PRELIMINARY REPORT ON THE
HYDROLOGY OF THE ROCHE BAY AREA
BOREALIS EXPLORATION LIMITED

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BOREALIS EXPLORATION LIMITED

CALGARY, ALBERTA

JANUARY, 1984

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This hydrological report should be read in conjunction with the following Borealis Exploration Limited Roche Bay Magnetite Project documentation:

Initial Environmental Evaluation,

Addenda to the Initial Environmental Evaluation,

Permit Applications.

1. INTRODUCTION

Borealis Exploration Limited is committed to bringing into production its magnetite properties on the Melville Peninsula. The ore is composed of interbedded magnetite and silica. Waste, other than the silica, can be either intrusive igneous rocks or metavolcanics. The ore is to be mined by conventional open pit methods. The ore will be concentrated by means of magnetic separation.

The final milling process has not been determined and will depend to a great extent on the requirements of the iron ore market. It appears, at this time, that the preferred product will be a high grade concentrate of over 71% iron. Should this be the case, some wet magnetic separation of the concentrate will be required. In addition, there are significant quantities of precious metals in the iron formation. Borealis Exploration Limited is currently evaluating the economic feasibility of recovering the precious metals by means of sulphide flotation. Should the decision be made to recover the precious metals by means of sulphide flotation, additional applications for water use will be made.

Borealis will impact on the hydrology of the region in two ways. The first is by extracting water to be used for processing as well as for generalized industrial and domestic purposes. The second set of impacts on the hydrology of the region will result from diversion of flow in order to facilitate mining and to prevent pollution or erosion in environmentally sensitive areas.

Based on the information to date, Borealis Exploration Limited will require water for the following uses:

1) Transportable moisture content--Borealis estimates that a moisture content of approximately 3% will be required for safe shipment of the Borealis magnetite concentrate. The transportable moisture content is defined as the moisture content at which the concentrate will remain stable in the hold of a ship.

2) Mill water--Water will probably be required for some part of the magnetic separation process. If water is required for wet magnetic separation, additional water to ensure the required transportable moisture content will not be required.

3) Industrial uses--Water will be used in the day-to-day operation of the mill and mine equipment and there may be some water required for wet scrubbers in a coal fired power plant.

4) Domestic water--Domestic water will be required to supply a bunkhouse community with approximately 450 residents.

The deposit to be mined first is bisected by a small river. Therefore, dams and diversion canals are required to prevent flooding of the pit. A dam will also be constructed to form a tailings pond and to prevent pollution of a major lake.

2. CLIMATE

The mean monthly temperature from December to March is -29°C. During the summer, the average temperature is 5°C. However, temperatures can reach as high as 16°C. Annual precipitation averages about 23 cm (9 inches). Fifty percent of the annual precipitation falls during the months of July, August, and September. Total snowfall averages about 124 cm. Relatively strong and directional winds whip the snow into drifts. Due to the relative uniformity of the prevailing winds, snow accumulates in large drifts at any break point in the wind. For example, in the winter of 1983, a D-4 tractor was completely covered, and snow had drifted up to the eves on the camp buildings. Valleys and gullies tend to fill completely with snow thus creating a relatively planar topographic surface.

Borealis established an automatic recording weather station during the 1982 field season. The station operated for a period of seven months. The data recorded by that station can be found in Appendix A. Monthly average windspeeds average between 16 km/hr (10 mph) to 26 km/hr (16 mph). Peak windspeeds of 98 km/hr (61 mph) can be expected to occur on a 30 year return period (National Research Council 1965). The predominant wind directions are: west, northwest, north, and northeast.

The climatic data presented in Table 1 is for the Hall Beach station. Empirical observations on Roche Bay indicate that the Roche Bay area may be warmer than the Hall Beach area. The apparent reason for this climatic difference is that the eastern-facing escarpment of the Canadian Shield creates a solar trap in the Roche Bay area. As a result, the snow melts sooner and more rapidly than in the Hall Beach area. By June 11, 1983, the Roche Bay area was approximately 40% snow covered, while the raised beach terrain between the mine site and Hall Beach was stillat least 80% snow covered.

TABLE 1

CLIMATIC DATA FOR HALL BEACH

MONTH	TEMPERATURE CELCIUS	PRECIPITATION RAIN cm	SNOW cm	DAYS WITH PRECIP
JANUARY	-31.00		8.80	9
FEBRUARY	-32.00		8.50	6
MARCH	-29.50		12.30	8
APRIL	-20.90		11.50	9
MAY	-9.10		16.20	11
JUNE	0.00	1.67		8
JULY	5.40	3.44		10
AUGUST	4.60	4.08		11
SEPTEMBER	-0.60	2.74		12
OCTOBER	-10.50		21.50	12
NOVEMBER	-21.50		12.90	10
DECEMBER	-27.40		9.20	9
AVERAGE	-14.37			
AVERAGE PRECIPITATION		22.02		

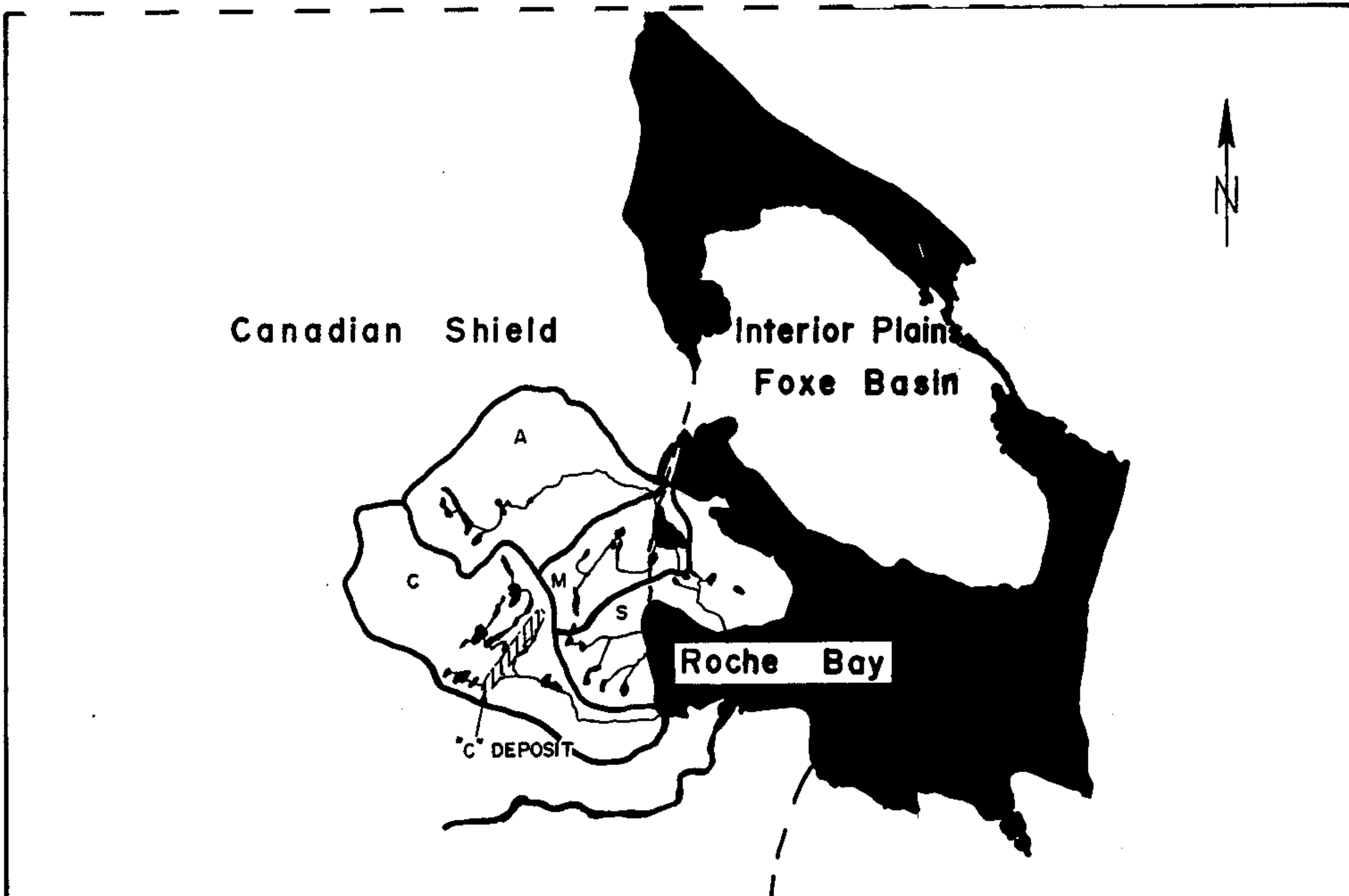
Prevailing winds are out of the north and northwest
Average windspeed is 25 km/hr
Maximum wind speed 127 km/hr in October
All months other than April, May, June, and July have winds in excess of 100 km/hr.

