Northshore Mining Company

Operations Plan For Milepost 7 Tailings Basin

November 28, 1995

N57.2

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Thomas G. Harper, Reg. No. 23479

Date: 11-28-95

TABLE OF CONTENTS

SITKA CORP

FIGURES

1. INTRODUCTION

This plan has been prepared to provide both Northshore Mining Company (Northshore) and regulatory agencies with guidelines on the operation of the Milepost 7 tailings basin located west of Silver Bay, Minnesota. Taconite tailings generated in the concentrating facility at Silver Bay are transported to, and contained in, the Milepost 7 basin.

This report presents a summary of operations to date and anticipated production. It also presents plans to transport and deposit tailings, control water accumulation, raise dams, reclaim water to the concentrator, maintain water quality in the discharge and prepare for closure. Details of dam construction will be presented in 1996 following a geotechnical investigation of the fine tailings and natural foundations.

A report, "Five Year Operating Plan For The Milepost 7 Tailings Basin," was issued by Barr Engineering and Sitka Corp in December, 1994. Since then, Northshore has decided to increase production, requiring modifications to the planning at Milepost 7. This operations plan has been prepared on the basis of guidelines set out at a meeting with Northshore Mining Company on June 1, 1995.

2. CONSTRUCTION TO DATE

Construction of the Milepost 7 tailings impoundment commenced in 1977 with stream diversions and starter dams constructed of borrow material. Three seepage recovery dams, pump stations and return pipelines were constructed by 1979.

Initially three splitter dikes were constructed across the tailings basin to allow discharge of fine tailings in the center of the basin. Splitter dikes were first constructed with sand and gravel then raised with coarse tailings. Splitter dike 2 was abandoned in 1980 and dikes 1 and 3 were raised above the water until 1986.

Tailings dams were last raised in 1986 to approximately elev. 1995 feet. The design criterion of being able to store a probable maximum flood (PMF) with three feet of freeboard has been maintained.

A water treatment and release plant was constructed and has been operated since July 1985.

Additional diversions have been constructed as recently as March 1992 to reduce inflow of water to the basin.

Current facilities at the basin are shown on Figure 1 at the end of this report.

3. OPERATIONS TO DATE

Coarse tailings hauling to Milepost 7 commenced October 3 1979, by train with the coarse tailings used to raise the dams and splitter dikes. Fine tailings pumping began June 25 1980. Fine tailings were discharged from the dams and splitter dikes 1 and 3 from 1980 until June 1986.

Operation of the concentrator ceased in June 1986 with the bankruptcy of Reserve Mining Company, and resumed in January 1990 under the ownership of Cyprus Northshore Mining Corporation. The operation was purchased by Cliffs Minnesota Minerals Company on September 30, 1994, and is operated as Northshore Mining Company.

The Milepost 7 basin operation resumed in 1990 under a plan known as the "Closure Consensus Plan". This plan was based on depositing the tailings to fill the basin while reducing the volume of free water and thereby reducing the long term liability for closure. The Closure Consensus Plan was predicated on a production of 3.0 million tons of pellets (approximately 2.89 million tons of concentrate) annually for 5 years. In August 1995 the production target for the Closure Consensus Plan was achieved.

The initial tailings basin design (Klohn Leonoff, 1976) was based on storing the tailings from 40 years of mine operation at an iron pellet production rate of 9.6 million long tons per year (MMLTPY). In the early 1980s, production of concentrates was reduced. This reduction in production, combined with higher than average precipitation resulted in excess water accumulating in the basin. At the same time, the availability of coarse tailings to raise the dams was limited. In order to control the accumulation of water and maintain freeboard for the dams, a water treatment and release plant was constructed and has operated since July 1985. This plant has been successful in controlling water buildup and forms an integral part of the plan for ongoing operations. Discharge of treated water has averaged 2,800 gallons per minute (gpm) year round, with the rate being higher in the summer than in winter.

In 1986 when the concentrator operations were shut down, water accumulated in the basin, reaching a peak of elev. 1184.2 in December 1986. Since that time, with ongoing operations and continued water treatment and release, the water pond has been reduced to elev. 1182.0 at July 1995. A comparison of the elevations, areas and volumes of the free water is presented in Table 3.1 below. The volume is approximate, as it is based on the DNR hydrometric survey of the pond in 1986. This survey, is known to have some inaccuracies, but is the only survey available.

Table 3.1, Pond Details, 1986 and 1995

	December 1986	June 1995
Pond Elevation, ft.	1184.2	1182.0
Pond Area, acres	1400	1173
Free Water Volume, ac-ft	34,000	23,000
Average Free Water Depth, ft	31.9	20.0

Fine tailings deposition since January 1990 has been from dams 1 and 2, with beaches being formed out into the basin, shrinking the pond volume and area. Coarse tailings have been placed over the beaches to control dusting potential and to provide access for spigotting. Currently fine tailings extend from 900 to 2,400 feet from dam 1, and 800 to 1,800 feet from dam 2 as shown on Figure 1. Coarse tailings areas extending into the basin cover 160 acres at dam 1 and 120 acres at dam 2. At dam 5A a very small beach of tailings exists beyond the dam.

Northshore desires to continue operations and expand production, not close the basin as planned in the Closure Consensus Plan. The concept of ongoing operations was envisaged in the Closure Consensus Plan and it was recognized that operation of the tailings basin would have to change when production went beyond that planned for the Closure Consensus Plan.

4. ANTICIPATED PRODUCTION

Northshore anticipates production of concentrate at the following rates:

- 1995 and 1996, 4.34 million LTPY
- 1997 and beyond, 5.30 million LTPY

Actual tonnage of concentrate produced can vary depending on ore grade, type of pellets being produced and other factors. The plant has the capacity to produce 6.0 million LTPY of concentrate.

Plans that are being considered by Northshore to implement forms of production other than those in current use, such as direct reduced iron, will not materially affect production tonnage and would cause only minor adjustments in tailings generation.

Tailings generated from the concentration operation will be proportionate to the concentrate production rate and are expected to be as follows:

- Fine tailings, 1.19 times the concentrate production, and
- Coarse tailings, 0.65 times the concentrate production

Therefore in 1995 and 1996, annual fine tailings generation anticipated is 5.18 million long tons, and coarse tailings 2.84 million long tons. In subsequent years, annual fine tailings generation is anticipated at 6.32 million long tons, with 3.47 million long tons of coarse tailings.

5. PROPOSED OPERATIONS

Fine tailings will continue to be transported to the basin in slurry form and discharged from the dams. Coarse tailings will continue to be hauled by train from Silver Bay and placed over the fine tailings, leaving beaches of fine tailings about 300 feet wide between the coarse tailings and the pond water.

