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EA Final Report EXX-21

FINAL REPORT:
WATER AND SEDIMENT CHEMISTRY AND HYDROLOGY IN SWAMP CREEK FOR THE CRANDON PROJECT

Prepared for
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1.0 INTRODUCTION

A one-year study of the aquatic biology, chemistry (water and sediment) and hydrology of Swamp Creek downstream from County Trunk Highway M was initiated by Ecological Analysts, Inc. (EA) in April 1982. The study was performed in the vicinity of the site originally proposed to receive the water discharge from the Crandon Project. Major components of the study included water and sediment chemistry, particle size analysis, current velocity, stream discharge, fisheries, and benthic macroinvertebrates. The frequency at which these components were examined is summarized below:

Task	Frequency
Regular water chemistry	Monthly; April 1982 through March 1983
Intensive water chemistry	Quarterly; May, August, November 1982, February 1983
Sediment chemistry	May 1982
Particle size analysis	May 1982
Current velocity	Monthly; April 1982 through March 1983
Stream discharge	Monthly; April 1982 through March 1983
Fisheries	June and November 1982
Benthic macroinvertebrates	Quarterly; May, August, November 1982, February 1983

The chemistry and hydrology data obtained during the studies are presented and discussed in this report. The aquatic biology data are presented in Appendix 2.5G. The specific objectives of the chemistry and hydrology studies were:

1) Establish existing water quality conditions in Swamp Creek at one station upstream and one station downstream of the proposed location of the treated water discharge from the proposed mine/mill complex;

2) Establish existing sediment chemistry conditions at stations upstream, immediately downstream, and approximately 1.6 km (1 mile) downstream of the site originally proposed as the discharge;

3) Establish an annual discharge record for a station below both the originally proposed discharge and the USGS gaging station at County Trunk Highway M; and

4) Establish the relationship between discharge readings from the USGS gaging station at County Trunk Highway M and the gaging station (SG 24) located upstream from Squaw Creek.

2.0 METHODS

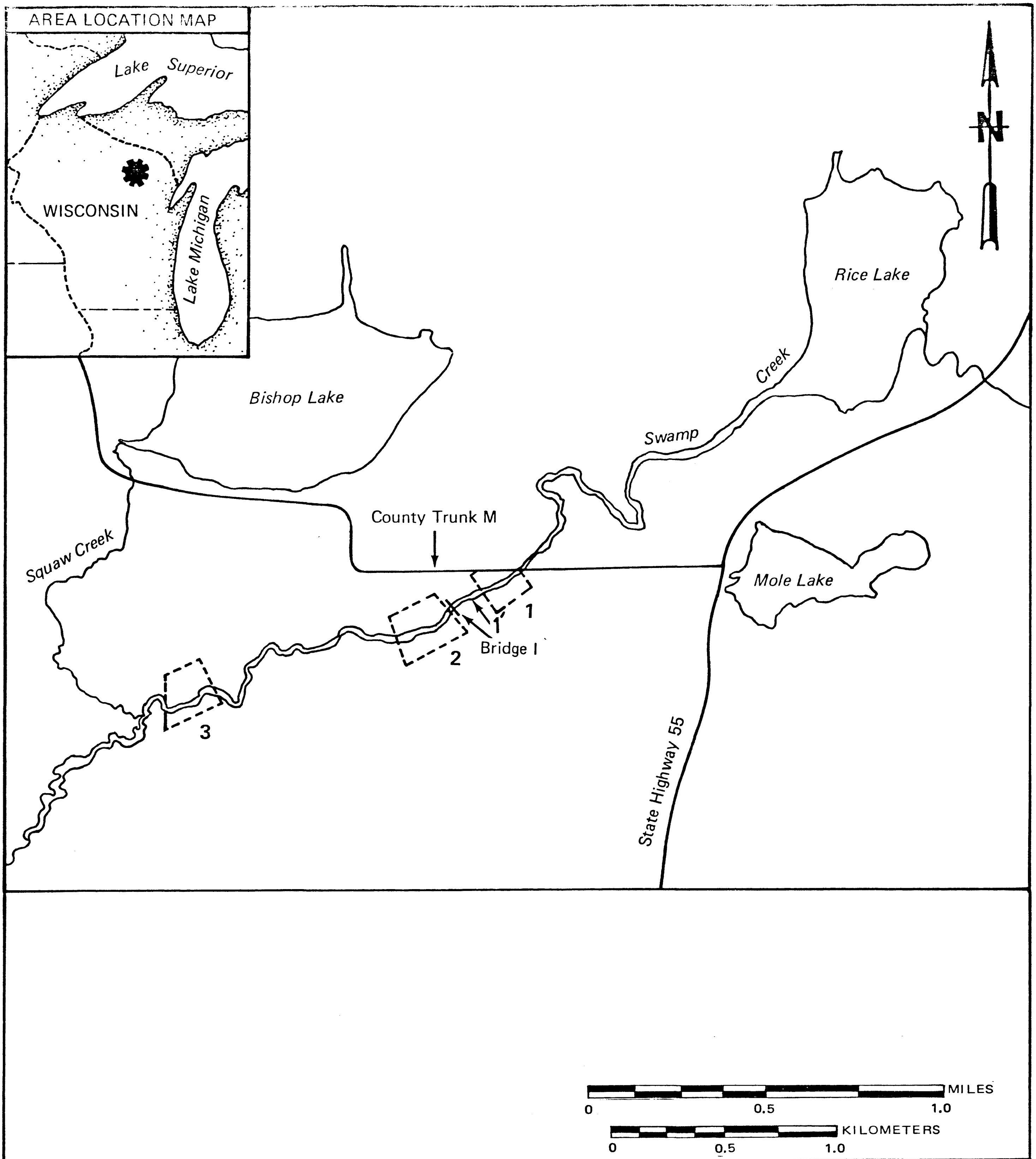
2.1 CHEMISTRY

2.1.1 Sampling Stations and Frequency

Three sampling stations were chosen (Figure L-1) based on their relationship to the proposed location of the water discharge from the mine/mill site and the habitat inventory results (Appendix 2.5G-A):

1) Station 1 was situated at the County Trunk Highway M bridge upstream of the location originally proposed for the water discharge;
2) Station 2 was situated at the private bridge (Bridge I) along Section lines 32/33 and was approximately 200 m (656 feet) downstream of the location originally proposed for the water discharge; and
3) Station 3 was located approximately 1.6 km (1 mile) downstream of the location originally proposed for the water discharge, at the point where a staff gage (SG 24) was installed.

Water samples were collected on a monthly and seasonal schedule at Stations 1 and 3 (Table L-1). Parameters that were measured are itemized in Table L-1. Duplicate water samples were collected except for the following parameters: cadmium, barium, lead, mercury, selenium, and silver. Samples for these six metals were collected in triplicate. In May 1982, duplicate samples of each available sediment type (silt, sand, or gravel) were collected at Stations 1, 2, and 3.



LEGEND:

1-3 = SAMPLING STATIONS

EXXON MINERALS COMPANY
CRANDON PROJECT

SAMPLING STATIONS FOR THE 1982-1983 AQUATIC MONITORING PROGRAM ON SWAMP CREEK BETWEEN COUNTY TRUNK HIGHWAY M AND SQUAW CREEK

ECOLOGICAL ANALYSTS

FIGURE L-1.

TABLE L-1

FREQUENCY OF COLLECTION, METHOD OF PRESERVATION, AND HOLDING TIME ASSOCIATED WITH EACH OF THE WATER AND BOTTOM SEDIMENT CHEMICAL PARAMETERS MONITORED IN SWAMP CREEK

PARAMETER	PRESERVATIVE	HOLDING TIME[a]	FREQUENCY OF COLLECTION SEASONAL	FREQUENCY OF COLLECTION MONTHLY	SEDIMENT ANALYSIS
Total Alkalinity	NA[b]	in field	X	X	
Specific Conductance	NA	in field	X	X	
pH	NA	in field	X	X	
Temperature	NA	in field	X	X	
Dissolved Oxygen	NA	in field	X	X	
Color, True	4C	24 hours	X		
Total Hardness	4C,HNO_3	6 months	X		
Total Dissolved Solids	4C	7 days	X		
Total Suspended Solids	4C	7 days	X		
Nitrogen, Ammonia	4C,H_2SO_4	24 hours	X		
Nitrogen, Nitrate	4C	24 hours	X		
Nitrogen, Nitrite	4C	48 hours	X		
Nitrogen, Organic	4C,H_2SO_4	24 hours	X		
Total Phosphorus	4C,H_2SO_4	24 hours	X		
Dissolved Orthophosphate	4C, Filter	24 hours	X		
Phenol	4C,H_3PO_4,$CuSO_4$	24 hours	X		X
Chloride	None	7 days	X	X	
Sulfur, Total	4C	7 days	X	X	X
Sulfate	4C	7 days	X	X	X
Total Cyanide	4C,NaOH	24 hours	X	X	
Biochemical Oxygen Demand	4C	24 hours	X		
Chemical Oxygen Demand	H_2SO_4	7 days	X		
Arsenic	HNO_3	6 months	X		X
Cadmium[c]	HNO_3	6 months	X	X	X
Chromium III	4C	48 hours	X		
Chromium VI	4C	48 hours	X		
Chromium, Total	HNO_3	6 months			X
Barium[c]	HNO_3	6 months	X	X	
Copper	HNO_3	6 months	X	X	X
Iron	HNO_3	6 months	X	X	X
Lead[c]	HNO_3	6 months	X	X	X
Fluoride	None	7 days	X	X	
Manganese	HNO_3	6 months	X		X
Mercury[c]	HNO_3	13 days	X	X	X
Selenium[c]	HNO_3	6 months	X	X	
Silver[c]	HNO_3	6 months	X	X	
Zinc	HNO_3	6 months	X	X	X
Sediment size	NA	NA			X

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[a] Water samples only.
[b] Not applicable.
[c] Analyses performed in triplicate.