3. PHYSIOGRAPHY

The area to be developed by Borealis falls within two main physiographic regions of Canada (see Figure 1). The low-lying peninsula which extends into Roche Bay ("the Roche Bay Peninsula") is part of the interior plains and has been further subdivided into the Foxe Basin Region. The more rugged upland areas belong to the Canadian Shield.

3.1 SHIELD REGION

The upland areas are composed of metamorphic and igneous rocks. The region was glaciated during the last glacial period and a thin (1 m to 2 m) veneer of till was deposited. The till is generally buff to grey in colour and silty. The till is derived from local rocks and thus is largely composed of shield type material. Due to the lack of vegetation, there has been extensive surface washing of the till which has resulted in a removal of fines leaving the ground surface littered with boulders. Existing and abandoned streams tend to concentrate boulders in their stream beds.



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Physiographic Region and Drainage Basins

FIGURE 1

PRELIMINARY

During glaciation the land mass was depressed, and wave action modified the landscape to an elevation of at least 110 masl. At elevations below the marine limit, the till has been reworked into beaches or completely eroded. The beaches consist of coarse pebbles and cobbles. All of the finer fraction has been removed by wave action. The beach at the highest elevation is generally poorly developed as beach. The terrain in the higher less developed beaches tends to be relatively flat and is capable of supporting vegetation. An organic mat up to 10 cm thick has formed on these areas.

3.2 FOXE BASIN REGION

The Roche Bay Peninsula extending into Roche Bay to the east of the mine site is underlain by relatively flat-lying Paleozoic sedimentary rocks. As the sea level dropped following deglaciation, the upper surface of the dolomite and limestone rocks were frost-shattered and wave-worked into beaches. A single borehole that penetrated the beaches indicated that the beach material was at least 3 m thick. The beaches are extensive and due to their mode of formation tend to form closed depressions. Relic bedrock structures have been identified in the interbeach areas. These structures suggest that the overburden layer in the interbeach regions may be relatively thin. The beach tops tend to be well drained, dry and devoid of vegetation, and the interbeach terrain is wet and is capable of supporting vegetation.

4. DESCRIPTION OF FACILITIES

4.1 INTRODUCTION

The Borealis Exploration Limited Magnetite Project will incorporate all of the elements of a standard mining venture. The location of the facilities is shown in Drawing C1 (Drawings C1 to C4 are in Appendix C). The placement of each of the components has undergone a number of evolutionary changes as more design data is collected. Hence, while Drawing 1 reflects the current state of knowledge, it is subject to change.

The mine, mill, and other elements of the infrastructure are briefly described in the following sections. Detailed descriptions of these facilities can be found in other reports, that deal with these project elements individually.

4.2 MINE

Borealis will extract the iron ore by means of traditional open pit mining methods. The ore and waste will be fragmented by blasting and loaded into trucks by shovel. The ore will be trucked to a primary crusher for processing. The waste will be disposed of in waste rock dumps.

Borealis intends on shipping 7.3 million tonnes of concentrate per year. The average grade of the deposit is estimated to be 25%, although grades in excess of 30% have been measured. The mill is capable of recovering 90% of the magnetic iron during the production of a 71.2% Fe concentrate. Therefore, the total ore mined each year will be in the order of 23 million tonnes. The waste-to-ore ratio is estimated to be 0.4 and, as such, the waste removal will amount to 9 million tonnes per year.

The ultimate pit will be in the order of 200 meters deep. The final depth will be reached some 20 years from present, and prevailing economics will dictate the final geometry of the pit.

4.3 MILL

The mill will probably use both wet and dry magnetic separation during the benefication of the ore. The concentrate will be shipped via conveyor to the tip of the Roche Bay Peninsula, where it will be stored prior to shipment. Testing has shown that for a 71% Fe product, dry magnetic separation is practical to -4 mesh. At this point approximately 35% of the waste material has been removed. The waste fraction will be conveyed to the sands disposal area located to the east of the mill. The -4 mesh material will be ground and wet concentrated. The waste from this stage of the beneficiation will be transported via pipeline to one of two tailings ponds. The two tailings ponds, Mill Lake and C Lake, have been designated (see

Drawings C1 and C2). Mill Lake, a lake to the northeast of the mill, will be used during the first years of operation, while C Lake, impounded behind the Waste Rock Dam, will be used during the remaining years.

4.4 INFRASTRUCTURE

By "infrastructure" is meant those project elements that are not directly involved in the mining and milling operations but are required to support those operations. Included in the list are: the townsite, airport, roads, general purpose docks, and power plant.

Approximately 450 men will be employed on site to mine and mill the ore. Accommodations will be provided in a bunkhouse community. These men will require a stable source of potable water. The location of the supply and required volumes are described in a subsequent section (5.8). Additional water may be required if wet scrubbing is used to control power plant emissions. However, the amount required for that purpose cannot be determined until final design of the thermal power plant has been completed.

5. GROUND WATER AND SURFACE WATER

5.1 GROUND WATER

Since the ground is permanently frozen there is no ground water as is ordinarily understood by that term. Melville Peninsula is an area of deep permafrost. The company has made no measurements of the depth of the permafrost but other studies have estimated the depth of permafrost from 300 m to 500 m. The active layer varies from about 20 cm to 92 cm depending on surface characteristics.

5.2 RUNOFF OBSERVATIONS FOR 1983

Little or no runoff was noted before the end of the first week in June. While the Roche Bay area was approximately 60% free of snow, the melt water had apparently not reached the major water courses. Melt waters were either infiltrating and saturating the ground, or were being retained in the remaining snow banks. By June 10, all the major rivers were flowing. However, portions of the river channels were cut through snow banks and in some cases were controlled by the position of the snow bank. For example, snow banks inhibited the full recharge of Irqalugarjuit Lake at the west end of the peninsula by directing the flow southward and ultimately to the sea on the south side of the peninsula. The melt waters that did reach the lake originated from that portion of the drainage basin downstream of the snow bank and the water appeared to flow over the ice, thus limiting recharge to the lake. By June 10, open water was present along the shore. The lake was not completely clear of ice until the middle of July.

