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December 4, 1998

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Dear Mr. Tans and Ms. Hauger:

Re: Crandon Project - Surface Water Mitigation Plan

Nicolet Minerals Company (NMC) is pleased to submit the enclosed report titled *Crandon Project Surface Water Mitigation Plan*. The report has been prepared on behalf of NMC by Foth & Van Dyke and Associates, Inc. This *Surface Water Mitigation Plan* is intended to be a stand-alone document that will be summarized in the Crandon Project *Mine Permit Application*. As noted on the attached distribution list, NMC has distributed the document to appropriate state and federal agencies, to local officials, and to various interested parties. It is our understanding that the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) will be responsible for distribution of the document to their appropriate staff members.

The purpose of the report is to describe NMC's proposed plan to protect surface water resources as relates to lake levels and stream flows in the vicinity of its proposed underground zinc/copper mine. The plan has been developed using the estimates of impacts on unmitigated surface water bodies as predicted by the regional groundwater flow model documented in the report titled *Addendum No. 2 to: Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Zinc and Copper Mine*

Mr. Bill Tans
Ms. Char Hauger
December 4, 1998
Page 2

Near Crandon, Wisconsin. This report, dated August 28, 1998, is included in Appendix 4.2-3 of the project's *Environmental Impact Report*.

If you have any questions, please contact me at (715) 478-3393.

Sincerely,

A handwritten signature in black ink, appearing to read "G. Reid". The signature is fluid and cursive, with the first name "G." and the last name "Reid" clearly distinguishable.

Gordon Reid
Manager of Engineering
Nicolet Minerals Company

GR:cer1

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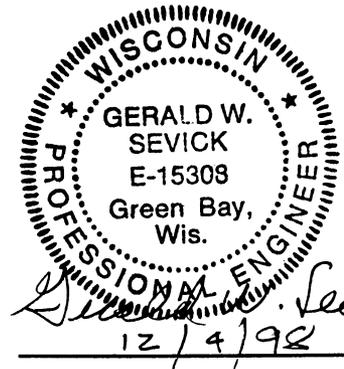
Crandon Project Surface Water Mitigation Plan

Scope ID: 93C049

Prepared for
Nicolet Minerals Company
7 North Brown Street, 3rd Floor
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Prepared by
Foth & Van Dyke and Associates Inc.

December 1998



Crandon Project Surface Water Mitigation Plan

Executive Summary

As part of the development of the proposed Crandon Project, Nicolet Minerals Company (NMC) has prepared a Surface Water Mitigation Plan. The purpose of the plan is to identify which surface water bodies in the vicinity of the proposed mine may need mitigating due to mine dewatering and to provide details regarding the design and operation of the planned mitigation system.

The first step in the development of the mitigation plan is to categorize surface water bodies in the vicinity of the proposed mine into one of four planning levels based on impacts predicted by the project's regional groundwater flow model. Water bodies which may be substantially affected by the project have been categorized as Level I. Level II includes water bodies that could possibly be affected. Level III water bodies are not likely to be affected by the project, but are located close enough to the mine to potentially experience impacts. Water bodies which are highly unlikely to be impacted but are in close proximity to the mine are categorized as Level IV.

Following the categorization of surface water bodies, the plan defines the appropriate degree of planning for each mitigation level. Complete mitigation designs for Level I and II water bodies have been included in the plan. Facilities for Level I will be constructed at the onset of mine dewatering, while Level II facilities will be constructed if data collected during operations indicate mitigation is needed. The mitigation system design for these two planning levels takes into consideration mitigation water requirements and sources for meeting these needs, and includes designs for the delivery of mitigation water to affected surface water bodies.

A conceptual design for Level III water bodies is included in the plan. Design details for Level III water bodies would be prepared and submitted for Wisconsin Department of Natural Resources review if data indicates that significant impacts to these water bodies could occur. A generic outline of a mitigation approach for Level IV water bodies is also included in the plan. The outline would be used in the future to prepare a design for the mitigation of a Level IV water body if monitoring data collected during mine operations shows such mitigation is necessary.

The plan also provides a discussion of how NMC will determine when mitigation of a Level I water body is needed and when it can cease, and when a water body needs to be upgraded from Level II, III, or IV to a higher level. It explains how the mitigation systems will be operated and maintained. Finally, the plan discusses the environmental impacts associated with construction and operation of the mitigation system.

The basis of the mitigation concept is to use groundwater provided from a well north of Swamp Creek for mitigation of hard water bodies such as creeks and streams, and to use treated mine water for mitigation of soft water lakes. The method of treatment for mitigation water for soft water lakes will include reverse osmosis and evaporation for metals and other ion removal.

**Nicolet Minerals Company
Crandon Project Surface Water Mitigation Plan**

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- Appendix D Assessment of Mitigation Water Requirements for Skunk Lake
- Appendix E Construction Cost Estimates
- Appendix F Transient Lake Mitigation Simulations

1 Introduction

As part of the Crandon Project's *Environmental Impact Report* (EIR) (Foth & Van Dyke, 1995/1998a), Nicolet Minerals Company (NMC) has completed a detailed assessment of regional water resources as relates to potential stream flow and lake level impacts due to mining. A detailed description of the proposed project is contained in the *Mine Permit Application* (MPA) (Foth & Van Dyke, 1995/1998b). Appendix 4.2-3 of the project's EIR describes the regional groundwater flow model used to predict surface water impacts associated with mine dewatering. These impacts were then used to develop the mitigation plan described in this report. The purpose of this report is to provide a detailed assessment of potential surface water mitigation needs and a surface water mitigation plan for the Crandon Project.

The mitigation plan builds upon the Wisconsin Department of Natural Resources' (WDNR) proposed approach for determining mitigation requirements and levels as outlined in the draft document titled *Conceptual Framework for Development of the Crandon Mine Surface Water Mitigation Plan* (mitigation framework), which was attached to an April 17, 1997, letter to Crandon Mining Company (CMC), the predecessor company to Nicolet Minerals Company, from Mr. Christopher P. Carlson of the WDNR (WDNR, 1997). The WDNR's draft document (Appendix A) was used as a basis for the development of a preliminary mitigation assessment (Foth & Van Dyke, 1997a) and draft mitigation plan (Foth & Van Dyke, 1997b) which were discussed at meetings between WDNR, the U.S. Army Corps of Engineers (USCOE), NMC, and others on August 21, 1997, and February 3, 1998. The preliminary mitigation assessment, draft mitigation plan, and regulatory agency discussions, have provided the basis for the plan presented in this report.

Section 2 of this report provides an overview discussion of WDNR's mitigation framework as it will be applied to the Crandon Project. Section 3 addresses the categorization of surface water bodies into the mitigation planning levels suggested by WDNR. Section 4 discusses the use of the public rights flow (PRF) of streams and public rights stage (PRS) of lakes as triggers for the commencement of mitigation for surface water bodies requiring mitigation.

Section 5 discusses engineering design considerations such as: mitigation water requirements, sources of mitigation water, treatment options, delivery structure options, and permit requirements. The design of the proposed mitigation system for Level I and II water bodies is presented in Section 6. The design presented in Section 6 addresses practical worst case (PWC) conditions. The mitigation system design is flexible enough to handle flow resulting from the BEJ case, as well as larger flows that could occur in the unlikely event that additional mitigation is required.

A conceptual design for Level III mitigation systems under PWC conditions is presented in Section 7 of the report. Based on the WDNR's conceptual mitigation framework, the intention is to develop the Level III mitigation systems in concept at this stage of the project, with NMC preparing and submitting detailed design plans after mine operations commence, if it is determined that mitigation of one or more Level III surface water bodies may be needed.

A generic outline for the future development of a detailed mitigation plan for the Level IV surface water bodies is discussed in Section 8. Section 9 discusses mitigation monitoring, system implementation, system operation, and maintenance. Section 10 addresses environmental impacts associated with the installation of the mitigation systems, and the effect of mitigation on surface water flows and stages. Treatment requirements for water designated for use in mitigation are described in this report in general terms. A more detailed description of the treatment system for mine inflow water that will be used for mitigation is presented in the *Preliminary Engineering Report for Wastewater Treatment Facilities for the Crandon Project* (PER) (Foth & Van Dyke, 1995/1998c).

The project's mitigation plan is intended to be a stand-alone document. It does relate, though, to the following other Crandon Project permit documents:

- Environmental Impact Report
- Mine Permit Application
- Wisconsin Pollutant Discharge Permit Elimination System Permit Application
- Preliminary Engineering Report for Wastewater Treatment Facilities
- High Capacity Well Permit Application
- Water Regulatory Permit Application for the Proposed Mine Site

Specific elements of the mitigation plan that relate to these other permit documents have been incorporated into those documents.

2 Mitigation Framework

A goal of the WDNR mitigation framework (WDNR, 1997) is to categorize each potentially affected surface water body in the vicinity of the ore body into one of four levels for mitigation planning. Associated with each level is a different degree of mitigation design and implementation. With respect to the initiation of mitigation, WDNR has established, or will establish public rights flows (PRF) and public rights stages (PRS) that will be used as trigger criteria for the initiation and cessation of mitigation.

The WDNR's mitigation framework and NMC's preliminary mitigation assessment (Foth & Van Dyke, 1997a) provide a workable approach for addressing mitigation planning design and implementation. It is understood that the guiding principle of the mitigation plan must be consistent with the provisions of s. 293.65(3)(b), Wis. Stats., which states that:

The department may not issue an approval under s. 281.17(1) if the withdrawal of groundwater for prospecting or mining purposes or the dewatering of mines will result in the unreasonable detriment of public or private water supplies or the unreasonable detriment of public rights in the waters of the state. No withdrawal of groundwater or dewatering of mines may be made to the unreasonable detriment of public or private water supplies or the unreasonable detriment of public rights in the waters of the state.

This provision of the state statutes acknowledges that some impact on surface waters is acceptable. This topic is discussed more fully in Section 3 of this report.

One objective of the mitigation plan is to use treated mine inflow water that meets discharge requirements when mitigation is required for soft water bodies. A second objective is that water from groundwater wells located in areas that will not compound impacts due to mine inflow should be used on water bodies that are groundwater fed. The discussion of engineering design considerations presented in Section 5 of this report was developed using these principles as a guide.

The WDNR identified a list of water bodies to be included in mitigation planning in its April 17, 1997, mitigation framework memorandum (WDNR, 1997). Through recent discussions with the WDNR, the Department has advised NMC that the following surface water bodies should be added to the list of potentially affected water bodies:

- Lake 6-8 west of Deep Hole Lake;
- Creek 19-14 originating from Swamp Creek Cedars;
- Creek 33-8, a tributary to Hemlock Creek;

- Creek 12-2 which is a tributary to Creek 12-9;
- Lake 35-7 east of Black Joe Road and Lake 34-1 west of Black Joe Road;
- The drainage canal along the northeast side of the Upper Pickerel Creek wetland complex; and
- Creeks 13-2b, 13-2c, 13-3, and 13-15 which are south of Creek 12-9 and flow into the east side of Rolling Stone Lake.

As described in NMC's preliminary mitigation assessment document (Foth & Van Dyke, 1997a), which was discussed at the August 21, 1997, meeting between the WDNR and NMC, it is recognized that the categorization of water bodies for permitting purposes should be based principally on the predicted impacts derived from the regional groundwater flow model. Significant collaborative effort between NMC and the WDNR, USCOE, and others has gone into the development of the regional groundwater flow model. The basic purpose of the model is to predict impacts. Thus, the output from the model provides the best available data to assess impacts and for use in completing surface water classifications for mitigation purposes. It is recognized that professional judgement may be used for classifying some water bodies. It is also noted that substantial monitoring data will be collected during the operations period of the project which will be used to test the accuracy of the original groundwater flow model predictions and to make decisions on the need to upgrade or downgrade the planning level for any given surface water body.

The use of the PRF and/or the PRS as one of the trigger criteria as described in WDNR's mitigation framework appears workable given the following understandings. It is understood that these levels (PRF/PRS) will be used as trigger points only for both the initiation and cessation of mitigation of Level I water bodies. It is also understood that the quantity of mitigation water to be added to a given body of water will not exceed the estimated quantity of water that is lost from that water body as a result of mine operations, based on flow model predictions and verified through the field monitoring program and updated groundwater modeling. Finally, it is understood that the total quantity of mitigation water to be added will not exceed the total quantity available from mine inflow. These assumptions are consistent with WDNR's mitigation goal which is to protect the public rights in streams, springs, and lakes. The concept outlined by these assumptions acknowledges that under normal conditions stream flows and lake elevations naturally fall below and rise above the PRF and PRS trigger points.

Also assessed in this mitigation plan are the mitigation requirements for the post-mining groundwater recovery phase when groundwater inflow toward the mine goes back into aquifer storage around the mine resulting in a continued need for surface water mitigation. The mitigation plan during this period of time calls for the use of a series of groundwater recovery wells around the mine to provide groundwater for mitigation.

During the groundwater recovery phase, inflow toward the mine will initially remain at its operational inflow rate until the mine workings below the weathered rock are reflooded. Once the reflooded level in the mine rises above the bottom of the weathered rock (the base of the aquifer), the inflow rate toward the mine will begin to decrease and mitigation requirements will begin to decline. Provided the mitigation requirement is always less than the total flux that is directed toward the mine, pumping from a series of groundwater recovery wells around the mine will allow the groundwater system to continue to recover, although at a slower rate, while also providing for mitigation needs. Since mitigation during and immediately after operations is only likely to be needed during seasonal low flow and stage conditions (i.e., late winter and late summer), amounting to 25 percent to 50 percent of the days on an annual basis, post-mining mitigation can be expected to delay full recovery of the groundwater table by 25 percent to 50 percent.

3 Categorization of Surface Water Bodies for Permitting

WDNR's mitigation framework identifies four planning levels into which the surface water bodies in the vicinity of the mine are to be placed for permitting purposes. Under this framework complete mitigation plans for Level I water bodies, those for which substantial impacts are predicted, are to be designed and permitted during the project permitting process and facilities are to be constructed at the initiation of mine dewatering, such that mitigation could begin as soon as needed. Level II mitigation plans for water bodies which could possibly experience substantial impacts are to be designed and reviewed during the master hearing, but would not be constructed until data collected during operations indicate the system may be needed. A conceptual mitigation plan is to be developed for review at the master hearing for each water body that is not likely to experience impacts (Level III), but could be impacted given the proximity of the water body to the mine. A generic outline for the development of a mitigation plan is to be prepared for review at the master hearing for Level IV water bodies which are highly unlikely to experience impacts, but could given their proximity to the mine. Detailed plans for water bodies initially categorized as Level III or IV would be developed should water bodies in these planning levels be upgraded to the next higher level.

Building upon the WDNR's approach, the charts contained in Figures 3-1 and 3-2 have been used to place each creek or lake into one of the four planning levels. The charts are based on the criteria identified in WDNR's mitigation framework, incorporate the provisions of s. 293.65(3)(b), Wis. Stats., and rely on results from the surface water impact assessment contained in Appendix B. The locations of the surface water bodies under consideration are shown in Figure 3-3. Table 3-1 summarizes the categorization of water bodies into one of the four planning levels based on the approach shown in Figures 3-1 and 3-2. Also provided in Table 3-1 are the estimated mitigation rates in gallons per minute and as a percent of mine inflow based on model runs 49C/49N and 50C/50N (HSI GeoTrans, 1998).

Note that the categorization process is based on BEJ and PWC impacts that are predicted to occur during zinc mining. As described in HSI GeoTrans (1998), the mine inflow and thus surface water impacts are predicted to be substantially less during the copper phase of mining. As such, the surface water categorization process and subsequent engineering design for Level I and II water bodies addresses the maximum impact that is likely to occur during the proposed mining operation.

In using Figures 3-1 and 3-2, predicted flow and water levels make up the input data for each water body. Predicted flow and water level data are derived from the recent (HSI GeoTrans, 1998) groundwater flow modeling work. Impact input data related to flow and water levels based on HSI GeoTrans (1998) work are presented in Appendix B. For creeks, the impact assessment presented in Appendix B was carried out using the methodology specified in Section 4.2.6 of the project's EIR (Foth & Van Dyke, 1995/1998a). For lakes, a gradational impact assessment, similar to that used for creeks, was used as requested in WDNR comments dated January 21, 1998 (WDNR, 1998a). The use of flow and water levels should address the most critical, if not all, of the public rights related criteria since the PRF and PRS address biological, recreational, navigational, and aesthetic issues.

Table 3-1

Summary of Impacts and Surface Water Body Mitigation Categorization for Permitting

Location	BEJ Impacts		PWC Impacts		Proximity of Creek to Mine	Proximity of Lake to Predicted 5-ft and 1-ft Drawdown Contour		BEJ Impact Ranking	PWC Impact Ranking	Mitigation Planning Level		Level I, II, and III Mitigation Requirement			
	Approximate BEJ Impact on Q _{7,10}	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Approximate PWC Impact on Q _{7,10}	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage (ft)		BEJ	PWC			BEJ	PWC	BEJ		PWC	
												Flow (gpm) ⁴	% Mine Inflow ⁴	Flow (gpm) ⁴	% Mine Inflow ⁴
Swamp Creek (STH 55) ¹	— ²	NA	— ²	NA	<1 mi	NA	NA	No flow reduction	No flow reduction	IV	IV	NA	NA	NA	NA
Swamp Creek (SG-3) ¹ (Includes 19-14)	— ²	NA	— ³	NA	<1 mi	NA	NA	No flow reduction	No flow reduction	IV	IV	NA	NA	NA	NA
Hemlock Creek (SG-6B) (Includes 33-8)	<10%	NA	<10%	NA	>1 mi	NA	NA	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Hoffman Spring	10% ⁵	NA	<15% ⁵	NA	<1 mi	NA	NA	Minimal	Moderate	III	II				
Hoffman Creek (Includes Hoffman Spring)	<10% ⁵	NA	<15% ⁵	NA	<1 mi	NA	NA	Minimal	Moderate	III	II	18	4	31	4
Creek 12-9 (SG-23) (Includes Creek 12-2)	<10%	NA	10%	NA	>1 mi	NA	NA	Minimal	Minimal	III	III	76	17	112	14
Creek 11-4 (Martin Springs)	<10% ⁵	NA	<15% ⁵	NA	>1 mi	NA	NA	Minimal	Moderate	IV	III	NA	NA	18	2
Upper Pickerel Creek (Drainage Canal)	<10%	NA	<10%	NA	>1 mi	NA	NA	Minimal	Minimal	III	III	63	14	99	13
Creek 19-14	>20% ⁵	NA	>20% ⁵	NA	<1 mi	NA	NA	Substantial	Substantial	I	I	9	2	13	2
Creek 33-8	<10% ⁵	NA	<15% ⁵	NA	>1 mi	NA	NA	Minimal	Moderate	IV	III	NA	NA	36	5
Creek 13-2b	— ⁶	NA	— ⁶	NA	>1 mi	NA	NA	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Creek 13-2c	— ⁶	NA	— ⁶	NA	>1 mi	NA	NA	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Creek 13-3	— ⁶	NA	— ⁶	NA	>1 mi	NA	NA	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Creek 13-15	— ⁶	NA	— ⁶	NA	>1 mi	NA	NA	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Little Sand Lake	NA	<50%	NA	50%	NA	w/in 5-ft	w/in 5-ft	Minimal	Moderate	II	II	61	13	134	17
Deep Hole Lake	NA	<50%	NA	<50%	NA	w/in 1-ft	w/in 1-ft	Minimal	Minimal	III	III	16	4	36	5
Duck Lake	NA	<50%	NA	<50%	NA	w/in 1-ft	w/in 5-ft	Minimal	Minimal	III	II	4	1	8	1
Skunk Lake	NA	>100%	NA	>100%	NA	w/in 1-ft	w/in 5-ft	Substantial	Substantial	II	I	31	7	50	6

Table 3-1 (Continued)

Location	BEJ Impacts		PWC Impacts		Proximity of Creek to Mine	Proximity of Lake to Predicted 5-ft and 1-ft Drawdown Contour		BEJ Impact Ranking	PWC Impact Ranking	Mitigation Planning Level		Level I, II, and III Mitigation Requirement			
	Approximate BEJ Impact on Q _{7,10}	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Approximate PWC Impact on Q _{7,10}	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage (ft)		BEJ	PWC			BEJ	PWC	BEJ		PWC	
												Flow (gpm) ⁴	% Mine Inflow ⁴	Flow (gpm) ⁴	% Mine Inflow ⁴
Lake 35-7	NA	Not Predicted w/LSP	NA	Not Predicted w/LSP	NA	outside 1-ft	w/in 1-ft	Minimal	Minimal	IV	III	NA	NA	~2 ⁷	<1 ⁷
Lake 34-1	NA	Not Predicted w/LSP	NA	Not Predicted w/LSP	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Mole Lake	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Rice Lake	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Rolling Stone Lake	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Oak Lake ⁹	NA	— ⁸	NA	— ⁸	NA	w/in 1-ft	w/in 5-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Lake 25-11 (Popple Pond) ⁹	NA	— ⁸	NA	— ⁸	NA	w/in 1-ft	w/in 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
St John's	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Walsh	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Kimberly	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Clark	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Ground Hemlock	NA	— ⁸	NA	— ⁸	NA	outside 1-ft	outside 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
Lake 6-8 ⁹	NA	— ⁸	NA	— ⁸	NA	w/in 1-ft	within 1-ft	Minimal	Minimal	IV	IV	NA	NA	NA	NA
											Total (gpm)	278	539		

¹Creek is likely to experience a slight increase in flow due to soil absorption system, and thus does not require mitigation. Model predicted impact does not reflect operation of soil absorption system within the Swamp Creek groundwater basin.

²Slight increase in flow of about 1 cfs or less is expected due to operation of the soil absorption system (see Appendix B).

³Slight increase in flow of about 1.2 to 1.3 cfs is expected due to operation of the soil absorption system (see Appendix B).

⁴Based on zinc phase steady state inflow prediction. BEJ runs 49C/49N, PWC runs 50C/50N from HSI GeoTrans (1998). For Skunk Lake, see Appendix D. For Lake 35-7, see Appendix B, Attachment A.

⁵BEJ and PWC impact based on low flow/recharge runs 49J/49S and 50J/50S. Q_{7,10} data not available.

⁶Creeks are not in area affected by mine drawdown.

⁷Based on analysis in Appendix B.

⁸Lake is outside predicted 1-ft drawdown area.

⁹Perched lake.

NA = Not Applicable

Prepared by: SVD1
Checked by: JJA1

For streams, the use of distance from the mine to differentiate between mitigation levels addresses the uncertainty in the flow model work by placing surface water bodies closest to the mine into the next higher level than the results from the impact assessment alone would dictate. This makes sense since it will take appreciably more time for impacts to be seen the farther from the mine a given water body is located. A 1-mile distance was selected as the criteria for use in the categorization process, since 1 mile is of sufficient distance from the ore body such that surface water bodies at or beyond this distance would not be affected during the early years of mine dewatering. This is so since during the first 1 to 4 years of mining most of the extraction will occur below the strongly and moderately weathered bedrock. As a result, during the first 4 years of operations, mine inflow and the capture zone of the mine will be substantially lower and smaller, respectively, than the steady state mine inflow and capture zone prediction which assumes that all of the mineable zinc ore is drained. Since stream impacts are related to the capture zone of the mine, which is a function of mine inflow and drawdown, potential stream impacts will also be limited to the immediate vicinity of the mine during the first 4 years of mining.

Finally, if the impact on a creek could affect dissolved oxygen conditions in Rolling Stone Lake, the creek is placed into the next higher planning category. Note that this condition is considered applicable only to Upper Pickerel Creek and Creek 12-9 as they are significant flow contributors, and therefore possible dissolved oxygen contributors to Rolling Stone Lake. Creek 11-4, although potentially affected by mine dewatering, is not considered a major contributor of dissolved oxygen to Rolling Stone Lake due to extensive beaver activity and the low flow in the creek relative to Upper Pickerel Creek and Creek 12-9. Creeks 13-2b, 13-2c, 13-3, and 13-15, although inlet creeks to Rolling Stone Lake, have groundwater basins that are predicted to not be measurably affected by groundwater drawdown. Since the flow in these creeks will not be measurably affected, the dissolved oxygen consideration relative to Rolling Stone Lake (see Figure 3-1) does not apply. During mine operations, collected monitoring data will be used to check model predictions, and to upgrade or downgrade surface water bodies to higher or lower planning levels (see Section 9 below).

For lakes, the use of drawdown to differentiate between mitigation levels addresses uncertainty in the flow model work by placing head-dependent seepage lakes within the area of significant groundwater drawdown (defined as groundwater drawdown greater than 5 feet) into the next higher level than the results from the impact assessment alone would dictate. As will be done for the creeks, monitoring data collected during operations will be used to check model predictions, and to upgrade or downgrade lakes to a higher or lower planning level (see Section 9 below).

Note that in categorizing the creeks and lakes, the proximity of head-dependent riparian wetlands relative to the mine and the 5-foot drawdown contour were examined. Head-dependent riparian wetlands only exist around Little Sand Lake and Skunk Lake. The riparian wetlands around Deep Hole and Duck Lakes are perched. Since Little Sand Lake and Skunk Lake fall within the 5-foot drawdown contours under PWC conditions, the consideration of riparian wetlands does not affect the categorization of the water bodies for design purposes.

For stream classification purposes, the criteria used to define minimal impacts to flow, as presented in Appendix B, has been used in the flow chart (Figure 3-1) to differentiate if the impact results in an unreasonable detriment of public rights. The minimal category is based primarily on a flow rate reduction of 10 percent or less, which will likely not be noticeable and which is likely beyond the limits of the ability to differentiate through monitoring. Using percent reduction based on the $Q_{7,10}$ flow rate for categorization of streams into Levels I through IV provides a good representation of the maximum extent of the impact a stream could experience.

To illustrate the appropriateness of using a 10 percent impact threshold to define unreasonable detriment of public rights for stream flow, a series of flow duration curves for stream gaging sites in the project vicinity are presented in Appendix C. Based on these curves, derived from USGS data, the $Q_{7,2}$ is equivalent to the Q_{95} . For all practical purposes the $Q_{7,10}$ falls on the stage duration curve at a value equal to the Q_{100} . For the examples provided, the curves show that stream flow would be below the $Q_{7,2}$ value approximately an additional 2 percent of the time given a 10 percent impact from the mine. It would also be expected that the flow would be below the $Q_{7,10}$ value about 2 percent of the time given a 10 percent impact from the mine. This is a small decrease which should not adversely affect the stream and would for all practical purposes be unmeasurable.

For lake classification purposes, the criteria used to define impacts to lake stage, as presented in Appendix B, has been used in the flow chart (Figure 3-2) to differentiate if the impacts result in an unreasonable detriment of public rights. Those lakes that are not within the predicted 1-foot drawdown area, and thus will not be impacted, are categorized as Level IV lakes. Lakes that are within the 1-foot drawdown area and are ranked in Appendix B as having minimal or moderate impacts are categorized as: 1) Level III water bodies if they are outside the 5-foot drawdown area; or 2) Level II water bodies if any part of the lake is inside the 5-foot drawdown area. Lakes that are within the 1-foot drawdown area and are ranked in Appendix B as having substantial impacts are categorized as: 1) Level II if they are outside the 5-foot drawdown area; or 2) Level I if they are inside the 5-foot drawdown area. Figure 3-3 shows the 1-foot and 5-foot drawdown contours under both BEJ and PWC conditions.

Using the charts in Figures 3-1 and 3-2, and the impact ranking in Appendix B, each of the surface water bodies in the vicinity of the mine has been categorized as either Level I, II, III, or IV. Table 3-1 presents the results of the categorization. The categorization has been completed for both best engineering judgement (BEJ) and practical worst case (PWC) conditions.

Included in the categorization of Creek 12-9 is the tributary Creek 12-2 which flows through a poorly defined stream channel. This creek flows into Creek 12-9 upstream of gaging station SG-23. As such, the measured base flow at SG-23 includes the base flow resulting from direct discharge into Creek 12-9 and discharge into Creek 12-2. Due to the poorly defined stream channel, Creek 12-2 is free flowing only in the immediate vicinity of the confluence with Creek 12-9. Consequently, this tributary creek is not believed to represent a significant biological resource with respect to trout spawning areas. Rather, the primary value of this

tributary creek, with respect to biological resources, is the contribution it provides to base flow in Creek 12-9. Given the above, by mitigating Creek 12-9, based on flow data at SG-23 which includes the contribution from Creek 12-2, the mitigation requirement on Creek 12-9 will account for base flow loss due to direct discharge into Creek 12-9 and direct discharge into the tributary Creek 12-2.

In evaluating the impacts in Swamp Creek, the impact assessment in Appendix B notes that Swamp Creek will actually experience a slight increase in flow due to the operation of the soil absorption system. As such, there will be no flow reduction that requires mitigation, and Swamp Creek is categorized as a Level IV water body.

Also note that in Table 3-1 the Upper Pickerel Creek drainage canal that is believed to discharge into Mole Lake is included in the categorization of Upper Pickerel Creek. This results from the data available from the regional groundwater model. The drainage canal was simulated as a drain (a discharge point) in the regional model. However, the model was unable to reproduce discharge to this area. This is attributed to the fact that there is little discharge in this area to begin with, and that if the calibrated groundwater elevation around the canal is as little as 0.01 foot below the land surface elevation (i.e., the drain elevation in the model), the model will compute zero discharge. As such, the model is unable to resolve this subtle hydrologic feature. Given that the drainage canal is in a similar hydrologic setting as Upper Pickerel Creek, it stands to reason that the degree of impact on the drainage canal will be similar to Upper Pickerel Creek. Accordingly, the drainage canal needs to be considered when selecting a potential pipeline route for Upper Pickerel Creek. The mitigation rate for the drainage channel will need to be defined based on future flow monitoring data collected during the early years of operations.

In the draft mitigation plan (Foth & Van Dyke, 1997b) Rolling Stone Lake was elevated from a Level IV to a Level III water body due to concerns about the potential for lowered dissolved oxygen levels during periods of ice cover. If this condition were to occur, it would be manifested through a reduction in stream flows from Creek 12-9 and Upper Pickerel Creek. Accordingly, the dissolved oxygen issue should be factored into the categorization of the creeks in question, the cause of the condition, and not Rolling Stone Lake, the result of the condition. As such, Creek 12-9 and Upper Pickerel Creek have been raised to a higher mitigation level than the results from the flow impact assessment in Appendix B would dictate. This implies that during periods of ice cover on Rolling Stone Lake, dissolved oxygen levels in the lake will be an additional trigger for mitigation of Creek 12-9 and Upper Pickerel Creek. Accordingly, if Creek 12-9 and/or Upper Pickerel Creek are upgraded to a Level I water body, dissolved oxygen levels in Rolling Stone Lake, and/or the flow in Creek 12-9 and Upper Pickerel Creek, could trigger mitigation of these creeks.

4 Trigger Criteria

During operations, trigger criteria will be required to determine when mitigation for Level I water bodies will be initiated and when it can cease. Criteria will also be needed to determine when a given surface water body should be upgraded or downgraded to a higher or lower planning level, respectively. The PRF for streams, the PRS for lakes, and groundwater level data are to be principally used as the initiation and cessation levels for the former category. Flow, water level, water chemistry monitoring data such as dissolved oxygen in Rolling Stone Lake, climatological data, and potentially biological data would be used for the latter category. The focus of the following discussion is on the development and use of the PRF and PRS. A more detailed discussion relating to the methodology to upgrade or downgrade surface water bodies during operations is presented in Section 9.

In comments dated January 21, 1998 (WDNR, 1998a), the WDNR provided preliminary public rights flow and public rights stage data for the creeks and lakes in the vicinity of the project site. A summary of those data is provided in Table 4-1. Pertinent gaging stations and lakes are shown in Figure 4-1.

The WDNR's previous PRF values for the streams listed above correlate to the Q_{75} on available flow duration curves. The Q_{75} equates to a flow value that is exceeded under natural conditions in the stream 75 percent of the time. Thus by definition, flow in streams will be below the PRF 25 percent of the time under natural conditions. The Q_{75} can also be considered a measurement of the base flow to the streams.

With respect to lakes, a preliminary PRS has been established by the WDNR for most of the lakes in the study area. For Little Sand Lake the PRS varies from 1591.0 for December through March, to 1591.51 from April through June, to 1591.25 from July through November. These values compare to a recorded lake stage that varies from 1590.81 to 1593.47 with an average historical lake stage of about 1592.07.

For Deep Hole Lake the PRS varied from 1605.0 for December through March to 1605.25 for April through November. These values compare to a recorded lake stage that varies from 1604.86 to 1607.09 with an average historical lake stage of about 1605.64.