Water will continue to be withdrawn from the pond and pumped to the concentrator. Treatment and release of tailings pond water will continue to be an integral part of maintaining a water balance. Splitter dikes will not be raised and in time will be submerged by the rising pond. As the pond rises, coarse tailings will be used to raise the dams to maintain storage for the fine tailings, flood inflow and freeboard.

At the production rate presently proposed, the basin has capacity to store tailings for about 60 years of production before reaching the 1976 design maximum elevation of 1306 feet.

6. DISCHARGE OF FINE TAILINGS

Fine tailings have been discharged since January 1990 from dams 1 and 2, forming wide, irregularly shaped beach areas a little above the pond water level. Most of the fine tailings beaches have been covered with coarse tailings. In the remainder of 1995 and into 1996 the fine tailings spigotting will fill the areas adjacent to dams 1 and 2 to a distance of 1700 feet from the dams. An active beach width of about 300 feet will remain after the coarse tailings are extended to 1400 feet from the dams. Once the beaches have been developed at the design locations for dams 1 and 2, fine tailings will be spigotted into the pond at dam 5A and extended out to 1700 feet from that dam. Spigotting will be rotated along each of the beaches in such a way as to raise the beaches uniformly.

Fine tailings will flow from the discharge areas into the pond with the bulk of the tailings being deposited underwater. It will be necessary to cut gaps in the splitter dikes to allow fine tailings to be distributed into the center cell of the basin.

Current practice for distributing fine tailings around the beaches is to discharge for several weeks at a time from one full pipe spigot before relocating. In future, smaller spigots will be required, placed at closer intervals. The time of discharge from each spigot will be restricted so that the beaches are raised uniformly around the basin. Once the beaches have been established at the prescribed distance from the dams, distribution pipes can be installed and short header lengths used to feed each spigot. Alternatively, a single full pipe spigot can be used if it is relocated more often than in the past. Over time, the distribution piping will need to be relocated small distances toward the pond as the water rises. As the dams are extended into the pond, some slurry discharge from floating locations in the pond may have to be considered in addition to the discharge from the dams to distribute fine tailings uniformly in the basin.

Once fine tailings beaches have been established at all the tailings dams, they will continue to be raised by spigotting, maintaining the pond at about 300 feet from the spigot locations.

By maintaining the beaches at 300 feet wide, the fine tailings will not extend far above the pond water elevation and dust generation will largely be controlled by wetting of the fine tailings through capillary rise. Areas of beach being actively spigotted will be wetted by the slurry flow. Any areas where dust generation could be a problem will be controlled by vegetation, application of chemical dust suppressant or other methods.

7. COARSE TAILINGS HANDLING

Coarse tailings will continue to be rail hauled to the basin and used to cover the fine tailings and to raise dams. Once dumped from the trains, coarse tailings will be hauled into position with loaders and trucks. There is potential to utilize conveyors for distributing the coarse tailings.

The current railroad embankment along the west side of the basin will continue to be the arterial access for several years. This embankment will be raised using coarse tailings to maintain the grade at or above the dam crests. When this embankment is at elev. 1220, it will be about 25 feet high with water on both sides. At about this stage the railroad will be reconstructed further west, upslope from the present alignment.

At present there are two railroad spurs on the tailings beach at dam 1. At dam 2 a spur will be constructed on the tailings south of the dam. When coarse tailings are required at dam 5A, an extension of the dam 2 line could be constructed along the east side of the basin.

As the pond rises, the dams will be raised using coarse tailings to maintain the design flood storage and freeboard. The downstream slopes on the coarse tailings will be constructed as required to maintain dam stability.

8. WATER BALANCE

8.1 General

Operation of the concentrator plant and the tailings basin are linked, with both being run as closed circuit operations except for water release through the treatment plant at the basin. The only location for storage of water in both systems is in the tailings basin. Key elements of the tailings basin water balance are: the Silver Bay plant water balance, which is dependent on concentrate production; the basin catchment and hydrology; the storage capacity of the basin; and the water release.

8.2 Silver Bay Plant Inflows And Outflows

Water inflows and outflows to the Silver Bay plant are linked to concentrate production rates. These have been determined by Northshore for the proposed production rates and are as shown in Table 8.1:

Table 8.1, Plant Water Flows in GPM

Concentrate production rate	**4.34 MMLTPY**	**5.30 MMLTPY**
Electrostatic precipitators	-455	-560
Concentrate drying	-246	-301
Product moisture	-67	-83
Filtered tailings	-52	-63
Dry cobb tailings	-7	-8
Slurry water	-6676	-6488
Ore feed	+46	+56
Plant runoff	+195	+195
Reagent water	+91	+111
Power house usage	+285	+285
Dust control & concentrate cooling	+600	+733
Misc. inflows	+300	+300
Reclaim water	+5986	+5823
Balance	0	0

Flows into the plant are shown as (+); flows out of the plant are shown as (-).

For a given concentrate production rate, the plant water balance is fixed. As the plant has no capacity for water storage, it must operate with balanced inflows and outflows and the rate of reclaim water flow is varied to achieve the plant water balance. Net flow of plant water into the basin is the difference between the slurry water flow and the concentrator reclaim flow as shown in Table 8.2.

Table 8.2, Net Plant Water Inflow To Basin

Concentrate Production Rate MMLTPY	Slurry Water Flow GPM	Concentrator Reclaim Flow GPM	Net Water Inflow To Basin GPM
4.34	6676	5986	690
5.30	6488	5823	665

8.3 Catchment Areas

The catchment of the tailings basin prior to construction of diversions was 31.3 square miles (20,030 acres). Stream diversions constructed prior to 1980 to probable maximum flood (PMF) standards diverted 22.6 square miles (14,460 acres). A diversion of Little 39 Creek to 1000 year return design storm standard was also constructed. A diversion along the west side of the basin was constructed in March 1982, to 10 year return flood design standard, diverting an additional 1360 acres. Additional diversions were constructed at the seepage recovery dams and at the west end of dam 1 in 1979, 1980 and 1992 to minimize water inflow to the basin. These diversions are shown on Figure 1.

Catchment areas for the basin have been reduced such that the catchment for a PMF is 8.7 square miles (5,570 acres), and the catchment for average hydrological conditions is 3,350 acres (including seepage recovery dam catchments).

The 3,350 acre catchment is used for water balance calculations. This catchment will remain fixed until the dams approach elev. 1210. At that time (approximately year 2002) the west side diversion will be taken out of service and replaced with diversions located further upslope.

For the water balance calculations, the areas discussed above were utilized along with tailings areas taken from a Northshore survey made on August 22, 1995.