The type of lake ice that remained during the first week of July is generally referred to as candlestick ice. The principal crystallographic axis of the ice crystals is vertical and the ice breaks along vertical planes. The floating remainder is usually removed from the surface of the lake by a wind that is strong enough to force the fragmented ice up onto the shore.

With the decrease in snowmelt came a corresponding decrease in stream flow. Due to the general lack of precipitation, the base flow in the rivers is a function of the melting of residual snow banks. It is estimated that stream flows decreased by about 90% during the summer for major streams and rivers, while smaller drainage courses dried up completely. No stream gauging was made due to the number of boulders in the stream and river beds. It was anticipated that staff gauges would be installed and monitored. However, due to the boulder concentrations in the stream beds, it was impossible to locate a suitable length of stream to gauge. Weirs may be a possible method of determining stream flows. Installation of a weir may be difficult, however, due to the nature of the stream beds and therefore diversion channels with weirs may be required.

5.3 DRAINAGE BASINS AND WATER QUALITY

5.3.1 Drainage Basins

The mine facilities will affect four main drainage basins. The location of the basins is shown on Drawing C2. For identification purposes, each basin has been identified according to the main mine facility falling within that basin. For example, the C Deposit is found within the C Basin. The size of the main basins are given in Table 2.

The four basins have been identified as follows:

Basin Name	Principal Mine Facility
1. The C Basin	"C" Deposit
2. The S Basin	Sands Disposal Area
3. The M Basin	Mill Site
4. The A Basin	Adler Deposit

The C Basin covers an area of 87 km^2 and drains entirely through the C River, a river which flows through the center of the C Deposit and then over a 20 m waterfall into Roche Bay. Largely because mining is now scheduled to begin on the C Deposit, much of the hydrological impacts of the project will be localized in this basin.

The S Basin, (the basin in which the Sands Disposal Area is located) is relatively small (about 22 km^2). The S Basin empties by a number of small streams directly into Roche Bay.

TABLE 2

BASIN AREAS

A Basin			C Basin			M Basin			S Basin		
	km^2	%		km^2	%		km^2	%		km^2	%
A1	1.03	1.8	C1L	11.05	12.6	M1	2.76	12.4	S1	0.38	1.7
A2	0.80	1.4	C1U	19.15	21.9	M2	2.13	9.6	S2	3.36	15.2
A3	0.44	0.8	C2	6.1	7.0	M3	1.51	6.8	S3	0.36	1.6
A4	2.24	4.3	C3	1.6	1.8	M4	0.96	4.3	S4	1.23	5.6
A5	0.56	1.0	C4	4.4	5.0	M5	1.23	5.5	S5	6.79	30.8
A6	0.62	1.1	C5	6.6	7.5	M6	0.96	4.3	S6	1.38	6.3
A7	0.45	0.8	C6	2.5	2.9	M7	3.0	13.9	S7	0.11	0.5
A8	4.46	7.9	C7	14.5	16.6	M8	9.67	43.5	S8	3.15	14.3
A9	4.17	7.4	C8	0.64	0.7				S9	0.37	16.8
A10	2.23	4.1	C9	0.65	0.7				S10	2.04	9.3
A11	9.25	16.4	C10	0.26	0.3				S11	0.02	0.1
A12	1.11	2.0	C11	0.31	0.4				S12	1.08	4.9
A13	5.95	10.6	C12	1.35	1.5				S13	0.34	1.5
A14	3.81	6.8	C13	2.4	2.7				S14	1.44	6.5
A15	6.92	11.3	C14	6.92	7.9						
A16	0.15	0.3	C15	0.84	1.0						
A17	0.13	0.2	C16	2.9	3.3						
A18	6.33	11.2	C17	1.3	1.5						
A19	0.87	1.5	C18	0.73	0.8						
A20	3.73	6.6	C19	0.28	0.3						
A21	0.71	1.3	C20	0.18	0.2						
A22	0.38	0.7									
A23	1.03	1.8									
Total	56.33			87.44			22.22			22.05	

Notes

-Drainage Basin Areas Calculated by Planimeter
-Waste Rock Dam Drainage Area 51.46 km^2
-FSL for Waste Rock Dam 180 masl
-New Outflow for C Basin via C7 Sub Basin and into Ajaqutalik River System of the M2 Sub Basin
-Mill Lake Dam Reverses Outflow into Sub Basin S5
-Potential Diversion From A River into Irqalugarjuit Lake

The M Basin is named for the mill location. The water from the M Basin collects in the Irqalugarjuit Lake and empties by means of a short river into Roche Bay. Irqalugarjuit Lake is a source of fish for Hall Beach residents. The M Basin is therefore environmentally sensitive and measures are being designed to divert any pollutants from entering this system.

The A Basin contains the Adler and B deposits. the A Basin empties into Roche Bay through a river which we have identified as the A River. We do not anticipate any major impacts on this basin unless it proves advisable to divert some of the water from the A Basin into the Irqalugarjuit Lake to maintain water levels in that lake.

5.3.2 Water Quality

The Northwest Territorial Water Board has taken several lake and stream water samples over the past two years. The company has not, as yet, received a map indicating where all these samples were taken. When Borealis has received the additional data, the company will undertake its own sampling program in order to establish co-ordinated base-line values for future water quality monitoring.

The analysis produced from Northwest Territorial Water Board samples indicate that the regional water has an average Ph of approximately 7.2, and is fairly free of harmful contaminants. This indicates that most of the lake water originates from snow melt.

5.4 MINE SITE

5.4.1 Introduction

The mine site falls within the C Basin. The drainage pattern and density of that basin is typical of a glaciated shield terrain (see Drawings C1 and C2). The area is dotted with many small lakes and the overall drainage pattern is controlled by faults and shears in the bedrock.

The orebody lies within a drainage basin that is approximately 87 km^2. Since the orebody is centrally located within the basin, only the upper 51 km^2 will contribute flow that will have to be diverted away from the mine. The volume of water that must be controlled can only be estimated at this time. For the purpose of calculation, it is assumed that evaporation will not result in a significant water loss and that all of the precipitation that falls on the basin will eventually reach the main water course and ultimately flow by the mine. Therefore, given that the basin is 51 km^2 and the precipitation is 22 cm, then the average flow in the C River at the mine site is 11,200,000 m^3/yr. All of the flow will occur between June and September. During the initial phases of mining, the river will not affect the mining operation.