For Duck Lake the PRS was established at 1610.59 for the entire year. This compares to a recorded lake stage that varies from 1610.24 to 1612.88 with an average historical lake stage of about 1611.74. For Skunk Lake the PRS was established at 1597.01 compared to a lake stage that varies naturally from 1595.18 to 1599.85, with an average historical stage of about 1597.66.

Table 4-1
Preliminary PRF and PRS Values

Surface Water Body	WDNR PRF/PRS (cfs or feet)
Swamp Creek at STH 55	18
Swamp Creek at SG-3	11
Hemlock Creek at Confluence with Swamp Creek	TBD
Hoffman Creek	0.55
Hoffman Springs	0.3
Upper Pickerel Creek	1.0
Creek 11/4/Martin Springs	0.4
Creek 12-9 (includes tributary Creeks 12-2)	2.5
Creek 19-14	0.17
Creek 13-2b	0.22
Creek 13-2c	0.05
Creek 13-3	0.15
Creek 13-15	0.32
Creek 33-8	TBD
Little Sand Lake	1591.0 (Dec. - Mar.) 1591.51 (Apr. - June) 1591.25 (July - Nov.)
Deep Hole Lake	1605.0 (Dec. - Mar.) 1605.25 (Apr. - Nov.)
Duck Lake	1610.59
Skunk Lake	1597.01
Oak Lake	TBD
Popple Pond	1602.60
Mole Lake	1549.76

Table 4-1 (Continued)

Surface Water Body	WDNR PRF/PRS (cfs or feet)
Lake 34-1	1550.31
Lake 35-7	1554.19
Rice Lake	TBD
Ground Hemlock Lake	TBD
Rolling Stone Lake	TBD
Walsh Lake	1599.45
Kimberly Lake	1599.48
St. John's Lake	1590.46
Clark Lake	1594.64
Lake 6-8	TBD

Prepared by: SVD1
Checked by: BDH

Dissolved oxygen (D.O.) levels in Rolling Stone Lake are also likely to play a role in triggering mitigation requirements on Upper Pickerel Creek and Creek 12-9. Specifically, the WDNR noted at the February 3, 1998 meeting that reduced flow from Upper Pickerel Creek and Creek 12-9 could affect D.O. levels in Rolling Stone Lake during the winter months when the lake is frozen. Accordingly, NMC is proposing that ice conditions on Rolling Stone Lake, in addition to flow, be used as triggers for mitigation of these two creeks in the event they are elevated to a Level I water body. If these creeks are elevated during operations to a Level I mitigation category, they would be mitigated when the following conditions occur:

- during ice cover on Rolling Stone Lake; and
- when the flow in the creeks fall below the PRF.

In both cases, the mitigation rate would be the estimated loss in base flow gain to the creek due to mine inflow.

5 Engineering Design Considerations

The first step in designing the mitigation system for the project involves defining mitigation water requirements and the sources of mitigation water. Treatment needs and delivery methods can then be selected. Permit requirements must also be considered in selecting system components and in completing system design. The following discussion addresses each of these topics as related to the ultimate design of Level I and II mitigation systems. The actual design for Level I and II systems is presented in Section 6 of this report. A conceptual mitigation system design for Level III surface water bodies is presented in Section 7, while a generic outline for the development of a mitigation system for Level IV surface water bodies is discussed in Section 8.

5.1 Mitigation Water Requirements

Mitigation of a Level I stream will be implemented in accordance with the process discussed in Section 9 of this report. Section 9 also discusses the process by which streams classified as Level II, III, or IV will be upgraded to a higher level, if needed. If a water body was upgraded from Level II to Level I, the design prepared during permitting would be verified, the system installed, and the water body would be mitigated in accordance with the criteria set forth in Section 9 below. As also described in Section 9, mitigation of a Level I lake and upgrading Level II, III, and IV lakes will proceed in a similar process to that used for streams.

Rolling Stone Lake has a naturally occurring dissolved oxygen problem. Potential further reductions in dissolved oxygen levels in the winter due to reduced inflow from Upper Pickerel Creek and Creek 12-9 are possible. Mitigation for reduced dissolved oxygen levels in Rolling Stone Lake would be accomplished via flow mitigation for Upper Pickerel Creek and Creek 12-9, which will increase the flow of oxygen enriched water to Rolling Stone Lake.

5.1.1 Water Requirements During Mining

Predicted BEJ and PWC flow reductions developed using the updated regional groundwater flow model (HSI GeoTrans, 1998) for surface water bodies are presented in Appendix B. The mitigation system is designed to provide mitigation water requirements for Level I and II water bodies under PWC conditions. In addition, the mitigation system is designed to accommodate contingencies for additional water requirements in the event that additional water bodies require mitigation. This concept provides the opportunity, as discussed in Section 6, to initially construct system features for Level I water bodies, while having the flexibility to expand the system, in a reasonable time frame, to accommodate Level II water bodies based on environmental monitoring data. The quick response time for Level II water bodies is afforded by the fact that designs and regulatory agency reviews will have been completed during the project's permitting process.

The estimated mitigation requirements for the Level I and II water bodies under PWC conditions are provided in Tables 5-1 and 5-2. The mitigation water requirements for creeks and lakes with outlets are based on water budget data provided in HSI GeoTrans (1998). In the case of Skunk Lake, the estimated mitigation requirement is based on the water budget analysis described in Appendix D.

Table 5-1

**Estimate of Mitigation Water Needs
PWC Level I Water Bodies**

Water Body	Water Characteristic	Mitigation Rate (gpm) ¹
Creek 19-14	Hard	15
Skunk Lake	Soft	50 ²
Total		65

¹ All values rounded to the nearest 5 gpm and are based on PWC runs 50C/50N (HSI GeoTrans, 1998).

² Skunk Lake mitigation rate based on Appendix D.

Prepared by: SVD1
Checked by: JJA1

Table 5-2

**Estimate of Mitigation Water Needs
PWC Level I and II Water Bodies**

Water Body	Water Characteristic	Mitigation Rate (gpm) ¹
Hoffman Springs/Creek	Hard	30
Creek 19-14	Hard	15
Skunk Lake	Soft	50 ²
Little Sand Lake	Soft	135
Duck Lake	Soft	10
Total		240

¹ All values rounded to the nearest 5 gpm and are based on PWC runs 50C/50N (HSI GeoTrans, 1998).

² Skunk Lake mitigation rate based on Appendix D.

Prepared by: SVD1
Checked by: JJA1

5.1.2 Water Requirements During Groundwater Recovery

The need for potential surface water mitigation will continue during the groundwater recovery period following the completion of mining. Estimates of the groundwater recovery period (GeoTrans, 1996) indicate that without mitigation it is likely to take approximately 10 years for the groundwater system to recover. With mitigation, the recovery period will likely be approximately 10 to 15 years. During this period of time, the mitigation requirements will decline as the groundwater system recovers. Initial mitigation requirements during the first 1 to 2 years will likely be comparable to the mitigation requirements during operations described above. The requirements are expected to decline significantly by about the fifth year after the end of mining as the groundwater system recovers.

5.2 Sources of Mitigation Water

5.2.1 Sources of Water During Operations

Potential mitigation water sources during operations are as follows:

Treated mine water

- Well water
- Other surface waters

The sources of potential mitigation waters were considered based on the nature of the receiving water body. In the case of lakes, all of the Level I and II water bodies are soft water bodies. As such, the most logical source of mitigation water is the treated mine water, which will have soft water quality characteristics that are similar to the precipitation and runoff fed Level I and II lakes.

For groundwater fed Level I and II water bodies, intercepted groundwater was originally planned (Foth & Van Dyke, 1997b) as the most logical source of mitigation water. This is no longer considered practical for mitigation planning, since the grouting program for the crown pillar will restrict the groundwater intercept system to elevations below the grout layer. This will restrict the ability to intercept groundwater before it comes in contact with mineralized zones of the bedrock. As such, no provisions are included in the mine plan for collecting clean intercept water. As a consequence, clean intercepted groundwater will not be available for use as a mitigation water source.

Well water is considered the most logical source of mitigation water for the Level I and II hard water bodies. Well water is considered feasible based on the limited quantities of water that will be required for Level I and II water bodies. In evaluating the use of well water for mitigation, the location of the water supply well is an important consideration. Locating the source north of Swamp Creek is considered logical since it places the water withdrawal point outside of the local groundwater basin affected by mine inflow. There will be no impact on the flow within Swamp

Creek due to the use of the well, since the Level I and II hard water bodies that are being mitigated flow into Swamp Creek.

5.2.2 Sources During Groundwater Recovery

During the groundwater recovery phase, inflow toward the mine will initially remain at its operational inflow rate until the mine workings below the weathered rock are reflooded. Once the reflooded level in the mine rises above the bottom of the weathered rock (the base of the aquifer), the inflow rate toward the mine will begin to decrease and the mitigation requirements will begin to decline. Since the mitigation requirements will always be less than total mine inflow or the total flux that is directed toward the mine, pumping from a series of groundwater recovery wells around the mine will allow the groundwater system to continue to recover, although at a slower rate, while also providing for mitigation needs. Since mitigation during and immediately after operations is only likely to be needed during seasonal low flow and stage conditions (i.e., late winter and late summer), amounting to 25 percent to 50 percent of the days on an annual basis, post-mining mitigation can be expected to delay full recovery by 25 percent to 50 percent. Note that the wastewater treatment system described in the PER (Foth & Van Dyke, 1995/1998c) will remain in operation during the post-mining groundwater recovery period to provide mitigation water needs for soft water lakes.

5.3 Overview of Treatment Options

Groundwater from local wells will be used for mitigation of hard water bodies. Since this groundwater is the same water which would naturally recharge these water bodies, treatment will not be required prior to mitigation discharge.

Treated water from the mine wastewater treatment system (WWTS) will be used for mitigation of soft water bodies. As discussed in the PER (Foth & Van Dyke, 1995/1998c), treated water not required for mitigation purposes will be discharged to groundwater by way of a soil absorption system. The base treatment processes for the WWTS includes hydroxide precipitation, sedimentation, sulfide precipitation, sand filtration, and pH adjustment. In order to meet projected effluent limits for both groundwater and mitigation discharge, advanced treatment of the base treatment system effluent will be required. Reverse osmosis (RO), ion exchange (IX), and evaporation (EV) were considered as applicable advanced treatment processes. The criteria used to evaluate these technologies included the following:

- Projected water quality limitations for groundwater, Skunk Lake, Little Sand Lake, Deep Hole Lake, and Duck Lake.
- The quality of effluent from the WWTS base treatment system.
- Hardness and metals reduction capabilities of RO, IX, and EV technologies.

- Capital and operation and maintenance costs associated with RO, IX, and EV technologies.
- Operational constraints associated with RO, IX, and EV technologies.
- The results of pilot testing of RO and EV technologies.

Based on this evaluation, a combination of RO and EV technologies was selected as the best available advanced treatment system to meet the requirements of both groundwater and mitigation discharge. This combined advanced treatment system was selected on the basis of operational flexibility, reliability, ease of operation, and effluent quality. The RO system will provide an effluent of sufficient quality to meet groundwater discharge limitations. The EV system will provide an effluent of sufficient quality to meet the more stringent limitations associated with soft water body mitigation. A detailed description of the base and advanced wastewater treatment systems is provided in the PER (Foth & Van Dyke, 1995/1998c). A discussion of the advanced treatment system, as applicable to soft water body mitigation, is provided in Section 6 of this plan.

5.4 Mitigation Water Delivery

Options for delivery of mitigation water to a surface water include:

- point source delivery directly to a surface water;
- point source delivery cascading into a surface water;
- point source delivery to wetlands that have a direct discharge to a surface water;
- groundwater delivery which feeds to a surface water; and
- groundwater delivery which feeds to a wetland contiguous to the surface water.

Each option presents potential advantages and disadvantages. A number of issues were evaluated to select the most appropriate delivery method. Simplicity of construction and operation, permitting requirements, and effectiveness were the primary areas of evaluation. Table 5-3 provides a breakdown of the delivery options evaluated for each water body with a specification of the preferred option.

The use of a point source delivery system that discharges below the water surface provides simplicity of construction, operation, and maintenance. Such systems are very effective, provide protection against freezing, and have very little aesthetic impact. While this method will require a slightly greater level of regulation and monitoring, it was selected as the method of choice. Additional details on the delivery structures themselves are presented in Section 6 of this report.

Table 5-3

Mitigation Water Delivery Options

Water Body	Hard or Soft Water	Delivery Method		
		Direct	Seepage	Wetland
Hoffman Springs/Creek	Hard	Preferred	Optional	Optional
Creek 19-14	Hard	Preferred	Optional	Optional
Skunk Lake	Soft	Preferred	NA	NA
Little Sand Lake	Soft	Preferred	NA	Optional
Duck Lake	Soft	Preferred	NA	Optional

NA = Not Applicable

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Checked by: SVD1

5.5 Permit Requirements

This mitigation plan is intended to be a stand-alone document that relates to the following Crandon Project permit documents: *Environmental Impact Report* (Foth & Van Dyke, 1995/1998a); *Mine Permit Application* (Foth & Van Dyke, 1995/1998b); *Preliminary Engineering Report for Wastewater Treatment Facilities* (Foth & Van Dyke, 1995/1998c); *WPDES Permit Application* (Foth & Van Dyke, 1995/1998d); *High Capacity Well Permit Application* (Foth & Van Dyke, 1995/1998e); and the *Water Regulatory Permit Application for the Proposed Mine Site* (Foth & Van Dyke, 1996/1998f). A discussion of the relationship of the mitigation plan to each of these other documents follows.

5.5.1 Environmental Impact Report

Appendix 4.2-3 of the project's EIR describes the regional groundwater flow model used to predict surface water impacts associated with mine dewatering. These impacts were then used to develop the mitigation plan described in this report.

5.5.2 Mine Permit Application

The mitigation plan presented in this report is summarized in the MPA. Various practices which pertain to the construction of the mitigation system, such as erosion control measures, are addressed in the MPA. Other items relating to the mitigation system, such as monitoring and contingency action planning, are also addressed in the MPA.

5.5.3 Preliminary Engineering Report

The PER (Foth & Van Dyke, 1995/1998c) describes the water management and wastewater treatment system associated with the Crandon Project. The PER addresses the water treatment needs for the proposed mitigation plan described in this report.

5.5.4 WPDES Permit

As part of the WPDES permit application process, NMC will obtain WPDES discharge permits for those aspects of its mitigation program that would constitute the "discharge of pollutants" within the meaning of s. 283.01(5), Wis. Stats. NMC believes that, under a conservative reading of Chapter 283, WPDES permits should be obtained for any use of treated mine contact water for mitigation.

NMC does not believe that the use of well water for mitigation of hard water bodies would require a WPDES permit. The delivery of such groundwater to hard water bodies would provide the most genuine simulation of natural conditions. If any mitigation were required, it would be because the natural groundwater contribution to the surface water had been reduced. Because groundwater would simply be replaced with groundwater, there would be no need to adjust the water quality to match existing conditions. The natural constituents of the groundwater supplement - hardness, micro-nutrients, cations and anions - would be present at similar levels found in the natural groundwater contribution to the hard water bodies because the groundwater used for mitigation would be from the same regional groundwater source. The distribution and delivery system (buried pipelines and outlets) would also control the mitigation water's temperature to mimic natural groundwater conditions. Therefore, simply replacing groundwater that was lost from a hard water body with intercepted groundwater of like kind and quality would not constitute the discharge of pollutants within the meaning of s. 283.01(5), Wis. Stats. Nor would it constitute pollution, defined in s. 283.01(14), Wis. Stats. as the "man-made or man-induced alteration of the chemical, physical, biological or radiological integrity of water." The proposed mitigation would not alter the receiving hard water bodies, but rather maintain them in their present condition.

Where treated mine contact water is used for a mitigation water source (Level I and II lakes), a WPDES discharge permit will be required. Potential effluent limits will be based on a number of factors including: background water quality, dilution rates in the receiving water, and water hardness. Final effluent limits will be established by the WDNR. An estimated range of effluent limits is presented in Table 5-4. These limits were developed using formulas defined in NR 105, NR 106, and NR 207.

Table 5-4

Estimated Water Quality Based Effluent Limitations for Mitigation Waters

Parameter ¹	Units	Estimated Treated Water Quality ²	Estimated Little Sand Lake Limits ³	Estimated Duck Lake Limits ⁴	Estimated Skunk Lake Limits ⁴
Arsenic	mg/L	0.000083	0.0050	0.017	0.017
Cadmium	mg/L	<0.000007	0.000071	0.00010	0.00010
Copper	mg/L	0.00017	0.00098	0.00041	0.00041
Cyanide	mg/L	<0.0034	NA	0.0038	0.0038
Lead	mg/L	<0.000025	0.00045	0.00070	0.00070
Mercury	mg/L	0.000000071	0.0000023	0.0000040	0.0000033
Nickel	mg/L	0.00014	0.030	0.0028	0.0028
Zinc	mg/L	<0.0039	0.022	0.0049	0.0049
Nitrogen (Ammonia)	mg/L	0.05 ⁵	NA	NA	NA
BOD 5	mg/L	<5 ⁶	7	5	15

¹ The parameters listed are from the May 20, 1998, Jim Schmidt, WDNR, draft memorandum for Duck Lake and Skunk Lake (WDNR, 1998b).

² The estimated treated effluent quality is based on average water balance flows and engineering judgement. Effluent quality based on evaporator system condensate.

³ The Little Sand Lake limits are set to the maximum background concentrations for the 1994-1995 time period as reported in EIR Table 3.7-36 (Foth & Van Dyke, 1995/1998a).

⁴ The Duck Lake and Skunk Lake limits are from the May 20, 1998, Jim Schmidt, WDNR, draft memorandum for Duck Lake and Skunk Lake (WDNR, 1998b). The most stringent of the daily, weekly, or monthly limits are listed in this table.

⁵ The ammonia concentration is after the air stripping unit operation.

⁶ Based on engineering judgement.

NA = Not available

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5.5.5 High Capacity Well Permit Application

The mitigation plan described in this report relies on treated mine water and well water to provide mitigation water. Therefore, the mitigation plan will affect groundwater withdrawals. Accordingly, the project's updated *High Capacity Well Permit Application* (Foth & Van Dyke, 1995/1998e) reflects the additional water withdrawal.

5.5.6 Water Regulatory Permit Application

The installation of the project's mitigation system for Level I and II surface water bodies will involve one stream crossing and the placement of water delivery structures on or within navigable waters. The required permit applications for each of the structures are included in the project's updated *Water Regulatory Permit Application* (Foth & Van Dyke, 1996/1998f).

6 PWC Level I and Level II Water Body Mitigation System Design

This section of the mitigation plan summarizes the design of the water treatment and water conveyance systems for the mitigation of Levels I and II water bodies. Sources of water available for mitigation purposes, quantities of water available for mitigation purposes, and distribution of available water are discussed. A description of the mitigation water treatment facilities in the form of design criteria and physical details is also provided. A detailed description of the water treatment system is provided in the project's PER (Foth & Van Dyke, 1995/1998c). Finally, a description of the water conveyance system to be used for transferring water to the various mitigation bodies is given for each mitigation case.

The proposed treatment and conveyance systems are intended to handle mitigation requirements for Level I and II water bodies. Systems for additional water bodies would be modular additions to the Level I and II water body systems, and will be constructed as needed.

The WDNR has expressed the desire to use the regional groundwater model to refine and update impact predictions as data are collected during mine development and operation. This will serve as a tool to provide a higher level of detail on the long term needs for mitigation water. The mitigation water treatment and conveyance system provides the flexibility to meet varying demands for mitigation water and will allow for the development of additional capacity based on actual needs.

6.1 Level I and Level II PWC Treatment & Conveyance Systems

6.1.1 Mitigation Water Source

Water for soft water body mitigation will be provided from treated mine water. Groundwater from a well near the proposed main access road north of Swamp Creek will provide water for use in the mitigation of hard water bodies, and will be directly delivered to each water body. This groundwater will replace the groundwater that has been taken out of the hydrologic water balance of the respective surface waters due to mine inflow. The hard water bodies have chemistries that reflect their sources of water, e.g., surface runoff and groundwater. The intent of the mitigation plan is to replace that portion of the groundwater not discharging to the hard water surface water body because of mine dewatering. Replacing the lost groundwater with similar groundwater provides more realistic replacement, affording a one for one (e.g., water quantity and characteristics) mitigation of lost groundwater.

6.1.2 Mitigation Water Treatment System Overview

Under PWC Level I conditions, 15 gpm of water will be required for hard water body mitigation and 50 gpm of water will be required for soft water body mitigation. Under PWC Level I and II conditions, 45 gpm of water will be required for hard water body mitigation and 195 gpm of water will be required for soft water body mitigation. The source water for hard water body mitigation will be groundwater from local wells. This water will have similar characteristics to

the receiving water and will not require treatment prior to use in mitigation. Water for mitigation of soft water bodies will be condensate from the WWTS evaporator system. Based on engineering evaluation and pilot testing of evaporation technology, the WWTS evaporator will be capable of consistently providing treated water capable of meeting anticipated mitigation water quality standards for all soft water bodies as defined in this report. The project's PER (Foth & Van Dyke, 1995/1998c) contains a detailed discussion of the development of the projected treated water quality for the evaporator system, and a discussion of the projected quality of water from the WWTS lime/sulfide and the reverse osmosis processes.

Since the project's WWTS is designed to handle the projected range of mine wastewater flows, it will be capable of producing treated water sufficient in quantity, and of sufficient quality, to meet soft water body mitigation requirements under PWC Level I conditions. Modification of the WWTS facilities will therefore not be required for mitigation purposes. A brief description of the planned WWTS follows.

The WWTS will consist of a base treatment system and an advanced treatment system. Discharge of treated water will be to groundwater by way of a soil absorption system. The base treatment system will include hydroxide precipitation, clarification, sulfide precipitation, filtration, and pH adjustment. This system will provide substantial removal of metals present in the wastewater generated by mine operations. However, the base treatment system, by itself, will need to be supplemented to provide the level of treatment required to meet effluent limits for groundwater discharges regulated under Chapter NR 140, Wis. Admin. Code. Consequently, advanced treatment processes will be required.

The advanced treatment system will include reverse osmosis (RO), evaporation (EV), ammonia stripping, and pH adjustment. Treated wastewater from the base treatment will typically flow to the RO system. When soft water body mitigation is required, a portion of the treated water from the base treatment system may flow directly to the evaporator. This condition would occur if evaporator condensate produced from the RO reject stream would not meet mitigation flow needs. The RO system will reduce the concentrations of residual metals, other inorganics, and organics present in the base treatment system effluent to levels below the effluent limits for groundwater discharge. The RO system will result in two water streams: a purified water (permeate) stream, and a concentrated reject stream. The permeate stream will be suitable for discharge to groundwater. The reject stream will be sent to an evaporator system for volume reduction. The evaporator will produce a highly purified condensate and a concentrated brine stream. The brine stream will be sent to the pyritic paste backfill system for use in producing cemented backfill. With the possible exception of ammonia, the evaporator condensate will meet projected effluent limits for both groundwater discharge and mitigation discharge. Ammonia, due to its relatively high vapor pressure, is readily volatilized in evaporators and consequently is likely to be concentrated in the evaporator condensate. In order to meet effluent limits for ammonia, condensate from the evaporator will be processed in an air stripper.

Additional treatment/discharge facilities associated with providing water for mitigation purposes include pH adjustment, internal pumping of treated water, temporary storage of treated water,

and the mitigation discharge pumping and conveyance system. The pH of the evaporator condensate will be raised to enhance performance of the ammonia air stripping process. After the air stripper, the condensate pH will be adjusted to meet discharge limitations for mitigation water bodies. An automated pH adjustment feed system will be provided. Pumps will be used to deliver acid/caustic as required. An in-line static mixer system will be used for mixing the acid/caustic with the condensate. The pH adjusted condensate will flow by gravity into mitigation water tanks. These will be covered tanks and will each be sized to provide a minimum one day storage at PWC Level I and Level II mitigation flows. Two tanks will be provided to allow condensate quality to be checked prior to final discharge. Condensate not meeting discharge limitations can be pumped back to wastewater storage basins 6 and 7 for reprocessing in the WWTS or, if the water meets discharge limitations for the soil absorption system, it could be pumped to the WWTS discharge basins. Condensate meeting discharge limitations will be pumped to the mitigation site(s) by the pumping and conveyance system as described in Section 6.1.3.

During times when mitigation is not required, the evaporator condensate will be combined with the RO permeate and sent to the WWTS discharge basins. From the discharge basins, the final treated water will be pumped to the soil absorption system for final discharge. During those periods when mitigation is required, condensate from the evaporator will be routed to the mitigation water storage tanks. The condensate will then be pumped from these tanks to the soft water bodies requiring mitigation.

Based on mine/mill water balance projections, the WWTS evaporator system will provide sufficient condensate to meet soft water body mitigation requirements under PWC Level I conditions. Based on the PER (Foth & Van Dyke, 1995/1998c) assumed mine inflow rate of 600 gpm and minimum water balance weather conditions (minimum year site precipitation/maximum year site evaporation), the evaporator condensate available for mitigation purposes is projected to be 103 gpm. This compares with a projected PWC Level I soft water body mitigation flow requirement of about 50 gpm and a projected PWC Level I and II soft water body mitigation flow requirement of 195 gpm. As indicated in the PER (Foth & Van Dyke, 1995/1998c), the evaporator system will be designed to produce a peak condensate flow sufficient to meet mitigation requirements under PWC Level I and II conditions. Generation of this quantity of water will require increasing the flow to the evaporator. This will be accomplished by routing the necessary quantity of lime/sulfide effluent or RO permeate to the evaporator system. An example of how this will be accomplished is as follows:

- Under the water balance conditions defined above, the flow to the RO system will be 415 gpm. If 116 gpm of this flow is bypassed around the RO system directly to the evaporator, and the remaining 299 gpm is processed through the RO system, the resulting total flow to the evaporator (lime/sulfide effluent flow of 116 gpm bypassed directly to the evaporator plus RO brine of 89 gpm) will be 205 gpm. Subtracting 10 gpm for evaporator brine flow results in an evaporator condensate flow of 195 gpm, which meets the projected PWC Level I and II mitigation flow requirement.

6.1.3 Water Pumping and Conveyance

Separate water sources, pumping facilities and conveyance systems will be provided for hard water body mitigation and soft water body mitigation.

6.1.3.1 Pumping Facilities

Pumping facilities will be designed to provide the Practical Worst Case (PWC) flow rate required for each level of mitigation. The installed pumping facilities may be larger than required for the lowest level of mitigation where it makes sense to provide capacity for the potential next level of mitigation with minimal or no increase in cost. The intent is to phase the construction of the mitigation facilities to provide what is necessary for the required level of mitigation as it occurs.

Mitigation water for the soft water bodies will be obtained from the mitigation water tanks associated with the wastewater treatment plant. Water from the storage tanks will be pumped to the soft water conveyance system. A centrifugal pump with a variable drive motor will be used to vary the flow rates to match mitigation requirements. The equipment will be located and housed near the wastewater treatment plant.

As shown on Figure 6-1, the water source for mitigation of the Level I and II hard water bodies will be from a groundwater well located within the proposed main access road corridor north of Swamp Creek. Water will be pumped from the well directly to the hard water conveyance system located in the right-of-way of the main access road. The well design is shown on Figure 6-2. A submersible pump will be used to meet the Level I and Level II mitigation flow rate requirements.

6.1.3.2 Soft Water Conveyance System

Figure 6-3 is a plan view and overall layout of the pipeline route locations for the soft water conveyance system. The drawings also show nominal pipe diameters for polyethylene (HDPE DR9) pipe material and pipe segment lengths for the system. The Level I pipeline route begins at the project's water treatment plant; follows the eastern edge of the plant site to an unpaved on-site access road at the southeast edge of the plant site; then follows the unpaved on-site access road to the northeast between wetlands 10 and F11 to a point along the road that is closest to Skunk Lake. From this point, the pipeline leaves the road for approximately 170 feet to traverse a semi-cleared area to the delivery system at Skunk Lake. Figure 6-4 contains a plan and profile drawing showing an enlarged plan of the pipeline route and the change in elevation along the route. The pipeline from the project's treatment plant to the point where it turns northeast toward Skunk Lake is sized to supply water for Levels I, II and III mitigation. Air release/vacuum relief valves will be installed in manholes at high points along the pipeline route, as needed, to vent entrapped air in the pipe.

The soft water conveyance system illustrated in Figure 6-3 shows the route extensions to Little Sand Lake and Duck Lake for Level II mitigation. The drawing also shows the nominal pipe

diameters for polyethylene (HDPE DR9) pipe material and pipe segment lengths for the system. The pipeline is sized to accommodate Level I and II mitigation water flow rates and, where appropriate, oversized to accommodate expansion for Level III mitigation flow rates.

As shown on Figure 6-3, the Level II pipeline routes to Little Sand and Duck Lakes begin at the southeast corner of the plant site connecting to the Level I soft water pipeline at the point where the Level I soft water pipeline turns east toward Skunk Lake. From this connection the pipeline extends through an uncleared area south along the west side of wetland F11 for approximately 789 feet to Sand Lake Road. At this point there are two separate pipeline extensions, with one heading west along the north side of Sand Lake Road for approximately 639 feet where it turns south and traverses the upland between wetlands F119 and F10 for approximately 1,047 feet to a clearing and the delivery system to Little Sand Lake. The other pipeline, which will be approximately 8,294 feet long, follows along the west side of the Sand Lake Road right-of-way to the south until the pipeline turns north through approximately 1,600 feet of uncleared area and travels to the delivery system for Duck Lake. Figure 6-5 is a plan and profile drawing showing an enlarged plan of the pipeline route and the change in elevation along the route.

6.1.3.3 Hard Water Conveyance System

Figure 6-1 is a plan view and overall layout of the pipeline route locations for the hard water conveyance system. The drawing also shows nominal pipe diameters for polyethylene (HDPE DR9) pipe material and pipe segment lengths for the system. The pipeline is sized to accommodate Level I and II mitigation water flow rates and, where appropriate, oversized to accommodate expansion for Level III mitigation flow rates. The Level I pipeline route begins at the Level I and II mitigation well site along the east side of the site access road at the curve in the road. From the well site the pipeline follows the proposed main access road along the east side to just south of the Swamp Creek crossing. At this point the pipeline turns east following an unpaved on-site access road through wetland P1 to a clearing west of Creek 19-14. From the clearing the pipeline continues east to the delivery system at Creek 19-14. The last approximately 240 feet to Creek 19-14 is within wetland 01. Figures 6-4 and 6-6 contain plan and profile drawings showing an enlarged plan of the pipeline route and the change in elevation along the route. The pipeline from the mitigation well site to the point south of Swamp Creek where it turns east toward Creek 19-14 (a Level I water body) is sized to supply water for Levels I, II and III mitigation. Air release/vacuum relief valves will be installed in manholes at high points along the pipeline route, as needed, to vent entrapped air in the pipe.

The hard water conveyance system illustrated in Figure 6-1 shows the route extension to Hoffman Creek/Hoffman Springs for Level II mitigation. The Level II hard water pipeline route begins at the Level I hard water pipeline along the west side of the proposed main access road at the point where the Level I hard water pipeline turns east toward Creek 19-14. From this location the pipeline follows the site access road to the plant site. From the plant site the pipeline turns west through approximately 500 feet of uncleared land through the uplands area near wetlands 3 and 4 to an unpaved on-site access road. Following the unpaved on-site access road, the pipeline route intersects with another unpaved on-site access road where the pipeline turns to

the southwest approximately 1,200 feet through uncleared land to Sand Lake Road. The pipeline turns west along the north side of Sand Lake Road to a point where it turns north approximately 300 feet through uncleared land to the delivery system for Hoffman Creek/Hoffman Springs. Figure 6-7 is a plan and profile drawing showing an enlarged plan of the pipeline route and the change in elevation along the route.

6.1.3.4 Construction

The pipelines will be trenched to a minimum depth of 6.5 feet within the plant site and within roadways. Outside the road and the plant site, the pipeline will also be trenched to a minimum depth of 6.5 feet. Trenching equipment consisting of either a chain trencher or a rotary trencher will be used to trench, install, and backfill the pipe with native materials in one operation. The trench width will not exceed 18 inches. The pipe will be placed on native material with no additional bedding material. The equipment width will not exceed 12 feet, and will require clearing and leveling of uneven surfaces across the machine track to a minimum width of 15 feet. In the construction process soil will be cast back into the trench, rather than to the side of the trench, which reduces the required clear operational space. The trench will be located in the center of unpaved on-site access roads and along the side of town roads approximately 6 feet off the edge of the pavement or traveled area. Swamp Creek and the associated wetland W1 will be crossed by directional drilling of the pipe under the areas a minimum of 5 feet below the wetland and creek bottom. Pipelines crossing wetland Z22 located near Lake 25-11 (Popple Pond) and wetland Z18 located near Hoffman Springs will also be installed using directional drilling. The pipeline will be constructed by trenching through other wetland crossings.

