA (1971).

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

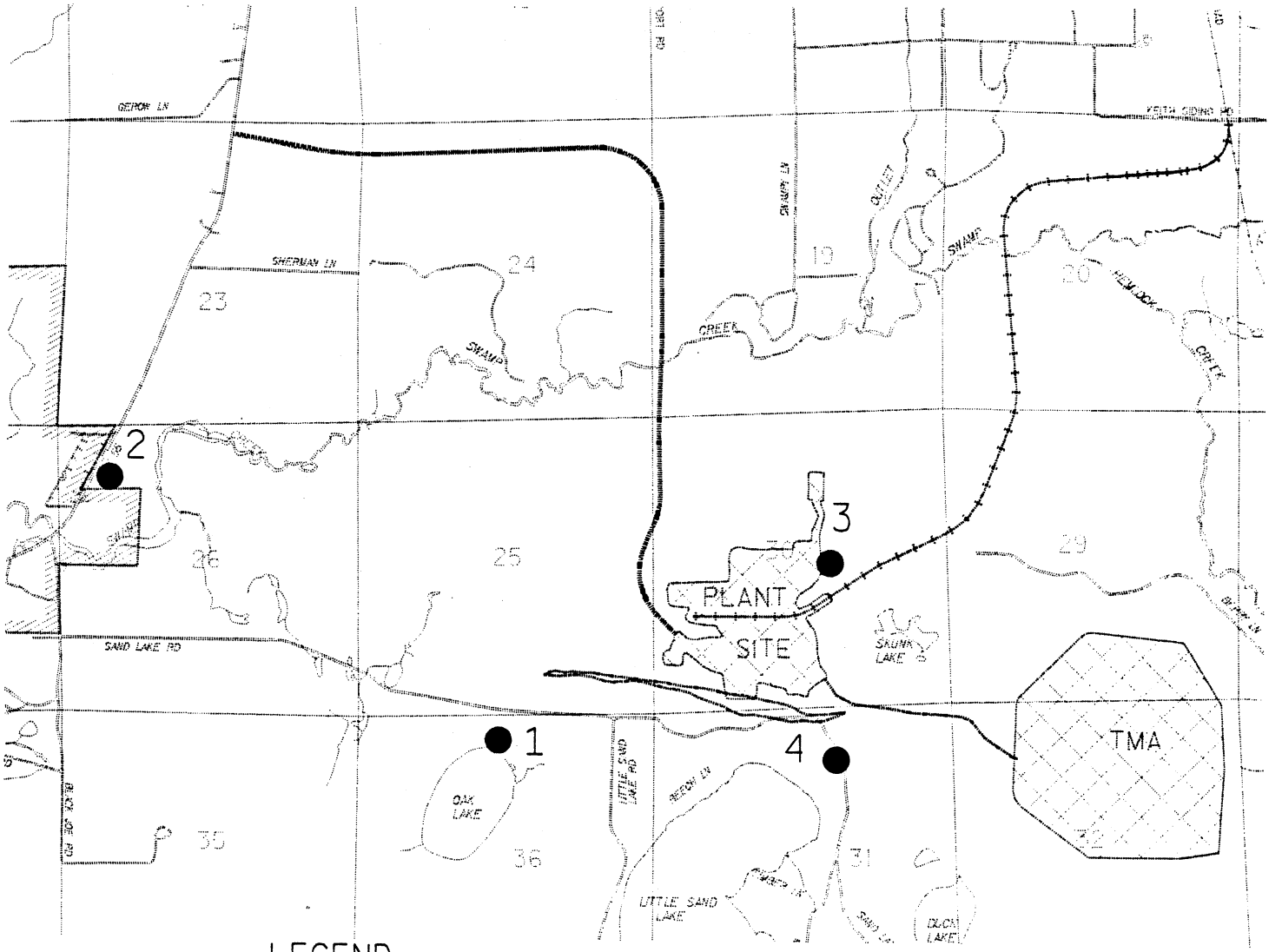
CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RFS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.11-2

TYPICAL A-WEIGHTED SOUND LEVELS OF COMMON SOURCES

Scale:	NOT TO SCALE	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH



LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- SECTION LINE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- 1 MONITORING LOCATION

N

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	NXP	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

Crandon Mining Company

FIGURE 3.11-3

MONITORING LOCATIONS
AMBIENT GROUND VIBRATION

Scale:	1" = 3000'	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	BSH

/d3/d1/users/jpr1/4c60f4.dgn

93C049

Crandon Mining Company

Environmental Impact Report

Section 3.12

Land Use and Zoning

Crandon Mining Company
Environmental Impact Report

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(Note: Figures for Section 3.12 are located at the end of the text, following page 3.12-16.)

Figure 3.12-1 Land Use and Zoning Study Area
Figure 3.12-2 Land Use in the Study Area
Figure 3.12-3 Recreational Resources in the Study Area
Figure 3.12-4 Recreational Trails in the Study Area

3.12 Land Use and Zoning

This section of the EIR identifies the land use types and zoning in Forest and Langlade Counties in general, and specifically in the study area. The study area evaluated for land use and zoning includes an approximate 100 square mile area surrounding the plant site, as shown on Figure 3.12-1. The study area consists of portions of Forest and Langlade Counties including portions of the Towns of Nashville and Lincoln in Forest County, and the northeast portion of the Town of Ainsworth in Langlade County.

3.12.1 Field and Laboratory Methods

Land use investigations consisting of literature searches and field reconnaissances were first conducted for the project in 1977. Additional evaluations were completed in 1982 and 1994/1995 to update the project's database. The literature searches were conducted to obtain published information on the land use and aesthetic characteristics of Forest and Langlade Counties. The types of information obtained during the literature search included USGS 7.5 minute topographic maps, plat books, regional outdoor recreation plans, Chamber of Commerce publications, and forest management plans. An important portion of the literature search consisted of contacting governmental bodies that might have information useful to the land use investigation. The agencies contacted included, but are not limited to, the WDNR; Wisconsin DOA, Wisconsin Department of Revenue, the North Central Wisconsin Regional Planning Commission (NCWRPC), and offices of the Forest and Langlade County Clerks and Zoning Administrators.

During January and September 1978, and again in May 1982, field reconnaissances were conducted of the study area. These reconnaissances were conducted by automobile and on foot to verify the information obtained during the literature search, and from April 1976, June 1978, and April 1981 aerial photographs. The type of information recorded included the distribution of land uses, vegetation types and residences, the location of recreational resources and businesses, and aesthetic characteristics. The minimum size of any land use delineated was 40 acres. Linear land uses, such as highways and railroads, were not included in acreage calculations.

The data developed from the previous field reconnaissances were compared to the April 1994 aerial photographs, Forest (1989) and Langlade (1992) County plat maps, and 1994 Wisconsin Department of Revenue Statement of Assessments for the Towns of Ainsworth, Lincoln and Nashville by Foth & Van Dyke. Based on these comparisons, as well as input from NCWRPC (January, 1995), it was determined that land use patterns have not changed significantly in the study area over the past twelve years.

3.12.2 Regional Land Use

Land use in Langlade County consists of approximately 70 percent forest lands and 24 percent farm/agricultural lands (UW-Extension, 1992). The majority of the farmlands are located in the south central portion of the county, with the majority of the forest lands located in the northern half and northeastern portions (Langlade County, 1990). Langlade County has 867 lakes totalling more than 6,800 acres (UW-Extension, 1992). A comprehensive land use plan for Langlade County forests (1985-1995) and an outdoor recreation plan (NCWRPC, 1991) are the only current county-wide land use plans available for Langlade County (Haering, 1995;

Haakenson, 1995). Both plans expire in 1995 and will be updated (Haering, 1995; Sohasky, 1995).

Land use in the Langlade County Town of Ainsworth, which comprises the southwestern quarter of the study area is shown in Table 3.12-1. As indicated in the table, more than 80 percent of the township is in forest and swamp lands, with residential and agricultural lands occupying less than 10 percent of the total land area in the town. The remaining 10 percent of the township includes tax-exempt lands such as public hunting/fishing grounds, Boy Scout lands, etc., which are also mostly forested.

Land use in Forest County consists of 84 percent forested lands, including national and county forest lands, and five percent agricultural lands (UW-Extension, 1992). Surface water resources in Forest County include 824 lakes with a total surface area of 22,324 acres and over 317 streams with an excess of 700 miles of waterway.

There are two land use plans available for Forest County. These include a ten-year (1985-1995) comprehensive land use plan for Forest County Forests and an outdoor recreation plan (1988). Both of these plans expire at the end of 1995, however, they are currently planned to be updated prior to their expiration date (Haering, 1995; Landsverk, 1995; Ziolkowski, 1995a).

Within Forest County, the Town of Lincoln comprises the northeastern portion of the study area. Land use in the Town of Lincoln is shown in Table 3.12-2. Approximately 87 percent of the town is forested, with about 10 percent of the lands being used for agricultural or residential land as indicated in the table.

Also within Forest County portions of the Town of Nashville comprise the northwestern and southeastern quarters of the study area. A breakdown of land use for the Town of Nashville is shown in Table 3.12-3. Similar to the Town of Lincoln, approximately 87 percent of the town is in forested lands with about 12 percent of the land area in agricultural or residential land.

Table 3.12-1

1994 Land Use, Town of Ainsworth, Langlade County

Land Use Category	Acres	%
Residential	1613	3.6
Commercial	45	0.1
Manufacturing	--	0
Agricultural	1,602	3.6
Swamp Lands	1,820	4.1
Forest Lands	35,027	78.8
Other[1]	4,330	9.8
Totals	44,437	100.0

Source: Wisconsin Department of Revenue, 1994 Statement of Assessment.

[1] Includes tax-exempt lands (i.e. public hunting/fishing grounds, lands owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

Table 3.12-2

1994 Land Use, Town of Lincoln, Forest County

Land Use Category	Acres	%
Residential	1,664	4.6
Commercial	90	0.2
Manufacturing	--	--
Agricultural	2,047	5.6
Swamp Lands	279	0.8
Forest Lands	31,580	86.9
Other[1]	699	1.9
Totals	36,359	100.0

Source: Wisconsin Department of Revenues, 1994 Statement of Assessment.

[1] Includes tax-exempt lands, (i.e. public hunting, fishing grounds; lands owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

Table 3.12-3

1994 Land Use, Town of Nashville, Forest County

Land Use Category	Acres	%
Residential	2,775	6.6
Commercial	76	0.2
Manufacturing	--	--
Agricultural	2,217	5.3
Swamp Lands	171	0.4
Forest Lands	36,503	86.5
Other[1]	440	1.0
Totals	42,182	100.0

Source: Wisconsin Department of Revenue, 1994, Statement of Assessment.

[1] Includes tax-exempt lands (i.e. public hunting, fishing grounds,land owned by religious groups, Boy Scouts, etc.).

Prepared by: GMS
Checked by: RVS

3.12.3 Study Area Land Use

Land use within the study area has been divided into five categories, defined as follows:

Forestry - Land being used to produce forest products such as pulp wood, saw timber, wood chips and/or maple syrup. This includes all forested land capable of producing trees with a diameter at breast height of over 2.5 cm (one inch) and where canopy coverage is greater than 25 percent. It also includes clearcuts that will be left to revert to forest cover and old agricultural fields that are being allowed to revert to forest cover.

Agriculture - Land being used for agricultural purposes. This includes crop fields, hay fields, and pastures. Old agricultural fields that can potentially be used as pasture because they are fenced and are not reverting to forest cover are also included in this category.

Recreation - This land use includes those lands whose primary use is recreation. It does not include areas where recreation is a secondary use, such as Forest Crop Law lands. Lands included within this category are primarily parks and water bodies. However, this category also includes marshes and shrub swamps as recreation is probably their only major active use.

Residential/Institutional - This includes all residential areas, both permanent and seasonal, as well as any institutional uses such as churches, schools, nursing homes, and/or hospitals.

Transportation - Any lands used by transportation systems, such as roads, railroads and airports.

The distribution of the major land uses in the study area is shown on Figure 3.12-2. The percentage of each land use is shown on Table 3.12-4.

Table 3.12-4

Study Area Land Use

Land Use	Area in Square Miles	Percent of Total Area
Forestry	76.5	76.5
Recreation[1]	11.8	11.8
Residential	6.4	6.4
Agriculture	5.0	5.0
Transportation[2]	0.3	0.3
Total	100.0	100.0

[1] Includes water bodies/wetlands.
[2] Highways/railroads not included in acreage totals.

Source: EIR, Exxon Minerals Company, November, 1985.

Prepared by: GMS
Checked by: RVS

The remainder of the land use discussion will focus on the major use categories found in the study area. These include: forest lands, agriculture, recreation, and residential. A special land use category, the Mole Lake Indian Reservation, is also discussed in this section. Commercial land use will not be addressed since it comprises a very minor proportion of the area.

3.12.3.1 Forestry

Approximately 77 percent of the study area is forest land that could conceivably be harvested, that is, used for forestry (Table 3.12-4 and Figure 3.12-2). In addition to providing resources for lumber, pulp and associated industries these forested lands provide numerous recreation opportunities, habitat for fish and wildlife and provide a stable environment along streams and other desirable resource areas (Foth & Van Dyke, 1988).

Forest County owns over 10,800 acres of forest lands, 97 percent of which are classified as commercial forest. These lands, wholly located in the town of Lincoln, are composed of the

North Lincoln and South Lincoln units. South Lincoln is included in the study area. Aspen and northern hardwood are the two major cover types that make up over 80 percent of the total county forest lands. The aspen cover type is composed, most commonly, of stands consisting of pure aspen or aspen mixed with white birch. The northern hardwood cover type consists of sugar maple, basswood, white ash, American elm, yellow birch, and red maple. Associated species include aspen, white birch, eastern hemlock, northern red oak, bitternut hickory, butternut, and ironwood (Forest County, 1986). Approximately 2,800 acres of Forest County-owned forest lands are included in the study area (Forest County Plat Book, 1989).

Langlade County owns approximately 126,500 acres of forest lands, of which 5,000 acres are located in the southwestern quarter of the study area, in the town of Ainsworth (Langlade County, 1992). Approximately 93 percent of the Langlade County forest is considered commercial forest, with more than half of the total forest lands being composed of northern hardwood (33.2 percent) and aspen (31.9 percent) (Langlade County, 1986).

According to Forest County (1989) and Langlade County (1992) plat books, approximately 35 percent (17,200 acres) of the forest land in the study area is owned by private corporations. Publicly owned state and county forest lands account for approximately 18 percent (9,000 acres), with the remaining 47 percent in private ownership (22,700 acres). Consolidated Papers, Inc. accounts for half of the corporately owned forest lands (8,750 acres) in the study area. Six other companies account for the remaining forested lands under corporate ownership, including CMC properties, of approximately 4100 acres.

3.12.3.2 Agriculture

Information on agricultural use in Forest and Langlade Counties was obtained from the Wisconsin Agricultural Statistics Service (1994), for the 1992-1993 seasons and is shown in Table 3.12-5.

As indicated in the table, Forest County is consistently low in the rankings for agricultural products produced by Wisconsin counties. Even though Langlade County is ranked higher in agricultural production, the portion of Langlade County in the study area is much more like Forest County than the more agricultural portions of Langlade County to the south and west.

Approximately five percent, 3,200 acres, of the study area is in agricultural use which includes dairy farming, livestock production, and crops of oats, barley, wheat, alfalfa, hay and potatoes. Irregular slopes, stoniness, dryness on rises, wetness in depressions and short growing season limit agricultural use of soils in the study area.

The majority of the agricultural lands in the study area are primarily located in Forest County near Mole Lake and to the north along Highway 55, along County Trunk Highway B near Nashville and south of Lake Metonga (Figure 3.12-2). Using the average size per farm listed in Table 3.12-5, and the number of acres in agricultural lands in the study area listed in Table 3.12-4, it is estimated that there are approximately 15 farms in the study area.

Table 3.12-5

Agricultural Statistics

	Forest County		Langlade County		1993 Statewide Rank
	1992	1993	1992	1993	Forest/Langlade
No. Farms	140	140	510	500	67/50
Ave. Size (acres)	214.3	221.4	282.4	284	
Crop Yields					
Corn bu./ac.	57.5	42.0	70.5	65.7	66/59
Oats bu./ac.	58.6	45.6	68.0	42.6	66/27
Barley bu./ac.	45.0	35.7	61.3	45.9	55/13
Wheat bu./ac.	28.0	--	33.1	43.2	--/27
Soybeans bu./ac.	--	--	18.1	18.0	--/59
Hay tons/ac.	2.1	2.3	1.9	2.9	68/30
Potatoes hundredweight/ acre	--	--	306	276	--
Milk Production lbs/cow	14,300	14,300	15,000	14,900	66/51

Source: Wisconsin Agricultural Statistics - 1994, Wisconsin Agricultural Statistics Service, Madison, WI.

Prepared by: GMS
Checked by: RVS

3.12.3.3 Recreation

The extensive amount of public forest lands, lakes and streams provide an abundance of outdoor recreational opportunities in the area. Figure 3.12-3 shows the recreational resources located in the study area. Approximately 9,000 acres of publicly owned state and county lands are available in the study area. Within Forest County alone there are a total of approximately 340,000 acres of publicly owned lands including U.S. Forest Service, county and state lands (Foth & Van Dyke, 1988). These lands are open to hunting, fishing, picnicking, and camping. Other uses such as berry picking, hiking and bike riding are encouraged, although special regulations governing those uses have not yet been developed (Forest County, 1986; Langlade County, 1986).

As shown in Figure 3.12-3, three campgrounds are located within the study area. Table 3.12-6 provides information on the number of sites and facilities located at each campground. According to this information, a total of 110 campsites are available between the three campgrounds, with electricity, flush toilets and showers available at some of the sites. Public boat access is available at four lakes in the study area, as shown in Figure 3.13-3. These include Rolling Stone, Crane, Little Sand and Lily Lakes. No other facilities are available at these sites (Foth & Van Dyke, 1988; NCWRPC, 1991).

Table 3.12-6

Forest County Campgrounds in the Study Area

	No. of Camp Sites	Facilities and Services													
		Boating	Dump Station	Electricity	Fishing	Flush Toilets	Grills	Handicapped accessible	Horse shoe Pits	Hot Water	Picnic Facilities	Pit Toilets	Showers	Swim-ming	Trailer Camping
Forest County Veteran's Memorial Park (Lake Metonga)	70	yes	yes	yes	yes	no	yes	yes	yes	no	yes	yes	no	yes	yes
Lily River (Marquardt Lodge & Campground)	20	yes	yes	yes	yes	yes	no	no	yes	yes	yes	no	yes	no	yes
Sokaogon Chippewa Community Park (Mole Lake)	20	yes	no	no	yes	no	no	no	no	no	yes	yes	no	no	yes

Source: Foth & Van Dyke; Comprehensive Outdoor Recreation Plan, Forest County Forestry Department, November 1988.

Prepared by: GMS
Checked by: RVS

Suggested bicycle routes as identified in the Forest and Langlade County recreation plans are shown on Figure 3.12-4. The plans recommended proper signage to caution drivers (NCWRPC, 1991) and paved shoulders on roadways designated as bike routes (Foth & Van Dyke, 1988). The bicycle routes, however, have not been formally implemented (Frisch, 1995; Ziolokowski, 1995b).

Over 300 miles of groomed and signed snowmobile trails are available in Forest County. The specific trail segments included in the study area, and shown on Figure 3.12-4, are the 100 Mile Snow Safari Trail, Lumberjack Memorial Trail and Tombstone-Pickerel Trail (Forest County, 1994).

Forest County Forestry Department developed and maintains an eight-mile all terrain vehicle trail (ATV) on Forest County forest land off of County Trunk Highway W at the end of Duff Road, shown on Figure 3.12-4. The trail is open for year round use. A loading dock is provided to assist with loading/unloading ATVs. A parking area is also available. No other services are provided (Forest County Forestry Department, n.d.).

Due to the abundance of lakes and streams in the area, the fishing pressure in Forest County is much less than what the available resource offers, however, fishing surfaces as the number one recreation experience. *The Forest County Comprehensive Outdoor Recreation Plan* (Foth & Van Dyke, 1988) referenced a special issues and actions report, prepared by the WDNR, that indicated protecting the existing water resources and addressing acid rain were two of the top three concerns expressed for WDNR's North Central Wisconsin District, which includes Forest County.

The *Forest County Comprehensive Outdoor Recreation Plan* (Foth & Van Dyke, 1988) includes a needs assessment for recreational facilities in Forest County for the period from 1986-1991. The needs assessment was determined by: (1) area based demand analysis; (2) trends in outdoor recreation activity participation; and (3) priority of facility needs. Through the needs assessment process priorities were established for the Forest County region, which also included Vilas and Oneida Counties. The recreation activities and their priorities are indicated below:

<u>High Priority</u>

Camping
Cross-country skiing
Fishing
Off Road Vehicle:other
Organized sports
Playground activities
Swimming:beach
Walking/jogging

<u>Medium Priority</u>

Bicycling
Canoeing
Hiking/backpacking
Ice fishing
Golfing
Picnicking
Snowmobiling
Swimming pool
Tennis

<u>Low Priority</u>

Downhill skiing
Horseback riding
Ice skating/hockey
Off Road Vehicle:cycles
Sailing
Motor boating/waterskiing

From this analysis, the plan included recommendations for new and/or improved facilities. There were no new facilities recommended for development within the study area. However, the plan included several general recommendations for future facilities, including the following:

- additional river access sites for canoeing;
- designated bicycle routes along thoroughfares which are properly designed and signed;
- better fishing access accommodations/handicapped accessible fishing docks/off-road parking; and
- upgrade existing boat launch facilities/construct new launch facilities at lakes without launch facilities.

The Langlade County Outdoor Recreation Plan (NCWRPC, 1991) provided several recommendations for future recreational facilities in the county. No new facilities were recommended or identified in the study area. Among those included the following:

- development of a county/regional park in the eastern portion of the county (no site identified);
- additional improved public access to state and federal lands; and
- undertake a county-wide bicycle trail study/identify suggested bicycle routes with route signs.

Specific improvements recommended for the Town of Ainsworth facilities located at Rolling Stone Lake included:

- upgrade to be handicap accessible;
- finish boat launch with cement planks and gravel; and
- establishment of a picnic area with table/grill.

3.12.3.4 Residential/Institutional

Residential land use, estimated to include approximately 4,000 acres or six percent of the total land area in the study area, is concentrated around the larger lakes as shown in Figure 3.12-2. Permanent population totals for the Towns of Nashville, Lincoln and Ainsworth in 1990 were 871, 630, and 474, respectively (Section 3.14.3.1, Population). However, in noting the large percentage of seasonal/recreational housing units in Forest County (50 percent, Section 3.14.3.3, Housing) it can be assumed that the population in the Towns of Lincoln and Nashville increases during summer months.

As noted in Section 3.14.3.3, Housing, Langlade County has approximately 27 percent seasonal/recreational housing units. The majority of this housing can be assumed to be located in the forested portions of Langlade County which would include the Town of Ainsworth.

Within the study area most permanent residences are located in Mole Lake, along Lakes Metonga and Lucerne and along Highway 55, County Highway B, and Airport Road in the northern portion of the study area. Little Sand Lake, the closest lake to the ore body, is developed along the western, northwest and eastern shorelines. Many of these residences as well as others on lakes in the study area are one to two bedroom seasonal cottages.

There are only four institutional buildings located in the study area. These include a chapel, school and tribal building in Mole Lake and the Nashville Town Hall, which is located at the intersection of Highway 55 and County B.

3.12.3.5 Transportation

Transportation land uses in the study area include State Trunk Highway 55, County Trunk Highways "B","M", "Q", and "W", local town roads/forest roads, a Wisconsin Central Limited Railroad line and the Crandon Municipal Airport. Transportation systems are discussed in more detail in Section 3.3, Transportation and Utilities.

3.12.3.6 Special Land Use Category

The Mole Lake Indian Reservation of the Mole Lake Bank of the Sokaogon Chippewa is a special land use category in the study area. The 1,800-acre reservation is located approximately 2 miles to the west of the plant site (Figure 3.12-1). A history of the Mole Lake Sokaogon Chippewa and the Reservation is located in Section 3.2.2 of the EIR. Rice Lake, located within the reservation, is an important resource to the Sokaogon Chippewa Community for cultural and rice harvesting purposes. Fish and game harvesting and plant harvesting for medicinal purposes occurs on the reservation. As described in Section 4.2.14 of the EIR, the Sokaogon Chippewa have off-reservation hunting and gathering rights on public property in the area. A discussion of Sokaogon Chippewa traditional cultural properties as they relate to land use is contained in Sections 3.2.2 and 4.2.1 of the EIR.

3.12.4 Zoning

The following discussion on zoning pertains to the lands identified for the land use assessment within the study area (Figure 3.12-1), and specifically the area to be occupied by facilities located within the mine site. Forest County, the Towns of Lincoln and Nashville, and the City of Crandon will have zoning authority over the mine site, but Langlade County and the Town of Ainsworth have also been included in the study area due to their proximity to the mine. The discussion below of zoning requirements is subject to Wis. Stats. 144.839, which allows local jurisdictions with zoning or land use authority over mining operations to enter into one or more "local agreements" with the operator for development of the mine. Local agreements provide an alternative method for local regulation of a mining operation, and could take the place of some of the zoning procedures discussed below. CMC is presently negotiating local agreements with Forest County, the Towns of Lincoln and Nashville, and the City of Crandon.

Subject to state and federal laws, counties, cities, villages and towns have the legal authority to adopt zoning ordinances to control and regulate development within their jurisdictional boundaries. Forest County and Langlade County have both adopted zoning ordinances to regulate development in unincorporated areas within their counties. The Towns of Lincoln and Nashville have both adopted their own zoning ordinances for lands within their townships. The Town of Ainsworth, in Langlade County, adopted the Langlade County zoning ordinance on September 30, 1993 (Viola, 1995). As of February, 1995, the zoning map for the town of Ainsworth is in the process of being updated, and is scheduled for adoption in the spring of 1995 (Higgins, 1995). The following discussion will address the Langlade County Zoning Ordinance as it relates to the Town of Ainsworth, and the specific individual ordinances for the Towns of Nashville and Lincoln.

According to the Langlade County Zoning Ordinance (1991), and the current zoning map for the Town of Ainsworth (1993), the area within the study area includes seven zoning districts: Conservancy (C-1), Forest (F), Flood Plain (FP), Exclusive Agricultural (A-1), Residential Single Family (R-1), Park and Recreation (PR) and Agriculture/Forest Residential (AFR). The R-1 and AFR districts are located around Rolling Stone, Berendsen and Agnes Lakes. The remaining area of the Town of Ainsworth within the study area is zoned C-1, F, FP, or A-1. The public boat landing located on Rolling Stone Lake is zoned PR.

Residential development is a permitted use in the following districts: Forest District, on parcels of 35 or more acres or conditional use for parcels from one to 34 acres; Exclusive Agricultural, as a part of a farm operation; Residential District, minimum lot size of one acre and minimum width of 100 feet, if served by public sanitary sewers minimum lot area of 20,000 square feet and minimum lot width of 100 feet; and Agricultural/Forest District, with the same lot requirements as Residential (Langlade County, 1991).

In Langlade County, Metallic Mining Exploration (MME) is provided as an overlay district to describe an area where exploration may occur for a specified period of time. In the event metallic minerals are found, a petition for a zoning amendment to a Mining District (M) is required for the specified site for which mining is to take place. The zoning map for the Town of Ainsworth (1993) does not show any lands zoned MME or M.

On June 20, 1994 the Town of Ainsworth Town Board passed a resolution that prohibits the placement of a mining waste disposal facility in the town. In the 1980s, an alternative tailings pond location, Site 40, was considered in portions of Sections 1 and 2, T34N, in the Town of Ainworth. The resolution noted, among other reasons, that Sections 1 and 3 in T34N are designated as floodplain according to the Langlade County Zoning maps.

The zoning ordinance for the Town of Lincoln in Forest County, includes eight zoning districts. The majority of the town, however, is zoned General Rural (GR) or Lake Development (LD) which includes the residential areas located around the lakes in the town (Carter, 1995). Minimum lot sizes for the GR and LD districts are 1.5 acres and 20,000 square feet, respectively.

Most of the mine and associated facilities will be located in the Town of Lincoln. The town's zoning ordinance includes a Planned Development (PD) provision to allow flexibility in dealing with large scale developments such as the proposed mine. The Metallic Mineral Mining and Prospecting Planned Development (MPD) is permitted in GR Districts. An application for approval of any PD must be filed with the town for approval which includes specific

environmental and socioeconomic information pertaining to the project. After receipt of the application by the town's Zoning Committee, a series of public hearings will be held (Town of Lincoln, 1982).

The Town of Nashville, which has been zoned since 1984, is in the process of updating its zoning ordinance and map. The update pertains mostly to LD districts and increasing the town's ability to enforce sanitary codes for residential development. Adoption of the updated map and ordinance is expected in the spring of 1995 (Marquardt, 1995).

The Town of Nashville's current zoning ordinance includes eight districts: General Rural (GR), Village Residential (VR), Village Commercial (VC), Lake Development (LD), Industrial (IN), One and Two Family Residential (R1), Multi-Family Residential (R2) and Commercial (CM). The R1, R2 and CM districts apply only to sewered areas. Minimum lot sizes for the GR district are 1.5 acres, and 20,000 square feet with a minimum lot width of 100 feet for LD districts. Unsewered residential development is also permitted in the VR district which is intended to be more compact than in more open rural areas. Minimum lot sizes in VR districts are 1.5 acres with a minimum lot frontage of 150 feet (Town of Nashville, 1984).

In addition, as noted in the Town's zoning ordinance, the Town has adopted a Socioeconomic Impact Ordinance (1985) that is to provide for the development and implementation of an impact mitigation plan for PD projects. Developers for any PD projects must submit socioeconomic information to the Town board, including data regarding town revenues, proposed housing units, sewer and water facilities, etc.; a description of the proposed project; an analysis of the proposed development on baseline conditions, and mitigation plans to mitigate or eliminate potential negative impact.

The City of Crandon enforces a zoning ordinance for areas around the Crandon Municipal Airport. The city's Zoning and Building Commissioner administers and enforces the ordinance. Height restrictions for structures are identified for areas around the airport. As indicated in Section 21.03 of the ordinance (City of Crandon, 1980), permits are required for structures within the zones shown on the zoning map for the Crandon Municipal Airport, which includes the proposed plant structures. Plant structures cannot exceed an elevation of 2,065 feet above mean sea level according to the zoning map. The maximum elevation of the 165 foot head frame will be an elevation of 1,830 feet above mean sea leave, within the requirements of the ordinance, however, permits will still be required. Permit applications are made to the city's Zoning and Building Commissioner. In addition, no land use is permitted that may create electrical interference with radio communication between airport and aircraft, make it difficult for pilots to distinguish between airport lights and others, or result in glare in the eyes of pilots using the airport, or impair visibility in the vicinity of the airport or otherwise endanger the landing, taking off or maneuvering of aircraft (City of Crandon, 1980).

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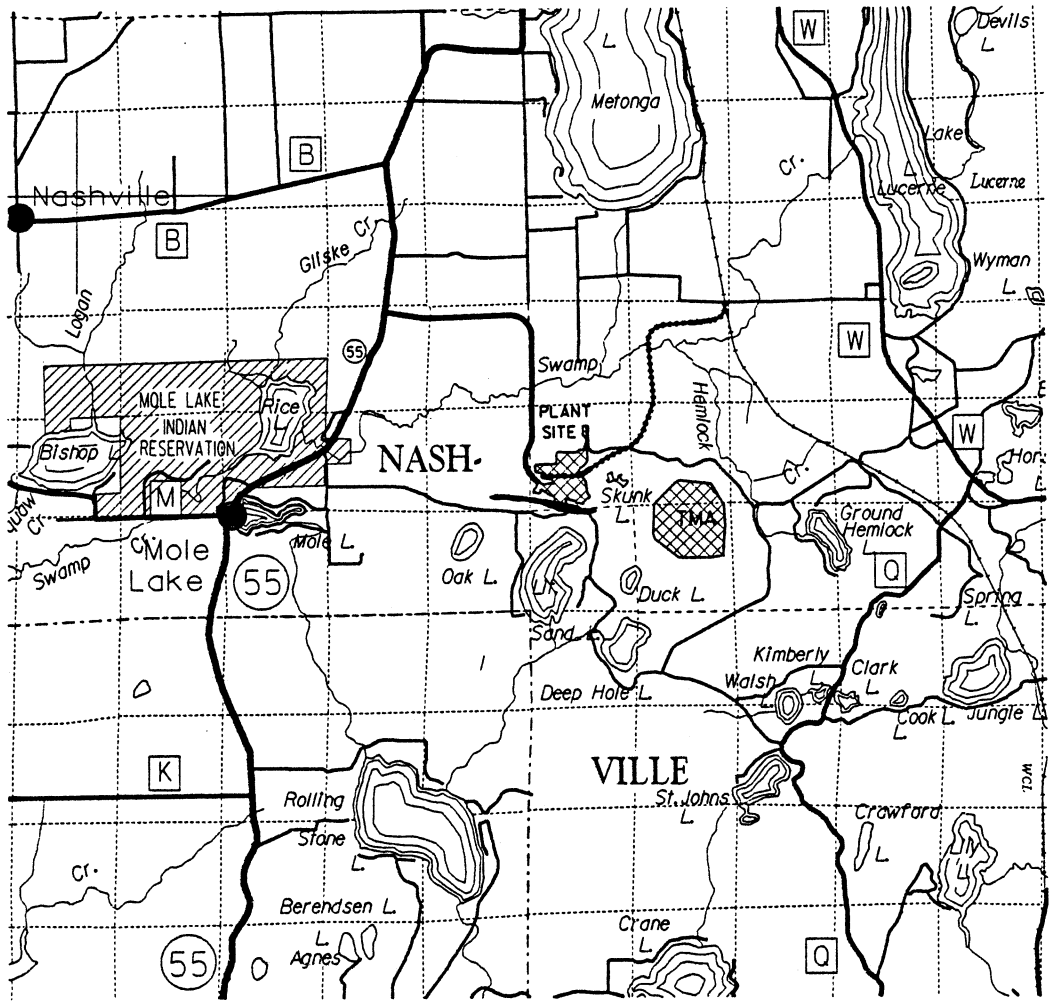
FIGURES FOR SECTION 3.12



LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- [W] COUNTY HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAY.'95
APPROVED BY:	GMS	DATE:	MAY.'95
APPROVED BY:	GWS	DATE:	MAY.'95

Crandon Mining Company

FIGURE 3.12-1
LAND USE AND ZONING
STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

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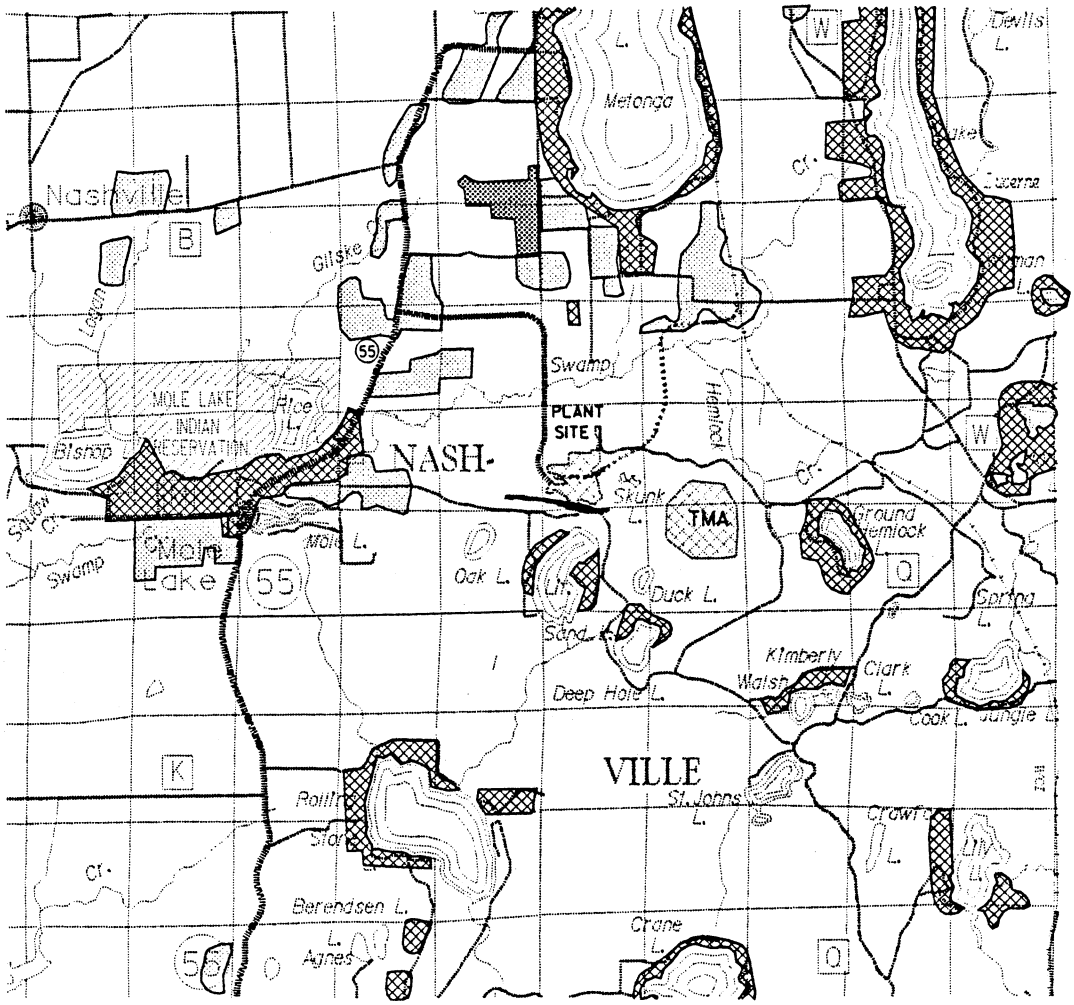

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- W COUNTY HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- AGRICULTURE
- FOREST LANDS/WETLANDS
- RESIDENTAL/INSTITUTIONAL
- TRANSPORTATION

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. MINIMUM LAND USE AREA DEPICTED 40 ACRES.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 3.12-2
LAND USE IN THE STUDY AREA

Scale: 0 10,000 20,000 Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JOW

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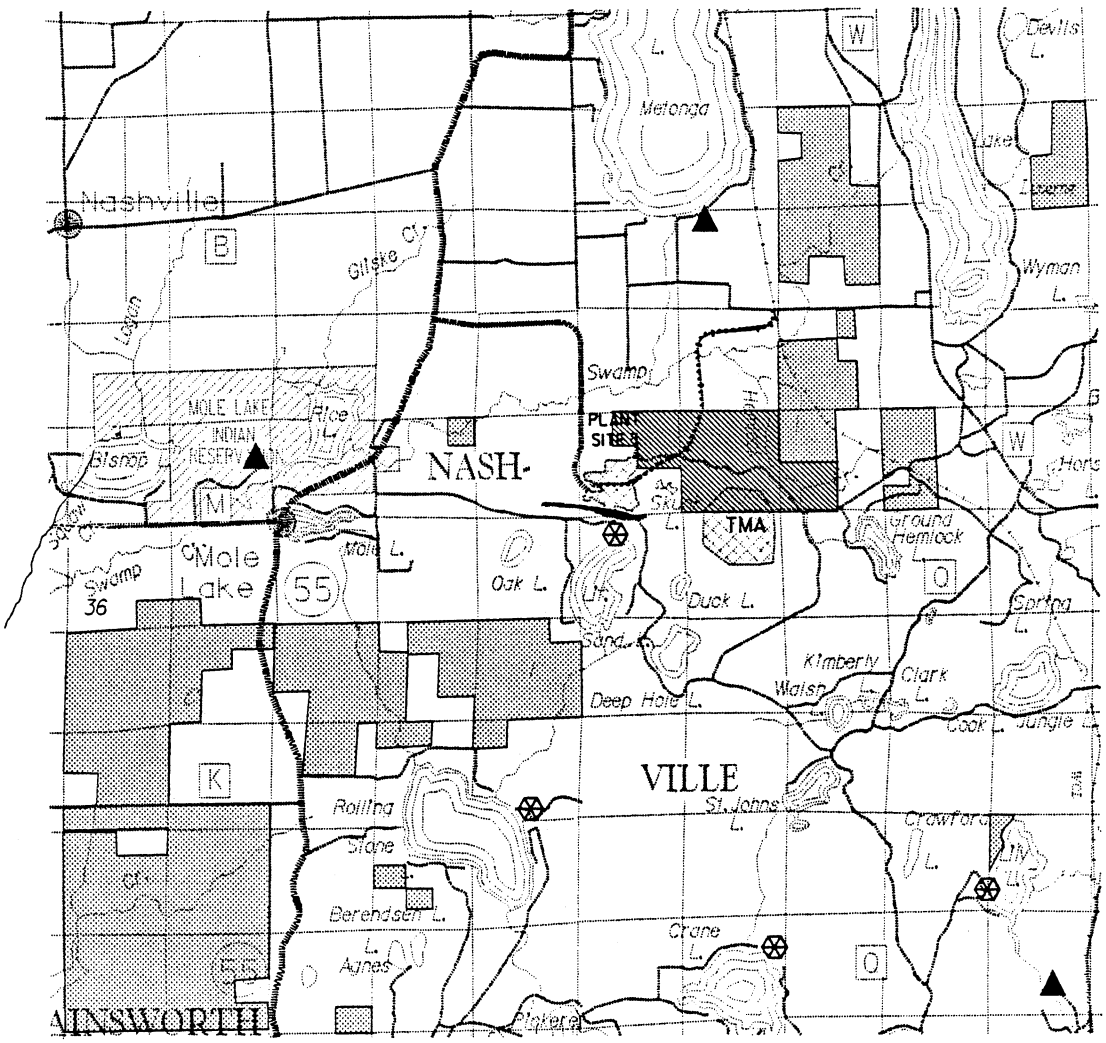

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- U.S. HWY NO.
- STATE HWY NO.
- COUNTY HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- BOAT ACCESS
- PARK/CAMPGROUND
- PUBLIC LANDS
- PUBLIC LANDS OPTIONED BY CMC

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.
3. SOURCE: NORTH CENTRAL WISCONSIN REGIONAL PLANNING COMMISSION; LANGLADE COUNTY OUTDOOR RECREATION PLAN 1991-1995, JANUARY 1991; FOTH & VAN DYKE, COMPREHENSIVE OUTDOOR RECREATION PLAN, FOREST COUNTY FORESTRY DEPARTMENT, NOVEMBER, 1988; FOREST COUNTY RECREATION MAP, 1994.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 3.12-3

RECREATIONAL RESOURCES IN THE STUDY AREA

Scale: 0 10,000' 20,000' | Date: MAY, 1995

Prepared By: Foth & Van Dyke | By: JOW

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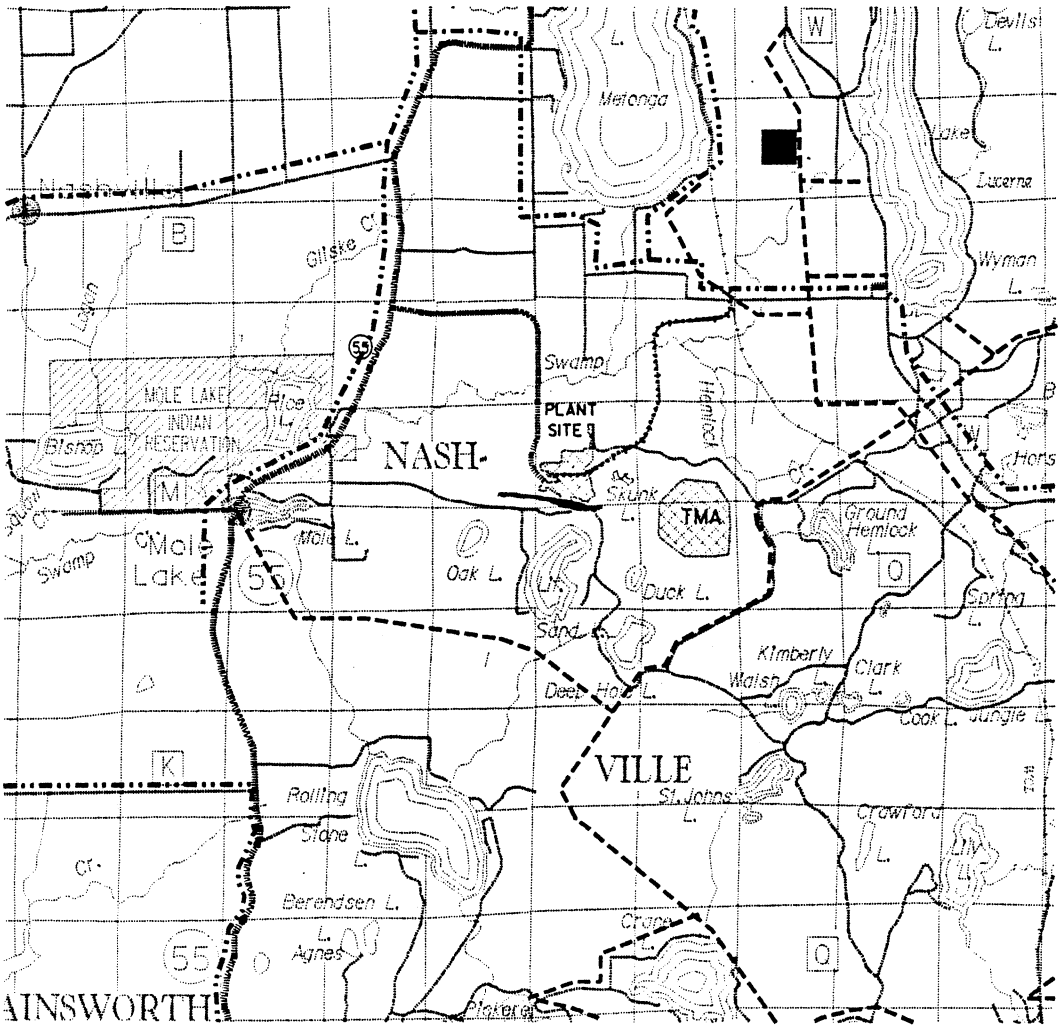

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- W COUNTY HWY LETTER
- RESERVATION LANDS
- UNINCORPORATED VILLAGE
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- ALL TERRAIN VEHICLE (ATV) TRAILS
- SNOWMOBILE TRAILS
- SUGGESTED BICYCLE ROUTES

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY.'95
APPROVED BY:	GMS	DATE: MAY.'95
APPROVED BY:	GWS	DATE: MAY.'95

Crandon Mining Company

FIGURE 3.12-4

RECREATIONAL TRAILS IN THE STUDY AREA

Scale: 0 10,000' 20,000' Date: MAY, 1995

Prepared By: Foth & Van Dyke By: JCW

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Crandon Mining Company

Environmental Impact Report

Section 3.13

Aesthetics

Crandon Mining Company
Environmental Impact Report

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Appendices

Appendix 3.13-1 Schreiber/Anderson Associates 1985 Report Titled "Visual Impact Assessment - Surface Facilities"
Appendix 3.13-2 1995 Field Data Forms

3.13 Aesthetics

3.13.1 Methods

In 1982, the Sanborn Group, Inc. prepared a visual impact assessment of the proposed surface facilities. Specific structures addressed included the headframe, tailings pond embankment and the railroad siding. Visibility of the proposed headframe and tailings pond embankments were determined by tethering a helium-filled balloon and allowing it to rise to a known elevation at these locations. The visibility of the proposed railroad siding was determined by placing white styrofoam markers at a height of eight feet spaced at 100 foot intervals. Photographs were taken of the balloons, and markers from 35 view points which were selected by the WDNR, EMC, and the Sanborn Group (Tables 3.13-1, 3.13-2 and 13.3-3). Each of the viewpoints were selected to identify visually sensitive areas or areas of intense land use, including roadways, residential housing, public access areas, areas of topographic elevation, and locations of sizable foreground openings.

Plant design changes resulted in a need to update the 1982 assessment. Schreiber/Anderson Associates (Schreiber/Anderson Associates, 1985) used the photographic documentation compiled by the Sanborn Group, Inc. to revise the visual impact assessment in 1985 (Appendix 3.13-1). The revision was accomplished by simulating the visible portions of the structures on eight inch by ten inch black and white photographs taken by the Sanborn Group, Inc. at the same 35 viewpoints and using the scaling equation technique. This technique recognizes that an object of known size (i.e. the height of the balloon is known) at a known distance in a photograph can be used to establish the size of other objects at the same distance. The Schreiber/Anderson Associates assessment also considered line-of-site obstructions such as changes in topography and vegetation.

In January 1995, Foth & Van Dyke revisited the above described 35 viewpoints to assess if potential land use changes have resulted in changes in the aesthetic environment since the previous assessments were completed. Observations regarding the visual features between each of the viewpoints and the proposed structure (i.e., headframe, TMA, or railroad spur) were made. An emphasis was placed on the identification of changes such as new buildings, clearcuts, or any other feature that may act as, or may have previously acted as, as a visual barrier. Field data forms are provided in Appendix 3.13-2.

It should be noted that Viewpoints 5 and 6 were eliminated from the list because of limited access to the Sokaogon Chippewa Reservation at Mole Lake. However, three new viewpoints were added: Viewpoint 1A at the highest peak of what is known as Spirit Hill; Viewpoint 22A at the highest point of Keith's Siding Road, approximately ¼ mile east of CTH W; and Viewpoint 33A on CTH Q south of CTH W.

3.13.2 Local Aesthetic Environment

Based on the results of the January 1995 verification survey, the visual environment surrounding the proposed plant site and associated facilities has not changed substantially. A comparison of the views in 1985 to the current views is provided in Tables 3.13-1, 3.13-2 and 3.13-3. In many cases the forests surrounding the proposed facilities have matured and may currently offer greater concealment of these features than that which was previously documented in the 1980s.

Table 3.13-1

Description of Representative Views Towards the Proposed Headframe[1]

Viewpoint	Location	Bearing (deg.)	Distance (mi.)	Foreground	Middleground	Background	Comparison[2]
1	Deep Hole Lake Boat Launch	330	2.0	Lake	Lake	HS >25'	Same
1A	Spirit Hill	77	1.5	HS >25'	NV	NV	*
2	North Duck Lake	308	1.2	Lake	Lake	HS >25'	Same
3	South Little Sand Lake	3	1.2	Lake	Lake	HS/CS >25'	Same
4	Oak Lake	53	1.0	Lake	Lake	HS >25'	Same
7	Rolling Stone Lake	22	3.5	Lake	Lake	Wooded Ridge	Same
8	STH 55 South of Mole Lake	82	3.5	STH 55	Ag. Field	HS/CS	Same
9	Sand Lake & Black Joe Roads	90	2.0	Road/Ag. field	Road/Ag. Field	Mixed Height HS/CS	Same
10	STH 55 North	115	2.0	Old Field	Old Field	Mixed Height CS	Same
11	STH 55 at Swamp Creek	100	2.5				Foreground/Middle Ground Vegetation Taller
				Ag. Field	Trees >25'	Trees >25'	Same
12	Veterans Memorial Park	95	2.5	Parking Lot	Parking Lot	Mixed Height CS	Same
13	North Lake Metonga	197	5.5	Lake	Lake	Faint Wooded Ridge line	Same
14	East Lake Metonga	195	4.8	Lake/Shore line	Lake/NV	Mixed Height HS/CS	Same
15	East Lake Lucerne	235	4	Lake	Lake	Mixed Height HS/CS	Same
16	East Ground Hemlock Lake	282	2.8	Lake	Lake	Mixed Height CS	Same

Table 3.13-1 *(Continued)*

Viewpoint	Location	Bearing (deg.)	Distance (mi.)	Foreground	Middleground	Background	Comparison[2]
17	Intersection of CTH Q & W	270	4	Mixed Height HS/CS	Clearcut	CS	Middle ground clearcut since 1985
18	Intersection of CTH Q St. Johns Lane	348	3.5	HS	HS	NV	Same
19	Sand Lake Road	0	0.2	Roadway	HS	HS	Same
20	Lakeview Road	180	6.0	Ag. Field	Mixed Height HS/CS	Distant Ridgeline	Same
21	Keith Siding Road	225	2.5	Ag. Field	Ag. Field/CS	Wooded Ridgeline	Same
22	Keith Siding Road	217	3.0	Ag. Field	Ag. Field	Uneven Height HS/CS	Same
22A	Keith Siding Road	240	3.2	Roadway	HS >25'	NV	*
23	North Lake Lucerne	217	6	Lawn	Lake	Uneven Height HS/CS	Same
24	Scenic Wayside on STH 8	220	7	Wayside Buildings	Uneven height HS/CS	Forested Ridge	Same
25	Western Boundary of Crandon	185	6.5	Old Field	Old Field	Uneven Height HS/CS	Same
26	Top of Sugarbush Hill Fire Tower	225	7	HS >25'	Clearing, Tornado Damage	Forested Ridges/ HS/CS >25'	Same
27	Airport Road	170	2.5	Ag. Field	Ag. Field	CS >25'	Same

[1] Based on January 1995 observations by Foth & Van Dyke.
[2] Comparison of the available views made in January 1995 to those made in 1982.

NV = Not Visible.
CS = Conifer Stand.
HS = Hardwood Stand.
CS/HS = Mixed Hardwood/Conifer Stand.
* = Location not Surveyed in Previous Assessment.

Prepared by: BDH
Checked by: RFS

Table 3.13-2

Description of Representative Views Towards the Proposed TMA[1]

Viewpoint	Location	Bearing	Distance to TMA	Foreground	Middleground	Background	Comparison[2]
28	Deep Hole Lake Road	280	0.2	Thick Shrubs	NV	NV	Same
29	Deep Hole & Sand Lake Roads	20	1	HS	NV	NV	Same
30	West Duck Lake	70	0.3	Lakes Edge	Lake	HS/CS	Same
31	West Deep Hole Lake	35	1	Lake	Lake	HS	Same
32	West Little Sand Lake	90	1.2	Lake	Lake	HS/CS	Same
33	CTH Q North of Kimberly Lane	305	3.5	Roadway	HS/CS	NV	Same
33A	CTH Q South of W	280	4.0	Roadway	Sapling HS	NV	*
34	Sand Lake Road	104	1.2	Roadway	HS/CS >25'	NV	**
35	County W	245	3	Clearcut	Mixed Height HS/CS	HS Ridgeline	Foreground/Middle Ground Clearcut Since 1985
35A	CTH W North of Q	280	4.0	Sapling CS	Sapling CS	Uneven Height CS	*

1 Based on January 1995 observations by Foth & Van Dyke.
2 Comparison of the available views made in January 1995 to those made in 1982.

NV = Not Visible.
CS = Conifer Stand.
HS = Hardwood Stand.
CS/HS = Mixed Hardwood/Conifer Stand.
* = Location not Surveyed in Previous Assessment.
** = Data From 1985 Report Incomplete.

Prepared by: BDH
Checked by: RFS

Table 3.13-3

Description of Representative Views Towards the Proposed Railroad Siding[1]

Viewpoint	Location	Bearing (deg.)	Distance (mi.)	Foreground	Middleground	Background	Comparison[2]
21	Keith Siding Road	225	0.5	Ag. Field	Ag. Field/CS	Wooded Ridgeline	Same
22	Keith Siding Road	145	0.6	Ag. Field	Ag. Field HS/CS	Uneven Height HS/CS	Same
22A	Keith Siding Road	240	3.2	Roadway	HS >25'	NV	*
35	County W	245	3.0	Clearcut	Uneven Height HS	NV	**

[1] Based on January 1995 observations by Foth & Van Dyke.
[2] Comparison of the available views made in January 1995 to those made in 1982.

NV = Not Visible.
CS = Conifer Stand.
HS = Hardwood Stand.
CS/HS = Mixed Hardwood/Conifer Stand.
* = Location not Surveyed in Previous Assessment.
** = No Photographs Taken in Previous Survey.

Prepared by: BDH
Checked by: RFS

The regional landscape encompassing the plant site and surrounding area is primarily forested upland with lesser amounts of forested wetland, and an abundance of lakes and streams (Schreiber/Anderson Associates, 1985). Vegetation in the upland zone occupying the majority of the plant site and surrounding areas is visually monotypical, consisting of northern hardwoods represented by maple, aspen and birch species. In general, the forest tends to dominate most views in the area. Upland drainage corridors support conifer stands of cedar and spruce, and penetrate site perimeters on the north, west, and southeast. These coniferous stands provide visual relief to the predominant upland deciduous vegetation. Additional visual interest is created by the presence of tamarack and alder in wetland vegetative communities.

Topography in this region is characterized by a general southwest trend of ridges and intervening valleys. Elevational changes range from 1,540 to 1,939 feet above mean sea level. Slope conditions vary from 0 to 35 percent. These ridges tend to obscure views of the proposed Crandon Project site from the east and west.

3.13.3 Bibliography

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Crandon Mining Company

Environmental Impact Report

Section 3.14

Socioeconomics

Crandon Mining Company
Environmental Impact Report

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Figure 3.14-1	Socioeconomic Study Area
Figure 3.14-2	Tourism Related Businesses Within a Five Mile Radius of Site

3.14 Socioeconomics

3.14.1 Introduction

Section 3.14 of the EIR describes historical and current socioeconomic conditions that exist in the region surrounding the proposed project site. The section defines the area to be studied and then presents a brief history of this area. This section also identifies and documents current conditions in the socioeconomic study area, including descriptions of the area's current population, economic base, housing, government structure and public finance, and public facilities and services. A description of current socioeconomic conditions of the Sokaogon Chippewa and Forest County Potawatomi Native American communities (SCC and FCP, respectively) based on 1990 census data is also presented.

3.14.2 Study Area

The socioeconomic study area is the geographic area that could potentially be affected by the construction, operation, closure, reclamation, and post-closure care of the proposed mine. Various aspects of the project may affect individuals and public and private institutions in the study area. For example, wages paid by the project and many of the purchases made directly by the project will increase retail sales in the study area. Mine activities will also bring new workers to the area, which in turn may cause increased economic activity, including higher demand for housing, municipal services, schools, social services and so forth.

At some point, depending on distance and magnitude, the social and economic interactions caused by the project become minimal or non-existent. Therefore, not all individuals or institutions within the study area will be affected by the project. The study area has been selected to be of sufficient geographical size to include areas that might be directly and indirectly affected by the project.

3.14.2.1 Basis for Selection

Certain socioeconomic characteristics of the region may be affected by the proposed project. These characteristics are grouped into several broad categories. The study area was selected based upon the potential for the project to affect the characteristics of the socioeconomic environment.

Location of Project-Induced In-Migrants. The labor force associated with the project will be composed of local area residents and workers that will migrate to the area. Additional workers may be required to meet labor needs in other sectors of the local economy. The amount of in-migration caused by the project will depend on direct and indirect employment requirements of the project within various skill categories, and the ability of the local labor market to provide these labor resources. Choices made by in-migrants as to where they will live and shop will be determined largely by their willingness to commute, availability and affordability of housing, and the availability of public and private services (e.g. schools, parks, retail establishments, etc.).

Previous studies or impact assessments of the proposed mine have shown that a commuting radius of one-hour from a major employment site will capture the location preference of most workers commuting to the site (Denver Research Institute, 1986) (WDNR, March 1990). Research conducted by the University of Wisconsin-Extension has found that the average one-way commuting distance for workers in 19 non-metropolitan Wisconsin counties was 18 miles. The average commuting distance for workers in agriculture, mining and construction industries was 22 miles (Dick, 1993). The socioeconomic study area must be of sufficient size to accommodate commutes of these distances.

Impacts on Existing Businesses. The project will introduce new spending in the study area through wages paid to workers and through direct purchases to support the project. Most increased commercial activity will occur in existing commercial centers such as Crandon, Rhinelander and Antigo, although retail sales will likely increase somewhat throughout the entire study area. Industrial purchases will be distributed over the study area as a function of existing industrial producers and suppliers. It is possible that industrial purchases resulting from the project made in areas of the state not included in the study area could exceed those made within the study area. Existing businesses may also be affected as the demand for various labor skills of the project absorbs currently employed, underemployed and unemployed labor resources in the area. Thus, the socioeconomic study area should be of sufficient size to capture impacts on commercial activities and secondary labor force impacts of the project.

Local Government Services and Revenues. Municipal governments (towns, villages and cities), county governments, and school and vocational education districts will be affected as project-induced population locate in the study area. As population and enrollments increase, governmental expenditures can be expected to also increase.

Off-setting this rise in local government service expenditures will be a corresponding increase in local government revenues. Revenues will increase directly for those communities immediately affected by the project due to increased project-related property values and/or mining impact fund payments. Property tax revenues and other forms of local government revenues also will increase for outlying communities as new housing is constructed, as stores are expanded, and as retail sales are increased. The study area therefore should encompass local governments where services needs and revenue generation will likely result due to the project.

Social Interactions. The introduction of new population and mining activities can affect the manner in which various segments of the population interact. For example, the overall age profile of the study area likely will get marginally younger as new population moves into the area. Changes in the population can have such effects as providing community enrichment and/or increasing social alienation through the introduction of new ideas and abilities.

In general, the potential for both positive and negative change in existing social interactions will be highest in areas experiencing greatest population growth and in areas immediately adjacent to the project.

3.14.2.2 Boundaries

The majority of socioeconomic impacts associated with the proposed mine will occur broadly within the three county area made up of Forest, Langlade and Oneida counties.

Prior socioeconomic studies for the mining project proposed in the 1980s used two different configurations of local municipalities within this three county area to define the study area. Studies conducted by the proposed mine's operators used the 40 towns and four incorporated municipalities shown in Figure 3.14-1, and the SCC and FCP Native American communities as the definition of the socioeconomic study area (Research and Planning Consultants, Inc., 1980). This definition was based on area housing market information and probable residential location decisions.

The previous socioeconomic impact study conducted by the Denver Research Institute (DRI) (DRI, 1986) used a smaller study area. The study area in this analysis was defined as: Forest, Langlade and Oneida Counties; the three cities of Crandon, Antigo and Rhinelander; the "secondary service centers and towns" of Antigo, Elcho, Crandon, Lincoln, Nashville, Crescent, Newbold, Pelican and Pine Lake; and the SCC and FCP Native American communities (DRI, 1986). These areas were included in the DRI's study area because of the likelihood of significant impact within these areas. All municipalities included in the DRI study area were included in the area used by the Research and Planning Consultants, Inc. studies.

To ensure that the study area defined in this study is of sufficient geographical size to allow clear demarcation of the places directly and indirectly affected by the proposed project, the broader definition of the two previous studies will be used. Specifically, the study area used in this study contains the counties and municipalities identified in Table 3.14-1 and the SCC and FCP Native American communities. Town, village and city classifications are shown for each municipality in Table 3.14-1.

3.14.2.3 History

In order to provide a comprehensive overview of the study area history, several approaches were evaluated. Richard Zeitlin (Zeitlin, 1986) submitted a monograph written for the DRI which was subsequently published in a report titled *Final Socioeconomic Impact Analysis of Exxon's Proposed Crandon Project*. The information in the DRI document provides a comprehensive overview of the study area history through the mid 1980s. The following section is an abridged version of Richard Zeitlin's monograph augmented with additional historic events through 1994.

Fur traders were among the earliest European resident settlers of the study area, arriving in the 1850s. The financial panic of 1857 and the Civil War (1861-1865) checked the exploration and settlement of northern Wisconsin temporarily.

Federal subsidization of a military road from Green Bay to Fort Wilkins in the Upper Peninsula between 1863 and 1870 brought men and money to the region, and with the end of the war, a wave of youthful veterans sought economic opportunities in the northern Wisconsin frontier. Virgin pine forests drew timber cruisers, woodsmen, log drivers, teamsters, sawmill operators, dance hall workers and saloon keepers into places such as Pelican Rapids (Rhinelander) and Lily during the 1870s. Between 1860 and 1890 the growth of the Wisconsin pine lumber industry increased dramatically, and Wisconsin became the nation's largest supplier of pine during the last decade of the 19th century.

Table 3.14-1

Study Area

Forest County		Langlade County		Oneida County		Native American Communities
Argonne	Town	Ackley	Town	Crescent	Town	SCC
Blackwell	Town	Ainsworth	Town	Enterprise	Town	FCP
Caswell	Town	Antigo	City	Lake Tomahawk	Town	
Crandon	City	Antigo	Town	Monico	Town	
Crandon	Town	Elcho	Town	Newbold	Town	
Freedom	Town	Evergreen	Town	Pelican	Town	
Hiles	Town	Langlade	Town	Piehl	Town	
Laona	Town	Neva	Town	Pine Lake	Town	
Lincoln	Town	Norwood	Town	Rhinelander	City	
Nashville	Town	Parrish	Town	Schoepke	Town	
Popple River	Town	Peck	Town	Stella	Town	
Ross	Town	Polar	Town	Sugar Camp	Town	
Wabeno	Town	Price	Town	Three Lakes	Town	
		Rolling	Town	Woodboro	Town	
		Upham	Town			
		White Lake	Village			
		Wolf River	Town			

Prepared by: JRH
Checked by: RVS

The railroads ushered in a new wave of development. Rails replaced log driving streams, as feeder and spur lines branched into the pinery. Once the pine had been cut, the railroads and the newly available portable sawmill made the cutting of hardwood and hemlock trees possible. Hardwood timbering led to yet another wave of economic development in the study area, and encouraged the establishment of a wood products industry in the region.

Rhinelander, with about 5,000 inhabitants in 1900, developed the largest wood products industrial base in the area. Rhinelander industries by 1905 included sawmills, a paper-making company which used hemlock pulp, a refrigerator-making plant (ice boxes were constructed of wood), a napkin and crepe paper factory, a sawmill machinery factory and a wooden boat-building concern.

After the pine had been harvested, landowners, real estate agents and local officials encouraged farmers to settle on low-priced cut-over lands, often making extravagant claims about the nature of area farming opportunities. As a result, the population of Oneida, Langlade and Forest counties rose dramatically. Oneida County population jumped from 8,875 in 1900 to 13,996 in 1920, with Rhinelander representing about one-half the total. Langlade County's population increased from 685 in 1880 to 12,553 by 1900. In 1920 the population of Langlade County reached 21,471. Forest County's population jumped from 1,396 in 1900 to 9,850 20 years later. Unfortunately, most farmers did not become prosperous; after the end of World War I, agricultural depression followed. Despite the failure of many farms during the 1920s and 1930s, agriculture continues to be an important source of employment in the study area. Areas suitable for agriculture are concentrated in Langlade and in Oneida Counties where dairy farming and potato growing predominate. Today, 70 percent of the seed potatoes grown in Wisconsin are cultivated in Langlade County.

After 1925, Wisconsin moved to deal with the economic problems of its northern counties. County officials and University of Wisconsin College of Agriculture representatives turned toward reforestation as the basis of future land use policy. The Forest Crop Law of 1927 and the granting of authority to restrictively zone the cut-over established in 1929 helped limit influx of farmers into areas unsuited for agriculture, and provided incentives for timber landowners not to abandon their properties. State forests were also established. In 1935, the Wisconsin Isolated Settlers Project evacuated agriculturalists from 9,948 acres in the Crandon area. State subsidies for recreation and county foresters appeared that same year. The federal government helped the state promote and undertake reforestation projects, and in 1933 created the Nicolet National Forest.

The University of Wisconsin College of Agriculture, through the Extension Service, promoted reforestation, scientific forest use and management techniques, and tourism. Pulp wood for paper-making began increasingly to utilize spruce and balsam, and by the late 1930, a scientific breakthrough allowed poplar/aspen to be used for pulp. Poplar remains a vital resource in the cut-over, for the species flourished on ex-pine lands. Poplar pulp assured the economic viability of reforestation from a commercial-industrial perspective.

Reforestation led to increases in tourism as recreational opportunities expanded. The Wisconsin Land O'Lakes Association, headquartered in Rhinelander, began promoting the recreational development of the entire northern part of Wisconsin. Tourism became the economic backbone of the area during the 1920s, and by 1930, tourism provided larger tax revenues than agriculture.

Depopulation of the cut-over during the 1920s was reversed during the 1930s. Some city dwellers who had family ties in the cut-over returned, sensing that life in remote rural northern Wisconsin was less bleak than in jobless urban areas. As a result, the population of the area reached new heights by 1940. Although World War II directed attention away from the northern cut-over, the area attracted new waves of recreation enthusiasts during the 1950s.

The period of 1940-1950 also witnessed a rise in the number of manufacturing concerns located in the study area. Some were associated with already existing pulp and other woods products industries. Shoes, bowling pins and gears were manufactured in Antigo. By 1960, about 22 percent of the working population of northern Wisconsin found employment in manufacturing.

A decline in the rail industry began in the 1950s. The Chicago and Northwestern, for example, laid off 400 Antigo employees in 1951 as a result of competition from local trucking. While some heavy industry remained in the study area during the 1960s, the region did not experience the economic growth that occurred elsewhere during the decade, in spite of some growth in tourism-related businesses.

During the 1960s, the three-county area population grew by only 1,768 persons, an average rate of 0.3 percent per year. A gradual decline in the number of working age people also began in the 1960s, and a sizable reduction in farm population in the study area was also witnessed, particularly in Forest County. In the 1970s, tourism continued to grow. Second homes and home building for retirees (mostly from Great Lakes region cities) furnished some economic activity and further growth of the older population. Between 1970 and 1980 the three county area experienced a 17 percent population increase, largely as a result of the increased number of retirees and tourism-related economic activity.

United States court decisions recognizing Chippewa off-reservation hunting, fishing and gathering rights, together with the development of tribal-owned casinos, tax-free tobacco sales, and other activities, have increased the socioeconomic impact of Native Americans in the study area.

3.14.3 Characteristics of the Study Area

The purpose of this section is to profile the current characteristics of the socioeconomic study area. The information collected is useful in projecting future conditions and in evaluating potential socioeconomic changes as a result of the proposed mine development. Data was collected on population, economic base, housing, government structure, public finance, public facilities and services, as well as Native American communities.

3.14.3.1 Population

Study area population trends can be characterized as slow growth or relatively stable in the last fifteen years. Three factors contribute to changes in the local population trend; local employment opportunities, decisions to retire in the local area, and year-round recreation induced population.

Between 1970 and 1980 the three county area experienced a significant increase in population. The largest increase was experienced in Oneida County where the population increased by 6,789 people or 28 percent. Forest County also experienced a double digit increase during this period of 18 percent. Langlade County was least affected, with a four percent population increase

between 1970 and 1980. During this period, the State of Wisconsin experienced a seven percent population increase.

Table 3.14-2 shows that Forest County grew substantially between 1970 and 1980. This trend was reversed somewhat between 1980 and 1990 with the loss of 268 people. Since 1990, Forest County's population demonstrated an upward turn with an increase of 166 people. The population of Forest County is less than either Oneida or Langlade Counties due in part to the large amount of National Forest land in the county.

Langlade County is less affected by recreation-related population and the economic base is more agricultural. Population increased only moderately between 1970 and 1980. Between 1980 and 1990 population decreased by 473 people or two percent (Table 3.14-3). Wisconsin Department of Administration official population estimates suggest that population increased by 521 persons or three percent between 1990 and 1993.

Oneida County is the most populated county in the study area. Recreation and retirement community development have contributed to population increases since 1970. Table 3.14-4 shows that Oneida County's population continues to increase while the City of Rhinelander has lost population. Townships surrounding the City of Rhinelander have experienced population increases which are due in part to expansion of the economic base of Rhinelander.

Table 3.14-5 compares changes in population for the study area to Forest, Langlade and Oneida Counties as a whole and to the state of Wisconsin.

3.14.3.2 Economic Base

The three-county area is less industrialized and less affluent than Wisconsin as a whole. Per capita personal income in all three counties is lower than statewide per capita income, and the three county unemployment rates have historically been higher.

Overall, forestry and wood products manufacturing dominate the study area economy, particularly in Forest and Oneida Counties. Agriculture is important primarily in Langlade County. The recreation and tourism industry is also substantial, and stimulates activity in retail trade and services. These are low wage industries which partially explain the low income levels in the study area.

Forest County is the least economically diverse of the three counties. With its small population, it has the lowest total income and earnings, and the lowest per capita income of the study area. Manufacturing and government are the largest income-producing sectors in Forest County. Since most of the county is heavily forested, most of the manufacturing jobs are in saw mills and wood products plants. Wages in the county tend to be the lowest in the study area, while unemployment is the highest. Per capita transfer payments in the county are higher than in the other counties, and are also higher than the statewide level.

Due to a relatively large agricultural base, Langlade County is the most economically balanced county of the study area. Although manufacturing is the most important economic sector, retail trade, farming, services and government are also important. Major manufacturing industries in the county include lumber and wood products, food and kindred products, and fabricated metals.

Table 3.14-2

Forest County Population
1970, 1980, 1990, 1993

				(Estimate)	Average Annual Percent Change		
	1970	1980	1990	1993	1970-80	1980-90	1990-93
Forest County	7,691	9,044	8,776	8,942	1.6%	-0.3%	0.6%
Study Area							
Argonne, Town	390	469	497	503	1.9%	0.6%	0.4%
Blackwell, Town	418	384	384	390	-0.8%	0.0%	0.5%
Caswell, Town	96	85	94	100	-1.2%	1.0%	2.1%
Crandon, City	1,582	1,969	1,958	2,037	2.2%	-0.1%	1.3%
Crandon, Town	406	569	529	520	3.4%	-0.7%	-0.6%
Freedom, Town	276	307	296	298	1.1%	-0.4%	0.2%
Hiles, Town	283	327	312	302	1.5%	-0.5%	-1.1%
Laona, Town	1,395	1,474	1,387	1,384	0.6%	-0.6%	-0.1%
Lincoln, Town	350	577	630	659	5.1%	0.9%	1.5%
Nashville, Town	519	703	871	935	3.1%	2.2%	2.4%
Popple River, Town	36	59	42	42	5.1%	-3.3%	0.0%
Ross, Town	178	203	159	154	1.3%	-2.4%	-1.1%
Wabeno, Town	1,144	1,222	1,012	1,007	0.7%	-1.9%	-0.2%
Study Area Total	7,073	8,348	8,171	8,331	1.7%	-0.2%	0.6%

Source: Wisconsin Department of Administration. Official Population Estimates for 1993.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-3

Langlade County Population
1970, 1980, 1990, 1993

				(Estimate)	Average Annual Percent Change		
	1970	1980	1990	1993	1970-80	1980-90	1990-93
Langlade County	19,220	19,978	19,505	20,026	0.4%	-0.2%	0.9%
Study Area							
Ackley, Town	681	639	540	536	-0.6%	-1.7%	-0.2%
Ainsworth, Town	348	447	474	477	2.5%	0.6%	0.2%
Antigo, City	9,005	8,653	8,284	8,529	-0.4%	-0.4%	1.0%
Antigo, Town	1,692	1,661	1,428	1,448	-0.2%	-1.5%	0.5%
Elcho, Town	885	1,078	1,075	1,082	2.0%	-0.0%	0.2%
Evergreen, Town	436	515	483	506	1.7%	-0.6%	1.6%
Langlade, Town	342	413	415	434	1.9%	0.0%	1.5%
Neva, Town	819	970	910	946	1.7%	-0.6%	1.3%
Norwood, Town	838	866	842	866	0.3%	-0.3%	0.9%
Parrish, Town	60	87	81	81	3.8%	-0.7%	0.0%
Peck, Town	413	424	402	407	0.3%	-0.5%	0.4%
Polar, Town	737	827	880	902	1.2%	0.6%	0.8%
Price, Town	259	243	248	250	-0.6%	0.2%	0.3%
Rolling, Town	914	1,236	1,316	1,360	3.1%	0.6%	1.1%
Upham, Town	486	545	626	641	1.2%	1.4%	0.8%
White Lake, Village	309	309	304	306	0.0%	-0.2%	0.2%
Wolf River, Town	545	604	750	792	1.0%	2.2%	1.8%
Study Area Total	18,769	19,517	19,058	19,563	0.4%	-0.2%	0.9%

Source: Wisconsin Department of Administration. Official Population Estimates for 1993.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-4

Oneida County Population
1970, 1980, 1990, 1993

				(Estimate)	Average Annual Percent Change		
	1970	1980	1990	1993	1970-80	1980-90	1990-93
Oneida County	24,427	31,216	31,679	32,662	2.5%	0.1%	1.0%
Study Area							
Crescent, Town	1,441	1,702	1,794	1,855	1.7%	0.5%	1.1%
Enterprise, Town	213	277	271	272	2.7%	-0.2%	0.1%
Lake Tomahawk, Town	434	738	851	891	5.5%	1.4%	1.5%
Monico, Town	306	291	294	297	-0.5%	0.1%	0.3%
Newbold, Town	1,234	2,171	2,281	2,355	5.8%	0.5%	1.1%
Pelican, Town	2,576	3,387	3,198	3,131	2.8%	-0.6%	-0.7%
Piehl, Town	64	94	66	78	3.9%	-3.5%	5.7%
Pine Lake. Town	1,853	2,656	2,494	2,576	3.7%	-0.6%	1.1%
Rhinelander, City	8,218	7,873	7,382	7,575	-0.4%	-0.6%	0.9%
Schoepke, Town	358	399	378	381	1.1%	-0.5%	0.3%
Stella, Town	299	489	525	542	5.0%	0.7%	1.1%
Sugar Camp, Town	816	1,337	1,376	1,448	5.1%	0.3%	1.7%
Three Lakes, Town	1,376	1,864	2,003	2,116	3.1%	0.7%	1.8%
Woodboro, Town	287	547	699	715	6.7%	2.5%	0.8%
Study Area Total	19,475	23,825	23,612	24,232	2.0%	-0.1%	0.9%

Source: Wisconsin Department of Administration. Official Population Estimates for 1993.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-5

Study Area Population

	1970	1980	1990	(Estimate) 1993	Average Annual Percent Change 1970-80	1980-90	1990-93
Study Area	45,317	51,690	51,291	52,126	1.3%	-0.2%	0.8%
Three County	51,338	60,238	59,960	61,630	1.6%	-0.0%	0.9%
State of Wisconsin	4,417,921	4,715,642	4,891,769	5,020,994	0.7%	0.4%	0.9%

Source: Wisconsin Department of Administration. Official Population Estimates for 1993.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Langlade County is one of Wisconsin's top potato producers. Antigo, the Langlade County seat, serves as the county's industrial and trade center, and accounts for about three-fourths of the county's total retail and service sales. Antigo is also the location of the county's major employers. Per capital personal income is higher in Langlade County than in Forest County. However, both were below the per capita income level in Oneida County and below state and national levels.

Oneida County is the most populous and most economically developed of the three counties. The county surpasses both Forest and Langlade Counties in total earnings, average weekly wages and employment. Nonetheless, Oneida County residents had a lower per capita income than the average Wisconsin resident. The major economic sectors of the county are manufacturing, services, retail trade and government. Paper and allied products, machinery (except electrical), printing and publishing, and lumber and wood products are important industrial sectors in the county. Oneida County has abundant recreational resources, and tourism is also an important source of income and employment. Rhinelander is the county seat of Oneida County, and the county's only incorporated community. It is the location of the county's major employers and serves as a trade center for surrounding jurisdictions.

3.14.3.2.1 Employment

Table 3.14-6 shows that employment in study area counties is dominated by the services, retail trade, manufacturing and government sectors. Wisconsin employment increased between 1988 and 1992. Employment in Forest, Langlade and Oneida counties also increased over the same period.

It is important to note that information provided is based on Department of Industry, Labor and Human Relations (DILHR) data from unemployment compensation reporting. Each employer in the state of Wisconsin must report the number of people they employ and the four-digit Standard Industrial Classification of their business. There is reason to believe that not all employers in the study area report employment in the proper classification. In particular,

Table 3.14-6

Wisconsin and Study Area County Employment - March 1988 and March 1992

	Forest County		Langlade County		Oneida County		Wisconsin	
	1988	1992	1988	1992	1988	1992	1988	1992
Agriculture, Forestry & Fishing	---	---	199	237	156	256	13,538	15,717
Mining	---	---	---	---	55	75	1,552	1,779
Construction	20	26	137	151	346	497	62,509	75,150
Manufacturing	411	309	1,263	1,597	1,856	2,388	536,316	537,382
Transportation, Communication and Utilities	183	156	368	459	514	477	91,473	102,698
Wholesale Trade	45	48	528	484	246	427	108,248	116,610
Retail Trade	271	352	1,230	1,433	2,836	3,067	379,205	410,563
Finance, Insurance & Real Estate	54	50	156	175	380	480	110,746	123,548
Services	294	614	954	1,186	3,032	3,728	420,961	501,654
Government	571	597	980	1,034	1,731	1,905	304,164	330,836
Total Covered Employment	1,849	2,152	5,815	6,756	11,152	13,300	2,028,712	2,215,937

--- = no data

Source: *Labor Market Planning Information, Northern Wisconsin River Valley Region. Wisconsin Department of Industry, Labor and Human Relations, 1993.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

forestry and mining employment may be incorrectly reported, i.e., many loggers who also transport forest products may report a classification of Transportation, Communication and Utilities, as opposed to Agriculture, Forestry and Fishing.

Forest County employment is the smallest of the three study area counties. While the overall employment base of the county has been increasing, manufacturing employment has been decreasing in recent years. Government sector employment continues to be the dominant employer. The Oneida County employment base is approximately six times that of Forest County and has been growing at the fastest rate of the three study area counties. Manufacturing is the dominant employment sector in this county followed by retail, service and government employment. Oneida County comprises nearly 60 percent of the area's total employment. Service and retail employment represent the largest shares of total county employment, reflecting the county's role as a regional service and trade center.

3.14.3.2.2 Earnings and Average Weekly Wages

Table 3.14-7 shows average weekly wages by industry group for the study area counties and Wisconsin. Average wages in the study area are consistently below statewide average wages. Average wages are lowest in Forest County and highest in Oneida County. In Forest County, average wages in the construction industry are over 50 percent below statewide wages. Manufacturing average wages throughout the study area are generally 10-40 percent below state average manufacturing wages.

3.14.3.2.3 Personal Income

Table 3.14-8 shows annual per capita personal income for the study area counties, Wisconsin and the United States. Wisconsin average per capita personal income is typically below that of the nation as a whole. The average Forest County per capita income is approximately 60 percent of state per capita income, while Langlade and Oneida per capita incomes are approximately 78 and 89 percent of state per capita income respectively. It appears that per capita personal income is growing at a similar or faster rate in the three-county study area than the state of Wisconsin, based on the 1987-1991 trend.

3.14.3.2.4 Retail Sales

Retail sales in the study area are concentrated in Oneida and Langlade counties. As shown in Table 3.14-9, over 92 percent of 1992 sales in the area occurred in these two counties. In 1987, 93 percent of Langlade County sales were accounted for by City of Antigo merchants, while 57 percent of Oneida County sales occurred in the City of Rhinelander (U.S. Department of Commerce, *Census of Retail Trade,* 1987). This information reflects revenue "leaks" as residents travel outside the study area to purchase big ticket items and specialty services.

Table 3.14-7

Wisconsin and Study Area Counties
Average Weekly Wage by Industry Group - 1993

Industry	Forest County Average Weekly Wage	Langlade County Average Weekly Wage	Oneida County Average Weekly Wage	Wisconsin Average Weekly Wage
All Industries	$286	$342	$367	$446
All Government	$394	$416	$535	$559
Agriculture, Forestry, Fishing	---	$265	$314	$327
Mining	---	---	$723	$592
Construction	$222	$413	$388	$516
Manufacturing	$326	$414	$509	$565
Transportation, Communication, Electric, Gas, & Sanitary Utilities	$276	$373	$401	$519
Wholesale Trade	$345	$413	$381	$534
Retail Trade	$143	$216	$199	$220
Finance, Insurance, & Real Estate	$320	$360	$381	$516
Services	$255	$298	$344	$375

Source: *Employment and Wages Covered by Wisconsin's U.C. Law Second Quarter 1993. Wisconsin Department of Industry, Labor, and Human Relations (DILHR), 1994.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

--- = no data

Prepared by: RVS
Checked by: SFJ

Table 3.14-8

U.S., Wisconsin and Study Area Counties Per Capita Personal Income 1987-1991

	1987	1988	1989	1990	1991	% Change 1987-1991
Forest County	8,713	9,344	10,244	10,979	11,283	29%
Langlade County	11,072	11,709	13,463	13,714	13,648	23%
Oneida County	12,711	13,656	14,619	15,705	16,436	29%
Wisconsin	14,592	15,408	16,534	17,455	17,919	23%
United States	15,638	16,615	17,696	18,635	19,091	22%

Source: *Wisconsin Department of Industry, Labor, and Human Relations (DILHR), 1993.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-9

Wisconsin and Study Area Retail Sales, 1992[1]

	Forest County	Langlade County	Oneida County	Wisconsin
Total Retail Sales	$34.4	$140.7	$296.0	$39,795
Food	18.4	31.0	44.0	6,982
Eating and Drinking	4.6	16.8	38.6	4,469
General Merchandise	.4	20.1	33.4	5,083
Furniture/Furnishings, Appliances	.4	3.1	11.6	2,146
Automobile	.5	30.3	68.0	8,125
Drugs	1.0	6.4	5.3	1,327
All Others	9.1	33.0	95.1	11,663
Estimated Population	8,900	19,800	32,700	5,008,200
Retail Sales per Capita	$3,869	$7,108	$9,053	$7,946

[1] All sales in millions of 1992 dollars.

Source: Sales & Marketing Management, "1993 Survey of Buying Power", August 30, 1993.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

3.14.3.2.5 Labor Market

The labor force available for employment in the study area is a function of the area's population of working age. Table 3.14-10 shows the distribution of study area county and statewide population by age category. The proportion of the study area's population between the prime working ages of 15 to 64 is significantly lower than this proportion for the state as a whole. This reflects the relatively large number of study area retirees and out-migration of youth.

Table 3.14-11 shows average annual unemployment rates for the study area counties, Wisconsin and the nation for 1983 and 1988-1992. The Forest County unemployment rate has been consistently the highest of the study area counties and approximately 40 percent higher than the state unemployment rate, except in 1983 and 1992. Langlade and Oneida counties have been consistently within 10 percent of the state unemployment rate. Since 1990, Oneida County's unemployment rate has equalled or been below the state unemployment rate. This reflects the increase in economic activities experienced in Rhinelander and surrounding townships.

3.14.3.2.6 Tourism in Study Area

The tourism industry in the study area is driven by the availability of recreational activities (both summer and winter). Significant recreation, water use and other outdoor activities exist in Forest, Langlade and Oneida Counties. Table 3.14-12 outlines some of the resources available in the study area.

According to the 1991 Wisconsin Statewide Comprehensive Outdoor Recreation Plan, nearly 200,000 Wisconsin anglers most often fish in the North Central District of Wisconsin including Forest, Langlade and Oneida Counties. Table 3.14-13 provides detail on trout streams in the study area.

The 1991 Wisconsin Statewide Comprehensive Outdoor Recreation Plan provides statistics on supply and demand of recreational facilities. While information is not available specifically for the study area, the North Central District includes Forest, Langlade and Oneida Counties, along with Vilas, Lincoln, Marathon, Wood, Portage, Juneau and Adams Counties. Table 3.14-14 provides detail on the supply and demand for a variety of recreational activities. This information suggests that recreational activities are relatively available when compared to the entire state of Wisconsin.

Tourism Within Five Miles of Project Site

In addition to the tourism industry within Forest, Langlade and Oneida Counties, a profile of tourism within five miles of the project site was estimated by identifying tourism related establishments within this distance. Each establishment's location is shown on Figure 3.14-2, along with an identifier number. A description of the identified establishments is included on the figure.

Table 3.14-10

Wisconsin and Study Area Counties
Percent of 1990 Population by Age Group

Age Group	0-14	15-64	65 & over
Forest County	22.0%	59.2%	18.8%
Langlade County	22.2%	58.9%	18.9%
Oneida County	20.1%	61.9%	18.0%
Wisconsin	22.4%	64.3%	13.3%

Source: *Wisconsin Department of Administration, June, 1993. Official Population Projections: 1990-2020.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-11

U.S., Wisconsin and Study Area Counties
Average Annual Unemployment Rate, 1983 and 1988-1992

	1983	1988	1989	1990	1991	1992
Forest County	20.6%	6.3%	6.1%	6.4%	7.9%	5.8%
Langlade County	11.9%	4.8%	5.1%	4.9%	5.8%	5.9%
Oneida County	11.3%	4.7%	4.7%	4.4%	5.1%	4.7%
Wisconsin	10.4%	4.3%	4.4%	4.4%	5.4%	5.1%
United States	9.6%	5.5%	5.3%	5.5%	6.7%	7.4%

Source: *Labor Market Planning Information, Wisconsin Department of Industry, Labor, and Human Relations.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-12

Recreational Amenities

	Forest County	Langlade County	Oneida County
Restaurants	45	77	197
Lodging Establishments	29	41	245
Lodging Rooms	305	407	3,204
Campgrounds	18	18	40
Campsites	1,044	492	1,765
Golf Courses (1991)	1	3	5
Hiking Trails (in miles, 1991)	114	139	164
Lakes	825	867	1,113
Percent of Land Area Forested	84%	70%	73%

Source: *Wisconsin Department of Development, County Economic Profiles (1992).*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-13

Miles of Trout Streams

	Forest County	Langlade County	Oneida County
Class I	86	140	50
Class II	341	241	89
Class III	53	6	55
Total	480	387	194

Source: *Wisconsin Department of Natural Resources, Wisconsin Trout Streams, 1980.*

Class I High quality trout waters, having sufficient natural reproduction to sustain populations of wild trout at or near carrying capacity. Streams in this category require no stocking of hatchery trout.

Class II Streams with some natural reproduction but not enough to utilize available food and space. Stocking sometimes is required to maintain a desirable sport fishery.

Class III Marginal trout habitat with no natural reproduction occurring. They require annual stocking of legal-size fish to provide trout fishing.

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-14

Comparison of Supply and Demand for Recreational Activities Based on 1990 Population

Activity	North Central District	State of Wisconsin
Play Equipment (play areas/1,000 children)	1.87	1.88
Hiking/Jogging Trails (miles/1,000 hiker and jogger/days)	.80	.28
Golf (holes/1,000 player/days)	2.27	1.47
Camping (sites/1,000 camper/days)	34.78	21.17
Baseball/Softball (diamonds/1,000 population)	.48	.50
Football/Soccer (fields/1,000 population)	.16	.13
Boat Launches (launches/1,000 boater/days)	1.634	.923
Canoe Launches (launches/1,000 canoeist/days)	9.145	3.693
Picnicking (areas/1,000 picnicker/days)	.60	.49
Ice Skating (rinks/1,000 population)	.15	.12
Swimming Pools (pools/1,000 swimmer/days)	.09	.058
Bicycle Trails (miles/1,000 biker/days)	.11	.13
Hunting (acres/1,000 hunter/days)	540	399
Tennis (courts/1,000 player/days)	1.63	1.34
Downhill Skiing (lifts/1,000 skier/days)	.468	.302
Horse Trails (miles/1,000 rider/days)	8.30	2.94
Cross-Country Ski Trails (miles/1,000 skier/days)	7.00	3.09
ATV Trails (miles/1,000 rider/days)	.84	1.21
Snowmobile Trails (miles/1,000 rider/days)	16.62	12.70
Ice Fishing (access point/1,000 fisher/days)	2.964	2.166

Source: *Wisconsin Department of Natural Resources, Bureau of Parks and Recreation.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

3.14.3.3 Housing

In order to evaluate the ability of the study area to absorb additional population, it is important to look at housing stocks. Age, type, quality and availability are key considerations in this evaluation. The purpose of this evaluation is to determine the number of housing units available for new in-migrants, and the availability of buildable lots for new housing that could be constructed. The term "housing stock" is used generally to describe the number and condition of single family homes, apartment buildings and mobile homes.

The following definitions will be used in the presentation of information relating to housing stocks within the study area:

> *Housing Unit* - includes a house, an apartment, a mobile home, a group of homes, or a single room that is occupied (or if vacant, is intended for occupancy) as separate living quarters.
>
> *Year Round Housing Unit* - a housing unit which is not held for seasonal, recreational or occasional use.
>
> *Occupied Housing Unit* - a housing unit which is the usual place of residence of the person or group of persons living in it.
>
> *Vacant Housing Unit* - a housing unit is classified as vacant if it is not occupied. A housing unit which has been sold or rented, but not occupied, is also classified as vacant.

Based on 1990 Census information, 49 percent of the total housing units in the study area are located in Oneida County. Consumer preferences created residential patterns characterized as medium to low density, with recent growth concentrated in the townships surrounding Rhinelander.

Vacancy rates in the study area average 5.1 percent for year round units. In addition, there are a total of 12,778 units held for "seasonal, recreational or occasional use" (Tables 3.14-15 through 3.14-17).

The 1990 census did not define "substandard" housing units as did the 1980 census. Information was collected on owner occupied housing valuation, total housing units that lack complete kitchen facilities, and occupied housing units that lack complete plumbing facilities. It was determined that this information would not be useful in determining the quality of vacant housing units.

While the 1990 census data does not address the issue of "substandard" housing, it is important to note that not all "vacant" housing units are desirable to potential new residents. Even the 1980 census did not have information on the condition of vacant housing units which would quantify the number of substandard units.

Table 3.14-15

1990 Housing Supply in the Study Area
Forest County

Location	Total Units	Year-Round Units	Occupied Units	Vacant Units	Vacancy Rate
Argonne, Town	270	182	177	5	2.75%
Blackwell, Town	102	45	42	3	6.67%
Caswell, Town	127	43	43	0	0.00%
Crandon, City	932	824	765	59	7.16%
Crandon, Town	340	200	190	10	5.00%
Freedom, Town	412	121	110	11	9.09%
Hiles, Town	663	146	135	11	7.53%
Laona, Town	760	564	537	27	4.79%
Lincoln, Town	812	237	227	10	4.22%
Nashville, Town	1,089	360	324	36	10.00%
Popple River, Town	95	25	22	3	12.00%
Ross, Town	199	71	68	3	4.23%
Wabeno, Town	701	406	383	23	5.67%
Total - Forest County Study Area	**6,502**	**3,224**	**3,023**	**201**	**6.23%**

Source: *U.S. Census, 1990. File Tapes 1A and 3A.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-16

1990 Housing Supply in the Study Area
Langlade County

Location	Total Units	Year-Round Units	Occupied Units	Vacant Units	Vacancy Rate
Ackley, Town	226	195	192	3	1.54%
Ainsworth, Town	475	191	179	12	6.28%
Antigo, City	3,619	3,520	3,405	115	3.27%
Antigo, Town	539	525	512	13	2.48%
Elcho, Town	1,408	522	489	33	6.32%
Evergreen, Town	244	177	168	9	5.08%
Langlade, Town	351	194	177	17	8.76%
Neva, Town	418	347	325	22	6.34%
Norwood, Town	323	280	273	7	2.50%
Parrish, Town	104	47	43	4	8.51%
Peck, Town	173	145	144	1	0.69%
Polar, Town	346	307	298	9	2.93%
Price, Town	110	86	83	3	3.49%
Rolling, Town	467	441	434	7	1.59%
Upham, Town	818	276	256	20	7.25%
White Lake, Village	158	120	113	7	5.83%
Wolf River, Town	762	333	312	21	6.31%
Total - Langlade County Study Area	**10,541**	**7,706**	**7,403**	**303**	**3.93%**

Source: *U.S. Census, 1990. File Tapes 1A and 3A.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-17

1990 Housing Supply in the Study Area
Oneida County

Location	Total Units	Year-Round Units	Occupied Units	Vacant Units	Vacancy Rate
Crescent, Town	1,019	696	675	21	3.02%
Enterprise, Town	407	120	113	7	5.83%
Lake Tomahawk, Town	952	363	341	22	6.06%
Monico, Town	190	111	108	3	2.70%
Newbold, Town	2,006	894	870	24	2.68%
Pelican, Town	1,679	1,282	1,228	54	4.21%
Piehl, Town	74	36	28	8	22.22%
Pine Lake, Town	1,267	954	917	37	3.88%
Rhinelander, City	3,293	3,171	3,035	136	4.29%
Schoepke, Town	574	181	165	16	8.84%
Stella, Town	334	228	211	17	7.46%
Sugar Camp, Town	1,269	554	523	31	5.60%
Three Lakes, Town	2,945	1,023	849	174	17.01%
Woodboro, Town	587	269	263	6	2.23%
Total - Oneida County Study Area	**16,596**	**9,882**	**9,326**	**556**	**5.63%**

Source: *U.S. Census, 1990. File Tapes 1A and 3A.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

The Wisconsin Department of Revenue has information available on residential parcels of land within the study area. This information is reported on the basis of land use type, indicating housing unit by structure, rather than by dwelling unit. Tables 3.14-18 through 3.14-20 provide an inventory of existing and potential residential land within the study area, indicating a substantial absorption capacity for new growth within the primary population centers. (A parcel is designated as "improved" if the local assessor's office shows taxable improvements in the parcel's valuation.) One significant indication of these data is the potential for future residential construction in Rhinelander and the surrounding townships.

It is important to note that there are more total housing units listed on Tables 3.14-15 through 3.14-17 than improved parcels (Tables 3.14-18 through 3.14-20). This indicates that an improved parcel can have several houses on it, or an apartment building with several housing units.

In summary, there is a relatively large number of "vacant" houses in the study area. There is also a significant number of housing units held for seasonal use which could be converted to year-round housing units. Finally, there is a large number of residential land parcels which are available for new home construction. Subtracting from this housing availability are the "substandard" housing units and residential parcels which are not desirable for building.

A report titled *Rhinelander Area Housing Study*, 1993 commissioned by the Rhinelander Area Chamber of Commerce (1993) indicated that a low number of housing units were for sale in and around the Rhinelander area. This report also stated that the number of residential parcels available for sale in the Rhinelander area is significantly less than the total number of vacant parcels on the local property tax role.

The most likely reason for the difference in the number of vacant housing units as reported in the 1990 census and the number of homes for sale as reported in the Rhinelander Area Housing Study is the fact that at any given time not all vacant units in the area are for sale. Likely reasons for the difference in the number of vacant residential parcels as reported by 1990 census and the number of vacant residential parcels available for sale as reported by the Rhinelander Area Housing Study are that some of the parcels may not lend themselves to development; at the current market price the owner is not willing to sell; or for personal preference reasons the owner does not currently wish to see development on the vacant lots.

3.14.3.4 Government Structure and Public Finance

The structure of Wisconsin's system of local government includes counties, incorporated cities and villages, towns, school districts, vocational/technical/adult education (VTAE) districts and various special purpose districts. Counties, cities, villages and towns are typically referred to as general purpose governments because of the wide variety of public services they provide. In contrast, school and VTAE districts and special purpose districts such as sanitary districts are referred to as special purpose governments since they provide specific public services.

Wisconsin is also served by a system of regional planning commissions. The North Central Regional Planning Commission that serves, Forest, Langlade, Oneida and seven other counties was established in 1973. The commission is a voluntary association of counties and other local units of government with statutory responsibility to prepare plans and to coordinate the orderly development of the region.

Table 3.14-18

1993 Residential Parcels Within the Study Area
Forest County

Location	Total Residential Parcels	Improved Parcels	Vacant Parcels	Percentage Improved
Argonne, Town	434	256	178	59%
Blackwell, Town	118	69	49	58%
Caswell, Town	124	93	31	75%
Crandon, City	1,171	698	473	60%
Crandon, Town	427	295	132	69%
Freedom, Town	508	341	167	67%
Hiles, Town	791	602	189	76%
Laona, Town	1,067	666	401	62%
Lincoln, Town	1,016	705	311	69%
Nashville, Town	1,389	876	513	63%
Popple River, Town	118	91	27	77%
Ross, Town	258	166	92	64%
Wabeno, Town	1,164	618	546	53%

Source: *Wisconsin Department of Revenue, 1993. Final Statement of Assessment.*

Note: Table does not include SCC or FCP.

Prepared by: RVS
Checked by: SFJ

Table 3.14-19

1993 Residential Parcels Within the Study Area
Langlade County

Location	Total Residential Parcels	Improved Parcels	Vacant Parcels	Percentage Improved
Ackley, Town	164	157	7	96%
Ainsworth, Town	619	395	224	64%
Antigo, City	3,144	2,805	339	89%
Antigo, Town	623	478	145	77%
Elcho, Town	1,637	1,169	468	71%
Evergreen, Town	275	195	80	71%
Langlade, Town	510	318	192	62%
Neva, Town	457	356	101	78%
Norwood, Town	300	246	54	82%
Parrish, Town	91	76	15	84%
Peck, Town	140	117	23	84%
Polar, Town	349	282	67	81%
Price, Town	116	83	33	72%
Rolling, Town	439	362	77	82%
Upham, Town	1,035	717	318	69%
White Lake, Village	209	152	57	73%
Wolf River, Town	1,163	634	529	55%

Source: *Wisconsin Department of Revenue, 1993. Final Statement of Assessment.*

Note: Table does not include SCC or FCP.

Prepared by: RVS
Checked by: SFJ

Table 3.14-20

1993 Residential Parcels Within the Study Area
Oneida County

Location	Total Residential Parcels	Improved Parcels	Vacant Parcels	Percentage Improved
Crescent, Town	1,145	908	237	79%
Enterprise, Town	457	319	138	70%
Lake Tomahawk, Town	1,376	826	550	60%
Monico, Town	372	183	189	49%
Newbold, Town	2,514	1,809	705	72%
Pelican, Town	1,716	1,259	457	73%
Piehl, Town	92	78	14	85%
Pine Lake, Town	1,549	1,203	346	78%
Rhinelander, City	2,933	2,491	442	85%
Schoepke, Town	618	469	149	76%
Stella, Town	378	259	119	69%
Sugar Camp, Town	1,539	1,064	475	69%
Three Lakes, Town	3,912	2,391	1,521	61%
Woodboro, Town	747	536	211	72%

Source: *Wisconsin Department of Revenue, 1993. Final Statement of Assessment.*

Note: Table does not include SCC or FCP.

Prepared by: RVS
Checked by: SFJ

In 1977 Wisconsin created the Mining Investment and Local Impact Fund (MILIF) to assist local governments in addressing various impacts of mining development at the local level. This Fund, administered by the MILIF Board, makes various types of payments to affected local governments over the planning, construction, operations and post-operations phases of a mining project. Revenues used by the MILIF are generated primarily by a net proceeds tax on mining, but also may include federal payments, interest income, and other fees paid by the mining company.

3.14.3.4.1 Net Proceeds Tax

The net proceeds tax (NPT) set forth in Wis. Stat. §70.395 is imposed by the State of Wisconsin on metalliferous mining operations. It was established to compensate the state, localities and Native American communities for mining impacts, and also to provide revenue to the state from the extraction of mineral resources. The NPT is administered by the Wisconsin Department of Revenue.

A mining operation pays its NPT by June 15 of each year, with allowances for a September 15 adjusted payment. Net proceeds are calculated by taking gross mining proceeds minus allowable deductions. Current year NPT obligations are determined by prior year net proceeds. The NPT is calculated by applying a progressive rate structure to the mining operation's net proceeds. Tax rates are indexed each year based on the gross national product implicit price deflator. The rates applied in 1993 for taxes due in 1994 by an operating mine are shown in Table 3.14-21.

Proceeds from the NPT are divided between the MILIF and the Badger Fund, a separate environmental trust fund established by the state legislature. Sixty percent of the NPT collected or the amount necessary to make "first dollar payments" (explained below) is deposited into the MILIF. The remaining amount, up to 40 percent of the tax collected, is deposited into the Badger Fund.

3.14.3.4.2 Mining Impact Fund

The funds received by the Mining Investment and Local Investment Fund are distributed to eligible jurisdictions in two primary ways. The highest priority distribution of funds is through direct, mandatory payments and lower priority distributions occur through the use of discretionary grants. There are several different types of direct payments made to eligible jurisdictions in which a mine or proposed mine is located. These payments require no application from local governments or communities, but eligibility requirements, priority and expenditure guidelines are specified by Wisconsin statutes and administrative rule.

Notice of Intent Payments

The first type of payment is Notice of Intent. These payments are distributed to counties, towns, cities, Native American communities or local impact committees as needed to defray costs associated with the development of local agreements. Associated costs may include legal counsel and technical expertise. Notice of Intent payments are funded from installment payments made directly by the permitting applicant to the Department of Revenue, and are statutorily limited to $150,000 in total. All unused Notice of Intent payments are returned to the permitting applicant after completion of local agreements.

Table 3.14-21

1993 Net Proceeds Tax Rates, Payable 1994

Tax Rate	Net Proceeds Range	
	Lower Bound	Upper Bound
0%	$ 0	$ 369,100
3%	$ 369,101	$ 7,383,900
7%	$ 7,383,901	$14,767,600
10%	$14,767,601	$22,151,500
13%	$22,151,501	$29,535,300
14%	$29,535,301	$36,919,000
15%	$36,919,001	no upper bound

Source: Wisconsin Department of Revenue, Division of Research and Analysis, July 1994.

Prepared by: JRH
Checked by: RVS

Construction Period Payments

Construction Period Payments are one-time $100,000 payments made to municipalities, counties and Native American communities having at least 15 percent of a minable ore body within their boundaries. Construction Period Payments are intended to assist affected governments with early impacts that are generated by mining construction. The Construction Period Payment is received at the beginning of mine construction and may be credited by the mining company against future net proceeds tax liability.

First Dollar Payments

First Dollar Payments are made annually to each county and municipality containing at least 15 percent of a minable ore body and each Native American community with tribal lands within a city, town or village which qualifies for First Dollar Payments. Payments are made in January of each year based on the prior year's Net Proceeds Tax payment. Maximum payments to each jurisdiction are indexed to $100,000 in 1982. A maximum 1994 payment based on sufficient 1993 NPT payments would be $147,600. Payments in any given year are prorated among all eligible jurisdictions in the event that the MILIF does not have sufficient funds to make First Dollar Payments in full.

With the exception of county government, recipients may use their First Dollar Payments for any public purpose. Counties are restricted in the use of their First Dollar funds to spending on mining-related activities.

Additional Payments to Counties

After all First Dollar Payments have been made in full, the county government in which a mine is located is entitled to an additional payment from the MILIF. The Additional Payment is made in January of each year and is based on the lesser of either 20 percent of the total NPT collected in the prior year or $250,000 indexed for inflation from the year 1982. The 1994 indexed payment based on sufficient 1993 NPT payments would be $369,100. Like First Dollar Payments, Additional Payments to Counties must be used only for mining-related purposes. Forest County would be eligible for Additional Payments from the current proposed mine.

Project Reserve Funds

Each year the lesser of 10 percent of the NPT collections generated by the particular mine or the amount available in the MILIF after all guaranteed payments have been made is allocated to a project reserve fund. This money is to be used for MILIF purposes in years that insufficient funds are available for mandatory payments only to municipalities and for cessation of mining and reclamation expenses. Disbursements from the MILIF follow a set of priorities. If NPT revenues are insufficient to fully fund all direct payments, the first priority is to fully fund all First Dollar Payments. After this is accomplished the second priority is to fully fund the Additional Payment to Counties. The last priority is payments from the project reserve fund.

Discretionary Grants

Discretionary grants are available only when funds remain in the MILIF after all mandatory payments have been made or when a special legislative appropriation is made. Discretionary Grants are intended to address mining impacts in a comprehensive, regional manner. Grant priority is given to governments with mining activity within their jurisdictions, then governments adjacent to mining activities, and lastly to other governments. School districts are also eligible for MILIF Discretionary Grants.

3.14.3.4.3 Local Government Spending

Although general purpose governments in the study area provide a wide range of services, it is also true that different levels of government tend to specialize in the provision of certain services. Health and human services expenditures and general administration expenditures tend to dominate county budgets in most of Wisconsin, and do so in the study area counties. It is also common for county governments to make significant expenditures for public works and law enforcement, but the relative importance of these categories vary from county to county.

City and village governments tend to provide a broad range of services, but budgets for these municipalities are often dominated by expenditures for capital or public works projects and general administration. It is not uncommon for city and village governments to provide law enforcement and fire protection, but the level of service varies significantly among places. Health and human services expenditures play a relatively minor role in city and village budgets.

Town governments in Wisconsin typically provide the smallest array of local government services and tend to have the lowest level of spending per capita of the three types of general purpose governments.

Table 3.14-22 shows average annual total expenditures per capita in constant 1992 dollars for all general purpose governments in the study area for the period 1988 to 1992.[1] On average, cities and villages in the study area spent $771 per person for all services that were provided. The level of total spending per capita for cities and villages ranges from $552 per person in the Village of White Lake to $995 per person in the City of Antigo. Towns in the study area averaged $333 in total expenditures per capita, or 43 percent of the average level for cities and villages. Total spending per capita by towns show greater variation than spending per capita by cities and villages. Total spending per capita ranges from $115 in the Town of Antigo to $1,112 in the Town of Popple River. Total spending per capita by county governments in the study area show little variation and averages approximately $480 per person.

Tables 3.14-23, 3.14-24 and 3.14-25 break out average total expenditures per capita into major categories of service for general purpose governments in the three counties of the study area. The numbers in these tables represent the average spending for each government for the period 1988 to 1992, stated in 1992 dollars.

Forest County General Purpose Governments

Table 3.14-23 shows that average overall per capita spending by Forest County general purpose governments varies little among the different levels of government. The City of Crandon spent an average of $555 per person for the 1988 to 1992 period (stated in 1992 dollars), Forest County spent an average of $494 per person, and the towns in the Forest County portion of the study area averaged $445 per person. The Town of Popple River, with its unique relationship to the National Forest, spent considerably more per person than all other jurisdictions in the county.

Over 85 percent of all Forest County government expenditures were used for health and human services, general government and law enforcement. The major expenditure categories for the City of Crandon are capital outlays, public works and general government administration. These expenditures accounted for over 65 percent of the City of Crandon's total expenditures. Similarly, town budgets in Forest County were dominated by public works, general government and capital outlays, but public works represent the major influence on most town budgets. Table 3.14-23 also shows that all towns in the Forest County portion of the study area provide fire protection, while two towns provide some form of law enforcement.

Langlade County General Purpose Governments

Table 3.14-24 shows the average per capita spending for general purpose governments in Langlade county. In general, towns within Langlade County spend considerably less per capita than their counterparts in either Forest or Oneida Counties. Langlade County government expenditures are comparable to Forest and Oneida County governments overall. Per capita spending in the Village of White Lake is comparable to other cities and villages in the study area, while per capita spending in the City of Antigo is among the highest in the study area.

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[1]Per capita spending in Tables 3.14-22, 3.14-23 and 3.14-24 was calculated for each year from 1988 to 1992 and was then adjusted to constant 1992 dollars using the gross national product implicit price deflator for each year (U.S. Department of Commerce, *Survey of Current Business*). These amounts were averaged for the five-year period 1988-1992.

Table 3.14-22

Study Area Average Annual Total Expenditures Per Capita: 1988-1992

		Total Spending Per Capita (1992 Dollars)		
		Low	Average	High
Cities/Villages				
	Forest County[1]	555	555	555
	Langlade County	552	766	981
	Oneida County[1]	995	995	995
	Study Area	552	771	995
Towns				
	Forest County	229	445	1,112
	Langlade County	115	231	343
	Oneida County	166	349	633
	Study Area	115	333	1,112
Counties				
	Study Area	452	480	494

Source: *Wisconsin Department of Revenue, Bureau of Local Financial Assistance.*

[1] Only one incorporated city exists in these counties.

Note: Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-23

Average Per Capita Expenditures for General Purpose Governments : 1988-1992
Forest County

	General Government	Law	Fire	Other Public Safety	Public Works	Health/ Human Services	Culture/ Recreation/ Education	Conservation/ Development	Capital Outlays	Debt Service	Other Financing	Total Expenditures
Argonne, Town	64	0	16	1	138	2	2	0	48	16	0	286
Blackwell, Town	52	0	6	2	175	0	16	0	2	0	18	270
Caswell, Town	141	0	16	3	244	12	4	3	44	0	6	472
Crandon, Town	32	0	14	0	134	1	0	0	19	28	0	229
Crandon, City	68	55	36	0	86	9	13	17	208	60	3	555
Freedom, Town	83	0	13	6	225	1	2	0	39	97	2	468
Hiles, Town	138	0	15	0	415	1	0	0	89	0	0	658
Laona, Town	44	5	10	9	83	10	16	69	77	0	4	326
Lincoln, Town	84	0	13	0	145	0	0	1	187	19	0	450
Nashville, Town	58	0	20	2	209	2	2	3	90	8	1	395
Popple River, Town	196	0	25	6	627	0	4	0	185	70	0	1,112
Ross, Town	106	0	23	1	172	4	30	0	0	39	0	375
Wabeno, Town	44	14	11	5	136	1	22	1	58	5	2	300
Forest County	98	75	0	10	3	248	15	35	7	0	2	494

Note: 1) All numbers are rounded to the nearest dollar, reported in 1992 dollars.
2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-24

Average Per Capita Expenditures for General Purpose Governments : 1988-1992
Langlade County

	General Government	Law	Fire	Other Public Safety	Public Works	Health/ Human Services	Culture/ Recreation/ Education	Conservation/ Development	Capital Outlays	Debt Service	Other Financing	Total Expenditures
Ackley, Town	34	0	27	0	164	0	0	0	3	2	0	231
Ainsworth, Town	47	0	17	0	143	5	0	0	28	4	4	249
Antigo, City	55	93	90	11	125	13	69	48	304	94	80	981
Antigo, Town	29	0	14	1	68	0	0	2	0	0	0	115
Elcho, Town	51	0	44	0	189	1	6	3	8	24	0	326
Evergreen, Town	26	0	13	7	181	2	0	0	4	0	0	233
Langlade, Town	44	0	11	9	90	2	5	0	19	0	3	184
Neva, Town	26	0	23	0	92	3	0	0	15	0	0	160
Norwood, Town	29	0	18	0	125	1	1	57	8	22	1	263
Parrish, Town	103	0	20	3	130	0	0	0	0	0	0	256
Peck, Town	45	0	22	0	138	1	8	0	26	14	0	255
Polar, Town	26	0	11	0	81	1	1	0	58	12	0	191
Price, Town	42	0	19	0	176	18	0	0	48	0	0	303
Rolling, Town	23	0	21	0	90	1	0	0	13	2	0	149
Upham, Town	41	0	24	0	126	2	0	0	9	0	0	200
White Lake, Village	127	1	63	18	180	0	33	2	106	21	0	552
Wolf River, Town	89	3	13	7	216	3	0	0	0	10	2	343
Langlade, County	80	41	10	14	37	207	33	22	42	7	0	494

Note: 1) All numbers are rounded to the nearest dollar, reported in 1992 dollars.
2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-25

Average Per Capita Expenditures for General Purpose Governments : 1988-1992
Oneida County

	General Government	Law	Fire	Other Public Safety	Public Works	Health/ Human Services	Culture/ Recreation/ Education	Conservation/ Development	Capital Outlays	Debt Service	Other Financing	Total Expenditures
Crescent, Town	31	0	5	0	86	0	22	0	21	0	0	166
Enterprise, Town	72	0	38	12	158	2	3	1	24	24	0	334
Lake Tomahawk, Town	102	9	27	1	283	4	14	3	0	45	0	488
Monico, Town	95	0	14	3	169	5	2	0	20	24	1	332
Newbold, Town	39	0	33	2	166	0	27	0	0	12	0	279
Pelican, Town	26	1	11	0	76	0	21	0	33	1	0	168
Piehl, Town	133	3	10	3	481	1	0	1	0	0	1	633
Pine Lake, Town	35	2	9	0	193	0	20	0	29	12	0	300
Rhinelander, City	64	130	123	9	233	21	81	29	153	81	71	995
Schoepke, Town	81	0	39	9	172	2	5	0	103	9	0	421
Stella, Town	53	1	4	0	134	0	1	0	0	6	2	201
Sugar Camp, Town	85	1	15	20	202	2	3	0	35	20	0	384
Three Lakes, Town	96	83	12	0	266	4	65	11	45	22	0	603
Woodboro, Town	29	0	14	0	167	0	2	8	3	0	2	226
Oneida County	81	57	0	15	48	139	16	25	44	17	9	452

Note: 1) All numbers are rounded to the nearest dollar, reported in 1992 dollars.
2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Nearly 75 percent of all Langlade County government expenditures are made for health and human services, general government administration, capital outlays and law enforcement. City and village spending is dominated by capital outlays, public works, general government administration and fire protection, but considerable difference exists between spending levels in the two incorporated municipalities. The City of Antigo spends relatively more per capita on law enforcement, conservation and development, capital projects and debt service while the Village of White Lake spends relatively more on general government administration, relatively little on law enforcement, and slightly more on public works. Towns in the Langlade County portion of the study area spend over 85 percent of their total budgets on public works, general government and fire protection. Once again, public works expenditures dominate town budgets in Langlade County.

Oneida County Local Purpose Governments

As shown in Table 3.14-25, per capita spending by the City of Rhinelander is relatively high in comparison to other incorporated places in the study area. At the same time, average per capita spending by town and county government in Oneida County is at or below average levels for the study area. Table 3.14-25 shows the composition of general purpose government spending for Oneida County.

Health and human services expenditures per capita make up a relatively smaller portion of the overall Oneida County budget, representing only 31 percent of overall county spending over the 1988-1992 period. This compares to 42 percent and 50 percent for Langlade and Forest Counties respectively. Nearly two-thirds of the budget for the City of Rhinelander is spent in the areas of capital outlays, public works, law enforcement and fire protection. Town government expenditures are dominated by public works, general government administration and capital outlays. Law enforcement is provided by a much larger proportion of towns in Oneida County.

3.14.3.4.4 Local Government Revenues

General purpose governments in Wisconsin have three main sources of revenue: property tax, intergovernmental aid, and public charges for services. Property tax is an important source of revenue for all general purpose governments. It is the most significant tax available to municipal governments (cities, villages and towns) and generally represents about 25 percent of total revenues. Property tax is the mainstay of local school district revenue, generally representing over half of total school district revenues.

Wisconsin property owners pay property taxes to the state, county, school district, VTAE district and municipality. The amount of tax paid is based on both the value of the property and the local property tax rate. Property is assessed at two levels. Individual parcels, excluding manufacturing and utility properties, are assessed by the local assessor as of January 1 of each year. Manufacturing value is assessed by the Wisconsin Department of Revenue. These values are used to apportion taxes to each property owner in a municipality.

The Department of Revenue estimates the full market value or equalized value of all property in each district. The equalized values are used to apportion levies of various overlying districts to the municipality based on the municipality's share of the overlying district's total equalized value. The property tax levy is the total amount of revenue that a municipality will collect in property taxes in a given year. The only property tax collected for state purposes in Wisconsin is the state

forestation tax. This tax is levied at a rate of $0.20 per $1,000 of value and is used for state forestry programs.

Intergovernmental revenues represent a large share of total local revenue in many cases. In 1992, intergovernmental revenue represented approximately 34 percent of all county and municipal revenue in the state. This revenue source includes federal aid, state highway aid, state shared revenues, transportation aid, aid for health and human services, public safety, sanitation and payments for municipal services (for state properties). The largest category of intergovernmental revenue is state shared revenues.

The state shared revenue program provides funds to county and municipal governments that may be used to finance general local government expenditures. In 1992, over $910 million was received by counties and municipalities under this program. The funding is distributed through a formula that includes four main parts: aidable revenues, per capita, special utility, and minimum and maximum constraints.

The aidable revenue formula is based on the concept of tax base equalization. It allocates aid to counties and municipalities to offset disparities in taxable property wealth. Allocations are made based on per capita property values and local efforts to raise revenues. The per capita component simply provides a specified amount to each county or municipality based on the number of residents residing in the jurisdiction. In 1993, the per capita payment rate was $28.66. This rate goes down (up) each year as overall state population increases (decreases).

The special utility component of the shared revenue program compensates local governments for costs incurred in providing services to (property tax-exempt) public utilities. The minimum/maximum component of the shared revenue program provides a buffer to prevent huge increases or decreases in shared revenue payments from year to year. Transportation aid is also a significant revenue source for local governments. This aid is paid by the state to municipalities to assist in the maintenance, improvement and construction of roads.

Public charges for services are another relatively important source of local revenue. This category includes services for which a charge is made to individuals, organizations and businesses. More specifically, such charges include sewer charges, fees for parks, library charges, fire and ambulance service, refuse collection, and so forth.

County governments in Wisconsin are also authorized to impose a 0.5 percent sales tax. The county government retains all collections and the tax is imposed on the same items and services subject to the state sales tax (five percent in 1994). Langlade, Forest and Oneida Counties have all enacted the county sales tax.

Table 3.14-26 shows average total revenues per capita for the study area for the period 1988 to 1992, stated in 1992 dollars.[2] Since counties and municipalities in Wisconsin must have balanced budgets each year, total revenues per capita mirror total expenditures per capita quite closely. In general, total revenues per capita are highest in study area cities and villages and are generally the lowest in towns. Within the study area, however, there are some towns that have higher total revenues per capita than do counties and incorporated places.

Forest County General Purpose Governments

Table 3.14-27 shows how average total revenues for all general purpose governments in Forest County were generated by major category of revenue. As a deviation from the normal city-town-county pattern found in Wisconsin, a number of towns in Forest County collect more total revenues per person than does the county or City of Crandon. In particular, the towns of Popple River, Hiles and Caswell have relatively high per capita total revenue levels.

Intergovernmental revenues represent the largest source of per capita revenues for every locality in the area, representing 58 percent of all revenues for the City of Crandon, 68 percent for all study area towns, and 56 percent for Forest County. Shared revenues are relatively most important to the City of Crandon, as are transportation aids to towns. Shared revenues and transportation aids are relatively minor to Forest County revenues.

Property taxes make up 16 percent of the City of Crandon's total revenues per capita, 13 percent of average total revenues for study area towns in Forest County, and 25 percent of Forest County revenues.

Langlade County General Purpose Governments

Table 3.14-28 shows average per capita revenues by major category for Langlade County. Per capita revenues vary significantly between the City of Antigo and the Village of White Lake. Average town revenues per capita are low in comparison to the study area while Langlade County per capita revenues are comparable to the other two counties.

As in Forest County, intergovernmental revenues are the most important source of revenues to all governments in Langlade County. Shared revenue payments are generally more important to all three types of government in Langlade County as compared to Forest County. Transportation aids continue to be an important source of funds to most town governments. Property taxes also continue to represent a significant source of revenues per capita for all levels of government in Langlade County.

[2]Per capita revenues in Tables 3.14-26, 3.14-27, 3.14-28 and 3.14-29 were calculated for each year from 1988 to 1992 and then adjusted to constant 1992 dollars using the gross national product implicit price deflator for each year (U.S. Department of Commerce, *Survey of Current Business*). These amounts were averaged for the five-year period 1988-1992.

Table 3.14-26

Study Area Average Annual Total Revenues Per Capita: 1988-1992

	Total Revenues Per Capita		
	Low	Average	High
Cities/Villages			
Forest County[1]	564	564	564
Langlade County	534	782	1,030
Oneida County[1]	996	996	996
Study Area	534	781	1,030
Towns			
Forest County	221	477	1,157
Langlade County	129	235	363
Oneida County	180	351	593
Study Area	129	345	1,157
Counties			
Study Area	468	498	517

Source: *Wisconsin Department of Revenue, Bureau of Local Financial Assistance.*

[1] Only one incorporated city exists in these counties.

Note: Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-27

Average Per Capita Revenues for General Purpose Governments : 1988-1992
Forest County

	Property Taxes	Tax Increment	Other Taxes	Special Assessment	Shared Revenues	Trans. Aid	Intergovt Revenues	Licenses/ Permits	Fines	Public Charges	Intergovt Charges	Misc. Revenues	Proceeds from Debt	Other Financial Sources	Total Revenues
Argonne, Town	16	0	3	0	65	100	102	1	0	10	1	18	5	0	321
Blackwell, Town	(18)	0	26	0	91	111	89	0	0	4	0	63	0	0	366
Caswell, Town	26	0	114	0	41	136	180	3	0	8	11	82	0	0	601
Crandon, Town	50	0	5	0	76	57	8	1	0	5	0	3	0	16	221
Crandon, City	93	0	6	0	172	29	127	3	6	9	11	32	76	2	564
Freedom, Town	217	0	0	0	29	134	54	3	1	20	1	14	0	19	492
Hiles, Town	97	0	2	0	31	241	274	2	0	32	0	30	0	0	709
Laona, Town	45	0	17	0	77	43	82	2	2	9	3	50	0	4	333
Lincoln, Town	161	0	8	0	32	137	20	5	0	12	15	27	13	0	429
Nashville, Town	126	0	11	0	33	89	15	4	0	49	4	31	28	0	389
Popple River, Town	2	0	22	0	33	576	435	2	0	6	0	50	0	32	1,157
Ross, Town	31	0	22	0	96	101	70	3	0	22	1	11	26	0	383
Wabeno, Town	17	0	1	0	117	68	51	3	5	40	8	18	0	0	327
Forest County	128	0	15	0	25	0	263	2	9	52	1	21	0	1	517

Note: 1) All numbers are rounded to the nearest dollar, reported in 1992 dollars.
2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-28

Average Per Capita Revenues for General Purpose Governments : 1988-1992
Langlade County

	Property Taxes	Tax Increment	Other Taxes	Special Assessments	Shared Revenues	Trans. Aid	Intergovt. Revenue	Licenses/ Permits	Fines	Public Charges	Intergovt Charges	Misc. Revenues	Proceeds from Debt	Other Financial Sources	Total Revenue
Ackley, Town	62	0	2	0	52	64	30	1	0	12	0	8	3	0	234
Ainsworth, Town	28	0	5	0	34	69	38	2	0	32	0	9	26	0	243
Antigo, City	128	16	25	12	324	35	128	8	7	47	4	76	120	100	1,030
Antigo, Town	23	0	0	0	45	27	5	2	0	7	10	10	0	0	129
Elcho, Town	138	0	6	8	31	75	16	4	0	27	16	19	0	22	363
Evergreen, Town	51	0	3	0	77	64	21	0	0	1	0	5	0	0	222
Langlade, Town	(1)	0	17	0	36	51	55	3	0	3	0	6	0	0	172
Neva, Town	53	0	1	0	61	31	5	1	0	8	0	6	0	0	166
Norwood, Town	66	0	0	0	64	57	30	1	0	3	4	12	24	0	262
Parrish, Town	1	0	14	0	33	82	127	2	0	5	1	1	0	0	265
Peck, Town	49	0	3	0	71	78	10	0	0	19	8	19	12	0	268
Polar, Town	24	0	1	3	62	57	4	1	0	1	2	9	27	0	192
Price, Town	95	0	10	0	45	101	29	1	0	14	0	26	0	0	321
Rolling, Town	33	0	3	0	62	40	4	1	0	4	1	13	8	0	168
Upham, Town	55	0	1	0	32	66	33	2	0	4	0	7	0	0	200
White Lake, City	84	0	55	0	246	36	31	2	1	6	18	55	0	0	534
Wolf River, Town	55	0	11	0	34	110	77	5	0	5	3	24	0	0	325
Langlade, County	114	0	56	0	89	6	129	1	4	76	5	22	8	0	509

Note:
1) All numbers are rounded to the nearest dollar, reported in 1992 dollars.
2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Oneida County General Purpose Governments

Average per capita revenues for Oneida County are shown in Table 3.14-29. Overall revenues per capita are relatively high in the City of Rhinelander, are relatively low for county government purposes, and are about equal to study area averages for Oneida County towns.

Intergovernmental aids play a much smaller relative role in the revenues of Oneida County general purpose governments. Total intergovernmental revenues per capita represent only 37 percent of the City of Rhinelander's total revenues, 38 percent of total revenues for towns in the study area, and only 29 percent of Oneida County government total revenues. Offsetting the lower contribution of intergovernmental revenues to total revenues, property taxes play a much larger role in local government revenues in Oneida County. Twenty-eight percent of the City of Rhinelander's total revenues per capita comes from the property tax, while over 40 percent of the average for Oneida County towns in the study area comes from the property tax. Oneida County government also raises over 30 percent of its total revenues from the property tax.

Overall, county and municipal fiscal conditions in the study area follow conditions found in non-metropolitan areas throughout the state. Expenditures and revenues are higher in incorporated places (cities and villages) than in towns, although there are exceptions to this general rule within the study area. County government tends to focus most of their available resources on health and human services expenditures, while municipalities tend to concentrate resources in the areas of public works and capital projects. Intergovernmental revenues are important to all levels of government, but the relative importance of these aids varies across the study area.

3.14.3.5 Public Facilities and Services

This section is intended to profile current public facilities and services provided to study area residents. It includes an evaluation of health, human and social services, education, water, sanitation, as well as solid waste disposal. The information collected is intended to be useful in evaluating changes in the demand for public facilities and services as a result of the proposed mine development.

3.14.3.5.1 Education

All eight school districts in the study area (Antigo, Crandon, Rhinelander, Three Lakes, White Lake, Laona, Wabeno, and Elcho) have seen enrollments fall since the peaks reached in the mid 1970s. The age of school buildings and equipment is a major concern common to all the districts. Renovations and additions have been completed to accommodate facility modifications necessary to comply with state and federal mandates. While the number of students has not increased since the 1970s, space requirements have. Table 3.14-30 provides detail on all eight school districts. Sources for these data are included on Table 3.14-30.

Antigo School District

The Antigo school district built a new high school that opened for the 1994-95 school year. It has capacity for 1,200 students, with current enrollment of 1,100. The 1993-94 district wide enrollment of 3,239 was down 23 percent from the 1975-76 peak of 4,215. The pupil/teacher ratio of 14.9 and pupil/staff ratio of 12.4 are less than the state average of 15.8 and 13.2

Table 3.14-29

Average Per Capita Revenues for General Purpose Governments : 1988-1992
Oneida County

	Property Taxes	Tax Increment	Other Taxes	Special Assessments	Shared Revenues	Trans. Aid	Intergovt. Revenue	Licenses/ Permits	Fines	Public Charges	Intergovt. Charges	Misc. Revenues	Proceeds from Debt	Other Financial Sources	Total Revenue
Crescent, Town	81	0	1	0	55	28	3	2	0	1	0	9	0	0	180
Enterprise, Town	164	0	15	0	31	51	46	2	0	3	0	19	24	0	356
Lake Tomahawk, Town	307	0	0	0	31	70	25	3	2	18	0	17	15	0	488
Monico, Town	42	0	60	0	84	81	31	1	0	2	0	31	16	0	349
Newbold, Town	162	0	1	1	31	48	26	2	0	4	0	18	9	0	303
Pelican, Town	80	0	1	0	70	23	3	2	0	0	0	12	0	0	192
Piehl, Town	101	0	130	0	57	203	61	5	0	1	0	36	0	0	593
Pine Lake, Town	112	0	2	0	82	26	6	1	0	0	0	11	60	0	300
Rhinelander, City	274	24	27	2	242	51	83	5	10	56	3	41	70	107	996
Schoepke, Town	216	0	25	0	30	87	19	4	0	1	0	41	0	0	423
Stella, Town	69	0	4	0	40	74	5	1	0	4	0	8	0	0	205
Sugar Camp, Town	230	0	5	0	32	54	15	3	0	6	0	12	13	0	371
Three Lakes, Town	387	0	1	0	32	66	29	3	1	12	0	15	43	2	592
Woodboro, Town	71	0	2	0	31	71	12	3	0	5	0	10	0	0	205
Oneida County	145	0	72	0	5	15	117	6	5	28	16	25	24	12	468

Note: 1) All numbers are rounded to the nearest dollar.