2.1.2 Sample Collection and Handling Procedures

Before being transported to the field, each sample bottle was cleaned according to procedures described in Chapter IV of EA's Quality Control Manual for Analytical Chemistry (Ecological Analysts, 1981). These methods are consistent with those described by U.S. EPA (1979). To prevent contamination, the appropriate preservatives (e.g., HNO_3, H_2SO_4, NaOH, H_3PO_4) were added to the sample bottles in the laboratory.

Samples were collected near midstream at each station either by direct filling of sample bottles just below the water surface (April through June) or by using a plastic Kemmerer sampler (July through March). To prevent contamination by disturbed sediment, each sample was collected at arm's length upstream from the point in the stream where the person collecting the sample was standing. When the direct filling method was used, care was taken not to introduce surface debris into the sample and to avoid overfilling the bottle, thereby preventing loss of preservatives. Samples analyzed for phenols were collected in glass bottles; all other samples were collected in plastic "poly" bottles. Samples that required refrigeration were placed in insulated shipping containers and immediately packed in ice and shipped to the laboratory. An exception to this procedure occurred in June when ice was added to the cooler approximately 1.5 hr after the samples had been collected. A Chain-of-Custody Record was completed at the time of sample collection and accompanied the samples to the laboratory. Samples for orthophosphate were filtered in the field and samples for total dissolved solids were filtered in the laboratory; no other samples were filtered.

Upon arrival in EA's laboratory, the samples in each shipping container were compared with the Chain-of-Custody Record and the samples were logged in according to the procedure described in EA's Quality Control Manual for Analytical Chemistry (Ecological Analysts, 1981). Those samples with 24 hr holding times were analyzed on the day of receipt; others were stored as appropriate. Holding times for all parameters were met throughout the study.

Sediment samples were collected using a Ponar sampler. Each Ponar sample was carefully emptied onto a plastic-covered pan. Sediment was taken from the center of the sample with a clean plastic cup and transferred to precleaned glass jars. These jars were shipped and handled in a manner identical to that described above for the water samples.

2.1.3 Sample and Data Analysis

Water samples were analyzed for 40 parameters and sediment samples for 12 parameters (Table L-1). Water temperature, dissolved oxygen, pH, specific conductance, and alkalinity were measured in the field during April through July using a Hydrolab Surveyor Model 6D water quality analyzer in conjunction with a Hydrolab Model 750 underwater probe system. From August through March, these parameters were measured using YSI Models 33 and 54A, and an Orion Model 399a. In conjunction with each monthly trip, these instruments were calibrated in the field in accordance with the specifications of their respective manufacturers. Two modified Winkler titrations were used to calibrate for dissolved oxygen; pH and conductivity were calibrated against standard solutions; and temperature was calibrated using a mercury thermometer. Calibration checks were recorded on appropriate calibration forms. Total alkalinity was determined titrimeterically using either the pH mode of the Hydrolab or the Orion Model 399a pH meter according to the procedures specified by U.S. EPA (1979). All remaining parameters were measured in EA's laboratory according to U.S. EPA (1979). The specific procedure used and the associated detection limit (the smallest concentration detectable with reasonable certainty, usually calculated as two times the standard deviation of replicated blanks) are presented in Table L-2. The detection limits presented in Table L-2 are those that typically can be achieved. However, parameter-specific limits were calculated during the analysis of each set of monthly samples. As a result, the less-than values reported in the tabular summaries (e.g., Tables L-3 and L-4) later in this report represent the detection limits achievable on the particular date in question. There is no "standard" method for measuring total sulfur. In this study, total sulfur was defined as the sum of sulfide and sulfate. To assure that all sulfate was measured, especially in the sediment samples, the sulfate portion of the total sulfur analysis was preceded by a vigorous acid digestion. The sulfate values reported in Table L-3 refer to those measured by Method 375.2 (U.S.EPA, 1979), not those obtained by the acid digestion phase of the total sulfur analysis. Concentrations in sediment samples were reported on a dry weight basis.

No commonly accepted (i.e., standard) procedures exist for incorporating less-than values (i.e., values below the detection limit) into the calculation of annual averages. In this study, mean values were not calculated if more than 50 percent of the monthly values consisted of less-than values or if the detection limit was variable. In situations where less-than values were used to calculate annual means, these values

TABLE L-2

METHODS USED TO DETERMINE PHYSICAL AND CHEMICAL WATER QUALITY PARAMETERS IN WATER AND SEDIMENT SAMPLES FROM SWAMP CREEK

PARAMETER	DETECTION LIMIT (mg/l)	METHOD	U.S. EPA 1979 METHOD NUMBER
Temperature	NA[a]	Thermometric	170.0
Color, True	NA	Spectrophotometric	110.3
Total Dissolved Solids	10	Gravimetric (180 C)	160.1
Total Suspended Solids	1	Gravimetric (103 C)	160.2
Dissolved Oxygen	NA	Membrane Electrode	360.1
Total Alkalinity	0.1	Titrimetric	310.1
pH	NA	Electrometric	150.1
Total Hardness	2	Automated EDTA	130.1
Total Phosphorus	0.05	Ascorbic Acid	365.2, 365.4
Dissolved Orthophosphate	0.01	Ascorbic Acid	365.1, 365.2
Ammonia Nitrogen	0.02	Potentiometric, Automated Phenate Potentiometric, Ion selective electrode	350.1, 350.3 350.3
Nitrate Nitrogen	0.01	Automated Cadmium Reduction	353.2
Nitrite Nitrogen	0.01	Automated Colorimetric	354.1
Organic Nitrogen	0.05	Kjeldahl minus Ammonia	351.2
Iron	0.03	Atomic Absorption	236.1
Chemical Oxygen Demand	10	Automated Colorimetric	410.4
Biochemical Oxygen Demand	1	5 day + 20 C	405.1
Copper	0.001	Atomic Absorption	220.2
Zinc	0.001	Atomic Absorption	289.2
Mercury	0.0002	Atomic Absorption	245.1
Lead	0.001	Atomic Absorption	239.2
Chromium, Hexavalent	0.004	Atomic Absorption	218.4
Manganese	0.002	Atomic Absorption	243.2
Chloride	1	Automated Ferricyanide	325.2
Sulfate	3	Automated Methyl Thymol Blue	375.2
Total Cyanide	0.01	Automated Colorimetric	335.3
Phenol	0.01	Colorimetric Automated with 4-AAP Distillation	420.2
Sulfur, Total	1	Sum of Sulfide + Sulfate (acid cooked)	-[b]
Arsenic	0.002	Atomic Absorption	206.2
Cadmium	0.0001	Atomic Absorption	213.2
Chromium, Trivalent	0.004	Atomic Absorption	218.2
Chromium, Total	0.001	Atomic Absorption	218.2
Barium	0.005	Atomic Absorption	208.2
Fluoride	0.1	Potentiometric, Ion-specific Electrode	340.2
Selenium	0.001	Atomic Absorption	270.2
Silver	0.0002	Atomic Absorption	272.2
Aluminum	0.003	Atomic Absorption	202.2
Cobalt	0.002	Atomic Absorption	219.2
Molybdenum	0.001	Atomic Absorption	246.2
Nickel	0.005	Atomic Absorption	249.2
Sediment Size	NA	Mechanical, U.S. Standard Sieves	NA

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[a] NA = Not applicable.
[b] No U.S. EPA method available.

were considered to be equivalent to their respective level of detection for averaging purposes. For example, <1 μg/l would be considered as 1 μg/l for calculation of the mean.

2.1.4 Quality Assurance and Quality Control

The Director of Quality Assurance at EA conducted two internal audits of the program to verify conformance with all project specifications. The first was a field audit to verify conformance with the field procedures described in subsection 2.1.2 (e.g., proper sample collection procedures, proper standardization of field instrumentation). The second was an audit of EA's chemistry laboratory in Sparks, Maryland, to verify that the procedures described in the Quality Control Manual for Environmental Analytical Chemistry (Ecological Analysts, 1981) were being followed.

To ensure proper quality control, all phases of the water and sediment chemistry program, from preparation of the sample bottles to final reporting and validation of the data, were conducted in accordance with the procedures described in EA's Quality Control Manual.

2.2 HYDROLOGY

2.2.1 Current Velocity

Current velocity was measured monthly along transects at Stations 1 and 1', except during January and February when the stream was ice covered. Station 1' was located at the point originally proposed for the water discharge (Figure L-1). Measurements were made at the 1/4, 1/2, and 3/4 points (as estimated visually) along each transect with a Marsh-McBirney Model 201 flow meter. In depths greater than 0.76 m (2.5 feet), measurements were taken at 0.8 and 0.2 depth (0.8 and 0.2 times the distance from the surface to the bottom) below the surface. In waters less than 0.76 m deep, measurements were recorded from 0.6 depth.