6.1.3.5 Mitigation Water Delivery Systems

The water conveyance pipeline will terminate at the "mitigation water delivery system" at the location of the control structure along the water body above the high water mark and outside the wetland area. The mitigation water delivery system consists of a control structure, a pipeline into the water body, and a diffuser within the water body as shown in Figure 6-8.

The control structure is a below grade structure to house and provide access to a hydraulically operated rate of flow controller, a flow meter, and isolation valves between the conveyance pipeline and the pipeline to the water body. The rate of flow controller will maintain a constant preset flow rate regardless of changing line pressure. The flow rate through the controller can be adjusted over a 4:1 range of maximum to minimum flow rates. The rate of flow controller will provide a constant rate of flow even when another mitigation discharge flow rate is changed or added to the system.

From the control structure the pipeline will extend below grade into the water body terminating at the bottom of the slope into the water. At the pipeline termination a diffuser pipe with a combination diffuser and check valve will be installed to prevent debris from entering the system when not in use. The diffuser will be anchored and protected by placing articulated concrete block mats over the diffuser pipe.

6.2 Cost Estimate

Based on the plan for the conveyance of water to Level I and II surface water bodies, construction cost estimates have been prepared. The cost estimates reflect the proposed system layout and construction techniques described above. Separate cost estimates have been established for Level I water bodies and Level I and II water bodies. Appendix E provides a summary of the estimated construction costs.

7 Mitigation System Selection and Design for Level III PWC Water Bodies

This section of the plan describes in concept water sources, water treatment, and water conveyance for mitigation of Level III water bodies. As shown in Table 3-1, water bodies categorized as Level III under PWC conditions include Creek 12-9, Creek 11-4/Martin Springs, Upper Pickerel Creek, Lake 35-7, Creek 33-8, and Deep Hole Lake. All of these water bodies, with the exception of Deep Hole Lake, are hard water bodies. Deep Hole Lake is a soft water lake.

For the mitigation of Creek 11-4/Martin Springs, a well located west and downgradient of the spring is proposed to supply mitigation water. The water requirement for Creek 11-4/Martin Springs is estimated to be approximately 20 gpm. Supplying mitigation water from a well west of Creek 11-4/Martin Springs is not expected to affect the flow in the creek given the small water demand, and since the well would not be located upgradient of the creek and spring. Any impact that this well may create on Upper Pickerel Creek could be mitigated by increasing the mitigation rate to Upper Pickerel Creek by about 20 gpm.

The approach to mitigating Deep Hole Lake will be similar to the approach described in Section 6 for soft water lakes. Treated mine water will be added to Deep Hole Lake. The delivery system would be designed to extend from the soft water mitigation pipeline supplying Duck Lake. The conceptual design involves delivering the water at the northeast side of Deep Hole Lake.

The approach to mitigating Upper Pickerel Creek, Creek 12-9, Creek 33-8, and Lake 35-7 will be similar to the approach described in Section 6 for Creek 19-14 and Hoffman Springs/Hoffman Creek. All of these water bodies are groundwater fed. Mitigation water will be supplied by mitigation wells located north of Swamp Creek. The pipeline routes for each of these water bodies would extend from Level I and II hard water pipelines.

For Upper Pickerel Creek the delivery pipeline would extend from Hoffman Springs west along Sand Lake Road, then south down Black Joe Road, terminating where Black Joe Road turns east. At this point, a manhole would be installed on the east side of the wetland. The pipeline from the manhole (housing the flow meter, etc.) to Upper Pickerel Creek would be installed via directional drilling. A small pipeline could also be extended from this manhole to the Upper Pickerel Creek drainage canal, if this water body required mitigation.

For Lake 35-7 the mitigation delivery pipeline would extend from the Upper Pickerel Creek pipeline. The delivery point would likely be the western side of the lake.

For Creek 12-9 the mitigation pipeline route would begin where the Level II hard water pipeline intersects Sand Lake Road. From this point the pipeline route would go east along the Sand Lake Road right-of-way to the point where Sand Lake Road turns southeast. The pipeline would then follow existing roads and trails down the east side of Little Sand Lake, eventually intersecting with Creek 12-9 east of the Forest County Line.

For Creek 33-8 the mitigation pipeline would begin where the hard water pipeline enters the plant site. The pipeline route would traverse the plant site to the TMA access road. The pipeline would then follow the TMA access road to the TMA, where it would extend around the southern boundary of the TMA east to Creek 33-8.

Mitigation requirements for Level I, II, and III water bodies are summarized in Table 7-1. With the exception of Creek 11-4/Martin Springs (described above), the mitigation water requirements under PWC conditions for Level I, II, and III water bodies can be met by the water sources that are required for Level I and II water bodies. A soft water requirement of 230 gpm can easily be supplied by treated mine water. Similarly, the hard water requirement of 265 gpm can easily be supplied by groundwater withdrawn north of Swamp Creek. In the event that Level III mitigation was required, a second well would likely be located along the east side of the access road. Having two wells would allow each well to be cycled on a 12-hour basis during periods of time when mitigation is required. Due to the operation of the soil absorption system north of Swamp Creek, the additional water withdrawn from the aquifer north of Swamp Creek will not adversely affect flow on Swamp Creek above the minimum impact ranking provided in Appendix B.

Under low flow conditions, the net impact on Swamp Creek at STH 55 during mitigation is a function of the mine inflow, water diverted from the wastewater treatment system for mitigation of soft water bodies, and the amount of water pumped from the mitigation wells north of Swamp Creek. Under PWC low flow conditions, the net impact on Swamp Creek is the net difference between groundwater diversions from the creek and water addition to the creek via the soil absorption system. This difference can be written as follows:

$$SAS - BR - HWB = \text{Net change in flow in Swamp Creek at STH 55}$$

where:

SAS = Discharge to the soil absorption system under low recharge conditions.

BR = Base flow reduction under low recharge conditions due to mine inflow (see Appendix B, Table 2, estimated to range between 215-295 gpm).

HWB = Water requirement for hard water bodies other than Hoffman Creek/Springs and Creek 19-14 (255 gpm).

The amount of water discharged to the SAS is assumed to be the amount of water treated by the WWTS (710 gpm inflow under PWC low recharge conditions, minus about 100 gpm which is used in the mine mill process, or approximately 600 gpm) minus water used for soft water body mitigation (230 gpm), or about 370 gpm under PWC low recharge conditions. Given the above, the change in flow on Swamp Creek at STH 55 during mitigation of Levels I, II and III water bodies is estimated to range between a net loss of 100 gpm (0.22 cfs) and a net loss of 180 gpm (0.40 cfs). This is a 5 percent impact on the low flow condition during mitigation, and is considered a minimal impact.

Table 7-1

**Estimate of Mitigation Water Needs
PWC Level I, II, and III Water Bodies**

<u>Water Body</u>	<u>Mitigation Level</u>	<u>Mitigation Rate^{1,2}</u>
<u>Hard Water Bodies</u>		
Creek 19-14	I	15
Hoffman Springs/Creek	II	30
Creek 12-9	III	115
Upper Pickerel Creek	III	100
Creek 33-8	III	35
Lake 35-7	III	~5
Total Hard Water from Well North of Swamp Creek		300
Creek 11-4/Martin Springs	III	20
Total Hard Water from Well West of Creek 11-4		20
<u>Soft Water Bodies</u>		
Skunk Lake	I	50
Little Sand Lake	II	135
Duck Lake	II	10
Deep Hole Lake	III	35
Total Soft Water from Wastewater Treatment		230

¹Derived from PWC model runs 50C/50N in HSI GeoTrans (1998).

²All volumes rounded to the nearest 5 gpm.

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8 Level IV PWC Water Bodies Mitigation Plan

Level IV water bodies will be monitored for potential upgrade to Level III according to the implementation chart presented in Section 9. In the event that a Level IV water body is upgraded to Level III, a conceptual mitigation design for the water body will be prepared and submitted to WDNR. A generic outline for the development of a detailed mitigation plan for a Level IV water body that has been elevated to Level III or higher is discussed below.

The first step in the development of the detailed mitigation plan would be the determination of the flow rate required for mitigation purposes. This value would be derived from the regional groundwater flow model as updated using data current at the time the plan is developed. The applicable PRF and/or PRS would need to be established if not already done so by WDNR during the permitting work.

An assessment to determine the mitigation water source would then be accomplished using the same procedures discussed above for Level I, II, or III water bodies. Potential sources would be treated mine water or water from groundwater wells. Treatment needs would then be assessed and the treatment system selected. WPDES permitting requirements, if any, would also be identified and permit conditions addressed by the design. The water pumping and conveyance system would then be designed using similar concepts as discussed in Section 6.

Finally, the monitoring plan for the water body(ies) in question would be reviewed and updated as needed to provide the data required to assess the effectiveness of the mitigation program.

9 Mitigation System Operation

The MPA (Foth & Van Dyke, 1995/1998b) describes in detail the mitigation plan environmental monitoring program and identifies critical monitoring elements (i.e., groundwater monitoring wells, stream flow gaging stations, etc.) that relate to the implementation of the mitigation plan. The monitoring plan includes collection of flow data from area creeks, water elevation data from area lakes, groundwater level data at key wells (sentinel wells) located between the mine and area water bodies, and precipitation data. Data collected from sentinel wells will be used to measure drawdown near lakes and within the groundwater basins of area creeks. The drawdown data will then be used to assess if a hydraulic connection has been made between the lakes or the groundwater basins of the area creeks and the mine induced area of groundwater drawdown. This information will then be used in conjunction with other data (i.e., the updated groundwater flow model) to assess the appropriateness of upgrading area water bodies to higher planning levels.

Mitigation of Level I water bodies, the upgrade of Level II, Level III, and Level IV water bodies to higher mitigation levels, or the downgrading of a surface water body to a lower mitigation level, will involve a combination of evaluating flow and stage monitoring data, precipitation data, and updated model predictions. This section of the report discusses monitoring for the surface water bodies in the four mitigation levels, the decision process for initiating mitigation and reclassifying streams and lakes to a higher mitigation level, and the operation and maintenance plan for the mitigation system infrastructure.

9.1 Surface Water and Groundwater Monitoring

The monitoring program in the Crandon Project MPA (Foth & Van Dyke, 1995/1998b), describes the monitoring program that will be used to assess the mitigation program. NMC has designed the monitoring program for the project to encompass the collection of data needed to assess the effectiveness of mitigation that may be occurring and to verify impact predictions to determine if upgrading of surface water bodies to higher mitigation levels is needed. Many components of NMC's planned program (e.g., regional groundwater and surface water level monitoring, surface water flow and quality monitoring, meteorological data collection, etc.) will provide the body of data needed to assess mitigation needs.

9.2 Mitigation Implementation

The decision process that will be followed for the initiation/cessation of mitigation on Level I water bodies and the reclassification of Level II, III, and IV water bodies is dependent on the type of surface water being considered. Creek mitigation will follow the mitigation process shown in Figure 9-1. Lakes will be mitigated and upgraded, if needed, in accordance with the implementation flow chart shown in Figure 9-2.

For creeks, the criteria for initiation of mitigation of Level I water bodies will be based on drawdown data at key monitoring wells within the groundwater basins of the creeks and the PRF.

If Upper Pickerel Creek or Creek 12-9 were upgraded to a Level I creek, ice conditions on Rolling Stone Lake would also trigger mitigation to maintain natural D.O. levels in the lake during the winter months.

Upgrading of Level II creeks to Level I would be based on drawdown at key sentinel wells within the creeks groundwater basin, mine inflow, drawdown and stream flow data, and/or revised model predictions indicating that a substantial impact is likely. If there is evidence based on the above that a Level II creek could affect D.O. conditions in Rolling Stone Lake, the creek will be upgraded to Level I water body even if the monitoring and revised modeling data indicates that a substantial impact to flow is unlikely.

Level III creeks would be upgraded to a Level II water body if hydraulic connection is made between mine induced drawdown and the groundwater basin of the creek, and monitoring and/or modeling data indicates that the impact ranking is likely to increase to moderate or greater. In the case of Upper Pickerel Creek or Creek 12-9, the creek would immediately be upgraded to Level I in the event that monitoring or modeling data indicates that the flow impact is likely to increase from minimal to moderate.

Level IV creeks will be upgraded to Level III if monitoring and revised model predictions indicate that impacts are likely to exceed original predictions. The implementation process also allows for other creeks to be considered for mitigation if measured impacts or future predictions of impacts are greater than current forecasts.

The key criteria for initiating mitigation of Level I lakes are drawdown in the aquifer at a key well or wells (sentinel wells) between the lake and mine and the PRS. For Level II lakes, the key criteria in upgrading the lake to a Level I water body are drawdown in the aquifer at key wells between the lake and the mine, whether the lake is a groundwater fed lake or head dependent seepage lake, precipitation trends, mine inflow, drawdown, lake stage trends, and/or revised model predictions. Before a Level II lake will be considered for upgrading to a Level I water body, hydraulic connection (i.e., drawdown) must be measured at the sentinel well between the lake and the mine. Once hydraulic connection is established at the sentinel well, the lake will be upgraded to a Level I water body if it is groundwater fed. If the lake is not groundwater fed, it will be upgraded to a Level I water body if precipitation data indicates an impending drought.

The key criteria in upgrading Level III lakes are whether or not the lake is groundwater fed, drawdown in the aquifer for head dependent seepage lakes (i.e., Deep Hole Lake), mine inflow data, lake stage data, and/or revised model predictions. For Level III lakes, groundwater fed lakes (i.e., Lake 35-7) will be upgraded to Level II if mine inflow, drawdown trends, and/or revised model predictions indicate that impacts are likely to exceed PWC predictions. Level III water bodies that are surface water fed (i.e., Deep Hole Lake) will be upgraded to a Level II water body if hydraulic connection is made at the sentinel well and monitoring data and/or revised model predictions indicate that impacts are likely to exceed PWC predictions. Upgrading of Level IV lakes and the addition of other lakes to the list of Level IV water bodies will be based on mine inflow data, environmental monitoring data, and revised model predictions.

Factored into the mitigation implementation process is a provision to augment the environmental monitoring plan as necessary in the event that Level III and IV water bodies are upgraded and if other water bodies are added to the list of Level IV water bodies. Note that NMC is proposing to recalibrate and revise model predictions on an annual basis for the first few years of mining to aid in the mitigation process. After 5 years, the model will have been sufficiently verified against field measured conditions so that an annual reassessment with the model would no longer be necessary. NMC is proposing to revise the model every 5 years after the fifth year of operation.

In evaluating the mitigation implementation process, there are some key criteria worth noting. With respect to lakes, the implementation process considers whether or not the lake is groundwater fed and whether or not there is an impending drought. The groundwater fed lake criteria applies primarily to far field lakes such as Mole Lake, Lake 34-1, Ground Hemlock, etc. All groundwater fed lakes are Level IV lakes (with the exception of Lake 35-7, a Level III lake) and would need to be upgraded to a Level III water body based on monitoring and revised model predictions before the groundwater fed criteria applies. Once upgraded to Level III, groundwater fed lakes will be upgraded to Level II in the event that monitoring and/or revised predictions indicate that impacts are likely to be greater than PWC conditions. This provision is included for groundwater fed lakes since they are likely to be more susceptible to drawdown than head dependent seepage lakes such as Little Sand Lake, Walsh Lake, etc. As previously stated, once upgraded to Level II, groundwater fed lakes will be upgraded to Level I when hydraulic connection with the lake is observed in the sentinel well for the lake. The sentinel well will be located at a sufficient distance away from the lake to allow time for the system to be installed before the drawdown propagates out to the lake.

The precipitation criteria included in the implementation plan for the lakes applies primarily to the head dependent seepage lakes in Level II. PWC predictions in HSI GeoTrans (1998) indicate that these lakes are likely to be impacted only under drought conditions. By including precipitation in the decision matrix, mitigation systems for drought sensitive lakes can be installed and be ready for mitigation in advance of the impact. This provision applies primarily to Little Sand and Duck Lake and will include Deep Hole Lake or other head dependent seepage lakes, in the event it or they are upgraded to a Level II water body.

9.3 Wastewater Treatment Facility Operation and Maintenance

Section 7 of the project's PER (Foth & Van Dyke, 1995/1998c) addresses operation and maintenance for the Crandon Project WWTS. During periods of mitigation, the pumping and conveyance system will be checked on a weekly basis to verify that the system is performing as designed and to verify, and if necessary, adjust mitigation flow rates.

10 Mitigation System Impacts

Installation of the mitigation system described above will result in additional surficial disturbance due to construction activities and will also affect changes in the predicted drawdown effects. Section 10.1 below discusses the environmental impacts from installation of the system with respect to the effect of the added surficial disturbance on local biological communities and on the predicted drawdown. Section 10.2 discusses impacts associated with the addition of the mitigation water to surface water bodies.

10.1 Construction and Reclamation

The planned construction of the Level I mitigation pipelines is described in Section 6.1.3.4. The construction of these pipelines for the mitigation system will result in approximately 3.1 acres of temporary surface disturbance. After the pipelines are installed, the impacted area will be backfilled, graded, and stabilized. A breakdown of the estimated disturbance as a result of the pipeline construction is presented in Table 4.2.9-1 of the project's EIR (Foth & Van Dyke, 1995/1998a). The majority of the pipeline will be constructed down the center of on-site access roads and within the right-of-way of town roads adjacent to the site. There will be approximately 2.9 acres of impact to stands of northern hardwoods where access roads do not currently exist. All of the impacted northern hardwoods will be reclaimed. Impacts to wetlands as a result of trenching activities have been avoided, where possible. Large wetland complexes that need to be crossed by the pipeline will be completed by horizontal drilling under the wetlands. There will, however, be approximately 0.1 acres of impact to wetlands where it is not feasible to use the horizontal drilling method. There will be no access roads constructed within wetland areas. All stream crossings will be completed by horizontal drilling. Therefore, no impact to named streams is anticipated as a result of the proposed action.

The overall impacts to the landscape as a result of the pipeline will be reduced by using a chain trencher. This method will reduce the amount of linear impact by cutting the trench, laying the pipe, and backfilling the trench in one process. This will reduce the impact corridor by eliminating the need to place the excavated material along the side of the trench and then placing it back into the trench after the pipeline is set. This method reduces the necessary width of the corridor from approximately 30 feet to 15 to 18 feet.

10.1.1 Reclamation and Erosion Control

A detailed description of erosion control techniques and reclamation procedures designed for the life of the Crandon Project are described in Sections 4 and 5 of the project's MPA (Foth & Van Dyke, 1995/1998b). These techniques will be used as a guide when reclaiming the mitigation pipeline corridors. However, because of the relatively minor impact as a result of the pipeline construction, it is anticipated that the required reclamation activities will be minimal. The impacted areas will need to be stabilized to control erosion during construction and after construction is complete. It is anticipated that after construction, the corridors will begin to revert back to their original state and native vegetation will colonize the disturbance area. The

following discussion presents a general overview of the stabilization techniques that will be implemented to reduce erosion until the natural reclamation begins.

During construction of the mitigation pipeline, exposed areas with potential for runoff of sediments will be controlled with straw bale sediment traps and/or silt fencing. The use of sediment control devices will need to be determined on a case by case basis depending on field conditions (i.e., weather conditions, site topography, etc.). Seeding and reestablishment of vegetation will immediately follow the trenching and backfilling operation.

The seeding of exposed soil will be necessary to reduce erosion until the native vegetation has recolonized the disturbed area. The upland areas disturbed during construction will be reseeded using the species presented in Table 10-1 as a guide. The species may vary based on field conditions.

The disturbed wetland areas will be reseeded using the species presented in Table 10-2. This seed mix was adapted from data presented in Section 5 of the MPA (Foth & Van Dyke, 1995/1998b). The species selection and application rates may need to be altered depending on field conditions and the type of wetland being impacted.

Table 10-1
Species for Use in Soil Stabilization

Species	Purity Min. Percent	Germination Min. Percent	Mixture Portions Percent (No. 30)
Kentucky Bluegrass	85	80	10
Creeping Red Fescue	97	85	30
Improved Turf Type Tall Fescue	98	85	25
Fults Salt Grass	98	85	10
Improved Fine Perennial Ryegrass	96	85	15
Empire Birdsfoot Trefoil	95	80	10

Prepared by: BFW
Checked by: JBH1

Table 10-2

General Species Selection for Wetlands¹

Plant Species	
Seed mixes recommended for hydric soils	
Native North American Grassland Forbs	Suggested rate/acre ²
Swamp milkweed (<i>Asclepias incarnate</i>)	2.0 oz bulk
New England aster (<i>Aster novae-angliae</i>)	1.0 oz bulk
Joe-pye week (<i>Eupatorium maculatum</i>)	1.5 oz bulk
Boneset (<i>Eupatorium maculatum</i>)	1.5 oz bulk
Common ox-eye (<i>Heliopsis helianthoides</i>)	2.0 oz bulk
Tall blazing star (<i>Liatris pycnostachya</i>)	3.0 oz bulk
Black-eyed susan (<i>Rudbeckia hirta</i>)	5.0 oz bulk
Arrow-head (<i>Sagittarian latifolia</i>)	0.5 oz bulk
Blue vervain (<i>Verbena hastata</i>)	1.0 oz bulk
Culvers root (<i>Veronicastrum virginicum</i>)	0.5 oz bulk
Golden alexander (<i>Zizia aurea</i>)	2.0 oz bulk
Total	24.0 oz/acre

¹Adapted from data in Section 5 of the MPA (Foth & Van Dyke, 1995/1998b).

²Flower seed is broadcast only.

Prepared by: BDH
Checked by: SVD1

10.2 Surface Water Impacts Resulting from Mitigation

The mitigation plan described in this report has been developed and designed to prevent the unreasonable detriment of public rights in waters of the State. Sections 10.2.1 and 10.2.2 discuss the effect of the proposed mitigation system on stream flows and lake levels for those water bodies that, under PWC conditions, may require mitigation and are categorized as Level I or Level II water bodies.

10.2.1 Effects of Mitigation on Stream Flow

Under PWC conditions, Creek 19-14 and Hoffman Springs/Creek are categorized as Level I and Level II hard water body streams. These water bodies are gaining streams. Mine dewatering will reduce the amount of groundwater discharging to these water bodies. By virtue of the fact that these water bodies are groundwater fed, flow is not lost to the aquifer. Since the mitigation system will add the water directly to the stream/spring, the flow in the creek will be increased, by the amount of water added, at all points downstream of the mitigation discharge points. Note that the mitigation discharge points for these two water bodies are at the headwaters. As such the flow in the creeks will be mitigated along the entire reach of the creek/spring.

Similar logic applies to the Level III and Level IV creeks. The Level III creeks are all groundwater fed and mitigation, if needed, will take place near the headwaters of the creek, thereby effectively mitigating the flow reduction at all points downstream of the creek. Level IV creeks are also groundwater fed. If mitigation of Level IV creeks were necessary, a suitable mitigation location will have to be considered as part of the conceptual design phase.

10.2.2 Effects of Mitigation on Lake Levels

Under PWC conditions, Skunk Lake, Little Sand Lake, and Duck Lake are categorized as Level I and Level II water bodies. To assess the effectiveness of the mitigation plan, the regional groundwater model (HSI GeoTrans, 1998) was used to evaluate the lake stage in response to the addition of mitigation water to the lake. Appendix F provides a technical memorandum summarizing the results from the simulation. The results of the mitigation simulation show that the head dependent seepage lakes can be effectively mitigated by adding water back into the lake. Level IV lakes are predominantly groundwater fed lakes which, like the gaining streams described above, would be effectively mitigated by a direct addition of water.

10.2.3 Mitigation Impacts on Biological Communities

The groundwater drawdown associated with mining activities, without the use of mitigation water, has the potential to reduce the flow in streams and to reduce normal lake stages. This may impact the biological communities that are dependent upon the various surface waters for survival and propagation. NMC has developed a mitigation program to prevent a significant

reduction in stream flow and lake stage, thus providing protection to the biological communities dependent upon these resources.

Naturally occurring low flow stream conditions or low water level lake conditions provide a stress point to the organisms that use surface waters. Some organisms, such as fish, rely on surface waters on a continuous basis. Others, such as invertebrates, are only associated with the surface water for a segment of their life cycle. In either case, protection is needed for these organisms to maintain their status in the overall ecosystem of the region. The intent of the mitigation program is to prevent the exacerbation of the naturally occurring low stream flow and low lake level stress periods. By providing mitigation water at times when the stream flow or lake elevation drops below the public rights flow or public rights stage, as presented in Sections 10.2.1 and 10.2.2, the naturally occurring stress point will be allowed to follow a normal cycle.

The characteristics of the mitigation water will also be controlled to prevent significant impacts from occurring. Hard water bodies, such as Creek 19-14, Hoffman Springs/Creek may see a reduction in the groundwater flow which naturally feeds these systems. The intent of the mitigation program is to provide groundwater from a source that is near these sites, yet outside of the area projected to be impacted by the mining activity. By using groundwater for mitigation, the chemical characteristics and the temperature will remain relatively consistent with the naturally occurring system.

Soft water bodies such as Skunk, Little Sand, and Duck Lakes rely on precipitation for their water source. The groundwater drawdown may result in a greater exfiltration rate through the bottom of these surface waters. To compensate for this loss, mitigation water of similar soft water characteristics to the water in the soft water lakes will be supplied when the water levels in these lakes drop below the public rights stage. As noted in Section 10.2.2, the mitigation water will be added to compensate for the increased exfiltration rates. This will allow the lakes to fluctuate under normal cycles. The water used for mitigation in soft water bodies will be provided by the project's wastewater treatment system. This system will use an evaporation process for polishing the already treated water prior to discharge to soft water bodies.

The use of treated water for mitigating soft water lakes will not impact the loading, or lack thereof, of silica to soft water lakes. Under current conditions, groundwater inflow is a small, if non-existent, component of the water budgets of these lakes. As such, any silica input to the lakes is primarily derived from surface runoff. Since surface runoff will not be significantly altered by mine operations (see EIR Section 4.2.6), the silica budget for the soft water lakes is not likely to be reduced. The silica budget is also not likely to be increased since condensate from the evaporator (i.e., distilled water) will be used for mitigation, and thus will not increase silica loading.

The chemical characteristics and temperature of the mitigation water will be regulated by a WPDES discharge permit. The limitations placed in this permit will be set, as a minimum, to

protect the most sensitive organisms associated with these surface waters. The regulations address the following areas:

- Acute toxicity criteria for fish and aquatic life
- Chronic toxicity criteria for fish and aquatic life
- Wild and domestic animal criterion
- Human cancer criteria and human threshold criteria
- Bioaccumulation factors

Additional WDNR regulations address antidegradation of Outstanding Resource Waters (ORW) and Exceptional Resource Waters (ERW). These regulations require discharges to protect the existing surface water quality criteria to a level that results in no measurable change to these criteria.

The mitigation program will provide a level of protection needed to the biological communities that rely on the area's surface water resources. With the mitigation program in place, no unreasonable impacts are expected.

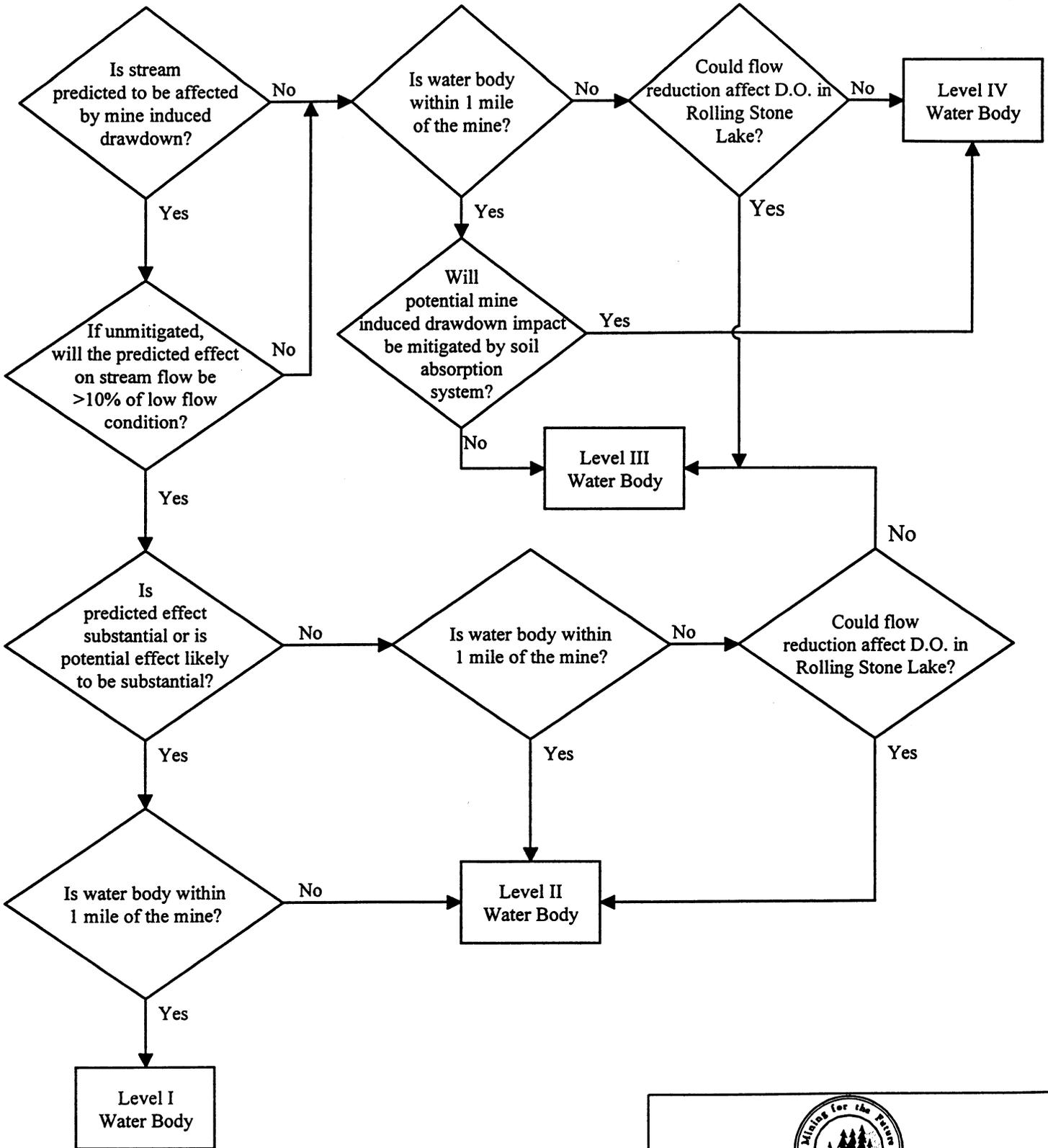
10.2.4 Modification of Mitigation Plan During Copper Mining

The mitigation plan presented above is based on maximum mine inflows that may occur during the zinc phase of mining. At year 16 of operations, zinc mining will end and copper mining in more competent, less permeable rock will begin. As a result, mine inflow will be substantially lower during the copper phase of mining. Consequently, the groundwater table will partially recover during the later years of mining. This will result in reduced mitigation rates and potentially lowering the mitigation level for various water bodies.