2) Table does not include SCC or FCP.

Prepared by: JRH
Checked by: RVS

Table 3.14-30

Profile of Study Area School Districts

School District	Year Built	Additions	Square Feet	Peak Enrollment	Year of Peak	Students 1993-94	School Capacity	Pupil/ Teacher	Pupil/ Total Staff	Expend./ Student
Crandon				1,115	1974-75	1,033		15.9	13.4	$5,796
Crandon K-12	1991		150,000			1,033	1,200			
Laona				530	1974-75	353		13.8	11.1	$5,782
Robinson Elementary	1963		16,445			185	240			
Laona High	1987		36,572			155	220			
Wabeno				702	1977-78	545		13.8	11.7	$5,450
Wabeno Elementary	1974	1993	46,577			305	N/A			
Wabeno High	1936	1963, 1980	72,406			160	N/A			
Antigo				4,215	1975-76	3,239		14.9	12.4	$4,982
Aniwa Elementary	1929	1988	11,870			83	over capacity			
Antigo High	1994					1,100	1,200			
Antigo Jr. High	1938		52,182			809	850			
Crestwood Elementary	1958		14,880			169	at capacity			
East Elementary	1961	1988	21,838			191	at capacity			
Lily Elementary	1929		6,300			29	40			
Mattoon Elementary	1951	1979, 1990	15,196			125	at capacity			
North Elementary	1961	1987, 1989	23,671			301	at capacity			
Pleasant View Elementary	1962		17,342			159	at capacity			
River Grove Elementary	1960	1976	19,777			138	at capacity			
Spring Valley Elementary	1961	1984	16,250			179	over capacity			
West Elementary	1961	1978	21,112			250	at capacity			
Elcho				613	1973-74	432		12.3	10.6	$5,673
Elcho Elementary	1937		15,872			226	N/A			
Elcho High	1918	1936	54,082			195	N/A			

Table 2-29, *continued*

School District	Year Built	Additions	Square Feet	Peak Enrollment	Year of Peak	Students 1993-94	School Capacity	Pupil/ Teacher	Pupil/ Total Staff	Expend./ Student
White Lake										
White Lake K-12	1917	1968, 1979	54,000	629	1974-75	265	700	11.9	10.2	$5,883
Rhinelander				4,272	1973-74	3,374		18.3	15.4	$5,148
Cassian-Woodboro	1956	1981	9,568			80	105			
Central Elementary	1939	1990	55,308			278	370			
Crescent Elementary	1961	1980, 1987	26,326			219	300			
Newbold Elementary	1956	1967	17,782			130	185			
Pelican Elementary	1990	1994	35,867			194	350			
Pine Lake Elementary	1955	1956, 1963, 1979, 1994	37,955			253	320			
Rhinelander High	1958	1968, 1974	197,800			1,032	1,400			
South Park Elementary	1952		22,914			120	75			
West Elementary	1923	1988	42,390			255	320			
Williams Jr. High	1974	1993	119,605			772	1,000			
Three Lakes				823	1977-78	753		14.0	11.8	$5,795
Sugar Camp Elementary	1939	1978, 1993	26,184			144	200			
Three Lakes High *	1922	1978, 1993	184,455			593	900			

* Three Lakes High School building has separate K-6 and 7-12 schools.

Sources: *Wisconsin Department of Public Instruction, 1992-1993. Center for Education Statistics, Information Series Numbers 5 and 13.*
Basic Facts: 1992-1993.
Telephone interviews May 17, 18 and 26.
Wisconsin Department of Public Instruction, *Wisconsin Public School Buildings 1991-1993.*

Notes: 1) 1993-1994 student enrollment for individual schools are based on estimates from school officials. They may vary from total school district enrollment reported to Wisconsin Department of Public Instruction.
2) Table includes socioeconomic characterization of SCC and FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

respectively. The average per pupil cost of $4,982 (1992-93) was three percent lower than the state average of $5,150.

Crandon School District

The 1993-94 Crandon School enrollment was 1,033 students, down from 1,115 in 1974-75. The pupil/teacher ratio of 15.9 and pupil staff ratio of 13.4 are right in line with the state average. The average cost per student of $5,796 was 13 percent higher than the state average. In 1991, the Crandon School District built a 150,000 square foot K-12 school with a capacity of 1,200 students. This $7,306,000 project alleviates the immediate facility concerns for the Crandon School District.

Elcho School District

The Elcho School District's enrollment has declined from a peak of 613 students in 1973-74 to 432 students in 1993-94. The pupil/teacher ratio of 12.3 and pupil/staff ratio of 10.6 are significantly lower than the state averages, and the average cost per pupil (1992-93) of $5,673 was 10 percent higher than the state average. Because of its relatively large tax base, the district currently receives minimum state school aid.

Rhinelander School District

Enrollment in the district has generally declined since the peak enrollment of 4,272 in 1973-74. Enrollment has increased six percent since 1990 to the current 1993-94 level of 3,374 students. The pupil/teacher ratio of 18.3 and pupil/staff ratio of 15.4 are higher than the state average. The average per pupil cost of $5,148 is right in line with the state average. In the last twenty years, Rhinelander School District has added facilities including the 1990 construction of Pelican Elementary School which is 26,543 square feet. The age of school facilities and unsuccessful bond issue referenda for school construction are prominent issues in the Rhinelander School District.

Wabeno School District

With current enrollment of 545 students, the Wabeno School District has experienced a steady or slightly declining enrollment since the peak of 672 students in 1972-73. The pupil/teacher ratio of 13.8 and pupil/staff ratio of 11.7 are less than the state average. Current cost per pupil of $5,450 is six percent higher than the state average. In 1993 Wabeno School District added eight additional classrooms to their elementary school, increasing square footage by 12,000.

Laona School District

This is one of the smallest school districts in the study area, with current 1993-94 enrollment of 353 students. Enrollment has generally declined since the peak in 1975-76 of 510 students. The pupil/teacher ratio of 13.8 and pupil/staff ratio of 11.1 are below the state average. Average cost per pupil of $5,782 is 12 percent higher than the state average.

Three Lakes School District

While current 1993-94 enrollment in the Three Lakes School District of 753 students is less than the peak of 823 students in 1977-78, it has increased significantly in the last two years. The pupil/teacher ratio of 14.0 and pupil/staff ratio of 11.8 are below the state average. Average cost per pupil of $5,795 is 13 percent higher than the state average.

White Lake School District

This is the smallest school district in the study area, with current 1993-94 enrollment of 265 students. Enrollment has generally declined since the peak in 1974-75 of 629 students. It should be noted that the White Lake school district served a larger geographic area in 1974-75 than today. The pupil/teacher ratio of 11.9 and pupil/staff ratio of 10.2 are below the state average. Average cost per pupil of $5,883 is 14 percent higher than the state average.

3.14.3.5.2 Water and Sanitation

In order to evaluate the ability of the study area to absorb additional population, it is important to look at water and sanitation services. The information collected is intended to be useful in evaluating changes in the demand for water and sanitation services as a result of the proposed mine development.

Municipal Water Systems

There are eight municipally owned and operated water supply and distribution systems in the study area, as shown in Table 3.14-31. All systems meet current water demands. All other residences in the study area are served by individual and/or private water supply wells.

City of Crandon

The system consists of two active wells, chemical addition equipment for emergency disinfection, underground storage reservoir, elevated storage tank and distribution system. A fire flow study has been recommended by WDNR to determine if the system can meet minimum fire flow requirements. The district now has pressure filters in service which remove iron and manganese before water enters the distribution system.

Laona Sanitary District

The Town of Laona owns the water system, which consists of one active well, two standby wells, chemical addition equipment (for chlorine, fluoride, potassium permanganate and polymer), sand filter, one elevated tank and distribution system. A fire flow study conducted in 1986 showed that some hydrants could not meet minimum fire flow requirements. High iron and manganese concentrations in the water have built up in the mains, restricting flows in the conveyance system.

Wabeno Sanitary District #1

The Town of Wabeno owns the water system, which consists of two active wells, chemical addition equipment for chlorine and fluoride, one elevated standpipe, and distribution system. The town adds chlorine for emergency disinfection only.

Table 3.14-31

Study Area Municipal Water Systems[1]

Location	# Active Wells (depth in feet)[1]	Water Quality[1]	Ground Storage[1] (gal)	Elevated Storage[1] (gal)	Distribution[1] (pressure, mains, flows)	Consumption[1,6] gal/capita/day	Avg Daily Prod.[1] (gal)
Forest County							
City of Crandon	2 (80-90)	Exceeds drinking water standards per NR 109 Wis. Admin. Code	200,000[2]	55,000	45-55 psi; cast iron mains; fire flow study needed	88	180,000[2]
Laona Sanitary District #1	1 (57)	Meets Safe Drinking Water Act standards; high manganese, iron	--	200,000	54 psi; asbestos-cement pipe	82	90,000[3]
Wabeno Sanitary District #1	2 (95-155)	Meets Safe Drinking Water Act standards	--	120,000	60-70 psi; cast iron mains; fire flow minimum requirements met	89	44,652
Langlade County							
City of Antigo	7 (56-62)	Meets Safe Drinking Water Act standards; lime softening plant	500,000	350,000	58-62 psi; cast iron mains; minimum fire flow requirements met	120	1,000,000[4]
Elcho Sanitary District	2 (163-195)	Meets Safe Drinking Water Act standards; high iron, manganese	100,000	200,000	35-52 psi; cast iron mains; minimum fire flow requirements met	70	39,576
Village of White Lake	2 (92-95)	Meets Safe Drinking Water Act standards	--	96,000	45-52 psi; asbestos-cement mains; minimum fire flow requirements met	99	37,074
Oneida County							
City of Rhinelander	3[5] (68-91)	Meets Safe Drinking Water Act standards[5]	1,000,000[5]	900,000[5]	System and pressures are adequate for all purposes, including fire protection.[5]	300[5]	2-2.5 million[5]
Three Lakes Sanitary District #1	2 (63-74)	Meets Safe Drinking Water Act standards.	--	56,000 (Recommend replacement of tower.)	<42 psi; ductile iron, cast iron mains; minimum fire flow requirements on some hydrants not met; pressure monitoring devices to be installed.	168	97,432

1 WDNR most recent available Water Supply Investigation Report, July 1989-February 1994.
2 Johnson, 1994.
3 Carter, 1994.
4 Wiseman, 1994.
5 Fruend, 1994.
6 Consumption gal/capita/day is Average Daily Production divided by Estimated Population from WDNR.

Note: Table does not include SCC or FCP.

Prepared by: GMS
Checked by: SFJ

City of Antigo

The city's water system consists of seven wells, chemical addition equipment for chlorine and fluoride, a lime softening plant, ground storage reservoir, two elevated storage tanks and distribution system. Two of the city's wells have been sampled in the past for the presence of volatile organic compounds (VOCs); however, detectable levels have not been identified since 1990 (Wiseman, 1994).

Elcho Sanitary District #1

The sanitary district owns the water system, which consists of two wells, chlorination equipment, aerator, ground storage reservoir, high lift pump system, standpipe and distribution system.

Village of White Lake

The village's system consists of two wells, chlorine feed system, elevated storage reservoir and distribution system.

City of Rhinelander

The city's water system consists of three wells, underground storage reservoir, two elevated tanks, chemical feed systems (for chlorine, sodium hydroxide and polyphosphates) and distribution system.

Three Lakes Sanitary District #1

The water system owned by the sanitary district consists of two active wells, chemical addition equipment for sodium hydroxide, an elevated tank and distribution system. The district has been required to install pressure monitoring devices to document pressure deficiencies in the system. Hydrants in the system are not capable of supplying minimum fire flow requirements (WDNR, 1993). The WDNR also recommends that the district replace the existing elevated tank with a larger and taller tank.

Municipal Wastewater Treatment

Characteristics of the municipal wastewater treatment facilities in the study area are summarized in Table 3.14-32. Residences in the remainder of the study area are served by individual, on-site systems.

City of Crandon

The Crandon facility consists of an aerated lagoon that discharges to seepage cells. The city is beginning a facilities plan to upgrade the facility due to inadequate aeration capacity and high organic loadings. Under existing conditions, the ability of the existing plant to handle additional residential loadings is questionable (Johnson, 1994).

Table 3.14-32

Study Area Municipal Wastewater Treatment Facilities[1]

Location	Facility Type	Plant Age (years)	Flow Rate[2] (MGD)	Design Capacity (MGD)
Forest County				
City of Crandon	Aerated lagoon w/seepage cells	12	0.213	0.260
Laona Sanitary District #1	Aerated lagoon	2	0.102	0.130
Wabeno Sanitary District #1	Aerated lagoon	22	0.100	0.100
Langlade County				
City of Antigo	Two-stage activated sludge with sand filtration	14	1.88	2.47
Elcho Sanitary District	Stabilization pond with seepage cells	23	0.051	0.060
Village of White Lake	Stabilization pond w/seepage cell	17	0.040	0.050
Oneida County				
Lake Tomahawk Sanitary District	Community mound	5	0.018	0.049
City of Rhinelander	Bio-tower	new	1.38	1.90
Three Lakes Sanitary District #1	RBCs	15	0.060	0.131

1 WDNR, North Central District *Discharge Monitoring Reports*, May 1993 to May 1994.

2 Average from previous 12 months (May 1993 - May 1994).

Note: Table does not include SCC or FCP.

Prepared by: GMS
Checked by: SFJ

Laona Sanitary District

An aerated lagoon system was recently constructed for this community and is currently operating within its current permit guidelines. The plant discharges to the Rat River. Under existing conditions, it is estimated that this plant could accommodate an additional 350 residential users based on additional plant capacity of 28,000 gallons per day, 200 gallons per day per household and an average of 2.5 persons per household.

Wabeno Sanitary District #1

The community operates an aerated lagoon system that, according to recent flow data, is operating at its designed flow capacity. The plant has also recently experienced BOD violations. It discharges to the North Branch of the Oconto River. The plant's permit expires in December 1996 and, due to its age and recent violations, will most likely require the completion of a facilities plan to upgrade the facility (Ohm, 1994a).

City of Antigo

Faced with stringent effluent discharge limitations for Spring Brook (15 mg/L BOD, 15 mg/L SS), this plant consists of a two-stage activated sludge system followed by rapid sand filtration. Future permit requirements may require phosphorus removal and additional sludge storage. It is estimated that this facility could accommodate an additional 7,375 residential users under current conditions, based on additional plant capacity of 590,000 gallons per day, 200 gallons per household per day, and an average of 2.5 persons per household.

Elcho Sanitary District #1

This facility consists of a stabilization pond that discharges to the Hunting River. The plant has experienced past problems with high infiltration from wet weather flows. The plant's new discharge permit will include a compliance schedule to upgrade the facility by November 1998 (Ohm, 1994b). Under existing conditions, until the facility is upgraded, the ability of this plant to safely handle additional loadings is questionable (Hubbard, 1994).

Village of White Lake

This system consists of a stabilization pond with discharge to seepage cells. Groundwater monitoring wells have recently been installed to evaluate the effectiveness of the seepage cells. Under current conditions, it is estimated that the plant could accommodate an additional 125 residential users, based on additional plant capacity of 10,000 gallons per day, 200 gallons per household per day and an average of 2.5 persons per household.

Lake Tomahawk Sanitary District

This facility consists of a mound treatment system. High nitrate levels have been detected in groundwater monitoring wells. The WDNR has requested that additional monitoring wells be installed and a report prepared and submitted to address the problem (Young, 1994).

City of Rhinelander

This plant recently has been upgraded using a bio-tower treatment system. Phosphorus removal will be required in the future. The plant discharges to the Wisconsin River. Under current conditions, it is estimated that the plant could accommodate an additional 6,500 residential users, based on additional plant capacity of 520,000 gallons per day, 200 gallons per day per household and an average of 2.5 persons per household.

Three Lakes Sanitary District

The plant uses rotating biological contactors (RBCs) for treatment and is currently operating well under its designed flow capacity. It discharges to a tributary of Thunder Lake. Under current conditions, it is estimated that an additional 885 residential users could be accommodated, based on additional plant capacity of 71,000 gallons per day, 200 gallons per day per household and an average of 2.5 persons per household.

3.14.3.5.3 Solid Waste Management

There are currently two active municipal sanitary landfills in the planning area (Table 3.14-33). The active portions of both landfills are designed and operated according to the rules in NR 500 of the Wisconsin Administrative Code. Out-of-county wastes are not accepted at either of the sites.

The City of Antigo's landfill brings in approximately 20 tons per day from within the city and Langlade County communities. The site life is estimated at approximately 20 years from 1994, based on current tonnages. The Oneida County Landfill is nearing capacity. Approximately 100 tons per day are hauled to the site from the City of Rhinelander and other Oneida County communities. Oneida County is currently in the process of investigating the expansion of the facility. The permitting and approval process for the expansion could take anywhere from five to ten years, until waste could be accepted at the expanded site.

Forest County has no active municipal sanitary landfills. The City of Crandon residents contract with private haulers for waste collection and disposal outside of the county. One of the private haulers transports the Crandon waste to a private transfer facility in Antigo, where it is loaded on semitrailers and hauled to Ridgeview Landfill, a landfill owned by Waste Management, Inc. in Manitowoc County. Forest County towns operate individual drop-off facilities where town residents haul and deposit their waste in containers located at the sites. The towns contract with private contractors to have the waste hauled and disposed of at landfills located outside the county. These landfills include Tork Landfill in Wisconsin Rapids and Ridgeview Landfill in Manitowoc County. A small fraction of the county's waste from the northeastern part of the county is hauled to a landfill in Michigan.

Other NR 500-approved landfills within 50 miles from Crandon are located in Marinette County to the east, and Vilas County to the north (Table 3.14-33). Both of these sites have extensive site capacity, but only accept waste generated within the county, for the Vilas County site, or wastes from Marinette or Oconto Counties, for the Marinette site.

Table 3.14-33

Active Municipal Sanitary Landfills

Name	1992 Tonnage[1]	Estimated Remaining Site Life	Service Area
Within Study Area			
Langlade County			
City of Antigo	5,078	20 years[2]	Langlade County Communities Only[2]
Oneida County			
Oneida County Landfill	25,902	6 years[3]	Oneida County Communities Only[3]
Outside of Study Area (within 50 miles of Crandon)			
Marinette County			
MAR-OCO Landfill	29,000	15 years[4]	Marinette and Oconto County Communities Only[4]
Vilas County			
Highway G Landfill	7,000	14 years[5]	Vilas County Communities Only[5]

1 Walsh, Patrick and Charlotte Zieve, Ph.D. 1993. "Case Study of Wisconsin's Management of Municipal Solid Waste." Presented at the 1994 Winter Conference of the Wisconsin Counties Solid Waste Management Association.

2 Vanderleest, 1994.

3 Sexton, 1994.

4 Lefebvre, 1994.

5 Dobrinski, 1994.

Prepared by: GMS
Checked by: SFJ

3.14.3.5.4 Human Services

The Wisconsin Department of Health and Social Services administers a wide range of direct service programs to clients in communities and institutions, regulates certain care providers, and supervises and consults with local public and voluntary agencies. Its responsibilities span physical and mental health services to the aged, public assistance, medical assistance, juvenile and children's services, and vocational rehabilitation. Each of the counties in the study area are responsible to provide human services as outlined below. The following summary provides a breakdown of these services and how they are typically provided:

Alcohol and Drug Abuse

Each of the counties in the study area must provide alcohol and drug abuse services per state statute. Forest and Oneida Counties provide these services through a consortium organization, called Lakeland Council on Alcoholism and Other Drug Abuse, which serves Forest, Oneida and Vilas Counties. Langlade County provides these services through a similar organization, North Central Healthcare Facilities, which serves Langlade, Marathon and Lincoln Counties. These programs provide outpatient counseling services to substance abusers and their families, crisis intervention services, a 24-hour hotline, information and referral services, and prevention services.

Developmental Disabilities

Each of the counties in the study area receives state funding to provide services to individuals with developmental disabilities. All three counties provide case management and operate supportive care programs directly through county staff case workers. Other services offered to developmentally disabled persons are typically contracted through private agencies. These contract services include group home living arrangements, day care services to teach daily living skills, work services in sheltered workshops, adult family homes, and supportive employment to assist in work place performance.

Domestic Violence

While the counties in the study area are not statutorily required to provide domestic violence services, there are non-profit organizations which provide these services under contract with the respective counties. Advocate for Victims of Abuse in Langlade (AVAIL) provides domestic abuse services in Langlade County. The Tri-County Consortium provides domestic abuse services in Forest and Oneida Counties. These programs provide short-term counseling, shelter up to 30 days, information and referral services, a 24-hour hotline, guidance through legal proceedings and relocation, support groups, transportation, community education, judicare and crime victim services.

Day Care

Counties in the study area are not statutorily required to provide day care facilities. Private providers offer day care services for children in the study area. All three counties provide funding for certain day care services, such as crisis respite day care and low income child care subsidy.

Hospitals

Two hospitals serve the study area. St. Mary's Hospital is a 150-bed facility located in Rhinelander. Langlade Memorial Hospital, located in Antigo, is licensed for 139 beds, but according to the hospital's Chief Executive Officer, it has downsized since the mid-1980s to 49 beds. There are no hospitals in Forest County.

3.14.3.5.5 Health Services

Forest, Langlade and Oneida Counties are served by primary care specialists as outlined in Table 3.14-34. The ratio of population to full time equivalent physician is higher in Forest and Langlade Counties than the state average.

Long-term care in the study area is provided by eight nursing homes with a total of 858 beds, according to Wisconsin Department of Health and Social Services 1992 data. Table 3.14-35 provides a breakdown of long-term care facilities by county for the study area. Table 3.14-36 outlines long-term care staffing for the three counties in the study area. Oneida County has the highest level of service with five nursing homes and two home health agencies.

3.14.3.5.6 Social Services

Each of the three counties in the project study area have a Department of Social Services which provides income maintenance and case management services to residents of the area. Social services include a variety of youth and adult programs, while income maintenance services include AFDC (Aid for Families with Dependant Children), medical assistance, food stamps, and general relief. Table 3.14-37 provides detail on case loads.

The Department of Social Services in Forest County has a staff of 16 people (13 full-time equivalents), including six social workers, four income maintenance workers, two business office workers, two clerical workers, one fraud investigator, and one Green Thumb worker. Total Department budget for 1994 is $1,200,000, plus contract services. The Department of Social Services in Langlade County has a staff of 29 people, including 13 social workers, seven clerical and nine economic support section employees. The total social services budget for 1993 is $2,715,742.

The Department of Social Services in Oneida County has a staff of 41 people, including seven management/administrative personnel, 19 social workers, seven income maintenance workers, and eight child support workers. The total social services budget for 1993 is $6,499,563. This does not include federal medical assistance payments, which the Oneida County Department of Social Services assists in processing.

Table 3.14-34

Primary Care Specialties, 1992
Full-Time Equivalent

	Forest County	Langlade County	Oneida County	State of Wisconsin
Total	2	8	29	2,698
Internal Medicine	1	1	14	727
General Practice	.5	1	1	190
Obstetrics and Gynecology	0	0	5	326
Pediatrics	.5	0	4	372
Family Practice	0	6	5	1,083
Population/FTE Physician Ratio	4,888:1	2,480:1	1,103:1	1,850:1

Source: *Wisconsin Department of Health and Social Services, 1992. The State's Profile.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-35

Health Care Facilities

	Forest County	Langlade County	Oneida County
Home Health Agencies	1	1	2
Home Health Patients	132	437	601
Nursing Homes	2	1	5
Nursing Home- Licensed Beds	150	173	535

Source: *Wisconsin Department of Health and Social Services, 1992.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-36

Long-Term Care Staffing in Full-Time Equivalents

	Forest County	Langlade County	Oneida County
Total Staff	4	6	13
Administrators	1	1	1
Public Health Nurses	0	2	6
Public Health Aides	1	0	0
Environmental Specialists	0	0	0
Office Support	1	1	4
Other Professionals	1	2	2

Source: *Wisconsin Department of Health and Social Services, 1992.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 3.14-37

Department of Social Service 1993 Caseload Summary

	Forest County	Langlade County	Oneida County
Economic Support			
Aid for Families w/Dependant Children	587/mo.	269/mo.	325/mo.
General Relief	3/mo.	61/mo.	36/mo.
Food Stamp Program	773/mo.	545/mo.	769/mo.
Medical Assistance	679/mo.	1,501/mo.	790/mo.
Nursing Home Care	115/mo.	124/mo.	299/mo.
Low Income Energy Assistance	737/yr.	1,099/yr.	1,260/yr.
Social Services			
Child Protection	304	542	327
Family Services	---	---	246
Substitute Care	12	40	109
Child Day Care	30	60	84
Juvenile Court Intake	186	---	363
Youth Aids Services	---	20	431
Guardianships/Protective Placement	116	30	230
Long Term Support Programs	48	84	240
Supportive Home Care	23	20	32
1993 Total Budget (including State and Federal Reimbursement, excluding Medical Assistance)	$1,000,000	$2,715,742	$6,499,563

Source: *Department of Social Services, Forest, Langlade and Oneida Counties, personal contacts, 1994: Spencer, Meisinger, Sekel.*

Note: Table includes socioeconomic characterization of SCC and the FCP living in the study area.

--- = no data

Prepared by: RVS
Checked by: SFJ

3.14.3.5.7 Police, Fire, Emergency Medical Services

Forest County

All police, fire and emergency medical services in Forest County are provided through the county sheriff's department, the City of Crandon, and the Towns of Laona and Wabeno. The county does not have an emergency 911 phone system at this time.

The Forest County Sheriff's Department includes 11 officers and deputies, including the sheriff and chief deputy, plus 21 reserve deputies. The department provides police protection for all unincorporated areas in the county and owns seven police vehicles; three marked and three unmarked squad cars, and a four-wheel drive vehicle. Through the county's Emergency Government Department, a spill response team is also available to contain hazardous material spills. An emergency government vehicle, located in Wabeno, is equipped with a foam gun for managing spills (Baetsen, 1994; Huettl, 1994).

The City of Crandon employs two full-time and three part-time police officers. All are also deputized by the county sheriff's department for back-up as needed. The city owns two police squad cars. The police department serves the City of Crandon, and provides back-up assistance to the county sheriff's department. As of September 1994, the police chief has requested another full-time officer from the city council in order to provide 24-hour police protection in the city, which is currently not provided (Berndt, 1994).

The Towns of Laona and Wabeno each employ part time constables and own a squad car for local police protection. Fire protection in the county is provided by three volunteer fire departments located in the City of Crandon and Towns of Laona, Wabeno and Nashville. The City of Crandon owns three tanker trucks and two pumpers. The Town of Laona, which also serves the entire Towns of Laona and Caswell, and half of the Towns of Blackwell and Wabeno, owns a rescue squad and three fire trucks. Wabeno's fire department consists of two fire trucks and a support van and provides coverage for portions of the Towns of Laona, Blackwell, Freedom and Wolf River, in addition to Wabeno. The fire hall is being expanded to accommodate a larger fire truck which was purchased recently (Baetsen, 1994; Tucker, 1994). The Town of Nashville volunteer fire department serves the southern half of the town, and the City of Crandon fire department serves the northern part of the town (Pitts, 1994).

Emergency medical services are provided in the county by three private agencies utilizing volunteer staff for operations. These services are located in Crandon, Laona and Wabeno, each covering approximately one third of the county. There are two rescue squads located in Crandon, and one each in Laona and Wabeno (Baetsen, 1994; Aubol, 1994).

Oneida County

Police protection is provided by the county's sheriff's department for the entire county except the City of Rhinelander and the Towns of Minocqua, Woodruff and Three Lakes, which have their own departments. The sheriff's department includes 26 sworn officers and deputies and has 15 police vehicles. A 911 phone system is in place in the county for emergencies (Harper, 1994).

The City of Rhinelander has a full-time police force that includes 21 officers and five squad cars (Allen, 1994). The Town of Three Lakes employs four full-time and one part-time police officers. The department has one squad car and shares an office with the Town Clerk (Lurvey, 1994). Towns in the study area that employ part-time constables include Monico, Newbold, Pelican, Pine Lake, and Stella. Rhinelander's full-time fire department has 19 staff and includes

three pumper trucks, an aerial ladder truck and one rescue squad. Paid-on-call or volunteer fire departments are available in all Towns except the Towns of Piehl and Woodboro, which contract with neighboring towns for this service (Knutson, 1994).

County-wide emergency medical services are available through the county. Ambulance stations are located at Three Lakes, unincorporated Village of Pelican Lake, and Sugar Camp. St. Mary's Hospital operates the service, with the vehicles and equipment owned by the county (Harper, 1994).

Langlade County

The Langlade County Sheriff's Department has 15 full-time officers that patrol the entire county, and eight police vehicles, including a four-wheel drive rescue vehicle. A mobile command post for operations from remote locations is also available. Class "B" emergency response team training has been included in the proposed 1995 county budget, however there is no emergency response team in place at this time. The county has a 911 phone system for residents' use in emergencies (Hovland-Frisch, 1994; Steger, 1994).

The City of Antigo police department includes 17 full-time police officers and four squad cars. Office and dispatch facilities are shared with the Langlade County Sheriff's Department (Racine, 1994). Town constables are employed by the following towns: Ainsworth, Antigo, Norwood, Polar and Wolf River.

The City of Antigo has the only full-time fire department in the county. The department includes 15 fire fighters, one pumper truck, one aerial ladder truck, one rescue van and three ambulances. The department will soon be purchasing an additional ambulance as well. Current space problems will be solved with the completion of a new fire station, now under construction. The department services the Antigo city limits and has mutual aid agreements with the surrounding towns and the City of Rhinelander (Bartz, 1994).

Volunteer fire departments are available to serve all of the unincorporated areas in the county. The Towns of Ainsworth, Antigo, Elcho, Langlade, Peck, Norwood, Wolf River; the Village of White Lake and the Rural Fire Control District, which includes the Towns of Ackley, Neva and Rolling, all have fire departments. The other towns have agreements with the departments in the neighboring towns for fire protection services (Hovland-Frisch, 1994).

Ambulance service is provided by Langlade County Sheriff's department through the Antigo fire department. The service is staffed by fire department personnel with the assistance of a number of volunteer emergency medical technicians (EMTs) located throughout the county. The Town of Elcho's fire department has a rescue van and has been interested in purchasing an ambulance, but has not due to budget constraints. Troutland Ambulance Service is a private, volunteer service that serves the Village of White Lake and the Town of Wolf River. This service may soon be discontinued, however, because the ambulance is old and may not be replaced. The Pickerel-Pearson area in the northeastern part of the county also has a private, volunteer ambulance service, which also provides service to the southern part of the Town of Nashville in Forest County. (Hovland-Frisch, 1994).

3.14.3.6 Native American Communities

This section of the report reviews the history and recognized rights of the SCC, and the FCP. The purpose of this section is to document the current conditions of these Native American communities. In particular, those socioeconomic conditions most likely to be affected by the

project will be described. The section also reviews the history and recognized rights of the Menominee Indian Tribe of Wisconsin (MITW) as they relate to the Wolf River watershed downstream from the proposed project site. The location of the SCC and FCP in relation to the plant site is shown on Figure 2-1 in Section 2 of this EIR. The MITW Reservation is located approximately 30 miles south of the plant site.

In order to provide a comprehensive overview of the history of Native American communities in the study area, several approaches were evaluated. The DRI published a report in April 1986 relating to the previously proposed project. This report includes a comprehensive summary of the history of both the FCP and SCC. The following narrative represents an abridged version of the DRI Native American history sections in the 1986 report, augmented with additional historic events through 1994.

3.14.3.6.1 Sokaogon Chippewa

The site of the Crandon Project ore body in Forest County lies approximately two miles east of the Mole Lake Sokaogon Chippewa Reservation. The following discussion describes the history, reservation rights, usufructuary rights, population, housing, services, and other characteristics of the Mole Lake Reservation.

General Geographic Description

The Mole Lake Sokaogon Chippewa Reservation consists of approximately 1,700 contiguous acres, located in the township of Nashville in Forest County. In addition, the tribe reportedly owns approximately 2,000 acres adjacent to the reservation. The region's topography is that of low rolling hills composed of glacial till. The area has some scattered lakes. Generally, the surface may be described as cut-over forest land containing second and third growth birch, norway and white pine, and spruce. The reservation lies within the Wolf River watershed.

The dominant physical feature is Rice Lake, a 208-acre body of water located entirely within the eastern third of the reservation. The major tributary to Rice Lake is Swamp Creek, which enters the reservation on its eastern border and whose course takes it just north of the Crandon ore body. Rice Lake is considered one of the best wild rice producing lakes in Wisconsin. The southwestern side of the reservation adjoins Bishop Lake.

State Highway 55 bisects the reservation along its eastern edge and connects with Crandon eight miles to the north and Lilly ten miles to the south. County Road M runs along the reservation's southern boundary, linking Highway 55 with Jennings and Pelican Lake to the west. The majority of homes on the reservation are located on either side of Highway 55, with a few residences also lying along interior reservation roads.

History

The Chippewa form a portion of an extensive series of diverse cultural groups which have inhabited the Great Lakes region, beginning with the Boreal Archaic culture 5,000 years ago. The Mound Builders followed from 1000 to 500 B.C., and then the Hopewell culture lasted until 700 A.D. Chippewa origins can be traced to a legendary group of Algonquian-speaking Indians who lived along the Atlantic coast near the mouth of the St. Lawrence River, and who migrated to the shores of Lake Huron near Sault Ste. Marie. There they split into three groups, each becoming a distinct tribe, the Ottawa, the Potawatomi, and the Chippewa, also known as the Ojibwa.

The Ojibwa hunting culture began in the conifer forests adjacent to the glacial lakes about A.D. 1200. Estimates of the aboriginal Chippewa population range from 4,500 to 50,000; an estimate of 25,000-30,000 seems to have been most probable. Depending on the season, the Chippewa lived in villages numbering between 30 and 300 people. Their culture was based primarily on hunting. In the winter, families tended to disperse in order to use the hunt to greatest advantage. They regrouped to gather maple sap and greens in the spring, and then berries and wild rice in the summer and nuts and tubers in the fall. The Chippewa did not experience direct white contact until about 1610. This came through fur trading with the French. By the 1690s, trade between the Chippewa and the French was flourishing, and they began moving away from the area around Sault Ste. Marie. Over the next 100 years, they extended their range over hundreds of thousands of square miles, from the northern shores of Lake Ontario in the east to the Turtle Mountains in North Dakota in the west, and to Norway House in central Manitoba in the north. The relationship between the Chippewa and the French was quite compatible and was based on traders' supplying the Indians with manufactured products in exchange for furs. By 1782, most of the beaver had been trapped in Chippewa country, and the Hudson's Bay Company had gained control of fur trading in the region. In Canada, the Chippewa had become thoroughly dependent on the Hudson's Bay Company; they had lost many of their aboriginal skills by taking up fur trading. In 1819, the United States government acquired their land in southern Michigan by the Treaty of Saginaw. Through the Treaty of Fond du Lac in 1826, the United States secured mineral rights from the Chippewa in return for an annual payment. In 1833, the Chippewa were removed from northern Illinois and in 1837, Minnesota and Wisconsin Chippewa made their first land cession by the Treaty of St. Peters.

In 1842, the Chippewa ceded the southern Lake Superior shore in Wisconsin and Michigan, and in 1854 they ceded lands and were reserved territory at Keweenaw and Ontanagon in Michigan, Fond du Lac and Grand Portage in Minnesota, and Bad River (Odanah), Lac Court Oreilles, Lac du Flambeau, and Red Cliffe in Wisconsin. By the 1870s, the Chippewa of both Canada and the United States had entered the reservation era, which still exists today.

Today the Chippewa constitute the third largest North American Indian people, numbering 50,000 in Canada and 30,000 in the United States. There are 16 bands in the United States (including the Mole Lake Chippewa), and 67 in Canada. Four distinct units of Chippewa exist. The Northern Chippewa, or Saulteaux, live north of Lake Superior and east of Lake Winnipeg in Ontario and eastern Manitoba. The Plains Chippewa, or Bungees, live west of Lake Winnipeg in Manitoba, eastern Saskatchewan and northeastern North Dakota. The Southeastern Chippewa live around Lake Huron in Michigan and southwest Ontario, and the Southwest Chippewa live in northern Wisconsin and Michigan and southern Ontario and Minnesota.

The Mole Lake Sokaogon Chippewa are part of the Southwest Chippewa and constitute one of the older resident communities in the Crandon area. The Southwest Chippewa are thought to have begun their migration into Wisconsin from the focal center of Chippewa culture at Chequamegon on the shore of Lake Superior. This occurred after the revival of fur trade with the British about 1765, after its disruption during the French and Indian War of 1755-1763. They prospered during this period by trading with the British. By the late 1770s, the Lac du Flambeau Chippewa were sending off splinter groups into the upper Wisconsin River area, and also into the upper Wolf River area in the direction of Green Bay. By 1837, the Pelican Lake "Suk-a-aug-un-ing" had settlements at Post Lake, Pickerel Lake, "Metawanga" Lake and Rice Lake in the upper Wolf River. The Sokaogon Chippewa (Sokaogon) are said to have numbered 200 individuals in 1848. Although names of Sokaogon representatives appear in the 1854 treaty under the heading of Lac du Flambeau members, both groups have long maintained a separate identity. The Sokaogon consider themselves the "People of the Post in the Lake".

For 80 years following the 1854 treaty, the Sokaogon continued to occupy their traditional territory, although they had no title to the land. Under the terms of the 1934 Indian Recognization Act, the United States established the reservation at Mole Lake. Membership in the Sokaogon is now determined by direct blood relationship to anyone on the 1937 tribal roll.

In 1975, the Mole Lake Indian Reservation opened a bingo hall on their Mole Lake reservation. In 1991, casino-style gambling was added. This gaming facility, along with associated employment opportunities and revenue generation, has changed the financial status of the SCC. The development of casino activity, tax-free tobacco sales, and other tribal-owned activities is a historically significant event for the SCC.

Reservation Rights

The Sokaogon hold a reservation consisting of approximately 1,700 acres located in the Township of Nashville, Forest County. This reservation was established in 1939 by the U.S. Department of the Interior pursuant to the Indian Reorganization Act of 1934. The federal government's creation of the 1939 reservation grew out of a long-standing dispute between the United States and the Sokaogon. Since at least the 1860s, the Sokaogon had been seeking a reservation of its own under the Treaty with the Chippewa of September 30, 1854. That treaty created four reservations for the Wisconsin Chippewa at Bad River, Red Cliffe, Lac Courte Oreilles, and Lac du Flambeau. Although the 1854 treaty made no provision for a separate reservation for the Sokaogon, the Sokaogon contended that they were entitled to such a reservation under the treaty's intent and by virtue of various other promises and actions of federal officials during the mid-19th century. The United States persistently rejected these claims and insisted that the Sokaogon relocate onto one of the Wisconsin reservations that had been created under the 1854 treaty. The Sokaogon refused to move from their historic homelands, and spent many decades living on cut-over timber lands and crowding onto small tracts that had been purchased by individual tribal members. The federal government's creation of the present reservation in 1939 was an effort to resolve this impasse. The Sokaogon continued to maintain after 1939 that it was entitled to a much larger reservation. As a result of years of litigation, the U.S. District Court for the Eastern District of Wisconsin held in 1992 that the Sokaogon have no treaty rights to possess, inhabit or occupy lands outside the currently defined reservation boundaries. The court reconfirmed earlier rulings that the Sokaogon have certain qualified hunting, fishing and gathering (usufructuary) privileges that extend to certain lands as discussed below. The district court's decision was upheld on appeals.

Hunting, Fishing and Gathering Privileges

In addition to its reservation rights, the Sokaogon have a privilege, guaranteed under the Treaty with the Chippewa of October 4, 1842, to engage in off-reservation usufructuary activities, consisting of hunting, fishing, gathering, and the like, on certain public lands in the vicinity of the Crandon Project. The federal courts have held that the exercise of these privileges is qualified in two respects:

(1) The rights of private property. Hunting, fishing and gathering privileges guaranteed by the 1842 treaty have been defined by the courts as extending only to public lands and not to lands owned by private parties. These privileges are extinguished on any public land that is conveyed into private ownership.

(2) The rights of mining development. The U.S. District Court has specifically held that mining has a legal right under the 1842 treaty to proceed and to "co-exist" with the Chippewas' exercise of their rights under that treaty.

1990 Census Information

The following information has been taken from the 1990 Census of Population and Housing (U.S. Department of Commerce, 1990) for the Wisconsin Sokaogon and Trust Lands. Included are summaries of general population, educational, labor force, employment, family income and housing characteristics.

Population

In 1990, the U.S. Bureau of Census reported that the Wisconsin SCC and Trust Lands had a total population of 337.

Education

In 1990, approximately 36 percent of the community's population was enrolled in school, mostly in elementary or high school. Of the people 25 years and over, approximately 57 percent were high school graduates or higher, as shown on Table 3.14-38. Educational attainment is defined as the highest level of school completed or the highest degree received.

Labor Force

Of the persons 16 years and over, 124, or 67 percent, were in the labor force. The labor force includes all of those employed and unemployed. "Employed" is defined as all civilians 16 years old and over who were either: 1) "at work", those who were gainfully employed at any time during the reference week, worked in their own business or profession, worked on their own farm, or worked 15 hours or more as unpaid workers on a family farm or in a family business; or 2) were "with a job but not at work", those who did not work during the reference week but had jobs or businesses from which they were temporarily absent. The reference week is the calendar week preceding the date on which the respondents completed the U.S. Census questionnaire or were interviewed by enumerators.

"Unemployed" is defined as civilians 16 years old and over that were: 1) neither "at work" nor "with a job but not at work" during the reference week, and 2) looking for work during the last four weeks, and 3) available to accept a job. Also included as unemployed are civilians who did not work at all during the reference week and were waiting to be called back to a job from which they had been laid off.

In 1990, approximately 43 percent of the labor force was unemployed. There was a 15 percent greater number of males 16 years and older in the labor force than females of the same age group. Other labor force characteristics are shown in Table 3.14-39.

Employment

Occupations for employed persons 16 years and over are listed in Table 3.14-40. Administrative support/clerical, professional specialty and precision production/craft/repair occupations account for more than half of the total number of employed. More than half of those employed work in public administration or manufacturing industries.

Table 3.14-38

1990 Educational Characteristics for the Sokaogon Chippewa Community

School Enrollment	
Persons three years and over enrolled in school	123
Preprimary school	15
Elementary or high school	96
Percent in private school	0
College	12
Educational Attainment	
Persons 25 years and over	132
Less than 9th grade	16
9th to 12th grade, no diploma	41
High school graduate	45
Some college, no degree	24
Associate degree	6
Bachelor degree	0
Graduate or professional degree	0
Percent high school graduate or higher	57
Percent Bachelor degree or higher	0

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-39

1990 Labor Force Characteristics for the Sokaogon Chippewa Community

Persons 16 years and over	185
In labor force	124
Percent in labor force	67
Civilian labor force	124
Employed	71
Unemployed	53
Percent unemployed	43
Armed Forces	0
Not in labor force	61
Males 16 years and over	92
In labor force	67
Percent in labor force	73
Civilian labor force	67
Employed	39
Unemployed	28
Percent unemployed	42
Armed Forces	0
Not in labor force	25
Females 16 years and over	93
In labor force	57
Percent in labor force	61
Civilian labor force	57
Employed	32
Unemployed	25
Percent unemployed	44
Armed Forces	0
Not in labor force	36

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-40

1990 Employment Characteristics for Sokaogon Chippewa Community

Occupation	
Employed persons 16 years and over	71
Executive, administrative and managerial occupations	9
Professional specialty	11
Technicians and related support occupations	0
Sales occupations	6
Administrative support occupations, including clerical	16
Private household	0
Protective service	0
Service occupations, except protective and household	8
Farming, forestry and fishing occupations	3
Precision production, craft and repair occupations	11
Machine operators, assemblers and inspectors	3
Transportation and material moving occupations	3
Handlers, equipment cleaners, helpers and laborers	1
Industry	
Employed persons 16 years and over	71
Agriculture, forestry and fisheries	0
Mining	0
Construction	7
Manufacturing, nondurable goods	2
Manufacturing, durable goods	11
Transportation	0
Communication and other public utilities	0
Wholesale trade	0
Retail trade	7
Finance, insurance and real estate	0
Business and repair services	0

Table 3.14-40 *(Continued)*

Personal services	0
Entertainment and recreation services	5
Health services	0
Educational services	7
Other professional and related services	6
Public administration	26

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Family Income

As shown in Table 3.14-41, median family income in 1989 was $6,513, with per capita income at $3,639. The majority, 73 percent, of families had an income of less than $10,000. In 1989, 64 percent of all persons for whom poverty status is determined (333) were below the poverty level, and 69 percent of all families (81) were below the poverty level. The average poverty threshold for a family of four persons was $12,674 in 1989.

Housing

As shown in Table 3.14-42, there were a total of 121 housing units as of March 1990. More than 80 percent of those housing units were constructed since 1980. Of the total occupied housing units, 82 percent are renter occupied.

3.14.3.6.2 Forest County Potawatomi

The FCP community is located a number of miles east of the proposed project site. This section describes current socioeconomic conditions relating to the FCP community.

General Geographic Description

FCP tribal lands consist of scattered holdings totaling about 11,800 acres in Blackwell, Lincoln, and Wabeno Townships within southeastern Forest County. The community is accessed by State Highway 32 and by roads maintained by the towns. The FCP lands were once a rich hardwood forest area which was subsequently logged. Thus, most of the tribal lands now consist of second-growth forest vegetation. There are also scattered lakes on the tribal lands. The land is principally suitable for timber production, not for agriculture.

Tribal lands are sparsely developed and houses and trailers are scattered. There are two main concentrations of residences, those located in the Stone Lake area (now called Lake Lucerne) near Crandon in Lincoln Township, and those located in Wabeno Township. The two communities are about 20 miles apart. The greater proportion of residences are located in the Stone Lake area as is the tribal hall, which contains tribal government offices. The differentiation between the Stone Lake community and the Wabeno community is significant socially as well as residentially.

The scattered, isolated nature of the FCP land holdings results from the fact that lands were purchased for the tribe by the United States government under a policy intended to stimulate assimilation. In 1914, cutover lands were purchased from four lumber companies with a Congressional appropriation of $150,000. At that time, each person over the age of 18 was allotted 40 acres in staggered sections; however, title to the land was held in trust for the tribe. Although it was intended that the FCP become farmers, the land was unsuitable for this type of development. Cutting timber and tribal employment have been the main sources of employment since the reservation was established.

Table 3.14-41

1989 Family Income Characteristics for Sokaogon Chippewa Community

Families	81
Less than $5,000	22
$5,000 to $9,999	37
$10,000 to $14,999	1
$15,000 to $24,999	15
$25,000 to $34,999	0
$35,000 to $49,999	4
$50,000 to $74,999	0
$75,000 to $99,999	2
$100,000 to $149,999	0
$150,000 or more	0
Median family income	$6,513
Per capita income	$3,639

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-42

1990 Housing Characteristics for Sokaogon Chippewa Community

Total housing units	121
Year Structure Built	
1989 to March 1990	33
1985 to 1988	44
1980 to 1984	22
1970 to 1979	11
1960 to 1969	2
1950 to 1959	0
1940 to 1949	3
1939 or earlier	6
Bedrooms	
no bedroom	0
1 bedroom	8
2 bedrooms	24
3 bedrooms	73
4 bedrooms	16
5 or more bedrooms	0
Selected Characteristics	
Lacking complete plumbing facilities	2
Lacking complete kitchen facilities	2
Condominium housing units	0
Source of Water	
Public system or private company	109
Individual drilled well	8
Individual dug well	4
Some other source	0

Table 3.14-42 *(Continued)*

Sewage Disposal	
Public sewer	2
Septic tank or cesspool	119
Other means	0
Occupied housing units	106
Owner occupied	19
Renter occupied	87

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

History

According to the traditions of each of the three tribes, the Potawatomi, Chippewa and Ottawa were originally one people. All three tribes speak the Algonquian language, and the close similarity of their cultures supports the thesis that their separation occurred within the last 300 years. The word Potawatomi means "People of the place of the fire." Tradition says that long before historic contact, the Potawatomi, Chippewa and Ottawa kept a perpetual fire. The Potawatomi were the "youngest brother", so that when the two older Chippewa and Ottawa brothers went off to war, the youngest brother was left to keep the fire.

Although archaeological and historical evidence is scant, the traditional histories of the Potawatomi, Chippewa and Ottawa claim a migration from the eastern seaboard and a splitting of a single people into the three divisions known today. The splitting occurred at the Straits of Mackinac, with the group which later became known as the Potawatomi moving southward into Michigan. Some of the Wisconsin Potawatomi fled north to the heavily forested areas of Wisconsin rather than be moved west. There they became nomads, occupying public land or territories cut over by lumber companies.

Including the FCP, there are currently approximately 20 groups who are identified as Potawatomi or who are descended from a Potawatomi group of the 19th Century. They are located in Canada, Oklahoma, Kansas, Michigan and northeastern Wisconsin. In the United States, there are four federal reservation groups: the Citizen's Band reservation in Oklahoma, the Prairie Band reservation in Kansas, the Hannahville community in Michigan, and the Forest County community in Wisconsin. The western bands are referred to as the "prairie bands". Those of Wisconsin and Michigan are called the "forest bands".

In 1991, the FCP community opened a bingo hall, and in March of 1992, added casino-style gambling in the unincorporated village of Carter. The additional income generated as a result of this gaming facility, along with associated employment opportunities and revenue generation, has

changed the financial status of the FCP. The development of casino activities, tax free tobacco sales, and other tribal-owned activities are a historically significant event for the FCP.

Reservation Rights

The FCP have the same legal rights with respect to their trust lands as do the SCC. The FCP possess hunting, fishing and gathering rights on non-tribal lands to the same extent as any other member of the general public.

1990 Census Information

The following information has been taken from the 1990 Census of Population and Housing for the FCP Reservation and Trust Lands. Included are summaries of general population, educational, labor force, employment, family income and housing characteristics.

Population

In 1990, the FCP Reservation and Trust Lands had a total population of 266.

Education

In 1990, approximately 40 percent of the population was enrolled in school, most of which were in elementary or high school. Of the people 25 years and over, approximately 47 percent were high school graduates or higher, as calculated from Table 3.14-43.

Labor Force

As shown in Table 3.14-44, the labor force included 94 people, of which 34, or approximately 36 percent, were unemployed. The unemployment rate for males 16 years of age and older was more than twice that of females for the same age group in 1990.

Employment

As shown in Table 3.14-45, two-thirds of the employed persons 16 years and over were in professional specialty, administrative support/clerical, or service occupations. About one-third of the workers were employed in public administration.

Family Income (1989)

As shown in Table 3.14-46, median family income in 1989 was $7,993, with per capita income at $2,995. No families had income greater than $35,000. In 1989, 62 percent of all persons for whom poverty status is determined (266) were below the poverty level, and 63 percent of all families (57) were below poverty level. The average poverty threshold for a family of four persons was $12,674 in 1989.

Table 3.14-43

1990 Educational Characteristics for Forest County Potawatomi

School Enrollment	
Persons three years and over enrolled in school	110
Preprimary school	15
Elementary or high school	83
Percent in private school	0
College	12
Educational Attainment	
Persons 25 years and over	129
Less than 9th grade	17
9th to 12th grade, no diploma	52
High school graduate	35
Some college, no degree	6
Associate degree	16
Bachelor degree	0
Graduate or professional degree	3
Percent high school graduate or higher	47
Percent Bachelor degree or higher	2

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-44

1990 Labor Force Characteristics for Forest County Potawatomi

Persons 16 years and over	153
In labor force	94
Percent in labor force	61
Civilian labor force	94
Employed	60
Unemployed	34
Percent unemployed	36
Armed Forces	0
Not in labor force	59
Males 16 years and over	79
In labor force	49
Percent in labor force	62
Civilian labor force	49
Employed	25
Unemployed	24
Percent unemployed	49
Armed Forces	0
Not in labor force	30
Females 16 years and over	74
In labor force	45
Percent in labor force	61
Civilian labor force	45
Employed	35
Unemployed	10
Percent unemployed	22
Armed Forces	0
Not in labor force	29

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-45

1990 Employment Characteristics for Forest County Potawatomi

Occupation	
Employed persons 16 years and over	60
Executive, administrative and managerial occupations	3
Professional specialty occupations	13
Technicians and related support occupations	3
Sales occupations	3
Administrative support occupations, including clerical	15
Private household occupations	0
Protective service occupations	2
Service occupations, except protective and household	12
Farming, forestry and fishing occupations	4
Precision production, craft and repair occupations	2
Machine operators, assemblers and inspectors	3
Transportation and material moving occupations	0
Handlers, equipment cleaners, helpers and laborers	0
Industry	
Employed persons 16 years and over	60
Agriculture, forestry and fisheries	6
Mining	0
Construction	0
Manufacturing, nondurable goods	0
Manufacturing, durable goods	5
Transportation	0
Communications and other public utilities	0
Wholesale trade	3
Retail trade	3
Finance, insurance and real estate	0
Business and repair services	2

Table 3.14-45 *(Continued)*

Personal services	0
Entertainment and recreation services	2
Health services	7
Educational services	8
Other professional and related services	5
Public administration	19

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Table 3.14-46

1989 Family Income Characteristics for Forest County Potawatomi

Families	57
Less than $5,000	8
$5,000 to $9,999	27
$10,000 to $14,999	8
$15,000 to $24,999	13
$25,000 to $34,999	1
$35,000 to $49,999	0
$50,000 to $74,999	0
$75,000 to $99,999	0
$100,000 to $149,999	0
$150,000 or more	0
Medium family income	$7,993
Per capita income	$2,995

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

Housing

As shown in Table 3.14-47, there were a total of 77 housing units as of March 1990. More than half of those housing units were constructed before 1969. Approximately 20 percent of these units lack complete plumbing facilities. Of the occupied housing units (70), 83 percent are owner occupied.

3.14.3.6.3 Menominee

The Menominee Reservation, which is also Menominee County, consists of approximately 230,000 acres. Most of this land is held in tribal status. The northern boundary of the Menominee Reservation lies approximately 30 miles south of the proposed plant site.

The Menominee Indian Tribe of Wisconsin (Menominee) is the oldest known continuous resident in Wisconsin, and is exclusively a Wisconsin tribe. Its present reservation dates from two treaties in 1854 and 1856. Congress abolished the reservation in 1961, however, and ended all federal support. The State of Wisconsin then turned the lands into Menominee County, and several thousand acres were sold into non-tribal ownership. The social, economic, and cultural consequences of the reservation's termination were severe. In response to the efforts of the DRUMS movement (Determination of Rights and Unity for Menominee Shareholders), Congress restored tribal trust status in 1973 and the Menominee Reservation was re-established. The Menominee continue to repurchase non-tribal owned property within the reservation boundaries as it goes back onto the market.

The Menominee have the same legal rights over their reservation lands as do the SCC and FCP. In addition, the Wolf River flows through the Menominee reservation and is of importance to the tribe. The Menominee have a federal right to insist that the integrity of these waters be maintained. The Menominee filed a federal lawsuit in January 1995 against the State of Wisconsin seeking recognition of claimed off-reservation usufructuary privileges in eastern and central Wisconsin pursuant to their treaties with the federal government. That lawsuit does not involve the Crandon Project vicinity, and the outcome is therefore not expected to have any impact upon the proposed project.

Table 3.14-47

1990 Housing Characteristics for Forest County Potawatomi

Total housing units	77
Year Structure Built	
1989 to March 1990	0
1985 to 1988	3
1980 to 1984	13
1970 to 1979	15
1960 to 1969	25
1950 to 1959	2
1940 to 1949	3
1939 or earlier	16
Bedrooms	
no bedroom	2
1 bedroom	18
2 bedrooms	23
3 bedrooms	29
4 bedrooms	5
5 or more bedrooms	0
Selected Characteristics	
Lacking complete plumbing facilities	15
Lacking complete kitchen facilities	8
Condominium housing units	0
Source of Water	
Public system or private company	2
Individual drilled well	64
Individual dug well	4
Some other source	7

Table 3.14-47 *(Continued)*

Sewage Disposal	
Public sewer	0
Septic tank or cesspool	75
Other means	2
Occupied housing units	70
Owner occupied	58
Renter occupied	12

Source: 1990 Census Summary File Tape 3A (U.S. Department of Commerce, 1990).

Prepared by: RVS
Checked by: SFJ

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FIGURES FOR SECTION 3.14

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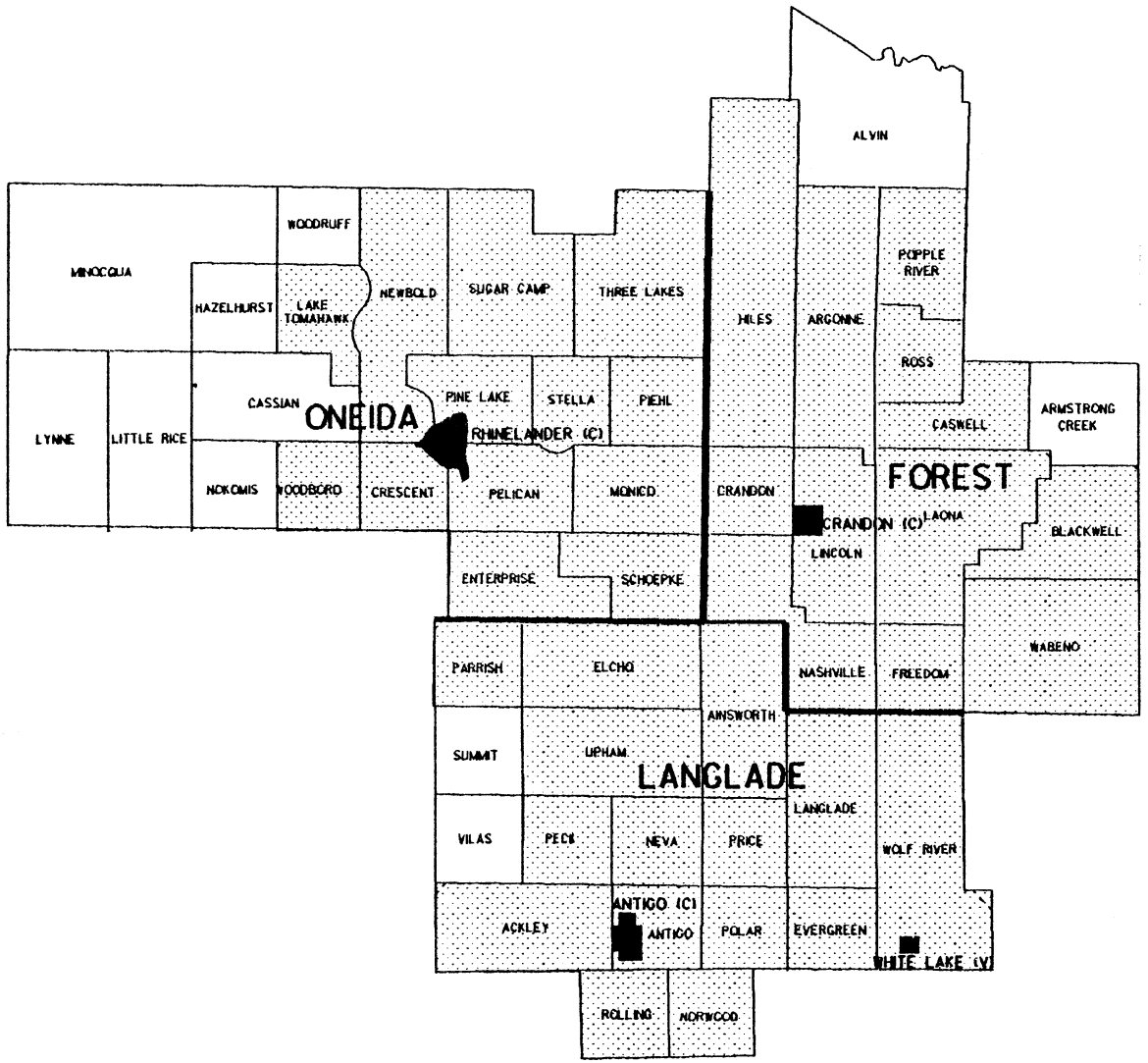

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LEGEND

SOCIOECONOMIC STUDY AREA

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	GWS	DATE: MAY '95

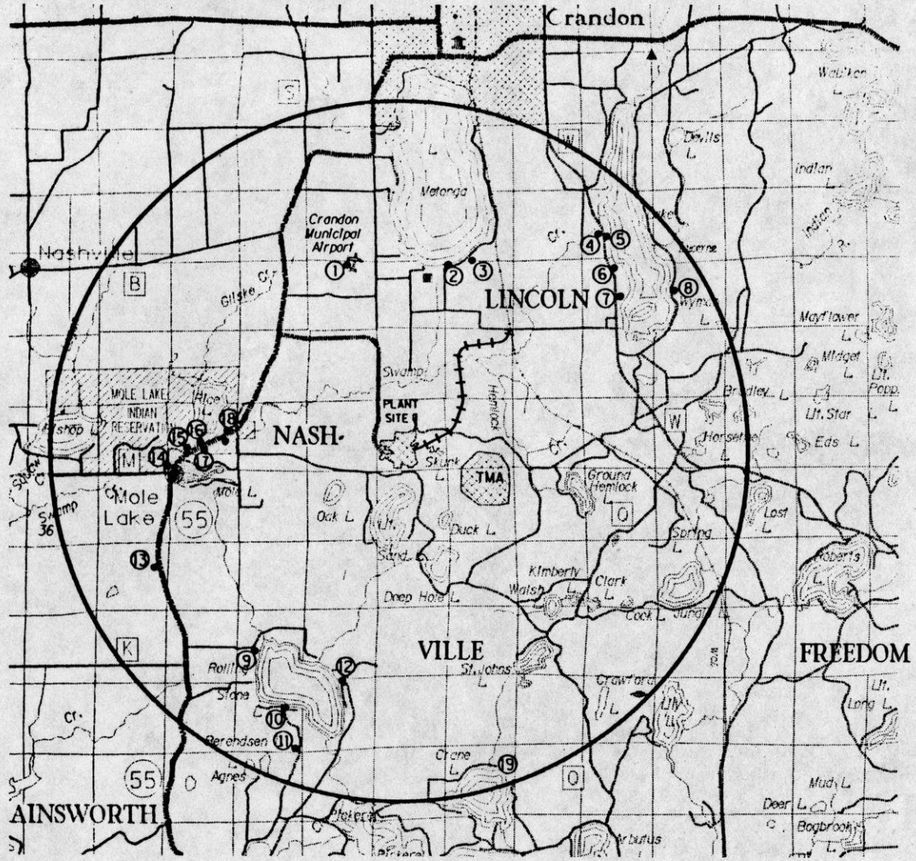
Crandon Mining Company

FIGURE 3.14.1

SOCIOECONOMIC STUDY AREA

Scale:	NTS	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	JPR

93C049



LEGEND

① CRANDON MUNICIPAL AIRFIELD
The airfield is a public airstrip designed to accommodate small private planes. There is one hanger on the property for storage of planes. The airfield is located southwest of Crandon on Airport Road. It is two miles from the proposed plant site.

② VETERANS MEMORIAL COUNTY PARK
With its excellent camping facilities, public boat landing and sandy beaches, the park is a popular vacation spot for tourists throughout the summer season. The park is located on the south end of Lake Metonga on County Park Road.

③ LAKE METONGA SUPPER CLUB AND RESORT
The Lake Metonga Supper Club and Resort is primarily a restaurant and bar. In addition, they have two cabins available for rent. It is located on East Shore Drive on the southeast end of Lake Metonga.

④ LAKE LUCERNE ASSOCIATION BUILDING
The Association is the host of Lake Lucerne Association Fun Days (July 30). It is located on CTH W on Lake Lucerne.

⑤ GRANTS MAPLES II
Formerly a full-service resort, Grants Maples II is now a restaurant and bar. Grants, which is also host of the Lake Lucerne water-ski show, is located across the street from the Lake Lucerne Association Building on the west shore of Lake Lucerne.

⑥ PFISTER'S ISLAND VIEW RESORT
This resort is rented out during the summertime only. It is located on the west shore of Lake Lucerne.

⑦ LAKE LUCERNE RESORT
The Lake Lucerne Resort has four cottages available for rental, a dining room and bar, and a swimming area. It also offers boat and equipment rental, and bait sales. It is located on the west shore of Lake Lucerne.

⑧ RUSTIC HAVEN RESORT
The Rustic Haven Resort, located on the east shore of Lake Lucerne is a family oriented resort. The Rustic has four cottages available for rent. It provides boat and motor rentals and a swimming area.

⑨ ROLLING STONE LAKE RESORT
The Rolling Stone Lake Resort is located on the northwest shore of Rolling Stone Lake. The resort has cabins available for rent, a campsite with showers and boat rental.

⑩ WALLEYE LODGE
The Walleye Lodge is located on the southwest shore of Rolling Stone Lake. The resort offers a new restaurant and bar, six rental cottages and a 30-space campsite just off the lake. The lodge also has boats available for rent.

⑪ HAROLD AND MARY KANE - CRAFT SALES
This business caters to tourists by selling various crafts. The business is based out of a private home, located south of Rolling Stone Lake.

⑫ EAST SHORE RESORT
The East Shore Resort, located on Rolling Stone Lake, is a full-service resort with a trailer court, six cottages and 42 trailers available for rent, and a beach and swimming area. In addition, the resort has a large refurnished bar and food service.

⑬ FOREST INN
The Forest Inn is a local bar located on State Highway 55, one and one-half miles south of the Mole Lake Indian Reservation.

⑭ LANDRU'S SUNDOWN TAP
Landru's Sundown Tap is a tavern located on the south end of the Mole Lake Indian Reservation on State Highway 55.

⑮ GRAND ROYAL CASINO
The Grand Royale, one of the two casinos located on the Mole Lake Reservation, offers blackjack, slots and video poker.

⑯ MOLE LAKE SMOKE SHOP
The Mole Lake Smoke Shop, located across the street from the Regency Resorts Casino, is a convenience store offering tobacco products, snacks, etc.

⑰ REGENCY RESORTS CASINO
The Regency Resorts Casino, like the Grand Royale Casino, offers blackjack, slots, and video poker. In addition, the casino has nightly bingo games and a bar and cafe.

⑱ MOLE LAKE MOTEL
The Mole Lake Motel is located across from the Bluegrass Festival Fairgrounds on State Highway 55. It contains 25 units and offers courtesy transportation to and from the casinos.

⑲ CRANE LAKE RESORT
Crane Lake Resort is located five miles east of State Highway 55 on Crane Lake. This seasonal establishment is open May through October. The resort includes cabin rental and a bar.

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- (8) U.S. HWY NO.
- (47) STATE HWY NO.
- W COUNTY HIGHWAY LETTER
- CORPORATE LIMITS
- PROPOSED ACCESS ROAD
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

N

NOTE:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY'94
APPROVED BY:	RVS	DATE: MAY'94
APPROVED BY:	JWS	DATE: MAY'94

Crandon Mining Company

FIGURE 3.14.2
TOURISM RELATED BUSINESSES
WITHIN A 5 MILE RADIUS OF SITE

Scale: 0 6000' 12,000' | Date: MAY, 1995
Prepared By: Foth & Van Dyke | By: GAM

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930049

Crandon Mining Company

Environmental Impact Report

Section 4

Environmental Impacts

Crandon Mining Company
Environmental Impact Report

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4 Environmental Impacts

The purpose of this section is to document the potential environmental and socioeconomic consequences of the construction, operation, and post-operation phases of the Crandon Project. The impacts associated with both the proposed and alternative actions are discussed. The documentation of existing conditions, presented in Section 3, provided the basis from which the impacts were evaluated. Both positive and negative effects, including secondary and indirect impacts, are described. Mitigative measures that will be taken to lessen potential impacts are discussed in Section 5.

The discussion of environmental impacts is based on the design life and post-closure period of the project and is presented for the three main phases of the project: Construction, Operation, and Post-Operation. The construction period is scheduled for approximately three years, operation for 28 years, and post-operation, which includes closure and reclamation, for approximately four years (Section 2, Table 2-1). The total project life is approximately 35 years. The environmental evaluation looks at the 35-year project life, the 40-year long-term care period, and environmental compliance at the site over the very long-term (well over 500 years).

The environmental review process for the project that was completed in the 1980s, prior to the decision to withdraw permit applications, resulted in the publication of an environmental impact report (EMC, 1985A) and an Environmental Impact Statement (WDNR, 1986). These documents described the project as it was planned at that time and identified and evaluated potential environmental impacts. While many features of the current project are similar to those from the 1980s project, many more are different. For instance, the project still involves mining zinc and copper ores at the same location, but the production rate has been decreased from about 7,400 tons per day (tpd) to 5,500 tpd. The minable ore reserve is now estimated to be 55,000,000 tons versus 67,400,000 tons. The tailings management area has been decreased in size and moved slightly northward in order to reduce impacts to wetlands. The project workforce has been decreased to reflect the lower daily production rate. Treated project wastewaters will be discharged to the Wisconsin River instead of Swamp Creek. As a result many of the potential impacts associated with the project have also changed. In addition, more field work, where necessary, has been completed to provide additional information for use in site design and the impact assessment process. Finally, new and more refined methods of analysis such as those related to groundwater modeling have been used to evaluate project conditions and to predict impacts. The net result is that the current project has been designed such that there will be fewer impacts than previously estimated.

Since the current project has many different features and since it is subject to a complete rigorous environmental review process based on its own merits, no overall effort has been made to directly compare all of the impacts of the current project to those estimated for the 1980s project. For a few select cases, such as groundwater impacts, a brief discussion is provided explaining the difference between former estimated impacts and the current impact estimates. This was felt necessary since groundwater is a key topic and was the focus of much of the debate in the 1980s.

The following narrative opens with a discussion of the no action (no mining) alternative. This is followed by a discussion of impacts related to the preferred alternative. Finally a discussion of alternatives to the preferred alternative and their impacts is presented. Numerous additional

reports and documents that support the impacts discussion have been included in the appendices to this report.

4.1 No Action Alternative

The purpose of this section is to review the no action alternative to the proposed project. The no action alternative means that the proposed mining project will not proceed. The environmental impacts of a no action situation are those impacts presently occurring, or those that would occur under the existing land use and predicted trends without mining. Obviously, the impacts and/or benefits of the proposed project will not occur. Under this scenario, CMC's existing employees would likely leave the Rhinelander area, and CMC would close its Rhinelander and Crandon offices. CMC might sell its land and mineral rights, or consider other options. If no action is taken on the project, all the drill holes would be permanently abandoned in accordance with applicable regulations, and the exposed sites regraded and revegetated. The drill sites would eventually revert to forest. Permanently abandoning the drill holes could allow CMC to secure the release of its exploration bond.

Logging in the area could result in the disturbance of goblin fern sites located on private property. Logging operations are also possible in the area of Spirit Hill under the no action alternative. However, prior to CMC exercising its purchase options, CMC has negotiated an agreement with the landowner to prevent this. CMC has no plans to log this area in the future, but the landowner is free to resume logging if CMC does not exercise the purchase option.

A no action alternative would have fiscal implications for the Mining Investment and Local Impact Fund Board (MILIFB) and the State of Wisconsin. During the permitting period, CMC contributes up to $150,000 to the MILIFB which is then distributed to local governments that are negotiating local agreements with CMC. While these funds would be received regardless of whether the project is implemented, an estimated $119.1 million of future net proceeds tax payments would not be made under the no action alternative.

The no action alternative will also mean the region will forego economic benefits associated with between 402 and 526 direct mine operation jobs. Also under the no action alternative the region will not realize the economic benefits associated with the projected construction expenditures estimated at $287 million. In addition, during the 28 years of the project operations an annual operation expenditure of $50 to $75 million dollars per year for labor, purchases, royalties and taxes is expected. Those monies would likewise be lost under the no action alternative.

4.2 Preferred Alternative

Section 4.2 presents the environmental impacts associated with the preferred alternative. A description of this alternative is presented in Section 2. Topics discussed are those addressed in Section 3, which discusses existing conditions in the project area. Included in Section 4.2.14 is a detailed assessment of potential impacts to Native American Communities, addressing the Sokaogon Chippewa Community, Forest County Potawatomi Community and Menominee Indian Tribe of Wisconsin.

The Section 4 impact discussion relates primarily to project features within the project area defined in Section 2. The environmental review and impact discussion related to the Wisconsin River discharge pipeline and wetland compensation site are presented in Volume IIIa,

Appendix 3-2 of the EIR (Foth & Van Dyke, 1995a) and to the project's *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995b), respectively.

4.2.1 Cultural Resources

This section focuses primarily on potential impacts to historical and archaeological resources and Native American traditional cultural properties. No Euro-American traditional cultural properties were identified in the area and, therefore, no impacts to such resources will occur as a result of project implementation.

4.2.1.1 Historical and Archaeological Cultural Resources

More than 5,000 acres within or adjacent to Crandon Project lands have been subjected to an intensive historic property inventory (Richards, 1994). For the most part, an archaeological survey has been conducted coincident with tracts where known or potential impacts would occur. As additional facility needs were identified by project-related engineering and environmental studies, additional affected tracts were inventoried to identify any potentially important historic or prehistoric resources which might be affected by project development.

A total of twenty-three (23) prehistoric and historic archaeological sites or properties are reported within the limits of CMC lands. Twenty-one of these locations are situated within the limits of the archaeologically surveyed project area. A single site (47 FR 151) is located outside the surveyed area. The remaining archaeological site is outside the project area at the location of a proposed wetland compensation site in Oconto County (Richards, 1995). Only two project area sites (47 FR 147 and 47 FR 150) are located directly within the area of planned disturbance. Project area sites, the prehistoric site at the proposed wetland compensation site, and estimated impacts are listed in Table 4.2.1-1. The locations of the project area sites are shown on Figure 3.2-1 located in confidential Appendix 3.2-17 which will be provided to relevant regulatory agencies upon request.

4.2.1.1.1 Construction Phase

During construction, sites known to be significant and those which may be significant will be clearly delineated in the field and will be monitored so they are protected. Construction of Crandon Project facilities will potentially impact two archaeological sites in the project area. Sites affected include 47 FR 147 and 47 FR 150.

4.2.1.1.1.1 47 FR 147

Site 47 FR 147 (Keith's Siding), a former 1910-1920 era railcamp/settlement, is situated coincident with portions of the construction easement associated with development of the railroad spur line (Appendix 3.2-4). The site was initially identified during GLARC's 1981 reconnaissance of the alignment of the proposed railroad spur (Overstreet and Brazeau 1982). Recently completed Phase II studies, reported in Mier et al. (1995), suggest that the Keith's Siding site is characterized by extensive subsurface integrity and is potentially significant from a historical and archaeological perspectives. Consequently, GLARC prepared a formal determination of eligibility (NPS Form 10-900) for the Keith's Siding site, which was forwarded to the USCOE and Wisconsin SHPO and others in September 1996 (Moe, 1996). Results suggest that the site is eligible for listing on the National Register of Historic Places (NRHP). Consequently, in order to avoid a finding of adverse effect relative to 47 FR 147, appropriate mitigation measures will be implemented as described in Section 5, if required.

Table 4.2.1-1

Impact Analysis for Historic Properties in the Crandon Project Area[1]

			Evaluated			NRHP Eligibility			Project Impacts				
Site #	Site Name	Component	Yes	No	Part	Yes	No	Unk	Construction	Operation	Post-Operation	None	Source
Fr-121	Oak Lake	Historic/Late Woodland			X			X				X	
Fr-143	Oak Lake II	Late Woodland			X			X				X	
Fr-144	Skunk Lake	Historic		X				X				X	
Fr-145	Oak Lake Midden I	Historic		X				X				X	
Fr-146	Oak Lake Midden II	Historic		X				X				X	
Fr-147	Keith's Siding	20th Century Historic	X			X			X	X			Railroad Spur
Fr-148	Deep Hole Lake Midden	Historic		X				X				X	
Fr-149	Parcel "B" Midden	Historic		X				X				X	
Fr-150	Plant Site Midden	Historic		X			X		X				Plant Site
Fr-151	Berry Lane Logging Camp	Late 19th Century		X				X				X	
Fr-229	Locus 4849	Unknown	X				X					X	
Fr-271	Locus 4856	Historic	X				X					X	
Fr-273	Locus 4850	Historic		X				X				X	
Fr-274	Locus 4850	Historic		X				X				X	
Fr-275	Locus 4852	Historic		X				X				X	
Fr-276	Locus 4851	Probably Historic		X				X				X	
Fr-658	Locus 4854	Euroamerican	X				X					X	
Fr-661	Oak Lake Logging Camp	Historic		X				X				X	
Lg-23	Parcel 1 Logging Camp	Late 19th Century		X				X				X	
Unassigned	Locus 4859	20th Century farmstead	X				X					X	
Unassigned	Locus 4860	20th Century log house	X				X					X	
Unassigned	Locus 4861	shack	X				X					X	
Unassigned	GLARC 950046.01	Prehistoric		X				X	X				Wetland Mitigation

[1]One additional site (GLARC 950046.01) located outside the project area but within the project's proposed wetland compensation site is also included in this table.

Prepared by: JDR
Checked by: JWS

4.2.1.1.2 47 FR 150

Site 47 FR 150, a former farmstead or logging-related site, is located within the footprint of the Plant Site construction area (Appendix 3.2-5). However, Site 47 FR 150 has been previously disturbed to the point that it is not considered eligible for listing on the National Register of Historic Places. Consequently, project development will have no adverse effect on 47 FR 150.

4.2.1.1.2 Operating Phase

Planned project designs and operation will have minimal effects on Crandon Project area historic properties. The sole exception is potential impacts to 47 FR 147 (described above). A finding of no adverse effect from project construction can be achieved through implementation of appropriate mitigation measures for this site (Section 5). In addition, care will be taken so that subsequent activity associated with railroad operations do not adversely affect the preserved portions of the site not mitigated by data recovery. Also the detailed recommendations outlined in the *Cultural Resource Management Plan For the Crandon Project* (Overstreet and Richards, 1995), should also provide sufficient safeguards for Crandon Project area cultural resources not within the areas of planned disturbance.

4.2.1.1.3 Reclamation and Post-Operation Phase

Reclamation and post-operation activities do not involve surface disturbance of any new areas. Post-operation activities should, therefore, have no adverse effect on Crandon Project area historic properties.

4.2.1.1.4 Summary

Impacts to Crandon Project area historic properties are restricted to construction and possibly operation phases of project implementation. Construction and operation of mine related facilities such as the TMA and the plant site are expected to have no adverse effect on Crandon Project area historic properties. The sole significant impact derives from construction of a planned railroad spur situated coincident with the location of the Keith's Siding site, a significant logging-era resource potentially eligible for listing on the NRHP. Planned mitigation for this site as discussed in Section 5 should result in a finding of no adverse effect from project construction.

4.2.1.2 Native American Cultural Resources

The discussion and analysis which follows incorporates new information with that previously published in the 1995 EIR. Section 4.2.1.2.3 below, addressing potential impacts to potential TCPs, is reproduced from the 1995 EIR (this information was originally presented in Sections 4.2.14.1.2, 4.2.14.2.2, and 4.2.14.3.2) with editing and revisions to incorporate information from the new studies conducted since the EIR was initially published. The analysis of impacts and proposed mitigation measures for the Inventory of Cultural Sites in the Study Area and Vicinity as described in Section 3.2.2.5 and the accompanying Table 3.2-2, was prepared by WCRI, and is new. Other potential impacts to Native American Communities relating to reservation and treaty rights, sociocultural impacts, etc., are discussed in Section 4.2.14.

4.2.1.2.1 Area of Potential Effect

The APE for the assessment of potential physical, visual, and auditory impacts to cultural sites is based upon the results of studies conducted by CMC for the Crandon Project and the APE guidelines provided by the USCOE in letters to the tribes from Ben A. Wopat (1996) and J.M. Wonsik (1996).

The USCOE has discussed the preliminary Area of Potential Effect (APE) for the cultural resources studies in several letters to the tribes. They note that "Until watershed and groundwater modeling efforts are concluded, the area of potential effect will include an area extending roughly two and one-half miles in circumference [radius] from the ore body", bounded by Swamp and Hemlock creeks to the north, Rice and Mole lakes to the west, Rolling Stone and St. John's lakes to the south, and Ground Hemlock Lake to the east. Other areas of potential disturbance include all ground disturbance and the corridor along the entire WWDC route. The USCOE will also evaluate any physical, visual, or auditory effects on any historic or traditional cultural property that has been determined eligible for listing on the National Register of Historic Places that the tribe believes will be affected by the project, as long as the tribe can clearly demonstrate the extent and nature of the effect (Wopat, 1996, letter). In a subsequent letter to the tribes, the USCOE states that ". . . we have determined that the best strategy is to not specifically define the Area of Potential Effects. Rather, we will review all properties the [tribes] submit for consideration as TCPs" (Wonsik, 1996, letter). Accordingly, the tribe/s will need to show that the property is a TCP, eligible for listing on the National Register, and that the project will have a physical, visual, or auditory effect on the property.

In summary, the preliminary APE identified by the USCOE, and mapped on Figure 1 of the Wopat letter, includes (1) an approximate 2.5-mile radius around the ore bodyto consider surface and ground water effects, (2) the wastewater pipeline route from the mine to the Wisconsin River, (3) all areas of ground disturbance within the APE including the plant site, tailings management area, access road, tailings pipeline corridor, wastewater pipeline, and railroad spur, and (4) all areas from which mine facilities and activities would be visible and audible. In addition, the USCOE will evaluate potential physical, visual, and auditory effects on any National Register eligible TCP as long as the extent and nature of the effect can be demonstrated.

4.2.1.2.2 Native American Cultural (Ethnographic) Sites

Although no TCPs have been identified for the CMC Area of Potential Effect (APE), the general guidelines for assessing effect at 36 CFR 800 have been used below in considering potential impacts to the inventory of cultural sites identified from archival sources in or adjacent to the area of potential project effects. In the event that potential TCPs are identified at a later date, these same procedures should be followed.

4.2.1.2.2.1 Methods

The regulations at 36 CFR 800 have been used as guidance for assessing project effects to historic properties, including Traditional Cultural Properties that are listed on or have been determined to be eligible for listing on the National Register of Historic Places (36 CFR 60.4). The USCOE and Wisconsin SHPO consult to determine site eligibility; the Keeper of the National Register is consulted if there is disagreement. Properties are impacted if the criteria that caused them to be determined eligible are affected. To be determined eligible, a property must demonstrate integrity of their significant features. This includes integrity of location,

setting, and feeling - if those features contribute to the site's significance. For TCPs, the loss of setting and feeling that are or were important aspects of the site's significance may be as important as a direct physical impact. Impacts to cultural properties can be direct or secondary. Examples of direct impacts include destruction of the property or destruction of the features that contribute to the properties' significance. Examples of secondary impacts include increased access to an area and/or restricted access for traditional use of a site.

Previous impacts, such as those which might effect the integrity of location, setting, or feeling of the sites inventoried in the study area and vicinity, are not factored into the impact analysis provided in this document. This could not be done without primary source data from the tribes whose resources may be potentially effected by project activities. This kind of information would be required to evaluate potential TCPs for National Register eligibility, but again, potential Sokaogon Chippewa and Forest County Potawatomi TCPs could not be identified, documented, and evaluated without input from the tribes. Contemporary land ownership and use, for example, could effect the integrity of many of the sites identified, as well as their eligibility for listing on the National Register of Historic Places. The Menominee TCP studies do include the full range of information required for National Register eligibility consideration, although these studies have not yet been released by the Menominee Tribal Legislature. Similarly, potential project impacts associated with the Menominee TCP studies are being prepared by the Menominee tribe, and are not yet available.

The area of potential effect defined by the USCOE and discussed above, and the federal regulations at 36 CFR 800.5, Assessing Effects, and 36 CFR 800.9, Criteria of Effect apply to prehistoric, historic, and traditional cultural properties eligible for listing on the National Register of Historic Places. The general guidelines are followed here in discussing potential project effects on the inventory of cultural sites, although none of these sites have been identified, documented, or evaluated as eligible TCPs for listing on the National Register.

In the discussion which follows, potential physical (including surface and groundwater), visual, and auditory impacts to the inventory of cultural sites identified from literature sources as described in Section 3.2.2.5 and Table 3.2-2 are assessed for the plant site (PS), tailings management area (TMA), wastewater discharge corridor (WWDC), wetland compensation site (WCS), access road (ACR), tailings pipeline corridor (TPL), and railroad spur (RRS). Impact assessment and mitigation procedures are commonly worked out with extensive input from the tribes whose cultural sites and associated values are involved. As noted above, however, primary source data has not been available from the Sokaogon Chippewa, the principal Native American occupants of the study area and vicinity during the late historic period, or the Forest County Potawatomi, to aid in either the identification or evaluation of cultural sites. Similarly, no systematic data could be collected to determine the level of Sokaogon Chippewa or Forest County Potawatomi concern for inventoried sites or areas, and perhaps more importantly, patterns of past, present, or planned future use (use patterns). The Menominee share several sites with the Sokaogon Chippewa in the study area, and have expressed concerns for the sites at Oak Lake (CS-10a and 10d). The trail which crosses north of the WCS in aboriginal Menominee territory is well beyond the area of project disturbance, although the Menominee have expressed concerns for potential archaeological sites in the area of the WCS. As noted above, information regarding potential project impacts to Menominee TCPs is pending.

Considering this, the information provided in archival sources, concerns expressed by the tribes to the USCOE in meetings and letters regarding the project, and the writer's experience with similar kinds of analyses are employed in conducting the impact analysis. The tribes may not

agree with the methods or results of the impact assessment or proposed mitigation, but a complete and satisfactory analysis can only be done with input from knowledgeable tribal members.

Physical impacts are those which would alter or otherwise affect the physical integrity of a cultural site or area; *visual impacts* are those which would affect the view from or modify the visual integrity of a cultural site or area; *auditory impacts* are those which would affect the auditory integrity of a cultural site or area. Impacts are commonly of a negative nature, in that they produce a negative effect on the resource, but an impact can also be positive, producing an effect which is beneficial to the resource. Improved Native American access to a previously inaccessible ritual site, or reclamation efforts which improve the resource or the resource setting are examples of potential long term beneficial effects.

4.2.1.2.2.2 Potential Physical Impacts

Physical impacts are considered for mine construction (3 years), operation (28 years), and reclamation (4 years). Physical impacts involve actual ground or structure disturbance and can be direct, such as destruction of all or part of a cultural site or area, or indirect, such as similar disturbance caused by increased people and vehicle access to a cultural site or area. Potential direct and indirect physical impacts are based upon actual ground disturbance. The discussion of potential physical impacts to cultural sites is derived from the relationship between known site locations taken from the inventory of cultural sites and actual ground disturbance as described in Section 2 of the EIR.

Plant Site Area

The inventory identifies traditional hunting and fishing grounds (CS-25b) at unspecified locations between lower Post Lake and lower Lake Metonga, and two small groves of bur oak found on Crandon Project lands (CS-26b). Construction, operation, and reclamation of the PS could effect traditional hunting and gathering activities in this area, although no locational or use pattern information is available to make an accurate assessment for these activities. The bur oak groves identified in Wetland F15 northwest of the TMA (CS-26b), and southeast of the PS at Oak Lake, will not be physically impacted by project activities at either location. No other apparent physical impacts are associated with PS construction, operation, or reclamation.

Tailings Management Area

The inventory identifies traditional hunting and fishing grounds (CS-25b) at unspecified locations between lower Post Lake and lower Lake Metonga, and two small groves of bur oak found on Crandon Project lands (CS-26b). Construction, operation, and reclamation of the TMA could effect traditional hunting and gathering activities in this area, although no locational or use pattern information is available to make an accurate assessment for these activities. The bur oak groves identified northwest of the TMA, and southeast of the PS at Oak Lake, will not be physically impacted by project activities at either location. No other apparent physical impacts are associated with TMA construction, operation, or reclamation.

Access Road

The inventory identifies traditional hunting and fishing grounds (CS-25b) at unspecified locations between lower Post Lake and lower Lake Metonga. Construction, operation, and reclamation of

the ACR could have some effect on traditional hunting and gathering activities where it crosses this area within an approximate 100-foot wide corridor, although no locational or use pattern information is available to make an accurate assessment for these activities.

The ACR crosses Swamp Creek (CS-19), identified by the Sokaogon Chippewa as the location of habitation (CS-19a, 19aa), burial (CS-19c, 19cc, 19ccc), and resource procurement (CS-19b) sites. The habitation and burial locations were all identified at the west end of Swamp Creek where it approaches Rice Lake, away from the ACR. Construction, operation, and reclamation of the ACR could impact resources gathered along the approximate 100-foot wide corridor that crosses Swamp Creek, although no locational or use pattern information is available to make an accurate assessment for these resources.

The ACR crosses a historic Indian trail segment (CS-34g) just east of STH 55. No on-the-ground evidence of this trail segment was identified during the archaeological investigations conducted for the ACR and physical impacts are not anticipated.

No other apparent physical impacts are associated with ACR construction, operation, or reclamation.

Railroad Spur

The inventory identifies traditional hunting and fishing grounds (CS-25b) at unspecified locations between lower Post Lake and lower Lake Metonga. Construction, operation, and reclamation of the RRS could have some effect on traditional hunting and gathering activities along the approximate 60- to 100-foot wide corridor that crosses this area, although no locational or use pattern information is available to make an accurate assessment for these activities.

The RRS crosses the eastern end of Swamp Creek (CS-19), identified by the Sokaogon Chippewa as the location of habitation (CS-19a, 19aa), burial (CS-19c, 19cc, 19ccc), and resource procurement (CS-19b) sites. The habitation and burial locations were all identified at the west end of Swamp Creek where it approaches Rice Lake, away from the RRS. Construction, operation, and reclamation of the Railroad Spur could impact resources gathered along the approximate 60- to 100-foot wide corridor that crosses Swamp Creek, although no locational or use pattern information is available to make an accurate assessment for these resources.

No other apparent physical impacts are associated with RRS construction, operation, or reclamation.

Tailings Pipeline Corridor

The inventory identifies traditional hunting and fishing grounds (CS-25b) at unspecified locations between lower Post Lake and lower Lake Metonga. Construction, operation, and reclamation of the TPL could effect these places along the approximate 60-foot wide corridor that crosses this area, although no locational or use pattern information is available to make an accurate assessment for these sites.

No other apparent physical impacts are associated with TPL construction, operation, or reclamation.

Wastewater Discharge Corridor

The WWDC is within the approximate 100-foot wide ACR corridor from the PS for the first 3 miles and then is within existing road rights-of-way within an approximate 20-foot corridor to the Wisconsin River. Where the WWDC follows the ACR, it crosses Swamp Creek (CS-19), identified by the Sokaogon Chippewa as the location of habitation (CS-19a, 19aa), burial (CS-19c, 19cc, 19ccc), and resource procurement (CS-19b) sites. The habitation and burial locations were all identified at the west end of Swamp Creek where it approaches Rice Lake, away from the WWDC. Construction and reclamation of the WWDC could impact resources gathered along Swamp Creek, although directional boring of the pipeline route underneath Swamp Creek should prevent significant impacts to any such activities associated with the WWDC. Additionally, no locational or use pattern information is available to make an accurate assessment for such potential gathering sites.

The WWDC crosses the Upper Wolf River (CS-18) identified in the inventory as a Sokaogon Chippewa habitation (CS-18a), wild ricing (CS-18b), and ritual/sacred (CS-18d) area. The habitation sites were identified to the north at Pine Lake and the south at Post Lake. Specific information regarding ricing and ritual/sacred locations is not available in the public record. At the Wolf River crossing, directional boring under the river will be used for the WWDC. Physical impacts to cultural sites during short-term construction and reclamation are not anticipated.

The WWDC crosses a historic Indian trail segment (CS-34g) twice on its northward leg along STH 55 from the Plant Site, another historic Indian trail segment (CS-40g) several miles after it turns to the west, and then another historic Indian trail segment (32g) twice at the eastern end of the corridor at and south of Rhinelander. No on-the-ground evidence of these trail segments was found during archaeological investigations conducted for the WWDC and physical impacts are not anticipated.

The WWDC inventory study area includes the two historic Indian Archaeology sites at the western end of the route, one near Lake Julia (CS-36a) and the other on the bank of the Wisconsin River (CS-37a). These cultural sites are not subject to physical disturbance, however, since they are 0.7 or more miles from the WWDC route.

No other apparent physical impacts are associated with WWDC construction, operation, or reclamation.

Wetland Compensation Site

No cultural sites were identified within the one mile buffer zone defined as the inventory study area for the WCS. A historic Indian trail segment (CS-33g) was identified approximately 1.4 miles to the northwest of the WCS, crossing the southwest corner of the Menominee Indian Reservation.

No other apparent physical impacts are associated with construction, maintenance, or reclamation of the WCS.

4.2.1.2.2.3 Potential Surface and Groundwater Impacts

The discussion of potential surface and groundwater effects on cultural sites is based upon the analysis of Groundwater (Section 4.2.5), Surface Water and Bottom Sediments (Section 4.2.6),

and Wetlands (Section 4.2.7) included in this EIR. As noted above, the USCOE has identified the APE for the consideration of surface and ground water effects to potential TCPs as bounded on the north by Swamp and Hemlock creeks, the west by Rice and Mole lakes, the south by Rolling Stone and St. John's lake, and the east by Ground Hemlock Lake (Wopat, 1996). This includes a diameter of roughly 6 miles centered over the ore body.

Cultural sites situated within the area of potential surface and groundwater effects defined by the USCOE include the unspecified traditional hunting and fishing grounds (CS-25b) between lower Post Lake and lower Lake Metonga, the two small bur oak groves on Crandon Project lands (CS-26b), the sites at Oak Lake (CS-10), the Sokaogon Chippewa cultural use area at Little Sand Lake (CS-12h), the Sokaogon Chippewa cultural use area at Deep Hole Lake (CS-16h), the Sokaogon Chippewa cultural use area at Ground Hemlock Lake (CS-13h), the southern shore of Lake Metonga (CS-5), the northern shore of Rolling Stone Lake (CS-7), the sites at Spirit Hill (CS-21), the sites on Swamp Creek (CS-19), the sites at Mole Lake (CS-4), the sites at Rice Lake (CS-3), and the eastern side of the Mole Lake Indian Reservation CS-22i).

As described in Sections 4.2.5.7 through 4.2.5.9 of the EIR, groundwater drawdown will be limited to the area encompassed by Swamp Creek to the north; Hemlock Creek to the east; Rolling Stone, Pickerel, and Crane lakes to the south; and Pickerel Creek, Mole Lake, and Rice Lake to the east. Surface water bodies outside this area will not be impacted by groundwater drawdown. Inside this area, Ground Hemlock, St. Johns, Rolling Stone, Crane, Pickerel, Mole, and Rice lakes will not be impacted by groundwater drawdown. Oak Lake and the northern sedge meadow containing a scattered population of bur oak (wetland F15) northwest of the TMA are perched (see EIR Section 3.6), and will not experience groundwater drawdown. Deep Hole and Little Sand lakes may experience drawdown ranging from several hundredths of a foot to one half foot, changes which are below normal annual fluctuations (Section 4.2.6.).

Based upon the most recent groundwater drawdown studies (Section 4.2.5.7), and studies conducted for the practical worst case scenario (Sections 4.2.5.9 and 4.2.7 and Figure 4.2.7-4), there will be no significant groundwater drawdown impacts to the Sokaogon Chippewa cultural use area at Ground Hemlock Lake (CS-13h), the southern shore of Lake Metonga (CS-5), the northern shore of Rolling Stone Lake (CS-7), the bur oak groves on Crandon Project lands (CS-26b) in wetland F15 or Oak Lake, the sites at Oak Lake (CS-10), the sites at Spirit Hill (CS-21), the sites at Mole Lake (CS-4), the sites at Rice Lake (CS-3), or the eastern side of the Mole Lake Indian Reservation CS-22i). Although the flow from Swamp Creek to Rice Lake may decrease, the change will be less than the normal annual fluctuations. Additionally, there will be no adverse impacts to the physical, chemical, or biological integrity of Rice Lake or any other reservation waters resulting from project operations (Section 4.2.14.1.1).

Groundwater drawdown may occur at sites closer to mining operations, to include portions of the unspecified traditional hunting and fishing grounds (CS-25b) between lower Post Lake and lower Lake Metonga and the unspecified resource procurement sites on Swamp Creek (CS-19). Locational and use pattern information for these sites is lacking, however, and particular impacts cannot be addressed. Similarly, information is lacking on the kinds of activities associated with the cultural use areas at Little Sand Lake (CS-12h) and Deep Hole Lake (CS-16h). Since the groundwater drawdown for these lakes do not represent significant changes from normal seasonal fluctuations, however, impacts are not anticipated.

Groundwater drawdown will cause slight changes to the composition and distribution of the vegetative species in some wetland areas, and could affect the resource procurement activities

identified for the unspecified traditional hunting and fishing grounds (CS-25b) between lower Post Lake and lower Lake Metonga, and the unspecified resource procurement sites on Swamp Creek (CS-19). Lacking locational or use pattern information for the hunting and fishing grounds (CS-25b) and the resource procurement sites on Swamp Creek (CS-19), however, impacts cannot be accurately assessed. wetland F15, which contains a scattered population of bur oak identified as CS-26b, will experience a less than 5 percent reduction in surface water runoff during the TMA operation phase along its southeastern margin. This may involve shifts towards vegetation adapted to drier conditions along the portions of the wetland adjacent to the TMA, but is not expected to result in any substantial changes in the character of the wetland. The bur oak population should not be effected in any way (Section 4.2.7 and Table 4.2.7-5). Similarly, groundwater drawdown should not change the composition or distribution of the vegetative species at Spirit Hill.

4.2.1.2.2.4 Potential Visual Impacts

Visual impacts are considered for mine construction (3 years), operation (28 years), and reclamation (4 years). Visual impacts involve modification of the viewshed from or to a cultural site, most often one with ritual or sacred elements, although contemporary habitation sites (traditional cultural sites which are still occupied) are also considered. Visibility is determined by the viewshed between the cultural site and project facilities, defined by the approximate location of the mine head frame (adjacent to the center of the ore body). Visual (and auditory) impacts associated with the WWDC and WCS are not considered significant since they are associated only with relatively short-term construction, occasional maintenance, and reclamation.

The discussion of potential visual impacts to ritual/sacred and contemporary habitation sites is based upon the analysis provided in Section 4.2.12 of the EIR, along with guidance from the USCOE regarding potential visual and auditory effects on cultural properties (Wonsik, 1996; Wopat, 1996). The visual analysis uses the 160 foot high mine head frame to represent the practical worst case views of the plant site from the surrounding area.

Plant Site

The PS, represented by the mine head frame, will not be visible from any of the inventoried contemporary habitation or ritual/sacred sites with full spring, summer, and fall vegetation. During this time, however, a "dome of light" in the sky reflected from the PS may be visible from Spirit Hill (CS-21), considered a sacred place by the Sokaogon Chippewa, even though low intensity lighting reflected towards the ground will be used. During the winter, without full vegetative cover, the mine head frame and possibly some other elevated portions of the PS may be visible from Spirit Hill, approximately 1.5 miles west of the PS. This potential "dome effect" would be similar to, but of less intensity than, the "dome effect" currently visible from the bingo hall, casino, and other tribal facilities on the Mole Lake Indian Reservation along STH 55, approximately 1.3 miles to the northwest of Spirit Hill. The historic ritual/sacred site inventoried about half-way down the western shore of Lake Metonga (CS-5d) will not be impacted visually, since the mine head frame will be visible only from the northern and eastern shores. The mine head frame will be visible from the southwest shores of Little Sand Lake (CS-12h), identified as a cultural use area for the Sokaogon Chippewa, although there are no known contemporary Indian habitation or ritual/sacred sites associated with this location.

The potential effect of the seasonal visual impacts from the PS to Spirit Hill appear to be minimal and insignificant, but cannot be accurately assessed without input from the Sokaogon Chippewa.

Tailings Management Area

The TMA will not be visible from any of the inventoried contemporary habitation or ritual/sacred sites.

Access Road

The ACR will not be visible from any of the inventoried contemporary habitation or ritual/sacred sites.

Railroad Spur

The RRS will not be visible from any of the inventoried contemporary habitation or ritual/sacred sites.

Wastewater Discharge Corridor

Potential visual impacts associated with the WWDC are not considered significant since they are associated only with relatively short-term construction, occasional maintenance, and reclamation.

Wetland Compensation Site

No known contemporary habitation or ritual/sacred sites were identified for the WCS, and no potential visual impacts are assessed.

4.2.1.2.2.5 Potential Auditory Impacts

Auditory impacts are considered for mine construction (3 years), operation (28 years), and reclamation (4 years). Sources of noise during construction would include site clearing and grading, excavation, equipment erection, facility construction, and landscaping. Surface or near surface blasting is not planned as part of normal construction activities although large boulders encountered during construction may be reduced in size by blasting, and blasting will be required when bedrock is encountered during shaft sinking for the main and ventilation shafts. Noise sources during mine operation would include fans, ventilators, compressors, road traffic, and rail traffic. Sources of noise during reclamation would include site grading and landscaping. Potential auditory impacts are based upon construction noise levels, with the understanding that these levels would decrease significantly during mine operation. Potential auditory (and visual) impacts associated with the WWDC and WCS are not considered significant since they are associated only with relatively short-term construction.

The discussion of potential auditory impacts to ritual/sacred and contemporary habitation sites is based upon the analysis of project noise provided in Section 4.2.10 of the EIR. Generally, this analysis indicates that (a) an increase less than 3 db would normally not be noticeable and result in no impact, (b) an increase greater than 3 db but less than 5 dB would be noticeable and have a minor impact, and (c) an increase of 5 dB or greater would be very noticeable.

Plant Site

Ritual/sacred sites which may be within the potential auditory range of the PS include the northern shore of Oak Lake (CS-10d) and Spirit Hill (CS-21d). Low level noise increases may occur at both sites during construction and reclamation, with little or no increase during operation. In the early stages of construction, before the ACR is built, there will be low level noise increases at both sites from an increased flow of vehicular traffic on Little Sand Lake Road. These low level noise increases are less than 3 dBs and not considered significant. Infrequent blasting during construction could result in intermittent noise level increases at the ritual/sacred sites on the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), and Rice Lake (CS-3d), and the Mole Lake Indian Reservation (CS-22i).

Tailings Management Area

The ritual/sacred site on the northern shore of Oak Lake (CS-10d) may be within the potential auditory range of the TMA. Low level noise increases may occur at this site during construction and reclamation, with little or no increase during operation. In the early stages of construction, before the ACR is built, there may be low level noise increases at the site from an increased flow of vehicular traffic on Little Sand Lake Road. These low level noise increases are less than 3 dBs and not considered significant. Infrequent blasting during construction could result in intermittent noise level increases at the ritual/sacred sites on the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), and Rice Lake (CS-3d), and the Mole Lake Indian Reservation (CS-22i).

Access Road

Ritual/sacred sites which may be within the potential auditory range of the ACR include the northern shore of Oak Lake (CS-10d) and Spirit Hill (CS-21d). A contemporary habitation site, the Mole Lake Indian Reservation (CS-22i), may also fall within this range, particularly during construction and reclamation. Low level noise increases may occur at these sites during construction and reclamation, with little or no increase during operation. Low level noise increases at the northern shore of Oak Lake (CS-10d) and the northern end of the Mole Lake Indian Reservation (CS-22i) may also be associated with increased vehicular traffic on the ACR during operation. These low level noise increases are less than 3 dBs and not considered significant. Infrequent blasting during construction could result in intermittent noise level increases at the ritual/sacred sites on the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), and Rice Lake (CS-3d), and the Mole Lake Indian Reservation (CS-22i).

Railroad Spur

The ritual/sacred site on the northern shore of Oak Lake (CS-10d) may be within the potential auditory range of the RRS. Low level noise increases may occur at this site during construction and reclamation, with little or no increase during operation. In the early stages of construction, before the ACR is built, there may be low level noise increases at the site from an increased flow of vehicular traffic on Little Sand Lake Road. These low level noise increases are less than 3 dBs and not considered significant. Infrequent blasting during construction could result in intermittent noise level increases at the ritual/sacred sites on the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), and Rice Lake (CS-3d), and the Mole Lake Indian Reservation (CS-22i).

Wastewater Discharge Corridor

Ritual/sacred sites which may be within the potential auditory range of the WWDC during construction and reclamation include the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), the west central shore of Lake Metonga (CS-5d) and the Upper Wolf River (CS-18d) at the Wolf River crossing. A contemporary habitation site, the Mole Lake Indian Reservation (CS-22i), may also fall within this range. Low level noise increases may occur at Oak Lake, Spirit Hill, and Lake Metonga during construction and reclamation, with no increase during operation. High level noise increases will be associated with construction across (under) the Wolf River, but the location of ritual/sacred sites along this stretch of the river are not known and impacts cannot be assigned. Low level noise increases at the northern shore of Oak Lake (CS-10d) and the northern end of the Mole Lake Indian Reservation (CS-22i) may also be associated with increased vehicular traffic on the ACR during operation. These low level noise increases are less than 3 dBs and not considered significant. Infrequent blasting during construction could result in intermittent noise level increases at the ritual/sacred sites on the northern shore of Oak Lake (CS-10d), Spirit Hill (CS-21d), and Rice Lake (CS-3d), and the Mole Lake Indian Reservation (CS-22i).

4.2.1.2.2.6 Mitigation

Procedures and measures developed to mitigate potential impacts to cultural (ethnographic) sites include data recovery for historic archaeological sites, limiting disturbance to Spirit Hill, continued efforts to seek tribal input in efforts to avoid, minimize, and mitigate potential adverse impacts to cultural sites, continued efforts to seek tribal input regarding Native American access and use of cultural sites which may be situated on Crandon Project lands, and the protection of cultural resources on and off the reservations. Overall project mitigation measures associated with cultural resources and Native American Communities are discussed in Section 5.1 and Section 5.10 of the EIR, respectively. Those relevant to cultural resources include the commitment to construct surface facilities during daytime hours only, install and operate low noise ventilation fans and generators, use of blast doors to minimize blasting noise at the main and ventilation shafts, and continue to avoid, minimize, and mitigate potential visual, noise, and other aesthetic impacts to the surrounding vicinity. The application of these general mitigation measures should eliminate or reduce impacts to Native American cultural sites to a negligible or acceptable level.

4.2.1.2.2.7 Summary

The absence of significant physical, visual, and auditory impacts can be explained in large part by the considerable distances and related absence of significant visibility and sound levels between the cultural sites and project facilities and activities. Considering the low impact levels and the application of mitigation measures, none of the effects or potential impacts are considered significant. Primary source data from the tribes whose resources may be effected, however, such as information regarding the location and use patterns for particular sites situated within the Crandon Project APE, could modify this finding.

4.2.1.2.3 Traditional Cultural Properties

Although a number of potential Traditional Cultural Properties (TCPs) in the study area are discussed in Section 3.2.2.6.4 and the *Interim Report of the Project Ethnologist* (Andrews, 1995), primary source data from the tribes for TCP identification, documentation, and evaluation is not

available from the Sokaogon Chippewa or Forest County Potawatomi. As such, potential impacts can be discussed but the analysis of impacts cannot be definitively applied to potential TCPs associated with either of these tribes. If the tribes do provide information adequate to identify potential TCPs in the study area and vicinity, and demonstrate adverse project effects on these properties, the impact analysis may need to be revised. The Menominee TCP studies have been completed and submitted to the Tribal Legislature for review. This is discussed further below.

The following discussion was originally presented in Sections 4.2.14.1.2, 4.2.14.2.2, and 4.2.14.3.2 of the 1995 Crandon Project EIR. It has been edited and revised to reflect the addition of new information and developments since the EIR was originally published.

4.2.1.2.3.1 Sokaogon Chippewa

Potential Burial Sites

Although burial sites and cemeteries are specifically excluded from National Register eligibility, they may contribute significantly to the eligibility of associated properties. Sokaogon Chippewa tribal members have expressed especially urgent concerns that project activities might disturb tribal burial sites. These concerns are taken very seriously, and all reasonable steps to identify, protect, and preserve any human remains that may be located on CMC property have been taken. Since 1977, over 5,000 acres of Crandon Project lands have been surveyed for potential archeological sites, numerous separate archeological surveys have been conducted, and hundreds of drill holes and mud pits have been created without encountering any evidence of burials. It is recognized that because of the variability of burial treatment (e.g., isolated burials, scattered crematory ashes, and above-ground burials that have vanished without traces in the ground), some Native American burial sites may not be detected through traditional archaeological survey methods. For this reason, repeated attempts have been made to obtain Sokaogon Chippewa assistance in the archeological work in general and to more fully identify any burial sites in particular. Such identification would be subject to guarantees that exact locations would be kept confidential in accordance with any requests from the Sokaogon Chippewa and the Native American Graves Protection and Repatriation Act (NAGPRA).

Two specific potential burial sites on Crandon Project lands are identified in the public record. The first is an area west of the plant site known to the Sokaogon Chippewa as "Spirit Hill." The second is an archeological site on the northeast side of Oak Lake known as site "47-Fr-121." Sokaogon Chippewa representatives have stated that Spirit Hill contains the remains of "at least 200 warriors," and believe that the Oak Lake site may be a potential burial ground because a fragment of "burned bone" was found there during a 1982 excavation undertaken for EMC (Morgan, 1994). As to the Oak Lake site, it is more plausible to infer that the "burned bone" was an animal remain from an ancient meal, particularly since other excavated sites in the immediate vicinity show evidence of cooking activities (Overstreet and Brazeau, 1982). The bone fragments were found in a food-processing rather than a burial context, and identified by the archaeologists as animal bone.

In any event, neither of these sites will be physically disturbed by the Crandon Project. Other than the archeological work at site 47-Fr-121 in 1982, and the installation of several groundwater monitoring wells in the early 1980s, there have been no digging, drilling, clearing, construction, or other ground-disturbing activities either on Spirit Hill or at site 47-Fr-121. Moreover, both locations are well outside the area of proposed physical disturbance of the plant site, the TMA,

the railroad spur, tailings pipeline, road corridors, and other areas of planned surface and underground activities associated with the Crandon Project. In addition, CMC has entered into agreements with the present owners of Spirit Hill to prevent logging activities on these lands, which will further protect any Native American remains which may be located there.

If CMC, or any of its contractors, were at any time in the future to find evidence of burial sites during the course of any ground-disturbing or other project activities, CMC would immediately suspend potentially site-disturbing activities and follow the procedures of federal and state law such that any burial sites and the human remains therein received the proper measure of protection and respect. This would include consultation with "most likely descendants" regarding treatment and disposition of the remains. CMC continues to seek the cooperation of the Sokaogon Chippewa in evaluating and preserving burial sites and all other potential traditional cultural properties.

Potential Traditional Cultural Properties

As discussed in Section 3.2.2.6.4, a comprehensive evaluation of Native American traditional cultural properties must focus on how Native Americans themselves interpret the resources that comprise their history and culture, and thus requires direct consultation with knowledgeable tribal members (see also Parker and King, 1990). CMC and its consultants have repeatedly sought to include the Sokaogon Chippewa in the Crandon Project Traditional Cultural Properties Investigations, on whatever reasonable terms are satisfactory to the tribal government, but the Sokaogon Chippewa have declined to participate or cooperate in the conduct of these studies. Accordingly, potential Sokaogon Chippewa TCPs have been identified and evaluated based on information available in the public record, as described in Section 3.2.2.5.2.1, Sources Consulted, and summarized in Section 3.2.2.5.3.1, Summary of Selected Sources.

The Inventory of Cultural Sites in Section 3.2.2.5 and Table 3.2-2 identifies numerous Sokaogon Chippewa habitation, resource procurement, mortuary, and ritual/sacred sites in the study area and vicinity. As indicated in Section 3.2.2.6.4, some of these individual sites may qualify as potential TCPs. Potential TCP districts are also discussed in Section 3.2.2.6.4. The majority of these potential TCP sites and districts, however, are well outside the APE defined for the mine by CMC and the USCOE.

Potential project impacts to the sites situated within the APE are assessed and discussed in the previous section. They include the traditional hunting and fishing grounds (CS-25b) between lower Post Lake and lower Lake Metonga, the two small bur oak groves on Crandon Project lands (CS-26b), the sites at Oak Lake (CS-10), the Sokaogon Chippewa cultural use area at Little Sand Lake (CS-12h), the Sokaogon Chippewa cultural use area at Deep Hole Lake (CS-16h), the Sokaogon Chippewa cultural use area at Ground Hemlock Lake (CS-13h), the southern shore of Lake Metonga (CS-5), the northern shore of Rolling Stone Lake (CS-7), the sites at Spirit Hill (CS-21), the sites on Swamp Creek (CS-19), the sites at Mole Lake (CS-4), the sites at Rice Lake (CS-3), and the eastern side of the Mole Lake Indian Reservation CS-22i). As assessed, none of these sites will be disturbed by the project. Visual and auditory impacts to the sites will be slight, and not considered significant.

It is suggested in the inventory section that the most likely potential Sokaogon Chippewa TCP districts (those that show evidence of the linkage and continuity of places, activities, and beliefs) are the Rice Lake-Mole Lake-Swamp Creek area (CS-3, CS-4, CS-19), the Rolling Stone Lake-Pickerel Lake-Pickerel Creek area (CS-7, CS-8, CS-20), and/or the Post Lake-Upper Wolf River

area (CS-2, CS-18). All of these areas, or potential TCP Districts, contain habitation, resource procurement, mortuary, ritual/sacred, and historic trail sites. The Rice Lake-Mole Lake-Swamp Creek area also contains evidence of trading posts (CS-3f) and the historic Chippewa-Sioux battle site (CS-3e, CS-4e), and is the only one of these potential TCP districts located within the APE. As indicated in the assessment of project effects to the individual sites, however, it is unlikely that the project will have a significant adverse impact on this potential TCP district.

As noted above, some of these individual sites and combinations of sites may qualify as potential TCP sites or districts, but not without primary source data from Sokaogon Chippewa tribal members. Lacking this data, the most likely sites and districts can only be suggested. Section 3.2.2.6.4.1 and Andrews (1995) discuss potential Sokaogon TCPs including Spirit Hill, Swamp Creek, the Chippewa-Sioux battleground near Mole Lake and STH 55, and Rice Lake. All of these sites fall within the preliminary APE as defined by the USCOE to access potential project effects to potential TCPs. There may be other places of Sokaogon Chippewa traditional cultural interest within the APE which also qualify as potential TCPs (Andrews, 1995). And, regardless of their location in relationship to the APE, all potential TCPS will be evaluated by the USCOE, as long as the tribes can demonstrate that they are potentially eligible for listing on the National Register and that the project will have an adverse physical, visual, or auditory effect on the property (Wonsik, 1996; Wopat, 1996).

With the qualifications noted below, none of these potential TCP sites or districts will be physically disturbed by Crandon Project construction, operation, or reclamation. There will be no digging, drilling, or other ground-disturbing activities at Spirit Hill, the Chippewa-Sioux battleground, Rice Lake, Swamp Creek (except for the ACR and RRS crossings), or the other specific potential TCP sites identified in Section 3.2.2.6.4. Andrews (1995) notes that any "erosion and/or changes to the species composition of [the] vegetation" on Spirit Hill caused by groundwater drawdown could be considered a direct physical impact to this potential TCP. There is no basis to believe that project operations will cause any erosion on Spirit Hill, nor, as discussed in Section 4.2.5, will groundwater drawdown be significant beneath Spirit Hill. And, no changes to the composition or distribution of the vegetative species are projected for Spirit Hill. Andrews (1995) also notes that any discharge of contaminants into Rice Lake could be considered a direct physical impact to this potential TCP. As discussed above, however, there should be no adverse impacts to the physical, chemical, or biological integrity of Rice Lake or any other reservation waters resulting from project operations (Section 4.2.14.1.1).

Places used for hunting, fishing, gathering, and other traditional subsistence activities may also qualify for consideration as TCPs. These include not only Swamp Creek, but many other places within the general vicinity as well. For example, recent oral testimony identifies Oak Lake, Little Sand Lake, and other nearby waterbodies as areas that were historically used for subsistence activities and temporary settlements (Morgan, 1994). Additionally, bur oak (*Quercus macrocarpa*), used as a food, dye, and medicinal plant, is reportedly restricted within the immediate vicinity of the reservation to several small groves on Crandon Project lands (WDNR, 1986). Other evidence indicates that the Sokaogon Chippewa historically used the lands and waters in a large area of northeastern Wisconsin for pursuing traditional subsistence activities (COACT, 1980; Wisdom, 1936).

If a potential TCP of this type were actually found to exist at a specific site on which project construction and operations activities will occur, then that site obviously would be physically impacted. Moreover, groundwater drawdown within the immediate vicinity of the mine will cause slight impacts to species composition in some wetland areas within the APE, which could

also be considered as a physical impact to a potential TCP. CMC is not aware of any such potentially impacted site that would qualify as a TCP, although there can be no certainty without Sokaogon Chippewa input to the TCP studies. It is important to note, however, that the WDNR has previously reported that, with the exception of bur oak, all plant and animal species gathered by the Sokaogon Chippewa on Crandon Project lands are widely distributed throughout the immediate vicinity and thus will continue to be readily available to the Sokaogon Chippewa. Thus, even if project construction or operations activities were to physically disturb a specific site used by the Sokaogon Chippewa for traditional subsistence activities, there will be abundant alternative sites available to tribal members for the pursuit of such activities. Based upon the information available at this time, project operations should not impact the bur oak groves on CMC lands, and CMC is prepared to discuss potential access to certain of its lands in the event that alternative gathering sites for bur oak or other species of concern are not available to tribal members.

It has been noted that TCPs can sometimes be adversely affected even if their physical integrity is unaltered (Andrews, 1995). For example, concerns have been expressed that project operations might interfere with the exercise of religious practices on Spirit Hill by adversely affecting the "viewshed" it affords and the tranquility of its setting (Morgan, 1994; USCOE-Sokaogon, 1995). These concerns cannot be evaluated without additional information from the Sokaogon Chippewa, and it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential impacts to the Sokaogon Chippewa's own culture, beliefs, and values. Nevertheless, as discussed in Section 4.2.10 and Section 4.2.12, it should be emphasized that CMC has attempted to take all reasonable steps to avoid, minimize, and mitigate potential visual, noise, and other aesthetic impacts to the surrounding vicinity, including to Spirit Hill and the Mole Lake Sokaogon Chippewa Reservation.

In addition, TCPs are not necessarily isolated phenomena. Inter-relationships between locations where traditional activities took place and continue to take place may exist within the cultural landscape that include locations within and beyond the APE. Whether or not these activity loci comprise a TCP cannot be evaluated without Sokaogon Chippewa input.

The Sokaogon Chippewa Tribal Government may be sponsoring their own TCP studies. Conclusions reached in this section of the EIR will be reevaluated as necessary in light of any additional TCP information provided on a timely basis by the Sokaogon Chippewa. In addition, CMC will continue to seek to work with the Sokaogon Chippewa in identifying and preserving traditional cultural properties, including through the development of an appropriate cultural resource management plan which would seek to accommodate all parties' concerns while maximizing the protection of TCPs.

4.2.1.2.3.2 Forest County Potawatomi

Potential Traditional Cultural Properties

As discussed in Section 3.2.2.6.4, a comprehensive evaluation of Native American traditional cultural properties must focus on how Native Americans themselves interpret the resources that comprise their history and culture, and thus requires direct consultation with knowledgeable tribal members (see also Parker and King, 1990). CMC and its consultants have repeatedly sought to include the Potawatomi in the Crandon Project TCPI, on whatever reasonable terms are satisfactory to the Tribal Government, but the Forest County Potawatomi have declined to participate or cooperate in the conduct of these studies.

Accordingly, potential Potawatomi TCPs have had to be evaluated based on the limited amount of publicly available information. The FCP have identified the Devils Lake area (CS-24h) as an important cultural area based upon the uniqueness of the area, the archaeological sites there, and their cultural ties to the area (FCP, 1994). The Devils Lake area is located on Forest County Potawatomi reservation lands approximately 5 miles northeast of the Crandon ore body. This may be a potential TCP site or district, although it cannot be evaluated without additional data from Forest County Potawatomi tribal members.

The project will cause no physical disturbances within the Devil's Lake area and there will be no discernible project-related water, air, or other environmental impacts to this area. Likewise, while there may be other potential Potawatomi TCPs on and within the immediate vicinity of their reservation, the project will cause no physical disturbances within that area or adverse environmental impacts to reservation resources. All reservation lands are located well beyond the APE.

TCPs are not necessarily isolated phenomena. Inter-relationships between locations where traditional activities took place and continue to take place may exist within the cultural landscape that include locations within and beyond the APE. Whether or not these activity loci comprise a TCP cannot be evaluated without input from Potawatomi tribal members.

The Forest County Potawatomi Tribal Government may be sponsoring their own TCP studies. Conclusions reached in this section of the EIR will be reevaluated as necessary in light of any additional TCP information provided on a timely basis by the Potawatomi. In addition, CMC will continue to seek to work with the Forest County Potawatomi in identifying and preserving traditional cultural properties, including through the development of an appropriate cultural resource management plan which would seek to accommodate all parties' concerns while maximizing the protection of TCPs.

4.2.1.2.3.3 Menominee Tribe of Wisconsin

Potential Traditional Cultural Properties

An extensive Traditional Cultural Property Investigation has been conducted by the Historic Preservation Department of the Menominee Tribe, in association with cultural resources contractors retained by CMC. This work was initiated as a joint endeavor with Commonwealth Cultural Resources Group, Inc., and subsequently undertaken as a joint endeavor with Woods Cultural Research, Inc. The Menominee TCP studies have been completed and submitted to the Tribal Legislature for review. The Tribal Legislature retains the authority to determine which information resulting from this work will be released to assist CMC and the reviewing agencies in evaluating potential impacts to traditional cultural properties.

The Menominee are currently preparing the impact section for their potential TCP on the middle Wolf River. This is in accordance with the USCOE position that they will evaluate all potential TCPs as long as the tribes can show that they are eligible for listing on the National Register and that the project will have an adverse physical, visual, or auditory effect on the property (Wonsik, 1996; Wopat, 1996).

As discussed above in Section 3.2.2.6.4.3, based on a preliminary identification of potential Menominee TCPs, it is unlikely that TCPs specific to the Menominee are located within the APE. There is a significant likelihood, however, that Menominee TCPs are located further south

within and along the Wolf River. There will be no digging, drilling, or other ground-disturbing activities within this area. Moreover, as discussed in Section 4.2.14.3.1, there will be no adverse impacts to the physical, chemical, or biological integrity of the Wolf River or to the quantity or flow of its waters. For these reasons, CMC does not believe that there will be any measurable physical impacts to any Menominee TCPs.

As noted above, TCPs can sometimes be adversely affected even if their physical integrity is unaltered. Any such potential effects cannot be addressed without additional information from the Menominee, and it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential impacts to the Menominees' own culture, beliefs, and values. CMC will reevaluate its conclusions in this EIR in light of any TCP information authorized for release by the Tribe on a timely basis. In addition, CMC will continue to work with the Menominee in identifying and preserving traditional cultural properties, including through the development of an appropriate cultural resource management plan which would seek to accommodate all parties' concerns while maximizing the protection of TCPs.

4.2.1.2.3.4 Summary

Based upon studies to date, there are no apparent Native American traditional cultural properties or districts that will be physically disturbed or otherwise adversely effected in a significant way by Crandon Project construction, operation, or reclamation activities. No definitive conclusions can be reached, however, in the absence of additional data from the tribes themselves. The SCC and FCP have declined to participate in the studies, and the MITW has not yet released any data to CMC or reviewing agencies. Conclusions reached in this section of the EIR will be reevaluated as necessary in light of any additional TCP information provided on a timely basis by the tribes associated historically with the study area and vicinity.

Without additional information from the tribes, it would be inappropriate to attempt to draw unilateral conclusions about potential project impacts to the tribes' own cultures, beliefs, and values. CMC is committed to developing the project in a way that will recognize, respect, and protect the separate sovereignty, cultures, traditions, and values of its Native American neighbors. It continues to seek to work with all interested Tribal Governments in promoting these goals.

4.2.2 Transportation and Utilities

4.2.2.1 Transportation

Transportation impacts were assessed as relates to vehicular transportation (roads), airports and railroads. A discussion of the assessment follows.

4.2.2.1.1 Roads

Vehicular traffic impacts relate to the ability of the existing road network to absorb additional traffic flow. This portion of the transportation impact analysis focuses on estimating additional traffic to be generated by the project, adding this amount to existing traffic as detailed in Section 3, and assessing the ability of the existing road networks to safely handle the additional traffic based on WisDOT criteria.

Impact Analysis Methods

Three separate future traffic conditions were evaluated. The first condition evaluated the traffic volume that would exist in year 2001 with no mine construction. The second condition evaluated traffic volumes during the construction of the mine, and the third condition evaluated the typical operations plus future construction activities that will occur periodically during operations. The projected traffic for these conditions was based on the total expected number of workers at the site, the typical operating shifts per day, and the anticipated vehicle occupancy rate. Employee data were provided by CMC and the peak-hour traffic volumes were determined based on the detailed characterization of the project presented in Section 4.2.13.

There are two sets of projected site related traffic volumes used in this analysis, construction volumes and typical operations volumes. The construction volumes reflect the average traffic volume for the peak year of the 3-year construction period. The traffic volumes during this period consist of construction traffic and a gradual buildup of operations traffic. Traffic volumes equal to or above this average will be present for approximately 6 months of the 36-month construction period. The construction volumes were evaluated to determine any short term capacity constraints which may be attributable to the peak construction traffic.

The typical operations volume is based on the average expected workforce at the site. However, there will be several periods of additional construction associated with TMA expansion which will generate additional traffic from time to time. The typical operations volume will, therefore, vary from employee-only trips to employee-plus-construction-activity trips that will occur during various stages of TMA construction. For the purpose of this analysis the higher volume was used as a conservative approach. The total average daily traffic (ADT) volume generated by the project, without taking into account the TMA construction periods, during typical operations is approximately 20 percent less.

Table 4.2.2-1 shows the projected workers and average daily traffic for each condition. The projected ADT volumes assume an automobile occupancy of 1.3 passengers per vehicle. This automobile occupancy rate was established by the Institute of Transportation Engineers for industrial land uses, and is published in the *Trip Generation Manual, 5th edition* (Institute of Transportation Engineers, 1991).

Not reflected in this analysis is the recent change to the proposed use of a geosynthetic clay liner (GCL) rather than natural clay during TMA construction. The truck traffic originally projected during TMA construction, 84 truck trips/day, would be reduced to approximately 2 truck trips/day through the use of the GCL. The analysis that follows is based on clay haulage of 84 truck trips/day during TMA construction. If the analysis were to be performed using 2 truck trips/day based on GCL use, the results would show less overall impact. Therefore, the results for the analysis based on 84 truck trips/day are conservative.

The majority of the construction traffic will occur between 7:00-8:00 a.m. and between 6:00-7:00 p.m., five days/week, except for shaft work, which will be completed 24 hours/day, and tailings management area construction, which will occur 12 hours per day, 7 days per week. During typical mine operations, the traffic volumes entering and exiting the mine site will center around the shift changes at 7:00-8:00 a.m., 3:00-4:00 p.m., and 11:00 p.m. - 12:00 a.m. The peak traffic volumes for area roadways during construction and typical operations are anticipated to occur at 7:00-8:00 a.m., and 4:00-5:00 p.m. based on historical traffic counts. For the purpose of this evaluation, the most conservative approach was to assume that the evening peak hours for the construction and operations traffic coincide with the area roadway evening peak hour from 4:00-5:00 p.m. The projected peak-hour traffic volumes for the project area roadways during construction and typical operations are shown in Table 4.2.2-2. The peak-hour volumes for each condition were determined based on worker statistics described in Section 4.2.13.

Table 4.2.2-1

Projected Workers and Average Daily Traffic[1]

	Workers	ADT
Construction	500	770
Operations	440[2]	775[3]

[1] Assuming a 1.3 passenger per vehicle occupancy.
[2] Total workers/employees during operations is 464, however the projected average number of employees off work at any time is estimated to be 64. In addition there are 40 employees added for additional TMA construction.
[3] Total ADT is based on 12 delivery trips/day for supplies and consumables and 84 truck trips/day for clay haulage during TMA construction. Since the original traffic analysis was completed, CMC has proposed the use of a geosynthetic clay liner (GCL) in lieu of native clay. The use of GCL will significantly reduce the truck trips required for TMA construction. The originally estimated 84 truck trips/per day would be reduced to 2 truck trips/day. If the analysis were performed with the reduced truck trips/day, the ADT during operations would decrease to approximately 690.

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Table 4.2.2-2

Site-Generated Peak Hour Traffic Volumes[1]

Condition	ADT	A.M. Peak Hour (two-way volume)	P.M. Peak Volume (two-way volume)
Construction	770	310	310
Operations	775	260	260

[1] If the use of a GCL during TMA construction were considered in the analysis, the site generated peak traffic hour volumes shown during Operations would be reduced by approximately 10 percent.

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The site-generated traffic was assigned to area roadways in accordance with a directional distribution analysis based on the roadway system, existing population census data, and the existing travel patterns. The directional distributions of site traffic for the construction and typical operations are shown in Figures 4.2.2-1 and 4.2.2-2, respectively. Figures 4.2.2-3 and 4.2.2-4 illustrate the assignment of peak hour site traffic to area roadways for the construction and typical operations conditions. The traffic volumes shown in Figures 4.2.2-3 and 4.2.2-4 will be approximately 10 percent less due to the reduction in truck trips resulting from the use of geosynthetic clay liner instead of native clay during TMA construction.

Impact Assessment Results

Three future volume scenarios were evaluated, the future with no mine traffic volumes, the future additive effects including construction volumes, and the future additive effects including the typical operations volumes. An evaluation of the existing traffic volumes, discussed in Section 3.3, and shown in Figure 3.3-4 was used in the analysis. The estimated 2001 no-mine peak hour volumes are shown in Figure 4.2.2-5. Figures 4.2.2-6 and 4.2.2-7 illustrate the addition of site peak-hour traffic volumes to the future construction phase and typical operations peak-hour conditions, respectively.

The future no mine volumes consist of the 1994 average annual daily traffic (AADT) volumes plus 2-percent-per-year (WisDOT) growth. Figure 4.2.2-8 shows the AADT volumes for the existing conditions and three future volume scenarios. These traffic volumes formed the basis for this analysis.

The future traffic conditions were evaluated using *Highway Capacity Manual* (National Research Council, 1994) methods, when applicable, for unsignalized intersections and two-lane highways. Results of the capacity analysis are illustrated in Table 4.2.2-3. This table shows the level of service for both the intersections and roadway segments surrounding the mine. WisDOT requires a level of service "C" or better for highway improvement projects. A complete discussion of level of service is included in Appendix 4.2-1.

