REVISED CONSTRUCTION SPECIFICATIONS
TAILINGS/WATER DAM
MINTO PROJECT, YUKON

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APPENDIX A – Site Investigation and Laboratory Testing Data

1.0 GENERAL

1.1 Description of Project

The project that this specification has been prepared for is a tailings and water retention dam for the proposed Minto Mine to be constructed north west of Carmacks, Yukon. The work covered by this specification includes the construction of the dam and the associated access road and diversion ditch which will carry the diverted Upper Minto Creek around the proposed mine, mill site and tailings areas.

The dam is located in a narrow portion of the Minto Creek valley. The dam will be about 80 feet high when constructed and about 300 feet wide along the centerline axis of the dam at the crest. The dam is a flow over earth - rockfill dam and contains the following general zones. The fill material for each zone is briefly described as well.

Zone 1 - Upstream Shell (coarse residuum)
Zone 2 - Semi Impervious Core (fine residuum)
Zone 3 - Fine Filter (processed fine gravel)
Zone 4 - Intermediate Filter (processed medium gravel)
Zone 5 - Coarse Filter (processed coarse gravel)
Zone 6 - Downstream Shot Rock Shell
Zone 7 - Downstream Shell (shotrock)
Zone 8 - Toe Berm (over sized shotrock)

The water flow over the dam will be handled by a riprap lined overflow section which will discharge down a riprap lined spillway. The riprap lined spillway is routed down the downstream shell of the dam, over and down the toe berm and into a riprap lined stilling basin. Due to the relatively coarse nature of the downstream shell and toe berm, the water flowing over the dam will primarily flow through the downstream shell. It is only during extreme flood events that water will flow in the spillway on the downstream face.

The spillway section requires some further explanation. The spillway consists of a preserved wood cut off wall and riprap with a layer of insulating material beneath to protect the core from freezing.

The proposed dam is a zoned dam and the nature of the Zone 2 Semi Impervious Core material and the nature of the Zone 7 Downstream Shell shotrock have resulted in three filters being required to provide adequate particle retention and drainage for the Zone 2 Semi Impervious Core material.

The soils beneath the dam will require some preparation depending on their location with respect to the various zones of the dam. This preparation is to prevent poor materials from acting as a conduit for water to seep under the dam. In addition to careful excavation and cleaning, it will be necessary to create a grout curtain immediately below the centerline of the dam to create a zone of uniform low permeability to reduce water seepage beneath the dam.

The Owner's current wish is to obtain as much borrow material for the dam construction as possible from the proposed area of the open pit mine. Each zone of material within the dam has its own specification which must be met in order to meet the design requirements. This results in some material having to be blasted, screened and crushed in order to meet these gradation limits.

The dam access road will be constructed over permafrost and nonpermafrost soils, thus necessitating the use of two typical sections. The typical section for crossing permafrost soils has less excavation and flatter road embankment slopes than the typical section that crosses nonpermafrost soils. The entire diversion ditch shall be lined with a watertight liner in order to minimize seepage into and resulting loss of strength and large deformations in the permafrost soils.

1.2 Definitions of Terms Used

Blanket Drain	- the filter material(s) beneath the downstream shell material that intercept seepage coming up from the subgrade
Contractor	- the general contractor for the project
Contract	- the legal and binding agreement between the Contractor and the Owner regarding the construction of the dam and how the Contractor is paid for the work
Chimney Filter	- the filter material(s) that is immediately downstream of the core material in the dam that intercept and drain seepage through the dam core while filtering or retaining the fine grained particles in the core
Dam	- the Minto Mine tailings and water retention dam
Drawings	- EBA Dam design drawings 11509-01 to 11509-10

Engineer	- the EBA representative on the site
Owner	- Minto Explorations Ltd.
Site	- the area in which all Dam construction activity is occurring
Suitable	- meeting all of the specifications and requirements given herein and/or receiving the approval of the Engineer
Unsuitable	- not meeting all of the specifications and requirements given herein and/or not receiving the approval of the Engineer

1.3 Soils Investigation

A soils investigation which included a series of boreholes has been carried out in selected locations. It is the responsibility of the Contractor to review the geotechnical information included in this document in **Appendix A - Site Investigation and Laboratory Testing Data** and any subsequent revisions or addendums which will be located in the offices of the Owner and Engineer. The onus is on the Contractor to ensure he has a clear understanding of the report and its contents. The Contractor shall ensure that his understanding of the information is clear of any assumptions and should make every attempt to clarify any areas in the report which appear to be unclear by consulting the Engineer prior to bid preparation.

The Owner does not offer or imply any warranty as to fact other than that:

a. the borings were located approximately as shown on the plan accompanying the soils report
b. the borings reached the approximate depths indicated on the borehole logs
c. the approximate classifications indicated in the borehole logs were encountered

Information in the soils report is based on field records and is therefore, subject to the usual limitations and reservations associated with such work. The soils report presents the Terms and Conditions associated with the soils report.

1.4 Equipment Cleaning and Maintenance

Prevent spillage of oil and fuel. If spillage occurs, promptly clean up spillage and remove and replace contaminated soil to the satisfaction of the Engineer at no cost to the Owner. Dispose of used oil, used filters, contaminated soil and other contaminants in a manner satisfactory to the Owner and in compliance with applicable legislation.

All fuel is to be stored in a fuel dump area. All fuel vessels will be surrounded by a compacted berm of sufficient height to contain 100% of the fuel tank volume.

No equipment is to be cleaned in a stream or within 60 feet of a stream.

2.0 CLEARING AND GRUBBING

2.1 Scope

The work specified in this section shall consist of the provision of all labour, plant and materials and the performance of all work necessary for clearing and grubbing in the work areas as specified herein.

2.1.1 Description of Work

The work shall include, but not necessarily be limited to, the removal and disposal of all trees, brush, embedded logs, fallen timber, stumps, roots and branches.

The extent of clearing and grubbing shall be as specified herein and as shown on the drawings and shall include, but shall not be limited to, the areas occupied by, or to be occupied by the;

- dam
- granodiorite borrow source(s) for filter and downstream shell material
- borrow area(s) for core and upstream shell
- temporary haul roads

Clearing or grubbing shall be confined to within the limits for these areas shown on the drawings or as required by the engineer. Any activity outside of these limits will not be measured for payment and any resulting costs incurred shall be borne by the Contractor.

2.1.2 Responsibility of the Contractor

The Contractor shall comply with the laws and regulations of the Yukon Territory and other authorities having jurisdiction in the area, particularly with regard to

disposal and fire regulations and public safety. The Contractor shall obtain the necessary burning permits for burning materials, if required, on Site and shall observe the conditions of the permits and comply with all requirements thereof.

2.2 Execution of Clearing and Grubbing

2.2.1 Clearing

All trees, brush, embedded logs, fallen timber, branches and surface litter except such trees and shrubs designated for preservation by the engineer, shall be cut, removed and disposed of. Such designated trees and shrubs shall be preserved from scarring, barking or other injury during construction.

2.2.2 Grubbing

All roots, stumps and other objectionable material shall be excavated, removed and disposed of. Areas disturbed by grubbing shall be levelled. All materials, debris and equipment shall be kept out of all streams.

Topsoil excavated from within the dam footprint, along the diversion ditch / tailings dam access road and in borrow areas shall be placed in a spoil waste dump.

2.2.3 Disposal

Debris from clearing and grubbing may be disposed of by burning in designated disposal areas according to the regulations of the Yukon Forest Fire Prevention Acts. Conduct burning to thoroughly reduce all combustible materials to ashes. Push outs of debris from the work site to the perimeter of the cleared areas are not permitted. Burial of materials resulting from clearing and grubbing in the work area is not permitted.

The Contractor shall take special precautions when burning any debris to ensure that the fires remain contained within the burning area. The Contractor shall be responsible for any damage to other property as a result of this operation. Burning shall be done in such a manner and at such times that smoke from the fires will not

constitute a safety concern on the Project Site. Burning shall conform to the requirements of all authorities having jurisdiction in the area.

Whenever debris is being burned, the Contractor shall have sufficient personnel and fire fighting equipment available on the Site to prevent any of the fires from spreading or from getting out of control.

No work shall commence on any excavation or filling in a cleared area until the clearing and grubbing has been completed.

2.2.4 Erosion and Sedimentation Control

The Contractor shall provide and maintain all necessary temporary drainage, erosion and sedimentation control. Appropriate drainage diversion and/or silt fencing shall be installed at all locations where construction activity such as clearing, grubbing, excavating, filling and other construction related activity could cause rock and earth material to enter an active stream channel or wet areas draining into an active stream. These measures shall be constructed prior to the commencement of any construction activity in that area.

3.0 EXCAVATION

3.1 Scope

The work specified in this section shall consist of the provision of all labour, plant and materials and the performance of all work necessary to loosen, drill, blast, rip, excavate, sort, load, transport, stockpile and spoil topsoil, mineral soil and rock from the required excavations, borrow areas and stockpiles to the required embankments or stockpiles or, if not suitable or not required for construction, to spoil disposal areas which shall be located by the Contractor with the Owners permission and as approved by the Engineer.

3.1.1 Description of Work

The work shall include but not necessarily be limited to;

a) excavation of topsoil, colluvium and residuum material from granodiorite borrow source area(s) (see Sections 3.4.3 and 3.4.4),

b) excavation of topsoil, alluvium, colluvium and residuum material from beneath the core of the Dam and downstream shell of the Dam. This includes both frozen and unfrozen materials (see Sections 3.3.1, 3.3.2, and 3.3.5),

c) excavation of loose, fractured and infilled bedrock beneath Dam core and chimney drain (see Section 3.3.2.2),

d) excavation of topsoil and unsuitable foundation material from beneath upstream shell of Dam (see Section 3.3.2.1),

e) excavation of topsoil and unsuitable fill materials from borrow source locations (see Sections 3.4.1, 3.4.2, 3.4.3 and 3.4.4),

f) excavation of ice rich and permafrost soils from south valley wall within dam footprint.

The process of excavation listed above and specified in this section shall include, but shall not necessarily be limited to:

a) transportation, placement, spreading and protection of embankment fill in the required respective stockpiles,

b) transportation, placement, spreading and compaction of unsuitable or unusable materials in the designated spoil areas,

c) transportation of residuum core material and upstream shell material, crushed granodiorite filter materials, and downstream shell and toe berm shot rock to the stockpile locations and/or required embankment locations,

d) controlled perimeter blasting of rock to the required excavation lines,

e) scaling of loose material from footprint of dam core and heel of downstream filter,

f) removal of loose material from quarry walls for safety purposes,

g) levelling, shaping, slope stabilization and draining of any borrow areas not within the impounded reservoir footprint or within the planned overburden removal limits for the first year of the mine's operating life,

h) transportation of embankment fill material from stockpile location to required embankment area(s).

3.1.2 Responsibility of Contractor

It is the responsibility of the Contractor to conduct the operations described in this section of the specification with work site safety being the first consideration. The Contractor will locate any borrow pits, stockpiles and spoil dumps as per the Owner's instructions and as approved by the Engineer.

The Contractor shall design, implement and maintain a dewatering system that will allow dewatering sufficient to facilitate all phases of Dam construction to the specifications herein.

3.2 Materials

Materials from excavations beneath the core of the Dam, from the granodiorite borrow source(s) and from the diversion ditch and tailings and water dam access road that meet the requirements for embankment fill specified in Section 6.3.2 shall be termed "suitable" materials and may be placed in the required embankments or in required stockpiles.

Materials from excavation beneath the Dam core, from the granodiorite borrow source(s) and from the diversion ditch and tailings and water dam access road that do not meet the requirements for embankment fill shall be termed "unsuitable" materials and shall be placed in the spoil disposal areas as per Section 3.4.5.3.

3.3 Execution

3.3.1 General

The excavation requirements and limits shown on the Drawings have been established on the basis of the results of the subsurface exploration investigation which has been qualified in Section 1.3. The Engineer will examine the conditions exposed at the required excavation lines and, if the conditions are deemed unacceptable, will require excavation to be continued locally beyond the lines, slopes and elevations shown on the Drawings, to remove the unacceptable material.

The Contractor shall draw his own conclusions from site inspection and from the boreholes and surface exposures and from other site data as to the excavation method that will be best suited for the satisfactory removal of materials to be excavated, and as to the behaviour of the in situ and excavated material.