11 References

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FIGURES FOR SURFACE WATER MITIGATION PLAN



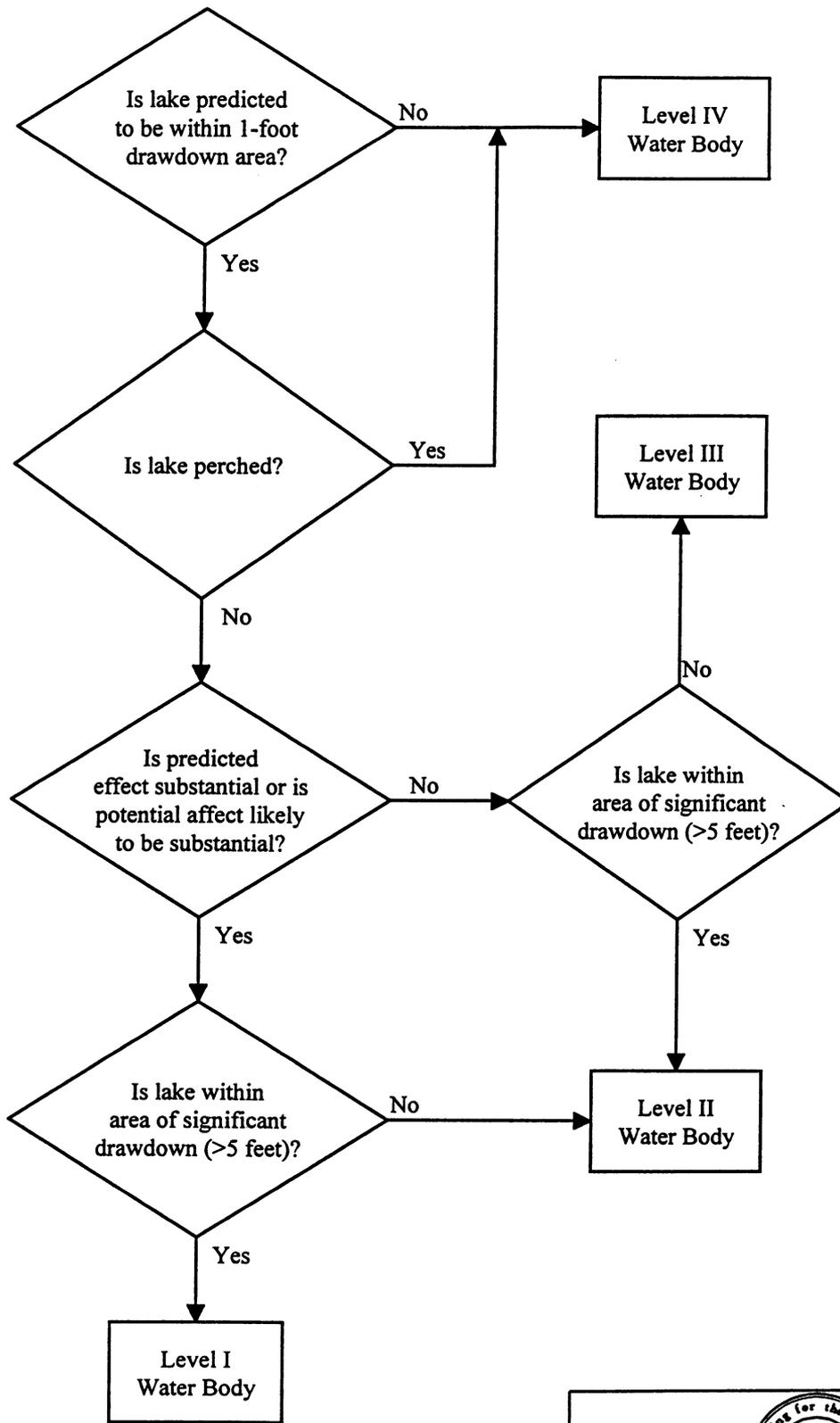
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FIGURE 3-1
SURFACE WATER MITIGATION
STREAM CATEGORIZATION FLOW CHART
FOR PERMITTING

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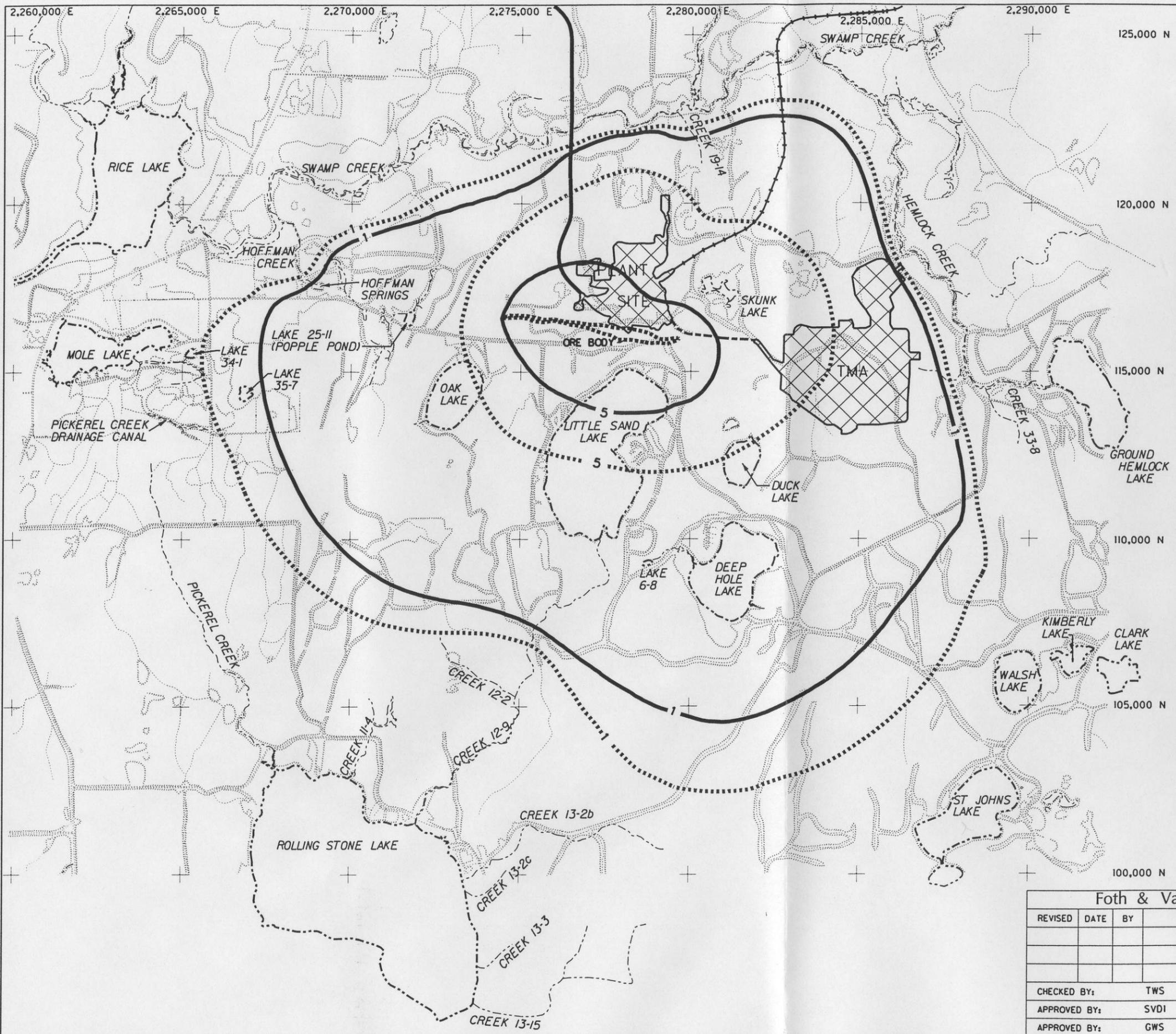
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FIGURE 3-2
SURFACE WATER MITIGATION
LAKE CATEGORIZATION FLOW CHART
FOR PERMITTING

Scale: NO SCALE Date: NOVEMBER, 1998
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LEGEND

- TREES/BRUSH
- UNPAVED ROAD/TRAIL
- PAVED ROAD
- CREEKS/RIVERS/LAKES
- ORE BODY
- PROPOSED ACCESS ROAD
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES
- PRACTICAL WORST CASE DRAWDOWN CONTOURS
- BEST ENGINEERING JUDGEMENT DRAWDOWN CONTOURS

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. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM.
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.

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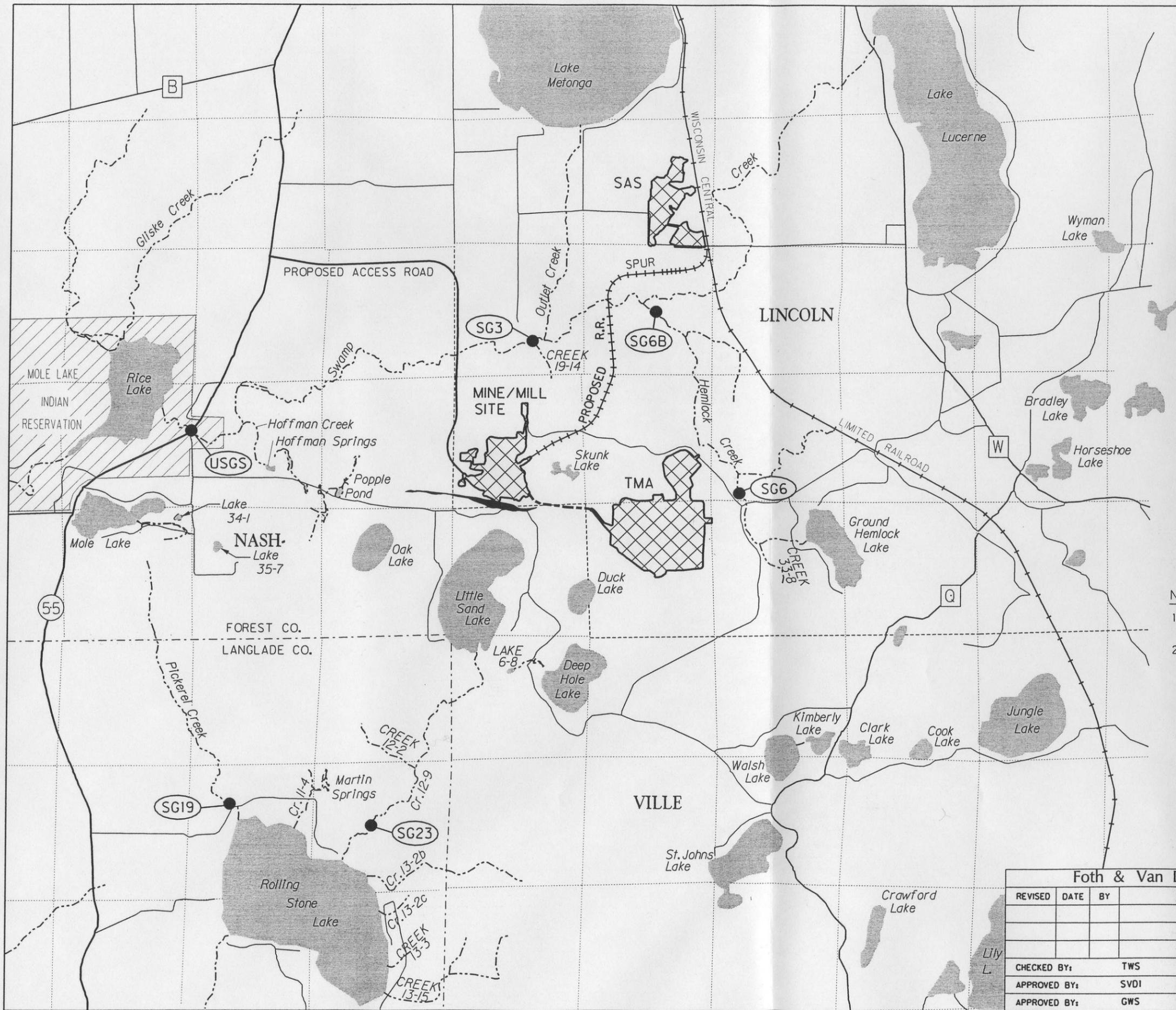


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FIGURE 3-3

BEJ AND PWC 1 FOOT AND 5 FOOT DRAWDOWN CONTOURS (RUNS 49C/49N AND 50C/50N)

Scale: Date: NOVEMBER, 1998
Prepared By: Foth & Van Dyke By: JOW 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
- LOCATION OF STREAM GAGE
- LOCATION OF USGS STREAM GAGE

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			
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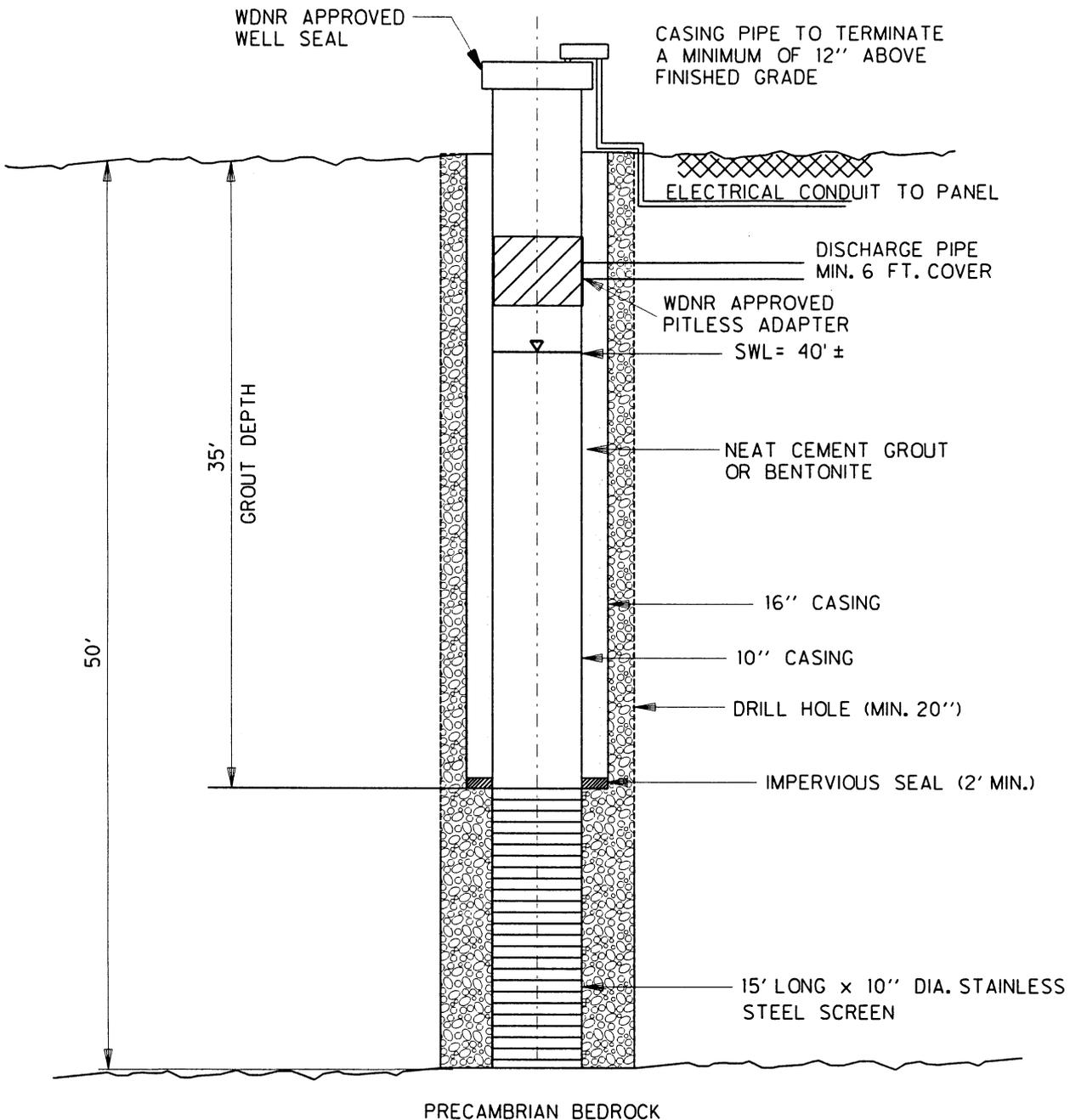
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FIGURE 4-1
SURFACE WATER GAGING STATIONS
IN THE ENVIRONMENTAL STUDY AREA
AT WHICH PRF DATA IS AVAILABLE

Scale: Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: KMB 93C049

MITIGATION WELL



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APPROVED BY:		SVDI	DATE: NOV'98
APPROVED BY:		GWS	DATE: NOV'98

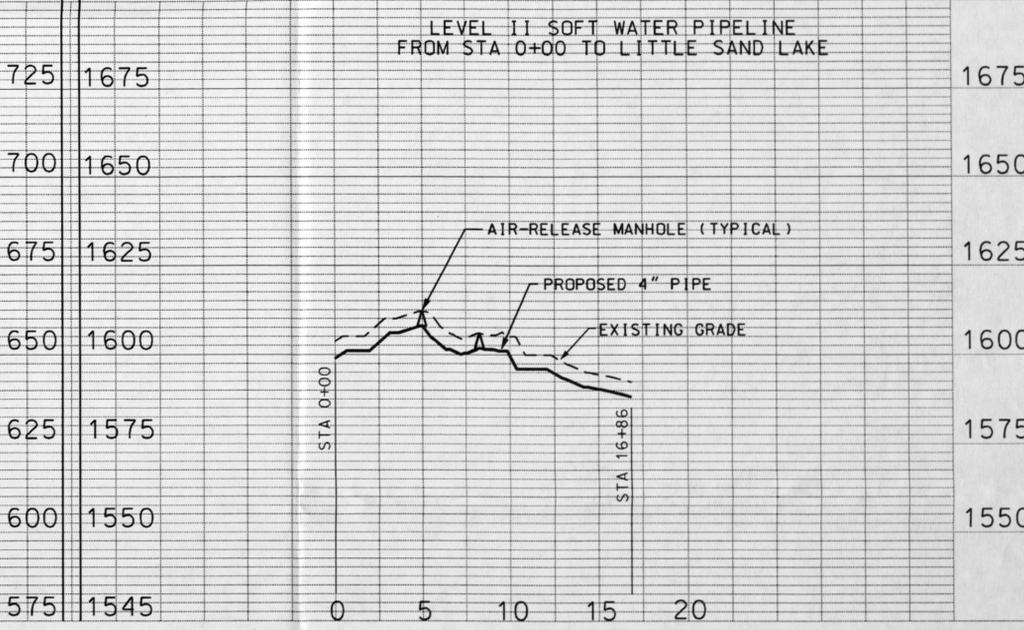
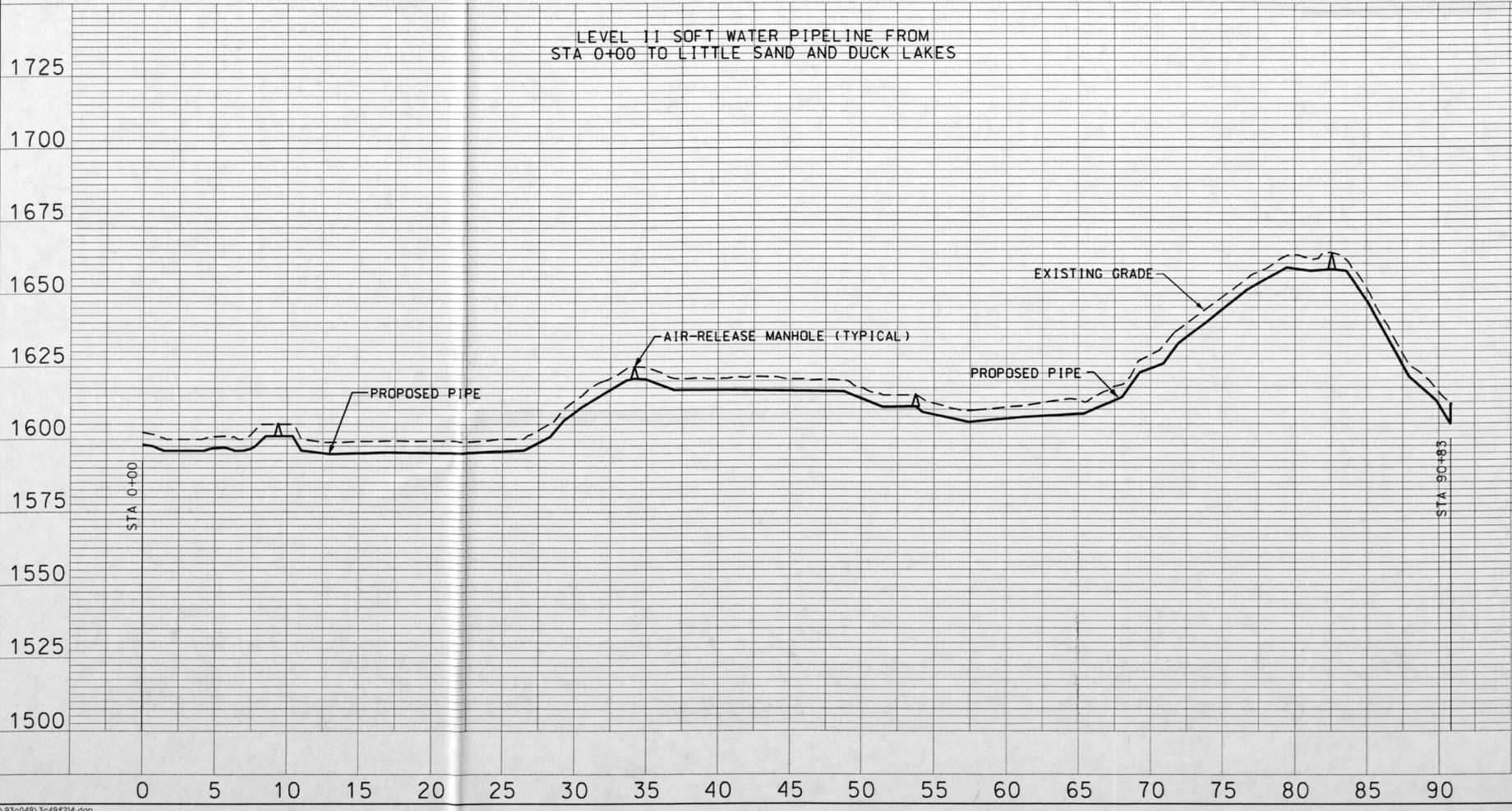
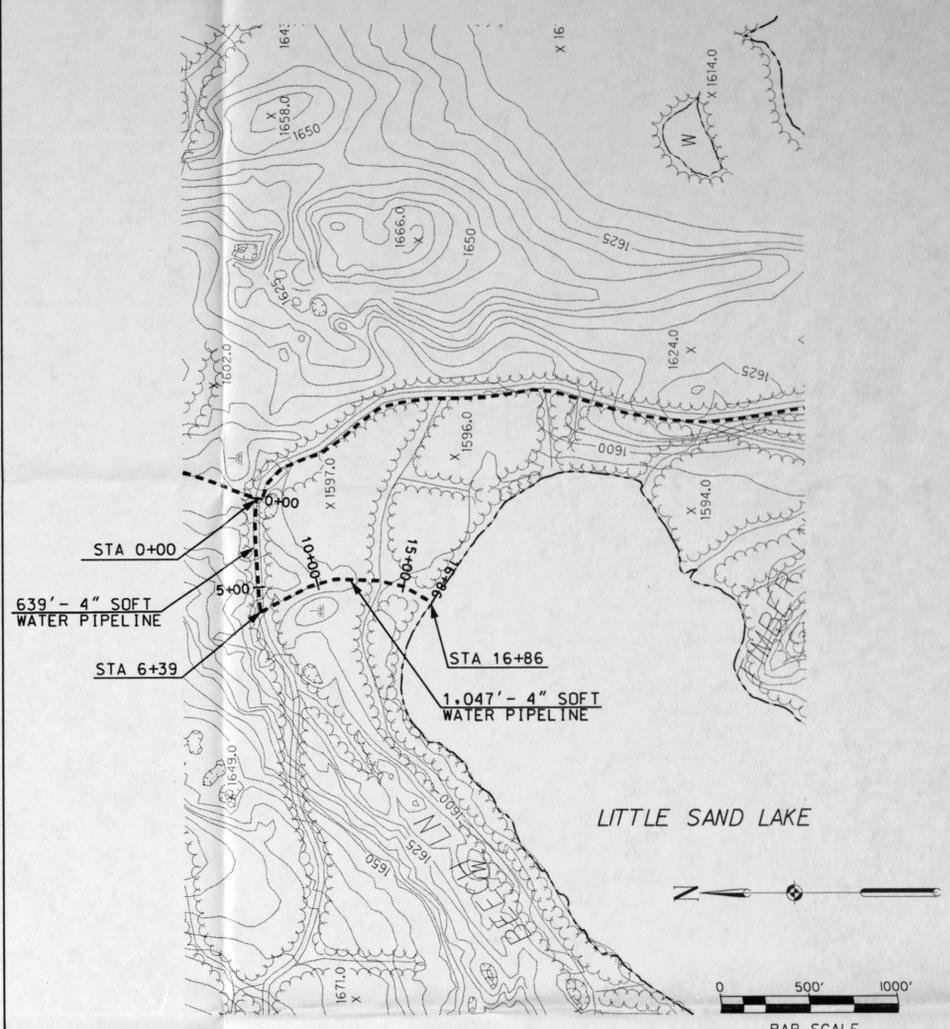
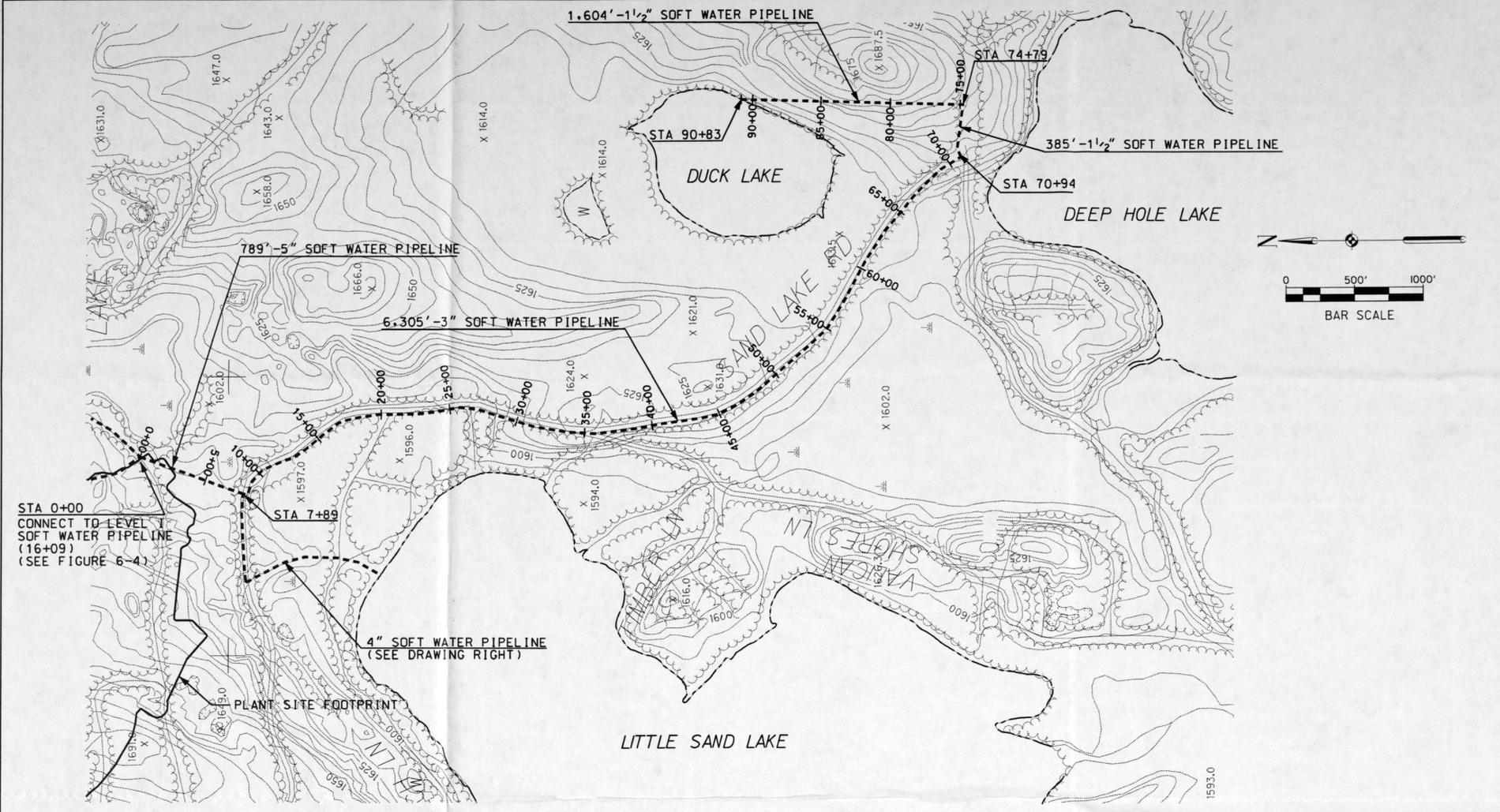


Nicolet Minerals

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FIGURE 6-2
MITIGATION WELL
CONSTRUCTION DETAIL

Scale: NOT TO SCALE	Date: NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: JRB2 93C049



TYPICAL REPRESENTATION; REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

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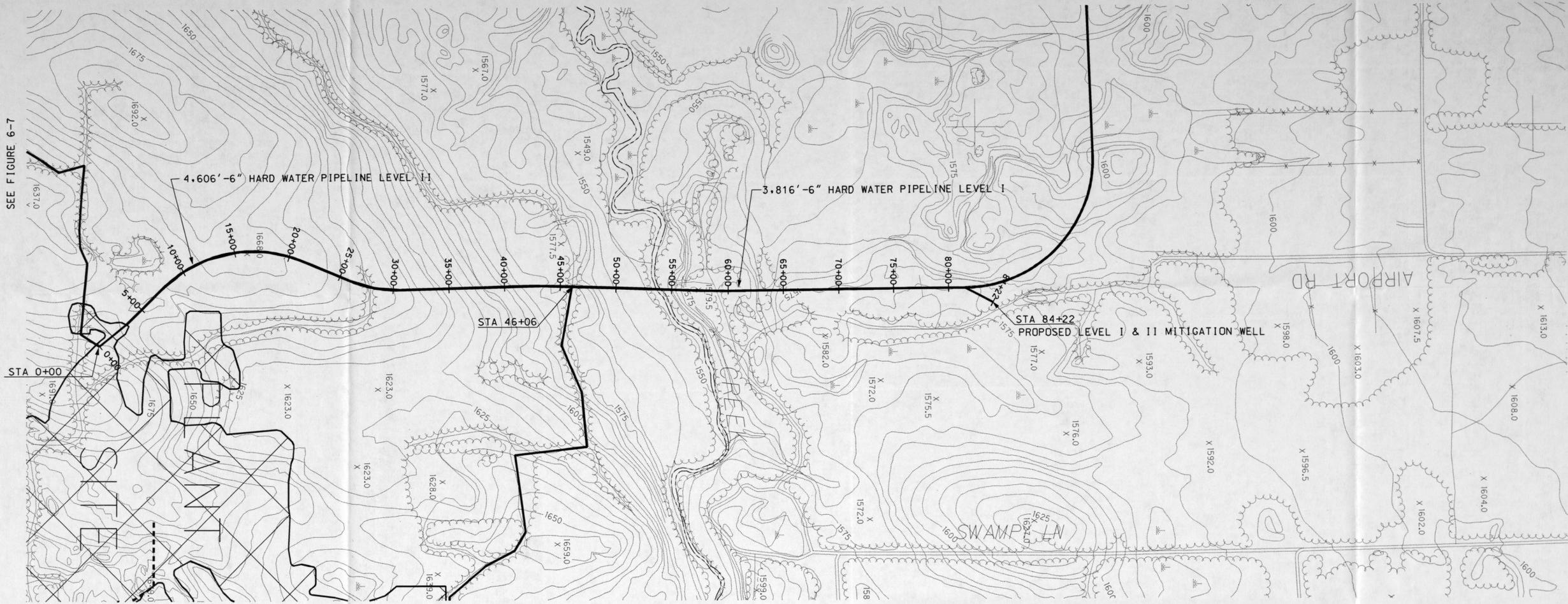


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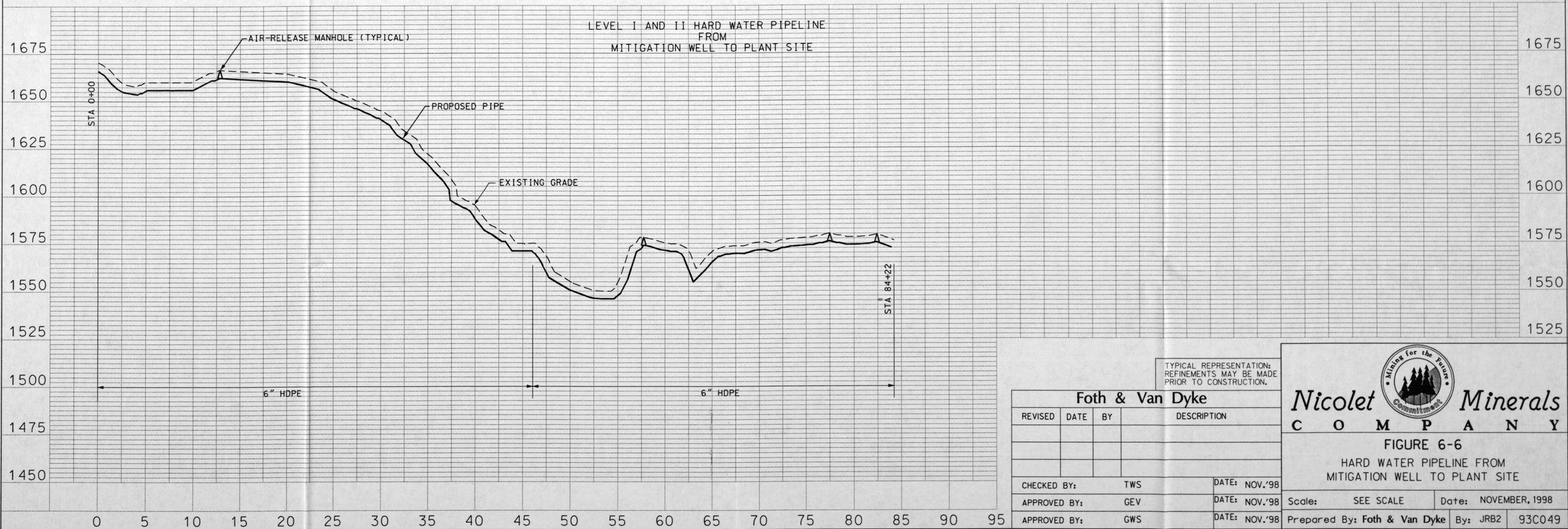
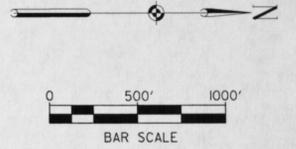
FIGURE 6-5
PIPELINES FROM STA 0+00 TO LITTLE SAND AND DUCK LAKES

Scale: SEE BAR SCALE	Date: NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: JRB2 93C049

SEE FIGURE 6-7



SEE FIGURE 6-4



TYPICAL REPRESENTATION:
REFINEMENTS MAY BE MADE
PRIOR TO CONSTRUCTION.