The intersections of STH 55 at USR 8 (east) and STH 55 at USR 8 (west) could not be evaluated through the use of a model. Current evaluation methods, including the *Highway Capacity Manual* methods do not have provisions for the evaluation of 3-way stop controlled, 4-approach intersections. Analysis of these intersections therefore consisted of field observations, engineering experience, and consultation with WisDOT staff. The analysis indicates that under existing conditions, these intersections operate at a level of service "C" or better. The analysis also indicates that these intersections will continue to operate at an acceptable level of service under future no mine conditions as well as under future with mine conditions. The increase in traffic volumes from existing to the year 2010 conditions with mining would cause a marginal increase in delay, however the delay would not be to a level at which CMC's analysis, or WisDOT staff, would consider below acceptable.

The analysis of future mine and no mine conditions indicates acceptable capacity levels, based on the current WisDOT criterion, will be provided for all intersection and roadway segments evaluated in this study.

4.2.2.1.2 Airports

Since the Crandon Municipal Airport does not service regularly scheduled passenger or commercial flights, it is not expected that the project will use this airport. The proposed headframe, which will be approximately 165 feet tall, will be equipped with red warning lights in accordance with the Federal Aviation Administration (FAA) requirements (FAA, 1991).

The closest commercial airport offering regularly scheduled passenger service is in Rhinelander, located 35 to 40 miles west of the plant site. It is anticipated that 50 to 70 boardings per year will be generated by Crandon Project personnel, on average, during the project's life. This represents approximately 0.2 percent of current annual boardings at the airport and, therefore, should not adversely impact levels of service (Briggs, 1995).

4.2.2.1.3 Railroads

The Wisconsin Central Limited Railroad track in the vicinity of the project is to be used for shipment of ore concentrates and delivery of selected project supplies is estimated to currently

Table 4.2.2-3

Intersection/Roadway Segment Level-of-Service[1,4]

	1995 Existing Conditions AM/PM	2001 Future No Mine AM/PM	2001 Future Construction AM/PM	2001 Future Operations AM/PM
Intersection				
• USR 8 at CTH S	A/A	A/A	A/A	A/A
• USR 8 (west) at STH 55	—[2]	—[2]	—[2]	—[2]
• STH 55 at USR 8 (east)	—[2]	—[2]	—[2]	—[2]
• STH 55 at CTH S	A/A	A/A	A/A	A/A
• STH 55 at Airport Road	A/A	A/A	A/A	A/A
• STH 55 at Mine Entr.	-	-	A/A	A/A
• STH 55 at CTH K	A/A	A/A	A/A	A/A
Roadway Segment[3]				
• STH 55 south of Mine Entr.	A	A	A	A
• STH 55 north of Mine Entr.	A	B	B	B
• STH 55 north of CTH S	A	B	B	B
• CTH S between STH 55 and USR 8	A	A	A	A

[1] A complete explanation of "Level of Service" is included in Appendix 4.2-1.

[2] See "Impact Assessment Results" narrative in Section 4.2.2.1.1 for a complete discussion of the future capacity at these intersections.

[3] Level of service is based on AADT volumes, *Highway Capacity Manual*, Table 8-10.

[4] The traffic impact results reported in this table reflect traffic volumes which include truck traffic related to using native clay during TMA construction. Since this analysis was performed, the use of a geosynthetic clay liner (GCL) has been proposed in lieu of native clay. The use of a GCL will require significantly less truck traffic. If the lower truck traffic associated with GCL use were considered in the analysis, the results in this table would be, at a minimum, equal to those shown.

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handle approximately 4.5 million tons of freight per year (Kelly, 1995). The freight generated by the Crandon Project is estimated to average 365,000 to 547,500 tons per year, which will result in an 8 to 12 percent increase. According to Wisconsin Central Limited Railroad personnel (Kelly, 1995), their current system (e.g., number of trains per day, track condition, switching equipment, etc.) is sufficient to handle the increased traffic, therefore an expansion of service to the area or additions to railroad system infrastructure will not be needed.

4.2.2.2 Utilities

The Crandon Project will be fully self-sufficient regarding water supply and treatment and therefore will require no public utility services in this regard. Telephone service will be provided by the Crandon Telephone Company. Per discussions with personnel of the Crandon Telephone Company (Wilson, 1995), a new buried line may need to be extended to the site from the existing remote telephone station at Mole Lake. A carrier unit may also need to be located somewhere along Sand Lake Road (Wilson, 1995). The new line will be installed by Crandon Telephone Company within existing road rights-of-way. Impacts will be within the previously disturbed rights-of-way and will be temporary.

Electrical and natural gas service will be provided to the project by Wisconsin Public Service Corporation. Plans relating to providing this service are currently being reviewed by the Public Service Commission of Wisconsin (PSC). Included as part of this review is an assessment of the environmental impacts associated with providing the required service. The results of this review will be incorporated into the Crandon Project EIS which is expected to be co-authored by WDNR and the PSC.

4.2.3 Air Quality

Analysis of the Crandon Project's impacts to local air quality demonstrate that under combined operating and construction conditions the proposed facilities will not cause or contribute to an exceedance of any National Ambient Air Quality Standards (NAAQS). Details of the mathematical impact analysis along with supporting emission rate calculations are provided in Appendix 4.2-2.

The overall expected air quality impacts are significantly less than the originally proposed project of the late 1970's and early 80's. The current project plan is at a reduced mining capacity and includes conditions that result in emission reducing features such as chipping cleared brush instead of open burning, combustion of natural gas in the electrical generators instead of diesel fuel, and a reduction in the area of land disturbance.

An ambient air quality impact analysis was conducted using United States Environmental Protection Agency (EPA) approved dispersion models to demonstrate compliance with the NAAQS. The modeling conducted represents a practical worst case (PWC) scenario that takes into account emissions from both the mine at full production and emissions resulting from the largest construction event at the TMA. The impact analysis report in Appendix 4.2-2 contains a detailed description of emission sources, rates, and the practical worst case scenario determination method. The results of this combined practical worst case analysis are displayed in Table 4.2.3-1. Maximum estimated impacts are added to existing background concentrations to determine the total impact. As demonstrated by the table, total maximum estimated impacts are well below the standards for all criteria pollutants.

Table 4.2.3-1

Comparison of Estimated Practical Worst Case Ambient Air Quality Levels to the Wisconsin Ambient Air Quality Standards[1]

Parameter	Averaging Period	Maximum Source Impact ($\mu g/m^3$)[2]	Total Background Concentration ($\mu g/m^3$)	Total Air Quality Impact ($\mu g/m^3$)	Primary Standards ($\mu g/m^3$)	Secondary Standards ($\mu g/m^3$)
Total Suspended Particulate (TSP)[3]	Annual	11.21	14.3	25.5	None	None
	24-hour	66.48	50.0	116.5	None	150
Particulate Matter less than 10 microns (PM10)	Annual[4]	11.21	9.9	21.1	50	50
	24-hour	66.48	33.0	99.5	150	150
Sulfur Dioxide (SO_2)	Annual[4]	1.16	10.4	11.6	80	--
	24-hour	10.15	39.0	49.2	365	--
	3-hour	38.57	143.9	182.5	--	1,300
Carbon Monoxide (CO)	8-hour	449.67	4,913.7	5,363.4	10,000	10,000
	1-hour	3,476.22	6,919.7	10,395.9	40,000	40,000
Nitrogen Dioxide (NO_2)	Annual[4]	8.01	11.0	19.0	100	100
Lead (Pb)	Quarterly[4]	0.00229	0.05	0.052	1.5	1.5

$\mu g/m^3$ = micrograms per cubic meter

[1] The impact analysis report in Appendix 4.2-2 contains a detailed description of emission sources, rates, and the practical worst case scenario demonstration method. Wisconsin Ambient Air Quality Standards include the NAAQS in addition to the state only TSP air quality standard.

[2] Short-term impacts (i.e., 24-hour average or less) are the highest second-highest concentrations predicted. Annual average impacts are the highest predicted.

[3] Total suspended particulate (TSP) is a Wisconsin standard only, the EPA NAAQS have been revised from TSP to PM10 and the federal TSP standard has been removed.

[4] Arithmetic mean: the average of the collection of concentrations obtained by dividing the sum of the concentrations by the number of samples.

Prepared by: MAD1
Checked by: MLM

The results listed in Table 4.2.3-1 represent the maximum concentrations at the project site, excluding areas inside the fence line of the TMA. Maximum impacts at the CMC property boundary and beyond can be found on the isopleths shown in Appendix 4.2-2. The estimated impacts for PM10 represent an additional conservative assumption in that PM10 emission rates are considered to be equal to those of TSP.

Concentrations at the project area boundary decrease, as would be expected, from the levels shown in Table 4.2.3-1 for locations farther away from the emission sources. Table 4.2.3-2 below shows the practical worst case estimated impacts at the project area boundary for several parameters, and provides a comparison to the existing background levels.

Table 4.2.3-2

Comparison of Estimated Practical Worst Case Ambient Air Quality Levels at the Project Area Boundary

Parameter	Averaging Period	Maximum Impact ($\mu g/m^3$)[1]	Background Concentration ($\mu g/m^3$)	Percent of Background Concentration
Total Suspended Particulate (TSP)	24 hr	29.8	50.0	59.6
Sulfur Dioxide (SO_2)	3 hr	21.2	143.9	14.7
Nitrogen Dioxide (NO_2)	Annual	3.6	11.0	32.7

$\mu g/m^3$ = micrograms per cubic meter
[1]Short-term impacts (i.e., 24 hours or less) are the highest second highest concentrations predicted.

4.2.3.1 Construction Phase

Air emissions from the project's construction phase result primarily from the use of construction equipment needed to clear, excavate, contour and grade land for the plant surface facilities, access road, railroad spur, and the first cell of the TMA. Air emission sources include site preparation activities, subsurface drilling and blasting associated with development of the underground mine, fugitive dust resulting from mobile equipment, wind-blown fugitive particulates, and natural gas combustion for mine air heating.

Total suspended particulates (TSP) constitute the major portion of the air emissions during the construction phase; a majority of which are fugitive dust emissions from grading activities and from excavation, hauling, loading and dumping. The estimated maximum TSP emissions for the initial construction phase will occur during the second year when approximately 2.1 million cubic yards of material is expected to be handled.

Minor emissions of sulfur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), and lead (Pb) will result from mobile equipment exhausts, natural gas combustion, and limited

underground development blasting. These emissions are also mostly fugitive and do not represent a significant quantity.

Although air emissions during initial construction were not specifically modeled, the largest contributions from the construction phase sources have air emission rates for TSP which are essentially equal in type, mode of release, and total quantity to those estimated for the construction of the second cell of the TMA. Approximately 2.2 million cubic yards of soils are expected to be handled during the construction of TMA 2. Since the estimated earth moving quantities for the initial construction period are less than that for subsequent construction periods, the practical worst case air quality impacts are based on the impacts of the operation and construction phase, which includes the construction of TMA 2. As shown in Table 4.2.3-1, concentrations of air quality constituents are expected to be considerably below the primary and secondary federal and state ambient air quality standards.

A series of control measures (i.e., watering on-site roadways and excavation areas) will be implemented during construction to minimize fugitive dust emissions and to limit air quality impacts. The plant site access road will be paved early in the construction phase to minimize fugitive dust generation.

Construction areas subject to cut-and-fill operations will be temporarily revegetated after final grading for soil stabilization and dust control. This activity will start during the first year of construction and continue through completion of construction. After final grading of embankment slopes, temporary or permanent vegetation will be planted for soil stabilization and to reduce wind blown dust.

During the pre-production phase, underground mine development drilling activities will be performed using wet drilling techniques to minimize emissions. Dust emissions from blasting will be reduced as a result of particle settling during air transport in the mine and the watering of broken rock (muck) piles prior to handling. Muck pile wetting will be a standard operating procedure. Mobile equipment used for handling of rock and transporting personnel, equipment, and materials will be fitted with catalytic converters for the reduction of exhaust gas emissions.

4.2.3.2 Operating Phase

The primary sources of air emissions during the operation phase will originate from underground stope and development blasting, mine air heating, mobile equipment exhaust, ore handling, surface facilities heating, electrical generators, and off-loading of lime and cement. Operation phase air emission sources, rates, and control efficiencies are presented in the project's *Air Pollution Control Permit Application* (Foth & Van Dyke, 1995c).

The impact analysis conducted for the combined operation and construction scenario fully addresses the emissions generated in this phase. Table 4.2.3-1 contains a summary of the estimated impacts. The resulting ambient air quality impacts from the project will meet all federal and state standards. As a result, no deleterious effects are projected to occur to the soil, vegetation, or animals. Because the NAAQS will be attained, the project will maintain the area's air quality and it will not create a risk to public health, safety and welfare.

Control measures will also be implemented during the operation phase to minimize potential air quality impacts. Specific controls and control efficiencies are summarized below.

As with the construction phase, operating control measures within the mine will consist of wet drilling, the use of water sprays and dust collectors. During operation of the mine, generation of dust from drilling will be controlled with water injection to drill bits. Emissions from underground rock crushing and other rock handling activities will be controlled by baghouses and/or water sprays.

Insertable dust collectors and baghouses will be used to control emissions from the mill and other surface operations. The use of these controls was based upon the physical characteristics of the particulates. Insertable collectors will typically be used where the captured material is fine and can be returned directly to the process. The insertable collectors will generally vent inside the buildings.

Control of potential particulate emissions due to wind erosion from exposed TMA surfaces will be accomplished through the use of stabilizing agents. These high strength binders form a flexible crust to control dusting, erosion and siltation. Application can be made in warm or cold weather using sprayers, hydroseeders, or high pressure water hoses. During the consolidation phase of a TMA, application of stabilizers to the center of the pond will be made with the aid of wooden walkways, pontoon vehicles, or other techniques to extend the reach of the applicator.

As described in the project's *Air Pollution Control Permit Application* (Foth & Van Dyke, 1995c), two programs will be instituted to provide protection and maintenance of federal and state ambient air quality standards. These programs are the Monitoring and Quality Assurance Plan, and the Malfunction Prevention and Abatement Plan. The Malfunction Prevention and Abatement Plan will also include programs to provide consistency with federal regulations such as the New Source Performance Standards for metallic mineral processing plants. Final design of these programs will be thoroughly reviewed with the WDNR before implementation.

4.2.3.3 Reclamation Phase

The project's closure or reclamation phase activities are expected to have very minor air emissions. The major air emissions expected during the reclamation phase of the project will be TSP. Most of the TSP will be from hauling and grading of soil for the final contouring and covering of the plant site and TMA. The quantities of soil moved during this phase during any given year will be less than those described in the practical worst case analysis.

4.2.3.4 Metal Deposition

In order to assess the depositional impacts of metal emissions to land and surface waters a comparison of the maximum estimated metal ambient air concentrations for the proposed Crandon Project to prior study work by EMC in 1985 was made as part of the Ambient Air Quality Impact Analysis report in Appendix 4.2-2. The comparison shows the currently proposed project results in similar or smaller ambient air impacts for metals than the original project. Since the 1985 concentrations resulted in negligible deposition impacts demonstrated as several orders of magnitude below the existing background concentrations in the tested surface waters, further analysis relating to metals deposition for the current project is not warranted.

4.2.3.5 Class I Areas

The proposed Crandon Project is not located within a 100-kilometer (km) radius of any current Class I areas. However, the Forest County Potowatomi Community (FCP) has submitted an application to EPA for redesignation of its reservation lands to Class I. The FCP lands are located between 5 and 6 miles to the east and northeast of the planned project site. The FCP's 1994 Technical Report on the redesignation proposal concludes that "redesignation to Class I will have no effect on the Crandon Project as it is currently proposed" (Potawatomi, 1994). Additional discussion of this topic is contained in Section 4.2.14.2 of this EIR.

4.2.4 Geology, Soils and Landforms

Impacts to site geology, soils and landforms are discussed in this section of the EIR.

4.2.4.1 Geology

The mining operation will deplete the known mineral resources from within the mined area. Recoverable metals including zinc, copper, lead, silver, and gold will be concentrated on-site. Metal concentrates will be sent to an off-site smelter for recovery. Some waste rock will also be removed from the mine in the course of mining. A portion of this rock will be used as construction material, as riprap in the TMA and reclaim pond, and some will remain in the mine for use as backfill material in mined out stopes. Approximately 50 percent of the tailings generated as part of the ore milling and concentration process will be used to backfill mined out stopes.

4.2.4.1.1 Backfilling

The majority of the Crandon deposit will be mined using blasthole open stoping with backfilling. The primary stopes will be mined and backfilled with hydraulic fill stabilized with cement. After the backfill has cured, the remaining pillars would be extracted as secondary stopes and then backfilled with a combination of cemented tailings, uncemented tailings, and small amounts of waste rock as described below. Backfilling mined out stopes will provide for long-term mine area rock mass stability, will allow more complete extraction of the ore body, and will minimize the amount of mine waste rock and mill tailings requiring surface storage.

Mill tailings will be the major mine stope backfill material, accounting for greater than 95 percent of all fill placed. The remaining fill of less than 5 percent will come from coarse or crushed mine development waste rock. Approximately 40 percent of the dry mill feed tonnage will be recovered as backfill product and returned to the mine for deposition either in a cemented or uncemented form. Mill tailings prepared as mine backfill product are expected to possess the following qualities:

- The ability to be transported hydraulically at relatively high (60 to 70 percent by weight) slurry densities.
- Low in-place compressibility, to provide appropriate support to stope walls.
- Development of adequate strength, when mixed with small proportions of cement (less than 10 percent by weight), to be self-supporting when exposed by removal of adjacent secondary stopes.

The blasthole open stoping mining method will be employed in ore horizons below an elevation of about 1,200 feet (MSL). Stopes backfilled in this area will be completely filled with tailings. Above the 1,200 feet (MSL) elevation, cut and fill mining methods (i.e., post pillar cut and fill or undercut fill mining) would be used in the ore below the base of the crown pillar. Cemented fill of higher strength than that used for stopes below 1,200 feet (MSL) will be placed in those stopes developed using cut and fill mining methods. This backfill will be placed to within less than 2 feet from the stope roof using a practice called "tight filling". It is possible, depending on

stope conditions, to achieve placement within less than 1 foot from the stope roof using this method of backfilling.

At the end of the mining life after all stopes have been backfilled, it may be possible to backfill the shaft and raises, but it would likely be impractical to fill horizontal level development for the following reasons:

- In the horizontal development drifts, a series of short bulkheads would be required to be constructed for the containment of fill. This construction method would require a dewatering system to allow for the consolidation of the backfill.

- The mine ventilation system would need to be changed to ensure that this work could be done safely.

- Only a portion of the horizontal drifts could be filled as safe working room would be required for the dewatering process.

If CMC were able to fill 50 percent of the mine voids created in waste development headings with tailings, approximately an additional 320,000 cubic yards of fill could be placed. This would result in a reduction of tailings placed in the TMA by about 2 percent. This is a relatively small quantity and as the underground openings could only be filled after mining and milling is complete, the tailings would have to be stored in the TMA, remobilized, and pumped back to the mine.

4.2.4.1.2 Underground Collapse

Collapse of underground openings is unlikely because the planned close cycling of mining extraction and backfilling will minimize the extent of large open excavations at any given time or location. After extraction of ore from stopes, backfilling operations will begin within approximately 2 weeks which will minimize the time any stope is open and minimize the possibility of collapse. Smaller access excavations, such as drifts or shafts, are required to provide a high degree of safety for passage of personnel and equipment. These smaller openings will therefore be supported with rock bolts, steel mats, wire mesh, shotcrete or lined with concrete to prevent collapse. Adverse changes in conditions of openings during mining will be identified by routine inspection and will be remediated, either by backfilling or increased rock support. A more detailed discussion of the different categories of openings are addressed in the following sections.

4.2.4.1.2.1 Drifts

<u>During Mining</u>

Drifts are unlikely to collapse during mining because they have relatively small dimensions and because the majority of the rock to be excavated in the hanging wall has high strength and high rock quality. Very small amounts of rock will be extracted in formation of the drifts, which will keep the resulting rock displacements small.

Drifts are generally routes of access for personnel and equipment and the movement of material. Weakened areas of rock will be supported (shored up) to provide safe working conditions

through the installation of rock bolts, shotcrete or other types of rock support. Rock conditions will be confirmed by visual inspection, and unsafe conditions repaired to maintain safety.

After Mining

Collapse is unlikely in drifts excavated in areas of strong, high quality rock which is planned for the Crandon Project. This is demonstrated by existing, open tunnels in other hard rock mines throughout the USA. Similarly, large open natural caverns in hard rock have demonstrated stability over geologic scale time periods.

If areas where weaker, weathered rocks are encountered, some drifts or portions of some drifts may need additional support with rockbolts and screening or with shotcrete, or may need to be lined with concrete to prevent collapse.

4.2.4.1.2.2 Stopes

During Mining

Collapse of stopes during mining is unlikely because of the generally high rock quality and because stope dimensions have been selected to provide stable large openings during extraction based on comparative data from case histories of operating mines in the Canadian Shield. The quality of the rock, as indicated by the Crandon project drilling data, was the basis of the comparative design.

The stope design and sequencing of mining and backfilling would be accomplished to prevent stope collapse. Stope collapse due to a delay in backfilling is unlikely, because the stope dimensions have been selected to provide stable excavations based on empirical design methods. The design approach incorporates considerable margin of safety for a delay in backfilling, because it is based on successful stopes in other mines with similar rock quality. Collapse of stope excavations represents an unacceptable condition from both the aspects of personnel health and safety, and the recovery of the resource.

The selected stope dimensions will be verified as underground excavations expose large scale rock surfaces to allow full characterization of the rock and rock structure. Assumed in situ stresses will be verified by underground measurements.

Stability of the selected dimensions will be further verified in the initial stopes. Stress and displacement instrumentation will be installed to measure the rock response to mining. Displacement of excavated stope walls will be measured in test stopes to verify stability.

The primary measures taken to prevent collapse of large stope excavations are placement of backfill and installation of cable bolts. The mine design is based on backfilling of stopes after ore extraction is finished to minimize the stope surface that is open in any area of the mine, at any given time. Local variation of ore zone dimensions or rock conditions might require reducing dimensions from the standard practice. This would be accomplished by subdividing an individual stope block into smaller units that are sequentially mined and backfilled. This would act to limit open dimensions as needed, and to reduce of the volume of backfill\time to backfill for individual units.

Cable bolting is a standard industry practice to provide additional stability to stope surfaces and to control dilution. It may be used to increase short-term stability, but does not replace backfill as the primary tool to provide long-term rock stability.

To prevent ground movement, both in the lower quality rocks in the weathered areas of the Crandon ore body and as mining begins to approach the Crown Pillar area, the stope design will transition from blasthole open stoping to a Vertical Crater Retreat (VCR) mining method. In the VCR method, rock is blasted downward into the stope bottom in multiple horizontal slices. To improve stope sidewall stability during blasting, only a small portion of the broken ore is removed from the stope to accommodate the volume expansion of the rubblized ore. After the entire stope has been blasted and is full of broken ore, the ore is removed in a continuous operation followed immediately by the backfilling operation. This minimizes the time that the VCR stope surfaces are open. VCR stope walls can be observed as the blasted ore is drawn out of the stope bottom. If stope surfaces were observed to become unstable, a plug of cemented backfill would be placed on top of the broken ore. Broken ore would be removed from under the backfill, after the cemented fill has stabilized.

Roof surfaces in stope excavations will be stabilized, as required, by rock bolting. If heavier rock support is required, vertical cable bolts can be installed.

After Mining

Collapse of stopes is unlikely after mining because the stopes are completely backfilled.

4.2.4.1.2.3 Crown Pillar

During Mining

Collapse of the Crown Pillar is unlikely because the extraction ratio will be reduced by leaving pillars of rock to support the Crown Pillar and because the mined void in between the rock pillars will be backfilled. As the base of the Crown Pillar is approached, the mining method will transition to post-pillar cut-and-fill mining to leave pillars of rock to support the roof. In the post-pillar cut-and-fill mining method, the ore would be extracted in approximately 15-foot horizontal slices, and each horizontal slice would be backfilled with cemented tailings to provide a working floor for the next slice above. The post-pillars would be stabilized by the backfill and the backfill would be placed to within 1 to 2 feet of the base of the Crown Pillar in the final slice.

Personnel and equipment are directly exposed to the excavations at all times during post-pillar mining and a high degree of safety is therefore required. During mining, the roof between pillars would be supported by rock bolts and shotcrete as required. Heavier roof support would be achieved, as required, by installing cable bolts.

After Mining

The mined area underneath the Crown Pillar is completely backfilled to within 1 to 2 feet to prevent collapse, therefore, as discussed in Agapito (1996), collapse of the Crown Pillar after mining is unlikely.

4.2.4.1.2.4 Other Underground Openings

During Mining

Collapse of other underground openings, for example ore passes, shops, and shafts, is unlikely. Shops and shafts require very high factors of safety to protect personnel. Installed rock support is therefore designed to be very conservative. Ore passes are not typically supported, however, they have small dimensions that make stability problems very unlikely.

After Mining

Collapse is unlikely because shops, shafts, ore passes and other auxiliary types of openings are typically placed in areas of high strength and high rock quality.

4.2.4.1.3 Subsidence

In regard to mine subsidence, evaluations of the proposed mining methods and stope sequences have been conducted, as have studies on bedrock, backfill, and overburden characteristics. Based on these analyses, a maximum subsidence of six inches was estimated (John D. Smith Engineering Associates Limited, 1982). A 6-inch subsidence is within the limits of conventional building design. A 6-inch subsidence would also have a negligible effect on future land use since the surface topography is quite irregular. In the event of a larger subsidence, off-site impacts would not be realized.

4.2.4.2 Soils

Site preparation will result in the disturbance of the topsoil layer and humus material in construction areas. Salvageable topsoil will be stockpiled for reuse during final grading and revegetation. The project's general construction plan is described in Section 4.8 of the *Mine Permit Application* (Foth & Van Dyke, 1995d). A detailed erosion control plan for the project is also included in Section 4.10 of the same document.

Clearing and grubbing of the plant site, access road corridor, and the railroad spur corridor will be the first construction activities. This will result in the clearing of approximately 128 acres, stockpiling of topsoil, and reseeding of areas not developed in early phases of construction. About 55 percent of the plant site area will be covered by buildings, parking lots, and roads. The remaining 45 percent of the site area will either not be disturbed or will be landscaped to reduce erosion potential.

Salvageable topsoil removed during TMA construction will be stockpiled in phases as individual TMA cells, runoff basins, the borrow area and the construction staging area are built. In total, approximately 345 acres of area will be disturbed during TMA construction activities over the life of the project. The TMA cells will be constructed sequentially as they are needed, which will minimize disturbance and erosion potential at any given time. Soil material excavated from the cells will be used for cell embankments, liners, underdrains and reclamation covers.

Mitigation measures initiated during the construction phase, such as reseeding and landscaping, will minimize potential erosion impacts in areas which have been disturbed. Sequential construction of facilities, such as proposed for the TMA area, is planned to reduce the total area

disturbed at any time. No long-term irreversible impacts to site area soils are projected to occur as a result of project construction, operation or reclamation activities.

Table 3.5-11d in Section 3.5 of the EIR presents a listing of the soil series, accompanying vegetation type and acreage, and percent vegetation type within each soil series for the areas of planned disturbance within the mine site. Table 4.2.4-1 presents an estimate of the volume of topsoil to be stripped within the mine site by soil series and the approximate sequence of stripping. The volume estimate is based on an estimated stripping thickness of 9 inches for all soil series with the exception of Capitola Muck, Vanzile Silt Loam, and Lupton, Cathro, and Markey Muck which have thicknesses greater than 9 inches. For these three series, the SCS typical thickness or mean thickness as shown in Table 3.5-11c were used for the calculations.

Generally, the topsoil salvaged during construction will consist of partially decomposed forest litter, the top surface soil layers and part of the subsoil. During the stripping of the topsoil, these layers will become mixed and will form a single soil unit. Some of the stripped topsoil will be used to dress berms and other project features during construction. The remaining topsoil will be stored in topsoil stockpiles for use during site reclamation. CMC plans to mitigate the loss of wetlands at the site through the establishment of off-site wetlands. Therefore, hydric soils collected from disturbed areas will be mixed and stored with the topsoil from the rest of the developed mine site. The stripping process will result in the collection of some topsoil with a low organic matter content (less than 1 percent) and the collection of a considerable volume of high organic content hydric soils.

The physical properties of the soils encountered on the site are shown in Table 3.5-11e. Review of the table indicates the properties of the upland soils regardless of the type are very similar.

The pH, CEC (cation exchange capacity), and organic matter content for the upland soils generally overlap for both the upper and lower horizons as defined by the SCS. The lowland hydric soils typically have a much higher organic content than upland soils. Other than their percent organic matter and bulk density, the lowland soil properties generally overlap the properties of the upland soils.

Since the properties of the soils on upland areas are very similar and incorporation of the high organic content soils with the upland soils would greatly increase their productivity, and since the Mud Lake Silt Loam and Wabeno-Goodman Complex make up such an overwhelming volume of the soils at the plant site and TMA, the segregation of topsoil by soil type is not deemed necessary. In addition, the vegetation selected for use during project reclamation is indigenous to the area and should be able to be established in a wide range of soils. Mixing of the topsoils during stripping should improve the organic content of the soil and thus improve the soil structure. The increased organic matter in the soil should improve the ability of plant materials to re-establish on-site.

As stated in Table 5-7 of the project's May 1995 Mine Permit Application, "species will be selected by soil type and soil moisture". Most species selected grow throughout northern Wisconsin on a variety of soil types. According to Gary L. Hightshoe (1988), for instance, Acer rubrum can grow in coarse sands and sandy loams to fine silty clays and clays on poorly aerated soils. Ostrya virginiana, an intermediate tree found in Wisconsin forests, can grow in moderately coarse sandy loams, loams to fine sandy clays, silty clays and heavy clays.

Table 4.2.4-1

Estimated Topsoil Stripping Volumes and Sequence

USDA Soil Series No.[1]	Area (ac)	Topsoil Thickness[2] (ft)	Stripped Volume[3] (cy yd)	Approximate Stripping Sequence (years)
Access Road				
18	1.5	0.75	1,800	0-3
20	7.9	0.75	9,600	0-3
27	<0.01	2.3	<100	0-3
100	15.7	0.75	19,000	0-3
106	1.7	0.75	2,100	0-3
107	2.6	0.75	3,100	0-3
109	2.5	0.98	4,000	0-3
707	6.1	2.4	25,900[4]	0-3
		Total	65,600	
Railroad Spur				
18	0.3	0.75	400	0-3
20	7.5	0.75	9,100	0-3
106	3.5	0.75	4,200	0-3
107	0.4	0.75	500	0-3
111	4.5	0.75	5,400	0-3
707	2.9	2.4	11,200[4]	0-3
		Total	30,800	
Plant Site				
18	22.5	0.75	27,200	0-3
20	100.6	0.75	121,700	0-3
106	4.4	0.75	5,300	0-3
707	0.2	2.4	800[4]	0-3
		Total	155,000	

Table 4.2.4-1 *(Continued)*

USDA Soil Series No.[1]	Area (ac)	Topsoil Thickness[2] (ft)	Stripped Volume[3] (cy yd)	Approximate Stripping Sequence (years)
TMA 1 and Access Road				
18	80.7	0.75	97,600	0-3
20	112.1	0.75	135,600	0-3
707	5.2	2.4	20,100[4]	0-3
		Total	253,300	
TMA 2				
17	5.3	0.75	6,400	7-10
18	23.2	0.75	28,100	7-10
20	60.8	0.75	73,600	7-10
		Total	108,100	
TMA 3				
17	6.3	0.75	7,600	16-18
18	8.2	0.75	9,900	16-18
20	31.8	0.75	38,500	16-18
707	1.6	2.4	6,200[4]	16-18
		Total	62,200	
TMA 4				
18	4.9	0.75	5,900	20-24
20	11.6	0.75	14,000[4]	20-24
		Total	19,900	

[1] 17 - Capitola Muck
18 - Mud Lake Silt Loam
20 - Wabeno-Goodman Complex
27 - Minocqua Muck
100 - Stambaugh Silt Loam
106 - Padus-Pence Complex
107 - Pence-Vilas Complex
109 - Vanzile Silt Loam
111 - Pence Sandy Loam
707 - Lupton, Cathro, and Markey Muck

[2] 0.75 for all soil series except 27, 109, and 707 where the actual thickness of organic rich soil was used.

[3] Rounded to the nearest 100 cubic yards.

[4] Hydric soils, organic content >10%.

Prepared by: EAS
Checked by: JWS

In developing the vegetation for reclamation, species were chosen that can adapt themselves to a variety of different soils. The species will then be matched to fit into the proper soil and soil moisture regime so as to maximize growth and sustainability.

For each area of disturbance, topsoil stripping and stockpiling methods will differ slightly. For the proposed access road and the proposed railroad spur, topsoils will be stockpiled on cleared portions of the access routes on a short-term basis. This topsoil will then be used to complete reclamation on shoulders and berms at these locations. Excess topsoil will be placed in the topsoil stockpile located at the plant site.

At the plant site, topsoil not used immediately for reclamation will be stockpiled on site for use in final reclamation. At the TMA, topsoil management will occur sequentially as each TMA cell is constructed and reclaimed. During construction of each portion of the TMA, topsoil will be used for berms and landscaping. The remainder will be stockpiled for use in the placement of final cover as each TMA cell is reclaimed. Section 10.3 of the January 30, 1997 *Addendum No. 3 to the Tailings Management Area Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1997) provides a detailed explanation of TMA phase construction, including topsoil management.

4.2.4.3 Landforms

Construction impacts to landforms will occur at the plant site, the TMA, along road and railroad access routes, along pipeline corridors, and along the TMA access road. These impacts will result from the initial modification of the surface topography during construction activities, whereas the reshaping and creation of new permanent landforms will occur during the operation (TMA only) and reclamation phases of the project.

The construction of the plant site facilities will create new drainage swales. Grading in areas to be filled will produce new embankment slopes. New embankments will be elevated above the original ground elevation and be similar in slope as surrounding topographic features. Resulting contours will be more regular than some of the original ground surfaces.

During site reclamation, removal of above-ground structures in the plant site will be followed by restoration of the land surface to more natural contours. Reclamation of the site will include above-ground structure removal, salvaging topsoil, grading to achieve final contours, maintaining established drainage patterns, replacing topsoil and seeding regraded areas to provide erosion control. Shafts and other underground openings will be plugged with concrete during final reclamation to prevent access to the mine. The creation of the restored landforms and the reshaping of the intrinsic landscape will resemble the original ground surface topography and result in minimal long-term impacts.

The proposed mining methods described in Sections 4.8 and 4.9 of the *Mine Permit Application* (Foth & Van Dyke, 1995d) including stoping sequence and dimensions, as well as backfill properties and placement procedures, will minimize the potential for subsidence. Based on the studies carried out by Smith Engineering (1979) and Dynatec Mining Limited (1982), the proposed mining activities would cause a maximum surface elevation subsidence of 6 inches assuming a 30-foot crown pillar were left in place. Current mining plans propose a 100-foot crown pillar, which will lessen this potential impact considerably. Any change in surface elevation due to subsidence will be limited to the area immediately above the ore mining areas and would extend less than 400 feet to the north or south of the orebody (Smith Engineering, 1979).

The total area disturbed by the TMA, reclaim pond, sedimentation ponds, and adjacent borrow area will be approximately 355 acres. No disturbance to the existing land forms or vegetation will occur outside this area. When completed, the TMA will consist of four ponds excavated from approximately 10 feet to approximately 100 feet below the existing ground surface. When constructed, the top of the embankments will vary from approximately 15 feet below grade to approximately 100 feet above grade. The impacts during construction will be temporary because construction of each cell is to be accomplished over two construction seasons with erosion control and reclamation activities being performed as construction progresses. When the grades of the embankments have been established, herbaceous plant species (grasses and legumes) will be planted to stabilize the soil surface. A fence will be erected around the TMA perimeter near the compliance boundary.

Detailed drawings of the TMA and a discussion of its construction, including dimensions of the cells, landscape disturbance and erosion control are presented in the project's *TMA Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995e). The Reclamation Plan in the *Mine Permit Application* (Foth & Van Dyke, 1995d) contains further information on the physical and vegetation aspects of initial reclamation of this facility during the construction phase. An assessment of the potential visual impacts of the TMA in relation to the surrounding undisturbed environment and mitigative measures are presented in section 4.2.12 of this EIR.

The Reclamation Plan as described in Section 5 of the *Mine Permit Application* (Foth & Van Dyke, 1995d) for the TMA includes landscaping of the topcover to resemble intrinsic landforms, establishing suitable drainage patterns, and revegetation for erosion control. The reclaimed TMA area will have a maximum height ranging from approximately 15 to 50 feet

4.2.7 Wetlands

The following discussion of wetland impacts has been divided into three sections; construction impacts, operation impacts and post-operation impacts. A summary of wetland impacts is presented in Table 4.2.7-9 at the end of this section. Construction impacts are direct physical impacts resulting from earthmoving activities during the construction of the various mine facilities. Construction impacts will result in a quantifiable physical loss of jurisdictional wetlands or, as in the case of utility installation, temporary disturbances. The reduction in wetland acreage or temporary disturbance due to project construction will not occur simultaneously at one point in time, but will occur in phases over a period of several years. These phases are described in Section 2 of this report and in the project's *Mine Permit Application* (Foth & Van Dyke, 1995d). For the purposes of this impact assessment, however, these phases are treated collectively.

Operation impacts will occur during the 28 year mine operation period and result from changes in topography and surface drainage to facilitate mine operation, and from changes in groundwater levels as a result of mine inflow. Wetland impacts during the operation period will not result in a quantifiable physical loss of wetland area but may result in changes in wetland plant and animal communities.

Once operations are complete, the mine site and TMA will be reclaimed as described in Section 2 above and in the project's *Mine Permit Application* (Foth & Van Dyke, 1995d). Wetland impacts during the post-operation period will result from final topographic changes within the watersheds of some wetlands and development of the final site drainage features. As with the operation impacts, quantifiable physical impacts will not occur but some changes in the wetland plant and animal communities existing at that point in time may occur.

A wetland water budget model as described in Appendix 4.2-5 was used to estimate the surface water losses/gains to plant site and TMA wetlands for both the operation and the post-operation periods.

4.2.7.1 Construction Impacts

Of the wetlands that were mapped, inventoried, and evaluated in the study area, 25 will be directly impacted through partial or total reduction in size during construction of the plant site, TMA and reclaim pond, plant site access road, TMA access road/tailings pipeline corridor, and railroad spur. Figure 3.10-1 in Section 3 above illustrates the relationship of potentially affected wetlands to the proposed project facilities.

As described in Table 4.2.7-1 the 25 affected wetlands include 0.34 acres of emergent marsh, 3.60 acres of shrub swamp, 9.96 acres of deciduous swamp, 15.30 acres of coniferous swamp, and 0.06 acres of bog. Impacts to these wetlands were assessed on the basis of the raw unnormalized scores that were calculated for each of the 178 wetlands in the Wetland Function Model described in Appendix 3.10-2. The scores associated with those wetlands that will be directly impacted are presented in Table 4.2.7-2. The Wetland Function Model was not applied to the three unnamed wetlands due to their small size.

The range of model scores for the 178 wetlands in the study area was 142 to 794 and the mean was 470. Wetlands with scores higher than the model mean were considered to be more important in function than other wetlands in the study area. Therefore, in this evaluation, the relative impact of the project on wetlands is considered to be greater to a higher scoring wetland when compared to another wetland with a lower model score. The wetland functions considered included: biological, hydrologic support, groundwater, storm and flood water storage, shoreline protection, water quality maintenance, cultural/economic, recreational, aesthetics and education. A discussion of the direct impacts resulting from each of the proposed surface facilities are presented in the following paragraphs.

4.2.7.1.1 Plant Site

Construction of the proposed plant site will result in direct impacts to wetland 5. This 0.01-acre isolated depression will be totally filled. Due to wetland 5's very small size and isolated nature, it has a low potential to provide valuable wetland functions and, therefore, scored below average at 361.

Table 4.2.7-1

Acreages of Wetland Types Removed During Project Construction

Wetland No.	Wetland Types: Emergent Marsh	Shrub Swamp	Deciduous Swamp	Coniferous Swamp	Bog	Total Area Impacted
Plant Site						
5	0.01					0.01
Subtotal Plant Site	0.01					0.01
Tailings Management Area & Surrounding Facilities[1]						
F30[2]			0.02			0.02
F31			2.16	4.29		6.45
F32			0.68			0.68
F33			1.82			1.82
F66		2.54		4.64		7.18
F81	0.33					0.33
13			0.07			0.07
14			0.06			0.06
15			0.14			0.14
16			0.10			0.10
17			0.54			0.54
M4			1.06			1.06
M3			1.82	1.60		3.42
Unnamed (3)			0.89			0.89
Subtotal TMA	0.33	2.54	9.36	10.53		22.76
Access Road Corridor						
W1				2.32		2.32
W2		0.24				0.24
Z6				0.44		0.44

Table 4.2.7-1 *(Continued)*

Wetland No.	Wetland Types: Emergent Marsh	Shrub Swamp	Deciduous Swamp	Coniferous Swamp	Bog	Total Area Impacted
Z7			0.28			0.28
Z9			0.32			0.32
Subtotal Access Road Corridor		0.24	0.60	2.76		3.60
TMA Access Road/Tailings Pipeline Corridor						
F11				0.50		0.50
Subtotal TMA Access Road/Tailings Pipeline Corridor				0.50		0.50
Railroad Spur Corridor						
T1					0.06	0.06
T4		0.82		1.51		2.33
Subtotal Railroad Spur Corridor		0.82		1.51	0.06	2.39
TOTAL	0.34	3.60	9.96	15.30	0.06	29.26

[1] Includes TMA, TMA borrow area, reclaim pond, perimeter road, exterior drainage system, and runoff basins.
[2] Wetland F30 is classified as a "streamside wetland" (SW) in Table 5-2 of the project's *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995b). The impacted portion of this wetland is dominated by deciduous swamp.

Prepared by: BDH
Checked by: JWS

Table 4.2.7-2

Unnormalized Functional Values Model Results for Wetlands Directly Impacted by the Crandon Project

Wetland No.	Biological	Hydrologic Support	Groundwater	Storm and Flood Water Storage	Shoreline Protection	Water Quality Maintenance	Cultural/ Economic	Recreational	Aesthetics	Education	Total
Z7	79	41	56	72	7	51	19	25	19	7	376
Z6	95	58	61	103	0	75	57	42	34	18	543
Z9	102	52	59	95	19	70	51	38	28	10	524
W2	102	57	56	96	19	79	51	38	31	10	539
W1	101	59	64	99	19	79	51	42	31	10	555
5	53	40	29	87	0	60	31	20	31	10	361
F11	78	48	42	100	0	73	57	42	31	15	486
13	44	8	33	86	0	58	37	24	31	15	336
14	47	12	33	86	0	56	37	28	31	15	345
15	44	8	33	86	0	58	37	24	31	15	336
F30	53	22	30	56	4	36	11	21	27	7	267
F31	83	48	31	98	0	69	51	38	34	10	462
F32	53	8	29	91	0	63	31	20	28	7	330
F81	58	20	29	77	4	50	17	24	37	15	331
16	48	8	33	86	0	58	31	24	31	15	334
F33	52	39	32	82	0	54	39	26	28	7	359
17	60	8	33	90	0	61	31	20	34	10	347

Table 4.2.7-2 *(Continued)*

Wetland No.	Biological	Hydrologic Support	Groundwater	Storm and Flood Water Storage	Shoreline Protection	Water Quality Maintenance	Cultural/ Economic	Recreational	Aesthetics	Education	Total
M3	73	44	28	98	0	68	39	31	31	10	422
M4	57	8	29	85	0	59	31	23	36	7	335
F66	94	48	33	99	0	68	51	38	31	10	472
T1	72	12	53	94	0	66	37	28	45	15	422
T4	118	65	62	96	17	84	54	55	37	14	602
Model Range[1]	29-158	6-67	20-68	29-123	0-32	18-98	11-87	10-71	9-66	7-24	142-794
Model Mean[1]	93	36	44	76	17	58	54	40	37	15	470

Note: Functional values were not assessed for the three unnamed wetlands due to their small size.
[1]Model range and mean for all 174 wetlands accessed in the study area.

Prepared by: RFS
Checked by: PAE

4.2.7.1.2 Tailings Management Area and Surrounding Facilities

Wetlands F30, F31, F32, F81, 13, 14, 15, 16, 17, F33, M4, M3, F66 and three unnamed wetlands will be directly impacted by the construction of the proposed TMA, TMA borrow area, reclaim pond, perimeter road, exterior drainage system, and runoff basins, herein after for the purposes of the wetland impact discussion referred to as the TMA. Only portions of wetlands F66, M3 and M4 will be directly impacted as a result of TMA construction. As described in *Addendum No. 1 to the May 1995 Crandon Project Tailings Management Area Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1996a), special construction techniques will be employed as required to protect the remaining portions of these wetlands. A silt fence will be installed across the wetland prior to construction. A cutoff wall, if required, will then be installed to hydraulically separate the wetland from the TMA. The TMA perimeter road will then be constructed on fill placed into the wetland. The perimeter road and cutoff wall, if installed, will then act as a barrier for any additional impact to these wetlands.

Wetland F30

Wetland F30 was previously classified as a "streamside" wetland. This wetland, totaling 0.02 acres, is a poorly defined channel through a wet deciduous forest connecting wetland F31 to F29. Wetland F30 scored below the model mean for all functional values with a total score of 267. This wetland will be totally filled.

Wetland F31

Wetland F31 consists of approximately 4.29 and 2.16 acres of coniferous and deciduous swamp, respectively, and will be totally filled as a result of the construction of the TMA. This wetland is situated in a semi-closed basin at the uppermost point in a chain of wetlands that ultimately drain to Duck Lake. Wetland F31 outlets through wetland F30 into wetland F29 which is directly connected to the wetland system surrounding Duck Lake. From a functional values standpoint, wetland F31 was scored as average for wetlands in the study area with a total score of 462. This wetland scored above the model mean for hydrologic support, storm and floodwater storage, and water quality maintenance. The position of wetland F31 at the headwaters of a series of hydrologically connected wetlands is the primary reason for the high scores in these functions. All other functions were scored below the model mean.

Wetlands 13, 14, 15, 16, 17, M4, F32, F33, F81, Three Unnamed Wetlands

Each of these wetlands, as well as three unnamed wetlands within the boundaries of the proposed TMA, share a number of characteristics and are therefore discussed together. With the exception of wetland M4, all of these wetlands will be entirely filled resulting in a direct impact of 5.69 acres as a result of the construction of the TMA. Approximately 0.31 acres of wetland M4 will remain. These wetlands are all small, ranging in size from less than one-tenth of one acre to 1.82 acres. With the exception of a small area of marsh (0.33 acres) in wetland F81, these wetlands are classified as deciduous swamp. All of these wetlands scored below the model mean (Table 4.2.7-2). However, average to slightly above average scores for the storm and flood water storage function were calculated for wetlands F32, F81, F33 and M4. These wetlands are depressions in the upper reaches of their watershed and therefore have capacity to store stormwaters prior to discharge to downgradient waterbodies or wetlands. Wetland F32 and M4 also received slightly above average scores for the Water Quality Maintenance function. With the exception of the functional values

associated with wetland M4, these functional values will be lost. The capacity of wetland M4 to provide wetland functional values will be reduced as a result of project construction.

Wetland M3

Wetland M3 is one of three wetlands (including M1 and M2) in a connected system that flows into Hemlock Creek. The TMA will directly impact 3.42 acres (76 percent) of this 4.51-acre mixed deciduous/coniferous forested wetland. The impacted portion is dominated by lowland conifers. This wetland occurs at the top of the watershed and intermittently contributes flow to wetland M2, M1 and ultimately Hemlock Creek. The total model score for this wetland is 422 which is slightly below the model mean. Above average scores, however, were assessed for the hydrologic support, storm and flood water storage and water quality maintenance functions due to this wetland's position at the top of the watershed and its storage capacity. The capacity of wetland M3 to continue to provide these wetland functional values will be reduced as a result of project construction.

Wetland F66

Wetland F66 is the uppermost wetland in a series of connected wetlands that ultimately drain into Deep Hole Lake. This wetland is predominantly a conifer swamp. The construction of the TMA will result in the filling of 7.18 acres (45 percent) of this 16.1-acre wetland. The total model score for wetland F66 was 472 which is slightly above the model mean. This wetland is surrounded by mixed northern forest, contains favorable edge and life form variability, and is part of a wetland corridor extending from Deep Hole Lake approximately 1.5 miles to the northeast. As such, the biological function was assigned a score above the model mean. The hydrologic support, storm and flood water storage and water quality maintenance functions were also scored above average largely based on this wetland's relative large size and juxtaposition at the uppermost point in a series of connected wetlands. The filling of slightly less than one-half of this wetland will reduce its capacity to continue to provide these functional values. The biological function will be impaired as a result of direct habitat loss. The reduction in size of this wetland will also reduce its capacity to provide the hydrologic support, storm and floodwater storage and water quality maintenance functions.

4.2.7.1.3 Access Road

The proposed access road will traverse Wetlands Z7, Z6, Z9, W2 and W1 resulting in a direct impact of 3.6 acres.

Wetland Z7

Wetland Z7 consists of a 3.89-acre linear strip of deciduous swamp bordering an ephemeral stream. The total wetland functional value score for this wetland was below the model average (Table 4.2.7-2). Structural variability, vegetative interspersion and amount of edge habitat are low in this wetland resulting in a below average biological function score. The isolation of this wetland resulted in below average scores for the cultural/economic, recreational, aesthetics and education functions. Low storage capacity and a relative low water balance resulted in low hydrology function scores. The proposed access road will cross this wetland at one point resulting in a direct impact of 0.28 acres (7.2 percent) of wetland. Due to the relative small size

of the direct impact to this wetland, the loss to wetland functional values associated with the proposed access road crossing is expected to be negligible.

Wetlands Z6 and Z9

Wetlands Z6 and Z9 are both mixed coniferous/deciduous forested wetlands contiguous with, and upgradient of wetland W2. Small ephemeral streams flow in and out of these wetlands. Wetland Z6 totals 44.68 acres. Wetland Z9 totals 9.54 acres. Both wetlands have high total wetland functional value scores with individual high scores for the biological and all of the watershed functions. The proposed access road will result in a direct impact to 0.44 (1 percent) and 0.32 (3.3 percent) acres of wetlands Z6 and Z9, respectively. The loss to wetland functional values associated with the proposed access road crossings is expected to be negligible. The watershed functions will be maintained through the installation of culverts sized to accommodate existing and expected flows. Due to the relative small size of the direct impacts to these wetlands, the biologic functions should not be impaired.

Wetland W2

Wetland W2 is a 78.47-acre conifer swamp contiguous with, and upstream of, Wetland W1. Two small intermittent tributaries to Swamp Creek flow through wetland W2. A small shrub swamp component exists along these streams. The total wetland functional value score for this wetland was well above the model average at 539. The vegetative characteristics of this wetland provide good wildlife habitat and opportunities for socio-cultural uses. A large water storage capacity exists and the wetland also provides a buffer to waters flowing to Swamp Creek.

The proposed access road will cross this wetland at its narrowest point at a location characterized as shrub swamp. A total of 0.24 acres (0.3 percent) of this wetland will be directly impacted. No significant impact to wetland functional values is expected due to this impact.

Wetland W1

Wetland W1 is a 503.1-acre wetland located largely within the floodplain and adjacent riparian zone associated with Swamp Creek. This wetland is predominantly a conifer swamp with a variable width shrub swamp and marsh component along the immediate Swamp Creek floodplain. For many of the same reasons stated for wetland W2, this wetland was assigned a total wetland functional value score well above average at 555. Four state species of concern plants, including sheathed sedge (*Carex vaginata*), sparse-flowered sedge (*C. tenuiflora*), northern black currant (*Ribes hudsonianum*), and American yew (*Taxus canadensis*) were observed throughout the portions of this wetland dominated by conifers. Mountain cranberry (*Vaccinium vitus-idaea*), a state endangered plant, was observed in an opening of alder within the conifer swamp matrix in the southwestern portion of this wetland.

The proposed access road will cross this wetland, bridging across Swamp Creek, resulting in the filling of 2.32 acres (0.46 percent). None of the above listed plant species were observed in this portion of Wetland W1. Due to the relative small size of the direct impact to this wetland, the loss to wetland functional values associated with the proposed access road crossing are expected to be negligible.

4.2.7.1.4 TMA Access Road/Tailings Pipeline Corridor

The construction of the TMA access road will result in clearing a 0.50-acre corridor through the 18.37-acre F11 wetland. This wetland is classified as a conifer swamp and is hydrologically connected to wetland F10 by a poorly defined channel and ultimately drains into Little Sand Lake. This hydrologic connection coupled with the wetland's relative large size and dominant wetland class resulted in an above average total Wetland Functional Model score (Table 4.2.7-2). The hydrologic support, storm and flood water storage and water quality maintenance functions all scored above average. This wetland also scored above average for the cultural/economic and recreational functions because of the dominant wetland class, large size and location adjacent to a public roadway (i.e., Sand Lake Road). The TMA access road/tailings pipeline corridor will be constructed in such a way as to allow water to pass at a rate and frequency equal to the existing conditions. Further, since less than 3 percent of this wetland will be impacted, the functional values of this wetland will be retained.

4.2.7.1.5 Railroad Spur

Wetland T1 and T4 will be impacted by the proposed railroad spur resulting in a total of 2.39 acres of direct wetland impact.

Wetland T1

Wetland T1 is a 1.66-acre bog located in an isolated depression bounded by Keith Siding Road to the north, the Wisconsin Central Limited Railroad to the east and agricultural lands to the south and west. This wetland's total wetland functional value score of 422 is slightly below the model mean. The biological function potential is reduced due to its location adjacent to two transportation corridors and the fact that this wetland is, in effect, an island in an agricultural matrix. This location, however, resulted in an above average score for the aesthetic function. Only 0.06 acres of the eastern edge of this wetland will be directly impacted. Although it will be reduced in size, its most significant function (i.e., aesthetics) should remain intact.

Wetland T4

Wetland T4 is a 199.02-acre conifer swamp within the floodplain of Swamp Creek and two small tributaries to Swamp Creek. The total wetland functional value score of 602 for this wetland is one of the ten highest scores for wetlands in the study area. This wetland is surrounded by mixed northern hardwood forest and contains a high variety of plant species and a large amount of edge habitat. It provides a water quality buffer to Swamp Creek and is also part of a contiguous wetland corridor along Swamp Creek extending nearly from Swamp Creek's origin in Lake Lucerne to STH 55. The location adjacent to Swamp Creek also adds value to the recreational, aesthetic, and educations functions of this wetland.

Wetland T4 will be crossed by the proposed railroad spur three times, resulting in a direct impact of 2.33 acres (1.2 percent) of the total wetland area. No significant impacts to wetland functional values are expected.

4.2.7.1.6 Utilities

Approximately 0.71 acres of wetlands will be temporarily disturbed as part of the construction of the Wisconsin River wastewater discharge pipeline in the access road corridor. As part of pipeline installation, the temporarily disturbed wetlands will be restored through grading to near original contours and through seeding and implementation of erosion control procedures as specified in Section 4.10 of the Crandon Project's May 1995 *Mine Permit Application* (Foth & Van Dyke, 1995d). The disturbed wetland areas are expected to recover within a few years to near original condition.

In addition, between 8.1 and 13.1 acres of temporary wetland disturbance will result due to the installation of the proposed Wisconsin River wastewater discharge pipeline beyond the access road corridor. Temporary impacts will also result due to the installation of the natural gas pipeline, and the installation of the electric transmission line. These impacts will be similar to those described in the above paragraph. Wetland recovery in a short period of time is expected for these temporary disturbances. Wetland impacts resulting from the construction of the Wisconsin River wastewater discharge pipeline are described in the Appendix 3-2 of this EIR. Wetland impacts relating to installation of the electric transmission line are being addressed by the Wisconsin Public Service Commission as part of its environmental assessment of Wisconsin Public Service Corporation's application for a Certificate of Public Convenience and Necessity.

4.2.7.1.7 Construction Impact Summary

A total of 29.26 acres, representing portions of 25 wetlands, will be directly impacted as a result of the proposed action. The 29.26 acres represent approximately 1.4 percent of the wetlands in the study area. These wetlands include 0.34, 3.60, 9.96, 15.30 and 0.06 acres of emergent marsh, shrub swamp, deciduous swamp, coniferous swamp and bog, respectively. Wetlands F33, 17, 16, F31, F81, F32, 5, 13, 14, and 15 will be entirely filled or excavated. Only portions of the remaining 15 wetlands will be impacted.

Each individual impacted wetland represents a unique set of associated functional values (Table 4.2.7-2). However, the project's overall impact to wetland functional values cannot be easily assessed by an individual wetland's functional value scores. Each wetland is variable in size, degree of impact, and potential to provide each of the ten assessed functional values.

Since the scores associated with each of the ten functions are not directly comparable (i.e., each of the ten functional models resulted in ranges of scores unique to that model), the scores for each function were assigned a rank of "high", "medium" or "low" values corresponding to a 3, 2, or 1, respectively. To determine which of the ten functional values is the most important to the wetland acreage directly impacted, the modified functional value scores for each function and each wetland were weighted by the percent of total impact each individual wetland represents. The weighted scores for each wetland function were then summed to determine which wetland function will be impacted to the greatest degree. The results are presented in Table 4.2.7-3. The greatest functional loss to wetlands associated with the proposed action will be to storm and floodwater storage followed by the water quality and hydrologic support functions. Wetlands F66, F31, M3 and T4 represented the greatest direct impacts (i.e., 24.5, 22, 11.7 and 8 percent of the total wetland impact, respectively) and, therefore, contributed the most to these results.

Table 4.2.7-3

Weighted Functional Value Model Results for Wetlands Directly Impacted by the Crandon Project

Wetland No.	Percent of Total Impact	Biological		Hydrologic Support		Groundwater		Storm and Flood Water Storage		Shoreline Protection		Water Quality Maintenance		Cultural and Economic		Recreational		Aesthetics		Education	
		Rank(1)	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted	Rank	Weighted
Z7	1.0	2	2	2	2	2	2	2	2	1	1	2	2	1	1	1	1	1	1	1	1
Z6	1.5	2	3	3	4.5	3	4.5	3	4.5	0	0	3	4.5	2	3	2	3	2	3	2	3
Z9	1.1	2	2.2	2	2.2	3	3.3	3	3.3	2	2.2	2	2.2	2	2.2	2	2.2	2	2.2	2	2.2
W2	0.8	2	1.6	3	2.4	2	1.6	3	2.4	2	1.6	3	2.4	2	1.6	2	1.6	2	1.6	2	1.6
W1	7.9	2	15.8	3	23.7	3	23.7	3	23.7	2	15.8	3	23.7	2	15.8	2	15.8	2	15.8	2	15.8
5	0.03	1	0.03	1	0.03	1	0.03	1	0.03	0	0	1	0.03	1	0.03	1	0.03	1	0.03	1	0.03
F11	1.7	2	3.4	2	3.4	2	3.4	3	5.1	0	0	3	5.1	2	3.4	2	3.4	2	3.4	2	3.4
13	0.2	1	0.2	1	0.2	1	0.2	1	0.2	0	0	1	0.2	1	0.2	1	0.2	1	0.2	1	0.2
14	0.2	1	0.2	1	0.2	1	0.2	1	0.2	0	0	1	0.2	1	0.2	1	0.2	1	0.2	1	0.2
15	0.5	1	0.5	1	0.5	1	0.5	1	0.5	0	0	1	0.5	1	0.5	1	0.5	1	0.5	1	0.5
F30	0.1	1	0.1	2	0.2	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1	1	0.1
F31	22.0	2	44	2	44	2	44	3	66	0	0	2	44	2	44	2	44	2	44	2	44
F32	2.3	1	2.3	1	2.3	2	4.6	3	6.9	0	0	2	4.6	1	2.3	1	2.3	1	2.3	1	2.3
F81	1.1	1	1.1	2	2.2	2	2.2	2	2.2	1	1.1	2	2.2	1	1.1	1	1.1	2	2.2	2	2.2
16	0.3	1	0.3	1	0.3	1	0.3	0	0	0	0	1	0.3	1	0.3	1	0.3	1	0.3	1	0.3
F33	6.2	1	6.2	2	12.4	2	12.4	2	12.4	0	0	2	12.4	2	12.4	1	6.2	1	6.2	1	6.2
17	1.8	1	1.8	1	1.8	1	1.8	0	0	0	0	1	1.8	1	1.8	1	1.8	1	1.8	1	1.8
M3	11.7	2	23.4	2	23.4	1	11.7	3	35.1	0	0	2	23.4	2	23.4	2	23.4	2	23.4	2	23.4
M4	3.6	1	3.6	1	3.6	2	7.2	2	7.2	0	0	2	7.2	1	3.6	1	3.6	2	7.2	1	3.6
F66	24.5	2	49	2	49	2	49	3	73.3	0	0	2	49	2	49	2	49	2	49	2	49
T1	0.2	2	0.4	1	0.2	1	0.2	3	0.6	0	0	2	0.4	1	0.2	1	0.2	3	0.6	2	0.4
T4	8.0	3	24	3	24	3	24	3	24	2	16	3	24	2	16	3	24	2	16	2	16
			185.1		202.5		196.9		269.7		37.8		210.2		182.1		183.9		181		177.2

Note: Functional values were not assessed for the three unnamed wetlands due to their small size.
(1) 0 = function not applicable, 1 = low, 2 = medium, 3 = high

Prepared by: RFS
Checked by: BDH
Revised by: JWS

In addition to the direct construction impacts, temporary impacts totalling between 8.8 and 13.8 acres will occur as a result of the construction of the Wisconsin River wastewater discharge pipeline. The temporarily disturbed wetland areas are expected to recover within a few years to near original conditions.

The product of the above analysis is the data that has been used to select and design the wetland compensation site discussed in Section 8 of the project's *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995b).

4.2.7.2 Operation Impacts

Wetland impacts during the 28-year mine operation period will occur as a result of changes in groundwater elevations caused by mine inflow, topographic and land use changes within the watersheds which affect surface water flowing to some wetlands, and changes in surface drainage patterns as a result of the installation of required sedimentation basins. Although exact wetland responses to changes in available moisture levels cannot be determined, qualitative estimates can be made as to the probable impacts. Changes in water regime will likely be manifested in the form of changes in the existing plant communities. Herbaceous vegetation is quick to respond to changes in inundation frequency, duration and water level. Woody vegetation, however, tends to reflect long-term trends in these parameters, often becoming established or killed during extreme drought or high water but tolerant of a wide range of conditions in between (Carter, 1986). Thibodeau and Nickerson (1985), in a controlled experiment resulting in both increases and decreases in moisture levels in a shrub swamp, found that the largest changes associated with decreases in moisture levels occurred within the first two years. Both the numbers of plant species and numbers of individual plants increased in the drained area. Effects from increases in water levels occurred more slowly, with the most pronounced effects occurring after five years. In the area with increased water levels, some plant species were extirpated and new species were slow to colonize the area.

As described in Section 3.6.4.3.2 and shown in Table 3.6-22, the wetlands in the study area have been divided into four hydrologic categories: Type 1 recharge wetlands, Type 2 recharge wetlands, Type 3 recharge wetlands and discharge wetlands. Type 1 recharge wetlands are separated from the underlying groundwater system by an unsaturated zone and, therefore, will not be subjected to impacts from mine inflow. The water budgets of Type 1 recharge wetlands are driven by surface water sources and direct precipitation. The remaining categories of wetlands have some degree of connection to the underlying groundwater system or are laterally connected to a surface water body. The water budgets of these categories of wetlands are governed by both surface water sources, precipitation and groundwater conditions. As a result, the following discussion of operation impacts treats those wetlands affected only by precipitation and surface water sources separately from the remaining three categories of wetlands.

4.2.7.2.1 Type 1 Recharge Wetlands

Type 1 recharge wetlands will only be affected by changes in surface water flow patterns and rates. Mine inflow will not affect this category of wetland. The degree of effect to these wetlands is expected to be commensurate with the estimated magnitude of change in surface water runoff volume. The impacts to Type 1 recharge wetlands associated with each of the proposed project facilities are discussed in the following paragraphs.

Access and Railroad Corridors

The site access road, TMA access road and railroad spur will traverse several wetland watersheds. These facilities have been designed to allow surface waters to flow unimpeded without any upstream or downstream changes in flow rates or timing. As a result, these facilities will not likely have an impact on wetland surface water hydrology.

Plant Site

As shown in Figure 4.2.7-1, the plant site comprises portions of the watersheds of each of the following Type 1 recharge wetlands: P2, O3, 11, 12, F116, 6, 8, 9, 10, and R7A. The need to route contact runoff to the wastewater treatment facility during the approximate 28-year mine operations period will result in the temporary loss of surface runoff from 61 acres of lands from these watersheds. Runoff from the remainder of the plant site will be routed through runoff basins prior to release to natural on-site drainageways. The wetland water budget model described in Appendix 4.2-5 was used to estimate the surface water losses/gains to these wetlands. The applicable results are presented in Table 4.2.7-4.

Surface water volume decreases ranging from 66 to 87 percent are estimated for wetlands 8, 11 and 12. These are forested wetlands of less than one-acre each. Existing mature trees in these wetlands should be able to withstand the decreased moisture levels. Over time, herbaceous vegetation better adapted to drier conditions may encroach in areas where sunlight is available. Although the vegetative communities may slowly change, the physical character of these wetlands should not change substantially. As a result, their functional values should not change.

A 94 percent decrease in surface water volumes is estimated for wetland 9, a 0.19-acre shallow marsh. This wetland will likely take on upland characteristics through the encroachment of shrubs, and ultimately trees adapted for drier conditions. The existing wetland functional values, although low due to this wetland's small size, will likely be lost during the operation phase.

A 41 percent increase in surface water runoff volumes is estimated for wetland F116, a 0.79-acre conifer swamp. The aerial extent of this wetland may increase slightly and it is possible that the existing vegetation community will change somewhat over the 28-year mining phase. Some of the existing trees may die-off and a vegetative community better adapted to increased sunlight and moisture may become established.

A 31 percent decrease in surface water runoff is estimated for wetland 10, a 1.41 acre conifer swamp. The existing forest cover in wetland 10 will not likely change, however, the herbaceous vegetation may experience a slight shift in community type during the operation of the plant site.

The remaining Type 1 recharge wetlands with drainage basins within the boundaries of the plant site (i.e., P2, O3, 6, and R7A) will experience decreases in surface water runoff ranging from five to 21 percent. These wetlands will not likely change noticeably from the minor changes in their water budgets.

Table 4.2.7-4

Plant Site Wetland Surface Water Runoff Volume Comparison Existing Conditions to Operation Conditions

Wetland	Classification	Percent Change in Runoff Volume
P2	Type 1 Recharge	- 21
O3	Type 1 Recharge	- 19
11	Type 1 Recharge	- 76
12	Type 1 Recharge	- 66
F116	Type 1 Recharge	+41
6	Type 1 Recharge	- 8
8	Type 1 Recharge	- 87
9	Type 1 Recharge	- 94
10	Type 1 Recharge	- 31
F11	Type 3 Recharge	+ 4
F119	Type 3 Recharge	+97
R7A	Type 1 Recharge	- 5

Prepared by: RFS
Checked by: JWS

TMA

In general, the TMA will be constructed in four cells (i.e., TMA 1, TMA 2, TMA 3 and TMA 4) over a 28-year period. Each cell will have two stages. During the operation of an individual stage (i.e., a time period lasting between 4 and 5 years), surface drainage will be internal and, therefore, not available for the downgradient wetlands. As each subsequent cell is developed, the previous cell will be reclaimed and drainage will be reestablished. As shown in Figure 4.2.7-2, the TMA comprises portions of the watersheds of the following Type 1 recharge wetlands: F15, F66, M3 and M4. Impacts to these wetlands will not occur simultaneously, but will occur according to the TMA construction schedule summarized in Section 2 of this EIR and described in detail in the Reclamation Plan included in the project's *Mine Permit Application* (Foth & Van Dyke, 1995d), and its *TMA Feasibility Report/Plan of Operation* and Addenda (Foth & Van Dyke, 1995e, 1996a, 1996b, 1997).

Appendix 4.2-5 contains an analysis comparing the existing surface water runoff to that which will occur during the operation of each TMA stage for the wetlands affected by TMA operation. Table 4.2.7-5 provides a summary of the results from this analysis.

As shown in Table 4.2.7-5, during operations, the Type I recharge wetlands downgradient of the TMA will experience both increases and decreases in surface water runoff. These surface water changes could occur for a long enough period of time to potentially result in changes in the herbaceous vegetation growing in these wetlands.

Table 4.2.7-5

TMA Wetland Surface Water Runoff Volume Comparison
Existing Conditions to Operation Conditions

		Runoff in Ac-Ft							
			TMA Stage[1]						
Wetland	Classification	Existing Conditions	1 (3 yrs)	2 (3 yrs)	3 (4 yrs)	4 (6 yrs)	5 (2 yrs)	6 (4 yrs)	7 (2 yrs)	8 (4 yrs)
F29	Type 2 Recharge	41.65	29.30	28.17	24.60	33.26	33.26	43.80	43.80	43.80
	% Change		-29.6	-32.4	-40.9	-20.1	-20.1	+5.1	+5.1	+5.1
F15	Type 1 Recharge	42.22	47.33	43.43	42.54	41.80	41.80	48.52	41.53	41.53
	% Change		+12.1	+2.9	+0.8	-1.0	-1.0	+14.9	-1.6	-1.6
F66	Type 1 Recharge	23.70	22.78	15.49	15.49	21.01	20.32	17.75	17.75	26.38
	% Change		-3.9	-34.6	-34.6	-11.4	-14.3	-25.1	-25.1	+11.3
M3	Type 1 Recharge	10.65	10.65	10.65	10.65	9.70	10.89	6.15	6.59	12.22
	% Change		—	—	—	-8.9	+2.2	-42.2	-38.1	+14.7
M1	Type 3 Recharge	31.04	31.04	31.04	31.04	30.09	31.28	26.54	26.98	32.61
	% Change		—	—	—	-3.1	+0.8	-14.5	-13.1	+5.1
M4	Type 1 Recharge	4.79	4.79	4.79	4.79	4.79	4.79	4.02	4.02	1.86
	% Change		—	—	—	—	—	-16.1	-16.1	-61.2

[1]Years represent approximate time over which the condition will occur.

Prepared by: RFS
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Revised by: JWS

For the first approximate 3 years of TMA operation (i.e., TMA Stage I) wetland F15 will receive approximately 12 percent additional surface water runoff. A similar condition will exist (i.e., 14.9 percent additional runoff) approximately 18 years later in TMA Stage VI. With the exception of these two stages of TMA operation, however, runoff to wetland F15 is predicted to be within 2.9 percent of existing conditions. It is unlikely that changes of less than 2.9 percent would have any affect on this wetland. Stages I and VI, however, may result in some minor changes in the composition of the vegetative community in the wetland. These affects will likely be most evident in the herbaceous layer with no affect on most of the tree layer. The functional values of this wetland should remain unchanged from existing conditions.

When compared to existing conditions, it is estimated that wetland F66 will receive between 3.9 and 34.6 percent less surface water runoff for a time period spanning up to approximately 24 years (i.e., TMA stages I-VII). During the last TMA stage, an approximate 4 year period, surface water runoff will increase 11.3 percent over existing conditions. As described in Section 4.2.7.1, wetland F66 is a forested wetland that will be partially taken during TMA construction. Likely the forest community remaining in this wetland and functional values will remain largely unchanged by the TMA operations. However, some changes in the herbaceous community are probable. A population of the State Special Concern *Botrychium simplex* was observed in the portion of F66 that will remain after TMA construction and reclamation. The habitat preference of this species is quite diverse, ranging from dry fields, marsh, bog and swamp to roadside ditches (Flora of North America Editorial Committee, 1993). As a result of this plant's adaptability to a variety of habitats, it may not be affected during TMA operations.

Wetland M3 is a forested wetland that will be partially taken during the construction of the TMA. From a water budget standpoint, the remaining portion of this wetland will receive between 14.7 percent more surface water runoff and 42.2 percent less surface water runoff than it currently receives depending upon the TMA stage in use at a given time. However, since the size of this wetland will be reduced by 76 percent during TMA construction, the net affect will be an increase in surface water runoff ranging from 139 to 375 percent. The remaining portion of wetland M3 will change significantly during the operation of the TMA. An increase in surface water inputs of this magnitude will likely result in a significant change in the existing plant community. This wetlands flood and stormwater storage capactity will be reduced during construction. Increased flow during TMA operation will discharge out of wetland M3 at a faster rate and increased volume. As a result, this could have an affect on wetland M1 which is connected to M3 by a natural drainage swale (i.e., wetland M2).

Similar conditions will occur in Wetland M4 during the last stage of TMA operations. TMA construction will result in a loss of 77 percent of this wetland. As a result, the remaining portion of Wetland M4 will receive considerably more surface water runoff than during existing conditions. This will likely result in a significant change in the wetland's plant community.

4.2.7.2.2 Wetlands Hydrologically Connected to the Groundwater System

Unlike Type 1 recharge wetlands, Type 2 and 3 recharge wetlands and discharge wetlands can be affected by groundwater changes associated with mine dewatering as well as changes in surface water contributions.

The important wetland issue associated with mine dewatering and groundwater drawdown is the change in water surface elevation within the root zone of the plants inhabiting the wetlands. For wetland conditions to persist, saturated soil conditions must exist within approximately the upper 18 inches of the soil profile for prolonged periods of time each growing season.

The approach used to estimate the impacts to the groundwater contribution to the water budgets of wetlands is described in Section 4.2.5. This approach considered two scenarios; best engineering judgement and practical worst case. The best engineering judgement scenario reflects the most likely outcome whereas the practical worst case scenario combines a series of events that are very unlikely to occur together, but if combined present the worst possible outcome. Although the results of both scenarios are presented in the following paragraphs, the focus is on the outcome that is most likely to occur, the best engineering judgement scenario.

Type 2 recharge wetlands are different from Type 1 recharge wetlands in that they are laterally connected to lakes and are potentially subject to drawdown impacts due to this connection. Such wetlands are associated with Duck and Deep Hole Lakes (Figure 4.2.7-3). Type 2 recharge wetlands associated with Duck Lake include wetlands F29 and F28. Type 2 recharge wetlands associated with Deep Hole Lake include wetlands F18, F19, F23, F37, F21, and F22. The estimated changes in lake elevation are 0.01 and 0.02 feet for the BEJ scenario for Duck and Deep Hole Lakes, respectively. Changes in the water surface elevation of the associated wetlands can be assumed to mirror these changes and will not result in any noticeable effects to the surrounding wetlands. Under the practical worst case scenario, the lake stage changes are 0.11 and 0.39 feet for Duck and Deep Hole Lakes, respectively. As with the previous scenario, no noticeable impacts are anticipated to the wetlands surrounding Duck Lake or Deep Hole Lake.

With the exception of wetland F29, mine dewatering and the associated groundwater drawdown is the only factor that could impact Type 2 recharge wetlands in the area of the proposed project. A portion of wetland F29's watershed, however, is directly within the limits of the proposed TMA and, therefore, it will also experience a change in surface water contributions. As shown in

Table 4.2.7-5, wetland F29 will experience between 20.1 and 40.9 percent less surface water runoff during the first approximate 18 years of TMA operation. For the last approximate 10 years of TMA operations surface water runoff volumes will recover and actually increase to 5.1 percent over existing conditions. Wetland F29 is predominantly a shrub swamp and a change in surface water runoff volumes of this magnitude will likely result in some changes to the existing vegetative community. The existing shrub component will likely remain, however, and this wetland's functional values are not expected to change substantially during the operation phase.

Type 3 recharge wetlands are head dependent seepage wetlands with generally continuously saturated soils from the wetland surface down to the regional groundwater system. These include the wetlands surrounding Little Sand Lake (F2, F4, F5, F7, F9, and F10) and Skunk Lake (F12). The surface watersheds of these wetlands will not be affected by the proposed project, therefore, no surface water impacts are anticipated. Based on the results of the groundwater modeling studies, water level impacts in these wetlands are estimated to be similar to that of the adjoining lakes. For Little Sand Lake, the lake stage changes are estimated to be 0.07 and 0.48 feet for the BEJ and practical worst case scenarios, respectively. Changes of this magnitude will result in negligible impacts. For Skunk Lake, the estimated lake stage changes are 0.53 and 0.58 feet for the best engineering judgement and practical worst case scenarios, respectively. This may result in a slightly reduced surface area of open water and increased area of emergent marsh. However, the general character of this wetland will remain the same and no significant impacts to the functional values are anticipated.

Wetlands F11, F40, M1, N1, L1, and F119 are additional Type 3 recharge wetlands that are not associated with area lakes. BEJ groundwater drawdown is estimated to be approximately 2 to 3 feet in the vicinity of wetland F40, and less than 1 foot in the vicinity of wetlands M1, N1, and L1. In the vicinity of the F11 and F119 wetlands, BEJ groundwater drawdown is estimated to be greater than 10 feet. Type 3 recharge wetlands are typically underlain by low permeability silt and clay soils. Thus drawdown in these wetlands will be less than that reflected in the groundwater system. For F40 the actual drawdown should be significantly less than 2 to 3 feet. For M1, N1, and L1, the actual drawdown will be significantly less than 1 foot. In addition to the potential groundwater effects, wetland M1, a 1.09-acre shrub swamp wetland, is estimated to experience up to a 13 percent reduction in surface water runoff volumes during the operation phase. This is not expected to result in a noticeable change to this wetland. For wetlands F11 and F119, it is likely that they will change from Type 3 to Type 1 recharge wetlands due to the degree of drawdown in their vicinity. A portion of the watershed of wetland F119 is located within the proposed plant site. As shown in Table 4.2.7-4, 97 percent increase in surface water runoff volume is estimated for this 1.11 acre conifer swamp as a result of the slightly changed grades during the operation period. The aerial extent of jurisdictional wetland may increase and it is very likely that the existing vegetation community will change over the 28-year mine operation phase. The effect will be similar to that observed in flooded areas behind beaver dams where many of the existing trees may die-off and a vegetative community better adapted to increased sunlight and moisture becomes established. This will result in an improved biologic function during the operation phase. The other wetland functional values will likely remain unchanged.

Discharge wetlands are those that are associated with and in close proximity to groundwater discharge points such as Swamp, Hemlock, and Pickerel Creeks. The groundwater table elevation is at or very near the surface in these wetlands and groundwater discharge is one of the input components in their water budgets. For discharge wetlands, the drawdown contours shown on Figures 4.2.7-3 and 4.2.7-4 represent a slight exaggeration of the expected drawdown of the water levels in these wetlands since runoff into the wetlands is not accounted for.

Impacts to discharge wetlands outside of the 1-foot drawdown contour will be minor and will not likely result in any noticeable changes. For the BEJ scenario, mine dewatering will result in a reduction in discharge and drawdown of one foot or greater in portions of wetlands W1, P1, O1, and F1. The surface watersheds of these wetlands will not be affected by the proposed project, therefore, no surface water impacts are anticipated. Potential impacts to these wetlands are summarized in Table 4.2.7-6.

Table 4.2.7-6

Potential Best Engineering Judgement Impacts to Discharge Wetlands

Wetland	Potentially Affected Acreage
W1	8.4
P1	3.0
O1	83
F1	5.6

Prepared by: RFS
Checked by: JWS
Revised by: SVD1

Wetlands W1, P1, and O1 are forested wetlands (conifer swamp or deciduous swamp). Even for substantial impacts, the general character of these wetlands should not change significantly. These wetlands will still receive significant amounts of surface water runoff in the spring which will provide moisture during the growing season. The dominant tree species will likely tolerate the reduction in moisture levels. The wetland vegetation in the understory and herbaceous layers, however, will likely be slowly replaced by species better adapted to drier soil conditions.

The water surface elevation in wetland F1 is controlled by a series of beaver dams. It is possible that the current water levels will be maintained through surface water inputs and the drawdown will not be experienced in these wetlands.

The area influenced by groundwater drawdown becomes larger for the practical worst case scenario. This would result in increased impacts to the previously discussed wetlands as well as impacts to additional wetlands. For the practical worst case scenario, a 1-foot or greater drawdown is estimated to occur in the vicinity of wetlands F1 and P1 in their entirety and in the vicinity of portions of wetlands Z24, D-1, Z17, O1, W1 and the wetlands along Hemlock Creek, Swamp Creek, and Creek 12-9.

4.2.7.3 Post-Operation Wetland Impacts

As described in Section 5 of the project's *Mine Permit Application* (Foth & Van Dyke, 1995d), the plant site, TMA, and associated facilities will be restored at the completion of the operation phase of the project. The plant site sedimentation basins will be removed and the plant site will be regraded to final restoration grades. A savannah vegetation community will be established. Final grades and drainage patterns will be established at the TMA and a prairie vegetation community will be established. As with the operation phase of the project, this will result in potential changes in surface drainage patterns to wetlands. Also, at the completion of operations, mine dewatering will cease and groundwater elevations will return to pre-mining levels within about ten years.

The proposed reclamation plan is designed to restore pre-mining hydrologic patterns to the maximum extent possible. As with the operation phase, in the following presentation of post-operation wetland impacts, study area wetlands have been divided into those whose water budget is governed by surface water only and those whose water budget is governed by both surface water and groundwater conditions.

4.2.7.3.1 Type 1 Recharge Wetlands

Access and Railroad Corridors

Access and Railroad Corridors will remain virtually the same as during the operation phase from a drainage perspective. As a result, no additional wetland impacts are anticipated during the post-operation phase.

Plant Site

Any changes in surface water runoff volumes that may have occurred to the wetlands within the surface water drainage area of the plant site during the 28-year mining operation period will have had ample time to result in permanent changes to the wetland plant communities that may have existed prior to the construction of this facility. The predicted changes in surface water runoff volume for the post-operation phase are shown in Table 4.2.7-7. In most cases, for those wetlands where minor surface water runoff changes are predicted when transitioning from the operation to the post-operation phase (i.e., P2, O3, 11, 12, 8, R7A), conditions should ultimately return to near pre-mining conditions over time. The post-operation surface water runoff contributions to wetland 10 will remain roughly the same as that estimated during operations. Therefore, no further change in this wetland is expected after site reclamation.

Table 4.2.7-7

Plant Site Wetland Surface Water Runoff Volume Comparison Existing Conditions to Post-Reclamation Conditions

Wetland	Classification	Percent Change in Runoff Volume
P2	Type 1 Recharge	-1
O3	Type 1 Recharge	-1
11	Type 1 Recharge	-16
12	Type 1 Recharge	-18
F116	Type 1 Recharge	+58
6	Type 1 Recharge	-21
8	Type 1 Recharge	-22
9	Type 1 Recharge	-44
10	Type 1 Recharge	-29
F11	Type 3 Recharge	+21
F119	Type 3 Recharge	+46
R7A	Type 1 Recharge	+2

Prepared by: RFS
Checked by: JWS

The post-operation phase of the project may result in a new affect for the remaining wetlands with watersheds within the boundaries of the plant site. For wetlands F116 and 6, the degree of change from pre-mining conditions will increase during the post-operation phase. Wetland F116 will experience a 58 percent increase in surface water runoff volumes during the post-operation phase as opposed to a 41 percent increase during the mine operation phase. The additional 17 percent surface water runoff volume during the post-operation phase will not likely result in a substantially new effect, but this wetland will not return to pre-mining conditions. The end result will be a slightly expanded area of jurisdictional wetland with a vegetative community composed of plants better adapted to wetter conditions.

The estimated surface water runoff volume for wetland 6 is within 8 percent of existing conditions during the operation phase of the project. As described previously, no impacts were predicted. During the post-operation phase, however, the runoff volume for wetland 6 will decrease by 21 percent. This will be a new affect, but should not result in more than a slight change in the existing plant community.

Although the surface water runoff contributions to wetland 9 will be increased during the post operation phase of the project (i.e., -94 percent during operations to -44 percent during post-operations), this wetland will likely never return to pre-mining conditions. The end result for the 0.19-acre wetland 9 may be a total loss of jurisdictional wetland area.

TMA

The predicted changes in surface water runoff volume to wetlands in the vicinity of the proposed TMA for the post-operation phase are shown in Table 4.2.7-8. As a result of discharges of surface water from sedimentation basins located around the TMA, runoff volumes will be returned to near pre-mining levels in the post-operation phase for wetland F66. However, the margin of this wetland, immediately adjacent to the TMA and at the discharge point of the sedimentation basin, will likely not return to pre-mining conditions. The discharge will likely result in a localized area of increased moisture where a new plant community will develop. However, the downgradient portion of wetland F66 will likely return to pre-mining conditions during the post-operation phase.

Any changes to wetland M3 will have already occurred prior to the post-reclamation phases of the project. The remaining portions of this wetland will continue to receive an increased volume of surface water runoff. By this time, the area of jurisdictional wetland may have increased (i.e., when compared to the area remaining after construction) and prolonged periods of inundation may have improved the biologic function for some groups of organisms.

The portion of wetland M4 remaining after construction will continue to receive 61 percent less surface water runoff during the post-operation phase when compared to existing conditions. Since the final area of wetland M4 will be reduced by 77 percent by TMA construction, the net change in water availability to the reduced wetland area will be increased by 71 percent. By the post-operation phase, this condition will have already occurred for approximately 6 years, resulting in some changes in this wetland's vegetation community. During the post-operation phase the change in plant community will likely continue until an equilibrium is reached.

Table 4.2.7-8

TMA Wetland Surface Water Runoff Volume Comparison Existing Conditions to Post-Reclamation Conditions

Wetland	Classification	Percent Change in Runoff Volume
F29	Type 2 Recharge	+21
F15	Type 1 Recharge	+5
F66	Type 1 Recharge	+11
M3	Type 1 Recharge	+47
M1	Type 3 Recharge	+16
M4	Type 1 Recharge	-61

Prepared by: RFS
Checked by: JWS
Revised by: JWS

Wetland F15 will experience approximately 5 percent more surface water runoff during the post operation phase of the project when compared to existing conditions. The additional runoff during the post-operational phase of the project will enter the wetland from the east as discharge from a sedimentation basin. Overall, this will not likely result in any noticeable changes to this wetland. This is particularly true at greater distances from the TMA and the sedimentation basin discharge location. The bur oaks in this wetland should not be affected in any way. The greatest effect will probably be within close proximity to the discharge point, where increased moisture may result in a localized encroachment of plants better adapted to wetter conditions.

4.2.7.3.2 Wetlands Hydrologically Connected to the Groundwater System

For most of the Type 2 and 3 recharge wetlands and discharge wetlands, the post-operation phase of the project will result in a return to pre-mining conditions within a time period of about 10 years. Any impacts discussed relating to the operation phase of the project will likely be reversed over time. This applies to Type 2 recharge wetlands adjacent to Duck and Deep Hole Lakes (i.e., F28, F18, F19, F23, F37, F21, F22), the Type 3 recharge wetlands adjacent to Little Sand Lake (i.e., F2, F4, F5, F7, F9, and F10), and Skunk Lake (i.e., F12), the Type 3 recharge wetlands not associated with area lakes (i.e., F40) and those discharge wetlands that were discussed previously under the operation phase impacts section (i.e., W1, O1, P1, and F1).

Wetlands F29, F11, F119, and M1, however, will still experience a surface water change during the post-operation phase. Surface water contributions to wetland F29 will return to near normal levels (i.e., 21 percent increase when compared to existing conditions). Over time, any impacts to this wetland that may have occurred during the operation phase will likely be reversed. The estimated surface water runoff volume for wetland F11 was within 4 percent of existing conditions during the mine operation phase of the project. During the post-operation phase, the surface water runoff volume to wetland F11 will increase to 21 percent above existing conditions. This will be a new affect, but should not result in more than a slight change in the existing plant

community. Wetland F119, however, will continue to experience an increase in surface water contributions (i.e., 46 percent) when compared to existing conditions. The end result will be a larger area of wetland containing a plant community better adapted to increased moisture.

As a result of increased flows from wetland M3, wetland M1 will receive more surface water runoff during the post-operation phase than during existing conditions. By this time, the character of this wetland may have changed. A new wetland plant community may exist and the area of jurisdictional wetland may have increased slightly.

4.2.7.4 Wetland Impact Summary

The previous wetland impact section presents quantitative estimates of direct wetland losses where possible. These are generally associated with earthmoving activities during the construction phase of the project. It is not possible to quantify many of the impacts to wetlands associated with the operation and post-operation phases of the project. These impacts can generally be classified as secondary or indirect impacts where changes in drainage patterns and mine dewatering result in changes to some wetland water budgets. This, in turn, results in changes in the character of the plant communities existing in these wetlands.

A qualitative summary of project related wetland impacts, by project phase, is presented in Table 4.2.7-9. A total of 29.26 acres, representing portions of 25 wetlands, will be directly impacted as a result of the construction of the proposed mine (see Table 4.2.7-1). The 29.26 acres represent approximately 1.4 percent of the wetlands in the study area. These wetlands include 0.34, 3.60, 9.96, 15.30 and 0.06 acres of emergent marsh, shrub swamp, deciduous swamp, coniferous swamp and bog, respectively. Wetlands F30, F33, 17, 16, F31, F81, F32, 5, 13, 14, 15, and three unnamed wetlands will be entirely filled or excavated (represented as "TL" in Table 4.2.7-9) . Only portions of the remaining 11 wetlands will be impacted (represented as "PL" in Table 4.2.7-9). These wetland losses will be replaced at a ratio of approximately 1.9:1.0 acres at a wetland compensation site located approximately 50 miles to the south.

The degree to which wetlands will be affected during the operation phase of the project is variable. For example, forested wetlands will be more tolerant to changes in moisture than other wetland types. The general character of forested wetlands may remain relatively unchanged for many years after a change in water levels. These effects will likely be manifested in a gradual encroachment of upland vegetation along the periphery of the wetland. The functional values of these forested wetlands may not be changed significantly, with one exception. The frequency of inundation and the areal extent of inundation in these wetlands may be reduced. This may result in a reduction in the biological function for those organisms requiring standing water. However, the general character of these wetlands will likely remain unchanged. From a functional values standpoint these wetlands will remain as forested habitats and continue to possess much of their hydrologic, aesthetic, education, and recreation functions.

Table 4.2.7-9

Wetland Affect Summary

Wetland ID	Total Acres	Dominant Vegetation Type[1]	Potential Affects During:[2]		
			Construction	Operation	Post-operation
5	0.01	SM	TL	-	-
6	0.16	SM	-	NSC	NSC
8	0.27	CS	-	PPCC	NSC
9	0.19	SM	-	TPCC/L	TPCC/L
10	1.41	CS	-	PPCC	PPCC
11	0.72	DS	-	PPCC	NSC
12	0.11	DS	-	PPCC	NSC
13	0.07	DS	TL	-	-
14	0.06	DS	TL	-	-
15	0.14	DS	TL	-	-
16	0.1	DS	TL	-	-
17	0.54	DS	TL	-	-
F1	3.9	SW	-	NSC	NSC
F2	20.3	SM	-	NSC	NSC
F4	3.81	CS	-	NSC	NSC
F5	3.32	CS	-	NSC	NSC
F7	20.46	SM	-	NSC	NSC
F9	7.74	CS	-	NSC	NSC
F10	9.02	CS	-	NSC	NSC
F11	18.37	CS	PL	PPCC	NSC
F12	7.8	SM	-	M	NSC
F15	36.47	DS	-	PPCC	PPCC
F18	56.34	CS	-	NSC	NSC
F19	9.21	SM	-	NSC	NSC
F21	1.35	SM	-	NSC	NSC

Table 4.2.7-9 *(Continued)*

Wetland ID	Total Acres	Dominant Vegetation Type[1]	Potential Affects During:[2]		
			Construction	Operation	Post-operation
F22	2.21	DS	-	NSC	NSC
F23	4.46	SM	-	NSC	NSC
F28	63.0	B	-	NSC	NSC
F29	3.16	SS	-	PPCC	PPCC
F30	0.02	DS	TL	-	-
F31	6.45	CS	TL	-	-
F32	0.68	DS	TL	-	-
F33	1.82	DS	TL	-	-
F37	15.72	SM	-	NSC	NSC
F40	7.9	SM	-	PPCC	NSC
F66	16.1	CS	PL	PPCC	PPCC
F81	0.33	SM	TL	-	-
F116	0.6	CS	-	PPCC/I	PPCC/I
F119	1.11	CS	-	TPCC/I	TPCC/I
M1	1.09	SS	-	PPCC	PPCC
M3	4.51	DS	PL	TPCC	TPCC/I
M4	1.37	DS	PL	TPCC	TPCC
N1	0.71	SS	-	NSC	NSC
O1	113.85	CS	-	PPCC	NSC
O3	2.22	DS	-	NSC	NSC
P1	2.75	DS	-	PPCC	NSC
P2	18.09	CS	-	NSC	NSC
R7A	2.72	SS	-	NSC	NSC
T1	1.66	B	PL	NSC	NSC
T4	199.02	CS	PL	NSC	NSC
W1	503.1	CS	PL	PPCC	NSC
W2	78.47	CS	PL	NSC	NSC

Table 4.2.7-9 *(Continued)*

Wetland ID	Total Acres	Dominant Vegetation Type[1]	Potential Affects During:[2]		
			Construction	Operation	Post-operation
Z6	44.68	CS	PL	NSC	NSC
Z7	3.89	DS	PL	NSC	NSC
Z9	9.54	CS	PL	NSC	NSC
Z17	3.35	SM	-	NSC	NSC
Z24	4.02	CS	-	NSC	NSC
Unnamed (3)	0.89	DS	TL	-	-

[1] SM = Emergent marsh/wet meadow.
CS = Coniferous swamp.
DS = Deciduous swamp.
B = Bog.
SS = Shrub Swamp.
SW = Streamside wetland.

[2] TL = Total loss of wetland acreage as a result of filling or excavation.
PL = Partial loss of an individual wetland's acreage as a result of filling or excavation. Operation and post-operation impacts apply only to the portion of wetland that remains after construction.
PPCC = Partial plant community change - one of the vegetative strata (e.g., herbaceous, saplings, overstory) may experience a shift in community type as a result of changes in moisture levels or increased sunlight penetration.
TPCC = Total plant community change - the existing plant community will likely change completely as a result of significant changes in moisture levels.
NSC = No substantial or noticeable change.
I = Increase in wetland area as a result of substantially increased moisture levels.
M = To be mitigated.
L = Loss of wetland area.

Prepared by: RFS
Checked by: JWS
Revised by: SVD1/RFS

In two cases with forested wetlands, significant changes in surface water runoff volumes will result in noticeable changes. Wetlands F116 and F119 (represented as PPCC/I and TPCC/I, respectively, in Table 4.2.7-9) will possibly experience a substantial change in their existing plant communities and water regimes as a result of predicted surface water runoff increases, but, this will result in an increase in the area of wetlands on site.

Under expected conditions, the wetland adjacent to Skunk Lake (i.e., wetland F12) will experience a 0.53-foot drawdown in groundwater levels. A similar lowering of water levels is expected in Skunk Lake. The net affect may be an increase in the area of the wetland fringe around the lake and a possible encroachment of plant species better adapted to drier conditions around the landward periphery of wetland F12. The functional values of this wetland are not expected to be impacted in any way.

The only other wetland substantially affected during the operation phase of the project is wetland 9. Wetland 9 will likely slowly convert to upland habitat as a result of changes in surface water runoff patterns.

In general, most impacts noted during the operation phase of the project will be slowly reversed during the post-operation phase of the project. However, permanent changes resulting from the proposed project (excluding the direct impacts during construction) will occur in wetlands F116, F119, 9, M3, and M4. Wetlands F116, F119, M3, and M4 will receive increased surface water runoff volumes after operations have ceased. The end result will likely be a larger area of wetland when compared to existing conditions. Wetland 9, however, will likely never convert back to wetland as a result of decreased surface water runoff volumes.

4.2.8 Aquatic Biology

The purpose of this section is to provide a description of potential impacts to aquatic biological resources which may occur during the construction, operation, closure, and post-closure activities associated with the Crandon Project. Different types of potential aquatic biological impacts will be associated with each phase of the project. The various activities which will occur during each project phase have been described elsewhere in this EIR, the *TMA Feasibility Report/Plan of Operation* and Addenda (Foth & Van Dyke, 1995e, 1996a, 1996b, 1997), and the *Mine Permit Application* (Foth & Van Dyke, 1995d).

Air deposition within the project area is anticipated to be minimal. A discussion of air deposition is provided in Section 4.2.3 of the EIR. Control of erosion, runoff, and sedimentation will be a function of the project's erosion control management plan (Foth & Van Dyke, 1995d). Adherence to this plan will minimize impacts to the aquatic ecology of local lakes and streams.

During the construction period the greatest potential for impacting surface water organisms will occur during the installation of the main access road and the railroad spur, while during the operating period, the most obvious impact will be related to potential groundwater drawdown and resultant surface water impacts.

4.2.8.1 Impacts Due to Potential Surface Water Flow and Water Level Changes

The exact manner in which the biota of any particular stream may react to a given change in flow depends on the inherent sensitivity of the organisms present in the stream itself to the change. With the exception of Skunk Lake, the estimated biological impacts to lakes in the project area are considered insignificant and are therefore not addressed in this section. The impact to Skunk Lake is one of potential habitat losses which is addressed in Section 4.2.8.2.2. Tables 4.2.8-1 and 4.2.8-2 use the information provided in Table 4.2.6-2 to estimate potential impacts to fish and macroinvertebrate populations given potential stream flow and level changes. The criteria used to develop Tables 4.2.8-1 and 4.2.8-2 are addressed in Section 4.2.8.2 of this section. The criteria were developed by the WDNR and used in the 1986 FEIS (WDNR, 1986).

With respect to Table 4.2.8-1, the criteria address three categories of impacts based on a range of percent flow reduction. The estimated effect is equated to a reduction in biomass of fish in the respective body of water. With respect to Table 4.2.8-2, the criteria address four categories of impacts based on a range of percent flow reductions. The criteria recognize not only the loss of surface area but also loss of other stream characteristics such as flow velocity, i.e., potential to increase lentic environments at the expense of lotic environments.

Because fish and macroinvertebrate communities have different sensitivities, changes in flow in each stream will result in a different biological response. In general, those streams which contain riffle areas or are spring fed will be inhabited by biota which are more sensitive to sedimentation, oxygen depletion, and temperature elevations. Conversely, streams which are slower moving with pooled habitats which may be fed from lakes or ponded areas such as the discharge from beaver ponds, tend to be populated by less sensitive species of organisms. The project area includes both types of streams.

Those streams which contain typical pool habitats (and associated organisms) with depositional substrates, low current velocities and substantial stream depth will not be impacted by a reduction in flow of less than 10 percent. Reducing base flows would alter the pool habitats in these streams only slightly. In addition, the benthic community of these streams is dominated by organisms that prefer depositional habitats. The dominant taxa at these stations (midge-fly larvae [*Procladius* sp. and *Tanytarsus* sp.], immature tubificid oligochaetes (worms) and the mayfly *Caenis* sp.) are commonly collected in silty slow-water habitats. A survey of an Illinois stream during drought conditions (Larimore et al., 1959) indicated that the above taxa were able to survive or quickly recover from extremely low water conditions.

Sudden reductions in flow could impact some species. Minshall and Winger (1968) found that a sudden reduction in flow caused a large increase in the percentage of drifting organisms. The relatively small projected decrease in Swamp Creek flow may cause an initial increase in drift during low flow conditions; however, since the current velocities are estimated to decrease only slightly, it is likely that the riffles will be quickly repopulated.

Table 4.2.8-1

Estimated Stream Fishery Impacts[1,2]

Stream	Estimated BEJ Impact			Practical Worst Case Impact		
	Average Flow	$Q_{7,2}$	$Q_{7,10}$	Average Flow	$Q_{7,2}$	$Q_{7,10}$
Swamp Creek (STH 55)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Swamp Creek (SG-3)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Swamp Creek (SG-AA)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Hemlock Creek (SG-6B)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Hoffman Creek (SG-E)	Minimal[3]	Minimal[4]	Minimal[4]	Moderate[5]	Moderate[6]	Moderate[6]
Creek 12-9 (SG-23)	Minimal	Minimal	Minimal	Minimal	Moderate	Moderate
Creek 11-4	Minimal[3]	Minimal[4]	Minimal[4]	Minimal[5]	Minimal[6]	Minimal[6]
Upper Pickerel Creek (SG-19)	Minimal	Moderate	Moderate	≤Moderate	≤Substantial	≤Substantial

NA = Data Not Available.

[1]Guidelines from 1986 FEIS (WDNR, 1986) used to summarize impacts to fish biomass are:
Minimal - flow reduction < 20%; average fall biomass reduction < 25%
Moderate - flow reduction 20-39%; average fall biomass reduction 25-48%
Substantial - flow reduction > 40%; average fall biomass reduction > 49%

[2]Flow data used to categorize impacts is contained in Tables 4.2.6-2 and 4.2.6-2a.

[3]Estimate based on BEJ groundwater model simulating average recharge/average flow conditions.

[4]Estimate based on BEJ groundwater model simulating low recharge/low flow conditions.

[5]Estimate based on PWC groundwater model simulating average recharge/average flow conditions.

[6]Estimate based on PWC groundwater model simulating low recharge/low flow conditions.

Prepared by: WMW
Checked by: JWS
Revised by: SVD1

Table 4.2.8-2

Estimated Impacts to Stream Macroinvertebrates[1,2]

Stream	Estimated BEJ Impact			Practical Worst Case Impact		
	Average Flow	$Q_{7,2}$	$Q_{7,10}$	Average Flow	$Q_{7,2}$	$Q_{7,10}$
Swamp Creek (STH 55)	Minimal	Minimal	Minimal	Minimal	Small	Small
Swamp Creek (SG-3)	Minimal	Minimal	Minimal	Minimal	Small	Small
Swamp Creek (SG-AA)	Minimal	Minimal	Minimal	Minimal	Minimal	Minimal
Hemlock Creek (SG-6B)	Minimal	Minimal	Minimal	Minimal	≤Small	≤Small
Hoffman Creek (SG-E)	≤Small[3]	≤Small[4]	Small[4]	Moderate[5]	Moderate[6]	Moderate[6]
Creek 12-9 (SG-23)	Minimal	Small	Small	Small	Moderate	Moderate
Creek 11-4	Minimal[3]	Minimal[4]	Minimal[4]	Small[5]	Minimal[6]	Minimal[6]
Upper Pickerel Creek (SG-19)	Small	Moderate	Moderate	≤Moderate	Moderate	Moderate

NA = Data Not Available

[1]Criteria from 1986 FEIS (WDNR, 1986) used to summarize impacts to macroinvertebrates are:
Minimal - habitat decrease of < 10%
Small - habitat decrease of 10-20%
Moderate - habitat decrease of 20-50%
Large - habitat decrease of > 50%

[2]Flow data used to categorize impacts is contained in Tables 4.2.6-2 and 4.2.6-2a.

[3]Estimate based on BEJ groundwater model simulating average recharge/average flow conditions.

[4]Estimate based on BEJ groundwater model simulating low recharge/low flow conditions.

[5]Estimate based on PWC groundwater model simulating average recharge/average flow conditions.

[6]Estimate based on PWC groundwater model simulating low recharge/low flow conditions.

Prepared by: WMW
Checked by: JWS
Revised by: SVD1

The results of experiments conducted by Rabeni and Minshall (1977) indicated significantly lower populations of certain riffle organisms (mayflies, stoneflies and riffle beetles) when subjected to a four-fold decrease in substrate-surface current velocities. Further reductions in densities were noted when these taxa were subjected to both reduced current and a light coating of silt. Of the organisms examined, the Chironomidae was the only taxon to show a significant increase in density because of reduced current or added silt.

Flow reductions could cause increased temperatures during the summer in surface water bodies receiving groundwater discharge; however, a reduction in flow does not automatically cause an increase in water temperatures. Curtis (1959) found that temperatures in the Pitt River in California remained essentially the same at greatly reduced flows. Similarly, Kraft (1972) found that flow reductions up to 90 percent in a segment of a stream did not measurably increase temperatures in that segment.

4.2.8.2 Specific Aquatic Biology Resource Impacts

Aquatic biological assessments were conducted for the Crandon Project from the 1970's to 1994. These assessments, described in Dames and Moore (1982) and also in Section 3.8 of this EIR, describe aquatic biological resources from a very broad drainage basin standpoint. The drainage basin addressed in these studies included all of Swamp Creek, Hemlock Creek, Pickerel Creek, and portions of the Wolf River downstream of the Lower Post Lake outfall. In addition, lakes bordered by these streams and rivers were also studied.

In addition to the different impacts which may be observed with each phase of the Crandon Project, each lake or stream and each biological community within each of these aquatic environments may have a unique response to a given activity. The following discussion provides an overview of local aquatic biological community responses to impacts associated with Crandon Project work.

4.2.8.2.1 Non-Impacted Aquatic Biological Resources

The aquatic biological resources associated with the following surface waters will not have any measurable impacts caused by the Crandon Project:

- Rice Lake and lower Swamp Creek, downstream of Rice Lake.
- Mole Lake.
- Lower Pickerel Creek.
- Wolf River, its entire length.
- Oak Lake.
- Rolling Stone Lake.
- Ground Hemlock Lake.
- Lake Lucerne.
- Lake Metonga.
- Any lakes and streams beyond the perimeter of the above named lakes and streams.

The rationale for the above determination pertaining to these lakes and streams is discussed below.

Rice Lake and Lower Swamp Creek: While Upper Swamp Creek will be in the influence of the mine, those portions downstream of the Rice Lake outfall are not likely to be impacted from a biological population standpoint. Sedimentation which may occur due to construction or operation activities will be intercepted by a combination of on-site controls and beaver dams in the slower reaches of Upper Swamp Creek. Reduced flow of water under low flow conditions (less than 4 percent for the BEJ and less than 7 percent for the practical worst case scenarios, respectively) due to dewatering in the near vicinity of the mine will likely result in no measurable impacts within Rice Lake and the lower reaches of Swamp Creek.

Rice Lake lies west of the mine site. No construction activities will occur in the vicinity of Rice Lake, therefore, no impacts are expected with respect to mine construction. Rice Lake lies beyond the western periphery of the expected groundwater level changes due to mine inflow. There may be an associated slight decrease in water flow-through based on the estimated reductions in flow for the Swamp Creek and Hoffman Creek drainage areas. Flow considerations for Swamp Creek and Hoffman Creek are discussed below.

Slight decreases in flow-through should have no impact on current biological populations residing in Rice Lake. It is believed that Rice Lake has a flow control structure on its outlet that helps to control the water elevation in the lake. Wild rice, a locally important species of aquatic macrophyte, should see no impact with respect to slight reductions in water flow within the Swamp Creek basin, particularly in Rice Lake. See also Section 4.2.14.1 of this EIR.

Lower Pickerel Creek: Lower Pickerel Creek, below Rolling Stone Lake, is fed by a significant watershed including the discharge from Rolling Stone Lake. It is unlikely that any impact from mine-related activities will be manifested in Lower Pickerel Creek.

Wolf River: The Wolf River is fed in part by both its Swamp Creek and Pickerel Creek tributaries. As discussed above for the BEJ case, lower Swamp Creek which is a tributary to the Wolf River may potentially see a 5 percent or less flow reduction under low flow conditions immediately below Rice Lake. Due to the large drainage basin along Swamp Creek below Rice Lake, this minimal impact will be negated prior to the confluence with the Wolf River. Pickerel Creek below Rolling Stone Lake will see no biological impacts throughout its entire reach to its confluence with the Wolf River. As outlined in the *EIR Supplement: Wisconsin River Wastewater Discharge Pipeline* report contained in Volume IIIa of the project's EIR (Foth & Van Dyke, 1995a), assuming the entire mine inflow of 700 gpm is lost to the Wolf River, this equates to approximately only 1 percent of the $Q_{7,10}$ flow of the Wolf River at Lily and will, therefore, result in no biological impacts.

Mole Lake: Mole Lake is outside the area of influence of groundwater drawdown due to mine inflow. Since the lake will not experience a change in water flow, no impacts will be realized by biotic communities.

Oak Lake: Oak Lake is located southwest of the project site. The basin of this perched lake is above the groundwater table. The lake is therefore isolated above the potential area where drawdown of the local aquifer may occur.

Rolling Stone Lake: Rolling Stone Lake is outside of the area of direct influence identified for groundwater drawdown due to mine inflow. A slight loss in water may be realized seasonally due to flow reductions in Creek 12-9, Upper Pickerel Creek, and Martin Springs. There will be no measurable impacts to biological communities within Rolling Stone Lake.

Lake Metonga, Lake Lucerne and Ground Hemlock Lake: Each of these lakes is outside of the area of groundwater drawdown and therefore will not be impacted significantly by mine dewatering. Furthermore, the discharge from each flows toward the project site. None of the drainage basins for the lakes is in the area of project disturbance, no impacts will be realized by biotic communities.

4.2.8.2.2 Potentially Impacted Aquatic Biological Resources

The aquatic resources described in this section may be variously impacted by activities conducted during each singular phase of development of the Crandon Project. No two water bodies appear to be potentially impacted the same, however, in many cases potential impacts on upstream water resources may affect downstream resources.

Hemlock Creek

Hemlock Creek originates from Ground Hemlock Lake located east of the project site. Flow in Hemlock Creek is in a north northwest direction from its origin to its confluence with Swamp Creek. Stream flow is supplemented by wetlands along the east side of the creek. A series of beaver dams creates several pools along the creek, which likely have an impact on the nature of the substrate as well as the biological inhabitants which can colonize and thrive in this setting.

There will be no impacts to biological communities in this stream due to mine construction activities. Based on the information presented in Tables 4.2.6-2 and 4.2.6-2a, the BEJ flow reduction under low flow conditions during mine operation will be less than 6 percent, while the practical worst case flow reduction under low flow conditions is estimated to be 10 percent. Ten percent flow reduction is the value which, when exceeded, is expected to cause a small impact in the biological populations. Because the potential maximum flow reduction only slightly exceeds the point of measurable impact, negligible impacts will be observed in Hemlock Creek for either fish or macroinvertebrate populations. Impacts due to the drawdown potential are also considered negligible since, to a great extent, the beaver dams already control the rate of flow and sedimentation occurring in Hemlock Creek.

With mine closure, a slight increase in water recharge from the west is expected. Again, with the presence of the beaver dams, the impact on stream biota is expected to be negligible.

Swamp Creek

Swamp Creek originates from Lake Lucerne, flowing from northeast of the project site in a southwesterly direction. Swamp Creek is a shallow meandering stream until it reaches the area directly north of the plant site, where the stream grade drops more rapidly forming an area of riffle about 3/4 of a mile in length. Beaver dams located both upstream and downstream of the riffle area ensure areas of lentic and lotic habitat in this reach of Swamp Creek. The area of Swamp Creek from Lake Lucerne to Rice Lake is referred to as Upper Swamp Creek in this section.

Impacts During Construction

During the construction phase of the project, two crossings will be installed across Swamp Creek. The railroad spur will cross Swamp Creek downstream of its confluence with Hemlock Creek but upstream of the riffle area. The bridge for the spur will completely span the stream. Runoff and erosion control will be provided. As the stream in this segment of Swamp Creek is fairly open, the opening of the railroad corridor should not represent a large change in habitat. Construction activity will be controlled and siltation and sedimentation will be curtailed. Beaver dams immediately downstream of the spur location will help prevent any downstream migration of sediments should a major storm event occur while construction is being conducted in this area.

The second crossing will be the main access road. This crossing will be located near the riffle zone of Swamp Creek. The bridge for the road crossing will completely span the stream. Runoff and erosion control will be provided. The stream segment for the riffle area is very closed canopy but opens up very rapidly as soon as the stream emerges from the riffle area. Two beaver dams downstream of the riffle area were present as late as 1994. Depending on the exact location of the road crossing, the roadway corridor may represent a major opening in the stream canopy or, if located downstream at the end of the riffle, may represent no significant habitat change. Because some aquatic species prefer closed canopy habitats while others prefer open canopy habitats, shifts in habitats due to mining activities may encourage species which preferentially seek habitat which has been newly created.

Since both crossings completely span Swamp Creek, there are no anticipated aquatic habitat changes associated with installation of these crossings. Intercepted runoff from the corridor channeled to the stream may provide a temporary infusion of flow where runoff may have otherwise reached the stream through subsurface drainage.

In evaluating the potential for impacts due to sedimentation, it is important to determine the inherent sensitivity of the community potentially affected. A total of 34 species of fish have been identified from Swamp Creek (WDNR, 1974; Ecological Analysts, Inc., 1983; Ecological Analysts, Inc., 1984b). Based on life history data, seven of these species were rated as sensitive to sedimentation and turbidity, 11 as non-sensitive, and 14 as intermediate (Table 4.2.8-3). Sensitive species were generally those that require clear water (i.e., low turbidity) and clean substrates (i.e., little sedimentation). Intermediate species were generally those that require clear water or clear substrates, but not necessarily both. Northern pike, yellow perch, and black crappie are examples of such species. Non-sensitive species generally are not limited by water clarity or substrate type. With the exception of the hornyhead chub, all the sensitive species listed in Table 4.2.8-3 are uncommon or not present in Swamp Creek downstream of Rice Lake, suggesting that habitats suitable to those sensitive species are lacking in the lower half of Swamp Creek. These sensitive species are also rare to locally common in Swamp Creek upstream of Rice Lake, suggesting that habitat is a limiting factor in the upper reaches of Swamp Creek.

Stream fishes are all adapted to periods of high turbidity (Muncy et al., 1979). For example, most streams become moderately to highly turbid during periods of heavy surface water runoff (i.e., during storm events, following snowmelt). During such periods, fish rely on their other senses to find food. Furthermore, sight-feeding fish may switch to alternative prey items during periods of high turbidity (Swensen, 1978). Similarly, sight feeders can feed in turbid conditions, although their efficiency is reduced (Vinyard and O'Brien, 1976; Gardner, 1981). It is only when

turbidity is severe or prolonged that fishes in general, and sight feeders in particular, are adversely affected.

Because Swamp Creek is dominated (25 of 34 species) by species that are non-sensitive or intermediate in sensitivity to turbidity and sedimentation, the likelihood of these factors causing a major impact to the overall fish community in Swamp Creek is small. Based on the information presented in Table 4.2.8-1, impacts to fisheries in Swamp Creek are anticipated to be minimal.

The techniques for constructing the access road and railroad spur bridge crossings over Swamp Creek (single span structures) will limit erosion and resulting runoff of sediments to the creek. These erosion and sedimentation control measures will result in any changes in stream turbidity attributed to construction activities being localized and temporary. Therefore, there should be no impacts to the fish populations in Swamp Creek.

Increased sedimentation can affect the macroinvertebrate fauna of a stream. Heavy sediment deposition can physically bury benthic organisms and also alter the habitats present in streams. Where this occurs, community structure changes from species that prefer gravel substrates to species tolerant of unconsolidated fine-grained sediments. Construction of the access road and railroad spur bridges over Swamp Creek is expected to increase sedimentation rates only slightly and, therefore, not alter the benthic community.

In the swifter upper portions of Swamp Creek, more rheophilic, sensitive macroinvertebrate taxa are present. However, populations of such taxa should not be affected because temporary local disruptions or displacements will be compensated by recolonization via drifting organisms. Impacts should be further minimized because the railroad will cross the stream where currents are relatively slow and fine sediments predominate, and few rheophilic taxa would be expected. The access road bridge, though located in a section of the stream with a higher velocity, is at the downstream end of this riffle section. Thus most sediments that are displaced would not be deposited in the riffle portions of Swamp Creek.

There are small populations of mussels in Upper Swamp Creek. Those that reside in the riffle area of Swamp Creek are subject to an extremely harsh environment as witnessed by the

Table 4.2.8-3

Sensitivities of Swamp Creek Fishes to Turbidity and Sedimentation Rankings Based on Life History Data from Trautman (1957); Scott and Crossman (1973); Clay (1975); and Pfleiger (1975)

Common Name	Scientific Name	Sensitivity[1]
Brook trout	*Salvelinus fontinalis*	S
Brown trout	*Salmo trutta*	S
Largescale stoneroller	*Campostoma oligolepis*	S
Blacknose dace	*Rhinichthys atratulus*	S
Longnose dace	*Rhinichthys cataractae*	S
Pearl dace	*Semotilus margarita*	I
Creek chub	*Semotilus atromaculatus*	NS
Hornyhead chub	*Nocomis biguttatus*	S
Fathead minnow	*Pimephales promelas*	NS
Bluntnose minnow	*Pimephales notatus*	NS
N. Redbelly dace	*Phoxinus eos*	S
Golden shiner	*Notemigonus crysoleucas*	NS
Brassy minnow	*Hybognathus hankinsoni*	NS
Common shiner	*Notropis cornutus*	I
Blackchin shiner	*Notropis heterodon*	I
Blacknose shiner	*Notropis heterolepis*	S
White sucker	*Catostomus commersoni*	NS
Shorthead redhorse	*Moxostoma macrolepidotum*	I
N. hogsucker	*Hypentilium nigricans*	S
Central mudminnow	*Umbra limi*	NS
Northern pike	*Esox lucius*	I
Brook stickleback	*Culaea inconstans*	I
Black bullhead	*Ictalurus melas*	NS
Yellow bullhead	*Ictalurus natalis*	NS
Tadpole madtom	*Noturus gyrinus*	NS
Yellow perch	*Perca flavescens*	I
Iowa darter	*Etheostoma exile*	I
Johnny darter	*Etheostoma nigrum*	NS
Rock bass	*Ambloplites rupestris*	I
Largemouth bass	*Micropterus salmoides*	I
Bluegill	*Lepomis macrochirus*	I

Table 4.2.8-3 *(Continued)*

Common Name	Scientific Name	Sensitivity[1]
Pumpkinseed	*Lepomis gibbosus*	I
Black crappie	*Poxomis nigromaculatus*	I
Mottled sculpin	*Cottus bairdi*	I

[1] S = Sensitive, defined as highly susceptible. Would be extirpated under continuous turbid conditions or if sedimentation was severe.
I = Intermediate; can withstand periodic high turbidities and some sedimentation.
NS = Not sensitive; unlikely to be affected adversely except in the most severely polluted conditions.

Source: EMC, 1985
Checked by: WMW

corrosion and pitting of their shells. Middens of the mussels *Lampsilis siliquoidea* and *Anodontoides ferussacianus* were collected in the vicinity of the proposed railroad spur crossing. *L. siliquoidea* and *Lasmigona compressa* were both found in the riffle area, albeit in small numbers, upstream of the proposed roadway crossing. Significant, long-term sedimentation could have an effect on the mussels found in these areas of Swamp Creek. Based on the erosion and sedimentation control procedures to be provided during construction as detailed in the *Mine Permit Application* (Foth & Van Dyke, 1995d), it is expected that impacts due to sedimentation should be insignificant and short-term.

Impacts During Mining

As indicated in the discussion above, the most notable potential impact associated with mining activities will be the drawdown of the local aquifer due to mine inflow. Based on the estimated reduction in groundwater contribution to Swamp Creek, the projected drop in water levels in riffle habitat will result in only a slight loss of available habitat. However, the relatively small decrease in flow and resulting reduced current velocity will probably affect only the strictly rheophilic organisms. The degree of this impact will depend on the actual current velocity reduction and sedimentation increase. Discontinuous flow is not likely to occur in Swamp Creek riffle areas.

Under BEJ conditions as described in Table 4.2.6-2, reductions in flow of 8 percent or less under low flow conditions are anticipated. With this low level of impact, no effect to the fisheries or macroinvertebrate populations are expected.

Impacts During Mine Closure

During mine closure, Swamp Creek will slowly regain flows which were lost during the period of active mining. There should be no impacts associated with this process other than the recolonization of small amounts of habitat.

Hoffman Springs

Hoffman Springs lies west of the plant site. Construction activities will not take place in the vicinity of Hoffman Springs, and therefore, no construction-related impacts to Hoffman Springs are anticipated.

As with Hoffman Creek which it feeds, the flow in Hoffman Springs is interrelated to the local groundwater table. Groundwater elevations will potentially change to some extent in the vicinity of Hoffman Creek as discussed in Section 4.2.6 of the EIR.

During the drawdown period, it is possible that the loss of groundwater recharge during mine operation could cause an elevation in temperature in Hoffman Springs. Hoffman Springs is a shallow pond with a several-foot layer of organic matter. It was observed in June 1994 that many shallow areas of the pond were rather warm and that trout would need sufficient oxygen and cool temperatures to survive during the summer months. Based on information provided in Table 4.2.6-2, it is estimated that for the BEJ scenario, Hoffman Springs could realize greater than a 10 percent reduction in flow under average conditions and greater than 20 percent under low flow conditions. This flow reduction may be sufficient to allow some portions of the pond to warm to the point of being unsuitable for trout. However, there is some degree of uncertainty whether the trout which inhabit Hoffman Creek in the fall are predominantly residents of Hoffman Springs or migrate upstream from cooler pools in Hoffman Creek or Swamp Creek. A trout fishery does exist in Hoffman Springs, but it is uncertain if the fishery is continuous year around.

Macroinvertebrate populations in Hoffman Springs appear to be limited in diversity. This condition would not appear to be significantly impacted by the project activities.

With closure of the mine, Hoffman Creek will realize a slow increase in flow rates to reflect pre-mining conditions. No further impacts are anticipated with the increase in flow.

Hoffman Creek

Hoffman Creek lies west of the plant site and flows northwest to its confluence with Swamp Creek. Due to its location, the creek will lie outside of the influence of the mine during the construction phase of the project.

As noted earlier, Hoffman Creek is a shallow stream which contains numerous gravel/sandy bars and undercut banks. As indicated in Section 4.2.6 of this EIR, mine inflow could impact the flow of Hoffman Creek. Hoffman Creek receives its flow primarily from Hoffman Springs and the local discharge wetland area in its vicinity.

Observed flows in Hoffman Creek during the summer of 1994 were low, with discernible flow meandering under watercress from undercut bank to undercut bank. This condition indicates that Hoffman Creek is an intermittent stream, at least during dry periods. Seasonally, a change in groundwater elevations could isolate small pools and reduce flows to the point where the stream would have a more pronounced intermittent flow. This situation may be unsuitable for rheophilic organisms and, in extremely dry periods, could interrupt the breeding activity of brook trout.

With the anticipated reduction in flow in Hoffman Creek during mine operation, there may be a slight shift from lotic to lentic vegetation, especially if sand and gravel bars are exposed for any length of time. If flow reductions are severe or occur over an extended period of time, a more permanent shift in vegetation may occur which may take many years to reverse after mine closure.

Information provided in Tables 4.2.8-1 and 4.2.8-2 indicates that under BEJ conditions, Hoffman Creek could experience a "minimal" impact with respect to fish, and a "small" potential for loss of habitat with respect to macroinvertebrates, during the mining phase of the project. Potentially, under the BEJ review, a 15 to 18 percent reduction in flow could be observed in the stretch of Hoffman Creek which is considered the discharge from Hoffman Springs. For the practical worst case scenario, the flow reduction could be 25 to 31 percent. It is unlikely that brook trout could use the redds in this stretch of the stream if these low flow conditions persisted through the fall breeding season. It is possible that the low flow condition could impact macroinvertebrates, however, out of necessity, these organisms are adapted to low flow conditions.

With mine closure, Hoffman Creek will witness a slow increase in flow. Habitat which may have been lost during mining activities will be regained. Recolonization of habitats will occur fairly rapidly by macroinvertebrates.

Creek 12-9

Creek 12-9 lies south of Little Sand Lake. When Little Sand Lake discharges, the flow becomes part of Creek 12-9. Otherwise, Creek 12-9 is fed by the wetlands immediately southwest of Little Sand Lake. Due to its location with respect to the mine site, no impact is expected at Creek 12-9 during the construction phase of the project.

Since Creek 12-9 receives a significant portion of its flow, directly or indirectly, from Little Sand Lake, loss of water in Little Sand Lake due to changes in groundwater levels as a result of mine operation will likely have an impact on Creek 12-9. During the summer, when there is less runoff, the natural flow at the outlet of Little Sand Lake is little more than a trickle. At these times, flows in the lower reaches of Creek 12-9 consist substantially of groundwater. Recorded temperatures of Creek 12-9 at the outlet to Rolling Stone Lake in August 1994 of 55 to 58°F, indicate the influence of groundwater is likely significant. This also indicates that the outlet from Little Sand Lake and the lower reaches of Creek 12-9 are discontinuous. While Upper Creek 12-9, which is the discharge from Little Sand Lake, is a losing stream, Lower Creek 12-9 is actually the result of wetland discharge and is, therefore, a gaining stream. The two stream segments are dissimilar with respect to temperature, physical features, and biota.

Creek 12-9 contains both riffle and pool habitat. The riffle habitat occurs in an area of the stream which is considered intermittent (Lower Creek 12-9). This condition will not likely change during mining activities, with the exception that intermittent reaches of the stream may become more intermittent. Populations of benthic organisms should remain relatively stable in Creek 12-9 because the anticipated changes due to flow reductions are unlikely to alter the habitat or water temperature.

It was noted that a population of brook trout reside in lower stretches of Creek 12-9. The intermittent nature of the upper reaches of the stream suggests that the trout are able to survive in the pooled areas of the stream. Because the groundwater has a significant impact on Creek

12-9, it is likely that the pooled areas of the stream reflect groundwater conditions more closely than those of Little Sand Lake.

Information provided in Table 4.2.6-2 suggests that there is a potential for a greater than 10 percent flow reduction under low flow conditions in the lower Creek 12-9 segment under BEJ conditions. This flow reduction if it occurs, could negatively impact the trout populations in this segment. However, since it is possible that the trout inhabit the cool pools of this segment, loss of flow by more than 10 percent may not have a significant impact. It is likely that the maintenance of pooled habitat at a preferred temperature may more than offset the reduction in flow that could be expected under low flow conditions. Table 4.2.8-1 indicates that there will be a minimal reduction of fish biomass for Lower Creek 12-9 while Table 4.2.8-2 indicates that the impact on macroinvertebrates will be minimal to small. Under the practical worst case scenario, it is estimated that a flow reduction of up to 27 percent could be realized. Biota could still tolerate the loss of stream flow if temperatures are maintained and sufficient habitat exists. However, these parameters may have to be monitored to be able to determine whether an impact is occurring or not.

With closure of the mine, Creek 12-9 will realize a slow increase in flow rates to reflect pre-mining conditions. Habitats which may have been reduced during the drawdown will be regained with the resultant recolonization of the benthic community.

Upper Pickerel Creek

Upper Pickerel Creek lies west of the project site and outside of the influence of mining activity during the mine construction phase. Therefore no biological impacts are anticipated during this phase of mining activity.

Existing flow in Upper Pickerel Creek is low (1.4 cfs) with 11 and 25 percent reductions predicted under the BEJ scenario and 20 to 40 percent reductions under the PWC scenario. These reductions equate to an impact ranking of moderate for average flows to substantial for low flow and the PWC scenarios. The biological species impacts for fish range from minimal to moderate under BEJ conditions, and from moderate to substantial under PWC conditions. For macroinvertebrates, the BEJ impacts range from small to moderate while the PWC impacts are moderate.

Because of the low flow in Upper Pickerel Creek, slight changes in stream flow will have moderate to substantial impact on biological organisms even without mine impacts. Therefore, it is likely that current fauna have developed to recover from such occurrences. If monitoring indicates the development of practical worst case impacts, ample time will be available to implement mitigation measures.

Skunk Lake

Skunk Lake lies directly east of the mine site. Skunk Lake may be impacted during intermediate TMA cell construction, as some of the lake's drainage areas will temporarily be increased or decreased by 4 to 3 percent, respectively, depending upon the TMA stage in use at any given time. This is expected to have a minimal impact.

During mining, the resultant change in groundwater levels in the vicinity of the lake will likely result in a decrease of the lake level by 0.53 feet. Skunk Lake is a small shallow lake which regularly experiences winterkill. The lake contains no fish and very few macroinvertebrate fauna. Natural fluctuations in lake levels (4.67 feet) far exceeds the estimated reduction due to mining. The sparse macroinvertebrate community in the lake is already composed of tolerant species and

changes in macroinvertebrate abundance and composition are not expected to occur as a result of the project.

With the termination of mining activities Skunk Lake water levels will rise to pre-mining conditions.

Duck Lake

Duck Lake lies southeast of the project site. Construction activities at the plant site and the TMA may peripherally impact Duck Lake. Dust, erosion, and sedimentation control methods provided for during the construction process will be sufficient to keep impacts associated with construction to a negligible level.

Duck Lake will be slightly impacted by changed groundwater levels due to mine inflow. Potential drawdown of the lake is described in Section 4.2.6 of this EIR and in Table 4.2.6-1.

During studies conducted in 1977-78 (Dames and Moore, 1982) and by the WDNR (Ramharter, 1982), only three species of fish were collected from Duck Lake, including yellow perch, black bullhead, and central mudminnow. Of these species, yellow perch were abundant, whereas the other two species were uncommon. The low number of species may be a result of the lake's low average pH (5.0). Other investigators have reported that acid lakes have fewer fish species than lakes having a neutral pH (Harvey, 1980; Rahel and Magnuson, 1983; Wiener, 1983). However, other factors also may contribute to the paucity of fish species because Wiener (1983) found 5 to 11 species of fish in six naturally acidic small lakes in northern Wisconsin. Likely contributing factors are low alkalinity, orthophosphate, and dissolved oxygen values. Because of its shallow nature, Duck Lake has approached being a winterkill lake (Andrews, personal communication). Dissolved oxygen values as low as 0.5 mg/L have been reported.

Estimated water level reductions under average climatic conditions should not significantly affect the aquatic biota of Duck Lake. Dry conditions could affect the composition of the macrophyte, benthic, and fish communities. Because all three fish species in the lake have relatively unspecialized spawning requirements (Becker, 1983), each should be able to spawn under low flow conditions. The increased likelihood of low dissolved oxygen concentrations in the winter would affect yellow perch more than they would black bullhead or central mudminnow.

It is unlikely that macrophytes, including the species *Potamogeton confervoides*, or benthic organisms will be impacted by the small decrease in water level anticipated in Duck Lake

During mine closure, water levels in Duck Lake will likely return to near pre-mining levels. No impacts should be realized during this period.

Little Sand Lake

Little Sand Lake lies south of the project site. Construction activities at the plant site and the tailings management area may peripherally impact Little Sand Lake. Dust, erosion, and sedimentation control methods provided during the construction process will be sufficient to keep impacts associated with construction to a negligible level.

As a result of mine dewatering, the lake levels of Little Sand Lake are estimated to decline slightly. Potential reductions in water levels are described in Section 4.2.6 of the EIR and shown in Table 4.2.6-1.

Among the fish species present in the lake, centrarchids (bluegill, pumpkinseed, black crappie and largemouth bass) and northern pike are the species potentially most susceptible to reductions in water levels. Centrarchids are vulnerable because of their nest building habits. However, a gradual decline of water level should not be harmful to the reproductive success of these species, because the sandy substrates they prefer for spawning are abundant in the lake and their nests should be beyond the depth affected by mine dewatering. Moreover, dewatering is estimated to have a minimal effect on the lake level.

Northern pike are uncommon in Little Sand Lake. This species requires marshes and wetlands for spawning, which are limited in Little Sand Lake. Because of a lack of suitable spawning habitat, Little Sand Lake will never support a large northern pike population without stocking.