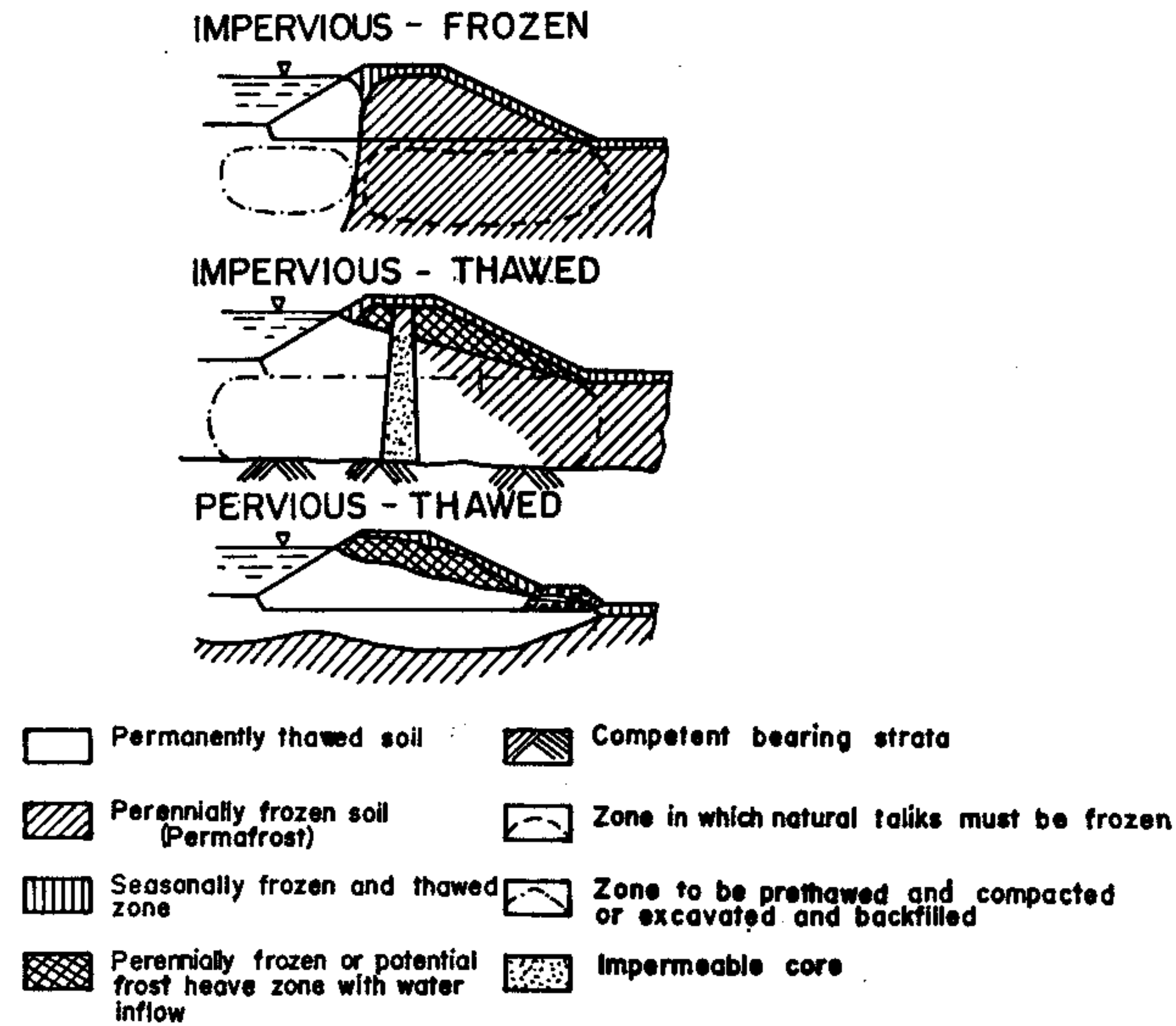
5.4.2 Stream Control and Dam Design

When the pit bottom reaches the same elevation as the stream bed, provisions to deal with the stream flow will be required. A 10 m high cliff 200 m to the east of the proposed pit creates a water fall. Minor blasting could lower the base of the channel by 10 m and extend the mining period where no major stream control would be required.

The diversion channel can consist of a tunnel or an open ditch designed to handle the peak flows. Tunnelling in hard rock is expensive and can be complicated by the permafrost. Therefore, a diversion channel is proposed. A dam is to be constructed across the existing channel. The location of the dam and the diversion channel are shown on Drawings C1 and C2. Water will be channelled from the C Basin and into the Ajaqutalik River system.

A dam in continuous permafrost terrain can take one of three forms (Johnston, 1981). The three forms are shown in Figure 2, and indicate that a truly impervious dam is possible in permafrost regions. Fulwinder (1973) states that dams of low head (<8 m) can be constructed by natural freezing of the fill. For dams higher than 8 m artificial freezing may be required. Natural dams of this sort are found on some lakes on Roche Bay Peninsula. These small lakes and ponds owe their existence to a frozen core within the raised beach shores. Therefore, construction of an impervious ice core dam is technically possible. The C Deposit Lake that would form behind the Waste Rock Dam would ultimately supply the mill and the mine with water and serve as a tailings pond.

The preliminary design of the Waste Rock Dam can be found in Appendix B. A longitudinal profile was surveyed during the 1983 field season (see Drawing C3). The survey and topographic maps,



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Thermal regimes of dams on permafrost

FIGURE 2

PRELIMINARY

indicate that it is possible to construct a 19 m high dam without extensive dike construction. The height of the dam will be a function of the relative cost of construction of additional dikes and the cost of a deeper diversion channel. While cost estimates have not as yet been produced, it is expected that the cost of excavating a 1 km diversion channel will exceed the cost of construction of dikes. Materials for the dam and dikes will come from the mine wastes or from local till sources. As shown in Appendix B, the depth of frost penetration for the year is approximately 4 m. Therefore, a permafrost core dam could be constructed in annual lifts of 4 m. The scheduling of the construction activities will be part of the final design of the structure.

The exact height of the dam will be established during the final design. Assuming that the design full stream level (FSL) is 180 m the lake impounded behind the dam will cover approximately 5 km^2. The average depth of the lake is 15 m for a volumetric water retention of 55,000,000 m^3.

Construction of the dam would be concurrent with development of the mine. Four meters of mine waste would be placed during each of the first five years of operation. The waste would be placed only during the summer months and allowed to freeze during the following winter. Since overtopping of the dam will likely occur during the first year of construction, riprap will be placed at a spillway to prevent erosion of the dam. In years 2 to 5 the height of the dam should contain all of each year's flow. The diversion canal must be completed at the same time as the dam.

The construction of the Waste Rock Dam should have little negative impact on wildlife in the area. Owing to the very steep waterfall on C River (the outlet of the C Drainage Basin), any fish in those lakes are land-locked. With the fish unable to migrate into the ocean or into other drainage systems in the region, the building of the dam should have no adverse effect on the regional char population. The increased size of the lake should enhance the local fish population and ultimately provide the area with excellent sport fishing. The area is not noted for large concentrations of other wildlife forms (see the I.E.E. and Addenda to the I.E.E.) and therefore the establishment of the Waste Rock Dam should have little other significant negative impact on wildlife.

The C Lake diversion canal should trap sediment originating from the mining activities, hence there should be no adverse impacts, on the Ajaqutalik River System.

5.4.3 Pit Water

Since the ground is permanently frozen, no ground water discharge into the pit is expected with the exception of very minor amounts from the active layer.

Nixon and McRoberts (1973) have shown that the rate of thaw penetration is directly proportional to the constant times root time. The constant is approximately 1.2 m/yr. Based on a 25 year mining life for the C Deposit, a thaw penetration of about 6 m can be expected. Thus, only those lakes that are in very close proximity to the pit must be drained.

In-pit pumps will be required to remove precipiitation and melt water. It is not anticipated that the mine-pit will extend below the permafrost. Therefore regional ground water discharge into the pit should not be a factor. Thus, the amount of water to be discharged into the local water course depends largely on the size of the pit and the amount of snow that is left in the pit during the spring thaw. Since the snow is known to drift, the pit may act as a snow trap and there could be more water pumped from the pit than would be calculated from annual snow fall. There will be a discharge point for the pit water into the C River above the dam.