Foth & Van Dyke

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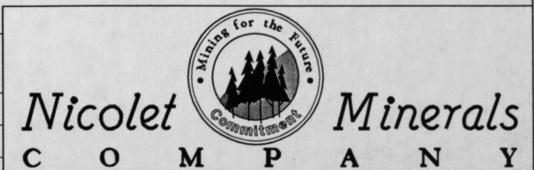
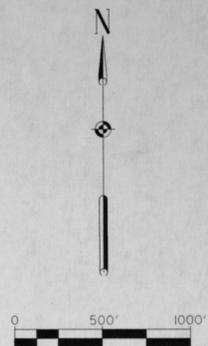
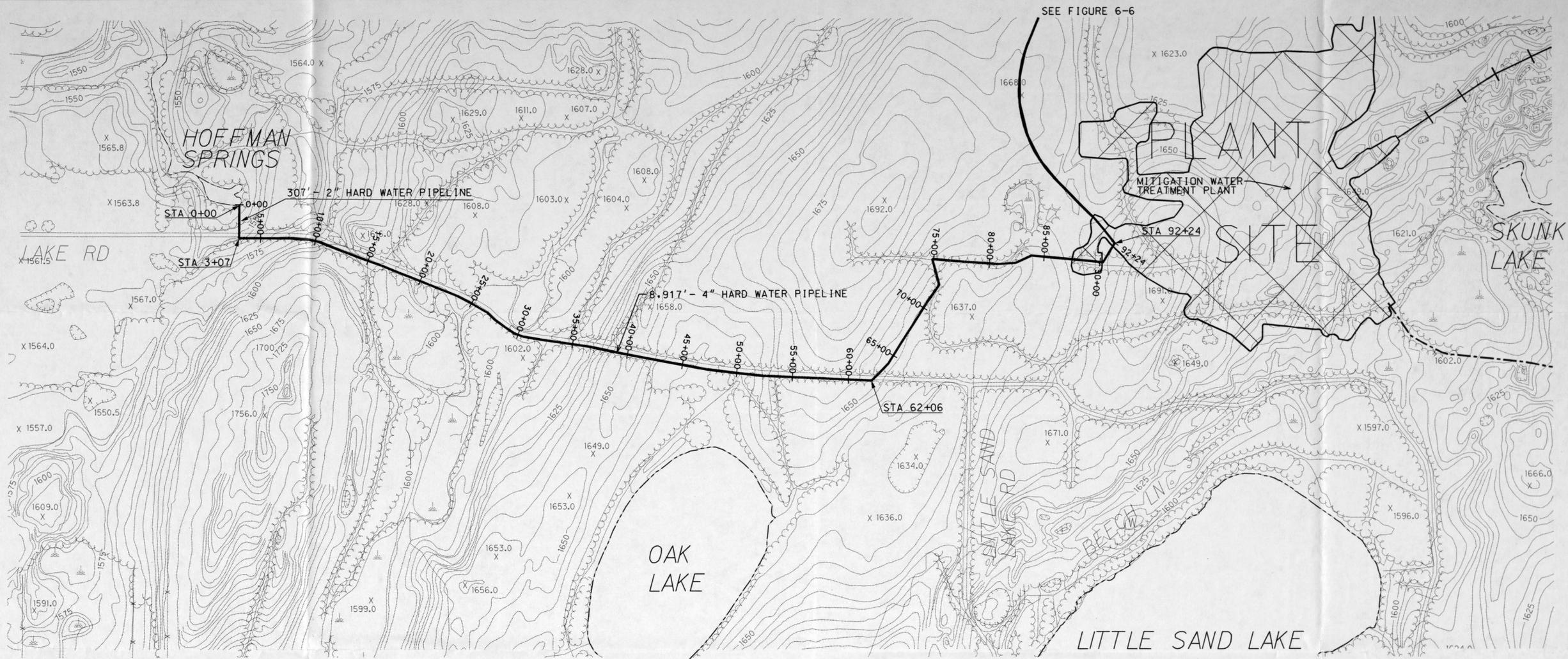


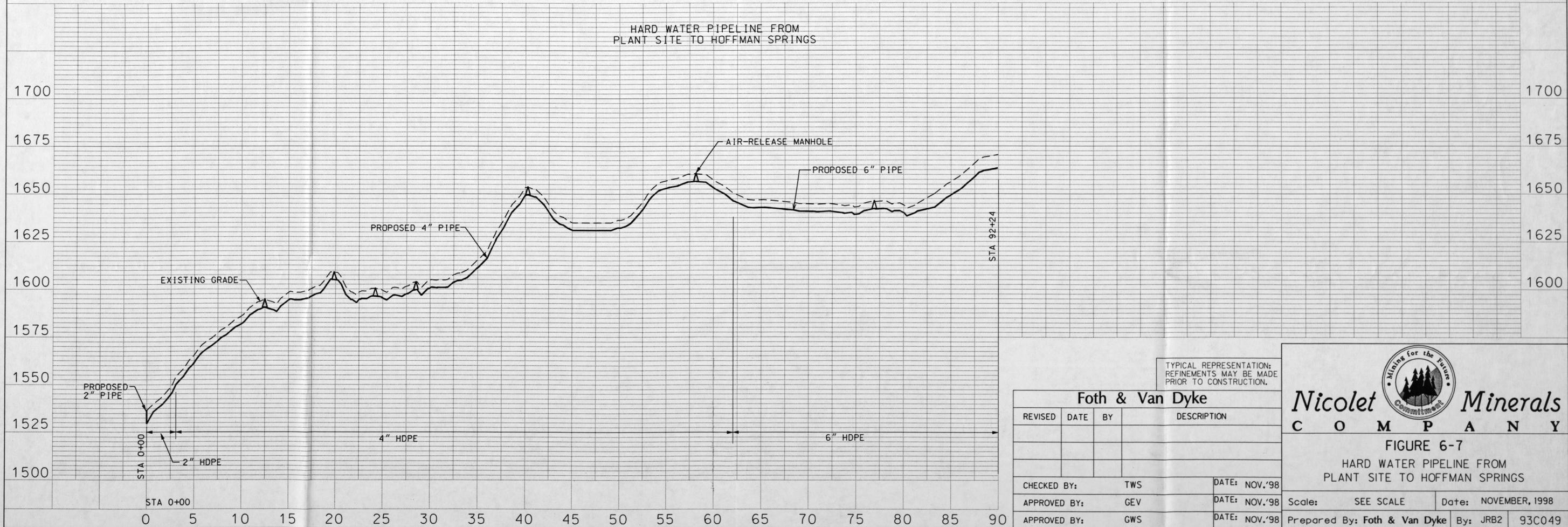
FIGURE 6-6
HARD WATER PIPELINE FROM
MITIGATION WELL TO PLANT SITE

Scale: SEE SCALE Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: JRB2 93C049



HARD WATER PIPELINE FROM PLANT SITE TO HOFFMAN SPRINGS



TYPICAL REPRESENTATION: REFINEMENTS MAY BE MADE PRIOR TO CONSTRUCTION.

Foth & Van Dyke

REVISED	DATE	BY	DESCRIPTION

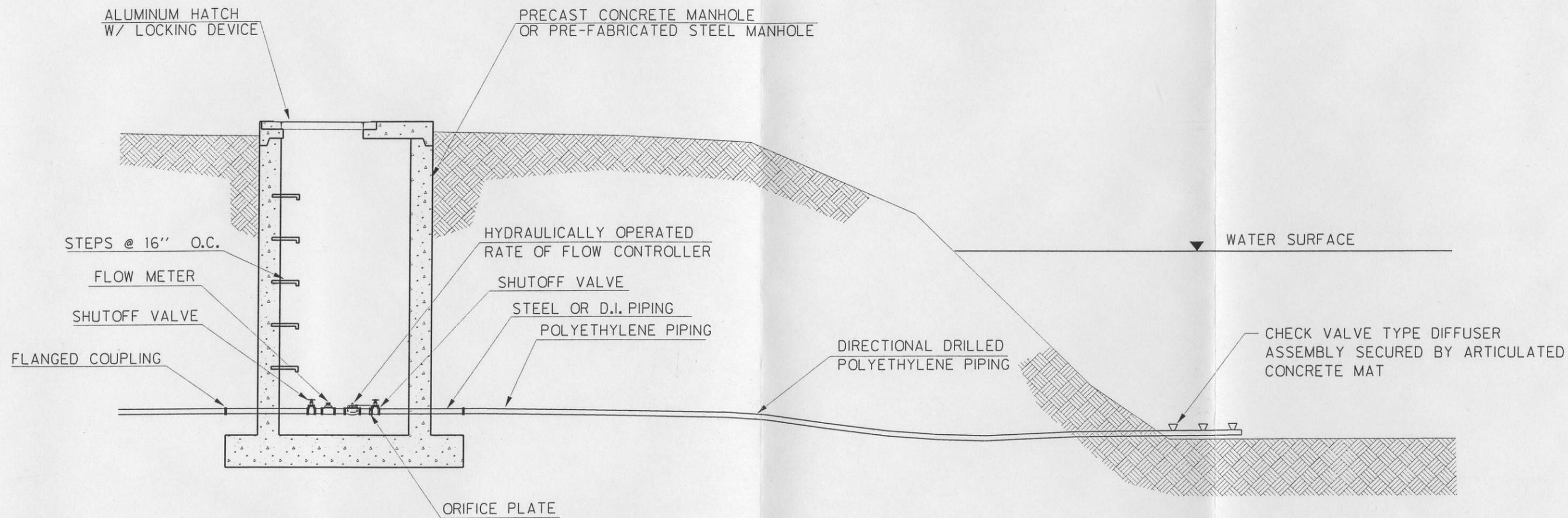
CHECKED BY:	TWS	DATE:	NOV.'98
APPROVED BY:	GEV	DATE:	NOV.'98
APPROVED BY:	GWS	DATE:	NOV.'98



Nicolet Minerals
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FIGURE 6-7
HARD WATER PIPELINE FROM PLANT SITE TO HOFFMAN SPRINGS

Scale: SEE SCALE Date: NOVEMBER, 1998
Prepared By: Foth & Van Dyke By: JRB2 93C049

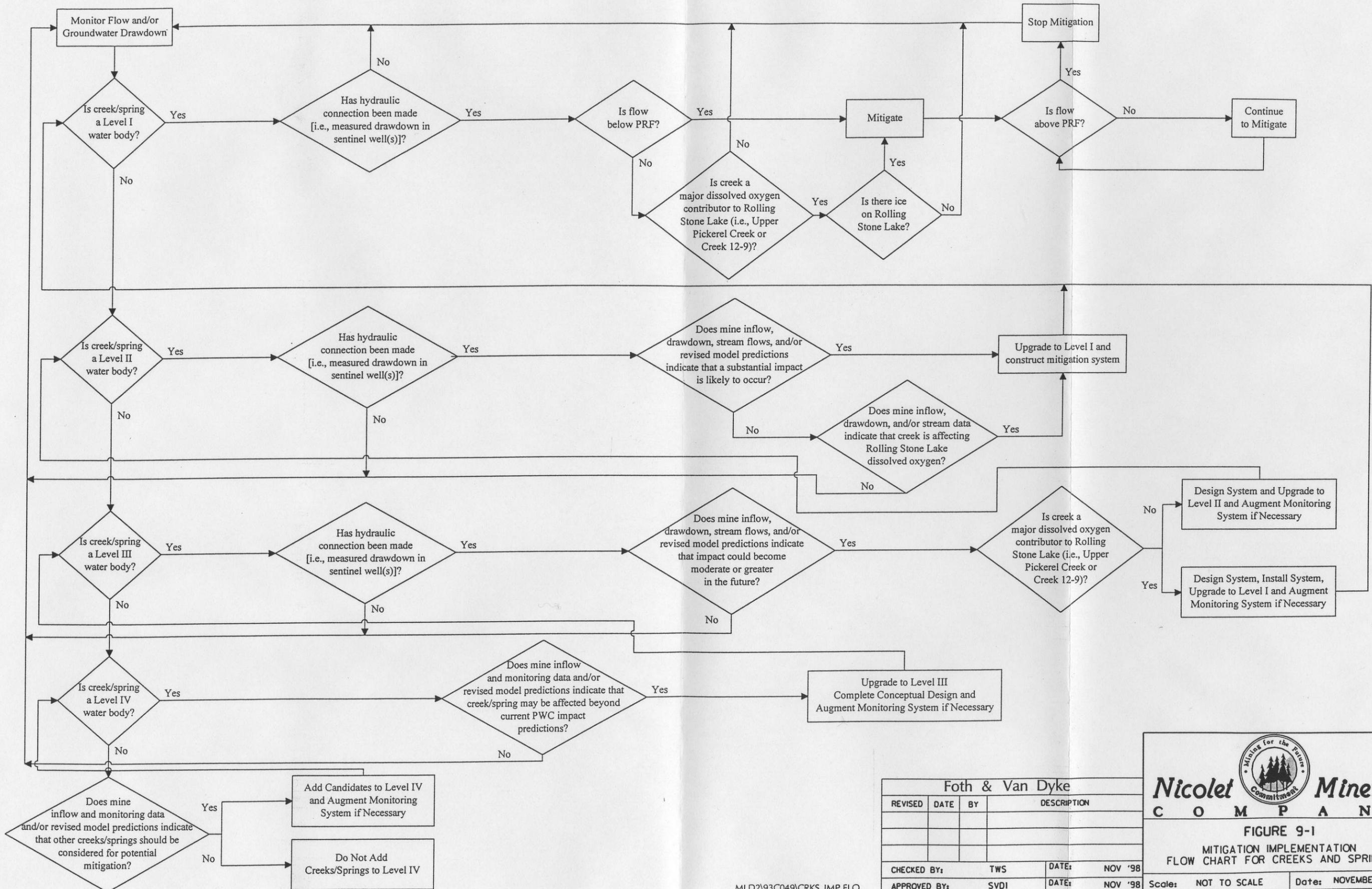


Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
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APPROVED BY:		GEV	DATE: NOV. '98
APPROVED BY:		GWS	DATE: NOV. '98


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 C O M P A N Y

FIGURE 6-8
 MITIGATION WATER DELIVERY SYSTEM

Scale: NOT TO SCALE	Date: NOVEMBER, 1998
Prepared By: Foth & Van Dyke	By: FMHI 93C049



MLD2\93C049\CRKS_IMP.FLO

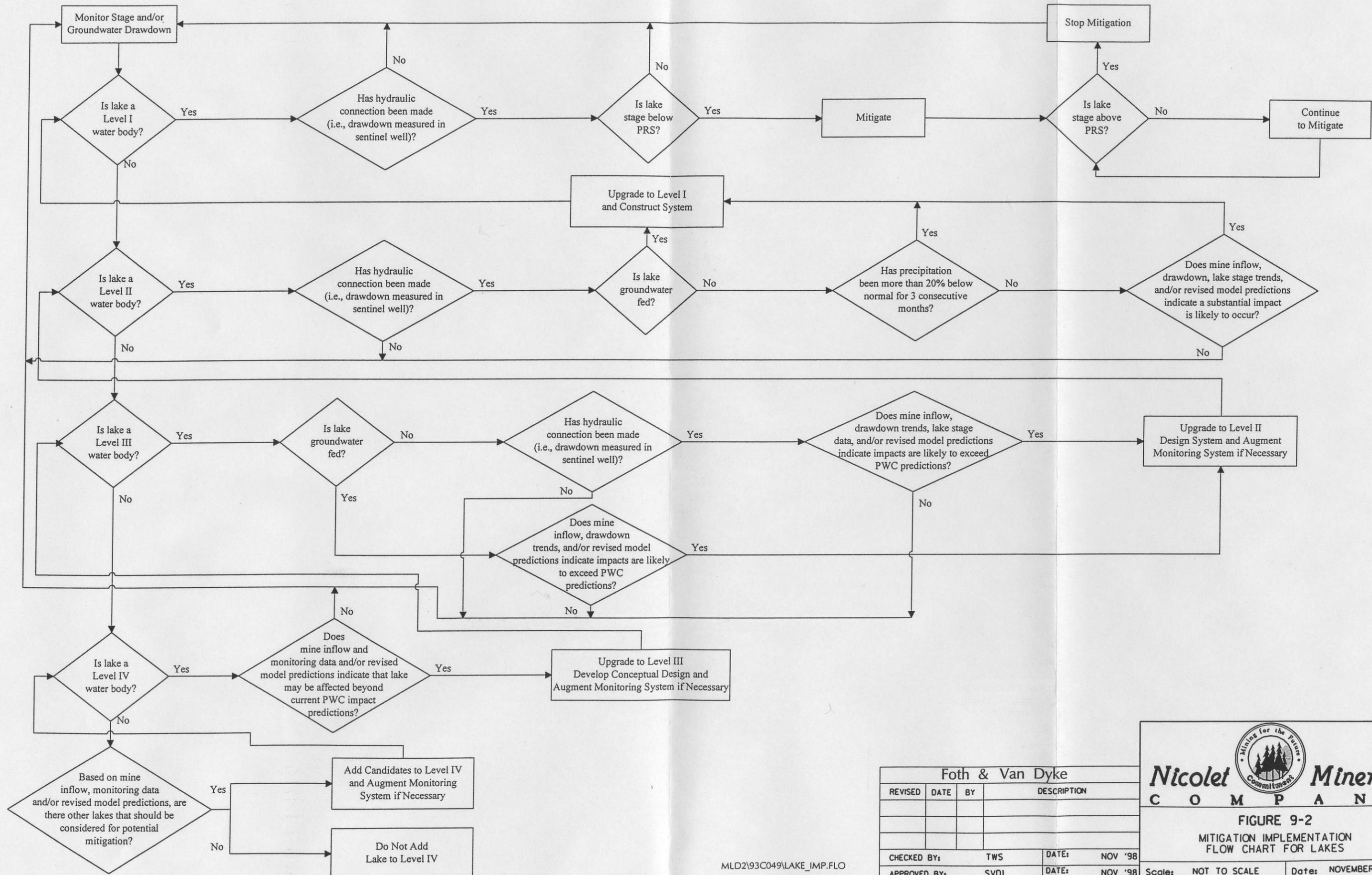
Foth & Van Dyke			
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APPROVED BY:	SVDI	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98

Nicolet Minerals
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FIGURE 9-1
MITIGATION IMPLEMENTATION
FLOW CHART FOR CREEKS AND SPRINGS

Scale: NOT TO SCALE Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: KMB 93C049



MLD2\93C049\LAKE_IMP.FLO

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	TWS	DATE:	NOV '98
APPROVED BY:	SVDI	DATE:	NOV '98
APPROVED BY:	GWS	DATE:	NOV '98



FIGURE 9-2
MITIGATION IMPLEMENTATION
FLOW CHART FOR LAKES

Scale: NOT TO SCALE Date: NOVEMBER, 1998
 Prepared By: Foth & Van Dyke By: KMB 93C049

Appendix A

**Wisconsin Department of Natural Resources
April 17, 1997, Conceptual Framework for Development
of the Crandon Mine Surface Water Mitigation Plan**



State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Tommy G. Thompson, Governor
George E. Meyer, Secretary

P.O. Box 7921
101 South Webster Street
Madison, Wisconsin 53707-7921
DNR TELEPHONE 608-266-2621
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April 17, 1997

Mr. Don Moe
Crandon Mining Company
7 North Brown Street, 3rd Floor
Rhineland, WI 54501

SUBJECT: Proposed Crandon Project Surface Water Mitigation Plan

Dear Mr. Moe:

The Department has prepared a draft conceptual framework for developing a surface water mitigation plan for the proposed Crandon Mine, which is attached. We would like to discuss this draft framework and any other issues surrounding surface water mitigation with you at a technical meeting on Tuesday, April 29th, at 10am in the Department's Northern Regional Office in Rhineland. We also expect to receive comments on the draft framework from other interested parties at this meeting. The Department intends to finalize this document following the meeting. The agenda for the April 29th meeting is detailed below.

AGENDA

- I. Introduction
- II. Definition and Goals of Surface Water Mitigation
- III. Draft Framework for Plan Development
- IV. Initial Ideas for Classification of Water Bodies
- V. Mitigation Techniques and Possible Concepts for Example Water Bodies
- VI. Other Issues

Please feel free to contact me at 608/267-0856 if you wish to discuss this further.

Sincerely,

Christopher P. Carlson, P.G., Hydrogeologist
Bureau of Waste Management

attachments

cc: Bill Tans - SS/6
Chuck Hammer - LS/5
Stan Druckenmiller - AD/5
Archie Wilson/Ken Markart - NR-Rhineland
Dennis Mack/Paul Huebner - WA/3
Larry Lynch - WA/3
Paul Luebke - WT/2
Dave Johnson - DG/2
Dave Webb - WT/2
Dave Siebert - SS/6
Chuck Fitzgerald - NR-Rhineland
Bill Jaeger - NR-Rhineland
Bob Young - NR-Rhineland
Dale Lang - NR-Rhineland
Steve AveLallement - NR-Woodruff
Jack Smith - NR-Woodruff
Edwina Kavanaugh - Public Intervenor - LS/5
Ken Bradbury - WGNHS
Jim Krohelski/Randy Hunt/Chuck Dunning - USGS-Madison
Jerry Sevick - Foth & VanDyke
Dave Ballman - US Army COE
Mark Myers - US Army COE
Dan Cozza - US EPA Region V
Margaret Thielke - US EPA Region V
Robert Jaeger - BIA
Janet Smith - USFWS
John Coleman - UW-Madison (GLIFWC)
Mark Nelson/Benjamin Gresser - Horsley & Witten
Doug Cherkauer - UW-Milwaukee
Arlyn Ackley - Mole Lake Sokaogon Chippewa
Apesanahkwat - Menominee Nation
Phil Shopodock - Forest County Potawatomi
Dave Blouin - Sierra Club

Conceptual Framework for Development of the Crandon Mine Surface Water Mitigation Plan

This document is designed to be a framework under which a final project-wide surface water mitigation plan is developed by the Crandon Mining Company (CMC). The project surface water mitigation plan will become a part of the project's High Capacity Well Permit Application. The detail necessary for water body-specific mitigation plans would be determined by the position of that water body within the hierarchy of this framework. This document would also provide the basis for the Department's review of the final plan submitted by CMC. It is recognized that the final formulation of the mitigation plan is important for the final development of the proposed monitoring plan.

This conceptual model involves seven main sections - the goals of mitigation; the identification of potentially affected surface water bodies; the establishment of a planning hierarchy for identified water bodies; the establishment of triggers or decision criteria for each water body that would lead to implementation of mitigation; the placement of water bodies into the planning hierarchy and the creation of a mechanism to reclassify water bodies as necessary during project operation to allow for unforeseen circumstances; the identification of possible sources of mitigation water; and the level of treatment necessary for discharge.

I. Goals of Mitigation

The primary goal of surface water mitigation is to protect public rights to lakes, springs and streams in the area of the proposed groundwater drawdown. The guiding principle of the project surface water mitigation plan should be the preservation of the existing hydrologic and ecologic systems. In addition, the plan should attempt to minimize additional pumping of groundwater to provide mitigation water. Mitigation alternatives that use available clean intercepted mine inflow water first and treated wastewater, where viable, second are preferable to limit groundwater drawdown and interbasin transfer.

Many of the streams and lakes in the project area have been, are, or could be affected by beaver activity. The modifications made to lakes and streams by beaver are largely transient in nature and are very difficult to predict. Therefore, mitigation will be expected to focus on the underlying hydrologic system to the extent possible.

Surface water mitigation, as a part of the project's surface water mitigation plan, covers only lakes and streams potentially affected by groundwater drawdown from the project. State laws and regulations do not provide for wetland mitigation (defined as the creation or replacement of wetlands to compensate for project-related wetland loss) in Wisconsin. Rather mining laws and regulations require that proposed projects minimize impacts to wetlands. Section 404 of the Federal Clean Water Act administered by the US Army Corps of Engineers (COE), however, does provide for compensatory mitigation for damage to wetlands. The compensatory wetlands mitigation plan for this project is a separate document primarily reviewed by the COE in the federal permitting process.

II. Surface Water Bodies within Zone of Potential Effect from Drawdown

This section is intended to identify all water bodies which have the potential to be affected by the proposed project due to groundwater drawdown. This list is intended to be inclusive. The effects to the water bodies could be evidenced by changes in water quantity or water quality. Water bodies not on the list are expected to be outside the zone of potential effect from the project as currently proposed.

Lakes

Skunk Lake
Duck Lake
Little Sand Lake
Deep Hole Lake
Oak Lake
Popple Pond
Mole Lake
Rice Lake
Ground Hemlock Lake
Rolling Stone Lake
Walsh Lake
Kimberly Lake
St. John's Lake

Streams & Springs

Swamp Creek (Hemlock Creek to Rice Lake)
Hemlock Creek
Hoffman Creek & Hoffman Springs
Pickerel Creek (Headwaters to Rolling Stone Lake)
Creek 11-4 & Martin Springs
Creek 12-9/Creek 12-9 Tributary
Influent stream(s) to Mole Lake from upper Pickerel wetland complex

III. Planning Hierarchy

The goal is to establish planning categories that are appropriate for each water body within the area of potential effects. This system will allow advanced plan development to the extent that is reasonably possible during both the permitting process and project operation, should it be approved. It will also make implementation of mitigation as easy as possible if and when it is necessary. This hierarchy assumes that trigger criteria for each water body have been individually established. During the permitting phase, worst-case analyses will be used to develop predictions and assign water bodies to the appropriate category.

Level I:

PERMITTING PHASE: THOSE WATER BODIES WHERE A SUBSTANTIAL EFFECT IS PREDICTED BY THE REGIONAL FLOW MODELING AND/OR EXPECTED FROM A REVIEW OF THE RESULTS AND SITE CONDITIONS

A complete mitigation plan for each water body is expected to be part of the project-wide mitigation plan reviewed in the master hearing. A complete mitigation plan is expected to include a fully-developed design of the proposed mitigation system with established operational criteria, a complete assessment of the impacts expected from implementation of the mitigation, an analysis of alternative mitigation systems, and a monitoring plan for evaluating the effects of mitigation. Construction of the mitigation system for each water body would coincide with the initiation of mine pumping. Initiation of the system operation for each water body would be contingent on satisfying the trigger criteria for that water body.

OPERATIONAL PHASE: THOSE WATER BODIES WHERE A SUBSTANTIAL EFFECT IS SEEN OR IS EXPECTED FROM REVIEW OF MONITORING DATA, GROUNDWATER MODELING INFORMATION, AND TRIGGER CRITERIA.

A complete mitigation plan for each water body is expected to be implemented upon the reclassification of a water body to this level. A complete mitigation plan is expected to include a fully-developed design of the proposed mitigation system with established operational criteria, a complete assessment of the impacts expected from implementation of the mitigation, an analysis of alternative mitigation systems, and a monitoring plan for evaluating the effects of mitigation. Construction of the mitigation system for each water body would be initiated as soon as reasonably possible. Initiation of the system operation for each water body would be contingent on satisfying the trigger criteria for that water body.

Level II:

PERMITTING PHASE: THOSE WATER BODIES WHERE A SUBSTANTIAL EFFECT IS DISTINCTLY POSSIBLE DUE TO KNOWN HYDROLOGIC CONDITIONS AND/OR PROXIMITY OF THE WATER BODY TO THE DRAWDOWN CONE, BUT NOT PREDICTED BY THE FLOW MODELING.

A complete mitigation plan for each water body is expected to be part of the project-wide mitigation plan reviewed in the master hearing. A complete mitigation plan is expected to include a fully-developed design of the proposed mitigation system with established operational criteria, a complete assessment of the impacts expected from implementation of the mitigation, an analysis of alternative mitigation systems, and a monitoring plan for evaluating the effects of mitigation. Implementation for a given water body would be contingent on satisfying the trigger criteria for that water body.

OPERATIONAL PHASE: THOSE WATER BODIES WHERE A SUBSTANTIAL EFFECT IS FOUND TO BE DISTINCTLY POSSIBLE FROM REVIEW OF MONITORING DATA, GROUNDWATER MODELING INFORMATION, AND TRIGGER CRITERIA.

A complete mitigation plan for each water body is expected to be prepared upon reclassification or addition of a water body to this level. A complete mitigation plan is expected to include a fully-developed design of the proposed mitigation system with established operational criteria, a complete assessment of the impacts expected from implementation of the mitigation, an analysis of alternative mitigation systems, and a monitoring plan for evaluating the effects of mitigation. Implementation for a given water body would be contingent on reclassification of the water body to Level I or satisfying the trigger criteria for that water body.

Level III:

PERMITTING & OPERATIONAL PHASES: THOSE WATER BODIES WHERE AN EFFECT IS A POSSIBILITY, BUT NOT CONSIDERED LIKELY DUE TO PROXIMITY TO THE DRAWDOWN CONE, KNOWN HYDROLOGIC CONDITIONS, AND/OR PREDICTIONS FROM THE FLOW MODELING.

A conceptual mitigation plan for each water body is expected to be part of the project-wide mitigation plan reviewed in the master hearing. A conceptual mitigation plan should be prepared upon reclassification or addition of a water body to this level during operation. A conceptual mitigation plan would involve the identification of potential mitigation techniques for the water body, a brief assessment of the efficacy of and likely impacts from each of those techniques, and the initial selection of a preferred technique. Further plan development and implementation would be contingent on satisfying the trigger criteria or the reclassification of the water body to Level II due to project monitoring results.

Level IV:

PERMITTING & OPERATIONAL PHASES: THOSE WATER BODIES WHERE AN EFFECT IS HIGHLY UNLIKELY AND IS NOT PREDICTED, BUT, DUE TO PROXIMITY TO THE DRAWDOWN CONE OR KNOWN HYDROLOGIC CONDITIONS, CANNOT BE COMPLETELY RULED OUT.

A generic outline for the development of a detailed mitigation plan is expected to be part of the mitigation plan reviewed in the master hearing. Water bodies added to this level during operation should fit into the generic outline or the generic outline should be revised accordingly. This generic outline is expected to be applicable to each water body in this category and to guide detailed plan development, should it be necessary. Further plan development and implementation would be contingent on satisfying the trigger criteria or the reclassification of the water body to Level III or Level II due to project monitoring results.

IV. Trigger Criteria

The establishment of individual trigger criteria for the implementation of mitigation for each water body listed above will be necessary. Water bodies with similar existing hydrologic conditions may receive similar criteria. The trigger criteria will be associated with the public rights stage (PRS) and/or the minimum in-stream flow (MIF) necessary to protect public rights as established by the Department for each water body. The public rights stages/flows will be the most significant trigger criterion for each water body. For certain water bodies, however, established seasonal background water chemistry for significant parameters may also serve as a major trigger criteria. In addition, it is expected that data from site and regional weather stations, monitoring results from adjacent groundwater and from similar water bodies removed from the project vicinity, and possibly some biologic information will be included in the criteria.

In addition to mitigation implementation criteria, for those water bodies requiring developed mitigation plans, mitigation suspension criteria should be established where appropriate. These would also involve the PRS and/or MIF for each water body, groundwater data, weather data, and surrogate lake/stream monitoring.