Aquatic macrophytes, particularly emergents, may be affected in Little Sand Lake. However, large scale shifts in either abundance or species composition seem unlikely because of the estimated small amount of reduction in water levels.

Pre-mining flows will return to Little Sand Lake after mine site closure. It should be noted that the estimated water reduction in Little Sand Lake is expected to be unmeasurable and no impacts to aquatic biota are expected.

Deep Hole Lake

Deep Hole Lake lies south of the mine site. Construction activities associated with the TMA will occur within the drainage basin of Deep Hole Lake. However, only slight flow reductions are anticipated. No impacts due to construction will be observed at Deep Hole Lake with respect to aquatic biota.

Deep Hole Lake lies on the southern periphery of the expected zone of influence for estimated groundwater level changes due to mine inflow. Drainage from Deep Hole Lake is toward Creek 12-9. Estimates of potential surface water level reductions due to mine dewatering are provided in Section 4.2.6 and shown in Table 4.2.6-1. The amount of lake level change associated with mining activities affecting Deep Hole Lake is considered minimal. No impacts are anticipated in the biological communities currently established in this lake.

Because of its distance from the project area, mine closure will likely have a negligible effect on Deep Hole Lake.

4.2.8.3 Potential Impacts to Threatened, Endangered, or Special Concern Species

In 1993 and 1994 work was performed to identify federal- or state-listed threatened, endangered, or special concern aquatic species residing in the Swamp Creek and Pickerel Creek drainage basins, Wolf River, and lakes near the Crandon Project site. These investigative efforts and a summary of findings are presented in Section 3.8 of the EIR.

Based on this investigation, it was reported that no threatened or endangered species of fish, macroinvertebrate, or mussels were found in any of the bodies of water investigated. Further, no special concern species of fish were observed.

Three special concern species of mussels were identified in the study area. All three were found in either Lower Swamp Creek (below Rice Lake) or the Wolf River. One of the three was also found in Upper Swamp Creek. As noted in the previous discussion, these waters are outside the area of potential effect for all three phases of the mining project. One mussel of special concern, *Lasmigona compressa*, was collected from the riffle area of upper Swamp Creek.

Although slight reductions in the flow of Swamp Creek are anticipated, the reductions will likely have no impact on this species. Reductions in stream velocity may help to reduce the extreme abrasive nature of the stream, which may create an environment more suitable to the mussel.

Several special concern species of macroinvertebrates were collected or observed in the study area. One caddisfly, *Triaenodes dipsius*, and one mayfly, *Caenis youngi*, were collected using light trapping techniques. *T. dipsius was collected* at several locations both proximal and distal to the mine site. Distal locations where the species was observed are considered well beyond any area of potential effect relative to mining activities. Sites where this species was observed which are considered local to the mine were all stream sample stations. As a broad overview, this species appears to enjoy a wide distribution in the area and mining activities are unlikely to impact its population. While *C. youngi* is less common in the study area, it was found exclusively outside the area of planned disturbance. None of the *T. dipsius* or *C. youngi* sites will be impacted during mine construction or closure activities and all will be only minimally impacted during mining activities.

A total of 13 special concern species of Odonata were observed in the study area, 11 dragonflies and two species of damselfly. The Odonata enjoy a wide distribution in the study area. Many of the special concern species were observed from the Wolf River and Lower Swamp Creek, locations considered outside the area of measurable project related impacts. Some species were observed in or collected from areas which may be impacted by mining activities. These species and habitat locations are described in Section 3.8 of this EIR. While adults of some special concern species were observed in the project area, it cannot be concluded that their aquatic stage (nymph) was necessarily from a nearby or adjacent water body. Conversely, while adults of *Somatochlora* sp. are often seen along roads at small stream crossings, their nymphal stage preference is wetland, bog, or swampy habitat.

Several species of aeshnids (dragonflies) were observed in the study area. They favor open water and depend on emergent vegetation for deposition of eggs. Drawdown of local lakes may impact emergent aquatic vegetation which could affect the aeshnids locally until new populations of emergent vegetation became established. However, based on information provided in Table 4.2.6-1, the estimated levels of drawdown for Deep Hole Lake, Duck Lake, or Little Sand Lake will affect neither emergent vegetation nor aeshnids.

Several special concern species of Odonata were identified in nymph and adult stages in the riffle area of Swamp Creek. As noted above, slight decreases in flow are estimated for Swamp Creek. However, sufficient flows should still be available to maintain the resident populations of dragonflies. No impacts due to construction are anticipated for the riffle zone of Swamp Creek.

The genus *Somatochlora*, which prefers bog, swamp, and marshy habitat in the nymphal stage may be temporarily displaced with wetland drawdown and permanently displaced locally with the loss of wetlands. It cannot be said with certainty which wetlands contain this special concern species, because no species in the nymph stage were collected from wetlands. However, few nymphs of *Somatochlora* were collected from Hoffman Springs and Martin Springs. A description of wetlands which will be lost or drawn down due to mining activities is provided in Section 4.2.7. Based on a review of the habitat available locally, it is anticipated that ample habitat is available in areas surrounding the mine site to support this species.

4.2.8.4 Summary

In this section the aquatic biological impacts which may be associated with each phase of the Crandon Project, construction, mining, and closure, have been discussed. Based on the available

information, a significant portion of the areas studied during the aquatic biological assessments will experience no impact at all during any phase of the project.

Areas which are considered to be outside of the area of groundwater drawdown and the area of disturbance include all of the Wolf River, Lower Swamp Creek (downstream of Rice Lake), Lower Pickerel Creek, Mole Lake, Oak Lake, Lake Lucerne, Lake Metonga, Ground Hemlock Lake, Rice Lake and Rolling Stone Lake.

Of the areas which may potentially experience some impact, only Swamp Creek may be impacted by stream crossings during the construction period. Plans for control of runoff, erosion, and sedimentation will reduce impacts due to construction to a negligible level. Indirect effects of construction, e.g., loss of drainage basin, could also temporarily affect Duck Lake, Deep Hole Lake, Little Sand Lake, and Skunk Lake.

Mining activities will result in the drawdown of groundwater. Local streams that may be slightly impacted from an aquatic biological perspective by the drawdown include Swamp Creek, Hemlock Creek, Hoffman Creek, Creek 12-9 and Upper Pickerel Creek (above Rolling Stone Lake). The assessment of the impacts of drawdown suggests that, with the exception of Hoffman Creek and Upper Pickerel Creek, no stream will be significantly impacted by the estimated flow reductions under the BEJ case.

During site closure groundwater recharge will result in a gain in water levels and flow to near pre-mining conditions. Impacts realized during this period will be associated with recolonization of reflooded habitats by flora and fauna.

The projected loss of water in surface water resources due to changes in local groundwater levels is anticipated to result in the loss of a small amount of habitat. For local streams, this impact will not be significant. For Hoffman Creek and Upper Pickerel Creek these impacts could be small to moderate. While some habitat may be reduced or temporarily displaced, no major shifts in biological populations are expected. Beyond the extremely local impacts, the overall interpretation suggests that adequate habitat and species distributions occur in all directions surrounding the project site and that no large-scale impact will likely occur relative to the biological populations.

4.2.9 Terrestrial Biology

The most obvious impact of the proposed project to the local terrestrial ecosystem resources will be the clearing of vegetation during construction activities and the resultant loss of habitat. However, the habitats to be disturbed are generally abundant in northern Wisconsin and the nature of this impact will be similar to that associated with common forestry practices in the region. The estimated impacts to vegetation, wildlife, and endangered or threatened species are discussed below.

4.2.9.1 Vegetation

Over the 35-year life of the Project, site preparation, facilities construction and reclamation will require the clearing of vegetation from approximately 540 acres of land. The vegetation community types impacted by the proposed project are listed in Table 4.2.9-1. Wetland vegetation communities comprise 5.4 percent of the total impact. These community types are discussed in Section 4.2.7. The northern hardwood forest community type dominates the

Table 4.2.9-1

Approximate Acreage of Each Vegetation Type Disturbed During Project Construction

Vegetation Type	Plant Site	Access Road[1]	Railroad Spur[2]	TMA & Surrounding Facilities[3]	TMA Access Road[4]	Potable Water Pipeline[5]	Total
Northern Hardwoods	127.7	23.6	13.2	316.3	6.4	2.6	489.8
Coniferous Swamp		2.8	1.5	10.5	0.5		15.3
Shrub Swamp		0.2	0.8	2.5			3.5
Bog			0.1				0.1
Emergent Marsh	<0.1			0.3			0.4
Deciduous Swamp		0.6		9.4			10.0
Pine Plantation		2.3					2.3
Agricultural		4.5	3.5				8.0
Old Field/Clearcut		4.0		5.8			9.8
Total	127.8	38.0	19.1	344.8	6.9	2.6	539.2

[1] Based on an average corridor width of 100 feet; except for the Swamp Creek crossing where the average width used in the calculations is 150 feet.
[2] Based on an average corridor width of 60 feet; except along the sidetrack where the average width is 80 feet, and except for the Swamp Creek crossing where the average width used in the calculations is 150 feet.
[3] Includes TMA, TMA borrow area, reclaim pond, perimeter road, exterior drainage system, and runoff basins.
[4] Based on average corridor width for access road and tailings pipeline of 100 feet, and including the drain down sump - Basin 4.
[5] Based on average corridor width of 30 feet.

Prepared by: BDH
Checked by: RFS
Revised by: JWS

impacted uplands and comprises approximately 90.8 percent of the total disturbed area. The other impacted upland community types comprise 3.8 percent of the total impact area and include old fields, agricultural lands, and pine plantations. This loss of vegetation will be reversible, since the disturbed areas will be reclaimed during operation and closure phases of the Project. Clearing and reclamation will be conducted in several phases so that the entire area is not disturbed in any one year.

Fugitive dust emissions from construction activities will have minimal effects on vegetation. Some dust will be created by site clearing, grading, vehicular traffic and the action of wind on exposed soils. Implementation of dust control measures will substantially reduce the quantity of dust from the construction activities. These dust control measures include paving the main access road, watering unpaved roads and excavation sites, and planting vegetation to stabilize exposed soils. The effects of dust on vegetation adjacent to the construction areas are expected to be minimal and similar in nature to those currently occurring adjacent to unpaved roads throughout the region.

Estimated emission rates of particulates, SO_2 and NO_x from the proposed project are discussed in Section 4.2.3 and the project's *Air Pollution Control Permit Application* (FVD, 1995c). The estimated emission rates reflect conservative assumptions on background air quality and conservative assumptions which were used for the air quality modeling. Nevertheless, the estimated air quality parameter concentrations are still well below the ambient air quality limits. The estimated air quality concentrations are also less than any reported concentrations that cause damage to vegetation (U.S. EPA, 1982a, b, c).

The most conspicuous impact of project operation activities on vegetation will be the loss of timber production on those lands occupied by the project facilities. This impact will be mitigated through reclamation of the disturbed areas as described in the reclamation plan for the plant site area. Long-term land use for the TMA will limit reforestation since the area will be maintained in grasses and shrubs.

4.2.9.2 Wildlife

The primary impacts to wildlife will result from direct habitat loss during facility construction. Additional impacts may potentially occur from changes in habitat resulting from groundwater drawdown and from increases in human activity in the vicinity of the proposed mine site during operation.

Once operations are complete (in year 31), the site will be reclaimed as described in Section 5 of the project's *Mine Permit Application* (FVD, 1995d). At the cessation of mining, a savannah community will be established at the plant site. Open grasslands will be established at the TMA. Grassland vegetation will also be established along the railroad spur. The access road will be maintained as required for long-term site maintenance activities. Ultimately, the access road will also be planted with grassland species. With the exception of the TMA, which must be maintained in grassland vegetation to protect the final cover, volunteer native plant species will be left to develop and natural succession will be allowed to occur. Over time, the site area will revert back to habitats typical for the region.

Impacts to each of the studied groups of terrestrial organisms (i.e., mammals, birds, butterflies, and herptiles) are discussed separately below.

4.2.9.2.1 Mammals

As described in Section 3.9, a total of 35 species of mammals have been observed in the project area. The home ranges of these mammals varies from less than 1 acre for some of the small rodents and shrews to several square miles, both within and outside of the project area, for some of the carnivores. Localized population reductions may occur for the less mobile mammals with small home ranges such as mice, shrews, and voles. Many of the more mobile species, such as the white-tailed deer, will likely disperse into adjacent habitats resulting in minimal impacts to these species. Some of the wider ranging carnivores, such as the coyote, black bear and fisher,

currently include the project area within their home range but may only visit the area occasionally. These mammals will likely avoid the project area once construction activities begin.

Trapping and tracking studies conducted in 1994 indicate that many of the mammal species are widely distributed across all habitat types in the study area and the home ranges of many of the resident mammals incorporate several of these habitats. Therefore, the loss of any one habitat type from the study area or the region becomes less important than the total loss of habitat. The habitat types in the project area, however, are common throughout the region and similar habitat exists immediately adjacent to the facility site. For example, the loss of northern hardwood forest represents only approximately 7 percent of the northern hardwood forest habitat type existing in the approximate 30-square-mile study area surrounding the mine facility and approximately 0.1 percent of the northern hardwood forest in the nearby Nicolet National Forest.

Potential groundwater drawdown effects during the operation phase of the project could result in lowered water tables in some wetland areas. These effects are discussed in Section 4.2.7 and could result in encroachment of plant species better adapted to drier conditions. These changes are expected to occur over a period of several years, will be localized to the margins of discharge wetlands and will not likely result in substantial habitat changes.

Disruption of wildlife communities peripheral to the immediate area of impact, resulting from increased human activity, will also occur during mine operation. Species less tolerant of human activities will likely avoid the area immediately surrounding the plant site and the tailings management area, while others that have a higher degree of tolerance to human activity may remain in the immediate area of the facilities.

Use of the site by many of the mammals currently inhabiting the area will resume soon after facility reclamation is complete. Initially, the proposed reclamation plan will result in an increase in edge habitat and forest openings. Ultimately, however, the site will revert back to habitat similar to that which exists today and use of the site by mammals will be similar to that experienced today.

4.2.9.2.2 Birds

At least 132 bird species were recorded in the study area during 1994 and 1995. The habitats showing the highest levels of species richness included conifer/shrub, northern hardwoods/mixed forest, northern hardwoods/wetlands, and northern hardwoods/conifer/shrub (Table 3.9-19). Northern hardwoods, northern hardwoods/conifers, and northern hardwoods/deciduous forests showed lower diversities in the study area.

The area of direct impact (i.e., area of disturbance) showed comparatively less habitat diversity than much of the surrounding study area. The northern hardwood forest habitat type dominates this area (91 percent of the total area within the construction limits). Based on the results of the 1994 and 1995 surveys, only four of the 132 observed bird species showed a significant preference for this habitat type (i.e., black-throated green warbler, hermit thrush, least flycatcher and ovenbird). The greatest impact associated with the loss of this habitat type, therefore, will be to those species preferring the northern hardwood forests.

As with the mammals, some birds will be displaced during construction and operation of the mine and nesting habitat will be lost. The lost habitat is not essential for the survival of any bird species since similar habitat exists immediately adjacent to the mine site and is common throughout northeastern Wisconsin.

The active tailings pond, reclaim pond, and contact water storage basins will have areas of open water with some potential for use or exposure by waterfowl and mammals. Although considerable toxicological information is available in the literature on potential impacts to waterfowl and mammals resulting from adverse exposure to metal-bearing waters, the impact evaluations are regarded to be site-specific.

In fact, in the recently published U.S.EPA proposed guidelines on general principles for consideration and use in the evaluation of potential impacts to wildlife (FR 61: 47552-47631) specific acute and chronic wildlife toxicity criteria were not developed for general use at potential exposure sites. Rather, U.S. EPA's intent is to permit sufficient flexibility in impact assessments recognizing that considerable differences exist at sites regarding: types of media present; concentrations of constituents in the media; wildlife diversity at a site; existing food and habitat conditions; and, the exposure regime of the wildlife to the media under evaluation.

The potential for wildlife exposures to the artificial ponds exists, however, the exposures will be limited due to the availability of superior habitats and food sources within the area, e.g., Skunk Lake, Hemlock Creek, Duck Lake, Sand Lake, etc. Ultimately, estimating the degree of exposure to a media becomes a key component in any evaluation of impacts to wildlife. Given that uncertainty exists in predicting future wildlife exposures to the artificial ponds and subsequent impacts, if any, CMC intends to monitor the ponds for wildlife activity and, if conditions dictate, implement a program to reduce exposure.

A paper presented at the 131st Meeting: Acoustical Society of America in May of 1996 (Russell, et al., 1996) indicated that observations of bald eagle nests near Aberdeen Proving Grounds between November 1993 and December 1995 "detected no response in a high percentage of nesting and roosting eagles exposed to numerous types of noise at varying levels of intensity." The results of nine studies performed by the U.S. Air Force on the effects of sonic booms on raptors demonstrated a slight decrease in reproduction success of experimental nests but overall no "statistically detectable effect of noise on reproductive success" (Bowles and Awbry, 1990). Additional research conducted in the late 1960s (Mathison, 1968) on the effects of human activity (including logging) on bald eagles demonstrates that these activities even within 1 mile do not adversely affect nesting success of this species.

A study on the peregrine falcon conducted by Ellis (1981) under cooperative agreement between the U.S. Fish and Wildlife Service and the U.S. Air Force involves data gathering at 24 breeding sites of 10 raptorial birds in an effort to record responses to low-level jets and sonic booms. The study concluded that "while the birds were often noticeably alarmed by the subject stimuli, the negative responses were brief and never productivity limiting. In general, the birds were incredibly tolerant of stimulus loads which would likely be unacceptable to humans." Ellis further states, "significantly, birds of prey of several genera commonly nest in the supersonic military operations areas in southern Arizona.

Groundwater drawdown affects will not likely result in the loss or creation of substantial areas of new or different habitat and therefore will likely have little impact on birds. Initially, the proposed reclamation plan will result in an increase in edge habitat and forest openings. Bird species adapted for this habitat type will likely predominate until the site reverts back to habitat similar to that which exists today.

4.2.9.2.3 Butterflies

Of the 50 species of butterflies recorded in the study area in 1994 and 1995, only eight were observed in the project area (Table 3.9-20). Three of these are forest species (banded purple, northern pearly eye and West Virginia white), two prefer openings (European skipper and American painted lady), two prefer bogs (bog copper and brown elfin), and one occurs generally in deciduous woods, bogs and open fields (mustard white). The West Virginia white and bog copper are state special concern butterflies and are discussed in Section 4.2.9.3.

The loss of habitat will result in a localized population reduction of butterflies that currently occupy that habitat. These species and the habitat in which they occur, however, are both well represented in the study area and region.

As with the birds, groundwater drawdown effects will not likely result in the loss or creation of substantial areas of new or different habitat and, therefore, will likely have little impact on butterflies. Other facility operations will not likely result in any impacts to butterflies. The proposed reclamation plan may initially provide new habitat for some of the butterfly species

preferring forest openings but will likely provide habitat similar to that which exists today over time.

4.2.9.2.4 Herptiles

Reptile and amphibian response to habitat loss should be limited to localized reductions and fragmentation of populations commensurate with the actual habitat loss. Fragmentation of populations result when movement barriers (such as roads, buildings, ditches, etc.) are constructed, and populations become isolated from each other. This can lead to disruption of normal migratory movement and dispersal patterns with negative impacts on fitness and survival. This effect may become evident at Skunk Lake, which will be isolated by the plant site to the west, the railroad spur to the north and the TMA access road to the south. Since no herptile populations in the project area are considered critical to any species survival in the region, population effects resulting from the project will be localized and of little regional significance.

On-site reclamation activities will not restore filled wetlands in their previous locations. The proposed wetland compensation site is located approximately 50 miles to the south (see Section 8 of the project's *Section 404 Permit Application Addendum 1* [FVD, 1995b]). As such, those herptiles relying on water for a portion of their life cycle will not likely return in substantial numbers to the project area after the site has been reclaimed. The open savannah habitat in the plant site and grassland habitat on the access road, railroad corridor and TMA will temporarily provide additional habitat for some species of snakes currently occupying forest openings and oldfield habitat in the study area.

4.2.9.3 Threatened and Endangered Wildlife Species

4.2.9.3.1 Mammals

No endangered or threatened mammal species were observed in the study area. Five special concern species, however, were observed during the 1994 surveys. These included bobcat, arctic shrew, pygmy shrew, water shrew, and woodland jumping mouse. Indirect evidence, in the form of tracks, was observed indicating the presence of bobcats in the study area. These observations were generally confined to the larger conifer swamps in the study area. No evidence exists indicating habitual use of the area proposed for the plant site or the TMA. Tracks were observed, however, in the conifer swamp (Wetland W1) along Swamp Creek. This wetland will be traversed twice by the proposed project; once for the access road and once for the railroad spur. The loss of habitat will be small and, based on the prevalence of bobcat tracks on the existing roadways and on the Wisconsin Central Limited Railroad, the proposed wetland crossings should not interfere significantly with bobcat movement within this wetland complex.

Arctic shrews were captured in 11 of 18 trap stations including a variety of habitat types both within and outside the project area. This species appears to prefer moist habitats as indicated by the highest capture rate in a alder swamp with sphagnum moss. The loss of habitat resulting from project construction will result in a localized population reduction. However, this species appears to be well established throughout the remainder of the study area.

Based on trapping results in 1994 (also captured in 11 trap stations), pygmy shrews apparently occur in low, moist habitats throughout the study area and the project area. As with the arctic shrew, project construction will result in a localized population reduction. Although in low numbers, this species also appears to be well established throughout the remainder of the study area. Further, specimens collected during the study indicate the pygmy shrews in the study area belong to the widespread subspecies *Sorex hoyi hoyi*, and not the less common *S. hoyi thompsoni*.

Water shrews were collected at three pitfall trap sites and in one minnow trap during the 1994 surveys. This species is known to exist almost exclusively within aquatic habitats. Water shrews may see some isolated reduction as a result of construction and operation of the project. However, even though water shrews were not seen in abundance, the are expected to continue to live within moist habitats throughout the study area.

A total of 52 woodland jumping mice were collected at six pitfall trap sites and along two transects. This data, along with the Dames & Moore (1981) and Normandeau (1982) collections, suggest that this is a fairly common species within the study area. As with the other small mammals, the development of the mine may result in an isolated reduction of the species. This, however, should not affect the overall species abundance in the area.

4.2.9.3.2 Birds

A total of three threatened and 24 special concern bird species were observed in the study area. An additional four special concern species were sighted in the vicinity of the study area or are suspected of possibly occurring in the study area. No endangered bird species were observed. State threatened species include the bald eagle, osprey and red-shouldered hawk. The bald eagle has been proposed for delisting from threatened status. Active bald eagle and osprey nests and nesting territories exist in the study area and both species have been observed hunting and flying over the project area. The nearest bald eagle nesting territories to the project area are approximately 2 miles to the east on Lake Lucerne and two and one-half miles to the southwest, north of Rolling Stone Lake (Figure 3.9-17). No direct impacts to these territories are anticipated. An osprey nesting territory exists northeast of the plant site with two known nests; one in the Swamp Creek Cedars (Wetland O1) and one near the confluence of Swamp and Hemlock Creeks (Figure 3.9-17). The proposed railroad spur will traverse this osprey nesting territory but will avoid the nearest known nest by approximately 1,000 feet. With proper construction timing for the railroad spur, no impacts to this nesting territory should occur.

Red-shouldered hawks were represented by only one direct observation of an adult hunting on the north side of Duck Lake in autumn and the observation of an active nest more than 1 mile south of the project site. This nest failed due to mammal predation. Based on the 1994 studies, use of the study area by red-shouldered hawks is currently minimal. As such, no impacts are anticipated.

A total of 28 special concern bird species were either documented in the study area, are suspected of possibly occurring in the study area, or were sighted in the vicinity of the study area. Nineteen of these, including the northern goshawk, northern harrier, great gray owl, common merganser, American black duck, black tern, American bittern, yellow rail, spruce grouse, black-backed woodpecker, yellow-bellied flycatcher, sedge wren, boreal chickadee, gray jay, blackburnian warbler, Connecticut warbler, Tennessee warbler, evening grosbeak, pine siskin were on the Wisconsin Natural Heritage Working List when field work was conducted. Nine of the 28 bird species were added to the working list subsequent to the field surveys. These include Cooper's Hawk, Blue-winged teal, veery, black-throated blue warbler, red-headed woodpecker, vesper sparrow, Eastern meadowlark, Golden-winged warbler, and Nashville warbler. Direct impacts to these 28 species resulting from the loss of habitat are not likely.

Sedge wren, spruce grouse and Tennessee warbler were documented only by previous investigators in the late 1970's or early 1980's. No evidence exists today that suggests that these species breed or spend a significant amount of time in the vicinity of the proposed project site or in the study area. Northern harriers were observed in agricultural areas and open fields in the study area. However, suitable habitat for this species does not currently exist in the project area. Studies in 1994 and 1995 indicate that one or more great gray owls may be using the study area but no evidence suggests that a nest is nearby or that the project site is used regularly by this species. Similar evidence exists for the northern goshawk, which was observed only in areas that will not be affected by the project.

Despite intensive searches, no active goshawk nests appear to exist in or near the project area. Limited numbers of black ducks have been observed in the study area including Ground Hemlock Lake and Pickerel Creek. No evidence of nesting exists in the project area for this species and, with the exception of Swamp Creek which will be crossed by the proposed access road and railroad spur, no suitable habitat exists for this species in the project area. Common mergansers were only observed during the migration period. No evidence of nesting in the project area or study area was observed. Black terns were observed west of the study area in a

small pond and are reported to occur on Rice Lake. However, no habitat for this species exists in the project area.

American bittern was documented in the study area on only two occasions and yellow rail only once. Neither species is resident in either the study area or the project area. Evidence of black-backed woodpeckers exists along Hemlock and Swamp Creeks. Robbins (1991) reports that this species is a regular breeder in tamarack bogs and recently burned jack pines. Although limited tamarack habitat exists in the project area, no evidence of the black-backed woodpecker was observed in the area of proposed direct impact. The yellow-bellied flycatcher, boreal chickadee and gray jay are generally residents of larger conifer swamps. These species have been observed in the study area in this habitat type, however, the area in which these species were observed will not be affected by construction or operation of the mine. Based on information from the Nicolet National Forest Bird Survey, blackburnian warblers can be expected most consistently in forests dominated by hemlock and white pine. Although this species was observed in the study area, significant areas of this species preferred habitat do not exist in the project area. Evening grosbeaks were observed in swamp conifer habitats in the study area and breeding in the study area is likely. No evidences exists, however, suggesting nesting activity in the project area. Although pine siskins were observed in March 1994, no evidence was observed indicating that this species breeds in the study area or project area.

The Cooper's Hawk is resident in the study area, and breeding was documented during the 1994 survey. Fragmentation of forests may reduce feeding habitat for this raptor. However, the Cooper's Hawk appears to be becoming more common in residential and other highly disturbed environments. Although blue-winged teal are among Wisconsin's most widespread breeding ducks, they are less common in northeastern Wisconsin. This is consistent with the findings of the study, in that blue-winged teal were not commonly observed anywhere in the study area, even during migration. They were, however, encountered in a wetland within the study area in June 1994, which suggests that a small number of pairs might breed locally. Black-throated blue warblers are also uncommon in northeast Wisconsin. They were encountered only four times at widely scattered sites during 1994.

Veeries were the 15th most abundant bird species observed during the investigation. They area characteristic of moist forests, ranging from shrubby riparian woodland to relatively mature upland forest. Breeding individuals will likely be displaced by the proposed project, however, similar habitat exists throughout the region. Golden-winged warblers favor shrubby habitats, including alder swamps and forest edges. They were observed at several census points on or near the project area, and some will likely be displaced as a result of the project. Nashville warblers are common throughout wet forests and uplands embedded with wetlands throughout Northern Wisconsin. Some individuals will likely be displaced as a result of the project, however, similar habitat exists throughout the region. Red-headed woodpeckers were observed in oak dominated woodlands in the vicinity of lakes. Because they are not deep forest species, the proposed mine is unlikely to impact habitat for this species. Vesper sparrow was observed in generally open areas within the study area. It is unlikely that this open country bird will be significantly affected as a result of the project. Much like the Vesper sparrow, the Eastern meadowlark is an open country bird, and will likely be unaffected by the project.

4.2.9.3.3 Butterflies

One state endangered and 13 state special concern butterflies were observed in the study area in 1994. The state endangered northern blue butterfly was collected, with its preferred host plant billberry (*Vaccinium caespitosum*), at one site at the periphery of the study area greater than 3 miles from the project area. The area in which this butterfly was collected will not be impacted in any way by the proposed project. Of the 13 state special concern butterflies observed in the study area, only the West Virginia white was observed in the project area. This species was most conspicuous in mesic woods of mostly sugar maple and was found in the greatest numbers in an area centered on, but much larger than, the proposed TMA. The loss of habitat will result in a localized population reduction for this species; however, the existence of this population should not be threatened. Further, it is well established elsewhere in the state and this slight loss of habitat should not represent a threat to the existence of this species.

4.2.9.3.4 Herptiles

Of the seven targeted herptile species potentially existing in the study area only two were observed; the four-toed salamander (state special concern) and the ringneck snake (state special concern). The four-toed salamander was observed in a wetland immediately south of the TMA and in a maple dominated forest west of Duck Lake. Based on these findings, it is thought that four-toed salamanders are probably uncommon throughout the study area in any wetland with a sphagnum moss component adjacent to hardwood or mixed upland forest. Potentially suitable habitat within the construction limits will be lost as a result of the proposed project. However, documentation exists for this species in Oconto, Oneida, and Vilas Counties and the survival of this species will not be threatened by the proposed project.

The ringneck snake is known throughout the region in moist deciduous forests (Casper, 1995; Vogt, 1981). There are records from Florence, Forest, Langlade, Marinette, Oconto, Oneida and Shawano Counties. Based on the 1994 surveys, during which two specimens were collected, this species is expected to be uncommon to common throughout the study area and project area in mixed and deciduous woods. The proposed project will result in the loss of some potentially suitable habitat and, thus, may result in localized population reductions.

4.2.9.3.5 Plants

During the course of the 1994 and 1995 field surveys, 23 species of vascular plants on the Wisconsin Natural Heritage Working List were found. Of the 23 species, only seven occurred in the area of proposed construction. These include the state endangered goblin fern and the following six state special concern species: blunt-lobe grape fern, lance-leaved grape fern, little grape fern, assiniboine sedge, variegated scouring rush, and ginseng.

A total of 48 new populations of *Botrychium mormo* (goblin fern) were discovered during the 1994 and 1995 field surveys. Sixteen of these populations were discovered at 15 sites in 1994, and 32 additional populations at 27 sites were found in 1995. Of these, five populations were located within the area of disturbance for the tailings management area, five additional were located within the study area, and the remaining 38 populations were found in a six county area (Forest, Langlade, Oconto, Marinette, and Florence Counties in Wisconsin, and Gogebic County, Michigan) adjacent to the project site. This data, as well as existing literature, suggests that this species is more widespread than previously thought. In view of the loss of habitat as a result of the construction of the TMA is not expected to have a significant effect on the survival of the species.

Three populations of blunt-lobe grape fern were found within the study area during the 1994 field survey. One was within the limits of the proposed construction of the TMA. A second population may be partially impacted by the proposed access road. The third population is located north of the proposed TMA, and will not be impacted by the proposed project.

The lance-leaved grape fern and the little grape fern were both found in the habitats and locations in which the goblin fern was found. The primary habitat within the project area exists within the TMA. Although this habitat will be lost, based on the experience of the botanical team these species are well represented elsewhere within their range in Wisconsin.

Assiniboine sedge was found at five locations: one within the plant site, one within the TMA, two in the study area and one in the Nicolet National Forest. The populations within the plant site and the TMA will be lost. Because this plant is frequently sterile and therefore difficult to identify, its apparent rarity may be more a function of misidentification rather than the scarcity of the plants.

Variegated scouring rush was represented in the 1994 surveys by only one population. This population was located in the TMA site in a forest opening created by one of the old well sites. Although this site is in an area that will be directly impacted, it is currently being invaded by seedlings of various trees and shrubs and the site will likely become unsuitable for this species within a few years.

Ginseng was observed in scattered sparse populations in an area covering and extending beyond the limits of the TMA and at a location north of the plant site. A portion of the habitat will be lost during the construction of the TMA. The remaining plants should go undisturbed. Although this plant is intensely sought for its medicinal properties and is becoming scarce, it is well represented throughout its range in the state and should not be threatened by the proposed project. Collection is likely the limiting factor for this species. Ginseng is cultivated in many regions of Wisconsin.

Secondary impacts may affect additional areas outside of the project area but within the study area boundaries. These areas will generally be confined to lakes, streams and wetlands. Impacts to these features were described previously in Sections 4.2.6 and 4.2.7. Endangered plant species observed associated with these features include only the mountain cranberry (*Vaccinium vitus-idaea*). One population of this species was observed in wetland W1. This area is well outside the area of groundwater drawdown for both the best engineering judgement and practical worst case scenarios. No impacts are anticipated that would jeopardize the survival of this species.

Three threatened plant species have been observed in these aquatic environments: algal-leaved pondweed, small yellow water crowfoot, and calypso orchid. Algal-leaved pond weed is a submerged aquatic plant existing in Duck Lake. The water quality and quantity changes estimated for this lake are negligible, therefore, no impacts are anticipated to occur to this plant. The small yellow water crowfoot is an aquatic plant existing in Upper Pickerel Creek near its confluence with Rolling Stone Lake. As with Duck Lake, the water quality and quantity changes to this water resource are negligible and will not affect this plant. Calypso orchid was observed in wetland O1, the Swamp Creek Cedars. They exist within the portion of this wetland that will experience potentially greater than 2 feet of drawdown in the groundwater beneath the wetland. The potential exists that changes in soil moisture associated with the drawdown will stress this threatened plant species at this location. Two other calypso orchid sites have been observed in portions of the study area where impacts are not anticipated. As described in the Monitoring Plan, these populations will be monitored and mitigation measures will be employed if stress is observed.

4.2.9.4 Summary

The most conspicuous impacts to the terrestrial ecosystem will be the conversion of approximately 540 acres of largely forested lands to mine related land uses during the construction and operation phases of the project. For some of the small and/or immobile organisms, this may result in a localized reduction in populations. These organisms include reptiles and amphibians that rely on small ephemeral pools or wetlands existing in the area of the TMA or plant site for a portion of there life cycle; some butterflies that rely on host plants existing in the areas to be cleared; mice, shrews and other small rodents that may not have the ability to relocate; and plants. This category of impact applies to three state special concern shrews, one state special concern mouse, one state special concern butterfly, one state special concern snake, one state special concern salamander, six state special concern plants and one state endangered plant. Based on studies conducted by CMC, it appears that all of these species are well represented elsewhere in the region and therefore, any impacts will only represent localized population reductions. Overall, the survival of these species should not be threatened by the project. Larger and/or more mobile organisms will likely move to adjacent habitat and should not be seriously threatened by the project. Once project operations are complete, the site will be reclaimed. Ultimately the entire area, with the exception of the TMA which will be maintained as a grassland, will be returned to forested habitats.

By and large, groundwater drawdown should not result in substantial impact to terrestrial biota. The uplands should not be affected in any way by changes in groundwater elevation. Some impacts may occur in discharge wetlands, however, they should not result in substantial changes in terrestrial habitats (see Section 4.2.7).

4.2.10 Mine-Related Noise and Vibration

The following analysis addressed potential project impacts related to noise and vibration.

4.2.10.1 Noise

Project-related noise will be generated during initial construction and reclamation construction activities and during operations. Estimated noise and a comparison of their levels in relation to source background conditions and published guidelines follows.

4.2.10.1.1 Construction Noise

Noise impacts from construction activities were addressed in the 1985 *Environmental Impact Report* (EMC, 1985). Daytime and nighttime noise contours were presented. With the re-initiation of the project, construction equipment requirements, construction schedule, and hours of activity were reevaluated and used to complete an updated analysis.

Effects of Noise

When high noise levels are experienced inside or outside people's homes, as may occur from the passage of motor vehicles or the operation of mechanical equipment, a feeling of annoyance may result. Noise levels may also interfere with the performance of various activities such as conversation, TV watching, sleeping, enjoying quiet outdoor settings, etc. The degree to which there is annoyance and/or activity interference depends on the magnitude and quality of the intruding noise level, the frequency with which it occurs, and the time of day of occurrence. In response to the Noise Control Act of 1972, which directed the EPA to establish a recommended measure to describe community noise, the day-night average sound level (Ldn), as previously defined in Section 3.11.1.1, was selected as the unit of measurement to be used to predict annoyance from noise exposure.

Several social surveys have been conducted in which people's reaction to their noise environment has been determined as a function of the Ldn occurring outside their homes. Guidelines have been developed for individual land uses based upon the information collected in these surveys and upon information concerning activity interference. For various land uses, the level of acceptability of the noise environment is dependent upon the activity that is conducted and the type of building construction (for indoor activities). The EPA has recommended an Ldn value of 55 dBA as adequate to protect the public health and welfare with an adequate margin of safety (EPA, 1974). Depending upon attitude and other nonacoustic factors, there would be no expected reaction from an average community with an Ldn of 55 dBA, although approximately 5 percent of the average population would indicate "highly annoyed" at this level (NRC, 1977). It should be recognized that not all individuals have the same susceptibility to noise and that in social society some people will always indicate annoyance and some people will never indicate annoyance regardless of noise level. Figure 4.2.10-1 presents the American National Standards Institute land-use compatibility guidelines for a variety of land uses based on Ldn (ANSI, 1990). Except for special function land uses (i.e., music shells), all land uses are compatible with an Ldn value of 55 dBA and below. The State of Wisconsin does not currently have independent regulations or standards for community noise control.

Incremental Increase Criteria

In addition to being concerned about the absolute noise level that might occur when a new noise source is introduced into an area, it is also important to consider the level of the existing noise environment. If the existing noise environment is quite low and the new noise source greatly

increases the noise exposure (even though a criterion level might not be exceeded), some impact may occur. General rules of thumb for real-life noise environments are that a change of over 5 dB is readily noticeable and would be considered a significant increase (ISO, 1971). Complaints may certainly be expected if the difference reaches 10 dBA or more. Changes from 3 to 5 dBA may be noticed by some individuals and would be considered a substantial increase, possibly resulting in sporadic complaints. Changes of less than 3 dBA are normally not noticeable and are considered "insignificant."

These general rules of thumb may be expanded upon in conjunction with the federal land use compatibility categories as follows:

1. When noise levels before and after addition of the project fall within the same classification (either "compatible" or "marginally compatible"), (a) an increase less than 3 dB would normally not be noticeable and result in no impact, (b) an increase greater than 3 dB but less than 5 dB would be noticeable and have a minor impact, and (c) an increase of 5 dB or greater would be very noticeable.

2. When noise levels increase after addition of the project and change compatibility classifications, (a) an increase less than 3 dB would result in no impact and (b) an increase greater than 3 dB could result in sporadic complaints.

Noise Model

The noise propagation model used for this analysis is based on the results of a mixture of experimental measurements, scale models, and physics. The basic equation of outdoor noise propagation includes the effects of divergence, atmospheric absorption, shielding by intervening structures, and absorption and shielding by ground cover. How each of these effects were considered in the model is discussed below. The effects of fog, precipitation, and air turbulence are generally negligible and are usually not considered, and therefore, are not discussed below.

- Divergence - The noise level decreases at a uniform rate of 6 dB per doubling of distance from the source.

- Atmospheric Absorption - As sound waves pass through the atmosphere acoustical energy is absorbed by the oxygen, nitrogen, and water molecules at various rates depending upon wave length of the sound, temperature, humidity, and atmospheric pressure. These conditions change both spatially and from moment to moment. For the purpose of analysis, an average temperature of 65°F and 50 percent relative humidity was used to compute absorption (ANSI, 1978).

  The atmospheric absorption values shown below were used in the analysis and are valid to within ± 3 dB for a wide range of temperature and humidity conditions (e.g., 75°F from 30 to 90 percent relative humidity; 50°F from 15 to 100 percent relative humidity; 25°F from 25 to 60 percent relative humidity; 0°F from 60 to 100 percent relative humidity).

Distance	dBA Reduction
1/2 mile	3.1
1 mile	5.8
2 miles	10.2
3 miles	13.3
4 miles	15.5
5 miles	17.1
6 miles	18.2

- Ground Cover - Absorption by ground cover can result in over 20 dB reduction. A conservative limit of 10 dB reduction is often recommended for use with open fields (Beranek, et al., 1992). The ground absorption is dependent upon the flow resistivity of the surface. The higher the resistivity the lower the noise reduction. The typical value for flow resistivity for dry snow is about 20 rayls, a forest floor is 50 rayls, plowed ground is 200 rayls, and asphalt is greater than 20,000 rayls. Since both snow-covered ground and forested ground have about the same resistivity, the effect should be present during all seasons of the year. Dense wooded areas can provide additional noise reduction if the trees protrude above the line of sight by over 15 feet and are sufficiently thick (over 300 ft). Reductions from 3 to over 25 dB for each 300 feet of forest have been reported (Beranek, 1971). A conservative limit of 10 dB is often recommended (Beranek, et al., 1992). For the purpose of conservative modeling, the Crandon Project activities total reduction from ground and tree effects was limited to 10 dB.

- Shielding - Intervening terrain and structures provide an obstacle to the noise and create a shadow zone behind the object where noise levels are 5 to 24 dB or less. Since there are few intervening structures and the local terrain is relatively flat, the effect of shielding was not incorporated into the model.

- Wind/Temperature Gradient - Vertical wind speeds and temperature gradients can refract (bend) sound waves either upward or downward. The downward refraction is the main reason that the noise reduction for ground cover and trees is limited to 10 dB. It is also a major reason why the noise reduction from screening is normally limited. This condition occurs when the air temperature increases with height above the ground or when a receiver is downwind of the noise source. When sound refracts upward, a sound shadow is created. This condition occurs when the receiver is upwind of the noise source or when the temperature near the ground is warmer than at higher elevations.

Construction Noise Sources

Construction activity will occur in several phases, which include: site clearing, grading, and excavation; equipment erection; facility fabrication; and finish work and landscaping. The following activities were included in the construction noise model:

- Plant Site.
- Tailings Management Area (TMA).

- Access Road.
- Railroad Spur.

Based upon the project's mine development plan, construction activities are expected to occur over a 36-month period. Surface construction will occur 12 hours per day, normally 5 days per week. Nighttime construction will be confined to underground activities. During approximately the last 16 months, mine ventilation fans will begin 24-hour operation 7 days a week. The earthmoving activities at the TMA will occur 7 days per week. Figure 4.2.10-2 presents ranges of noise levels for various types of construction-related machinery. In addition to the mechanical noise from this equipment, the noise from vehicle back-up alarms was considered. Because of the nature of this activity, the number, type, and loudness of equipment will vary throughout the period. Sound pressure levels for the equipment associated with the construction activities are presented in Appendix 4.2-6.

The location of activity will also vary, especially for the access road and railroad spur construction. In order to determine the months when noise levels may be the highest, the construction equipment schedule, hours of operation, typical noise emissions, and loading and usage were used to determine the noise emission by month of each of the activities in terms of Ldn (BBN, 1971). Figure 4.2.10-3 presents the estimated construction noise emission by month in terms of Ldn normalized to a distance of 50 feet for each of the construction activities. Based upon this analysis, noise during month 5 will be the highest for the construction activities at the plant site. The access road construction will be the noisiest during months 1 through 6. The railroad spur construction will be the noisiest during months 11 through 14. The TMA construction will be the noisiest during months 12 through 14. Additional construction activities at the TMA during the life of the project will occur over a 3 to 9 month period and have maximum noise emissions similar to month 30. Based upon the 36-month construction schedule, the noisiest months of construction along with the associated construction activities are listed in Table 4.2.10-1 below.

Table 4.2.10-1

Activities Assumed During Month Modeled

Month 5	Month 12	Month 18	Month 30
Plant	Plant	Plant	Plant
Access Road	TMA	Access Road	Mine Fan
	Railroad Spur	TMA	TMA
		Railroad Spur	

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Construction Phase Noise Impact Assessment

In order to evaluate construction noise impacts, noise from the noisiest months of construction was estimated for each of the 13 noise survey locations, which are shown in Table 3.11-1 and Figure 3.11-1. During the daytime hours, the construction noise levels are expected to vary according to actual numbers and types of equipment operating, equipment load conditions, actual location of equipment, and atmospheric conditions. Since the actual location of construction activity will progress along the corridors, road and railroad construction activities were assumed to be located at the shortest distance to each monitor location in order to provide an indication of practical worst case noise levels. The calculations assume hemispherical divergence, atmospheric absorption (65°F, 50 percent relative humidity), and attenuation from trees (Beranek, et al., 1992, and ANSI, 1978). Table 4.2.10-2 presents the estimated Ldn for the noisiest months during construction.

Typical ranges of noise levels based upon a general description of the area (NRC, 1977) and measured background Ldn values are also tabulated in Table 4.2.10-2 for comparison. As presented in Section 3.11, existing Ldn values vary from the mid-30 to the mid-50 dBA range depending upon proximity to traveled roads and human activities. Except for location 5, which is next to the proposed plant site, all estimated Ldn values are less than or within the range of both the measured background levels and the typical range of Ldn values expected based upon the land use (NRC, 1977). All estimated Ldn values are less than or equal to the EPA's recommended Ldn of 55 dBA.

Since noise levels add logarithmatically, there will be little increase at most locations. To add two noise levels, find the difference between the two levels and add the correction from Table 4.2.10-3 to the higher level.

The Ldn is estimated to increase by 3 dB or more at only locations 5 and 6 during some conditions. Location 5 is across Little Sand Lake Road from the plant site and will experience as much as a 10 dB increase in noise level during some months. Location 6 is about a half mile further south of location 5 and the Ldn is estimated to increase by over 3 dB during part of the first 6 months of construction when road construction activities occur along the south end of the access road.

Table 4.2.10-4 compares the range of measured daytime noise levels with the estimated daytime hourly Leq (described in Section 3.11.1.1) from construction. The estimated daytime Leq for construction falls within or below the range of measured Leq values for most locations. The estimated increase during the quieter hours of the day is less than 3 dB during construction for many areas. During some hours of the day for some of the construction period the noise levels at locations 3, 5, 6, and 9 may increase by more than 3 dB. During the quieter hours of the daytime, location 3 may experience an 8 dB increase when road construction activity is closest but this is well below the maximum levels measured. The estimated levels at locations 5 and 9 are within the existing range of measured levels. Location 6 may experience an increase during the quieter hours of the day for some of the first 14 months and noise from construction would be very noticeable.

Table 4.2.10-2

Modeled Ldn from Construction

Monitor Location	Location	Ambient Ldn, dBA		Modeled Construction Ldn, dBA Month				Estimated Increase in Ldn over Ambient Conditions
		Typical[1]	Measured[2]	5	12	18	30	
1	School at Mole Lake	40-50	42w, 50s	23	18	17	16	<1
2	Community Center STH 55 and Sand Lake Road	40-50	38w, 47s	29	24	23	21	<1
2A	Residential Backyards on STH 55	45-55	(53w)	33	25	27	22	<1
3	Mihalko Residence	35-45	(52w), 38w, 51s	38	25	33	20	<1 to 3
4	Residence 3712	35-45	44w, 62s	20	29	23	19	<1
4A	Southeast of Location 4	35-45	--	20	27	22	19	--
5	CMC Field Office	35-45	45w, 55s	55	48	47	51	<1 to 11
6	Webb Residence	35-45	40w, 45s	43	38	36	35	<1 to 5
7	Lake Metonga	35-45	49w, 49s	29	31	27	19	<1
8	Rolling Stone Lake	35-45	(37w), 38w, 46s	22	20	17	18	<1
9	Ground Hemlock Lake	35-45	(48w), 37w, 41s	29	40	35	37	<1 to 5
9A	Northeast Shore of Ground Hemlock Lake	35-45	--	25	32	28	29	--
10	St. Johns Lake	35-45	38w, 38s	20	25	21	23	<1

[1] Typical range based on National Research Council, 1977. Partially developed rural area = 35 to 45 dBA; quiet residential area = 40 to 50 dBA; near roadways = 45 to 55 dBA.

[2] Single values ( ) are 24-hr measurement data; other values are based upon measured short-term samples presented in Sec. 3.11; s = summer and w = winter.

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Table 4.2.10-3

Correction Factors

dB difference	dB Correction to be Added to Higher Level
0 - 1	+3
2 - 3	+2
4 - 9	+1
≥10	+0

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Table 4.2.10-4

Leq from Construction

Monitor Location	Range of Measured Daytime[1] Leq, dBA	Modeled Construction Daytime Leq, dBA Month 5	12	18	30	Estimated Increase in Leq
1	31-47	26	21	20	17	<1
2	38-43	32	27	26	22	<1
2A[2]	42-54	36	28	30	23	<1
3[2]	34-71	41	28	36	21	<1 to 8
4	33-65	23	32	26	21	<1 to 3
4A	42-49	23	30	25	22	<1
5	25-58	58	51	50	51	1 to 33
6	23-43	46	41	39	36	1 to 23
7	39-49	32	34	30	21	<1
8[2]	27-46	25	23	20	20	<1 to 2
9[2]	22-50	32	43	38	40	<1 to 21
9A	39	28	35	31	32	<1 to 2
10	28-48	23	28	24	25	<1 to 3

[1]Daytime hours start at 7 a.m. and end at 10 p.m.
[2]Daytime range includes results of 24-hour monitoring.

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Noise From Construction Blasting

Surface blasting is not planned as part of the normal surface construction activities. However, large boulders may be encountered during grading activities and may have to be reduced in size by blasting.

Blasting will be required when bedrock is encountered during shaft sinking for the main shaft and ventilation shafts. The depth at which bedrock may be encountered is 75 feet to over 150 feet below the surface. The sound pressure levels associated with blasting are impulsive in nature and highly variable depending upon the number of holes, depth of charge, and weight of charge.

The main shaft will be the largest shaft and will require the largest charge weights. For the purposes of estimating blast noise, each blast was assumed to consist of a total of 45 holes containing approximately 8 pounds of ANFO to be detonated using 15 delays. A delay refers to the millisecond interval between successive groups of detonations (typically 25 to 100 milliseconds). Two blasts per day are planned and the analyses assumed that one would occur during nighttime hours. The estimates are based upon data from surface mines (USDC, 1978; USDC, 1983). Blast doors will be located at the top of the shaft and will be closed during the detonation to prevent debris from exiting the shaft. These doors muffle the sound escaping the shaft. In addition, noise levels at the surface are expected to decrease with shaft depth. However, the muffling effect by the shaft depth and by the blast doors is not documented in the literature and no corrections were made for these effects in the analysis. The presented peak levels are conservatively based upon surface mines and are higher than would be anticipated for vertical shafts equipped with blast doors.

Day-night average sound level, which is A-weighted, is the primary descriptor of environmental noise. However, for high-energy impulsive sounds, C-weighting is considered more appropriate. C-weighting better predicts the induced vibrations of structures that generate annoyance from secondary auditory effects such as "house rattling," "startle," and activity interference. Table 4.2.10-5 presents the peak overpressure level in dB and the C-weighted day/night average level Lcdn.

The percent highly annoyed is a standard description used to describe the average community response to acoustic stimuli from exterior high-energy impulsive sounds. The efforts by CHABA Work Group 84 on community response to high-energy impulsive sounds have resulted in a relationship between Lcdn and percent of population estimated to be highly annoyed (ANSI, 1986; NRC, 1981). Over 5 percent of the population would be estimated to be annoyed when exposed to Lcdn above 54 dBC, over 10 percent above 59 dBC, and over 15 percent above 62 dBC.

Wisconsin Administrative Code, Section ILHR 7.64, "Control of Adverse Effects," sets airblast limits to 129 dB peak level at the location of any dwelling, public building, place of employment, school, church, or community or institutional building outside the controlled blasting area. The Wisconsin Air Blast Limit of 129 dB peak level is estimated to be met for locations beyond 700 feet from the mine shaft. No residences or public buildings are within this controlled blasting area and, in fact, no such structures are within 2,800 feet of the plant site.

Table 4.2.10-5

Unmitigated Noise From Surface Blasting

Monitor Location	Distance (miles)	Peak Level, dB	Lcdn, dB
1	3.4	101	51
2	2.5	104	53
2A	2.4	104	54
3	2.6	103	53
4	3.4	101	51
4A	3.4	101	51
5	0.6	116	66
6	0.8	113	63
7	2.8	103	52
8	3.0	102	52
9	2.0	106	55
9A	2.5	104	53
10	3.1	102	52

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4.2.10.1.2 Operation Noise

The methodology used to estimate the project-generated noise during the operation phase is identical to that for construction phase noise analyses. For a general discussion of sound levels, see Section 4.2.10.1. The 13 noise monitoring locations are presented in Table 3.11-1 and on Figure 3.11-1. The major sources of noise during the project operation phase will be associated with the following facilities:

- Plant site.
- Tailings management area (TMA).
- Access road.
- Railroad spur.
- TMA access road.

The noise impacts from plant operation included in the 1985 *Environmental Impact Report* (EMC, 1985) considered a "worst case" scenario. Project description and equipment have changed and the noise impacts have been reassessed using a practical worst case approach based upon new projections and additional ambient noise measurements. The facilities modeled and hours of operation are listed in Table 4.2.10-6. Most of the surface mechanical equipment will be located within buildings, including the concentrator building, pump house, wastewater treatment facility, compressor room, emergency generator, and hoist house. Mine air will be

provided by the east ventilation shaft, which will be equipped with two centrifugal fans having a total capacity of 700,000 cfm. The air will be heated in the winter by 70,000,000 Btu/hr natural gas-fueled heaters. The emergency generator operates 4 hours per day for peak load shedding. Other noise sources include transformers and miscellaneous small pumps and motors scattered throughout the facility. Noise level emissions for the concentrator are based upon the 1985 EIR (EMC, 1985).

During the period of mine operation, construction at the TMA will occur intermittently during the life of the project. The TMA activities are expected to occur during daytime hours except for unusual situations. During this construction, mobile equipment will move soils from the interior of each TMA cell and build up the embankment berms around each cell. Equipment operating inside these cells will have noise levels reduced while the equipment is operating behind the berm. Traffic on the access road is expected to be less than approximately 364 cars per day and five delivery trucks per day. Clay haul trucks traveling on the TMA access road are expected to pass by every 7.5 minutes during 12 of the daytime hours.

Table 4.2.10-6

Operation Noise Sources

Equipment	Description	Hours of Operation		A-Weighted Levels Normalized to 50 ft	
		Day	Night	Leq	Ldn
Concentrator Building	ref. 1986 EIS	15	9	90	96
Mine Air Heaters	70 mm BTU/HR.	15	9	86	92
Ventilation Fans	700,000 cfm	15	9	85	91
Compressor House	ref. 1986 EIS	15	9	53	59
Transformer	ref. 1986 EIS	15	9	72	78
Emergency Generator	2.5 MW	4	0	79	71
Railroad Spur Activity	Locomotive + 15 Cars	3	2	46	56
Access Road	738 Vehicles[1]	12	9	54	52
TMA Access Road	96 Tandem Trucks/day	12	0	68	65
TMA	Construction	12	0	90	87

[1]A conservative vehicle occupancy rate of 1.1 was used.

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Railroad spur operations will occur intermittently for a total of five hours throughout the day. The activity will include moving and switching 10 to 15 cars per day of concentrate and two cars per day of consumables. A train from the site to the Wisconsin Central Limited Railroad will take less than two hours to traverse the 5 miles and return. The Wisconsin Central Limited

Railroad currently operates two trains per day but expects to double this service within the next two years due to operational considerations not related to the proposed project.

Operation Noise Impact Assessment

The estimated contributions to ambient noise levels during operation are presented in Table 4.2.10-7. The quietest hours of the day and night will be increased over 3 dB at locations 5, 6, and 9. However, the estimated levels exceed the range of nighttime ambient levels only at location 5 and are below or within the range of measured daytime and nighttime levels at all other locations. Actual mine operation noise will probably be less than these estimates, since ground and tree effects were limited and barrier effects were not included. Shielding by buildings and terrain can produce up to a 24-dB reduction.

The estimated Ldn from mine operations does not exceed the EPA's level requisite to protect the public health and welfare with an adequate margin of safety at any of the residential locations and, thus, no noise impact is projected. The Ldn from mine operations fall within or below the range of measured Ldn values at all locations. Except for locations 5, 6, and 9, the Ldn is expected to increase by less than 3 dB and, thus, no impact would be projected there. Locations 6 and 9 may experience 4 to 5 dB increase during some periods of the year, representing a minor impact.

The noise impact from traffic on STH 55 was estimated based upon existing traffic flow data, projected traffic from the mine operation, and procedures consistent with the Federal Highway Administration (FHWA, 1978). The average daily traffic on STH 55 heading north is estimated to increase from 940 vehicles per day to 1,457 vehicles per day. Heading south the traffic is estimated to increase from 530 vehicles per day to 751 vehicles per day. The Ldn from increased traffic on STH 55 is expected to increase by less than 2 dB for any areas adjacent to STH 55.

4.2.10.1.3 Summary

The noise analysis considered practical worst case construction activities and periods when construction activities would be the nearest to each residential location. Effects of upwind conditions, shielding by barriers and terrain, and conservatively low estimates of the absorption by ground cover and the forested areas should result in actual noise levels lower than those presented in this evaluation. During the construction of the proposed project, noise levels will increase for adjoining areas. However, the increase in Ldn at all residential areas evaluated is estimated to be 3 dB or less even during the periods of highest activity and closest proximity (an increase of 3 dB or less would be expected to produce no impact). The current residential land use compatibility would not be changed by construction-generated noise and no impacts to residential land uses are expected.

During plant operation the Ldn for the nearest residential areas evaluated could increase by 5 dB. The noisiest condition would occur during the daylight hours when the TMA is under construction. Residential locations within approximately a mile of the TMA construction activity may notice a minor increase of 4 to 5 dB in noise during some periods of the year. These increases are within existing ranges measured in the area. Most residential locations evaluated are further away, however, and would not experience a noticeable increase in noise due to plant operation. The current residential land use compatibility would not be substantially changed by noise from plant operation, and no significant impacts to residential land uses are expected.

Table 4.2.10-7

Mine Operation Noise Levels

Monitor Location	Range of Measured Leq		Ambient Ldn, dBA		Estimated A-Weighted Levels from Mine Operations			Estimated Increase in Ldn
	Daytime	Nighttime	Typical[1]	Measured[2]	Daytime Leq	Nighttime Leq	Ldn	
1	31-47	30-43	40-50	42w, 50s	18	17	24	<1
2	38-43	29-40	40-50	38w, 47s	24	23	29	<1
2A	42-54	28-52	45-55	(53w)	25	24	30	<1
3	34-71	24-58	35-45	(52w), 38w, 51s	24	23	29	<1
4	33-65	35-47	35-45	44w, 62s	22	16	24	<1
4A	42-49	31-42	35-45	--	23	16	24	--
5	25-58	27-44	35-45	45w, 55s	46	46	52	2 to 8
6	23-43	19-40	35-45	40w, 45s	39	38	44	3 to 6
7	39-49	33-43	35-45	49w, 49s	23	20	27	<1
8	27-46	27-40	35-45	(37w), 38w, 46s	20	18	25	<1
9	22-50	22-51	35-45	(48w), 37w, 41s	42	25	39	<1 to 4
9A	39	--	35-45	--	32	21	31	--
10	28-48	22-31	35-45	38w, 38s	24	17	25	<1

[1] Typical range based on National Research Council, 1977. Partially developed rural area = 35 to 45 dBA; quiet residential area = 40 to 50 dBA; near roadways = 45 to 55 dBA.

[2] Single values ( ) are 24-hr measurement data; other values based upon short-term samples presented in Section 3.11; s = summer and w = winter.

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4.2.10.2 Vibration

CMC has provided descriptions of mining and construction methods in the project's *Mining Permit Application* (Foth & Van Dyke, 1995d). Most of the mining will be accomplished by means of blasting. Use of explosives for development as well as stope production can lead to noise and ground vibration. Estimates of noise levels during the blasting of the maximum anticipated charge were discussed in Section 4.2.10.1. Surface vibrations caused by underground blasting were estimated for several scenarios of charge weights and blast distances (EMC, 1985c). These calculations are also relevant for the current application because the range of charge weights investigated includes the maximum charge weight presently anticipated (i.e., 2,000 lb per delay). None of the other parameters have changed. Isograms for particle velocities were developed for the maximum anticipated charge of 2,000 pounds per delay and are depicted on Figure 4.2.10-4. This figure also shows all existing structures within the zone of vibration at a radial distance of approximately 0.85 mile (see following paragraphs for the zone of vibration). Based on this figure and the work completed in 1985 it can be concluded that:

- For four buildings the estimated particle velocities may be between 0.2 and 0.5 inch/sec which is slightly higher than the human response threshold of 0.2 inch/sec, but much smaller than the damage threshold of 2.0 inches/sec. Each of these buildings are owned by CMC.

- Vibration levels (measured as peak particle velocities) from all typical Crandon Project blasting events will fall well below the 0.2 inches/sec human response threshold for all other buildings. In fact, the vibration levels from the smaller shaft sinking, drift mining and production blasting activities are estimated to be completely undetectable at that distance.

- Off site vibration levels will be low as a result of the applied on-site blast design criteria. The local seismic effects of blasting will be limited to generally less than the damage threshold of 2.0 inches/sec in the immediate mine/plant area. Blast delay patterns and explosives charge weights per delay will be managed accordingly.

The above conclusions are based on limits of peak particle velocities for human response cited in the report titled *Supplemental Information on the Seismic Effects of Mine Blasting Practice* (EMC, 1985c), included in Appendix 4.2-7. These values are valid based on the limits contained in Chapter ILHR 7.64, Wis. Admin. Code.

All blasting operations at the site will be conducted according to DILHR regulations. This will include but not be limited to pre-blasting notifications (ILHR 7.35 and 7.61), blasting logs (ILHR 7.37), blasting schedules (ILHR 7.62) and instrumentation (ILHR 7.63). A monitoring plan has been detailed in the project's *Mine Permit Application* (Foth & Van Dyke, 1995d). The main purpose of this monitoring is to verify the design parameters during initial construction and mine operation events. With these data, scaled distance factors will be computed so that blasting can continue without seismic monitoring. This will comply with ILHR 7.64(A)(c). In the unlikely event that peak particle velocities observed in the field show a need to reduce ground vibrations, this will be accomplished by reducing the charge per delay, or reducing the total charge in each blast.

The current blast designs are based on a maximum charge per delay of 2,000 lb. For such blasting, estimates of ground vibrations show no damage to structures will occur in the near vicinity of blasting (mine-related structures) and that the vibrations will generally be below the human response threshold beyond 0.85 miles from the blasting site.

4.2.11 Land Use

As a result of plant site and TMA construction and operation, there will be direct land use impacts on approximately 540 acres of land in the project area and indirect land use impacts from project-related population and support business changes in the Forest, Langlade, and Oneida county region. In addition there will be short-term and temporary impacts during the construction of the Wisconsin River discharge pipeline, and a permanent change in converting the wetland compensation site from farmland back to wetland.

4.2.11.1 Local Land Use

As a result of facility development, approximately 540 acres of land will be converted from primarily forest use to mine-related uses such as building construction, paved access road, railroad spur, parking areas, and the TMA itself. Approximately 60 percent of the area will be converted to impervious surfaces. The remaining land will continue to support varying levels of vegetation (i.e., grass to forest regeneration). Once reclaimed, the plant site area will consist of a combination of savannah/forested vegetation. The TMA area will be sequentially constructed and reclaimed during the project's construction and operating life. Once reclaimed, the TMA area will be returned to a northern prairie environment that will support non-woody vegetation.

Subject to the WDNR's approval, Forest County will convey approximately 1,000 acres of county forest lands to CMC for use by CMC in connection with the TMA and as buffer lands. CMC has agreed to convey approximately 1,396 acres to Forest County to replace these lands. The net result of these transactions will be a slight increase in the amount of publicly owned lands in Forest County. There will be a small net loss of land available for certain public uses, however, because the replacement lands to be conveyed to Forest County already are enrolled in the Forest County cropland program and, thus, are already open to hunting, fishing, and other activities. This small net loss will have negligible impacts given the vast amounts of land in the immediate vicinity which are either publicly owned or enrolled in the forest cropland program.

The impact on forestry will be removal of merchantable timber with an estimated value of approximately $250 per acre. (Steigerwaldt, 1995) A ready market for this timber exists both as saw logs and pulp wood. Depending on the regeneration allowed on certain lands within the plant site complex, a portion of that timber may be allowed to regenerate during the project life. After the plant site is reclaimed, much of the remaining land area will ultimately revert back to forestry use.

Approximately 15 acres of land now used for agriculture will be impacted as a result of the project. This land is presently used for pasture/hay production. Upon receipt of permits and the initiation of construction, this area will no longer produce agricultural related crops.

Recreational land use on the project site will be impacted as a result of the land changing from primarily forest to an industrial setting. Approximately 540 acres of land will be removed from hunting, hiking, cross-country skiing and other recreation related uses during the life of the mine. This impact is minimal when considering the vast area of alternative lands available for recreational use in Forest, Langlade, and Oneida counties. After the site is reclaimed much of it will again be available for recreational use.

There are no direct impacts anticipated to residential land uses near the project site. Commercial and industrial land uses will be enhanced as a result of the project. Utility services will be extended to the site including natural gas, electric, railroad spur corridor and main access road corridor.

4.2.11.2 Regional Land Use

In addition to the direct land use impacts on the project site, minimal secondary and indirect land use impacts are anticipated throughout the region. Such impacts result from project-related population changes and responses from project-related support businesses.

Project related population changes during the operational phase of the project are estimated to generate 238 new in-migrant families (see Section 4.2.13.4.1). While this increase is small in comparison to the total amount of land zoned and available for residential development, it does represent increased demand for residential land use. While there is sufficient land zoned for residential development in the study area to accommodate project related housing development, it can be assumed that a portion of the 238 in-migrant families will demand new residential land and housing in areas that are now in other land uses. Because of the small number of land parcels anticipated to be converted to residential use, this impact is projected to be minimal throughout the Forest, Langlade, and Oneida county region.

Businesses supplying goods and services to the project's facility as well as mine employees will increase demand for commercial and industrial land use in the Forest, Langlade, and Oneida county area. This increase is anticipated to be relatively small because most of these support businesses are already established and land required to provide these services is zoned and available for commercial and industrial land use.

4.2.12 Aesthetics

This analysis considered the off-site visual impacts of the proposed project. Chapter NR 132.17, Wis. Admin. Code, regulates site elements as they relate to the location, design, painting, maintenance, and screening of the facilities to minimize the visual impact to the surrounding area.

The proposed surface facilities will be concentrated in two areas; the plant site and the TMA. The tallest and most readily visible features in each of these areas were selected to represent the worst case views of these facilities. The proposed railroad spur and access road, although only visible from localized areas, were also considered in this analysis.

The plant site will be constructed within a 128-acre area surrounded by forest, consisting of 50 to 70 feet tall mixed hardwoods and conifers. The width of the surrounding forest will range from a minimum of 300 feet along Sand Lake Road to greater than 1 mile to the north. Because of this vegetative screening many of the plant facilities will not be readily visible from off-site locations. The dominant visual feature of the plant site will be the approximately 160-foot tall headframe. As such, the headframe has been selected to represent the practical worst case views of the plant site.

The TMA will be constructed in phases and will also be surrounded by forest. When completed, the TMA will occupy approximately 345 acres and will rise a maximum of approximately 100 feet above existing grade. The TMA will be constructed in four phases. The final surface cover will consist of a naturally appearing northern prairie interspersed with low shrubs. The full visual impact of the TMA will not be realized until it is completed during the final phases of operations. As such, the highest point of the final configuration of the TMA has been selected to represent the practical worst case view of this facility.

The railroad spur line will extend from the Wisconsin Central Limited Railroad, immediately to the south of Keith Siding Road, to the plant site. The spur will create an approximate 2.5-mile long, open, narrow corridor through a variety of generally forested habitats. Because of existing tree cover, the railroad spur line will only be visible from Keith Siding Road. The greatest impact will occur when the tracks are occupied by a train which may rise up to 20 feet above the existing ground surface. This view has been selected to represent the practical worst case views of the railroad spur line.

The access road will extend north and west from the plant site to STH 55. The road will create an approximate 3.1-mile corridor through a variety of forest habitats and agricultural land. It will only be visible as it traverses through an agricultural field to intersect STH 55.

Low intensity lighting (i.e., sodium type) will be used on the exterior of buildings on the plant site. In addition similar lighting will be required on the interior roads and parking area. All lighting will be directed downward with reflectors as required to direct lights towards the ground. Except at transfer stations or intersections in the area of the plant site, lighting will not be necessary on the railroad spur, main access road or the access road to the TMA. In accordance with FAA regulations, red warning lights will be placed on top of the headframe for aircraft safety.

Buildings will be typical industrial type constructed with metal siding. The buildings will likely be a muted brown, green, gray or blue in color. A minor amount of reflectivity will occur from windows in the administration/services building. Other buildings will have few windows.

Potential aesthetic impacts of the above described surface facilities have been evaluated. A description of the evaluation is presented below. However, this is preceded by a discussion of the factors which affect aesthetics to provide a basis for interpretation of the impacts.

A total of 38 viewpoints from commonly traveled or readily accessible sites around the plant site have been inventoried. A description of the observations made at each of these viewpoints is presented in Appendices 3.13-1 and 3.13-2. Figure 4.2.12-1 illustrates the varying degrees of visibility of the headframe in the vicinity of the plant site. The degrees of visibility are separated into three groups: totally obscured by topographic variation, partially to totally obscured by vegetation, and visible with varying degrees of vegetative screening. In areas which are "obscured by topography" there is no visual impact created by the headframe. For locations "partially to totally obscured by vegetation", views of the headframe are possible in some areas, but will be largely screened by vegetation. Areas which are designated as "visible with varying degrees of vegetative screening" have been identified as those locations where the headframe may be visible.

The results of data compiled in 1994 by Foth & Van Dyke verified the information reported by Schreiber/Anderson Associates (Appendix 3.13-1). This information showed that three principal geographic areas will be potentially affected by the headframe. These areas include:

- A segment of STH 55, about 0.6 miles in length, beginning approximately 1.1 miles south of Sherman Corners.
- The north and east shores of Lake Metonga.
- The southwest shore of Little Sand Lake.

In addition, the headframe will be visible from the Sugarbush Hill Lookout Tower, and a portion of Sand Lake Road, approximately 300 feet in length, located 0.5 miles southeast of the headframe. A separate discussion of each geographic area is presented below.

STH 55 Corridor - Intermittent views of the headframe may be available along a 0.6-mile segment of the highway approximately 1.1 miles south of Sherman Corners. This segment of the highway is located approximately 2.5 miles west of the headframe. Schreiber/Anderson Associates (1985) reported that the headframe would be slightly visible at the tops of the distant trees in the summertime, however, and the outline of the structure is expected to be very faint at these distances. Viewpoint 11 was also identified as a potential winter time view. The angle of view to the headframe from STH 55, however, is outside the 65 degree cone of concentrated vision established for a driver traveling at a 45 m.p.h. highway speed (Versar, 1990). Therefore, although partially visible, the headframe may not be readily perceived from an automobile traveling on STH 55. The effects of viewing duration will play a role in the potential visual impact sensed by the viewer from points along the highway. Viewing time can be directly related to the degree of visual impact witnessed from a given viewpoint (Versar, 1990). Although the headframe will be visible from STH 55, the degree of visibility may be less than that which is imposed on a stationary land use such as a residential concentration.

There are four houses, and one business along this stretch of STH 55 which could potentially be affected by the presence of the headframe. An existing visual screen of vegetation affects the view from all of these except the place of business.

- Lake Metonga - The headframe will be visible from several areas at Lake Metonga, including the public boat landing and swimming beach along the north shore and a residential area along the east shore. While the headframe will be visible from these areas, the impacts will be reduced due to the distance (4.5 to 5.5 miles). Also, the background view is dominated by the uneven vertical form of trees which will cause the vertical structure of the headframe to blend into the scenery.
- Adjacent Lakes - The lakes in the vicinity of the Crandon Project represent recreational areas within a 1.5-mile radius of the proposed structure. The view from these areas will be from the observer normal position and are, therefore, susceptible to line of site obstructions, such as trees, topography, etc. The headframe will be visible from the southwest shore of Little Sand Lake, but not from Oak or Duck Lakes. The portion of Little Sand Lake from which the headframe will be visible is currently undeveloped and supports wetland vegetation. A residential population is established on the northwestern edge of the lake, but the headframe will not be visible from this area because of vegetational screening.
- Sugarbush Hill Lookout Tower - The Sugarbush Hill Lookout tower is 7.2 miles from the plant site. This is the furthest viewpoint from which the headframe will be visible. The elevation at the base of the tower is approximately 1,939 feet (MSL), the view

from this point will be observer superior. Upon ascending the tower, a viewer gains a panoramic view of the project area landscape. This added height differential may allow views of not only the headframe in clear weather, but also the clear areas made for the plant site, and the TMA.

- Sand Lake Road - The portion of Sand Lake Road located along a 0.5-mile corridor southeast of the headframe was the closest location from which the headframe may be visible. Orientation of the road in the direction of the headframe allows views of the facility from the road corridor. Vegetation close to the road edge will obstruct visibility to the headframe from other portions of Sand Lake Road which are not oriented in the direction of the structure.

The visual presence or absence of the TMA from the surrounding area is shown in Figure 4.2.12-2. This figure illustrates that the TMA will only be visible in the areas adjacent to its outside berms. In the surrounding areas the TMA will be screened either by topography or vegetation. At its closest points the southwest and southeast corners of the facility will be approximately 3,300 and 2,400 feet from Sand Lake and Deep Hole Lake Roads, respectively. Duck Lake, which is southwest of the facility, is approximately 1,700 feet away. In all three instances, the existing forest cover is 50 to 70 feet high. The vegetation, in combination with topography, will screen the TMA.

The visibility of the railroad siding from the surrounding area is shown in Figure 4.2.12-3. For the most part, the railroad siding will run through existing forest which will provide visual screening. The only area where the railroad siding will be visible is a segment of Keith Siding Road located approximately 2 miles west of the intersection with CTH W and extending westerly for approximately 0.5 miles. Keith Siding Road is a combination secondary and light-duty highway which, along with CTH W, is a primary traffic artery connecting the Crandon and Lake Metonga areas with the Lake Lucerne area. There are three homes which will be potentially affected by the railroad siding. Although there is some existing vegetative screening, most of the area is agricultural, so there is little vegetation above the ground layer. Also there will be a railroad spur line crossing on Swamp Creek which will be visible to persons using the stream at that location.

The access road will, for the most part, be screened by existing vegetation. The only segment of this corridor visible from STH 55 will be at its outlet onto the highway. This view will be across an agricultural field to the forest edge, a distance of approximately 3,200 feet. There will also be a crossing on Swamp Creek which will be visible to persons using the stream at that location.

In addition to physical structures that can be observed, there is a potential for the formation of a water vapor plume at the west vent shaft located at the western edge of the plant site and roughly 1,000 feet north of Little Sand Lake Road. Air exhausted from the underground mine is expected to be about 55°F and saturated with moisture. Conditions that may possibly result in a visible plume are characterized by low ambient temperatures and high relative humidity. Under these conditions, as the warmer, moist mine exhaust air mixes with the cooler ambient air, a super saturated mixture can form and result in the formation of water droplets which appear as a visible plume. When this occurs at the west vent shaft outlet, it is expected that the plume will dissipate in a relatively short distance due to the low release height of the vent shaft and the heavily forested surroundings.

Other aspects of the operation perceptible to the human senses are noise, odor, movement (e.g., trains, traffic, congestion), dust, smoke, etc. Noise impacts are addressed in Section 4.2.10 of the EIR. Movement and dust are addressed in Sections 4.2.2 and 4.2.3, respectively. Some exhaust will be visible from construction equipment which will burn diesel fuel. No odors are expected from the operation at the site fence lines.

4.2.13 Socioeconomics

4.2.13.1 Introduction

This section presents analysis and discussion of the potential socioeconomic impacts of the proposed project. Impacts are estimated for periods covering construction, operation, closure and long-term maintenance, assuming a 28-year active mining operation. The effects of a premature closure of the proposed facility are also considered in this section. In addition, the possible cumulative impacts of further mining development are considered. Impacts are estimated primarily for the study area identified in Section 3.14, but statewide impacts are noted where appropriate.

The analysis presented in this section is structured around the comparison of "baseline" or "without-project" conditions to conditions that are likely to exist "with-project". Three with-project scenarios have been developed for purposes of this comparison. The Minimum with-project scenario basically assumes a permanent project work force of 402 workers and relatively low rates of new worker in-migration. The Maximum with-project scenario assumes a permanent project work force of 526 workers and relatively high rates of new worker in-migration. The Middle scenario assumes a work force (464 workers) and in-migration rates between those assumed for the Minimum and Maximum scenarios. Most of the results presented in this section use the Middle scenario as the point of reference, although variations among scenarios are noted when appropriate.

It is important to note in considering the estimated socioeconomic impacts reported in this section that a significant amount of uncertainty surrounds the forecasting of social and economic conditions into the future. Specific decisions about where to live and shop, how much to spend, governmental responses to temporary increases in population, and so forth are all subject to determinants that cannot be predicted with precision by existing socioeconomic forecasting models. Such models can, however, provide reasonable estimates of broad changes that are likely to occur due to the proposed project. Accordingly, greater attention should be given to the direction and relative magnitude of the estimates presented in this section rather than specific estimates in specific years.

There are four major parts of Section 4.2.13. The first component contains a description or characterization of the Crandon Project from a socioeconomic perspective. This is followed by a description of the baseline conditions that are forecast to exist without the project. The third component contains the estimated impacts of the proposed project in comparison to baseline conditions. This section also contains discussion of impacts to the study area in the event of a premature closure of the project. The final major portion of this section presents an assessment of the possible cumulative impacts of further mining development in the area.

4.2.13.2 Project Characterization

Socioeconomic impacts associated with the proposed project will largely be determined by characteristics of the project itself. This section presents information on four key elements of the proposed project. These include direct project employment, project purchases of goods and services, project valuation for property tax purposes, and annual project "net proceeds" or net revenues and expenses.

4.2.13.2.1 Employment

Crandon Project employment estimates have been developed which detail employment needs by discipline, skill level, schedule, and pay range. These estimates are based on similar projects and projects in similar labor market situations. For employment estimation purposes the project can be divided into four phases, as shown in Table 4.2.13-1.

Table 4.2.13-1

Project Phases

Phase	Length	Time Frame
Construction	3 years	1997-1999
Operation	28 years	2000-2027
Closure	4 years	2028-2031
Post-Closure	4 years*	2032 +

*While the post-closure phase will extend into perpetuity, only the first four years are evaluated here.

Source: Crandon Mining Company Estimates.

Prepared by: RVS
Checked by: SFJ

Manpower requirements are anticipated to be met first by available local workers, and in the event there are insufficient local hires available for a particular job classification, the remaining positions are anticipated to be filled with in-migrant workers from outside the study area.

Manpower estimates for the project are divided into two general categories for the socioeconomic evaluation; Construction (temporary) workers, and Owner's work force (permanent) workers. The socioeconomic characteristics of these two categories differ in that construction workers will be hired by specific construction contractors and subcontractors to perform specific tasks (i.e., electricians will be hired to wire the wastewater treatment plant). After construction workers complete their particular task, they will move on to other unrelated projects. The permanent work force, on the other hand, will be hired directly by CMC and will continue beyond project construction and into the operation phase of the project.

Three different sets of mine operation labor estimates have been developed, each with an estimate of permanent worker needs. One of these sets of assumptions has a lower estimate for total requirements to operate the mine than the other two sets of assumptions. As a result of this minimum labor force/ maximum labor force variation, a minimum middle and maximum permanent worker estimate has been incorporated into the evaluation. Table 4.2.13-2 shows the estimated number of permanent operations workers needed during the life of the mine. The middle employment scenario is mid range between the minimum and maximum employment estimates.

Table 4.2.13-2 also provides monthly employment estimates during the construction phase of the project. Construction workers will be needed for various aspects of the project development, including construction of the mill facility, tailings management area (TMA), wastewater

treatment plant, and construction of the underground mine facility. Some of these activities require specialized craftsmen (i.e., shaft sinkers, explosives experts, etc.), while many of the activities can be performed by less specialized tradesmen and general laborers (i.e., electricians, equipment operators, etc.).

Labor rates were developed from a salary survey of the expected wages to be paid to the workforce. The estimated average annual labor cost for the maximum case is $23,384,000 or $21.37 per hour inclusive of benefits. The wage range for the 526 employees is $20.15 to $22.56, which includes an allowance for benefits. The estimated average annual labor cost for the minimum case is $17,741,000 or $21.37 per hour. The wage for the 402 employees is similar to the maximum case, including the benefits allowance.

From a socioeconomic perspective, construction workers and permanent work force differ significantly. A large percentage of the construction workers will not be working on the project for more than twelve months, whereas permanent work force positions will become available during the construction phase and remain in place during the 28 years of operation. These attributes change the assumptions for percent local hires and family status of workers. For example, none of the in-migrant construction workers are anticipated to bring their families with them to the local study due to the short duration of their employment. New in-migrant permanent workers, on the other hand, will likely move their entire families to the study area.

Table 4.2.13-3 provides detail on the educational requirements for the project work force, as well as more specific job types. It is interesting to note that a slightly higher percentage of post secondary education is required under the maximum employment scenario than the minimum scenario. This can be attributed to increased overhead staffing assumed under the maximum employment scenario.

4.2.13.2.2 Project Expenditures

The estimate for project expenditures relates to the total cost to construct, operate, close, and to maintain long term care of the reclaimed mine. For socioeconomic evaluation purposes, cost estimates are broken into categories which allow for estimation of secondary or indirect effects as a result of local purchases of goods and services. These local purchases will result in additional employment and income to the study area economy.

Total construction expenditure for mine development has been estimated at $287 million. This includes costs for CMC labor, direct purchases, contractor services, royalties, taxes, etc. In addition, annual mine operation costs will vary between $50 and $78 million per year during the operation phase. Closure costs are estimated at $22 million, and post-closure costs are estimated at $178,000 per year. All of these estimates are in 1994 dollars.

Table 4.2.13-4 provides a breakdown of estimated purchases that will occur in Wisconsin by year, by economic sectors. This table includes only purchases of goods and services (including contractor services) from Wisconsin sources. It does not include CMC payroll or benefits, taxes, royalties, or other related expenditures.

Table 4.2.13-2

Projected Manpower Summary

Year	Month	Contractors (Temporary)	Operation (Permanent)			Total		
			Minimum Case	Middle Case	Maximum Case	Minimum Case	Middle Case	Maximum Case
1997	1	118	33	33	33	151	151	151
	2	173	33	33	33	206	206	206
	3	201	33	33	33	234	234	234
	4	284	33	33	33	317	317	317
	5	311	35	35	35	346	346	346
	6	289	35	35	35	324	324	324
	7	236	35	35	35	271	271	271
	8	242	36	36	36	278	278	278
	9	227	37	37	37	264	264	264
	10	187	40	40	40	227	227	227
	11	169	40	40	40	209	209	209
	12	137	42	42	42	179	179	179
Avg. 1997		215	36	36	36	251	251	251
1998	13	133	42	42	42	175	175	175
	14	149	46	46	46	195	195	195
	15	209	58	58	58	267	267	267
	16	213	59	59	59	272	272	272
	17	201	59	59	59	260	260	260
	18	184	59	59	59	243	243	243
	19	237	59	59	59	296	296	296
	20	267	62	62	62	329	329	329
	21	258	62	62	62	320	320	320
	22	367	64	64	64	431	431	431
	23	363	65	65	65	428	428	428
	24	427	66	66	66	493	493	493
Ave 1998		251	58	58	58	309	309	309
1999	25	401	74	74	74	475	475	475
	26	452	96	96	96	548	548	548
	27	408	136	136	136	544	544	544
	28	468	172	172	172	640	640	640

Table 4.2.13-2, continued

Year	Month	Contractors (Temporary)	Operation (Permanent) Minimum Case	Operation (Permanent) Middle Case	Operation (Permanent) Maximum Case	Total Minimum Case	Total Middle Case	Total Maximum Case
	29	542	208	208	208	750	750	750
	30	462	243	243	243	705	705	705
	31	356	279	279	279	635	635	635
	32	232	309	309	309	541	541	541
	33	205	329	329	329	534	534	534
	34	127	367	367	367	494	494	494
	35	136	397	397	397	533	533	533
	36	105	415	415	415	520	520	520
Ave 1999		325	253	253	253	578	578	578
2000	37		402	412	422	402	412	422
	38		402	423	443	402	423	443
	39		402	433	463	402	433	463
	40		402	443	484	402	443	484
	41		402	454	505	402	454	505
	42		402	464	526	402	464	526
	43		402	464	526	402	464	526
	44		402	464	526	402	464	526
	45		402	464	526	402	464	526
	46		402	464	526	402	464	526
	47		402	464	526	402	464	526
	48		402	464	526	402	464	526
Ave 2000			402	464	500	402	451	500
2001			402	464	526	402	464	526
2002			402	464	526	402	464	526
2003			402	464	526	402	464	526
2004			402	464	526	402	464	526
2005			402	464	526	402	464	526
2006			402	464	526	402	464	526
2007			402	464	526	402	464	526
2008			402	464	526	402	464	526
2009			402	464	526	402	464	526
2010			402	464	526	402	464	526

Table 4.2.13-2, continued

Year	Month	Contractors (Temporary)	Operation (Permanent) Minimum Case	Operation (Permanent) Middle Case	Operation (Permanent) Maximum Case	Total Minimum Case	Total Middle Case	Total Maximum Case
2011			402	464	526	402	464	526
2012			402	464	526	402	464	526
2013			402	464	526	402	464	526
2014			402	464	526	402	464	526
2015			402	464	526	402	464	526
2016			402	464	526	402	464	526
2017			402	464	526	402	464	526
2018			402	464	526	402	464	526
2019			402	464	526	402	464	526
2020			402	464	526	402	464	526
2021			402	464	526	402	464	526
2022			402	464	526	402	464	526
2023			402	464	526	402	464	526
2024			402	464	526	402	464	526
2025			402	464	526	402	464	526
2026			402	464	526	402	464	526
2027			402	464	526	402	464	526
2028		150	69	69	69	219	219	219
2029		127	17	17	17	144	144	144
2030		38	9	9	9	47	47	47
2031		0	4	4	4	4	4	4
2032		0	4	4	4	4	4	4
2033		0	4	4	4	4	4	4
2034		0	4	4	4	4	4	4
2035		0	4	4	4	4	4	4

Source: Crandon Mining Company Estimates, January 1995.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-3

Permanent Work Force by Job Type

Job Type	Employment		Educational Requirement		
	Minimum	Maximum	Institution	Minimum	Maximum
Administration	9	10	College Degree	8	9
			Technical Degree	1	1
			High School		
Accounting / Purchasing					
Accountants	4	11	College Degree	3	11
Computers	2	3	Technical Degree	8	11
Purchasing/Whse.	8	12	High School	7	10
Clerical	4	6			
Marketing					
Staff	3	3	College Degree	1	1
Clerical	1	1	Technical Degree	1	1
			High School	2	2
Environmental / Safety					
Safety & First Aid	6	6	College Degree	3	3
Environmental	5	5	Technical Degree	4	6
Security	2	4	High School	6	6
Human Resources					
Personnel Admin.	3	4	College Degree	3	4
Clerical	1	4	Technical Degree	1	4
			High School		
Mine					
Engineering	6	6	College Degree	12	12
Supervision	10	28	Technical Degree	12	15
Geologist	4	4	High School	159	206
Surveyors / Tech	7	15			
Clerical	1	4			
Operators	155	176			

Table 4.2.13-3, continued

Job Type	Employment		Educational Requirement		
	Minimum	Maximum	Institution	Minimum	Maximum
Mill					
Engineering	3	3	College Degree	5	6
Supervision	5	5	Technical Degree	9	15
Assaying	5	12	High School	38	56
Operators	36	47			
Clerical	1	2			
Metallurgical Technician	2	8			
Maintenance					
Supervision	11	15	College Degree	2	4
Repairmen	69	69	Technical Degree	100	126
Electricians	16	25	High School	17	17
Instrument Techs.	4	4			
Planning	3	3			
Engineering	2	3			
Hoistmen	3	5			
Clerical	1	1			
Technicians		1			
Misc.	10	21			
Total	402	526	College Degree	37	50
			Technical Degree	136	179
			High School	229	297
			Total	402	526

Source: Crandon Mining Company Estimates, January 1995.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-4

Projected Total Project Expenditures in Wisconsin
(In 1994 U.S. $, 000s)

Description	Year												
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
landscape/horticultural services		2,938	5,186					1,210	2,324				
metal mining services	2,404	4,614	2,561			3,731	4,710		391	6,192			
new industrial commercial buildings	3,437	12,532	8,335	182	109	1,320	1,637	277	109	109	109	109	109
new utility structures	2,060	3,116	4,420					448					
new highways/streets		582	532										
metal office furniture	71	700	492										
stationary products	497	497	497	620	620	620	620	620	620	620	620	620	620
inorganic chemicals, n.e.c.		20	22	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218
cyclic crudes, interm/industrial		14	16	834	834	834	834	834	834	834	834	834	834
explosives				569	569	569	569	605	605	605	605	605	605
chemical preparations, n.e.c				2,456	2,456	2,456	2,456	2,577	2,577	2,577	2,577	2,541	2,541
tires, inner tubes				2,171	2,171	2,171	2,171	2,473	2,473	2,473	2,473	2,383	2,383
rubber/plastic hose/belts		40	42	408	408	408	408	408	408	408	408	408	408
gaskets, packing/sealing devices		18	18										
nonclay fractories		89	95	581	581	581	581	581	581	581	581	581	581
fabricated structural metal				35	35	35	35	35	35	35	35	35	35
metal doors, sash/trim	22	212	149										
fabricated plate work		142	150										
prefabricated metal buildings	314	3,084	2,171										
screw machine products/bolts				245	245	245	245	245	245	245	245	245	245

Table 4.2.13-4, continued

Description	Year												
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
pipe, valve/pipe fittings	53	691	1,190										
mining machinery				2,171	2,171	2,171	2,171	2,473	2,473	2,473	2,473	2,383	2,383
conveyors/conveying equipment		174	184										
hoists, cranes/monorails		30	31										
industrial trucks/tractors		3,409											
pumps/compressors	20	396	593	415	415	415	415	415	415	415	415	415	415
blowers/fans		29	30										
power transmission equipment													
industrial furnaces/ovens		128	136										
general industrial machinery, n.e.c.		210	221	498	498	498	498	498	498	498	498	498	498
electronic computers	107	1,050	739										
typewriters/office machines	14	140	100										
transformers	881	392											
switchgear/switchboard apparatus	440	197											
motors/generators	162	73											
relays/industrial controls	162	73											
electrical industrial apparatus	146	65		300	300	300	300	300	300	300	300	300	300
tanks/tank components				3,127	3,127	3,127	3,127	3,561	3,561	3,561	3,561	3,431	3,431
laboratory apparatus/furniture	71	700	492										
automatic temperature controls		139	240										
analytical instruments	328	145											
railroads/related services		1,966	2,749										

Table 4.2.13-4, continued

Description	Year												
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
motor freight transport			90										
communications, ex. radio	107	1,050	739										
electric services				3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020
building materials				248	248	248	248	248	248	248	248	248	248
general merchandise stores													
miscellaneous retail				348	348	348	348	396	396	396	396	381	381
engineering/architectural services			2,995										
Total	11,296	39,655	35,213	20,447	20,374	25,316	26,612	23,442	24,331	27,808	21,616	21,255	21,255

Table 4.2.13-4, continued

Description	Year													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
landscape/horticultural services				1,210	2,324					1,210	2,324			
metal mining services		3,731	4,710					3,731	4,710					
new industrial commercial buildings	109	1,320	1,637	277	880	109	109	1,320	1,637	277	109	109	109	109
new utility structures				448	69					448				
new highways/streets														
metal office furniture														
stationary products	620	620	620	620	620	620	620	620	620	620	620	620	620	620
inorganic chemicals, n.e.c.	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218	2,218
cyclic crudes, interm/industrial	834	834	834	834	834	834	834	834	834	834	834	834	834	834
explosives	605	605	605	605	605	605	605	605	605	605	605	605	605	605
chemical preparations, n.e.c	2,541	2,541	2,543	2,543	2,543	2,543	2,529	2,529	2,529	2,529	2,496	2,496	2,496	2,496
tires, inner tubes	2,383	2,383	2,388	2,388	2,388	2,388	2,355	2,355	2,355	2,355	2,272	2,272	2,272	2,272
rubber/plastic hose/belts	408	408	408	408	408	408	408	408	408	408	408	408	408	408
gaskets, packing/sealing devices														
nonclay fractories	581	581	581	581	581	581	581	581	581	581	581	581	581	581
fabricated structural metal	35	35	35	35	35	35	35	35	35	35	35	35	35	35
metal doors, sash/trim														
fabricated plate work														
prefabricated metal buildings														
screw machine products/bolts	245	245	245	245	245	245	245	245	245	245	245	245	245	245
pipe, valve/pipe fittings														
mining machinery	2,383	2,383	2,388	2,388	2,388	2,388	2,355	2,355	2,355	2,355	2,272	2,272	2,272	2,272

Table 4.2.13-4, continued

Description	Year													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
conveyors/conveying equipment														
hoists, cranes/monorails														
industrial trucks/tractors														
pumps/compressors	415	415	415	415	415	415	415	415	415	415	415	415	415	415
blowers/fans														
power transmission equipment														
industrial furnaces/ovens														
general industrial machinery, n.e.c.	498	498	498	498	498	498	498	498	498	498	498	498	498	498
electronic computers														
typewriters/office machines														
transformers														
switchgear/switchboard apparatus														
motors/generators														
relays/industrial controls														
electrical industrial apparatus	300	300	300	300	300	300	300	300	300	300	300	300	300	300
tanks/tank components	3,431	3,431	3,439	3,439	3,439	3,439	3,391	3,391	3,391	3,391	3,271	3,271	3,271	3,271
laboratory apparatus/furniture														
automatic temperature controls														
analytical instruments														
railroads/related services														
motor freight transport														
communications, ex. radio														

Table 4.2.13-4, continued

Description	Year													
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
electric services	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020	3,020
building materials	248	248	248	248	248	248	248	248	248	248	248	248	248	248
general merchandise stores														
miscellaneous retail	381	381	382	382	382	382	377	377	377	377	364	364	364	364
engineering/architectural services														
Total	21,255	26,197	27,515	23,103	24,441	21,277	21,142	26,084	27,380	22,968	23,135	20,811	20,811	20,811

Table 4.2.13-4, continued

Description	Year													
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Total
landscape/horticultural services					2,565	2,800	237	237						24,565
metal mining services														41,484
new industrial commercial buildings	109	109	55											36,758
new utility structures					4,185	4,569	387	387						20,537
new highways/streets														1,114
metal office furniture														1,262
stationary products	620	620	620	620										18,850
inorganic chemicals, n.e.c.	2,218	2,218	2,218	2,218										62,146
cyclic crudes, interm/industrial	834	834	834	834										23,382
explosives	316	316	316	316										15,642
chemical preparations, n.e.c	2,423	2,423	2,381	2,345										70,138
tires, inner tubes	2,121	2,121	2,121	2,121										64,651
rubber/plastic hose/belts	408	408	408	408										11,506
gaskets, packing/sealing devices														36
nonclay fractories	581	581	581	581										16,452
fabricated structural metal	9	9	9	9										881
metal doors, sash/trim														383
fabricated plate work														292
prefabricated metal buildings														5,569
screw machine products/bolts	186	186	186	186										6,629
pipe, valve/pipe fittings														1,934
mining machinery	2,121	2,121	2,121	2,121										64,649

Table 4.2.13-4, continued

Description	Year													
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Total
conveyors/conveying equipment														358
hoists, cranes/monorails														61
industrial trucks/tractors														3,409
pumps/compressors	415	415	415	415										12,629
blowers/fans														59
power transmission equipment														0
industrial furnaces/ovens														264
general industrial machinery, n.e.c.	498	498	498	498										14,375
electronic computers														1,896
typewriters/office machines														254
transformers														1,273
switchgear/switchboard apparatus														637
motors/generators														235
relays/industrial controls														235
electrical industrial apparatus	300	300	300	300										8,611
tanks/tank components	3,055	3,055	3,055	3,055										93,096
laboratory apparatus/furniture														1,262
automatic temperature controls														379
analytical instruments														473
railroads/related services														4,715
motor freight transport														90
communications, ex. radio														1,896

Table 4.2.13-4, continued

Description	Year													
	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Total
electric services	3,020	3,020	3,020	3,020										84,560
building materials	248	248	248	248										6,944
general merchandise stores														0
miscellaneous retail	340	340	340	340										10,345
engineering/architectural services														2,995
Total	19,821	19,821	19,725	19,634	6,750	7,369	624	624						739,913

Source: Crandon Mining Company Estimates, January 1995.

Prepared by: JRH
Checked by: SFJ

From Table 4.2.13-4, it can be seen that the two most significant Wisconsin expenditures will be for "Tank and Tank Components" and "Electric Services". Together, these expenditures total over $177 million, and are expensed relatively evenly during the 28-year operation of the mine. During the three year construction phase, purchases of Wisconsin goods and services total $86 million. The largest construction phase expenditure is for "New Industries/Commercial Buildings", totaling $24 million or 28 percent of the total construction phase expenditures. It is important to note that the geographic delineation of project expenditures are defined by the place of business of the vendor who is likely to supply goods or services to CMC. For example, CMC may contract with a local tire supply company to supply tires which are produced outside Wisconsin. This would be classified as a local purchase from a wholesale tire supplier within Table 4.2.13-4.

4.2.13.2.3 Property Valuation

The proposed project represents a major investment in land and industrial capital and will significantly increase the tax base available for property tax purposes in the Towns of Lincoln and Nashville, the Crandon School District and Forest County. Table 4.2.13-5 shows estimated full market or equalized value of the proposed project over its anticipated life. These values were estimated by classifying all construction expenditures into either "taxable" or exempt" categories. Standard depreciation allowances were used to determine depreciation of project value over time. Project property values at the end of mining operation reflect lower land values due to the exhaustion of underground mineral reserves. A portion of the decrease in taxable value shown in the closure period is due to the assumed sale of project land to other owners in the study area.

Total taxable value of the project will be at its highest, $110,200,000, during the first year of operation. The entire project value will accrue to Forest County and the Crandon School District. Taxable project value is distributed between the Towns of Lincoln and Nashville based on the physical location of taxable value. As shown in Table 4.2.13-5, the majority of this value is located in the Town of Lincoln.

4.2.13.2.4 Net Proceeds

As discussed in Section 3.14.3.4.1, mining operations in Wisconsin pay a graduated tax based on the "net proceeds" of their operations each year. The "net proceeds" from mining in any given year is generally the difference between the revenues received from mining production and the costs incurred for that production. Annual net proceeds are thus determined by mineral prices, levels of production, and costs of production and distribution. Net proceeds would be highest when mineral prices are high and production costs are low. Conversely, net proceeds would be lowest when mineral prices are low and production costs are high.

The mineral prices used to calculate net proceeds are shown in Table 4.2.13-6. Because of mineral price fluctuations, five mineral price scenarios are shown. Table 4.2.13-7 shows alternative net proceeds streams under five sets of varying conditions. The first two columns show net proceeds over time when mineral prices are relatively low and labor costs are relatively high due to the large project permanent work force. The last two columns show net proceeds over time when mineral prices are relatively high and labor costs are relatively low due to the smaller project work force. The middle column shows net proceeds over time when "base"

Table 4.2.13-5

Property Value Estimate for Property Subject to Taxation Equalized Full Value (in 1994 U.S. $, 000)

Tax Year	Total Taxable Value	Town of Lincoln	Town of Nashville
1994	6,400	2,300	4,100
1995	6,500	2,300	4,200
1996	6,500	2,300	4,200
1997	6,500	2,300	4,200
1998	36,400	31,900	4,500
1999	65,000	60,500	4,500
2000	110,300	105,800	4,500
2001	108,200	103,700	4,500
2002	106,000	101,500	4,500
2003	103,900	99,400	4,500
2004	101,800	97,300	4,500
2005	99,700	95,200	4,500
2006	97,600	93,100	4,500
2007	95,500	91,000	4,500
2008	93,300	88,800	4,500
2009	91,200	86,700	4,500
2010	89,100	84,600	4,500
2011	87,000	82,500	4,500
2012	84,900	80,400	4,500
2013	82,800	78,300	4,500
2014	80,700	76,200	4,500
2015	78,500	74,000	4,500
2016	76,400	71,900	4,500
2017	74,300	69,800	4,500
2018	72,100	67,700	4,500
2019	70,100	65,600	4,500

Table 4.2.13-5, continued

Tax Year	Total Taxable Value	Town of Lincoln	Town of Nashville
2020	68,000	63,500	4,500
2021	65,800	61,300	4,500
2022	63,700	59,200	4,500
2023	61,600	57,100	4,500
2024	59,500	55,000	4,500
2025	57,400	52,900	4,500
2026	55,300	50,800	4,500
2027	53,200	48,700	4,500
2028	51,000	46,500	4,500
2029	38,500	34,000	4,500
2030	16,500	12,000	4,500
2031	7,500	6,000	1,500
2032	5,000	3,500	1,500
2033	5,000	3,500	1,500
2034	5,000	3,500	1,500

Notes:
(1) All assessed property values are at estimated 100 percent Fair Market Value as represented by purchase or construction costs.
(2) Assessed Values have been depreciated at 2 percent per year from start of Operations, without additions for replacement capital.
(3) Values from year 2032 forward reflect value of remaining land.

Source: Crandon Mining Company Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-6

Mineral Prices Used in Alternative Net Proceeds Estimates (in 1994 U.S. $, 000)

	80 Percent of Base Mineral Prices	90 Percent of Base Mineral Prices	Base Mineral Prices	110 Percent of Base Mineral Prices	120 Percent of Base Mineral Prices
Zinc, $/pound	0.52	0.59	0.65	0.72	0.78
Lead, $/pound	0.24	0.27	0.30	0.33	0.36
Copper, $/pound	0.96	1.08	1.20	1.32	1.44
Silver, $/ounce	3.96	4.46	4.95	5.45	5.94
Gold, $/ounce	319.78	359.75	399.72	439.69	479.66

Source:
- 1989 to 1993 average metal price per Platt's Metals Week. For copper, lead and zinc prices equating to London Metal Exchange Settlement Prices. Gold price is from London Precious Metal Fix and silver is from Handy & Harman.
- Historical price adjusted by the GNP Implicit Price Deflator to 1994 dollars.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-7

Net Proceeds Estimates[1] (in 1994 U.S. $, 000)

	80 Percent of Base Max Labor	90 Percent of Base Max Labor	Base Prices Mid Labor	110 Percent of Base Min Labor	120 Percent of Base Min Labor
2000	(17,786)	(5,321)	9,333	23,987	36,452
2001	(13,493)	5,205	26,674	48,143	66,840
2002	5,503	26,278	49,825	73,371	94,146
2003	13,034	33,809	57,356	80,903	101,678
2004	16,787	37,562	61,108	84,655	105,430
2005	17,185	37,960	61,506	85,053	105,828
2006	19,976	40,751	64,297	87,844	108,619
2007	28,080	48,855	72,401	95,948	116,723
2008	37,211	57,986	81,533	105,079	125,854
2009	37,620	58,394	81,941	105,488	126,263
2010	37,710	58,485	82,032	105,578	126,353
2011	37,256	58,031	81,578	105,125	125,900
2012	35,583	56,358	79,905	103,451	124,226
2013	33,630	54,405	77,951	101,498	122,273
2014	33,700	54,475	78,022	101,568	122,343
2015	8,451	22,652	39,626	56,598	70,799
2016	(17,539)	(9,608)	1,096	11,798	19,729
2017	(18,932)	(11,001)	(299)	10,404	18,335
2018	(19,413)	(11,482)	(780)	9,923	17,854
2019	(21,457)	(13,526)	(2,824)	7,879	15,810
2020	(20,635)	(12,704)	(2,002)	8,701	16,632
2021	(16,659)	(8,728)	1,975	12,677	20,608
2022	(16,662)	(8,731)	1,972	12,674	20,605
2023	(16,629)	(8,698)	2,005	12,707	20,638
2024	(16,088)	(8,157)	2,546	13,248	21,179
2025	(14,403)	(6,472)	4,232	14,933	22,864
2026	(14,011)	(6,080)	4,624	15,326	23,257
2027	(18,367)	(10,436)	267	10,969	18,900

Source: Crandon Mining Company Estimates, January 1995.

[1] See Table 4.2.13-45 for actual estimated net proceeds tax payments.

Prepared by: JRH
Checked by: RVS

mineral prices exist and the middle work force configuration is utilized. It is clear by comparing the low price/high cost (i.e., 80 percent of Base Mineral Prices/Maximum Labor) scenario to the high price/low cost (120 percent of Base Mineral Prices/Minimum Labor) scenario in Table 4.2.13-7 that positive net proceeds from mining are directly affected by mineral prices and production costs. Positive net proceeds are anticipated each year of operation under the high price/low cost scenario, while positive net proceeds are anticipated in only the zinc ore period (2002-2015) under the low price/high cost scenario. As discussed in Section 4.2.13.4.4.1, the net proceed stream experienced by the project directly affects the net proceeds tax collected from the project and the distribution of funds from the Mining Investment and Local Impact Fund.

4.2.13.3 Baseline Forecasts

Before project impact assessments can be made, it is necessary to estimate future conditions without the impacts of the proposed project. Such "baseline forecasts", provide a basis on which to evaluate project impacts. Whenever possible, the baseline forecast estimates were made with the assistance of appropriate professional staff at the state and/or local level. Following the discussion of baseline forecasts, Section 4.2.13.4 presents a discussion of the projected impacts of the proposed project on the socioeconomic conditions of the study area.

4.2.13.3.1 Population

Population forecasts by age group have been developed by the Wisconsin Department of Administration (DOA) and compiled in a June 1993 report titled *Official Population Projections: 1990-2020* for each county in the study area. Information on cohort survival and migration rates were supplied by the DOA, Demographic Services. The DOA also provided fertility (birth rate) estimates to use in projecting through the year 2040. Based on this information, population projections were developed for Forest, Langlade and Oneida Counties for the period 1990 through 2035.

The DOA also developed a June 1993 report titled *Official Municipal Population Projections: 1990-2015*. This report provides population projections through the year 2015 by minor civil division (MCD). In order to project MCD population through the year 2035, the percentage of estimated county population in the year 2015 was applied to the future county population estimates. Figure 4.2.13-1 provides a graphic picture of population projections for Forest, Langlade and Oneida Counties. The decline in projected population late in the forecast period (2025-2035) can be attributed to the relatively large older population component. Population estimates for Forest, Langlade and Oneida Counties, as shown on Table 4.2.13-8, Table 4.2.13-9 and Table 4.2.13-10 were reviewed by research analysts at the DOA. The results of the review supported the methodology used and the population projections that were developed.

It should be noted that the Forest County Zoning Administrator reviewed the population projections. With the possible exception of the Town of Crandon, the Zoning Administrator indicated that population forecasts are reasonable. The Zoning Administrator feels that population in the Town of Crandon may grow at a rate higher than what the DOA population projections suggest. This insight is based on the fact that the Town of Crandon has a relatively large amount of privately owned land which is attractive for residential and commercial development and that Highway 8 is a major transportation route in Forest County, which runs through the Town of Crandon. While this insight could prove correct in the future, it is currently speculative, and insufficient statistical evidence is available to warrant a change in the population forecast.

Table 4.2.13-8

Study Area Population Forecast Without Project-Forest County

	(Actual) 1990	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Argonne, Town	497	517	532	547	557	567	571	576	575	569
Blackwell, Town	384	413	427	442	452	463	466	470	469	465
Caswell, Town	94	103	108	114	117	122	123	124	124	123
Crandon, City	1,958	2,036	2,093	2,149	2,189	2,226	2,240	2,260	2,256	2,235
Crandon, Town	529	520	517	514	511	503	506	511	510	505
Freedom, Town	296	305	310	315	318	320	322	325	324	321
Hiles, Town	312	305	300	295	290	283	285	287	287	284
Laona, Town	1,387	1,388	1,379	1,371	1,361	1,341	1,349	1,362	1,359	1,347
Lincoln, Town	630	676	714	753	782	814	819	827	825	817
Nashville, Town	871	955	1,020	1,086	1,135	1,190	1,197	1,208	1,206	1,195
Popple River, Town	42	44	46	47	49	50	50	51	51	50
Ross, Town	159	148	142	135	129	121	122	123	123	122
Wabeno, Town	1,012	953	909	865	828	777	782	789	787	780
Forest County Total	8,776	8,980	9,119	9,257	9,344	9,399	9,458	9,544	9,525	9,439

Sources: [1] Wisconsin Department of Administration, Official Municipal Population Projections 1990-2015, June 1993.
[2] Foth & Van Dyke Estimates based on Wisconsin Department of Administration methodology and data.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: SFJ
Checked by: RVS

Table 4.2.13-9

Study Area Population Forecast Without Project-Langlade County

	(Actual) 1990	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Ackley, Town	540	536	526	512	500	483	476	478	473	462
Ainsworth, Town	474	485	492	494	495	493	486	488	483	472
Antigo, City	8,284	8,649	8,737	8,744	8,727	8,655	8,532	8,561	8,481	8,278
Antigo, Town	1,428	1,433	1,408	1,371	1,338	1,291	1,273	1,277	1,265	1,235
Elcho, Town	1,075	1,102	1,113	1,115	1,113	1,104	1,088	1,092	1,082	1,056
Evergreen, Town	483	519	538	551	560	568	560	562	557	543
Langlade, Town	415	436	448	455	459	462	455	457	453	442
Neva, Town	910	968	997	1,016	1,028	1,037	1,022	1,026	1,016	992
Norwood, Town	842	853	849	838	827	808	796	799	792	773
Parrish, Town	81	83	85	85	85	85	84	84	83	81
Peck, Town	402	413	413	410	407	401	395	397	393	384
Polar, Town	880	935	964	985	998	1,009	995	998	989	965
Price, Town	248	263	268	272	273	274	270	271	268	262
Rolling, Town	1,316	1,399	1,453	1,494	1,521	1,545	1,523	1,528	1,514	1,478
Upham, Town	626	653	669	679	684	687	677	680	673	657
White Lake, Village	304	312	312	310	307	303	299	300	297	290
Wolf River, Town	750	799	830	852	868	882	869	872	864	844
Langlade County Total	19,505	20,300	20,572	20,650	20,658	20,548	20,255	20,326	20,135	19,653

Sources: [1] Wisconsin Department of Administration, Official Municipal Population Projections 1990-2015, June 1993.
[2] Foth & Van Dyke Estimates based on Wisconsin Department of Administration methodology and data.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: SFJ
Checked by: RVS

Table 4.2.13-10

Study Area Population Forecast Without Project-Oneida County

	(Actual) 1990	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Crescent, Town	1,794	1,889	1,907	1,891	1,865	1,823	1,766	1,752	1,709	1,636
Enterprise, Town	277	269	261	250	240	226	219	217	212	203
Lake Tomahawk, Town	851	914	945	958	960	956	926	919	896	858
Monico, Town	294	297	289	277	265	251	243	241	235	225
Newbold, Town	2,281	2,426	2,493	2,512	2,507	2,486	2,408	2,389	2,330	2,231
Pelican, Town	3,198	3,204	3,235	3,206	3,158	3,082	2,985	2,962	2,888	2,766
Piehl, Town	66	76	79	82	83	83	80	80	78	74
Pine Lake, Town	2,494	2,558	2,549	2,497	2,438	2,356	2,282	2,264	2,208	2,114
Rhinelander, City	7,382	7,733	7,581	7,309	7,050	6,712	6,501	6,450	6,290	6,023
Schoepke, Town	378	392	390	381	372	359	348	345	336	322
Stella, Town	525	568	588	598	600	598	579	575	560	537
Sugar Camp, Town	1,376	1,460	1,494	1,500	1,493	1,476	1,430	1,418	1,383	1,324
Three Lakes, Town	2,003	2,200	2,288	2,330	2,344	2,345	2,271	2,254	2,198	2,104
Woodboro, Town	699	767	806	829	839	846	819	813	793	759
Oneida County Total	31,679	33,563	34,067	33,953	33,601	32,992	31,954	31,705	30,920	29,604

Sources: [1] Wisconsin Department of Administration, Official Municipal Population Projections 1990-2015, June 1993.
[2] Foth & Van Dyke Estimates based on Wisconsin Department of Administration methodology and data.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: SFJ
Checked by: RVS

4.2.13.3.2 Employment

The Wisconsin Department of Revenue has developed employment forecasts for the state through the year 2018. County level employment forecasts beyond the year 2000 do not exist. In order to determine the correlation between Forest, Langlade, and Oneida County employment and Wisconsin employment, County Business Patterns employment data was assembled from 1980 through 1991 (most recent year available).

A non-linear model was developed which correlates closely with the Wisconsin Department of Revenue model projecting state employment through 2018. Using this model, state employment was projected through 2036. Figure 4.2.13-2 provides statewide employment projections including both the Department of Revenue forecast through 2018, and the non-linear model which projects employment through 2036. The figure shows that the non-linear model very closely replicates the Department of Revenue estimates through 2018.

For study area employment forecasts Department of Revenue employment estimates were used through 2018, with the non-linear model estimates used from 2019 through 2036. This method was applied to each of the three counties to project total employment based on the correlation of Wisconsin employment with the individual county employment (Figure 4.2.13-3).

Employment estimates for each MCD were based on the percentage of individual MCDs employment within each county as reported in the 1990 Census. Table 4.2.13-11, Table 4.2.13-12 and Table 4.2.13-13 provide total employment estimates for MCDs in Forest, Langlade, and Oneida counties, respectively.

The study area total employment forecasts as shown on Figure 4.2.13-3 provide insight into the economic base within Forest, Langlade and Oneida Counties. Forest County has the least diversified economy and also the lowest total county employment. Oneida County has the highest total employment and is projected to experience the most significant employment growth between 1995 and 2020. Correlating closely with the population forecasts, employment in all three counties is projected to decline after the year 2020.

Employment estimates were provided to Wisconsin Job Service for review and comment. While noting it is difficult to accurately project employment for a period of forty plus years, Wisconsin Job Service indicated that the employment projections are a correct representation of general trends (Goodwin, 1994).

4.2.13.3.3 Housing

In order to project the supply of housing through the study period, a model was developed based on the age of housing structures in the study area. This model takes into consideration the effects of aging on projected housing availability. Demand for housing is also incorporated into the model based on forecasted changes in population and average household size over the forecast period.

The results of the housing model provide a tabular estimate of available housing stock, demand for housing, and finally, the anticipated surplus or deficit housing stock.

Table 4.2.13-11

Study Area Employment Forecast Without Project-Forest County

MCD/Percent of County Employment	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Argonne, Town (2.112 percent)	41	43	45	46	46	47	47	46	45
Blackwell, Town (0.603 percent)	12	12	13	13	13	13	13	13	13
Caswell, Town (0.792 percent)	15	16	17	17	17	18	17	17	17
Crandon, City (55.392 percent)	1,074	1,126	1,172	1,196	1,216	1,229	1,223	1,205	1,174
Crandon, Town (4.148 percent)	80	84	88	90	91	92	92	90	88
Freedom, Town (0.415 percent)	8	8	9	9	9	9	9	9	9
Hiles, Town (0.830 percent)	16	17	18	18	18	18	18	18	18
Laona, Town (15.950 percent)	309	324	337	344	350	354	352	347	338
Lincoln, Town (1.094 percent)	21	22	23	24	24	24	24	24	23
Nashville, Town (3.469 percent)	67	70	73	75	76	77	77	75	74
Popple River, Town (0.867 percent)	17	18	18	19	19	19	19	19	18
Ross, Town (0.189 percent)	4	4	4	4	4	4	4	4	4
Wabeno, Town (11.576 percent)	224	235	245	250	254	257	256	252	245
Forest County Total Employment	1,939	2,032	2,115	2,159	2,195	2,219	2,208	2,175	2,120

Sources:
[1]Wisconsin Department of Revenue, Wisconsin Economic Outlook, June 1, 1994.
[2]Foth & Van Dyke Estimate.
Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-12

Study Area Employment Forecast Without Project-Langlade County

MCD/Percent of County Employment	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Ackley, Town (0.887 percent)	62	65	68	69	71	71	71	70	68
Ainsworth, Town (0.324 percent)	23	24	25	25	26	26	26	26	25
Antigo, City (72.935 percent)	5,126	5,372	5,590	5,708	5,802	5,867	5,837	5,749	5,604
Antigo, Town (8.445 percent)	593	622	647	661	672	679	676	666	649
Elcho, Town (3.702 percent)	260	273	284	290	294	298	296	292	284
Evergreen, Town (0.422 percent)	30	31	32	33	34	34	34	33	32
Langlade, Town (0.450 percent)	32	33	35	35	36	36	36	35	35
Neva, Town (1.506 percent)	106	111	115	118	120	121	121	119	116
Norwood, Town (0.718 percent)	50	53	55	56	57	58	57	57	55
Parrish, Town (0.014 percent)	1	1	1	1	1	1	1	1	1
Peck, Town (0.028 percent)	2	2	2	2	2	2	2	2	2
Polar, Town (1.126 percent)	79	83	86	88	90	91	90	89	87
Price, Town (1.956 percent)	137	144	150	153	156	157	157	154	150
Rolling, Town (1.717 percent)	121	126	132	134	137	138	137	135	132
Upham, Town (0.338 percent)	24	25	26	26	27	27	27	27	26
White Lake, Village (3.068 percent)	216	226	235	240	244	247	246	242	236
Wolf River, Town (1.464 percent)	103	108	112	115	116	118	117	115	112
Langlade County Total Employment	7,028	7,366	7,665	7,826	7,955	8,044	8,003	7,882	7,683

Sources:
[1]Wisconsin Department of Revenue, Wisconsin Economic Outlook, June 1, 1994.
[2] Foth & Van Dyke Estimate.
Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-13

Study Area Employment Forecast Without Project-Oneida County

MCD/Percent of County Employment	1995[1]	2000[1]	2005[1]	2010[1]	2015[1]	2020[2]	2025[2]	2030[2]	2035[2]
Crescent, Town (0.208 percent)	28	29	30	31	32	32	32	31	30
Enterprise, Town (0.111 percent)	15	16	16	17	17	17	17	17	16
Lake Tomahawk, Town (0.561 percent)	75	79	82	84	85	86	86	84	82
Monico, Town (0.360 percent)	48	51	53	54	54	55	55	54	53
Newbold, Town (0.561 percent)	75	79	82	84	85	86	86	84	82
Pelican, Town (3.233 percent)	433	454	473	482	490	496	493	486	474
Piehl, Town (0.048 percent)	7	7	7	7	7	7	7	7	7
Pine Lake, Town (0.755 percent)	101	106	110	113	114	116	115	113	111
Rhinelander, City (60.235 percent)	8,073	8,461	8,805	8,990	9,138	9,240	9,193	9,054	8,825
Schoepke, Town (0.408 percent)	55	57	60	61	62	63	62	61	60
Stella, Town (0.055 percent)	7	8	8	8	8	8	8	8	8
Sugar Camp, Town (0.692 percent)	93	97	101	103	105	106	106	104	101
Three Lakes, Town (3.745 percent)	502	526	547	559	568	575	572	563	549
Woodboro, Town (0.062 percent)	8	9	9	9	9	10	10	9	9
Oneida County Total Employment	13,402	14,046	14,617	14,924	15,170	15,340	15,261	15,031	14,651

Sources: [1] Wisconsin Department of Revenue, Wisconsin Economic Outlook, June 1, 1994.
[2] Foth & Van Dyke Estimate.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-14, Table 4.2.13-15, and Table 4.2.13-16 present the three housing forecast models for Forest, Langlade and Oneida Counties. Census information from 1960 through 1990 is presented to show the basis for calculations of future estimates. The model works by aging housing structures in 10-year increments throughout the projection period and dropping a percentage of the structures from the housing supply once they become 41 years or older. This was accomplished through the use of a housing replacement factor and a housing survival factor. Table 4.2.13-17 shows housing replacement factors and housing survival factors used in the model for each of the counties. Figure 4.2.13-4 provides a graphic picture of the projected supply and demand for housing within the three counties.

A review of Figure 4.2.13-4 shows that actual and projected supply and demand for Forest and Langlade Counties are closely matched. It should be noted that a housing shortage is forecast in Langlade County in the year 2030. While it is impossible to have a negative number of available housing units, the results of the model predict more demand for housing than available supply. This can be interpreted to mean that housing replacement will occur at a faster pace than historically occurred, and/or more older housing units will survive than has occurred in Langlade County's recent past. The figure also shows that housing supply in Oneida County continues to increase at a decreasing rate throughout the forecast period. At the same time, the figure shows that demand for housing in Oneida County will increase through the year 2020, and decrease rather dramatically from 2020 to 2040. As shown in Table 4.2.13-14, the decrease in demand is primarily a function of the decrease in population forecast to begin in the year 2000.

The fact that the Oneida County housing supply is forecast to increase while demand is decreasing in the latter portion of the forecast period relates to housing replacement and housing survival characteristics during periods of changing populations and periods of changing average household size. A review of Table 4.2.13-16 shows that Oneida County population is projected to increase 54 percent from 1960 to 2000. Further review shows that population is forecast to decrease 18 percent from 2000 to 2040, as shown on the county housing forecast models. At the same time, average household size is projected to decrease 29 percent from 1960 to 2000. The household size is forecast to decrease another 15 percent between 2000 and 2040.

The combination of increasing population and decreasing average household size between 1960 and 2000 results in a forecast increase in housing demand of 118 percent during that period. Housing that was added or projected to be added to the supply during periods of increasing population remain in the housing stock even as demand decreases. Furthermore, even though a housing surplus exist in the latter years of the forecast period, new housing will be added to the supply. This new housing results from consumer preference for newer housing in lieu of housing approaching the end of its useful life.

The phenomenon of significant surplus housing occurred in Oneida County in the past as shown by the number of vacant housing units recorded in the 1960, 1970 and 1980 censuses. Table 4.2.13-16 shows that 3,616 vacant housing units existed in the county in 1970. This was an increase of 2,844 units from 1960 census information. In 1980 and 1990, the surplus had decreased by 770 and 2,375 units, respectively. In 1970, vacant housing units in the county represented approximately 32 percent of total year-round housing units. In 2040, vacant housing units are projected to be approximately 31 percent of total year-round housing units.

Table 4.2.13-14

Study Area Housing Forecast Model Without Project-Forest County

	Actual				Projected				
	1960	1970	1980	1990	2000	2010	2020	2030	2040
Population	7,542	7,691	9,044	8,776	9,119	9,344	9,458	9,525	9,283
Average Household Size	3.44	3.39	2.99	2.67	2.65	2.62	2.54	2.50	2.50
Total Housing Units	3,976	4,583	5,928	7,203					
Year-Round Housing Units	2,497	3,666	3,846	3,627	3,899	4,258	4,631	4,825	4,979
Occupied Housing Units	2,191	2,269	3,025	3,290	3,441	3,566	3,716	3,805	3,708
Vacant Housing Units	306	1,397	821	337	458	692	915	1,020	1,270
Held for Seasonal, Recreational, Occupational Use	1,479	917	2,082	3,576					
Age of Structure									
0-10 years		697	1,205	687	667	693	710	719	724
11-20 years		553	480	1,009	687	667	693	710	719
21-30 years		568	314	341	1,009	687	667	693	710
31-40 years		1,848	402	182	341	1,009	687	667	693
41-50 years			1,445	235	182	341	1,009	687	667
51+ years				1,174	1,014	861	865	1,349	1,466
Total		3,666	3,846	3,627	3,899	4,258	4,631	4,825	4,979

Source: Actual data from 1960 through 1990 Census Summary File Tape 3A. Projected data developed from Foth & Van Dyke Housing Forecasts.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-15

Study Area Housing Forecast Model Without Project-Langlade County

	Actual				Projected				
	1960	1970	1980	1990	2000	2010	2020	2030	2040
Population	19,916	19,220	19,978	19,505	20,572	20,658	20,255	20,135	18,993
Average Household Size	3.52	3.26	2.83	2.58	2.48	2.34	2.23	2.13	2.13
Total Housing Units	7,070	7,819	9,187	10,825					
Year-Round Housing Units	6,115	7,575	7,702	8,231	9,092	9,229	9,374	9,311	9,229
Occupied Housing Units	5,654	5,889	7,068	7,563	8,279	8,825	9,098	9,474	8,937
Vacant Housing Units	461	1,686	634	668	813	404	276	(163)	292
Held for Seasonal, Recreational, Occupational Use	955	244	1,485	2,594					
Age of Structure									
0-10 years		901	1,661	1,043	1,677	926	930	911	906
11-20 years		824	613	1,717	1,043	1,667	926	930	911
21-30 years		901	604	766	1,717	1,043	1,677	926	930
31-40 years		4,949	921	685	766	1,717	1,043	1,677	926
41-50 years			3,903	675	685	766	1,717	1,043	1,677
51+ years				3,346	3,204	3,099	3,081	3,824	3,879
Total		7,575	7,702	8,231	9,092	9,229	9,374	9,311	9,229

Source: Actual data from 1960 through 1990 Census Summary File Tape 3A. Projected data developed from Foth & Van Dyke Housing Forecasts.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-16

Study Area Housing Forecast Model Without Project-Oneida County

	Actual				Projected				
	1960	1970	1980	1990	2000	2010	2020	2030	2040
Population	22,112	24,427	31,216	31,679	34,067	33,601	31,954	30,920	28,012
Average Household Size	3.40	3.15	2.73	2.50	2.41	2.25	2.12	2.05	2.05
Total Housing Units	11,640	14,977	20,311	25,173					
Year-Round Housing Units	7,271	11,373	14,272	13,907	15,521	17,176	18,657	19,376	19,894
Occupied Housing Units	6,499	7,757	11,426	12,666	14,157	14,939	15,060	15,083	13,664
Vacant Housing Units	772	3,616	2,846	1,241	1,364	2,237	3,597	4,294	6,230
Held for Seasonal, Recreational, Occupational Use	4,369	3,604	6,039	11,263					
Age of Structure									
0-10 years		2,695	4,902	2,332	2,376	2,555	2,520	2,397	2,319
11-20 years		2,222	2,325	4,414	2,332	2,376	2,555	2,520	2,397
21-30 years		1,778	1,725	1,640	4,414	2,332	2,376	2,555	2,520
31-40 years		4,678	1,440	1,488	1,640	4,414	2,332	2,376	2,555
41-50 years			3,880	942	1,488	1,640	4,414	2,332	2,376
51+ years				3,091	3,271	3,859	4,460	7,197	7,728
Total		11,373	14,272	13,907	15,521	17,176	18,657	19,376	19,894

Source: Actual data from 1960 through 1990 Census Summary File Tape 3A. Projected data developed from Foth & Van Dyke Housing Forecasts.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-17

Study Area Housing Replacement and Survival Factors

	Housing Replacement Factors				
	2000	2010	2020	2030	2040
Forest County	0.076	0.076	0.076	0.076	0.076
Langlade County	0.086	0.045	0.045	0.045	0.045
Oneida County	0.075	0.075	0.075	0.075	0.075

Note: Housing replacement factors were calculated using historic housing replacement information and historic population changes for the 1970-1980 and 1980-1990 decades.

	Housing Survival Factors				
	2000	2010	2020	2030	2040
Forest County	0.720	0.720	0.720	0.720	0.720
Langlade County	0.797	0.797	0.797	0.797	0.797
Oneida County	0.811	0.811	0.811	0.811	0.811

Note: Housing survival factors were calculated using historic housing survival information from the 1970-1980 and 1980-1990 decades.

Source: Foth & Van Dyke estimates.

Prepared by: RVS
Checked by: SFJ

For each MCD the same housing model was created using appropriate census data. Forecasts of housing stock were then calculated for each MCD using the appropriate county level housing replacement and housing survival factors. The housing forecast models for each MCD are contained in Appendix 4.2-8.

The difference between projected total year round housing units (supply) and projected occupied housing units (demand) is the number of vacant housing units. If during the forecast period the number of vacant units is negative, a housing deficit is projected. While it is impossible to have a negative number of housing units, the results of the model predict more demand for housing than available supply. This means that based on the historic housing replacement rate, the anticipated number of new housing units to be built will not be sufficient to replace the number of old housing units which are no longer in service. This housing deficit phenomenon can be interpreted to mean that housing replacement will occur at a faster pace than historically occurred, and/or more older housing units will survive than had occurred in the recent past. Figure 4.2.13-5 provides a map of areas where a housing deficit is anticipated sometime during the forecast period.

While this model did not include a forecast of housing units "held for seasonal, recreation or occasional use", it is important to understand that such units are included in the overall housing stock and change in number and condition over time. As can be seen in Tables 4.2.13-14, 4.2.13-15, and 4.2.13-16, the number of housing units held for seasonal, recreation, and occasional use has increased 242 percent in Forest County, 272 percent in Langlade County, and 258 percent in Oneida County between 1960 and 1990. In 1990, seasonal units represented

40 percent of the overall housing stock in the three county area. Some of the seasonal housing units could be converted to year-round use. Minor modifications such as insulation, improved plumbing, heating or electrical could make additional houses available for year-round use.

During the completion of housing forecast work, an issue was raised regarding the accuracy of housing census data. To assess the accuracy of the census data, efforts were initiated to validate housing statistics in the study area. Local zoning administrators for Forest, Langlade and Oneida Counties were contacted. Six local realtors, collectively representing a significant residential housing market share, were sent information on the number of housing units and residential lots by MCD.

A review of population projections and the housing forecast models was conducted with each of the three county zoning administrators. The zoning administrators indicated that the population projections and housing forecasts were reasonable. The local realtors commented on MCDs in their respective service areas. While none of the local realtors had statistical information on which to comment on the census data, they felt that the census data appeared to be accurate. Given this validation work it is concluded that the housing model and census data on which it is based is an accurate representation of existing and future projected conditions in the study area.

4.2.13.3.4 Government Structure and Public Finance

Existing fiscal conditions in the general purpose governments comprising the study area were described in Sections 3.14.3.4.3 and 3.14.3.4.4. These conditions will change over time as the local population base changes or as the level of governmental services provided changes. Local government spending or revenues may also vary from year to year depending on unique events, such as unusual snow falls, floods, and so forth.

The primary indicator of local government fiscal conditions that is used in this assessment is the property tax rate for each jurisdiction. The property tax rate contains information on several components that are of crucial importance to local governments. In particular, and as shown in the definitions below, the property tax rate reflects each jurisdiction's overall spending, property tax and non-property tax revenues, and overall tax base. As a jurisdiction's property tax rate increases, the cost of government to existing residents increases. Conversely, as a jurisdiction's property tax rate decreases, the cost of government to existing taxpayers decreases.

