MILE POST 7 ERND
REFERENCE 28

PRELIMINARY ENGINEERING REPORT

MILEPOST 7 TAILINGS DISPOSAL SYSTEM

EXCESS WATER DISCHARGE

RESERVE MINING COMPANY

SILVER BAY, MINNESOTA

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.

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STATEMENT OF PROJECT NEED

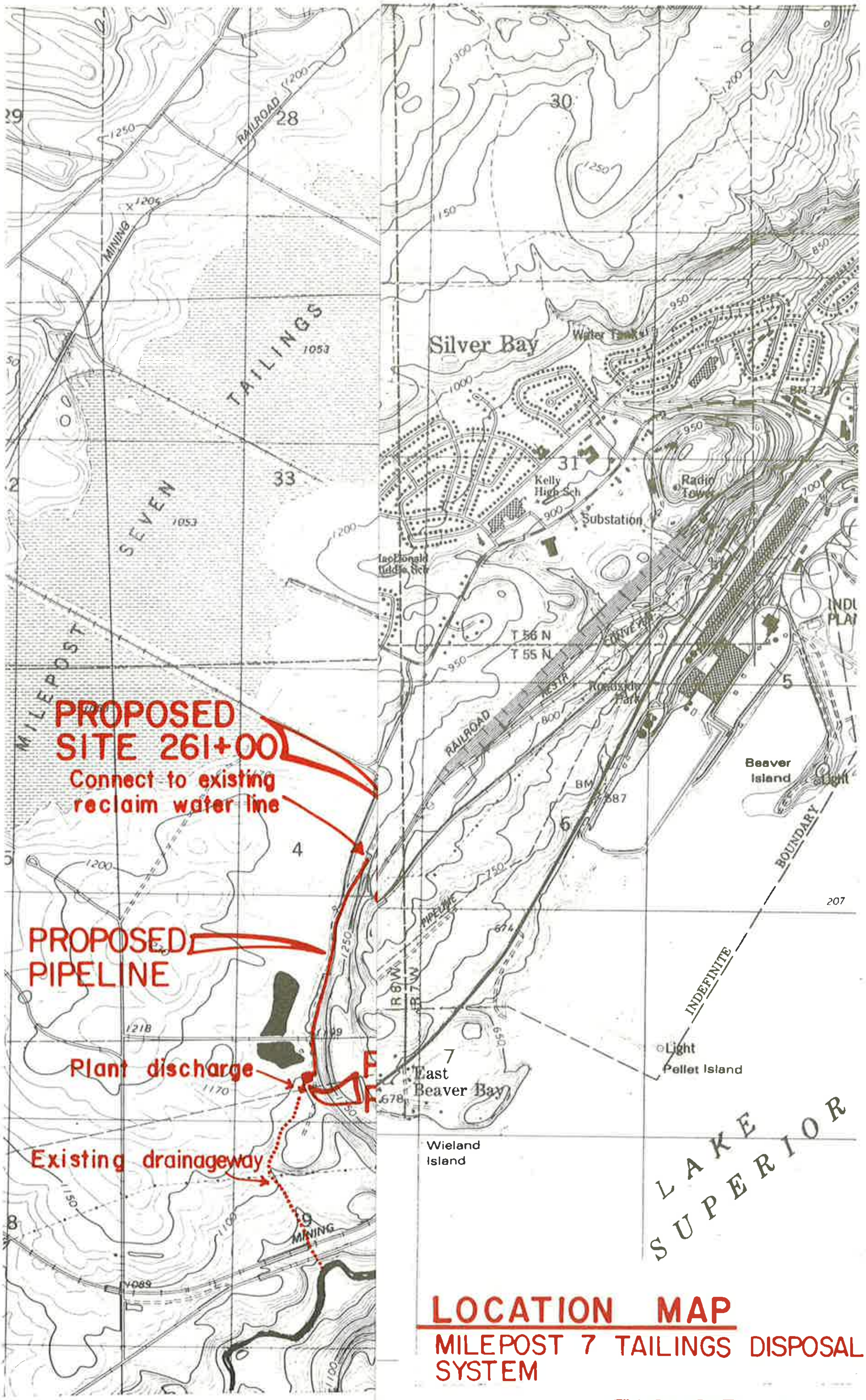
Milepost Seven

Milepost 7 is a man-made facility designed to serve as the ultimate point of disposal for the crushed waste rock (tailings) generated by the taconite processing operations of the Reserve Mining Company. The disposal basin is located, generally, in Townships 55 and 56 North, Range 8 West of the Fourth Principal Meridian, approximately four miles west of the Silver Bay townsite as shown on Figure 1.

Construction of the basin was initiated during the last years of the 1970's, under permits issued by the Minnesota Pollution Control Agency, the Minnesota Department of Natural Resources, and the U.S. Army Corps of Engineers. Construction of containment structures at the disposal basin was to be accomplished utilizing coarse tailings generated during operations. The projected construction rates were based on an annual pellet production rate of 9 million tons per year. Operation of the basin is predicated upon total containment of the tailings generated during the years of production, with eventual dewatering of the basin upon cessation of operations.

The projected water balance for the disposal system anticipated a requirement to augment the total water in the system on a continuing basis.

The past several years of economic slowdown, particularly in the mining and steel industries, have imposed upon the Reserve Mining Company a level of production substantially below those projected. The result has been that the water levels in the basin are rising faster than the dams can be constructed at current operating



LOCATION MAP

MILEPOST 7 TAILINGS DISPOSAL SYSTEM

FIGURE 1

levels. Because of these facts, it has become necessary to discharge some portion of water stored in the basin.

The long-term operation of the tailings basin, with a future phase to include dewatering of the basin, did anticipate the need to discharge some water into the natural environment when operations cease. This early need to release water is the result of a protracted period of slow economic activity.

Point of Discharge

Two options for selecting a receiving water from a treatment plant were considered, a treatment plant located at the E.W. Davis works, that would discharge into Lake Superior, or a treatment plant located near the basin with discharge entering the Beaver River.

Consideration of a preferred point of discharge has been addressed. The plan presented anticipates construction of a discharge facility at or near the tailings basin, with point of discharge into the Beaver River either in Section 9 or 15, T55W, R8W.

Effluent Characteristics

Pertinent data on water quality characteristics of the proposed basin discharge, before treatment, and corresponding characteristics of the Beaver River near the point of discharge are exhibited in Table Three.

After reviewing the available data and taking into consideration appropriate water quality regulations, the Minnesota Pollution Control Agency has specified the following discharge guidelines to be used in the design of a treatment process. These are:

(1) amphibole fiber count less than 15 million fibers per liter

(2) chrysotile fiber count less than 3 million fibers per liter

(3) fluoride content of the Beaver River water beyond the mixing zone not greater than 1.5 mg/l.

The above guidelines are to be met at least 95 percent of the time.

EFFLUENT STANDARDS AND TREATMENT TECHNOLOGY

Historical

Environmental concern regarding the presence of asbestos-like fibers in drinking water became a significant issue during the early 1970's.

Research conducted at Duluth, Minnesota, in 1974 and funded jointly by the EPA and the United State Army Corps of Engineers, demonstrated that asbestiform fiber counts could be reduced, effectively, from the waters of Lake Superior by fairly conventional water treatment technologies.

Specific MPCA Effluent Guidelines

The MPCA, as cited in the previous section, has tentatively set effluent levels for three parameters: amphibole, chrysotile, and fluoride.

Amphibole Fiber

The presence of the amphibole fiber has been conclusively demonstrated by the extensive research conducted at Duluth, first, by the EPA Water Lab in its early work and, subsequently, by the pilot plant work in 1974 and a continuing program of research which was mandated by the terms of the EPA construction grant given to the City of Duluth. Citing, particularly, this latter work, amphibole fiber counts of Lake Superior water, made over the period from January 1977 to August 1980 show a range of raw water fiber counts from a low of, perhaps, two to three million fibers per liter to a high of approximately 1.2 billion fibers per liter. Most values lie between the ten million and two hundred million fiber count levels. The filtered water fiber counts posted at the City of Duluth demonstrated a consistent ability to reduce the counts to one hundred thousand fibers per liter or less, even under conditions of extreme influent turbidity.

Fiber counts of the Milepost Seven Reclaim Water, measured by an MPCA laboratory investigation conducted in late 1983 and tabulated in a letter to the Reserve Mining Company, dated January 5, 1984, show the following results:

RW1	123	million	fibers	per	liter
RW2	205	"	"	"	"
RW3	174	"	"	"	"

The samples were taken from the system during a period of plant shutdown.

On the 2nd of February, 1984, subsequent samples, taken while the plant was in partial operation, were delivered to the MPCA for analysis. The basin reclaim water shows higher fiber count levels as follows:

RW1B	416 million fibers per liter
RW2B	382 million fibers per liter
RW3B	333 million fibers per liter

The pilot work done at Duluth and the operating results of three North Shore municipal water purification plants, Duluth, Two Harbors and Silver Bay, have demonstrated, conclusively, the adequacy of filtration to reduce the amphibole fiber counts to levels well below the MPCA guideline.

Chrysotile Fiber

The inclusion of this standard appears to be unnecessary. Only one chrysotile fiber was found from the three basin return water collected February 2, 1984.

The research work performed by Dr.Cook at the EPA Water Lab in the early 1970's and the subsequent fiber analyses done by the Lake Superior Basin Studies Groups at the University of Minnesota, Duluth, and by the EPA in Duluth have indicated amphibole fibers in the lake but not chrysotile.

Fiber Origin

The geological literature make no mention of any chrysotile minerals associated with the Mesabi Range ores. The closest relative is the iron-rich form of Antigorite, Greenalite. Although of similar chemical formula, the Antigorite structure does not form the tubular asbestiform strands that Chrysotile does. The metamorphic activity of the eastern Mesabi, would have altered such minerals to the amphibole or pyroxene group.

However, as demonstrated by an EPA funded research project at Seattle, Washington, raw South Fork Tolt River water, a clean but fiber-laden Cascade Range stream, bearing both amphibole and chrysotile fibers, was amenable to fiber removal with a treatment technology not unlike that demonstrated at Duluth for the amphibole fiber.

The Seattle pilot work suggests that the technology which has been applied in the water filtration plants on the North Shore will also, successfully, remove chrysotile fibers. The removal process, utilizing alum coagulation, exhibited a similar sensitivity to pH in both waters. Chemical feed rates and minor process modification may be indicated to achieve the highest degree of fiber removal, if chrysotile fibers are, in fact, found to be in need of monitoring and removal.