8.4 Hydrology

Hydrologic parameters were first developed to assess the water balance in the basin as part of the 1976 design. With the reduced production in the 1980s and the resulting water accumulation, these parameters were reviewed in detail (Klohn Leonoff, August 1987). It was concluded that some of the parameters used in 1976 warranted minor changes based on measurements made since that time. Design mean annual parameters recommended were as follows:

- Precipitation, 28 in;
- Evaporation, 26.5 in;
- Runoff from uncleared areas, 14 in;
- Runoff from cleared areas, 17 in;
- Runoff from all tailings areas, 25 in.

The runoff from all tailings areas represents a blend of 23 inches on fine tailings, 28 inches on unvegetated coarse tailings, and 14 inches on vegetated coarse tailings.

It was concluded in the August 1987 report that accurate predictions of future pond levels and release requirements can be made using the revised hydrologic inflows and outflow parameters and that there are no major unaccounted inflows to, or outflows from, the tailings basin.

8.5 Fine Tailings Properties

Fine tailings dry density after settling has been assumed as 92 pounds per cubic foot (pcf) based on Klohn Leonoff, May 1985. With a specific gravity of 3.1, the fine tailings porosity, which determines the amount of water stored in the voids, is 0.524.

Fine tailings being deposited in the basin displace water as well as providing void space that stores water permanently. By using the fine tailings porosity, the rate of displacement of water and the rate of storage of void water were calculated.

Discharge of fine tailings results in an increasing elevation of fine tailings which in turn increases the water elevation. The water between the fine tailings level and the pond water surface is supernatant or free water. This is the only place in the plant and basin system where free water can be stored.

8.6 Tailings Basin Water Balance

A water balance has been run for each year from mid-1995 until the year 2003 to determine the pond elevation. This will be used to plan the required dam raising and water release. Annual flows to, and from, the basin have been determined. Water inflow from upland runoff, direct precipitation on the pond, and evaporation from the pond surface were all based on the hydrology as reported in Section 8.4.

The tailings basin is influenced by both the rate of production and the natural hydrologic cycle. Plant water balance flows determined by Northshore give slurry water and reclaim flow rates as shown in Table 8.2.

Inflows to the basin increase the pond elevation, and outflows reduce the pond elevation. The volume of free water is directly affected by the rate of discharge of water from the basin.

Annual average runoff and evaporation rates have been reported in Section 8.4. Other variables include the pond area, area of tailings and area of cleared and uncleared catchment.

Conditions at August 1995 are as follows:

• Tailings dam crest elevation	1195 feet
• Pond water elevation	1182.0 feet
• Area of water pond	1121 acres
• Reclaim basin water area	57 acres
• Area of coarse tailings upstream of dams	280 acres
• Catchment area inside diversions	3350 acres
• Free water volume in the pond	23,000 acre feet
• Average water depth in pond	20.0 feet

A summary of the pond inflows and outflows, and the calculated pond water elevations at the end of each year are presented in table 8.3.

Table 8.3, Tailings Basin Water Balance

Year	1995 [1]	1996	1997	1998	1999	2000	2001	2002	2003
Concentrate production[2]	4.34	4.34	5.30	5.30	5.30	5.30	5.30	5.30	5.30
Pond elev., Jan 1	1182.0	1182.5	1183.4	1184.7	1187.7	1190.7	1193.5	1196.4	1199.1
Pond area, ac.[3]	1178	1178	1111	1139	1204	1268	1329	1270	1285
Tailings area, ac.	450	450	545 [4]	545	545	545	545	625 [5]	625
Uncleared area, ac.	1722	1722	1694	1666	1601	1537	1476	1455	1440
Runoff [7]	+1474	+2944	+3111	+3079	+3003	+2928	+2857	+3000	+2982
Pond precip. minus evap. [7]	+74	+147	+139	+142	+151	+159	+166	+159	+161
Slurry water minus reclaim	+554	+1108	+1070	+1070	+1070	+1070	+1070	+1070	+1070
Fine tailings	+1446	+2892	+3535	+3535	+3535	+3535	+3535	+3535	+3535
Water to voids	-756	-1513	-1850	-1850	-1850	-1850	-1850	-1850	-1850
Water release [8]	-2254	-4508	-4508	-2441	-2374	-2307	-2243	-2379	-2363
Net change	+538	+1080	+1497	+3535	+3535	+3535	+3535	+3535	+3535
Pond elev., Dec 31	1182.5	1183.4	1184.7	1187.7	1190.7	1193.5	1196.4	1199.1	1201.9

Notes on Table 8.3:

1. The calculations for 1995 are for July to December only
2. Concentrate production is million LTPY
3. Pond area includes the reclaim basin water area through year 2001
4. Dam 5A spigotting to start in 1997. Tailings area includes 60 acres of splitter dikes
5. In year 2002, dams 1E and 5B to be spigotted, and splitter dikes will become submerged
6. All quantities unless otherwise noted are acre-feet per year

7. All rates are for annual average hydrologic conditions

8. Release rate in years 1995 through 1997 is 2800 gpm (4508 acre-feet per year), then drops to match the rate at which supernatant water is generated, in the range of 1400 to 1500 gpm

9. Plus sign indicates flow adding to pond volume; minus sign indicates flow decreasing pond volume

10. Catchment cleared area assumed to be zero as areas cleared in the 1970s are now revegetated

8.7 Discussion

Water is currently treated and released at the rate of 2800 gpm. From the plant shutdown in June 1986, and through the low production years from 1990 through 1994, this rate of release has been successful in reducing the volume of supernatant water. As production continues, the surface of the submerged fine tailings will be rising faster than the water surface. In the short term the volume of supernatant water will continue to be reduced, and the average depth of water over the fine tailings will be reduced. This rate of release cannot be continued indefinitely as the depth of supernatant water pond would be drawn down to the point where either the fine tailings beaches would have to be increased in width, or the coarse tailings sections would have to be moved in closer to the pond.

Once the rate of release is reduced in 1998, the annual rate of rise of the pond will increase from 1.0 feet to about 3.0 feet under average hydrologic conditions. In wetter than average years the water would tend to rise at an increased rate, but this could be controlled by increasing the release rate from the treatment plant.

Should the concentrate production rate vary from that anticipated, then the water release rate would have to change in order to maintain a fixed volume of supernatant water. Higher production rates decrease the net plant water flow to the basin, and provide increased tailings void volume in which water is stored. This improves the water balance and decreases the required rate of release of water. At lower production rates, the required release rate increases.

The rising water level in the basin drives the need to raise the dams to maintain the PMF storage with freeboard. Dam raising is required by the end of 1997.

9. WATER DISCHARGE QUALITY

The quality of the water released from the tailings basin is covered by the terms of a National Pollutant Discharge Elimination System (NPDES) permit. Water flows from the tailings pond to the reclaim basin, then is pumped to the water treatment plant, treated and released downstream of dam 1.