Property Tax Levy = Total Spending - Local Non-Property Tax Revenues and Intergovernmental Aids

Property Tax Rate = Property Tax Levy/Total Equalized Value

The baseline fiscal conditions forecast represents an estimate of what each of these variables will be for the period 1997 through 2036 assuming the project is not constructed and operated. While there is uncertainty about how individual governments will respond to conditions existing in a particular year, the baseline fiscal conditions forecast represents a benchmark against which anticipated with-project impacts can be assessed. The following section describes the approach taken in forecasting without-project fiscal conditions and is followed with a summary of the baseline fiscal conditions forecast.

4.2.13.3.4.1 Forecast Methodology

Typical fiscal impact assessment methodologies employ some version of a per capita approach. Under this approach expenditures and revenues of a local government in a current or

representative year are divided by the jurisdiction's population to arrive at spending or revenue per capita. These ratios are then applied to population forecasts to estimate what local government spending and revenues might be in the future. While appropriate, such approaches are limited in their ability to capture the effects of capacity exhaustion, service level changes and so forth (Burchell and Listokin, 1979).

The methodology used in this assessment is a modified per capita approach. Fiscal data for years 1985-1992 were collected for each jurisdiction and adjusted to 1992 dollars. Per capita ratios were calculated for various spending, revenue and property value categories for each year. As described below, this data was used to develop forecasting models for local government spending, revenues and tax base (equalized value). The models as developed allow changes in local conditions to change the amount of spending or revenue per capita that will occur in a local jurisdiction.

Local Government Expenditures

Local government expenditures over the forecast period were primarily determined by applying population forecasts from Section 4.2.13.3.1 to modified per capita spending ratios. These forecasted expenditures were augmented by the addition of large capital project expenditures or service level changes that can be anticipated to be funded by the general property tax.

Historical per capita spending ratios for each jurisdiction were used in regression analysis to determine how spending might change over time. For most jurisdictions, total per capita spending was regressed against the natural logarithm of population, and commercial and manufacturing equalized value. In jurisdictions containing the project site (Forest County, City of Crandon, Town of Lincoln and Town of Nashville), per capita spending ratios were estimated for specific spending categories, such as police, fire, etc. Baseline spending forecasts for each jurisdiction were developed by applying appropriate adjusted per capita ratios to forecasted population, and commercial and manufacturing values. All spending estimates have been adjusted to 1994 constant dollars.

The spending estimates produced using the modified per capita approach reflect probable spending patterns over the forecast period assuming no additional large capital projects or service level changes. The impact of large capital projects on local government tax spending was added to the modified per capita estimates by first determining the type and cost of such projects that would be needed over the forecast period. Projects for water and sanitation, solid waste, and police, fire and emergency medical services are identified in Section 4.2.13.3.6. The baseline fiscal conditions forecasts assume that the portion of each of these projects that would be paid by local property taxes would be financed by general obligation debt with a 20-year term and an annual interest rate of 6.5 percent. In particular, this assumption is applied to the construction of new jail facilities in Forest, Langlade and Oneida counties, the 911 service in Forest County, and the facility upgrade in the Lake Tomahawk Sanitary District. Service level changes, such as the addition of county sheriff deputies, were added as direct new expenditures for each year of the anticipated service level change. All capital improvements and service level changes have been stated in constant 1994 dollars.

Local Government Revenues

Local government revenues can be broken into three large categories: property tax revenues, local non-property tax revenues, and intergovernmental aids.

Local non-property tax revenues, such as license fees, were forecast using a modified per capita approach similar to that described above.

Intergovernmental aids in Wisconsin are complex. The Shared Revenue program is the dominant intergovernmental aid program for general purpose governments in Wisconsin. Until 1991, this program was primarily composed of four parts: utility payment, per capita payment, aidable revenue payment, and minimum and maximum adjustments. Beginning in 1991, several changes have occurred that alter the distribution of intergovernmental aids throughout the state. These changes include the Tax Rate Disparity Program, the Small Community Improvement Program (SCIP), the County Mandate Relief Program and the County Tax Rate Limit Program. Shared revenue payments, including the various new components, were forecast by assuming that intergovernmental aid programs would not change from their 1994 structure. The impact of forecasted changes in population, local government spending, local government non-property tax revenues, and property values were estimated using a simulation model based on the 1994 structure of the Shared Revenue program.

Local government property tax levies (the amount of local spending raised by property taxes) for each year of the forecast period was determined by subtracting anticipated local non-property tax revenues and intergovernmental aids from anticipated total spending. For many towns in the study area projected revenues exceed projected spending, thus, producing a surplus or negative levy in a particular year. The introduction of the new Small Community Improvement Program also produced an erratic pattern to local levies that was uncommon prior to 1994. In places with very low levies, annual SCIP payments can fluctuate such that local levies can make large relative (but small absolute) changes from year to year.

All local government revenues are stated in constant 1994 dollars.

Equalized Value

Equalized value is a measure of property value determined by the Wisconsin Department of Revenue that can be used to compare property values across jurisdictions. The tax base of local governments is composed of four broad categories of property: residential, commercial, manufacturing, and other.

Three of the categories, residential, commercial and other, were forecast using a modified per capita approach similar to that described above. In this case, however, per capita ratios for each class were regressed only on the natural logarithm of population for the period 1985-1992. This process allowed identification of changes in the per capita value ratio as populations either increased or decreased over time. Equalized values for residential, commercial and other uses were forecast by applying modified per capita ratios for each jurisdiction to the population forecast for that jurisdiction.

Manufacturing value was forecast based on the number of manufacturing workers forecast for each jurisdiction. The historical pattern of the ratio of manufacturing value per employee is

mixed over the three study area counties. Between 1988 and 1991 the value per worker decreased dramatically in Forest County, decreased slightly in Langlade County, and increased slightly in Oneida County. The dramatic decrease in Forest County is largely attributable to a change in the reporting of manufacturing value that occurred between 1988 and 1991. Baseline manufacturing value was forecast by applying the 1994 manufacturing value per worker to the projected number of manufacturing workers in each jurisdiction. All equalized value estimates are stated in constant 1994 dollars.

Property Tax Rate

The property tax rate for a jurisdiction is simply the forecast local government levy divided by the forecast total equalized value. This rate is stated in dollars of property taxes per $1,000 of equalized value.

4.2.13.3.4.2 Baseline Equalized Value and Property Tax Rate Forecasts

Table 4.2.13-18, Table 4.2.13-19 and Table 4.2.13-20 report projected baseline total equalized value and property tax rates for all general purpose governments in the study area. Baseline forecasts are made for each year from 1994 to 2036. The summary baseline forecast tables report projections for years 1997, 2000, 2010, 2020, 2030 and 2036.

Table 4.2.13-18 reports baseline fiscal forecasts for the study area jurisdictions in Forest County. Annual spending will increase in eight jurisdictions in Forest County between 1997 and 2036, and will decrease in six jurisdictions. Peak annual spending can occur anywhere from 1997 to as late as 2020 throughout the county. In general, property value in Forest County without the project is projected to grow moderately from a level of $289 million (in 1994 dollars) in 1997 until it reaches a peak of approximately $303 million in 2020. By 2036, the end of the forecast period, total equalized value in the county is projected to decrease to approximately $288 million, which is slightly below its level in 1997.

The property value change pattern within the county is quite varied and reflects anticipated changes in population and manufacturing activity without the project. The towns of Lincoln, Nashville and Caswell are projected to have relatively high rates of tax base growth without the project, with four other towns experiencing lesser levels of increase. The City of Crandon's tax base will grow moderately from approximately $34 million in 1997 to a peak of approximately $37 million in 2020, decreasing to approximately $35 million by 2036. Four towns are projected to lose tax base over the forecast period.

In general, the projected changes in local government spending, tax base, and intergovernmental aids in Forest County produce only minor changes in anticipated tax rates without the project. The exceptions to this general statement include the City of Crandon, Forest County, and the Town of Caswell. It appears that the City of Crandon will experience upward pressures on its tax rate for municipal purposes. This projection is consistent with historical trends in the city and reflects the combined influences of population and manufacturing growth, and corresponding adjustments to state intergovernmental aids. The relatively large increase in Forest County's tax rate is largely due to debt service requirements associated with the new jail expansion and installation of 911 service. The increases to the Forest County levy due to the above improvements may be of sufficient magnitude to require special approval by the County Board under provisions of the County Tax Rate Limit Program. The apparent high increases in the

Table 4.2.13-18
Forest County Without-Project Expenditures, Equalized Values and Property Tax Rates for Study Area Jurisdictions: 1997-2036

	1997	2000	2010	2020	2030	2036
	Total Annual Expenditures (1000s $ 1994)					
Argonne, Town	196	200	209	215	208	201
Blackwell, Town	136	139	147	151	147	141
Caswell, Town	72	75	81	85	83	80
Crandon, City	1,052	1,075	1,136	1,172	1,150	1,117
Crandon, Town	148	148	146	145	140	135
Freedom, Town	144	145	149	151	146	141
Hiles, Town	240	238	231	228	222	215
Laona, Town	351	350	344	341	329	316
Lincoln, Town	282	292	321	337	326	314
Nashville, Town	400	417	467	494	478	460
Popple River, Town	55	56	60	61	60	57
Ross, Town	71	69	63	59	57	55
Wabeno, Town	341	331	302	285	277	267
Forest County	5,437	5,799	5,933	5,769	5,610	5,486
	Total Equalized Value ($1000s $ 1994)					
Argonne, Town	9,794	9,962	10,429	10,690	10,354	10,000
Blackwell, Town	2,900	2,963	3,137	3,235	3,137	3,026
Caswell, Town	3,489	3,585	3,870	4,049	3,911	3,774
Crandon, City	34,317	34,918	36,539	37,375	36,155	34,829
Crandon, Town	11,805	11,760	11,625	11,483	11,116	10,681
Freedom, Town	17,982	18,157	18,623	18,856	18,273	17,632
Hiles, Town	33,541	33,214	32,116	31,564	30,575	29,476
Laona, Town	31,201	31,091	30,675	30,385	29,430	28,368
Lincoln, Town	45,373	46,864	51,266	53,659	52,042	50,230
Nashville, Town	51,760	53,794	59,788	63,011	61,127	58,983
Popple River, Town	2,976	3,042	3,240	3,306	3,240	3,108
Ross, Town	3,585	3,492	3,192	3,030	2,938	2,845
Wabeno, Town	20,783	20,160	18,356	17,328	16,788	16,183
Forest County	289,221	292,019	299,433	303,191	294,359	287,510
	Property Tax Rate (Dollars per $1000 Equalized Value)					
Argonne, Town	0.00	0.00	0.00	0.00	0.00	0.00
Blackwell, Town	0.00	0.00	0.00	0.00	0.00	0.00
Caswell, Town	0.00	2.83	2.97	3.12	3.12	3.13
Crandon, City	5.79	6.13	6.91	7.37	7.36	7.13
Crandon, Town	2.20	2.30	2.35	2.38	2.34	2.33
Freedom, Town	2.83	2.84	2.86	2.87	2.89	2.89
Hiles, Town	0.00	0.00	0.00	0.00	0.00	0.00
Laona, Town	0.00	0.00	0.00	0.00	0.00	0.00
Lincoln, Town	1.97	2.00	2.08	2.12	2.09	2.08
Nashville, Town	2.85	2.89	3.01	3.06	3.03	2.99
Popple River, Town	0.00	0.00	0.00	0.00	0.00	0.00
Ross, Town	0.00	0.00	0.00	0.00	0.00	0.00
Wabeno, Town	0.00	0.00	0.00	0.00	0.00	0.00
Forest County	3.25	4.32	4.29	3.51	3.53	3.54

Source: Foth & Van Dyke Estimates.
Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-19

Langlade County Without-Project Expenditures, Equalized Values and Property Tax Rates for Study Area Jurisdictions: 1997-2036

	1997	2000	2010	2020	2030	2036
			Total Annual Expenditures (1000s $ 1994)			
Ackley, Town	133	130	123	118	113	108
Ainsworth, Town	196	197	198	195	188	180
Antigo, City	10,342	10,406	10,391	10,152	9,744	9,311
Antigo, Town	181	179	170	162	156	149
Elcho, Town	387	390	390	381	366	350
Evergreen, Town	130	132	138	138	133	127
Langlade, Town	87	89	91	90	87	83
Neva, Town	164	167	172	171	164	157
Norwood, Town	282	282	274	264	254	244
Parrish, Town	21	22	22	21	21	20
Peck, Town	119	119	117	114	110	105
Polar, Town	144	147	152	151	145	139
Price, Town	147	148	151	150	144	138
Rolling, Town	293	300	315	315	302	289
Upham, Town	162	165	169	167	161	153
White Lake, Village	191	191	188	183	176	168
Wolf River, Town	259	265	277	278	267	255
Langlade County	10,170	10,408	10,661	10,471	10,003	9,595
			Total Equalized Value (1000s $ 1994)			
Ackley, Town	16,119	15,696	14,911	14,188	13,615	13,012
Ainsworth, Town	19,428	19,587	19,706	19,348	18,593	17,759
Antigo, City	165,132	166,217	165,754	161,452	154,377	147,197
Antigo, Town	49,342	48,837	46,407	44,118	42,324	40,419
Elcho, Town	59,444	59,824	59,818	58,468	56,210	53,737
Evergreen, Town	9,342	9,508	9,950	9,950	9,545	9,103
Langlade, Town	16,429	16,690	17,100	16,951	16,317	15,571
Neva, Town	28,040	28,522	29,398	29,221	28,080	26,855
Norwood, Town	21,703	21,653	21,107	20,337	19,566	18,666
Parrish, Town	2,843	2,876	2,876	2,843	2,743	2,609
Peck, Town	9,833	9,833	9,685	9,388	9,018	8,600
Polar, Town	23,020	23,421	24,217	24,119	23,165	22,146
Price, Town	9,931	10,042	10,227	10,116	9,745	9,301
Rolling, Town	38,526	39,349	41,051	41,000	39,271	37,548
Upham, Town	42,015	42,639	43,575	43,138	41,515	39,704
White Lake, Village	5,548	5,563	5,455	5,268	4,989	4,725
Wolf River, Town	32,854	33,608	35,114	35,154	33,806	32,377
Langlade County	564,303	568,887	570,814	558,849	535,993	511,923
			Property Tax Rate (Dollars per $1000 Equalized Value)			
Ackley, Town	0.49	1.68	0.66	0.65	0.64	0.61
Ainsworth, Town	3.85	3.88	3.89	3.88	3.76	3.63
Antigo, City	15.01	15.12	15.11	14.70	13.93	13.02
Antigo, Town	0.62	0.65	0.68	0.70	0.72	0.72
Elcho, Town	0.50	0.51	0.53	0.55	0.57	0.58
Evergreen, Town	1.02	1.10	1.31	1.54	1.36	1.15

Table 4.2.13-19, continued

	1997	2000	2010	2020	2030	2036
Langlade, Town	0.09	0.11	0.13	0.14	0.16	0.16
Neva, Town	1.29	1.43	1.50	1.58	1.50	1.41
Norwood, Town	1.44	1.55	1.62	1.62	1.57	1.50
Parrish, Town	0.00	0.00	0.00	0.00	0.00	0.00
Peck, Town	0.22	2.12	2.28	2.34	2.24	2.25
Polar, Town	0.05	0.41	0.52	0.60	0.49	0.36
Price, Town	5.98	6.00	6.03	6.07	6.00	5.85
Rolling, Town	0.94	0.78	0.88	0.88	0.82	0.82
Upham, Town	1.44	1.45	1.46	1.48	1.49	1.34
White Lake, Village	3.32	5.27	5.99	5.72	5.70	5.56
Wolf River, Town	1.39	1.41	1.43	1.44	1.45	1.45
Langlade County	4.93	5.37	5.76	5.76	5.57	5.52

Source: Foth & Van Dyke Estimates.

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-20

Oneida County Without-Project Expenditures, Equalized Values and Property Tax Rates for Study Area Jurisdictions: 1997-2036

	1997	2000	2010	2020	2030	2036
			Total Annual Expenditures (1000s $ 1994)			
Crescent, Town	339	341	334	317	290	267
Enterprise, Town	72	70	64	58	53	48
Lake Tomahawk, Town	380	388	394	380	344	316
Monico, Town	127	125	114	104	94	87
Newbold, Town	651	660	664	640	587	544
Pelican, Town	530	533	522	497	456	424
Piehl, Town	75	77	81	78	72	66
Pine Lake, Town	1,352	1,349	1,291	1,210	1,103	1,016
Rhinelander, City	10,806	10,679	9,928	9,147	8,309	7,636
Schoepke, Town	184	184	175	164	149	137
Stella, Town	120	122	124	120	110	101
Sugar Camp, Town	594	604	603	577	524	481
Three Lakes, Town	1,480	1,514	1,550	1,503	1,373	1,266
Woodboro, Town	124	128	133	130	119	110
Oneida County	15,479	15,773	15,857	15,124	13,990	13,113
			Total Equalized Value (1000s $ 1994)			
Crescent, Town	77,516	77,969	76,241	72,168	65,671	60,288
Enterprise, Town	20,872	20,492	18,897	17,297	15,769	14,543
Lake Tomahawk, Town	60,407	61,635	62,605	60,407	54,975	50,639
Monico, Town	6,452	6,339	5,797	5,301	4,807	4,404
Newbold, Town	133,797	135,944	136,695	131,380	119,666	110,195
Pelican, Town	98,340	98,939	96,576	91,244	82,908	76,178
Piehl, Town	2,630	2,698	2,833	2,732	2,495	2,292
Pine Lake, Town	88,208	88,036	84,231	78,882	71,815	66,083
Rhinelander, City	253,172	250,678	233,831	215,336	195,122	179,083
Schoepke, Town	31,013	30,934	29,516	27,623	25,099	23,125
Stella, Town	21,721	22,091	22,536	21,758	19,829	18,269
Sugar Camp, Town	96,966	98,535	98,470	94,349	85,841	79,031
Three Lakes, Town	250,564	256,321	262,349	254,344	232,190	213,834
Woodboro, Town	39,376	40,522	42,166	41,170	37,482	34,539
Oneida County	1,953,269	1,970,788	1,943,576	1,847,907	1,711,984	1,598,273
			Property Tax Rate (Dollars per $1000 Equalized Value)			
Crescent, Town	2.42	2.43	2.46	2.49	2.52	2.53
Enterprise, Town	0.89	0.89	0.91	0.92	0.93	0.94
Lake Tomahawk, Town	5.07	5.09	5.11	5.11	5.10	5.08
Monico, Town	3.51	3.41	2.71	2.16	1.93	1.64
Newbold, Town	2.41	2.42	2.44	2.46	2.49	2.50
Pelican, Town	1.82	1.99	2.02	2.05	2.09	2.11
Piehl, Town	7.28	7.47	7.84	7.57	6.85	6.12
Pine Lake, Town	3.79	3.80	3.81	3.83	3.84	3.84
Rhinelander, City	12.22	12.14	11.72	11.29	11.25	11.15

Table 4.2.13-20, continued

	1997	2000	2010	2020	2030	2036
Schoepke, Town	3.10	3.10	3.09	3.06	3.02	2.99
Stella, Town	1.39	1.43	1.46	1.46	1.43	1.26
Sugar Camp, Town	0.00	0.00	0.02	0.04	0.06	0.07
Three Lakes, Town	3.72	3.73	3.74	3.75	3.75	3.74
Woodboro, Town	0.49	0.50	0.52	0.53	0.56	0.58
Oneida County	3.04	3.13	3.31	3.32	3.29	3.30

Source: Foth & Van Dyke Estimates.

Prepared by: JRH
Checked by: RVS

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Town of Caswell's tax rate as shown in Table 4.2.13-18 are an artifact of the years chosen for reporting purposes and the potential instability created by the new SCIP program. As discussed earlier, communities with very low municipal tax rates such as Caswell can experience significant swings in their local levies from year to year due to the nature of SCIP payments. While seemingly high in any given year, the local tax rate in these places remains low on average over all years. Table 4.2.13-19 reports baseline fiscal forecasts for study area jurisdictions in Langlade County. The projected underlying demographic and economic dynamics in Langlade County are somewhat different from those projected for Forest County. Langlade County's population is projected to peak at about 20,700 people in the year 2010 and then decrease to a level in 2036 that is about 4 percent lower than it's 1997 level. Manufacturing employment and associated property value are projected to decrease throughout the forecast period.

Annual spending in all Langlade County general purpose governments is projected to be lower in 2036 than in 1997. In a majority of jurisdictions, however, total annual spending will rise until 2010, and then begin a decrease to the lower levels of 2036. Total equalized value in Langlade County will increase moderately from a level of approximately $566 million in 1997 to a peak of approximately $571 million in 2010. The decrease in total county equalized value after this peak is relatively greater in Langlade County, reaching a level of approximately $511 million by 2036. The pattern of equalized value in Langlade County is again largely a function of anticipated without project population and manufacturing changes.

All local units of government in Langlade County are projected to lose total equalized value over the forecast period. The largest relative decreases are projected in the Towns of Ackley and Antigo, and the Village of White Lake. The City of Antigo is projected to lose 12 percent of its 1997 tax base by the year 2036. Projected tax rate changes for general purpose governments in Langlade County are generally small and suggest slightly higher tax rates. The apparent high increases in the Towns of Ackley and Peck are similar to those discussed above concerning the Town of Caswell in Forest County. The apparent high increase in the Village of White Lake's tax rate is due to a large surplus that was applied to local levies in the beginning year of the tax rate simulation model that was not carried forward into later years.

Table 4.2.13-20 reports baseline fiscal forecasts for study area jurisdictions in Oneida County. In many ways, the projected underlying demographic and economic dynamics in Oneida County are more similar to those of Langlade County than those of Forest County. The population of Oneida County is projected to peak at approximately 34,000 people in the year 2000 and then

decrease to a level in 2036 that is approximately 12 percent lower than its 1997 level. Like Langlade County, Oneida County's manufacturing employment is projected to decrease over the entire forecast period. Total annual spending is projected to decrease in all general purpose governments in Oneida County between 1997 and 2036. Annual spending decreases throughout the entire forecast period for four towns and the City of Rhinelander, and peaks in 2000 to 2010 for the remainder of the general purpose governments in the county. Total equalized value in Oneida County will reach a peak of approximately $1,973 million in 2000 and decline steadily after this to a level of approximately $1,602 million in 2036. Projected population losses play a relatively larger role in explaining anticipated tax base decreases in Oneida County, in comparison to Forest and Langlade Counties. Like Langlade County, all general purpose governments in Oneida County are projected to experience tax base decreases over the forecast period. The places projected to experience the largest relative decreases in tax base include the City of Rhinelander, and the Towns of Crescent, Enterprise, Monico, Pine Lake and Schoepke.

In general, the population and manufacturing decreases projected for Oneida County do not produce detrimental fiscal conditions for general purpose governments within the county. As shown in Table 4.2.13-20, tax rate changes for local governments in the county will be only slightly higher over the forecast period for jurisdictions experiencing higher tax rates and are projected to be lower in five jurisdictions, including the City of Rhinelander.

4.2.13.3.4.3 Study Area School Districts

Eight school districts comprise the majority of the study area. Existing conditions in each of these districts is described in Section 3.14.3.5.1. Projected enrollments under without-project conditions are reported in Section 4.2.13.3.5.1.

Table 4.2.13-21 summarizes projected total annual expenditures and total equalized value and spending for each study area school district for the years 1997, 2000, 2010, 2020, 2030 and 2036. School district property values are estimated using the projected equalized value (Section 4.2.13.3.4.2) of each general purpose government that is contained in the school district. For example, the Laona school district includes the Towns of Laona, Caswell, Popple River, Ross and a portion of Blackwell. The Laona school district's total equalized value is determined by summing the projected equalized value of each of the underlying local governments. The portion of Blackwell's value that is assigned to the school district in any year is equal to the proportion that existed in 1992.

School district expenditures were projected using a modified per pupil approach similar to that used for local government spending. Data for years 1985 to 1992 were used to estimate how per pupil spending changed in response to enrollment and equalized value changes. Natural logarithm models (non-linear) were employed in this analysis. Projected school district expenditures are stated in constant 1994 dollars.

Revenue caps enacted by the state legislature in 1993 and changes that are still underway that deal with collective bargaining reform create possible, if not probable distortions to historical fiscal relationships for Wisconsin school districts. Even greater uncertainty is created by Wisconsin Act 437, passed in 1994, which provides for two-thirds state funding of local public education by the 1996-97 school year (Reschovsky, 1994). Forecasting school district fiscal conditions is extremely difficult under current conditions.

Table 4.2.13-21

Without-Project Total Spending and Equalized Values for Study Area School Districts: 1997-2036

	1997	2000	2010	2020	2030	2036
			Total Annual Expenditures (1000s $ 1994)[1]			
School Districts						
Antigo	19,204	18,486	15,535	14,403	13,224	11,980
Crandon	6,469	6,578	6,564	6,486	5,908	5,305
Elcho	2,746	2,649	2,238	2,078	1,919	1,746
Laona	2,409	2,457	2,450	2,423	2,203	1,978
Rhinelander	20,087	19,783	15,546	13,927	13,324	11,921
Three Lakes	5,664	5,570	4,365	3,908	3,741	3,347
Wabeno	3,402	3,465	3,462	3,421	3,120	2,801
White Lake	1,917	1,809	1,433	1,249	1,076	944
			Total Equalized Value (1000s $ 1994)[2]			
School Districts						
Antigo	420,136	422,564	421,928	411,795	394,572	376,659
Crandon	188,087	192,182	203,933	210,206	203,708	196,449
Elcho	176,154	176,908	175,026	169,356	160,529	152,063
Laona	41,341	41,302	41,074	40,871	39,616	38,189
Rhinelander	787,860	791,447	770,876	728,038	662,012	608,767
Three Lakes	362,478	369,716	375,106	362,277	330,681	304,697
Wabeno	151,475	147,859	137,313	131,238	127,146	122,579
White Lake	67,473	68,854	71,582	71,450	68,610	65,616

Source: Foth & Van Dyke Estimates, 1995.
[1]Includes Sokaogon Chippewa Community and Forest County Potawatomi students enrolled in study area public schools.
[2]Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: JRH
Checked by: RVS

In general, Table 4.2.13-21 shows that study area school districts are likely to experience the same diminishing tax base over the forecast period as do the underlying communities that comprise each school district's tax base. At the same time, total school district spending is likely to decrease as school enrollments decrease over time, although the effects of recent legislative changes makes predictions of future school district spending uncertain.

4.2.13.3.5 Public Facilities and Services

Service levels for public facilities and services provided in the study area have been projected for the forecast period. School district enrollment; water and sanitation; solid waste management; police, fire and emergency medical services; as well as human, health and social services have been estimated assuming the project is not constructed. The following sections provide detail on the resulting projected public facility and service levels.

4.2.13.3.5.1 School District Enrollment

Enrollment for the eight school districts was projected based on the population projections developed earlier. Population by county for school age children (age 5-19) was taken from the population projections. The percentage change of school age children for each five year period from 1990 through 2035 was applied to the actual enrollment for each school district for the 1993/94 school year.

The major underlying assumption is that school district enrollment will correlate with changes in the population of school age children. While the eight districts do not perfectly align with county boundaries, they are close enough to assign population changes from the county in which the majority of land area is located.

School age population projections for each county have been developed by the Department of Administration through the year 2020. Beyond this point DOA methodology was used to project enrollments through 2035. The projection methodology is based on changes in total population, school age population and current school district enrollment. Table 4.2.13-22 provides a summary of enrollment projections for each school district. The Wisconsin Department of Public Instruction reviewed the school district enrollment projections, and concluded that the projections were reasonable.

4.2.13.3.6 Water and Sanitation

Municipal water and sanitary sewer services are provided to many residents within the study area. An attempt was made to evaluate baseline forecasts of capital improvement needs to the existing systems and to identify other areas which may develop water and sanitary sewer services during the forecast period.

Table 4.2.13-22

Study Area Public School District Enrollment Forecast - Without Project

School Districts	1995	2000	2005	2010	2015	2020	2025	2030	2035
Forest County									
Crandon	1,034	1,064	1,090	1,063	1,050	1,051	1,029	964	883
Laona	353	364	373	363	359	359	352	329	302
Wabeno	545	562	575	561	554	554	543	508	466
Total	1,933	1,989	2,038	1,988	1,963	1,964	1,923	1,801	1,651
Langlade County									
Antigo	3,267	3,071	2,817	2,593	2,486	2,409	2,351	2,202	2,023
Elcho	436	410	376	346	332	321	314	294	270
White Lake	267	251	230	212	203	197	192	180	166
Total	3,969	3,732	3,423	3,151	3,022	2,928	2,857	2,676	2,459
Oneida County									
Rhinelander	3,434	3,348	2,988	2,635	2,431	2,361	2,374	2,242	2,036
Three Lakes	766	747	667	588	543	527	530	500	454
Total	4,200	4,095	3,654	3,223	2,974	2,888	2,904	2,742	2,490

Source: Foth & Van Dyke Estimates.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Municipal Water Systems

Communities that may require municipal water system improvements between the years 1994 and 2036 are shown in Table 4.2.13-23. The information is based on current system needs as identified by system operators or the WDNR (Section 3.14.3.5.2), as well as the baseline population projections for each community.

It is estimated that five out of the eight communities will require capital expenditures to improve their water systems during the projected time frame. For the city of Antigo, Foth & Van Dyke estimates the need for additional elevated storage (500,000 gallons) to equal future average daily consumption, based on maximum projected population increases and associated water consumption rates. The communities of Wabeno, Elcho and Three Lakes should have adequate systems to meet future needs. The costs reflect capital expenditures only and do not include financing or normal operation and maintenance (O&M) costs.

Municipal Wastewater Treatment

The information included in Section 3.14.3.5.2, baseline condition of municipal wastewater treatment facilities, and the baseline population projections in Section 4.2.13.3.1 were used to project necessary capital improvements for each municipality for the years 1994 to 2036. This information is shown in Table 4.2.13-24. The projections take into account future population changes, as well as improvements that are currently planned for the facilities. Wastewater treatment facility plant life was generally estimated at 40 to 50 years and 20 years for community mound systems. The costs developed by Foth & Van Dyke based on past construction costs for similar facilities, reflect capital expenditures only and do not include financing or normal operation and maintenance (O&M) costs. In general, the estimated improvements will be necessary due to current plant performance and/or plant age and not due to projected population increases. Future population increases estimated for these communities will have an insignificant impact on these facilities, based on projected flows of 70 gallons per person per day.

4.2.13.3.6.1 Solid Waste Management

It is assumed that the current solid waste management systems (i.e. hauling, transfer, disposal) in Oneida, Langlade and Forest counties will remain as they are. Based on current filling rates, the sanitary landfills serving Oneida and Langlade counties will require expansion within the next 6 and 20 years, respectively. Estimated construction costs developed by Foth & Van Dyke based on past construction costs for similar sized landfills are included in Table 4.2.13-25. The cost estimates assume expansion at the current sites. Costs for permitting, engineering design and operations are not included.

4.2.13.3.6.2 Human, Health and Social Services

There are no current expansion plans for Langlade Memorial Hospital, according to its Chief Executive Officer (Schneider, 1994). As of November 1994, it has been running at an average occupancy rate of 25 beds per week. The hospital will continue to expand its outpatient services. According to the Vice President of St. Mary's Hospital in Rhinelander, St. Mary's will be merging with three other hospitals in the region: Sacred Heart Hospital, Tomahawk (Lincoln County); Howard Young Medical Center, Woodruff (Oneida County); and Eagle River Memorial Hospital, Eagle River (Vilas County), to form Northern Network Healthcare.

Table 4.2.13-23

Study Area Municipal Water Systems - Without Project
Estimated Capital Improvements 1994-2036

Location	System Needs/ Improvements	Estimated Date[1]	Estimated Capital Costs (1994 $)[2]	Probable Financing Method
Forest County				
City of Crandon	200,00 gal. elevated storage[3]	2015-2020	$400,000	User fees[4]
Langlade County				
City of Antigo	500,000 gal. elevated storage[5]	2001-2002	$800,000	User fees[6]
Oneida County				
City of Rhinelander	500,000 gal. elevated storage[7]	1996-1997	$800,000	User fees[8]
Three Lakes Sanitary District #1	100,000 gal. elevated storage[9]	1996-1997	$200,000	User fees[10]

[1]Foth & Van Dyke (based on current system condition, facility needs, future population projections).
[2]Foth & Van Dyke (based on past construction costs for similar facilities).
[3]WDNR, 1988, *Report on an Investigation of the Public Water Supply at Crandon*, Wisconsin, November 3.
[4]Johnson, 1994.
[5]Foth & Van Dyke (based on projected future needs).
[6]Hoerman, 1994.
[7]Fruend, 1994.
[8]Breivogel, 1994.
[9]Wisconsin Department of Natural Resources, 1993, *Report on the Investigation of the Public Water Supply at Three Lakes Sanitary District*, Wisconsin, June 15.
[10]Coates, 1994.

Prepared by: GMS
Checked by: SFJ

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Table 4.2.13-24

Study Area Municipal Wastewater Treatment Systems - Without Project
Estimated Capital Improvements 1994-2036

Location	System Needs/ Improvements	Estimated Date[1]	Estimated Capital Costs (1994 $)[2]	Probable Financing Method
Forest County				
City of Crandon	plant upgrade[3]	1995-1996	$2,000,000	User fees[3]
Laona Sanitary District #1	---	---	---	---
Wabeno Sanitary District #1	plant upgrade[4]	1999-2000	$1,000,000	User fees[5]
Langlade County				
City of Antigo	phosphorus removal/[6] additional sludge storage	1999-2000	$1,000,000	User fees[7]
	plant upgrade[1]	2020	$10,000,000	User fees[7]
Elcho Sanitary District	plant upgrade[6]	1998	$500,000	User fees[8]
Village of White Lake	plant upgrade[1]	2017	$1,500,000	User fees[9]
Oneida County				
Lake Tomahawk Sanitary District	facility upgrade[1]	2010	$500,000	66% user fees, 34% advelorem tax[10]
City of Rhinelander	plant upgrade[1]	2014	$2,000,000	User fees[11]
Three Lakes Sanitary District #1	plant upgrade[1]	2005	$1,000,000	User fees[12]

Table 4.2.13-24, continued

Sources:

[1]Foth & Van Dyke, 1994; based on plant age, type and construction.
[2]Foth & Van Dyke, 1994; based on past construction costs for plants of similar size and treatment type.
[3]Johnson, 1994.
[4]Ohm, 1994a.
[5]Hogan, 1994.
[6]Hubbard, 1994.
[7]Hoerman, 1994.
[8]West, 1994.
[9]Sellers, 1994.
[10]Young, 1994b.
[11]Breivogel, 1994.
[12]Coates, 1994.
--- No data

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-25

Without Project - Study Area Sanitary Landfill Capital Expenditure Forecast

Landfill	Estimated Year	Estimated Construction Cost (in 1994 $)	Estimated Financing Method*
City of Antigo	2014	$500,000	Tipping fees
Oneida County	2000	$500,000	Tipping fees

* Based on current method.
Source: Foth & Van Dyke; discussions with landfill operators September-October, 1994.
Note: Includes construction costs only. Engineering/permitting costs are not included.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-26, Planning Standards and Service Levels in Social Impact Analysis, was used to evaluate current and future needs in the study area for healthcare and police, fire and emergency services. "Planning standards" are guidelines established by professional organizations that indicate optimum resources to satisfy per capita needs. "Service level standards" are based on observed national (or regional) average amounts of resources expended per capita. The standards are based on average annual permanent population figures. These standards will be used to estimate current baseline needs and to estimate project-related impacts. The study area typically experiences an increase in population during the tourist season, which may result in short term needs above those determined using the average annual permanent population figures. Since the mine will not appreciably affect these seasonal variations, any short term needs should be the same with or without the project.

The affiliation will enable the hospitals to work together to share costs and ensure the continued availability of health care services in each of the communities. The implementation of the affiliation plan and consolidation of services will gradually occur over the next five years. There are 243 available beds between the four hospitals, with only 150 being used, which indicates an over supply in the region. It is estimated that by 1998 only 130 beds will be necessary, based on declining inpatient use (Erickson, 1994; O'Donnell, Erickson, 1994).

Table 4.2.13-27, Planning Standards for Hospital Beds, shows the current number of future required beds, according to the standards, for the estimated maximum county population from 1995 to 2036 are also shown. The table shows that with the exception of Forest County, which has no hospitals, both Langlade and Oneida Counties exceed the planning standards as well as the projected future maximum. From a regional perspective, the total number of licensed beds in 1992 exceeds the planning standards as well as those projected for the peak population in the future.

Table 4.2.13-26

Planning Standards and Service Levels in Study Area

Factor	Unit	Planning Standard/ Service Level	Type	Source
Elderly Care				
Nursing Home	beds per 1,000 elderly	45	service level	National Center for Health Statistics, *National Nursing Home Survey*, 1977.
Health Services				L.W. Canter, S.F. Atkinson, and F. Leistritz, *Impact of Growth*. Chelsea, WI: Lewis Publishers, 1985.
physicians	per 1,000 population	1.50	planning standard	
hospital beds	per 1,000 population	4.00	planning standard	
Public Safety				
Emergency Medical Services (EMS)				International Association of Fire Chiefs
EMS vehicles	per 30,000 population	1	planning standard	
Police				L.W. Canter, S.F. Atkinson, and F. Leistritz, *Impact of Growth*. Chelsea, WI: Lewis Publishers, 1985.
personnel	per 1,000 population	2	planning standard	
vehicles	per 1,000 population	0.6	planning standard	
Fire				L.W. Canter, S.F. Atkinson, and F. Leistritz, *Impact of Growth*. Chelsea, WI: Lewis Publishers, 1985.
personnel	per 1,000 population	1.65	planning standard	
vehicles	per 1,000 population	0.2	planning standard	

Source: Development Impact Assessment Handbook, Urban Land Institute, 1994, Exhibit 6.1, pp. 92-93.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-27

Planning Standards for Hospital Beds

	Total Licensed Number 1992[1]	Planning Standard[2]	Maximum Future[3] (year)
Forest County	0	35	38 (2025)
Langlade County (Langlade Memorial)	139	79	83 (2010)
Oneida County (Sacred Heart/St. Mary's)	150	129	136 (2000)
Total	289	243	257

Sources:
1. Peck, 1995; Schoone, 1995.
2. Four beds/1,000 population (1992 County Population Estimates, Wisconsin Department of Administration). Source: *Development Impact Assessment Handbook*, the Urban Land Institute, 1994, Exhibit 6.1, p. 93.
3. Four beds/1000 population using future population estimates, Wisconsin Department of Administration, estimated maximum year, 1995-2036.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

There is a current shortage in the total number of physicians in the region, according to the planning standards shown in Table 4.2.13-28, based on 1992 population estimates. The table also illustrates the maximum number of physicians required based on these standards for the peak county population between the years 1995 and 2036. Service level standards for nursing home beds are displayed in Table 4.2.13-29. As shown in the table, Forest County and Langlade County are currently above accepted service level standards for the number of nursing home beds, while Langlade County is very close to the standards. On a regional level, the number of licensed nursing home beds exceeds the standards for the current elderly population, as well as the projected peak elderly population.

According to the director of the Forest County Department of Social Services (Sekel, 1994), no additional programs or space requirements are anticipated in the future. One additional half-time employee will be added to his staff in 1995, with the funding for this position coming from the State of Wisconsin. The Oneida County Department of Social Services has proposed to the County Board the addition of a permanent part-time accountant, starting in 1995 (Spencer, 1994). Also, grant funds to administer a new program directed toward adjudicated delinquents has been applied for to the state. If the grant is successful, an additional two to three staff positions will be funded. The department director indicated that perhaps in five years there may be a need for additional space, although there are no current plans nor have there been any formal discussions about space needs.

The director of the Langlade County Department of Social Services (Meisinger, 1994) indicated there are no plans for adding new staff or programs to his department in the future. There have been space problems in the department for the last 12 to 15 years that will need to be addressed sometime in the future. According to the director, there is a need for an additional 2,000-2,500 square feet of storage and office space, however, there has not been any formal discussions at the county board level concerning additional space needs for this department.

4.2.13.3.6.3 Police, Fire, Emergency Medical Services

Current police, fire and emergency medical service needs as identified by county and city officials are listed in Table 4.2.13-30. Only new facilities/additions and additional staff and/or equipment is included. Replacement staff and equipment is not included. According to the Forest County Emergency Government Director (Baetsen, 1994a), the State Division of Corrections has recently informed Forest county that the current jail facility is inadequate. The current facility was constructed in 1909 and is too small to meet current needs. The county is in the process of determining specific space needs and developing cost estimates for necessary improvements and/or replacement to this facility. According to county officials (Baetsen, 1994b), the size of the facility should include anywhere from 25-60 beds. In addition, plans are underway for the implementation of a "911" Emergency Phone system for Forest County, which is proposed to be installed by 1998.

Table 4.2.13-28
Planning Standards for Physicians

	Total Number 1992[1]	Planning Standard[2]	Maximum Future[3] (year)
Forest County	7	13	14 (2025)
Langlade County	11	30	31 (2010)
Oneida County	35	48	51 (2000)
Total	53	91	96

Sources:
1. Wisconsin Department of Health and Social Services, "The State's Profile - 1992".
2. 1.5 physicians/1,000 population (1992 County Population Estimates, Wisconsin Department of Administration). Source: *Development Impact Assessment Handbook*, the Urban Land Institute, 1994, Exhibit 6.1, p. 93.
3. 1.5 physicians/1000 population using future population estimates, Wisconsin Department of Administration, estimated maximum year, 1995-2036.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-29
Service Level Standards for Nursing Home Beds

	1992 Licensed Beds[1]	1992 Elderly Population[1]	Service Level Standard[2]	Maximum Future[3] (year)
Forest County	150	1,670	75	121 (2035)
Langlade County	173	3,770	170	304 (2030)
Oneida County	535	5,850	263	551 (2030)
Total	858	11,290	508	976

Sources:
1. Wisconsin Department of Health and Social Services, "The State's Profile - 1992".
2. Forty-five beds/1,000 elderly (65 years and over). Source: *Development Impact Assessment Handbook*, the Urban Land Institute, 1994, Exhibit 6.1, p. 92.
3. Peak year for the number of people in age group of 65 and older. Forty-five beds/1000 elderly.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-30

Without Project - Study Area Estimate of Police, Fire and EMS Needs Future Expenditure Forecast 1995-2036

Location	Needs	Estimated Date
Forest County[1]	new jail	1998
	"911" emergency phone system	1998
Forest County Sheriff's Dept.[2]	5 additional deputies	1998
	3 additional patrol cars	1998
City of Crandon[3]	1 additional police officer	1996
Langlade County[4]	jail addition	2000
Langlade County Sheriff's Dept.[4]	1 additional deputy	1995
	3 additional deputies	2000
City of Antigo Fire Dept.[5]	1 new pumper	1996
Oneida County[6]	jail addition	2000
Oneida County Sheriff's Dept.[6]	8 additional deputies	2000
City of Rhinelander Fire Dept.[7]	building extension (2 bays)	2000
	high level rescue equipment	2000
	water rescue team	2000
	hovercraft	2000
	second fire station	2010
	additional staff (3)	2010
City of Rhinelander Police Dept.[8]	additional officer (1)	1995

Sources:
1. Baetsen, 1994a, Baetsen, 1994b.
2. Huettl, 1994.
3. Berndt, 1994.
4. Steger, 1994.
5. Bartz, 1994; Donovan, 1994.
6. Crofoot, 1994.
7. Lehman, 1994.
8. Sebastion, 1994.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

The Langlade County Sheriff (Steger, 1994) indicated a recent five-year project plan for Langlade County identified a need for enlarging the current jail. No specific costs or space requirements were identified, however according to the sheriff, within the next five years another 20-30 beds will be necessary. The facility currently has 35 beds and has been at capacity for the last two years. The department will add an additional deputy in 1995, and has current needs for three additional deputies within the next five years.

Oneida County has no current plans for jail improvements, however, according to the county sheriff (Crofoot, 1994), there will be a need for 14-24 additional beds within the next five years. An additional 16 beds could be accommodated through remodeling the facility and doubling up inmates. The sheriff's department also has a need for eight additional deputies, according to the sheriff.

The City of Crandon does not currently provide 24-hour police coverage, according to the city's police chief (Berndt, 1994). A request for an additional full-time police officer has been made for the last six years, but remains unfunded.

A new fire station is under construction in the City of Antigo, which will solve the current space needs of the department. In addition, the city recently purchased a new ambulance, and has plans to purchase an additional pumper truck in the next two to three years, according to officials in the fire department (Bartz, 1994; Donovan, 1994).

According to the Rhinelander fire chief (Lehman, 1994), in the next five to ten years, an addition (two bays) will be necessary at the existing fire station to accommodate new aerial rescue equipment. Also, in a about ten years, a second two-bay fire station may be necessary. Three additional full-time staff would also be necessary at that time. There is a current need for a water rescue team and hovercraft, according to the fire chief.

The Rhinelander Chief of Police (Sebastion, 1994) has requested an additional full-time police officer in 1995. No other future needs have been identified at this time. A space study for the department is proposed for 1995 to evaluate the allocation of existing space. No new space is anticipated at this time.

Planning Standards and Service Levels for Social Impact Analysis, was used to assess current and future police personnel/vehicles, fire personnel/fire vehicles and emergency medical vehicle needs in the planning area. This information was then used to estimate future public expenditures for these services. Police personnel needs, based on planning level standards, are shown on Table 4.2.13-31. According to the standards, additional police personnel are needed in each of the counties in the planning area. The city police departments are shown to have sufficient personnel currently, as well as to meet future population needs.

Current future police vehicle needs, based on planning standards as shown in Table 4.2.13-32, are able to be met in all departments except in the City of Antigo, which shows a need for one more vehicle. Fire personnel and vehicle needs based on planning standards are shown in Table 4.2.13-33. The table shows standards for full-time fire departments only. Based on the standards, the number of personnel and vehicles for these departments is sufficient currently, as well as in the future. Current and emergency medical vehicle needs, as shown in Table 4.2.13-34, based on planning standards, are met with the current number of vehicles.

Table 4.2.13-31

Without Project - Study Area Police Personnel Needs Based on Planning Standards

Entity	Total Officers/ Deputies, 1994	Planning Standard[1]	Current Needs	Maximum Future Needs[2] (year)	Total Additional Officers/Deputies 1995-2035
Forest County Sheriff's Dept.	11	14	3	15 (2025)	4
City of Crandon	5	4	---	4 (2025)	---
Langlade County Sheriff's Dept.	16	22	6	23 (2010)	7
City of Antigo	17	17	---	17 (2005)	---
Oneida County Sheriff's Dept.	26	36	10	37 (2000)	11
City of Rhinelander	21	15	---	15 (1995)	---

Source: Foth & Van Dyke Estimates, 1995.

1 Two per 1,000 population (1994 population estimates). Source: *Development Impact Assessment Handbook*, Urban Land Institute, 1994, Exhibit 6.1, p. 93.

2 Two per 1,000 population based on future population estimates, Wisconsin Department of Administration, estimated maximum year, 1995-2036.

--- No need identified.

Note: 1) Police coverage for county sheriff's departments assume unincorporated areas only, except Village of White Lake, Langlade County, and Towns of Three Lakes, Minocqua and Woodruff, Oneida County.

2) Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-32

Without Project - Study Area Police Vehicle Needs Based on Planning Standards

Entity	Total Vehicles 1994	Planning Standard[1]	Current Needs	Maximum Future Needs[2] (year)	Total Additional Vehicles 1995-2036
Forest County Sheriff's Dept.	7	4	---	4 (2025)	---
City of Crandon	2	1	---	1 (2025)	---
Langlade County Sheriff's Dept.	8	7	---	7 (2010)	---
City of Antigo	4	5	1	5 (2005)	---
Oneida County Sheriff's Dept.	15	11	---	11 (2000)	---
City of Rhinelander	5	5	---	5 (1995)	---

Source: Foth & Van Dyke Estimates, 1995.

[1] 0.6 vehicles per 1,000 population. Source: *Development Impact Assessment Handbook*, Urban Land Institute, 1994, Exhibit 6.1, p. 93.

[2] 0.6 vehicles per 1,000 population based on future population estimates, Wisconsin Department of Administration, estimated maximum year, 1995-2036.

--- No need identified.

Note: 1) Coverage for county sheriff's departments assume unincorporated areas only, except the incorporated Village of White Lake, is serviced by Langlade County Sheriff's Department, and the incorporated Towns of Three Lakes, Minocqua and Woodruff are not serviced by Oneida County's Sheriff Department.

2) Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-33

Without Project - Study Area Fire Personnel and Vehicle Needs Based on Planning Standards

	1994 Total	Planning Standard[1]	Current Needs	Maximum Future Needs[2] (year)	Total Future Needs 1995-2036
Personnel					
City of Rhinelander	19	13	---	13 (1995)	---
City of Antigo	15	14	---	14 (2005)	---
Vehicles					
City of Rhinelander	5	2	---	2 (1995)	---
City of Antigo	2	2	---	2 (2005)	---

Source: Foth & Van Dyke Estimates, 1995.

1 Personnel: 1.65 per 1,000 population; vehicles: 0.2 per 1,000 population.

2 Planning standards based on future population estimates, Wisconsin Department of Administration, estimated maximum year, 1995-2036.

--- No need identified.

Note: 1) Full-time departments.

2) Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-34

Without Project - Study Area EMS Vehicle Needs Based on Planning Standards

	Total[1]	Planning Standard[2]	Current/Future Needs
City of Crandon	2		
Town of Laona	2		
Town of Wabeno	1		
Forest County Total	5	1	---
City of Antigo	4		
Troutland Ambulance	1		
Pickerel-Pearson	1		
Langlade County Total	6	1	---
Three Lakes	1		
Pelican Lake	1		
Sugar Camp	1		
City of Rhinelander	3		
Oneida County Total	6	1	---

Source: Foth & Van Dyke Estimates, 1995.

[1] Based on telephone conversations with local fire, police and emergency government personnel, September-October, 1994.

[2] One vehicle per 30,000 population. Source: *Development Impact Assessment Handbook*, Urban Land Institute, 1994, Exhibit 6.1, p. 93.

--- No need identified.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

The data based on phone contacts with department heads concerning future police, fire and EMS needs (Table 4.2.13-30), along with the data based on planning standards in the previous tables, were used to estimate future public expenditures for police, fire and EMS needs, which are shown in Table 4.2.13-35. Costs for vehicles and additional personnel were taken from estimates given by department heads. Costs for jail additions were estimated at $55,000/bed, assuming 400 square feet per prisoner, at $137 per square foot of jail construction (R.S. Means, 1993), with the number of beds based on preliminary discussions with department heads.

4.2.13.3.7 Native American Communities

The following sections describe baseline forecasts for both the Sokaogon Chippewa Community and the Forest County Potawatomi for the period 1997 through 2036. The baseline forecast attempts to project population, employment, housing, and other socioeconomic characteristics of both Native American communities. The purpose for this information is to provide a baseline forecast, assuming the mine is not constructed, so that socioeconomic impacts can be evaluated against this set of data.

Numerous attempts have been made to obtain information directly from the Sokaogon Chippewa Community and Forest County Potawatomi regarding baseline information and information that could be used for baseline forecasting. Neither Native American community has provided such information. In the absence of direct specific information the best available data contained in the public record has been used to prepare the following baseline forecasts.

4.2.13.3.7.1 Sokaogon Chippewa Community

Before baseline forecasting for the Sokaogon Chippewa Community is discussed it is important to note that socioeconomic characteristics of this community have been included in the baseline forecast for both the Town of Nashville, as well as Forest County. In the overall socioeconomic baseline forecast no delineation has been made between the ethnic background of the people in each geographic community.

The population of the Sokaogon Chippewa Community was reported as 432 according to the annual report to the U.S. Bureau of Indian Affairs in March, 1991. In the August, 1993 annual report to the U.S. Bureau of Indian Affairs, the population was reported as 512. In these same Bureau of Indian Affairs reports, the Sokaogon Chippewa Community reported another 41 (March, 1991) and 48 (August, 1993) individuals living adjacent to the reservation. The Bureau of Indian Affairs information would suggest population increased by 18.5 percent during the 29 month period between March, 1991 and August, 1993 (see Table 4.2.13-36).

Population on and adjacent to the reservation is anticipated to continue to rise and ultimately stabilize between 500-1,500 over the forecast period of 1997 through 2036. This forecast is based on information from the Bureau of Indian Affairs reports, and information on general economic development efforts of the Sokaogon Chippewa Community. Table 4.2.13-36 also shows that total tribal enrollment, regardless of where the members reside, was 1,548 in August 1993. As a result of increased job opportunities and overall tribal income, tribal members have been relocating back to the reservation in recent years. These trends are anticipated to continue over the near term. However, at some point it is anticipated that the majority of tribal members wishing to return to the Sokaogon Chippewa Community will have done so.

Table 4.2.13-35

Without Project - Estimated Future Expenditures for Police, Fire and EMS Needs 1995-2036

Entity	Need	Expenditures	Year
Forest County	new jail (est. 45 beds)	$2,500,000	1998
	911 emergency phone system	$ 55,000	1998
Forest County Sheriff's Dept.	(4) additional deputies*	(1) 40,000	1996
		(1) 40,000	1998
		(1) 40,000	2000
		(1) 40,000	2002
Langlade County	jail addition (est. 15-20 beds)	$1,000,000	2000
Langlade County Sheriff's Dept.	(7) additional deputies*	(2) 80,000	1996
		(2) 80,000	1998
		(2) 80,000	2000
		(1) 40,000	2002
City of Antigo Police Dept.	(1) police vehicle*	$ 17,000	1996
Oneida County	jail addition (est. 20 beds)	$1,000,000	2000
Oneida County Sheriff's Dept.	(11) additional deputies*	(2) 80,000	1996
		(2) 80,000	1998
		(2) 80,000	2000
		(2) 80,000	2002
		(2) 80,000	2004
		(1) 40,000	2006

Source: Foth & Van Dyke Estimates, 1995.

* Based on "Planning Standards" (see Table 4.2.13-26, "Planning Standards and Service Levels in Social Impact Analysis"), *Development Impact Assessment Handbook*, 1994.

Note: 1) New staff, equipment or facilities only. Does not include replacement or maintenance costs.

2) Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-36

Sokaogon Chippewa Community Population Trend - Without Project

	May 1980	April 1983	March 1991	August 1993
Within the Reservation	260	271	391	464
Adjacent to the Reservation	52	72	41	48
Total Resident Population	312	343	432	512
Total Tribal Enrollment	N/A	N/A	1,448	1,528

Source: U.S. Bureau of Indian Affairs, Annual Reports.

Prepared by: RVS
Checked by: SFJ

Reportedly employment opportunities for Sokaogon Chippewa Community members have increased dramatically as a result of opening the bingo hall in 1975, casino style gambling in 1991, and other tribal owned businesses such as tax-free tobacco sales. According to the August 1993 annual report to the Bureau of Indian Affairs, there were 198 individuals in the Sokaogon Chippewa Community labor force, of which 115 were employed. This represents an increase of 24.5 percent in the number of individuals in the labor force, and 38.6 percent in the number of individuals employed from the March, 1991 Bureau of Indian Affairs report when 159 individuals were reported in the labor force, and 83 were employed, respectively.

The following employment forecast for the Sokaogon Chippewa Community assumes that governing law will continue to allow gaming activities on the reservation while restricting competition off reservation. The employment forecast also assumes the Sokaogon Chippewa Community will continue a policy of aggressively promoting economic development activities to create job opportunities for tribal members. Sokaogon Chippewa Community employment is projected to increase until all tribal members are given sufficient job opportunities on or near the reservation, and educational opportunities to seek professional careers off the reservation if they choose. Based on this information, employment is projected to stabilize between 150 and 500.

Until present, the housing stock of the Sokaogon Chippewa Community has been dominated by federal housing projects. According to the 1990 census, only 18 percent (19) of the occupied housing units were owner occupied. The census also indicates that the housing stock is relatively new - only 9 percent (11 units) were built before 1970. While no specific statistics are available on average household size, it is assumed that the Sokaogon Chippewa Community follows Forest County's trend of reduced household size. As shown on Table 4.2.13-14, between 1960 and 1990 the average household size in Forest County deceased by 22 percent, from 3.44 persons per household in 1960 to 2.67 persons per household in 1990.

Housing stocks are projected to continue to be relatively new as low quality federally assisted units are replaced with higher quality housing units. This transition is projected as a result of increased average income of tribal members and desire for better housing conditions. Based on information outlined here, the housing stock is projected to increase from the 121 housing units

reported in the 1990 census to 150 to 500 by the year 2036. The trend of reduced household size will stabilize at some point, but not before creating additional demand for housing. The new in-migrants to the reservation will also create additional demand for housing.

With the increased economic activity on the Sokaogon Chippewa reservation there will likely be increased need for public facilities and services. Community wide sewerage treatment will likely be needed by the year 2036. The existing water system will likely need upgrade and/or replacements. Demand for other public facilities and services such as police, fire, EMS, solid waste removal, human, health, and social services will all increase as a result of increased population and economic activity.

If the Sokaogon Chippewa Community continues their efforts to attract non-Native American people to their gaming facilities, there will be a changed social as well as economic culture. Increased income will afford the Sokaogon Chippewa Community an opportunity to make changes that otherwise would not be possible.

4.2.13.3.7.2 Forest County Potawatomi

Before discussing the baseline forecasts for the Forest County Potawatomi, it is important to note that socioeconomic characteristics of this community have been included in the baseline forecast for Forest County, as well as the specific townships in which Forest County Potawatomi's live (Lincoln, Blackwell and Wabeno). In the overall socioeconomic baseline forecast no delineation has been made between the ethnic background of the people in each geographic community.

The population of the Forest County Potawatomi as reported to the U.S. Bureau of Indian Affairs in 1980, 1983, 1991 and 1994 is outlined in Table 4.2.13-37. In addition to the Bureau of Indian Affairs annual reports, the 1990 Census indicated the Forest County Potawatomi population was 266. No explanation is readily available for the 22 percent disparity between the 1990 census population estimate and population as reported in the February 1991 Bureau of Indian Affairs report.

Table 4.2.13-37

Forest County Potawatomi Population - Without Project

	April 1980	December 1983	February 1991	February 1994
Within the Reservation	265	333	325	462
Adjacent to the Reservation	51	133	161	---
Total Resident Population	316	466	486	462
Total Tribal Enrollment	N/A	683	760	847

Source: U.S. Bureau of Indian Affairs, Annual Reports.

Prepared by: RVS
Checked by: SFJ

Population is anticipated to continue increasing and to stabilize between 500 to 850 over the forecast period of 1997 through 2036. This forecast is based on the rising population trends as shown in the Bureau of Indian Affairs Annual reports, and is consistent with general economic development efforts of the Forest County Potawatomi. Table 4.2.13-37 shows that tribal enrollment, regardless of where the members reside, was 847 in February 1994. As a result of increased job opportunities and overall tribal income, tribal members have been relocating back to the reservation in recent years. These trends are anticipated to continue over the near term. However, at some point it is anticipated that the majority of tribal members wishing to return to the Forest County Potawatomi reservation will have done so.

Employment opportunities for Forest County Potawatomi members have increased dramatically as a result of opening tribal owned gaming facilities. According to the Bureau of Indian Affairs February, 1994 annual report there were 228 individuals in the labor force, of which 152 were employed. This represents increases of 15 percent and 111 percent from February, 1991 when 198 were in the labor force and 72 were employed, respectively.

Employment is forecast to stabilize between 150 and 300. The employment forecast for the Forest County Potawatomi assumes that governing law will continue to allow gaming activities on the reservation while restricting competition off reservation. The employment forecast also assumes the Forest County Potawatomi will continue a policy of aggressively promoting economic development activities to create job opportunities for tribal members. Forest County Potawatomi employment is projected to increase until all tribal members are given sufficient job opportunities on or near the reservation, and educational opportunities to seek professional careers off the reservation if they choose.

Unlike the Sokaogon Chippewa Community, the Forest County Potawatomi housing stock is older and a higher percentage is owner occupied. According to the 1990 census, 83 percent (58 units) are owner occupied and 60 percent (46 units) were built before 1970. While no specific statistics are available on average household size, it is assumed that the Forest County Potawatomi follows Forest County's trend of reduced household size. As shown on Table 4.2.13-14, between 1960 and 1990 the average household size in Forest County deceased by 22 percent, from 3.44 persons per household in 1960 to 2.67 persons per household in 1990.

The Forest County Potawatomi housing stock is projected to increase from the 77 total housing units reported in the 1990 census to 100 to 200 by the year 2036. This forecast is based on the assumption that a result of increased income for Forest County Potawatomi members, new housing units will be constructed. Higher quality housing units will replace substandard or less desirable federally assisted housing units. The trend of reduced household size will stabilize at some point, but not before creating additional demand for housing. The new in-migrants to the reservation will also create additional demand for housing.

With the increased economic activity on Forest County Potawatomi reservation land there will likely be increased need for public facilities and services. Because reservation land is scattered throughout Forest County it is unlikely that sewer or water service will be provided to all tribal members. It is likely that residents within Forest County will develop utility districts (sewer and/or water) which will serve portions of Forest County Potawatomi lands. Demand for other public facilities and services such as police, fire, EMS, solid waste removal, human, health, and social services will all likely increase as a result of increased population and economic activity.

If the Forest County Potawatomi continue their efforts to attract non-Native Americans to their gaming facility, there will be a changed social as well as economic culture. Increased income will afford the Forest County Potawatomi an opportunity to make changes that otherwise would not be possible.

4.2.13.4 Project Impacts

The preceding portion of Section 4.2.13 assessed projected socioeconomic changes likely to occur in the study area without the project. The following sections assess how the socioeconomic development of the area is likely to be affected by the project.

The socioeconomic impact section includes analyses of impacts to the study area population, employment, housing, government structure and public finance, public facilities and services, and Native American Communities.

The socioeconomic study area (Figure 3.14-1) is the area expected to encompass the project impacts. It is important to note that not all of the minor civil divisions in the study area are likely to experience impacts. Impacts in the towns, villages and cities of the study area could come from one or more of the following sources:

1. Conversion of seasonal cottages to permanent use by mine workers.

2. Development of single family dwellings, multi-family apartments or mobile home parks.

3. Increased traffic through the region. Many in-migrants would be expected to live closer to cities with shopping areas, businesses, and schools.

4. Increased school district costs from an increased population of school children. These costs could be mitigated by the Mining Impact Fund.

5. Increased need for public services such as police, fire, and snow plowing to the extent private development would occur.

6. Increased assessed property tax valuation in school districts and townships to the extent that private development would occur.

7. Elevated business activity.

These changes are not estimated to cause significant or unmanageable impacts or stress the existing infrastructure of the predominantly rural character of the area. Minor civil divisions could have a substantial influence on encouraging or discouraging some impacts through zoning and other local controls.

There are a series of uncertainties which the socioeconomic baseline projections and impact forecasts are subject to. Some of the uncertainties have a compounding effect, with one uncertain forecast dependent on the outcome of other preceding uncertain forecasts. Forecasts as to exactly what would happen in what year in what place should be evaluated with caution, considering the uncertainties which are found throughout the project.

An important part of the overall construction is a decision to select union or non-union prime contractors. Union contractors would probably hire only through union hiring halls, whereas non-union contractors would hire from more local sources. It is assumed that CMC will encourage contractors bidding for work to maximize their local hiring while obtaining the necessary skills and experience to perform the tasks.

Other uncertainties which could affect socioeconomic impacts of the project include:

- county and state highway improvements within the study area before and during mine development;
- legislative changes to the Mining Investment and Local Impact Fund and distribution of mine generated funds;
- permanent or unscheduled temporary shutdowns on the mine; and
- final decisions on which employees are hired as a result of various factors, such as skills, availability, government requirements, etc.

After baseline forecasts have been developed and the project has been characterized, it is possible to estimate project impacts. This process involves adding project induced impacts to the baseline forecast for socioeconomic aspects of the project. The following section provides detail on project impacts.

4.2.13.4.1 Population Impacts

This section analyzes the potential changes in the study area population caused by the project. Population impacts are directly related to housing impacts, public facility and service needs, fiscal revenues and costs, as well as social and economic effects of the project. The distribution of the in-migrants influences the allocation of impacts to the various school districts and minor civil divisions in the study area.

In order to determine the net population impact of the project, population impacts must be added to future baseline population forecasts. The number and characteristics of the in-migrant workers (and their families) who would obtain construction, operation or indirect/induced jobs was used to predict the impact population. By applying a family size factor of 3.01 for each operation, and indirect/induced in-migrant, the total in-migrant population estimate was derived. This family size factor was derived from 1990 U.S. census data on average household size for all employed persons.

Population impacts are a function of project-related employment. In order to determine population impacts, the following process was used:

1. Estimate total project-related employment.

   Estimates of construction, direct mine, and indirect/induced project employment are explained in more detail in Section 4.2.13.4.2, Employment Impacts.

2. Estimate percent in-migrant employment.

Table 4.2.13-38 provides a breakdown of percentage of jobs to be filled by study area residents. The remainder is assumed to be new in-migrants to the study area.

3. Allocate new workers to individual Minor Civil Divisions (MCDs).

Different allocation methods were used for allocating new construction, permanent mine, and indirect/induced in-migrant workers within the study area as follows:

- Construction workers - a gravity allocation model was used. Attractiveness indicators for individual MCDs were number of vacant permanent homes, number of mobile and seasonal homes, and number of lodging units. Attractiveness was diminished based on distance from the mine.

- Permanent mine workers - a gravity allocation model was used. Attractiveness indicators for individual MCDs were number of occupied and vacant year round housing units and total retail and service employment. Attractiveness was diminished based on distance from the mine.

- Indirect/induced workers - These workers were allocated according to each MCD's percent of total study area employment.

Preconstruction activity has already generated minor changes in the study area population. Projections for the study area population show an initial rapid increase in population peaking in the third year of construction, followed by a sustained growth over the operation period to a population level about 750 higher than the baseline forecast.

Construction worker population impacts are based on the highest monthly employment for each construction year. It is estimated that each construction job represents a temporary population increase of one individual. Direct and indirect mine employment is estimated to be taken first by study area residents and when insufficient labor is available for specific job classification, in-migration of workers is anticipated. Each in-migrant permanent worker is estimated to generate a total population impact of approximately three people.

Three population impact scenarios have been developed. The minimum scenario represents the lowest total number of workers estimated and the lowest percentage of in-migrant workers. The maximum scenario represents the highest total number of workers and the highest percentage of in-migrant workers. The middle scenario represents a mid-range estimate between minimum and maximum scenarios. For presentation purposes, the middle scenario was used and a range of minimum to maximum population impacts were discussed.

Figure 4.2.13-6 provides a graphic picture of population impacts when they are added to baseline forecasts. While Forest county shows the largest relative increase in population it represents only a small percentage of the county's overall population.

Table 4.2.13-38

Proportion of Jobs to be Filled by Study Area Residents

Type of Worker	Minimum Scenario	Middle Scenario	Maximum Scenario
Construction	30%	20%	10%
Permanent Operations	80%	70%	60%
Indirect/Induced	80%	70%	60%

Source: Foth & Van Dyke Estimates.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-39, Table 4.2.13-40 and Table 4.2.13-41 provide estimates of both absolute population change as well as percentage change over baseline forecast. During the construction phase of 1997-99 temporary workers along with the buildup of permanent workers causes the population impact to be greatest. The year 1999 represents the most significant population increase. Population of the study area is anticipated to increase between 875 minimum and 1,474 maximum scenario. This represents an average population change of 2.2 percent for the study area.

The Towns of Lincoln and Nashville are projected to experience the largest relative population change. During the highest impact month of 1999 the Town of Lincoln and the Town of Nashville are projected to experience a 11.8 percent and 8.2 percent increase in population, respectively.

Figure 4.2.13-6a provides a graphic representation of anticipated population impacts. Note that project related population impacts are greatest near the project site and near Crandon, Rhinelander, and Antigo.

After the mine is closed and employment is reduced, project induced population is assumed to be reduced. Permanent operations workers will chose one of the following:

- Remain in the study area and obtain employment within commuting distance;
- Remain in study area and start their own business;
- Obtain employment outside the study area and relocate to that area; and,
- Retire and remain in the study area.

2. Estimate percent in-migrant employment.

Table 4.2.13-38 provides a breakdown of percentage of jobs to be filled by study area residents. The remainder is assumed to be new in-migrants to the study area.

3. Allocate new workers to individual Minor Civil Divisions (MCDs).

Different allocation methods were used for allocating new construction, permanent mine, and indirect/induced in-migrant workers within the study area as follows:

- Construction workers - a gravity allocation model was used. Attractiveness indicators for individual MCDs were number of vacant permanent homes, number of mobile and seasonal homes, and number of lodging units. Attractiveness was diminished based on distance from the mine.

- Permanent mine workers - a gravity allocation model was used. Attractiveness indicators for individual MCDs were number of occupied and vacant year round housing units and total retail and service employment. Attractiveness was diminished based on distance from the mine.

- Indirect/induced workers - These workers were allocated according to each MCD's percent of total study area employment.

Preconstruction activity has already generated minor changes in the study area population. Projections for the study area population show an initial rapid increase in population peaking in the third year of construction, followed by a sustained growth over the operation period to a population level about 750 higher than the baseline forecast.

Construction worker population impacts are based on the highest monthly employment for each construction year. It is estimated that each construction job represents a temporary population increase of one individual. Direct and indirect mine employment is estimated to be taken first by study area residents and when insufficient labor is available for specific job classification, in-migration of workers is anticipated. Each in-migrant permanent worker is estimated to generate a total population impact of approximately three people.

Three population impact scenarios have been developed. The minimum scenario represents the lowest total number of workers estimated and the lowest percentage of in-migrant workers. The maximum scenario represents the highest total number of workers and the highest percentage of in-migrant workers. The middle scenario represents a mid-range estimate between minimum and maximum scenarios. For presentation purposes, the middle scenario was used and a range of minimum to maximum population impacts were discussed.

Figure 4.2.13-6 provides a graphic picture of population impacts when they are added to baseline forecasts. While Forest county shows the largest relative increase in population it represents only a small percentage of the county's overall population.

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Source: Foth & Van Dyke Estimates.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

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Checked by: SFJ

Table 4.2.13-39, Table 4.2.13-40 and Table 4.2.13-41 provide estimates of both absolute population change as well as percentage change over baseline forecast. During the construction phase of 1997-99 temporary workers along with the buildup of permanent workers causes the population impact to be greatest. The year 1999 represents the most significant population increase. Population of the study area is anticipated to increase between 875 minimum and 1,474 maximum scenario. This represents an average population change of 2.2 percent for the study area.

The Towns of Lincoln and Nashville are projected to experience the largest relative population change. During the highest impact month of 1999 the Town of Lincoln and the Town of Nashville are projected to experience a 11.8 percent and 8.2 percent increase in population, respectively.

After the mine is closed and employment is reduced, project induced population is assumed to be reduced. Permanent operations workers will chose one of the following:

- Remain in the study area and obtain employment within commuting distance;
- Remain in study area and start their own business;
- Obtain employment outside the study area and relocate to that area; and,
- Retire and remain in the study area.

Table 4.2.13-39

With Project - Study Area Population Impact-Forest County[1]

	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
Argonne, Town - Number	2	3	5	3	4	3	3	4	3	0	0
% of Baseline	0.4%	0.5%	0.9%	0.6%	0.7%	0.6%	0.6%	0.6%	0.6%	0.0%	0.0%
Blackwell, Town - Number	1	1	2	1	1	1	1	1	1	0	0
% of Baseline	0.2%	0.3%	0.4%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.0%	0.0%
Caswell, Town - Number	1	2	2	1	1	1	1	1	1	<1	0
% of Baseline	1.1%	1.6%	2.3%	0.9%	1.0%	0.9%	0.9%	0.9%	0.8%	0.1%	0.0%
Crandon, City - Number	32	51	102	105	112	108	108	111	107	5	1
% of Baseline	1.6%	2.5%	4.9%	5.0%	5.2%	4.9%	4.8%	5.0%	4.8%	0.2%	<0.1%
Crandon, Town - Number	11	16	29	23	24	24	24	24	24	2	0
% of Baseline	2.1%	3.0%	5.5%	4.4%	4.6%	4.6%	4.7%	4.7%	4.6%	0.3%	0.0%
Freedom, Town - Number	5	7	10	3	3	3	3	3	3	1	0
% of Baseline	1.6%	2.2%	3.2%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	0.2%	0.0%
Hiles, Town - Number	5	8	10	2	2	2	2	2	2	1	0
% of Baseline	1.8%	2.5%	3.4%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.2%	0.0%
Laona, Town - Number	10	16	27	21	23	21	21	22	21	1	0
% of Baseline	0.7%	1.2%	2.0%	1.5%	1.6%	1.6%	1.6%	1.7%	1.6%	0.1%	0.0%
Lincoln, Town - Number	39	54	83	38	39	39	39	39	39	5	0
% of Baseline	5.6%	7.7%	11.8%	5.3%	5.2%	5.0%	4.8%	4.8%	4.7%	0.6%	0.0%
Nashville, Town - Number	38	53	83	38	39	39	39	39	39	5	0
% of Baseline	3.9%	5.4%	8.2%	3.7%	3.6%	3.5%	3.3%	3.3%	3.2%	0.4%	0.0%
Popple River, Town - Number	1	1	2	1	1	1	1	1	1	<1	0
% of Baseline	1.9%	2.8%	3.8%	1.4%	1.5%	1.3%	1.3%	1.4%	1.3%	0.2%	0.0%
Ross, Town - Number	1	2	3	1	1	1	1	1	1	<1	0
% of Baseline	1.0%	1.3%	2.0%	0.7%	0.7%	0.8%	0.8%	0.8%	0.8%	0.1%	0.0%

Table 4.2.13-39, continued

	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
Wabeno, Town - Number	7	11	17	10	11	10	10	11	10	1	0
% of Baseline	0.8%	1.2%	1.9%	1.1%	1.3%	1.2%	1.3%	1.4%	1.3%	0.1%	0.0%
Forest County - Total Number	154	225	375	246	260	254	253	258	252	21	2
Total % of Baseline	1.7%	2.5%	4.1%	2.7%	2.8%	2.7%	2.7%	2.7%	2.6%	0.2%	0.0%

Source: Foth & Van Dyke Estimate.

[1] Example of table use - Town of Argonne in 1997, an additional two people are forecast to move into the town because of the mine, for a net increase of 0.4 percent to
the town population.

Note: Table includes socioeconomic characterizations of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-40

With Project - Study Area Population Impact-Langlade County[1]

	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
Ackley, Town - Number	1	2	3	2	2	2	2	2	2	0	0
% of Baseline	0.2%	0.3%	0.5%	0.4%	0.5%	0.5%	0.5%	0.5%	0.5%	0.0%	0.0%
Ainsworth, Town - Number	13	18	27	13	13	13	13	13	13	2	0
% of Baseline	2.6%	3.6%	5.6%	2.5%	2.6%	2.6%	2.6%	2.7%	2.6%	0.3%	0.0%
Antigo, City - Number	58	101	150	101	117	104	103	114	101	6	1
% of Baseline	0.7%	1.2%	1.7%	1.2%	1.3%	1.2%	1.2%	1.3%	1.2%	0.1%	<0.1%
Antigo, Town - Number	7	12	18	14	16	14	14	15	14	1	0
% of Baseline	0.5%	0.8%	1.3%	1.0%	1.1%	1.1%	1.1%	1.2%	1.1%	0.1%	0.0%
Elcho, Town - Number	21	30	44	19	20	19	19	20	19	3	0
% of Baseline	1.9%	2.7%	4.0%	1.7%	1.8%	1.7%	1.8%	1.8%	1.8%	0.2%	0.0%
Evergreen, Town - Number	1	2	3	2	2	2	2	2	2	0	0
% of Baseline	0.2%	0.3%	0.6%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.0%	0.0%
Langlade, Town - Number	3	5	8	5	5	5	5	5	5	<1	0
% of Baseline	0.7%	1.0%	1.7%	1.2%	1.2%	1.2%	1.1%	1.2%	1.2%	0.1%	0.0%
Neva, Town - Number	3	4	8	7	7	7	7	7	7	0	0
% of Baseline	0.3%	0.4%	0.8%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.0%	0.0%
Norwood, Town - Number	1	2	4	4	4	4	4	4	4	0	0
% of Baseline	0.1%	0.2%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%	0.4%	0.0%	0.0%
Parrish, Town - Number	1	1	2	1	1	1	1	1	1	<1	0
% of Baseline	0.8%	1.2%	1.8%	0.9%	1.0%	1.0%	1.0%	1.0%	1.0%	0.1%	0.0%
Peck, Town - Number	1	1	2	2	2	2	2	2	2	0	0
% of Baseline	0.1%	0.2%	0.4%	0.4%	0.4%	0.4%	0.4%	0.5%	0.5%	0.0%	0.0%
Polar, Town - Number	2	3	6	6	6	6	6	6	6	0	0
% of Baseline	0.2%	0.3%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.6%	0.0%	0.0%
Price, Town - Number	2	3	5	4	4	4	4	4	4	<1	0
% of Baseline	0.7%	1.1%	1.8%	1.3%	1.5%	1.3%	1.3%	1.5%	1.3%	0.1%	0.0%
Rolling, Town - Number	2	3	6	5	5	5	5	5	5	0	0
% of Baseline	0.1%	0.2%	0.4%	0.3%	0.4%	0.3%	0.3%	0.3%	0.3%	0.0%	0.0%
Upham, Town - Number	7	10	15	5	5	5	5	5	5	1	0
% of Baseline	1.1%	1.6%	2.3%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.1%	0.0%

Table 4.2.13-40 *(Continued)*

		1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
White Lake, Village	Number	3	5	7	5	5	5	5	5	5	<1	0
% of Baseline		1.0%	1.7%	2.3%	1.5%	1.7%	1.6%	1.6%	1.7%	1.5%	0.1%	0.0%
Wolf River, Town -	Number	7	10	14	6	6	6	6	6	6	1	0
% of Baseline		0.8%	1.2%	1.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.1%	0.0%
Langlade County Total -	Total Number	132	210	321	198	221	204	202	217	200	16	2
Total % of Baseline		0.6%	1.0%	1.6%	1.0%	1.1%	1.0%	1.0%	1.1%	1.0%	0.1%	<0.1%

Source: Foth & Van Dyke Estimate.

[1] Example of Table use - Town of Ackley - in 1997, one person is forecast to move into the town because of the mine for a net increase of 0.2% to the town population.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Table 4.2.13-41

With Project - Study Area Population Impact-Oneida County[1]

	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
Crescent, Town - Number	4	6	11	7	7	7	7	7	7	1	0
% of Baseline	0.2%	0.3%	0.6%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	<0.1%	0.0%
Enterprise, Town - Number	5	7	11	3	3	3	3	3	3	1	0
% of Baseline	2.0%	2.8%	4.0%	1.2%	1.3%	1.3%	1.4%	1.5%	1.5%	0.3%	0.0%
Lake Tomahawk, Town - Number	5	7	10	3	4	3	3	4	3	1	0
% of Baseline	0.5%	0.7%	1.0%	0.3%	0.4%	0.3%	0.3%	0.4%	0.3%	0.1%	0.0%
Monico, Town - Number	2	3	6	4	5	5	5	5	5	<1	0
% of Baseline	0.8%	1.2%	2.1%	1.5%	1.7%	1.7%	1.8%	1.9%	1.9%	0.1%	0.0%
Newbold, Town - Number	10	14	20	7	7	7	7	7	7	1	0
% of Baseline	0.4%	0.6%	0.8%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.1%	0.0%
Pelican, Town - Number	19	29	45	26	28	27	27	28	27	2	0
% of Baseline	0.6%	0.9%	1.4%	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.1%	0.0%
Piehl, Town - Number	1	1	2	1	1	1	1	1	1	<1	0
% of Baseline	1.0%	1.4%	2.1%	1.2%	1.2%	1.1%	1.1%	1.2%	1.2%	0.1%	0.0%
Pine Lake, Town - Number	7	10	17	11	11	11	11	11	11	1	0
% of Baseline	0.3%	0.4%	0.7%	0.4%	0.4%	0.4%	0.5%	0.5%	0.5%	0.0%	0.0%
Rhinelander, City - Number	97	168	249	169	195	174	171	190	168	10	2
% of Baseline	1.3%	2.2%	3.3%	2.2%	2.7%	2.5%	2.6%	2.9%	2.6%	0.2%	<0.1%
Schoepke, Town - Number	11	16	23	8	8	8	8	8	8	1	0
% of Baseline	2.9%	4.1%	5.9%	1.9%	2.1%	2.1%	2.2%	2.3%	2.2%	0.4%	0.0%
Stella, Town - Number	2	3	4	3	3	3	3	3	3	0	0
% of Baseline	0.3%	0.4%	0.7%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.0%	0.0%
Sugar Camp, Town - Number	8	11	15	5	5	5	5	5	5	1	0
% of Baseline	0.5%	0.7%	1.0%	0.3%	0.4%	0.3%	0.3%	0.4%	0.4%	0.1%	0.0%
Three Lakes, Town - Number	30	43	61	20	22	21	21	22	20	4	0
% of Baseline	1.3%	1.9%	2.7%	0.9%	0.9%	0.9%	0.9%	1.0%	0.9%	0.2%	0.0%
Woodboro, Town - Number	3	4	6	2	2	2	2	2	2	0	0
% of Baseline	0.3%	0.5%	0.7%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.0%	0.0%

Table 4.2.13-41, continued

	1997	1998	1999	2000	2005	2010	2015	2020	2025	2030	2035
Oneida County Total - Total Number	**204**	**322**	**479**	**269**	**301**	**276**	**273**	**295**	**270**	**24**	**2**
Total % of Baseline	**0.6%**	**1.0%**	**1.4%**	**0.8%**	**0.9%**	**0.8%**	**0.8%**	**0.9%**	**0.9%**	**0.1%**	**0.0%**
Study Area Total - Number	490	787	1,174	713	783	734	728	770	722	60	6
Total % of Baseline	0.9%	1.4%	2.2%	1.3%	1.5%	1.4%	1.4%	1.5%	1.4%	0.1%	0.0%

Source: Foth & Van Dyke Estimate.

[1] Example of table use - Town of Crescent - in 1997 four people are forecast to move into the town because of the mine for a net increase of 0.2% to the town population.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Based on experience with other mine projects, CMC estimates an annual employee turnover rate of 5 percent per year. The average age of permanent operations workers is assumed to be evenly distributed between 20 and 54 years of age. The average retirement age is assumed to be 65 years of age.

If it is assumed that permanent operations employees are hired as outlined in Table 4.2.13-2, and workers are hired to replace employees that retire or quit during mine operations, the average age of workers would increase during the life of the mine. When the mine closes in 2027, the displaced workers will need to decide whether to retire or seek employment elsewhere.

Project-related population impacts as outlined in Tables 4.2.13-39, 4.2.13-40, and 4.2.13-41, assume a conservative approach when evaluating population impacts at the end of the mine life. Based on the above outlined assumptions, there will be approximately 142 workers 55 years or older when the mine closes in 2027. It is reasonable to assume that a portion of these people will choose to retire and stay in the study area. This phenomenon will in fact reduce the population decline at the end of mine operation.

4.2.13.4.2 Economic Base

Economic base impacts as a result of the project are broken into two categories: employment and tourism related. Employment impacts are further described as construction, permanent worker, and indirect/induced. Tourism impacts are also described in the following section.

4.2.13.4.2.1 Employment Impacts

During the construction and operations phases, the proposed project would be a source of new employment, personal income, and increased business activity in the study area. A decline in project-related employment and indirect economic activity will occur during the closure phase. Employment by CMC contractors during years one through three of the construction phase would average 215, 251, and 325 persons, respectively. In addition, direct mine employment by CMC during the construction phase would average 36, 58, and 253 persons, respectively. These are average annual employment figures and not peak employment.

Indirect employment created by mine related purchases, and induced employment created by mine related payroll expenditures was estimated using an IMPLAN input/output model of the three county area. This model uses mine related expenditures and mine related payroll as inputs. The results of the IMPLAN model provide an estimate of indirect and induced employment.

The number and percent of project related jobs filled by existing study area residents as opposed to in-migrants is very important. Prime contractors and various related subcontractors are anticipated to construct the mine and related surface facilities. CMC has stated it would encourage prime contractors and all subcontractors to use local labor and services to the maximum extent possible. CMC intends to give preferential hiring to the extent allowed by law to local residents for operations employment opportunities. These policies should afford existing study area residents an advantage in securing direct project employment. Programs will be developed either by CMC or through the school systems to provide appropriate job skill training for operating positions.

In order to assess employment impacts the following process was used:

1. Employment estimates for construction and operation of the mine were made. Three scenarios for direct mine employment (minimum, middle, and maximum) were developed along with one scenario for construction and closure employment. Project expenditure estimates, which drive indirect employment estimates, were also made. These estimates are outlined in Section 4.2.13.2, Project Characterization. Finally,

employment estimates were made for construction, direct mine employment and indirect/induced employment for minimum, middle and maximum scenarios. The middle scenario is presented in Table 4.2.13-42.

2. As shown in Table 4.12.13-38, estimates were made for the percentage of jobs to be filled by study area residents. The table shows that for the middle scenario for permanent operations it is estimated that 70 percent of the jobs will be filled by study area residents.

The estimates of the numbers and types of direct project construction jobs filled by existing study area residents assume employment policies would encourage local hiring. On this basis, about 43 construction jobs in the first year, 50 construction jobs in the second year, and 65 construction jobs in the third year could be filled by existing study area residents.

Table 4.2.13-42

With Project - Study Area Employment Impacts-Middle Scenario

Year	Direct Employment (Average)		Indirect/Induced	Total	% of Baseline
	Construction	Owner's Work force			
1997	215	36	229	480	2.6%
1998	251	58	404	713	3.8%
1999	325	253	568	1,146	6.0%
2000		451	341	792	4.1%
2010		464	350	814	4.0%
2020		464	391	855	4.1%
2030	38	9	23	70	0.3%
2035		4	2	6	0.0%

Source: Foth & Van Dyke Estimates.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

CMC conducted a number of analyses of manning the facilities and these have been presented as minimum and maximum cases. CMC's approach was to review the manning schedule as originally prepared in prior studies. In 1994, CMC further optimized these manpower estimates by reviewing each department organizational chart and categorizing the number of employees as local hires or non-local hires.

The basis of this determination is CMC's mining experience and other mining operations. The analysis evaluated the various job functions within each department to determine a range of manpower and the entry level educational requirements that would be required. The following is a summary of this review.

Mine Department

The mine department consists of a broad range of work activities including mine operations personnel, supervision, and technical support. The manpower evaluation reviewed each mining function (i.e., stope drilling, stope mucking, development drilling, development mucking, crushing, supervision and support services, etc.) to assess the degree of mining experience required and their educational level. Entry level for mine operators will be high school equivalency. An in-house skills training program will be implemented to provide the necessary skills to these employees. Employees hired outside the study area will be predominantly employed in supervisory and mine technical support staff.

Mill Department

The manning requirements for the mill operations were determined by the different type of concentrating processes (i.e., grinding, flotation, filtration, loading, supervision, technical support, laboratory personnel, etc). Again, the evaluation assessed the functions of the job and experience or skills necessary to perform these jobs. The in-house skills training program will be developed in modules so that employees will learn one processing operation at a time. As knowledge and skills are advanced in the process, then the employee will be progressively advanced to learn other operations within the mill. Operators will be required to have a minimum of one year of high school. Employees hired outside the study area will be predominantly employed in supervisory and metallurgical technical support staff.

Maintenance Department

The manning requirements for the maintenance department have been established based on the needs of the mining/milling process. The type of experience and skills required to maintain both underground and surface milling equipment will require skills such as heavy duty mechanics, industrial electricians, millwrights, pipefitters, welders, supervisors, technical support, etc.

Support Departments

Support departments consist of accounting, senior administration, human resources, marketing and environment and safety. A large percentage of these employees require advance training and some experience in the mining industry.

By the nature of some job classifications or functions, it will be necessary for CMC to hire personnel outside the local area. However, CMC remains committed to hire and train approximately 70 percent of its work force from the local area.

Table 4.2.13-42a contains a summary of the analysis of manning requirements under a maximum and minimum case. Number of employees is broken out by department as depicted in Table 4.2.13-3 but split by local hires and non-local hires.

Table 4.2.13-42a

Local and Non-Local Project Employment

	Maximum Case			Minimum Case		
Department	Local Hires	Non-Local Hires	Total	Local Hires	Non-Local Hires	Total
Administration	1	9	10	1	8	9
Accounting/Warehousing	26	6	32	13	5	18
Maintenance	95	52	147	77	42	119
Mine	174	59	233	137	46	183
Mill	57	20	77	35	17	52
Human Resources	8	0	8	4	0	4
Environment/Safety	10	5	15	9	4	13
Marketing	2	2	4	2	2	4
Totals	373	153	526	278	124	402
Percent Local Hire	71%			69%		

Prepared by: KB
Checked by: RVS

To support the anticipated hiring rate from the local area, four other mining operations were studied. These facilities were constructed in the 1980s and 1990s and are typical operations that have multiple industry demography. Each of the facilities studied took the approach that improved efficiency of their operation depended on reducing turnover and absenteeism. By implementing skills training programs and encouraging local hire, these goals were achieved.

Case 1: McLaughlin Mine
Homestake Mining Company

The 6,000 ton per day mine is located on a 1,200-acre site in Northern California near Clear Lake. The operation is sited in three counties; partially in Napa County whose regional economy is based on the wine grape industry. The other counties are principally dominated by walnut farming and tourism.

Construction of the McLaughlin Mine commenced in the early 1980s and has a workforce of 350 employees. McLaughlin met their commitment to hire 60 percent of the construction and operation employees locally.

Case 2: East Kemptville Mine
Rio Algom Limited

East Kemptville Mine is located in a rural forested area approximately equidistant from the town of Yarmouth in Yarmouth Co. and the town of Shelburne in Shelburne Co., Nova Scotia, Canada. Fishing and forest industries are the largest employers in the region. The cotton mill was the largest industrial employer in the town of Yarmouth. The 10,000 ton per day mining operation occupied approximately 1,200 acres and was opened in 1985 and closed in 1992. Employment was predominantly drawn from three counties, Yarmouth, Digby, and Shelburne. Rio Algom Limited was committed to hire locally and to provide the necessary skills training. Employment was approximately 220 people for the operational period; of which 73 percent were from the local tri-county area.

Case 3: Troy Mine
Asarco Incorporated

The Troy Mine is located in the northwestern part of Montana in Lincoln County. The population in the area peaked in the 1960s during the construction of the Libby Dam. The largest sector of the economy is the manufacturing industry resulting from lumbering. The unemployment rate in the area prior to mine operations was approximately 15 percent. The Troy Mine, an 8,500 ton per day silver-copper mine, opened in 1981, and has been under temporary care and maintenance since mid-1996. Employment at the mine was about 350 people with 89 percent of their labor force from the local area.

Case 4: Flambeau Mining Company
Kennecott Corporation

The Flambeau Mine is located southwest of the City of Ladysmith in Rusk County, WI. Farming, forestry and quarrying of gravel are the predominant industries within the area. Flambeau was granted an operating permit in January 1991 and commenced mining in the second quarter of 1993. The Flambeau Mine is a 32-acre open pit operation which produces 1,300 tons per day. The total area of disturbance is approximately 182 acres. Employment at the mine is approximately 49 people with 84 percent of their labor force from the local area. In their local agreement, Flambeau committed to hiring 75 percent of their employees from the local area.

On the basis of the 1990 census of population, the following is a summary of the educational attainment for the tri-county area. This census is based on the number of persons 25 years and older.

Total Population	59,960
Total Population (>25 years of age)	40,694
Total Labor Force	27,339
Total Population with High School or above	30,033
% High School Graduates and above	73.8%[1]
% Bachelors or Associates Degree Graduates	14.1%

[1]Percentage of population with one or more years of high school is higher than this value.

One important consideration in estimating the percentage of local hires deals with labor force participation rates. The tri-county area has experienced a substantial increase in the percentage of persons age 16 and over participating in the labor force, particularly women. As shown in Table 4.2.13-42b, between 1980 and 1990 the labor force participation rate in the tri-county area increased 5.8 percent from 55.5 percent in 1980 to a rate of 58.7 percent in 1990. This is still substantially below the statewide average labor force participation rate of 67.6 percent. If the participation rate for the tri-county area increased to the state average, then the total available workers could increase by 4,145.

Table 4.2.13-42b

Labor Force Participation

	1980		1990	
	Labor Force	Participation Rate	Labor Force	Participation Rate
Forest County	3,273	48.9%	3,629	54.1%
Langlade County	8,161	55.3%	8,788	58.9%
Oneida County	13,756	57.5%	14,922	59.8%
Tri-County Area	25,190	55.5%	27,339	58.7%
State of Wisconsin	2,266,079	64.1%	2,522,025	67.6%

Source: Labor Market Planning Information, Wisconsin Job Service, 1993. Checked by: RVS

In part, the lower labor force participation rate for the tri-county area can be explained by the percentage of population 65 years and older. In 1990, the tri-county area included 11,093 persons age 65 and older (18.5 percent of the total population). Statewide the population age 65 and older is 13.3 percent. If it were assumed the tri-county area had the statewide average population over the age of 65, there would be 7,975 persons age 65 and older. This is 3,118 less than reside in the tri-county area now. Assuming that all of the 3,118 people 65 and over would not enter the labor force if additional employment opportunities were available and if the labor force participation rate for the remaining population age 16 and over increased to the statewide average, available workers in the tri-county area could increase by 1,027 (4,145 - 3,118).

In short, the labor force participation rate reflects personal preferences of individuals age 16 and greater. Limited career opportunities and job availability tends to lower labor force participation within the tri-county area as compared to the state as a whole.

CMC believes sufficient workers are in the study area to provide 70 percent local hires. Without solicitation, CMC already has approximately 150 applications on file from the local study area.

Maximum project related employment impacts are projected to occur in 1999. The number of construction, permanent worker, and indirect/induced jobs to be filled by study area residents is estimated to be 640 in 1999. To put this in perspective with the labor force participation rate, 640 jobs represents 1.4 percent of the tri-county population over the age of 16. In other words, if the labor force participation rate increases to 61.1 percent in the tri-county area, the labor force would increase by 640 workers.

Because the project will create a diverse array of job opportunities, some increase in the labor force participation rate is anticipated. Relatively high paying mining jobs, along with indirect/induced employment will encourage individuals to participate in the labor force that otherwise may not have.

The overall assumption that 70 percent of the permanent project work force will come from the study area can be further explained by analyzing the pool of study area unemployed workers and job upgrade opportunities created as a result of the project. The tri-county area has a labor force of 27,339 available workers based on 1990 data (Table 4.2.13-42b). With an assumed 4.5 percent unemployment rate, there are 1,230 workers actively seeking employment at any given time.

While not all of these available workers would be interested or qualified to work at the mine, job upgrades and job vacancies created by individuals leaving existing employment to work at the mine will create increased employment opportunities for the pool of unemployed workers.

The project is anticipated to create employment opportunities for 640 study area residents in the peak year of 1999. In addition to the 1,230 workers who are actively seeking employment, an increase in the labor participation rate could generate between 1,027 and 4,145 additional workers. In summary, it is anticipated that a sufficient number of workers are available in the study area to meet project needs as outlined above.

Annual middle scenario employment during the operations phase of the project is expected to average 464 persons. Table 4.2.13-42 contains the projections of total employment from construction, operations, and indirect sources in the study area under the middle impact scenario. During the operations phase, indirect employment is predicted at a level of about 80 percent of the direct project employment. For every ten direct jobs created at the plant by the project, there would be eight additional non-mine jobs created. Project related employment of over 1,100 employees in the final year of construction and total new employment of over 800 jobs during operations represents about 6 percent and about 4 percent, respectively, of the total projected study area baseline employment.

4.2.13.4.2.2 Tourism Impacts

Impacts on the local and regional tourism can be divided into the five following categories: 1) general business, 2) housing, 3) traffic, 4) crime, and 5) demand for water resources. The following discussion addresses each of these potential impacts.

The project may impact tourism related general businesses in the study area. A positive impact is anticipated for restaurants and other general service businesses that provide goods and services required by the project related population. Some congestion could be experienced at local convenience stores and eating establishments during peak hours of demand. Project related impacts to area casinos may occur as a result of an influx of workers with relatively high disposable income. Impacts to area casinos are anticipated to be positive. Overall general business impacts are anticipated to be minimal in consideration that project related population will represent a small percent of the overall population in the study area.

The project may impact tourism related housing such as hotels, motels, resorts, and seasonal housing units during the construction period. Housing demand by construction workers during the 3-year construction phase may impact tourism related housing by generating increased demand during off-season periods, which is a positive impact, while increasing demand during peak tourism periods, which could be viewed as a negative impact. Because the overall temporary housing impact represents only 2.7 percent of the study area housing supply in the highest impact month of the highest impact year (1999), it is anticipated that impact on tourism housing will be minimal.

The project may impact local and regional tourism through increased traffic. Section 4.2.2.1 provides an evaluation of transportation impacts to roads, airports, and railroads as a result of the project. While overall traffic impacts will be minimal, some traffic congestion can be anticipated during peak periods of tourism traffic where project related traffic is entering or leaving the site. High tourism traffic periods include Friday nights and holiday weekends.

There is a preception voiced by some that the project may impact local and regional tourism through increased crime. While there is no known information available that would suggest crime will increase as a result of the project, this is perceived as a potential tourism related impact. The fact that mining and tourism based economies exist elsewhere (e.g., Lead, South Dakota; Leadville, Colorado; Salt Lake City, Utah; and Ladysmith, Wisconsin) suggests that the project should not create a significant impact on tourism.

The project may impact tourism through increased demand on the use of water resources. Water resources such as lake and stream frontage are significant attractants for the local and regional tourism industry. The project may impact demand for water resources because part of the project related housing will demand stream and lake frontage.

During periods of peak tourism activity, it is estimated that the study area population doubles. Project related population impacts on boating, fishing, and other water resource activities could increase pressure on these limited resources. The propensity of project related population to use these resources is unknown, however, assuming that the propensity of the new in-migrants to use water resources is the same as the study area population as a whole, demand for study area water resources would only increase by 1.1 percent to 2.2 percent.

Construction, operation, and closure of the mine and related facilities is anticipated to have minimal impact on the local and regional tourism industry. Project related population will increase demand for certain goods and services offered by the tourism industry. Mine tours will likely draw tourists to the mine site.

Figure 3.14-2 identifies 19 tourism related facilities within a 5-mile radius of the mine site. Many of these facilities will likely experience increased business as a result of the project.

4.2.13.4.3 Housing Impact

The impact on study area housing is broken into two components. Because the housing needs of construction workers are significantly different than those of permanent operations workers, the housing impacts have been evaluated separately. For purposes of evaluating housing impacts each new in-migrant worker is assumed to demand one housing unit.

In-migrant construction workers are assumed to locate in the study area for a temporary period. For this reason housing demand is based on the number of lodging units, mobile homes, vacant permanent housing units, and seasonal housing units within each study area MCD. Construction workers are allocated to individual minor civil divisions based on a gravity allocation model as described in Section 4.2.13.4.1. Table 4.2.13-43 provides information on the geographic distribution of construction workers within the study area.

Only the middle scenario of construction worker housing impacts are shown on Table 4.2.13-43. The range from minimum to maximum scenario for the highest impact month of the highest impact year (1999) ranges from 379 to 488 construction workers. In general, the range from minimum to maximum scenario represents plus or minus 12.6 percent from the middle scenario.

Overall temporary housing impacts represent 2.7 percent of the study area housing supply in the highest impact month of the highest impact year (1999). It is important to note that baseline temporary housing has not been forecast. The impact comparison is based on 1990 census data on the number of lodging units, mobile homes, and seasonal housing units. The Town of Lincoln and Nashville are forecast to experience the largest demand for temporary housing. It is anticipated that a portion of the temporary housing supply could be augmented by conversion of second homes to primary residences during periods of high demand, and reconverted to second homes after demand has peaked.

While the results of our research conclude that temporary housing impacts will be relatively minor when spread over the study area hotels, motels, resorts and available seasonal housing units, there are several alternatives for mitigation. Construction workers will locate in the study area for a relatively short period of time and typically work extended hours. Their needs for housing are rather basic; a bed, wash facilities, and food. Most of the workers travel home on weekends. While the conclusion of our research indicates that the study area can support projected construction worker housing demand, it is possible that local entrepreneurs may develop more attractive housing alternatives.

Table 4.2.13-43

With Project - Temporary Worker Housing Impacts

	1997		1998		1999		2028		2029		2030	
	# of units	Percent of Baseline	# of units	Percent of Baseline	Number of Units	Percent of Baseline	Number of Units	Percent of Baseline	Number of units	Percent of Baseline	Number of units	Percent of Baseline
Forest County												
Argonne	1	1.1	2	1.5	2	1.9	1	0.5	<1	0.4	<1	0.1
Blackwell	1	0.9	1	1.3	1	1.6	<1	0.4	<1	0.4	<1	0.1
Caswell	1	1.0	1	1.4	2	1.7	<1	0.5	<1	0.4	<1	0.1
Crandon, City	10	5.2	14	7.2	18	9.1	5	2.5	4	2.1	1	0.6
Crandon, Town	8	4.2	11	5.8	14	7.4	4	2.0	3	1.7	1	0.5
Freedom	5	1.5	6	2.0	8	2.6	2	0.7	2	0.6	1	0.2
Hiles	5	0.9	7	1.2	9	1.6	2	0.4	2	0.4	1	0.1
Laona	5	1.7	7	2.4	8	3.0	2	0.8	2	0.7	1	0.2
Lincoln	35	5.3	48	7.3	61	9.3	17	2.6	14	2.2	4	0.6
Nashville	34	4.2	47	5.6	60	7.3	17	2.0	14	1.7	4	0.5
Popple River	1	0.7	1	1.0	1	1.2	<1	0.3	<1	0.3	<1	0.1
Ross	1	0.9	2	1.3	2	1.6	1	0.4	1	0.4	<1	0.1
Wabeno	4	1.0	5	1.4	6	1.8	2	0.5	1	0.4	<1	0.1
Langlade County												
Ackley	<1	0.7	<1	0.9	<1	1.2	<1	0.3	<1	0.3	<1	0.1
Ainsworth	11	2.9	16	4.0	20	5.1	6	1.4	5	1.2	1	0.4
Antigo, City	3	0.9	4	1.2	4	1.5	1	0.4	1	0.4	<1	0.1
Antigo, Town	<1	1.1	<1	1.6	1	2.0	<1	0.6	<1	0.5	<1	0.1
Elcho	17	1.8	23	2.4	29	3.1	8	0.9	7	0.7	2	0.2
Evergreen	1	0.9	1	1.2	1	1.5	<1	0.4	<1	0.4	<1	0.1
Langlade	2	1.6	3	2.3	4	2.9	1	0.8	1	0.7	<1	0.2
Neva	1	1.5	1	2.1	2	2.6	1	0.7	<1	0.6	<1	0.2
Norwood	<1	0.9	1	1.3	1	1.6	<1	0.4	<1	0.4	<1	0.1
Parrish	1	1.1	1	1.5	1	1.9	<1	0.5	<1	0.4	<1	0.1

Table 4.2.13-43, continued

	1997		1998		1999		2028		2029		2030	
	# of units	Percent of Baseline	# of units	Percent of Baseline	Number of Units	Percent of Baseline	Number of Units	Percent of Baseline	Number of units	Percent of Baseline	Number of units	Percent of Baseline
Peck	<1	0.9	1	1.3	1	1.6	<1	0.4	<1	0.4	<1	0.1
Polar	1	1.3	1	1.7	1	2.2	<1	0.6	<1	0.5	<1	0.2
Price	<1	1.2	<1	1.7	<1	2.2	<1	0.6	<1	0.5	<1	0.2
Rolling	1	0.7	1	1.0	1	1.2	<1	0.3	<1	0.3	<1	0.1
Upham	7	1.2	9	1.6	12	2.1	3	0.6	3	0.5	1	0.1
White Lake	<1	1.0	1	1.3	1	1.7	<1	0.5	<1	0.4	<1	0.1
Wolf River	5	1.0	7	1.4	9	1.8	3	0.5	2	0.4	1	0.1
Oneida County												
Crescent	4	0.9	5	1.2	6	1.5	2	0.4	1	0.3	<1	0.1
Enterprise	5	1.5	7	2.0	9	2.6	2	0.7	2	0.6	1	0.2
Lake Tomahawk	4	0.6	5	0.8	7	1.1	2	0.3	2	0.3	<1	0.1
Monico	1	1.8	2	2.5	3	3.2	1	0.9	1	0.7	<1	0.2
Newbold	8	0.6	11	0.9	15	1.1	4	0.3	3	0.3	1	0.1
Pelican	13	1.2	18	1.6	22	2.0	6	0.6	5	0.5	2	0.1
Piehl	1	1.4	1	1.9	1	2.4	<1	0.7	<1	0.6	<1	0.2
Pine Lake	5	0.9	7	1.2	9	1.5	2	0.4	2	0.4	1	0.1
Rhinelander	3	1.5	4	2.1	6	2.7	2	0.7	1	0.6	<1	0.2
Schoepke	10	2.0	14	2.6	18	3.5	5	1.0	4	0.8	1	0.2
Stella	2	1.1	2	1.5	3	1.9	1	0.5	1	0.4	<1	0.1
Sugar Camp	6	0.6	9	0.9	11	1.1	3	0.3	3	0.3	1	0.1
Three Lakes	23	1.0	32	1.4	40	1.8	11	0.5	9	0.4	3	0.1
Woodboro	2	0.7	3	1.0	4	1.2	1	0.3	1	0.3	<1	0.1
Study Area	**249**	**1.5**	**342**	**2.1**	**434**	**2.7**	**120**	**0.7**	**102**	**0.6**	**30**	**0.2**

Note: 1) Housing impacts for individual MCDs are rounded to the nearest whole number. The percent of baseline represents the impact on mobile homes, seasonal units, and lodging units from the 1990 census.

2) Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Source: Foth & Van Dyke Estimates.

Prepared by: RVS
Checked by: SFJ

Mobile home park development is one alternative which could appeal to construction workers locating in the study area temporarily. This type of development would need to be permitted by one or more of the local jurisdictions and would need to provide necessary services such as electric, sewer and water. While our research does not address the feasibility of this type of development, it is possible that existing baseline demand, in addition to project related demand may be sufficient to justify development of a mobile home park.

It is also possible that a local entrepreneur may develop apartment units near the project site. This type of development could provide room and board, food service, and other amenities which appeal to temporary construction workers.

It is not known if plans exist for any mobile home park or apartment development near the project site. If such a development is proposed, it would need to acquire all necessary permits. The extent to which these alternatives are used will determine the housing impact during the construction phase of the project.

Company sponsored temporary housing provided on or near the project site is one alternative. A "Construction Camp", as it is commonly called, is an alternative temporary housing arrangement commonly used when the local housing stock is not capable of absorbing project related housing demand. Typically, a contractor will be selected which has trailer type mobile apartment units. These units will be placed on or near the construction project in an area where bath and shower facilities, along with a cafeteria can be situated. While this arrangement can respond to the needs of a fairly large construction work force in a short period of time, the housing situation is less than desirable.

Campgrounds and recreational vehicle accommodations are temporary housing alternatives which will appeal to a small percentage of the construction work force during summer months. Most public camp grounds limit occupancy to no longer than fourteen consecutive days, however, many private camp grounds appeal to construction worker. They structure pricing which favors long term occupancy and provide amenities which appeal to construction workers staying for several months.

One temporary housing strategy used during the construction of the East Kemptville mine in Nova Scotia, Canada, used a somewhat innovative approach to solving temporary housing needs. The company hired a part time housing coordinator to solicit interest from private parties within commuting distance of the mine construction project. Private parties were asked if they had an interest in providing room and board services to one or more construction workers. The housing coordinator compiled a list of providers outlining services offered and the cost. When new construction workers arrived at the project they were given information on available housing and afforded the opportunity to negotiate directly with the service providers.

As a result of this temporary housing "brokering" service, several objectives were accomplished:

1. The mine company did not have to deal with problems associated with a construction camp.

2. Construction workers had a source of information on available housing options and could decide how much they want to spend and what amenities they wanted.

3. Many local residents had a revenue source which afforded them an opportunity to remodel their homes and generate additional income.

Operation (permanent) worker housing impacts are outlined on Table 4.2.13-44. Demand is forecast to begin in 1997 and increase steadily through 2000. Permanent worker housing demand remains relatively constant throughout the project life after full mine operation is forecast to begin.

Table 4.2.13-44 outlines middle scenario permanent worker housing impacts. The range from minimum to maximum scenario represents plus or minus 33 percent from the middle scenario for the maximum impact year (1999). Overall, permanent worker housing impacts represent 1.1 percent of the study area baseline housing in the highest impact year (1999). Figure 4.2.13-7 provides a graphic picture of permanent worker housing impacts.

While the results of our research conclude that project related impacts on permanent housing in the study area will be minimal, it is important to analyze how project related housing demand will affect specific segments of the permanent housing market (i.e., low priced verses high priced housing). In order to evaluate the capacity of project related in-migrants to afford housing, we utilize general housing affordability methodology. The following methodology was developed in conjunction with comments from Ann Ziebarth, Housing Policy Specialist with the University of Wisconsin Extension.

Assumptions:

Average CMC worker gross wage	= $34,500
Average Housing Expenditure	= 30%
Average Utility, Property Tax, and Housing Insurance Cost	= $4,000
Average Monthly Housing Payment	= 1% of Home Value

Based on assumptions stated above, the average CMC in-migrant worker could afford a $50-55,000 house. ($34,500 x 30% - $4,000)/12 months x 100 = $52,900) The next step in the evaluation of permanent housing impacts is to evaluate average new home construction as well as average residential home sale prices in the study area.

While there is no single source for housing value statistics in the study area, we have compiled available information as follows:

The Northwoods Association of Realtors provided information on 1994 residential home sales:

1994 Forest County

Average Home Sale on Waterfront	= $84,642
Average Home Sale off Water	= $33,835

This information is based on statistics provided by participating realtors representing approximately 200 home sales.

Table 4.2.13-44

With Project - Permanent Worker Housing Impacts[1]

Minor Civil Division	1997	1998	1999	2000	2010	2020	2030	2035
Forest County								
Argonne Number	<1	<1	1	1	1	1	0	0
% of Baseline	0.1	0.2	0.5	0.6	0.5	0.5	0.0	0.0
Blackwell Number	<1	<1	<1	<1	<1	<1	0	0
% of Baseline	0.1	0.2	0.4	0.4	0.3	0.2	0.0	0.0
Caswell Number	<1	<1	<1	<1	<1	<1	0	0
% of Baseline	0.2	0.4	0.7	0.8	0.7	0.7	0.0	0.0
Crandon, City Number	7	12	28	35	36	37	1	0
% of Baseline	0.9	1.4	3.2	4.0	3.8	3.6	0.1	0.0
Crandon, Town Number	1	2	5	8	8	8	<1	0
% of Baseline	0.4	0.7	2.2	3.3	3.0	2.8	0.1	0.0
Freedom Number	<1	<1	1	1	1	1	0	0
% of Baseline	0.1	0.1	0.5	0.7	0.7	0.7	0.0	0.0
Hiles Number	<1	<1	<1	1	1	1	0	0
% of Baseline	0.1	0.1	0.3	0.4	0.4	0.4	0.0	0.0
Laona Number	2	3	6	7	7	7	0	0
% of Baseline	0.3	0.5	1.1	1.2	1.1	1.1	0.0	0.0
Lincoln Number	1	2	7	13	13	13	<1	0
% of Baseline	0.4	0.7	2.7	4.7	4.2	3.7	0.1	0.0
Nashville Number	1	2	8	13	13	13	<1	0
% of Baseline	0.3	0.5	1.9	3.1	2.8	2.4	0.1	0.0
Popple River Number	<1	<1	<1	<1	<1	<1	0	0
% of Baseline	0.3	0.6	1.0	0.8	0.8	0.8	0.0	0.0
Ross Number	<1	<1	<1	<1	<1	<1	0	0
% of Baseline	0.1	0.1	0.3	0.4	0.4	0.4	0.0	0.0
Wabeno Number	1	2	4	3	3	4	0	0
% of Baseline	0.3	0.5	0.8	0.8	0.8	0.8	0.0	0.0

Table 4.2.13-44, continued

Minor Civil Division	1997	1998	1999	2000	2010	2020	2030	2035
Forest County Number	15	24	61	82	84	86	2	1
% of Baseline	0.4	0.6	1.6	2.1	2.0	1.9	0.1	<0.1
Langlade County								
Ackley Number	<1	<1	1	1	1	1	0	0
% of Baseline	0.1	0.2	0.4	0.3	0.3	0.3	0.0	0.0
Ainsworth Number	<1	1	2	4	4	4	0	0
% of Baseline	0.2	0.3	1.1	1.9	1.8	1.8	0.0	0.0
Antigo, City Number	19	32	48	34	35	38	2	0
% of Baseline	0.5	0.9	1.3	0.9	0.9	1.0	0.1	0.0
Antigo, Town Number	2	4	6	5	5	5	0	0
% of Baseline	0.4	0.7	1.0	0.8	0.8	0.8	0.0	0.0
Elcho Number	1	2	5	6	6	7	0	0
% of Baseline	0.2	0.4	0.9	1.1	1.1	1.1	0.0	0.0
Evergreen Number	<1	<1	1	1	1	1	0	0
% of Baseline	0.1	0.1	1.3	0.3	0.3	0.3	0.0	0.0
Langlade Number	<1	<1	1	2	2	2	0	0
% of Baseline	0.1	0.2	0.5	0.8	0.8	0.8	0.0	0.0
Neva Number	1	1	2	2	2	2	0	0
% of Baseline	0.1	0.2	0.5	0.6	0.6	0.6	0.0	0.0
Norwood Number	<1	<1	1	1	1	1	0	0
% of Baseline	0.1	0.1	0.3	0.4	0.4	0.4	0.0	0.0
Parrish Number	0	<1	<1	<1	<1	<1	0	0
% of Baseline	0.0	0.1	0.3	0.5	0.5	0.5	0.0	0.0
Peck Number	0	<1	<1	1	1	1	0	0
% of Baseline	0.0	0.1	0.2	0.4	0.4	0.3	0.0	0.0
Polar Number	<1	1	2	2	2	2	0	0
% of Baseline	0.1	0.2	0.4	0.5	0.5	0.5	0.0	0.0
Price Number	1	1	1	1	1	1	<1	0
% of Baseline	0.5	0.9	1.5	1.2	1.2	1.2	0.1	0.0

Table 4.2.13-44, continued

Minor Civil Division		1997	1998	1999	2000	2010	2020	2030	2035
Rolling	Number	1	1	2	2	2	2	0	0
	% of Baseline	0.1	0.2	0.3	0.3	0.3	0.3	0.0	0.0
Upham	Number	<1	<1	1	2	2	2	0	0
	% of Baseline	0.1	0.1	0.3	0.5	0.5	0.5	0.0	0.0
White Lake	Number	1	2	3	3	3	3	<1	0
	% of Baseline	0.7	1.2	2.0	1.9	2.0	2.1	0.1	0.0
Wolf River	Number	<1	1	1	1	1	1	0	0
	% of Baseline	0.1	0.2	0.3	0.3	0.2	0.3	0.0	0.0
Langlade County	Number	27	46	77	66	68	72	3	1
	% of Baseline	0.3	0.5	0.9	0.7	0.7	0.8	<0.1	<0.1
Oneida County									
Crescent	Number	0	<1	1	2	2	2	0	0
	% of Baseline	0.0	0.1	0.2	0.3	0.3	0.2	0.0	0.0
Enterprise	Number	<1	<1	1	1	1	1	0	0
	% of Baseline	0.1	0.2	0.5	0.8	0.8	0.7	0.0	0.0
Lake Tomahawk	Number	<1	<1	1	1	1	1	0	0
	% of Baseline	0.1	0.1	0.2	0.2	0.2	0.2	0.0	0.0
Monico	Number	<1	<1	1	1	2	2	0	0
	% of Baseline	0.2	0.4	0.9	1.1	1.1	1.0	0.0	0.0
Newbold	Number	0	1	2	2	2	2	0	0
	% of Baseline	0.0	0.1	0.2	0.2	0.2	0.2	0.0	0.0
Pelican	Number	2	4	8	9	9	9	0	0
	% of Baseline	0.2	0.3	0.5	0.6	0.5	0.5	0.0	0.0
Piehl	Number	<1	<1	<1	<1	<1	<1	0	0
	% of Baseline	0.1	0.2	0.5	0.8	0.7	0.7	0.0	0.0
Pine Lake	Number	1	1	3	4	4	4	0	0
	% of Baseline	0.1	0.1	0.2	0.3	0.3	0.3	0.0	0.0
Rhinelander	Number	31	54	81	56	58	63	3	1
	% of Baseline	0.9	1.6	2.4	1.7	1.6	1.7	0.1	<0.1

Table 4.2.13-44, continued

Minor Civil Division	1997	1998	1999	2000	2010	2020	2030	2035
Schoepke Number	<1	1	2	3	3	3	0	0
% of Baseline	0.2	0.3	0.9	1.3	1.2	1.2	0.0	0.0
Stella Number	0	<1	1	1	1	1	0	0
% of Baseline	0.0	0.1	0.2	0.4	0.3	0.3	0.0	0.0
Sugar Camp Number	<1	1	2	2	2	2	0	0
% of Baseline	0.1	0.1	0.2	0.3	0.2	0.2	0.0	0.0
Three Lakes Number	2	4	7	7	7	7	0	0
% of Baseline	0.2	0.3	0.6	0.6	0.6	0.5	0.0	0.0
Woodboro Number	0	0	<1	1	1	1	0	0
% of Baseline	0.0	0.0	0.1	0.2	0.2	0.2	0.0	0.0
Oneida County Number	39	67	108	89	92	98	4	1
% of Baseline	0.3	0.4	0.7	0.6	0.5	0.5	<0.1	<0.1
Study Area Number	80	138	246	237	244	256	10	2
% of Baseline	0.4	0.6	1.1	1.0	1.0	1.0	<0.1	<0.1

Note: 1) Percent of baseline represents the impact on total year-round housing units.

2) Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Source: Foth & Van Dyke Estimates.

[1] Example use of table - Argonne - in 1997 less than one new home would be required as a result of the mine for a net increase of 0.1% to the number of homes in the town.

Prepared by: RVS
Checked by: SFJ

1994 Oneida County

Average Home Sale on Waterfront	=	$124,172
Average Home Sale off Water	=	$ 61,557

This information is based on statistics provided by participating realtors representing approximately 610 home sales.

In addition, the 1993 Oneida County Planning and Zoning Department Annual Report indicated "The average cost stated on building permits for a one family home constructed during 1993 was approximately $79,500 and an average of 1,255 square feet in size. Of these homes reported, 52 percent were on water and a total of 76 percent were year-round."

In summary, project related in-migrant workers will create demand for a range of housing from low cost to relatively high cost. Two family wage earners, and CMC employees earning above average pay may be demand higher cost housing while other direct and indirect project related employees, including service industry employees, may demand lower cost housing. While waterfront homes may appeal to some families, many of the new in-migrants could choose to locate elsewhere based on housing cost and other locational factors. We conclude that project related housing demand will be spread over a range of housing values.

Because temporary and permanent worker housing impacts are forecast to peak in the year 1999, it is important to view the impacts cumulatively. Temporary worker housing impacts are most acute near the project site. Location is more important than typical housing amenities for temporary workers. Permanent workers make housing decisions based on long term issues. Other family members are also affected by their housing location decision.

In summary, 1999 temporary housing impacts are forecast to be most acute in Forest County, while the majority of permanent workers are forecast to seek housing in Oneida County. Langlade county is forecast to experience a baseline housing shortage in the year 2030. Permanent workers are forecast to demand an additional three housing units in Langlade County during the 2030 period of housing shortage. The overall result is forecast to be an opportunity for study area residential housing contractors to supply new housing units.

4.2.13.4.4 Government Structure and Public Finance

The jurisdictions directly affected by the project, including the Towns of Lincoln and Nashville and Forest County, have existing committees to oversee and plan for mining-related activities and have established planning and zoning ordinances. Local Agreements, as provided by Chapter 144.839 of Wisconsin Statutes, will be implemented with the Towns of Lincoln and Nashville, the City of Crandon and Forest County. This section contains estimates of Net Proceeds Tax collections that will be associated with the project; estimates of distributions to be made from the Mining Investment and Local Impact Fund (MILIF); estimates of project impacts on local government expenditures, property values and property tax rates; and estimated impacts on study area school district expenditures and property values.

4.2.13.4.4.1 Net Proceeds Tax

As discussed in Section 3.14.3.4.1, a net proceeds tax (NPT) is imposed by the State of Wisconsin on metalliferous mining operations and is to be used to compensate local governments for mining-related planning that occurs and for mitigation of any impacts that arise due to mining activities. Net proceeds tax collections are also used to partially fund the Badger Fund, a trust fund from which the interest is to be used equally to fund recreation and education in Wisconsin. The Badger Fund received its first money in 1995 from the Flambeau Mine net proceeds tax payments to the state. In 1996, legislation was passed to transfer the principal balance of the Badger Fund to the general fund. The 1996 legislation did not change the framework of the Badger Fund.

Net proceeds tax collections in any given year are a function of current NPT tax rates (as adjusted for inflation), levels of production during the year, minerals prices, and the costs of production. Tax rate structures and definitions pertaining to each of the elements of the NPT are contained in Chapter 70.375 of Wisconsin Statutes. Although CMC believes that the statutes provide for a deduction of federal and state income taxes for net proceeds tax calculation, no deduction for these taxes was taken in preparing the net proceeds tax estimates, as there is some disagreement about their deductibility.

Table 4.2.13-45 reports estimates of NPT payments from the proposed project under different mineral price and labor cost assumptions. Net proceeds tax payments will be smallest when mineral prices are low (smaller revenues) and labor costs are high (larger deductible expenses). Conversely, NPT collections will be highest when mineral prices are high and labor costs are low. Table 4.2.13-45 shows estimated net proceeds tax payments given expected base level mineral prices for the minerals anticipated to be extracted by the proposed project and lower and higher deviations from this base level. All prices are stated in 1994 dollars and are held constant over the analysis period. Three different levels of permanent project work force were used to develop Table 4.2.13-45: Minimum Labor, 402 workers and Maximum Labor, 526 workers, along with five levels of mineral prices.

The first two columns of Table 4.2.13-45 show expected NPT collections when minerals prices are lower than anticipated base level mineral prices and labor costs are at their maximum. Column 3 of the table shows anticipated NPT payments under base mineral prices and the middle work force configuration. The last two columns of the table report anticipated NPT payments when mineral prices are higher than base levels and the minimum project work force is employed. All payment amounts are shown in constant 1994 dollars and reflect the $100,000 construction period payments that will be made separately to the Towns of Lincoln and Nashville and Forest County. The years shown in Table 4.2.13-45 represent the year in which the NPT will be paid.

The NPT payments under the alternative scenarios range from a low of $29.9 million over the life of the project to a high of $233.4 million. If mineral prices follow base levels in 1994, over the life of the project and if the middle range employment configuration (426 permanent workers) is used in the operation of the mine, approximately $119.1 million would be generated in net proceeds taxes. As discussed in the next section, the distribution of NPT payments over time is important in determining annual payments made from the MILIF to local governments. In general, large NPT payments are generated under all conditions during years that the zinc ore is being extracted. Net proceeds tax payments decrease during years that the copper ore is extracted, and may reach zero in years with relative low mineral prices and/or high labor costs.

Table 4.2.13-45

Estimated Net Proceeds Tax Payments Under Different Mineral Price and Labor Cost Assumptions (in 1994 U.S. $, 000)

Year	80 Percent of Base Maximum Labor	90 Percent of Base Maximum Labor	Base Prices Middle Labor	110 Percent of Base Minimum Labor	120 Percent of Base Minimum Labor
1997	300	300	300	300	300
1998	0	0	0	0	0
1999	0	0	0	0	0
2000	0	0	0	0	0
2001	0	0	347	1,404	3,094
2002	0	145	1,754	5,143	7,948
2003	154	1,702	5,395	8,927	12,043
2004	606	3,024	6,525	10,057	13,173
2005	738	3,556	7,088	10,620	13,736
2006	860	3,615	7,147	10,679	13,796
2007	1,248	4,034	7,566	11,098	14,214
2008	2,236	5,250	8,782	12,314	15,430
2009	3,503	6,619	10,151	13,683	16,800
2010	3,564	6,681	10,213	13,745	16,861
2011	3,578	6,694	10,226	13,758	16,874
2012	3,510	6,626	10,158	13,690	16,806
2013	3,272	6,375	9,907	13,439	16,555
2014	2,999	6,082	9,614	13,146	16,262
2015	3,009	6,093	9,625	13,157	16,273
2016	285	1,531	3,865	6,411	8,541
2017	0	0	22	519	1,223
2018	0	0	0	422	1,084
2019	0	0	0	388	1,036
2020	0	0	0	246	832
2021	0	0	0	303	914
2022	0	0	48	581	1,311
2023	0	0	48	581	1,311
2024	0	0	49	583	1,314

Table 4.2.13-45, continued

Year	80 Percent of Base Maximum Labor	90 Percent of Base Maximum Labor	Base Prices Middle Labor	110 Percent of Base Minimum Labor	120 Percent of Base Minimum Labor
2025	0	0	65	621	1,368
2026	0	0	116	744	1,558
2027	0	0	128	783	1,609
2028	0	0	0	461	1,141
Total	29,862	68,327	119,139	177,803	233,407

Source: Crandon Mining Company Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

The estimated NPT payments reported in Table 4.2.13-45 are based on several assumptions in addition to the mineral prices reported in Table 4.2.13-6. It is assumed, for example, that approximately 2.0 million tons of ore will be milled each year after the initial start of production. Production costs, including transportation costs, are assumed to be those specified by the mining engineering firm of Pincock, Allen & Holt. Lastly, the NPT payments reported in Table 4.2.13-45 assume that federal and state income taxes are not deductible for NPT purposes. As stated earlier, discussions are currently taking place concerning the appropriateness of this assumption. If federal and state income taxes are deductible for NPT purposes, the total NPT payments would be approximately 20 percent lower than those reported in Table 4.2.13-45.

4.2.13.4.4.2 Mining Investment and Local Impact Fund Distributions

Net proceeds taxes collected each year by the Department of Revenue are distributed in that same year to either the MILIF or to the Badger Fund, a trust fund from which the interest is used equally to fund a state endowment fund used to support education and recreation in Wisconsin. The legislature has not designated a use for the principal amount of the fund. In years that NPT collections exceed the amount necessary to fully fund "first dollar" payments to eligible local governments and Native American communities, 60 percent of NPT collections are distributed to the MILIF and 40 percent to the Badger Fund. In years that the NPT collection is not sufficient to fully fund first dollar payments, all NPT collections are distributed to the MILIF.

Funds received by the MILIF in one year are distributed to eligible local governments and Native American communities in the following year. Allocation rates and conditions for first dollar payments, additional county payments, and reserve fund allocations and disbursements are discussed in detail in Section 3.14.3.4.2. For purposes of understanding contributions to and distributions from the MILIF it is important to note that net proceeds taxes are not paid until the year following the generation of the net proceeds from operation and that disbursements from the MILIF are not made until the year following payment of the NPT in January.

Table 4.2.13-46 shows years in which construction period payments or NPT payments would be made under the case with base minerals prices in effect and the middle labor force configuration used to operate the mine. Under this scenario the project would generate approximately $119.1 million dollars in net proceeds taxes over the life of the project.[1] As shown in Table 4.2.13-46, the Towns of Lincoln and Nashville would each receive approximately $4.0 million over the life of the project, starting with construction period payments in 1997 and the rest being received over the 2002-2028 period. The Forest County Potawatomi and Sokaogon Chippewa Native American Communities would each receive approximately $2.4 million under this scenario.

Forest County would receive approximately $2.5 million in construction period and first dollar payments and approximately $5.5 million in additional county payments.

The project reserve fund would have $8.6 million remaining after augmented first dollar payments have been made to Lincoln and Nashville. As specified in Chapter 70.395(2)(d)4. of Wisconsin Statutes, this can be used to reimburse Lincoln and/or Nashville for costs associated

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[1]It should be noted that the initial $300,000 in construction period payments are not strictly considered as net proceeds tax payments. While separate from NPT calculations, they do serve as credits against NPT liabilities in later years and, thus, can be considered as part of the NPT stream associated with the project.

Table 4.2.13-46

Net Proceeds Tax Distribution for Base Minerals Prices and Middle Labor Force Configuration Scenario (in 1994 U.S. $, 000)

	Construction Period/First Dollar Payments									
Year	Construction Period/NPT Payments	Town of Lincoln	Town of Nashville	Forest County Potawatomi	Sokaogon Chippewa	Forest County	Additional County Payment	Reserve Fund Contributions	Discretionary MILIF Grants	Badger Fund Contributions
1997	300.0	100.0	100.0	---	---	100.0	---	---	---	---
1998	---	---	---	---	---	---	---	---	---	---
1999	---	---	---	---	---	---	---	---	---	---
2000	---	---	---	---	---	---	---	---	---	---
2001	347.0	---	---	---	---	---	---	---	---	---
2002	1,754.0	69.4	69.4	69.4	69.4	69.4	---	---	---	---
2003	5,395.0	147.6	147.6	147.6	147.6	147.6	314.4	---	---	701.6
2004	6,525.0	147.6	147.6	147.6	147.6	147.6	369.1	539.5	1,590.4	2,158.0
2005	7,088.0	147.6	147.6	147.6	147.6	147.6	369.1	652.5	2,155.4	2,610.0
2006	7,147.0	147.6	147.6	147.6	147.6	147.6	369.1	708.8	2,436.9	2,835.2
2007	7,566.0	147.6	147.6	147.6	147.6	147.6	369.1	714.7	2,466.4	2,858.8
2008	8,782.0	147.6	147.6	147.6	147.6	147.6	369.1	756.6	2,675.9	3,026.4
2009	10,151.0	147.6	147.6	147.6	147.6	147.6	369.1	878.2	3,283.9	3,512.8
2010	10,213.0	147.6	147.6	147.6	147.6	147.6	369.1	1,015.1	3,968.4	4,060.4
2011	10,226.0	147.6	147.6	147.6	147.6	147.6	369.1	1,021.3	3,999.4	4,085.2
2012	10,158.0	147.6	147.6	147.6	147.6	147.6	369.1	1,022.6	4,005.9	4,090.4
2013	9,907.0	147.6	147.6	147.6	147.6	147.6	369.1	1,015.8	3,971.9	4,063.2

Table 4.2.13-46, continued

Construction Period/First Dollar Payments										
Year	Construction Period/NPT Payments	Town of Lincoln	Town of Nashville	Forest County Potawatomi	Sokaogon Chippewa	Forest County	Additional County Payment	Reserve Fund Contributions	Discretionary MILIF Grants	Badger Fund Contributions
2014	9,614.0	147.6	147.6	147.6	147.6	147.6	369.1	990.7	3,846.4	3,962.8
2015	9,625.0	147.6	147.6	147.6	147.6	147.6	369.1	961.4	3,699.9	3,845.6
2016	3,865.0	147.6	147.6	147.6	147.6	147.6	369.1	962.5	3,705.4	3,850.0
2017	22.0	147.6	147.6	147.6	147.6	147.6	369.1	386.5	825.4	1,546.0
2018	---	147.6	147.6	4.4	4.4	4.4	---	-286.4	---	---
2019	---	147.6	147.6	---	---	---	---	-295.2	---	---
2020	---	147.6	147.6	---	---	---	---	-295.2	---	---
2021	---	147.6	147.6	---	---	---	---	-295.2	---	---
2022	48.0	147.6	147.6	---	---	---	---	-295.2	---	---
2023	48.0	147.6	147.6	9.6	9.6	9.6	---	-276.0	---	---
2024	49.0	147.6	147.6	9.6	9.6	9.6	---	-276.0	---	---
2025	65.0	147.6	147.6	9.8	9.8	9.8	---	-275.6	---	---
2026	116.0	147.6	147.6	13.0	13.0	13.0	---	-269.2	---	---
2027	128.0	147.6	147.6	23.2	23.2	23.2	---	-248.8	---	---
2028	---	147.6	147.6	25.6	25.6	25.6	---	-244.0	---	---
Total	119,139.0	4,007.0	4,007.0	2,378.6	2,378.6	2,478.6	5,481.8	8,569.4	42,631.6	47,206.4

Source: Foth & Van Dyke Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

with the cessation of mining operations or with reclamation expenses. An additional $42.6 million will be available for discretionary MILIF grants. As discussed in Section 3.14.3.4.2 these grants can be awarded by the MILIF to local governments and school districts to mitigate impacts that are attributable to mining operations, permanent or temporary closure, and reclamation.