Fluoride

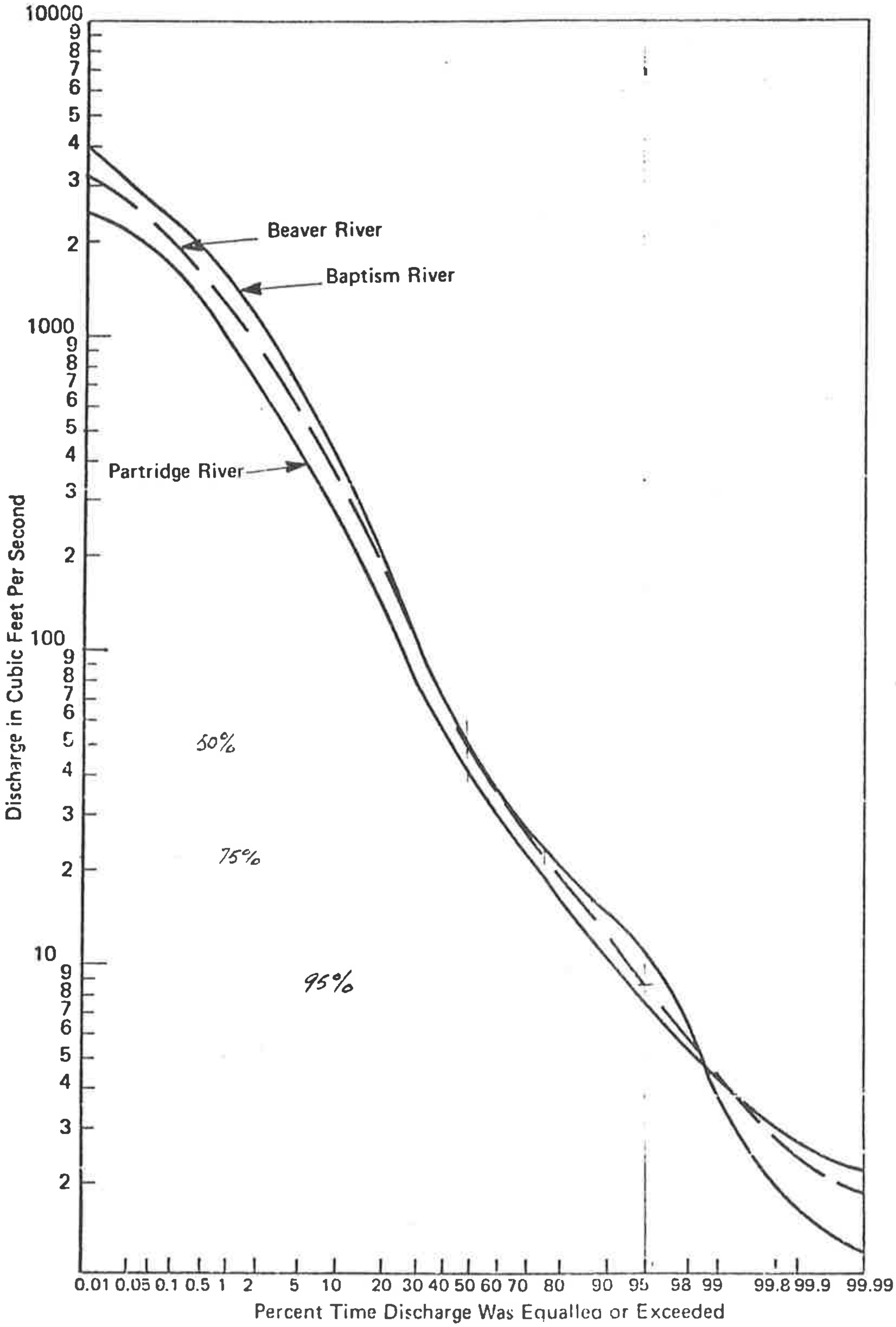
Reserve's beneficiation process has been shown to release small amounts of fluoride to the process water. Measured fluoride levels are indicated in Table Three.

The fluoride effluent guideline is to be applied to the mixed water in the receiving stream.

The normal, proposed discharge rate from the tailings basin will be 2,500 GPM which is equivalent to 5.6 cubic feet per second. In general, one volume of tailings basin water mixed with three volumes of Beaver River water would achieve the desired stream fluoride level.

A flow-duration curve, as derived by E. A. Hickok & Associates, for flow in the Beaver River is shown on Figure 2.

Approximately eighty percent of the time, with the treatment plant operating at the 2,500 GPM design point, the three to one ratio of flows would achieve the designated fluoride level of the mixed water. The discharge rate from the treatment plant could be adjusted downward to maintain the required ratio during periods of low flow.



Source: E.A. Hickok & Associates

FIGURE 2 FLOW-DURATION CURVE FOR THE BAPTISM, PARTRIDGE AND BEAVER (THEORETICAL) RIVERS

BASIS FOR PROPOSED TREATMENT TECHNOLOGY

Lake Superior Experience

Under an agreement and study funded jointly by the EPA and the Corps of Engineers, pilot plant studies were conducted at the Lakewood Pumping Station, Duluth, Minnesota, from April to September of 1974 by the company of Black and Veatch, Consulting Engineers, Kansas City, Missouri.

The purposes of the pilot plant studies were (1) to obtain information on asbestos fiber removal and (2) to operate pilot plants in such a way as to generate data for engineering design and cost estimates. Two hundred twenty seven granular media filter runs were performed during that period. Equipment variations included use of dual media, mixed media, no settling, tube settlers, single-stage rapid mix and two-stage rapid mix with propeller mixers, two-stage and three-stage rapid mix with in-line mixers, alum or ferric chloride as the primary coagulant, anionic, cationic and non-ionic polymers, and filtration rates of 2 - 7 gpm/sq. ft. (1)

The conclusion of Logsdon, regarding the results of the Duluth pilot plant work, were that "...amphibole asbestos fibers can be removed readily by filtration...Treatment of the raw water with alum and a non-ionic polymer was considered to be the most effective for amphibole fiber removal by granular media filtration." (3)

Following the completion of the pilot studies, three municipal water treatment plants were built on Lake Superior's North Shore to remove fibers from the raw lake water. Design parameters were based upon the results of the pilot plant work. Individual plant hydraulic parameters are compared in the following Table.

TABLE ONE

PLANT HYDRAULIC DESIGN INFORMATION, DULUTH, TWO HARBORS, and SILVER BAY

	Duluth	Two Harbors	Silver Bay
Rapid Mix Chambers Detention, minutes	1.5	8.5	8.1
Flocculation Facilities Detention, minutes	40	38.5	40
Sedimentation Facilities Detention, minutes	140	n/a	n/a
Filters Filtration Rate, gpm/sf	4.9	4.0	2.6
Backwash Rate, gpm/sf	18.7	15.0	7.4
Duration of Backwash, min.	10	10	7

"The (Duluth Filtration Plant) water quality data collected since January, 1977 show that the plant performance has exceeded expectations...The plant consistently produces filtered water turbidities in the 0.04 to 0.06 ntu range...

"Raw and filtered amphibole fiber counts are shown in Figure 3. Filtered water amphibole fiber counts have consistently been below 0.1 X 10^6 fibers/liter since the plant operation started." (3)

"The plant at Two Harbors was started early in 1978...Filtered water turbidity at Two Harbors generally ranges from 0.03 to 0.20 ntu, and fiber counts typically have been from <0.034 to 2 X 10^6 fibers/liter..." (3)

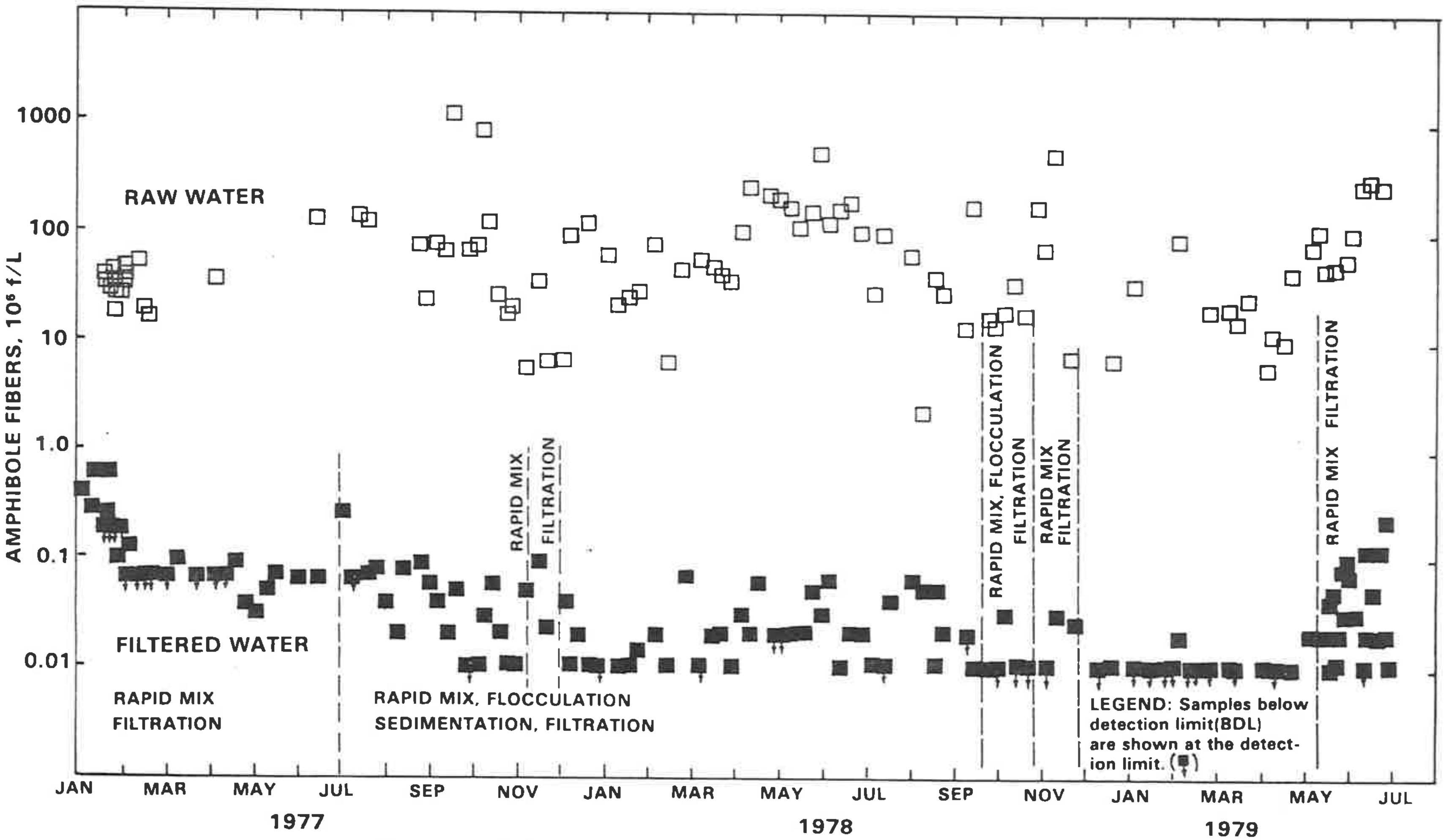


Figure 3. Lakewood filtration plant amphibole fiber data.

Source: EPA Water Filtration
for Asbestos Fiber
Removal EPA-600/2-79-206

Percent reductions in fiber count for the Two Harbors facility, based upon two series of samples taken from 1979 through 1981 by the EPA-Duluth and the Minnesota State Health Department, respectively, range from 89 percent to 99.9 percent. Raw water fiber counts associated with these tests ranged from 1.25 million to 356 million fibers per liter. Raw water turbidities ranged from 0.3 to 1.5 ntu. The granular media at the Two Harbors plant is the proprietary Neptune-Microfloc tri-media.