All excavations shall, as a minimum, be to the required excavation lines shown on the Drawings. No material of any kind shall be left unexcavated within the excavation lines. Excavated surfaces shall not contain overhanging rock and shall be sloping down and in towards the centerline of the Dam.

All necessary precautions shall be taken to preserve in an undisturbed condition all material outside of the required excavation. The Contractor shall adopt excavation procedures such that the stability of excavated slopes is not impaired. The Contractor shall be responsible for the stability and safety of all excavations until final acceptance of the work and shall perform all remedial work required to ensure that the excavated soil and rock surfaces are maintained in a sound and stable condition.

During excavation, and at any time during the Work, all material which is unsafe or appears to endanger persons, work or property, shall be scaled and removed from the excavations. The fact that that such scaling and removal may enlarge the excavation beyond the minimum required excavation lines shall not relieve the Contractor from the necessity of doing such scaling and removal to prevent loose material from falling.

Soil or rock at or beyond the required excavation lines that are damaged by the Contractor's operations shall be removed at no cost to the Owner.

The excavation operations and schedule shall allow for interruption while the geological conditions exposed at the surface of the required excavation lines are assessed by the Engineer. Local areas shall be cleaned off where required by the Engineer to expose a fresh undisturbed surface.

Construction traffic shall only be routed over suitably protected parts of the excavated surfaces to ensure that the excavated surface is not damaged. Construction traffic or vehicle traffic of any kind will not be permitted on any final cut slopes in core trench area without the prior approval of the Engineer in each instance. The granting of such approval shall not in any way relieve the Contractor of his responsibility to maintain stable slopes in the overburden excavation or to repair damage thereto at his own expense. Should any instability or failure of the final cut slopes be, in the opinion of the Engineer, caused by the Contractor's construction methods, all damage resulting from such instability or failure shall be repaired or remedied by the Contractor at his own expense.

The Contractor shall submit to the Engineer, in writing, the details of his proposed methods, including blasting, ripping, methods of excavation, schedules and sequence of operations he plans to follow to complete the Work. This submission should be within 15 days after the award of contract for the Work.

3.3.2 Dam Foundation Excavation

3.3.2.1 Upstream Shell

Excavation beneath the Upstream Shell shall consist of removal of all organic soils, ice-rich soils, colluvium, alluvium and residuum required to expose competent residuum soil. Excavation shall proceed to bedrock if the Engineer determines that competent residuum soils have not been found. Local overexcavation to competent soils may be required but immediate backfilling with suitable upstream shell fill and grading is required to provide a surface which will drain water off of the working surfaces. The Contractor is responsible for preserving the excavated surface and shall clean the surface as required by the Engineer in the event that it deteriorates due to weather or other construction activities.

3.3.2.2 Semi-Impervious Core

The Owner has the option to either excavate to 5 feet (1.5 m) below the top of the grout curtain rock (excavate only option) or to excavate to rock where fractures are open (no calcite or erodible material infill present) and the rock mass is interlocking and then blanket grout (blanket grout option) to a depth that gives a 15 foot overlap with the grout curtain. The blanket grout option is detailed in Section 5.2. The excavate only option will be permitted only if the subgrade at 5 feet below the top of the grout curtain is sound, interlocking, competent rock with no infilled joints. The "excavate only" and the "blanket grout" options are only available for the portions of the Dam footprint where the grout curtain was constructed. The only option available for the north facing slope is to excavate to sound, interlocking, competent rock with tight, joints with no infill as curtain grouting was not possible due to the frozen rock mass.

The Drawings illustrate the anticipated minimum excavation limits.

The requirements for rock cleaning and dental excavation in any part of the core trench will be determined by the Engineer after completion of overburden excavation in that area as described in Section 4.0 – Foundation Preparation. The approximate location of the bedrock surface inferred from subsurface investigation data is shown on the Drawings. The actual location of bedrock surface may differ from the location shown on the Drawings. All subsurface investigation data are included in Appendix A.

The Contractor's methods, techniques and procedures for all rock excavations shall be such that, by controlling the relationship among such factors as: the location and configuration of required excavation; the spacing and size of holes; the amount and type of explosive; the depth of charge and delay pattern; and by employing the most effective controlled blasting techniques acceptable to the Engineer, the surfaces of all completed excavations shall be smooth, sound and to the minimum lines of excavation as specified or as otherwise directed by the Engineer. In particular, the Contractor's rock excavation methods and procedures in the excavation of the final surface upon which the dam core is to be placed shall be such as to leave this surface sound and relatively smooth.

Not less than 15 days prior to commencing core trench rock excavation, and at any time the Contractor proposes to alter his methods for such excavation, the Contractor shall submit to the Engineer for review, full details of the methods, techniques and procedures he proposes to use to complete the work. Such details shall include drawings and statements on all of the factors noted in the preceding paragraph of this clause and such other relevant data as are required by the Engineer to permit the Engineer to review the Contractor's proposed method of producing solid, smooth, excavated rock surfaces. Such submissions shall fulfill all requirements of this Section and shall be signed by a qualified person under whose supervision they were prepared. The Contractor shall not commence any excavation, or change his methods of excavation, until the relevant submission of methods, techniques and procedures has been approved in writing by the Engineer. This approval shall in no way be construed as relieving the Contractor of his responsibilities under the Contract nor restrict him from proposing more conservative methods designed to reduce the blast shock on the rock adjacent to the excavation.

Shattering or splitting of the rock, or the opening up of seams in the rock not required to be excavated, shall be avoided. Any shattered material and loose rock beyond the required excavation lines shall be scaled and removed to expose sound bedrock. Backfilling with concrete or other material approved by the Engineer shall be undertaken if additional excavation beyond the required excavation lines is required to remove rock that has been damaged by the Contractor. The backfilling work shall be done at the expense of the Contractor if the Engineer believes that it is the result of poor excavation practice or negligence.

Dental excavation, as described in Section 4.2.2, may be required to produce a competent bedrock surface at the base of the excavation for the core trench.

Rock may be excavated to the required excavation lines at any time of the year provided that rock in the Dam core trench is excavated only when the ambient air temperature is above 1°C. All rock surfaces excavated to the final excavation lines in the Dam core trench shall be protected from freezing where the Engineer deems this to be appropriate.

3.3.2.3 Blanket Filter / Drain

In areas beneath the downstream blanket filter / drain, excavation shall consist of the removal of all overburden soil to bedrock surface where the bedrock surface is within 1.5 feet of existing ground surface. Where the bedrock surface is more than 1.5 feet from the existing ground surface, common excavation shall be carried out to an acceptable foundation of soil with an acceptable in situ dry density. This will include removal of all organics, organic soils and loose, wet soils to the satisfaction of the Engineer. Some overexcavation of alluvium, colluvium and residuum soils may be required, but must be followed by immediate backfilling with core material and compacting as per the specification for that material.

3.3.3 Test Pits and Trenches

Test pits or trenches shall be excavated by the Contractor using equipment and hand labour in any zone of required embankments for inspection, sampling, and testing by the Engineer. The test pits shall be located and excavated where required by the Engineer. The test pits and trenches may be between 3 and 20 feet deep. All trenching and test pits that require workers to enter shall be constructed in accordance with the Occupational Health and Safety Regulations and any other authority or regulatory body having jurisdiction over the construction site. No worker shall enter any excavation that is greater than 4 feet deep without the sides of the excavation being sloped back from the bottom of the excavation at a slope no steeper than 0.75 horizontal to 1 vertical. Excavated materials must be kept back at least 5 feet from the edge of the excavation and no heavy equipment other than that involved in the excavation is permitted to operate any closer than 10 feet away from the excavation.

Clauses 175 to 177 of the Yukon Occupational Health and Safety Act were used in the above paragraph of this clause. The inclusion of this information does not relieve the Contractor of his duty to review the Occupational Health and Safety Act and to conduct his operations in strict accordance with this act.

Testpits shall be backfilled with embankment fill material meeting the requirements of the zone in which the test pit or trench was excavated. The backfill material may be compacted with special compactors in accordance with Section 6.6.5.1 of this document to the moisture and density requirements specified herein for that zone.

3.3.4 Blasting and Vibration Control

The Contractor is responsible for ensuring that blasting procedures used are within guidelines set by all regulatory bodies and authorities having jurisdiction in the area.

3.3.4.1 Blasting

The Contractor shall develop controlled blasting techniques, which will satisfy the excavation requirements specified herein. For that purpose, the Contractor's initial blasts in each area shall be performed as trials, and the drillhole pattern, hole depth, explosive type and quantity, blasting sequence and drill delay pattern shall be modified to achieve the requirements specified herein.

Twenty-four hours prior to commencement of drilling for each blast, the Contractor shall submit complete details of the proposed blast to the Engineer. Such data shall include:

i) the location, depth and area of each blast,

ii) the type, strength, quantity, column load and distribution of explosives to be used per hole, per delay and per blast,

iii) the sequence and pattern of delay, and

iv) the description and purposes of any special methods to be adopted.

If, in a specific area, a plan which has been previously adopted does not produce rock conditions in accordance with the requirements of these Specifications, the Contractor shall submit a revised plan to the Engineer before continuing excavation in adjacent areas.

Whenever there is danger of causing damage or injury by flying rock, the shots shall be suitably blanketed.

3.3.4.2 Vibration Control

The Contractor shall monitor all blasting operations, using seismographic equipment to determine the magnitude and intensity of ground vibrations. The Contractor shall supply and operate equipment for measuring particle velocities. The equipment shall be of the three component type for measuring vertical, transverse and longitudinal wave forms, such as the Instantel DS 377 or approved equivalent. A record of each seismograph measurement shall be delivered to the Engineer within twelve hours after each monitoring operation, and shall be accompanied by a detailed diagram of the blast, showing the number of holes, delay sequences, and quantity of explosives in each hole. The locations for deployment of seismographs shall be subject to the review of the Engineer.

The vibrations from blasting shall not exceed a peak particle velocity of 4 inches per second at a distance of 100 feet from the blast, or a peak particle velocity of 2 inches per second at a distance of 200 feet from the blast. Regardless of these limitations, the Contractor shall minimize the effects of ground vibration which may shatter or damage the rock mass that is required to remain intact.

Except as otherwise approved by the Engineer, the Contractor will not be permitted to blast within 100 feet of any concrete, grout or shotcrete which has been in place less than 2 days. Blasting within 100 feet of concrete, grout or shotcrete that has been in place 2 days or less, or within 100 feet of dam fill material in place, will be permitted only after submission by the Contractor, and approval by the Engineer, of the Contractor's proposed blasting procedures together with an outline of precautions to be taken. Regardless of these limitations, the Contractor shall minimize the effects of ground vibration which may shatter or damage the rock mass that is required to stay intact.

These blasting restrictions are given as a guide only and may be modified by the Engineer on the basis of seismic measurements and observations during the progress of the Work.

Should the results of the blast monitoring indicate that the Contractor's methods may endanger excavations, grouting or concrete work or impact the surrounding environment in an adverse manner, the Contractor shall change his methods to prevent such damage. Such changes shall be at no extra cost to the Owner.

Replacement or repair of concrete or grout damaged by blasting vibrations shall be at the Contractor's expense.

3.3.5 Excavation Records

In addition to other records, the Contractor shall maintain accurate records of all rock excavation and blasting operations performed under the contract and at the end of each shift shall provide the Engineer with two copies of the daily record. The following data shall be recorded on forms approved by the Engineer, together with any additional data the Engineer may request, and shall bear the signatures of the Contractor's and the Engineer's representatives who shall review and certify the appropriate form at the end of each shift.

i) If blasting is employed, details of the drilling pattern, number, locations and sizes of drill holes, and the type and amount of explosives used in each round, the type, location, and firing pattern of detonators, and the time of each blast.

ii) Details of ripping and other methods of excavation used during each shift together with the volume of rock excavated and removed from the excavation.

iii) Number and classification of men and plant engaged on each excavation.

3.4 Borrow Area, Stockpile and Spoil Disposal Area Development

3.4.1 Submittals

The Contractor shall give the Engineer not less than 20 working days notice of his intention to develop borrow areas, stockpile or spoil disposal areas, and will indicate the location of these areas and the order in which they will be developed.