5.5 MILL SITE

5.5.1 Introduction

The mill is to be situated on a bedrock knoll to the northeast of the mine. The mill is located in the far southwest of the M Basin in a sub basin which has been labelled the M2 Sub Basin (see Drawing C2). Water from the M2 Sub Basin will be diverted from the M Basin into the S5 Sub Basin in part so as not to pollute Irqalugarjuit Lake. The M2 Sub Basin contributes approximately 10% of the flow into Irqalugarjuit Lake. Should this 10% prove significant, water will be diverted from the A River into Irqalugarjuit Lake to compensate for any loss.

Local drainage improvements will be required to adequately develop the site. These improvements will consist of ditching and culverting to divert surface runoff away from the facilities. All water will be diverted to the northeast into the Mill Lake (see Drawing C2) and subsequently out of the M2 Basin.

The mill will produce two sorts of waste products; wet and dry. About 40% of the tailings will be dry and relatively coarse. The remainder of the tailings will be relatively fine and in a slurry. The wet segment will be disposed of in tailings ponds. The tailings ponds are described separately in the next section.

5.5.2 Tailings Ponds

There will be two tailings ponds. The first will be in use only until the Waste Rock Dam is completed after which time the C Lake will serve both as a source of process water and as a long term tailings pond.

In the design of the milling process, it was considered prudent to maximize the dry portion of the circuit. Previous grinding tests by Eriez Magnetics have shown that regardless of the initial feed grade, the grade at -4 mesh, after first stage dry magnetic separation, is approximately 40% Fe. From geological data, it would appear that the average grade before comminution will be 25%. The final concentrate is projected to have a grade of over 71% Fe. To produce 7.3 million tonnes of concentrate, approximately 23.0 million tonnes of iron ore are to be mined each year. Of the total ore treated 13,700,000 tonnes may be wet concentrated and produce 6.4 million tonnes of tailings. Assuming a density of the tailings of 1500 kg/m^3 then the tailings will have a volume of 4,200,000 m^3. The tailings will consolidate under their own weight and should eventually reach a density of 2000 kg/m^3. Therefore, the annual production of tailings will be in the order of 3,200,000 m^3.

Mill Lake has been designated as a tailings pond, for use until the Waste Rock Dam is completed. The lake currently drains to the north and ultimately into the Irqualugarjuit Lake. The Irkalugarjuit Lake is environmentally sensitive and should be protected from pollutants. It is therefore proposed that a dam be constructed across the north end of Mill Lake. Surveyed lake levels indicate that raising the lake by 5.3 m will result in a reversal of flow. Design data for the dam can be found in Appendix B.

No bathymetry of the lake has been carried out. However, based on a visual examination of the topography surrounding the lake and the addition of 5.3 m of water as a result of the dam, an average depth of 30 m has been assumed for the lake. The lake has a surface area of 490,000 m^2. Storage available for tailings is estimated to be 15,000,000 m^3, or sufficient volume to last 5 years. By the end of the 5 year period, the Waste Rock Dam will be completed and the C Lake will become the tailings pond.

The water flowing out of the M2 Sub Basin Tailings Pond (Mill Lake) will pass through two small lakes in the S5 Sub Basin. These two lakes will help to trap sediment and clean the water prior to its ultimate discharge into the sea. It is anticipated that the formation of a tailings pond will not adversely affect the aquatic life in the ocean as Mill Lake contains only land-locked fish.

Once the Mill Lake is full of tailings, the Waste Rock Dam will have been constructed and tailings from the mill will be pumped to C Lake. C lake is large enough to accommodate tailings for 20 years.

Leach testing has been performed on material from the surface and the indications to date (see Addenda to the I.E.E.) are that there is no significant acid leaching from those tailings.

5.5.3 Sands Disposal

The dry silica sand that forms the waste mineral in the ore will be disposed of to the southeast of the mill. A conveyor will transport the sands to the disposal area. The S Basin is a small basin and only the 5.5 km^2 of the S Basin is affected by the sands disposal. Therefore, the impact of the sands disposal on the regional drainage system will be minimal.

Initially, precipitation will infiltrate the sands. With time, permafrost conditions will be established within the sands and any porewater will remain frozen throughout the year. The sands should therefore become a low permeable mass and thus leaching of the minor soluble component will be inhibited.

5.6 CONVEYOR AND ROAD ROUTES

The main conveyor routes and the service road for the conveyor will have an impact on the drainage of areas which it crosses. These impacts will be minimized by the building of culverts and drainage channels. The conveyor will originate in Sub Basin M2, traverse a portion of Sub Basin M3, and then cross into the S Basin. With the exception of Sub Basin M3, all flow will be directed away from recharge into the Irqalugarjuit Lake. Therefore, the conveyor route will not impact on the environmentally sensitive areas.

The total length of the conveyor will be approximately 12 km. Of the 12 km, approximately half will traverse shield terrain, while the other half will traverse raised beach terrain. Field work carried out along the conveyor route indicates that the shield terrain is underlain by up to 2 m of silty glacial till. During breakup, the till becomes soft and saturated. The poor bearing capacity of the till can be largely attributed to the lack of a distinct drainage system and saturated conditions. Since the ground is frozen at depth, no surface waters infiltrate. Therefore, all the melt water flows overland until a drainage channel is encountered.

The conveyor will be constructed on a gravel berm which will serve as an access road and a foundation for the conveyor. The road embankment will be approximately .3 m to .6 m high. In certain locations, the road will form a drainage divide and provisions must be incorporated into the design to prevent erosion. It is expected that ditching and culverts will be required to control the flow. All culverts and ditches will be designed to prevent erosion and icing.

The portion of the conveyor to be constructed on the raised beaches will present few difficulties. The form and nature of the beaches has resulted in a poorly developed drainage system. Since the terrain is essentially flat, there will be little if any disruption of the natural drainage system. Where minor creeks must be traversed, culverts or bridges will be used. Some filling of the interbeach areas will be required so as to provide an adequate foundation for the road and conveyor.

5.7 OTHER FACILITIES

Under the classification "other facilities" fall the airport, connecting roads, camp, town site, and docks. Since all of these facilities will be constructed on the raised beaches, there will be little or no impact on the natural drainage system.

5.8 DOMESTIC WATER AND INDUSTRIAL WATER

The water for the town site and construction camp will be obtained from the Irqalugarjuit Lake. The daily requirements for domestic water are estimated to be 50 gallons per day per man.

Given a 500 man operating work force, approximately 25,000 gallons per day are required. The lake appears to be quite deep and since it does not freeze to the bottom during the winter, domestic water will be available year-round. The inlet structure will have to be deeper than the ice thickness (2 m to 2.5 m). Should the amount of water used exceed recharge to the Irqalugarjuit Lake, additional water can be diverted from the A River.

Sewage will be disposed of in an isolated lake on the Roche Bay Peninsula. One lake has been identified as a potential lagoon. The lake does have an active outlet which drains through a poorly defined creek directly into the Bay. Embankments will be constructed where the raised beaches do not adequately contain the lake. In this manner, it will be possible to completely contain the waste. Since the lake has no aquatic life, there will be no adverse environmental impact. The sewage from the town and the construction camp will be either trucked or pumped to the lagoon.

6. CONCLUSIONS

Borealis Exploration Limited is currently developing the Borealis Roche Bay Magnetite Project in the eastern arctic. Existing data on the hydrology of the Roche Bay area indicates that the mine will have little adverse impact on the local and regional drainage system. Indications to date are that water quality in the area should not be adversely affected by the operation of the mine, and that where alteration of the flow will occur, standard engineering techniques can be used to ensure that both water quality and quantity are preserved.