The modified plant at Silver Bay was placed in service in May of 1978. The plant has dual media filters. Filtered water turbidities on samples taken during a period from 1978 through 1981, as determined by the Minnesota Department of Health, range from 0.02 to 0.07 ntu. Amphibole fiber counts of the filtered water range from less than 20,000 fibers per liter to 330,000 fibers per liter. Percentage reductions for amphibole fibers ranged from 78 to 99.3. Raw water fiber counts, (much lower than recorded for the Cities of Duluth or Two Harbors), ranged from 320 thousand fibers per liter to 25.3 million fibers per liter. (4)

<u>Treatment Effectiveness of Duluth Plant During Storms</u>

The turbidity values of the Reserve Mining Company Reclaim Water line tend to range from 1 ntu to 5 or more ntu. Of particular interest, then, are measured treatment efficiencies at the North Shore plants when raw water turbidities have equalled or exceeded values of 5 ntu.

Examination of available turbidity values listed for the North Shore plants indicates that the raw Lake Superior water normally has a turbidity value of 1.0 or less. The monitored results from the Duluth plant do include several storms with raw water turbidity readings in excess of 10 ntu.

On September 19th of 1977 a storm caused a rise of turbidity and fiber count readings to values of 14.0 ntu and 1.2 billion f/l, respectively. Corresponding filtered water turbidity and fiber counts, during the storm, were 0.045 ntu and 48,000 f/l.

On October 8th of 1977, a storm resulted in raw water turbidity and fiber counts of 11.0 and 830 million f/l. Filtered water turbidity and fiber counts were 0.05 ntu and 120,000 f/l, during the storm, before adjustment of the chemical feed rate, and 0.045 and 29,000 f/l after adjustment of chemical feed rates.

Duluth Continuing Pilot Plant Studies

In conjunction with the research carried out at full plant scale at the Duluth filtration plant, additional studies were carried out at pilot plant scale to examine treatment responses to profoundly altered raw water characteristics which could not be simulated in the plant, itself.

One series of studies examined the treatment response under conditions of high suspended solids. A clay slurry was mixed with raw water with a resulting turbidity level of 4 to 10 ntu. The effluent turbidity remained between 0.040 and 0.050 ntu during the injection period. (2)

"During a second group of high suspended solids tests the influent turbidity was held at 10.0 ntu. Six runs were made in two groups of three. All three runs in a group were performed on the same day in the winter, which provided a stable raw water influent. The alum concentration was set at 15, 20, and 25 mg/l.

Consistent effluent turbidities were obtained between 0.035 and 0.040. The results are listed in Table (Two, below). Although there was no significant difference in effluent turbidity, there was a decrease in fiber counts with the incresed alum except in run 6, which was higher than run 5 but less than run 4...(2)

TABLE TWO (ref.2)

HIGH SUSPENDED SOLIDS TEST RESULTS

Run	Alum Dose (mg/l)	Filtered Water: Amph Fibers (10^6 f/l)	Filtered Water: Turbidity
1	15	0.067	0.034
2	20	0.029	0.032
3	25	0.0096	0.031
4	15	0.12	0.034
5	20	0.058	0.032
6	25	0.11	0.031

This series of filter runs indicates that the fiber removal technology, demonstrated by the existing North Shore plants, is applicable to the purification of raw waters with a broader range of chemical and physical impurities than is typical of Lake Superior raw water.

The turbidity values posted by more than a year of monitoring of the Reclaim Water by the Mining Company indicate a range of 1 to 5 ntu, well below that turbidity level maintained during the pilot work cited above.

PLANT DESIGN PARAMETERS

Raw Water Characteristics

Tailings basin and receiving water characteristics pertinent to the design of this facility are set forth in the following table.

TABLE THREE

PHYSICAL AND CHEMICAL PROPERTIES
OF
PLANT RAW WATER AND RECEIVING STREAM

	Reclaim Water			Beaver River Water		
	High	Low	Average	High	Low	Average
Turbidity	5.6	0.8	2.0	74	1.2	7.9
Fiber Count (amphibole fibers per liter x 10^6)	416	333	377	61.8	4.5	15.8
Alkalinity	176	108	143	107	12	47
pH	8.11	7.53	7.79	8.48	6.51	7.48
Fluoride	7.6	4.0	6.1	<0.5	<0.5	<0.5

Hydraulic

Reference is made to Table One for comparison regarding the hydraulic parameters selected for the existing North Shore plants.

The hydraulic design parameters selected for the design of this facility are listed in Table Four.

TABLE FOUR

PROPOSED TREATMENT PLANT HYDRAULIC PARAMETERS

Design Capacity, gpm	2,500
Rapid Mix Chambers Detention, minutes	4.0
Flocculation Basins Detention, minutes	20.0
Filters Filtration Rate, gpm/sf	5
Backwash Rate, gpm/sf	15
Duration of Backwash, min.	10
Chemical Feeders	
Alum - probable range of feed rate, mg/l	15 - 30
Polymer - probable range of feed rate, mg/l	0.1 - 1.0

General Building

Consideration has been given to several building and process equipment systems. In particular, in view of the intent to have this plant "on line" by early in 1985, maximum utilization is proposed of pre-engineered building and equipment elements.

Rapid mix, flocculation, and filter tankage is illustrated as steel-fabricated construction. The modular elements would be constructed elsewhere and be skid-mounted for transportation to the site.

Buildings are illustrated as pre-fabricated steel buildings with concrete foundation walls and interior slab-on-grade construction.

Concrete reservoirs are required for Sites 238+00 and 261+00 and are shown as field built, below grade construction and located under the floor slab.

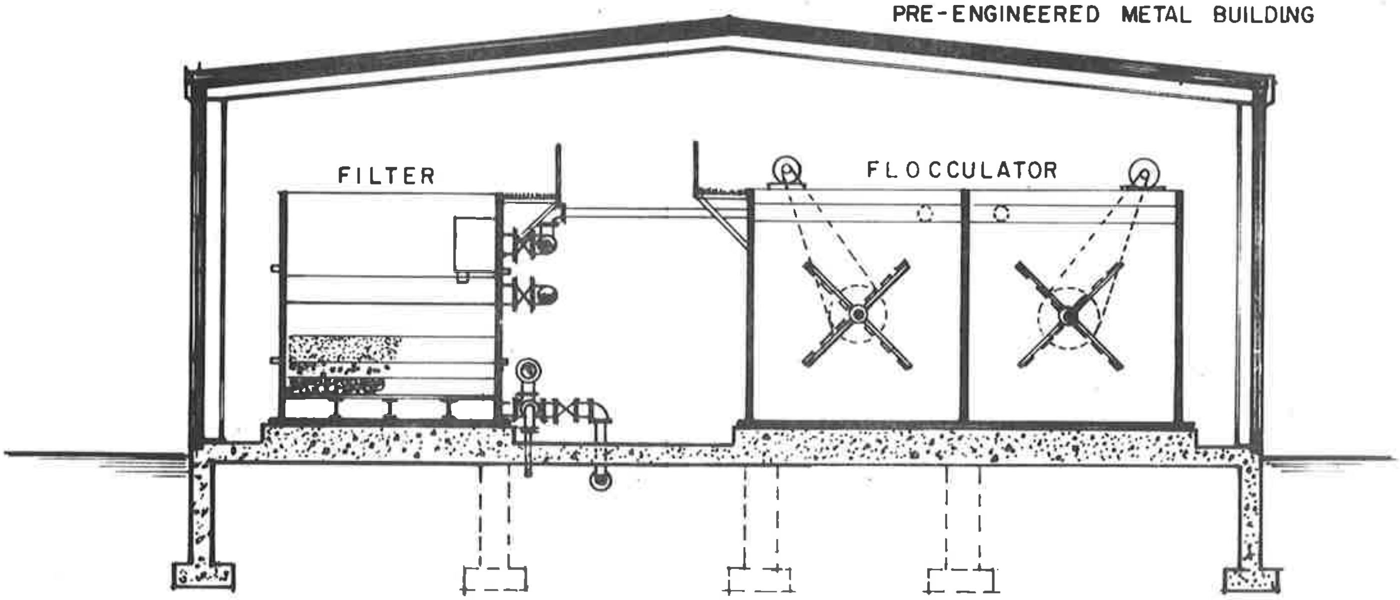
Sections through a typical plant arrangement are shown on Figure 4.

Power

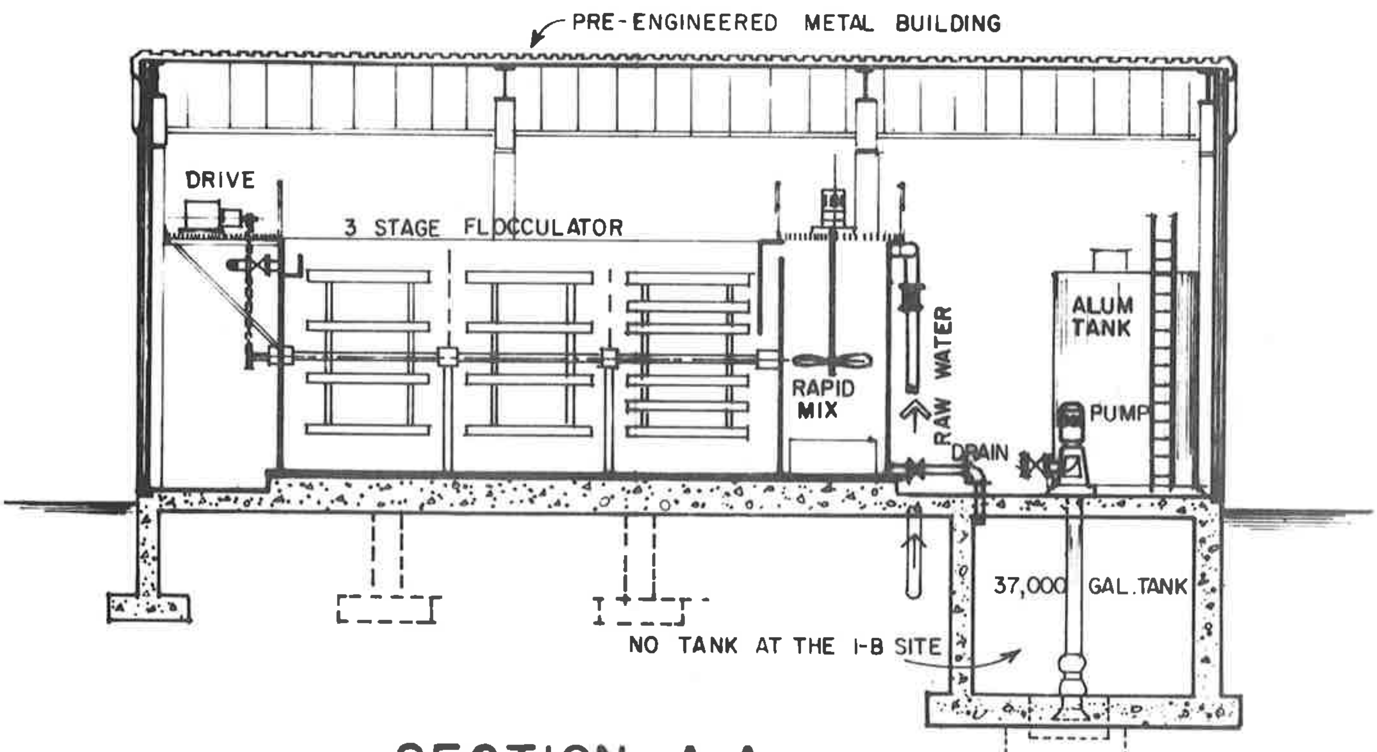
Electric power at 13.8 Kv is immediately available at sites 238+00 and 261+00. Plant operating voltage would be 460 volts for process equipment and 120 volts for lighting circuits.