The method statement shall include, but shall not necessarily be limited to:

i) the scheduled date of the start of the development,

ii) the method of excavation,

iii) the method of handling and dewatering groundwater and surface water,

iv) the method of preventing siltation and contamination with suspended colloidal and/or organic material of Minto Creek,

v) the method of stabilizing excavated slopes,

vi) the method of excavation to yield a maximum of materials meeting the specified requirements,

vii) the method of removal of unsuitable material,

viii) the equipment that will be used, and

ix) the location plan for haul roads.

The method statement for the development of borrow areas other than those on the Owner's property shall include documents concerning the permission of landowners and permits from the regulatory authorities.

The Engineer will perform tests on soil samples from proposed borrow sources in the on site field laboratory to assess the suitability of the proposed borrow source. The Contractor will assist the Engineer in collecting soil samples.

3.4.2 Survey

The corner points of boundaries of each designated borrow area, stockpile and spoil disposal area shall be staked by the Contractor prior to the start of work in the designated borrow area, stockpile or spoil disposal area.

3.4.3 Limit of Topsoil and Common Excavation

Topsoil excavation and common excavation of borrow pits shall be limited to the area required to produce the volume of embankment fill to complete the required

embankments. The stripped surfaces of the borrow areas and stockpiles shall be maintained free of vegetation until excavation or stockpiling operations are complete. The excavated slopes of borrow pits shall not be steeper than one vertical to one horizontal. The top of the borrow pit slopes shall be at least 10 feet from the edge of the cleared and grubbed area.

3.4.4 Unsuitable Materials

In the event that zones, strata or lenses within the various borrow pits are found to be unsuitable for use as fill materials, the Contractor shall either excavate and remove these materials to spoil disposal areas, or excavate and remove these materials to locations within the borrow pits which have been worked out and exhausted of usable materials, or the materials shall be left in place.

3.4.5 Required Stockpiling and Spoil Disposal Areas

3.4.5.1 General

Spoil disposal and stockpile areas shall be maintained in a stable and safe condition and shall be sloped to drain. Spoil disposal areas shall not be used as garbage dumps. The Engineer shall have the right to establish the maximum elevation and the slopes to which spoil may be dumped in any particular area.

The Contractor shall take all necessary and effective measures to preserve natural drainage channels and to prevent any objectionable accumulation of water resulting from the formation of stockpile and spoil heaps. If necessary, natural drainage courses shall be diverted around spoil disposal and stockpile areas.

3.4.5.2 Stockpiling

Stockpile locations for processed and unprocessed embankment fill, topsoil and spoil shall be determined by the Contractor with the permission of the Owner and approval of the Engineer. At least 20 working days before any material is stockpiled, the Contractor shall submit details of the proposed stockpiling techniques to the Engineer. Stockpiling of embankment fill material shall be kept to a minimum.

Stockpiling methods for processed and unprocessed Dam fill shall ensure that segregation, particle breakdown, deterioration and contamination with deleterious materials or substances do not occur. A 1 foot thick layer of compacted granular fill shall be placed on the surface of the processed fill stockpile areas after topsoil excavation and before any fill material is placed in the stockpile. This material can be constructed with crusher rejects if necessary. Non processed fill stockpiles do not require this measure.

Stockpiles and stockpile areas shall be maintained at all times in a stable, safe condition and shall be sloped to provide positive drainage to the perimeter of the stockpile area(s). Fill materials which may require drying before final placement and compaction in the Dam should be stockpiled in such a manner that prevents further wetting due to precipitation.

Material for different zones shall be stockpiled separately with at least 30 feet space between stockpiles to prevent cross contamination of stockpiles.

3.4.5.3 Spoil Disposal

All materials that do not meet the specifications for Dam fill or topsoil shall be placed in spoil disposal areas or in worked out areas of borrow pits outside of the open pit mine footprint as directed by the Owner and approved by the Engineer.

Other construction materials such as timber, steel, rubber, chemicals, or grease shall not be dumped in the spoil disposal areas. Such construction debris shall be transported and disposed of as directed by the Owner and shall be done in accordance with any applicable legislation.

Disposal of unsuitable and unusable excavated materials shall be carried out in an orderly and safe manner. A bulldozer shall be employed to level off the spoil disposal areas on a regular basis. The spoil disposal shall not interfere with water passages and general drainage of the area. Materials placed in the spoil disposal areas shall be compacted by track packing in two passes with a D8 sized or larger bulldozer. The surface of the disposal pile shall be sloped to drain. Materials in spoil disposal areas shall be placed at slopes not steeper than 3 horizontal to 1 vertical (3H:1V).

Materials damaged, contaminated, rejected, or otherwise not meeting the requirements of the Specifications are to be removed from the Dam and placed in a disposal area separate from spoil materials from the clearing and grubbing operations.

4.0 FOUNDATION PREPARATION

4.1 Scope

The Work specified in this section shall consist of the provision of all labour, plant and materials and the performance of all work necessary to prepare the excavated surface of soil and rock foundation surfaces of the Dam as shown on the Drawings and as specified herein.

4.1.1 Description of Work

The Work shall include, but shall not necessarily be limited to, the preparation of the excavated soil and rock foundation in the Dam core trench and the preparation of soil foundations on which filter and other Dam fill materials will be placed.

The necessity for any or all of the various components of foundation preparation will be established by the Engineer.

4.1.1.1 Dam Core Trench Rock Foundation

Foundation preparation of the rock surface exposed by excavation in the Dam core trench within the limits shown on the Drawings shall consist of the following operations done in the order listed.

- dewater to permit execution of work to specifications and Engineer's satisfaction
- scale and hand clean surface using air and/or water jets (see Section 4.2.2.2)
- where necessary, do dental excavation (see Section 4.2.2.2)
- where necessary, place backfill concrete (see Section 4.2.2.3)
- where necessary, apply dental mortar (see Section 4.2.2.3)
- apply surface shotcrete to a wetted rock surface (see Section 4.2.2.3)
- blanket grout where excavation is not taken to 5' below top of grout curtain (see Section 5.2)

- repair and cleaning of shotcreted surface after blanket grouting (see Section 4.2.2.3)
- if necessary, place cold temperature protection during cold weather shutdown periods.
- remove cold temperature protection where installed after cold weather passes.

A grout curtain was constructed in the summer of 1998 and is shown on the Drawings. Details on the construction of this grout curtain are given in "Construction Monitoring Report – Grout Curtain for Tailings/Water Dam – Minto Project, Yukon" (EBA, 1998).

4.1.1.2 Soil Foundation Beneath Upstream and Downstream Shells

Foundation preparation of soil surfaces exposed by excavation and on which granular fill materials will be placed shall consist of the following operations done in the order listed. Excavated soil slopes steeper than 2 horizontal to 1 vertical (2H:1V) may be prepared concurrently with embankment fill placement.

- scarify the surface (see Section 4.2.3)
- level, where necessary (see Section 4.2.3)
- where necessary, moisture condition the surface material (see Section 4.2.3)
- compact the surface material (see Section 4.2.3)

4.2 Execution

4.2.1 General

Foundation preparation of excavated surfaces for any part of the Dam foundation shall not commence until that part of the foundation excavation has been completed and accepted by the Engineer.

Excavated foundations shall be drained and maintained free of water, snow and ice during foundation preparation. No shotcrete, concrete or grout shall be placed on or applied to frozen surfaces. Soil foundations shall be cleared of loose, thawed and soft soil, ice, snow and other deleterious material before foundation preparation can commence.

4.2.2 Dam Core Trench Rock Foundations

4.2.2.1 General

This subsection applies to excavated bedrock surfaces exposed in the **Dam core trench and core trench slopes only**. The Contractor is responsible for maintaining the quality of the prepared surfaces throughout construction and shall make any repairs to damaged surfaces at no cost to the Owner.

4.2.2.2 Cleaning

The excavated surface shall be scaled and cleaned of all soil, loose rock, debris, oil and other foreign materials after common excavation has been completed to the required lines on the Drawings or as otherwise specified by the Engineer (see Section 3.3.2). Scaling, cleaning and dental excavation may require the use of manual labour, with hand held pneumatic tools, shovels, bars, trowels, compressed air jets, brooms, brushes and other hand held tools. Dental excavation may also require the careful use of earth and rock moving equipment and blasting as required.

Plant and accessories used for applying compressed-air jets to the foundation shall be capable of producing a minimum of 100 psi pressure to the foundation through a nozzle of 1 inch minimum diameter. Hydro-brooming equipment shall be capable of delivering water in jets of variable pressures to a maximum of 8000 psi and shall be available with a selection of nozzle sizes and configurations. The Contractor shall conduct a series of nozzle trials of the equipment using various nozzle and pressure combinations to determine the optimum equipment and operating conditions 15 working days prior to the start of foundation preparation.

Scaling and cleaning shall be carried out concurrent with dental excavation to remove all soil, loose, broken, detached, slabby rock fragments and unsound, slaked, deteriorated and closely fractured rock which remains in the excavated surface of the rock in open and debris filled joints, cracks, fissures, seams, crevices, faults, shear zones and other relatively narrow openings. Seams, cracks, or fissures containing sand or clay or other soft or incompetent material occurring in the rock foundations under the core shall be cleaned out to the greatest depth practicable, and in any case, to a minimum depth of five times their width and to the Engineer's satisfaction. The purpose of scaling, cleaning and dental excavation is to produce a

surface of sound, intact, tightly wedged and naturally anchored rock. Dental excavation may necessitate the removal of some sound rock to permit excavation of adjacent unsuitable foundation material and the treatment of the cavities formed by the dental excavation.

Scaling and cleaning may be necessary after dental excavation is complete as required by the Engineer.

4.2.2.3 Backfill Concreting, Dental Concreting and Surface Shotcreting

Backfill concrete shall be used to fill relatively large natural or excavated depressions and openings, to eliminate abrupt changes in excavated slope, overhangs and vertical faces and to produce a foundation surface with smooth slope transitions for the placing of embankment fill. Wooden forms shall be shaped to approximately conform to the rock surface and to produce the required smooth transitions and shall be used for backfill concrete in large excavated openings and cavities on the slopes of the river valley. Backfill concrete shall be vibrated into place and shall have a minimum compressive strength of 2200 psi at 28 days. **Shotcrete may be used as an alternative means of placing backfill concrete and dental mortar subject to the prior approval of the Engineer.** Shotcrete mix designs must be submitted to the Engineer for review 30 days before construction. All cement, water and aggregate used in the production of concrete, shotcrete and mortar shall be at a minimum temperature of 10 degrees Celsius at the time of batching.

Dental mortar shall be used to fill joints and other relatively narrow openings and cavities resulting from dental excavation and the scaling and cleaning operations. Dental mortar shall be a thick cement-sand water mortar that is placed and compacted by hand methods. Dental mortar shall have a minimum compressive strength of 2200 psi at 28 days. The finished surface of dental mortar and backfill concrete shall be approximately flush with the adjacent rock surfaces such that no abrupt changes or breaks in the finished slope shall exist.

The exposed rock surfaces shall be saturated by applying water with hoses and then shotcrete shall be applied in accordance with the following requirements prior to blanket grouting. Surface shotcrete shall be applied within the core-rock contact area to a nominal thickness of 2 inches and a minimum thickness of 1 inch, as directed by the Engineer. In general it is anticipated that surface shotcrete will be

applied to most of the core-rock contact area, including those areas which have been backfilled with concrete and dental shotcrete in order to seal completely the core-rock contact surface. Exceptions to this complete shotcrete coverage shall be only as determined by the Engineer. Prior to the application of shotcrete, the Contractor shall clean the receiving surfaces to the same extent as that required and described above as required prior to the placement of backfill concrete.

Blanket grouting or routing of construction equipment over prepared areas will take place no less than 7 days after dental concrete and dental mortar have been placed. Surface shotcreting will recommence to repair any damage once blanket grouting operations are completed. The use of high early strength cement or other accelerants may be used with the prior approval of the Engineer. The Owner may wish to have two test panels 3 feet by 3 feet fabricated 1 week before construction commences so that the minimum setting time can be optimized.

Prior to the placement of embankment fill material, the shotcrete will be inspected and sounded by the Engineer. Shotcrete which has separated from the surface of the rock, or that is not in contact with the rock, or that is not firmly attached to the rock or that can be easily detached from the rock shall be removed and replaced, all as determined by the Engineer.