The company will monitor both water quality and flow as the project progresses and will continue to make every effort to minimize the environmental impacts of the Borealis Roche Bay Magnetite Project.

APPENDIX A

WIND DATA

SECOND WIND INC.
7 DAVIS SQUARE
SOMERVILLE, MASS. 02144
(617)-776-8520

WIND DATA PRINT-OUT

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

SITING DEVICE MODEL: AL-2000
SOFTWARE SERIAL NUMBER: 58 SOFTWARE VERSION: 4
SITING START DATE: 7/25/1982 AT 23:03
SITING END DATE: EARLY TERMINATION
DAYLIGHT SAVINGS TIME CORRECTION INVOKED? YES
TIME CONSTANT: 1704
NUMBER OF COMPLETE OR PARTIAL MONTHS OF DATA: 7

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 7/1982 FOR SENSOR A

PEAK WIND SPEED OF: 33.0 MPH ON DAY 27 AT 16:03

LONGEST ENERGY LULL OF 5 HOURS ENDING ON DAY 28 AT 10:15

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	))38
TOTAL:	10	4	7	11	17	24	27	22	14	7	2	0	0	0	0	0	0	0
SLOW D0/DT:		4	7	11	17	24	26	22	14	7	2	0	0	0	0	0	0	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	))24
NORTH:	6	18	7	0
NOREAST:	0	6	2	0
EAST:	1	4	10	1
SOUEAST:	1	1	3	0
SOUTH:	0	0	0	0
SOUWEST:	1	0	0	0
WEST:	4	16	7	0
NORWEST:	9	23	14	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	15.125	15.125	12.625	12.250	14.375	15.500	16.750	15.625	16.750	16.625	15.125	15.000
STANDARD DEVIATION:	3.0	3.5	5.5	6.5	5.0	3.5	3.0	5.0	3.0	4.0	3.5	2.5

MONTHLY AVERAGE WINDSPEED: 15.07 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 8/1982 FOR SENSOR A

PEAK WIND SPEED OF: 31.5 MPH ON DAY 12 AT 02:09

LONGEST ENERGY LULL OF 15 HOURS ENDING ON DAY 29 AT 09:07

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	140	90	98	98	92	81	61	40	25	13	5	1	0	0	0	0	0	0
SLOW D0/DT:	89	97	97	92	80	61	40	25	13	5	1	0	0	0	0	0		
MEDIUM D0/DT:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
FAST D0/DT:	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	82	46	5	0
NOREAST:	24	7	0	0
EAST:	34	10	0	0
SOUEAST:	24	4	0	0
SOUTH:	6	0	0	0
SOUWEST:	7	5	0	0
WEST:	38	94	54	5
NORWEST:	70	69	19	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	10.625	10.750	10.625	10.000	10.750	11.500	12.125	11.500	11.375	11.375	10.000	10.000
STANDARD DEVIATION:	5.5	5.5	5.0	5.5	5.0	4.0	4.5	4.0	5.0	5.0	4.5	5.0

MONTHLY AVERAGE WINDSPEED: 10.89 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 8/1982 FOR SENSOR A

PEAK WIND SPEED OF: 31.5 MPH ON DAY 12 AT 02:09

LONGEST ENERGY LULL OF 15 HOURS ENDING ON DAY 29 AT 09:07

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	140	90	98	98	92	81	61	40	25	13	5	1	0	0	0	0	0	0
SLOW D0/DT:		89	97	97	92	80	61	40	25	13	5	1	0	0	0	0	0
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FAST D0/DT:		1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	82	46	5	0
NOREAST:	24	7	0	0
EAST:	34	10	0	0
SOUEAST:	24	4	0	0
SOUTH:	6	0	0	0
SOUWEST:	7	5	0	0
WEST:	38	94	54	5
NORWEST:	70	69	19	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	10.625	10.750	10.625	10.000	10.750	11.500	12.125	11.500	11.375	11.375	10.000	10.000
STANDARD DEVIATION:	5.5	5.5	5.0	5.5	5.0	4.0	4.5	4.0	5.0	5.0	4.5	5.0

MONTHLY AVERAGE WINDSPEED: 10.89 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 8/1982 FOR SENSOR A

PEAK WIND SPEED OF: 31.5 MPH ON DAY 12 AT 02:09

LONGEST ENERGY LULL OF 15 HOURS ENDING ON DAY 29 AT 09:07

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	140	90	98	98	92	81	61	40	25	13	5	1	0	0	0	0	0	0
SLOW D0/DT:		89	97	97	92	80	51	40	25	13	5	1	0	0	0	0	0	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	82	46	5	0
NOREAST:	24	7	0	0
EAST:	34	10	0	0
SOUEAST:	24	4	0	0
SOUTH:	6	0	0	0
SOUWEST:	7	5	0	0
WEST:	38	94	54	5
NORWEST:	70	69	19	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	10.625	10.750	10.625	10.000	10.750	11.500	12.125	11.500	11.375	11.375	10.000	10.000
STANDARD DEVIATION:	5.5	5.5	5.0	5.5	5.0	4.0	4.5	4.0	5.0	5.0	4.5	5.0

MONTHLY AVERAGE WINDSPEED: 10.89 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 8/1982 FOR SENSOR A

PEAK WIND SPEED OF: 31.5 MPH ON DAY 12 AT 02:09

LONGEST ENERGY LULL OF 15 HOURS ENDING ON DAY 29 AT 09:07

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	140	90	98	98	92	81	61	40	25	13	5	1	0	0	0	0	0	0
SLOW D0/DT:		89	97	97	92	80	61	40	25	13	5	1	0	0	0	0	0	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	82	46	5	0
NOREAST:	24	7	0	0
EAST:	34	10	0	0
SOUEAST:	24	4	0	0
SOUTH:	6	0	0	0
SOUWEST:	7	5	0	0
WEST:	38	94	54	5
NORWEST:	70	69	19	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	10.625	10.750	10.625	10.000	10.750	11.500	12.125	11.500	11.375	11.375	10.000	10.000
STANDARD DEVIATION:	5.5	5.5	5.0	5.5	5.0	4.0	4.5	4.0	5.0	5.0	4.5	5.0

MONTHLY AVERAGE WINDSPEED: 10.89 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 8/1982 FOR SENSOR A

PEAK WIND SPEED OF: 31.5 MPH ON DAY 12 AT 02:09

LONGEST ENERGY LULL OF 15 HOURS ENDING ON DAY 29 AT 09:07

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	140	90	98	98	92	81	61	40	25	13	5	1	0	0	0	0	0	0
SLOW D0/DT:		89	97	97	92	80	61	40	25	13	5	1	0	0	0	0	0	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	82	46	5	0
NOREAST:	24	7	0	0
EAST:	34	10	0	0
SOUEAST:	24	4	0	0
SOUTH:	6	0	0	0
SOUWEST:	7	5	0	0
WEST:	38	94	54	5
NORWEST:	70	69	19	1

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	10.625	10.750	10.625	10.000	10.750	11.500	12.125	11.500	11.375	11.375	10.000	10.000
STANDARD DEVIATION:	5.5	5.5	5.0	5.5	5.0	4.0	4.5	4.0	5.0	5.0	4.5	5.0

MONTHLY AVERAGE WINDSPEED: 10.89 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 9/1982 FOR SENSOR A