Heating

Electric unit heaters are proposed to be installed for space heating requirements.



SECTION B-B
SCALE 3/32" = 1'-0"



SECTION A-A
SCALE 3/32" = 1'-0"

FIGURE 4

TREATMENT PROCESS AND EQUIPMENT

Process Flow

A general site plan, a floor plan of the proposed water plant and process flow diagram are shown in Figures 5, 6 and 7 for Site 238+00; Figures 8, 9 and 10 for Site 261+00; and Figures 11, 12 and 13 for the seepage pond 1B site.

Pumping requirements vary from site to site as discussed in a section on site specific considerations, later in this report.

Raw water will be delivered to the first stage rapid mix basin, where the primary coagulant alum is added to initiate coagulation. The polymer coagulant aid is applied to the second stage of the rapid mix coagulation process. The proposed plant will contain two process flow lines, with the flow in each line going through two rapid mix stages prior to entering the flocculation basin. An axial flow propeller type rapid mixer is proposed at each of the rapid mix basins. The power input to disperse the chemicals in the rapid mix basins is expressed by the mean velocity gradient G, which is defined as follows:

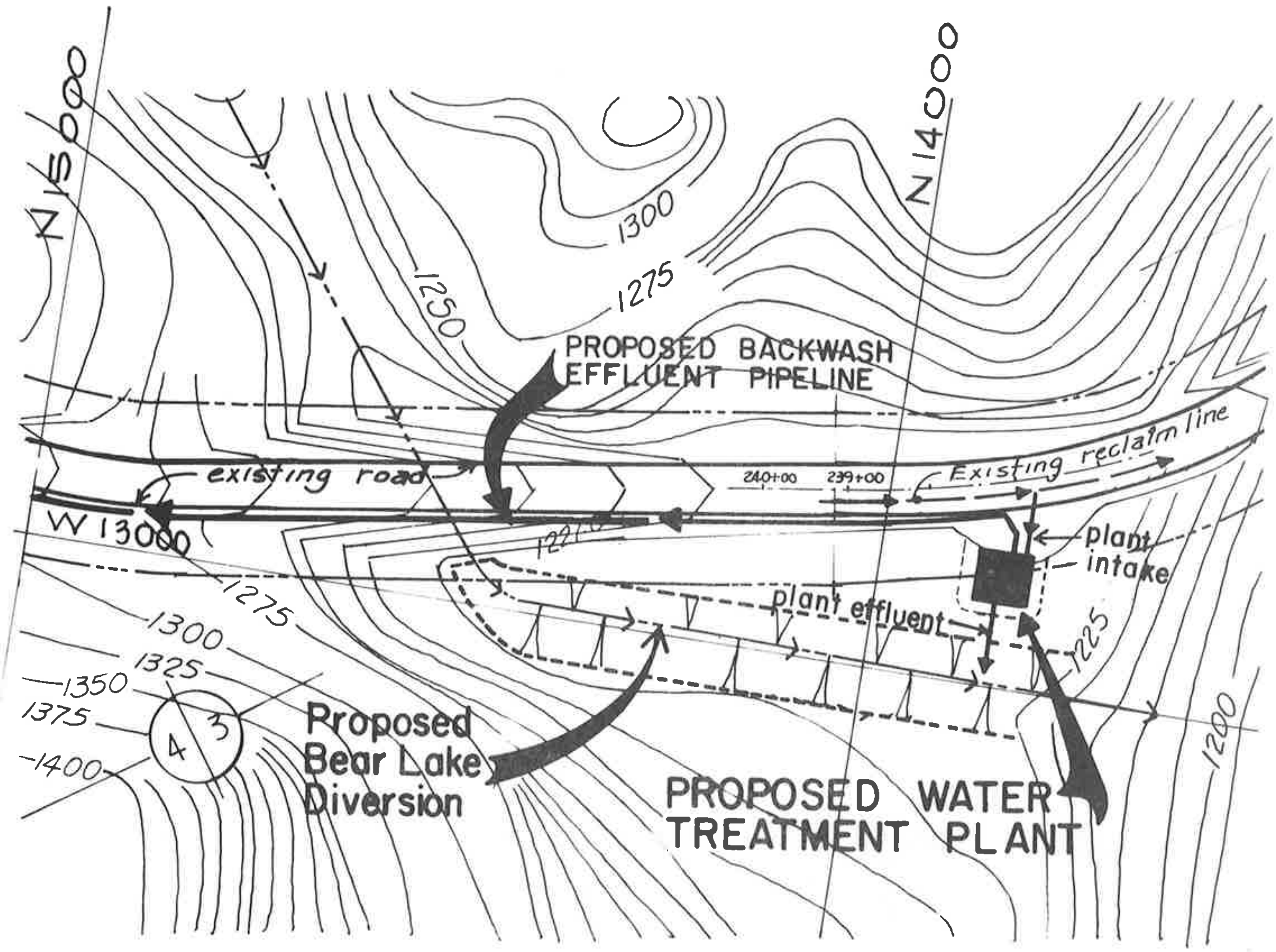
$$G = (P/uV)^{1/2}$$

Where: P is the power dissipated in the water (ft.-lb./sec.)

V is the volume of the basin ($ft.^3$)

u is the absolute viscosity of the water ($lb.-sec/ft^2$).

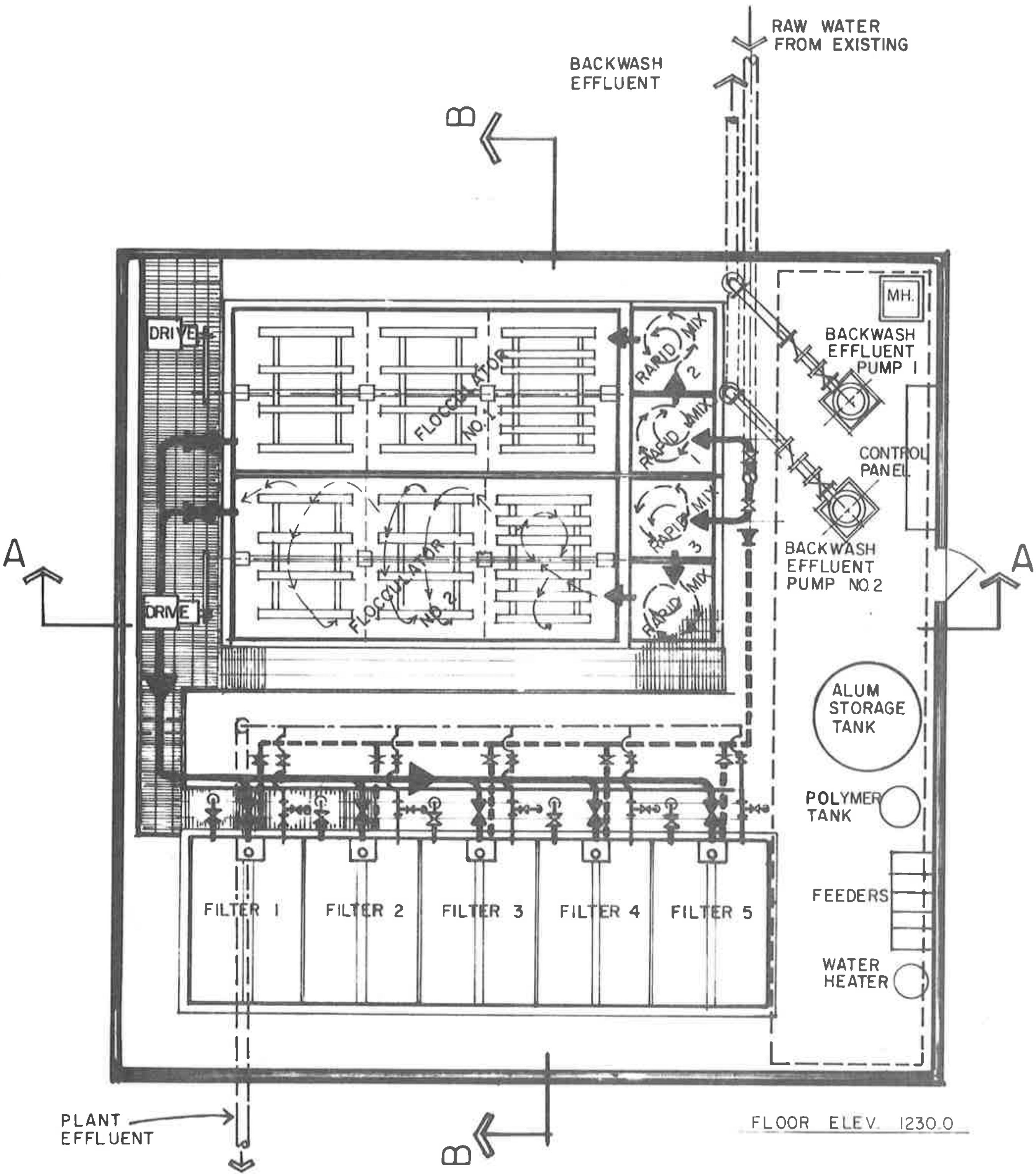
The proposed mean velocity gradient for this plant is approximately 200 sec^{-1}.