4.2.3 Soil Foundations

Foundation preparation specified in this subsection applies to excavated soil surfaces on which the upstream shell and downstream shell material will be placed.

All soil foundations on which shell fill materials will be placed shall be scarified and loosened to a depth of at least 8 inches to provide a satisfactory bonding surface for fill placement. All lumps of foundation material larger than 6 inch size shall be removed from the foundation. The moisture content of the bonding layer shall then be conditioned to within two percent and one percent below the optimum moisture content obtained in the Standard Proctor Compaction Test carried out in accordance with ASTM Designation D698. The bonding layer shall be compacted to a density equal to or greater than 98 percent of the maximum dry density obtained in the Standard Proctor Compaction Test carried out in accordance with ASTM Designation D698.

4.2.4 Protection of the Prepared Foundations

With the exception of the foundation preparation operations for rock surfaces in the Dam core trench (Subsection 4.2.2) up to and including the application of shotcrete, the Contractor may prepare the foundation in accordance with the Specifications and Drawings at any time to suit his construction schedule provided that the prepared surfaces are protected from the deleterious effects of frost action, rain, groundwater seepage and construction equipment and provided further that any damage to the prepared surface due to poor construction practice or lack of protection is repaired prior to fill placement at no additional cost to the Owner.

5.0 CURTAIN GROUTING

5.1 Scope

The work to be done in this section includes the supply of all labour, plant, and materials, and the performance of all work necessary to drill, wash and test holes, and supply, transport, store, mix and inject grout materials and additives for curtain grouting in the Dam core trench, as shown on the Drawings, and as required by Engineer.

5.1.1 Description of the Work

The work shall include but shall not necessarily be limited to:

a) Drilling and washing 1.5 inch diameter curtain grout holes inclined 30 degrees (preliminary) to the vertical as indicated on the Drawings using percussion or rotary drills.

b) Water pressure testing of exploratory holes and grout holes

c) Supplying and setting packer assemblies

d) Supplying, mixing and injecting cement grout mixes, including the backfilling of holes.

e) Supplying and mixing sand in cement grout mixes

f) Supplying, installing and operating electronic grout flow recorder units, electronic pressure transducers, and surveying and recording the locations and inclinations of grout holes

g) Supplying and using grout additives as required

h) Drilling and water testing exploratory holes during and after the curtain grouting process to verify the effectiveness of the grouting operation.

5.1.2 Technical Direction

The extent of the drilling and grouting program shown on the Drawings and specified herein is preliminary and the Engineer will increase or decrease the scope of any part of the drilling and grouting program should subsurface conditions indicate that this is advisable. Drilling and grouting shall be performed under the technical direction and supervision of the Engineer. The technical direction will include:

- location of grout holes,
- orientation and sequence of drilling and washing grout holes,
- depth of packer settings,
- sequence of grouting completed holes,
- selection of grout materials, additives, pressures, pumping rates and durations to be used,
- grout mix control and testing, and
- modifications and adjustments to any aspect of the grouting procedures.

5.1.3 Responsibility of the Contractor

The Contractor shall provide experienced operating and supervisor personnel for each grout plant in operation. Adjustments and modifications required by the Engineer shall be executed by the Contractor immediately upon receipt of notice of the Engineer's requirements.

5.1.4 Scheduling

No embankment fill shall be placed on any foundation surface until the curtain grouting and surface treatment at that location has been completed within a horizontal distance of at least 60 feet of the proposed fill placement location.

Grout holes shall not be drilled within 30 feet of another grout hole which is being grouted, or which has been grouted in the previous 24 hours.

The Contractor shall provide in his schedule sufficient flexibility for any adjustments that may be required by the Engineer during the work to ensure that the curtain grouting is continuous and complete and provides an impervious barrier beneath the Dam. This may include providing and grouting additional holes beyond the lines shown on the Drawings.

5.2 References

Publications listed below form part of this Specification to the extent specified in this Section.

CAN3-A5-M88 - Portland Cement
CAN3-A23.1-94 - Concrete Materials and Methods of Concrete Construction.
ASTM C-404-93 - Standard Specification for Aggregates for Masonry Grout

5.3 Materials and Equipment

5.3.1 Materials

All materials shall be handled, stored and protected from deterioration and contamination. Deteriorated or contaminated materials shall not be used.

5.3.1.1 Water

Water used for drilling and washing and as an ingredient of grout mixtures shall be fresh, clean and free from deleterious amounts of oil, silt, organic matter, alkali, acids, salts and other impurities and shall conform to the requirements of CSA

Standard CAN3-A23.1-94. At the time of mixing, the temperature of water used in grout mixes shall be less than 25°C and greater than 10°C.

Adequate water storage facilities shall be provided to ensure a continuous supply of water for washing drill holes and for the grouting operations, and to ensure that grouting operations will not be hindered by a temporary breakdown in the main supply line.

5.3.1.2 Cement

Cement used in the grout mixes shall meet all of the requirements of Type 50 Sulphate Resistant Portland Cement, in accordance with of CSA Standard CAN3-A5-M88.

Cement containing lumps or foreign matter which the Engineer considers detrimental to the results of the grouting program shall be removed from the Site by the Contractor. The temperature of the cement shall be at least 10°C when added to the grout mix.

Each shipment of cement shall be stored so that it is protected from the weather and is readily distinguished from other shipments. To prevent undue aging of cement, cement shall be used in the chronological order in which it is delivered to the Site. The cement shall not be older than 3 months upon delivery to the site.

5.3.1.3 Sand

Sand added to the grout shall consist of clean, durable stone particles, shall be free from lumps of clay and foreign matter, shall have a moisture content of less than 3 percent of the dry weight and shall conform to CSA Standard CAN3-A23.1-94 with the following modified grading requirements:

Sieve Size (in)	Percentage Passing
0.1	100
0.05	95-100
0.025	60-85
0.012	30-50
0.006	10-30

5.3.1.4 Admixtures

The mixing, handling, storing and rates of application of admixtures shall be in accordance with the manufacturers recommendations.

Retarding and expanding admixtures for cement and sand-cement grouts shall be used only with the Engineer's prior approval.

Accelerants will be required for grouting bedrock beneath the south abutment that is below 0 degrees Celsius.

Admixtures shall be obtained from the same manufacturer to ensure that they are compatible with each other.

5.3.1.5 Bentonite

Bentonite incorporated in grout mixes shall be of a type that disperses easily in water. It is recommended that the bentonite be pre mixed with a known quantity of water and allowed to stabilize 24 hours prior to mixing with the grout. The Bentonite shall be bond bentonite (sodium montmorillonite bentonite) as manufactured by Black Hills Bentonite, Mills, Wyoming or equal.

5.3.2 Grout Mixes

Grout shall consist of a mixture of cement and water plus admixtures, bentonite or sand which may be required by the Engineer. The proportions of materials in the grout mixes shall be varied during the work to suit the particular conditions encountered. When required, bentonite shall be between one and three percent by mass of the cement. Proportions of materials used in grout mixtures and any adjustments thereto during grouting operations shall be subject to prior written approval by the Engineer.

At least 20 days prior to the start of grouting and at such other times requested by the Engineer, the Contractor shall perform tests in an approved materials and testing laboratory, on the grout mixes proposed for use in the Works, and using the actual materials to establish the consistencies of mixes, practical mixing ratios, initial and final setting times, the optimum quantities of sand, bentonite, silica fume and other admixtures, compatibility of admixtures with grout mix ingredients, and such other properties as may affect the quality of the grout. It is recommended that the following water-cement ratios be used in the grouting operation; 3:1, 2:1, 1:1, 0.8:1 and 0.5:1.

In general, a sanded grout mix shall be used in backfilling grout holes and grouting up large open seams, cracks, and other voids where viscosity in-place is desired. A non-sanded grout mix shall be used for pressure injection into narrow cracks and fractures in the rock which are unable to accept a viscous sanded grout.

A separate grout mix using an accelerant may be required for grouting the frozen bedrock beneath the south abutment of the Dam due to the anticipated permafrost conditions in that area.

The proposed grout mix designs and the results of the laboratory testing shall be submitted to the Engineer for review at least 30 working days prior to the start of grouting.

5.3.3 Drilling and Grouting Equipment

The Contractor shall provide all drilling and grouting equipment including mixers, grout pumps, packers, pipes, grout lines, fittings, valves, nipples, drills, pressure gauges, electronic pressure transducers, gauge savers, electronic grout flow meters, plotters, computers, telephones or radios, lighting circuits, supplies, tools and spare parts necessary to drill and core grout holes and to inject a continuous supply of grout into the rock foundation under accurate pressure control. Grout plants shall be mobile, self-contained units.

All equipment provided by the Contractor for the drilling and grouting work shall be new or shall have been completely overhauled to an "as-new" condition immediately prior to delivery to the Site.

Details of the drilling and grouting equipment and the layout of the grouting plant shall be submitted to the Engineer at least 20 working days prior to the start of drilling and grouting. The Engineer will provide inspection staff to monitor and record the grouting operations and will provide appropriate record and other required forms. The Contractor shall assist the Engineer in the collection and recording of all grouting data.

5.3.3.1 Drills

Standard drilling equipment of the percussion or diamond drill type shall be used for drilling all grout holes.

Drilling equipment shall be equipped for continuous washing of the holes with water after drilling.

5.3.3.2 Drillhole Orientation

The Contractor shall supply and operate a NL Sperry-Sun magnetic multi-shot drillhole survey instrument or approved equal that measures the direction and inclination of drill holes to an accuracy of one-half degree, at any point in the drill hole.

5.3.3.3 Washing and Water Pressure Testing Equipment

The washing and water pressure testing plant shall include pumps, piping, pressure gauges, valves, fittings, and seal assemblies (packers). The pumps furnished shall have a maximum output of not less than 74 gal/min at 200 psi gauge pressure, and shall be capable of maintaining constant pressure. Water storage tanks sufficient to supply all of the pumps for a period of 1 hour shall be used. Two sets of flowmeters, pressure transducers, and Bourbon gauges shall be installed for calibration checking. Water testing prior to grouting shall be conducted at 15 psi.

5.3.3.4 Packers

The seal assemblies or packers shall be of the hydraulically or pneumatically expanded rubber or neoprene sleeve types. The packers shall be capable of sealing

holes of diameters of up to 3 inch at depths of up to 150 feet and a maximum effective pressure of 600 psi without leakage. The type of packer shall be varied to suit ground conditions, as necessary. The packers shall be capable of being used either singly or in pairs separated by either 5 feet or 10 feet of perforated pipe. There shall be sufficient perforations in the pipe to provide negligible obstruction to the water during water pressure testing. The diameter of the packer pipe shall be the maximum possible for the size of the hole.

The tube conveying the grout through the packer shall have a minimum diameter of 1 inch.

5.3.3.5 Mixers and Agitators

Sufficient plant including spare parts capable of supplying, mixing, agitating and pumping grout shall be provided to meet the construction schedule.

Grout materials shall be mixed with a mechanically operated high speed, high shear mixer that operates at a mixing speed of more than 1500 rpm ("Colcrete" type or equivalent). Facilities shall be provided at the mixer for the accurate measurement of grout materials so that mix proportions can be controlled. A sufficient number of mixers should be available, ready for immediate use, to produce grout at the rates required by the hole or holes being grouted and without interruption due to mixer breakdown.

Grout materials shall be maintained in suspension in an agitator equipped with screens to remove hardened grout. Screen openings shall be 1/4 inch. Agitators shall be equipped with baffles to reduce vortex formation and shall be provided with adequately marked dip sticks or graduations for measuring the volume of their contents.

Each grout plant shall be provided with acceptable storage for adequate supplies of cement, additives and other materials so that grouting can be carried on without interruption. Each plant shall have a suitable housing for protection against rain and frost and shall have direct radio or telephone communications with personnel at the point of grout injection.

5.3.3.6 Grout Pumps and Valves

Grout pumps shall be of the helical rotor-progressive cavity type and shall be capable of pumping at least 30 gal/min of grout having a water:cement ratio of 0.5:1 at a maximum discharge pressure of 400 psi. The pump shall be located at a distance not greater than 200 feet from the hole being grouted and shall also be located to obtain pressures in the circulation lines at the holes that are not greater than those required for grouting.

Valves in contact with grout shall be diaphragm and/or plug cock valves each equipped with its own handwheel control.