The expectation of the surface water mitigation plan is that if the drawdown has affected a particular water body and the trigger criteria for that water body are met, CMC would be required to implement mitigation for that water body based on protection of public rights to that water body. The point of reaching the trigger criteria may only occur seasonally, so mitigation may only need to be applied seasonally.

Listed below are rough trigger criteria for each major type of water body. Final criteria will need to be developed for each individual water body within each water body type.

Lakes

Initiation: The trigger criteria would be the PRS of the lake in combination with adjacent groundwater levels and/or water chemistry (including water temperature). Regional precipitation/evaporation and surrogate upland lake measurements would provide additional information.

Cessation: Water Quantity- Recovery of lake level and adjacent groundwater levels.
Water Quality - Demonstration of no continuing need.

There are two broad categories of lakes in the project vicinity - lakes fed by groundwater and lakes recharging groundwater. It is likely that those types of lakes would have somewhat different trigger criteria and would need to have somewhat different mitigation plans.

Springs:

Initiation: The trigger criteria would be the ability of the spring to maintain the associated pool elevation (possibly PRS) in combination with adjacent groundwater levels and/or water chemistry (including water temperature) and/or ability of spring to maintain the existing biotic community. This could be measured by water flow/stage, groundwater levels, water chemistry, and/or plant/critter surveys.

Cessation: Water Quantity- Recovery of spring pool elevation or flow and adjacent groundwater levels.
Water Quality - Demonstration of no continuing need.

Streams

- Initiation: The trigger criteria would be the MIF/PRS for the stream in combination with adjacent groundwater levels and/or water chemistry. Regional precipitation/evaporation and surrogate stream flow measurements would provide additional information.
- Cessation: Water Quantity - Recovery of stream flows/stages and adjacent groundwater levels.
Water Quality - Demonstration of no continuing need.

V. Categorization of Water Bodies

The positioning of water bodies in the above categories will be done for planning purposes during the permitting process and any potential project operation. During final mitigation plan development, the water bodies listed in the first part of this document will be placed into one of the above categories and the appropriate associated plan development will be expected within the final project-wide mitigation plan. The placement of a water body into a particular category prior to the master hearing will be based on a worst-case analysis of area hydrologic information, flow modeling results, and professional judgement.

Should the project be approved, we expect that an annual assessment of the mitigation program and the state of the area surface water bodies listed above would be contained in the project's annual report. If, during site operation, monitoring results indicate that the drawdown effects on a particular water body are likely to be greater than anticipated, the water body shall be reclassified to the appropriate higher level and the necessary additional planning shall be undertaken by CMC. Any reclassification decisions necessary would be made by the Department for individual water bodies based on review of monitoring data, groundwater modeling predictions, and the specific trigger criteria for those water bodies.

VI. Potential Sources of Mitigation Water

The potential sources of mitigation water for the project as a whole are likely limited to three possible options: treated wastewater, clean intercepted mine-inflow water, and specially pumped groundwater. The potential sources of mitigation water may be further limited for specific water bodies due to the surface water management classification, water chemistry, or location of the water body.

VII. Mitigation Water Treatment

In order for water supplied to a surface water body as a part of a mitigation program to be protective of the existing hydrologic and ecologic system, the added water should be treated to mimic the general background water chemistry of the water body. Addition of water of substantially different chemistry may substantially and permanently alter the system.

Appendix B

Surface Water Impact Assessment Based on Updated Regional Groundwater Flow Model Simulations

Foth & Van Dyke Memorandum

November 30, 1998

TO: Jerry Sevick, Foth & Van Dyke

CC: Gordon Reid, Nicolet Mining Company
Master File

FR: Steve Donohue, Foth & Van Dyke *SVD*

RE: Crandon Project - Surface Water Impact Assessment

On August 28, 1998, Nicolet Minerals Company provided to the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (USCOE) *Addendum No. 2 to: Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Zinc and Copper Mine Near Crandon, Wisconsin* (HSI GeoTrans, 1998). That report addresses updated estimates of potential groundwater flow and surface water impacts reflecting the proposed mining and grouting plan which were added to the project plan in 1998. This memorandum serves as the basis for ranking surface water impacts based on the updated water budget data contained in HSI GeoTrans (1998).

The updated groundwater model predictions (HSI GeoTrans, 1998) examined steady-state inflow during both the zinc and copper phase of mining. The model indicates considerably higher inflows will occur during the zinc phase of mining. This is consistent with site characterization data discussed in Section 3.6 of the Crandon Project's *Environmental Impact Report (EIR)* (Foth & Van Dyke, 1995/1998), which shows that the Crandon formation exhibits higher permeability due to more intense weathering. Given that the highest inflows will occur during the zinc phase of mining, the potential maximum impact on surface waters will also occur during zinc mining (years 1 to 16). Accordingly, the assessment of surface water impacts and subsequent mitigation considerations will focus on potential impacts during zinc mining.

Model Predicted Impacts to Creeks

Groundwater discharge into creeks represents what is typically referred to as the base flow component of surface water flow in creeks. Potential stream flow impacts are a function of the mine dewatering process intercepting some regional groundwater that would, under an unstressed condition, flow to and discharge into surrounding creeks and springs. As a result of mining activities, potential impacts to creeks and springs will be in the form of reduced base flow rather than an actual withdrawal of water from the creeks.

The regional groundwater model (HSI GeoTrans, 1998) presented in Appendix 4.2-3 of the EIR (Foth & Van Dyke, 1995/1998) provides the basis for assessing impacts due to reductions in base flow induced by mine dewatering. The model runs that are used for this impact assessment include Best Engineering Judgment (BEJ) Runs 49C/49N and 49J/49S, and Practical Worst Case (PWC) Runs 50C/50N and 50J/50S.

For ranking purposes, reductions in flow resulting from mine dewatering have been categorized as follows:

- ♦ Minimal - 0% to 10% - Potential Changes to stream condition will likely be unnoticeable.
- ♦ Moderate - 11% to 20% - Subtle changes in stream flow may be seen during natural low-flow conditions.
- ♦ Substantial - >20% - The character of the stream will likely change during low-flow conditions. Potential changes include reduction in channel widths and depths and reduction in stream velocity.

Discussions in this memorandum also refer to terminology such as average flow, $Q_{7,10}$ and $Q_{7,2}$. For clarification purposes, the following definitions should be used when referring to these terms.

- ♦ Average Flow - Stream flow will equal or exceed this flow rate 50% of the time. These flow rates are based on a correlation of measured discharges at the gaging stations with concurrent discharge rates for the Wolf River at Langlade. The correlation has been developed by the U.S. Geological Survey.
- ♦ $Q_{7,10}$ - The calculated 7-day low-flow level that will occur naturally in 10 years. These flow levels have been established by the U.S. Geological Survey.
- ♦ $Q_{7,2}$ - The calculated 7-day low-flow level that will occur naturally in 2 years. These flow levels have been established by the U.S. Geological Survey.

A summary of the effect on stream flow changes due to the mine intercepting regional groundwater is presented in Tables 1 and 2 for the BEJ and PWC simulations, respectively. The tables contain information pertaining to the model predicted percent impact to base flow under average recharge conditions and low recharge conditions. In Tables 1 and 2, the percent impact computed under average recharge conditions is applied to the average flow conditions to derive an approximate flow reduction under average flow conditions. Similarly, the percent impact to base flow under low recharge conditions is applied to the $Q_{7,2}$ and $Q_{7,10}$ to derive an approximate flow reduction under low-flow conditions.

Computing impacts in this fashion is slightly different than previous stream flow impact summaries for the Crandon Project. In 1995, impact summaries used the absolute modeled reduction (in cfs) in base flow for average conditions to compute flow reductions under average

and even low-flow conditions. This approach did not appropriately represent low-flow conditions since a low-flow simulation using reduced recharge was not computed. In 1996, the absolute modeled reduction (in cfs) in base flow was used to assess impacts under average flow conditions whereas the percent change in base flow, as derived from the low recharge simulation, was used to assess flow reductions under low-flow conditions. Upon further review it has been concluded that using the percent change in base flow as computed by the regional groundwater model is the most appropriate use of model results in assessing impacts to stream flow. This is based on the fact that the calibrated regional groundwater model does in some cases slightly overpredict or underpredict base flow gain. As such, using the absolute modeled change in base flow (in cfs) could underestimate or overestimate stream impacts. Using the percentage impact as computed by the model reduces the potential for overestimating or underestimating the impact.

Using the percent impact to base flow, as computed by the model works well for estimating the expected flow reduction listed in column five of Tables 1 and 2 for low-flow conditions when stream flow is likely to be derived solely from groundwater discharge to the stream. However, under average flow conditions, surface runoff is likely to be a significant component of the total stream flow. In this case applying the modeled percent reduction to base flow overestimates the expected flow reduction since the computed percent is being multiplied by a flow number that is greater than base flow (i.e., percent base flow reduction \times [base flow + flow from runoff]). Although this issue is worth recognizing, it does not affect the ranking of impacts for mitigation purposes since stream impacts are assessed based on the low-flow impact.

Another point worth recognizing is the effect that applying model derived percent base flow reductions has on assessing impacts for Swamp Creek versus the other pertinent creeks. For Upper Pickerel Creek, Hemlock Creek, Hoffman Creek, Creek 19-14, Creek 33-8, Creek 12-9 and its tributary, and Creek 11-4/Martin Springs, the model computes the percent base flow reduction for the entire stream reach. Thus, applying the modeled percent reduction correctly estimates the percent impact on base flow for these creeks. However, in the case of Swamp Creek, the modeled percent reduction in stream flow excludes the contributions of Outlet Creek and Swamp Creek above its confluence with Hemlock Creek. Thus the modeled percent impact to base flow on Swamp Creek is only for a portion of the creek system. Applying the percent reduction to, for example the $Q_{7,10}$ at STH 55, overestimates the expected reduction since the $Q_{7,10}$ value is for the entire stream system upstream of STH 55. As such the estimated impacts on Swamp Creek are conservative.

An additional conservative feature of the impact analysis summarized in Tables 1 and 2 is that the impacts on Swamp Creek do not account for the soil absorption system that will be used for infiltrating mine water that is treated to NR 140 Wis. Admin. Code, preventative action limits. The soil absorption system as proposed is located within the Swamp Creek groundwater basin. Thus, the treated water will actually contribute to the baseflow of Swamp Creek during operations. Since the mine is intercepting the groundwater from other groundwater basins (i.e., 12-9, Upper Pickerel Creek), the net result of discharging treated water to the soil absorption system will be a slight net increase in baseflow on Swamp Creek. Under BEJ conditions with average and low recharge, the increase is estimated to be less than 1 cfs at SG-3,

SG-AA, and STH 55. Under PWC conditions, the estimated increase in flow at Swamp Creek gaging stations due to the soil absorption system is as follows:

- ♦ At SG-3, an increase of about 1.2 to 1.3 cfs under low flow conditions, and about 1.1 cfs under normal recharge conditions.
- ♦ At STH 55 and SG-AA, an increase of about 0.9 to 1.1 cfs under low flow conditions, and 0.4 cfs under normal recharge conditions.

The estimates cited above are based on inflow and impact from BEJ Runs 49C/49N and 49J/49S, and PWC Runs 50C/50N and 50J/50S in HSI GeoTrans (1998). Overall, with the incorporation of the soil absorption system there will be no measurable reduction in flow on Swamp Creek.

Creeks 13-2b, 13-2c, 13-3, and 13-15 flow into the east side of Rolling Stone Lake. The creeks were not on the original list from the WDNR of surface water bodies identified by the WDNR that were to be considered for surface water mitigation. However, the WDNR has recently requested that these water bodies be included in the mitigation plan. Since these water bodies and their groundwater recharge areas are predominantly outside the area of groundwater drawdown due to mining, they were not incorporated into the regional groundwater model. However, qualitative and semi-quantitative information is available from the model with respect to potential impacts on the systems. Figures 1 and 2 display the predicted groundwater drawdown for both BEJ and PWC conditions.

Figures 1 and 2 also display topographic elevations at various points along the creeks and in the vicinity of the creeks. Based on this topographic data and the potentiometric surface map shown in Figure 3, the creeks are not likely to receive groundwater until the surface elevation falls below about 1550 ft MSL. Thus, groundwater discharge to the creeks is restricted to a small area in the immediate vicinity of Rolling Stone Lake (see Figures 1 and 2). This area is not predicted to experience groundwater drawdown that could affect baseflow and is substantially removed from the drawdown area.

Potential impacts to Creeks 13-2b, 13-2c, 13-3, and 13-15 were also estimated based on calculations using data from the groundwater model and equations used in the River Package of MODFLOW (see Attachment A). Based on these calculations, the creeks in question are estimated to experience a change in baseflow that is less than 10%. Based on both the topographic data and MODFLOW-based calculations, the creeks are estimated to experience minimal impacts.

Model Predicted Impacts to Lakes

At the February 3, 1998, mitigation meeting with the WDNR, department staff requested that lake impacts be ranked in a gradational fashion similar to that applied above for the creeks. Accordingly, minimal, moderate, and substantial impact rankings are proposed for the lakes. The application of these rankings is dependent on the location of the lake relative to projected drawdown and available data from the regional groundwater model. For impact assessment purposes, lakes are divided into three groups:

- ◆ Farfield lakes that are outside the immediate vicinity of the mine.
- ◆ Perched lakes.
- ◆ Near field lakes that the are near the mine, and therefore have the greatest potential to be impacted by groundwater drawdown, and were simulated with the lake stage package.

The regional groundwater model (HSI GeoTrans, 1998) presented in Appendix 4.2-3 of the EIR (Foth & Van Dyke, 1995/1998) provides the basis for assessing impacts. The model runs that are used for this impact assessment include the BEJ Runs 49C/49N and the PWC Runs 50C/50N. A discussion of the impact rankings for the lakes is presented below. Tables 3 and 4 present the results of the ranking for both BEJ and PWC conditions.

For ranking purposes, predicted reductions in lake stage due to mine dewatering, have been categorized as follows:

- ◆ Minimal - No change in lake stage or an unmeasurable change in lake stage is anticipated based on predicted groundwater drawdown, or a predicted change in lake stage that is less than 50% of the difference between predicted pre-mining stage and the maximum PRS.
- ◆ Moderate - A potential small measurable change in lake stage that is unlikely to impact public rights or a predicted change in lake stage that is greater than 50% but less than 100% of the difference between predicted pre-mining stage and the maximum PRS.
- ◆ Substantial - A potential change in lake stage that is measurable and may impact public rights or a predicted change in lake stage that is greater than 100% of the difference between predicted pre-mining stage and the maximum PRS.

Farfield Lakes

Under BEJ and PWC conditions, Rice Lake, Mole Lake, Rolling Stone Lake, St. Johns Lake, Walsh Lake, Kimberly Lake, Clark Lake, and Ground Hemlock Lake are all projected to be outside the area of 1 ft of groundwater drawdown. With the exception of Walsh Lake, Kimberly Lake, and Clark Lake, the lake stage of these lakes is reflective of the regional water table. Less than 1 ft of drawdown in the groundwater table is, in the context of natural variations, an immeasurable impact. As such, there will be no impact, or an unmeasurable impact, on these groundwater-fed lakes. Consequently, these lakes are classified as having minimal impacts under BEJ and PWC conditions as noted in Tables 3 and 4. Similarly, Lakes 35-7 and 34-1 are outside the 1-ft drawdown contour under BEJ conditions and are considered to have no measurable impact and are classified as being minimal in Table 3.

Walsh Lake, Kimberly Lake and Clark Lake are head dependent seepage lakes deriving water from direct precipitation and surface water runoff. The flux of surface water from these lakes to

the glacial aquifer is a function of the hydraulic gradient across a low permeability lake bed. The groundwater drawdown in the glacial aquifer below these lakes is predicted to be less than 1 ft under both BEJ and PWC conditions, or unmeasurable in the context of natural variations. Since the hydraulic gradient across the lake bed will not be affected by mine-induced drawdown, the lake stage of these lakes will not be measurably affected and the impact is classified as minimal under BEJ and PWC conditions.

Groundwater in the vicinity of Lake 34-1 is predicted to be drawn down by less than one foot under PWC conditions. Since the lake is small and is located in an area where the model grid is large, seepage calculations were performed to assess drawdown impacts on the lake. These seepage calculations shown in Attachment A indicate that the seepage change in Lake 34-1 could be about 0.001 cfs under BEJ and PWC conditions, respectively. A less than one-foot change in groundwater elevation is almost unmeasurable in the context of natural variation and is likely to have little effect on seasonal stages. Given the small almost immeasurable change in groundwater around Lake 34-1 and the small seepage change, the impact is considered minimal under PWC conditions.

Under PWC conditions, the analysis of potential effects on Lake 35-7 is similar to Lake 34-1. Drawdown in the area of Lake 35-7 is predicted to be slightly greater than 1 ft. The change in seepage is predicted to be between 0.002 cfs and 0.004 cfs (see Attachment A). Again, the magnitude of this change is almost unmeasurable in the context of natural variation, and is likely to have little effect on seasonal stages. Given the small, almost immeasurable, change in groundwater around Lake 35-7 and the small seepage change, the impact is considered minimal under PWC conditions.

Perched Lakes

Oak Lake is a known perched water body, and therefore, will not be affected by groundwater drawdown and thus the impacts are ranked as minimal under BEJ and PWC conditions. Popple Pond is also considered to be a perched lake given its proximity to Oak Lake and an approximate 45-ft separation between the land surface at the lakes edge and the surrounding groundwater elevations (see EIR Figure 3.6-46). Similarly, Lake 6-8 is also considered to be perched since it resides in a perched wetland, and given that a sandpoint installed near the lake in the winter of 1995 was dry after having been driven to a depth of about 20 ft. Given the above, Popple Pond and Lake 6-8 will not be impacted and are ranked as being minimal in accordance with the definitions noted above.

Near Field Lakes

Model predicted lake stage changes from model Runs 49C/49N and 50C/50N were used to rank impacts on Little Sand Lake, Deep Hole Lake, Duck Lake, and Skunk Lake. As noted in the impact definitions described above, the predicted lake stage decline is compared to the difference between the pre-mining lake stage and maximum PRS. For example, in the case of Little Sand Lake, the BEJ lake stage decline of 0.04 feet is 29% of the difference between the model predicted pre-mine lake stage and the maximum PRS. As such, the impact on Little Sand Lake is

ranked as minimal. Under PWC conditions, the lake stage decline of 0.07 ft on Little Sand Lake is 50% of the difference between the pre-mine stage and maximum PRS and the impact is ranked as moderate.

BEJ and PWC impacts to Duck Lake, Deep Hole Lake, and Skunk Lake are ranked in an identical fashion. Under BEJ conditions, the impacts to Deep Hole Lake, Duck Lake, and Skunk Lake are ranked as minimal, minimal, and substantial, respectively. Under PWC conditions, the impacts to Deep Hole Lake, Duck Lake, and Skunk Lake are also ranked as minimal, minimal, and substantial, respectively. Note that potential impacts due to the occurrence of drought conditions in addition to mining will be addressed as part of the mitigation plan.

References

- Foth & Van Dyke, 1995/1998. *Environmental Impact Report for the Crandon Project.*
- HSI GeoTrans, Inc., 1998. *Addendum No. 2 to Numerical Simulation of the Effect on Groundwater and Surface Water of the Proposed Zinc and Copper Mine Near Crandon, Wisconsin.*
- Wisconsin Department of Natural Resources, January 21, 1998. *Comments on Proposed Crandon Project Draft Surface Water Mitigation Plan.*

Table 1

Best Engineering Judgement Flow Reductions in Streams

Location	Flow Category	Existing Flow (cfs)	Model Predicted Percent Reduction ¹	Estimated Flow Reduction (cfs)	Flow with Estimated Impact (cfs)	Impact Ranking
Swamp Creek (STH 55)	Average	27	3	0.81	26.19	Minimal
	Q7,2	11	4	0.44	10.56	Minimal
	Q7,10	8	4	0.32	7.68	Minimal
Swamp Creek (SG-3) (Includes 19-14)	Average	16	3	0.48	15.52	Minimal
	Q7,2	6.7	3	0.20	6.50	Minimal
	Q7,10	4.7	3	0.14	4.56	Minimal
Swamp Creek (SG-AA)	Average	41	2	0.81	40.19	Minimal
	Q7,2	19	2	0.44	18.56	Minimal
	Q7,10	15	2	0.32	14.68	Minimal
Hemlock Creek (SG-6B) (Includes 33-8)	Average	8.3	3	0.25	8.05	Minimal
	Q7,2	3.4	4	0.14	3.26	Minimal
	Q7,10	2.4	4	0.10	2.30	Minimal
Hoffman Spring	Public Rights Flow ²	0.3	10 ³	0.03	0.27	Minimal
Hoffman Creek (Includes Hoffman Spring)	Public Rights Flow ²	0.55	9 ³	0.05	0.50	Minimal

B-9

Table 1 (Continued)

Location	Flow Category	Existing Flow (cfs)	Model Predicted Percent Reduction ¹	Estimated Flow Reduction (cfs)	Flow with Estimated Impact (cfs)	Impact Ranking
Creek 12-9 (SG-23) (Includes Creek 12-2)	Average	3.8	6	0.23	3.57	Minimal
	Q7,2	1.5	8	0.12	1.38	Minimal
	Q7,10	1.1	8	0.09	1.01	Minimal
Creek 11-4 (Martin Springs)	Public Rights Flow ²	0.4	7 ³	0.03	0.37	Minimal
Upper Pickerel Creek	Average	1.4	5	0.07	1.33	Minimal
	Q7,2	0.6	6	0.04	0.56	Minimal
	Q7,10	0.4	6	0.02	0.38	Minimal
Creek 19-14	Public Rights Flow ²	0.17	50 ³	0.09	0.08	Substantial
Creek 33-8	Modeled Base Flow	0.38 ³	8 ³	0.03	0.35	Minimal
Creek 13-2b	Public Rights Flow ²	0.22	NP	NP	0.22	Minimal
Creek 13-2c	Public Rights Flow ²	0.05	NP	NP	0.05	Minimal
Creek 13-3	Public Rights Flow ²	0.15	NP	NP	0.15	Minimal
Creek 13-15	Public Rights Flow ²	0.32	NP	NP	0.32	Minimal

B-10

¹ Model predicted percent impact to base flow condition. Model numbers for average flow condition derived from Runs 49C and 49N. Model numbers for Q_{7,2} and Q_{7,10} derived from low-flow simulation Runs 49J and 49S.

² Public Rights Flow established by WDNR (1998).

³ Model numbers derived from low-flow simulation (Runs 49J and 49S).

NP = Not predicted since creek was not simulated with river package or stream routing package.

Prepared by: SVD1
Checked by: JJA1

Table 2

Practical Worst Case Flow Reduction in Streams

Location	Flow Category	Model Predicted		Expected Flow Reduction (cfs)	Flow with Estimated Impact (cfs)	Impact Ranking
		Existing Flow (cfs)	Percent Reduction ¹			
Swamp Creek (STH 55)	Average	27	5	1.35	25.65	Minimal
	Q7,2	11	6	0.66	10.34	Minimal
	Q7,10	8	6	0.48	7.52	Minimal
Swamp Creek (SG-3)	Average	16	4	0.64	15.36	Minimal
	Q7,2	6.7	5	0.34	6.36	Minimal
	Q7,10	4.7	5	0.24	4.46	Minimal
Swamp Creek (SG-AA)	Average	41	3	1.35	39.65	Minimal
	Q7,2	19	3	0.66	18.34	Minimal
	Q7,10	15	3	0.48	14.52	Minimal
Hemlock Creek (SG-6B)	Average	8.3	5	0.42	7.88	Minimal
	Q7,2	3.4	6	0.20	3.20	Minimal
	Q7,10	2.4	6	0.14	2.26	Minimal
Hoffman Spring	Public Rights Flow ²	0.3	13 ³	0.04	0.26	Moderate
Hoffman Creek (Includes Hoffman Spring)	Public Rights Flow ²	0.55	13 ³	0.07	0.48	Moderate

B-11

Table 2 (Continued)

Location	Flow Category	Existing Flow (cfs)	Model Predicted Percent Reduction ¹	Expected Flow Reduction (cfs)	Flow with Estimated Impact (cfs)	Impact Ranking
Creek 12-9 (SG-23) (Includes Creek 12-2)	Average	3.8	9	0.34	3.46	Minimal
	Q7,2	1.5	10	0.15	1.35	Minimal
	Q7,10	1.1	10	0.11	0.99	Minimal
Creek 11-4 (Martin Springs)	Public Rights Flow ²	0.4	11 ³	0.04	0.36	Moderate
Upper Pickerel Creek	Average	1.4	8	0.11	1.29	Minimal
	Q7,2	0.6	8	0.05	0.55	Minimal
	Q7,10	0.4	8	0.03	0.37	Minimal
Creek 19-14	Public Rights Flow ²	0.17	100 ³	0.17	0.00	Substantial
Creek 33-8 (3)	Modeled Base Flow	0.40 ³	13 ³	0.05	0.35	Moderate
Creek 13-2b	Public Rights Flow ²	0.22	NP	NP	0.22	Minimal
Creek 13-2c	Public Rights Flow ²	0.05	NP	NP	0.05	Minimal
Creek 13-3	Public Rights Flow ²	0.15	NP	NP	0.15	Minimal
Creek 13-15	Public Rights Flow ²	0.32	NP	NP	0.32	Minimal

¹ Model predicted percent impact to base flow condition. Model numbers for average flow condition derived from Runs 50C and 50N. Model numbers for Q_{7,2} and Q_{7,10} derived from low-flow simulation Runs 50J and 50S.

² Public Rights Flow established by WDNR (1998).

³ Model numbers derived from low-flow simulation (Runs 50J and 50S).

NP = Not predicted since creek was not simulated with river package or stream routing package.

Prepared by: SVD1
Checked by: JJA1

Table 3

Best Engineering Judgement Lake Impacts

Location	Category ¹	Maximum Public Rights Stage (ft msl) ²	Steady State Pre-Mine Stage (ft msl)	Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Steady State Stage with Mine (ft msl) ³	Steady State Impact (ft)	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage	Impact Ranking
Little Sand Lake	N	1591.51	1591.65	0.14	1591.61	0.04	29	Minimal
Deep Hole Lake	N	1605.25	1605.74	0.49	1605.72	0.02	4	Minimal
Duck Lake	N	1610.59	1611.94	1.35	1611.85	0.09	7	Minimal
Skunk Lake	N	1597.01	1597.54	0.53	1596.42	1.12	211	Substantial
Lake 35-7	F	1554.19	NP	NC	NP	Unmeasurable	NP	Minimal
Lake 34-1	F	1550.31	NP	NC	NP	Unmeasurable	NP	Minimal
Mole Lake	F	1549.76	NP	NC	NP	Unmeasurable	NP	Minimal
Rice Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Rolling Stone Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Oak Lake	P	TBD	NP	NC	NP	0	NP	Minimal
Lake 25-11 (Popple Pond)	P	1602.60	NP	NC	NP	0	NP	Minimal
St John's Lake	F	1590.46	NP	NC	NP	Unmeasurable	NP	Minimal
Walsh Lake	F	1599.45	NP	NC	NP	Unmeasurable	NP	Minimal

B-13

Table 3 (Continued)

Location	Category ¹	Maximum Public Rights Stage (ft msl) ²	Steady State Pre-Mine Stage (ft msl)	Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Steady State Stage with Mine (ft msl) ³	Steady State Impact (ft)	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage	Impact Ranking
KimberlyLake	F	1599.48	NP	NC	NP	Unmeasurable	NP	Minimal
Clark Lake	F	1594.64	NP	NC	NP	Unmeasurable	NP	Minimal
Ground Hemlock Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Lake 6-8	P	TBD	NP	NC	NP	0	NP	Minimal

TBD = To Be Determined by WDNR.
 NC = Not Calculated, since lake was not simulated with lake stage package.
 NP = Not Predicted, since lake was not simulated with lake stage package.

Prepared by: SVD1
 Checked by: JJA1

¹ N = Near Field Lakes Simulated with the Lake Stage Package
 F = Farfield Lake
 P = Perched Lake
² Established by WDNR (1998)
³ Model numbers derived from Runs 49C/49N.

B-14

Table 4

Practical Worst Case Lake Impacts

Location	Category ¹	Maximum Public Rights Stage (ft msl) ²	Steady State Pre-Mine Stage (ft msl)	Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Steady State Stage with Mine (ft msl) ³	Steady State Impact (ft)	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage	Impact Ranking
Little Sand Lake	N	1591.51	1591.65	0.14	1591.58	0.07	50	Moderate
Deep Hole Lake	N	1605.25	1605.74	0.49	1605.68	0.06	12	Minimal
Duck Lake	N	1610.59	1611.94	1.35	1611.43	0.51	38	Minimal
Skunk Lake	N	1597.01	1597.53	0.52	1596.31	1.22	235	Substantial
Lake 35-7	F	1554.19	NP	NC	NP	<1	NP	Minimal
Lake 34-1	F	1550.31	NP	NC	NP	<1	NP	Minimal
Mole Lake	F	1549.76	NP	NC	NP	Unmeasurable	NP	Minimal
Rice Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Rolling Stone Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Oak Lake	P	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Lake 25-11 (Popple Pond)	P	1602.60	NP	NC	NP	Unmeasurable	NP	Minimal
St John's Lake	F	1590.46	NP	NC	NP	Unmeasurable	NP	Minimal
Walsh Lake	F	1599.45	NP	NC	NP	Unmeasurable	NP	Minimal

B-15

Table 4 (Continued)

Location	Category ¹	Maximum Public Rights Stage (ft msl) ²	Steady State Pre-Mine Stage (ft msl)	Difference Between Pre-Mine Stage & Public Rights Stage (ft)	Steady State Stage with Mine (ft msl) ³	Steady State Impact (ft)	% Impact to Difference Between Pre-Mine Stage & Public Rights Stage	Impact Ranking
Kimberly Lake	F	1599.48	NP	NC	NP	Unmeasurable	NP	Minimal
Clark Lake	F	1594.64	NP	NC	NP	Unmeasurable	NP	Minimal
Ground Hemlock Lake	F	TBD	NP	NC	NP	Unmeasurable	NP	Minimal
Lake 6-8	P	TBD	NP	NC	NP	Unmeasurable	NP	Minimal

TBD = To Be Determined by WDNR.

NC = Not Calculated, since lake was not simulated with lake stage package

NP = Not Predicted, since lake was not simulated with lake stage package.

Prepared by: SVD1

Checked by: JJA1

¹ N = Near Field Lake Simulated with Lake Stage Package

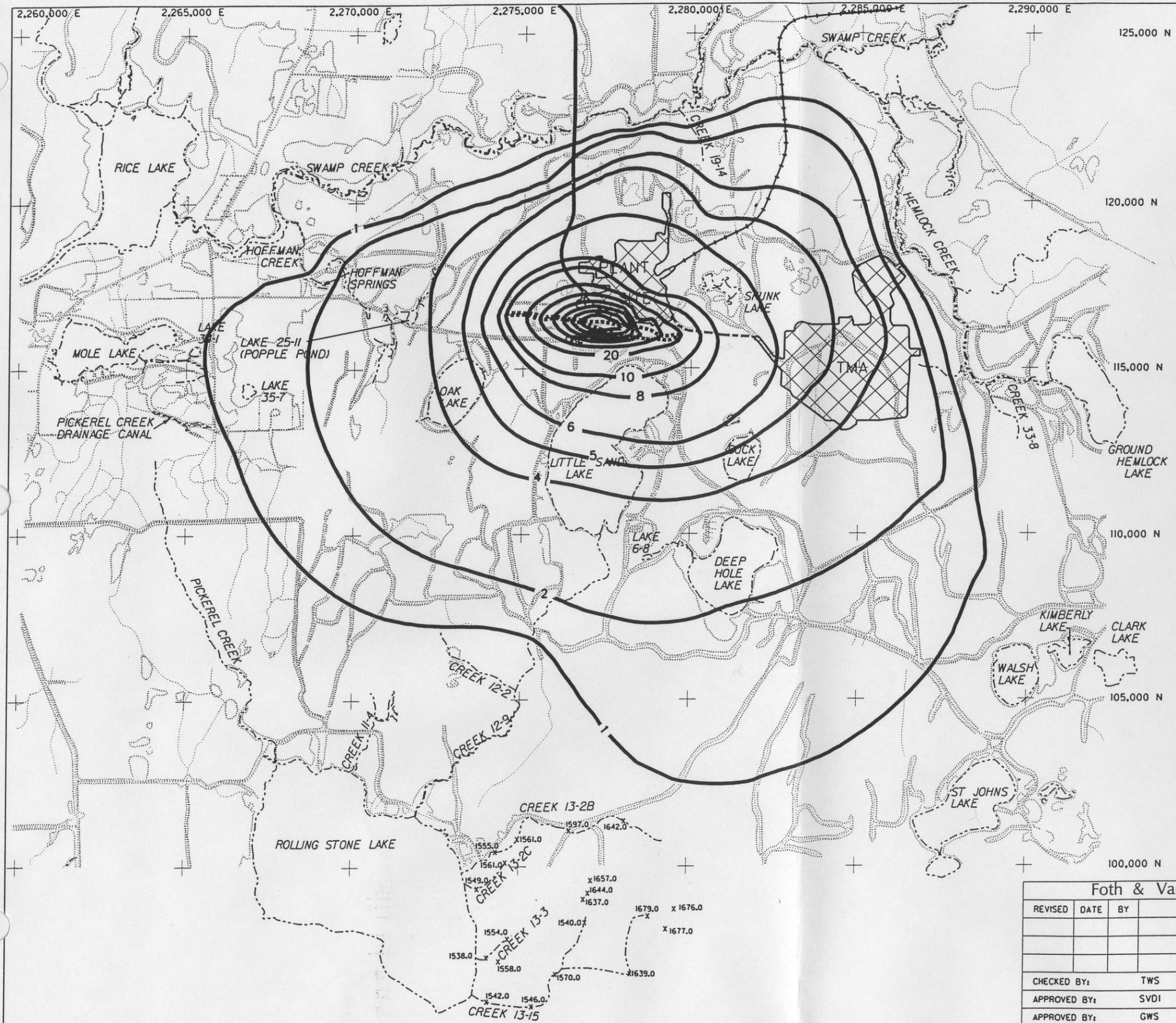
F = Farfield Lake

P = Perched Lake

² Established by WDNR (1998)

³ Model numbers derived from Runs 50C/50N.