PEAK WIND SPEED OF: 40.5 MPH ON DAY 13 AT 11:59

LONGEST ENERGY LULL OF 28 HOURS ENDING ON DAY 5 AT 09:57

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	142	53	55	65	80	87	74	52	35	27	21	15	9	4	2	0	0	0
SLOW D0/DT:		52	55	64	80	86	74	51	35	26	21	15	9	4	2	0	0	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	13	33	19	13
NOREAST:	2	14	4	0
EAST:	9	20	6	0
SOUEAST:	11	9	1	0
SOUTH:	22	13	4	0
SOUWEST:	26	11	2	1
WEST:	44	65	29	14
NORWEST:	45	77	47	22

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	11.750	12.125	11.875	11.875	12.250	13.750	14.250	14.250	14.000	13.250	12.500	11.875
STANDARD DEVIATION:	5.5	6.5	6.5	6.5	6.5	7.0	6.0	6.0	6.5	6.5	6.5	6.5

MONTHLY AVERAGE WINDSPEED: 12.81 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 10/1982 FOR SENSOR A

PEAK WIND SPEED OF: 48.0 MPH ON DAY 22 AT 01:11

LONGEST ENERGY LULL OF 41 HOURS ENDING ON DAY 28 AT 21:00

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	))38
TOTAL:	145	54	57	48	52	59	59	59	53	42	34	28	21	15	9	5	2	1
SLOW D0/DT:		53	57	48	51	58	59	59	53	42	34	28	21	15	9	5	2	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	))24
NORTH:	29	38	15	0
NOREAST:	10	11	11	0
EAST:	36	36	11	0
SOUEAST:	18	14	4	0
SOUTH:	13	7	2	0
SOUWEST:	13	4	1	0
WEST:	28	43	75	84
NORWEST:	12	15	36	31

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	15.250	15.125	14.500	14.375	14.000	13.750	13.750	14.250	14.625	14.500	14.375	14.375
STANDARD DEVIATION:	8.0	8.0	7.5	7.5	7.5	8.0	8.5	8.0	8.5	9.5	9.0	8.5

MONTHLY AVERAGE WINDSPEED: 14.41 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 11/1982 FOR SENSOR A

PEAK WIND SPEED OF: 60.5 MPH ON DAY 20 AT 04:30

LONGEST ENERGY LULL OF 92 HOURS ENDING ON DAY 4 AT 20:43

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	232	27	25	21	24	29	38	42	38	37	36	33	30	25	21	16	12	33
SLOW DØ/DT:		27	25	21	23	29	38	41	38	37	36	33	30	25	21	16	12	
MEDIUM DØ/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST DØ/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	6	13	15	30
NOREAST:	0	0	0	0
EAST:	1	1	1	0
SOUEAST:	3	0	0	0
SOUTH:	4	2	1	2
SOUWEST:	13	14	13	13
WEST:	24	41	60	110
NORWEST:	22	20	27	51

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	16.125	16.125	16.750	16.875	16.125	15.375	15.125	14.875	15.000	14.625	15.250	15.250
STANDARD DEVIATION:	12.5	13.0	13.0	13.0	12.5	12.5	12.0	11.0	11.0	11.5	11.5	12.0

MONTHLY AVERAGE WINDSPEED: 15.63 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 12/1982 FOR SENSOR A

PEAK WIND SPEED OF: 57.0 MPH ON DAY 4 AT 19:56

LONGEST ENERGY LULL OF 37 HOURS ENDING ON DAY 24 AT 11:20

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	))38
TOTAL:	196	64	59	62	66	58	43	31	26	26	25	22	16	12	8	6	6	18
SLOW D0/DT:		64	59	62	66	58	43	31	26	26	25	22	16	12	8	6	6	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	))24
NORTH:	28	14	1	0
NOREAST:	0	0	0	0
EAST:	0	0	0	0
SOUEAST:	5	6	1	0
SOUTH:	9	6	3	1
SOUWEST:	14	11	5	2
WEST:	91	109	64	107
NORWEST:	38	22	9	4

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	12.750	12.750	12.125	13.375	12.500	13.125	13.375	13.875	13.375	13.000	13.500	13.125
STANDARD DEVIATION:	9.0	9.5	10.0	9.5	8.5	9.0	9.0	9.5	9.5	9.5	10.0	9.5

MONTHLY AVERAGE WINDSPEED: 13.07 MPH

Second Wind Inc.
7 Davis Square
Somerville Massachusetts 02144
(617) 776-8520

SITING DATA FOR: Borealis Exploration Inc.

SITING LOCATION: Roche Bay

DATA FOR MONTH 1/1983 FOR SENSOR A

PEAK WIND SPEED OF: 61.5 MPH ON DAY 23 AT 16:05

LONGEST ENERGY LULL OF 47 HOURS ENDING ON DAY 10 AT 18:58

VELOCITY DISTRIBUTIONS FOR THIS MONTH: (HOURS)

RANGE: (MPH)	00-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30	30-32	32-34	34-36	36-38	>>38
TOTAL:	231	61	67	57	46	46	44	36	25	18	13	11	11	11	11	11	11	34
SLOW D0/DT:		60	66	57	46	46	44	36	25	18	13	11	11	11	11	11	11	
MEDIUM D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
FAST D0/DT:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Note: '255' represents an overflow.

WIND ROSE DATA: (HOURS)

RANGE: (MPH)	06-12	12-18	18-24	>>24
NORTH:	38	12	1	0
NOREAST:	7	13	3	0
EAST:	0	0	0	0
SOUEAST:	15	5	6	4
SOUTH:	3	0	0	0
SOUWEST:	12	7	4	2
WEST:	50	70	60	98
NORWEST:	59	29	5	9

DIURNAL DATA: (MPH)

TIME: (O:CLOCK)	00-02	02-04	04-06	06-08	08-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24
AVERAGE:	13.250	13.500	12.875	12.625	12.625	12.000	12.500	13.375	13.625	13.250	12.750	12.625
STANDARD DEVIATION:	10.5	10.0	10.5	11.0	10.5	10.0	11.0	11.5	11.5	10.5	10.0	10.0

MONTHLY AVERAGE WINDSPEED: 12.92 MPH

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Appendix B

DESIGN OF DAMS

INTRODUCTION

Two dams are required for water control and tailings containment. The location of the dams and their anticipated purpose have been described in the main body of the text. In this appendix an overview of the design is presented.

It must be stressed that these plans are essentially tentative. Additional field work will be required to finalize the design. However, sufficient data does exist to show that the construction of dams on permafrost is technically feasible.

WASTE ROCK DAM

Foundation Conditions

The Waste Rock Dam will be founded on vertically dipping meta sedimentary and meta vocanic rocks. The bedrock is overlain by 1 m to 2 m of sandy silty till. A 0.2 m thick layer of organics is found on top of the till. Since the surface of the till has been reworked due to overland flow, the ground surface is littered with boulders.

The till is similar to the tills identified along the proposed conveyor route. Therefore, the till will likely be saturated and soft during the spring thaw. The thawed wet tills therefore represent a weak strata which could cause slope stability problems. It is recommended that all of the till be removed from beneath the dam prior to construction. If the till is allowed to dry, it could be used for construction of the dam core.