Discharge of fine tailings into the pond causes turbidity in the water. Water in the reclaim basin is currently separated from areas where fine tailings are discharged by splitter dikes and a filter dike designed to clarify the flow. Tailings water has four opportunities to be clarified prior to being pumped to the treatment plant: firstly by detention in one of the tailings cells, secondly by flowing through a splitter dike, thirdly by detention in cell 2-3, and fourthly by having to flow through the filter dike. As both the treatment plant influent and the concentrator reclaim pump share the reclaim basin, the total flow through the filter dike has been up to 9,000 gpm. In the past year the splitter dikes and filter dike have become progressively blinded by fines as evidenced by increasing head differentials required to develop the flow through the dikes. Northshore has made a variety of efforts to enhance the through flow, but because the tailings cells are being reduced in size by deposition, the detention times have been reduced and the clarification has become less effective.

Because of the way the treatment plant operates, quality of water in the discharge is proportional to the quality of the treatment plant influent. It is therefore important to maintain the quality of the influent to the water treatment plant.

Several options to maintain the quality of the water flow to the water treatment plant and the concentrator reclaim pump station are being evaluated by Northshore including the following:

- extension of the concentrator pump intake into cell 2-3 to reduce the flow through the filter dike
- improvement of the filter dike cross section
- use of flocculant to clarify tailings pond water
- relocation of the concentrator reclaim pump station to the west side of the basin, utilizing the railroad embankment as a filter dike

10. WATER TREATMENT PLANT

In 1983 production of iron concentrates at Silver Bay was curtailed and, as a result, water began accumulating in the basin. A water treatment and release facility was constructed and commenced operation in July 1985. Since then, ongoing release of water has been a central part of controlling pond water elevations particularly in the shutdown period June 1986 to December 1989.

The water treatment plant has an output capacity of approximately 3,500 gpm. The rate is higher in summer with warm influent water and lower in the winter. A year round release rate averaging 2,800 gpm has been maintained to date taking into account maintenance and repair downtime as well as the seasonal variations.

In the near future, the release rate for the treatment plant will be maintained at the maximum year round rate of 2,800 gpm. This rate will continue to reduce the volume and average depth of supernatant water in the pond, as described in Section 8.7. Continued reduction of the volume of supernatant water beyond 1997 would interfere with tailings deposition and cause the fine tailings beaches to increase in width. It is estimated that by 1998 the release rate will have to be reduced to the rate of generation of supernatant water, calculated to be in the range of 1,400 to 1,500 gpm.

If operations were to cease in the near future, a release rate of approximately 1,900 gpm would be required under average hydrologic conditions to maintain a constant water elevation. Release of water is required on an ongoing basis, during operations as well as during any temporary closures, and as part of water control in final closure.

11. DAM RAISING

11.1 General

Tailings dam crests are presently at elev. 1195, and are capable of meeting the design criterion of storing the PMF with three feet of freeboard. This design criterion can be met until 1997 when the dams will have to be raised above elev. 1195 because of the rising water level.

11.2 Revised Dam Design

The tailings dam designs were detailed in the original tailings disposal report (Klohn Leonoff, August 1976). Since then the designs have been updated as foundation performance data became available and tailings production changed. A substantial body of detailed designs, construction records and instrumentation performance data has been compiled in the 19 years since the initial designs were completed.

SITKA CORP

The existing design includes three main dams to contain the fine tailings, all constructed from borrow material and coarse tailings. Dams 1 and 5 have an upstream till facing and are designed to be raised by downstream methods; dam 2 has a central till core and is designed to be raised by centerline methods. The original 1976 design required all fine tailings to be placed underwater and kept in a flooded condition.

For the 1988 Closure Consensus Plan, the design was altered to allow formation of fine tailings beaches above water. This modification allowed a reduction in the volume of pond water while maintaining sufficient storage for the PMF. The plan calls for the fine tailings to be covered with coarse tailings, or other means to control fugitive dust.

By 1997, the dams will have to be raised to contain the anticipated tailings production and the PMF. In the 1976 design, where all fine tailings were submerged, this would have meant raising the dams by downstream or centerline methods (depending on the dam), and raising the till facing (or core) to contain the PMF. However, with exposed beaches as agreed to in the Closure Consensus Plan, it is reasonable to consider raising the dams in the upstream direction.

This method, used at other tailings impoundments on the Iron Range, achieves the goals of reducing the free water volume and providing storage for the PMF. As an added advantage, it will not encroach on the valley bottom beyond the existing dam toes. This will allow the dam slopes to be revegetated as the embankments are raised, will minimize future wetlands disturbance downstream of the dams, and will minimize closure liability.

As stated earlier, no dam raises are required until 1997. During 1996, the design of future upstream raises will be developed. Design parameters for undrained strength analyses (Ladd, 1991) will be needed and will be developed from geotechnical drilling and testing to be performed through the coarse tailings, and into the fine tailings and clay foundation. The new parameters will be validated by analyzing the existing design and comparing the results with the performance of the existing structures. Sufficient engineering work has been performed to determine that upstream construction is a feasible approach to raising the dams for the life of the mine; development of the design details for the dam raising remains to be completed. The upstream method of dam raising provides much flexibility in the dam cross-section, allowing adjustments to be made as raising progresses and as performance data become available.

In the upstream configuration, the coarse tailings will form the outer shell of the embankment and will provide the structural support for the fine tailings. Based on the expected production volumes, the coarse tailings shell will be about 1,400 ft wide. Since the coarse tailings will be placed mechanically, it will be possible to ensure (with compaction, if necessary) it has the required strength to contain the fine tailings and a PMF.

Does this mean that CT interface can be exposed to free water? What then about the SRD freeboard!

Over the next two years, fine tailings beaches will be extended into the pond to provide a base for the 1,400-ft-wide coarse tailings shell. The exposed fine tailings will be covered with coarse tailings, reducing the potential for dust. After this two-year period, when the upstream dam raises commence, the fine tailings will be spigotted from the upstream edge of the coarse tailings shell; that is, about 1,400 ft from the downstream face of the embankments as shown on Figure 3. The resulting beaches will be about 300 ft wide, similar to those constructed under the Closure Consensus Plan.

The downstream limit of the raises will start approximately 100 ft inside the present upstream dam crests as shown on Figure 3. This distance will allow for collection and conveyance of seepage through the coarse tailings shell. Seepage through the foundation will continue to be collected in the seepage recovery reservoirs below the dams.

Increased seepage at later stages or closure. For how long will the company

Upstream construction eliminates the need for glacial till construction, allows for concurrent reclamation of the dam slopes, shrinks the pond and reduces the ultimate closure liability. This method of dam raising requires careful consideration of flood storage capacity, stability of the dams, and mass balance of the fine and coarse tailings. These issues are all addressed in this report.