5.3.3.7 Hoses, Connections and Headers

A circulating system of hoses, of maximum 1 inch internal diameter, from the pump to the header and back to the holding tank shall be used. A single hose, of maximum 60 feet length and maximum 11/2 inch internal diameter shall connect the header to the grout hole.

Grouting headers shall be provided for feeding grout into the holes. The grout headers shall include a supply connection, a connection with a valve to the hole, and a return line with a valve. Two 6 inch Bourbon type pressure gauges for the appropriate pressure range shall be installed. One shall be located at the grout pump to indicate the pressure of the supply of grout to the hole. The other shall be positioned to measure the back pressure of grout at the point of injection. A pressure transducer shall be located at the point of injection.

The hoses, valves, joints and couplings shall be capable of withstanding pressures double those required for grouting.

5.3.3.8 Water Meters

Water meters shall be equipped with an accumulative total indicator and a reset knob, or equivalent. The diameter of the meter dial shall not be less than 6 inches. The water meters supplied shall be able to measure flows in the range of 2 to 80 gallons per minute with an accuracy of +/- 5 gallons. Each water meter shall be identified with a number.

5.3.3.9 Pressure Gauges

The grout pressure shall be monitored using electronic pressure transducers of the type GOULD PG3000-200-42-13, 0 - 200 psi or approved equivalent. The pressure transducers shall be placed as close as possible to the moving grout to avoid the risk of having the grout set in the injection line prior to reaching the transducer. A spare transducer shall be available at all times. All electrical equipment for the pressure transducers shall be compatible with the transducers. The pressure transducers must have a voltage output which is recordable by a computer and plotter. Backup bourbon gauges shall be used to calibrate and check the pressure transducers.

Backup pressure gauges shall be Bourbon tube type of heavyduty quality with face diameter no less than 4 inches. The gradation of the pump discharge pressure gauge shall be the same as the header gauge and both gauges shall be changed, to suit the range of grouting pressures required by the Engineer. Gauge ranges of 0 - 100 psi, 0 - 300 psi and 0 - 600 psi or similar shall be provided. All gauges installed anywhere in the grout lines shall be protected by a membrane-type straightway gauge saver filled with glycerine, or equal non-freezing fluid. A standard master gauge shall be provided against which all other gauges shall be checked periodically for accuracy and satisfactory operation. Gauges shall have an accuracy of +/- 5% and shall be checked against a master gauge at maximum intervals of 7 days. Each gauge shall be identified with a number.

5.3.3.10 Electronic Grout Flow Recorders

Electronic grout flow recorders conforming to the following specification shall be provided and connected into the grout circulation line. The grout flow recorders shall be capable of measuring flows of 1 gallon/5 minutes (+/- 5%) and must have a voltage output which is recordable by a computer and plotter.

5.3.3.10.1 Power Supply

The Contractor shall supply the appropriate quality of power to meet the requirements of the measuring and recording equipment to obtain the specified accuracy.

5.3.3.10.2 Flow tubes

Two flow tubes per unit for monitoring the grout flow in the supply and return lines shall be provided. The liner shall be polyurethane.

5.3.3.10.3 Flow Transmitter

Transmitters compatible with the model flow tubes shall be provided with system accuracy of ±1.0% of upper range value. Low temperature protection shall be provided for the unit if the ambient temperature is below -25°C. Communication cable at least 20 feet long shall be provided from the flow tubes to the transmitter. The power supply shall be sufficient to operate this unit.

5.3.3.10.4 Recorder

The Contractor must provide a recorder capable of plotting the flow rates and volumes of grout pumped into each hole versus time. The plotter shall have at least two pen colours.

5.3.3.10.5 Communications

Telephone or radio communications shall be provided and used between the key elements of the grouting plant, from the mixing equipment to the pumps and to the grout hole.

5.3.3.11 Arrangement of Equipment

The arrangement of the grouting equipment shall be such that the grout supply line shall connect the pump to the hole and return to the agitator in one continuous circuit controlled for pressure with one pressure gauge placed at the outlet of the pump and one placed slightly downstream of the grout hole immediately in front of the return valve for pressure control at the header.

5.3.3.12 Compressed Air Supply

The minimum delivery pressure in the air supply lines shall be 100 psi. Sufficient compressed air shall be supplied to operate compressed air equipment at full capacity.

5.3.3.13 Foundation Displacement Indicators

Foundation displacement indicators as shown on the Drawings shall be provided and shall be installed where required by the Engineer.

5.4 Execution

5.4.1 Drilling

This subsection covers the drilling of grout holes and exploratory holes.

All holes shall be located and drilled in the sequence, orientation, and to the depths shown on the Drawings, and as required by the Engineer. The groutholes are to be angled 30° to the horizontal along the centerline of the dam. The orientation and alignment of the grout holes may be changed by the Engineer upon review of new geological information from excavation of the core trench or through further drilling and sampling.

Exploratory holes to determine the rock conditions in the Dam core trench shall be drilled where required by the Engineer.

Curtain grout holes, drilled from the shotcreted or excavated rock surface shall have short casings installed 6 inches into rock and protruding at least 6 inches above the shotcrete or rock surface to prevent the entry of foreign materials. Casings may be installed in advance of drilling.

After holes have been grouted, the casings shall be removed prior to fill placement. All holes shall be filled with grout flush to the rock surface.

Grease, rod dope, drilling mud, or other lubricants shall not be used on drill rods or in the drilling fluids during grout or water pressure test holes.

Grout hole collars shall be established to within 8 inches of the location specified. The orientation of every hole shall be measured. Grout holes that deviate more than three degrees from the required orientation or direction may be filled with grout tremmied from the bottom and abandoned. Such abandoned holes may be redrilled as required by the Engineer at no additional cost to the Owner.

After drilling, each hole shall be protected from becoming clogged or obstructed by means of a temporary cap at the collar. Any hole that becomes clogged or otherwise obstructed before the start of grouting shall be cleaned out in a manner acceptable to the Engineer, or the hole shall be redrilled as required by the Engineer at no additional cost to the Owner.

Exploratory grout curtain holes shall be water pressure tested in sections, as specified herein, and the test results will determine whether the exploratory hole will be used as a primary grout hole or will be backfill grouted to full depth immediately. The location of these holes shall be determined by the water testing and grout take records for the curtain grout holes.

5.4.2 Washing and Water Pressure Testing

Grout holes shall be washed under pressure immediately before pressure testing and immediately before pressure grouting. Holes shall be washed out with water injected through a wash pipe at the bottom of the holes until clear water returns to the surface. Washing may be required after each stage. The Contractor will be responsible, at no cost to the Owner, for cleaning hardened grout from the sides of the hole if washing is required and not done soon after grouting.

When required by the Engineer, exploratory holes and grout holes shall be water pressure tested. Water pressure tests shall be done in sections from the bottom of the hole upwards. Each section shall be isolated by means of two packers spaced a distance of 10 feet apart. For each section, backpressure shall be measured at the collar of the hole with the hole full of water. Water pressure shall then be applied to the test section for a minimum period of 12 minutes and a maximum period of 60 minutes. If the rock conditions do not permit a test to be completed using the 10 feet spaced packers, the Engineer may require packers spaced at 5 feet to be used.

The applied pressure used in washing and water pressure testing shall be as required by the Engineer and shall, in general, correspond with the pressure specified for grouting as specified herein.

If the water test in any stage or hole shows a permeability less than 1 Lugeon (3.3E-7 ft/s), the stage need not be separately grouted but may be grouted as an extension of the subsequent stage.

5.4.3 Grouting

5.4.3.1 General

The grout mixes, pressures, pumping rates and the locations and sequences in which holes are drilled and grouted shall be as specified herein and as shown on the Drawings or as otherwise required by the Engineer. The Engineer will adjust the grouting requirements, from time to time to suit the subsurface conditions encountered.

Grout materials including water shall be protected from freezing and shall be at a temperature between 10°C and 25°C, throughout the mixing and agitation period up to the time of injection. The grout plant and the work area around the drill hole shall be covered and heated as necessary. Temperature sensors shall be placed at the locations required by the Engineer to monitor temperature conditions. The construction schedule may require that some grouting be done during winter conditions.

Grout shall be mixed in batches of suitable volume and in such a way as to enable the water-cement ratio and the composition of grout suspensions to be changed to ensure continuous flow and minimum wastage. Grouts shall be mixed for a minimum of 5 minutes before injection.

All grout which cannot be injected within one hour of mixing shall be wasted at no cost to the Owner.

Changes to the grout mix may be required by the Engineer at the grout plant. Specific criteria for changing the grout mix will be established by the Engineer. In general, grout injection shall be started using a grout mix with a water-cement ratio

of 3:1 by mass. This mix shall be maintained or thickened, depending on the rate of grout acceptance. The grout mix used at the start of any section of a hole shall be injected at the required pressure for a 10-minute period with the grout pump operating at constant speed. If the rate of absorption is observed to drop steadily, the starting mix shall be continued until refusal is reached.

If the absorption of grout is high during the initial period or does not decrease appreciably, the water-cement ratio shall be gradually decreased and successively thicker mixes used. Each successive mix shall be injected for a minimum 10 minute period until either the grout absorption stabilizes and a thicker mix is used or the grout absorption decreases in which case grouting may be continued to refusal.

In areas of high grout absorption, sand may be required to be added to the mix. The proportion of sand shall not exceed 2 parts sand to 1 part cement by mass, and all sand mixes and neat cement mixes with a water-cement ratio less than 2:1 by mass shall include an approved fluidizer additive.

When the absorption of thicker mixes begins to decrease or causes the pressure to rise above the value desired, the Contractor may reduce the pressure to the value desired by reducing the grout flow rate.

If the grout absorption rate drops suddenly the grout mix shall be immediately thinned, or water introduced into the grouting system, to prevent the hole from becoming plugged.

Holes shall be grouted in sections from the bottom of the hole upwards using a single packer. The length of the section shall be as required by the Engineer. The mix shall be maintained or thickened as required by the Engineer. The maximum pressures to be used will be determined by the Engineer and will depend on the static pressure of water measured in the hole and the distance of the section to be grouted from adjacent excavations. A person shall be stationed at each header unit being used to manipulate the return valves so as to continuously maintain the required pressure of grout going into the hole. The Contractor shall ensure that the header pressure gauge is accurate and in good working condition at all times during grouting operations. The Contractor will ensure that proper bleeding of the grout hole is allowed to occur.

The Contractor may chose to adopt a different grouting procedure (i.e. from top to bottom with or without packers) if ground conditions make grouting from bottom to top with packers not practical or uneconomical. The alternative grouting procedure shall be described in detail and submitted to the Engineer for review and approval within 3 days of the proposed change in grouting procedure.

Refusal criteria for grouting shall be as required by the Engineer. In general, the grouting of any hole in which a water-cement ratio of less than 3:1 by mass is being used shall be continued until the hole refuses to take grout at the maximum effective pressure required for the stage of the hole. At this time, the Contractor shall return to the initial thinner mix and apply the following criteria. The grouting of any hole in which the water-cement ratio of 3:1 by mass, or higher, is being used shall not be considered complete until the hole takes grout at the rate of less than 0.9 gallons of grout per foot of hole in 20 minutes if effective pressures of 50 psi or less are being used or in 15 minutes if effective pressures of 50 to 100 psi are being used.

If the grout absorption of a hole being grouted is such that it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum workable water-cement ratio, the rate of pumping shall be reduced or the pumping stopped temporarily and intermittent grouting performed, allowing sufficient time between injection for the grout placed to stiffen. If this procedure is not successful, grouting shall be discontinued, the grout allowed to set, and additional drilling and grouting shall be done in this hole or in adjacent holes until the desired resistance is built up.

During the grouting of a hole, adjacent ungrouted holes shall be left uncapped to facilitate the escape of air and water. If sufficient grout flows from these holes to interfere with grouting, these holes shall be temporarily capped and/or grouting pressures reduced accordingly. Alternatively, the Engineer may require that these holes be grouted simultaneously. Surface leaks shall be caulked to prevent an excessive seepage of grout. An ample supply of oakum, soft wooden wedges and premixed quick setting cement and mortar shall be available at the work site at all times. Should caulking not be feasible, grouting shall be discontinued, the grout allowed to set, and additional drilling and grouting shall be done in this hole or in adjacent holes until the desired resistance is built up.