91-B



LEGEND

- TREES/BRUSH
- UNPAVED ROAD/TRAIL
- PAVED ROAD
- CREEKS/RIVERS/LAKES
- PROPOSED ACCESS ROAD
- ORE BODY
- DRAWDOWN CONTOUR
- PROPOSED TMA ACCESS ROAD AND TAILINGS PIPELINE ROUTE
- PROPOSED RAILROAD SPUR
- PROPOSED FACILITIES

x 1676.0
 APPROXIMATE LAND SURFACE ELEVATION FT. MSL BASED ON 1976 AERO-METRIC TOPOGRAPHIC MAP OR USGS TOPOGRAPHIC MAP.

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. VERTICAL DATUM BASED ON MEAN SEA LEVEL DATUM.
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.

Foth & Van Dyke			
REVISED	DATE	BY	DESCRIPTION
CHECKED BY:	TWS	DATE:	NOV. '98
APPROVED BY:	SVDI	DATE:	NOV. '98
APPROVED BY:	GWS	DATE:	NOV. '98

Nicolet Minerals
C O M P A N Y

FIGURE 2
 PRACTICAL WORST CASE DRAWDOWN
 (RUN 50C/50N)

Scale: Date: NOVEMBER, 1998

Prepared By: Foth & Van Dyke By: JOW 93C049

Attachment A

**Water Budget Calculations for Lake 34-1,
Lake 35-7, Creek 13-2b,
Creek 13-2c, Creek 13-3, and Creek 13-15**

**HSI GEOTRANS
TECHNICAL MEMORANDUM**

TO: File

FROM: Greg Council *GC*

DATE: November 17, 1998

SUBJECT: Calculated baseflow changes during mining for Lake 34-1 and Lake 35-7.
HSI GeoTrans Project No. N015-021

In this memorandum, we present results from our BEJ and PWC models (see our *Addendum No. 2 to: Numerical Simulation of the effect on groundwater and surface water of the proposed zinc and copper mine near Crandon, Wisconsin* document of August 28, 1998) to estimate the impact of mining on the water budgets of Lake 34-1 and Lake 35-7. These two lakes lie in the flow model domain east of Mole Lake, but are not explicitly modeled as groundwater flow boundary conditions. Lake 34-1 is about 1.5 acres in area, while Lake 35-7 covers about 3 acres.

Since they were not explicitly incorporated into the model, analytical calculations were made to estimate the flow changes on Lakes 34-1 and 35-7. The areas of the lakes were determined from our GIS coverage of site water bodies, the sediment thickness was approximated to be 5 feet, and the vertical hydraulic conductivity was set to 0.01 ft/day to match the modeled external lakes. Using the model-predicted water table at cells covered by the two lakes, the groundwater drawdown during zinc mining was approximated for each lake. The approximate maximum change in flow at each lake was then calculated as the drawdown times the lake area times the bed leakance (conductivity divided by thickness). The results of these calculations are shown in Table 1. Note that if the lakes had been explicitly modeled, they would have likely limited drawdown in this area, decreasing the predicted flow impacts.

Table 1. Calculation of flow changes due to zinc mining on Lake 34-1 and Lake 35-7

Lake	Area (sq ft)	Kv (ft/d)	Thk (ft)	Drawdown (ft)		Change in Flow (cfs)	
				BEJ	PWC	BEJ	PWC
34-1	63818	0.01	5	0.63	0.98	0.001	0.001
35-7	129929	0.01	5	0.78	1.23	0.002	0.004

Notes:

- 1 Area taken from GIS coverage.
- 2 Vertical conductivity, and sediment thickness estimated based on other modeled lakes.
- 3 Water table drawdown taken from cell 68,5 for Lake 34-1; cell 80,6 for Lake 35-7.

Prepared By: GWC
Checked By: PFA

Simulations 49N and 50N
September 1998
\\CrandonFlowMod2\Excel\Pond.xls

**HSI GEOTRANS
TECHNICAL MEMORANDUM**

TO: File

FROM: Greg Council *GC*

DATE: November 17, 1998

SUBJECT: Calculated baseflow changes during mining for creeks east of Rolling Stone Lake
HSI GeoTrans Project No. N015-021

There are four small creeks, Creek 13-2b, Creek 13-2c, Creek 13-3, and Creek 13-15, that flow into Rolling Stone Lake from the east. These creeks are located within the domain of the regional groundwater model, but are not explicitly-modeled water bodies. In this memorandum, we estimate the maximum change in baseflow for each of these creeks during mining, using the results of our latest BEJ and PWC models (see our *Addendum No. 2 to: Numerical Simulation of the effect on groundwater and surface water of the proposed zinc and copper mine near Crandon, Wisconsin* document of August 28, 1998).

For this memorandum, analytical calculations were made to estimate the flow changes on the subject creeks. First, the portion of each creek that is hydraulically connected to the groundwater was delineated on an area map. This delineation was approximated from observed field conditions. In this area, on average, the creeks become disconnected from the water table above an elevation of about 1550 feet (msl). The length of each creek below 1550 feet (msl) was determined from the map. The width of each creek was observed to be approximately 5 feet. Based on the modeled streams in the groundwater flow model, each streambed was assumed to be 1 foot thick, with a vertical hydraulic conductivity of 1 ft/day. Using zoomed-in maps of model-predicted water-table drawdown during zinc mining, the average change in head beneath each creek was tabulated for both BEJ and PWC scenarios (Table 1). The approximate maximum change in baseflow to each creek was then calculated as the drawdown times the length times the width times the streambed leakance (conductivity divided by thickness). The results of these calculations are shown in Table 1.

Table 1. Calculation of flow changes due to mining on creeks near Rolling Stone Lake.

Creek	L (ft)	W (ft)	Kv (ft/d)	Thk (ft)	Drawdown (ft)		Change in Flow (cfs)	
					BEJ	PWC	BEJ	PWC
13-2B	900	5	1	1	0.12	0.22	0.0063	0.0115
13-2C	600	5	1	1	0.12	0.15	0.0042	0.0052
13-3	900	5	1	1	0.13	0.15	0.0068	0.0078
13-15	2300	5	1	1	0.10	0.11	0.0133	0.0146

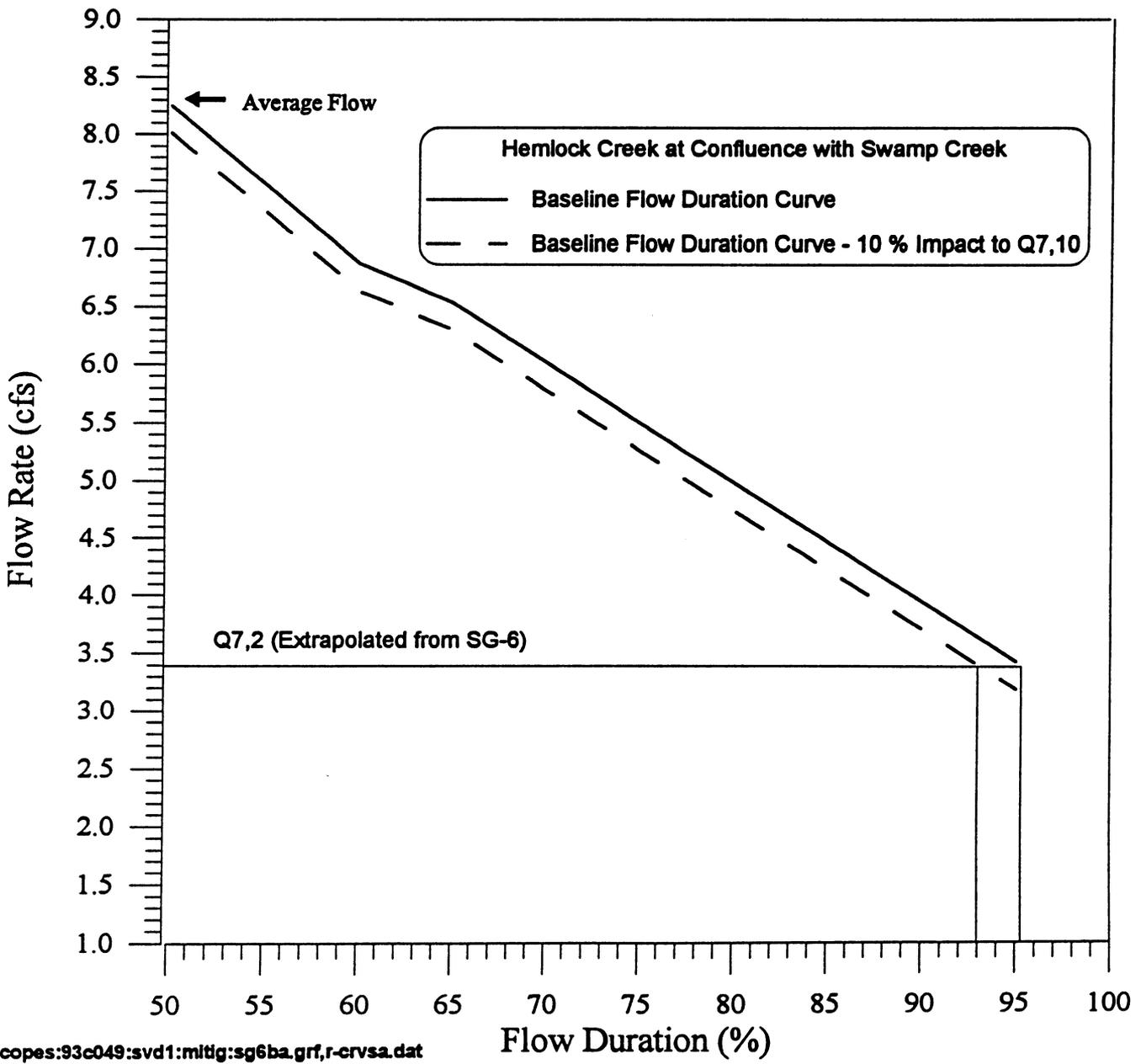
Notes:

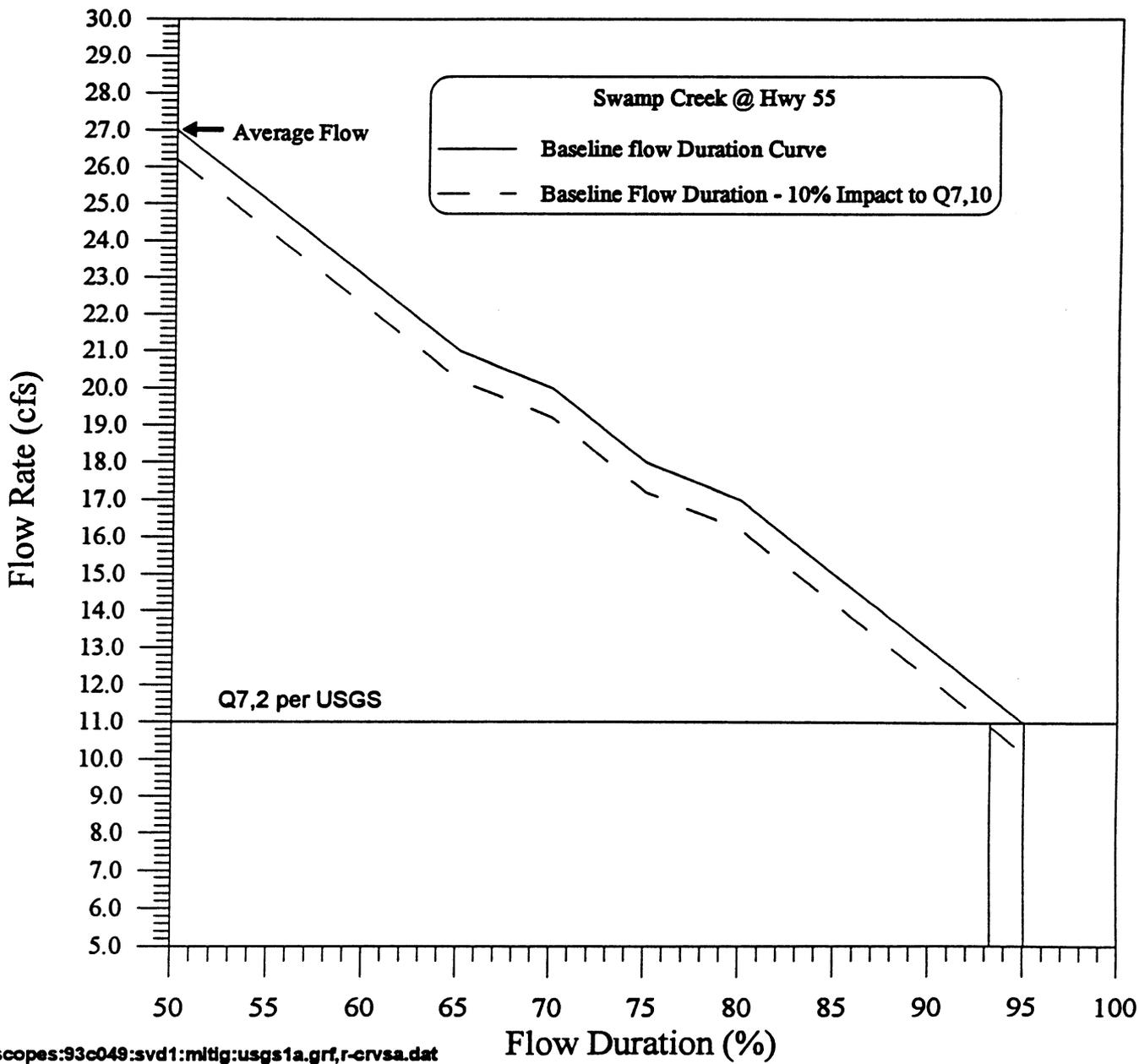
- 1 Length estimated as the portion of the creeks that receive groundwater inflow.
- 2 Vertical conductivity, and sediment thickness estimated based on other modeled creeks.
- 3 Average drawdown estimated from contoured maps of water table drawdown.

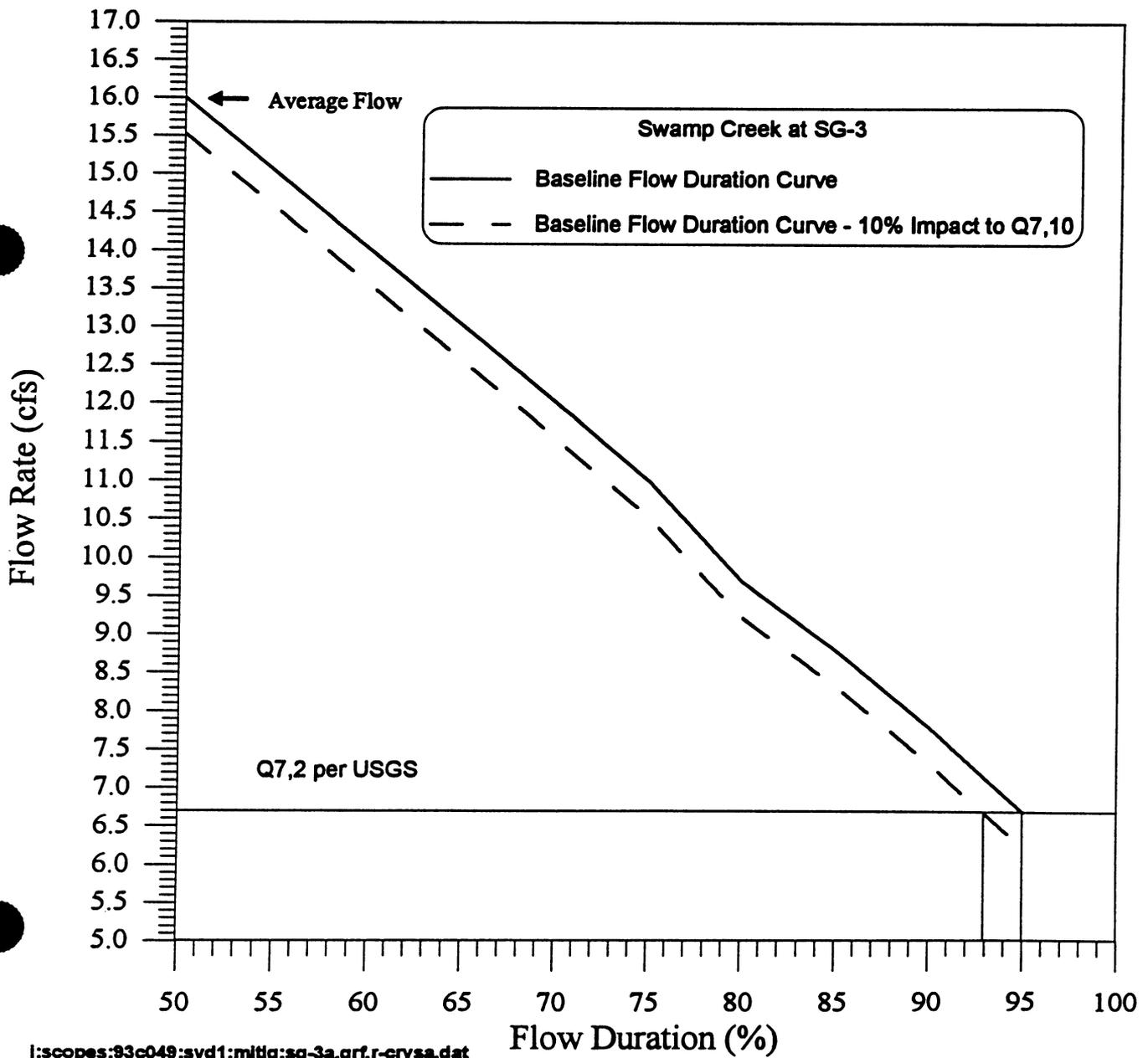
Prepared By: GWC
 Checked By: PFA

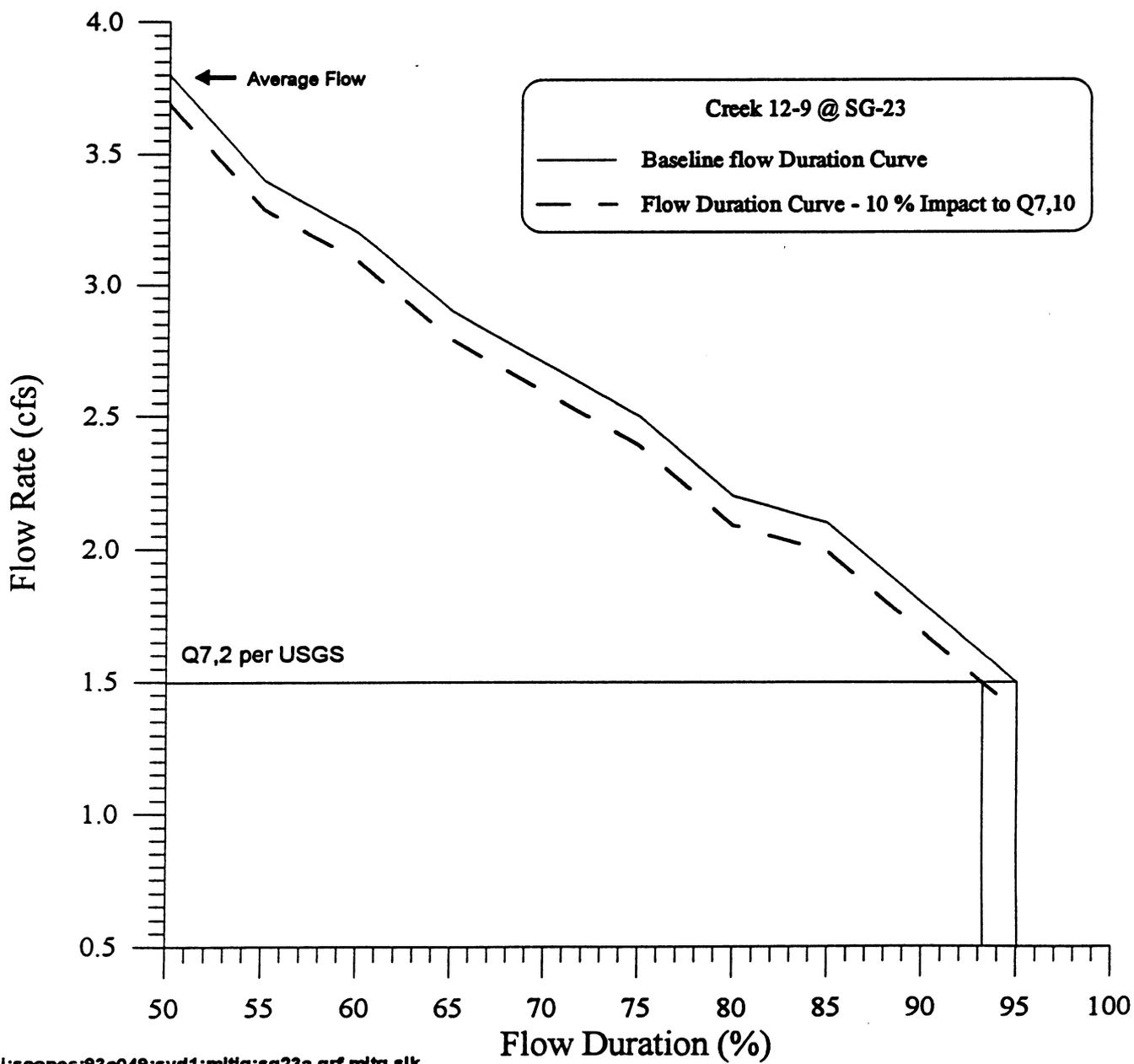
Appendix C

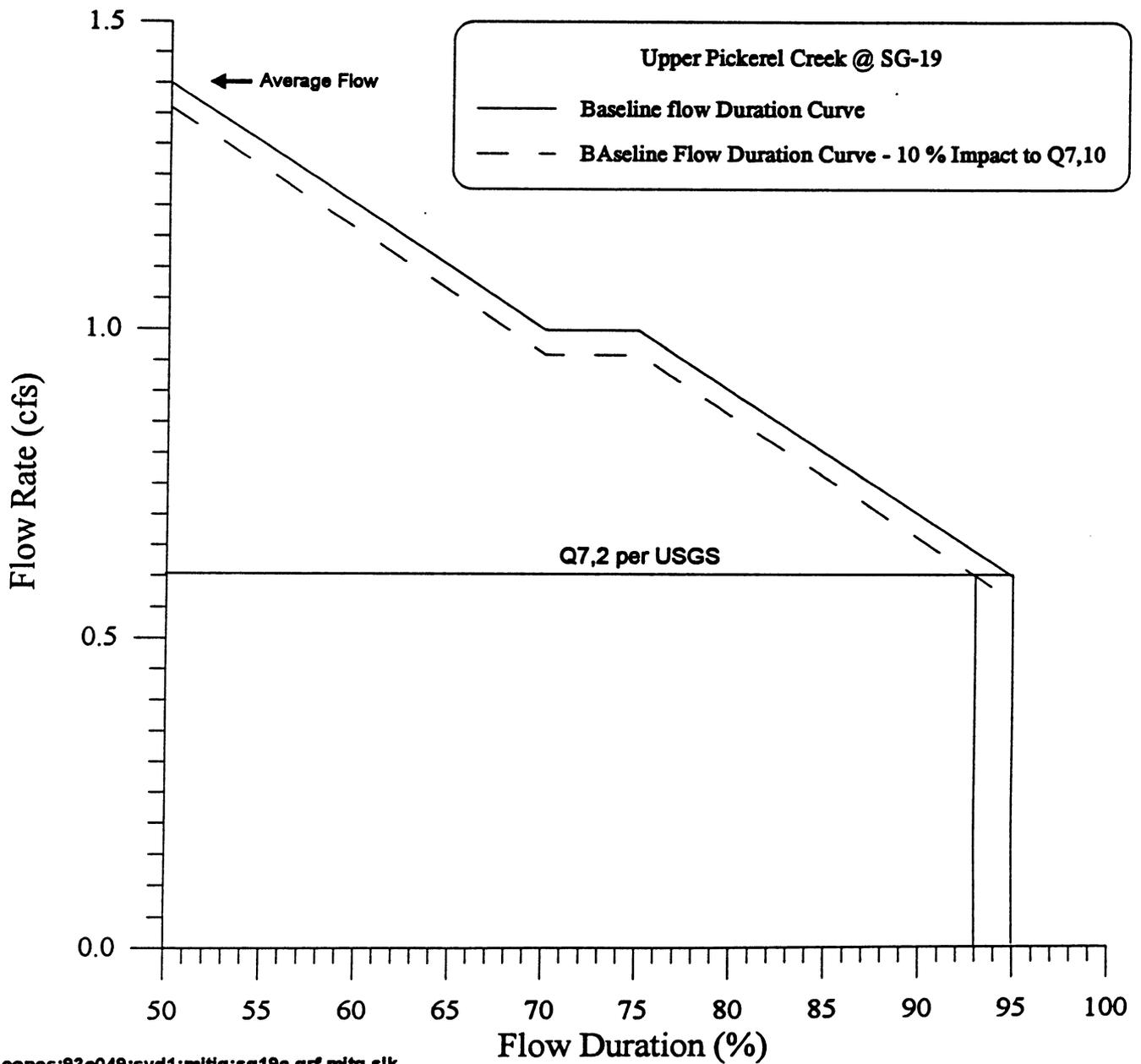
Flow Duration Curves for Crandon Project Gaging Stations











Appendix D

Assessment of Mitigation Water Requirements for Skunk Lake

**HSI GEOTRANS
TECHNICAL MEMORANDUM**

TO: File

FROM: Greg Council *GCW*

DATE: November 17, 1998

SUBJECT: Skunk Lake Mitigation
HSI GeoTrans Project No. N015-021

Under zinc mining conditions, our BEJ model predicts an average (steady-state) stage of 1596.42 feet (msl) for Skunk Lake and our PWC model predicts an average stage of 1596.31 feet (msl) (see our *Addendum No. 2 to: Numerical Simulation of the effect on groundwater and surface water of the proposed zinc and copper mine near Crandon, Wisconsin* document of August 28, 1998). Per the project's mitigation plan, Skunk Lake will be mitigated when the stage falls below 1597.01 feet (msl). We have used the regional groundwater flow models to estimate the amount of water that would be required for mitigation.

Procedure

Two new simulations were made: one with the BEJ predictive model (49U), and one with the PWC predictive model (50U). These simulations are exactly like our previous BEJ and PWC steady-state predictive simulations (49N and 50N), except that the stage of Skunk Lake is held constant at 1597.01 feet (msl). Using this procedure, the amount of water needed to keep the lake at this stage is found simply by looking at the MODFLOW output file. The "Net Flow" rate out of the lake is equal to the rate at which water would have to be added in order to keep the lake in volumetric (steady-state) balance at the given stage.

Results

Based on the steady-state BEJ predictive simulation with the Skunk Lake stage held constant, 31 gpm of water would be required to mitigate the lake to an average stage of 1597.01 feet (msl). Similarly, using the PWC model, the required rate would be 50 gpm.

Appendix E

Construction Cost Estimates

**Estimate of Probable Construction Costs
Mitigation Water Supply Well
Surface Water Mitigation
Nicolet Minerals Company**

Description	Quantity	Units	Unit Cost	Total Cost
Mobilization	1	Each	\$10,000.00	\$10,000
Drill 20" Hole	50	Linear Feet	\$100.00	\$5,000
Furnish and install 16" casing	30	Linear Feet	\$90.00	\$2,700
Furnish and install 10" casing	35	Linear Feet	\$40.00	\$1,400
Furnish and install 10" screen	15	Linear Feet	\$200.00	\$3,000
Gravel Pack	6	Cubic yards	\$200.00	\$1,200
Grout/bentonite	50	Bags	\$30.00	\$1,500
Develop Well	24	Hours	\$150.00	\$3,600
Mobilize pumping equipment	1	Each	\$2,000.00	\$2,000
Test Pump Well	18	Hours	\$150.00	\$2,700
Pump and drop pipe	1	Each	\$25,000.00	\$25,000
Pitless adapter	1	Each	\$5,000.00	\$5,000
Electrical and controls	1	Each	\$30,000.00	\$30,000
Total estimated construction cost				\$93,100

Prepared by: EHF
Checked by: GEV

**Estimate of Probable Construction Costs
Level I Soft Water Conveyance System - Skunk Lake
Surface Water Mitigation
Nicolet Minerals Company**

Description	Quantity	Units	Unit Cost	Total Cost
6" HDPE pipe trenched in place	1,609	Linear Feet	\$14.00	\$22,526
3" HDPE pipe trenched in place	1,448	Linear Feet	\$13.00	\$18,824
Air Release/Vacuum Relief Structures	6	Each	\$2,500.00	\$15,000
Mitigation Water Delivery System - 3" Equip.	1	Each	\$10,290.00	\$10,290
Clearing and grubbing	0.069	Acre	\$9,750.00	\$673
Erosion control - silt fence	144	Linear Feet	\$1.25	\$180
Seeding, mulching and fertilizing	0.73	Acre	\$3,000.00	\$2,190
Total estimated construction cost				\$69,683

Prepared by: GEV
Checked by: TMM

**Estimate of Probable Construction Costs
Level I Hard Water Conveyance System - Creek 19-14
Surface Water Mitigation
Nicolet Minerals Company**

Description	Quantity	Units	Unit Cost	Total Cost
6" HDPE pipe trenched in place	3,096	Linear Feet	\$14.00	\$43,344
1 1/2" HDPE pipe trenched in place	5,340	Linear Feet	\$12.00	\$64,080
6" HDPE directional bored in place	720	Linear Feet	\$30.00	\$21,600
Air Release/Vacuum Relief Structures	8	Each	\$2,500.00	\$20,000
Mitigation Water Delivery System - 1 1/2" Equip.	1	Each	\$7,240.00	\$7,240
Clearing and grubbing	0.099	Acre	\$9,750.00	\$965
Erosion control - silt fence	380	Linear Feet	\$1.25	\$475
Crushed stone ATV roadway surface	37	Cubic Yard	\$25.00	\$925
Seeding, mulching and fertilizing	0.10	Acre	\$3,000.00	\$297
Total estimated construction cost				\$158,926

Prepared by: GEV
Checked by: TMM

Estimate of Probable Construction Costs
Level II Soft Water Conveyance System - Little Sand Lake & Duck Lake
Surface Water Mitigation
Nicolet Minerals Company

Description	Quantity	Units	Unit Cost	Total Cost
5" HDPE pipe trenched in place	789	Linear Feet	\$14.00	\$11,046
4" HDPE pipe trenched in place	1,656	Linear Feet	\$14.00	\$23,184
4" HDPE directional bored in place under road	30	Linear Feet	\$30.00	\$900
3" HDPE pipe trenched in place	6,275	Linear Feet	\$13.00	\$81,575
3" HDPE directional bored in place under road	30	Linear Feet	\$30.00	\$900
1 1/2" HDPE pipe trenched in place	1,959	Linear Feet	\$12.00	\$23,508
1 1/2" HDPE directional bored in place under road	30	Linear Feet	\$25.00	\$750
Air Release/Vacuum Relief Structures	6	Each	\$2,500.00	\$15,000
Mitigation Water Delivery System - 4" Equip.	1	Each	\$12,940.00	\$12,940
Mitigation Water Delivery System - 1 1/2" Equip.	1	Each	\$7,240.00	\$7,240
Clearing and grubbing	1.10	Acre	\$9,750.00	\$10,725
Erosion control - silt fence	392	Linear Feet	\$1.25	\$490
Crushed stone ATV roadway surface	99	Cubic Yard	\$25.00	\$2,475
Seeding, mulching and fertilizing	1.10	Acre	\$3,000.00	\$3,300
Total estimated construction cost				\$194,033

Prepared by: GEV
Checked by: TMM

Estimate of Probable Construction Costs
Level II Hard Water Conveyance System - Hoffman Creek/Hoffman Springs
Surface Water Mitigation
Nicolet Minerals Company

Description	Quantity	Units	Unit Cost	Total Cost
6" HDPE pipe trenched in place	10,624	Linear Feet	\$14.00	\$148,736
4" HDPE pipe trenched in place	7,407	Linear Feet	\$14.00	\$103,698
4" HDPE directional bored in place	1,510	Linear Feet	\$30.00	\$45,300
2" HDPE directional bored in place	307	Linear Feet	\$25.00	\$7,675
Air Release/Vacuum Relief Structures	9	Each	\$2,500.00	\$22,500
Mitigation Water Control Structure - 2" Equip.	1	Each	\$7,890.00	\$7,890
Clearing and grubbing	0.69	Acre	\$9,750.00	\$6,728
Erosion control - silt fence	811	Linear Feet	\$1.25	\$1,014
Seeding, mulching and fertilizing	0.69	Acre	\$3,000.00	\$2,070
Total estimated construction cost				\$345,611

Prepared by: GEV
Checked by: TMM

Appendix F

Transient Lake Mitigation Simulations

**HSI GEOTRANS
TECHNICAL MEMORANDUM**

TO: File

FROM: Greg Council *GC*

DATE: November 17, 1998

SUBJECT: Transient Lake Mitigation Simulations
HSI GeoTrans Project No. N015-021

Previous simulations made with the Crandon regional flow model have shown a stage decline due to zinc mining that is amplified under natural drought conditions (see Section 3.2.2 and 4.2.2 of our *Addendum No. 2 to: Numerical Simulation of the effect on groundwater and surface water of the proposed zinc and copper mine near Crandon, Wisconsin* document). To mitigate this effect, NMC is proposing to pump treated water into one or more of the four "internal" lakes (Deep Hole, Duck, Little Sand, and Skunk). New simulations were made with the regional model to show what effect such a mitigation plan would have.