11.3 Geotechnical Design Criteria

The geotechnical design criteria for the next two years will remain identical to those agreed to in the Closure Consensus Plan. No dam raises are planned during this period, and no investigations have been done to provide new data. A summary of the geotechnical parameters used in the last stability analysis (Klohn Leonoff, May 1985, Nov. 1987) is in the following table.

Table 11.1, Effective stress shear strength parameters used in stability analyses.

	Unit weight, pcf		**Effective shear strength**	
Soil type	Moist	Saturated	Cohesion, psf	Friction angle
Coarse tailings	144	157	0	42°
Glacial till fill	143	145	0	31°
Sand & gravel fill	132	137	0	38°
Lacustrine clay	-	113	0	15°/18°
Glacial till foundation	-	147	0	34°

An effective stress friction angle of 15° was used for potential failure surfaces passing through the lacustrine clay parallel to the bedding planes. For portions of the potential failure surfaces passing across the bedding planes (through both silty gray clay and red clay), an average effective stress friction angle of 18° was used. A full description of how these parameters were developed is presented in Klohn Leonoff (1985).

11.4 Dam Stability

The geometry of the embankments has not changed since late 1986 and is not expected to change over the next two years. In 1987, the stability of the three dams was analyzed (Klohn Leonoff, November 1987). At Dams 1 and 5, the factors of safety all exceeded 1.3 and were judged adequate for continued operations. At Dam 2, the factor of safety was 1.25 for a pond elevation of 1184 ft (the level at that time) and 1.33 for a pond level of 1179 ft. On July 27, 1995, the pond level was 1182.0 ft, corresponding to a factor of safety of 1.28. While this is slightly below the desired factor of safety of 1.3, the difference is so small as to be negligible.

what about at ▽ 1195' under new scheme?

In summary, Klohn Leonoff's stability analyses of the dams indicate acceptable factors of safety for the anticipated pond levels during the next two-year period. Filling the coarse tailings zone upstream of the present dams to elevation 1195 ft will not affect the stability of the dams.

The strength of the clay in the foundation below the dams is a key factor influencing the dam stability and therefore the design in the valley bottom. The clay is not present above elev. 1165 and the foundation is much stronger glacial till or rock. Dam designs for the higher elevations will make use of the higher strength foundations to minimize dam sections while maintaining stability.

11.5 Dam Construction

Construction of the dams in the next two years will not require raising beyond the current crests at elevation 1195 ft. Fine tailings will be spigotted upstream. Beaches will be built up and progressively covered with coarse tailings until the fine tailings discharge locations are approximately 1,400 ft from the existing dam crests. Coarse tailings will continue to be hauled to the basin by rail, dumped and dozed into place. As coarse tailings are raised above elev. 1195, the zones critical to dam performance and safety will be constructed to dam specifications.

Calculations of the basin filling beyond 1996 have been based on the anticipated tailings output as follows: fine tailings 6.32 million LTPY, and coarse tailings 3.47 million LTPY. To raise the fine tailings and coarse tailings at the same rate, a shell of coarse tailings 1,400 ft wide will be placed at each end of the impoundment and at dam 5. The fine tailings will be discharged into the basin from the inside of the coarse tailings. A transition is required during the next two years to build the fine tailings out to the 1,400 ft location and cover them with coarse tailings. Coarse tailings are expected to have an in-place dry density of 140 pcf, and the fine tailings 92 pcf. Fine tailings will deposit on a slope of approximately 1.5 percent above water as measured by the operators. Below water the fine tailings profile is assumed to be the same as measured previously and as used in the closure planning (Klohn Leonoff, 1987).

When PMF or tailings storage requirements dictate, dams will be raised by placing coarse tailings over the 1,400 ft width of previously constructed coarse tailings. Because the coarse tailings will form the dam section, it is essential that they be placed at a density sufficient to avoid contraction if any foundation straining takes place.

12. CONSTRUCTION SCHEDULING

During the next two-year period, fine tailings will be spigotted into the pond from dams 1, 2, and 5A. Spigotting will be done from dams 2 and 5A during the summer, and winter operations will be confined to dam 1 to minimize pipe freezing problems. Spigot lines will be progressively relocated as fine tailings beaches are formed until the lines are 1,400 ft from the dams. Coarse tailings will be placed over the beaches, and up to elev. 1195 ft. Active beaches approximately 300 ft wide will be maintained.

Yearly construction schedules will be provided in the annual operating plans.

13. INSTRUMENTATION AND MONITORING

Groundwater monitoring wells were installed around the basin in 1976. Geotechnical instruments were installed in a test fill in 1977, and further instruments to measure foundation pore pressures and settlement were installed in the starter dams at dams 1 and 2. Geotechnical instrumentation includes pneumatic and Casagrande piezometers, settlement gauges, settlement plates, relief wells and groundwater monitoring wells. These instruments have been read periodically since installation, with the results last reported in 1986 (Klohn Leonoff, 1986). In that report the observation was made that "generally speaking, apart from minor fluctuations, piezometric levels recorded from piezometers and groundwater wells have shown little change in the last four years. The same observation is made for flow rates in relief wells." Some of the dam instrumentation has been damaged or has malfunctioned over the 19 years since installation. However, with the dams not being raised since 1986 and the pond elevation having dropped about 2 ft since then, no need was seen to update the instrumentation.

In the coming year, the instrumentation performance to date will be reviewed, the current state of the instrument hardware investigated and a program implemented for replacing and updating the instruments. This program will take into account the dam construction method to be utilized beyond the next two year period. Northshore will be reading all the operable instruments in the fall of 1995, preparatory to a review and recommendation program.

14. FLOOD STORAGE

The current operating permit requires storage of the runoff from the PMF with a freeboard of three feet. In the 1976 design, a PMF of 30 inches of runoff was used. An updated PMF of 20 inches of runoff was developed in 1994 (Barr Engineering and Sitka Corp, December, 1994). Using this runoff and a catchment area of 8.7 square miles (5570 acres), the volume of storage required is 9,300 acre feet, or approximately 7.5 feet of rise on the present pond and beach surface.

vs 4.5' of beach

?

As discussed in Section 12.1, the dams will have to be raised above the present elev. 1195 in 1997 to maintain the PMF storage with three feet of freeboard.

? what happens to SRD overtopped?