If a backpressure exists after grouting of a hole is completed, the hole shall be capped until the pressure falls to a negligible amount.

Grouting pressures for each packer setting shall be as required by the Engineer. In general, the maximum grouting pressure at the packer depth is anticipated to be 1 psi per foot of hole. This pressure may be increased if conditions warrant. Starting pressures at each stage will be much less, in the order of 15 psi for about 5 minutes and increased gradually to full pressure within a 5 minute time span.

For a given packer depth, the excess pressure of the grout, at the packer depth shall be calculated considering the gauge pressure at the header plus the hydrostatic pressure head of the grout in the packer pipe minus the friction losses in the pipe, minus the hydrostatic pressure head of the ground water if any, outside the pipe. This excess pressure shall not exceed the effective weight of the rock and soil overburden above the packer depth. Effective unit weight of dry and saturated rock shall be assumed to be respectively, 22.5 and 13.8 kN/m of vertical depth. Effective unit weight of dry and saturated soil shall be assumed to be respectively 19.5 and 11.8 kN/m of vertical depth. Grouting pressures at the gauge shall be calculated in accordance with the above.

After grouting, each hole shall be backfilled flush to the excavated rock surface, shotcrete protected surface or overburden surface by injection of a non-shrink grout. Additional grout shall be added to compensate for any settlement of the initially injected grout.

During grouting operations, the Contractor shall take such precautions as may be necessary to prevent machine treads, drill cuttings, equipment exhaust, oil, wash water and grout from damaging the shotcrete or excavated rock surface. Wastewater and grout shall be pumped from the prepared foundations or excavations within a reasonable amount of time.

Grouting of the lines shown on the Drawings shall commence with the primary grout holes, and depending on the grout takes, shall be followed by the secondary grout holes at split spacing. Water tests on the secondary holes and exploration holes as required by the Engineer will indicate the need for further grouting. If grout takes do not decrease during grouting of the secondary holes, tertiary grout holes at split spacing shall be drilled and grouted, as required by the Engineer. All exploratory holes shall be grouted over their full length as specified herein for primary grout holes.

Injection of grout into a hole in sections shall be in one continuous operation until the specified refusal criteria have been achieved at all sections and the grout hole has been backfilled. In case of breakdown of grouting equipment, the Contractor shall immediately flush the hole with water until the return water flow is clear.

The following procedures shall be followed to grout the zone at, and immediately above, bedrock surface in holes that are drilled and cased through overburden. When the hole has been grouted to the bottom of the casing, the casing shall be withdrawn in three stages of three feet each. At each stage a falling head permeability test shall be made in accordance with the procedures described in Designation E-18 of US Bureau of Reclamation Earth Manual and the hole shall be grouted at the effective pressures required by the Engineer. After the third stage has been grouted the casing shall be completely withdrawn. Thin grout mixes shall be used. If required by the Engineer additional holes drilled and cased to bedrock surface shall be split spaced until the zone at bedrock surface is sealed.

5.4.3.2 Foundation Uplift Monitoring

Foundation displacement indicators shall be installed prior to water pressure testing or grouting of the holes in the vicinity of areas where the Engineer considers that the grout take trends are indicating that rock uplift as a result of grouting may be taking place.

Whenever the foundation displacement indicators show the initiation of rock uplift, the grouting pressure shall immediately be reduced.

The foundation displacement indicators shall consist of a steel rod anchored at the bottom of a shallow drill hole as indicated on the Drawings. The top of the steel rod shall be surveyed as required by the Engineer throughout the grouting process.

Foundation displacement indicators shall be suitably protected against damage. Instruments damaged by the Contractor's construction equipment shall be replaced at no additional cost to the Owner.

5.5 Quality Control

5.5.1 General

All grouting shall be done in the presence of the Engineer. During drilling, water pressure testing and grouting operations, the Contractor shall provide experienced operating personnel for each drilling and grouting plant in operation.

Gauges shall be cleaned and recalibrated at start of each working shift and periodically during each shift as necessary.

5.5.2 Progress Records

Drilling, water testing and grouting records will be kept by the Contractor. The records will include Project Name; Owner; name and signature of individual supervising the grouting and record keeping; date(s) and time(s) of all grouting; location and ID# of hole; orientation, azimuth and depth of hole; diameter of hole; water testing results; type, number and depth of packers for each grouting increment or stage; water/cement ratio and changes and time of change of water cement/ratio; number of bags of cement injected, wasted and left in hole; pressure, changes in pressure and time of change; time and duration of injection; volume of sand or bentonite added, litres of water added to mix; and any other changes in procedures, pressures, grout takes, mix or equipment that has direct effect on grouting operations. Completed and signed copies of grouting records will be submitted to the Engineer 24 hours after completion of grouting.

The grouting data will be plotted by the Contractor immediately and continuously as the data are measured. The data will be plotted in tabular and graphical form. These field plots will be used by the Engineer to evaluate the grouting operation and to adjust the required procedures where necessary.

The drilling and grouting records shall be signed by the Contractor and the Engineer's representative after each shift.

5.5.3 Testing

Whenever requested by the Engineer, the Contractor shall provide grout trial batches to verify the quality of grout to be placed.

5.6 Clean Up

5.6.1 Clean up Prior to, and During Grouting

All grouting areas shall be kept free of water, grout, sludge, oil or any deleterious material regardless of origin so that none of these materials drain onto any part of the Works completed or under construction. At all times during the progress of the Work, all open drill holes shall be protected.

5.6.2 Clean Up After Grouting Operation

Upon completion of grouting, all grout supply connections shall be removed from the work area.

Prior to final acceptance of the Work, the exposed surfaces of all rock, concrete and shotcrete shall be cleaned and restored to their original condition. All hardened grout on surfaces within the work areas shall be removed if it is deemed to be unsound or poorly bonded to the underlying surface, as determined by the Engineer.

Each grout hole shall be clearly marked and numbered by the Contractor upon completion of the grout hole.

6.0 BLANKET GROUTING

6.1 Scope

The work to be done in this section includes the supply of all labour, plant and materials, and the performance of all work necessary to drill, wash and test holes, and supply, transport and store, mix and inject grout materials and additives for blanket grouting in the Dam core trench, as shown on the Drawings, and as required by the Engineer.

6.1.1 Description of Work

The description of work shall include but shall not necessarily be limited to:

a) Drilling and washing 4-inch (minimum) diameter vertical blanket grout holes as indicated on the Drawings using percussion drilling methods.
b) Water testing of exploratory holes and some grout holes.
c) Supplying and setting packer assemblies.
d) Supplying, mixing and injecting cement grout mixes, including backfilling of holes.
e) Supplying and mixing sand in cement grout mixes.
f) Supplying and setting materials to stem the flow out grout from cracks in the exposed rock mass beneath the Dam core.
g) Surveying locations and elevations of blanket grout holes on a daily basis.
h) Supplying and using grout additives as required.

6.1.2 Technical Direction

The extent of the drilling and grouting program shown on the Drawings and specified herein is preliminary and the Engineer may increase or decrease the scope of any part of the drilling and grouting program should subsurface conditions indicate that this is advisable. Drilling and grouting shall be performed under the technical direction and supervision of the Engineer. The technical direction will include:

- location of grout holes,
- orientation and sequence of drilling and washing grout holes,
- sequence of grouting completed holes
- selection of grout materials, additives, pressures and pumping rates to be used,
- grout mix control and testing, and
- modifications and adjustments to any aspect of the grouting procedures.

6.1.3 Responsibility of the Contractor

Adjustments and modifications required by the Engineer shall be executed by the Contractor immediately upon receipt of notice of the Engineer's requirements.

6.1.4 Scheduling

No embankment fill shall be placed on any foundation surface until the blanket grouting and surface treatment at that location has been completed within a horizontal distance of at least 60 feet of the proposed fill placement location.

Grout holes shall not be drilled within 30 feet of another grout hole which is being grouted, or which has been grouted in the previous 24 hours.

The Contractor shall provide in his schedule sufficient flexibility for any adjustments that may be required by the Engineer during the work to ensure that the blanket grouting is continuous and complete and provides an impervious barrier beneath the Dam. This may include providing and grouting additional holes beyond the lines shown on the Drawings.

6.2 References

Publications listed below form part of this Specification to the extent specified in this Section.

CAN3-A5-M88 - Portland Cement.
CAN3-A23.1-94 - Concrete Materials and Methods of Concrete Construction.
ASTM C-404-93 - Standard Specification for Aggregates for Masonry Grout.

6.3 Materials and Equipment

6.3.1 Materials

All materials shall be handled, stored and protected from deterioration and contamination. Deteriorated or contaminated materials shall not be used.

6.3.1.1 Water

Water used for drilling and washing and as an ingredient of grout mixtures shall be fresh, clean and free from deleterious amounts of oil, silt, organic matter, alkali, acids, salts and other impurities and shall conform to the requirements of CSA

Standard CAN3-A23.1-94. At the time of mixing, the temperature of water used in grout mixes shall be less than 25°C and greater than 10°C.

Adequate water storage facilities shall be provided to ensure a continuous supply of water for washing drill holes and for the grouting operations, and to ensure that grouting operations will not be hindered by a temporary breakdown in the main supply line.

6.3.1.2 Cement

Cement used in the grout mixes shall meet all of the requirements of Type 10 Normal Portland Cement, in accordance with of CSA Standard CAN3-A5-M88.

Cement containing lumps or foreign matter which the Engineer considers detrimental to the results of the grouting program shall be removed from the Site by the Contractor. The temperature of the cement shall be at least 10°C when added to the grout mix.

Each shipment of cement shall be stored so that it is protected from the weather and is readily distinguished from other shipments. To prevent undue aging of cement, cement shall be used in the chronological order in which it is delivered to the Site.

6.3.1.3 Sand

Sand added to the grout shall consist of clean, durable stone particles, shall be free from lumps of clay and foreign matter, shall have a moisture content of less than 3 percent of the dry weight and shall conform to CSA Standard CAN3-A23.1-94 with the following modified grading requirements:

Sieve Size (in)	Percentage Passing
#8	100
#16	95-100
#30	60-85
#50	30-50
#100	10-30

6.3.1.4 Admixtures

The mixing, handling, storing and rates of application of admixtures shall be in accordance with the manufacturers recommendations.

Retarding and expanding admixtures for cement and sand-cement grouts shall be used only with the Engineer's prior approval.

Admixtures shall be obtained from the same manufacturer to ensure that they are compatible with each other.

6.3.2 Grout Mixes

Grout shall consist of a mixture of cement and water plus admixtures, bentonite, sand and additives which may be required by the Engineer. The proportions of materials in the grout mixes shall be varied during the work to suit the particular conditions encountered. When required, bentonite shall be between one and three percent by mass of the cement. Proportions of materials used in grout mixtures and any adjustments thereto during grouting operations shall be subject to prior written approval by the Engineer.

It is recommended that the following water-cement ratios be used in the grouting operation; 3:1, 2:1, 1:1, 0.8:1 and 0.5:1 (mixed by volume). A sanded grout mix shall be used in backfilling grout holes and grouting up large open seams, cracks, and other voids where grout absorption is high and viscosity in-place is desired. A non-sanded grout mix shall be used for pressure injection into narrow cracks and fractures in the rock, which are unable to accept a viscous sanded grout. In areas of high grout absorption, sand may be required to be added to the mix. The proportion of sand shall not exceed 2 parts sand to 1 part cement by mass, and all sanded mixes shall include an approved fluidizer additive.

6.3.3 Drilling and Grouting Equipment

The Contractor shall provide all drilling and grouting equipment including mixers, grout pumps, packers, pipes, grout lines, fittings, valves, nipples, drills, pressure gauges, gauge savers, electronic grout flow meters, telephones or radios, lighting

circuits, supplies, tools and spare parts necessary to drill and core grout holes and to inject a continuous supply of grout into the rock foundation under accurate pressure control. Grout plants shall be mobile, self-contained units.

All equipment provided by the Contractor for the drilling and grouting work shall be new or shall have been completely overhauled to an "as-new" condition immediately prior to delivery to the Site.

Details of the drilling and grouting equipment and the layout of the grouting plant shall be submitted to the Engineer at least 20 working days prior to the start of drilling and grouting. The Engineer will provide inspection staff to monitor and record the grouting operations and will provide appropriate record and other required forms. The Contractor shall assist the Engineer in the collection and recording of all grouting data.