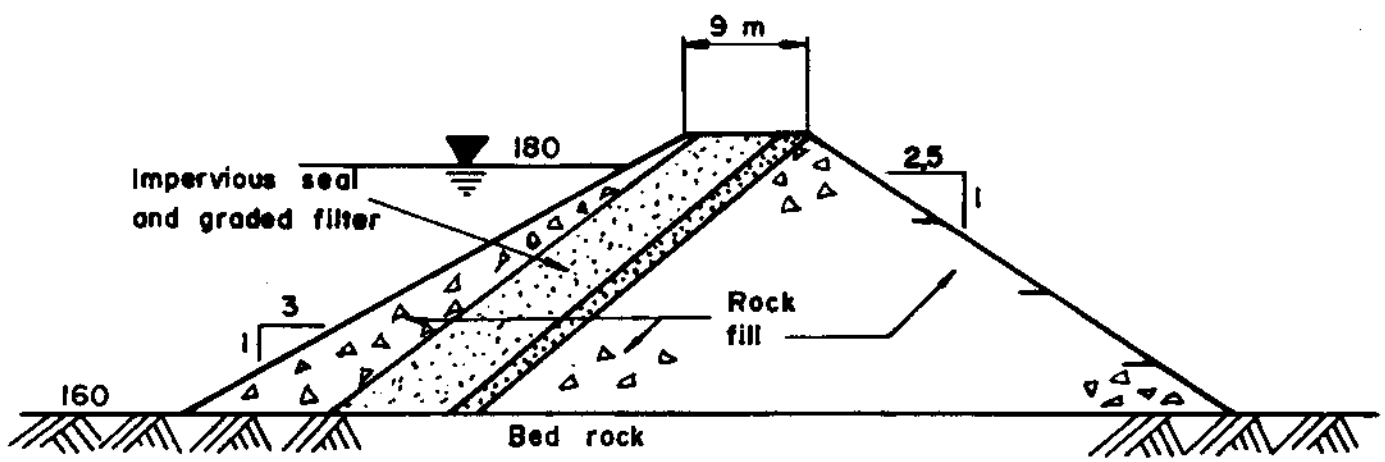
Design

The center line profile of the dam is shown in Figure B1. The design FSL is 180 masl. A typical cross section of the dam is shown in Drawing C3. The majority of the dam would be constructed with waste rock from the mine. The till would be used as a core and sand from the peninsula area would be used as a graded filter. The dam is to be constructed in lifts of 4 m, saturated and allowed to freeze completely each year. Monitoring of the freezing front is required and should the lift not freeze during the winter, artificial freezing will be required. The dam will be constructed over a period of five years and will serve as a tailings pond after the Mill Lake tailings pond is filled to capacity.

MILL LAKE

Foundation Conditions

The entire Mill Lake Dam will be constructed on intact granitic rock. The thin till veneer and boulder concentration in the stream bed will be removed prior to construction of the dam. The till will be used as core material after it has dried out.



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ROTHE BAY MAGNETITE PROJECT

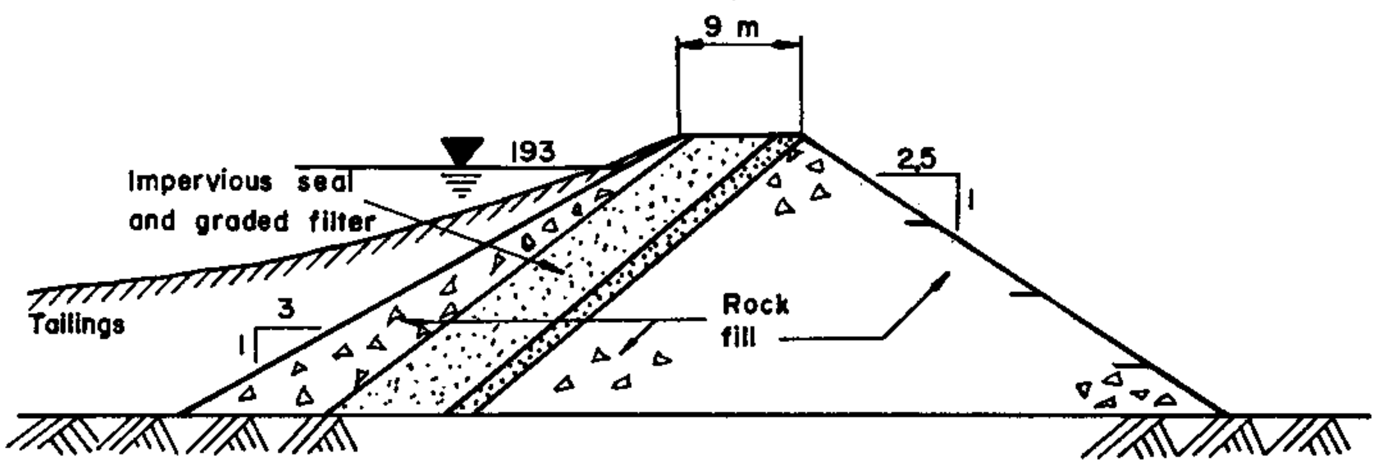
WASTE ROCK DAM

FIGURE B1

PRELIMINARY

Design

The longitudinal profile for the dam is shown in Figure B2. The design FSL is 193 masl. A cross section profile is shown in Drawing C4. The dam is similar in design and construction to the Waste Rock Dam except that its requirement for impermeability is less than that required for the Waste Rock Dam. The primary purpose of the Mill Lake Dam is to prevent significant amounts of mill water from reaching the M Basin. The dam should freeze during construction and become relatively impermeable. The minor amount of water that may seep through the dam is not considered to be an environmental risk. As the tailings pond is filled with tailings, the volume of water lost through the dam will diminish.



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MILL LAKE DAM

FIGURE B 2

PRELIMINARY

Depth of Frost Penetration

Ref: Yong & Warkington

Stephan Model

Freezing Index	9965.3°F/days
Freezing Period	273 days
Mean Annual Temperature	6.1°F

$$X = \sqrt{\frac{48\ K_f\ F}{L}}$$

K_f = Frozen Thermal Conductivity
F = Freezing Index = 9965 days
L = Latent Heat
X = Depth of Frost Penetration

Assume

Water content (w) 18.5%, at 100% saturation
Dry Bulk Density 110 pcf
Sandy Soil
$K_f = 2.3$ Btu/hr/ft/°F
$L = 1.434\ w\gamma_d = 2918.2$
$X = 19.4$ feet $= 5.9$ m

Berggren Model

$$X = \lambda\sqrt{\frac{48\ FK_e}{L}}$$

K_f = Frozen Thermal Conductivity
K_u = Unfrozen Thermal Conductivity

$K_e = (K_f + K_u)/2 = (2.3 + 1.35)/2 = 1.83$
$C_u = \gamma_d(0.17 + w/100) = 39.05$
$C_f = \gamma_d(0.17 + w/200) = 28.88$
$C_e = (C_u + C_f)/2 = 33.97$
$u = C_e F/LT = 0.42$
$\alpha = 0.71$
$\lambda = 0.74$
$X = 12.8$ ft $= 3.9$ m

The Stephan equation over estimates the depth of frost penetration by ignoring the volumetric heat of the soil mass. The Berggren model is a more accurate representation and will be used for the dam design. All parameters will be verified prior to the final design.

APPENDIX C

DRAWINGS

REFERENCES

FULWINDER, C. W., "Thermal Regime in an Arctic Earthfill Dam," Proc. 2nd International Conference on Permafrost, Yakutsk, U.S.S.R., North American Contribution, U.S. National Academy of Sciences, 1973, pp.622-628.

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NIXON, J. F., & MCROBERTS, E. C., "A Study of Some Factors Affecting the Thawing of Frozen Soils," Canadian Geotechnical Journal, Vol. 13, No. 1, 1976, pp. 40-57.

YONG, R. N., & WARKENTON, B. P., Introduction to Soil Behavior, The MacMillan Company, New York, 1966