2.2.2 Stream Discharge

Monthly discharge measurements were taken at Station 3, adjacent to the staff gage, according to standard procedures (USGS, 1969). A permanent fixed point was established at each end of a transect established just upstream of the staff gage and perpendicular to the stream's flow. A line marked in 0.38 m (1.25 feet) and 0.76 m (2.5 feet) intervals was stretched across the stream. Depth and current velocity were measured every 0.76 m (2.5 feet) along the line. From August through March, additional measurements were taken at 0.38 m (1.25 feet) intervals in order to keep the flow in any one segment to <10 percent of the total and the number of vertical sections between 25 and 30 as recommended by both USGS (1969) and Linsley et al. (1975). The velocity measurements were made with a Marsh-McBirney Model 201 flow meter. In water less than 0.76 m (2.5 feet) deep, a single velocity measurement was taken at 0.6 depth. In depths greater than 0.76 m (2.5 feet), measurements were made at 0.2 and 0.8 depths below the surface. In July, it was observed that the velocities at 0.8 depth were reduced due to macrophyte beds that had developed along the transect. Thus, from August through November, when macrophyte development was at its peak, a reading was also taken at 0.6 depth, wherever total depth was greater than 0.76 m (2.5 feet). These velocity measurements were then used to determine stream discharge (m^3/s [cubic feet per second]) by multiplying the cross-sectional area of each 0.76 m (2.5 feet) segment by the mean stream velocity for that segment and summing the resultant values. It was observed that when flows were high (>80 cfs) and/or gage readings exceeded 0.61 m (2 feet), some flow bypassed the gage by flowing through the wetland that bordered the eastern side of the stream. Although a quantitative estimate is not possible, it is believed that the amount of flow not measured at the gage was small, probably less than 10 percent.

The discharge values were used to develop a rating curve for staff gage 24 according to standard procedures (i.e., plotting water levels [gage heights] versus discharge values on double log paper, USGS, 1969). The rating curve, in conjunction with weekly gage measurements provided by Exxon, was used to prepare a hydrograph depicting seasonal variations in stream discharge. A similar hydrograph was prepared using data collected by the USGS at the continuous recording gaging station at County Trunk Highway M.

3.0 RESULTS

3.1 CHEMISTRY

3.1.1 Water Chemistry

The results of all 12 months of sampling are presented in Tables L-3 and L-4. To facilitate discussion, the results have been grouped into three major categories: general water quality, nutrients, and metals.

General water quality - Temperature, alkalinity, pH, specific conductance, dissolved oxygen, true color, total hardness, total and suspended solids, COD, BOD, chloride, sulfate, total sulfur, total cyanide, phenol, and fluoride are included in the general water quality group. The results of sampling during the year indicate that Swamp Creek is a moderately hard (72-116 mg/l) (see Section 2.4 of the EIR), adequately buffered stream, with pH's in the neutral range (Tables L-3 and L-4).

Temperature followed normal seasonal patterns with annual maxima (23.5-24.2°C) occurring in July and annual minima (0°C) occurring in January and February (Tables L-3 and L-4). The pH values were consistently near 7 and no seasonal pattern was apparent. Alkalinity values were somewhat variable (46-116 mg/l) but generally were between 70 and 100 mg/l. No seasonal pattern was apparent. Dissolved oxygen (DO) values varied from 2.8 to 11.2 mg/l at Station 1 and from 4.4 to 11.9

TABLE L-3

RESULTS OF WATER QUALITY SAMPLING AT STATION 1 ON SWAMP CREEK, APRIL 1982 THROUGH MARCH 1983

PARAMETER (UNITS)	4/26	5/10	6/14	7/19	8/26	9/14	10/21	11/9	12/7	1/24	2/16	3/23	Average	Range
Temperature (^{o}C)	9.3	10.0	20.5	24.2	18.0	15.7	4	2.5	0.5	0	0	1	8.8	0-24.2
pH (units)	7.1	7.1	6.2	7.0	6.7	6.8	6.8	7.1	6.7	7.1	7.3	7.1	6.9	6.2-7.3
Total alkalinity (mg/l)	51	63	97	89	116	94	79	76	79	108	102	88	87	51-116
Dissolved oxygen (mg/l)	9.3	8.1	8.1	4.9	6.5	2.8	9.8	11.2	10.9	6.4	5.4	10.3	7.8	2.8-11.2
Specific Conductance (μmhos/cm)	128	160	235	150	223	194	161	174	154	196	194	172	178	128-235
True color (units)	-[a]	111	-	-	61	-	-	81	-	-	29	-	71	29-111
Total hardness (mg/l)	-	72	-	-	116	93	85	85	85	105	116	87	94	72-116
Total dissolved solids (mg/l)	-	158	-	-	141	-	-	109	-	-	150	-	139	109-158
Tot.suspended solids (mg/l)	-	4	-	-	1	-	-	6	-	-	2.5	-	3.4	1-6
Ammonia, N (mg/l)	-	0.03	-	-	0.07	-	-	<0.01	-	-	0.08	-	0.05	<0.01-0.08
Nitrate, N (mg/l)	-	0.10	-	-	0.06	-	-	0.07	-	-	0.15	-	0.10	0.06-0.15
Nitrite, N (mg/l)	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	<0.01	<0.01
Organic nitrogen, N (mg/l)	-	0.51	-	-	0.15	-	-	0.77	-	-	0.19	-	0.41	0.15-0.77
Tot. phosphorus, P (mg/l)	-	0.06	-	-	0.4	-	-	0.21	-	-	<0.2	-	0.22	0.06-0.4
Dissolved orthophospate, P(mg/l)	-	<0.01	-	-	0.03	-	-	0.09	-	-	<0.02	-	0.04	<0.01-0.09
Total phenol (mg/l)	-	0.01	-	-	0.10	-	-	0.07	-	-	<0.02	-	0.05	0.01-0.10
Chloride (mg/l)	1.7	2.3	2.5	3.7	3.0	2.8	2.8	2.9	3.5	3.1	3.1	3.2	2.9	1.7-3.7
Total sulfur, S (mg/l)	2.2	2.1	1.3	1.7	1.5	1.9	1.3	1.4	1.9	1.7	<1.7	5.2	2.0	1.3-5.1
Sulfate[b] (mg/l)	6.6	6.1	4.0	5.1	4.5	5.5	4	4.1	6	5	<5	7	5.2	4.0-7
Total cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, 5-day (mg/l)	-	2.9	-	-	2.1	-	-	1	-	-	1.0	-	1.8	1-2.9
COD (mg/l)	-	52	-	-	40	-	-	13	-	-	35	-	35	13-52
Fluoride (mg/l)	0.11	0.08	0.09	0.2	0.02	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	NC[c]	0.02-0.11
Arsenic (μg/l)	-	<2	-	-	1	<0.5	<1	<0.2	0.3	<2	1	<2	NC	<0.2-1
Barium (μg/l)	11	14	9	15	9	15	<5	11	9	15	7	15	11	<5-15
Cadmium (μg/l)	<0.1	0.2	<0.1	0.5	<0.2	0.2	<0.1	0.4	0.3	<0.1	0.3	1.4	0.2	<0.1-1.4
Chromium + 3 (μg/l)	-	<4	-	-	3	<1	<3	<4	<2	<1	<1	<1	NC	<1-3
Chromium + 6 (μg/l)	-	<4	-	-	<1	<1	<3	<4	<2	<1	<1	<3	NC	<1-<4
Copper (μg/l)	<1	1.7	1.2	7	6	4.5	6.3	6.7	22.8	<1	5.9	8	6.0	<1-22.8
Iron (μg/l)	140	175	260	610	140	440	90	300	220	200	210	210	250	90-610
Lead (μg/l)	<1	<1	1	3.6	3	1	<1	<1	2	<1	3.4	4	2	<1-4
Manganese (μg/l)	-	38	-	-	37	40	26	23	19	35	37	35	32	19-40
Mercury (μg/l)	<0.05	<0.03	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2-0.2
Selenium (μg/l)	1.4	<1	<1	<4	<2	<0.5	<0.5	<2	<1	1.1	<1	<1	NC	<0.5-1.4
Silver (μg/l)	<0.2	<0.2	<0.2	<0.2	<0.3	<0.1	<0.2	<0.2	0.5	<1	0.1	<0.2	NC	<0.1-0.5
Zinc (μg/l)	2.5	3.1	6.1	20	30	1.2	1.7	1.1	7.1	2.3	29	42	12.2	1.1-42
Aluminum (μg/l)	-	-	-	-	43	73	37	9	51	6	33	26	35	9-73
Cobalt (μg/l)	-	-	-	-	<2	<1	<1	<1	2	2.1	<1	<1	NC	<1-2.1
Molybdenum (μg/l)	-	-	-	-	3	<1	<2	<2	1	<1	3.0	2.4	NC	<1-3.0
Nickel (μg/l)	-	-	-	-	<5	5	9	8	<1	1	<2	<1	NC	<1-9

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[a] Dash indicates no data collected.

[b] Sulfate measured by Method 375.2.

[c] Not calculated because most values were less than the detection limit and/or the detection limit was variable.