Net proceeds tax payments and distributions from the MILIF are not affected significantly by the labor force configuration used to operate the mine. As shown in Table 4.2.13-47 payments received by various local governments and Native American communities vary only slightly under different permanent worker configurations.

Table 4.2.13-48 suggests that net proceeds tax collections will be lowest when mineral prices are low relative to base prices and when the larger project permanent work force is employed. Table 4.2.13-48 shows the distribution of NPT payments under these conditions. Distributions to local governments and Native American communities are reduced under these conditions but it is apparent that the project reserve fund, MILIF discretionary grants and the Badger Fund absorb most of the decrease that occurs when overall NPT collections are low. It appears that those local governments most affected by the proposed project are reasonably well protected against swings in overall NPT collections.

Table 4.2.13-47

Net Proceed Tax Payments and Distributions From the Mining Investment and Local Impact Fund Under Different Project Labor Force Scenarios: Base Minerals Prices (in 1994 U.S. $, 000)

	Minimum Labor	Middle Labor	Maximum Labor
Net Proceeds Tax/Construction Period Payments	126,257	119,139	112,414
Town of Lincoln	4,185	4,007	3,978
Town of Nashville	4,185	4,007	3,978
Forest County Potawatomi	2,566	2,379	2,270
Sokaogon Chippewa Community	2,566	2,379	2,270
Forest County	8,203	7,960	7,635
Project Reserve Fund	9,332	8,569	7,828
Discretionary MILIF Grants	45,542	42,632	39,721
Badger Fund	49,678	47,206	44,734

Source: Foth & Van Dyke Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-48

Net Proceed Tax Payments and Distributions From the Mining Investment and Local Impact Fund Under Different Mineral Price Scenarios: Maximum Labor (in 1994 U.S. $, 000)

	80 Percent of Base Minerals Prices	90 Percent of Base Minerals Prices	Base Minerals Prices
Net Proceeds Tax/Construction Period Payments	29,862	68,327	112,414
Town of Lincoln	3,216	3,819	3,978
Town of Nashville	3,216	3,819	3,978
Forest County Potawatomi	1,833	2,095	2,270
Sokaogon Chippewa Community	1,833	2,095	2,270
Forest County	4,896	7,088	7,635
Project Reserve Fund	0	3,218	7,828
Discretionary MILIF Grants	3,979	19,039	39,721
Badger Fund	10,890	27,153	44,734

Source: Foth & Van Dyke Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

4.2.13.4.4.3 Impact on Local Government Expenditures

The impact of the proposed project on local government expenditures will in most cases result from increased project-induced population or manufacturing growth that occurs. The project is not expected to place any direct requirements for public services such as fire protection or security upon local governments in the area.

The fiscal impact models used for baseline (without project) forecasts as described in Section 4.2.13.3.4.1 were used to forecast with-project fiscal conditions. The with-project simulations were driven by estimated increases in each jurisdiction's population or manufacturing activity. The relatively small new population increases expected with the project are not expected to change the basic level of services provided by any local government in the study area. As noted in Section 4.2.13.4.5, Public Facilities and Services, no additional infrastructure projects are anticipated in any jurisdiction due to construction and operation of the project. Thus, no direct capital costs were added to the basic with-project fiscal forecasts.

Tables 4.2.13-49, 4.2.13-50 and 4.2.13-51 show expected fiscal conditions in Forest, Langlade and Oneida Counties respectively under base mineral price and middle permanent labor force conditions. "Impacts" are reported as increases or decreases in reference to the baseline forecast. All dollar amounts are stated in constant 1994 dollars. The "percent" (percent) column of each table represents the percentage increase or decrease that the estimated with-project impact is of the forecast baseline level.

Table 4.2.13-49 reports estimated expenditure impacts for affected local governments in Forest County. As expected, the largest increases in local government expenditures occur in the Towns of Lincoln and Nashville and the City of Crandon. These three places are expected to receive the bulk of new migrants to the study area due to the project. It appears that expenditures may rise approximately 5 percent above the levels that would exist without the project. It also appears that the Town of Crandon will experience a relative increase in its expenditures due to the project, but the absolute change will remain small. Expenditures by Forest County government will rise by approximately 2 to 3 percent during peak years of mine operation.

Table 4.2.13-50 reports estimated expenditure impacts for affected local governments in Langlade County. Total expenditures in the City of Antigo may rise by approximately $130,000 a year during peak operation years, but this represents a relatively small increase for the city in comparison to its expected baseline expenditures. Expenditures in the Towns of Ainsworth and Elcho and the Village of White Lake may rise moderately due to new workers moving to their communities. Langlade County government expenditures are expected to be only slightly higher than baseline due to the project.

Table 4.2.13-51 reports estimated expenditure impacts for affected local governments in Oneida County. Expenditures in the City of Rhinelander may increase by approximately $267,000 a year over baseline levels during peak operation years, an increase of approximately 2 to 3 percent over baseline conditions. Impacts in most other jurisdictions in the county are expected to be minimal due to the project. Annual expenditures by Oneida County government may increase by approximately $130,000 during peak operation years.

4.2.13.4.4.4 Impact on Local Government Property Values and Property Tax Rates

Impacts of the project on local property values can be observed at two different levels: the impacts to the individual property parcels, or impacts to entire taxing jurisdictions. At the individual parcel level, it is possible that permanent homes located in close proximity to the project will experience increases in value as demand for housing in the study area increases due to the project. This would be especially true for homes located on nearby lakes, including Rolling Stone, Crane, Pickerel and Ground Hemlock.

It is probable that changes in individual property values will be difficult to detect. Analysis conducted on a large landfill site in southeastern Wisconsin, for example, concluded that properties located adjacent to the site were no different than comparable properties elsewhere in the study area in terms of property value changes over time (Valuation Research Corporation, 1994). Other features of the local economy, such as population growth, development patterns, etc., will most likely have more influence on individual property values than the project.

Table 4.2.13-49

Forest County
Project Impacts on Total Annual Expenditures, Equalized Value and Property Tax Rates for Study Area Jurisdictions, 1997-2036: Middle Scenario

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
					Total Annual Expenditures (1000 $ 1994)							
Argonne, Town	1	0.5	1	0.5	1	0.5	1	0.5	0	0.0	0	0.0
Blackwell, Town	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Caswell, Town	1	1.4	0	0.0	1	1.2	1	1.2	0	0.0	0	0.0
Crandon, City	14	1.3	48	4.4	57	5.0	60	5.1	12	1.0	5	0.4
Crandon, Town	3	2.0	6	4.1	7	4.8	6	4.1	1	0.7	0	0.0
Freedom, Town	2	1.4	2	1.4	2	1.3	1	0.7	1	0.7	0	0.0
Hiles, Town	4	1.7	2	0.8	2	0.9	2	0.9	1	0.5	0	0.0
Laona, Town	3	0.9	5	1.4	6	1.7	6	1.8	1	0.3	0	0.0
Lincoln, Town	17	5.9	17	5.7	17	5.3	17	5.1	2	0.7	0	0.0
Nashville, Town	17	4.2	17	4.0	17	3.7	17	3.5	2	0.5	0	0.0
Popple River, Town	1	1.8	1	1.8	1	1.7	1	1.6	0	0.0	0	0.0
Ross, Town	0	0.0	0	0.0	0	0.0	1	1.7	0	0.0	0	0.0
Wabeno, Town	3	0.9	4	1.2	4	1.3	4	1.4	0	0.0	0	0.0
Forest County	91	1.7	145	2.5	149	2.5	152	2.6	12	0.2	1	0.0

Table 4.2.13-49, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
					Total Equalized Value (1000 $ 1994)							
Argonne, Town	38	0.4	56	0.6	55	0.5	75	0.7	0	0.0	0	0.0
Blackwell, Town	7	0.2	7	0.2	7	0.2	7	0.2	0	0.0	0	0.0
Caswell, Town	32	0.9	31	0.9	32	0.8	32	0.8	0	0.0	0	0.0
Crandon, City	544	1.6	1,786	5.1	1,838	5.0	1,889	5.1	69	0.2	18	0.1
Crandon, Town	247	2.1	516	4.4	539	4.6	538	4.7	45	0.4	0	0.0
Freedom, Town	291	1.6	175	1.0	175	0.9	175	0.9	58	0.3	0	0.0
Hiles, Town	546	1.6	218	0.7	218	0.7	218	0.7	109	0.4	0	0.0
Laona, Town	251	0.8	478	1.5	478	1.6	501	1.6	46	0.2	0	0.0
Lincoln, Town	2,461	5.4	105,952	226.1	84,604	165.0	63,391	118.1	9,872	19.0	1,148	2.3
Nashville, Town	1,892	3.7	2,147	4.0	1,735	2.9	1,489	2.4	76	0.1	-1,049	-1.8
Popple River, Town	66	2.2	66	2.2	66	2.0	66	2.0	0	0.0	0	0.0
Ross, Town	23	0.6	24	0.7	23	0.7	23	0.8	0	0.0	0	0.0
Wabeno, Town	178	0.9	223	1.1	223	1.2	244	1.4	0	0.0	10	0.1
Forest County	6,576	2.3	111,679	38.2	89,994	30.1	68,648	22.6	10,274	3.5	127	0.0
					Property Tax Rate (Dollars per $1000 Equalized Value)							
Argonne, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Blackwell, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Caswell, Town	0.00	0.0	0.01	0.4	0.01	0.3	0.00	0.0	-0.01	-0.3	0.06	1.9
Crandon, City	0.10	1.7	0.35	5.7	0.51	7.4	0.53	7.2	0.29	3.9	0.13	1.8
Crandon, Town	0.13	5.9	0.12	5.2	0.03	1.3	0.02	0.8	-0.12	-5.1	0.16	6.9

Table 4.2.13-49, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
Freedom, Town	0.01	0.4	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.3
Hiles, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Laona, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Lincoln, Town	-1.97	-100.0	-1.34	-67.0	-2.08	-100.0	-2.12	-100.0	-0.32	-15.3	-0.06	-2.9
Nashville, Town	-1.82	-63.9	0.03	1.0	-2.19	-72.8	-2.07	-67.6	0.18	5.9	0.05	1.7
Popple River, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Ross, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Wabeno, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Forest County	-0.36	-11.2	-1.05	-24.3	-1.95	-45.3	-0.12	-3.4	0.44	12.6	0.59	16.5

Source: Foth & Van Dyke Estimates, January 1995.

Prepared by: JRH
Checked by: RVS

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Table 4.2.13-50

Langlade County
Project Impacts on Total Annual Expenditures, Equalized Value and Property Tax Rates for Study Area Jurisdictions, 1997-2036: Middle Scenario

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
					Total Annual Expenditures (1000s $ 1994)							
Ackley, Town	0	0.0	0	0.0	1	0.8	0	0.0	0	0.0	0	0.0
Ainsworth, Town	4	2.0	5	2.5	10	5.1	5	2.6	0	0.0	0	0.0
Antigo, City	70	0.7	119	1.1	122	1.2	133	1.3	7	0.1	0	0.0
Antigo, Town	1	0.6	1	0.6	2	1.2	2	1.2	0	0.0	0	0.0
Elcho, Town	8	2.1	7	1.8	7	1.8	7	1.8	1	0.3	0	0.0
Evergreen, Town	0	0.0	1	0.8	1	0.7	1	0.7	0	0.0	0	0.0
Langlade, Town	1	1.1	1	1.1	1	1.1	1	1.1	0	0.0	0	0.0
Neva, Town	0	0.0	1	0.6	1	0.6	1	0.6	0	0.0	0	0.0
Norwood, Town	0	0.0	0	0.0	1	0.4	1	0.4	0	0.0	0	0.0
Parrish, Town	1	4.8	0	0.0	0	0.0	1	4.8	0	0.0	0	0.0
Peck, Town	0	0.0	0	0.0	1	0.9	0	0.0	0	0.0	0	0.0
Polar, Town	1	0.7	1	0.7	1	0.7	1	0.7	0	0.0	0	0.0
Price, Town	1	0.7	3	2.0	2	1.3	2	1.3	0	0.0	0	0.0
Rolling, Town	1	0.3	1	0.3	1	0.3	1	0.3	0	0.0	0	0.0
Upham, Town	2	1.2	1	0.6	1	0.6	1	0.6	0	0.0	0	0.0
White Lake, Village	2	1.0	5	2.6	5	2.7	5	2.7	0	0.0	0	0.0
Wolf River, Town	2	0.8	1	0.4	1	0.4	1	0.4	0	0.0	0	0.0

Table 4.2.13-50, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
Langlade County	64	0.6	95	0.9	98	0.9	104	1.0	2	0.0	0	0.0
					Total Equalized Value (1000s $ 1994)							
Ackley, Town	30	0.2	60	0.4	61	0.4	60	0.4	0	0.0	0	0.0
Ainsworth, Town	476	2.5	516	2.6	1,033	5.2	517	2.7	40	0.2	0	0.0
Antigo, City	1,060	0.6	1,816	1.1	1,870	1.1	2,050	1.3	108	0.1	0	0.0
Antigo, Town	240	0.5	481	1.0	481	1.0	515	1.2	35	0.1	0	0.0
Elcho, Town	1,122	1.9	1,016	1.7	1,015	1.7	1,069	1.8	160	0.3	0	0.0
Evergreen, Town	18	0.2	37	0.4	37	0.4	37	0.4	0	0.0	0	0.0
Langlade, Town	111	0.7	186	1.1	187	1.1	186	1.1	0	0.0	0	0.0
Neva, Town	85	0.3	198	0.7	198	0.7	199	0.7	0	0.0	0	0.0
Norwood, Town	0	0.0	50	0.2	50	0.2	50	0.2	0	0.0	0	0.0
Parrish, Town	33	1.2	34	1.2	34	1.2	33	1.2	0	0.0	0	0.0
Peck, Town	0	0.0	50	0.5	49	0.5	50	0.5	0	0.0	0	0.0
Polar, Town	48	0.2	142	0.6	142	0.6	141	0.6	0	0.0	0	0.0
Price, Town	74	0.7	148	1.5	148	1.4	148	1.5	0	0.0	0	0.0
Rolling, Town	77	0.2	128	0.3	129	0.3	128	0.3	0	0.0	0	0.0
Upham, Town	499	1.2	312	0.7	311	0.7	312	0.7	62	0.1	0	0.0
White Lake, Village	46	0.8	125	2.2	124	2.3	125	2.4	0	0.0	0	0.0
Wolf River, Town	238	0.7	119	0.4	119	0.3	118	0.3	39	0.1	0	0.0
Langlade County	4,157	0.7	5,418	1.0	5,988	1.0	5,738	1.0	444	0.1	0	0.0

Table 4.2.13-50, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
	Property Tax Rate (Dollars per $1000 Equalized Value)											
Ackley, Town	0.96	195.9	-1.09	-64.9	0.01	1.5	0.01	1.5	0.00	0.0	0.06	9.8
Ainsworth, Town	0.07	1.8	0.06	1.5	0.09	2.3	0.08	2.1	0.01	0.3	0.04	1.1
Antigo, City	0.13	0.9	0.22	1.5	0.22	1.5	0.26	1.8	0.02	0.1	0.00	0.0
Antigo, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	-0.01	-1.4	0.04	5.6
Elcho, Town	0.01	2.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	3.4
Evergreen, Town	0.01	1.0	0.02	1.8	0.02	1.5	0.02	1.3	0.00	0.0	0.24	20.9
Langlade, Town	0.01	11.1	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.03	18.8
Neva, Town	0.00	0.0	0.01	0.7	0.01	0.7	0.01	0.6	-0.01	-0.7	0.08	5.7
Norwood, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.11	7.3
Parrish, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
Peck, Town	0.00	0.0	0.01	0.5	-0.01	-0.4	-0.01	-0.4	-0.01	-0.4	0.14	6.2
Polar, Town	0.00	0.0	0.01	2.4	0.00	0.0	-0.01	1.7	-0.01	-2.0	0.09	25.0
Price, Town	0.01	0.2	0.02	0.3	0.02	0.3	0.02	0.3	0.00	0.0	0.06	1.0
Rolling, Town	0.00	0.0	0.01	1.3	0.25	28.4	0.25	28.4	0.23	28.0	0.36	43.9
Upham, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.7
White Lake, Village	0.13	3.9	0.31	5.9	-0.03	-0.5	0.00	0.0	-0.27	-4.7	0.50	9.0
Wolf River, Town	0.01	0.7	0.00	0.0	0.01	0.7	0.00	0.0	0.00	0.0	0.02	1.4
Langlade County	-0.06	-1.1	0.01	0.2	-0.00	-0.1	0.00	0.0	-0.01	-0.2	-0.01	-0.2

Source: Foth & Van Dyke Estimates, January 1995.
Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-51

Oneida County
Project Impacts on Total Annual Expenditures, Equalized Value and Property Tax Rates for Study Area Jurisdictions, 1997-2036: Middle Scenario

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
					Total Annual Expenditures (1000s $ 1994)							
Crescent, Town	1	0.3	1	0.3	1	0.3	1	0.3	0	0.0	0	0.0
Enterprise, Town	1	1.4	1	1.4	1	1.6	1	1.7	0	0.0	0	0.0
Lake Tomahawk, Town	1	0.3	1	0.3	1	0.3	1	0.3	0	0.0	0	0.0
Monico, Town	1	0.8	1	0.8	2	1.8	2	1.9	0	0.0	0	0.0
Newbold, Town	2	0.3	2	0.3	1	0.2	1	0.2	0	0.0	0	0.0
Pelican, Town	3	0.6	4	0.8	4	0.8	4	0.8	1	0.2	0	0.0
Piehl, Town	1	1.3	1	1.3	1	1.2	1	1.3	0	0.0	0	0.0
Pine Lake, Town	3	0.2	6	0.4	6	0.5	6	0.5	0	0.0	0	0.0
Rhinelander, City	136	1.3	238	2.2	245	2.5	267	2.9	14	0.2	2	0.0
Schoepke, Town	6	3.3	4	2.2	4	2.3	4	2.4	0	0.0	0	0.0
Stella, Town	0	0.0	1	0.8	1	0.8	1	0.8	0	0.0	0	0.0
Sugar Camp, Town	3	0.5	2	0.3	2	0.3	2	0.3	0	0.0	0	0.0
Three Lakes, Town	19	1.3	13	0.9	13	0.8	14	0.9	3	0.2	0	0.0
Woodboro, Town	1	0.8	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Oneida County	90	0.6	119	0.8	122	0.8	131	0.9	11	0.1	1	0.0

Table 4.2.13-51, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
						Total Equalized Value (1000s $ 1994)						
Crescent, Town	206	0.3	288	0.4	288	0.4	288	0.4	41	0.1	0	0.0
Enterprise, Town	378	1.8	228	1.1	227	1.2	228	1.3	76	0.5	0	0.0
Lake Tomahawk, Town	194	0.3	194	0.3	193	0.3	194	0.3	0	0.0	0	0.0
Monico, Town	45	0.7	90	1.4	113	1.9	113	2.1	0	0.0	0	0.0
Newbold, Town	483	0.4	375	0.3	375	0.3	376	0.3	53	0.0	0	0.0
Pelican, Town	588	0.6	804	0.8	835	0.9	865	0.9	92	0.1	1	0.0
Piehl, Town	34	1.3	34	1.3	34	1.2	33	1.2	0	0.0	0	0.0
Pine Lake, Town	240	0.3	377	0.4	377	0.4	377	0.5	34	0.0	0	0.0
Rhinelander, City	2,967	1.2	5,170	2.1	5,324	2.3	5,816	2.7	306	0.2	61	0.0
Schoepke, Town	867	2.8	631	2.0	630	2.1	631	2.3	78	0.3	0	0.0
Stella, Town	74	0.3	111	0.5	111	0.5	111	0.5	0	0.0	0	0.0
Sugar Camp, Town	457	0.5	327	0.3	327	0.3	327	0.3	66	0.1	0	0.0
Three Lakes, Town	3,249	1.3	2,163	0.8	2,269	0.9	2,380	0.9	431	0.2	0	0.0
Woodboro, Town	100	0.3	100	0.2	99	0.2	99	0.2	0	0.0	0	0.0
Oneida County	9,882	0.5	10,892	0.6	11,202	0.6	11,838	0.6	1,177	0.1	62	0.0
						Property Tax Rate (Dollars per $1000 Equalized Value)						
Crescent, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	0.8
Enterprise, Town	-0.01	-1.1	0.00	0.0	0.00	0.0	0.00	0.0	0.01	1.1	0.01	1.1
Lake Tomahawk, Town	0.01	0.2	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.2
Monico, Town	0.03	0.9	0.08	2.3	0.15	5.5	-0.03	-1.4	-0.10	-5.2	0.13	7.9

Table 4.2.13-51, continued

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
Newbold, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	0.8
Pelican, Town	0.01	0.5	0.00	0.0	0.00	0.0	0.00	0.0	-0.01	-0.5	0.07	3.3
Piehl, Town	0.09	1.2	0.09	1.2	0.07	0.9	0.08	1.1	-0.01	-0.1	-0.02	-0.3
Pine Lake, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.06	1.6
Rhinelander, City	0.06	0.5	0.12	1.0	0.14	1.2	0.15	1.3	-0.10	-0.9	0.26	2.3
Schoepke, Town	0.02	0.6	0.02	0.6	0.01	0.3	0.02	0.7	0.01	0.3	0.01	0.3
Stella, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.02	1.6
Sugar Camp, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	14.3
Three Lakes, Town	0.01	0.3	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	0.3
Woodboro, Town	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.01	1.7
Oneida County	0.00	0.1	0.01	0.2	0.01	0.2	0.01	0.3	0.00	0.0	0.00	0.0

Source: Foth & Van Dyke Estimates, January 1995.

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: JRH
Checked by: RVS

At the jurisdiction level, equalized property value will increase in the study area for two primary reasons. Property value in the Towns of Lincoln and Nashville and Forest County will increase due to construction of the mining facility. Estimated project equalized values are described in Section 4.2.13.2.3. In 2031 the project is expected to sell to private owners approximately two million dollars of land adjacent to the former mine site in the Town of Nashville. This sale or transfer of ownership will not affect the overall tax base of either the Town of Nashville or Forest County. Equalized property value in the Towns of Lincoln and Nashville are reduced after closure of the project to reflect the reduced mineral value of the land. In addition to the direct equalized value of the project, all jurisdictions are anticipated to experience an increase in equalized value as new housing is constructed or as commercial and manufacturing activities expand.

Table 4.2.13-49 reports expected impacts to equalized property values and property tax rates for local governments in Forest County. The largest gain in property value occurs in the Town of Lincoln. Equalized property value here will increase over two times due to construction of the mine facility. The Town of Nashville will also experience an increase in its property value because of the project, but the increase here will be much smaller than that experienced in the Town of Lincoln. The project represents a large increase to the overall tax base of Forest County.

Increased tax base in the Towns of Lincoln and Nashville would give local officials the opportunity to decrease property tax rates. For example, in the Town of Lincoln, the property tax rate for town services could be reduced to zero for all residents in the town while a surplus of approximately $847,000 would still be generated over the life of the project due to net proceeds tax revenues. Residents in the Town of Nashville could see a reduction in their town property tax rate of approximately $2 per $1,000 of equalized value during peak years of operation. This would represent a reduction of approximately 60 to 70 percent over the rates levied by the town that would be expected without the project. Property tax rates for Forest County government could also decrease over most years of project operation. This is especially true during years that the county receives first dollar and additional county payments from the MILIF. It should be noted that the estimates reported in Table 4.2.13-49 do not include the contribution of the half-cent sales tax that the county enacted effective April 1, 1995. It has been estimated that this county sales tax could raise an additional $232,000 in 1995 (Stauber, 1994).

Most local governments affected by the project will experience an "expenditure-revenue gap" to some degree. While local government budgets are "balanced" each year, on average it is probable that spending increases will precede revenue increases in years that the local population or economic base grows. New residents, for example, will demand services in the current year, while the property value associated with these residents may not be reflected on the property tax roll until the following year. Taxes on the higher value are not collected until the year following its inclusion on the property tax roll. The expenditure-revenue gap problem is common and is not unlike that found in rural communities experiencing large project developments (Murdock and Leistritz, 1979).

The "gap" problem especially exists for local governments directly affected by the project. Local government expenditures will begin to increase during early stages of the project's construction. These expenditures will be partially offset by increasing local property values and the MILIF construction period payment during the first year of construction. As discussed in Section 4.2.13.4.4.1, however, MILIF first dollar payments are not received by eligible local

governments until at least two years after mining operations begin. This lag in the first dollar receipts contributes to the expenditure-revenue gap experienced by local governments directly affected by the project.

Property tax rates are expected to rise in the City of Crandon and the Town of Crandon as a result of project related expenditures without identified revenue sources to offset these expenditures. In the former case this appears to be a problem in early and middle years of project operation and the latter case the problem seems to be greatest during construction and early operations of the project.

Table 4.2.13-50 reports property value impacts and property tax rate impacts for local governments in Langlade County. The City of Antigo and the Towns of Ainsworth and Elcho are predicted to experience the largest increases in equalized property values. Tax rate changes throughout the county are expected to be small in comparison to without-project levels.

Table 4.2.13-51 reports property value impacts and property tax rate impacts for local governments in Oneida County. The City of Rhinelander is expected to experience an increase in its tax base of approximately $5 million during peak years of project operation. The tax base of the county could increase by approximately $11 million over this same period. Tax rate changes throughout the county are expected to be small in comparison to without-project levels.

4.2.13.4.4.5 Impact on School District Expenditures and Property Values

As discussed in Section 4.2.13.3.4.3, forecasting the impact of the proposed project on the fiscal conditions of study area school districts is made difficult by the many changes that have occurred, or are occurring to public education finance policy in the state. Most notable among these changes is the possible continuation of "revenue caps" for school districts and the ultimate means by which Wisconsin Act 437 is implemented and funded.

Two impacts of the proposed project on study area school districts have been estimated, however. These include estimated impacts on overall school district spending and estimated impacts on school district equalized value, or tax base. In the case of school district spending, project impacts were estimated by simulating the impact on school district costs of adding project-related children to the various school districts in the study area. Anticipated project-related enrollment increases are discussed in Section 4.2.13.4.5.1. Project impacts to school district equalized values were estimated by summing the projected with-project equalized values of the underlying jurisdictions for each school district. The summation process is identical to that used for the baseline forecast, as discussed in Section 4.2.13.3.4.3. The equalized values reported in Tables 4.2.13-49, 4.2.13-50 and 4.2.13-51 are the values used to determine with-project school district equalized values.

As shown in Table 4.2.13.22, public school enrollments in all study area school districts are forecast to decrease over the forecast period under baseline conditions. The expected decrease in public school enrollments throughout the entire study area is approximately 3,300 students. Peak additions to public school enrollments due to the project range from 106 additional students (1999) under Minimum Scenario conditions to 249 additional students (2014) under Maximum Scenario conditions. Since capacity will become increasingly available as enrollments decrease over time, it appears that the additional students associated with the project will not cause construction of new public school facilities.

Three school districts in the study area will likely experience the greatest increase in enrollments due to the project. The Rhinelander, Crandon and Antigo school districts are expected to serve from 82 to 85 percent of the new students that will be locate in the study area due to the project.

Table 4.2.13-52 reports projected impacts of the proposed project on study area school districts under Middle Scenario conditions. This scenario adds 164 new students to study area enrollments in the peak year of 2020. As expected, the greatest impact on school district spending will occur in the Rhinelander, Crandon and Antigo school districts. Total annual expenditures in the Rhinelander school district will increase from $283,000 - $313,000 per year during mine operations years in comparison to without-project expenditures, representing a 1.4-2.2 percent increase. Annual expenditures in the Crandon and Antigo school districts will increase approximately $198,000-$248,000 per year over the same time period. The expenditure impacts in the Crandon school district will represent a 3.2 to 3.8 percent increase in spending in this district over without-project levels. It is important to note that school districts adversely impacted by the proposed project are eligible for discretionary MILIF grants.

Increased housing and commercial/industrial development in the various underlying jurisdictions throughout the study area will increase the property tax base available to school districts. Table 4.2.13-52 also reports the estimated impacts of the proposed project on school district equalized values over the life of the project. Property value will go up in all school districts in the study area due to the project, with the greatest increases occurring in the Antigo, Crandon, Elcho, Rhinelander, Three Lakes and Wabeno school districts.

The clear beneficiary from the proposed project in terms of new tax base is the Crandon school district. This district contains the entire project site. Total equalized value in the Crandon school district is projected to increase by over $110 million in the year 2000, the first year of project operation. This increase represents an increase of over 57 percent in comparison to the projected level of equalized value without the project.

Although it is impossible to predict the impact of school district spending and value increases on property tax rates, it is possible to examine the impact of the project on equalized value per pupil. Equalized value per pupil in the Crandon school district is shown in Table 4.2.13-53 for Baseline and Middle Scenario conditions. The project is projected to increase the value-per-pupil ratio in the district by over $92,000 at its peak in 2000. This ratio remains high through the operations years of the project. If the school district were to tax value within the district at approximately $16.70 per thousand as it has in recent years, the new value would allow increased expenditures for each student of from $890-$1,549 over the operations years of the project. These increased expenditures could occur without raising the projected equalized property tax rate to residents within the district.

In interpreting this school district analysis, it is important to remember the difficulty that surrounds forecasting of Wisconsin school district fiscal conditions at the moment.

Table 4.2.13-52

Project Impacts on Total Annual Expenditures and Equalized Values For Study Area School Districts, 1997-2036: Middle Scenario

	1997		2000		2010		2020		2030		2036	
	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent	Impact	Percent
						Total Annual Expenditures (1000s $1994)[1]						
Antigo	93	0.5	198	1.1	203	1.3	215	1.5	12	0.1	0	0.0
Crandon	40	0.6	212	3.2	231	3.5	248	3.8	6	0.1	0	0.0
Elcho	12	0.4	64	2.4	64	2.9	64	3.1	0	0.0	0	0.0
Laona	7	0.3	35	1.4	35	1.4	34	1.4	0	0.0	0	0.0
Rhinelander	130	0.6	283	1.4	289	1.9	313	2.2	18	0.1	0	0.0
Three Lakes	14	0.2	53	1.0	52	1.2	52	1.3	0	0.0	0	0.0
Wabeno	6	0.2	18	0.5	18	0.5	18	0.5	0	0.0	0	0.0
White Lake	8	0.4	21	1.2	20	1.4	18	1.4	0	0.0	0	0.0
						Total Equalized Value (1000s $1994)[2]						
Antigo	2,046	0.5	3,785	0.9	3,854	0.9	4,119	1.0	174	0.0	0	0.0
Crandon	5,748	3.1	110,997	57.8	89,323	43.8	67,943	32.3	10,166	5.0	121	0.1
Elcho	3,262	1.9	2,408	1.4	2,925	1.7	2,542	1.5	415	0.3	0	0.0
Laona	372	0.9	599	1.5	599	1.5	621	1.5	45	0.1	0	0.0
Rhinelander	4,849	0.6	7,358	0.9	7,576	1.0	8,073	1.1	628	0.1	58	0.0
Three Lakes	3,875	1.1	2,651	0.7	2,780	0.7	2,890	0.8	515	0.2	0	0.0
Wabeno	1,416	0.9	1,573	1.1	1,572	1.1	1,710	1.3	60	0.0	0	0.0
White Lake	445	0.7	358	0.5	358	0.5	358	0.5	62	0.1	0	0.0

Source: Foth & Van Dyke Estimates, January 1995.
[1]Includes Sokaogon Chippewa Community and Forest County Potawatomi students enrolled in study area public schools.
[2]Does not include Sokaogon Chippewa Community or Forest County.

Prepared by: JRH
Checked by: RVS

Table 4.2.13-53

Projected Impacts of Project on Per Pupil Equalized Value in the Crandon School District ($ 1994)

	1997	2000	2010	2020	2030	2036
Equalized Value per Pupil						
Middle Scenario	184,079	273,381	264,433	253,323	223,251	228,836
Baseline	179,815	180,622	191,847	200,006	212,861	228,695
Increase in Value per Pupil	4,263	92,758	72,586	53,318	10,389	141
Additional Revenue per Pupil at School Tax Rate of 0.01670	71	1,549	1,212	890	174	2

Source: Foth & Van Dyke Estimates, January 1995.

Note: Includes Sokaogon Chippewa Community and Forest County Potawatomi students enrolled in study area public schools.

Prepared by: JRH
Checked by: RVS

4.2.13.4.4.6 Other Public Revenue Impacts

It is important to note that the proposed project will affect public revenues in ways other than those described above. For example, Table 4.2.13-53a shows the state and county sales taxes that would be generated by the labor payments made directly to project workers. Assuming that all temporary workers hired from outside the state spend one-half of their disposable income outside of Wisconsin (e.g., send money to family living outside of the state) and permanent workers spend all of their disposable income in Wisconsin, state and county sales taxes would increase $3.2 to $4.2 million over the life of the project, not including the long-term care period. During operations years, the payroll of permanent workers would generate between $109,000 and $143,000 in state and county sales taxes each year. This estimate does not include sales taxes likely to be paid directly by the project for purchases of non-labor goods and services.

State income taxes would also increase due to the project. State income taxes paid by workers directly employed by CMC or its contractors would increase by $22 to $28 million over the life of the project. During operations years, this would equate to an increase in state income taxes of approximately $686,000 to $899,000 per year. State income taxes paid directly by CMC would range between $7 to $65 million over the life of the project, depending on mineral prices and costs of production. State income taxes under base minerals prices and the maximum scenario project work force would equal approximately $31 million over the life of the project. State income taxes paid directly as a result of CMC operations with base minerals prices and the minimum work force would equal approximately $37 million over the project's life.

Table 4.2.13-53a

Projected Impacts on Other Public Revenues (In 1994 $, 000s)

	Gross Payroll	Disposable Income Available for Spending in Local Study Area	Purchases Subject to State and County Sales Tax	State Sales Tax Collections (at 5.0%)	County Sales Tax Collections (at 0.5%)
Total for Years 1997 - 2030					
Temporary Workers	41,348	14,265	2,996	150	15
Permanent Workers					
Minimum Workforce	384,188	265,090	55,669	2,783	278
Middle Workforce	443,464	305,990	64,258	3,213	321
Maximum Workforce	502,740	346,891	72,847	3,642	364
Typical Operations Year (2000 - 2027)					
Permanent Workers					
Minimum Workforce	13,721	9,467	1,988	99	10
Middle Workforce	15,854	10,939	2,297	115	11
Maximum Workforce	17,987	12,411	2,606	130	13

Source: Foth & Van Dyke Estimates, December 1994.

Prepared by: JRH
Checked by: JWS

4.2.13.4.5 Public Facilities and Services

This section provides additional discussion of public facility and service requirements and certain nonmonetary effects of the project. The costs associated with the new public facilities and services identified here would be above and beyond baseline forecast costs shown in Section 4.2.13.3.

4.2.13.4.5.1 School District Enrollment

Estimates of school district enrollment impacts are based on two significant assumptions. Public school enrollment is assumed to be 90.6 percent of total school age children (age 5-19). This assumption is based on 1993/94 study area public verses private school enrollment. The second significant assumption is that each permanent worker will bring an average of .7 school age children to the study area. This assumption is based on 1990 U.S. census information on all employed persons as it relates to the number of school age children (age 5-19) in their family. Based on the assumptions outlined above, it is possible to estimate school district enrollment impacts for minor civil divisions within the study area. School district impacts are allocated to minor civil divisions based on gravity allocation as outlined in Section 4.2.13.4.1, Population Impacts.

Most school district boundaries follow township boundaries, however, not all school district boundaries follow township boundaries exactly. Based on review of township and school district boundaries, it was possible to assess school district impacts with a high degree of confidence in the allocation. Table 4.2.13-54 provides a summary of school district enrollment impacts. Total school district enrollment impacts are forecast to be more than 150 students when the mine is operational. The Rhinelander area school district is forecast to receive the majority of school district enrollment impacts, while the project is forecast to have the highest percentage impact on the Crandon school district.

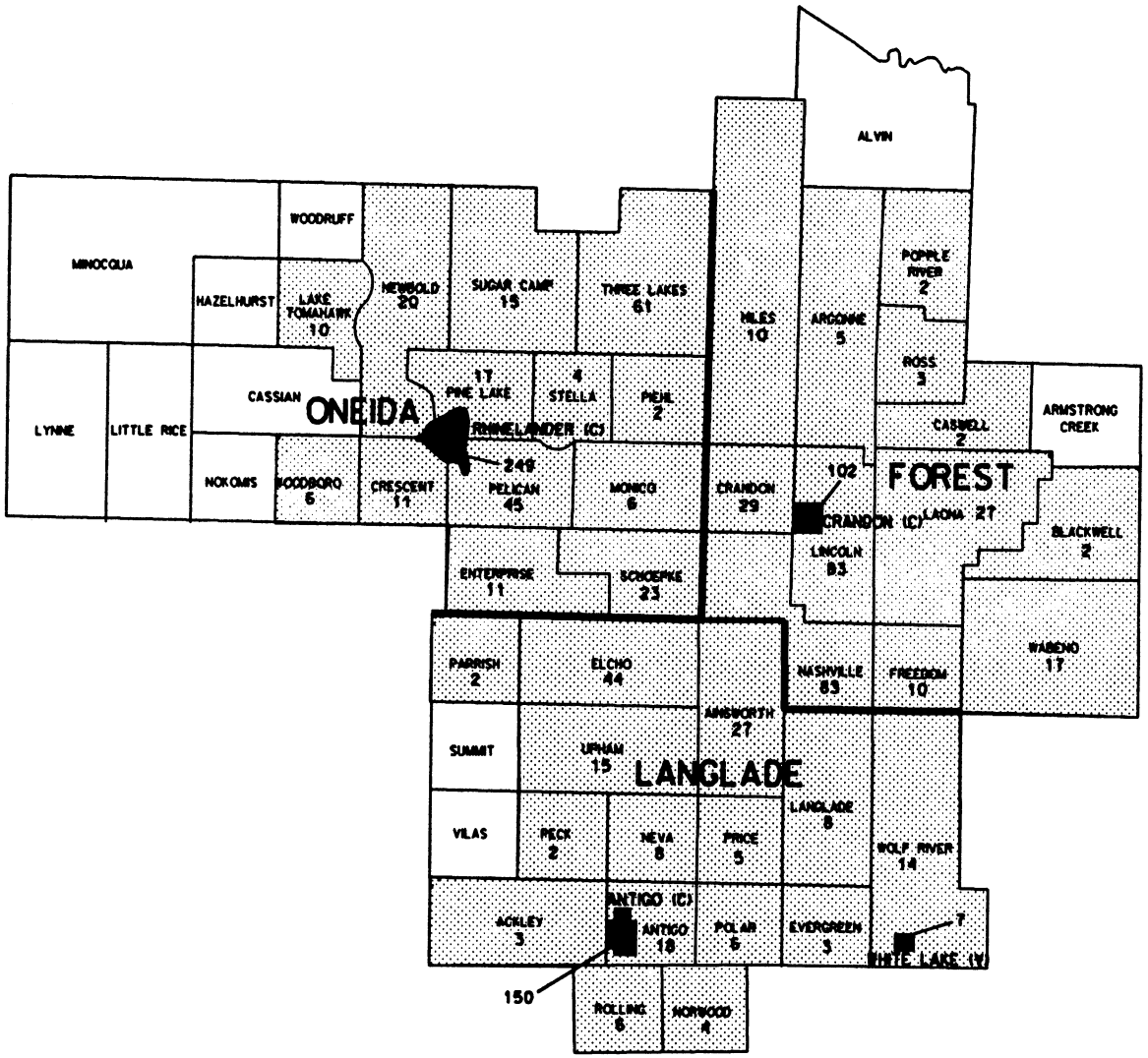
Overall school district enrollment impacts are forecast to be minor in relationship to baseline enrollment trends. Figure 4.2.13-8 shows that total study area school district enrollment is forecast to decline over the next 40 years. While project impacts will offset this decline, the impact is too small to be of significance.

4.2.13.4.5.2 Water and Sanitation

One of the significant public facility and service categories is water and sanitation. The availability of these services is a key determinant in residential development patterns.

Municipal Water Systems

Based on current per capita pumping rates, and system operations, the water supply systems identified in Section 3.14 (Table 3.14-31) will have sufficient capacity to accommodate the anticipated community population growth associated with the project.



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY: JKSI			DATE: AUG. '96
APPROVED BY: RVS			DATE: AUG. '96
APPROVED BY: GWS			DATE: AUG. '96

Crandon Mining Company

FIGURE 4.2.13-6A

PROJECTED MAXIMUM YEAR (1999) POPULATION INCREASE (WITH PROJECT)

Scale:	NOT TO SCALE	Date:	AUGUST, 1996
Prepared By:	Foth & Van Dyke	By:	JOW

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Table 4.2.13-54

With Project - School District Enrollment Impacts

School District		1997	1998	1999	2000	2010	2020	2030	2035
Antigo	Number	15	26	41	32	33	35	2	0
	% of Baseline	0.5	0.8	1.3	1.0	1.3	1.5	0.1	0.0
Crandon	Number	7	12	32	45	46	47	1	0
	% of Baseline	0.7	1.1	3.0	4.2	4.3	4.4	0.1	0.0
Elcho	Number	2	3	7	10	10	10	<1	0
	% of Baseline	0.4	0.6	1.7	2.4	3.0	3.3	0.1	0.0
Laona	Number	1	2	5	5	5	5	<1	0
	% of Baseline	0.4	0.6	1.3	1.4	1.4	1.5	0.1	0.0
Rhinelander	Number	22	39	61	48	49	53	3	0
	% of Baseline	0.7	1.2	1.8	1.4	1.9	2.3	0.1	0.0
Three Lakes	Number	2	3	6	7	7	7	<1	0
	% of Baseline	0.3	0.4	0.8	0.9	1.1	1.3	0.1	0.0
Wabeno	Number	1	2	3	3	3	3	0	0
	% of Baseline	0.2	0.3	0.5	0.5	0.5	0.6	0.0	0.0
White Lake	Number	1	2	3	3	3	3	<1	0
	% of Baseline	0.3	0.6	1.1	1.1	1.3	1.5	0.1	0.0
Study Area	Number	51	88	158	152	156	164	6	1
	% of Baseline	0.5	0.9	1.6	1.5	1.9	2.1	0.1	<0.1

Source: Foth & Van Dyke Estimates, January 1995.
Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: RVS
Checked by: SFJ

Municipal Wastewater Treatment

Construction of the plant could impact municipal sewage treatment systems in two ways. The most important impact would be the increased population. Population increases in the study area would change the loadings to the current municipal sewage treatment facilities. The population impact forecasts are used as reasonable representations of sewer service area populations and potential treatment plant loadings.

Secondarily, sanitary sewage from the construction crews might be treated in local wastewater treatment plants (e.g., Crandon). The maximum amount of undigested sanitary waste which would require disposal would be about 3,000 gallons per week (from 600 employees). Should the City of Crandon be unable to accept the wastes, it would have to be taken elsewhere.

Periodic disposal of waste activated sludge would be required once the on-site sanitary sewage treatment plant is in operation. The sludge would contain inorganic materials, highly inert organic solids, and volatile solids. Disposal at a wastewater treatment plant is not considered acceptable because of the highly inert nature of the sludge. Procedures in Chapter NR 204, Wis. Admin. Code, guide sludge disposal (landspreading), and if followed, there would be acceptable impacts to the environment.

To evaluate the impact the mine project will have on area wastewater treatment facilities, peak population estimates (baseline projection with project scenario) were used to predict future wastewater loadings at the area wastewater facilities. Current (1993) per capita wastewater flows were multiplied by the total peak population estimated for each municipal wastewater plant. As shown in Table 4.2.13-55, all plants, except for Wabeno, which is currently at capacity, should have sufficient treatment capacity based on these projections.

4.2.13.4.5.3 Solid Waste Management

Refuse at the mine site would be collected and hauled to a state approved landfill for disposal. An estimated 4,500 cubic yards of refuse would need to be disposed of at an off-site landfill during the construction period. In addition, 900 cubic yards of refuse per year will be generated during the 28-year operation phase. Closure will generate an additional 4,700 cubic yards of non-recyclable refuse.

The landfills in the study area (Oneida County and the City of Antigo in Langlade County) do not accept out-of-county wastes. Other county-owned facilities in the area (Marinette, Vilas and Lincoln) have the same policy of not accepting out-of county wastes. Refuse from the mine site will have to be to be hauled to one or more of the privately owned and operated facilities located in Menominee, Riverview, and Iron Mountain, Michigan; or in Ladysmith, Wisconsin Rapids, or Berlin, Wisconsin.

Table 4.2.13-56

With Project - Solid Waste Impacts[1]

Facility	Maximum Service Area Increase (Year)	1992 Annual Tonnage	1992 Per Capita Waste Generation	Total Tons/ Week Increase	Percent Increase/Week
City of Antigo	321 (1999)	5,078	1.5	1.7	2
Oneida County	479 (1999)	25,902	4.5	7.6	1.5

[1] Includes solid waste generated from project related population only.

Source: Foth & Van Dyke Estimates.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-57

With Project - Human, Health and Social Service Impacts Based on Planning Standards

		Project Impact			
	Planning Standard[1] (per 1,000 population)	Forest County (375 pop.)	Langlade County (321 pop.)	Oneida County (479 pop.)	Total (1,175 pop.)
Physicians	1.50	.56	.48	.72	1.76
Dentists	0.53	.20	.17	.25	.62
Nurses	4.50	1.69	1.44	2.16	5.29
Mental Health Support Personnel	0.50	.19	.16	.24	.59
Health Service Support Personnel	2.50	.94	.80	1.20	2.94
Hospital Beds	4.00	1.50	1.28	1.92	4.70
Health, Welfare, Recreation, Cultural Municipal Personnel	1.19	.45	.38	.57	1.40

Source: Foth & Van Dyke Estimates, 1995.

[1]*Development Impact Assessment Handbook*, Urban Land Institute, 1994.

Note: Table includes socioeconomic characterization of Sokaogon Chippewa Community and the Forest County Potawatomi living in the study area.

Prepared by: GMS
Checked by: SFJ

Table 4.2.13-55

With Project - Wastewater Treatment Impacts

Entity	1993-1994 Average Flow (gpd)	Per Capita (gpd)	Future Peak Population	Year	Future Peak Flow	Current Design Flow
City of Crandon	180,000	88[1]	2,368	2025	208,300	260,000
Laona Sanitary District	102,000	93[2]	1,080	1999	100,400	130,000
Wabeno Sanitary District[7]	100,000	200[3]	500	1990	100,000	100,000
City of Antigo	1,880,000	220[1]	8,869	1999	1,952,000	2,470,000
Elcho Sanitary District	51,000	90[4]	610	1999	54,900	60,000
Village of White Lake	40,000	131[1]	319	1999	41,800	50,000
Lake Tomahawk Sanitary District	18,000	100[5]	190	1999	19,000	49,000
City of Rhinelander	1,380,000	182[1]	7,860	1999	1,430,500	1,900,000
Three Lakes Sanitary District	60,000	103[6]	661	1999	68,100	131,000

Source: Foth & Van Dyke Estimates, 1995.

[1]1993 population estimate.
[2]1988 population estimate from August 1989 WDNR Water System Report.
[3]1989 population estimate from August 1990 WDNR Water System Report.
[4]1990 population estimate from January 1993 WDNR Water System Report.
[5]Foth & Van Dyke Estimate.
[6]1992 population estimate from February 1994 WDNR Water System Report.
[7]Population projected to decline from 1990 through the project period.

Note: Assumes project population increases in Towns of Laona, Wabeno, Elcho, Lake Tomahawk and Three Lakes occurs within the sanitary districts.

Note: Does not include Sokaogon Chippewa Community or Forest County Potawatomi.

Prepared by: GMS
Checked by: SFJ

The projected maximum service area population increase as a result of the mine, will have minimal impact on the sanitary landfills currently operated by Oneida County and the City of Antigo. As shown in Table 4.2.13-56, it is estimated that the study area landfills will experience a maximum weekly tonnage increase of 2 percent or less, based on 1992 per capita waste generation rates. This maximum increase as a result of the project is expected to occur in 1999.

4.2.13.4.5.4 Human, Health and Social Services

Increased costs would be incurred at the county level for statutorily required human services (e.g., mental health, alcohol and drug abuse, social services, youth services), as well as increased costs for nonstatutory services (e.g., public health, emergency medical services, senior services and school health programs). The average per capita cost factors used to estimate future costs under both the baseline forecast and impact scenarios are derived from prevailing baseline standards and levels of expenditures (Table 4.2.13-57).

While planning standards are not an absolute indicator of impacts, they provide a guideline by which to measure change in human, health, and social service requirements as they relate to population change. Table 4.2.13-57 indicates that total project impacts will generate a need for; two additional physicians, one part time dentist, five nurses, one part time mental health support staff, three health service persons, five hospital beds, and more than one health, welfare, recreation, and culture municipal person. Whether the individual counties will decide to add staff as a result of this project is difficult to determine.

In Forest County, the number of doctors, nurses, dentists, and optometrists is below standard, and there is no hospital. Furthermore, a multi-person accident in Forest county could exceed the response capacity considering the long distance to the Rhinelander hospital. While these conditions currently exist in Forest County, the project impacts on medical services are forecast to be minimal. There will be a medical vehicle stationed at the Crandon Project site. While the addition of 375 persons in Forest county is unlikely to justify construction of a hospital, it may encourage health service providers to increase medical services in the county.

4.2.13.4.5.5 Police, Fire, Emergency Medical Services

The maximum population impacts arising from the project which includes the mine construction phase, were evaluated for police, fire and emergency medical service (EMS) needs. The maximum permanent population impact estimated for the project for each local unit of government was applied to planning standards (see Section 4.2.13.3.6.3) for police personnel, police vehicles, fire personal and vehicles, and EMS vehicles.

Table 4.2.13-58 indicates the estimated maximum population impact from the project and the anticipated staffing needs as a result, based on the planning standards. The needs identified in Table 4.2.13-58 are in addition to the current personnel needs identified previously in Table 4.2.13-31. Forest County Sheriff's Department and the City of Rhinelander Police Department both would require an additional half-time officer. No other police or sheriff's departments would be affected. No other staffing or vehicle needs were identified for fire personal, fire vehicles or EMS vehicles based on the maximum population impacts projected to result from the project when applied to planning standards.

Table 4.2.13-58

With Project - Police Staffing Impacts

Entity	Maximum Population Impact From Project (Year)	Total Officers Required Per Planning Standards[1]
Forest County Sheriff's Department	273 (1999)	0.5
City of Crandon	112 (2005)	*
Langlade County Sheriff's Department	164 (1999)	*
City of Antigo	150 (1999)	*
Oneida County Sheriff's Department	169 (1999)	*
City of Rhinelander	249 (1999)	0.5

Source: Foth & Van Dyke Estimates, 1995.

[1]Two officers per 1,000 population. Source: *Development Impact Assessment Handbook*, Urban Land Institute, 1994. Exhibit 6.1, page 93.

*No additional officers needed.

Note: Police coverage for county sheriff's departments assume unincorporated areas only, except Village of White Lake, Langlade County, and Towns of Three Lakes, Minocqua and Woodruff, Oneida County.

Prepared by: GMS
Checked by: SFJ

4.2.13.4.6 Native American Communities

Potential socioeconomic impacts to Native American communities are addressed in detail in Section 4.2.14. It should also be noted that the populations of Native American communities already have been included in the broader socioeconomic impact assessments for the townships in which they reside.

4.2.13.4.7 Temporary Suspension or Premature Closure

The following evaluation was developed to address the socioeconomic impacts associated with the premature closure or suspension to planned operations. The cases evaluated while not expected to occur were selected in discussions with the WDNR to represent the worst case scenario (post construction closure) and other operational contingencies. It is assumed that even though a complete early closure is unlikely, communities and local residents should recognize that possibility and begin immediate planning for ultimate closure. Such planning would include wise use of net proceeds tax revenues and economic development efforts aimed at attracting and building long-term business growth. Appropriate early planning for cessation of operations will help mitigate the socioeconomic impacts of mine closure, whenever that may occur.

As shown in Table 4.2.13-1, CMC anticipates constructing the proposed project over a three year period beginning in 1997. Operations would take place over a 28-year period beginning in 2000. Zinc ore would be mined over the first 15 years of this period (2000-2014) and copper ore over the remaining 13 years (2015-2027). During this time frame, production activities at the site would occur 24-hours per day, seven days per week.

Suspension of the operations for short-periods of time (for example, up to six months) would have manageable socioeconomic impacts on the study area. The plant facility is relatively self-contained in terms of public service demands and, thus, would have little direct impact on surrounding communities. Disposable income in the study area would also be only slightly affected as unemployment compensation would provide an income "buffer" to workers idled by a temporary shutdown at the plant facility.

Circumstances could arise requiring permanent closure of the project prior to completion of the planned 28-year operations period. This would most likely happen due to key mineral prices decreasing to non-economic levels for sustained periods of time. Two possible premature closure scenarios are considered here. The first, post-construction closure, assumes that the project is built as proposed during the 1997-1999 period, but never operated. The second, post-zinc closure, scenario assumes that the project is constructed and operated through the zinc ore phase (2000-2014), but is closed and reclaimed immediately thereafter.

Under the post construction closure scenario, the study area would experience the influx of construction and CMC workers associated with years 1997-1999 as shown in Table 4.2.13.2. Employment at the plant site would range between 151 and 750 workers over the construction period. Many of the workers employed at the site during this period will be in the study area for less than three months. Increased pressures will be experienced in the local temporary housing stock during this period but little new construction is anticipated, given the temporary nature of most construction period jobs. As shown in Table 4.2.13-54, public school enrollments will likely increase in the study area school districts, particularly in the Antigo, Crandon and Rhinelander school districts. No new public school construction is anticipated due to the excess capacity

expected to exist in these school districts. As discussed in Section 4.2.13.4.5, no local public facilities or services are expected to be constructed due to construction of the project.

Governmental revenues in the study area will be affected by premature closure of the project immediately following construction. Equalized property value in the Towns of Lincoln and Nashville, the Crandon School District and Forest County will have increased to the levels shown for year 2000 in Table 4.2.13.49 due to construction of the project. Property value would decrease each year thereafter (due to depreciation) until a final decision is made by CMC to remove all physical structures from the site. At this point, equalized property value increases in the directly affected jurisdictions would approach those shown for years 2029 through 2032 in Table 4.2.13-49.

Net proceeds tax payments and distributions from the Mining Investment and Local Impact Fund would be significantly affected with closure of the project immediately following construction. Without operation of the facility, zero net proceeds tax would be collected. Payments by CMC to local jurisdictions would consist of Notice of Intent Payments to the Towns of Lincoln and Nashville, the City of Crandon and Forest County, and the $100,000 Construction Period Payments to the Towns of Lincoln and Nashville and Forest County. No other revenues would be available in the MILIF to mitigate local impacts caused by construction of the facility.

The post zinc closure scenario assumes that the project is constructed and operated through the massive zinc phase (through 2014). Due to lower mineral value of the ore during the copper phase, continued operations during this period (2015-2027) will be more sensitive to mineral price variations and thus, more susceptible to possible premature closure.

Under this scenario the project has been constructed and operated for over a decade. Housing stock adjustments will have been made over this period in response to location decisions of project workers and their families and local governments will have adjusted the level and quality of their public services accordingly. Most notably, as noted in Section 4.2.13.4.5, no capital improvements projects will have been undertaken by either general purpose governments or school districts in response to population changes caused by the project. Debt retirement should not be an issue with premature closure of the plant facility after the zinc ore phase.

Impacts of closure following zinc ore extraction will have only minimal impacts on the revenues of local governments. Premature closure in year 2015 will shorten by approximately a decade the benefits received by the Towns of Lincoln and Nashville, the Crandon School District and Forest County from the project's equalized value. Assessed value of the project would have been 33 to 65 percent lower than peak value over this shortened period due to natural depreciation of the facility's capital stock, thus, minimizing the actual loss in tax base to these jurisdictions.

It is important to note that net proceed tax payments and distributions from the Mining Impact and Local Investment Fund would be only minimally affected by closure of the facility after the zinc ore phase. As shown in Table 4.2.13-45, over 96 percent of all anticipated net proceeds tax payments are made through the zinc ore period (2000-2014) with base mineral prices and the

middle work force configuration[2]. Distributions from the MILIF to study area communities directly affected by the project are also only minimally affected by closure of the facility in 2015. First Dollar and Reserve Fund payments to the Towns of Lincoln would be virtually unaffected by early closure. Anticipated First Dollar payments to the Forest County Potawatomi and Sokaogon Chippewa Native American Communities would be approximately $243,000 (10 percent) lower than if the project is operated through 2027. First Dollar and Additional payments to Forest County would be approximately $612,000 (8 percent) lower. Funds available for Discretionary MILIF Grants would be approximately $825,000 (2 percent) lower and contributions to the Badger Fund approximately $1.5 million (3 percent) lower if the project closes permanently in 2015.

In general, the impacts on the study area would be manageable if the project were either temporarily suspended or were permanently closed short of its projected lifetime.

4.2.13.5 Cumulative Impacts

Two other zones of base metal (copper or zinc) mineralization exist in relative close proximity to the proposed project. Little is known about the zone located near Bishop Lake on the Mole Lake Indian Reservation, but it is understood to contain some marginal copper mineralization with lesser amounts of zinc. The second, discovered by Noranda, is located on the Pelican River in Oneida County. The Pelican River deposit, is small and contains low grade mineralization. It is unlikely that either can be developed independently given expected mineral prices.

There are a number of additional small, low grade, currently uneconomic base metal occurrences in the state. Table 4.2.13-59 lists those which are within approximately 50 miles of the Crandon deposit.

[2]Approximately 90 percent of all net proceeds tax payments are made during the zinc ore period under the more extreme 120 percent mineral price/minimum labor force scenario. Note that NPT payments are made the year following net proceeds determination.

Table 4.2.13-59

Metallic Mineral Occurrences Located Within Approximately 50 Miles of the Project

Occurrence	County
Lynne	Oneida
Ritchie Creek	Lincoln
Spirit	Lincoln
Somo	Lincoln
Hawk	Lincoln
Horseshoe	Lincoln
Pelican River	Oneida
Mole Lake	Forest
Catwillow	Forest
G-23	Forest
Duval	Marinette

Source: Crandon Mining Company, January 1995.

Prepared by: AJE
Checked by: RVS

It may be technically possible to use the proposed CMC mill to concentrate ore from some of these sites. Such operations would likely require changes in CMC ore concentrating processes to accommodate different ore characteristics from the respective locations. CMC does not have an interest in such custom milling arrangements at this time and does not now contemplate making any provision in the mill design to accommodate other ore sources.

If custom milling is pursued at a later time, modifications to the various CMC licenses and permits in affect at that time would be required. CMC's permits will be specific to the Crandon ore body. Any change would require further review by the regulatory agencies. In addition, an independent permitting and environmental review process would be required to allow mining of such ores. The permitting process would be substantially the same as that applied to the Crandon Project and would take three to five years to accomplish. Environmental impacts associated with the mining of any of the above areas and custom milling at CMC's facility would be identified and evaluated as part of such respective permitting and permit modification processes.

4.2.13.6 Summary of Socioeconomic Impacts

In general, the socioeconomic impacts of the proposed project are expected to be beneficial to the study area and the State of Wisconsin. Although socioeconomic impact assessment techniques do not allow precise estimation of specific impacts in specific locations, the estimates presented in this report indicate the cumulative positive impacts that the proposed project will likely produce.

Population impacts associated with the project will peak at approximately 1,200 people in 1999, the last year of construction. Most of these individuals will be temporary construction workers that will be in the study area for short periods of time. Approximately 740 new residents (246 new workers) will live in the study area during plant operations. Construction and operations population impacts represent only 2.2 and 1.4 percent of anticipated baseline population, respectively.

Total employment directly associated with construction of the plant facility will peak at approximately 750 workers during one month in the third year of construction. The average monthly direct employment during the construction period will be approximately 380 workers. Total employment at the plant facility during operations will range between 402 and 526 workers each year. The spending of project payroll and direct purchases by the plant operation will produce significant additional employment in the study area and the state.

The demand for housing will increase by 1 to 3 percent over the baseline increase in demand that would be present without the project. Minor housing shortages may exist in specific locations during project construction and operation, although ample housing is available throughout the entire study area.

Local governments immediately affected by the proposed project will, in general, see significant increases in the tax base available to finance additional public services. In particular, the Towns of Lincoln and Nashville, the Crandon School District and Forest County will experience significant increases in their tax bases over the life of the project. The City of Crandon, however, may experience moderate municipal tax rate increases due to increased numbers of residents living in the city. The City of Crandon may be able to mitigate such impacts through terms of its Local Agreement with CMC and through Discretionary Grants from the MILIF.

Net proceeds taxes generated by the project will range between $30-$233 million. In general, 60 percent of this amount will be distributed to affected local governments (including school districts) to mitigate project-induced impacts, and 40 percent will be contributed to the Badger Fund for other environmental uses throughout the state. In addition, state and county sales tax revenues will increase over $3.4 million over the life of the project and state income tax collections will increase by $20 to $83 million over this same period.

The project is not expected to require additional public facilities or capital improvements projects. Demands on health or social service resources will experience modest increases due to the project. Currently emergency response capabilities in Forest County may be inadequate to handle a multi-person accident occurring at or near the plant facility.

4.2.14 Native American Communities

Evaluating the Crandon Project's potential impacts to Native American communities requires a careful consideration of many factors. These include potential impacts to local reservation environments, to the exercise of reserved treaty rights, to the local Tribes' separate sovereign, cultural, and social integrity, and to the Tribes' governmental, economic development, and other goals.

Any evaluation of potential impacts must also account for issues of "environmental justice". The USEPA's Office of Environmental Justice defines this term as:

> the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no group of people, including racial, ethnic, or socioeconomic group should bear a disproportionate share of the negative environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local, and tribal programs and policies.

This required concerted efforts to understand and evaluate all issues of concern to a minority community, and to consider alternatives and mitigation measures with those special concerns in mind. It also required "[e]arly and sustained communications with the affected community throughout the NEPA process" so as to ensure an opportunity for full input from the community itself (USEPA, 1996).

From the time the mining partnership was first formed in September 1993, CMC has been engaged in intensive efforts to reach out to local Native American Tribes so as to better understand their concerns, include them in the planning and environmental review processes, ensure that potential adverse impacts to the tribes and their members are avoided, minimized, and mitigated, and explore ways in which the project can be structured to offer enhanced benefits to Native American communities. These efforts have included repeated efforts by CMC's management and personnel to communicate directly with tribal representatives, repeated attempts by expert consultants retained by CMC to establish dialogue with the tribes, and repeated attempts to work with government agencies in appropriate outreach efforts.

CMC has devoted its best efforts over the past three years, and will continue to do so, in seeking to ensure that the Crandon Project is designed, permitted, operated, and reclaimed in accordance with the following principles:

- Full respect for the land, water, air, and other natural resources in the Crandon Project vicinity, and full compliance with all applicable laws aimed at preserving these resources. This will protect the interests of Native Americans along with all other citizens. CMC is committed to avoiding, minimizing, and mitigating adverse environmental impacts to the local reservations, and to protecting the natural resources used by Native Americans in the surrounding vicinity.

- Active efforts to promote open, respectful, and on-going dialogue with the Sokaogon Chippewa Community (SCC), the Forest County Potawatomi Community (FCP), and the Menominee Indian Tribe of Wisconsin (MITW) on all matters of environmental,

socioeconomic, and cultural concern. CMC continues to seek information and assistance from these Tribes on a variety of matters within their special expertise and expressed interest.

- A commitment that the Crandon Project will recognize, respect, and protect the separate sovereignty, cultures, traditions, and values of CMC's Native American neighbors. CMC has sought to be an active business and local leader in promoting cultural understanding, respect, and preservation. It would welcome the opportunity to work with area Tribes in further promoting these goals.

- Active efforts to explore potential service, supplier, and other business opportunities with tribal enterprises that could be of significant mutual benefit, and a commitment to pursue outreach and job training efforts so as to increase the numbers of Native Americans in the Crandon Project workforce. CMC is committed to working with Tribal Governments to ensure that the Crandon Project has a net positive impact upon tribal economic development and finance.

- Full recognition of the separate sovereignty and legal rights of all affected Native American Tribal Governments. This includes good-faith efforts to fully comply with the letter and spirit of all governing laws regarding Native American rights. This also includes full respect for, and cooperation with, the federal "government-to-government" initiatives toward affected Tribal Governments, subject to the President's directive that all such government-to-government consultations "are to be open and candid so that all interested parties may evaluate for themselves the potential impact of relevant proposals." (Presidential Memorandum, 1994.)

CMC's efforts to consult with Tribal Governments and to exchange information with them have met with only limited success to date. The SCC, FCP, and MITW have all expressed strong opposition to the project. Menominee representatives agreed in January 1995 to supply certain requested socioeconomic information, but have not yet done so (Greene, 1995). The Menominee Tribal Government also is participating in CMC's evaluation of traditional cultural properties, subject to final approval by the Tribal Legislature before any results may be released to CMC or others. The Sokaogon and the Potawatomi Tribal Governments, however, have declined to respond to CMC's numerous initiatives and requests for information. CMC continues to seek constructive dialogue with all affected Tribal Governments, and would welcome any efforts by the Tribes, intertribal organizations, the U.S. Army Corps of Engineers, or other federal agencies in facilitating such a dialogue.

Because the Tribes have chosen to limit their discussions and cooperation with CMC, potential impacts to Native American communities have had to be evaluated in this EIR using other available sources of information, including environmental studies of the general vicinity, data developed as part of project-related socioeconomic investigations during the 1980s, court and agency filings, and published studies. It should also be noted that the populations of Native American communities already have been included in the broader socioeconomic impact assessment, discussed in Section 4.2.13, for the townships in which they reside.

Although the Sokaogon, Potawatomi, and Menominee Tribes are separate sovereign governments with their own unique cultures, they share many common concerns (USCOE-Menominee, 1995; USCOE-Potawatomi, 1995; USCOE-Sokaogon, 1995). These common concerns are addressed in great detail in the following section on potential impacts to the Sokaogon. Subsequent

discussions of potential impacts to the Potawatomi and Menominee incorporate the more detailed analysis found in the Sokaogon section.

4.2.14.1 Sokaogon Chippewa Community

4.2.14.1.1 Reservation and Treaty Rights

4.2.14.1.1.1 Impacts to the Reservation Environment

The Crandon Project will not adversely affect the land, surface water, groundwater, air, or other natural resources within the Sokaogons' reservation. The maximum zone of potential groundwater drawdown caused by mine inflow will not extend as far west as the area of the reservation, and thus there will be no direct drawdown impacts to reservation surface waters, groundwater supplies, or wetlands. Moreover, as discussed in Sections 4.2.5 and 4.2.6.3, mine dewatering will not adversely affect the off-reservation flows of Upper Swamp Creek, which is a tributary of Rice Lake. The level of Rice Lake would not be significantly affected by any fluctuations in Upper Swamp Creek because the creek is only one of several inlets supplying water to the lake, and the lake has a water level control structure at its outlet. High water levels are much more dangerous to wild rice than are low water levels (WDNR, 1986). As discussed in Sections 4.2.5, 4.2.6.3, and 4.2.7.3, mine dewatering will have no other direct or indirect adverse effects on any other reservation surface waters, the reservation's groundwater supplies, or the reservation's wetlands.

The project will likewise protect the quality of reservation waters. There will be no point-source discharges into Swamp Creek or any other tributaries of reservation surface waters. All surface construction activities along and near Upper Swamp Creek will have stringent runoff and erosion controls. Moreover, any of the minor sedimentation that might result from construction activities in the creek would be intercepted in the slower reaches of the creek by beaver dams. CMC and any successors will be perpetually responsible under Wisconsin law for ensuring that the Tailings Management Area ("TMA") does not harm the reservation's surface waters or groundwater resources. As discussed in Sections 4.2.5 and 4.2.6, no other adverse impacts to the physical, chemical, or biological integrity of reservation groundwaters or surface waters will result from project operations.

For these reasons, the Crandon Project will not adversely affect the wild rice habitat and crop in Rice Lake and other nearby waters. The quantity of wild rice harvested in Rice Lake and elsewhere will continue to vary based on environmental conditions (temperature, high water levels, etc.) completely unrelated to the Crandon Project. CMC recognizes that the integrity of the wild rice resource is of paramount concern to the Sokaogon, and has sought to take all necessary design and operational steps to protect this resource. CMC would welcome the opportunity to discuss further cooperative efforts that might be undertaken to monitor and protect reservation waters in general and the wild rice habitat and crop in particular.

In September 1995, the EPA granted the Sokaogon's request for Treatment as a State (TAS) status for purposes of administering the Clean Water Act (CWA) within reservation boundaries. In January 1996, the EPA approved the Sokaogon's Proposed Water Quality standards adopted pursuant to this grant of TAS authority. The state of Wisconsin has filed federal litigation against the EPA, contending that (1) the Sokaogon are not entitled to TAS status because the state has exclusive sovereignty, ownership, and regulatory jurisdiction over navigable waters within the reservation, and (2) the Sokaogon's standards are excessively broad and unauthorized

by the CWA. CMC will make no point source discharges into any tributaries of reservation waters, and thus believes that it is unaffected by any tribal standards within the scope of the EPA's grant of TAS authority. CMC further believes that the Crandon Project can and will comply with any lawful tribal water quality standards that ultimately emerge from the present litigation.

Because the Crandon Project will be only a minor source under the Clean Air Act, and because of the comprehensive measures that CMC will implement to reduce airborne emissions, the project will have negligible impacts to the air quality of the Sokaogon reservation. Nor, as discussed in Section 4.2.3, will the Sokaogon's land, water, or other natural resources be harmed through deposition of metals or other airborne pollutants.

The project will cause some increased traffic on STH 55, part of which is located within a right-of-way that cuts through the southeast corner of the Sokaogon reservation. Given existing residential and travel patterns, most of this increased traffic volume on STH 55 will occur to the north of the reservation. Any increased traffic through the reservation will center around project shift changes (Section 4.2.2). The preferred mode for shipping fuels and reagents needed for project operations will likely be by truck transport, and some of these deliveries may come from south of the project site by way of STH 55. The transport of all of these types of materials is common in northern Wisconsin. CMC has prepared an extensive risk assessment of possible transportation-related spills and other releases of these materials, which is included in Section 4.13 of the project's *Mine Permit Application* (FVD, 1995d). As demonstrated in that analysis, the risks that such materials might be spilled or released during transportation are negligible, and any such spills or releases would be promptly contained and remediated. CMC would welcome the opportunity to review its proposed contingency measures with the Sokaogon and to work with the Tribal Government in further developing and coordinating appropriate accidental spill notification and response plans.

4.2.14.1.1.2 Impacts to the Exercise of Treaty Rights

Some members of the SCC have asserted that their Tribe has continuing rights under the 1842 and 1854 treaties with the United States to occupy and use Crandon Project lands (USCOE-Sokaogon, 1995). These claims, however, have previously been rejected by the federal courts. The courts have held, specifically, that the Sokaogon have no treaty-based rights to occupy off-reservation lands in the Crandon vicinity (including any lands owned by CMC); that the Sokaogons' qualified off-reservation treaty rights to hunt, fish, and gather in the area are restricted to public lands; and that mining has a right to proceed under the treaties, subject only to mining and environmental laws of general applicability (Sokaogon, 1992; LCO, 1991).

It has been reported that some Sokaogon have occasionally continued to hunt, fish, and gather on certain CMC lands (WDNR, 1986). Such activities are unauthorized and, for safety and security reasons, may need to be further restricted once mining operations begin.

The WDNR reported in 1986 that, with only one exception, all plant and animal species gathered by the Sokaogon on Crandon Project lands are widely distributed throughout the immediate vicinity and thus will continue to be readily available to the Sokaogon. The single exception is bur oak (*Quercus macrocarpa*), used as a food, dye, and medicinal plant, which was reported to be restricted within the immediate vicinity of the reservation to several small groves on Crandon Project lands. Alternative bur oak gathering sites were reported to lie within 60 miles (WDNR, 1986). Subsequent research has identified significant stands of bur oak in the Crandon Project

area and at other locations within less than 60 miles of the Crandon area. Bur oak is a common species south of the tension zone in Wisconsin, with scattered occurrences in the northern Wisconsin (Curtis, 1959) and as far north as Lake Superior in Michigan (Voss, 1985). This species is found in a variety of habitats and moisture regimes ranging from moist peat lands bordering sedge meadows to dry, rocky cliffs (Curtis, 1959). In the Crandon Project study area, bur oak was found in two clusters; one in the bur oak swamp northwest of the TMA (Wetland F15) and the other along the northern shores of Oak lake. Scattered individuals are likely throughout the study area as well as the region. For example, a number of specimens were observed approximately 30 miles west of the Crandon Mine site along the Wisconsin River during aquatic plant surveys conducted in 1996.

CMC would welcome the opportunity to work with tribal representatives in reviewing the location and distribution of bur oak or any other species of concern. CMC would also be prepared to discuss potential access to certain of its lands in the event that alternative gathering sites for bur oak or other species of concern are not available to tribal members.

Subject to the WDNR's approval, Forest County will convey approximately 1,000 acres of county forest lands to CMC for use by CMC in connection with the TMA and as buffer lands. These include riparian lands along Hemlock Creek. The Sokaogon presently have hunting, fishing, and gathering rights under their 1842 treaty on these county forest lands. Under controlling court decisions, these rights will be extinguished when the lands are conveyed into private ownership (Sokaogon, 1992). CMC has agreed to convey approximately 1,396 acres to Forest County to replace the lands conveyed by Forest County to CMC. These replacement lands already are enrolled in the forest cropland program, so the Sokaogon already have some hunting, fishing, and gathering rights on these replacement lands. The net result of these transactions will be a slight reduction in the amount of public lands and forest croplands available to the Sokaogon for hunting, fishing, and gathering.

This reduction should not adversely affect the Sokaogons' ability to engage in sufficient hunting, fishing, and gathering activities. There are vast reserves of public lands in the immediate vicinity of the Sokaogon reservation, including county- and state-owned lands, private lands enrolled in the forest cropland program, and the nearby Nicolet National Forest. The WDNR reported in 1986 that there were 28,400 acres of public land in the nine townships immediately surrounding the Sokaogon reservation (WDNR, 1986). The proposed Forest County sale to CMC would reduce this figure by less than 4 percent. It should be noted that this figure includes none of Nicolet National Forest, which lies 10 miles to the north and 8 miles to the east of the reservation, and which offers large amounts of additional public lands for usufructuary pursuits. The WDNR found in 1986 that the public lands readily available to the Sokaogon following the Crandon Project acquisition of county lands would be more than sufficient to meet tribal usufructuary needs, and that access to Hemlock Creek could readily be obtained from sites other than the county lands to be acquired by the project (WDNR, 1986). Here again, CMC would welcome the opportunity to review these conclusions with the Sokaogons' representatives and to evaluate any additional information or concerns that may be presented.

The Sokaogon have historically hunted, fished, and harvested a wide variety of mammals, birds, amphibians, fish, plants and plant materials, and other resources on public lands and waters in a large region in northeastern Wisconsin. Because the Tribal Government has declined to assist in CMC's environmental baseline studies, it has been necessary to inventory these historically harvested resources by relying upon the previous permitting record, judicial findings in court litigation, and other sources such as COACT, 1980; LCO, 1987; Ackley, 1987; and USCOE-

Sokaogon, 1995. As outlined in Sections 4.2.8 and 4.2.9, the Crandon Project will not cause any adverse physical, chemical, or biological impacts to any of the plant or animal species that are identified in these sources, nor will it adversely impact any habitat required for the survival of these species. This conclusion includes deer and other mammals, waterfowl and other birds, fish, wild rice, plant foods and materials, and medicinal herbs. CMC continues to seek tribal input with respect to these matters, and will evaluate any additional information or concerns that may be presented.

4.2.14.1.2 Other Sociocultural Impacts

4.2.14.1.2.1 Impacts to Population

Sokaogon authorities estimated in 1985 that over 100 people could move back to the reservation as a result of the increased prosperity that would come with mining (WDNR, 1986). Without the Tribal Government's present cooperation, it is difficult to determine how many nonresident tribal members might now return due to mining, although there probably will be substantially fewer than those estimated in 1985. Tribal population on and adjacent to the reservation has risen significantly over the past decade due to better job opportunities and increased tribal income from gaming and other tribal businesses. These trends are projected to continue. Thus, tribal members who wish to return to the reservation appear to be doing so irrespective of the Crandon Project. The 1985 forecast undoubtedly included many people who have returned in the intervening decade for other reasons or who will do so in the future.

Nevertheless, it is not unreasonable to expect that the increased employment and business opportunities created by mining will attract some additional tribal members back to the reservation and the immediate vicinity. Any population increase on the reservation could be expected to have some increased impacts on demand for tribal housing, health and human services, and related services. Without the Tribal Government's assistance, these potential impacts cannot be quantified with any precision. Any economic impacts of such increased service demands could be met through the increased revenue sources discussed below.

4.2.14.1.2.2 Other Potential Sociocultural Impacts

Concerns also have been expressed about potential impacts to the pace and texture of Sokaogon reservation life, to the psychological health of some reservation members, to existing divisions within the tribal population, to religious beliefs and practices, and to other aspects of Sokaogon culture. Special concerns have been raised that a mining-related influx of new people into the Crandon area could increase "racism" and cultural conflicts between Native Americans and nonindigenous peoples. The Sokaogon Tribal Government has declined to assist with any of CMC's socioeconomic studies or its traditional cultural properties investigation, or to allow CMC representatives to survey tribal members directly. Without such information, it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential impacts to the Sokaogons' own culture, beliefs, and values. CMC instead would welcome the opportunity to learn more from the Sokaogon themselves and to attempt to further avoid, minimize, and mitigate potentially adverse cultural impacts through a cooperative approach with the Tribe.

It should be noted, however, that concerns about the increased potential for cross-cultural conflicts are generally based on the assumption that there will be a large migration of new workers and their families into the area. In fact, any such in-migration should be minimal

because, with the exception of a short period during the construction phase, most jobs will be filled by existing study area residents (see Section 4.2.13.4.1).

It should also be noted that the Sokaogon and other Tribes have made a concerted effort in recent years to increase their interactions with nonindigenous peoples by attracting visitors to reservation gaming and other tourist operations. Racism and cultural conflicts have not been insurmountable concerns in these other contexts. Of course, the visitors to these tribal operations are only temporarily on the reservation, and the Tribe retains control over all on-reservation activities. The same will be true for mining, although CMC recognizes that the analogy between mining and gaming is imperfect. Other than traffic on the STH 55 right-of-way through the reservation, the Tribal Government will continue to have the power to choose who enters its reservation, and the Tribe will continue to have full control over activities on its reservation and over its ways of life. Beyond this, gaming and mining raise many similar sorts of potential cultural conflicts, such as issues of traditional versus new values, money economy versus subsistency, increased interactions among cultures, and so forth. The Sokaogons' adjustment to these challenges in the gaming context is instructive. A modern, underground, off-reservation mining operation should similarly be able to co-exist with the Sokaogons' separate and unique traditions, customs, and culture.

Many of the Sokaogons' expressed sociocultural concerns are grounded on the belief that the Crandon Project will harm the reservation environment and surrounding natural resources. CMC's efforts to avoid, minimize, and mitigate any such potential impacts to the physical, chemical, or biological environment should likewise serve to lessen potential sociocultural impacts (USEPA, 1992).

CMC strongly agrees that the health and integrity of minority cultures is a critical concern. As already noted, CMC is striving to be a leader in promoting cultural understanding, tolerance, diversity, and preservation. CMC continues to seek to discuss these matters with tribal representatives and to identify ways in which it might work together with the Tribe, and would welcome the opportunity to do so in the future, either directly with the Tribal Government or through the offices of the federal government.

4.2.14.1.3 Economic Development and Tribal Finance

The Crandon Project is expected to have a net positive impact upon Sokaogon economic development and tribal finance for the following reasons, among others:

4.2.14.1.3.1 Direct Net Proceeds Tax Payments

As discussed more fully in Section 4.2.13.4.4.2, the Sokaogon Tribal Government is expected to receive between $1.8 and $2.5 million in "first dollar" net proceeds tax distributions during the life of the project, depending upon base minerals prices and the size of the project labor force. In addition, the Tribal Government will be eligible to receive substantial additional funds through Mining Investment and Local Impact Fund ("MILIF") discretionary grants during the project life. These distributions will assist the Sokaogon in meeting the economic aspects of any mining-related impacts, such as potential additional housing demand on the reservation, social welfare needs, and tribal environmental monitoring.

4.2.14.1.3.2 Indirect Net Proceeds Tax Payments

Forest County and the Town of Nashville, of which the Sokaogon are residents, will also receive substantial MILIF distributions and grants during the life of the project. These revenues, along with other local tax revenue increases resulting from the project, will enable county and town governments to meet additional police and fire, educational, and social welfare needs caused by the project. As county and town residents, the Sokaogon will directly benefit from these additional local expenditures.

4.2.14.1.3.3 Employment Opportunities

The project will create significant new employment opportunities for tribal members, which could provide an additional economic boost to the reservation. CMC recognizes that many Sokaogon have indicated that they are not interested in working for CMC, and that the Great Lakes Chippewa have historically not worked in the mining industry in any significant numbers. Nevertheless, approximately one-third of Sokaogon respondents indicated in 1985 that they would be interested in project-related job training if offered (WDNR, 1986). CMC intends to pursue outreach and training efforts to increase the number of Sokaogon and other Native Americans in its work force. CMC would be pleased to work with the Tribal Government in promoting Sokaogon employment opportunities. Tribal members hired by the company would earn higher wages and benefits than generally available in the region. Such hiring would reduce unemployment on the reservation and increase tribal wealth.

Tribal employment opportunities will also grow through increased job demand by CMC's local suppliers and vendors; through jobs created by tribal enterprises that choose to take advantage of service, supplier, and other business opportunities with CMC; and through job openings created by other study area workers leaving existing jobs to work at the mine. All of this will result in diverse increased employment opportunities and increased tribal income.

4.2.14.1.3.4 Entrepreneurial Opportunities

CMC has emphasized to the Sokaogon its active interest in exploring potential service, supplier, and other business relationships with tribal enterprises that could be of mutual benefit. Tribal-owned businesses such as the grocery store, tax-free tobacco sales, and other operations will also prosper as a result of increased patronage from mine employees and visitors. This should mean further job growth and business opportunities for tribal members.

4.2.14.1.3.5 Gaming and Other Tourism Activities

The project can be expected to have a positive impact upon the Tribe's casinos and related operations. In recent years the Sokaogon have conducted an aggressive advertising campaign to attract non-Native Americans to their reservation so as to maximize tribal income from gaming and other visitor activities. Although most project-related jobs will be filled by current study area residents, the project will attract some new residents during the construction and operations periods. These new residents, along with current study area residents who will enjoy additional disposable income as the result of mining, can be expected to patronize the Tribe's casinos and related operations. Moreover, the experience of Flambeau Mining Company shows that a modern mining operation can be a popular draw and enhance the local tourism industry. This too should result in increased tribal income.

4.2.14.1.3.6 Long-term Financial Responsibility

Concerns have been expressed that the Tribal Government might in the long term need to finance the costs of necessary environmental monitoring, repairs, or remediation associated with the Crandon Project. However, CMC and its successors will be permanently responsible under Wisconsin law for the long-term environmental care of the project site, and will be liable for repairing any environmental damage caused by project facilities and operations. Thus, even if environmental problems were to occur in the distant future, those problems would be remedied without cost to the Sokaogon.

4.2.14.2 Forest County Potawatomi Community

4.2.14.2.1 Reservation Rights

The Crandon Project will not adversely affect the land, surface water, groundwater, air, or other natural resources within the Potawatomi reservation. The Potawatomi reservation is located upstream of the project and thus does not face the downstream concerns of the Sokaogon. There will be no physical disturbances to Potawatomi lands; no adverse impacts to the physical, chemical, or biological quality of reservation surface waters or groundwater supplies; no adverse impacts to the quantity or flow of reservation surface waters; and no adverse impacts to reservation wetlands or groundwater supplies, all of which lie well beyond the zone of projected groundwater drawdown.

The Tribal Government has designated the Devil's Lake area as a "protected wilderness area" under tribal law "due to the uniqueness of the area, the archeological evidence at this location, and the cultural tie to this area" (Hansen, 1994). This tribal wilderness area lies approximately 5 miles northeast of the proposed plant site. There will be no discernible project-related water, air, or other environmental impacts to this area.

The Potawatomi have expressed special concerns for their reservation air quality. The Tribe has asked the EPA for approval to redesignate tribal lands from "Class II" to "Class I" status under the Clean Air Act ("CAA"), and to be allowed to function as a "State" for purposes of administering the CAA within its reservation boundaries. The Governors of Wisconsin and Michigan have formally objected to this request, thus requiring EPA to mediate between the Tribe and the objecting States. Because, as discussed in Section 4.2.3, the Crandon Project will be only a minor source under the CAA, and because of the comprehensive measures that CMC will implement to control emissions to the air, the project will have negligible impacts to the air quality of the reservation. Thus, the project should be entirely unaffected whatever the eventual outcome of the Potawatomis' redesignation efforts. The Potawatomis' 1994 *Technical Report* on the redesignation proposal supports this conclusion, emphasizing that "redesignation to Class I will have no effect on the Crandon Project as it is currently proposed" (Potawatomi, 1994).

4.2.14.2.2 Other Sociocultural Impacts

4.2.14.2.2.1 Impacts to Population

In 1986, the WDNR estimated on the basis of survey results that there could be a total in-migration of 176 Potawatomi onto or adjacent to reservation lands as a result of the opportunities and prosperity brought by mining operations (WDNR, 1986). Because the Potawatomi have chosen not to assist in CMC's present studies, it is unknown how many

nonresident tribal members might now return to the Crandon area, although the numbers probably are less than those forecast in 1986 for the same reasons noted above in the Sokaogon analysis in Section 4.2.14.1.2. Nevertheless, it is not unreasonable to believe that mining will attract some additional tribal members back to the reservation vicinity. Any population increase on reservation lands would have some increased impacts on demand for tribal housing, health and human services, and related services. Any economic impacts of such increased service demands could be met through the increased revenues available to the Tribe as the result of mining (see below).

4.2.14.2.2.2 Other Potential Sociocultural Impacts

Most of the discussion of this issue in the Sokaogon impacts analysis in Section 4.2.14.1.2 applies equally to the Potawatomi. The Potawatomi have chosen not to provide CMC with requested information or to assist in CMC's studies. Without such information, it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential impacts to the Potawatomis' own culture, beliefs, and values.

Nevertheless, it should be emphasized that mine-related in-migration is projected to be modest and manageable. Moreover, the Potawatomi have made a concerted effort in recent years to attract nonindigenous peoples to their reservation so as to profit from gaming and tourism. Cultural conflict has not been an insurmountable problem in those contexts. While the analogy between mining and gaming is imperfect (see the discussion in Section 4.2.14.1.2), there is no sound reason why a modern, underground, off-reservation mining operation cannot co-exist with the Potawatomis' separate and unique traditions, customs, and culture. CMC remains committed in its desire to work with the Potawatomi Tribal Government in avoiding, minimizing, and mitigating potentially adverse cultural impacts in a cooperative approach, and in promoting cross-cultural understanding, tolerance, diversity, and accommodation.

4.2.14.2.3 Economic Development and Tribal Finance

The Crandon Project should have a net positive impact upon Potawatomi economic development and tribal finance for all of the reasons set forth above in Section 4.2.14.1.3 of the Sokaogon analysis, which will not be repeated in detail here. The tribal leadership and individual tribal members will ultimately determine the degree of this net positive impact, based upon their interest in taking project-related jobs and in pursuing potentially lucrative tribal business opportunities.

The Potawatomi will receive the identical "first dollar" net proceeds tax distributions as the Sokaogon and, likewise, will be able to apply for substantial additional funds through MILIF discretionary grants. These distributions will be available to meet any increased tribal costs associated with mining, such as potential additional reservation housing demand, social welfare needs, and tribal environmental monitoring. The Potawatomi also will benefit from the substantial MILIF distributions and grants to Forest County and the Town of Lincoln, which directly provide many essential public services to tribal members on and off reservation lands.

There will be significant new employment and entrepreneurial opportunities opened up for tribal members. Fifty-three percent of Potawatomi respondents indicated in 1985 that they would apply for a job at the Crandon Project (WDNR, 1986). As already noted, CMC intends to pursue outreach and training efforts to increase the numbers of Native Americans in its work force. CMC also has an active interest in exploring potential service, supplier, and other business

relationships with tribal enterprises. The Forest County Potawatomi Excavating and Construction Company, for example, could realize substantial business opportunities during the project construction phase; it already employs many skilled journeymen, heavy equipment operators, and mechanics. Other tribal operations should benefit both directly and indirectly from mine-induced spending.

Like the Sokaogon, the Potawatomi have actively promoted gaming operations on their tribal lands in recent years. The project should have a positive impact on these efforts for the reasons discussed above in Section 4.2.14.1.3 of the Sokaogon analysis. The Tribe continues to promote other on-reservation tourist activities, and intends to construct a campground and an RV park in the future to encourage further tourism. The experience of Flambeau Mining Company shows that local tourism may actually be enhanced by mining. This would further increase tribal prosperity.

Like the Sokaogon, the Potawatomi will not need to bear the economic costs of any necessary long-term environmental monitoring, repair, or remediation associated with the Crandon Project. As already noted, CMC and its successors will be permanently responsible under Wisconsin law for the long-term care of the project site and for any necessary environmental repairs.

4.2.14.3 Menominee Indian Tribe of Wisconsin

4.2.14.3.1 Reservation and Treaty Rights

4.2.14.3.1.1 Impacts to the Reservation Environment

The Menominee Reservation is located approximately 30 miles south of the Crandon Project site. There will be no adverse environmental impacts to the land, surface water, groundwater, air, or other natural resources on the reservation. Special concerns have been expressed about the preservation of the Wolf River, which has been described as the "backbone" and "lifeblood" of the Menominees' reservation and culture (Greene, 1994; USCOE-Menominee, 1995). There will be no point source discharges either to the Wolf River itself or to any of its tributaries. As discussed in EIR Volume IIIa, Appendix 3-2, treated mine wastewater will instead be piped to the Wisconsin River for discharge there. This EIR and CMC's permit submittals demonstrate that the Crandon Project will comply with the strict antidegradation standards imposed under Wisconsin law due to the Wolf River's status as an Outstanding Resource Water ("ORW"). Similarly, the project will comply with the stringent preservation standards of the Federal Wild and Scenic Rivers Act, which governs the portion of the Wolf River that flows through the reservation (See Section 4.2.6.1). As discussed in Sections 4.2.5 and 4.2.6.3 there will be no measurable impacts to the levels or flows of the Wolf River. CMC and any successors will be perpetually responsible for ensuring that the TMA does not harm the region's surface waters or groundwater resources.

For these reasons, as described in Sections 4.2.8 and 4.2.9, there will be no adverse physical, chemical, or biological impacts to the Menominees' cultivation of wild rice and medicinal plants along the banks of the Wolf River; to hunting, fishing, gathering, and other tribal uses in and adjacent to the river; to culturally and religiously important animals, fish, and birds that use the river; or to any traditional cultural properties that may lie along or within the Wolf River (for example, spiritually significant rapids and waterfalls).

Sturgeon have historically been a particularly important resource to the Menominee from a variety of cultural, social, and economic perspectives. For the past century, however, dams on the Wolf River south of Keshena Falls have prevented sturgeon from migrating north to the reservation. The Menominees' Sturgeon Enhancement Plan is presently seeking to re-establish sturgeon populations within reservation waters (Teller, 1995). Because the Crandon Project will not cause adverse physical, chemical, or biological impacts to the Wolf River, it will not adversely impact the Sturgeon Enhancement Plan.

Concerns have been raised about the potential for transportation-related spills of fuels and reagents along STH 55, which runs parallel to part of the Wolf River (USCOE-Menominee, 1995). As discussed above in Section 4.2.14.1.1, CMC has prepared an extensive risk assessment of possible transportation-related spills and other releases of these materials, which is included in Section 4.13 of the project's *Mine Permit Application* (FVD, 1995d). As demonstrated in that analysis, the risks that such materials might be spilled or released during transportation are negligible, and any such spills or releases would be promptly contained and remediated. CMC would welcome the opportunity to review its proposed contingency measures with the Menominee and to work with the Tribal Government in further developing and coordinating appropriate accidental spill notification and response plans.

As noted in the introduction to Section 4.2.14, the Menominee are assisting CMC in the extensive traditional cultural properties investigation being conducted for the project initially through Commonwealth Cultural Resources Group, Inc., and currently through Woods Cultural Research, Inc. The Tribal Legislature retains the authority to determine which information resulting from this work will be released to assist CMC and reviewing agencies in evaluating potential impacts to traditional cultural properties. CMC will reevaluate its assessment of potential impacts to the Menominee reservation environment in light of any information that the Tribe chooses to release.

In January 1996, the EPA granted the Menominee's request for Treatment as a State (TAS) status for purposes of administering portions of the Clean Water Act (CWA) within reservation boundaries. The State of Wisconsin has filed federal litigation against the EPA, contending that the Menominee are not entitled to TAS status because the state has exclusive sovereignty, ownership, and regulatory jurisdiction over navigable waters within the reservation. The Tribe released draft Surface Water Regulations for public comment in February 1995. CMC has filed comments on those draft regulations, believes that they are overbroad and unauthorized by the CWA, and believes that they would need to be significantly modified in order to comply with governing law (even assuming that the Tribe qualifies for TAS status). The State of Wisconsin has also formally objected to the Tribe's proposed regulations. Nevertheless, CMC believes that the Crandon Project can and will comply with any authorized tribal water quality standards that ultimately emerge from the prescribed CWA process. To reiterate, there will be no point source discharges into any reservation waters or their tributaries. The project simply will have no adverse impacts to the physical, chemical, or biological integrity of reservation waters or to the quantity and flow of such waters.

4.2.14.3.1.2 Impacts to the Exercise of Treaty Rights

The Menominee filed a federal lawsuit in January 1995 seeking recognition of claimed tribal rights under the 1831, 1836, 1848, and 1854 treaties with the United States to hunt, fish, and gather on public lands throughout much of eastern and central Wisconsin and in the offshore waters of Lake Michigan and Green Bay. The United States District Court for the Western

District of Wisconsin dismissed the Menominee's treaty claims in their entirety on September 16, 1996, and the case is no on appeal (Menominee v. Thompson, 1996). The Crandon Project area and the Wisconsin River discharge pipeline corridor lie to the northwest and well outside of the territory at stake in the Menominee litigation. CMC's proposed wetland compensation site, which lies in Shawano and Oconto Counties to the east of the Menominee reservation, may fall within the claimed territory. However, the Menominee have restricted their claims to public lands and to private property "open to the public for the conduct of the usufructuary activity at issue" (Menominee, 1995). The proposed wetland compensation site is presently privately owned farmland and thus not subject to the Menominees' claims. CMC has proposed to dedicate the site to public conservancy uses in the future, which would ultimately result in an increase in lands available for the Menominees' use. CMC's operations will not cause any adverse physical, chemical, or biological impacts to animals, plants, waters, or other natural resources within the Menominees' claimed treaty territory. For these reasons, the outcome of the Menominee litigation will have no bearing on the Crandon Project.

4.2.14.3.2 Other Sociocultural Impacts

Social, cultural, and economic impacts are anticipated to be minimal given the reservation's location. Nevertheless, the Menominee have expressed similar concerns as the Sokaogon and Potawatomi with respect to potential increased cultural conflicts, potential adverse impacts to traditional cultural properties, and the potential for conflicts with tribal beliefs, customs, traditions, and practices. As with the other Tribes, many of the Menominees' expressed concerns are grounded on the premise that the Crandon Project will harm the reservation environment and surrounding natural resources. Because that will not occur, many of the Menominees' sociocultural concerns should be avoided or minimized. Moreover, many predictions of increased sociocultural stress are based upon the assumption that there will be a large migration of new workers and their families into the area. In fact, the socioeconomic evaluation described in Section 4.2.13.4 concludes that the project area will not experience a significant increase in population. The modest influx of new residents will be concentrated well north of the Menominee reservation.

As discussed above, CMC strongly agrees that the health and integrity of minority cultures is a critical concern. CMC has actively sought in good faith to promote cultural understanding, tolerance, diversity, and preservation. CMC has stressed its commitment to building and operating the mine in a way that is respectful and protective of all neighboring Native American communities. CMC sees no sound reason why a modern, underground, off-reservation mining operation cannot co-exist with the Menominees' separate and unique traditions, customs, and culture. CMC is committed to working with the Tribal Government so as to understand, avoid, minimize, and mitigate potential adverse sociocultural impacts wherever possible.

4.2.14.3.3 Economic Development and Tribal Finance

Project-related impacts to Menominee economic development and tribal finance are expected to be positive though minimal. Due to the location of their reservation, the Menominee will not receive "first dollar" net proceeds tax distributions, but they would be eligible to receive MILIF discretionary grants in the event the project were to cause any demonstrable impacts to their reservation. Tribal members will also be eligible to take advantage of the project-related employment opportunities, and could benefit from CMC's Native American outreach and training efforts. Nevertheless, overall employment of Menominee at the mine probably will be low due to the relatively long commuting distance. Tribal enterprises could, however, pursue

potentially profitable service, supplier, and other commercial relationships with CMC and other mining-related businesses. The project will not harm the Tribe's thriving gaming and tourism operations. CMC and its successors will retain responsibility for long-term environmental monitoring, repair, and remediation, and thus the Menominee will not bear any long-term environmental expenses.

4.2.14.4 Summary

The Crandon Project will not cause adverse physical, chemical or biological impacts to the lands, surface waters, groundwater supplies, air or other natural resources within neighboring Native American reservations. Nor will the project harm any plant or animal species that are the subject of off-reservation hunting, fishing, and gathering activities. Based upon available data, population increases on the reservations will be modest and manageable. In addition, the project is expected to have a net positive effect upon tribal economic development and finance, though the degree of this net positive effect will ultimately be determined by the Tribal Governments and individual tribal members.

4.2.15 Environmental Impact Summary

The Crandon Project has been designed to avoid and minimize environmental impacts to the maximum extent feasible. As described in Sections 7 and 10 of the project's *Mine Permit Application* (FVD, 1995d), CMC has developed comprehensive plans to monitor the project area before construction, during construction and operations, and during and after reclamation. Contingency plans presented in Section 8 of the *Mine Permit Application* will be implemented in the event that monitoring reveals that impacts greater than expected are beginning to develop. In addition to monitoring and contingency planning, CMC has conducted a thorough risk assessment for the project which is detailed in Section 4.13 of the *Mine Permit Application*. A summary of the potential impacts without mitigation is presented below. Mitigation is discussed in Section 5.

Project impacts for air quality, terrestrial biology, vibration, water quality and transportation and utilities are expected to be negligible. Air quality emissions will be in compliance with all state and federal standards. Emission rates for mine sources will be within the limits of the new source performance standards for metallic mineral processing plants. Estimated ambient air quality emissions will be in compliance with and well below the National Ambient Air Quality Standards. Impacts to terrestrial biota will largely result from the conversion of approximately 540 acres of forested lands to mine related land uses during the construction and operation of the mine. Although localized population reductions for small and/or immobile organisms may occur, these organisms are well represented in similar habitat elsewhere in the region. For blasting, estimates of ground vibrations show that no damage to structures will occur in the near

Note: As a result of changes made to Section 4.2.14 on December 3, 1996, pages 4-263 through 4-266 have been deleted.

and Scenic Rivers Act, which governs the portion of the Wolf River that flows through the reservation (See Section 4.2.6.1). As discussed in Sections 4.2.5 and 4.2.6.3 there will be no measurable impacts to the levels or flows of the Wolf River. CMC and any successors will be perpetually responsible for ensuring that the TMA does not harm the region's surface waters or groundwater resources.

For these reasons, as described in Sections 4.2.8 and 4.2.9, there will be no adverse physical, chemical, or biological impacts to the Menominees' cultivation of wild rice and medicinal plants along the banks of the Wolf River; to hunting, fishing, gathering, and other tribal uses in and adjacent to the river; to culturally and religiously important animals, fish, and birds that use the river; or to any traditional cultural properties that may lie along or within the Wolf River (for example, spiritually significant rapids and waterfalls).

Sturgeon have historically been a particularly important resource to the Menominee from a variety of cultural, social, and economic perspectives. For the past century, however, dams on the Wolf River south of Keshena Falls have prevented sturgeon from migrating north to the reservation. The Menominees' Sturgeon Enhancement Plan is presently seeking to re-establish sturgeon populations within reservation waters (Teller, 1995). Because the Crandon Project will not cause adverse physical, chemical, or biological impacts to the Wolf River, it will not adversely impact the Sturgeon Enhancement Plan.

Concerns have been raised about the potential for transportation-related spills of fuels and reagents along STH 55, which runs parallel to part of the Wolf River (USCOE-Menominee, 1995). As discussed above in Section 4.2.14.1.1, CMC has prepared an extensive risk assessment of possible transportation-related spills and other releases of these materials, which is included in Section 4.13 of the project's *Mine Permit Application* (FVD, 1995d). As demonstrated in that analysis, the risks that such materials might be spilled or released during transportation are negligible, and any such spills or releases would be promptly contained and remediated. CMC would welcome the opportunity to review its proposed contingency measures with the Menominee and to work with the Tribal Government in further developing and coordinating appropriate accidental spill notification and response plans.

As noted in the introduction to Section 4.2.14, the Menominee are assisting CMC in the extensive traditional cultural properties investigation being conducted under the supervision of Commonwealth Cultural Resources Group, Inc. The Tribal Legislature retains the authority to determine which information resulting from this work will be released to assist CMC and reviewing agencies in evaluating potential impacts to traditional cultural properties. CMC will reevaluate its assessment of potential impacts to the Menominee reservation environment in light of any information that the Tribe chooses to release. Any information authorized for release by the Tribe will be included in supplemental submissions.

Like the Sokaogon, the Menominee have begun the process of seeking EPA authorization to act as a "State" within their reservation borders for purposes of administering the Clean Water Act (CWA). The Tribe released draft Surface Water Regulations for public comment in February 1995. CMC has filed comments on those draft regulations, believes that they are overbroad and unauthorized by the CWA, and believes that they would need to be significantly modified before ever being accepted by the EPA and the courts. The State of Wisconsin has also formally objected to these proposals. Nevertheless, CMC believes that the Crandon Project can and will comply with any authorized tribal water quality standards that ultimately emerge

from the prescribed CWA process. To reiterate, there will be no point source discharges into reservation waters or any of their tributaries. The project simply will have no adverse impacts to the physical, chemical or biological integrity of reservation waters or to the quantity and flow of such waters.

Impacts to the Exercise of Treaty Rights

The Menominee filed a federal lawsuit in January 1995 seeking recognition of claimed tribal rights under the 1831, 1836, 1848, and 1854 treaties with the United States to hunt, fish, and gather on public lands throughout much of eastern and central Wisconsin and in the offshore waters of Lake Michigan and Green Bay. The Crandon Project area and the Wisconsin River discharge pipeline corridor lie to the northwest and well outside of the territory at stake in the Menominee litigation. CMC's proposed wetland compensation site, which lies in Shawano and Oconto Counties to the east of the Menominee reservation, may fall within the claimed territory. However, the Menominee have restricted their claims to public lands and to private property "open to the public for the conduct of the usufructuary activity at issue" (Menominee, 1995). The proposed wetland compensation site is presently privately owned farmland and thus not subject to the Menominees' claims. CMC has proposed to dedicate the site to public conservancy uses in the future, which would ultimately result in an increase in lands available for the Menominees' use. CMC's operations will not cause any adverse physical, chemical, or biological impacts to animals, plants, waters, or other natural resources within the Menominees' claimed treaty territory. For these reasons, the outcome of the Menominee litigation will have no bearing on the Crandon Project.

4.2.14.3.2 Traditional Cultural Properties

The *Interim Report of the Project Ethnologist* is included in Appendix 4.2-9. As discussed therein, CMC is underwriting an extensive Traditional Cultural Property Investigation ("TCPI") presently being conducted by the Menominee under the supervision of Commonwealth Cultural Resources Group, Inc. The Tribal Legislature retains the authority to determine which information resulting from this work will be released to assist CMC and reviewing agencies in evaluating potential impacts to traditional cultural properties. The Menominee are still conducting the TCPI, and have not yet released any of the results.

As discussed above in Section 3.2.2.1.3, based on a preliminary identification of potential Menominee TCPs, there does not appear to be much likelihood that TCPs specific to the Menominee are located within the APE (area of potential effect, defined as the area within a 2-mile radius of the center of the orebody). However, there is a significant likelihood that Menominee TCPs are located further south within and along the Wolf River, including waterfalls, rapids, dells, archeological sites, and burial grounds. There will be no digging, drilling, or other ground-disturbing activities within this area. Moreover, as discussed above in Section 4.2.14.3.1, there will be no adverse impacts to the physical, chemical, or biological integrity of the Wolf River or to the quantity or flow of its waters. For these reasons, CMC does not believe that there will be any measurable physical impacts to any Menominee TCPs.

As discussed in the *Interim Report*, TCPs can sometimes be adversely affected even if their physical integrity is unaltered. Any such potential effects cannot be addressed without additional information from the Menominee, and it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential impacts to the Menominees' own culture, beliefs, and

values. CMC will reevaluate its conclusions in this EIR in light of any TCP information authorized for release by the Tribe on a timely basis, and will include that information in supplemental submissions. In addition, CMC will continue to seek to work with the Menominee in identifying and preserving traditional cultural properties, including through the development of an appropriate cultural resource management plan which would seek to accommodate all parties' concerns while maximizing the protection of TCPs.

4.2.14.3.3 Other Sociocultural Impacts

Social, cultural, and economic impacts are anticipated to be minimal given the reservation's location. Nevertheless, the Menominee have expressed similar concerns as the Sokaogon and Potawatomi with respect to potential increased cultural conflicts, potential adverse impacts to traditional cultural properties, and the potential for conflicts with tribal beliefs, customs, traditions, and practices. As with the other Tribes, many of the Menominees' expressed concerns are grounded on the premise that the Crandon Project will harm the reservation environment and surrounding natural resources. Because that will not occur, many of the Menominees' sociocultural concerns should be avoided or minimized. Moreover, many predictions of increased sociocultural stress are based upon the assumption that there will be a large migration of new workers and their families into the area. In fact, the socioeconomic evaluation described in Section 4.2.13.4 concludes that the project area will not experience a significant increase in population. The modest influx of new residents will be concentrated well north of the Menominee reservation.

As discussed above, CMC strongly agrees that the health and integrity of minority cultures is a critical concern. CMC has actively sought in good faith to promote cultural understanding, tolerance, diversity, and preservation. CMC has stressed its commitment to building and operating the mine in a way that is respectful and protective of all neighboring Native American communities. CMC sees no sound reason why a modern, underground, off-reservation mining operation cannot co-exist with the Menominees' separate and unique traditions, customs, and culture. CMC is committed to working with the Tribal Government so as to understand, avoid, minimize, and mitigate potential adverse sociocultural impacts wherever possible.

4.2.14.3.4 Economic Development and Tribal Finance

Project-related impacts to Menominee economic development and tribal finance are expected to be positive though minimal. Due to the location of their reservation, the Menominee will not receive "first dollar" net proceeds tax distributions, but they would be eligible to receive MILIF discretionary grants in the event the project were to cause any demonstrable impacts to their reservation. Tribal members will also be eligible to take advantage of the project-related employment opportunities, and could benefit from CMC's Native American outreach and training efforts. Nevertheless, overall employment of Menominee at the mine probably will be low due to the relatively long commuting distance. Tribal enterprises could, however, pursue potentially profitable service, supplier, and other commercial relationships with CMC and other mining-related businesses. The project will not harm the Tribe's thriving gaming and tourism operations. CMC and its successors will retain responsibility for long-term environmental monitoring, repair, and remediation, and thus the Menominee will not bear any long-term environmental expenses.

4.2.14.4 Summary

The Crandon Project will not cause adverse physical, chemical or biological impacts to the lands, surface waters, groundwater supplies, air or other natural resources within neighboring Native American reservations. Nor will the project harm any plant or animal species that are the subject of off-reservation hunting, fishing, and gathering activities. Based upon available data, population increases on the reservations will be modest and manageable. In addition, the project is expected to have a net positive effect upon tribal economic development and finance, through the degree of this net positive effect will ultimately be determined by the Tribal Governments and individual tribal members.

Based upon studies to date, CMC is unaware of any specific Native American traditional cultural properties that will be physically harmed by Crandon Project construction or operations activities. No definitive conclusions can be reached, however, in the absence of additional data from the Tribes themselves. The SCC and FCP have declined to cooperate in any way with CMC's studies, and the MITW has not yet released any data to CMC or reviewing agencies. CMC will reevaluate its conclusions in this EIR should any of the interested Tribal Governments choose to share any TCP information on a timely basis.

Without additional information from the Tribes, it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential project impacts to the Tribes' own cultures, beliefs, and values. CMC is committed to developing the project in a way that will recognize, respect, and protect the separate sovereignty, cultures, traditions, and values of its Native American neighbors. It continues to seek to work with all interested Tribal Governments in promoting these goals.

4.2.15 Environmental Impact Summary

The Crandon Project has been designed to avoid and minimize environmental impacts to the maximum extent feasible. As described in Sections 7 and 10 of the project's *Mine Permit Application* (FVD, 1995d), CMC has developed comprehensive plans to monitor the project area before construction, during construction and operations, and during and after reclamation. Contingency plans presented in Section 8 of the *Mine Permit Application* will be implemented in the event that monitoring reveals that impacts greater than expected are beginning to develop. In addition to monitoring and contingency planning, CMC has conducted a thorough risk assessment for the project which is detailed in Section 4.13 of the *Mine Permit Application*. A summary of the potential impacts without mitigation is presented below. Mitigation is discussed in Section 5.

Project impacts for air quality, terrestrial biology, vibration, water quality and transportation and utilities are expected to be negligible. Air quality emissions will be in compliance with all state and federal standards. Emission rates for mine sources will be within the limits of the new source performance standards for metallic mineral processing plants. Estimated ambient air quality emissions will be in compliance with and well below the National Ambient Air Quality Standards. Impacts to terrestrial biota will largely result from the conversion of approximately 550 acres of forested lands to mine related land uses during the construction and operation of the mine. Although localized population reductions for small and/or immobile organisms may occur, these organisms are well represented in similar habitat elsewhere in the region. For blasting, estimates of ground vibrations show that no damage to structures will occur in the near

vicinity of blasting (i.e., mine-related structures) and vibrations will generally be below human response thresholds at 0.5 miles away from blasting. Surface water discharges will be regulated by permit at levels established to protect human and aquatic life. As a result, water quality impacts associated with the discharge of treated water from the site will be negligible. Based on WisDOT criterion, the traffic analysis of future mine and no mine conditions indicates acceptable capacity levels will be provided for all intersection and roadway segments evaluated in the study.

The Crandon Project will be fully self-sufficient regarding water supply and treatment and therefore will require no public utility services in this regard. Telephone service will be provided by the local telephone company and not require major changes to existing services. Electrical and natural gas service will be provided to the project by the area utility. Plans relating to providing this service are currently being reviewed by the Public Service Commission of Wisconsin. The results of this review, which will include an assessment of the environmental impacts associated with providing the required service, will be incorporated into the Crandon Project EIS.

Without mitigation, unavoidable project impacts exist for cultural resources, land use, geology and soils, noise, private water wells, surface water quantity, wetlands, aquatic biology, and aesthetic resources. Construction of the railroad spur may impact the abandoned site of a 1910 era logging camp located near the intersection of the Wisconsin Central Limited Railroad and Keith Siding Road. During construction and operation, land use will be converted from primarily forestry to commercial mine related uses. Following reclamation the plant site will ultimately be returned to near its original use, while the TMA will be returned to use as a northern prairie environment.

Removal of the mineable ore and backfilling the mined out stopes with tailings will change the geology in the location of the orebody. This change will not have any detrimental affect on area geology, nor will it result in detrimental subsidence. As part of the construction and reclamation processes topsoil and subsoil will be excavated and relocated. Topsoil will be salvaged and used for reclamation purposes. Subsoils will be regraded at the plant site during reclamation to return this area to a form compatible with surrounding landforms. The reclaimed TMA area will resemble other land forms in the area. No long-term irreversible impacts to site soil are projected to occur as a result of the project.

During construction, noise levels will increase in areas adjoining the mine site. It is estimated that the increases will be 3 dB or less at all but the closest receptors. The current residential land use compatibility would not be changed by construction generated noise and no impacts to residential land uses are anticipated. During operations, residential locations within approximately 1 mile of the mine may notice an increase in noise levels during the periodic TMA construction phases. Most locations evaluated, however, would not experience a noticeable increase during typical plant operations.

Mine water inflow has been estimated based on a comprehensive groundwater modeling effort to be about 700 gallons per minute. This will result in predictable impacts to the groundwater system and secondary impacts to the surface water bodies and wetlands connected to the groundwater system. Direct impacts associated with groundwater drawdown include potentially lowered water levels in 12 private domestic water wells located in the vicinity of the project site. Groundwater elevations will be monitored, and if necessary, these wells will be deepened.

Secondary effects resulting from groundwater drawdown include lowered water levels and/or reduced flows in area lakes, streams and wetlands. Lake level impacts are expected to be

negligible to minor. Skunk Lake is the only lake that will experience lowered water level greater than 1 inch (6.4 inches under the BEJ scenario). A potential also exists for lowered water levels in Hoffman Springs. The remaining lakes are not estimated to experience noticeable water level reductions. Streams adjacent to the project site may also experience minor reductions in flows. With the exception of Hoffman Spring/Creek, Creek 12-9, and Upper Pickerel Creek, these reductions are estimated to be less than 10 percent and should not result in impacts to public water rights or biota inhabiting these streams. Reductions in average groundwater flow contribution to Hoffman Springs/Creek, Creek 12-9, and Upper Pickerel Creek are estimated to be less than 20 percent. Reductions in groundwater contributions to Hoffman Springs and Upper Pickerel Creek during low flows are estimated to be 25 percent or less. Estimated stream fishery impacts for all streams under average groundwater flow contribution are expected to be minimal. Under low flow conditions they are also expected to be minimal for all streams with the exception of Upper Pickerel Creek where moderate impacts are expected. Estimated impacts to stream macroinvertebrates under average groundwater flow contribution are expected to be minimal to small. Under low flow conditions these impacts are also expected to be minimal to small, with the exception of Upper Pickerel Creek where the impacts are expected to be moderate.

Groundwater drawdown will not affect the majority of the area wetlands as they are separated from the underlying aquifer. Discharge wetlands are the only wetlands substantially affected by groundwater drawdown. Generally, the impacts to discharge wetlands will only affect small portions of large wetlands and will not substantially alter the existing wetland's functional values. Groundwater drawdown effects to wetland O1, the Swamp Creek Cedars, are not easily defined. It is not certain at this time if lowered groundwater levels under wetland O1 will result in the reduction of wetland area or result in substantial changes in wetland habitat. Wetland impacts resulting from groundwater drawdown will reverse after mine operations are complete.

Direct impacts to wetlands resulting from construction total approximately 29.3 acres. These wetlands will be permanently lost. Compensation for the direct impacts is described in the project's *Section 404 Permit Application Addendum 1* (FVD, 1995b). The proposed compensation site replaces the lost wetland acreage at a 1.9 to 1.0 ratio and enhances the wetland functional values lost due to the project.

A significant portion of the area studied will experience no aquatic biologic impact during any phase of the project. The estimated loss of water in surface water resources due to changes in local groundwater levels is anticipated to result in the minor loss of some habitat. For local streams, this impact will not be significant with the possible exception of Hoffman Creek, Upper Pickerel Creek, and Creek 12-9. For local lakes, no impact is expected. While some habitat may be reduced or temporarily displaced, no major shift in biological populations is expected. Beyond the extremely local impacts, adequate habitat and species distributions occur in all directions surrounding the project site and no large-scale impact will likely occur relative to the biological populations.

Aesthetic impacts will be minor for the project. The headframe will be the most conspicuous structure and will only be visible from a few vantage points. In every case, views of the project structures will be screened by natural existing vegetation.

The socioeconomic impacts of the proposed project are expected to be beneficial to the study area and the State of Wisconsin. Construction and operations population impacts represent only 2.2 and 1.4 percent of anticipated baseline population, respectively. The average monthly direct employment during the construction period will be approximately 380 workers. Total

employment at the plant facility during operations will range between 402 and 526 workers each year. The demand for housing will increase by 1 to 3 percent over the baseline increase in demand that would be present without the project.

Local governments immediately affected by the proposed project will, in general, see significant increases in the tax base available to finance additional public services. Net proceeds taxes generated by the project are estimated to be $119.1 million. In general, 60 percent of this amount will be distributed to affected local governments (including school districts) to mitigate possible project-induced impacts. In addition, state and county sales tax revenues will increase over $3 to $4 million over the life of the project and state income tax paid by workers directly employed by CMC or its contractors would increase by $22 to $28 million over this same period.

The project is not expected to require additional public facilities or capital improvements projects. Demands on health or social service resources will experience modest increases due to the project.

The Crandon Project will not cause adverse physical, chemical or biological impacts to the lands, surface waters, groundwater supplies, air or other natural resources within neighboring Native American reservations. Nor will the project harm any plant or animal species that are the subject of off-reservation hunting, fishing, and gathering activities. Based upon studies to date, CMC is unaware of any specific Native American traditional cultural properties that will be physically harmed by Crandon Project construction or operations activities. No definitive conclusions can be reached, however, in the absence of additional data from the Tribes themselves.

Without additional information from the Tribes, it would be inappropriate to attempt to draw unilateral conclusions in this EIR about potential project impacts to the Tribes' own cultures, beliefs, and values. CMC is committed to developing the project in a way that will recognize, respect, and protect the separate sovereignty, cultures, traditions, and values of its Native American neighbors. It continues to seek to work with all interested Tribal Governments in promoting these goals.

4.3 Alternatives to the Preferred Alternative

The purpose of this section is to discuss a number of the alternatives which were considered leading to the selection of the proposed action.

4.3.1 Project Scope Alternatives

4.3.1.1 No Action

The no action alternative means that the proposed mining project will not proceed. The environmental impacts of a no action situation are essentially those impacts presently occurring, or those that would occur under the existing land use and predicted trends without mining. This alternative was discussed in Section 4.1 above.

4.3.1.2 Project Expansion or Reduction

Mine/mill production must provide a satisfactory economic return. Although an increase in production over the proposed rate is possible, a significant increase is unlikely without facility modification. An accelerated production rate could increase some of the estimated impacts, result in additional impacts that would not occur under the proposed action or advance the time in which an estimated impact will occur. Significant metal price changes could result in changes to the rate and amount of zinc and copper ore removal, as well as changes of the estimate of ore reserves.

In general, there is an optimum rate of ore removal for a given ore body. The most important factor influencing ore removal is whether the ore body can be mined by open pit surface methods versus underground methods. For an underground mine, ore body characteristics such as size, shape, orientation, maximum depth and extent, degree of weathering, ore grade and distribution influence the method of ore removal and the size of mine facilities. Expanding the size of the main shaft would require a shutdown of the operations. Increasing the number of production shafts to increase production would be expensive, would require the installation of a second crusher facility and would not optimize economic return from the mine. Moveover, the mill facilities also would have to be upgraded to allow for this increased output, otherwise there would be little benefit to this alternative.

Long-term reductions in the rate of ore removal and processing could occur under certain economic and market conditions. Short-term pauses in production can occur during a breakdown of one or more ore processing elements, transportation problems, labor disputes, or for other reasons. These possible interruptions are alleviated by surge storage areas for the ore or the concentrate (coarse ore storage building, ore concentrate storage and the preproduction ore storage pad) so that at least part of the process could continue. Fixed costs such as mine pumping and environmental protection measures would continue even if the mine were temporarily closed. A temporary reduction in operating rate would not significantly alter the environmental impacts other than extending the impacts over a longer time period and delaying final reclamation. Staffing, taxes and other socioeconomic impacts would depend on the severity and longevity of the reduced production.

The life of the mine might be extended if greater ore reserves were discovered. If this occurs, some changes in permits, such as the *Mine Permit Application* (Foth & Van Dyke, 1995d), would be necessary to account for the increased volume of tailings. Overall environmental impacts would be much the same as presently estimated, but they would extend over a longer period and the return of the area to a non-mining condition would be delayed. Significant changes in production rates or addition of ore reserves to the ore body may require permit modifications and could require additional environmental review.

An unlikely alternative is a shortened mine life due to lower than anticipated ore reserves. This is unlikely since extensive drilling and metallurgical studies have been used to define the economic ore reserves. A more likely alternative is to expand the ore reserve during the operating life of the property. Surface drilling to the lower reaches of the ore body is extremely difficult and expensive and is limited until operations begin. The customary method to fully investigate the lower ore body is to drill from underground mine openings as the mine is developed. However, CMC has conducted sufficient deep drilling to indicate that the potential for expanding ore reserves at depth is unlikely.

A variation of the shortened mine life alternative is the closure of the mine after the zinc ore phase. This could occur if the anticipated economic return on metal concentrates to be produced during the copper ore phase does not justify further operations. If the project were terminated after the zinc ore phase (approximately project year 19), the impacts would be lessened. The approximately 25 million ton copper ore body would be left intact. Approximately 130 acres of the TMA would not be developed because Tailings Management Area (TMA) cells would not have to be constructed. Of this total, about 13 acres would be wetlands. Electric power, natural gas and liquid fuel consumption would be cut by 30 to 35 percent. Noise and traffic levels would return to pre-mining conditions about 13 years earlier than if the copper ore were mined. Return of the land to forestry and recreational uses would be hastened by early mine closure. In addition to the curtailment of mining, manpower requirements would be reduced, the tax base for municipalities would decline and other potential socio-economic impacts would occur. The groundwater drawdown caused by mine inflow would be of shorter duration than if the project had continued. In addition, the amount of leachate from the TMA that would be collected and treated would be reduced by about 45 to 50 percent, because only two TMA cells would have to be built. Discharge of treated process and mine intercept waters would cease earlier.

4.3.1.3 Delay in Mine Development

Projected prices for zinc and copper could cause a delay in mine development following the Master Hearing, even if the necessary permits are issued. Depending on the length of the delay, new baseline data may have to be collected and interpreted.

4.3.2 Siting Alternatives

Regulations that affect mining in Wisconsin include locational criteria for mining-related facilities. The siting criteria include avoidance, to the extent practicable, of sensitive areas such as archaeological or historical sites, scientific areas, parks, locations within 1,000 feet of a lake or 300 feet of a river or stream, within 1,000 feet of a roadway, or within wetlands. These criteria were used in the screening of alternative locations for mining-related facilities.

4.3.2.1 Plant Site Location

To provide access to the underground mine, the mine surface facilities must be located near the orebody. Given the orientation of the deposit and the proximity of Little Sand Lake Road and Little Sand Lake, the headframe and mine surface facilities are situated in the most viable location north of the orebody. Environmental impacts of the plant site are associated with land disturbance and changes in land use. Whatever site location and layout is selected, the same or similar operational impacts will occur.

The proposed project includes processing the ore into a concentrate that will be shipped off-site to a smelter located outside of Wisconsin. An alternative approach would be to ship all ore directly from the mine to an out-of-state concentrator with minimal on-site processing. This would require the shipping of approximately 55 million tons of material in railcars. Ore shipping increases costs to a level that would result in an economically non-viable project. A variation to this option is to ship the ore off-site and dispose of the tailings out of state. This alternative is also not economically viable due to the increased shipping cost.

4.3.2.2 TMA Locations

TMA siting locations studied in the 1980s were re-evaluated as part of the current project permitting work. The 1980's siting studies were conducted in a phased manner as shown on Figure 4.3-1 and included independent third-party review. Table 4.3-1 and Figure 4.3-2 present information relating to, and the location of the areas considered in the overall evaluation. Based on the results of the reevaluation using additional data collected during 1994 and 1995, it was concluded that Area 41 is the TMA location with the least overall impact to the environment. A detailed discussion of the entire TMA siting study and alternative analysis is contained in Section 10.1 and 10.2 of the project's *Tailings Management Area Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995e).

4.3.2.3 Reclaim Pond

The reclaim pond will require approximately 8 acres. It is an integral part of the overall project water management system, including storage and treatment of water used in operating the mill, water used to transport tailings to the TMA, and some site runoff. These waters are either available for reuse in the mill or tailings slurry or are treated and discharged. The reclaim pond can be located near the TMA as was previously proposed, or on the plant site. The two optional locations are depicted on Figure 4.3-3. Locating the reclaim pond at the plant site would result in an additional 8 acres of land disturbance at that location and require the placement of high-pressure pumps within each active cell of the TMA to return water back to the plant site. Therefore, a location adjacent to the TMA was selected for this facility.

4.3.2.4 Ancillary Facilities

4.3.2.4.1 TMA Access Road/Tailings Transport Pipeline Corridor to TMA

As part of screening activities performed in the 1980s, four alternative TMA access road/tailings pipeline corridors were evaluated. The environmental consequences to wetlands and wildlife habitat of the four alternatives are summarized below. Figure 4.3-4 illustrates the various routes.

The total length of Alternative Routes 1 and 2 at approximately 3,800 feet is slightly less than Alternative Route 3, which is approximately 4,400 feet long. Alternative Routes 2, 3 and 4 would cause a direct disturbance to, and partial filling of, wetland F11, a coniferous swamp which drains into F10 and ultimately into Little Sand Lake. Alternative Route 1 would cross wetland F116. Alternative Route 4 is the longest, approximately 4,700 feet, of all routes considered. It would reduce new disturbance of wetland F11 since it would use a portion of Sand Lake Road and thus cross wetland F11 at a narrower section.

Both Alternative Routes 2 and 3 would be located in the watershed of F11. This would increase the discharge to F11 slightly because of increased surface water runoff as a result of the TMA access road outward slopes. Alternative Route 4 would primarily be located in the watershed of wetland F11, but part of the route would follow the watershed divide between F11 and F10. However, given the small area that would be affected with any of the alternatives compared to the size of F11, the effect on biological functions would be minimal.

Table 4.3-1

Characteristics of Potential TMA Areas

Site Number	Distance from Mine (miles)	Total Area Evaluated (acres)	Estimated Storage Capacity yd^3 (million)
1	1.4	300	12
2	2.8	350	22
3	2.1	250	4
4	2.0	600	15
5	1.2	200	4
6	2.4	500	19
7	5.9	650	10
8	4.8	650	22
9	6.0	250	10
10	3.6	350	13
11	4.1	150	7
12	5.0	200	7
13	5.9	600	7
14	7.1	300	10
15	6.4	100	1
16	6.3	350	9
17	6.4	250	5
18	7.6	250	4
19	7.2	500	15
20	3.9	450	8
21	2.2	200	1
22	4.2	300	7
23	7.4	450	15
24	6.1	600	20
25	3.5	200	4
26	6.4	200	5

Table 4.3-1 *(Continued)*

Site Number	Distance from Mine (miles)	Total Area Evaluated (acres)	Estimated Storage Capacity yd^3 (million)
27	5.2	200	22
30	2.3	600	22
31	3.9	1,000	22
32	6.6	650	22
33	6.8	500	22
34	8.1	650	22
40	1.3	650	22
41	1.6	650	22
42	3.6	650	22

Source: WDNR; 1986

Prepared by: TJW
Checked by: GWS

Alternative Route 4 would have an additional public road traffic loading impact in that it parallels, for a short distance, the existing Sand Lake Road. During certain phases of the project life, haul trucks will be required to transport waste rock or construction material to and from the plant facility and the TMA. Also, the existing road corridor would have to be widened to accommodate the TMA access road adjacent to the new area cleared for Sand Lake Road. Alternative Route 4 would also disturb wetland F11 as the TMA access road splits from its parallel run with Little Sand Lake Road.

During 1994 and 1995 Alternative Routes 1 and 2 were reevaluated for use as the TMA access road/tailings pipeline route. Based on the reevaluation the updated routes shown in Figure 4.3-5 were developed.

The total length of the 1995 version of the Alternative Route 1 corridor is approximately 4,700 feet. This route would not cause a direct disturbance to wetland F11 but would result in a 135-foot separation distance to Skunk Lake. Alternative Route 1 was not chosen as the preferred alternative because of its close proximity to Skunk Lake.

Another alternative route was evaluated during the previous siting activities performed in the 1980s. This route entirely avoided wetlands by paralleling Alternative Route 4 except Little Sand Lake Road was followed for an additional 700 feet. The route then ran 1,200 feet northeast to rejoin Alternative Route 4. Since this route would require relocating approximately 1,150 feet of Little Sand Lake Road, it was eliminated from further consideration.

The preferred 1995 TMA access road/pipeline corridor is a modified version of Alternative Route 2 with a total length of approximately 4,900 feet. As shown on Figure 4.3-5 this route was adjusted slightly from the original Alternative Route 2 to minimize the disturbance of wetland F11. A slight change in the route was also required to allow the proper intersection with the TMA at its revised location.

The total wetland disturbance for the 1995 route is estimated to be 0.47 acres. The total wetland disturbance for the four routes evaluated in the 1980s ranged from 0.07 to 0.63 acres depending on the route.

Two alternatives were evaluated for draindown basin No. 4 located along the TMA access road/pipeline corridor. The first involved constructing the basin with a composite liner consisting of compacted low permeability soil overlain by a flexible membrane liner. The second involved constructing the basin using concrete. It was determined that either alternative provided the same degree of environmental protection. The composite liner alternative was chosen due to operational considerations.

4.3.2.4.2 Railroad Spur

The wetland and wildlife impacts of various alternative railroad spur routes evaluated prior to 1994 are summarized below. Alternative routes are shown on Figure 4.3-6.

None of the alternatives would result in a significant decrease in wetland area or biological function resulting from project construction and operation. The preferred choice is Alternative Route D.