SITE 238+00

SCALE 1" = 200'

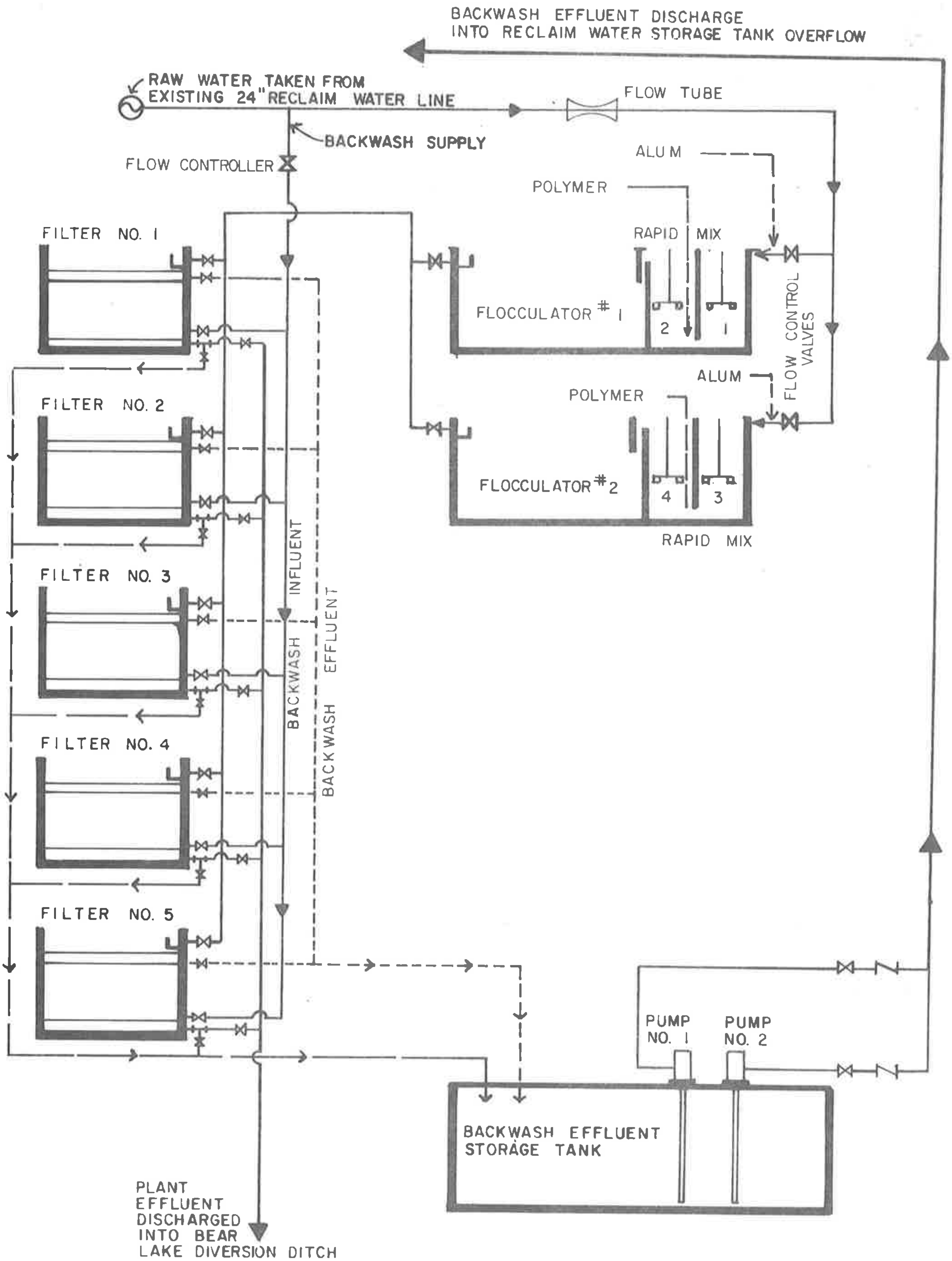
FIGURE 5



FLOOR PLAN - SITE 238+00

SCALE 3/32" = 1"-0"

FIGURE 6



FLOW DIAGRAM - SITE 238+00

FIGURE 7

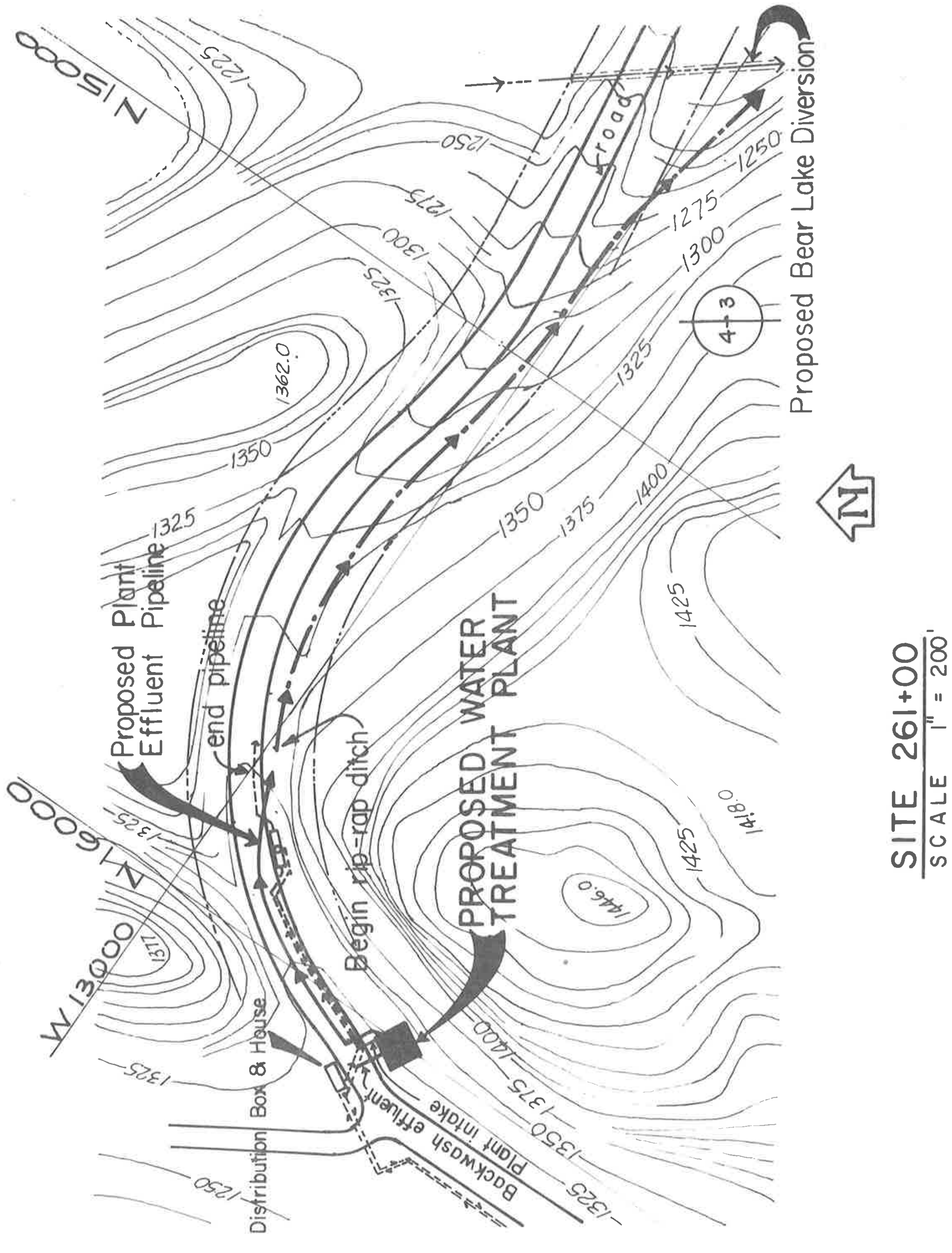
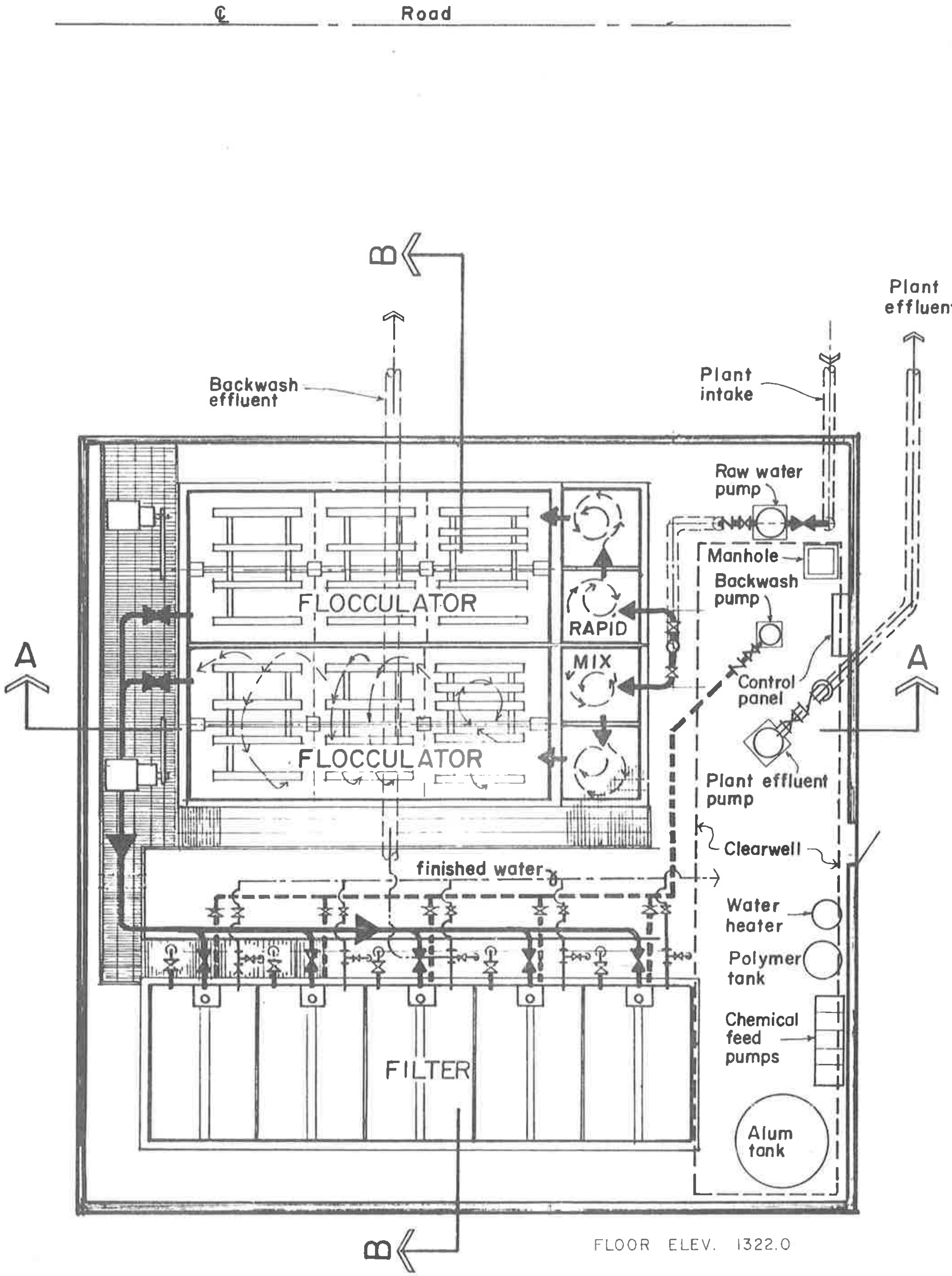

W 13000
N 16000
N 15000
Proposed Plant Effluent Pipeline
end pipeline
Begin rip-rap ditch
PROPOSED WATER TREATMENT PLANT
Distribution Box & House
Backwash effluent
Plant intake effluent
road
Proposed Bear Lake Diversion
4-3
1362.0
1446.0
1418.0
1377
SITE 261+00
SCALE 1" = 200'