TABLE L-4

RESULTS OF WATER QUALITY SAMPLING AT STATION 3 ON SWAMP CREEK, APRIL 1982 THROUGH MARCH 1983

PARAMETER (UNITS)	4/26	5/10	6/14	7/19	8/26	9/14	10/21	11/9	12/7	1/24	2/16	3/23	Average	Range
Temperature (°C)	8.4	10.0	19.5	23.5	18.5	15.7	4	3.0	0.5	0	0	1	8.7	0-23.5
pH (units)	6.9	7.0	6.5	7.3	7.4	6.9	6.9	7.6	6.5	7.1	7.3	7.2	7.1	6.5-7.6
Total alkalinity (mg/l)	46	63	94	89	112	92	76	87	75	106	102	81	85	46-112
Dissolved oxygen (mg/l)	9.3	8.1	9.2	6.5	10.1	4.4	10.6	11.9	11.3	6.2	5.7	10.9	8.7	4.4-11.9
Specific Conductance (µmhos/cm)	128	158	225	165	223	185	158	176	149	162	198	172	175	128-225
True color (units)	-[a]	115	-	-	66	-	-	79	-	-	30	-	73	30-115
Total hardness (mg/l)	-	76	-	-	113	92	83	85	82	106	116	87	93	76-116
Total dissolved solids (mg/l)	-	91	-	-	126	-	-	119	-	-	177	-	128	91-177
Tot.suspended solids (mg/l)	-	10	-	-	3	-	-	10	-	-	1.5	-	6.1	1.5-10
Ammonia, N (mg/l)	-	0.05	-	-	0.03	-	-	<0.01	-	-	0.11	-	0.05	<0.01-0.11
Nitrate, N (mg/l)	-	0.09	-	-	0.04	-	-	0.15	-	-	0.27	-	0.14	0.04-0.27
Nitrite, N (mg/l)	-	<0.01	-	-	<0.01	-	-	<0.01	-	-	<0.01	-	<0.01	<0.01
Organic nitrogen, N (mg/l)	-	0.69	-	-	0.12	-	-	0.83	-	-	0.42	-	0.52	0.12-0.83
Tot. phosphorus, P (mg/l)	-	0.06	-	-	0.5	-	-	0.35	-	-	<0.2	-	0.28	0.06-0.50
Dissolved orthophospate, P(mg/l)	-	<0.01	-	-	0.02	-	-	0.09	-	-	<0.01	-	0.03	<0.01-0.09
Total phenol (mg/l)	-	0.01	-	-	0.03	-	-	0.05	-	-	<0.02	-	0.03	0.01-0.05
Chloride (mg/l)	1.7	2.3	2.4	2.9	3.0	2.9	2.9	2.9	3.2	3.2	3.3	3.3	2.8	1.7-3.3
Total sulfur, S (mg/l)	2.2	2.0	1.5	1.6	1.3	1.5	1.3	1.4	1.9	1.7	<1.7	4.8	1.9	1.3-4.8
Sulfate[b] (mg/l)	6.5	5.9	4.4	4.7	4.0	4	4	3.8	6	6	5	7	5.1	4-7
Total cyanide (mg/l)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
BOD, 5-day (mg/l)	-	2.3	-	-	2.3	-	-	<1	-	-	1.1	-	1.7	<1-2.3
COD (mg/l)	-	85	-	-	14	-	-	12	-	-	39	-	38	12-85
Fluoride (mg/l)	0.09	0.06	0.08	0.10	0.02	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	NC[c]	0.06-0.10
Arsenic (µg/l)	-	<2	-	-	<1	<0.5	<1	<0.2	<0.3	<2	1.1	<2	NC	<0.2-1.1
Barium (µg/l)	12	13	9	19	5	17	7	9	8	15	5	11	11	5-19
Cadmium (µg/l)	<0.1	<0.1	<0.1	0.2	<0.2	<0.1	<0.1	0.4	0.2	<0.1	0.3	0.4	NC	<0.1-0.4
Chromium + 3 (µg/l)	-	<4	-	-	3	<1.5	<3	<2	<2	<1	<1	<2	NC	<1-3
Chromium + 6 (µg/l)	-	<4	-	-	<1	<1	<3	<2	<2	<1	<1	<2	NC	<1-<4
Copper (µg/l)	<1	1.6	1.1	2	9	5.5	6.3	4.5	4.7	1.4	6.3	3	3.9	<1-9
Iron (µg/l)	175	230	350	680	80	400	<30	490	220	200	270	270	283	<30-680
Lead (µg/l)	<1	<1	<1	1	2	<1	<1	<1	1	<1	3.0	1	1	<1-3
Manganese (µg/l)	-	45	-	-	15	10	23	27	23	40	37	39	29	10-45
Mercury (µg/l)	<0.05	<0.03	<0.2	<0.2	<0.2	<0.1	<0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<.2-0.2
Selenium (µg/l)	1.2	<1	<1	<4	<2	<0.5	<0.5	<2	<1	1.1	<1	<1	NC	<0.5-1.2
Silver (µg/l)	<0.2	<0.2	<0.2	<0.2	0.3	<0.1	<0.2	<0.2	<0.5	<1	<0.1	<0.2	NC	<0.1-0.3
Zinc (µg/l)	4.9	3.7	9.6	43	40	1.0	3.7	0.9	1.9	2.7	13	11	11	0.9-43
Aluminum (µg/l)	-	-	-	-	47	116	44	8	45	10	31	22	40	8-116
Cobalt (µg/l)	-	-	-	-	<2	<1	<1	<1	<2	2.1	<1	<1	NC	<1-2.1
Molybdenum (µg/l)	-	-	-	-	3	<1	<2	<2	1	1.2	3.1	2.9	1.3	<1-3.1
Nickel (µg/l)	-	-	-	-	<5	5.5	7	7	<1	1	<2	<1	NC	<1-5.5

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[a] Dash indicates no data collected.

[b] Sulfate measured by Method 375.2.

[c] Not calculated because most values were less than the detection limit and/or the detection limit was variable.

mg/l at Station 3. Percent saturation values at Station 1 ranged from 28 to 89 percent, with the majority being between 72 and 82 percent. At Station 2, percent saturation values ranged from 44 to 106 percent, with the majority being between 72 and 81 percent. The reason for the low values (2.8-4.4 mg/l) in September is unknown. Dissolved oxygen was one of only two parameters that exhibited a noticeable difference between the two stations; values at Station 3 averaged approximately 1 mg/l higher than at Station 1. This difference was attributed to the large beds of aquatic macrophytes that were present at Station 3 but not at Station 1. Specific conductance averages and ranges were similar at both stations. True color values in Swamp Creek ranged from 29 to 115 with no apparent seasonal pattern. Total hardness values were consistently between 72 and 116 mg/l at both stations. Total dissolved solids (TDS) values were consistent at Station 1 ranging only from 109 to 159 mg/l, whereas TDS values at Station 3 were more variable, ranging from 91 to 177 mg/l. Total suspended solids were low $\leq$10 mg/l at both stations indicating minimal turbidity and sedimentation in Swamp Creek. Phenols were also low, typically less than 0.05 mg/l. Chloride concentrations were consistently between 1.7 and 3.7 mg/l at both stations. Sulfate concentrations were low ($\leq$7 mg/l) and consistent (range of 4-7 mg/l). Of the two components of total sulfur, one (sulfide) was always below its detection limit (0.7 mg/l). As a result, the total sulfur values of 1.3-5.1 mg/l presented in Tables L-3 and L-4 are based solely on the concentration of sulfate found in the acidified sample.

Total cyanide concentrations were below the limit of detection (0.01 mg/l) at both stations throughout the year. Biological oxygen demand concentrations were also low throughout the year, and usually were

<2 mg/l. Chemical oxygen demand concentrations were variable, particularly at Station 3 where they ranged from 12 to 85 mg/l. Fluoride concentrations were consistently $\leq$0.11 mg/l throughout the year. The values for all the general water quality parameters measured in Swamp Creek during the year were within the ranges reported for streams in northern Wisconsin (USGS, 1978, 1979, 1980, 1981, and 1982).

Nutrients - This group includes the various forms of nitrogen and phosphorus. Total phosphorus concentrations ranged from 0.06 to 0.50 mg/l and orthophosphate concentrations from <0.01 to 0.09 mg/l (Tables L-3 and L-4). All forms of nitrogen were low.

Metals - This group includes iron, copper, zinc, mercury, lead, aluminum, cobalt, molydenum, nickel, chromium, manganese, cadmium, barium, silver, and for the purposes of this report, arsenic and selenium. With the exception of iron, aluminum, manganese, barium, and zinc, concentrations of all the other metals were near or below their respective levels of detection (Tables L-3 and L-4). Barium concentrations were consistently between 5 and 20 µg/l at both stations. Manganese concentrations varied from 10 to 45 µg/l, but generally were between 20 and 40 µg/l. Zinc concentrations were generally <10 µg/l but values of 20-43 µg/l occasionally were measured. No pattern was apparent with regard to these higher values. Aluminum concentrations were between 8 and 51 µg/l, except on 14 September when values of 73 and 116 µg/l were reported at Stations 1 and 3, respectively. The reason for the high values in September is unknown. Iron was present in much higher concentrations than any of the other metals in Swamp Creek. Iron concentrations varied from <30 to 680 µg/l, with values between 150 and

350 µg/l being typical. The iron values at Station 1 (mean = 250 µg/l) were generally lower than at Station 3 (mean = 283 µg/l) for reasons which were not apparent.

3.1.2 Sediment Chemistry

Of the 12 parameters measured in the sediment, only iron, and to a lesser extent manganese and total sulfur, were present in relatively high concentrations (Tables L-5, L-6, and L-7); a pattern similar to that seen in the water samples (see subsection 3.1.1). The concentration of these parameters varied depending on substrate. The concentrations of most of the parameters were considerably higher in silt than in sand or gravel; concentrations in sand and gravel were generally comparable. High metal concentrations in the silt fraction are typical because the small size of the particles making up the silt fraction provides proportionally greater surface area compared to the sand or gravel fractions.

3.1.3 Particle Size Analysis

Sediment composition within the two gravel habitats was similar: course materials (>2.80 mm) constituted 68.3 and 66.6 percent, sand ($\leq$2.80 mm to $\geq$0.125mm) constituted 31.3 and 32.9 percent, and fines (<0.125 mm; very fine sand, silt, and clay) constituted 0.4 and 0.5 percent of the sediment material at Stations 1 and 2, respectively (Table L-8).