6.3.3.1 Drills

Percussion drills with the ability to set casing 4" inside diameter minimum, while drilling, to the bottom of the grouthole shall be used for drilling all grout holes and exploratory holes. The method of drilling, including information on the drill rig to be used, shall be submitted to the Engineer at least two weeks prior to mobilization to site. A trial demonstration may be requested by the Engineer to confirm the performance and capability of the drill rig.

6.3.3.2 Water Pressure Testing Equipment

The water pressure testing plant shall include pumps, piping, pressure gauges, valves, fittings, and seal assemblies (packers). The pumps furnished shall have a maximum output of not less than 74 gal/min at 200 psi gauge pressure, and shall be capable of maintaining constant pressure. Water storage tanks sufficient to supply all of the pumps for a period of 1 hour shall be used. Two sets of flowmeters and Bourbon gauges shall be installed for calibration checking. Water testing prior to grouting shall be conducted at 15 psi.

6.3.3.3 Packers

The seal assemblies or packers shall be the mechanically expanded surface packer types. The packers shall be capable of sealing holes of diameters of up to 4½ inch (due to potential for hole oversizing during drilling) and seal up to a maximum effective pressure of 100 psi without leakage. The Contractor shall have pneumatic packers and related equipment for inflation on site as required. The type of packer shall be varied to suit ground conditions, as necessary. The diameter of the packer pipe shall be the maximum possible for the size of the hole and shall have a minimum diameter of 1 inch.

The tube conveying the grout through the packer shall have a minimum diameter of 1 inch.

6.3.3.4 Mixers and Agitators

Sufficient plant including spare parts capable of supplying, mixing, agitating and pumping grout shall be provided to meet the construction schedule.

Grout materials shall be mixed with a mechanically operated high speed, high shear mixer that operates at a mixing speed of more than 1500 rpm ("Colcrete" type or equivalent). Facilities shall be provided at the mixer for the accurate measurement of grout materials so that mix proportions can be controlled. A sufficient number of mixers should be available, ready for immediate use, to produce grout at the rates required by the hole or holes being grouted and without interruption due to mixer breakdown.

Grout materials shall be maintained in suspension in an agitator equipped with screens to remove hardened grout. Screen openings shall be 1/4 inch. Agitators shall be equipped with baffles to reduce vortex formation and shall be provided with adequately marked dipsticks or graduations for measuring the volume of their contents.

Each grout plant shall be provided with acceptable storage for adequate supplies of cement, additives and other materials so that grouting can be carried on without interruption. Each plant shall have a suitable housing for protection against rain and

frost and shall have direct radio or telephone communications with personnel at the point of grout injection.

6.3.3.5 Grout Pumps and Valves

Grout pumps shall be of the helical rotor-progressive cavity type and shall be capable of pumping at least 30 gal/min of grout having a water:cement ratio of 0.5:1 at a maximum discharge pressure of 400 psi. The pump shall be located at a distance not greater than 200 feet from the hole being grouted and shall also be located to obtain pressures in the circulation lines at the holes that are not greater than those required for grouting.

Valves in contact with grout shall be diaphragm and/or plug cock valves each equipped with its own handwheel or handle control.

6.3.3.6 Hoses, Connections and Headers

A circulating system of hoses, of maximum 1 inch internal diameter, from the pump to the header and back to the holding tank shall be used.

Grouting headers shall be provided for feeding grout into the holes. The grout headers shall include a supply connection, a connection with a valve to the hole, and a return line with a valve. Two 6 inch Bourbon type pressure gauges for the appropriate pressure range shall be installed. One shall be located at the grout pump to indicate the pressure of the supply of grout to the hole. The other shall be positioned to measure the backpressure of grout at the point of injection.

The hoses, valves, joints and couplings shall be capable of withstanding pressures double those required for grouting.

6.3.3.7 Perforated Sleeve Pipes

Perforated sleeve pipes shall be used to ensure that grout transmission to all sections of the boreholes is possible should the borehole walls collapse after removal of the casing. The bottom of the sleeve pipes shall be open ended. The pipe shall be 3 inch diameter and shall have 1 inch diameter apertures spaced every 3 inches all the way around the pipe over the entire length of the sleeve pipe as indicated on the

Drawings. The pipe shall have sufficient wall thickness to permit handling onsite without damage to the pipe.

6.3.3.8 Water Meters

Water meters shall be equipped with an accumulative total indicator and a reset knob, or equivalent. The diameter of the meter dial shall not be less than 6 inches. The water meters supplied shall be able to measure flows in the range of 2 to 80 gallons per minute with an accuracy of +/- 2 gallons. Each water meter shall be identified with a number.

6.3.3.9 Pressure Gauges

Pressure gauges shall be Bourbon tube type of heavy-duty quality with face diameter no less than 4 inches. The gradation of the pump discharge pressure gauge shall be the same as the header gauge and both gauges shall be changed, to suit the range of grouting pressures required by the Engineer. Gauge ranges of 0 - 100 psi, 0 - 300 psi and 0 - 600 psi or similar shall be provided. All gauges installed anywhere in the grout lines shall be protected by a membrane-type straightway gauge saver filled with glycerin, or equal non-freezing fluid. A standard master gauge shall be provided against which all other gauges shall be checked periodically for accuracy and satisfactory operation. Gauges shall have an accuracy of +/- 5% and shall be checked against a master gauge at maximum intervals of 7 days. Each gauge shall be identified with a number.

6.3.3.10 Communications

Telephone or radio communications shall be provided and used between the key elements of the grouting plant, from the mixing equipment to the pumps and to the grout hole.

6.3.3.11 Arrangement of Equipment

The arrangement of the grouting equipment shall be such that the grout supply line shall connect the pump to the hole and return to the agitator in one continuous circuit controlled for pressure with one pressure gauge placed at the outlet of the pump and one placed slightly downstream of the grout hole immediately in front of

the return valve for pressure control at the header. The grout plant shall not be placed at an elevation which leads to unacceptable grouting pressures.

6.4 Execution

6.4.1 Drilling

This subsection covers the drilling of blanket grout holes and exploratory holes.

All holes are so that the pattern of holes shown on the Drawings is followed and as required by the Engineer. Exploratory holes to determine the rock conditions in the Dam core trench shall be drilled where required by the Engineer.

Grease, rope dope, drilling mud or other lubricants shall not be put into the grout or water test holes by any means.

Blanket grout holes and exploratory holes shall be continuously cased throughout the drilling operation using percussion drill rig. The drill rods and bit shall be removed and the perforated sleeve pipe shall be inserted downhole once drilling has been completed to the required depth. The top of the sleeve pipe shall be 2 feet below ground surface. The casing will be withdrawn after insertion of the perforated sleeve pipe, leaving 1 foot stickup above the prepared shotcrete surface and at least 6 inches and no more than a foot of casing in the ground.

All casing shall be removed from the Dam core trench footprint after grouting is complete and the holes have been backfill grouted.

6.4.2 Water Testing and Grouting

6.4.2.1 General

The grout mixes, pressures, pumping rates and the locations and sequences in which holes are drilled and grouted shall be as specified herein and as shown on the Drawings or as otherwise required by the Engineer. The Engineer will adjust the grouting requirements, from time to time to suit the subsurface conditions encountered.

Grout materials including water shall be protected from freezing and shall be at a temperature between 10°C and 25°C, throughout the mixing and agitation period up to the time of injection. The grout plant and the work area around the drill hole shall be covered and heated as necessary. Temperature sensors shall be placed at the locations required by the Engineer to monitor temperature conditions.

6.4.2.2 Setting Packers

Blanket grout holes shall be grouted in one interval using a single packer set at the surface above the perforated sleeve pipe. The perforated sleeve pipe will convey the grout past any borehole collapse zones. It may be necessary to use the sequential packer down procedure should the Engineer deem that excessive surface leaks or caving are affecting the quality of blanket grouting. This procedure involves drilling the upper 10 feet, water testing grouting at low pressure with the packer set at surface, waiting 6 hours for the grout to set, drilling the hole to final depth, water testing the final interval, setting the packer at surface again and grouting the final interval. The hole would be backfilled upon completion of the final round of grouting.

6.4.2.3 Water Testing

When required by the Engineer, exploratory holes and grout holes shall be water pressure tested. Water pressure testing intervals shall be established by the Engineer on site and shall be changed based on varying ground conditions. Water pressure testing shall be done with packers with test pressures of 15 psi.

It is anticipated that water tests will be exploratory in nature, conducted within the middle 3-blanket grout hole lines, primarily as a means of assessing the effectiveness of the blanket grouting. The number of water tests conducted shall be at the discretion of the Engineer but it is not anticipated to exceed 15.

6.4.2.4 Mixing Grout and Injection

Grout materials including water shall be protected from freezing and shall be at a temperature between 10°C and 25°C throughout the mixing and agitation period up to the time of injection. The grout plant and the work area around the drill hole

shall be covered and heated if necessary. Single bead thermistors shall be placed at locations required by the Engineer to monitor temperature conditions.

Grout shall be mixed in batches of suitable volume and in such a way as to enable the water-cement ratio and the composition of grout suspensions to be changed to ensure continuous flow and minimum wastage. Grouts shall be mixed for a minimum of 5 minutes before injection.

All grout mixed and not injected within one hour of mixing shall be wasted.

Changes to the grout mix shall be done as directed by the Engineer. Guidelines for thickening the grout mixes during injection shall be made using the grout thickening chart (EBA, 1999).

The grout shall be injected at a maximum pressure of 15 psi at the header. The Engineer shall determine if increases in injection pressure are warranted.

Refusal shall be defined as an injection rate of less than 3 Litres of grout per meter of grout interval per minute over a 15 minute period.

If the grout absorption of a hole being grouted is such that it is found impossible to reach the required pressure after pumping a reasonable volume of grout at the minimum water cement ratio, the rate of pumping shall be reduced or stopped to allow for the grout in place to set before additional grouting of that interval takes place.

An ample supply of oakum, soft wooden wedges and premixed quick setting cement and mortar shall be available on the work site at all times for use in sealing surface grout leaks around the grout hole. Should caulking be not feasible due to excessive leakage, the hole shall be washed out, the injected grout shall be left to set for 12 hours and additional grouting be conducted afterwards.

6.4.2.5 Achieving Closure

The grouting shall be conducted in a grid pattern of holes on 10' spacings. The grout holes shall be drilled in the order shown on the Drawings so that closure assessment can be conducted. The sequence of drilling and grouting of the three

suites of holes shall proceed from the outside towards the centreline as shown on the Drawings in order to facilitate closure assessment.

Additional groutholes, over and above that which is designated secondary and tertiary holes shall be drilled as required so that the desired standard of rock mass hydraulic conductivity is achieved. These additional holes shall be drilled on a grid pattern as well. Grout takes of 50 kg/m or greater on the inner three rows of the third suite of blanket grout holes (see Drawings) will necessitate additional grout holes set by the Engineer.

The blanket grouting shall decrease the hydraulic conductivity of the rockmass beneath the core trench to 3 Lugeons.

6.4.2.6 Foundation Uplift Monitoring

Foundation displacement monitoring shall be conducted during water pressure testing or grouting of the holes in the vicinity of areas where the Engineer considers that the grout take trends are indicating that rock uplift as a result of grouting may be taking place.

Whenever the foundation displacement monitoring shows the initiation of rock uplift, the grouting or water test pressure shall immediately be reduced.

6.4.2.7 Grout Hole Backfilling

Grout holes shall be backfilled to surface upon completion of grouting with 1:1 grout. The grout shall be tremied to the bottom of the hole so that all water and/or grout thinner than 1:1 will be displaced from the hole by the grout.

6.5 Quality Control

6.5.1 General

All grouting shall be done in the presence of the Engineer. During drilling, water pressure testing and grouting operations, the Contractor shall provide experienced operating personnel for each drilling and grouting plant in operation.

Gauges shall be cleaned and recalibrated at the start of each working shift and periodically during each shift as necessary.