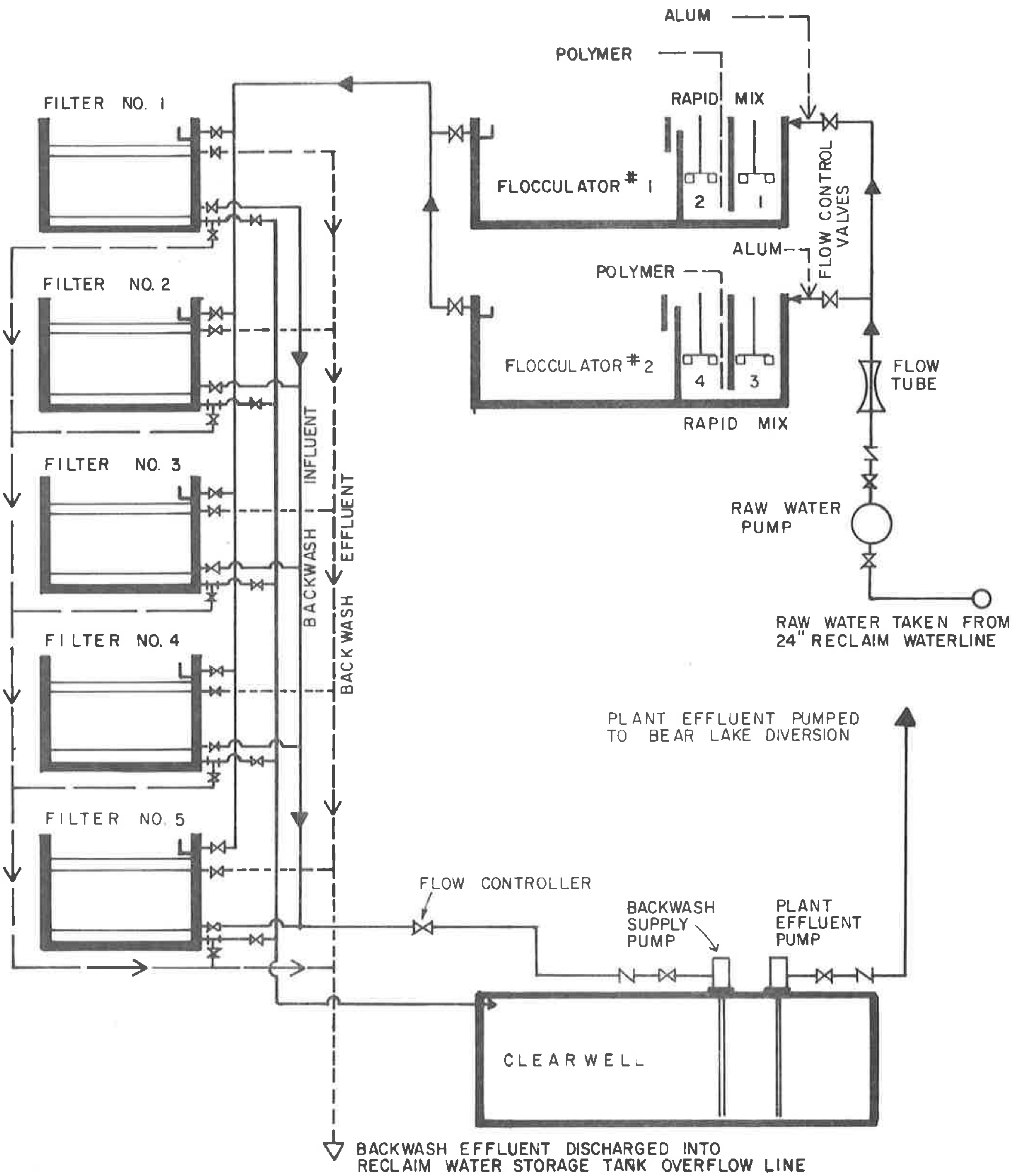
FIGURE 8



SITE 261+00

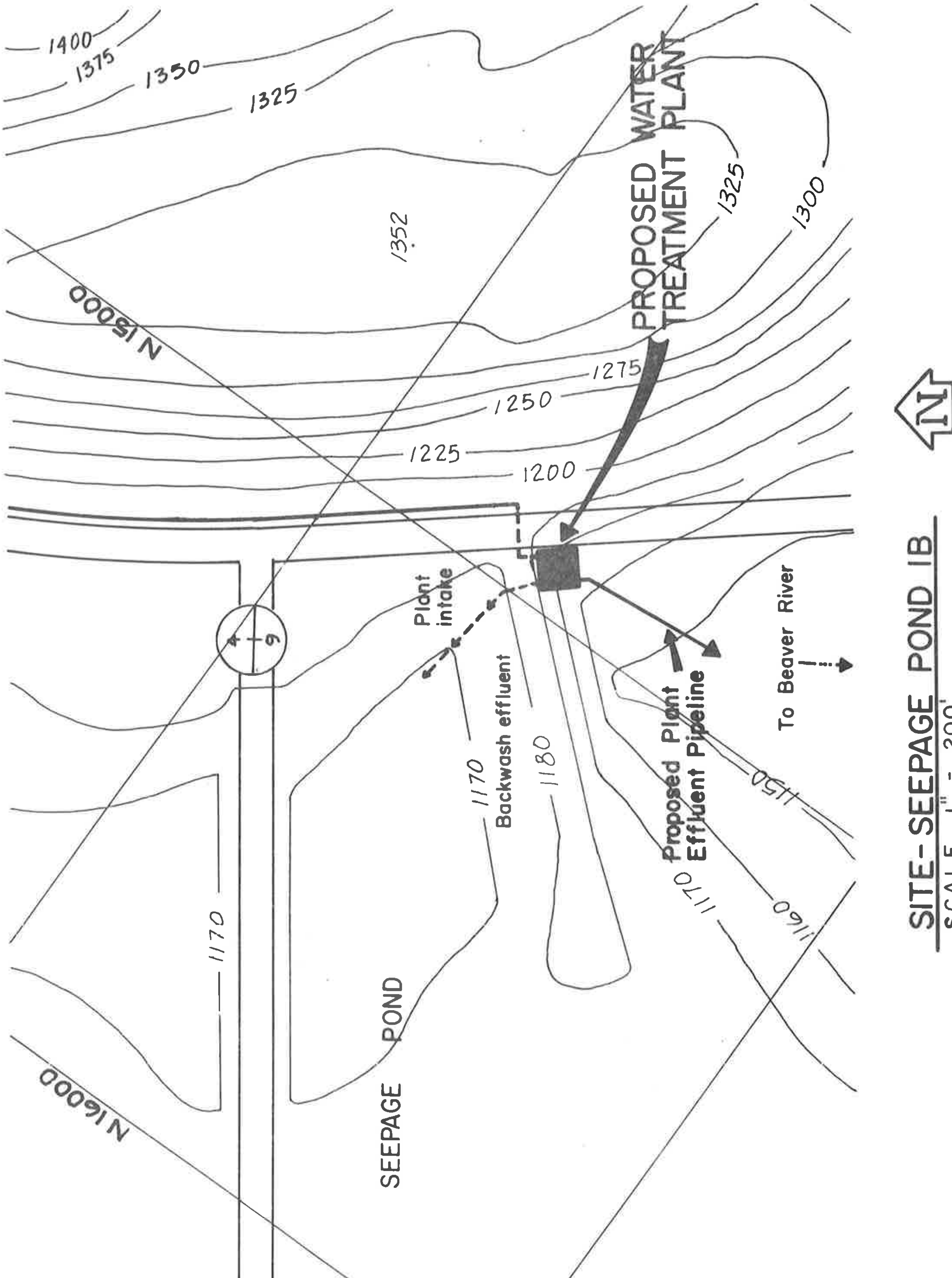
SCALE 3/32" = 1'-0

FIGURE 9



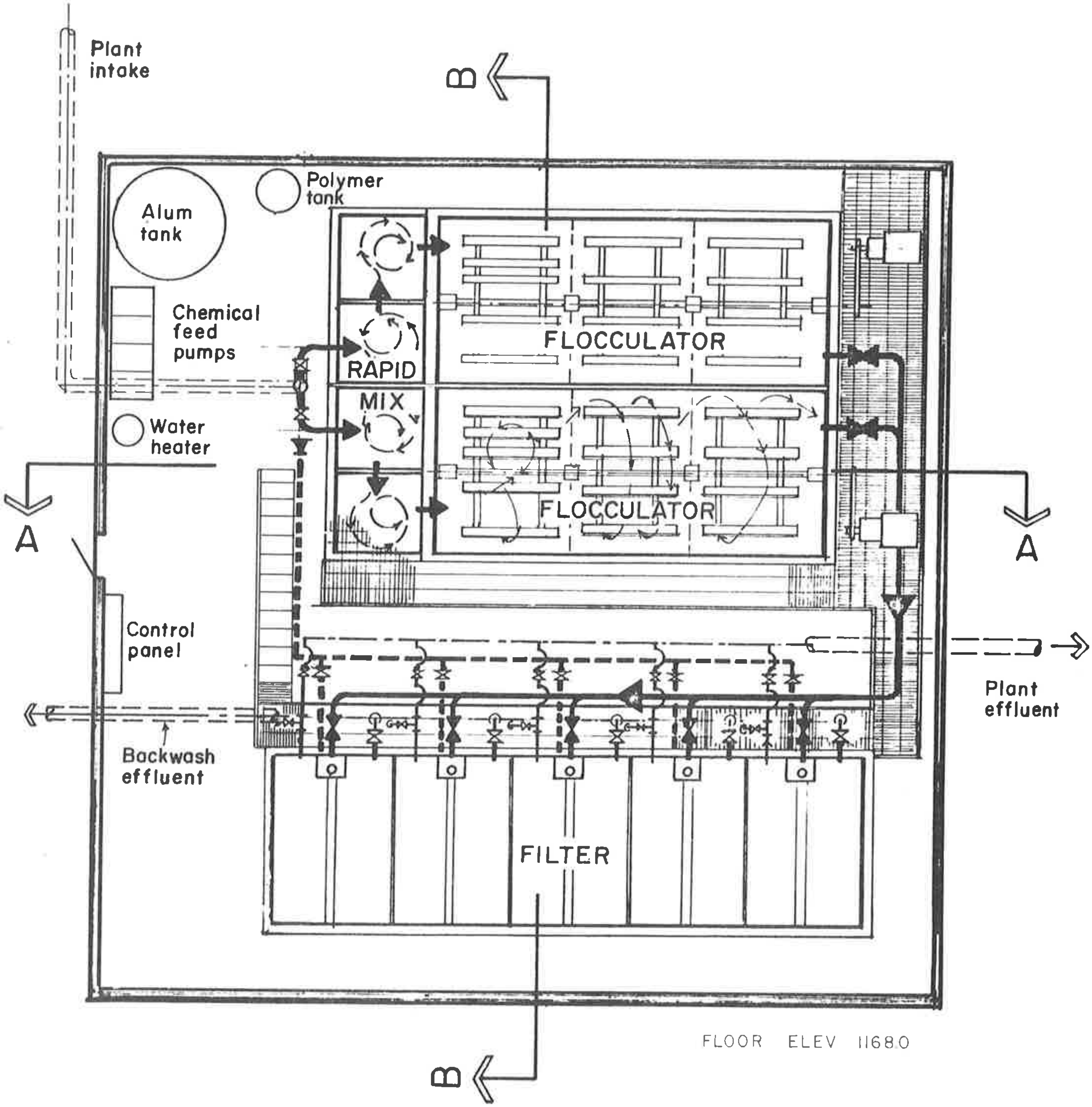
FLOW DIAGRAM-SITE 261+00

FIGURE 10



SITE-SEEPAGE POND IB
SCALE 1" = 200'