The substrates in silt and sand habitats were more variable

TABLE L-5

RESULTS OF CHEMICAL ANALYSIS OF SEDIMENT SAMPLES COLLECTED AT STATION 1 ON SWAMP CREEK IN MAY 1982

PARAMETER (mg/kg)[a]	SILT-A[b]	SILT-B[b]	SAND-A	SAND-B	GRAVEL-A	GRAVEL-B
Sulfate	255	111	644	24	14	17
Total sulfur	108.9	79.4	136.2	93.5	11.9	7.3
Arsenic	1.7	2.0	1.2	<0.02	<0.2	<0.2
Cadmium	0.75	0.61	0.06	0.07	0.02	0.05
Total Chromium	5.0	3.7	1.7	2.2	1.4	1.8
Copper	21.0	7.5	1.7	1.5	3.7	1.3
Iron	10,600	2,080	1,300	890	1,160	700
Lead	20.6	16.7	2.5	2.5	0.6	2.3
Manganese	246	51.9	12.3	17.1	101	34.6
Mercury	0.23	<0.17	<0.03	<0.03	<0.03	<0.03
Zinc	70.3	45.2	12.3	6.8	6.0	7.7
Phenol	<0.31	<0.23	<0.05	<0.02	0.31	<0.03

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[a] Dry weight.

[b] A and B = Replicate samples taken from separate Ponar grabs.

TABLE L-6

RESULTS OF CHEMICAL ANALYSIS OF SEDIMENT SAMPLES COLLECTED AT STATION 2 ON SWAMP CREEK IN MAY 1982

PARAMETER (mg/kg)[a]	SILT-A[b]	SILT-B[b]	SAND-A	SAND-B	GRAVEL-A	GRAVEL-B
Sulfate	500	640	23.7	37.2	15.8	44.3
Total sulfur	480	627	14.6	42.4	5.6	16.4
Arsenic	4.74	3.53	1.34	1.54	1.32	1.43
Cadmium	0.32	0.31	0.03	0.03	0.02	0.03
Total Chromium	24.2	14.0	5.2	5.1	4.4	2.8
Copper	3.48	4.44	4.06	3.67	5.50	4.89
Iron	5,820	7,350	1,890	1,790	1,820	1,610
Lead	25.9	20.6	1.6	2.0	1.5	2.1
Manganese	229	253	31.1	31.0	82	40.8
Mercury	<0.27	<0.25	<0.06	<0.05	<0.06	<0.04
Zinc	44.7	41.2	6.8	8.7	7.1	6.6
Phenol	<0.03	<0.03	<0.16	<0.25	<0.02	<0.02

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[a] Dry weight.

[b] A and B = Replicate samples taken from separate Ponar grabs.

TABLE L-7

RESULTS OF CHEMICAL ANALYSIS OF SEDIMENT SAMPLES COLLECTED AT STATION 3 ON SWAMP CREEK IN MAY 1982

PARAMETER (mg/kg)[a]	SILT-A[b]	SILT-B[b]	SAND-A	SAND-B
Sulfate	124	78	65	24
Total sulfur	263.7	46.7	70.4	38.4
Arsenic	<0.2	<0.2	4.9	7.4
Cadmium	0.39	0.06	0.09	0.05
Total Chromium	18.2	3.2	2.6	1.7
Copper	5.61	2.48	2.59	1.89
Iron	8,300	1,850	2,400	1,110
Lead	9.9	2.1	2.2	1.1
Manganese	339	52	84	39
Mercury	0.11	<0.03	<0.03	<0.03
Zinc	31.2	5.8	8.7	4.7
Phenol	<0.14	<0.04	<0.05	<0.03

[a] Dry weight.

[b] A and B = Replicate samples taken from separate Ponar grabs.

TABLE L-8

SEDIMENT SIZE DISTRIBUTION OF THE VARIOUS HABITAT TYPES COLLECTED AT STATIONS 1, 2 AND 3 ON SWAMP CREEK. DATA ARE PERCENT (BY WEIGHT) AND REPRESENT THE MEAN OF TWO SAMPLES

PARTICLE SIZE (mm)	HABITAT: STATION:	SILT 1*	SILT 2	SILT 3	SAND 1*	SAND 2	SAND 3*	GRAVEL 1	GRAVEL 2
> 2.80		2.5	9.7	1.7	0.9	1.7	0.1	68.3	66.6
0.125 to ≤ 2.80		36.7	48.4	17.4	17.1	39.8	7.2	31.3	32.9
< 0.125		60.8	41.9	80.9	82.0	58.5	92.7	0.4	0.5

*One sample only.

among stations. The percentage of fine materials (<0.125 mm) in the silt samples ranged from 41.9 percent at Station 2 to 80.9 percent at Station 3, and from 58.5 percent at Station 2 to 92.7 percent at Station 3 in the sand samples (Table L-8). These results indicated that sand and silt substrates at Station 2 were composed of a greater percentage of large particles than were in these same substrates at Station 1. Similarly, the particles in the sand and silt substrates at Station 1 were, on the average, larger than those at Station 3.

3.2 HYDROLOGY

3.2.1 Velocity Transects

Velocity measurements were taken along the quarter points on 10 dates at Station 1 and 8 dates at Station 1' (Table L-9). Velocities at Station 1 were between 0.05 and 0.20 m/s (0.15 and 0.67 feet per second) on 8 of the 10 dates, and typically were between 0.09 and 0.18 m/s (0.3 and 0.6 feet per second). Higher velocities (0.12 to 0.38 m/s [0.40-1.24 feet per second]) occurred on 10 May and 21 October. These dates corresponded to the two periods when flows were highest, and in general, there was a good correlation between flows and velocities. Conversely, there was little apparent correlation between flows and velocities at Station 1'. This lack of correlation is probably a result of the macrophyte growth that developed at this station but not at Station 1.

3.2.2 Discharge Measurements

Discharge measurements were made on 12 dates during the 1982-83 program. Data collected on 16 February were not used because the measured flow was much different than was expected (i.e., predicted) for the respective gage height. This apparently erroneous value was probably the result of the ice on the stream shifting the staff gage. When the 11 remaining points were plotted (Figure L-2), it became apparent that because of extensive macrophyte growth in the stream, two different rating curves were applicable. The equation of the "no macrophyte" curve is Q (flow) = 63.2 (gage ht) $^{0.7109}$ and the equation for the "macrophyte

TABLE L-9

A SUMMARY OF VELOCITY MEASUREMENTS (FPS) MADE AT STATIONS 1 AND 1'

	QUARTER POINT			MID-POINT			THREE-QUARTER POINT			
DATE DEPTH[a]:	0.8	0.6	0.2	0.8	0.6	0.2	0.8	0.6	0.2	DISCHARGE[b] (CFS)
Station 1										
10 May	0.80		1.24	0.80		1.00	0.60		0.76	71
2 June		0.45		0.35		0.43		0.30		29
14 June		0.47		0.35		0.37		0.30		35
19 July	0.67		0.65	0.50		0.62	0.31		0.38	42
26 August		0.30			0.33			0.15		20
14 September	0.32		0.29	0.59		0.56	0.41		0.37	44
21 October	0.40		0.40	0.70		0.70	0.85		0.80	75
9 November	0.40		0.29	0.45		0.44	0.45		0.45	44
7 December	0.30		0.25	0.45		0.35		0.45		49
23 March		0.60			0.60			0.40		NA[c]
Station 1'										
10 May		0.64		0.80		0.92		0.72		71
2 June		0.91			0.91			0.95		29
14 June		0.95			0.60			0.35		35
19 July		0.50			0.40			0.32		42
26 August		0.21			0.41			0.10		20
14 September		0.28			0.19		0.17		0.41	44
10 November		0.60			0.50			0.10		46
7 December (Station frozen in)										
23 March		0.50			0.60			0.40		NA

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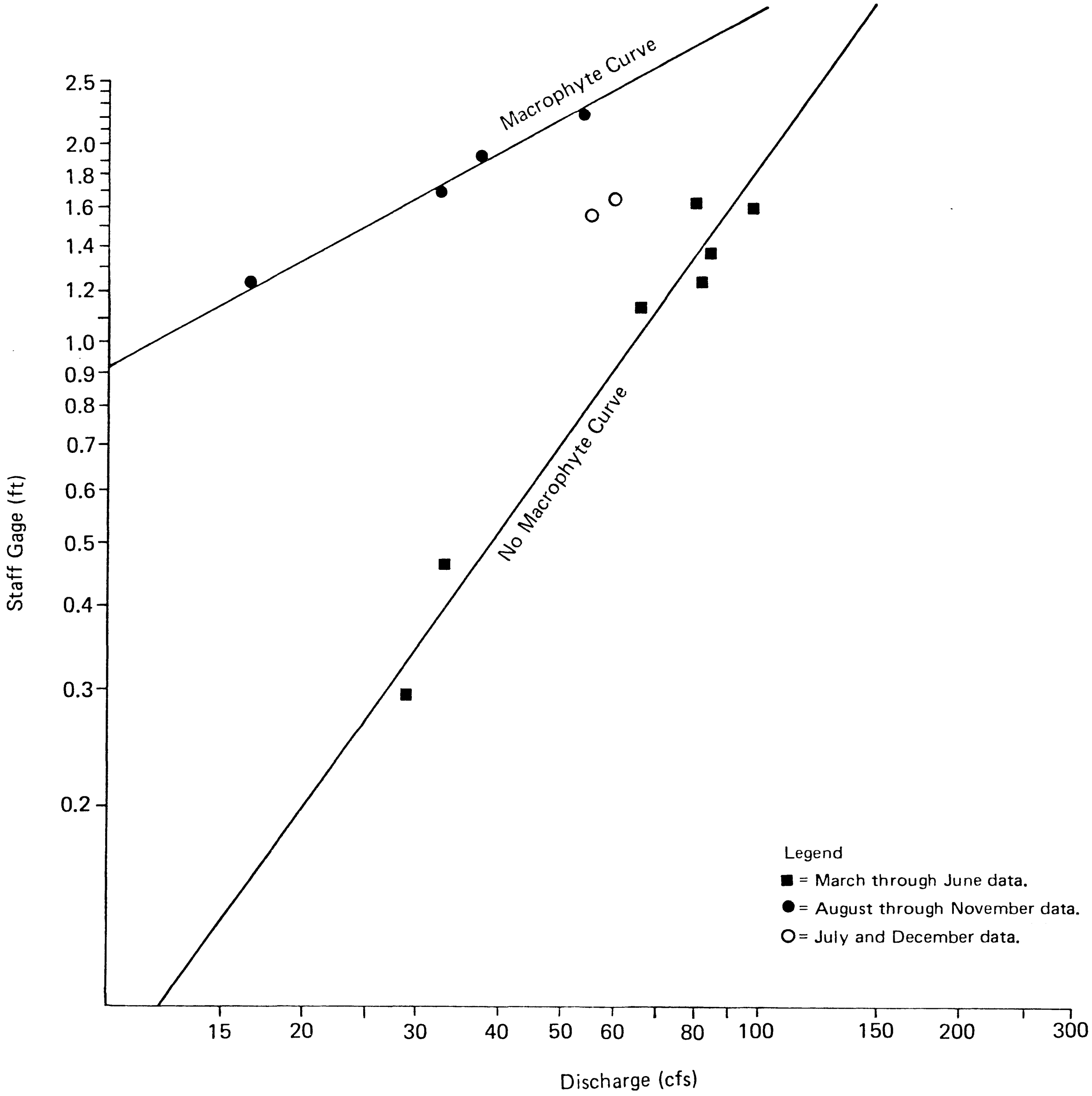
[a] Multiple of total depth as measured from the surface down.