15. DIVERSIONS

Headwater stream diversions were constructed as part of the initial basin construction between 1977 and 1980. These diversions were designed to reduce the catchment contributing to the basin during operations and were located outside the ultimate basin. Diversion ditches were constructed in the seepage recovery basins in the same period. Further diversions have been constructed since 1980, one along the west slope of the basin and several around the seepage recovery areas, to divert natural runoff around the tailings and seepage recovery basins. The most recent diversions were completed prior to the spring of 1992 in the seepage recovery and dam abutment areas. Headwater diversions and most of the seepage recovery basin diversions will remain in use through the operating life of the tailings basin and beyond. The west diversion and some of the small diversions at the present dam abutments will have to be replaced as the dams are raised.

The diversion constructed just west of the pond crosses the centerline of dam 2 at elev. 1210, and will require replacement with a diversion further upslope by the year 2002.

A diversion of the natural outlet of Bear Lake will be required prior to the dams reaching the lake level at elevation 1209 ft. This is projected to occur about the year 2002. A preliminary design for this diversion was presented in Klohn Leonoff, 1982.

Potential exists for additional diversions to be constructed; this is currently being investigated by Northshore.

16. SEEPAGE FROM THE TAILINGS BASIN

Seepage from the tailings basin is controlled by the low permeability of the fine tailings and the very low permeability of the natural clay in the bottom of the valley. The low rate of seepage cannot be directly measured either by instrumentation, or calculated from the basin inflows and outflows because of the inherent inaccuracies in the flow estimates. Flow net calculations have been performed (Klohn Leonoff, 1985) to determine the seepage rates through the tailings dams and the foundations at the ultimate elevation of the tailings. The total seepage through the dams, estimated at 93 gpm, will flow into the seepage recovery reservoirs and be returned to the basin. Seepage through the foundations of the dams has been estimated at 817 gpm, only 74 gpm of which may not be intercepted by the seepage recovery systems. The seepage escaping the seepage recovery systems has been estimated at 29 gpm with the pond water at elevation 1184 ft which is higher than the present pond, hence the current rate of unrecovered seepage is expected to be slightly lower.

In the next two-year period with the water elevation not expected to rise more than two feet, and the pond being reduced in area and moved away from the dams, the rate of unrecovered seepage is not expected to exceed the 29 gpm calculated in 1986.

Beyond the two-year period, with the change to upstream construction, some seepage reduction measures implemented to date will not be continued. These include extension of the cutoff trenches at the tailings dams, extension of the grouted zones in the rock abutments, and continuation of the upstream cutoff on the western side of dam 2. Each of these measures was tied to the placement of the upstream glacial till zone in the tailings dams, which will be discontinued. With the original design, water was ponded against the dams and the full basin hydraulic head was adjacent to the dams. With the upstream construction proposed, the free water pond will be located at least 1,700 ft from the dams, reducing the potential for seepage under the dams.

17. SEEPAGE RECOVERY

Three seepage recovery facilities, each comprising a dam, pumpstation and return pipeline, were constructed downstream of the tailings dams in 1978 and 1979. These facilities collect seepage from the downstream areas of the tailings dams, runoff from the coarse tailings areas of the dams, and runoff from the seepage dam catchment areas. Water that collects in these reservoirs is pumped to the tailings basin as required. Calculations of seepage rates show that the majority of water accumulated in the seepage recovery reservoirs is runoff. Testing has shown that the quality of the accumulated water could be for suitable for direct release without treatment.

There is a potential to reroute the discharge from the pumpstations directly to the water treatment plant in order to keep the treatment plant influent water quality as high as possible. Alternatively, depending on the quality of these waters, the possibility exists for direct discharge with moderate amounts of treatment through use of downstream sediment ponds or modular filter systems. These options will be explored by Northshore.

These seepage recovery facilities have been sited such that they will remain operable for the operating life of the basin and beyond as needed. No changes are proposed to these facilities in the short term.

18. LONG TERM CONSIDERATIONS

The Milepost 7 tailings basin has the capacity for tailings disposal for about 60 years at the 5.3 million LTPY concentrate production rate. The operations plan as presented in this report can be extended to cover tailings disposal until the full storage capacity of the basin is reached. Over the decades of operation, if the width of coarse tailings is maintained at 1,400 feet from the dams, the area of coarse tailings will approximately double. The fine tailings storage area - pond plus beaches - will have to increase in proportion so the dams and pond will rise simultaneously while maintaining flood storage and freeboard. To maintain this balance, the pond area will increase to about 2,200 acres by the end of the operational life of the basin. To minimize the pond area, the fine tailings beach area will have to be increased. This could be achieved by increasing the width of beaches, and by spigotting along the entire east side of the basin.

19. BASIN CLOSURE

19.1 General

One of the primary aims of operating plans since the Closure Consensus Plan has been to limit future closure liability by reducing the volume and area of the pond water. This concept has been continued in this operating plan to the extent possible. With ongoing operations, there is a balance between the fine tailings area and the coarse tailings area so that both the coarse and fine tailings rise at the same rate. The volume of supernatant water will be reduced over the next two years then when it reaches an operating minimum, the volume will be held approximately constant over the long term.

19.2 Definition Of Closure

Closure is defined as a cessation of tailings deposition, and can occur for one of several reasons. "Temporary closure" is for a limited period of up to a few years such as that experienced between 1986 and 1990. This could result from a bankruptcy, a strike, a breakdown in the plant, or a short-term downturn in the iron market. "Planned final closure" occurs at the end of the mine life and is planned in advance. "Premature closure" is permanent closure before the planned life of mine closure. This could result from a permanent retrenchment in the iron market, a technological outdating of the process or a devastating fire in the plant. Plans for each of these are described below.

19.3 Temporary Closure

Temporary closure could occur at any time, with or without warning, so the time for planning of the closure could be very limited. When tailings discharge ceases so does the supply of coarse tailings to raise the dams; thus it is important at all times to maintain sufficient freeboard in the dams to store the design flood event. As has been demonstrated with the 3.5 year shutdown to 1990, the water treatment plant has adequate capacity to control the rise in water level that would occur without water release. This treatment plant would continue to be operated and maintained. Monitoring of water discharge and the air, water, and geotechnical instrumentation would continue. Beaches of fine tailings would be treated with dust suppressant to minimize dust generation potential, and areas of coarse tailings where dust could be generated could also be treated. Permanent downstream slopes on the dams would be vegetated (an ongoing process), and roads would be treated to minimize dust potential. Stream diversions would continue to be inspected and maintained.

19.4 Planned Final Closure

Planned final closure will be at the end of mine life. There will be several years to develop and implement a detailed plan tailored to the circumstances at the time. The plan set out below is conceptual in nature, as set out in the Closure Consensus Plan, and is designed to illustrate the approach to the final closure.

Final closure will require the basin to be closed in an orderly fashion, allowing for direct water discharge once water quality is acceptable, with dams left in a safe state, spillways to handle major flood events, equipment and plant removed, surfaces reclaimed and the area left in such a way as to minimize ongoing maintenance.