Alternative Route A would be approximately 2.4 miles long from the Wisconsin Central Limited Railroad mainline to the plant perimeter, some 0.3 miles shorter than Route D, the proposed route. Alternative Route A would require the filling of approximately 6.3 acres of wetlands, which is twice the 3.05 acres required by Route D. Alternative A would cross Swamp Creek three times, thereby requiring much more land disturbance in and around Swamp Creek during construction than Route D which would cross Swamp Creek twice.

Alternative Route A would cross wetlands 01, T2 and T4. Wetland T4 is one of the more valuable wetlands in the study area (NAI and IEP, Inc., 1982). Alternative A would cross this wetland twice and would parallel Swamp Creek in some areas and be perpendicular to it in others, therefore requiring a more extensive system of bridges and culverts to maintain existing surface water flow characteristics in the wetlands. Alternative A would cross two sections of wetland T4, whereas the proposed route would cross three narrower sections of wetland T4.

Alternative Route B would be approximately 2.4 miles long from the Wisconsin Central Limited Railroad mainline to the plant site perimeter, which is 0.3 miles shorter than the proposed route. Alternative Route B would require the filling of approximately 4.8 acres of wetlands, which is approximately 1.7 acres more than the proposed route.

Alternative Route C avoids the Swamp Creek wetlands but would cross several perched wetlands, including wetland F12, a shallow marsh surrounded by burr oak. Alternative Route C would be located within 720 feet of Skunk Lake and would require crossing Hemlock Creek and cutting through a high ridge, an engineering disadvantage. This route would pass along the south edge

of the wetland-spring pond complex located west of the intersection with the Wisconsin Central Limited Railroad mainline track. This alternative route would follow the higher ground south of the wetland and would infringe on the boundary of the wetland-spring complex bordering Hemlock Creek. Total wetland area that would be taken by Alternative Route C is approximately 7.1 acres versus approximately 3.05 acres for the preferred alternative.

Alternative Routes E and F share a common corridor between the Wisconsin Central Limited Railroad mainline track and a point approximately 320 feet south of the Swamp Creek crossing. Alternative Route E would parallel Swamp Creek for approximately one mile from the interface point with Alternative Route D to the southwest portion of Section 19 prior to changing alignment in a southerly direction to the plant site. Alternative Route E would have a greater effect on the Swamp Creek deeryard and wetlands than all other alternatives except Alternative Route A. The total wetland area that would be taken by this alternative is approximately 5.6 acres.

Alternative Route F would connect to the Wisconsin Central Limited Railroad mainline at the same point as Alternative Route D and would extend west approximately 1.1 miles before turning south toward the plant site. Alternative Route F would be approximately 740 feet longer than the proposed route and would cross both Outlet and Swamp creeks. Alternative Route F would take approximately 5.4 acres of wetlands.

During recent siting evaluations the railroad spur routes were reevaluated and Alternative Route D was again identified as the preferable route. The updated railroad spur route is shown in Figure 4.3-7. Based on modifications made to the plant site, efforts made to minimize disturbance to small wetlands east of the plant site and to avoid wetland 01, the railroad spur was shifted slightly to the south and east from the 1980s alignment. Also, the southern spur of the railroad at the intersection with the Wisconsin Central Limited Railroad line was eliminated to avoid wetland T2 and the Keith Siding archaeological site.

4.3.2.4.3 Access Road

The environmental impacts to wetlands, wildlife, habitat and safety for the various alternative access road routes identified and evaluated prior to 1994 are summarized below. Alternative access road routes are shown on Figure 4.3-8.

Access road Alternative Route A-1 would be approximately 2.5 miles in length, approximately 0.4 miles shorter than the proposed route, resulting in a slight decrease in runoff from the pavement to Swamp Creek. However, Alternative Route A-1 would require filling approximately 6.9 acres of wetlands compared to 3.2 acres for the proposed route (Figure 4.3-8). Alternative Route A-1 crosses wetlands W1 and W2, whereas the proposed route crosses narrow sections of W1, W2, Z6, Z7 and Z9. Wetlands W1 and W2 had high scores for functional values (NAI and IEP, Inc., 1982), whereas wetlands Z6, Z7, and Z9 have lower scores (IEP, Inc., 1983). Crossing a large section of wetland area, Alternative Route A-1 would have a greater potential hydrologic impact to the watershed functions (NAI and IEP, Inc., 1982) than would crossing small sections.

Alternative Route E would follow the existing route of Sand Lake Road from STH 55 to the plant site. The road would require widening and paving, and thus would cause minor additional disturbance (0.98 acres) to the wetlands adjacent to the existing road. No new crossing of Swamp Creek would be required and there would, therefore, be no hydrologic alterations of

associated wetlands. Alternative Route E would direct all mine related traffic through the Mole Lake Reservation and would increase traffic over 60 percent in a residential area which includes the Mole Lake Reservation, as compared to the traffic flow generated by Alternative Route A-1. Therefore, Alternative Route E is the least preferred alternate route for the access road.

Based on the results of previous alternatives analysis and the additional evaluations in 1994 and 1995, Alternative Route B-1 was chosen as the preferred alternative due to the lower impact to traffic in the Mole Lake Reservation and less wetland impact than the other remaining alternatives. Figure 4.3-9 shows the proposed access road route which results in the least impact.

4.3.3 TMA and Reclaim Pond Design Alternatives

TMA design alternatives were evaluated as part of the project's *Tailings Management Area Feasibility Report/Plan of Operation* (Foth & Van Dyke, 1995e). Based on the results of the design alternatives evaluation, the TMA preferred design was established. Section 10 of the TMA report presents design alternatives to control oxidation rates and alternatives for major design components and operational components.

Reclaim pond design alternatives were evaluated considering size, liner system, pumping system, and solids removal methods. The evaluation resulted in the selection of design features established to satisfy flow equalization, removal of suspended solids and a liner meeting the requirements of Subchapter II of NR 213, Wis. Admin. Code. Details regarding the reclaim pond design are contained in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995h).

4.3.4 Wetland Compensation Alternatives

As presented in Section 8.1 of the project's *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995b), an alternative analysis for the wetland compensation site was performed which evaluated both on-site and off-site alternatives.

4.3.5 Construction and Operation Alternatives

This section provides a description of major structural and operational alternatives to those proposed for the project in the *Mine Permit Application* (Foth & Van Dyke, 1995d). Alternative mining, mine water control, mine backfill and ore processing methods are described below. In addition, descriptions are provided for waste rock transport alternatives; and alternatives for storage of preproduction ore and concentrate, tailings transport systems, tailings disposal, water management systems, sanitary waste treatment, and mine air heating and energy conservation.

4.3.5.1 Mining Methods

The primary criteria for selection of a mining method are the size, shape, ore grade, rock strengths, and location of the deposit. On this basis, the Crandon deposit can be characterized as a large tabular ore body of average grade, near vertically oriented in a host of predominantly competent volcanic rocks, overlain by a thick mantle of partially saturated glacial overburden, situated in an environmentally sensitive lake, wetland and forest natural resource area.

Mining method alternatives considered included open pit, underground, and combination mine plans. It was concluded at an early phase of project evaluation that open pit mining at the mine site would be impractical, uneconomical and environmentally unacceptable. Extensive site dewatering would be required for pit development. Large volumes of overburden and waste rock would be generated for surface disposal. Nearby surface waters and wetland resources would limit pit expanse and thus depth and resource recovery. Finally, pit and waste stockpile reclamation approaching pre-mining site conditions would be extremely difficult.

The underground mining method selected for primary recovery of the Crandon ore body is mechanized sublevel blasthole open stoping with delayed backfill of depleted stopes. It is a highly efficient method for mining steeply dipping deposits in competent ground with techniques for drilling, blasting, and haulage similar to those of surface mines. A cost effective method like this is required for economic viability since the deposit is of only average grade. No alternative mining method is applicable on a broad scale. The only planned method variation is reduction of stope dimensions for recovery of weakened but enriched weathered zones beneath the ore body crown pillar. In these areas shrinkage blasthole stoping and horizontal cut and fill methods will be practiced where these less efficient methods can remain profitable.

4.3.5.2 Mine Water Control

Hydrologic studies for mine design have indicated that groundwater from the glacial overburden aquifer will seep into the mine at an average rate of about 600 gallons per minute. For mine facility design purposes the mine inflow quantity has been based on the practical worst case assumption of 1,200 gallons per minute. The proposed plan is to intercept as much groundwater inflow as possible prior to any contact with mining facilities. The normal mine drainage and the intercepted groundwater inflow will be separately collected, pumped to the surface, treated as required, and discharged or reused. Alternatives to the proposed action include reduction of inflow by pumping down the glacial aquifer above the mine, aquifer flow restriction methods such as selective placement of grout, slurry trenching and vertical grout curtains, and natural uncontrolled groundwater inflow throughout the mine.

Potential mine inflow control techniques were investigated by Klohn Leonoff (1982). This study included a review of technically applicable groundwater control methods and a comparison of their site specific feasibility, including relative effectiveness and cost. The discussion of mine inflow control techniques presented below is based on the results presented in the Klohn Leonoff report which are still applicable today.

Surface pumping of the glacial aquifer would reduce the water in the overburden aquifer available for influx into the mine. This technique has the advantage that groundwater is intercepted prior to the mine facilities and is, therefore, potentially suitable for surface discharge with minimal treatment. With this technique, however, larger volumes of water would be discharged than in the proposed method.

The results of Klohn Leonoff's investigation indicated that overburden pumping atop the ore body might moderately reduce inflow. Generally, more than twice as much groundwater would have to be evacuated from the glacial overburden above the mine area to create a dry area above the mine. However, on a very localized basis involving only a few wells, overburden aquifer pumping may be applicable if a small and particularly active subcrop water course is identified. In such a case, groundwater could be pumped to provide local aquifer desaturation. Well field

discharge could be directed to surface waters if it meets discharge standards, to the wastewater treatment plant facilities, or a soil absorption system exterior to the locally pumped area of impact. Groundwater displaced by a segregated program of this type should maintain its existing quality. Potential environmental ramifications of using this alternative include recharge of aquifers, maintenance of water supply wells, preservation of wetland hydrology in the area of impact, and protection of major surface water drainage patterns.

General aquifer flow restriction methods would be impractical at the Crandon site because of the extensive overburden depth. However, underground rock grouting may be used to reduce and redirect localized water inflows.

Another alternative is to capture all of the natural inflow to the mine in the mine drainage water sump system and pump it to the wastewater treatment plant for subsequent discharge or use. The uncontrolled inflow up to the design maximum would not greatly affect mining methods or general mine conditions. Furthermore, the ability to intercept ambient groundwater is related to the rate of natural inflow. As lower inflow rates are experienced, it will become increasingly difficult and less practical to attempt segregation, collection and pumping of non-contact groundwater. Should steady state inflow rates drop below about 300 gallons per minute, it may be prudent to allow all groundwater seepage to flow to the normal mine drainage sumps.

Finally, numerous conservative assumptions have been incorporated into the project's regional groundwater modeling work. Based on these assumptions, the project's water balance for minimum conditions shows it is possible that very little discharge (<80 gpm) of treated project wastewaters could occur. It is also possible that actual mining conditions could result in less inflow than the conservative modeling has estimated even under minimum conditions. In this event, it is possible that the mine inflow rate could be insufficient to meet the water makeup needs for the project's process requirements. If this condition were to occur, a single well or a series of wells screened in the overburden over the ore body could be installed to provide the needed water. The capacity of this system would be approximately 200 gpm. Impacts associated with this water development plan, if needed, would be less than those projected for the BEJ mine inflow case as discussed in Section 4.2 above.

4.3.5.3 Mine Backfill

The proposed mine backfill will consist primarily of the coarse fraction of the mill tailings. Coarse tailings will be recovered by cyclones at a size fraction exhibiting free drainage characteristics when placed uncemented in depleted mine slopes. Cement will be added to about 60 percent of the total backfill placed in the mine to add stability so that the column of fill will stand unsupported. Based on metallurgical lab tests, coarse tailings will be available to meet backfill demand. However, backfill will also be supplemented with coarse waste rock from development headings underground.

A potential future alternative backfill preparation concept is to leave all or most of the fines in the backfill slurry and reduce its water content. Such a fill would be paste-like in consistency and would be pumped or "extruded" into the stopes. When placed at a 70 to 80 percent solids density, as opposed to 60-70 percent for conventional backfill, the material would require a minimum of water drainage by percolation and/or decantation. Potential advantages of high density backfilling are:

- Increase in backfill strength, both cemented and especially uncemented.
- Increase in the quality of available fill.
- Reduction in backfill drainage and mine pumping requirements.

All three of these effects would benefit project operations.

The two main obstacles to implementation of the high density paste backfill alternative is the lack of wide industrial experience and a lack of site specific tailings for design calculations. This technology could be incorporated into the project after proper testing. Implementing this change would likely require only a relatively minor retrofit of equipment in the backfill preparation plant. The progress of high density backfill research and development will be monitored with ultimate use depending on engineering, economic and environmental considerations at the time.

4.3.5.4 Process Alternatives

The proposed process for treating both types of Crandon ore is similar to processes which are commercially proven and accepted in the industry. The proposed process will include grinding and flotation circuits and was developed by extensive bench scale and pilot plant testing. A semi-autogenous grinding and ball mill grinding circuit will be used to liberate valuable mineral particles from the gangue (waste) minerals. Flotation circuits will selectively separate and concentrate the zinc, copper and lead minerals into three concentrate products. Once the basic process was developed for treating the ore, further testing and pilot scale studies led to process simplification and a reduction in the number of reagents required for the flotation process.

4.3.5.4.1 Pyrite Flotation

Pyrite (FeS_2) flotation was evaluated as an additional step to the proposed concentration process, not as a replacement alternative. It was evaluated from a technical and economic standpoint prior to finalizing the design for the proposed flotation process. In this step, the final zinc tailings would be subjected to additional flotation to produce a pyrite concentrate and low pyrite tailings. The pyrite tailings would be treated in the backfill preparation plant separately to recover the coarse fraction for use as mine backfill. Depending on available markets, the pyrite concentrate may also be processed at the backfill plant to recover the coarse fraction for use as backfill.

The pyrite concentrate would be stored as a separate waste product, marketed, or processed further to recover sulfur, iron and minor nonferrous metals, if economical. To determine the viability of marketing and/or further processing, a study was done in 1981 (Davy McKee, 1981) to determine if pyrite could be marketed in its basic form, and, if not, whether marketable products could be made using proven technology. Capital and operating cost estimates were developed to determine whether the processing of pyrite was economically viable. In 1995, an updated evaluation was conducted by Market Access International (1995). As a result of these study efforts, the following conclusions were reached:

Market Access International completed a report titled "Crandon Project Pyrite Marketing Update" in April, 1995 (See Appendix Q of the *Tailings Management Area Feasibility Report/Plan of Operation* [Foth & Van Dyke, 1995e]). This report considered information presented in the 1981 Davy McKee Pyrite study as well as the 1984, Trevino critique (Trevino, 1984), and the 1986 Coefield update (Coefield, 1986). This re-examination of current market conditions

focused on the most viable products identified in earlier studies consisting of sulfuric acid, iron pellets, and diammonium phosphate. It also reviewed earlier marginal product alternatives in view of the time lapse since the initial work. The evaluation considered both processing and marketing of the pyrite fines and the total pyrite expected to be generated.

It was found that the conclusions of earlier studies remain valid with regard to the lack of viable markets for pyrite concentrates, elemental sulfur, liquid sulfur dioxide, phosphoric acid, and byproduct gypsum. The pertinent microeconomic market conditions for sulfuric acid from by-product pyrites have improved from the time of the original work, and the viability of marketing this product improves if it could be processed at the Crandon plant site rather than a remote processing center. This option would require construction of a plant and installation of a roaster and wet gas cleaner to produce sulfuric acid.

Capital cost for on-site production of sulfuric acid and a by-product iron pellet plant were estimated at $169 million (1980 dollars) in the Davy McKee (1981) report. The Gross National Production Implicit Price Deflator was applied to this estimate, resulting in a capital cost to construct this plant of approximately $320 million in 1994 dollars.

Generally, the environmental impacts of on-site pyrite processing would:

- Include more land disturbance to locate the roaster, wet gas cleaner, and sulfuric acid and pelletizing plant, including more potential for wetland disturbance.
- Include the new facility being classified as a major air emitter.
- Not eliminate waste disposal needs (e.g., potentially reactive slag, gypsum, etc., would remain).
- Increase railroad and highway traffic to transfer raw materials and waste products to market or disposal sites.

Based on the environmental impacts and capital cost requirements, on-site pyrite processing and sulfuric acid production are not considered to be viable options and have been eliminated from further consideration as a part of this project.

4.3.5.4.2 Other Process Alternatives

The 1980s project EIR (1985a) presented an evaluation of other process alternatives. A review of the processing alternative still applicable is presented below.

In the recovery of copper minerals from zinc ore, sodium cyanide in combination with zinc sulfate and lime is used to control and prevent the activation and premature flotation of zinc materials which would otherwise be a contaminant in the copper-lead bulk product. It also serves to depress the flotation of pyrite. Sodium cyanide is added to the process as a zinc cyanide complex (Zn[CN]4=) which is formed in a mixture of sodium cyanide, zinc sulfate and lime. Sodium cyanide is not required in the treatment of the copper ore which is planned to be mined beginning in approximately project year 19 of operation.

Researchers have been attempting to develop alternatives to sodium cyanide as a depressant or as a component of a depressant scheme. During the development of the process for treating the Crandon Project zinc ore, many alternatives to sodium cyanide were investigated, none of which were sufficiently effective. During operations, CMC will continue to evaluate alternatives.

Sodium sulfite (Na_2SO_3) and sodium sulfate (Na_2S) were investigated as replacements for the sodium cyanide-zinc sulfate mixture. The combination of sodium cyanide-zinc sulfate allows for higher recovery of copper and lead, while keeping the amounts of pyrite and sphalerite in the copper-lead rougher scavenger concentrate at a minimum.

4.3.5.5 Waste Rock Transport

The proposed waste rock transport system at the plant site will use trucks to move waste rock generated during initial mine development about 0.5 miles from the mine shaft to the production ore storage area on the north side of the plant site.

A conveyor system was considered as an alternative to the proposed truck transfer system. Factors which were considered in the evaluation of a conveyor system for waste rock transport included:

- Waste rock volume.
- Waste rock size.
- Maintenance requirements.
- Loading and handling.
- Economic sensitivity.

Waste rock will be produced in high volumes during the initial years of pre-production of mine development, ranging up to about 3,000 tons per day, but will more typically be only several hundred tons per day over most of the operating mine life. Trucks can more readily accommodate this range, while a conveyor would need to be sized for the higher volumes and then would be significantly oversized for most of the mine life.

The waste rock produced during the first 3 years of development will be about minus 24 inches in size. The remainder, over the life of the mine, will be about minus 8 inches in size. Trucks can easily handle this change in material size, while conveyors would need to be designed for the larger size material.

At the preproduction ore storage pad, truck dumping will allow flexibility. Conveyors would have to be moved periodically or another means of handling the rock included.

4.3.5.6 Storage of Preproduction Ore and Concentrate

4.3.5.6.1 Preproduction Ore Storage

The proposed preproduction ore storage pad will have the capacity to accommodate in excess of about 450,000 tons of rock. This storage pad will be located immediately north of the plant site. The pad will be 8 acres in area. Details of the design are outlined in Section 4.8.5.9 of the project's *Mine Permit Application* (Foth & Van Dyke, 1995d).

The ore and waste rock will be hauled to the pad in trucks and will be reclaimed using a front-end loader. The total haul distance from the discharge near the headframe to the storage pad is approximately 0.5 mile.

The northern portion of the TMA is an alternative site for the temporary storage of preproduction ore. However, the haul distance to this area (approximately 1.5 miles) is longer than to the proposed storage area, and its use for storage of preproduction ore would interfere with the development of the TMA. The longer haul would also contribute to increased noise and air emissions at the TMA and increase development within the Duck Lake watershed.

4.3.5.6.2 Concentrate Storage

Under normal operating procedures direct loadout of concentrates to railcars located on parallel tracks immediately north of the mill building is proposed. The anticipated availability of railcars is such that only limited storage space for concentrates has been provided. Should normal operation of the railroad be interrupted, approximately 2 days' production of zinc concentrate, 5 days' production of copper concentrate, and 19 days' production of lead concentrate can be accommodated in concrete bunkers directly below the filters. If an extended suspension of rail service should occur, plant operations would have to be discontinued or an alternative location would be required for the storage of additional concentrates.

An alternate contingency storage location would be to use the preproduction ore storage pad. Concentrates would be placed in three individual stockpiles separated sufficiently to avoid intermixing. Assuming a 15-foot wide roadway is maintained between the stockpiles and an angle of repose of 30°, three concentrate stockpiles, each holding approximately 66,000 tons, could be placed in the preproduction ore storage area. This would accommodate in excess of 188 days of mill concentrate production.

As with any contingency measure, the duration of possible concentrate storage on the preproduction ore storage pad cannot be accurately estimated. However, assuming concentrate shipments had to be curtailed and concentrates temporarily stored at this site, the length of storage time would be kept to a minimum. Stored quantities of concentrates would be shipped within approximately two to three months after normal shipping operations resumed. The concentrate would be reclaimed from temporary storage with front-end loaders and conveyors loading into railcars.

While stored on this lined pad, measures would be taken to prevent wind or water erosion of the concentrates. The piles would be stabilized to restrict dusting by covering with synthetic materials, foam or self-sealing cover materials such as "Concover" which is a finely-ground paper that would be sprayed onto the piles. The method of stabilization would be dependant on the size of the concentrate pile, expected duration of storage, and the availability of cover material.

Proposed water control facilities associated with the preproduction ore storage pad involves capturing runoff and directing it into the surface drainage basin located adjacent to the pad. The permanent pump that is installed at this location will then transfer any collected water to the concentrator for the reuse.

Because the preproduction ore storage pad will be a relatively secure site designed to minimize impacts to the environment, it will be maintained by grading the compacted surface. Other potential uses for this pad could include equipment staging or other temporary uses.

4.3.5.7 Tailings Transport System

The proposed tailings transport system consists of either one or two high density polyethylene (HDPE) pipelines located on the surface of a lined trench. Alternatives consist of installing the pipelines below the land surface or using a utilidor on the surface. A discussion of tailings transport system alternatives is presented in Sections 10.9.2 and 10.9.3 of the project's *Tailings Management Area Feasibility Report/Plan or Operation* (Foth & Van Dyke, 1995e). As presented within that report, the proposed HDPE piping and lined ditch provides the most effective containment and easier inspection of the available alternatives.

4.3.5.8 Wastewater Treatment System

Wastewater treatment system alternatives and discharge location alternatives are discussed in the project's *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995h). As presented in that report, the proposed treatment method and discharge location results in the least overall environmental impact.

4.3.5.9 Wastewater Treatment Solids Management

4.3.5.9.1 Temporary Management of Lime Precipitation Solids

The wastewater treatment plant is scheduled for completion in month 19 of construction. However, the first tailings cell would not be ready for use until month 35. Therefore, a storage area for wastewater treatment solids will be required between months 19 and 35. The following four alternative facilities were evaluated for use in storing wastewater treatment solids.

- A separate composite clay and geomembrane-lined holding pond.
- A temporary holding tank.
- A temporary diked area within water storage basin 6.
- Temporary storage in water storage basin 6.

Because of the low projected mine inflow during months 19 through 35, it is expected that all of the mine drainage for this period can be contained in one cell of the wastewater storage pond. The water treatment facility will be operated for performance testing during this period, but current projections indicate that water will not have to be routinely treated for discharge. The solids, which are produced from either water treatment plant shake-down testing or from treatment of relatively small volumes of water for discharge, will be temporarily stored in wastewater storage basin 6. The solids would be dredged out and placed in the TMA following completion of TMA cell construction. The proposed disposal of wastewater treatment solids in the TMA will be less costly than the other alternatives and will not require any additional land disturbance.

4.3.5.9.2 Long-Term Management of Lime Precipitation Solids

Lime precipitation solids produced by the wastewater treatment facility will be placed in the TMA with the mill tailings. Alternative disposal methods include the development of a separate solids disposal site, or the use of an off-site landfill licensed to accept this material. Either of these latter two options would require placement in a landfill designed with a liner and leachate collection system. The on-site landfill option would involve additional land disturbance, additional monitoring and additional long term care. The use of an off-site landfill would involve transportation and consume space at that facility. Both of these alternatives would increase impacts as well as project costs. Placement of the solids in the TMA would provide secure disposal, take little space and make the calcium carbonate portion of the solids available to assist in pH control.

4.3.5.9.3 Solid Waste Management

Solid waste management alternatives evaluated previously included on-site disposal and off-site commercial collection and disposal. Due to the low volume of waste produced and the significant permitting and construction costs associated with development of a small on-site landfill for nonrecyclable wastes, as well as the additional environmental impacts of such a facility, CMC has eliminated the on-site disposal alternative. As a result, disposal of all refuse and waste will be at an off-site facility. Recyclable materials will be separated and processed by the waste hauler.

4.3.5.9.4 Mine Air Heating and Energy Conservation

During the winter months at the Crandon Project site, it will be necessary to heat a portion of the fresh air entering the mine to provide tempered air to the working environment. Air in the downcast shaft will be maintained at approximately 40°F.

Three major methods for supplying the required air stream heat were evaluated.

- Direct-fired air heaters in which the heat and gaseous products of combustion mix directly with the air stream passing through the heater.
- Direct-fired heat exchangers in which the combustion is contained and the heat transferred to the air stream by contact with the combustion chamber surfaces.
- Indirect heat exchangers in which the air stream is heated by passing coils containing a circulating fluid warmed by a remote heat source.

Direct-fired natural gas air heaters have been selected for principal mine air heating service at the Crandon Project. The advantages of such a system include:

- Excellent control of temperature and energy consumption over a wide range of intake air temperatures; turn-down ratio ranges from 45:1 to 5:1 maximum.
- Higher efficiency, approximately 90 percent, and thus lower energy costs.
- Simple construction requiring minimum maintenance.

- Lower first cost for the size of units required.

A design day minimum temperature of -25°F was selected based on weather data from Laona, Wisconsin, for the period December 1966 through February 1976. The maximum operating period mine ventilation volume will be approximately 700,000 cubic feet per minute. About 70 M BTU/hour will be required to adequately heat the mine intake air on a design day. Air heating equipment utilization will vary widely, not only with temperature, but with the dynamics of required mine ventilation quantities during different periods of mine operation.

During the course of project design, several sources of supplemental heat with possible application for intake air heating have been identified. These included:

- Mine exhaust air expected to exit at an average temperature of approximately 55°F.
- Mine drainage water expected to exit the mine at average temperatures of 50-60°F.
- Waste heat from mine/plant air compressor cooling.
- Waste heat from the on-site electrical generators.

At some underground mines, it has been practical to capture such waste heat sources for secondary use. The Crandon mine plan has not incorporated these sources into the current design, but has recognized their potential application to developing mine operations. A study by Bovay Engineering, Inc. (1977) identified four systems for mine exhaust air heat exchange, including recirculating glycol methods, a refrigeration type cycle, and a direct air to air plate-type exchanger. The study also included an evaluation of heat recovery from groundwater pumped through coils in the intake air shaft.

The Crandon Project, however, will not have some of the special features that have allowed supplemental waste heat usage to be practical and effective at other mines. For example, it has been estimated (S.A. Scott & Company, 1978) that the exhaust air streams might theoretically contain up to 30 percent of the heat required for intake air heating. However, the exhaust air raises are at distances of 1,000 to 3,500 feet from the air intake shaft, limiting the potential efficiency and practicality of a waste heat transfer system (recirculating glycol-coil exchange type). Exhaust air to intake air heat exchange is, of course, most likely feasible when the intake and exhaust air openings are adjacent to one another on the surface.

Water pumped from the Crandon mine will contain some potentially recoverable heat; however, use of this heat must be evaluated in consideration of the desired wastewater treatment plant entry temperature. Supplemental heat recovery systems at other mines have been most successful where mine water temperatures are considerably higher (90°F) than those expected at Crandon (50°F).

The waste heat from mine/plant compressor cooling and on-site electrical generators may have the best potential for supplemental waste heat recovery, but, again, are located some distance from the air intake shaft. Waste heat recovery from these sources may be considered during final engineering.

4.3.6 Surface Plant Energy Conservation

Based on an average minimum design day temperature of -14°F, most surface facilities will require heating during the winter months. Peak demand has been estimated to be approximately

9 M BTU/hr. Only the compressor plant will be self-heating during winter and will, as mentioned in the previous subsection, also be a source of potentially recoverable waste heat. Final engineering evaluation of this excess heat source may show it more practically used to supplement nearby surface facility heating demands than converted for mine intake air heating use. Potential surface uses might include heating of the pump house or main shaft collar house.

The plant final design will incorporate energy management as a primary objective toward cost effective project operation. Identified waste heat sources will be re-examined for feasibility and used for supplemental heating where practicable. Northern Wisconsin's climatological conditions are such that there are no current plans to include industrial scale solar techniques as a part of final mine/plant design.

4.3.6.1 Energy Sources

4.3.6.1.1 Fossil Fuels

The major use of heating fuel for the project is the mine air heating system during the winter months. An average yearly usage of 73,324 thousand standard cubic feet of natural gas is required to meet this load. In addition to natural gas, propane and #2 distillate were evaluated as alternatives.

Both propane and #2 distillate would require a minimum of 5 days' storage on-site, about 350,000 gallons of propane or 250,000 gallons of #2 distillate. The railcar traffic required to service the tanks during the extreme winter months would be greater than that needed for concentrate shipment.

The alternative fuels are not as efficient as natural gas and would require additional land disturbance. The permit for a #2 distillate installation might be difficult to obtain; with the NO_x emissions, in particular, being very close to allowable limits for an indirect fired fuel heater.

While propane is only about 5 percent less efficient than natural gas for mine heating, the need to store approximately 350,000 gallons of propane on the site and operate an evaporator and expansion tank makes it less desirable than natural gas. In addition, using propane would require unloading about two to three tank cars a day. The risk of a problem during the unloading process, while minimal, would still be present.

Use of propane as a fuel for mobile vehicles was evaluated as an alternative to gasoline or diesel fuel. However, most of the mobile equipment to be used for the project is located underground. MSHA regulations (Title 30 CFR Part 55 and 57) require the underground equipment to be electric or diesel driven and fitted with a exhaust gas control system. With the exception of light trucks and three to five automobiles, few surface equipment items can use propane fuel. Propane use would be less than 125 gallons per day equivalent of gasoline. This change would not affect overall air emissions, would not alter the area's air quality or provide a problem in meeting standards.

In addition to the above energy alternatives, heating some of the buildings with wood-fired heaters or boilers has been considered. Currently, the alternative of heating with wood is not being pursued; however, it could become viable in the future depending on the costs and availability of other fuels.

4.3.6.1.2 Electrical

The use of a lower voltage power line (69kV versus 115 kV) was addressed in the Crandon Mine Electric Transmission Line Application (Wisconsin Public Service Corporation, 1995). The CPCN Application indicates that the 69 kV alternative would cost approximately 32 percent more than the 115 kV project. The major difference in costs for the 69 kV power line is the requirement to add a 115 kV/69 transformer at the Venus substation.

The use of self-generation was considered for some or all of the operating load requirements. However, it was not considered viable from economic or environmental standpoints. The need for process steam is minimal (i.e., building heating) and, therefore, a cogeneration steam system with waste heat recovery is not practical. Environmental impacts associated with NO_x and TSP concentrations from a plant fired with coal or wood chips also would have to be considered. There also would be potential environmental impacts from fly ash disposal facilities.

4.4 Bibliography

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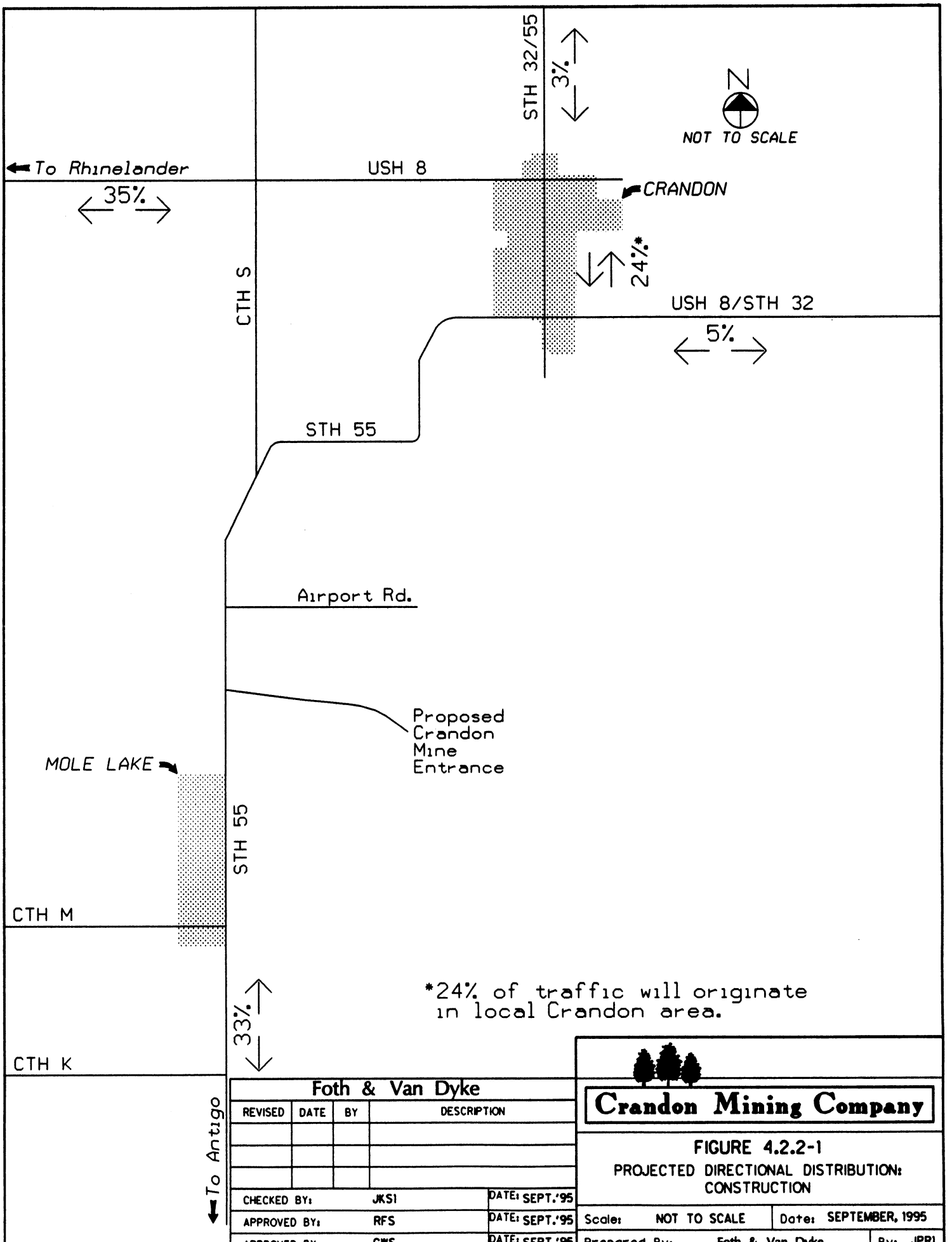
FIGURES FOR SECTION 4



Foth & Van Dyke

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CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-1

PROJECTED DIRECTIONAL DISTRIBUTION: CONSTRUCTION

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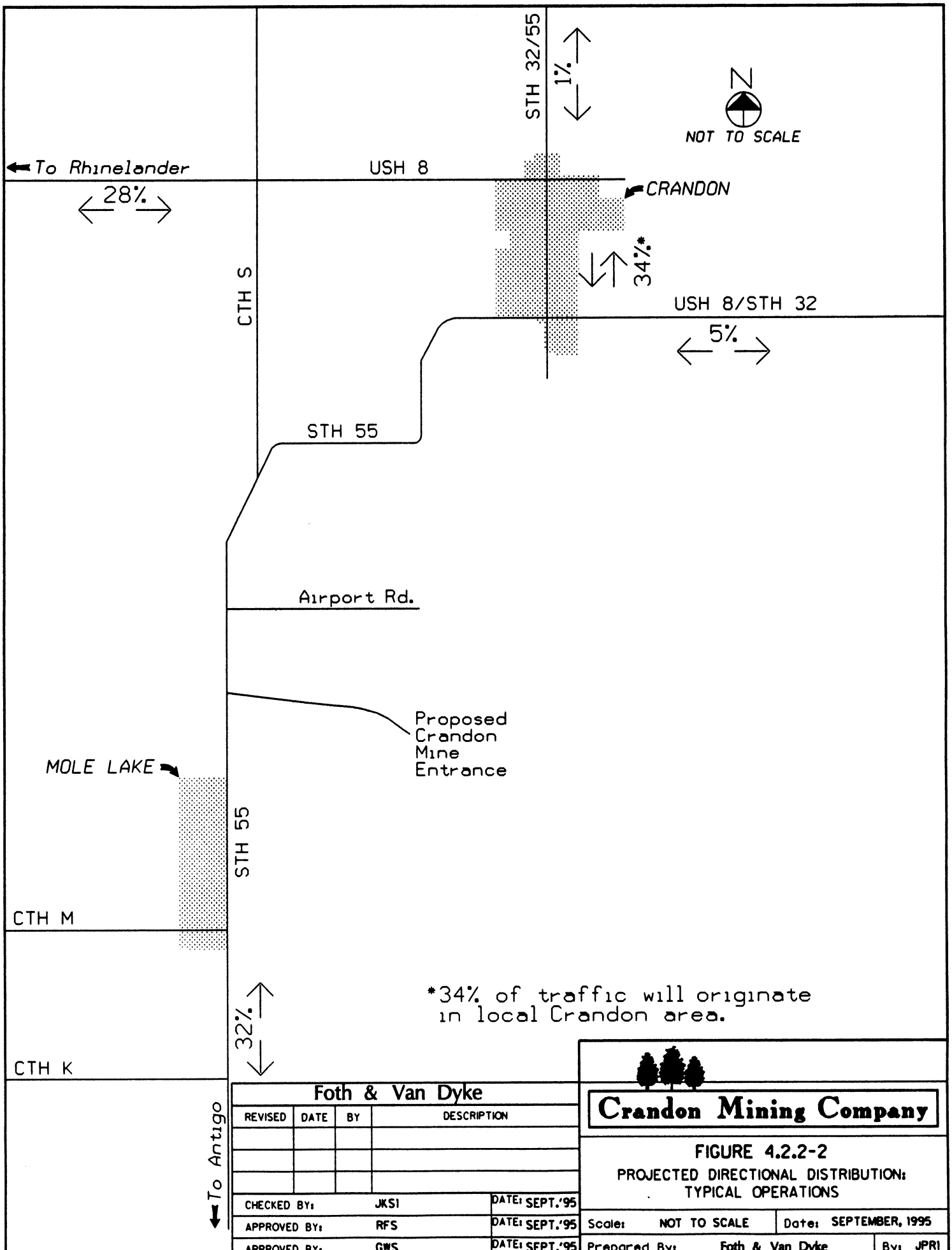

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APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-2

PROJECTED DIRECTIONAL DISTRIBUTION:
TYPICAL OPERATIONS

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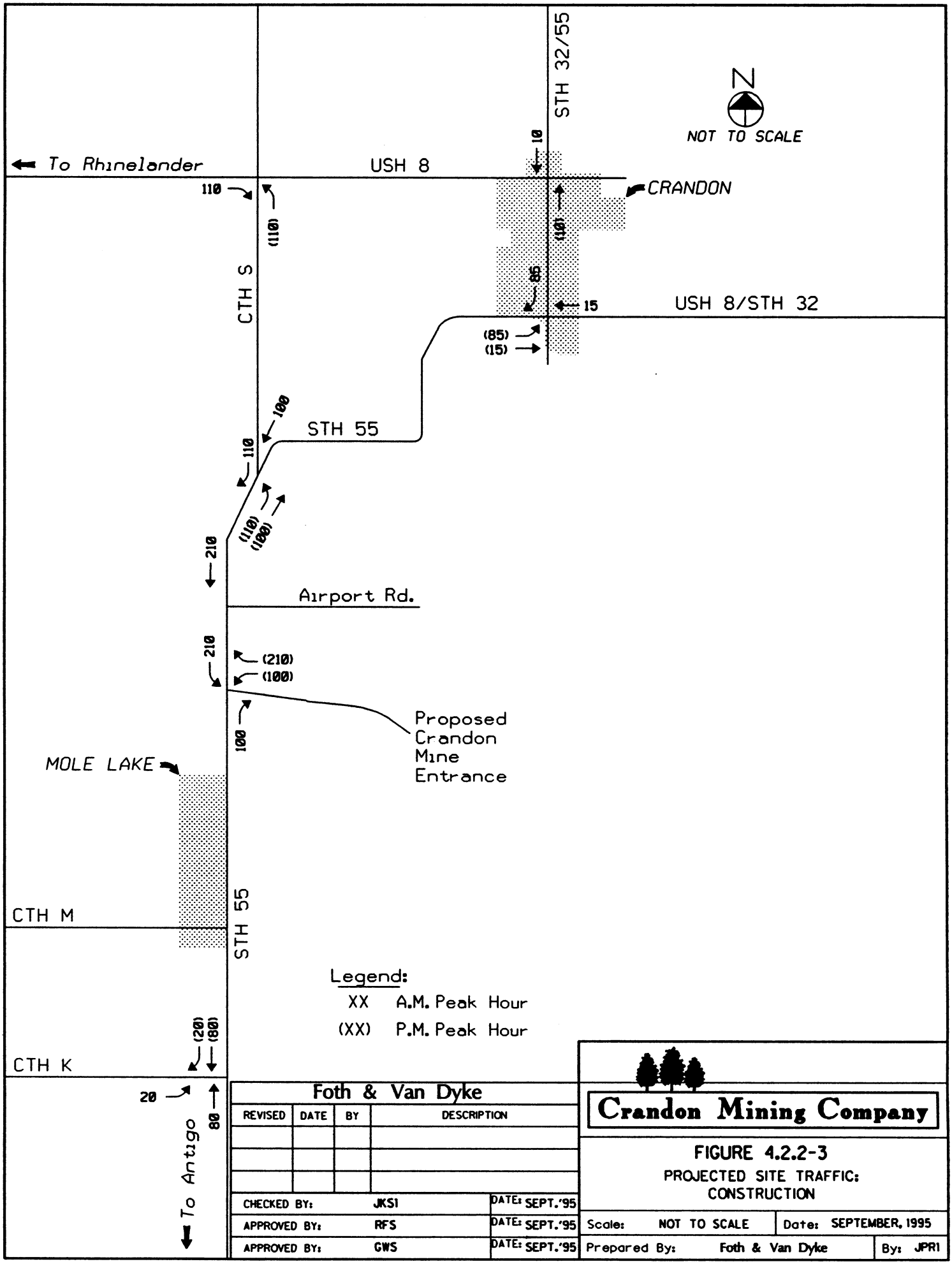

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CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-3

PROJECTED SITE TRAFFIC:
CONSTRUCTION

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
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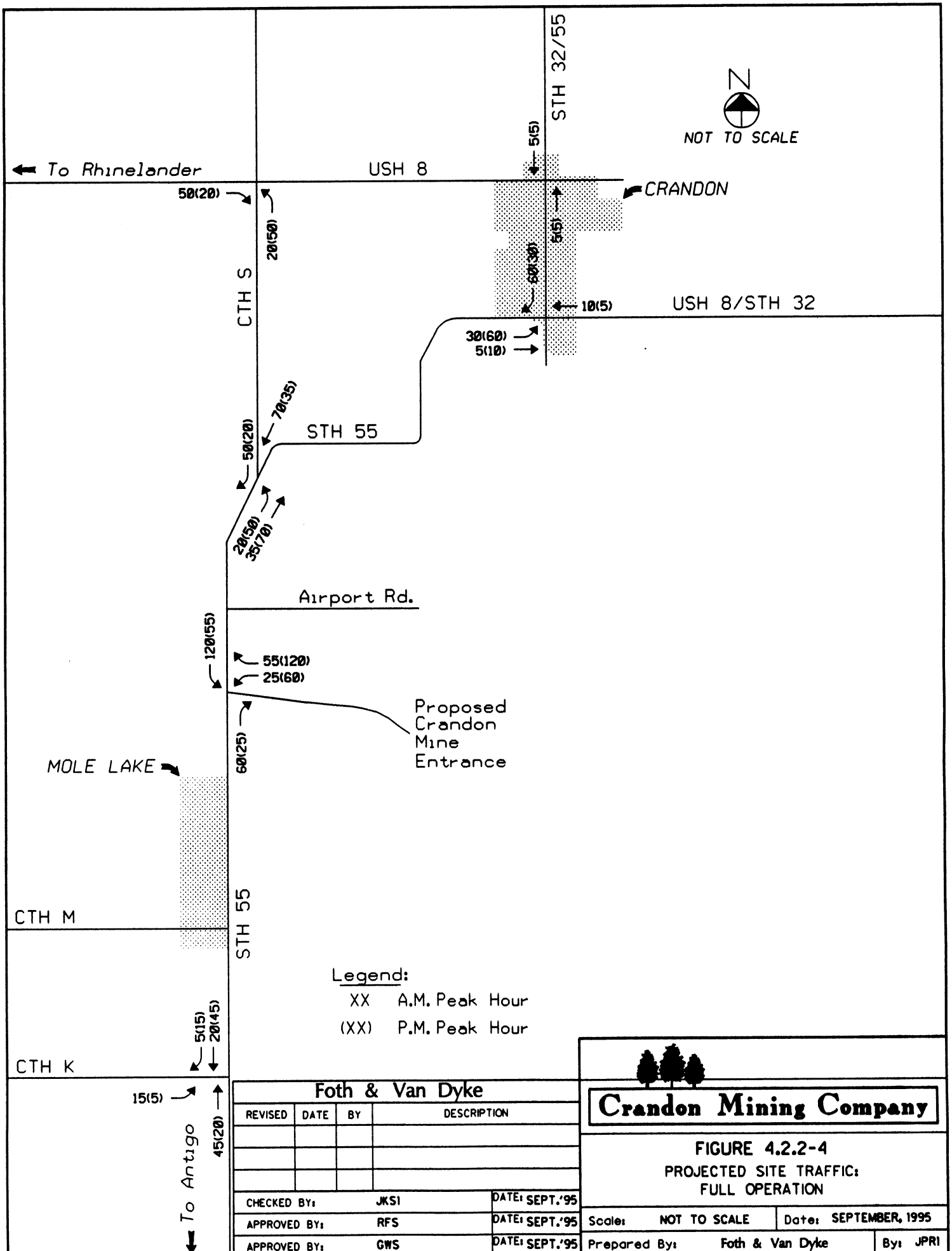

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CHECKED BY: JKSI			DATE: SEPT.'95
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APPROVED BY: GWS			DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-4

PROJECTED SITE TRAFFIC:
FULL OPERATION

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
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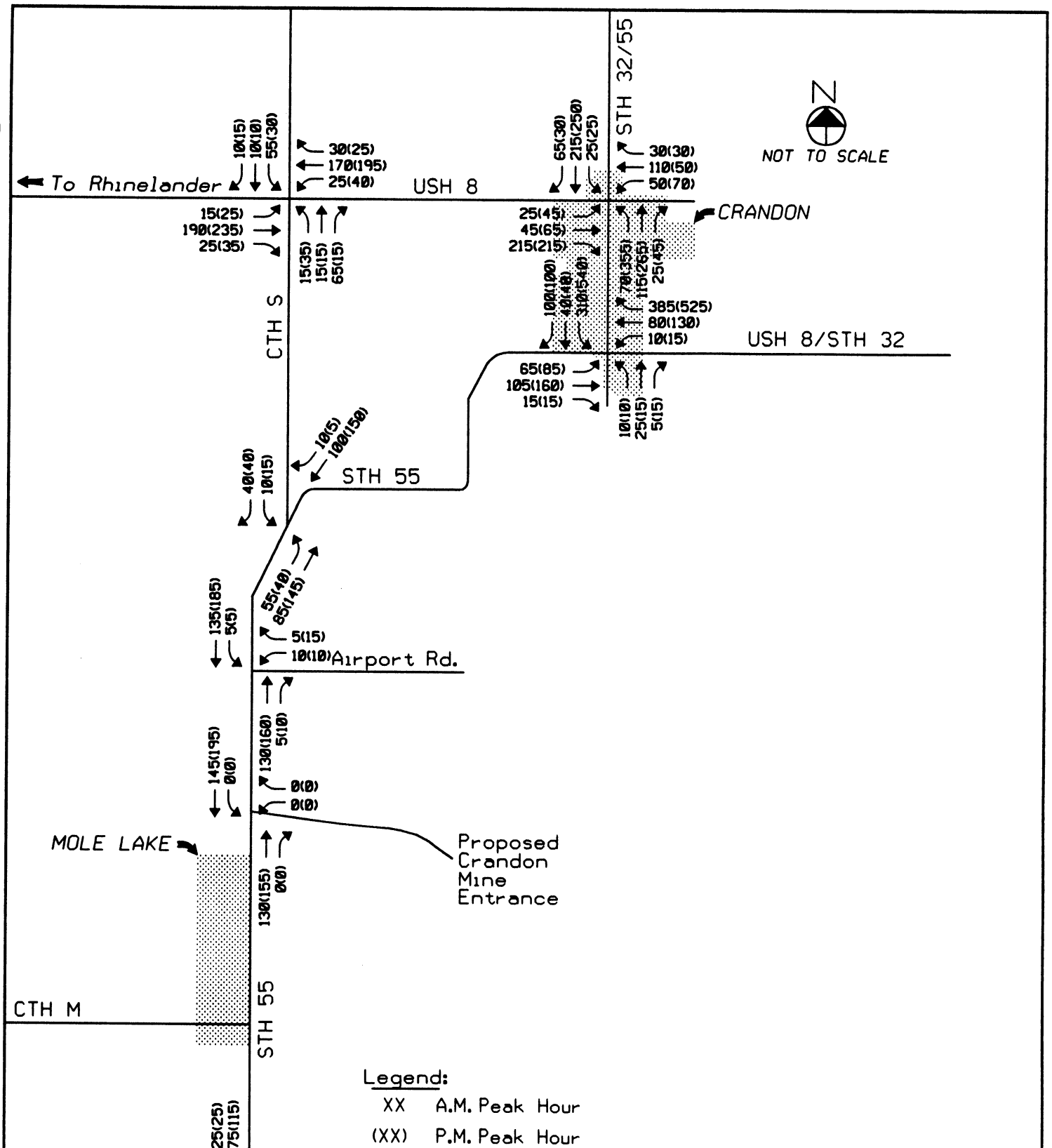

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY: JKSI			DATE: SEPT.'95
APPROVED BY: RFS			DATE: SEPT.'95
APPROVED BY: GWS			DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-5
PROJECTED FUTURE NO-MINE TRAFFIC 2001

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

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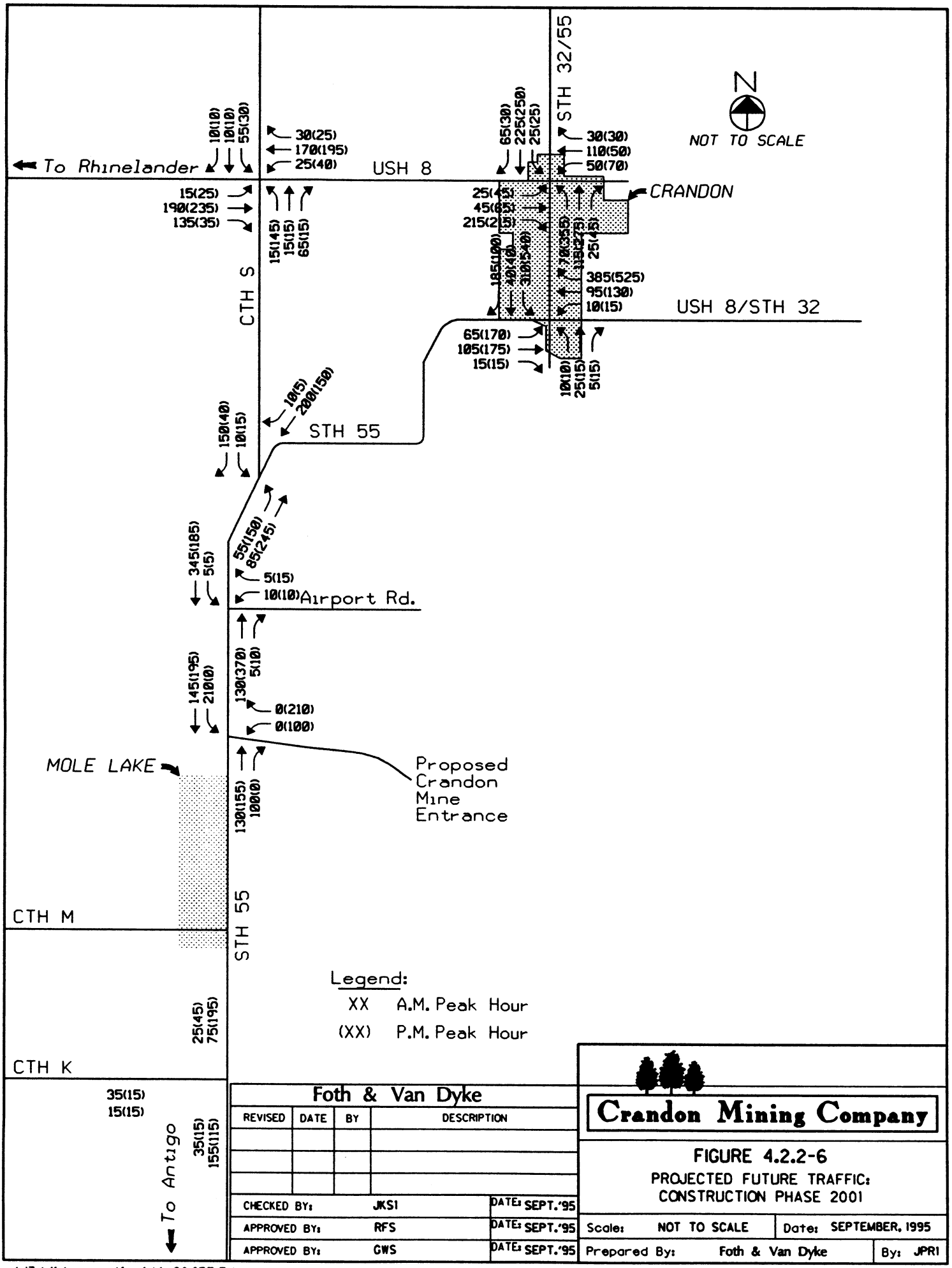
93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	JKS1	DATE: SEPT.'95	
APPROVED BY:	RFS	DATE: SEPT.'95	
APPROVED BY:	GWS	DATE: SEPT.'95	

Crandon Mining Company

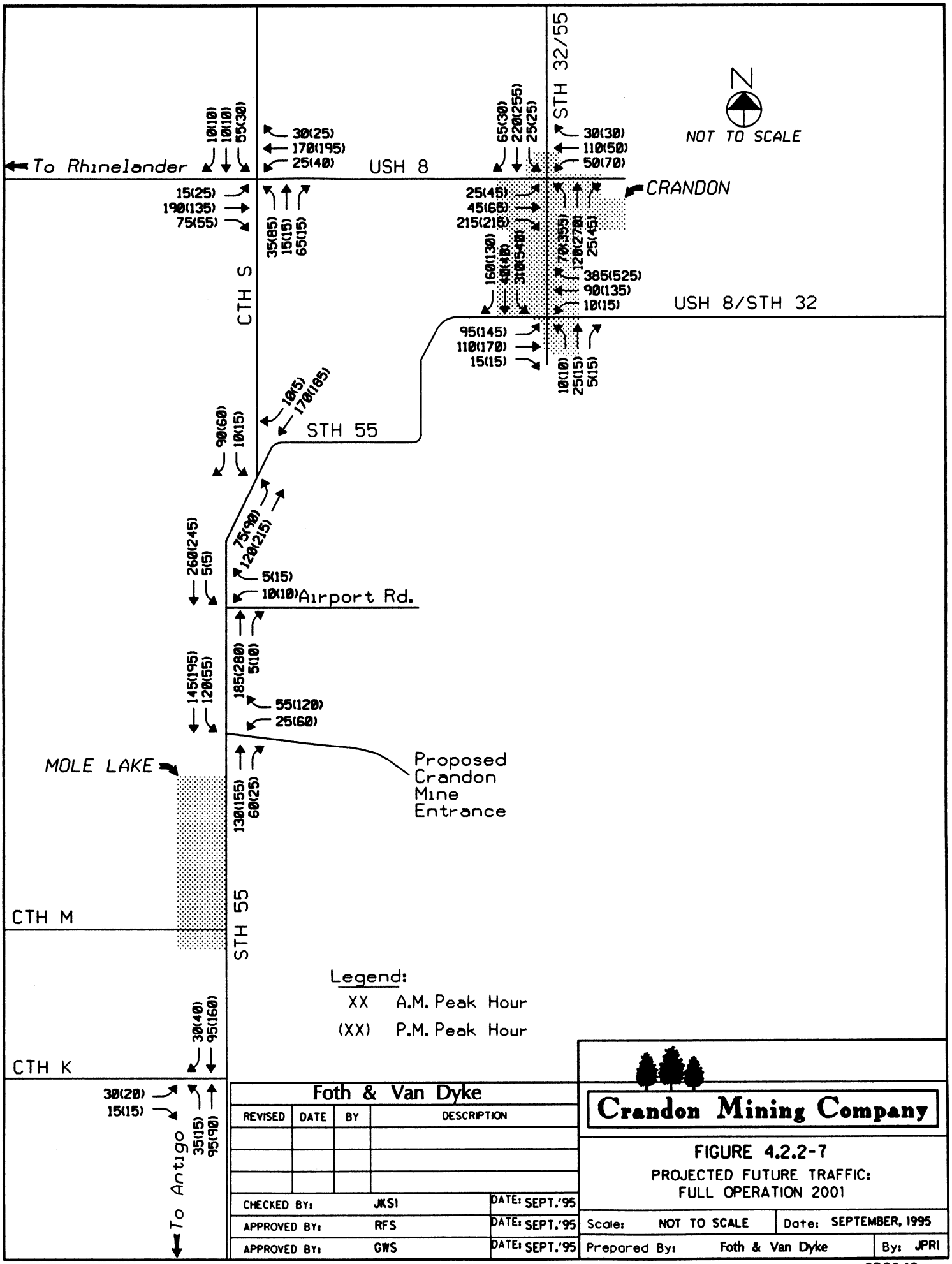
FIGURE 4.2.2-6

PROJECTED FUTURE TRAFFIC:
CONSTRUCTION PHASE 2001

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR1

/d3/dl/users/jpr1/4c60f37.3d

93C049



Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

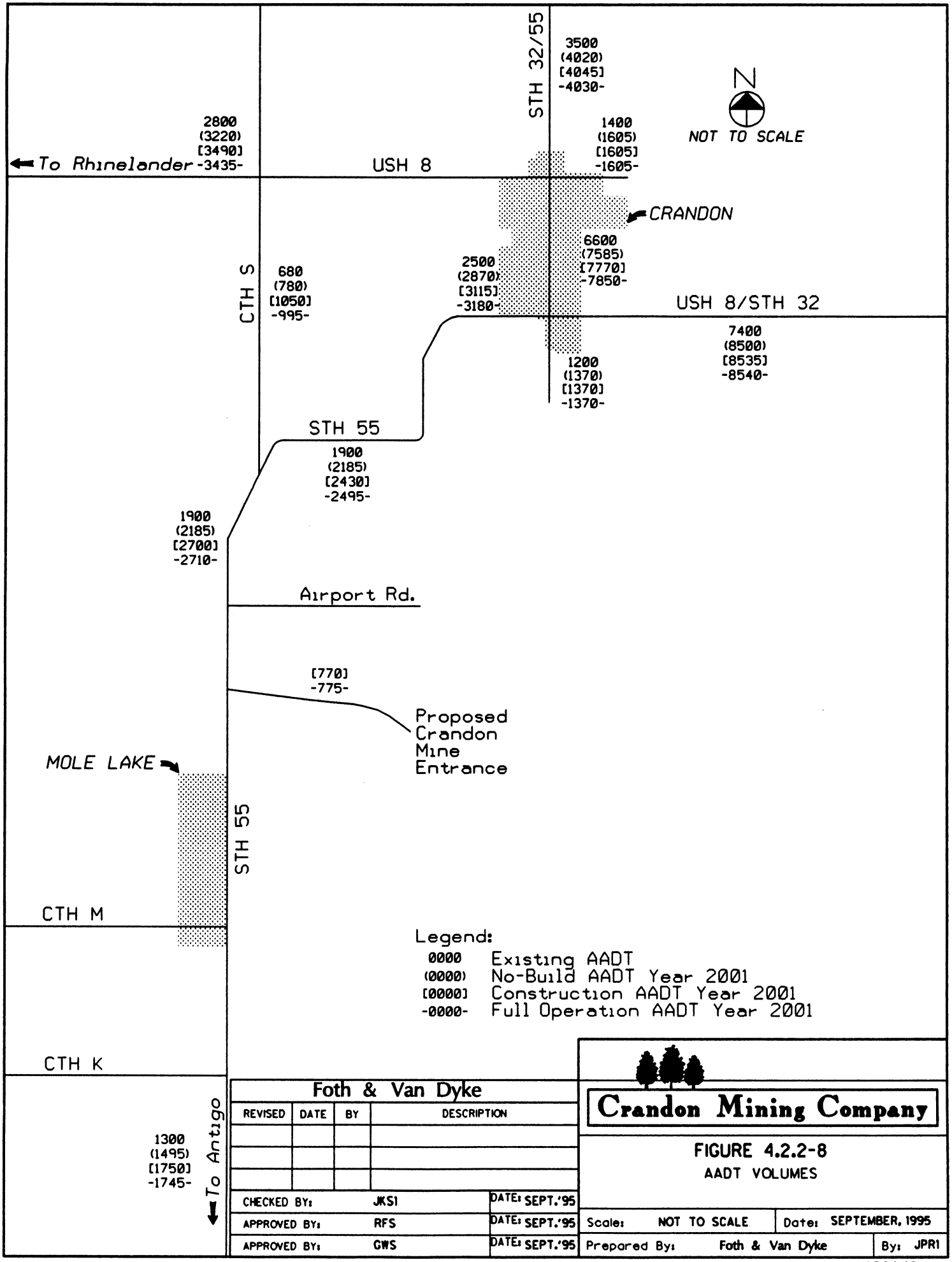
FIGURE 4.2.2-7

PROJECTED FUTURE TRAFFIC:
FULL OPERATION 2001

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

/d3/dl/users/jpr1/4c60f38.3d

93C049



Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.2-8
AADT VOLUMES

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPR1

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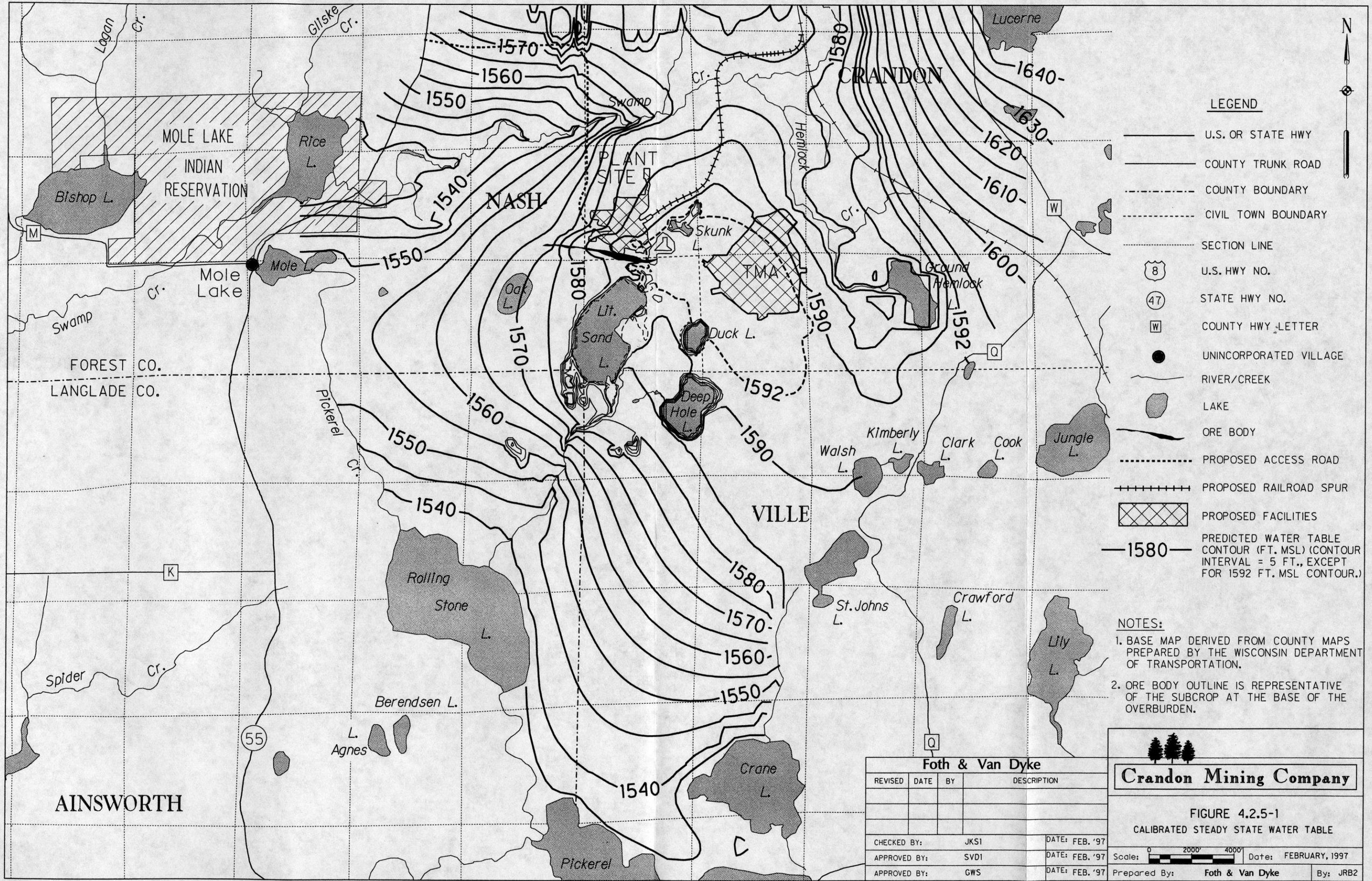
93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	GWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-1

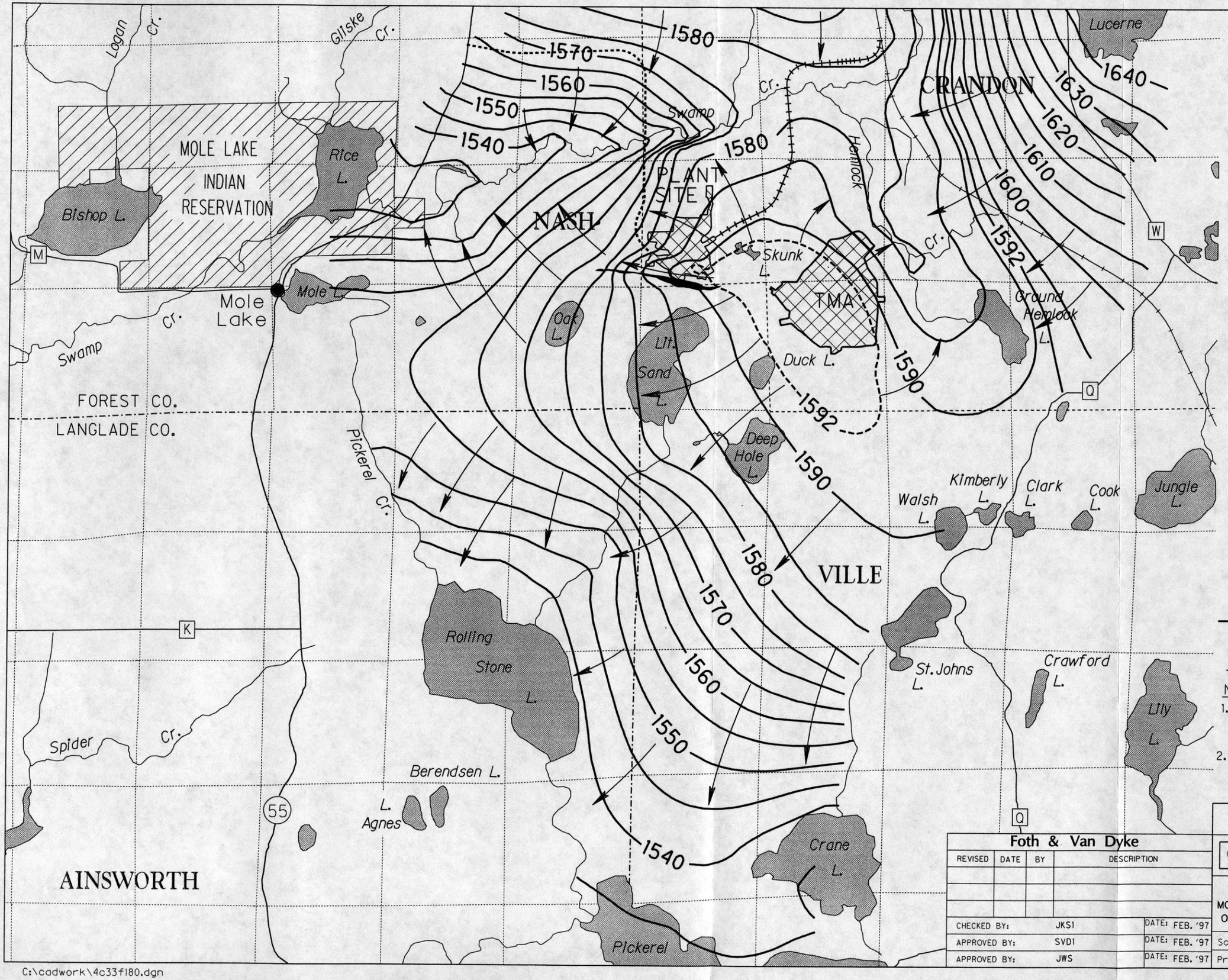
CALIBRATED STEADY STATE WATER TABLE

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

C:\cadwork\4c33f188.dgn

93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-2

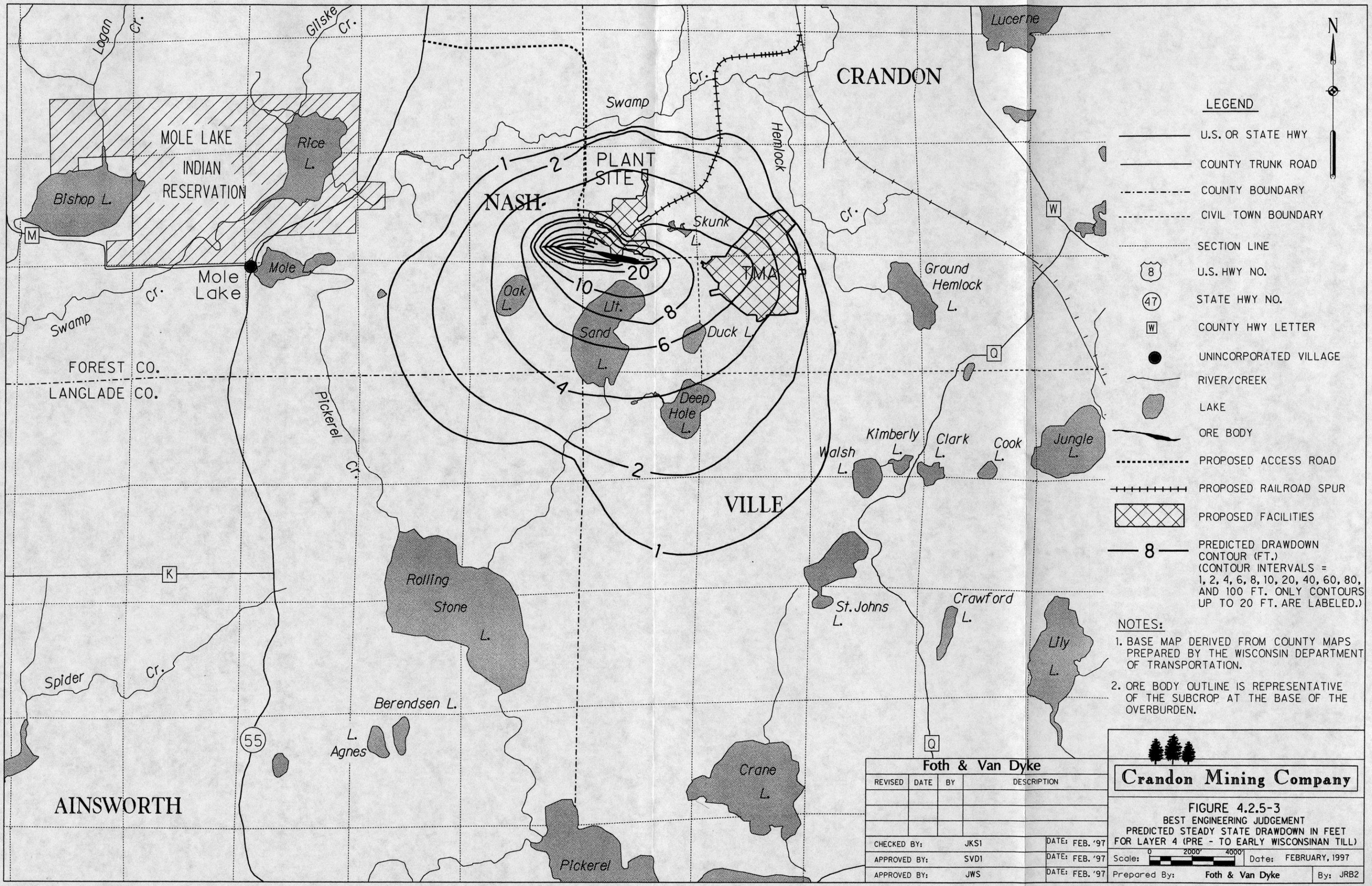
MODELED STEADY STATE POTENTIOMETRIC SURFACE OF LAYER 4 (PRE - TO EARLY WISCONSINAN TILL)

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

C:\cadwork\4c33f180.dgn

93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

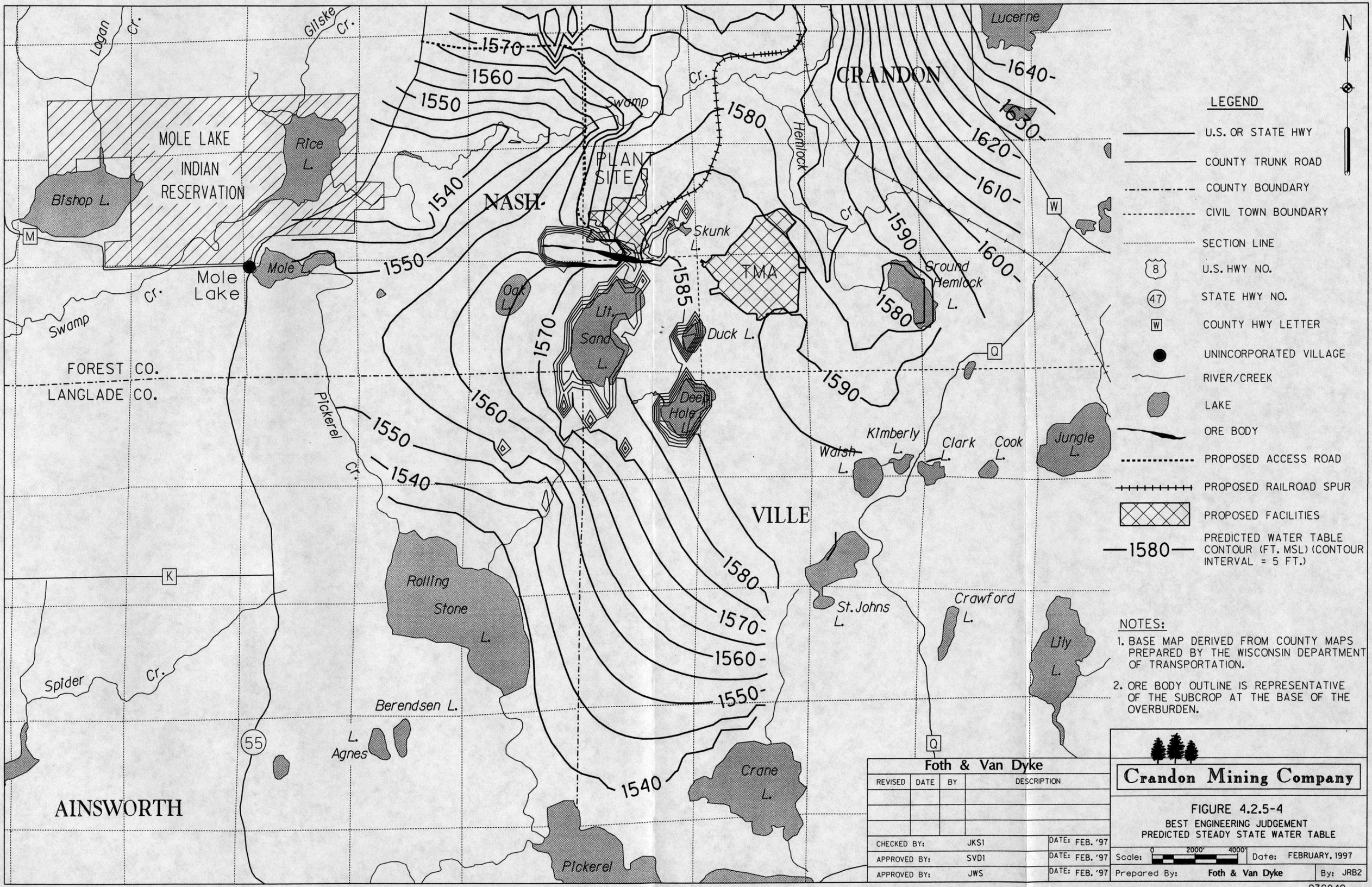
FIGURE 4.2.5-3
BEST ENGINEERING JUDGEMENT
PREDICTED STEADY STATE DRAWDOWN IN FEET
FOR LAYER 4 (PRE - TO EARLY WISCONSINAN TILL)

Scale: 0 2000' 4000' | Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke | By: JRB2

C:\cadwork\4c33f182.dgn

93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	JKS1	DATE: FEB. '97	
APPROVED BY:	SVD1	DATE: FEB. '97	
APPROVED BY:	JWS	DATE: FEB. '97	

Crandon Mining Company

FIGURE 4.2.5-4

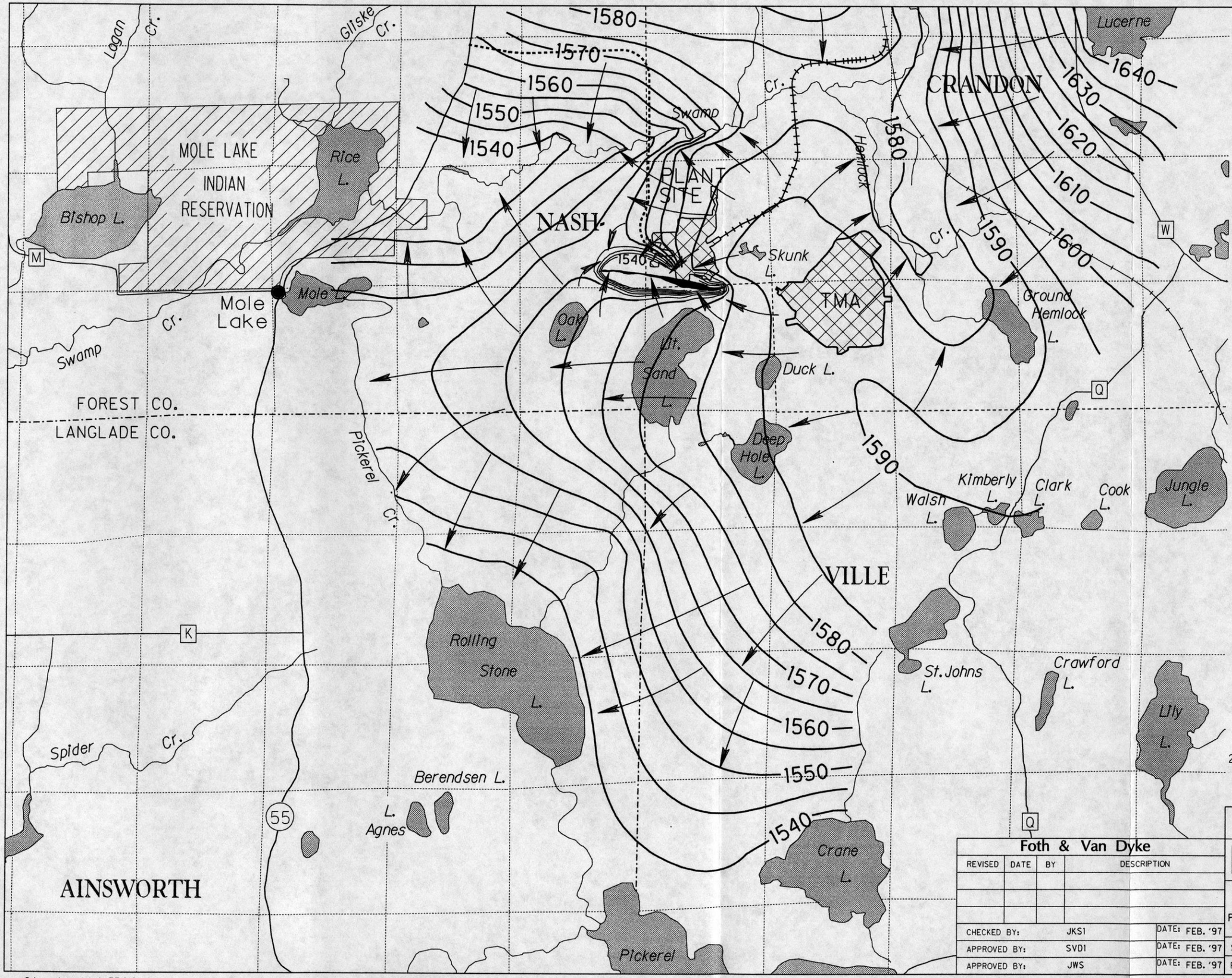
BEST ENGINEERING JUDGEMENT
PREDICTED STEADY STATE WATER TABLE

Scale: 0 2000' 4000' | Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke | By: JRB2

93C049

C:\cadwork\4c33f189.dgn



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-5
BEST ENGINEERING JUDGEMENT
PREDICTED STEADY STATE POTENTIOMETRIC SURFACE OF LAYER 4 (PRE - TO EARLY WISCONSINAN TILL)

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

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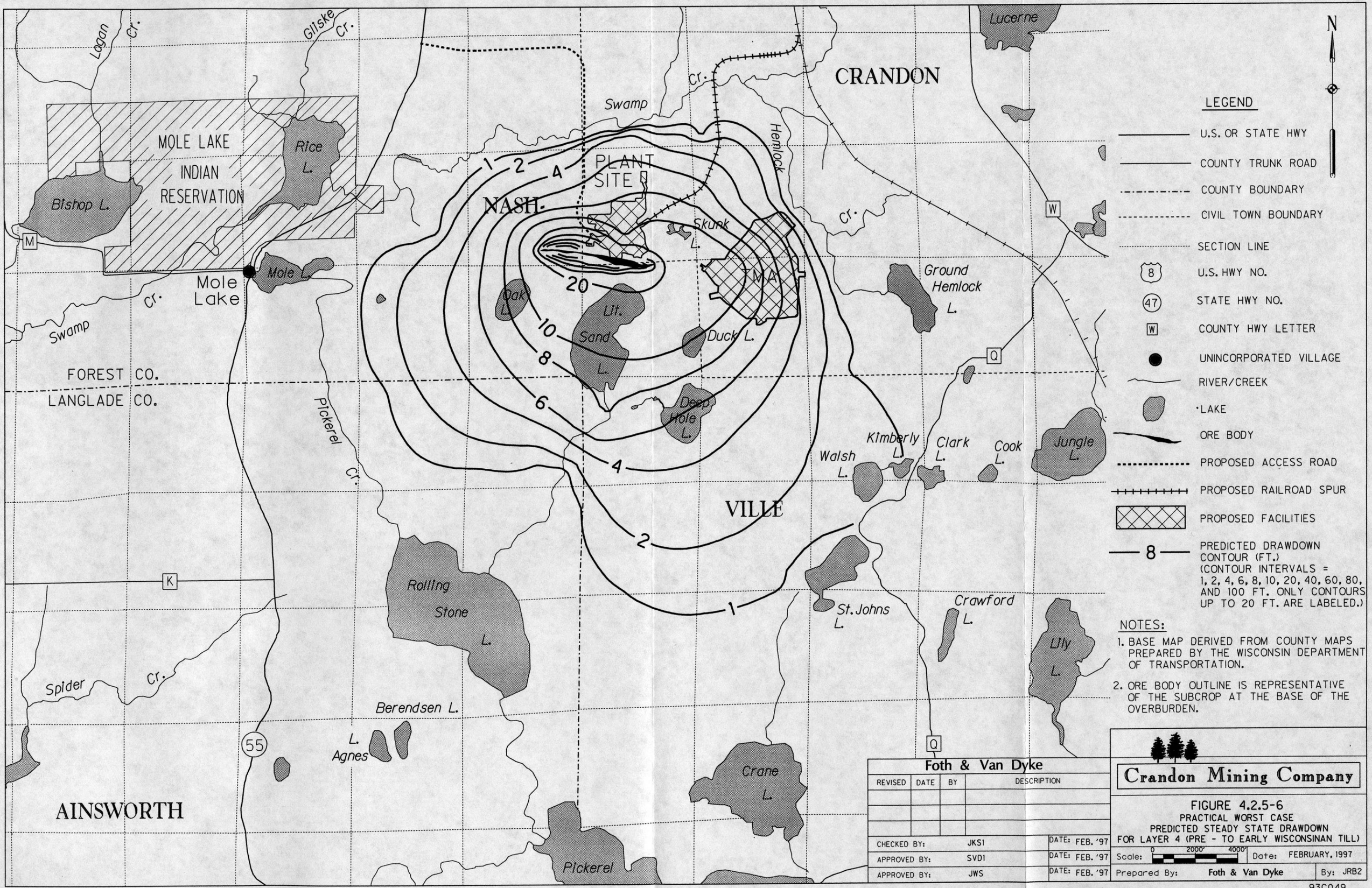
93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-6
PRACTICAL WORST CASE
PREDICTED STEADY STATE DRAWDOWN
FOR LAYER 4 (PRE - TO EARLY WISCONSINAN TILL)

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

93C049

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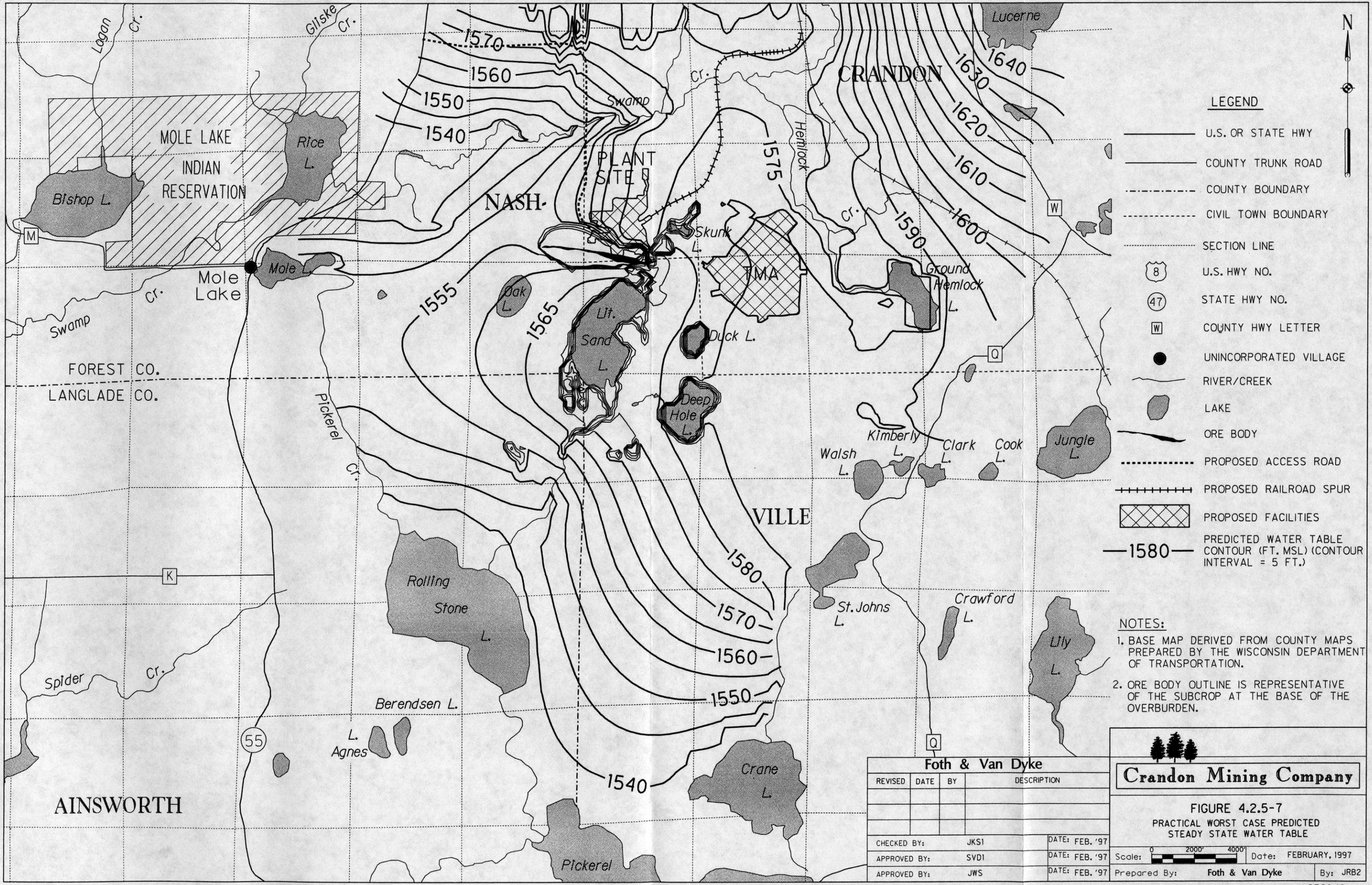


NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-7

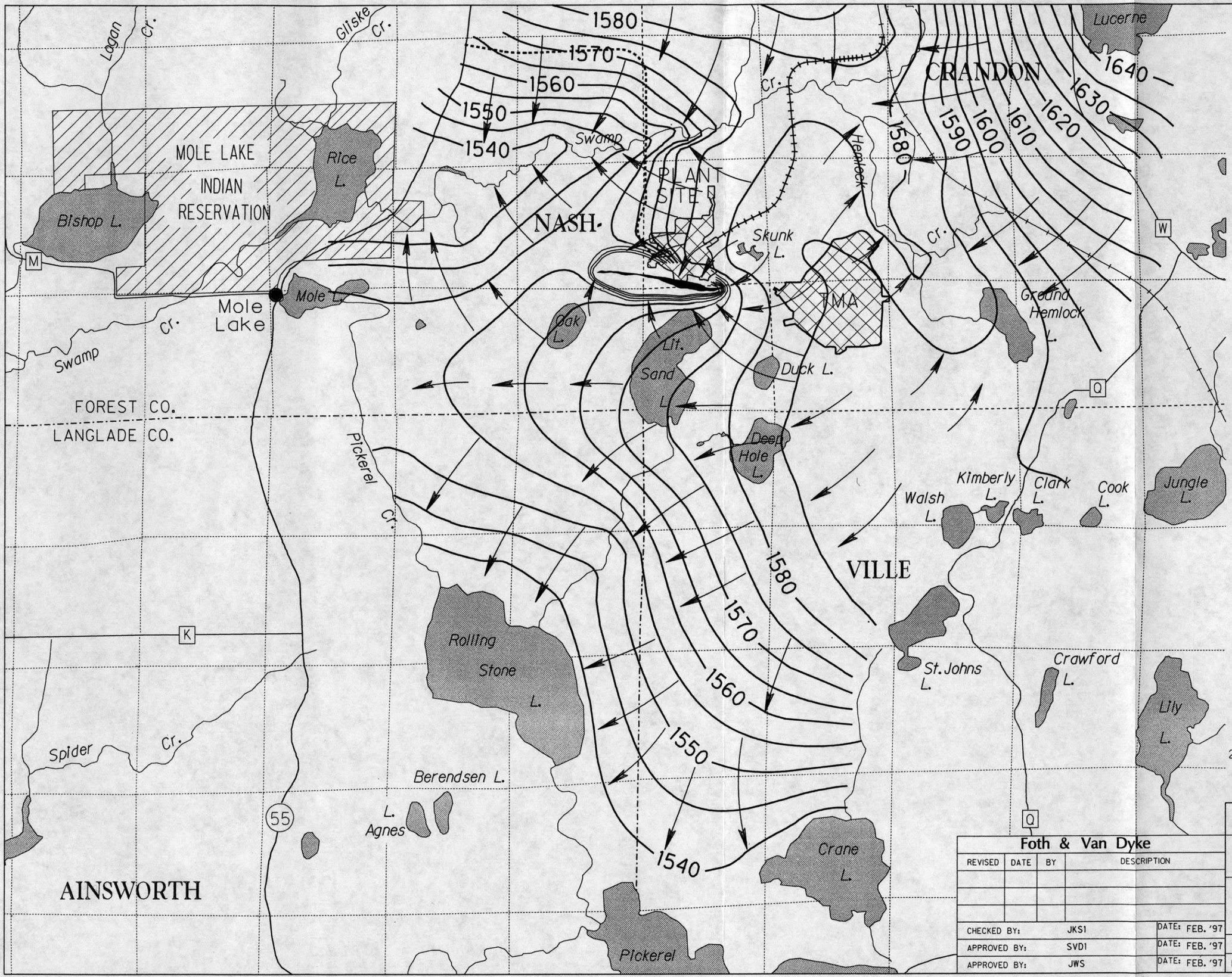
PRACTICAL WORST CASE PREDICTED STEADY STATE WATER TABLE

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

C:\cadwork\4c33f187.dgn

93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	SVD1	DATE: FEB. '97
APPROVED BY:	JWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.5-8
PRACTICAL WORST CASE PREDICTED STEADY STATE POTENTIOMETRIC SURFACE FOR LAYER 4 (PRE - TO EARLY WISCONSINAN TILL)

Scale: 0 2000' 4000' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

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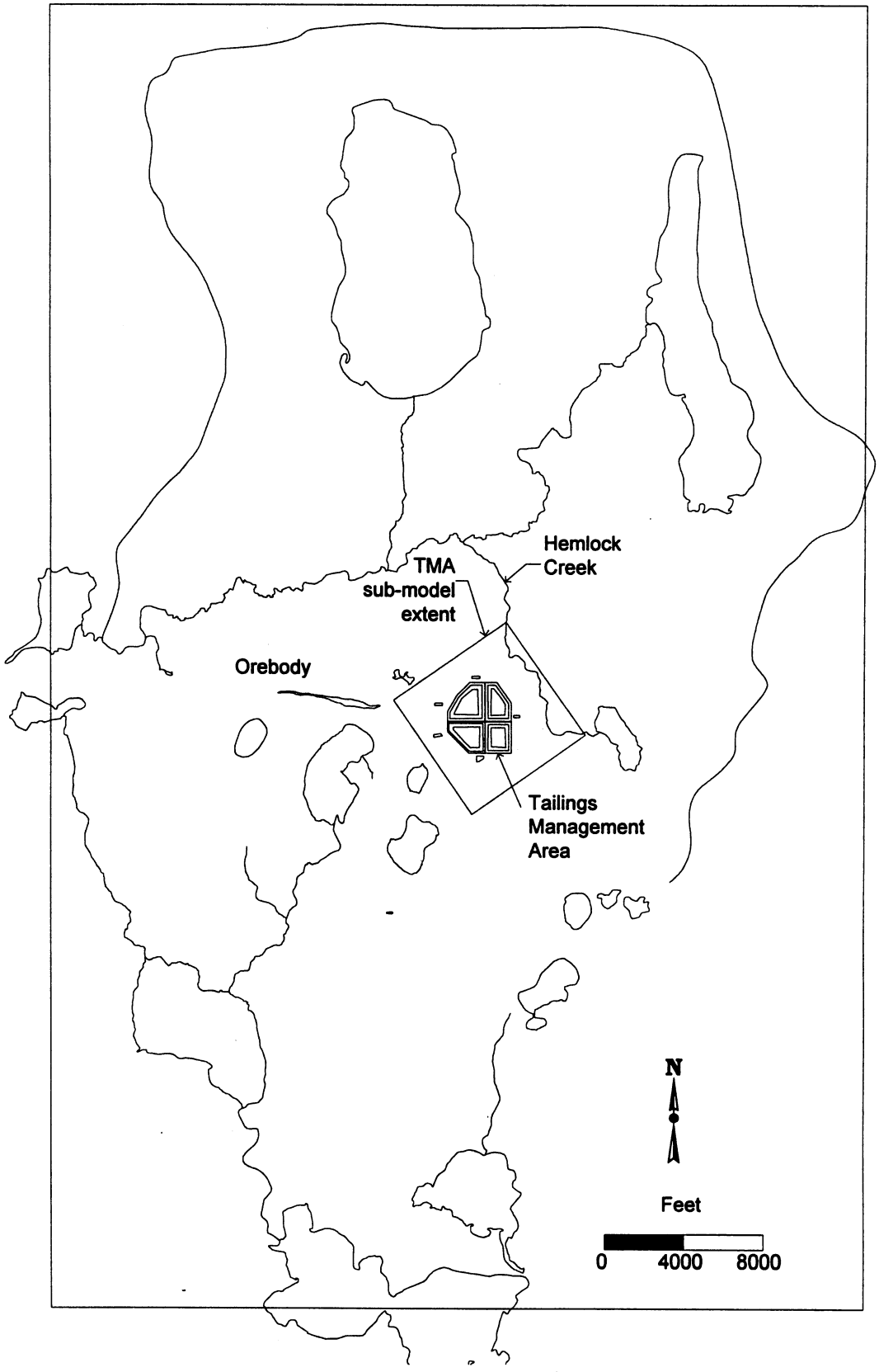
93C049



GeoTrans, inc.

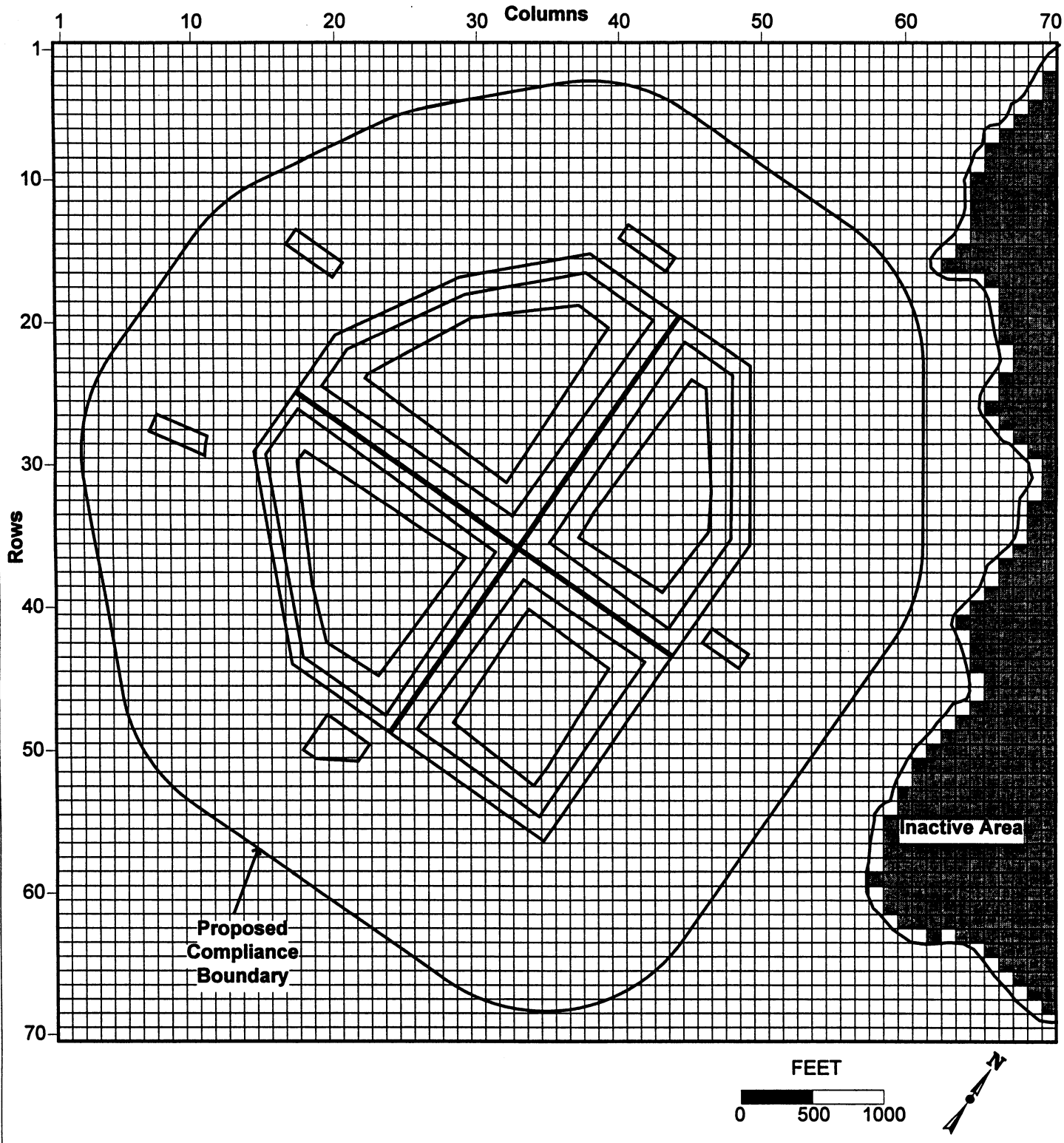
REVISED	DATE	BY	DESCRIPTION

CHECKED BY: PV	DATE: NOV 96
APPROVED BY: RTH	DATE: NOV 96
APPROVED BY: PFA	DATE: NOV 96

Crandon Mining Company

Figure 4.2.5–9
Tailings Management Area and TMA sub-model location map

Scale: 1" = 8000'	Date: Nov 1996
Prepared By: GeoTrans, Inc.	By: GWC



GeoTrans, inc.

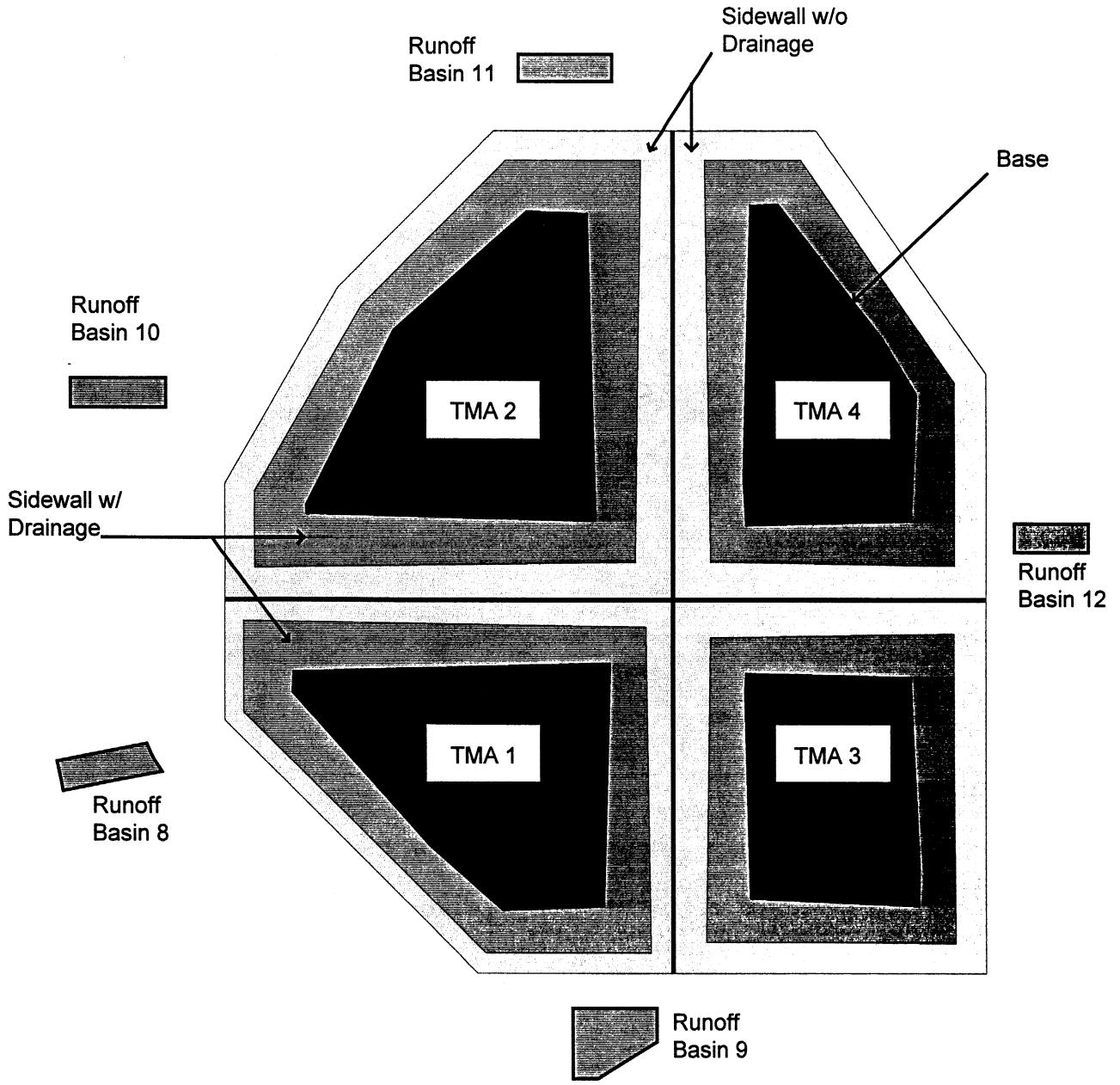
REVISED	DATE	BY	DESCRIPTION

CHECKED BY: PV	DATE: NOV 96
APPROVED BY: RTH	DATE: NOV 96
APPROVED BY: PFA	DATE: NOV 96

Crandon Mining Company

Figure 4.2.5–10
Model grid

Scale: 1" = 1000'	Date: Nov 1996
Prepared By: GeoTrans, Inc.	By: GWC



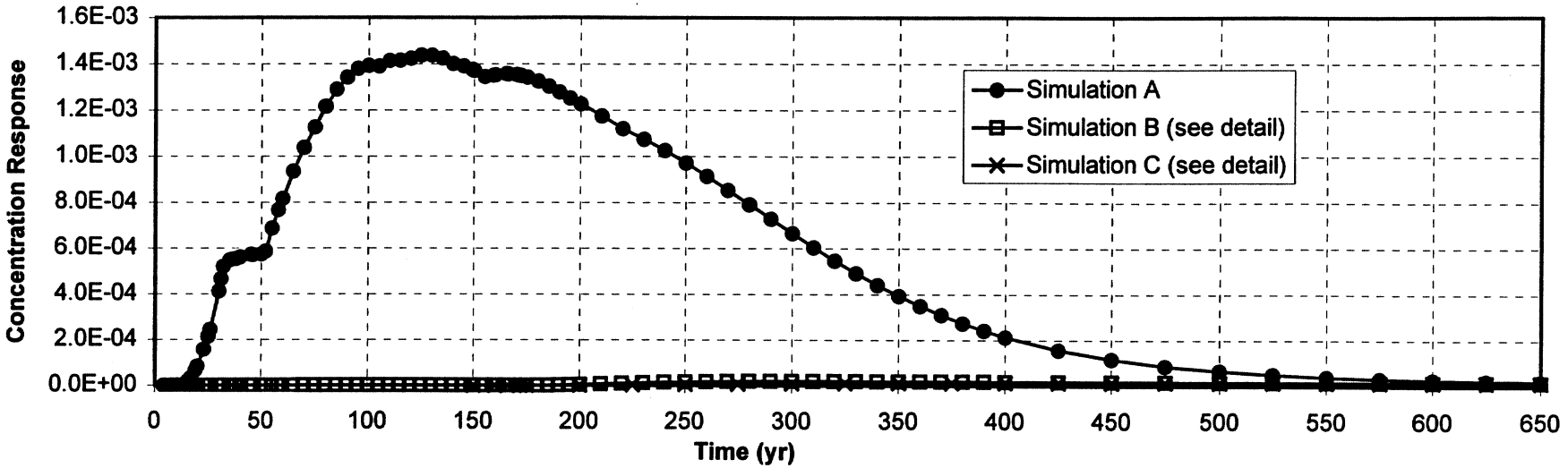
GeoTrans, inc.			
REVISED	DATE	BY	DESCRIPTION

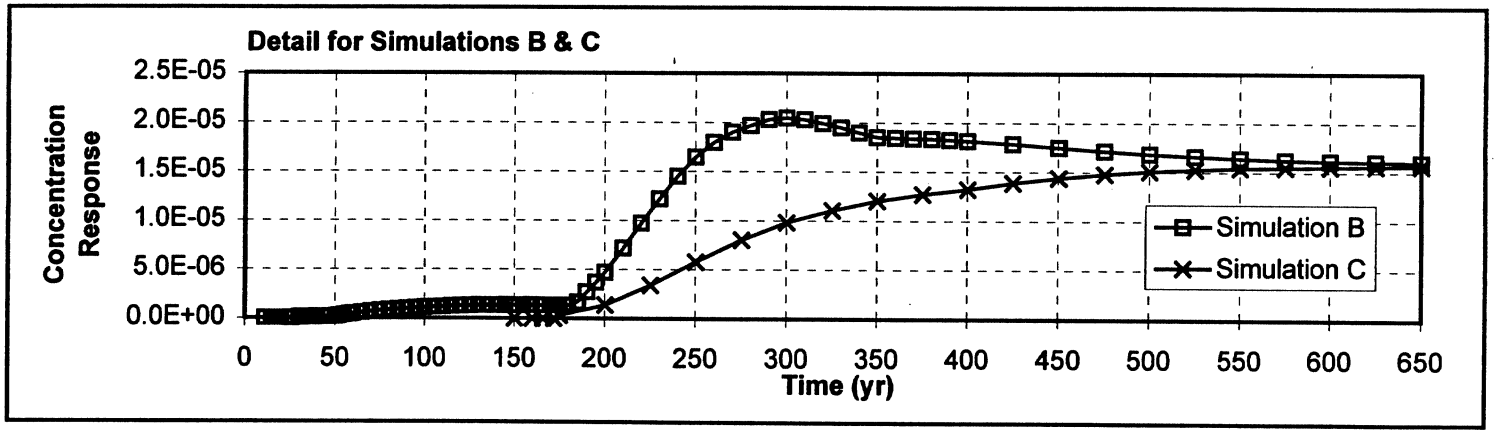
CHECKED BY: PV	DATE: NOV 96
APPROVED BY: RTH	DATE: NOV 96
APPROVED BY: PFA	DATE: NOV 96

Crandon Mining Company

Figure 4.2.5–11
Tailings Management Area detail

Scale: 1" = 700'	Date: Nov 1996
Prepared By: GeoTrans, Inc.	By: GWC





Note:
For these plots, the start time for Simulation C is set to 150 years.

GeoTrans, inc.

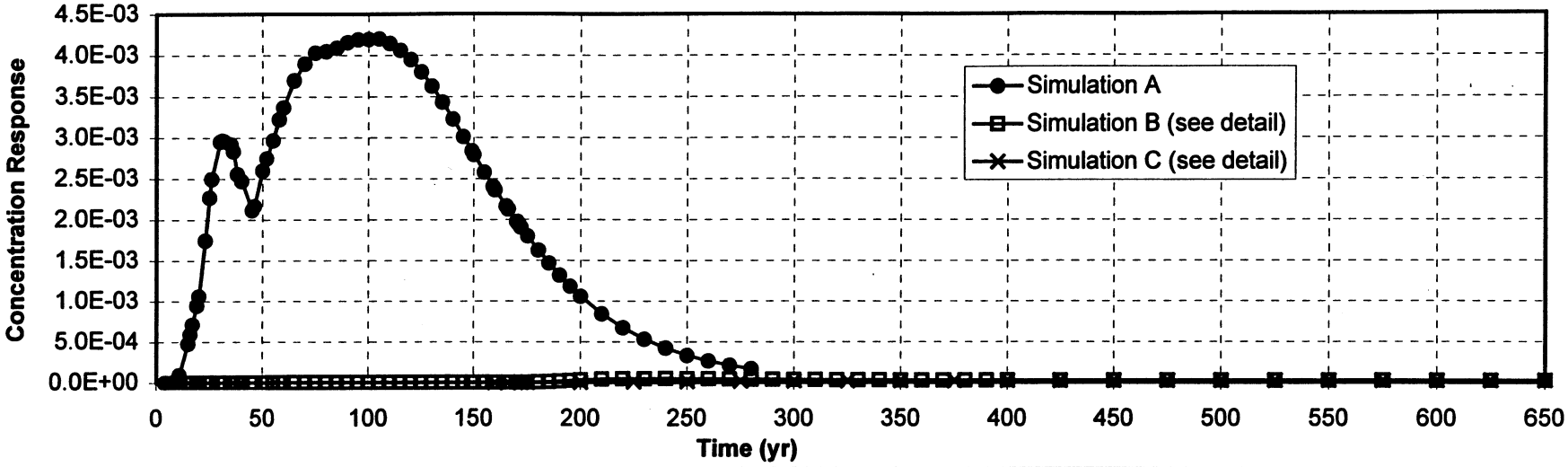
REVISED	DATE	BY	DESCRIPTION

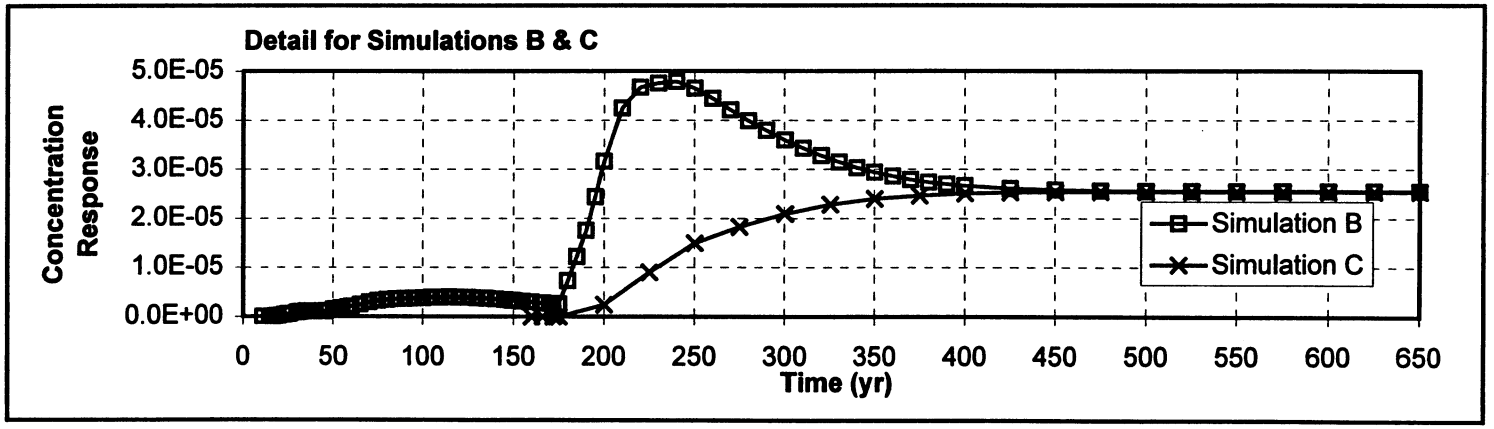
CHECKED BY:	PV	DATE: NOV 96
APPROVED BY:	RTH	DATE: NOV 96
APPROVED BY:	PFA	DATE: NOV 96

Crandon Mining Company

Figure 4.2.5–12
BEJ Concentration response curves at the compliance boundary

Scale: None	Date: Nov 96
Prepared by: GeoTrans, Inc.	By: GWC





Note:
For these plots, the start time for Simulation C is set to 150 years.

GeoTrans, inc.

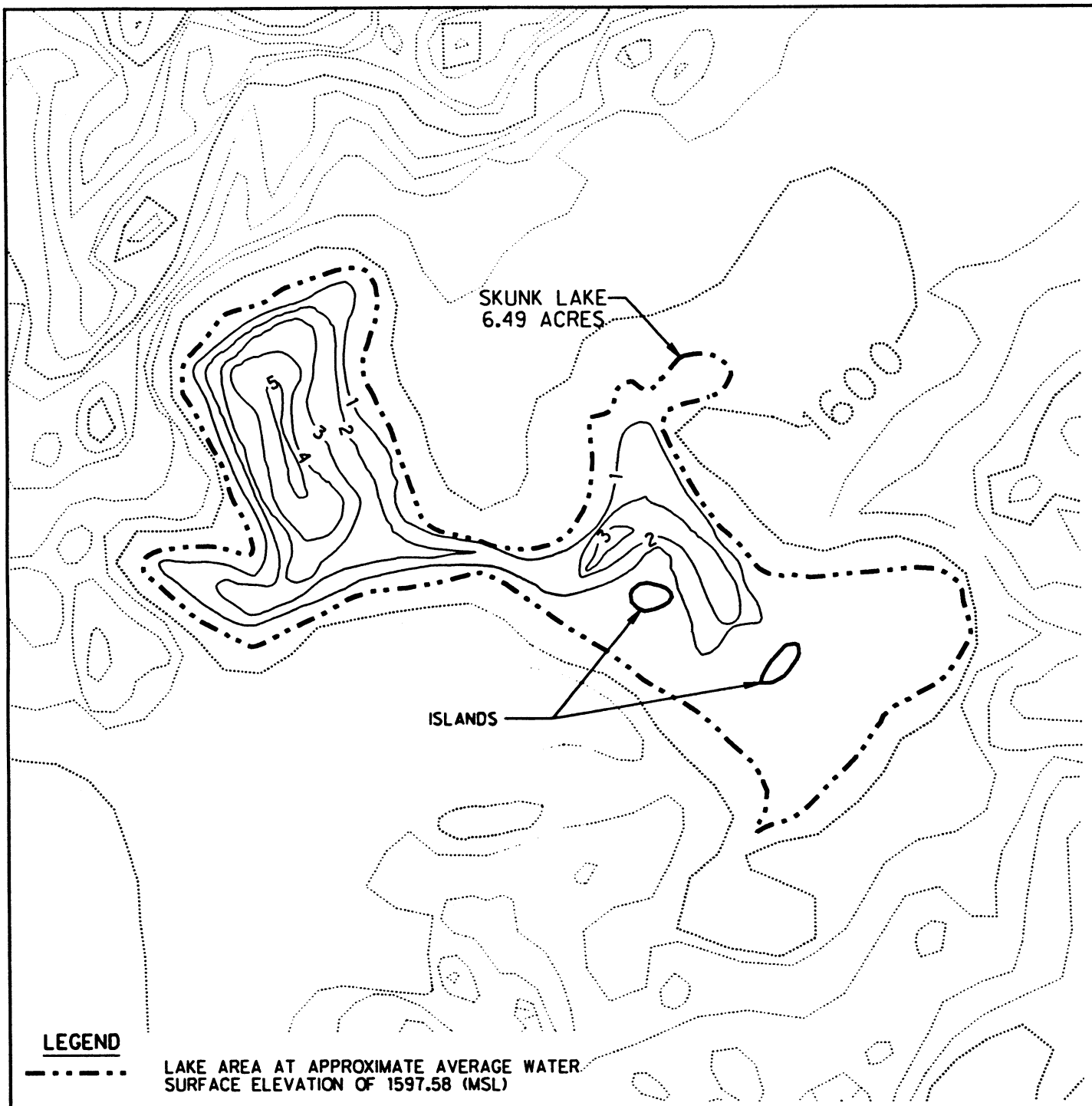
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	PV	DATE: NOV 96
APPROVED BY:	RTH	DATE: NOV 96
APPROVED BY:	PFA	DATE: NOV 96

Crandon Mining Company

Figure 4.2.5–13
PWC Concentration response curves at the compliance boundary

Scale: None	Date: Nov 96
Prepared by: GeoTrans, Inc.	By: GWC



LEGEND

- LAKE AREA AT APPROXIMATE AVERAGE WATER SURFACE ELEVATION OF 1597.58 (MSL)
- 5 — LAKE BOTTOM CONTOUR

NOTE: DEPTH TO LAKE BOTTOM REFERENCED TO A DECEMBER 27, 1984 SURFACE WATER ELEVATION OF 1597.58 (MSL).

SOURCE: LAKE MAP DIGITIZED FROM INMAN FOLTZ AND ASSOCIATES, INC., MINOCQUA, WI. FIGURE 2.3 EXXON MINERALS COMPANY LAKE CONTOUR MAPPING FOREST AND LANGLADE COUNTIES, WI., JANUARY 22,1985.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAR.'97
APPROVED BY:	RFS	DATE:	MAR.'97
APPROVED BY:	GWS	DATE:	MAR.'97

Crandon Mining Company

FIGURE 4.2.6-1

SKUNK LAKE BOTTOM CONTOURS

Scale: 0 100' 200' Date: MARCH, 1997

Prepared By: Foth & Van Dyke By: JOW

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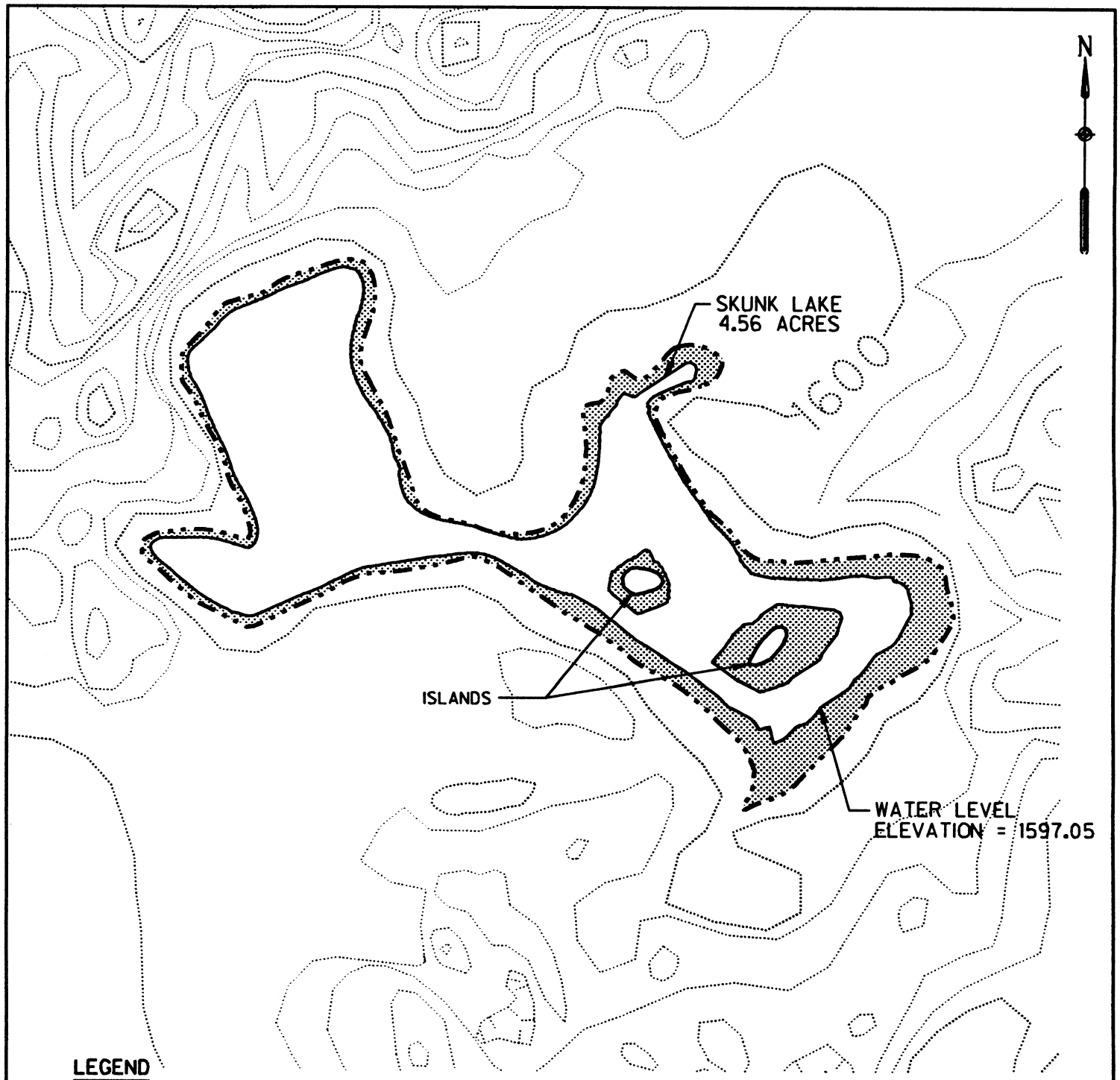
93C049



LEGEND

- LAKE AREA AT APPROXIMATE AVERAGE WATER SURFACE ELEVATION OF 1597.58 (MSL)
- REDUCTION IN LAKE SURFACE AREA DUE TO 0.53 FT. DECREASE IN GROUNDWATER LEVELS.