[b] Values based on USGS data.

[c] Not available.



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RATING CURVES FOR STREAM GAGE 24

ECOLOGICAL ANALYSTS

FIGURE L-2

curve" is $Q = 10.88 (ht)^{1.9465}$. The fit for both curves was good; $R = 0.9787$ and $R = 0.9968$ for the "no macrophyte" and "macrophyte" curves, respectively. The "no macrophyte" curve is applicable during those months of the year when macrophyte growth is minimal (i.e., January through mid-June). The "macrophyte" curve applies during those months when macrophyte development is maximal (i.e., August through November). The data points for July and December did not appear to fit either curve and were not used in either regression (Figure L-2). This suggests that these two months are transitional periods when macrophyte growth is at an intermediate state. The curves developed for SG 24 were used in conjunction with weekly gage readings supplied by Exxon to compute weekly discharge measurements for the year (Table L-10). These data were then used to develop a hydrograph (Figure L-3) which graphically depicts the annual flow cycle at SG 24.

TABLE L-10

SUMMARY OF READINGS FROM STREAM GAGE SG 24, APRIL 1982 - MARCH 1983

DATE	GAGE READING (FT)	DATUM ELEVATION (FT AMSL)[a]	WATER SURFACE ELEVATION (FT AMSL)	MEASURED DISCHARGE (CFS)	COMPUTED[b] DISCHARGE (CFS)
26 April-1982	1.65	1528.61	1530.26	98	-
3 May	1.06	1528.61	1529.67	-	66
10 May	1.40	1528.61	1530.01	84	-
17 May	0.92	1528.61	1529.53	-	60
24 May	0.61	1528.61	1529.22	-	44
28 May	0.50	1528.61	1529.11	-	39
2 June	0.47	1528.61	1529.08	39	-
7 June	0.33	1528.61	1528.94	-	29
14 June	0.31	1528.61	1528.92	29	-
21 June	0.60	1528.61	1529.21	-	44
28 June	0.57	1528.61	1529.18	-	42
6 July	0.53	1528.61	1529.14	-	-
12 July	1.22	1528.61	1529.83	-	-
19 July	1.62	1528.61	1530.23	57	-
26 July	1.30	1528.61	1529.91	-	-
2 August	1.43	1528.61	1530.04	-	22
9 August	1.51	1528.61	1530.12	-	24
16 August	1.18	1528.61	1529.79	-	15
23 August	1.10	1528.61	1529.71	-	13
26 August	1.23	1528.61	1529.84	16	-
30 August	1.65	1528.61	1530.26	-	29
7 September	1.75	1528.61	1530.36	-	32
14 September	1.91	1528.61	1530.52	37	-
20 September	2.17	1528.61	1530.78	-	49
27 September	1.97	1528.61	1530.58	-	41
4 October	1.98	1528.61	1530.59	-	41
11 October	2.30	1528.61	1530.91	-	55
18 October	1.98	1528.61	1530.59	-	41
21 October	2.25	1528.61	1530.86	53	-
25 October	2.22	1528.61	1530.83	-	52
1 November	1.94	1528.61	1530.55	-	40
8 November	1.69	1528.61	1530.30	-	30
9 November	1.69	1528.61	1530.30	32	-
15 November	2.39	1528.61	1531.00	-	59
22 November	1.84	1528.61	1530.45	-	36
29 November	1.34	1528.61	1529.95	-	19
6 December	1.50	1528.61	1530.11	-	-
7 December	1.60	1528.61	1530.21	54	-
15 March-1983	1.97	1528.26	1530.23	-	89
21 March	2.13	1528.26	1530.39	-	95
23 March	2.00	1528.26	1530.39	79	-
28 March	1.85	1528.26	1530.11	-	84

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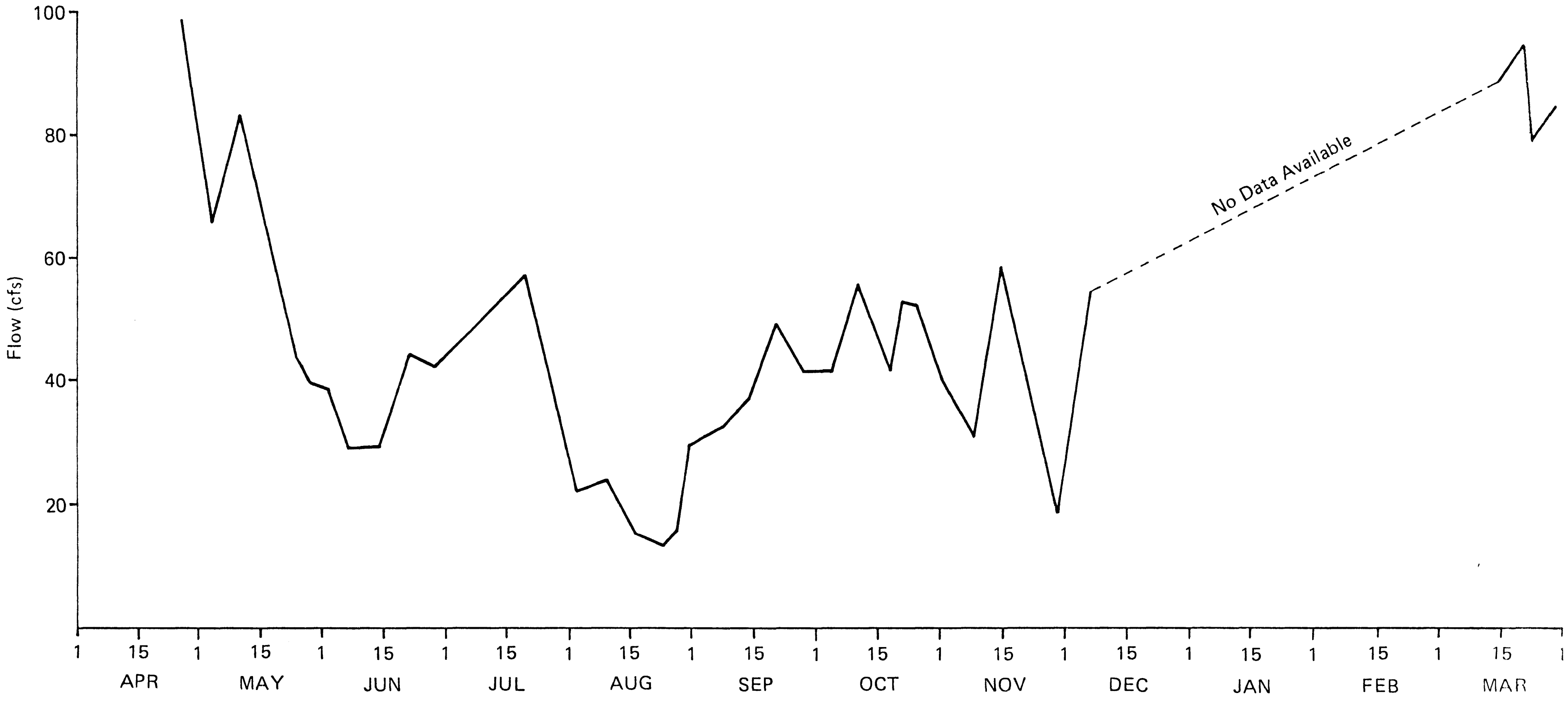
[a] Feet above mean sea level.

[b] Computed according to the formulas $Q = 10.88\ (\text{gage ht})^{1.9465}$ for August through November and $Q = 63.199\ (\text{ht})^{0.7109}$ for January through June.