Starting several years prior to the closure, fine tailings beaches will be extended into the pond to reduce the pond water volume and area. These beaches will be covered with coarse tailings to provide a reclaimable surface, then vegetated. The pond will be reduced to a predetermined area becoming a permanent lake. Fine tailings in the shallow areas of the water pond which could be affected by wave action will be stabilized to minimize the potential for the fine tailings to mix with the pond water.

Water will continue to be treated and released until it is agreed that the water quality is suitable for direct release. An operating spillway sized to handle the 10,000 year return flood from the 14.8 square mile catchment will be constructed in bedrock. An emergency spillway will be constructed at an appropriate location, designed to handle the PMF from the entire original catchment area of 31 square miles, assuming that in the very long term all the diversions fail. Once the spillways are constructed, diversion dikes 1A and 1C will be breached to take the low flow channel out of service. Seepage recovery dams will be breached and the pump stations and pipelines removed.

Railroad track, pipelines, other equipment and plant at the basin will be removed. All dam surfaces, borrow pits, closed roads, and railroad grades not needed for access or maintenance will be vegetated.

SITKA CORP

19.5 Premature Closure

Premature closure could occur at any time, with or without any warning and would require implementation of a final closure plan. All of the elements of the planned final closure would be undertaken except that the elevation and geometry of the tailings surface would be different. Fine tailings in the shallow areas of the remaining water pond which could be affected by wave action would be stabilized to minimize the potential for the fine tailings to mix with the pond water.

Not Adequate!

Location and details of the operating and emergency spillways would have to be determined depending on the elevation of the dams at the time of closure.

20. REFERENCES

Klohn Leonoff (1976). *Engineering Report On Geotechnical, Hydrologic And Hydraulic Design For Tailings Disposal.*

Klohn Leonoff (1982). *Preliminary Design Alternatives, Permanent Bear Lake Diversion.*

Klohn Leonoff (1985). *Update Of The Engineering Design For The Reserve Mining Company On-land Tailings Disposal.*

Klohn Leonoff (August 1987). *Assessment Of Hydrologic Parameters For Tailings Pond Water Balance.*

Klohn Leonoff (November, 1987). *Dam Stability For Tailings Basin Closure.*

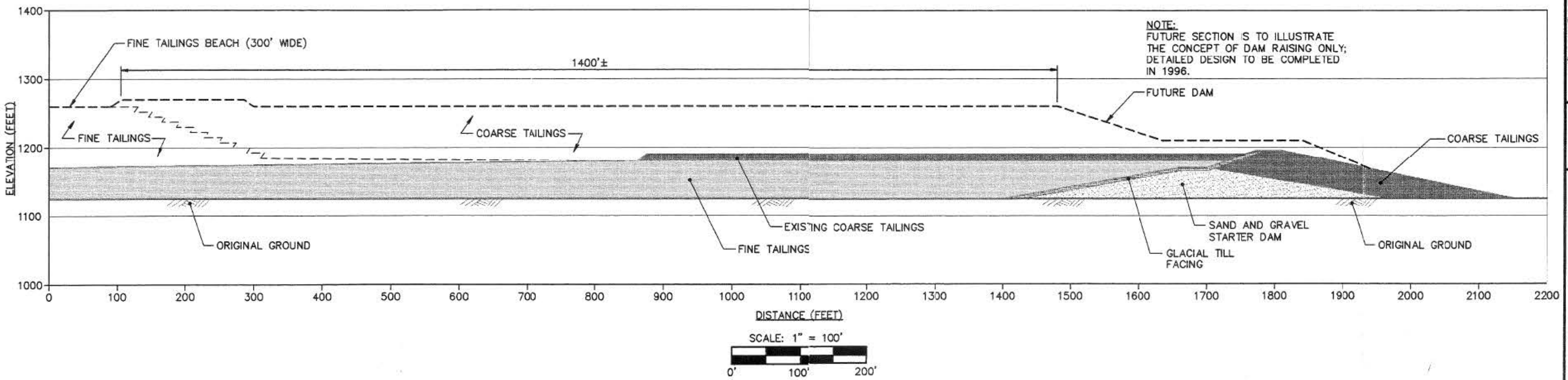
Klohn Leonoff (August 1988). *Tailings Basin Closure Consensus Plan for Reserve Mining Company.*

Klohn Leonoff (1990). *Development Of 4.5 Year operating Plan For The MP7 Tailings Basin.*

Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *J. Geotech. Engrg.*, ASCE, 117(4), 537-615.

Barr Engineering Company and Sitka Corp. (1994). *"Five Year Operating Plan For The Milepost 7 Tailings Basin"*

FIGURES



SITKA CORP.

NORTHSHORE MINING CO.