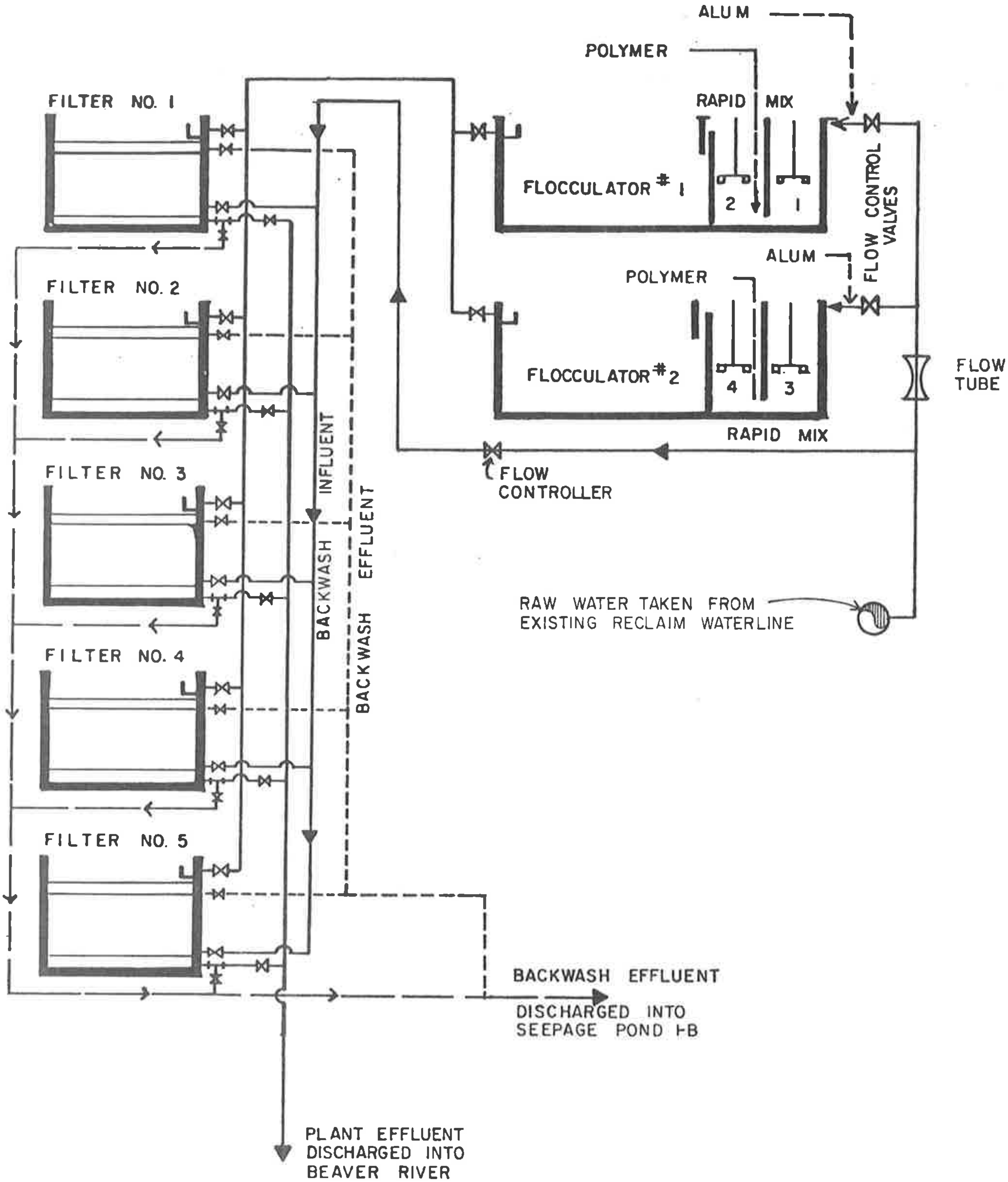
FIGURE 11



SITE - SEEPAGE POND IB

SCALE 3/32" = 1'-0

FIGURE 12



FLOW DIAGRAM - SEEPAGE POND I-B SITE

FIGURE 13

Each of the two flocculation basins will contain a single-drive, 3-stage horizontal paddle flocculator. The proposed intensity of mixing in the flocculator (temporal mean velocity gradient G) is 20 sec^{-1}. The product of the detention time (T) and the mean velocity gradient (G) has been considered a useful parameter for flocculator design. For the proposed plant, this product (GT) is 12,000 which is within the range found to give satisfactory performance in the flocculation process.

Water from the flocculation basins is distributed to five filters. Each filter will contain three layers of filter media consisting of anthracite coal, silica sand, and garnet. Filter backwashing will be accomplished in a 2-step process. The initial step will consist of injecting air into the filter media to assist in the breakup of clumps or mud balls of filter media cemented together by the coagulant chemicals. The second step will consist of backwashing with water at the rate of approximately 15 gpm per sq. ft. The backwash water will be returned to the tailings basin for the proposed plants at site 238+00 and site 261+00. Backwash water from seepage pond 1B site would be discharged into the seepage recovery pond. The method of conveyance of the backwash water varies from site to site as shown in the respective Figures.

Where raw water is used for backwashing the filter (site 238+00 and Seepage Pond Site 1B), provisions are made to discharge to waste for a few minutes after filter startup, for the filter to stabilize.

The liquid chemical feeder system will consist of two metering pumps for liquid alum and two metering pumps for the polymer mixture. The chemical feeders will be automatically activated by a signal proportional to the influent flow. Each feeder will be driven by a 1/4 HP motor. A totally automatic-type polymer feeder-mixer system will be provided. This feeder will have an adjustable solution polymer concentration range of from 0.1 percent to 2 percent by weight.

A glass-fiber reinforced plastic tank will be provided for storage of liquid alum. The tank will be 8 feet in diameter and approximately 12 feet high, providing a storage volume of about 4500 gallons.

Steel piping will be used throughout the plant except for the chemical feed piping which will be Schedule 80 PVC.

Process Control

It is intended that this treatment plant be a fully automated plant which will be unattended much of the time. Critical data and alarms will be telemetered to the control room in the Reserve Mining Processing Plant at Silver Bay.

Flow elements include an influent flow meter and a backwash flow meter. It is proposed that the influent meter be a flow tube; whereas, the backwash flow meter may be an orifice plate or an annubar element.

Process analyzers include continuous flow-through turbidimeters for each filter effluent and for monitoring the final plant effluent. A flow-through pH analyzer will be provided for monitoring the pH of the flocculation effluent.

The influent flow meter signal will be input to a flow controller which can be set at the desired flow. The flow controller will modulate an influent control valve to maintain the desired flow rate. The water level in the flocculation basins will be monitored and this level will determine the position of the filter effluent valves to assure proper submergence of the filter media. The flocculation basin level will also serve as an override to modulate the influent valve, if the water level gets too high due to downstream conditions.

The chemical feeders will be paced by a signal received from the influent flow meter. For a given chemical feed rate, the amount of chemical fed is proportional to the influent flow rate.

The control system will include a filter effluent flow interlock which will close the filter effluent valves, and thereby prohibit the filters from completely draining, whenever the treatment process is interrupted either by manual intervention, by malfunction of a process unit, or in the event of a power failure.

The control system will contain an automatic backwash control sequence initiated on reaching a preset loss of head in any one of the filters. Loss of head will be measured by differential pressure transmitters. When the preset loss of head in any one of the five filters is reached, the automatic backwash sequence will be initiated through the backwash flow controller for that filter. Filters will be backwashed on a first come, first serve basis. In general, the backwash cycle will follow this sequence:

1. Reduce the influent flow rate
2. Close the filter influent valve
3. Reduce the water level in the filter to be backwashed to a preset elevation.
4. Close the filter effluent valve

5. Open the backwash drain valve

6. Initiate air wash

7. Open backwash influent valve

8. Open backwash supply flow control valve or initiate backwash supply pump.

After the backwash cycle is completed, the operations listed above will be operated in reverse sequence, with initial filter effluent being wasted during a set-up period.

Pumping units, where required, will be automatically started and stopped. At Site 238+00, the operation of the backwash discharge pumps will be controlled by the water level in the backwash holding tank. At Site 261+00, the raw water pumps will be initiated by the influent flow controller, the backwash supply pumps will be initiated during the automatic backwash sequence, and the plant effluent pump operation will be controlled by the water level in the clearwell. The pumps on the floating barge, supplying the water to the seepage pond 1B site, will be initiated by plant startup procedures.

The control panel at the treatment plant will include recorders for plant flow and plant effluent turbidity. Indicators will be provided for effluent turbidity at each filter, loss of head at each filter, plant influent turbidity, floc pH, flocculation water level, and backwash flow rate.

Alarm indications at the pump station will include high filter turbidity for each filter, high filter head loss for each filter, high or low flocculation pH, and high flocculation water level. In addition, if the plant is built at Site 238+00, a high backwash effluent tank level alarm would be included and at Site

261+00, a high clearwell level alarm would be included.

It is proposed that critical plant operating data and alarms be telemetered to a control room at the Reserve Mining Processing Plant at Silver Bay. Indicators would be provided for influent flow, influent turbidity, plant effluent turbidity, flocculation pH, filter effluent turbidity for each filter, and filter head loss for each filter. Alarm signals to be telemetered include treatment plant building high or low temperature, plant power failure, smoke or fire detector, high flocculation water level, high or low flocculation pH, and high filter effluent turbidity for each filter.

SITE CONSIDERATIONS

The water treatment plant outlined in the previous section consists, essentially, of basic coagulant feed, flocculation, and filtration modules. Variations to the basic process are introduced by site-specific factors unique to each proposed plant location. Three sites have been considered and are shown on Figure One.

Site RWL 238+00

This site, downstream of the Reclaim Water Line headtank, permits, perhaps, the simplest hydraulic solution to the facilities that are proposed for construction by the project.

Water will be drawn from the Reclaim Water Line at approximate pipeline Station 238+00. Flow through the plant to the effluent pipe would be driven by gravity without internal repumping. Backwashing would be accomplished with untreated reclaim water. Initial filter operation or set-up, following backwash, would be wasted to a spent backwash water holding tank. This holding tank will be sized to accommodate two sequential backwash cycles. Pumping of spent backwash water will be required to convey this process waste back into the tailings basin.

A comparison among the several sites summarizing pumping requirements is shown in Table Five.

Site RWL 261+00

This site is located adjacent to the Distribution Box and House, near the Reclaim Water Line Headtank.

Based upon the specific final site selection, it is probable that plant influent and effluent and backwash influent water would have to be pumped. Influent and effluent pumping would require very low-head pumps. Spent backwash water should be capable of direct disposal to the headtank overflow line; however, the hydraulics of flow in this line should be examined during an early design stage to ascertain that the hydraulic profile would permit gravity discharge to the tailings basin under all conditions of operation of the reclaim water line.