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HYDROGRAPH OF SWAMP CREEK FLOWS MEASURED AT STREAM GAGE 24 FROM 26 APRIL THROUGH 7 DECEMBER 1982 AND MARCH 1983

ECOLOGICAL ANALYSTS

FIGURE L-3

4.0 DISCUSSION

4.1 CHEMISTRY

4.1.1 Water Chemistry

The USGS maintains a stream gage at County Trunk Highway M which corresponds with Station 1. The USGS has typically measured a series of chemical parameters on a few dates each year since the gage was installed in 1977. Data from the USGS for those parameters measured during this study are presented in Table L-11. The USGS data (Table L-11) are in close agreement with the data gathered during this study (Tables L-3 and L-4). The USGS data confirm that metal concentrations in Swamp Creek are low, generally near or below their respective levels of detection, with the exception of aluminum, iron, manganese, and zinc. The USGS data also confirm that aluminum and zinc concentrations are variable in Swamp Creek.

As part of the environmental studies conducted in 1977-1980 for the Crandon Project, water quality studies were performed on a number of waterbodies in the area (see Section 2.4 of the EIR). Six sampling stations were studied on Swamp Creek: three upstream and three downstream of Rice Lake . The three downstream stations are most relevant to the present study. Station V, located at County Trunk Highway K, was sampled from October 1977 through September 1978. Data from this station are summarized in Table L-12. Although Station V is located approximately 6.4-8.0 km (4-5 miles) downstream of the stations sampled during this study, the data are generally in agreement. Both data sets

TABLE L-11

SUMMARY OF WATER QUALITY DATA COLLECTED AT COUNTY TRUNK HIGHWAY M ON SWAMP CREEK DURING 1977-1980 BY USGS, STATION 04074548 (USGS, 1978, 1979, 1980, 1981)

	DATE									
PARAMETERS (UNITS)	8/2/77	10/4/77	3/9/78	4/12/78	8/8/78	11/6/78	1/12/79	4/24/79	8/30/79	8/11/80
Temperature (°C)	23.0	8.5	0.0	2.0	25.5	7.0	0.0	7.5	19.5	21.5
pH (units)	7.7	7.7	7.5	7.6	8.3	8.3	7.4	7.4	7.7	7.3
Total alkalinity (mg/l)	110	90	110	53	91	100	120	27	87	86
Dissolved oxygen (mg/l)	11.4	--*	5.0	12.1	10.1	14.2	1.0	9.0	8.3	6.2
Conductivity (μmhos/cm)	235	190	265	140	180	225	240	75	200	195
Total hardness (mg/l)	120	96	120	53	96	110	130	39	90	100
Tot.diss.solids (mg/l)	134	126	138	88	120	125	148	58	135	133
Tot.susp. solids (mg/l)	5	--	--	--	--	--	--	--	--	--
Ammonia, N (mg/l)	0.01	--	0.07	0.03	0.00	0.00	0.09	0.01	0.06	0.02
Nitrate, N (mg/l)	0.02	0.05	0.27	0.16	0.12	0.05	0.16	0.06	0.04	0.01
Nitrite, N (mg/l)	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.00
Organic nitrogen, N (mg/l)	0.48	--	0.27	0.96	1.0	0.29	0.38	0.28	0.40	0.40
Tot. phosphorus, P (mg/l)	0.04	--	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.04
Diss.orthophos., P(mg/l)	0.01	--	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Total phenol (mg/l)	0	--	--	--	--	--	--	--	--	--
Chloride (mg/l)	2.5	--	2.4	1.3	2.8	3.0	3.2	1.5	2.8	2.3
Sulfate (mg/l)	4.4	--	7.0	6.5	3.6	4.6	4.2	4.3	4.5	3.5
Total cyanide (mg/l)	0.00	--	--	--	--	--	--	--	--	--
Fluoride (mg/l)	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.1
Arsenic (μg/l)	0	--	--	--	1	--	--	--	1	1.
Cadmium (μg/l)	0	--	--	--	--	--	--	--	0	0
Chromium + 3 (μg/l)	<10	--	--	--	--	--	--	--	--	--
Chromium + 6 (μg/l)	0	--	--	--	--	--	--	--	--	--
Copper (μg/l)	3	--	--	--	2	--	--	--	3	0
Iron (μg/l)	210	--	--	--	--	--	--	--	--	310
Lead (μg/l)	0	--	--	--	12	--	--	--	0	0
Manganese (μg/l)	20	--	--	--	--	--	--	--	--	30
Mercury (μg/l)	<0.5	--	--	--	<0.5	--	--	--	<0.5	0.2
Selenium (μg/l)	0	--	--	--	0	--	--	--	0	0
Silver (μg/l)	0	--	--	--	--	--	--	--	--	--
Zinc (μg/l)	20	--	--	--	40	--	--	--	10	20
Aluminum (μg/l)	60	--	--	--	20	--	--	--	300	200
Cobalt (μg/l)	0	--	--	--	0	--	--	--	1	--
Molydenum (μg/l)	2	--	--	--	--	--	--	--	--	1
Nickel (μg/l)	7	--	--	--	--	--	--	--	--	0

*Dashes indicate that no data were collected.

TABLE L-12

A SUMMARY OF WATER QUALITY DATA OBTAINED MONTHLY FROM OCTOBER 1977 THROUGH SEPTEMBER 1978 IN SWAMP CREEK AT COUNTY TRUNK HIGHWAY K*

PARAMETER (mg/l)	MEAN	MIN	MAX
Aluminum, Total	<.01	<.01	<.01
Arsenic	<.001	<.001	<.001
Cadmium	<.001	<.001	<.003
Chromium, Hexavalent	<.01	<.01	<.01
Chromium, Trivalent	<.001	<.001	<.001
Cobalt, Total	<.01	<.01	<.01
Copper, Total	<.003	<.001	.015
Iron, Total	.80	.26	2.54
Lead, Total	<.01	<.01	<.01
Manganese, Total	.062	.016	.156
Mercury, Total (ug/l)	<.1	<.1	<.1
Molybdenum, Total	<.01	<.01	<.01
Nickel, Total	<.01	<.01	.01
Zinc, Total	<.005	<.001	.013
Dissolved Orthophosphate	<.01	<.01	.02
Total Phosphorus	<.03	<.01	.04
Ammonia Nitrogen	.95	.32	1.60
Nitrate Nitrogen	<.21	<.01	.54
Nitrite Nitrogen	<.01	<.01	<.01
Organic Nitrogen	1.03	.26	2.39
Sulfate	<5	<1	8
Sulfide	<.01	<.01	.01
Sulfur, Total	<1.66	<.01	2.64
Dissolved Solids	126	85	161
Suspended Solids	5	1	16
Alkalinity, Total	81	64	112
Biochemical Oxygen Demand (5-day)	2	1	3
Chemical Oxygen Demand	69	-	-
Chloride	<3	<1	4
Color, True (Color Units)	85	15	200
Specific Conductance (μmhos/cm)	110	60	145
Cyanide	<.001	<.001	.001
Dissolved Oxygen	6.7	3.8	11.6
Hardness	95	76	124
pH (standard units)	6.8	5.8	7.6
Phenol (ug/l)	<7	<1	15
Temperature, °C	8.5	0	22

*Data obtained from Section 2.4 of the EIR.

show Swamp Creek to be a moderately hard, nearly neutral stream with low to moderate nutrient concentrations and metal concentrations generally at or close to their respective detection levels. As reported by the USGS and in the results of the present study, data from Station V show that of the metals, only iron, manganese, and zinc were consistently present in measureable concentrations. One area of disagreement is that aluminum concentrations at Station V were <10 µg/l on all four dates sampled (Table L-12), whereas the aluminum concentrations from the present study and USGS were considerably higher (8-300 µg/l, Tables L-3, L-4 and L-11). No reason for this discrepancy was apparent.

4.1.2 Sediment Chemistry

In general, there was good agreement between replicate samples. However, at Station 1, iron and manganese concentrations in the two silt replicates differed by a factor of 5. Similarly, concentrations of total sulfur, total chromium, iron, and manganese in the two silt replicates differed by factors of 4 to 7 at Station 3. At both stations, the difference between replicate values appears to be related to the percentage of clay in the sample. The "A" replicates, which had the higher concentrations of the parameters identified above at both Stations 1 and 3 (Tables L-5 and L-7), had much higher percentages of clay than did the corresponding B replicates. At Station 1 the percentages of clay were 21.5 and 3.6 for replicates A and B, respectively. At Station 3 the percentages of clay were 28.3 and 1.4 for replicates A and B, respectively. It is generally accepted that metals and many other chemical constituents are adsorbed preferentially onto fine-grained sediments, particularly clays (Carmody, 1973; Harris, 1976).

Although limited, data collected by USGS (1979, 1980) are in agreement with data collected during the present study regarding the concentrations of cadmium, chromium, copper, lead, mercury, and zinc concentrations in sediments from Swamp Creek downstream of the County Highway M bridge (Table L-13). Concentrations of all parameters listed were greater in Swamp Creek sediments at stations upstream of Rice Lake (see Section 2.4 of the EIR) than at stations downstream of Rice Lake (Table L-13). Data are too sparse, however, to judge the validity of this observation because the concentrations of most of these parameters varied according to the substrate sampled (Table L-13). Thus, apparent difference in sediment concentrations may be related to the substrate type sampled. If the differences are real, it seems likely that Rice Lake is acting as a sediment trap to reduce further downstream migration of sediments with comparatively greater concentrations.