SOURCE: LAKE MAP DIGITIZED FROM INMAN FOLTZ AND ASSOCIATES, INC., MINOCQUA, WI. FIGURE 2.3 EXXON MINERALS COMPANY LAKE CONTOUR MAPPING FOREST AND LANGLADE COUNTIES, WI., JANUARY 22,1985.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAR.'97
APPROVED BY:	RFS	DATE: MAR.'97
APPROVED BY:	GWS	DATE: MAR.'97

Crandon Mining Company

FIGURE 4.2.6-2
SKUNK LAKE SURFACE AREA REDUCTION AS A RESULT OF 0.53 FT. DRAWDOWN COMPARED TO AVERAGE WATER ELEVATION

Scale: 0 100' 200' | Date: MARCH, 1997

Prepared By: Foth & Van Dyke | By: JOW

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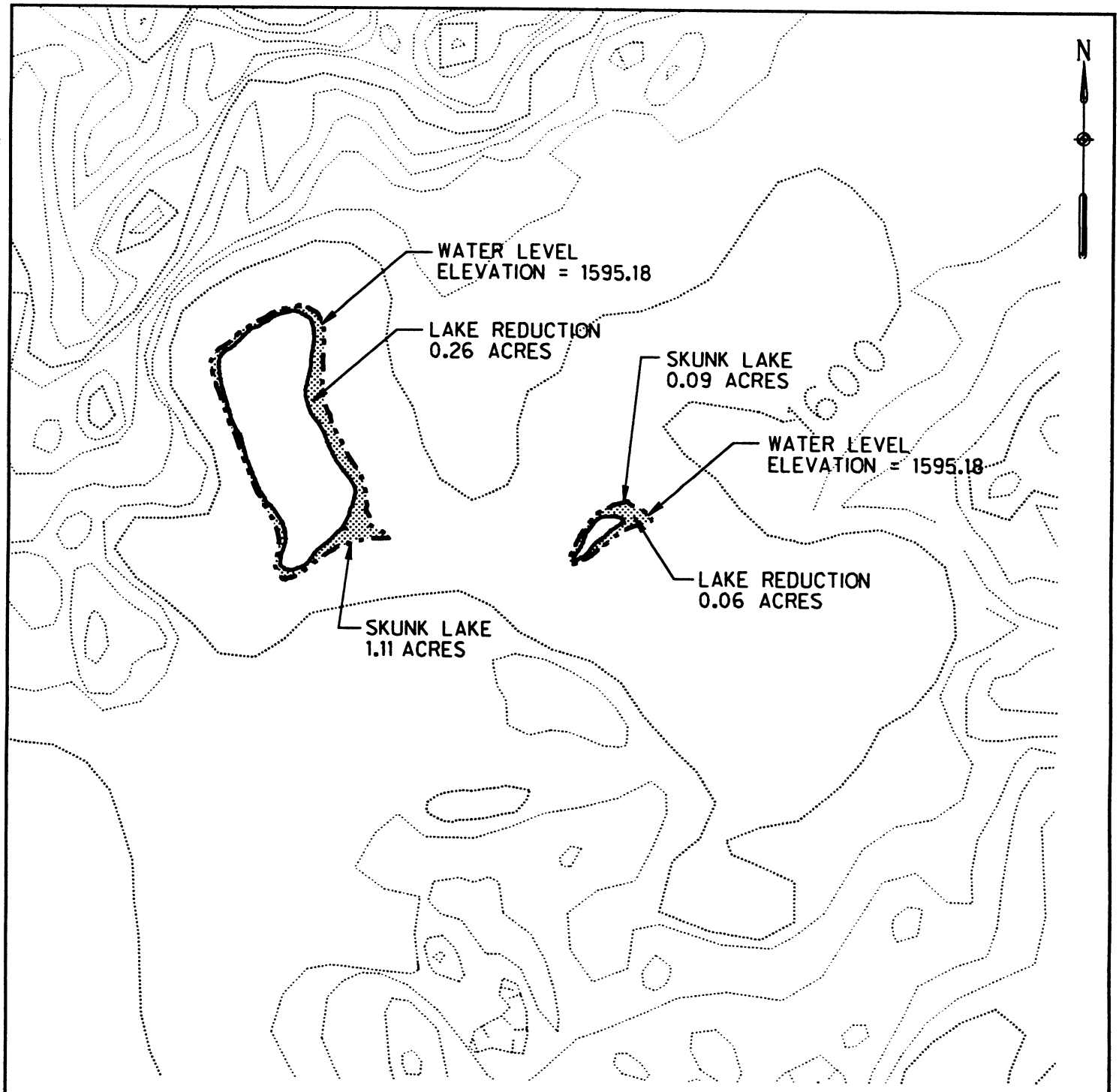

LEGEND

LAKE AREA AT RECORDED LOW WATER SURFACE ELEVATION OF 1595.18 (MSL)

REDUCTION IN LAKE SURFACE AREA DUE TO 0.53 FT. DECREASE IN GROUNDWATER LEVELS.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE:	MAR.'97
APPROVED BY:	RFS	DATE:	MAR.'97
APPROVED BY:	GWS	DATE:	MAR.'97

Crandon Mining Company

FIGURE 4.2.6-3
SKUNK LAKE AREA SURFACE REDUCTION AS A RESULT OF 0.53 FT. DRAWDOWN COMPARED TO LOW WATER ELEVATION

Scale: 0 100' 200' Date: MARCH, 1997

Prepared By: Foth & Van Dyke By: JOW

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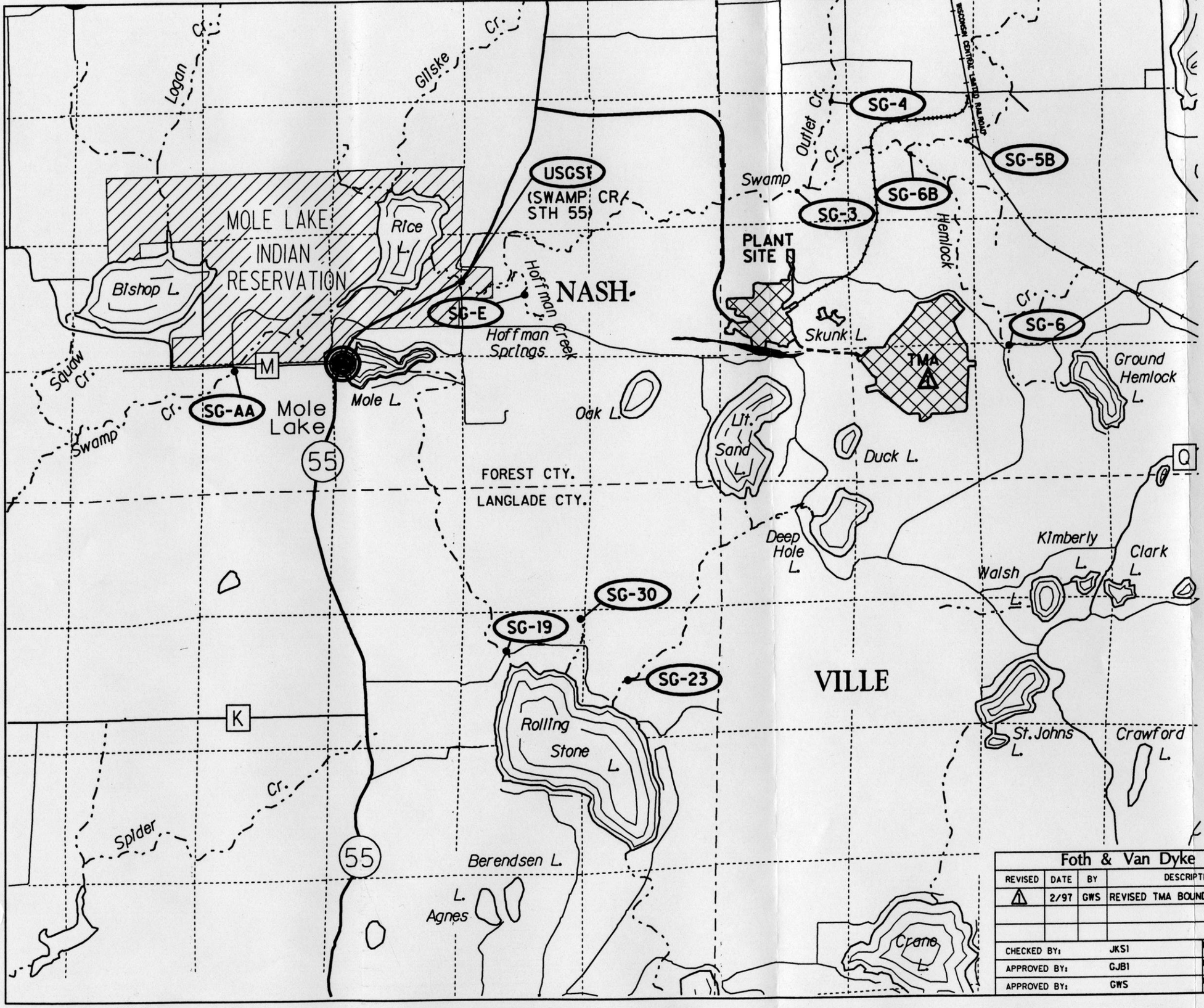
93C049



NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION.
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	2/97	GWS	REVISED TMA BOUNDARY

CHECKED BY:	JKS	DATE: SEPT.'95
APPROVED BY:	GJB	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.6-4
STREAM MONITORING LOCATIONS

Scale: 0 2000' 4000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: GAM

93C049

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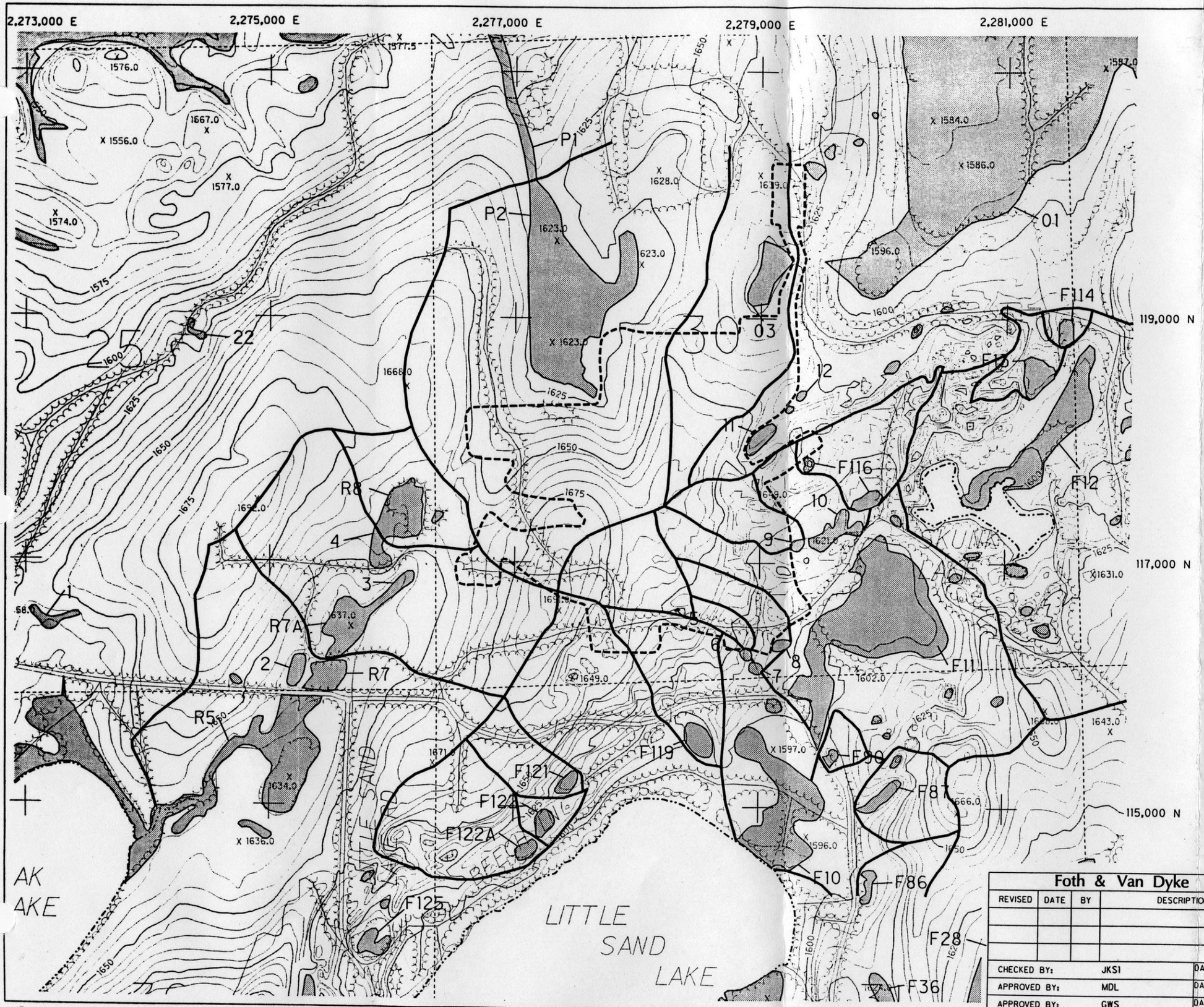

N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 — EXISTING CONTOUR
- x 1692.0 EXISTING SPOT ELEVATION
- SECTION LINE
- PROPOSED PLANT SITE OUTLINE
- EXISTING WETLAND
- EXISTING WETLAND WATERSHED OUTLINES

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 400' 800'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	MDL	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.7-1
PLANT SITE
EXISTING WETLAND WATERSHEDS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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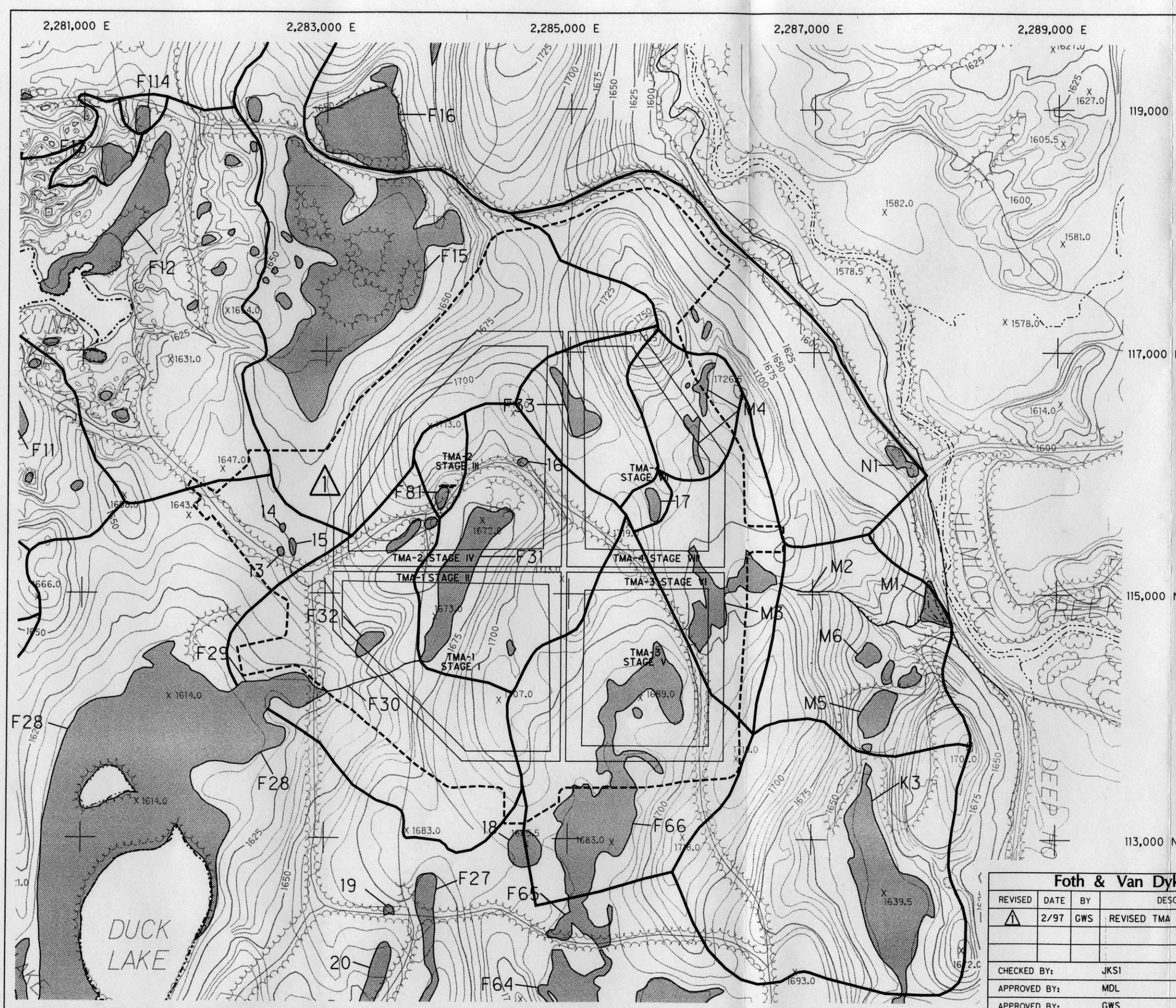
93C049



N

LEGEND

- LAKES
- STREAMS
- EXISTING ROAD
- 1675 EXISTING CONTOUR
- x1692.0 EXISTING SPOT ELEVATION
- SECTION LINE
- PROPOSED TMA DISTURBANCE AREA
- EXISTING WETLAND
- EXISTING WETLAND WATERSHED OUTLINES

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1"=1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS FIVE FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.

SCALE
0 400' 800'

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	2/97	GWS	REVISED TMA BOUNDARY

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	MDL	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.7-2
TMA
EXISTING WETLAND WATERSHEDS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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LEGEND

- TREES/BRUSH
- UNPAVED ROAD/TRAIL
- PAVED ROAD
- WETLAND
- EXISTING SPOT ELEVATION (x 1542.0)
- EXISTING CONTOUR (1600)
- CREEKS/RIVERS/LAKES
- PROPOSED ACCESS ROAD
- WETLAND DIVIDER

- DISCHARGE WETLAND.
- RECHARGE WETLAND TYPE 1. UNSATURATED ZONE EXISTS UNDER WETLAND.
- RECHARGE WETLAND TYPE 2. UNSATURATED ZONE EXISTS UNDER WETLAND. WETLAND IS CONNECTED LATERALLY TO A HEAD DEPENDENT SEEPAGE LAKE WATER BODY.
- RECHARGE WETLAND TYPE 3. HEAD DEPENDENT SEEPAGE WETLAND CONTINUOUSLY SATURATED SOILS FROM WETLAND SURFACE TO REGIONAL GROUNDWATER SYSTEM.

- —4— DRAWDOWN CONTOUR IN FEET. (DRAWDOWN CONTOURS GREATER THAN 20 FT. DIRECTLY OVER THE ORE BODY ARE NOT SHOWN)
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 5 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
BAR SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	8/96	SVD1	BEJ1-D4 / BEJ-D4
2	2/97	GWS	REVISED TMA BOUNDARY

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.7-3
BEST ENGINEERING JUDGMENT
DRAWDOWN CONTOURS (IN FEET)

Scale:	SEE BAR SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	KMP

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2,260,000 E | 2,265,000 E | 2,270,000 E | 2,275,000 E | 2,280,000 E | 2,285,000 E | 2,290,000 E

N

130,000 N | 125,000 N | 120,000 N | 115,000 N | 110,000 N | 105,000 N | 100,000 N

LAKE METONGA
RICE LAKE
MOLE LAKE
OAK LAKE
LITTLE SAND LAKE
DUCK LAKE
DEEP HOLE LAKE
SKUNK LAKE
PLANT
ORE BODY
TMA
GROUND HEMLOCK LAKE
KIMBERLY LAKE
WALSH LAKE
CLARK LAKE
ST JOHNS LAKE
ROLLING STONE LAKE

Z1 Z2 Z3 Z4 Z5 Z6 Z7 Z8 Z9 Z10 Z11 Z12 Z13 Z14 Z15 Z16 Z17 Z18 Z19 Z20 Z21 Z22 Z23 Z24 Z26
T1 T2 T3 T4 T5
SC-1 SC-2 HC-1 PC-1 ML-1 MS-1 CR1&9-1
W1 W2
R1A R3 R7 R7A R8
A2 A5 B1 B2 B3 B4 B5 B8 C1 D1 D2 D4 D4A D5 D8 D18
F1 F2 F4 F5 F6 F7 F8 F9 F10 F18 F19 F21 F22 F23 F26 F28 F29 F31 F34 F35 F36 F37 F38 F39 F40 F42 F43 F45 F46 F48 F50 F51 F52 F53 F54 F55 F57 F58 F61 F63 F64 F65 F66 F69 F70 F72 F86 F87 F90 F116 F119 F121 F122 F122A F126 F127
M1 M2 M3 M4 M5 M6
K1 K2 K3 K4 K5
L1 J1
X1 X2 X3 X4

1 2 4 6 8 10 12 14 16 18 20

LEGEND

- TREES/BRUSH
- UNPAVED ROAD/TRAIL
- PAVED ROAD
- WETLAND
- x 1542.0 EXISTING SPOT ELEVATION
- 1600 EXISTING CONTOUR
- CREEKS/RIVERS/LAKES
- PROPOSED ACCESS ROAD
- WETLAND DIVIDER

- DISCHARGE WETLAND.
- RECHARGE WETLAND TYPE 1. UNSATURATED ZONE EXISTS UNDER WETLAND.
- RECHARGE WETLAND TYPE 2. UNSATURATED ZONE EXISTS UNDER WETLAND. WETLAND IS CONNECTED LATERALLY TO A HEAD DEPENDENT SEEPAGE LAKE WATER BODY.
- RECHARGE WETLAND TYPE 3. HEAD DEPENDENT SEEPAGE WETLAND CONTINUOUSLY SATURATED SOILS FROM WETLAND SURFACE TO REGIONAL GROUNDWATER SYSTEM.

- —4— DRAWDOWN CONTOUR IN FEET. (DRAWDOWN CONTOURS GREATER THAN 20 FT. DIRECTLY OVER THE ORE BODY ARE NOT SHOWN)
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

NOTES:

1. TOPOGRAPHIC BASE MAP DIGITIZED FROM 1" = 1000' SCALE, 5' CONTOUR INTERVAL MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM. CONTOUR INTERVAL IS 5 FEET.
4. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
5. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

0 1000' 2000'
BAR SCALE

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	8/96	SVD1	PWC1-D4 / PWC-D4
2	2/97	GWS	REVISED TMA BOUNDARY

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.7-4
PRACTICAL WORST CASE
DRAWDOWN CONTOURS (IN FEET)

Scale: SEE BAR SCALE | Date: AUGUST, 1996
Prepared By: Foth & Van Dyke | By: GAM

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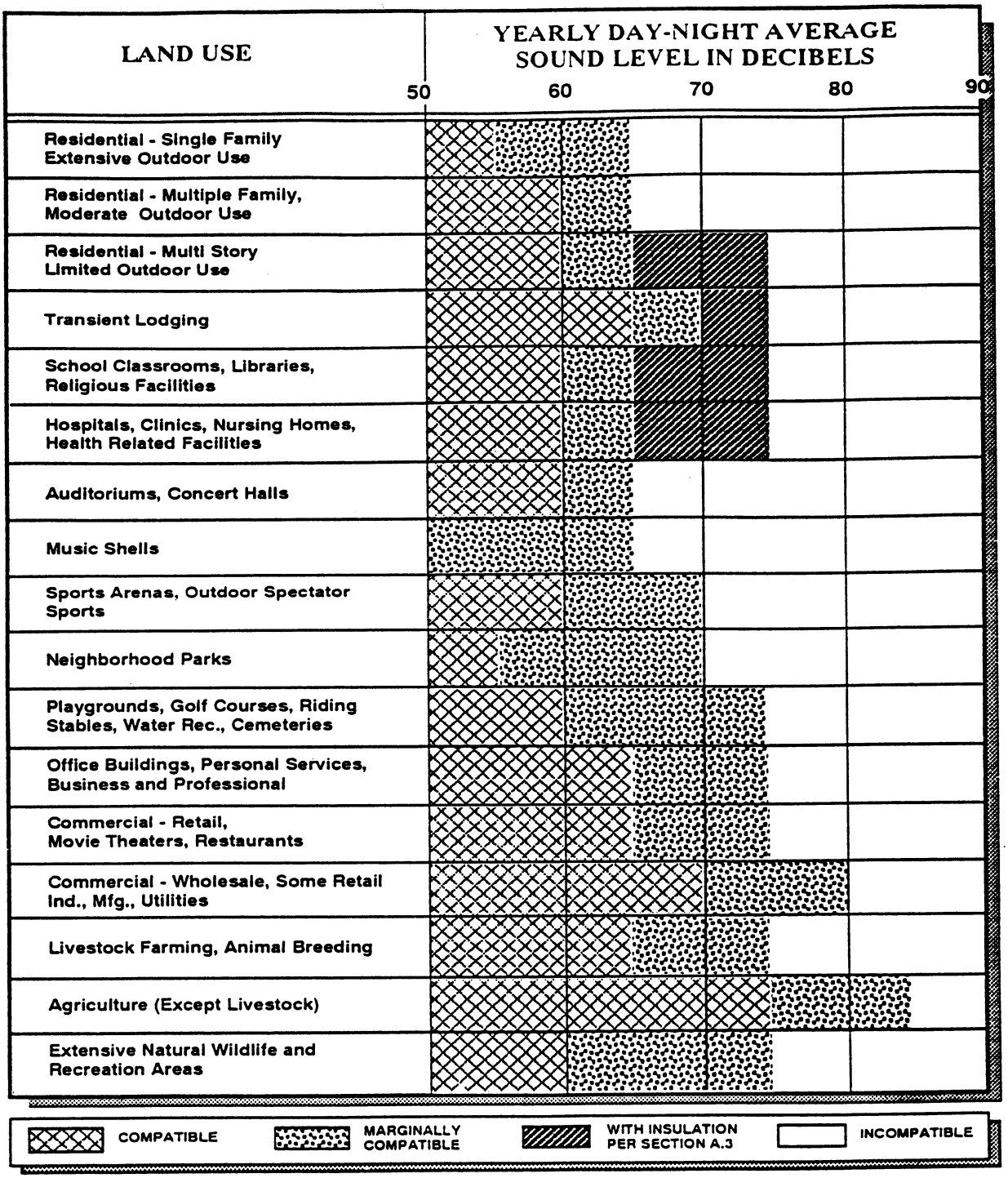

LAND USE COMPATIBILITY WITH YEARLY DAY-NIGHT AVERAGE SOUND LEVEL AT A SITE FOR BUILDINGS AS COMMONLY CONSTRUCTED (ANSI S12.40-1990)

Source: ACENTECH-From ANSI S12.40-1990

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.10-1
LAND USE COMPATIBILITY

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

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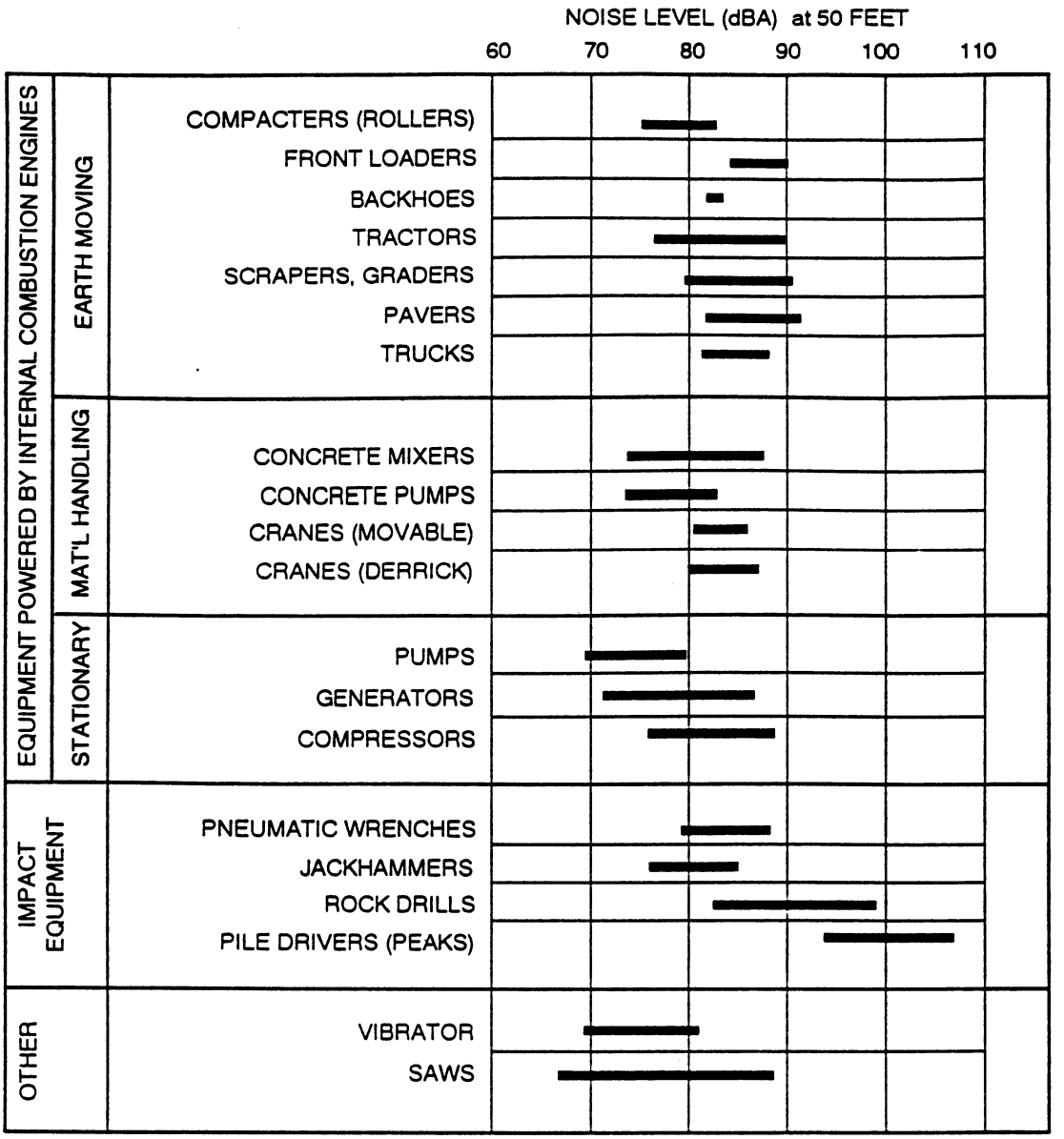

THE NOISE LEVELS LISTED FOR VARIOUS TYPES OF CONSTRUCTION RELATED MACHINERY ARE BASED ON LIMITED SAMPLES. THE VALUES ARE PRESENTED IN ORDER TO GIVE THE READER A BASIC UNDERSTANDING OF WHERE PARTICULAR PIECES OF MACHINERY FIT ON A NOISE-RANGE BASIS. TAKEN FROM BBN REPORT NO. 3321, "POWER PLANT CONSTRUCTION NOISE GUIDE" (1977).

Source: ACENTECH-From BBN REPORT NO. 3321

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.10-2
CONSTRUCTION EQUIPMENT NOISE RANGES

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JPRI

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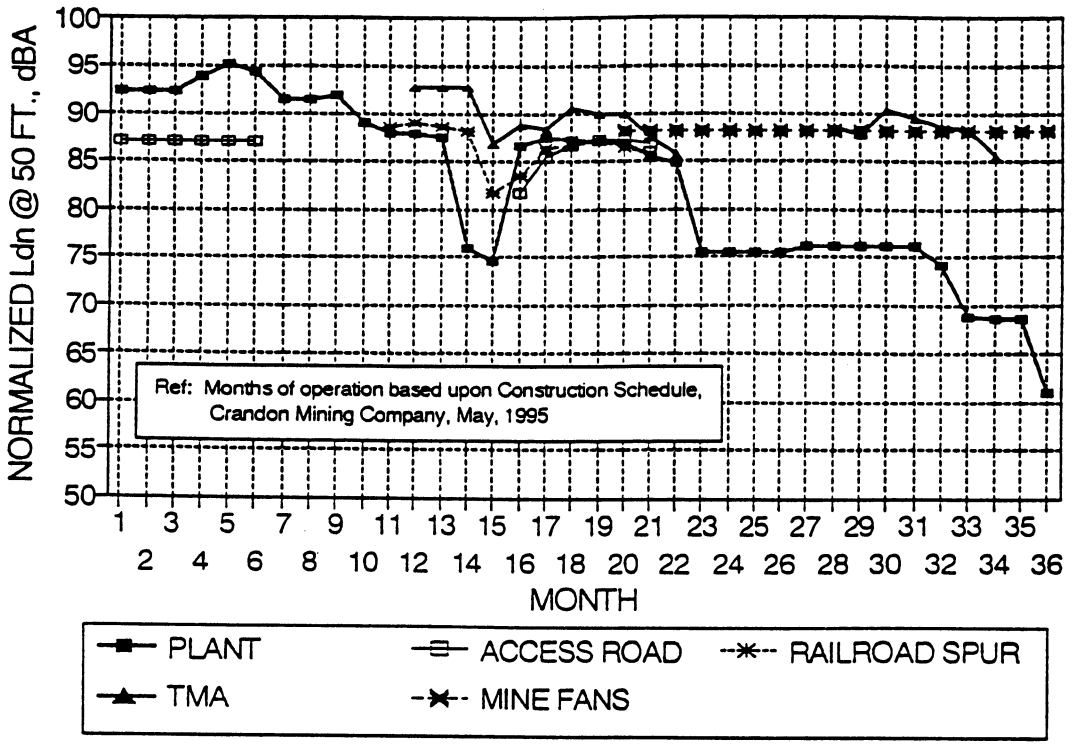

Source: ACENTECH

Foth & Van Dyke				
REVISED	DATE	BY	DESCRIPTION	
CHECKED BY:	JKS1			DATE: SEPT.'95
APPROVED BY:	RFS			DATE: SEPT.'95
APPROVED BY:	GWS			DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.10-3
ESTIMATED CONSTRUCTION NOISE EMISSIONS

Scale: NOT TO SCALE	Date: SEPTEMBER, 1995
Prepared By: Foth & Van Dyke	By: JPR1

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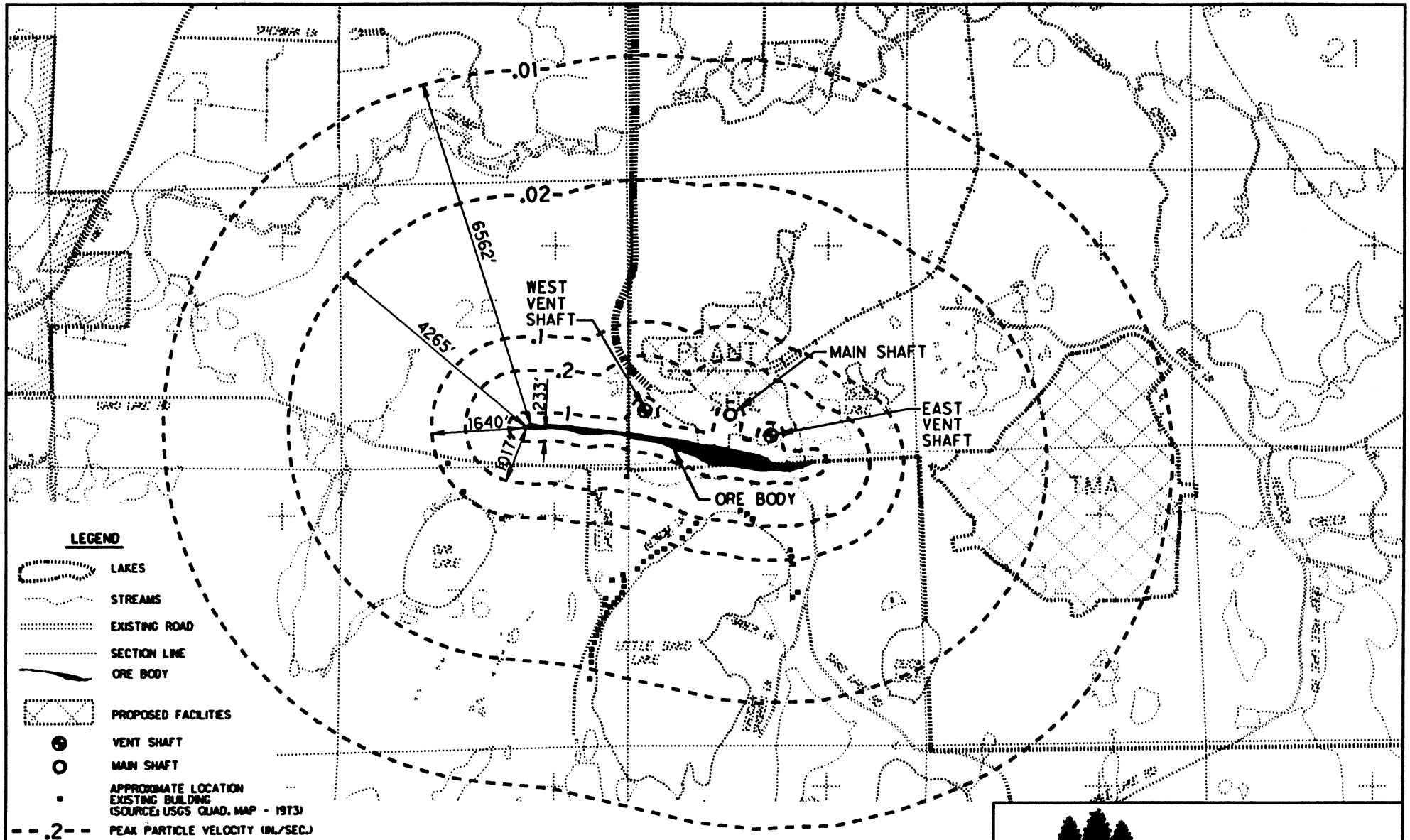

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.
3. COUNTY AND TOWNSHIP LINES DIGITIZED FROM 7.5' SERIES USGS MAPS.
4. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKS1	DATE: FEB. '97
APPROVED BY:	NXP	DATE: FEB. '97
APPROVED BY:	GWS	DATE: FEB. '97

Crandon Mining Company

FIGURE 4.2.10-4

ESTIMATION OF BLASTING RESIDUALS IN THE VICINITY OF THE MINE

Scale: 0 1250' 2500' Date: FEBRUARY, 1997

Prepared By: Foth & Van Dyke By: JRB2

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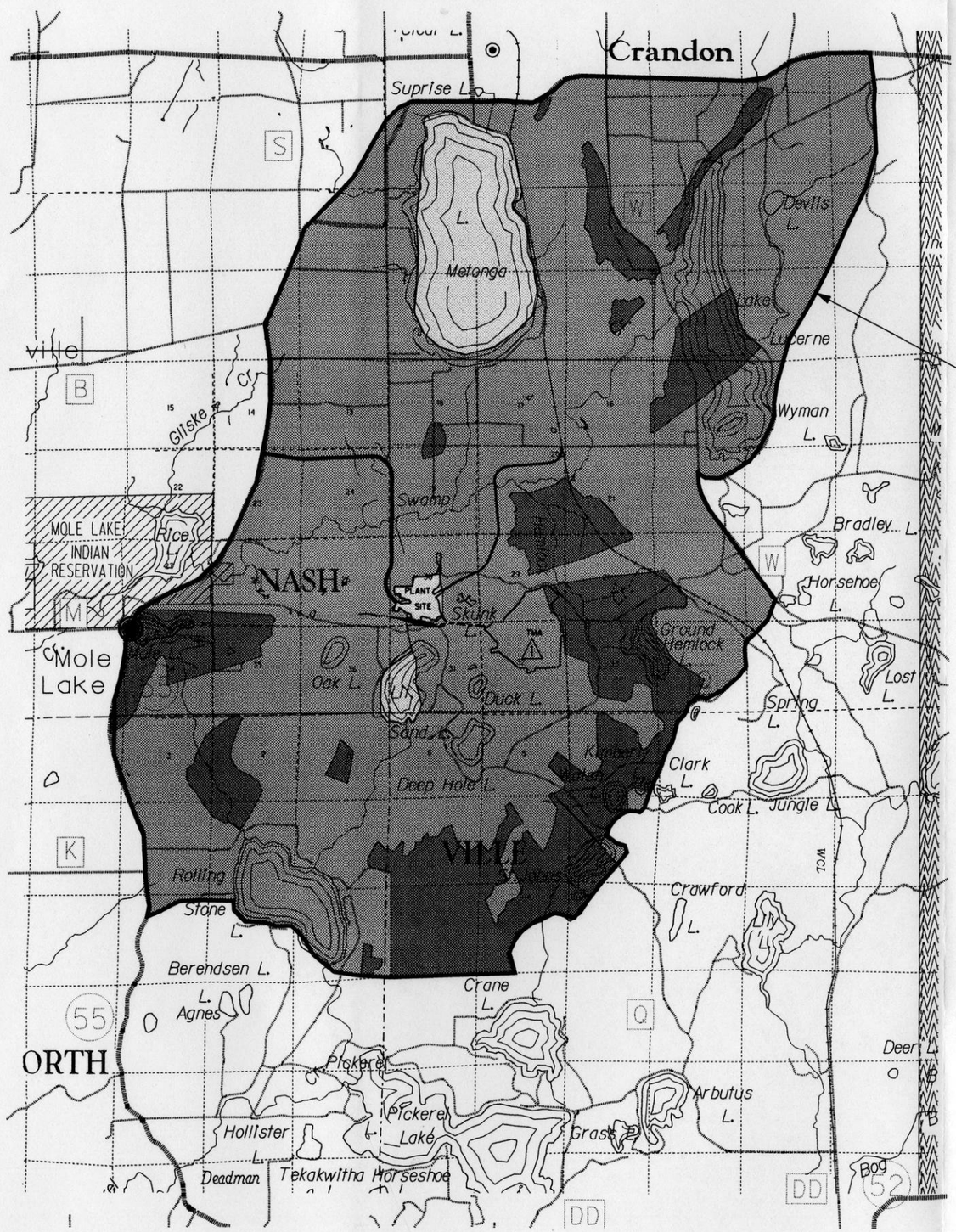

LIMITS OF STUDY AREA

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- U.S. HWY NO.
- STATE HWY NO.
- NATIONAL & STATE FOREST BOUNDARY
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- TOTALLY OBSCURED BY TOPOGRAPHY
- PARTIALLY TO TOTALLY OBSCURED BY VEGETATION
- VISIBLE WITH VARYING DEGREES OF VEGETATIVE SCREENING

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	2/97	GWS	REVISED TMA BOUNDARIES

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.12-1

AESTHETIC VIEWS OF HEADFRAME

Scale: 0 4000' 8000' Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke By: JPR1

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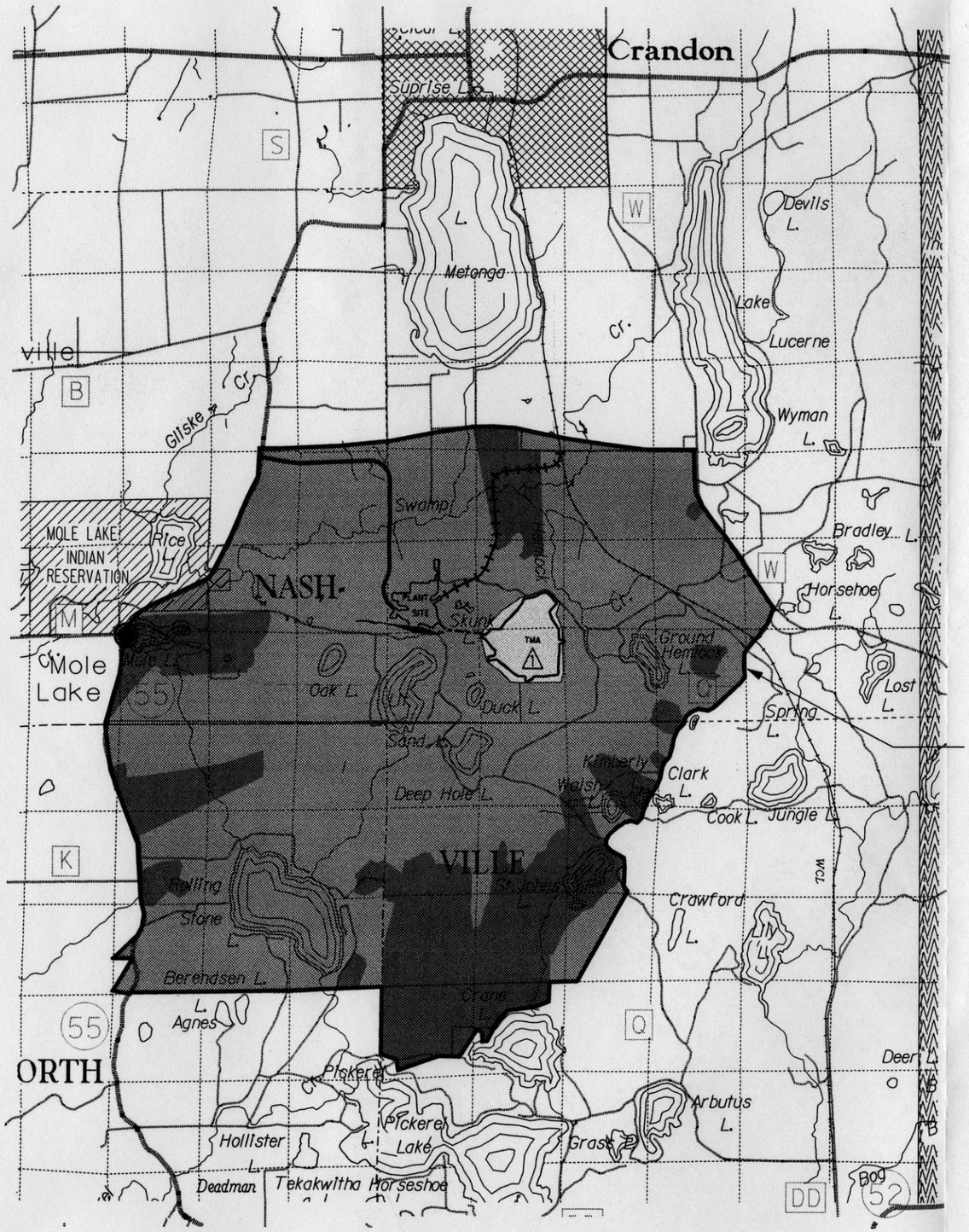

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- U.S. HWY NO.
- STATE HWY NO.
- NATIONAL & STATE FOREST BOUNDARY
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- TOTALLY OBSCURED BY TOPOGRAPHY
- PARTIALLY TO TOTALLY OBSCURED BY VEGETATION
- VISIBLE WITH VARYING DEGREES OF VEGETATIVE SCREENING

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
1	2/97	GWS	REVISED TMA BOUNDARY

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.12-2
AESTHETIC VIEWS OF TMA

Scale: 0 4000' 8000' Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke By: JPR1

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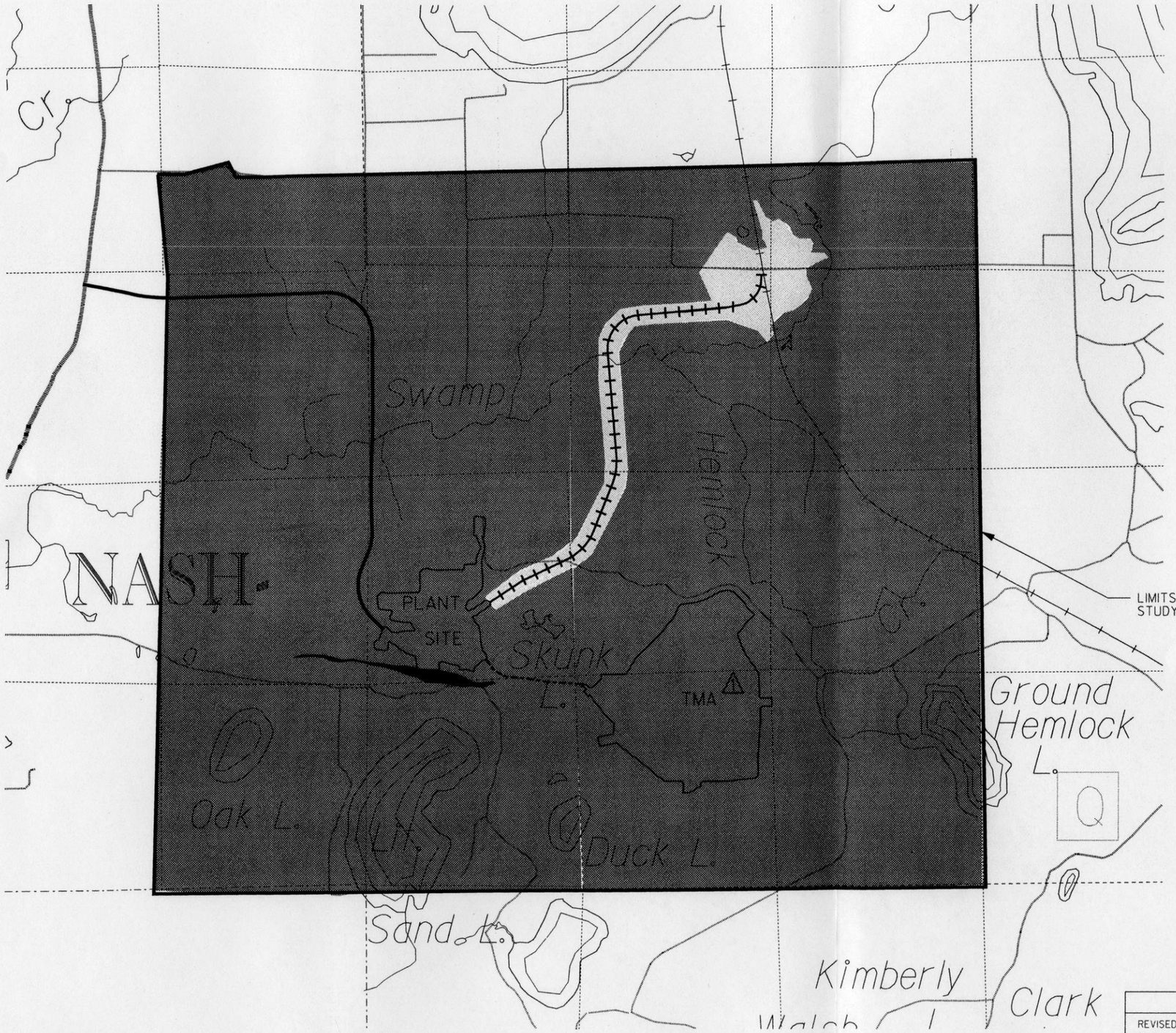

LEGEND

- U.S. OR STATE HWY
- COUNTY TRUNK ROAD
- TOWN ROAD
- COUNTY BOUNDARY
- CIVIL TOWN BOUNDARY
- SECTION LINE
- U.S. HWY NO.
- STATE HWY NO.
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- TOTALLY OBSCURED BY VEGETATION AND TOPOGRAPHY
- VISIBLE WITH VARYING DEGREES OF VEGETATIVE SCREENING

N

NOTES:

1. BASE MAP DERIVED FROM COUNTY MAPS PREPARED BY THE WISCONSIN DEPARTMENT OF TRANSPORTATION
2. ORE BODY OUTLINE IS REPRESENTATIVE OF THE SUBCROP AT THE BASE OF THE OVERBURDEN.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION
1	2/97	GWS	REVISED TMA BOUNDARIES

CHECKED BY:	JKS1	DATE: SEPT.'95
APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

Crandon Mining Company

FIGURE 4.2.12-3

AESTHETIC VIEWS OF RAILROAD SIDING

Scale: 0 1500' 3000' | Date: SEPTEMBER, 1995

Prepared By: Foth & Van Dyke | By: JPR1

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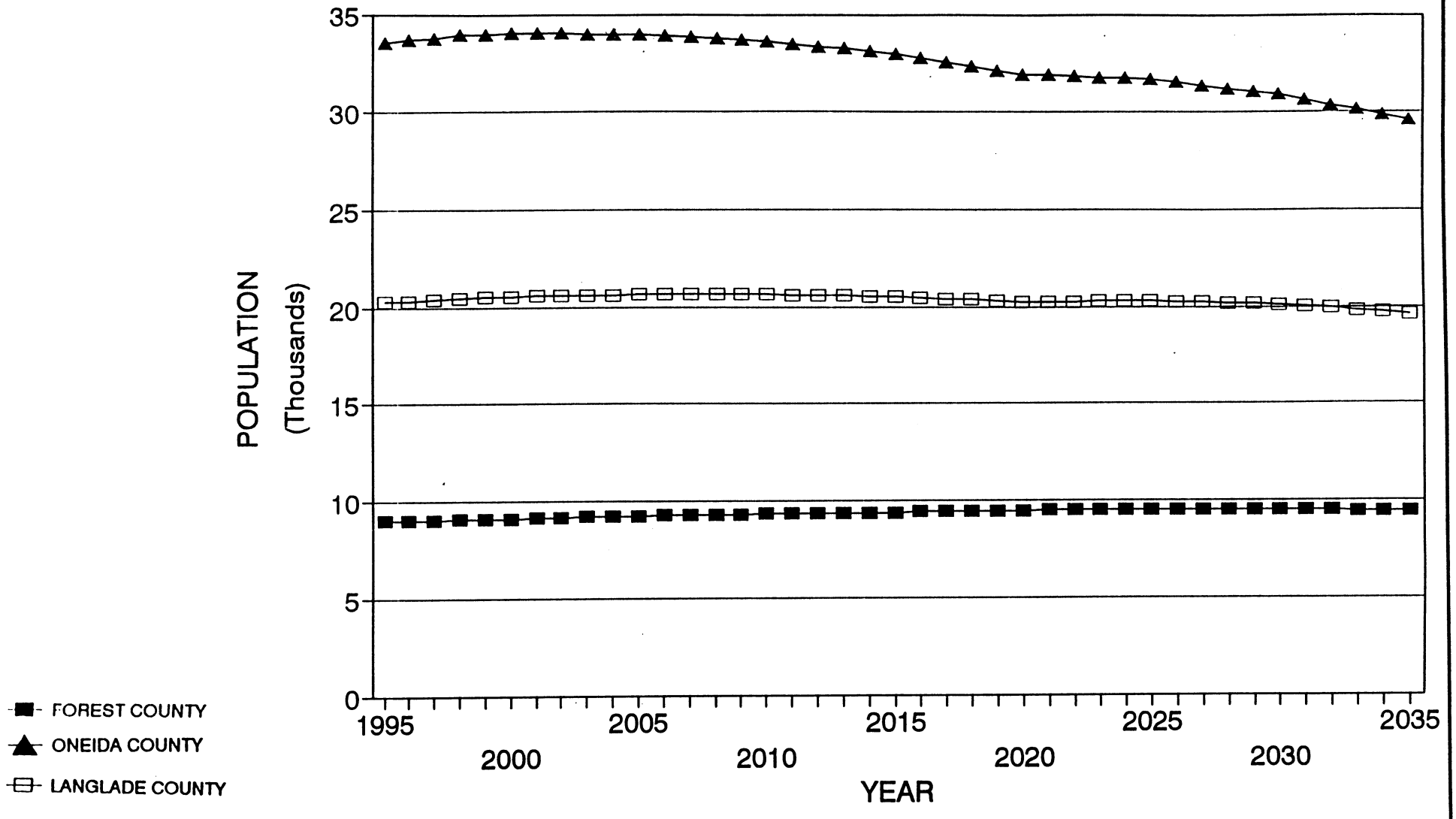

Notes:

1) Based on WDOA, *Official Municipal Population Projections 1990-2015* and Foth & Van Dyke estimates using WDOA methodology and data.

2) Figure shows stable projected population for Forest and Langlade Counties and declining projected population for Oneida County.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	JWS	DATE: MAY '95

Crandon Mining Company

FIGURE 4.2.13-1
POPULATION FORECAST
(W/O PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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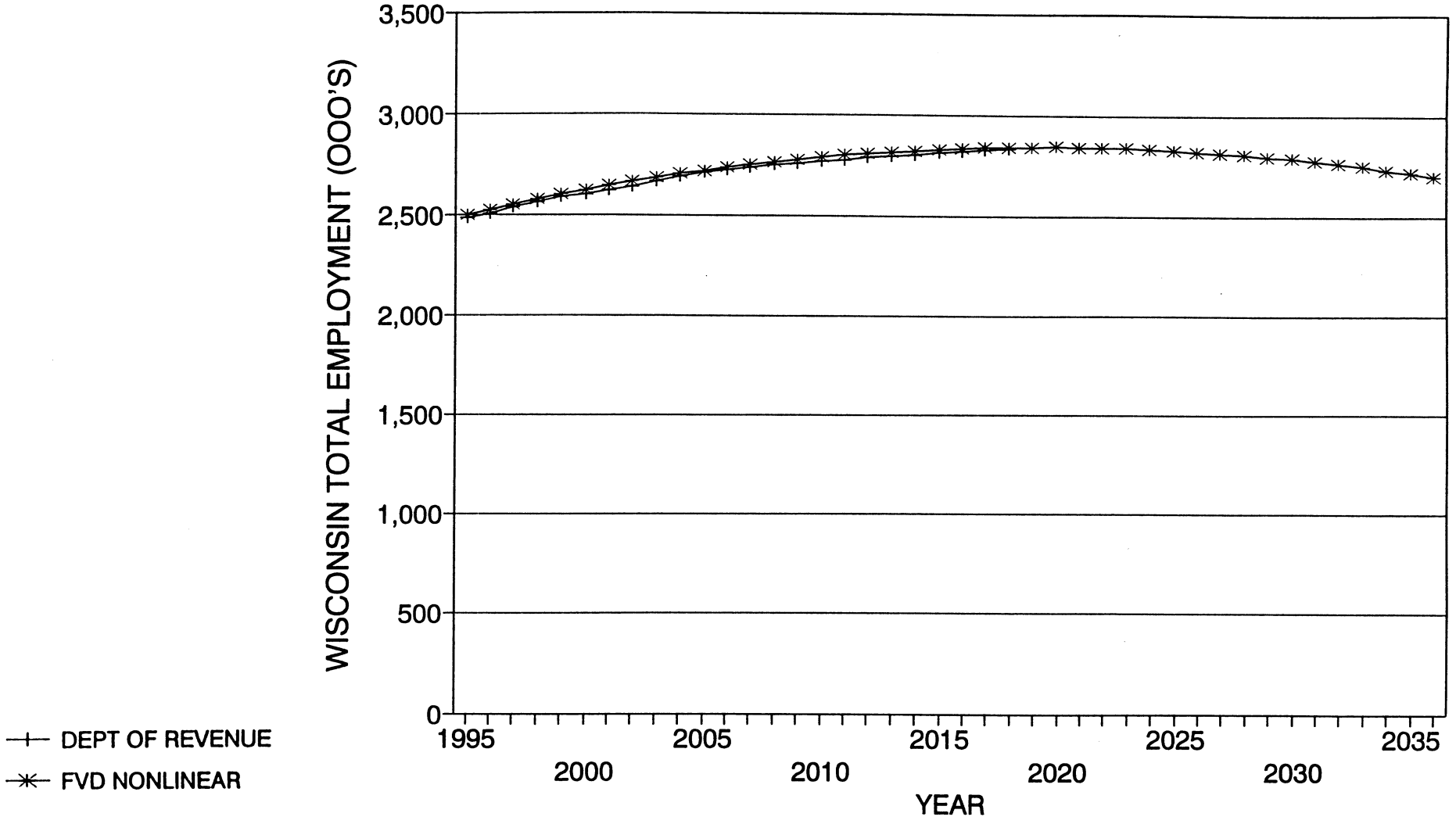
/d3/dl/users/jpr1/4c59stdy.dgn



Notes:
1) Based on WDOR employment estimates through 2018 and Foth & Van Dyke Projections 2019 through 2035.
2) Figure shows a moderate employment increase for about 20 years followed by a moderate decline.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	JWS	DATE: MAY '95

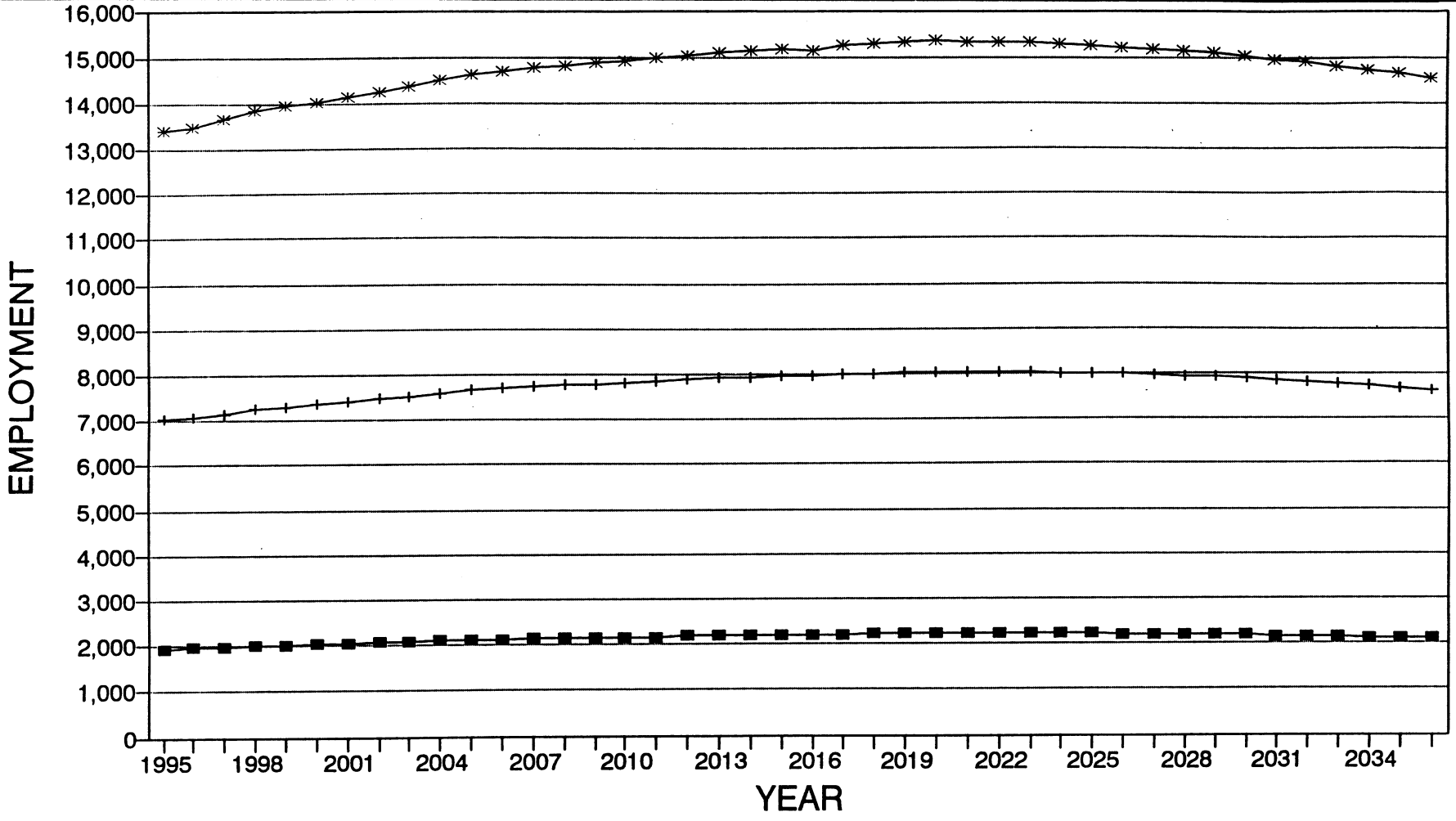
Crandon Mining Company

FIGURE 4.2.13-2
WISCONSIN EMPLOYMENT FORECAST
(W/O PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

93C049

/d3/dl/users/jprl/4c59study.dgn



Notes:

1) Based on correlation of individual county employment data with Wisconsin employment data (1980 through 1991). Individual county employment projections assume county employment correlates with Wisconsin employment trends as outlined in Figure 4.2.13-2.

2) Figure shows a moderate increase in forecast employment over the first 20-25 years followed by a moderate decline.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	JWS	DATE: MAY '95

Crandon Mining Company

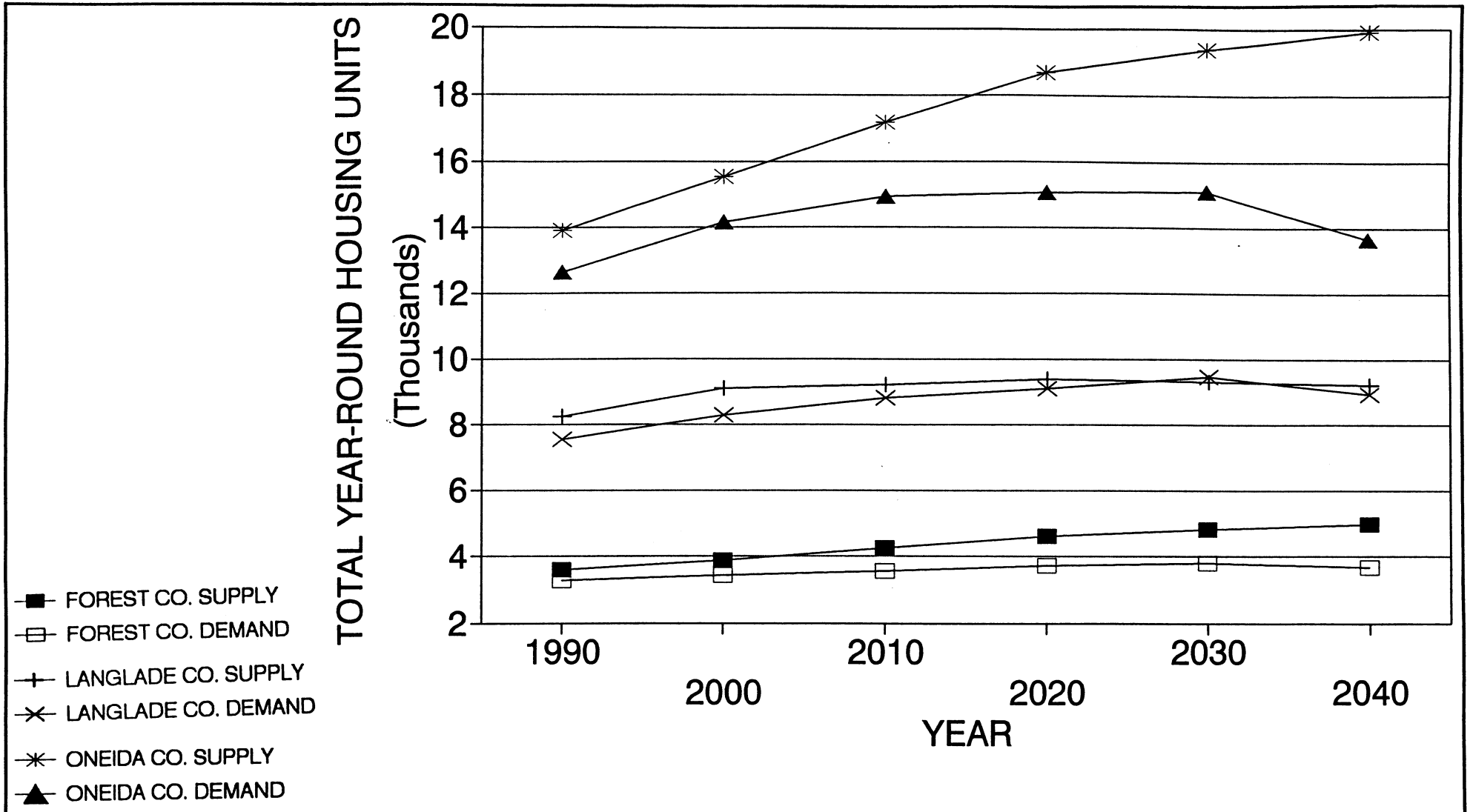
FIGURE 4.2.13-3

TOTAL EMPLOYMENT FORECAST (W/O PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

93C049

/d3/dl/users/jpr1/4c59study.dgn



Notes:

1) Housing supply for individual counties is based on census data for age of structure. It assumes that housing replacement and survival will occur in the future as it has in the past. Housing demand projections are based on population forecasts as well as projected average household size estimates as provided by the WDOA Applied Population Laboratory.

2) Figure shows that Langlade County projected housing supply and demand are closely matched, while for Forest and Oneida Counties the spread between supply and demand increases over time.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	JWS	DATE: MAY '95

Crandon Mining Company

FIGURE 4.2.13-4
HOUSING STOCK FORECAST
(W/O PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

93C049

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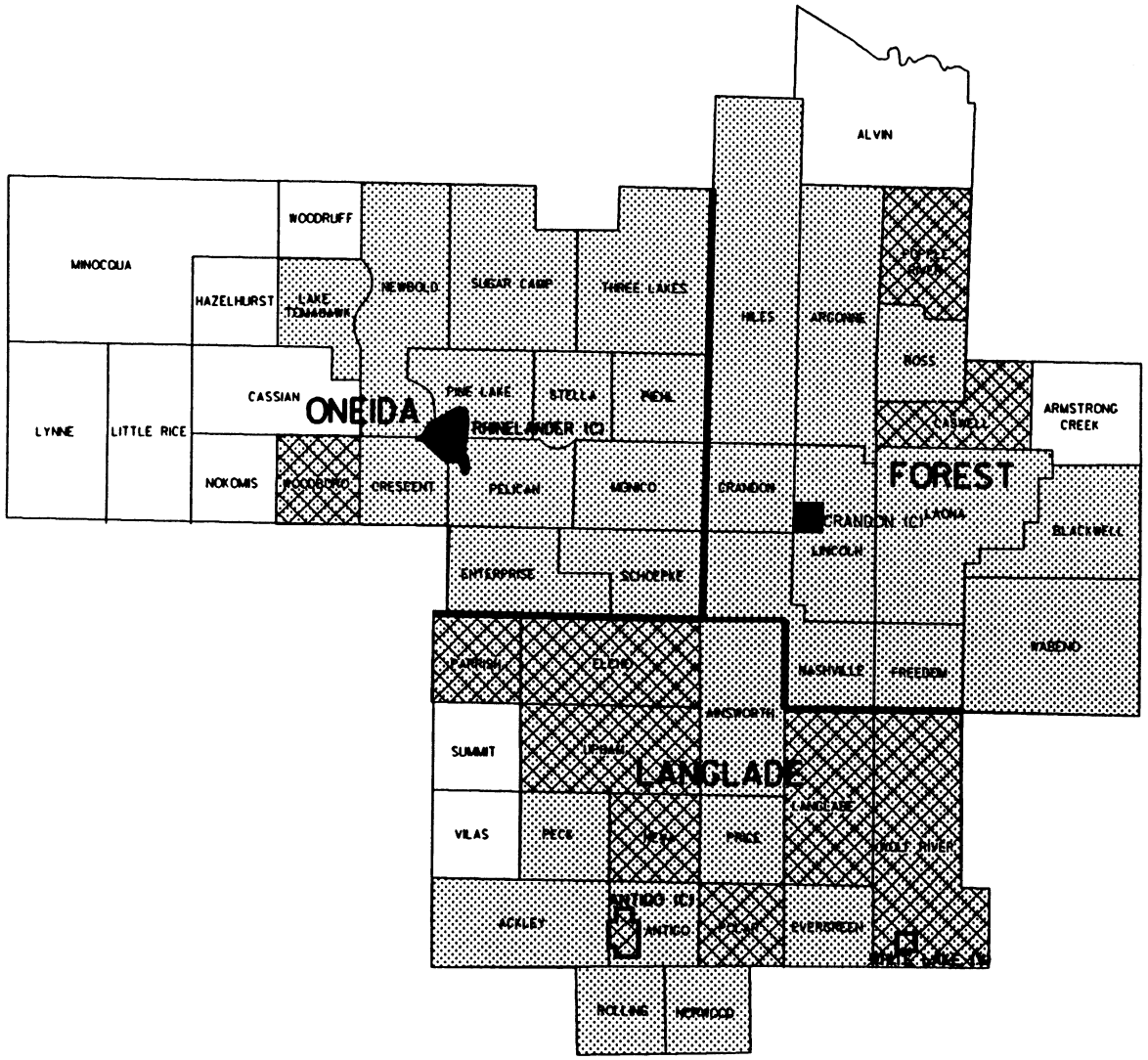

N

LEGEND

STUDY AREA

HOUSING SUPPLY DEFICIT SOMETIME IN THE FORECAST PERIOD

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
APPROVED BY:	JWS	DATE: MAY '95

Crandon Mining Company

FIGURE 4.2.13-5

PROJECTED HOUSING SHORTAGES THRU 2040
WITHOUT PROJECT

Scale:	NTS	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

94C059

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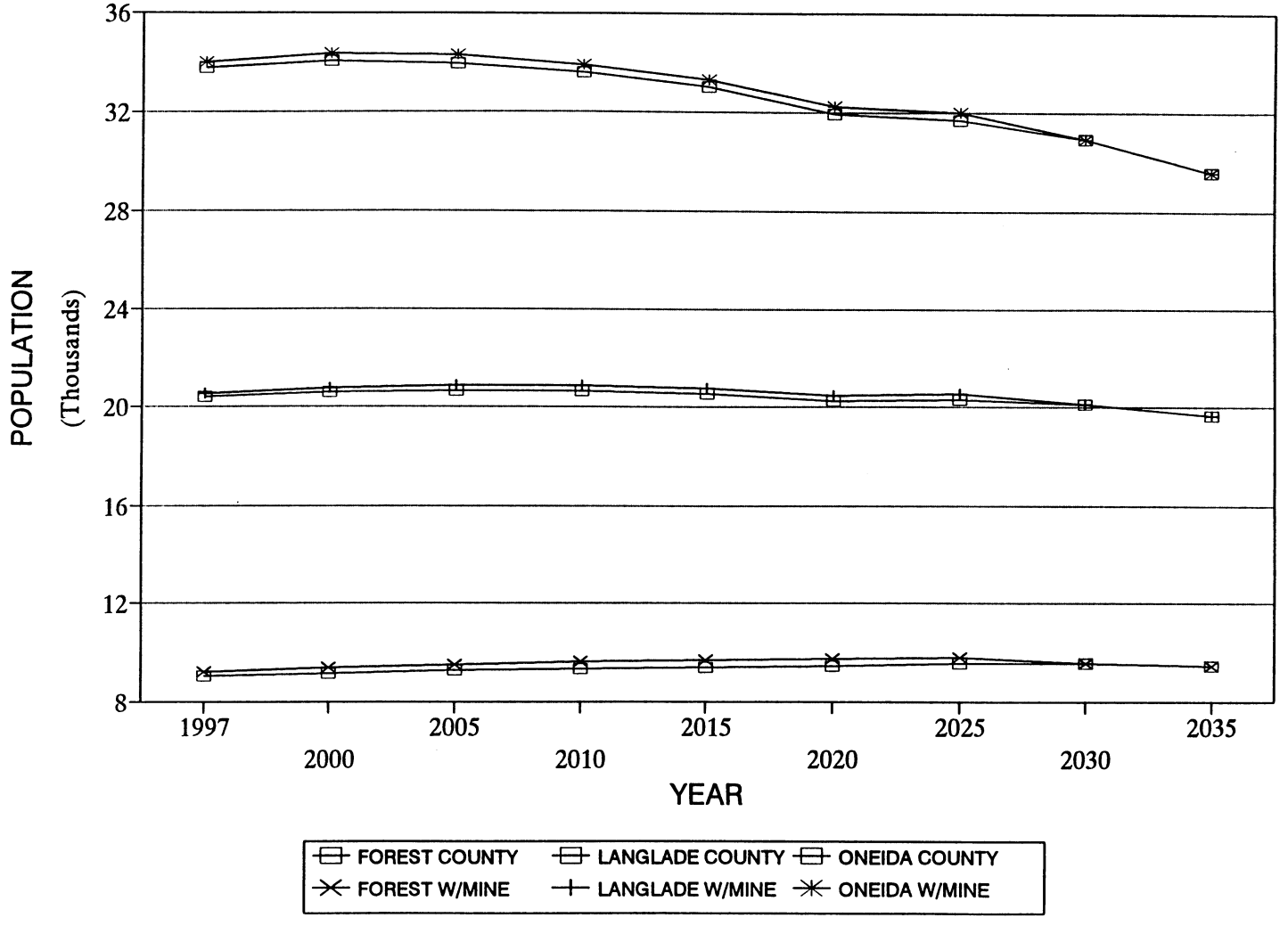

Notes:

1) Based on WDOA, *Official Municipal Population Projections 1990-2015* and Foth & Van Dyke estimates using WDOA methodology and data.

2) Population impacts assume 80% of construction workers, 30% of operations workers, and 30% of indirect/induced workers will be in-migrants to the study area. Average household size for all in-migrant workers is estimated at 3.01 persons per household.

3) Figure shows a very small increase in population under the with project scenario.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

CHECKED BY:	JKSI	DATE: MAY '95
APPROVED BY:	RVS	DATE: MAY '95
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FIGURE 4.2.13-6

POPULATION IMPACT (WITH PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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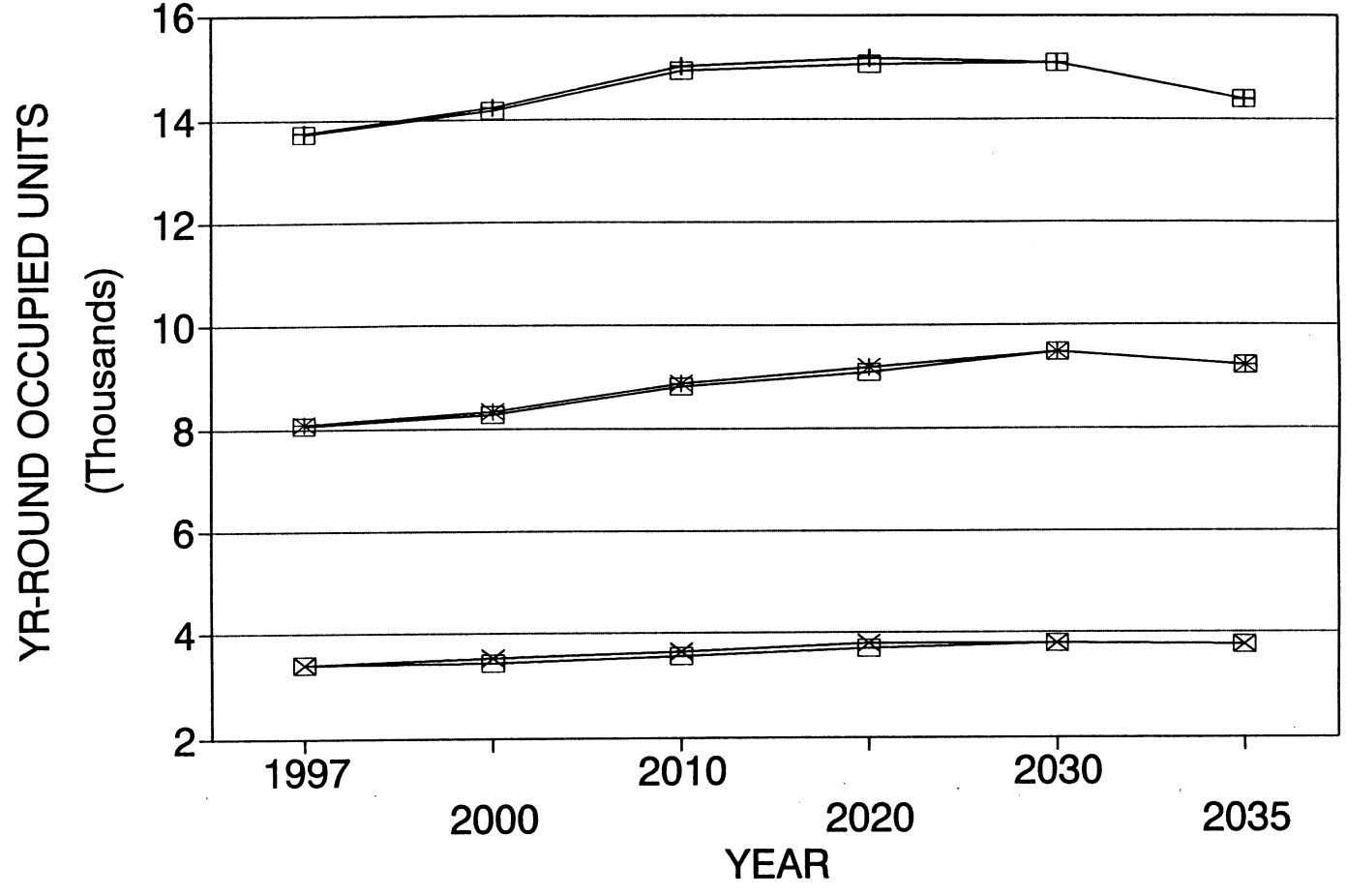

Notes:

1) Housing supply for individual counties is based on census data for age of structure. It assumes that housing replacement and survival will occur in the future as it has in the past. Housing demand projections are based on population forecasts as well as projected average household size estimates as provided by the WDOA Applied Population Laboratory.

2) Permanent worker housing impacts are assumed to be one housing unit per worker.

3) Figure shows a very small increase in permanent worker housing under the with project scenario.

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APPROVED BY:	JWS	DATE: MAY '95

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FIGURE 4.2.13-7
PERMANENT WORKER HOUSING IMPACT
(WITH PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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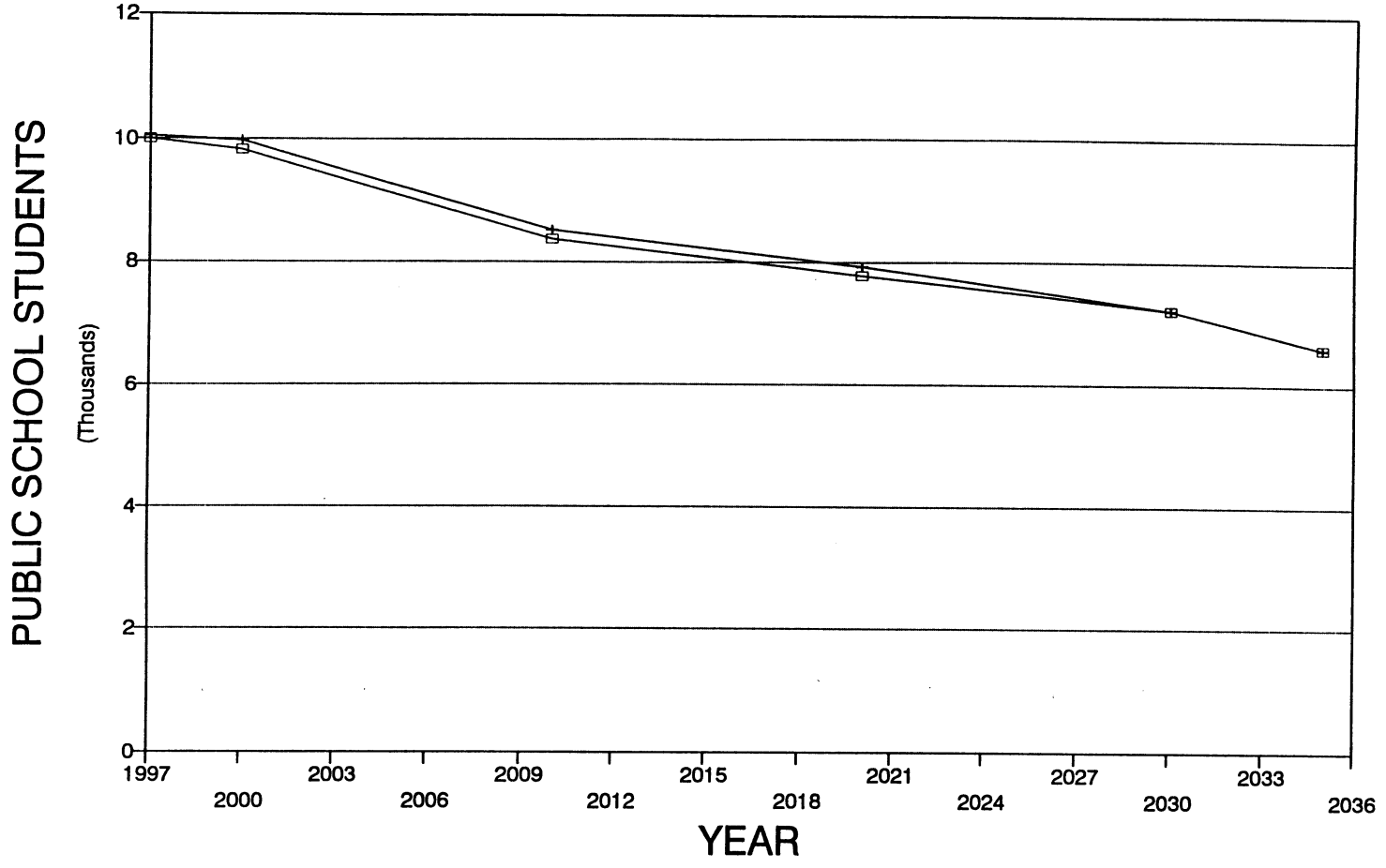
/d3/dl/users/jpr1/4c59stdy.dgn



Notes:

1) Baseline school district enrollment projections were derived from population projections for the age group 5-19.

2) Public school district enrollment impact assumes 90.6 percent of study area children (age 5-19) are enrolled in public schools. Operations workforce is assumed to average 0.7 school age children per in-migrant worker.

3) Figure shows school district enrollment declining over the next 40 years with a small increase due to the project during the period of decline.

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APPROVED BY:	JWS		DATE: MAY '95	

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FIGURE 4.2.13-8
SCHOOL DISTRICT ENROLLMENT IMPACT
(WITH PROJECT)

Scale:	AS SHOWN	Date:	MAY, 1995
Prepared By:	Foth & Van Dyke	By:	GAM

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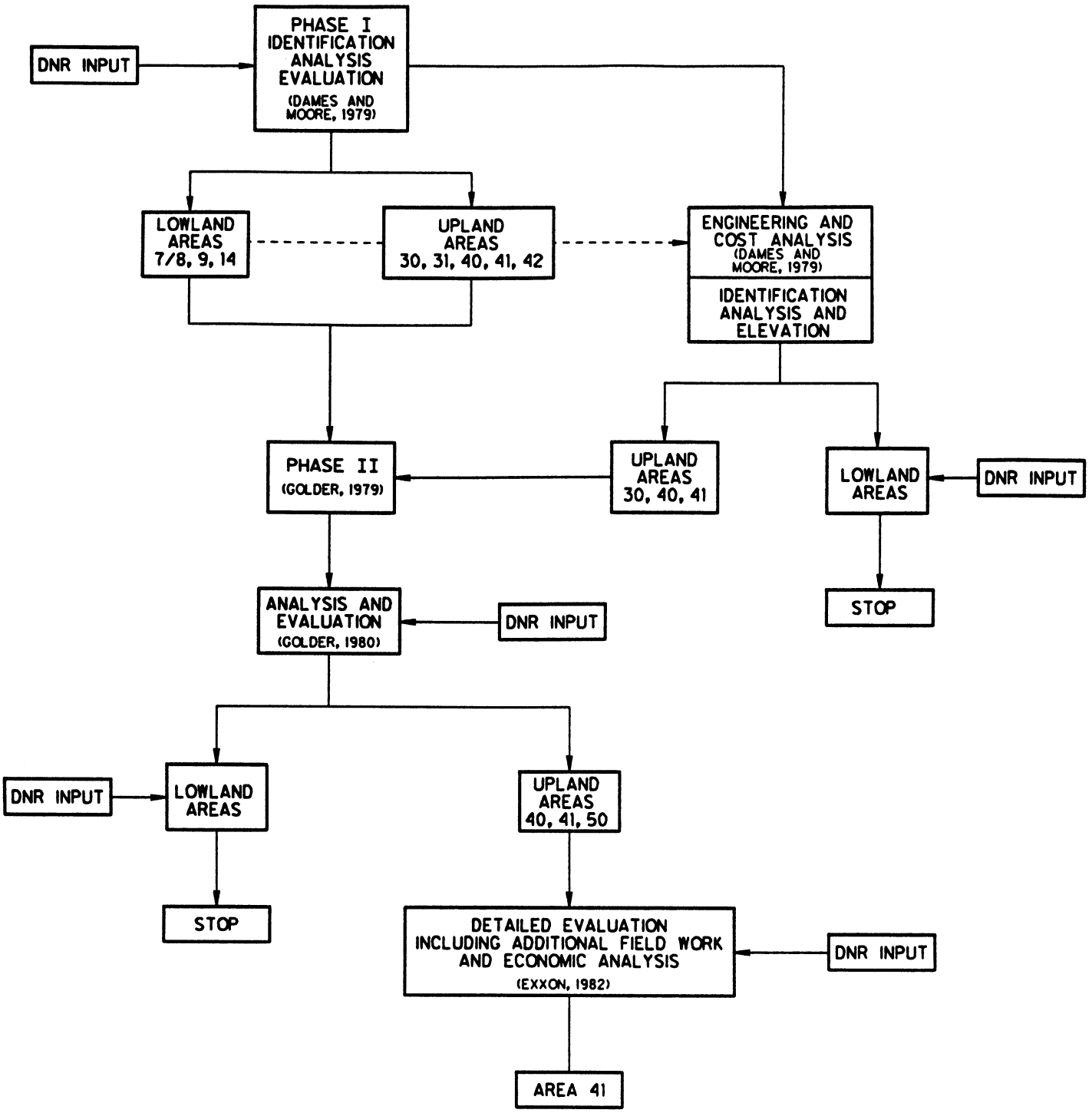

SOURCE: EXXON, 1985

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FIGURE 4.3-1
SITE SCREENING PROCESS
FOR THE TMA

Scale:	NOT TO SCALE	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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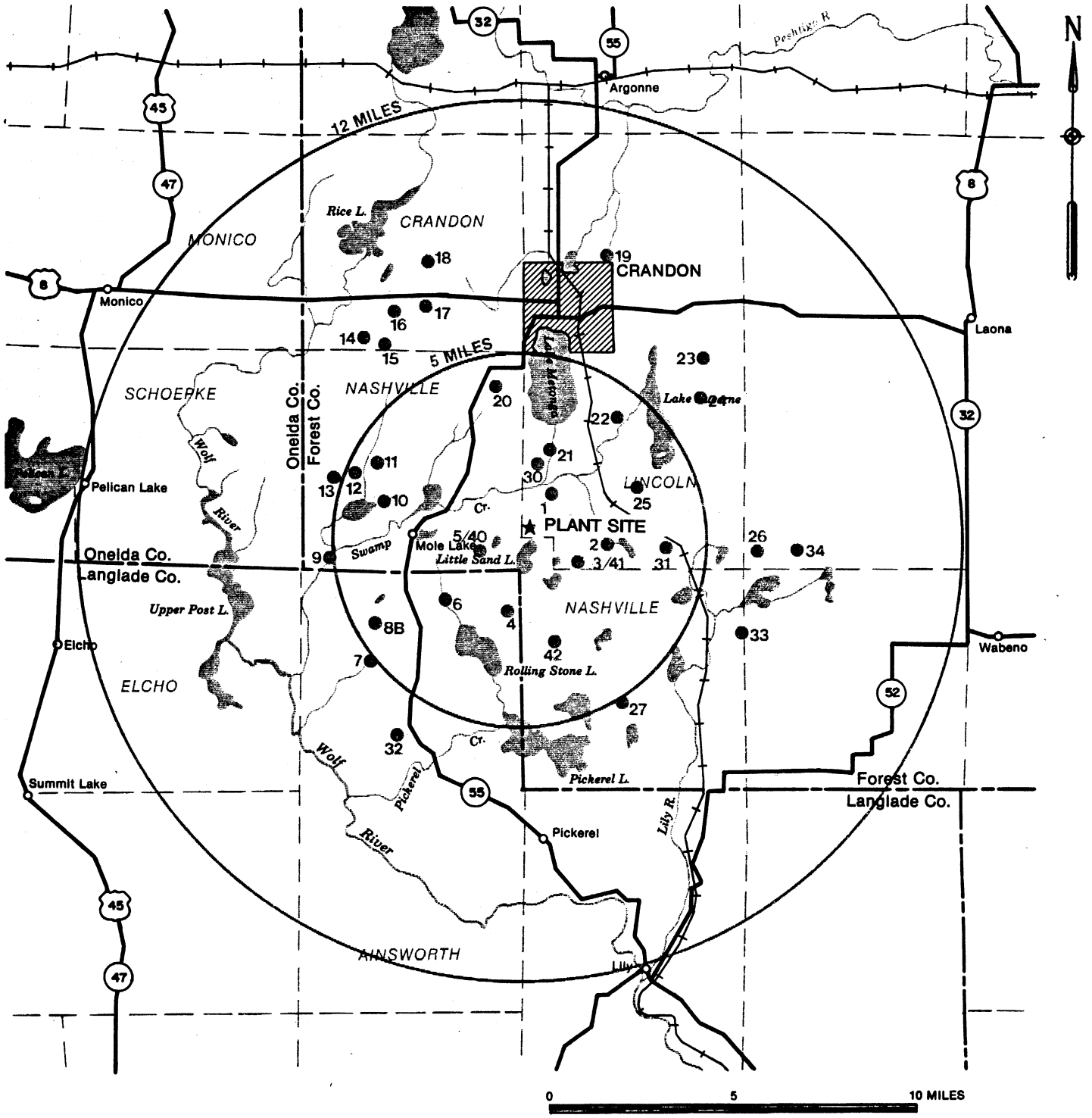

SOURCE: WDNR, 1986 FEIS ECMC, ZINC-COPPER MINE

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APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-2
ALTERNATIVE TMA SITE LOCATIONS
IDENTIFIED IN THE 1980'S

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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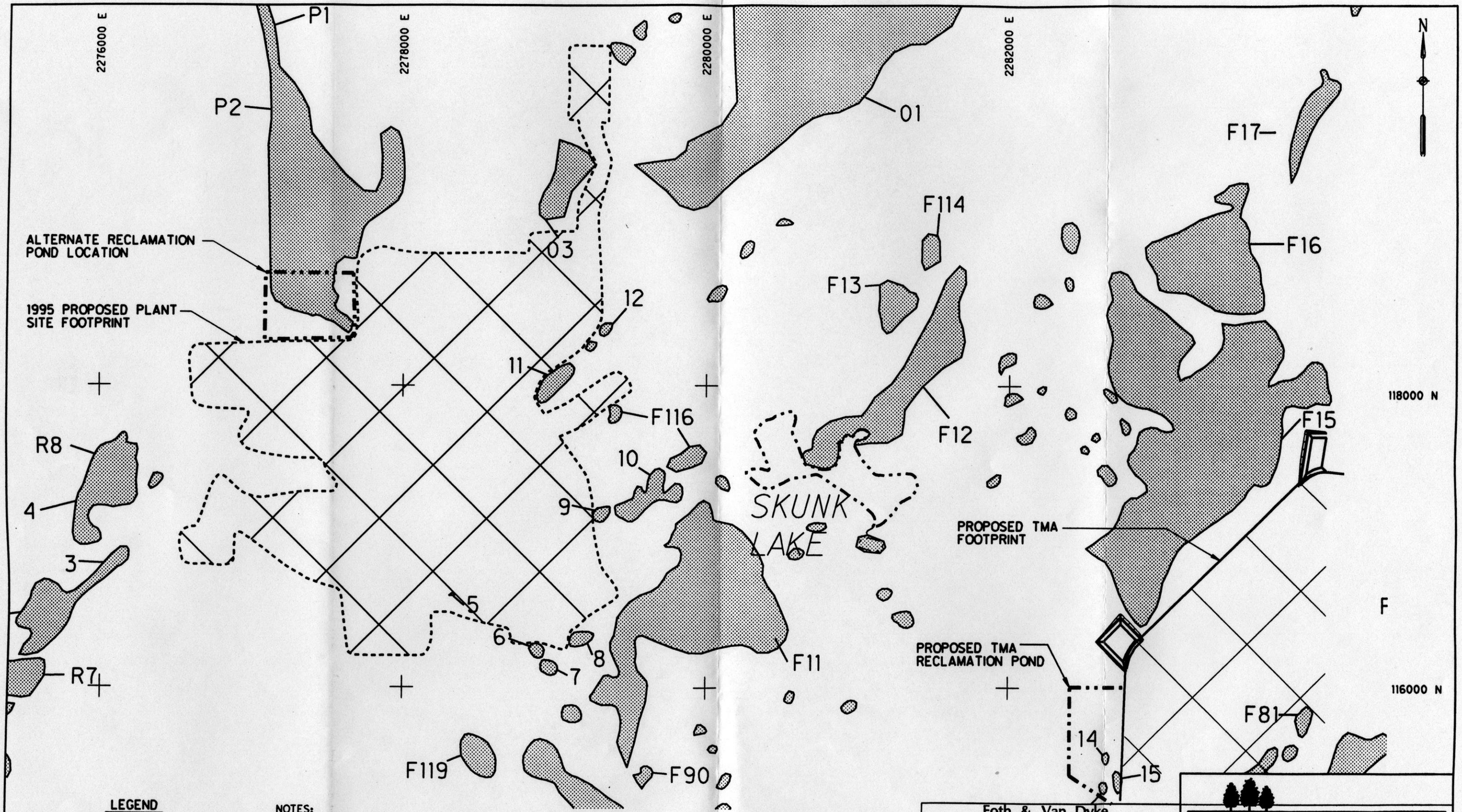

LEGEND

- WETLAND
- F15 — WETLAND ID NUMBER
- STREAMS
- LAKES

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

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APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-3

ALTERNATIVE RECLAIM POND LOCATIONS

Scale:	1" = 600'	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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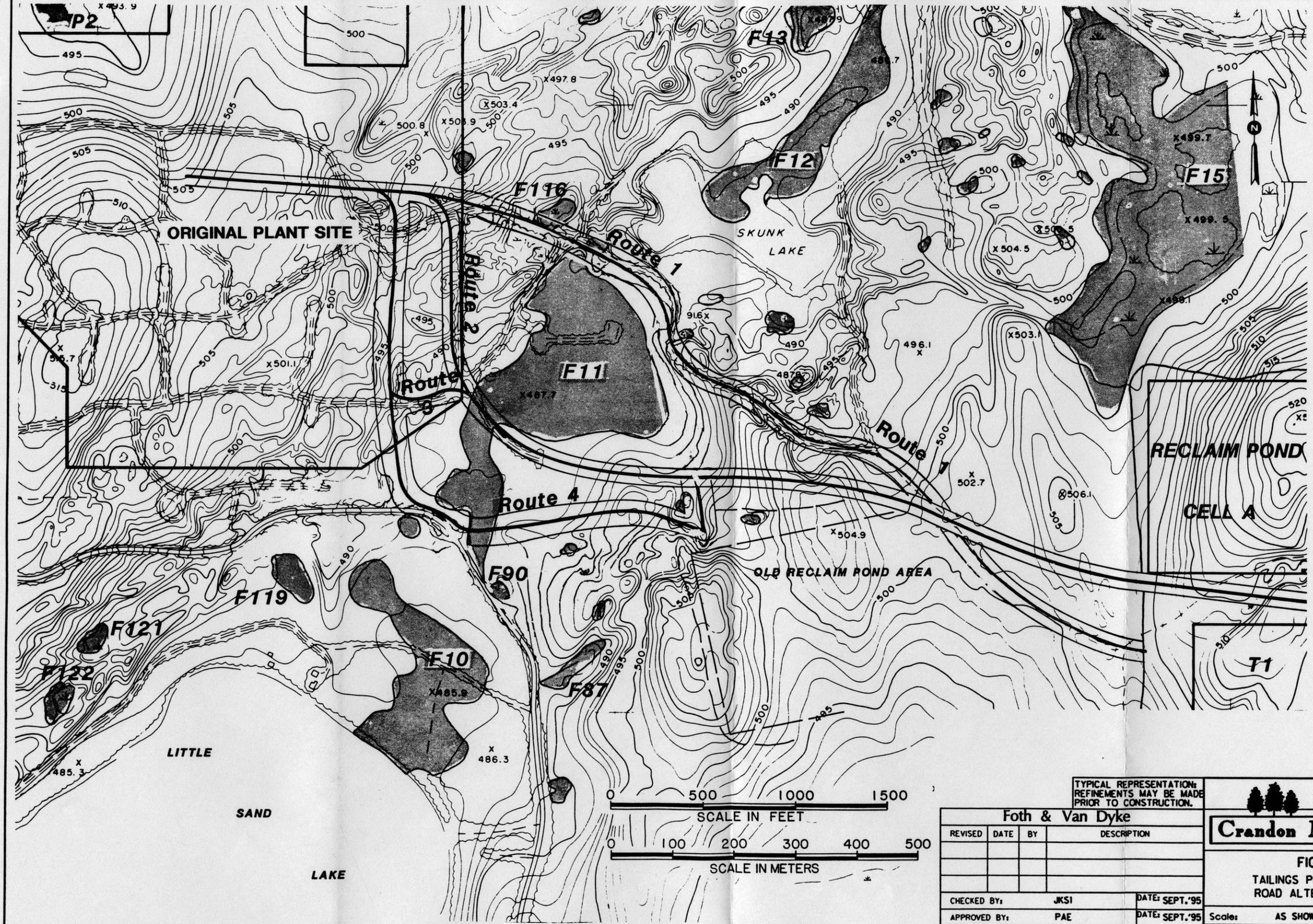

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-4
TAILINGS PIPELINE/TMA ACCESS ROAD ALTERNATIVE COORIDORS

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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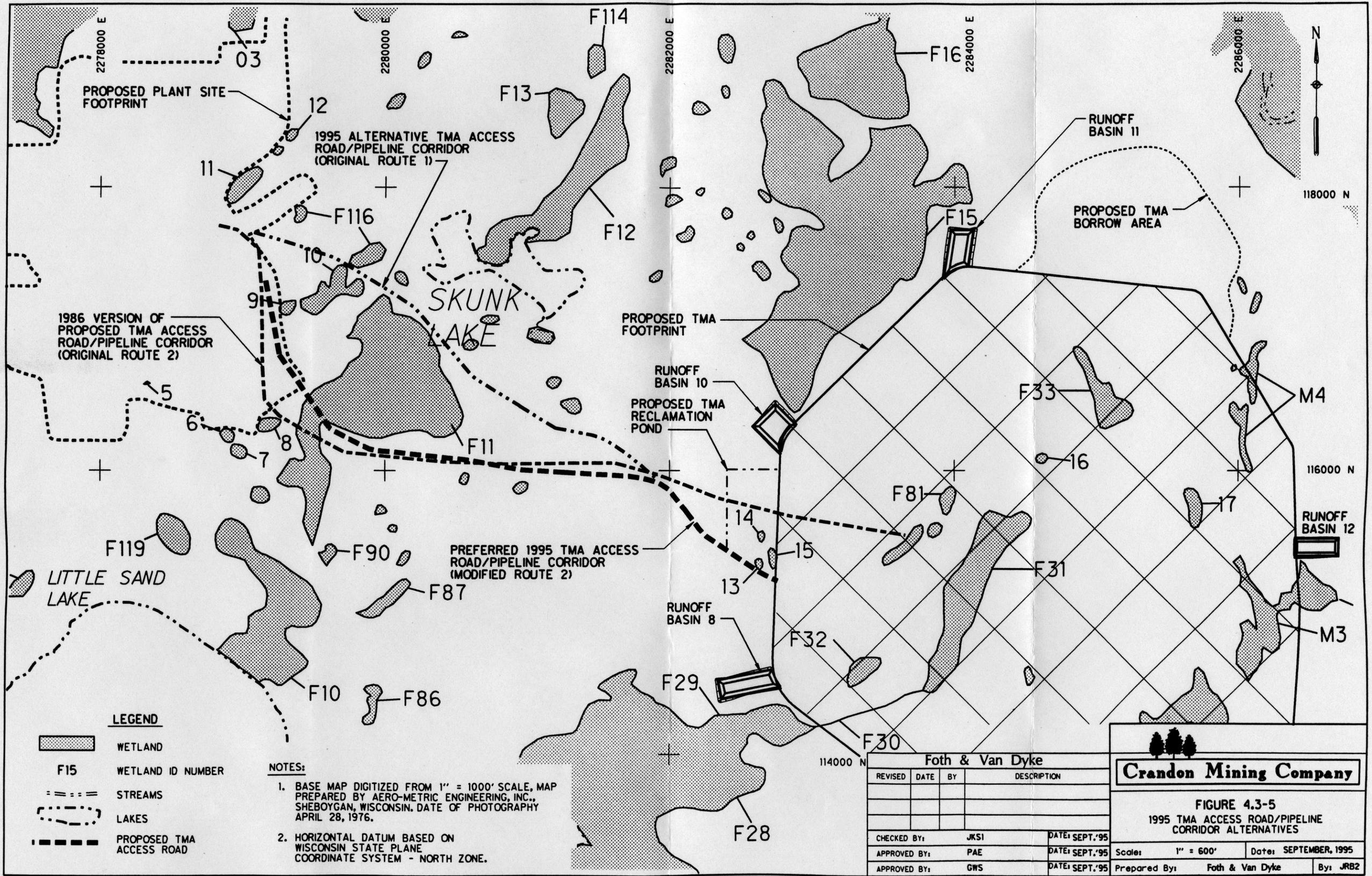

LEGEND

- WETLAND
- F15 — WETLAND ID NUMBER
- STREAMS
- LAKES
- PROPOSED TMA ACCESS ROAD

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

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APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-5
1995 TMA ACCESS ROAD/PIPELINE CORRIDOR ALTERNATIVES

Scale:	1" = 600'	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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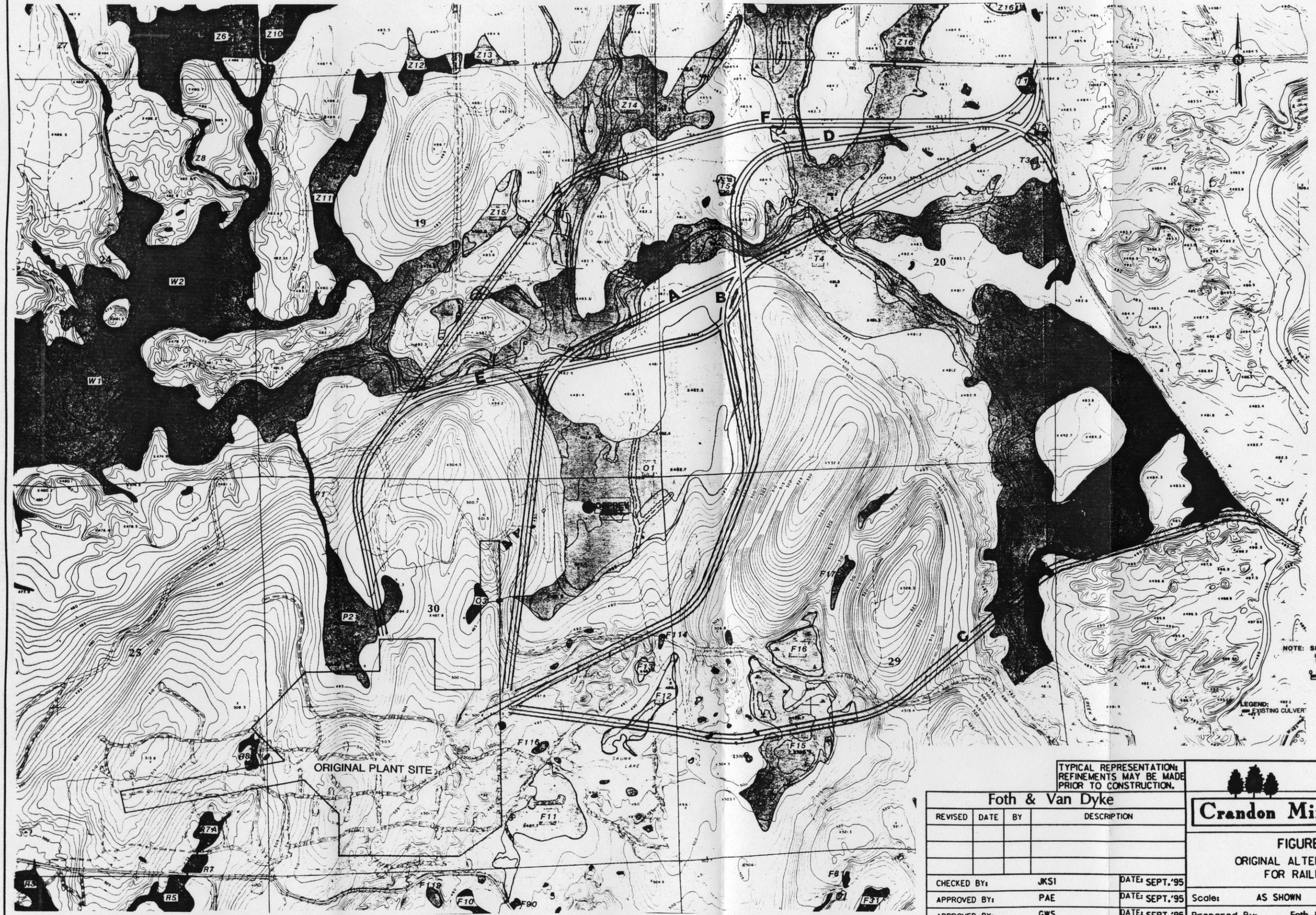

TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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APPROVED BY:	PAE	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-6
ORIGINAL ALTERNATIVE ROUTES FOR RAILROAD SPUR

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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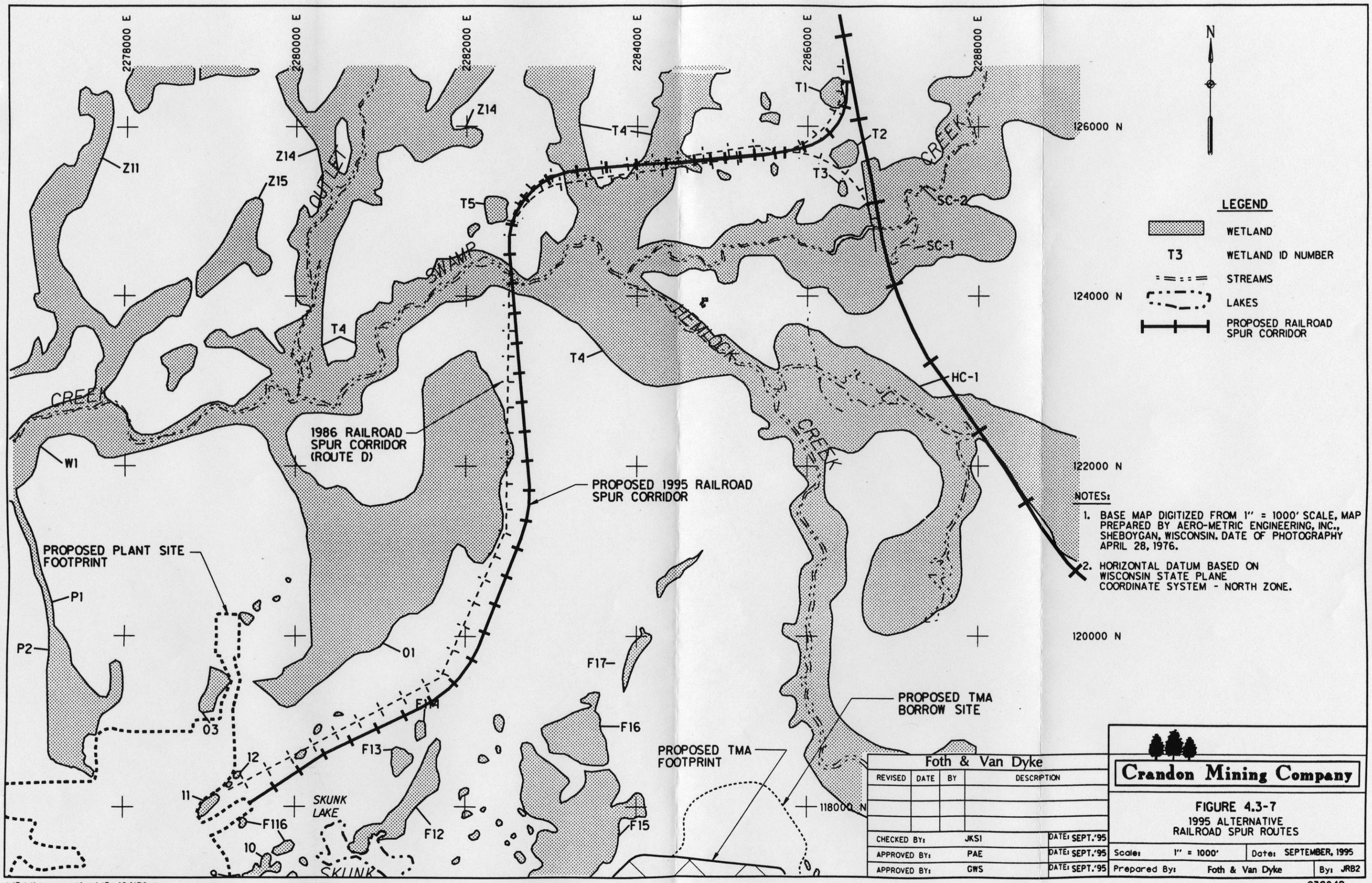

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

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APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-7
1995 ALTERNATIVE RAILROAD SPUR ROUTES

Scale:	1" = 1000'	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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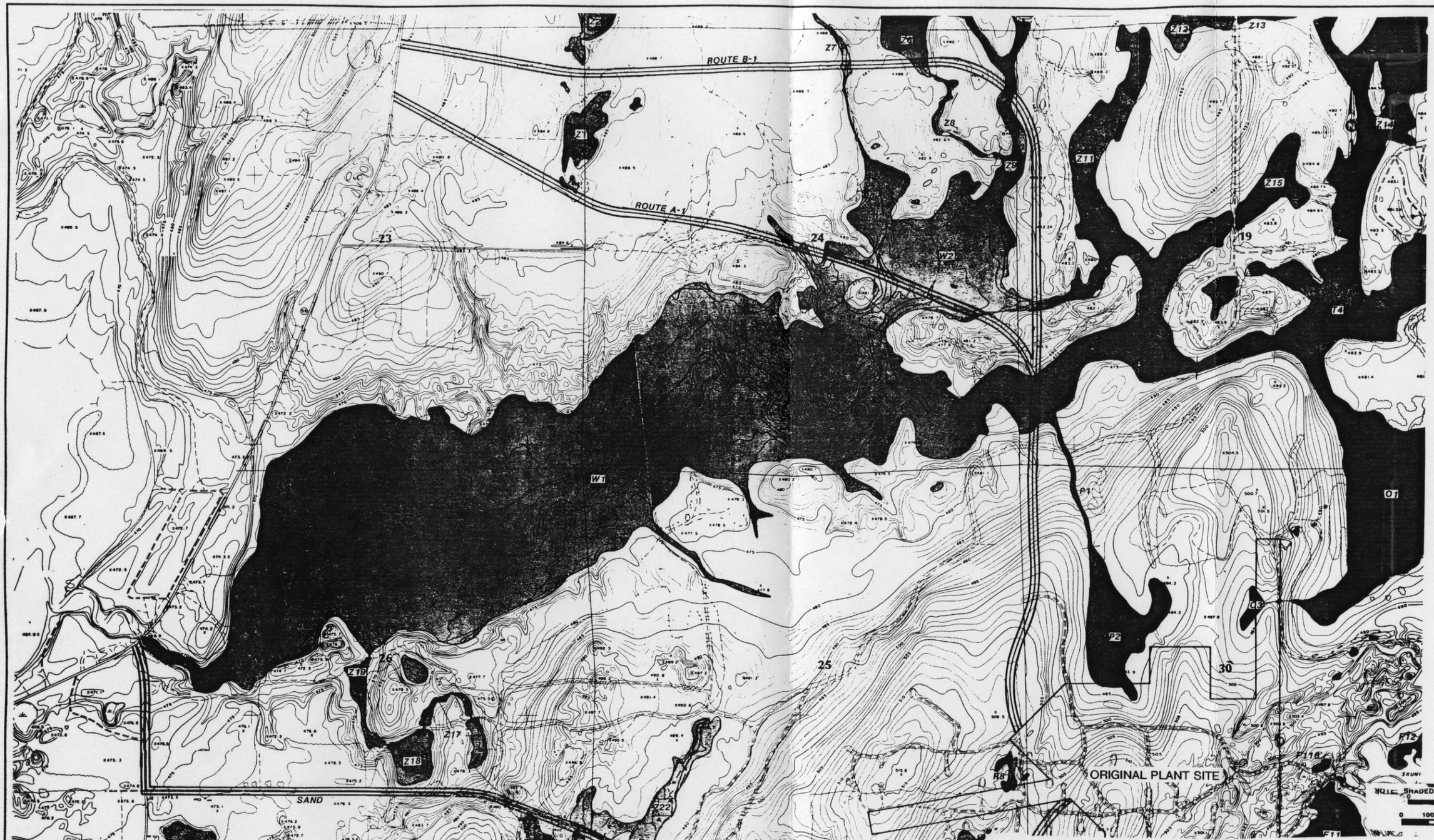

TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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FIGURE 4.3-8
ALTERNATIVE ROUTES
FOR ACCESS ROAD

Scale:	AS SHOWN	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JOW

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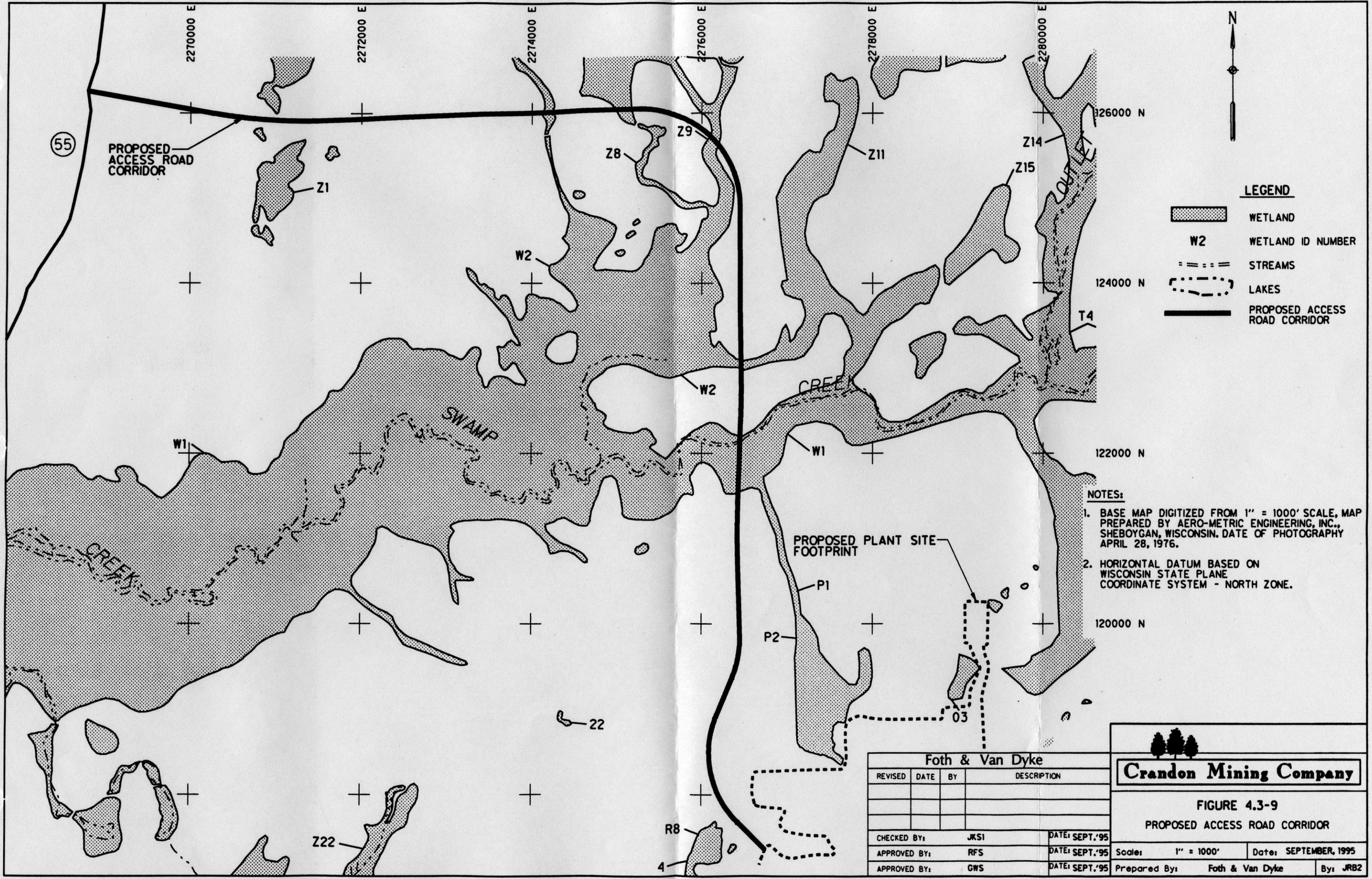

NOTES:

1. BASE MAP DIGITIZED FROM 1" = 1000' SCALE, MAP PREPARED BY AERO-METRIC ENGINEERING, INC., SHEBOYGAN, WISCONSIN. DATE OF PHOTOGRAPHY APRIL 28, 1976.
2. HORIZONTAL DATUM BASED ON WISCONSIN STATE PLANE COORDINATE SYSTEM - NORTH ZONE.

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APPROVED BY:	RFS	DATE: SEPT.'95
APPROVED BY:	GWS	DATE: SEPT.'95

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FIGURE 4.3-9

PROPOSED ACCESS ROAD CORRIDOR

Scale:	1" = 1000'	Date:	SEPTEMBER, 1995
Prepared By:	Foth & Van Dyke	By:	JRB2

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Crandon Mining Company

Environmental Impact Report

Section 5

Mitigation

Crandon Mining Company
Environmental Impact Report

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  - 5.9.2 Temporary Suspension or Premature Closure 6
- 5.10 Native American Communities 6
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Tables

Table 5-1 Domestic Wells Potentially Impacted by Groundwater Withdrawal 3

5 Mitigation

The Crandon Project as described in the *Mine Permit Application* (MPA) (Foth & Van Dyke, 1995a) and related documents has been designed to avoid and minimize environmental impacts and comply with all pertinent environmental regulations by using modern mining methods, sound engineering practices and advanced environmental control technologies.

Section 4 of this EIR outlines in detail and quantifies the expected effects of mine construction, operation, closure and long term care, based on comprehensive scientific studies. The findings described in Section 4 show that the project design and operational procedures will limit the vast majority of impacts to a minor or inconsequential level. Such impacts will not require mitigation.

The impacts listed below are those estimated by scientific and engineering investigation to be sufficiently consequential to require mitigation, and those that will require monitoring during construction or operation to determine if and when active mitigation may be necessary. Beyond these specific items, the MPA includes a complete description of how these and any additional potential environmental impacts will be monitored, and a contingency plan setting procedures for responding to adverse impacts, if they should occur. CMC will use these procedures throughout the life of the mine project and after closure to detect and mitigate environmental problems.

5.1 Cultural Resources

The only area identified as having cultural significance within the Crandon Project construction boundaries is a historic logging camp known as 47 Fr 147 (Keith Siding). This site is located adjacent to the intersection of the proposed railroad spur and the Wisconsin Central Limited Railroad south of Keith Siding Road. The design of the railroad spur has been reconfigured to the extent possible to avoid disturbance of this site. However, impact to a small area of the site cannot be avoided. To mitigate this impact, a formal archeological recovery operation has been proposed. This effort would first include a survey of the site, identification and documentation of the artifacts, followed by removal for preservation or further study, as appropriate. The final plan for recovery of this site will be developed in conjunction with the USCOE and the Wisconsin State Historical Preservation Office. In addition, CMC has developed an internal policy relating to the discovery of archaeological materials or human remains on its property during site activities. CMC will require that this policy be made part of contracts for project construction or operations.

As discussed in Section 4.2.14, the Sokaogon Chippewa Community and the Forest County Potawatomi Community have declined to participate in or cooperate with CMC's Traditional Cultural Properties Investigation ("TCPI"). In addition, the Menominee Tribe of Wisconsin has not yet released any of the TCP data gathered in cooperation with the Tribe. A condition of the agreement between CMC and the Menominee Indian Tribe of Wisconsin is that all the information on potential TCPs is confidential to the tribe and will not be shared with CMC unless approved by the Tribal legislature. Accordingly, potential TCPs have been evaluated in this EIR based upon publicly available information and CMC's baseline studies. Therefore, impacts cannot be more fully described without the involvement of the tribes.

As detailed in Section 4.2.14, CMC is not aware of any specific TCPs that will be physically disturbed by project construction and operation activities. CMC is also attempting to avoid, minimize, and mitigate potential visual, noise, and other aesthetic impacts to the surrounding

vicinity, which may contain TCPs. For example, CMC has purchase options for the lands comprising Spirit Hill and has reached an agreement with the present owner to avoid lumbering and other clearing activities. Should CMC exercise its purchase options, it will avoid any activities which could adversely affect the "viewshed" afforded from this potential TCP. This was done even though the construction and operation of the project will have no physical impact on Spirit Hill.

In addition, CMC will continue to seek to work with the Tribes in identifying TCPs and mitigating any potential impacts to such properties, including the development of appropriate cultural resource management plans which would seek to accommodate all parties' concerns while maximizing the protection of TCPs.

5.2 Transportation

Significant adverse traffic/transportation impacts were not identified. To minimize the effect of the access road traffic movements on STH 55, however, a southbound bypass lane and northbound right turn lane could be constructed on STH 55 at the intersection of the mine entrance. This would facilitate free flow of traffic on STH 55.

5.3 Groundwater

If groundwater monitoring shows a potential impact to private domestic water wells, CMC will implement mitigation measures to assure an adequate supply of water. Well modifications or replacement will be made based on the well condition and the change in the groundwater elevations measured as part of the project's extensive groundwater monitoring program. If practical, the pump will be lowered in the existing well to a depth that will allow continuous use. If this measure is impractical, then the well will be deepened and the pump lowered. If the existing well cannot be modified for use, a new well will be constructed to a depth sufficient to supply reliable, potable water.

Based on the groundwater drawdown predictions discussed in Section 4.2.5, 20 domestic water wells, located on 19 properties, may be impacted (Table 5-1). CMC has obtained purchase options for eight of these properties, leaving 12 privately owned domestic wells on 11 properties that may be impacted.

5.4 Surface Water

As discussed in section 4.2.5, groundwater drawdown resulting from the mine is estimated, under best engineering judgement, to reduce the water level in Skunk Lake by approximately 0.53 feet. Under pre-mining conditions, the majority of Skunk Lake is less than 3 feet deep with a natural variation of 4.67 feet. As discussed in Section 4.2.8, a reduction in water elevation of 0.53 feet is not expected to result in adverse impacts to this water body.

Table 5-1

Domestic Wells Potentially Impacted by Groundwater Withdrawal

Domestic Well Owner	Well Number
Becker, William J.	108
Betters, William[1]	118
Buckley, Gerald[1]	167
Dhuey, David J.	166
Dietzler, Ruth[1]	115
Fritsche, Franklin J.	107
Haferman, Ralph W.	106
Johnson, Gary[1]	162
Kelchner, Robert M.	105
Kelchner, Robert M.	105a
Kloehn, Gerald[1]	168
Lijewski, Edward	144
Mantey, James P.	121
Menominee Tribe of Wisconsin	68
Pallen, Herman[1]	116
Parker, R. W.	143
Pieritz, Richard[1]	102
Schallock, Jerry L.	145
Walentowski, Clement	119
Yeager, Florence Ann[1]	120

[1]A land purchase option has been obtained by CMC for these properties.

Prepared by: JJA1
Checked by: XXC

The reduction in groundwater elevation resulting from the mining activity may also reduce the groundwater contribution to Hoffman Springs and Hoffman Creek. Using best engineering judgement, the reduction in groundwater flows to Hoffman Springs and Hoffman Creek are estimated to be 17 and 15 percent, respectively. This reduction in flow is considered to be moderate. If monitoring indicates a decline in the groundwater table that may result in the development of negative impacts, ample time will be available to implement mitigation measures.

The reduction in groundwater elevation resulting from mining activity may also reduce the groundwater contribution to Creek 12-9. Using best engineering judgement, this reduction is estimated to equal to 9 percent for average conditions and 18 percent for low flow ($Q_{7,10}$) conditions. From a surface water flow perspective this impact, if it occurs, would be considered as moderate. From a stream fishery and macroinvertebrate standpoint the impact is estimated to be minimal to small, respectively. After review of the combined impacts on Creek 12-9 as described in Section 4.2, no mitigation is currently planned.

The reduction in groundwater elevation resulting from mining activity may also reduce the groundwater contribution to Upper Pickerel Creek. Using best engineering judgement, this reduction is estimated to equal 11 percent for average conditions and 25 percent for low flow ($Q_{7,10}$) conditions. From a surface water flow perspective, this impact, if it occurs, would be considered as moderate to substantial. From a stream fishery and macroinvertebrate standpoint, the impact is estimated to be minimal to moderate and small to moderate, respectively. If monitoring indicates the development of negative impacts, ample time will be available to implement mitigation measures.

As described in Section 7 of the *Mine Permit Application*, CMC will monitor the water flow in Hoffman Springs/Creek, Creek 12-9, and Upper Pickerel Creek. The steps to be taken in the event that monitoring data indicate a substantial change from the BEJ conditions are presented in Section 8 of the *Mine Permit Application* (Foth & Van Dyke, 1995a).

5.5 Terrestrial Biology

The potential exists at the site for possible impacts to waterfowl and mammals resulting from sufficient exposure to the waters contained in the artificial storage ponds. Although the exposures will be limited due to the availability of superior habitats and food sources within the area, CMC intends to monitor the ponds for wildlife use and exposures. In the event that adverse exposures and impacts occur CMC will implement a pond mitigation plan consisting of wildlife control techniques such as the addition of spherical polyethylene bird balls to the open water ponds.

5.6 Wetlands

Section 404 of the Clean Water Act requires mitigation for all unavoidable direct impacts to wetlands. Direct unavoidable wetland impacts resulting from the Crandon Project total 29.26 acres. Under a wetland replacement formula used by the WisDOT (1993), CMC would need to create 35.11 acres of wetlands which is a ratio of 1.2 new acres for each acre directly impacted by the mine project. CMC plans to create 57 acres, a ratio of 1.9 to 1, which is 62 percent more than dictated by the WisDOT formula. The wetland compensation acreage is intended to cover direct, temporary, and transient wetland impacts associated with the mine project. A complete description of the proposed wetland compensation project is provided in the project's *Section 404 Permit Application Addendum 1* (Foth & Van Dyke, 1995b).

Groundwater drawdown may result in adverse impacts to wetland O1, the Swamp Creek Cedars. Under the best engineering judgement scenario, groundwater levels below the southern tip of this wetland may be lowered by as much as 4 feet. However, it is not possible to predict how this large cedar swamp will react to lowered groundwater levels. Surface water runoff and spring snow-melt will continue to provide moisture to this wetland. Reduced groundwater discharge

may result in a gradual replacement of the herbaceous wetland vegetation with vegetation better adapted to reduced soil moisture levels. Any effects would likely be most prominent along the upland periphery of this wetland. Maintenance of soil moisture levels in wetland O1 is important due to the presence of the state threatened Calypso Orchid. As a result, both water levels and vegetation will be monitored, as described in Section 7 of the *Mine Permit Application* (Foth & Van Dyke, 1995a), to identify potential changes in this wetland system. The steps to be taken in the event substantial changes are indicated by the monitoring program are listed in the Section 8 of the *Mine Permit Application*.

5.7 Ambient Noise

A number of engineering and operational controls have been incorporated into the plant facilities to reduce the impact of noise during operation of the mine facilities. Some of these include:

- TMA construction will be limited to daytime hours.
- Mine ventilation fans will be selected with emphasis placed on their low noise emission potential. Mine air intake facilities will be equipped with noise abatement equipment.
- Emergency generators will be equipped with both residential grade air intake and exhaust silencers.

5.8 Aesthetics

As previously discussed in Section 4.2.12, the headframe will be visible from limited viewpoints. Topography and existing vegetation should satisfactorily screen the TMA from most viewpoints.

The railroad siding does not create major visual contrasts with other features in the existing landscape. However, in the open area around Keith Siding Road, the proposed railroad spur may create a visual impact. If visual mitigation is required, a row of plantings parallel to the outside track could be used to screen the railroad siding from the Keith Siding Road viewing area.

5.9 Socioeconomic

The overall socioeconomic impacts of the proposed project are forecast to be beneficial to the study area and the State of Wisconsin. There are several sources of funding which are generated from Mining Investment and Local Impact Fund payments which are designed to reduce negative mining related impacts. The purpose of the following sections is to identify potential negative socioeconomic impacts and mitigation measures which address those impacts.

There are two main categories of potential negative socioeconomic impacts from the project for which mitigation is appropriate: those related to project related population increases, and those related to temporary suspension or premature closure.

5.9.1 Project Related Population Increases

Population impacts associated with the project will peak at approximately 1,200 people in the last year of construction. Many of these individuals will be temporary construction workers that will be in the study area for short periods of time. Approximately 740 new residents which includes new mine employees, new indirect employees, and their families will live in the study area during plant operations. Construction and operations population impacts represent 2.2 and 1.4 percent of anticipated baseline population, respectively.

Population related impacts are not anticipated to be negative except as they relate to temporary housing. In-migrant workers will require housing during the construction phase. There is a significant amount of vacant mobile homes, lodging units, and seasonal homes which could be used to house construction workers for short periods of time. These impacts will be mitigated by CMC encouraging contractors to hire workers from within the study area, thus minimizing the number of in-migrant workers needed. As well, CMC will encourage location citizens to provide temporary accommodations for these in-migrants.

5.9.2 Temporary Suspension or Premature Closure

Mitigation measures for temporary suspension of mining operations are somewhat different from mitigation measures for permanent premature closure. Unemployment compensation would provide an income "buffer" to workers idled by a temporary shutdown. This would reduce the negative impact to the local economy as a result of temporary suspension of operations. The Net Proceeds tax which is assessed on mining companies is specifically designed to provide monies to local communities to allow the communities to plan for the future and to deal with impacts caused by a mining operation.

Mitigation measures for premature closure of the mine would depend on the amount of net proceeds tax payments available and efforts by study area communities and the State of Wisconsin to attract other industry to the area. These efforts would need to focus on available resources in the area and the creation of alternative job opportunities. Regardless of how long the mine operates, at some point the study area will need to explore alternative opportunities for mine related workers and resources. Mitigation measures for premature mine closure should be combined with general economic development efforts for the study area to plan for the future beyond the life of the mine.

In general, mitigation measures for socioeconomic impacts depend on a cooperative effort by CMC to minimize the number of in-migrant workers needed and the combined efforts of the State of Wisconsin and local jurisdictions to use net proceed tax revenue to plan for the future. These mitigation measures will help to reduce negative socioeconomic impacts.

5.10 Native American Communities

As detailed in Section 4.2.14, CMC has sought to take all reasonable steps to avoid and minimize potential adverse environmental, socioeconomic, and cultural impacts to Native American communities. These efforts have been made more difficult because of the decision by the Sokaogon Chippewa Community and Forest County Potawatomi Community not to cooperate with any of CMC's studies, to provide any requested information, or to allow tribal members to be surveyed. CMC's project design and environmental studies have, therefore, of necessity been

based upon other available sources of information, including environmental studies of the general vicinity, data developed as part of project-related socioeconomic investigations during the 1980s, court and agency filings, and published studies.

Based upon this information, CMC does not believe that there will be any adverse environmental impacts to Native American communities requiring additional mitigation. As emphasized in Section 4.2.14, however, CMC continues to seek tribal input and would welcome the opportunity to discuss further cooperative efforts that might be undertaken to avoid, minimize, and mitigate any and all potential adverse impacts to Native American communities. These include efforts to protect natural resources on and off the reservations, to respect burial sites and other traditional cultural properties, to promote cross-cultural respect and understanding, and to enhance tribal economic prosperity. CMC will continue to devote its best efforts to respect and protect the separate sovereignty, traditions, customs, and cultures of neighboring Native American communities.

5.11 Bibliography

Foth & Van Dyke, May, 1995a. *Mine Permit Application for the Crandon Project.*

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