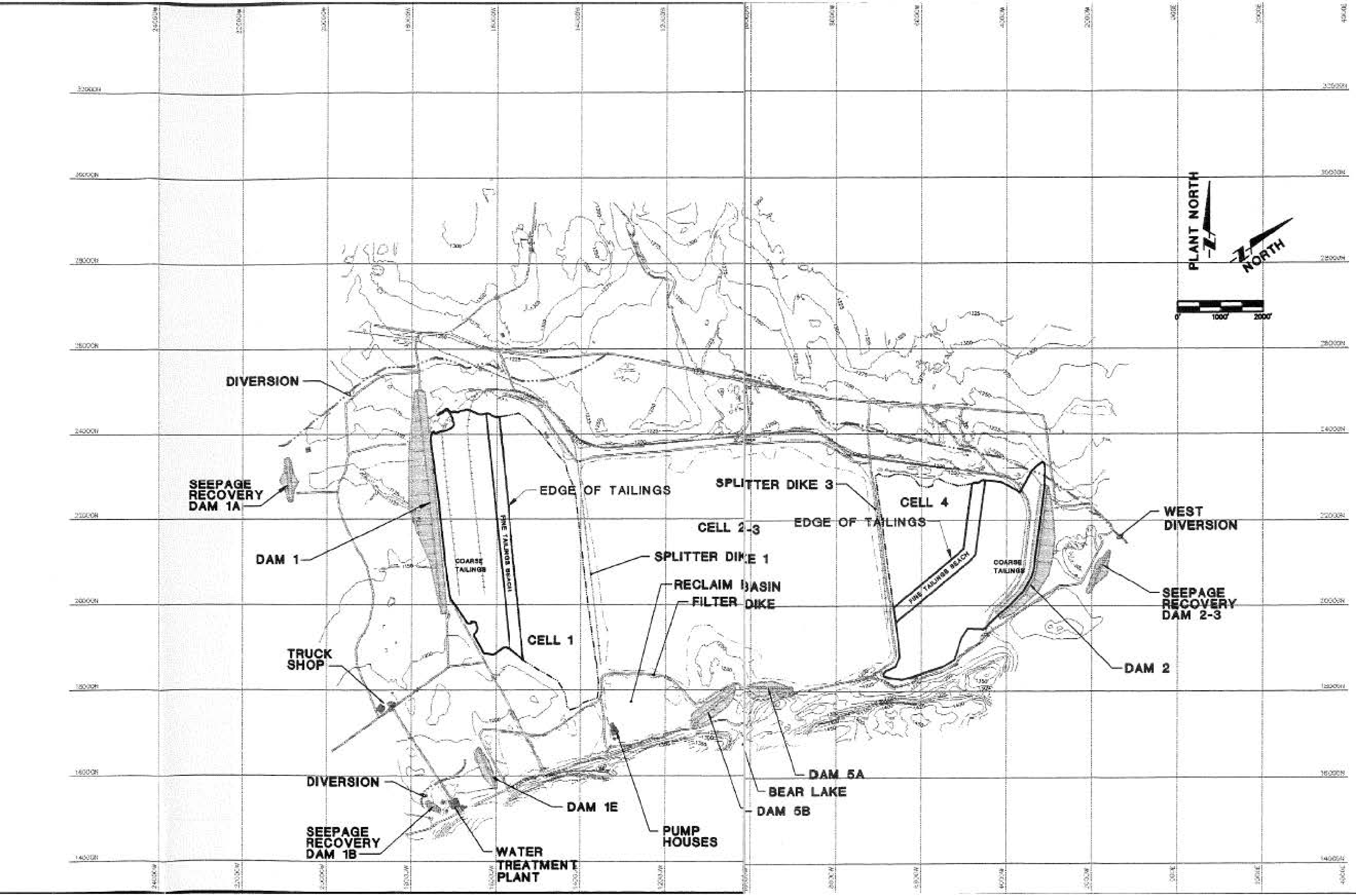
DAM 1 SECTION

MILEPOST 7 TAILINGS BASIN

SILVER BAY MINNESOTA

FIG. 3

JOB NUMBER N57.2



NOTE:
MAPPING PROVIDED BY BARR ENGINEERING.
TAILINGS OUTLINES IN CELLS PROVIDED BY
NORTHSHORE MINING CO.

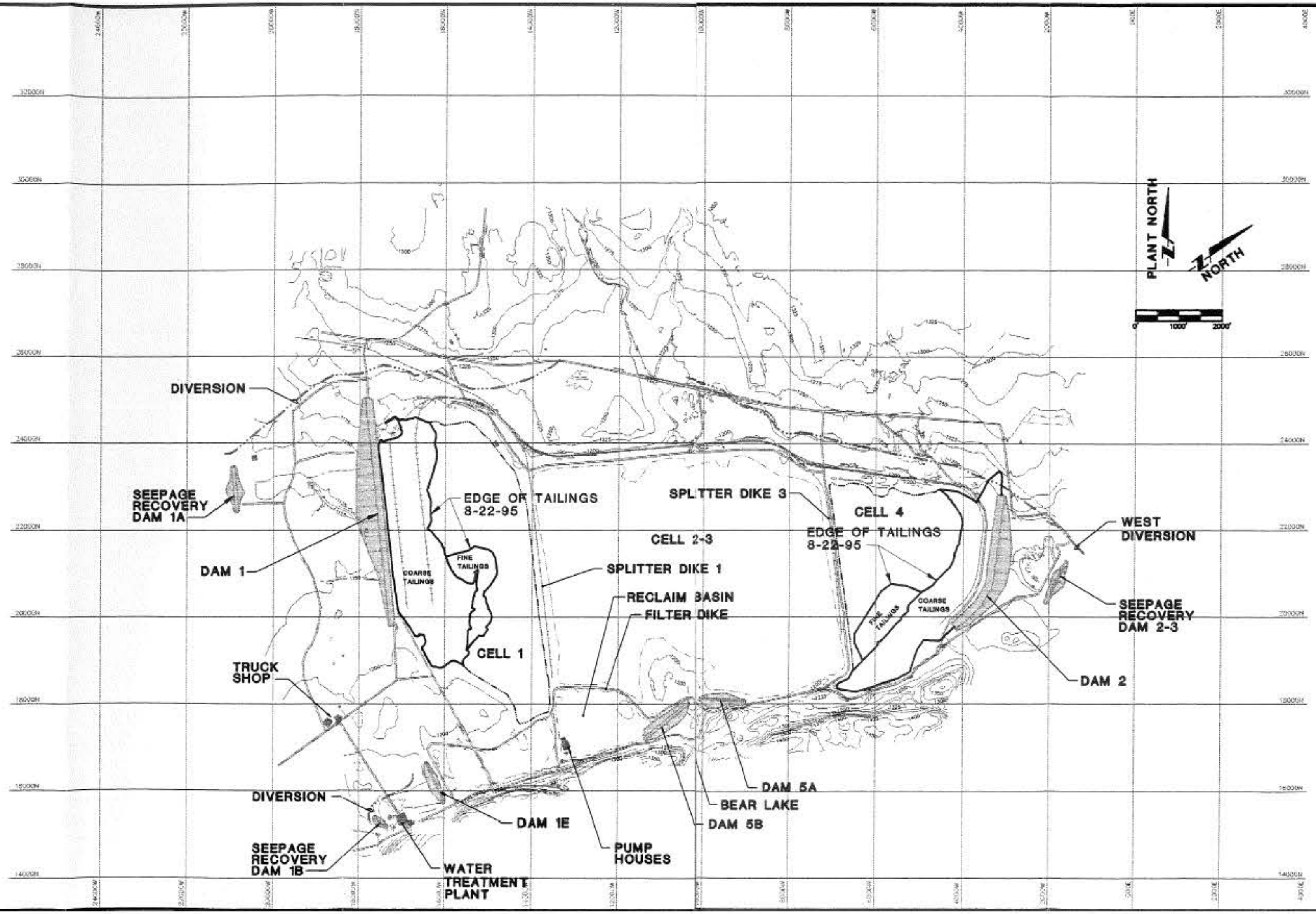
SITKA CORP.

NORTHSHORE MINING CO.

PLAN, 1997
MILEPOST 7 TAILINGS BASIN
SILVER BAY MINNESOTA

FIG. 2

N57.2



NOTE:
MAPPING PROVIDED BY BARR ENGINEERING.
TAILINGS OUTLINES IN CELLS PROVIDED BY NORTHSHORE MINING CO.

SITKA CORP.

NORTHSHORE MINING CO.

PLAN, 1995
MILEPOST 7 TAILINGS BASIN
SILVER BAY MINNESOTA

FIG. 1

JOB NUMBER N57.2