TABLE L-13

COMPARISON OF SEDIMENT CHEMISTRY DATA OBTAINED IN SWAMP CREEK

PARAMETER (mg/kg)	DATE:	MARCH 1978[a]	MAY 1982[b]			AUGUST 1978[c]	AUGUST 1979[d]
	NO. OF SPLS:	MEAN OF SIX	MEAN OF FOUR TO SIX			ONE	ONE
	LOCATION:	ABOVE RICE LAKE	STATIONS 1, 2, AND 3 COMBINED			HIGHWAY M	HIGHWAY M
	SUBSTRATE:	UNKNOWN	SILT	SAND	GRAVEL	UNKNOWN	UNKNOWN
Solids (%)		8.66	28.3	71.3	75.3	-[e]	-
Arsenic		2.8	2.1	2.7	0.8	-	0
Cadmium		1.9	0.4	0.05	0.03	30	<10
Chromium		63.1	11.4	3.1	2.6	<10	<10
Copper		18.0	7.4	2.6	3.9	<10	<10
Iron		7,628	6,000	1,563	1,323	-	-
Lead		<18	16.0	2.0	1.6	<10	<10
Manganese		948	195	36	65	-	-
Mercury		<0.01	<0.18	<0.04	<0.04	0.0	0.00
Zinc		80	40	8	7	4	10
Phenol		10.13	<0.13	<0.9	<0.9	-	-
Sulfate		2,735	285	136	23	-	-
Total Sulfur		3,592	268	66	11	-	-

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[a] See Section 2.4 of the EIR.

[b] This study.

[c] USGS 1979.

[d] USGS 1980.

[e] Dashes indicate no data collected.

4.2 HYDROLOGY

The USGS maintains a staff gage at County Trunk Highway M, which corresponds with Station 1. Station 3, where the discharge measurements for this study were taken, is located approximately 2 km (1.25 miles) downstream of the USGS gaging station. Because there are no tributaries between the USGS station and Station 3, flows at the two stations should be comparable unless ground water enters the stream between the two stations.

A comparison of the data from Station 3 (Table L-10) and the USGS gage (George, 1983, Table L-14) shows that flow rates at these two gages were within 20 percent of one another on seven of the 11 dates for which comparisons are possible. The discrepancies on the other four dates may be the result of one or more of the following factors. First, the values reported by USGS are daily averages, whereas the values for SG 24 are instantaneous flows. This is significant if flows are changing rapidly as they were on 21 October 1982, for example. Second, the USGS gage is influenced by the backwaters from a beaver dam located approximately 335 m (1100 feet) downstream of County Trunk Highway M. This beaver dam has caused USGS to take periodic (approximately every two weeks) in-stream measurements rather than relying on a rating curve (George, personal communication). Third, the USGS data for October through March are provisional, so the apparent discrepancies on 21 October, 9 November and 23 March may not actually exist. Fourth, the macrophyte growth at SG 24 may have affected the data. This seems unlikely with regard to the October and November data that were gathered

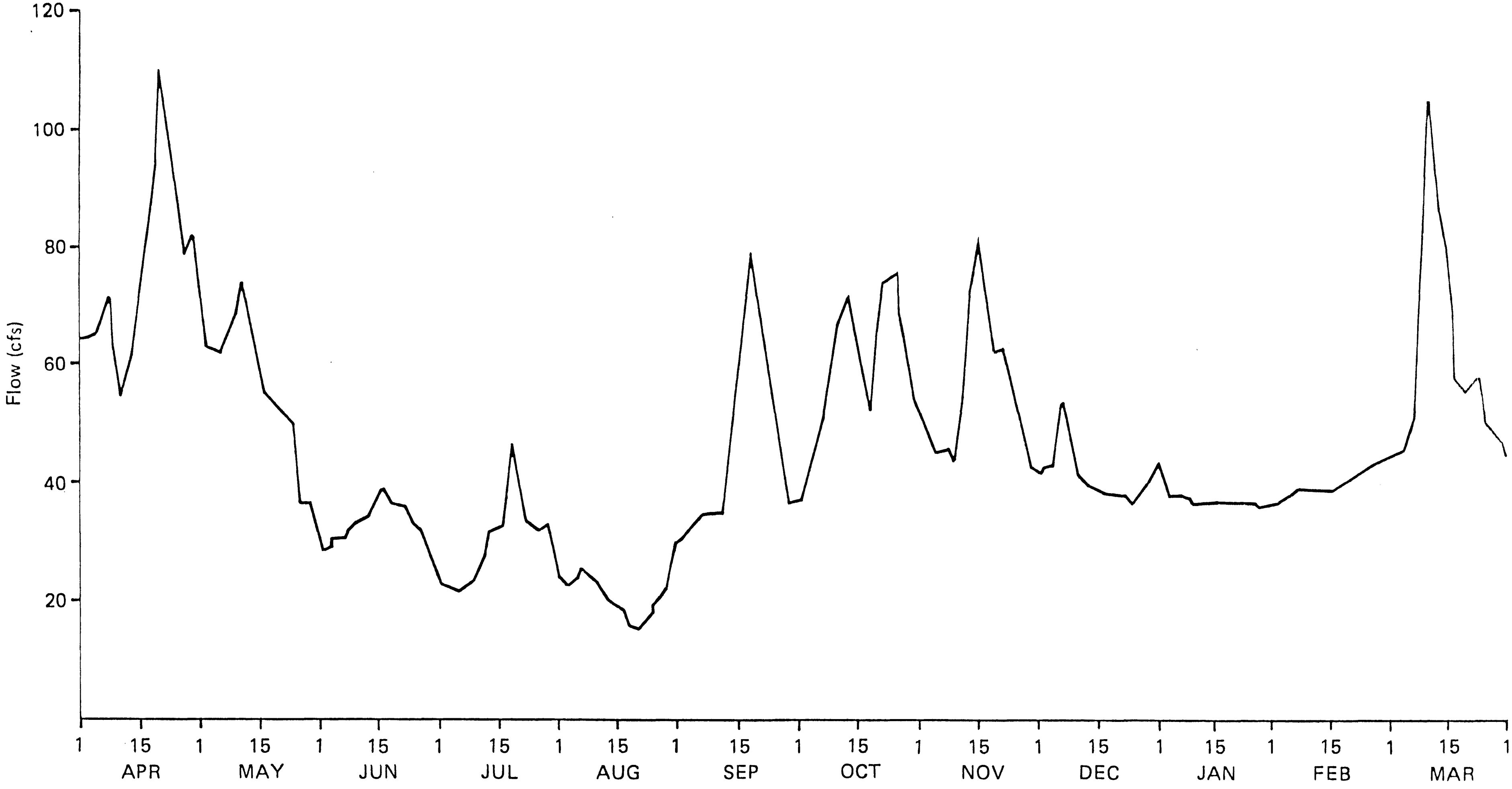
TABLE L-14

SUMMARY OF FLOWS (CFS) IN 1982-83 REPORTED BY USGS FOR THEIR GAGING STATION IN SWAMP CREEK AT COUNTY TRUNK HIGHWAY M. OCTOBER THROUGH MARCH DATA ARE PROVISIONAL

DAY	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
1	64	63	28	23	28	29	37	50	42	44	38	46
2	68	62	29	22	27	31	41	48	42	40	39	46
3	66	61	30	22	27	31	44	45	43	39	39	47
4	78	60	30	22	26	31	45	43	46	38	39	48
5	80	61	30	22	25	32	45	44	48	39	39	50
6	72	66	31	22	25	34	50	45	53	39	40	54
7	59	75	32	23	24	35	61	45	49	38	40	67
8	54	79	32	23	24	35	64	44	45	38	40	88
9	54	74	33	24	23	34	64	44	42	38	40	109
10	56	71	34	25	22	34	70	46	41	38	40	104
11	60	68	35	28	21	34	74	50	41	38	40	96
12	62	64	34	31	20	34	73	68	40	38	40	82
13	65	61	34	37	19	35	67	85	40	38	40	68
14	71	58	35	34	18	44	64	89	40	38	40	61
15	78	54	38	32	18	63	61	82	39	38	40	59
16	90	51	38	38	17	74	57	74	39	38	40	57
17	100	50	38	45	16	79	53	67	38	38	41	57
18	110	52	36	46	15	79	51	62	38	38	41	57
19	120	56	35	42	15	72	45	59	38	38	42	56
20	110	56	35	36	15	72	59	60	38	38	43	55
21	92	50	35	33	15	66	75	63	38	38	43	60
22	84	44	34	33	15	59	84	54	37	38	44	55
23	80	37	33	32	16	51	82	50	37	38	44	52
24	79	36	32	32	18	48	76	54	37	38	44	50
25	80	35	30	32	18	45	72	50	41	38	43	49
26	84	33	29	32	20	40	67	46	47	38	45	49
27	82	36	27	32	22	36	62	43	50	38	45	48
28	73	35	26	31	24	36	57	43	53	37	45	47
29	67	35	26	30	26	36	54	42	50	37	--	46
30	65	33	24	30	27	36	54	42	49	38	--	45
31	--	31	--	29	28	--	54	--	45	38	--	45
MEAN	76.8	53.1	32.1	30.4	21.1	45.5	60.1	55.2	42.8	38.3	41.2	59.8
MAXIMUM	120	79	38	46	28	79	84	89	53	44	45	109
MINIMUM	54	31	24	22	15	29	37	42	37	37	38	45

using the three point method but is a possibility regarding the July data, which was the last data set gathered before the three point method was initiated. The problem of macrophyte growth affecting discharge rating curves is fairly common (George, personal communication).

The USGS data when plotted in the form of a hydrograph (Figure L-4) follow the same patterns that are evident in the hydrograph prepared from the data collected at SG 24 (Figure L-3).



EXXON MINERALS COMPANY
CRANDON PROJECT

HYDROGRAPH OF SWAMP CREEK
FLOWS MEASURED BY USGS AT
COUNTY TRUNK HIGHWAY M FROM
APRIL 1982 THROUGH MARCH 1983

ECOLOGICAL ANALYSTS | FIGURE L-4

5.0 REFERENCES

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