This site, topographically, is difficult. The cliff to the south, the access road and pipelines to the north, and the 13.8 KV line overhead, leave a very confined space available for a plant. The 1983-4 winter season has provided ample evidence of the need for snow plowing and snow storage space. Maps available at this time do not accurately reflect "as built" contours in this area. Serious continuing consideration of this site should be preceded by topographic survey, without snow cover, to permit a careful appraisal of the site and surroundings.

Site Seepage Recovery Dam 1B

This site, as shown on Figure 1, is more immediately accessible to the maintenance garage and entrance road.

Influent water is not readily available to the site and will have to be piped for a considerable distance in a new transmission line. Two alternatives were examined, in terms of an influent source, (1) construction of an independent floating pump house, and (2) a tap into the existing Reclaim Water Line (RWL). The present areal extent of the basin water suggests that connection to the Reclaim Water Line is the most feasible.

Plant effluent would be discharged by gravity to a natural water course.

Backwash water influent would be derived from the plant influent line. Spent backwash water would be discharged to the seepage recovery pond, for eventual discharge into the tailings basin by the existing seepage pond pumping system.

TABLE FIVE

PROCESS PERIPHERALS ASSOCIATED WITH SITES 238+00, 261+00 and 1B

	Site 238+00	Site 261+00	Site 1B	
Influent supply	gravity (RWL)	pumped (indep.sta)	gravity (RWL)	or pumped (indep. sta.)
Effluent	gravity	pumped	gravity	
Backwash Supply	gravity (RWL)	pumped fr.effluent tk.	gravity (RWL)	or pumped (indep. sta.)
Backwash Effluent	pumped	gravity	gravity	

PROJECT COST ESTIMATES

Construction Costs

Estimated construction costs for the three plant locations are presented in the following three tables, Six, Seven, and Eight.

Many cost items are the same from table to table. Noteworthy differences occur among the items relating to:

(1) Sitework and Exterior Piping

(2) Concrete Foundation, Slab, and Tank

(3) Interior Piping and Valves

(4) Pumps

Brief commentary regarding these items of significant difference is offered.

The sitework estimates are based upon most limited field information. Two of the sites have been visited, to the extent that observations could be made from the road, under Winter 1983-4 conditions of severe snow accumulation. Cost differences are based upon possible soil differences and map interpretations.

The soil type at Site 238+00 is assumed to consist of glacial till. Ledge rock removal is not anticipated.

Due to the obvious exposed rock cliff, immediately to the south of the Site 261+00, and the rock excavation which is reported to have occurred during

TABLE SIX

ESTIMATED CAPITAL COST

SITE 238+00

Sitework and exterior piping	$ 48,100
Concrete foundation, slab, tank	96,500
Metal superstructure	86,400
Misc. metals	20,000
Painting	15,000
Rapid mix, Floc, Filter Tanks (steel) with mixers and flocculators	405,000
Interior piping and valves	85,600
Pumps	12,000
Blowers and Air Compressor	9,900
Misc. mechanical (monorail, plumbing, H&V, etc.)	18,100
Chemical storage and feed system	35,400
Electrical	94,000
Instrumental and controls	175,000
Miscellaneous (Mobilization, bond, insurance)	55,000
Estimated Construction Cost	$1,156,000
Contingency	114,000
Engineering (Final Design)	80,000
Estimated Project Cost	$1,350,000

TABLE SEVEN

ESTIMATED CAPITAL COST

SITE 261+00

Sitework and exterior piping	$ 60,500
Concrete Foundation, slab, tank	96.500
Metal superstructure	86,400
Misc. metals	20,000
Painting	15,000
Rapid mix, Floc, Filter Tanks (steel) with mixers and flocculators	405,000
Interior piping and valves	91,700
Pumps	23,000
Blowers and Air Compressor	9,900
Misc. mechanical (monorail, plumbing, H&V, etc.)	18,100
Chemical storage and feed system	35,400
Electrical	96,400
Instrumental and controls	175,000
Miscellaneous (Mobilization, bond, insurance)	55,000
Estimated Construction Cost	$1,187,500
Contingency	118,500
Engineering (Final Design)	84,000
Estimated Project Cost	$1,390.000

TABLE EIGHT

ESTIMATED CAPITAL COST

SITE 1B

Sitework and exterior piping	$ 180,200
Concrete foundation, slab, tank	50,000
Metal superstructure	86,400
Misc. metals	20,000
Painting	15,000
Rapid mix, Floc, Filter Tanks (steel) with mixers and flocculators	405,000
Interior piping and valves	81,900
Blowers and air compressor	9,900
Misc. mechanical (monorail, plumbing, H&V, etc.)	18,100
Chemical storage and feed system	35,400
Electrical	94,000
Instrumental and controls	175,000
Miscellaneous (Mobilization, bond, insurance)	55,000
Estimated Construction Cost	$1,225,900
Contingency	122,100
Engineering (Final Design)	86.000
Estimated Project Cost	$1,434,000

construction of the distribution house and service road, the soil type at Site 261+00 is assumed to consist, extensively, of ledge rock. The cost estimate includes a substantial allowance of rock removal, both for the setting of the concrete effluent tank and for possible leveling to permit foundation construction.

Site 1B is the most uncertain, as far as location and site preparation are concerned. The site has not been inspected by persons from RREM, Inc. Indications, from interpretation of contours shown on Reserve Mining Company map No. 22-0181, suggest that the termination of the seepage recovery dam with the terrain on the east end may be on a fairly steeply sloped site. Inspection of the area, under conditions that permit careful exploration, may reveal an acceptable, natural setting for the plant which would substantially reduce site preparation costs.

For purposes of this estimate, the Site 1B is assumed to be built up on the outside face of the seepage recovery dam. The bulk of the increased cost is contained in the estimate for placing coarse tailings, or other engineered fill, to create a suitable building site.

Other significant differences relate to items which were identified in Table Five in the previous section. As shown in the plates, two of the sites require underground storage reservoirs; Site 261+00 requires a total of three additional pump settings, when compared with Site 1B, and Site 238+00, one additional pump setting, when compared with 1B.

Operating Costs

Estimated plant operating costs are presented in Table Nine. The footnotes indicate certain of the assumptions upon which the table is based.

The most important omission is the cost of labor. It is the intent of the design to automate plant operations in order to permit operation without full-time attendance by a plant operator. Plant performance data and alarm conditions which are essential to successful operation will be transmitted to the E. W. Davis main plant control center for regular observation. A cost for labor, nevertheless, will certainly be chargable to water treatment plant operations.

A cost for pumping the water into each plant is included in the operating cost data. Two of the sites take water directly from the reclaim water line and are fed without repumping. Site 261+00 includes a cost both for pumping in the Reclaim Water Line and for repumping at the site.

Footnote (2) of Table Nine suggests that consideration should be given to the installation of an additional pump in the floating pump house which would be suitable for water plant operation, alone, when the E. W. Davis plant is shutdown. The lower head-discharge condition associated with passing 2,500 GPM through the 24-inch RWL should be matched by a pump operating in its most efficient range. Throttling of the 6,500 GPM pumps to the lower output, or pumping at the design point, with return of the excess water to the tailings basin, are both costly and inefficient practices.

Chemical costs have been computed on the basis of an alum feed rate of 20 mg/l.; polymer on the basis of 0.20 mg/l.

Full-year operation has been assumed.

TABLE NINE

ESTIMATED WATER PLANT OPERATING COSTS (1)

COST ITEM		238+00	261+00	1B
PUMPING:	RWL (Influent)	$ 38,700(2)	$38,700(2)	$ 38,700(2)(3)
	Repumping (Influent)	N/A	2,300	N/A
	Effluent	N/A	11,000	N/A
	Backwash (Influent)	N/A	600	N/A
	Backwash (Effluent)	1,400	N/A	1,000(4)
PROCESS EQUIPMENT:	Rapid mix, Flocculator, Chem Feeders, Mixers, Fans, etc.	$ 4,500	$ 4,500	$ 4,500
CHEMICALS:	Alum	$ 33,800	$33,800	$ 33,800
	Polymer	7,550	7,550	7,550
BUILDING:	Heating and Lighting	$ 7,000	$ 7,000	$ 7,000
DEPRECIATION & REPLACEMENT:		$ 9,100	$ 9,815	$ 8,390
		$102,050	$115,265	$100,940

Note: (1) The above cost estimates do not include labor costs, only commodity costs: electric power, chemicals, etc.

(2) If a 2,500 to 3,500 GPM pump is installed on the floating barge, to pump to the water plant site, during periods of shut down, the annualized cost of such pumping would be approximately $28,650.

(3) A slight reduction in this cost would be realized because the estimated 9,000 GPM combined pumping rate would occur only to the tap for the water plant. The net flow for the last 1,000 feet would be 6,500 GPM. A slight reduction in pumping head would result.

(4) The seepage recovery pond pump house will have to move this additional flow back to the tailings pond. In the early years the pumpings head will be small. As the tailings dam nears completion, the pumping head will exceed 130 feet.

SUMMARY AND RECOMMENDATIONS

Water treatment process pilot plant studies and more than six years accumulated operating experience of three North Shore of Lake Superior municipal water plants have demonstrated the ability of polymer-assisted alum coagulation and filtration to remove amphibole fibers from Lake Superior (and chemically similar) raw waters.

Stipulated effluent water quality for fiber removal from the proposed tailings basin appropriation and discharge has been set at specific values which are somewhat less rigorous than the removals accomplished, on a consistent basis, by each of the existing municipal plants.

An amphibole fiber count of less than 15 million fibers per liter ninety-five percent of the time has been set as the definitive fiber removal standard.

Coagulation and filtration rates have been selected, for the design of the proposed plant, which fall within the parameters which have been tested repeatedly by the North Shore plants. A water treatment plant is proposed that meets the following hydraulic parameters:

(1) 2,500 GPM flow rate.

(2) Four minute detention, rapid mix.

(3) Twenty minute detention, flocculation basin.

(4) Design filtration rate of 5 GPM per square foot.

Three sites have been examined, each located adjacent to the tailings basin. The basic fiber removal process examined by this report is identical for each site. Cost differences, upon which to base decisions regarding location, result from site specific factors. Comparative construction and operating costs for the three sites are presented in the following Table.

TABLE TEN

COST COMPARISON FOR SITES 238+00, 261+00 AND RECOVERY DAM 1B

	238+00	261+00	1B
Construction Cost	$1,350,000	$1,390,000	$1,434,000
Annual Operating Cost	$ 102,050	$ 115,265	$ 100,940

A recommendation for construction of the plant at Site 238+00 is based upon the following factors:

(1) Existence of a heavy duty, all-weather road.

(2) Access to power.

(3) Construction cost.

(4) Operating cost.

REFERENCES

1. "Direct Filtration of Lake Superior Water for Asbestiform Fiber Removal." Black & Veatch, Consulting Engineers for the EPA, National Environmental Research Center, Water Supply Research Laboratory, Cincinnati, Ohio. (March 1975)

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4. "Filter Plant Design for Asbestos Fiber Removal." Gary S. Logsdon et al, Journal of Environmental Engineering, Vol. 109, No. 4, American Society of Civil Engineers. (August 1983)

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