BEJ Mitigation

Under a BEJ zinc mining scenario without mitigation (Figure 1 — a reproduction of Figure 3.21 of *Addendum No. 2...*), the stage of Duck Lake falls below its pre-mine stage by nearly 1 foot near the end of the simulated drought. Little Sand Lake shows somewhat less stage drawdown, and Deep Hole Lake has even less. Skunk Lake exhibits a seasonal pattern of stage drawdown that is not as dependent on drought conditions.

A new simulation was made with the BEJ model (49V) with mitigation of all four lakes simulated as additional runoff inflow. For Deep Hole, Duck, and Little Sand Lake, flow rates of 16, 5, and 61 gpm (respectively) were added to the lakes during the drought period only (from 2 years to 5.5 years in the 12-year simulation). For Skunk Lake, 31 gpm was added to the lake for the entire simulation. The mitigation flow rates for Deep Hole, Duck, and Little Sand Lake were determined from the steady-state mass balance table in *Addendum No. 2...* (Table 3.5, change in groundwater seepage). For Skunk Lake, the rate was based on an earlier analysis of steady-state mitigation (Technical Memorandum of September 25, 1998). Note that the area of Skunk Lake changes substantially for stage declines of around 1 foot.

The results of the new BEJ mitigation simulation are shown in Figure 2. As in Figure 1, the zinc-mining simulation results are shown on the same plots as the pre-mine simulation results. Compared with Figure 1, Figure 2 shows noticeably less stage decline at all lakes.

During the 3.5-year mitigation period simulated, there is a negligibly small difference between pre-mine and during-mine stage for Deep Hole, Duck, and Little Sand Lake. For Skunk Lake, the full-time mitigation simulation tends to reduce the natural stage fluctuations and keep the lake from drying up (as may occur naturally without mining).

PWC Mitigation

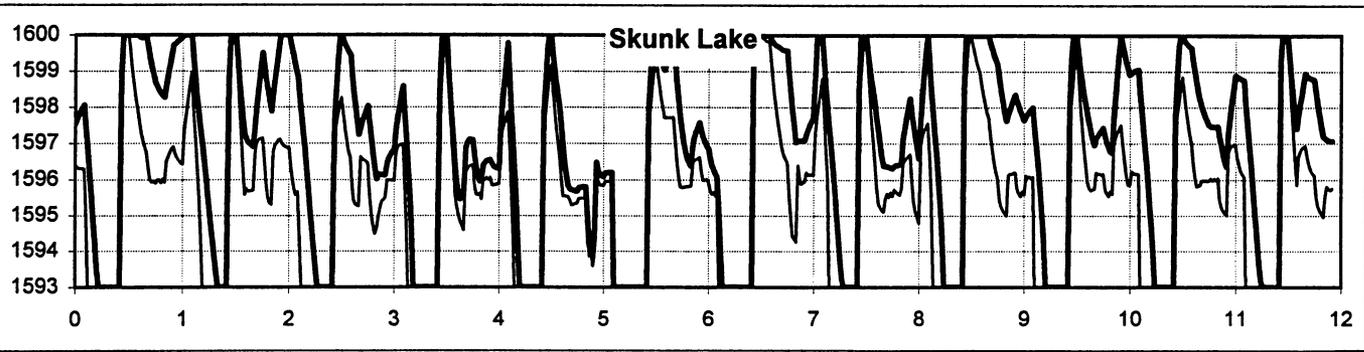
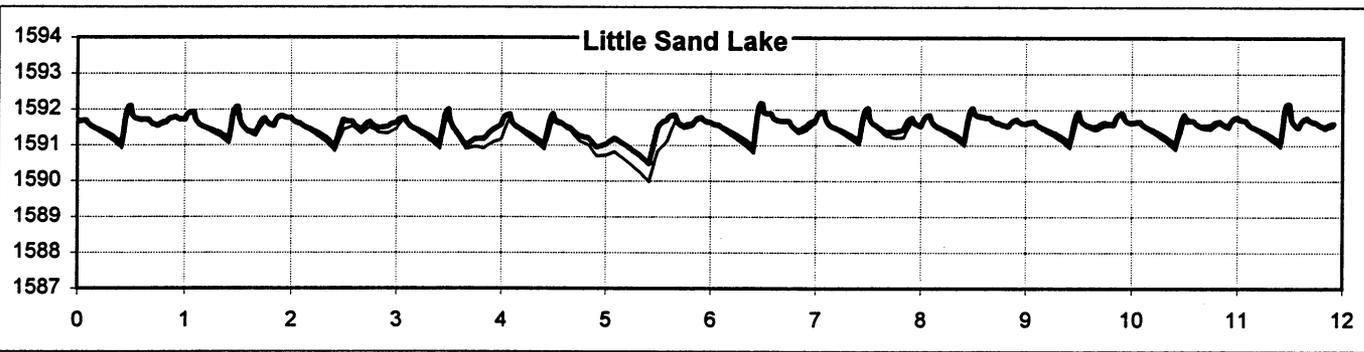
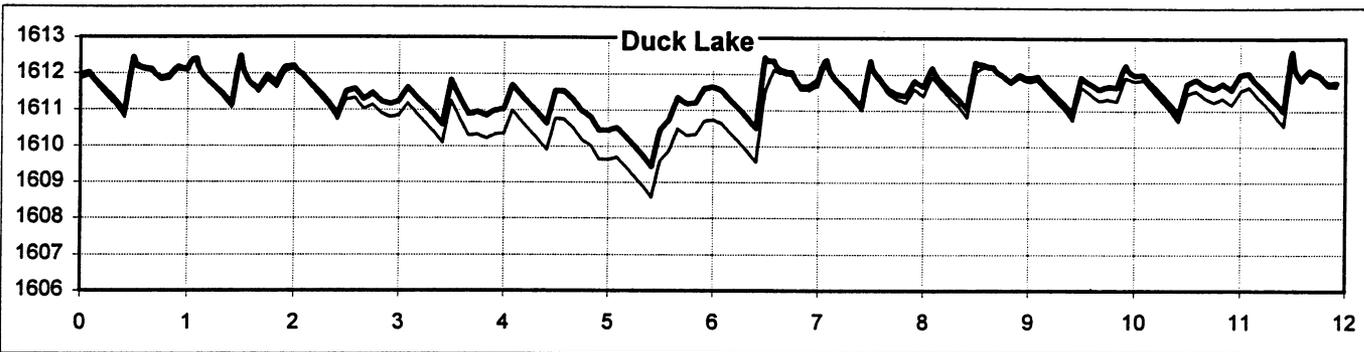
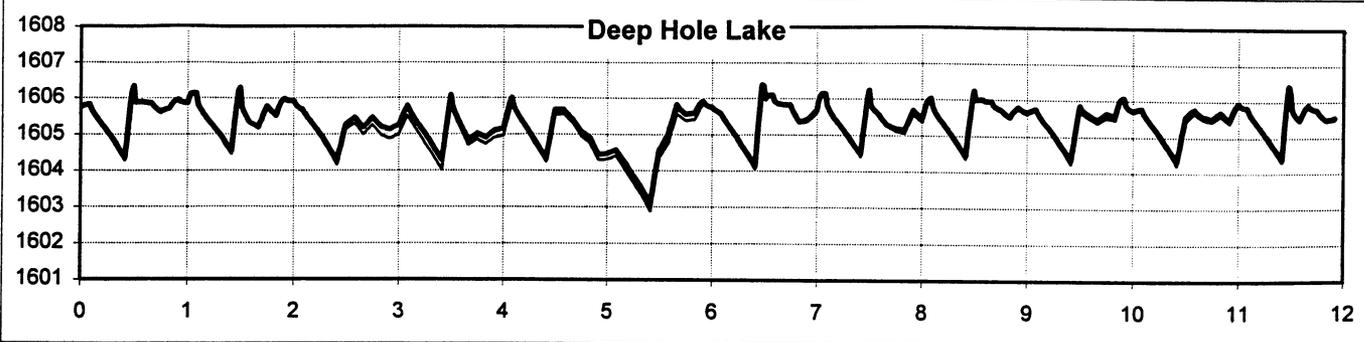
A new PWC mitigation simulation (50V) was set up similarly for comparison with the transient stage declines predicted without mitigation (Figure 3 — a reproduction of Figure 4.21 of *Addendum No. 2...*). In this simulation the drought-period flow augmentations for Deep Hole, Duck, and Little Sand Lake were 36, 8, and 134 gpm (respectively) (from Table 4.5 of *Addendum No. 2...*). The full-time mitigation rate for Skunk Lake was 50 gpm (from September 25, 1998 Technical Memorandum).

The new PWC simulation shows effective mitigation of stage declines for all four lakes (Figure 4, as compared with Figure 3). These results are qualitatively very similar to those of the BEJ mitigation simulation.

Conclusion

The BEJ and PWC mitigation simulations presented here show that stage declines at the four internal lakes can be mitigated by adding treated water directly to the lakes. In practice, NMC will likely propose to activate mitigation for a lake when the stage falls below a certain level instead of over a continuous period of years as simulated here. While these simulations do not include such detail, they do show that the listed flow rates will be effective under the most critical drought conditions.

Also, please note that these simulations show the combined effect of a natural drought and a fully-opened zinc mine. As such, the input results may be overstated (conservative) and the required mitigation rates may be lower.



Notes:
 1) Precipitation and Evaporation from Barr (1996), Nov-84 through Sep-96.
 2) Top line tracks stage without mining, bottom line tracks stage during mining.
 3) X-axes show time in years.
 4) Y-axes show modeled lake stage in feet above mean sea level.

Legend
 — Without Mining
 - - - Zinc Mining (No Mitigation)

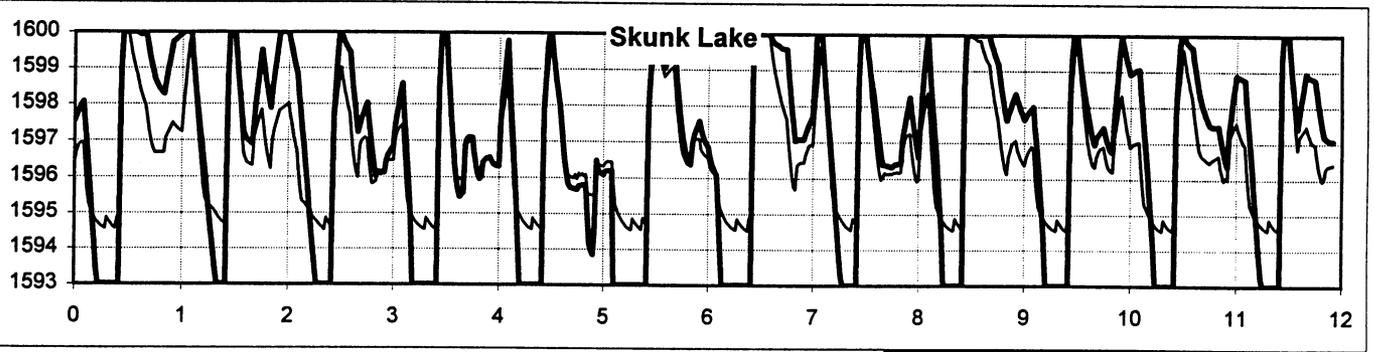
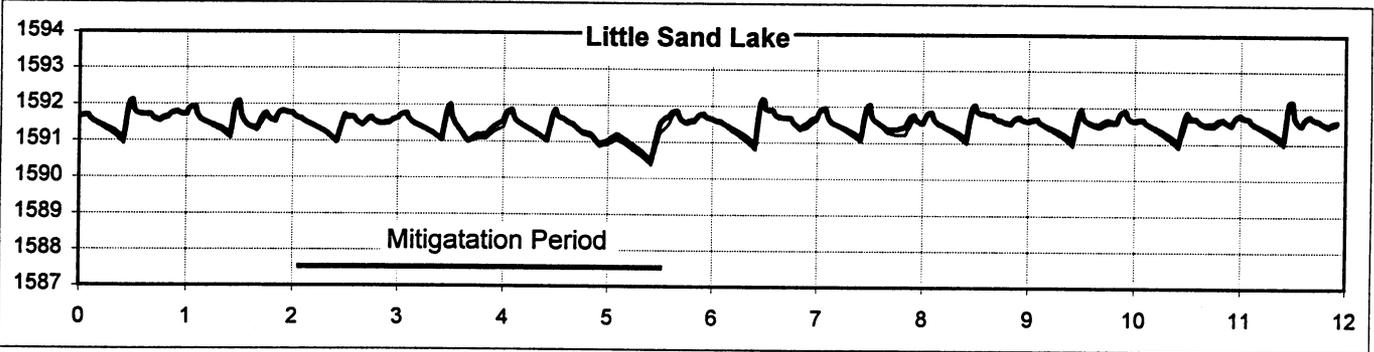
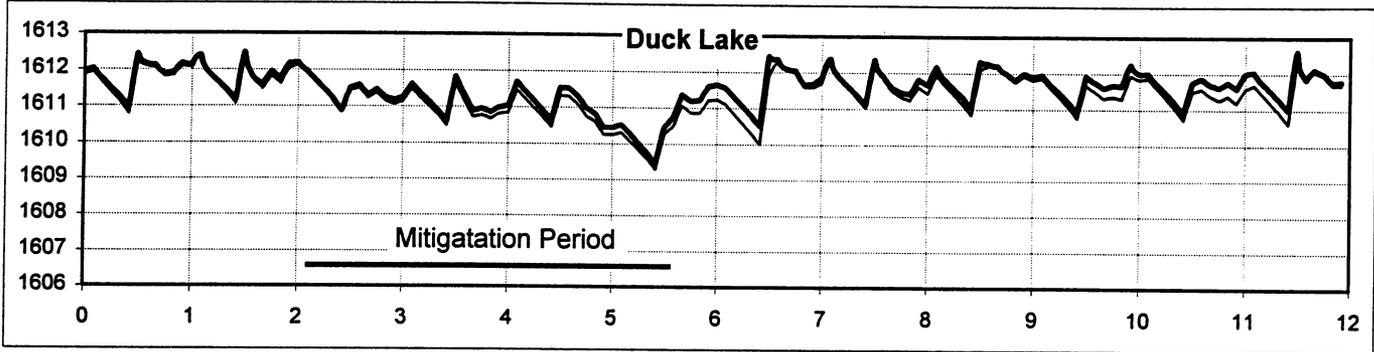
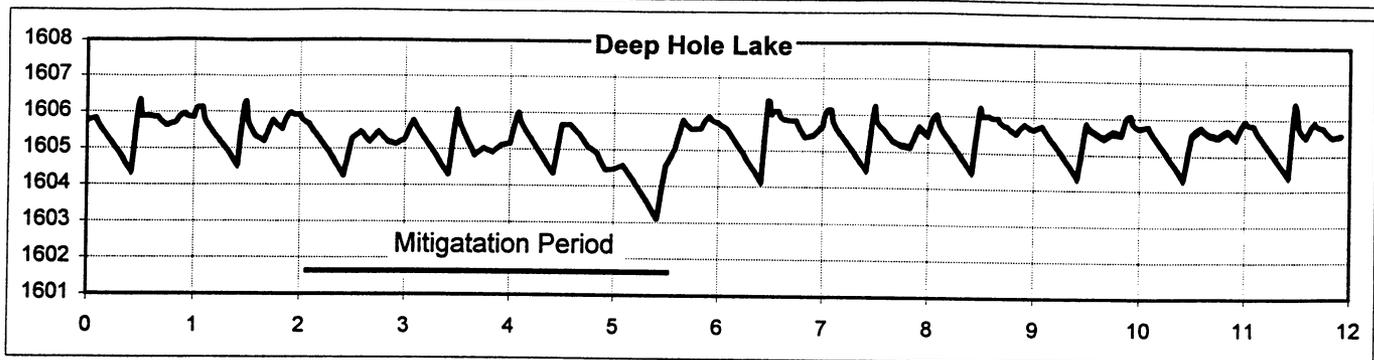
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CHECKED BY: KMR		DATE: Aug 98	
APPROVED BY: PFA		DATE: Aug 98	
Simulation 49R	APPROVED BY:		DATE:



Figure 1
 Modeled Transient Lake Stage
 Without Mitigation (BEJ)

Scale: None Date: Aug. 1998
 Prepared By: HSI GEOTRANS By: GWC



- Notes:
- 1) Precipitation and Evaporation from Barr (1996), Nov-84 through Sep-96.
 - 2) X-axes show time in years.
 - 3) Y-axes show modeled lake stage in feet above mean sea level.
 - 4) Skunk Lake is mitigated throughout the simulation.

Legend

———— Without Mining

- - - - - Zinc Mining + Mitigation

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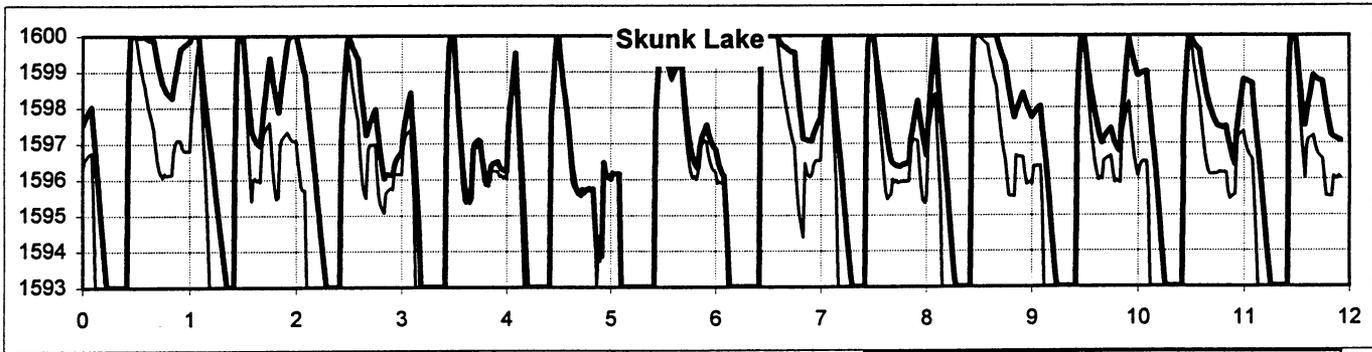
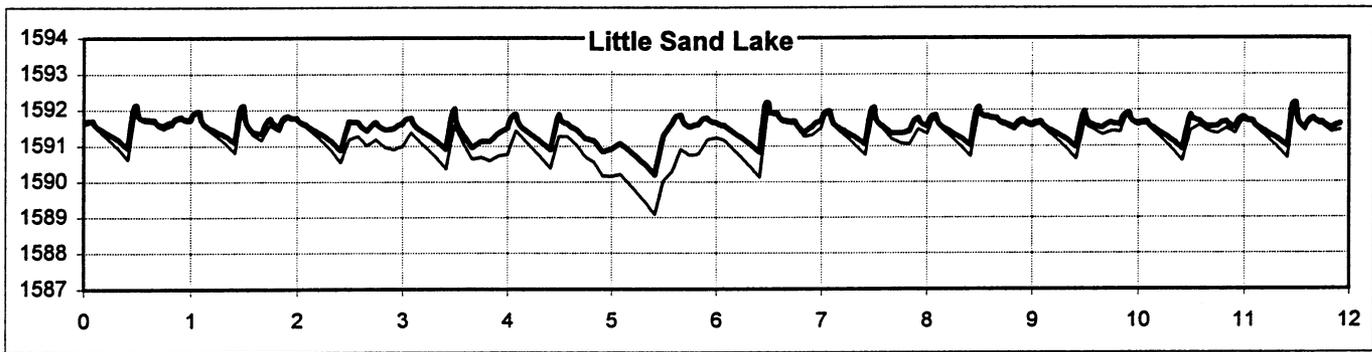
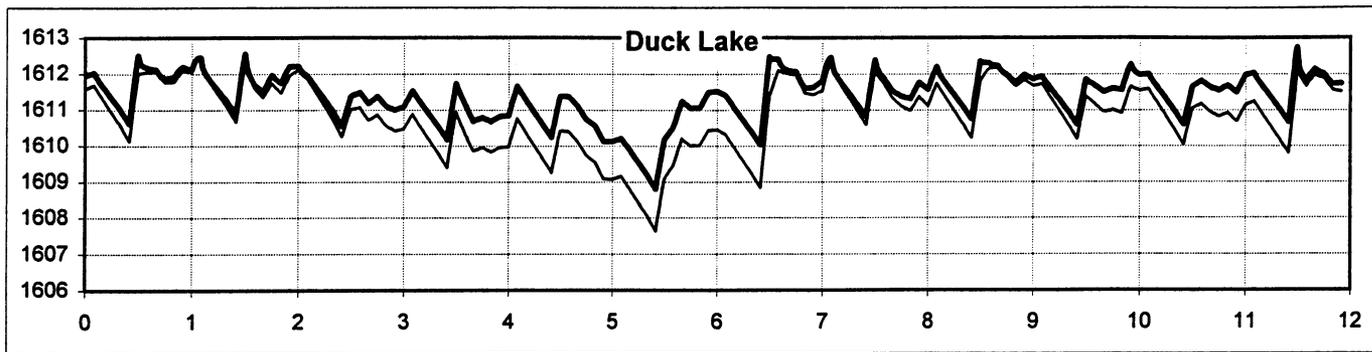
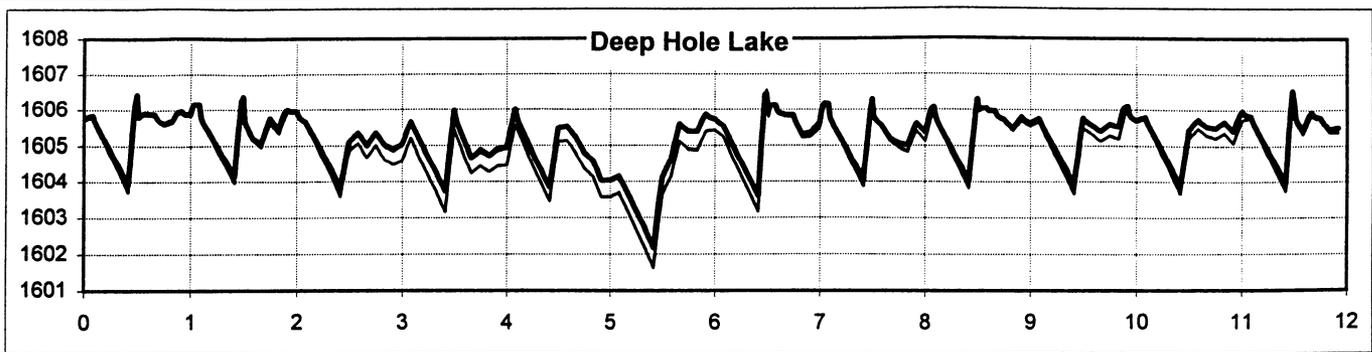
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		DATE:	



Figure 2
Modeled Transient Lake Stage
With Mitigation (BEJ)

Scale: None Date: Sep. 1998

Prepared By: HSI GEOTRANS By: GWC



Notes:
 1) Precipitation and Evaporation from Barr (1996), Nov-84 through Sep-96.
 2) Top line tracks stage without mining, bottom line tracks stage during mining.
 3) X-axes show time in years.
 4) Y-axes show modeled lake stage in feet above mean sea level.

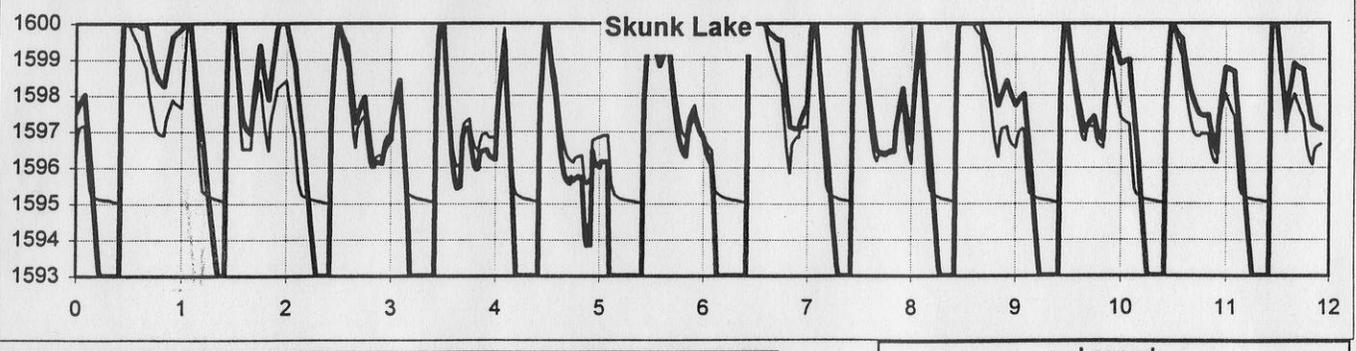
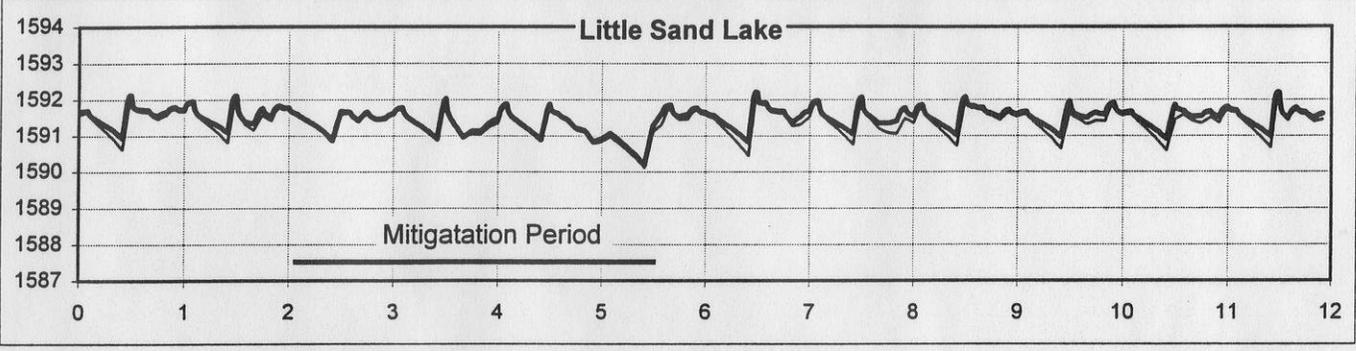
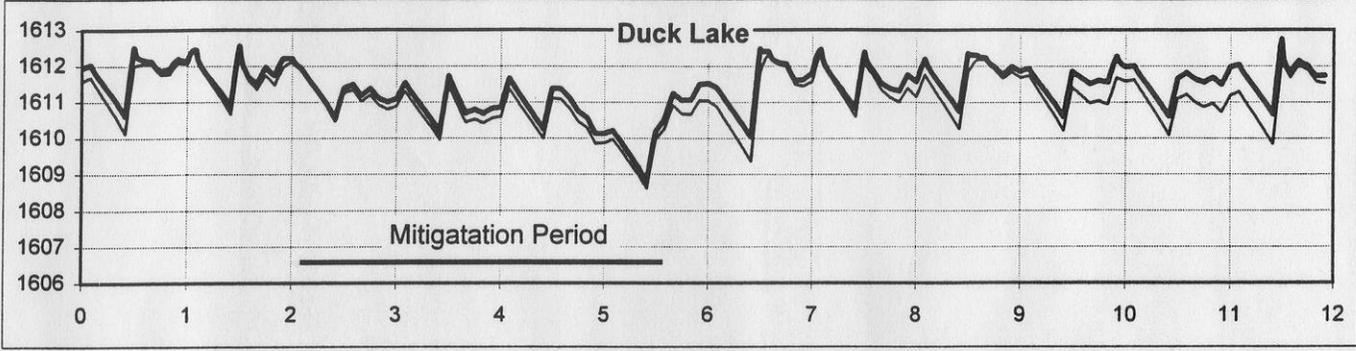
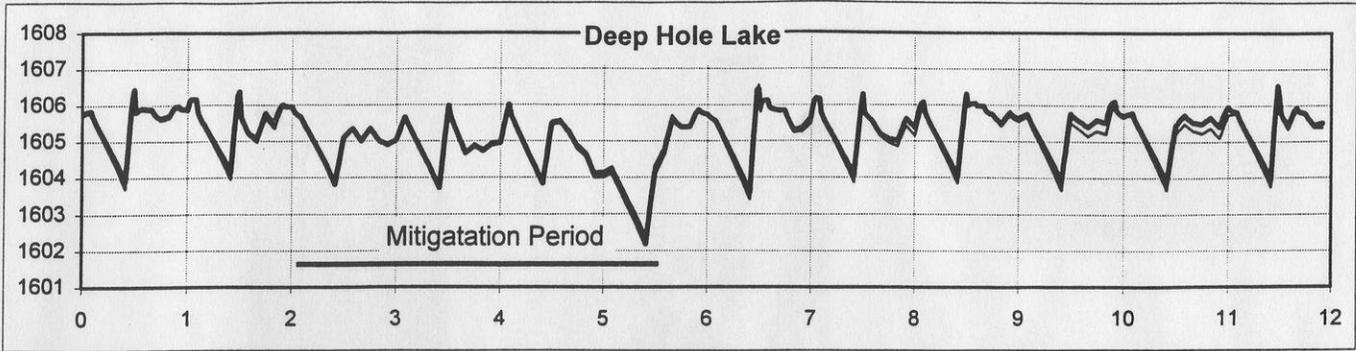
Legend
 — Without Mining
 — Zinc Mining (No Mitigation)

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APPROVED BY: PFA		DATE: Aug 98	
APPROVED BY:		DATE:	



Figure 3
Modeled Transient Lake Stage Without Mitigation (PWC)
 Scale: None Date: Aug. 1998
 Prepared By: HSI GEOTRANS By: GWC



Notes:

- 1) Precipitation and Evaporation from Barr (1996), Nov-84 through Sep-96.
- 2) X-axes show time in years.
- 3) Y-axes show modeled lake stage in feet above mean sea level.
- 4) Skunk Lake is mitigated throughout the simulation.

Legend
 — Without Mining
 - - - Zinc Mining + Mitigation

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Figure 4
Modeled Transient Lake Stage
With Mitigation (PWC)

Scale: None Date: Sep. 1998
 Prepared By: HSI GEOTRANS By: GWC