6.5.2 Technical Direction

The Engineer will technically direct the drilling and operations. Such technical direction shall include, but shall not necessarily be limited to:

a) Detailed technical supervision and inspection.

b) Issuance of specific instructions for the locating, drilling, and grouting including mix control and grouting pressures for each hole.

c) Control of the sequence of drilling and grouting of all holes, to ensure there is no interference or interconnection between adjacent holes. The Engineer may only issue instructions for specific holes in any immediate area at the one time and will not issue instructions for adjacent holes until the results of previous holes are completed.

d) Issuance of evaluations of the test results will either release parts of the grouting work as completed or indicate the necessity for further work.

6.5.3 Progress Records

Drilling, water testing and grouting records will be kept by the Engineer. The records will include the number, location, orientation, azimuth, size and depth of all holes, date of drilling, water testing, grouting, re-drilling and re-grouting, the type of grouting, mix proportions, grout consumption, pressures used, time and duration of injection, interconnection, and any other information on the amount of work done during the shift for measurement, record, and quality control purposes. The Contractor shall assist the Engineer in keeping records.

The grouting data will be plotted by the Engineer immediately and continuously as the data are measured. These field plots will be used by the Engineer to evaluate the grouting operation and to adjust the required procedures where necessary.

The drilling and grouting records shall be signed by the Contractor and the Engineer's representative after each shift.

6.5.4 Testing

Whenever requested by the Engineer, the Contractor shall provide grout trial batches to verify the quality of grout to be placed.

6.6 Clean Up

6.6.1 Clean up Prior to, and During Grouting

All grouting areas shall be kept free of water, grout, sludge, oil or any deleterious material regardless of origin so that none of these materials drain onto any part of the Works completed or under construction. At all times during the progress of the Work, all open drill holes shall be protected.

6.6.2 Clean Up After Grouting Operation

Upon completion of grouting, all grout supply connections shall be removed from the work area.

Prior to final acceptance of the Work, the exposed surfaces of all rock, concrete and shotcrete shall be cleaned and restored to their original condition. All hardened grout on surfaces within the work areas shall be removed if it is deemed to be unsound or poorly bonded to the underlying surface, as determined by the Engineer.

7.0 EMBANKMENT FILL

7.1 Scope

The Work specified in this section comprises the supply of all labour, plant, and materials and the performance of all work necessary to process, moisture condition, load, transport, dump, place, spread, trim and compact embankment fill in the various zones of the Dam, and other required embankments as specified herein and as shown on the Drawings.

7.1.1 Description of the Work

The Work shall include, but shall not necessarily be limited to the construction of the following required embankments:

a) Dam

b) Upstream cofferdam

7.1.2 Responsibilities of Contractor

The Contractor is responsible for locating, sizing, constructing and maintaining the upstream cofferdam so that water is contained and diverted around the dam site. The Contractor is responsible for sizing pumps to divert water and for ensuring that significant erosion, slope instability or siltation/contamination of Minto Creek does not occur as a result of water containment, diversion or discharge associated with the cofferdam.

7.2 References

Publications listed below are referred to in this Section and form part of these Specifications:

a) ASTM Designation D422: Particle-Size Analysis of Soils.
b) ASTM Designation D2216: Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures.
c) ASTM Designation D698: Test for Moisture-Density Relations of Soils and Soil Aggregate Mixtures, using 5.5-lb. (2.49 kg) Rammer and 12-in (305 mm) Drop.
d) ASTM Designation D4253: Maximum Vibrated Density Test

7.3 Materials

The purpose of this subsection is to define the embankment fill materials which shall be placed in each zone of the required embankments and fill bodies as specified herein. Except as otherwise provided, the Contractor shall not place within any zone of the Dam or other required fills, embankment fill material not satisfying completely the requirements specified herein for that zone.

7.3.1 General

The Dam will be composed of the following general fill zones:

Zone 1 - Upstream Residuum Shell
Zone 2 - Semi Impervious Core
Zone 3 - Fine Filter
Zone 4 - Intermediate Filter
Zone 5 - Coarse Filter
Zone 6 - Downstream Shot Rock Shell
Zone 7 - Oversize Shot Rock Toe Berm
Zone 8 - Spillway and Upstream Face Riprap

Each of these zones will perform a particular function in the performance of the Dam and must contain fill having definite and known characteristics that will fulfill its design function. Such characteristics will be determined by the nature and condition of the fill materials placed within each zone, and the procedures used in fill placement.

The Contractor shall submit to the Engineer for review at least 30 working days prior to the scheduled commencement of fill placement for the required embankments, a plan and details of the various stages, materials, equipment, methods and procedures he proposed to be used for such operations, including the location of haul roads and methods and location of processing and moisture conditioning.

The Contractor shall provide all of the required embankment fill materials. The suitability of materials for use as embankment fill will be confirmed by the Engineer based laboratory testing of samples supplied by the Contractor.

Fill materials shall be unfrozen and shall be composed of sound, durable mineral particles. Fill materials shall not contain ice, roots, topsoil, organic matter, debris or any other material determined by the Engineer to be unsuitable. Fill material shall be well graded within the specified gradation limits. The specified gradation limits shall apply to the materials after they have been placed, spread and compacted in the required embankments.

Where processing, blending and moisture conditioning is required, fill materials shall be thoroughly mixed in such a manner that the product is uniform and consistently within the specified gradation limits and moisture content requirements when it is placed in the Dam.

Granular fill material may be stockpiled to suit the Contractor's operations, provided that the Contractor exercises every precaution necessary to prevent segregation, breakdown of grain sizes, deterioration, contamination and wetting above the specified moisture content. Embankment fill materials temporarily stored in stockpiles shall be placed in the stockpiles in layers not exceeding 6 feet in thickness. Materials that become segregated or contaminated and that have been determined by the Engineer as being unsuitable for use as embankment fill shall be removed to the designated spoil disposal areas.

7.3.2 Material Grain Size Distribution Specifications for Dam Fill and Topsoil

7.3.2.1 Zone 1 - Upstream Residuum Shell

The Zone 1 Upstream Residuum Shell material shall consist of residuum material that does not contain sufficient fines to be used in Zone 2.

Sieve	% Passing
3"	100
0.5"	80 – 100
#4	60 – 100
#40	25 – 55
#200	0 - 25

7.3.2.2 Zone 2 - Semi Impervious Core

The Zone 2 - Semi Impervious Core material shall be residuum material containing a large portion of fines material. The specification band for this material is given below.

Sieve (in)	% Passing (by weight)
0.5	100
#4	85 - 100
#10	67 - 85
#20	50 - 70
#40	35 - 55
#100	18 - 36
#200	10 - 25

7.3.2.3 Zone 3 - Fine Filter

Sieve (in)	% Passing (by weight)
0.5	100
3/8	70 - 100
#4	30 - 60
#10	0

7.3.2.4 Zone 4 - Intermediate Filter

Sieve (in)	% Passing (by weight)
2	100
1 1/2	60 - 100
1	10 - 45
¾	0 - 10

7.3.2.5 Zone 5 - Coarse filter

Sieve (in)	% Passing (by weight)
6	100
4	50 - 100
3	10 - 60
2	0

7.3.2.6 Zone 6 - Downstream Shotrock Shell and Upstream Face Riprap

Sieve (in)	% Passing (by weight)
24	100
12	30 - 80
6	0

7.3.2.7 Zone 7 - Oversize Shotrock Toe Berm

The oversize shotrock toe berm shall consist of any sound rock particles greater than 2 feet diameter.

7.3.2.8 Zone 8 - Spillway Riprap

The riprap referred to in the Drawings is described below as a function of particle size and particle weight. It should be noted that the Upstream Face riprap will be the 2 foot minus shotrock specified in Section 7.3.2.6.

% Passing	12 inch Median Size	24 inch Median Size
	Rock Size (in)	
100	16	40
40 – 80	14	28
20 – 50	12	24
<15	8	14
	Rock Weight (lb)	
100	275	3080
40 - 80	130	1050
20 - 50	88	660
<15	22	130

7.4 Sources of Fill Materials

The Contractor shall obtain fill materials for construction of the various zones of the required embankments from borrow sources and from within the boundaries of the required excavations. The Contractor shall choose his borrow pit locations in consultation with the Owner and develop them as he sees fit provided the material contained within them is considered to be suitable material by the Engineer. The Contractor shall carry out a subsurface investigation and obtain and submit soil samples as required by the Engineer for on site laboratory testing to enable an adequate assessment to be made of the suitability of the materials in the area for use as embankment fill. The Contractor shall keep accurate records of any testpit, trench or drill hole which he makes for the purpose of investigating fill materials, and a copy of such record shall be submitted to the Engineer within 30 working days of the completion of the test pit, trench or drill hole.

The Engineer's approval of any sample does not mean approval of an entire source. All materials from any source are subject to further sampling, testing and approval/rejection.

The limits of contract shown on the Drawings around the borrow areas delineate the extent of the property that has been acquired by the Owner for the use of the Contractor as sources of fill materials. Any material within the limits of contract shown on the Drawings may be used by the Contractor as embankment fill in the Dam and other required embankments free of royalty payments at no cost to the Contractor.

The Owner shall be responsible for obtaining the property rights and for paying royalties for alternative off-site sources.

7.5 Tolerances

The permissible maximum deviation of the finished outside slope surfaces and zone boundaries of the required embankments from the lines and grades shown on the Drawings shall be plus or minus 1 foot measured normal to such surfaces or boundaries provided that:

- the crest width shall not be less than the dimensions shown on the Drawings,
- the finished outside surfaces of any zone shall not be lower than the elevations shown on the Drawings, and
- the thickness of Zone 3, 4 and 5 Filters and Zone 8 Spillway and Upstream Face Riprap shall not be less than those shown on the Drawings.

7.6 Execution

7.6.1 General

The Contractor shall be responsible for the design, provision, and operation of all facilities and equipment necessary for the transporting of fill materials from borrow areas, required excavations, and stockpiles to the final point of placement within the required embankments. The Contractor shall vary the method of placing and compaction in order to meet the requirements of these Specifications as determined by testing and as accepted by the Engineer. The Contractor shall design, provide, and operate such facilities and equipment in such a manner that fill materials, when placed, fulfill the specified requirements. If the design or method of operation of the facilities and equipment provided by the Contractor produces unacceptable segregation, wetting, drying, freezing, or other undesirable effects on the fill materials, the Contractor shall modify such facilities and equipment, or change the methods of operation.

Fill materials shall not be placed in any part of the required embankments until the excavation and foundation preparation have been completed to within a horizontal distance of 60 feet from the proposed fill placing location.

Should a slide of any material occur within or onto any part of a required embankment, all slide and any fill materials affected shall be removed and placed in a designated spoil disposal area. The slide debris shall be placed in a separate spoil disposal area separate from the excavated fill materials. The portions of the required embankment so removed shall be rebuilt in accordance with the Specifications. The removal and disposal of material and the rebuilding of the fill shall be performed at the Contractor's cost except where, in the opinion of the Engineer, the slide was not caused by the fault or neglect of the Contractor.

7.6.2 Moisture Conditioning

The Contractor shall submit details of the equipment, methods and procedures he proposes to use to moisture condition Zone 1 Upstream Shell and Zone 2 Semi Impervious Core to the Engineer for review at least 30 working days prior to the scheduled commencement of fill placement for the Dam and other required embankments.

The Contractor shall effectively drain the borrow pits to prevent the wetting of fill materials in the borrow pits and required excavations by precipitation or by surface runoff or subsurface seepage to moisture contents in excess of those specified.

If the material in the required excavations or borrow pits for Zone 1 Upstream Shell or Zone 2 Semi Impervious Core material contains excessive moisture before or during excavating operations, the moisture content shall be reduced to produce fill materials whose moisture content is uniformly within the specified limits throughout the mass of the fill material immediately prior to placement.

If the in situ moisture content of the Zone 1, Upstream Shell or Zone 2 Semi Impervious Core material is lower than that specified for placement, the material shall be moisture conditioned to produce fill materials whose moisture content is uniformly within the specified limits throughout the mass of the fill material immediately prior to placement. If the Contractor chooses to wet the material at the fill site, care must be taken to ensure that the material is wetted before any significant compaction has occurred and that wetting does not cause contamination of the adjacent Zone 3 Fine Filter. Moisture conditioning is to be done with a water truck equipped with a water bar or some equivalent means of applying moisture

evenly to the uncompacted fill surface. The Contractor shall not use hoses as a means of moisture conditioning the fill materials.

Zone 1 Upstream Shell or Zone 2 Semi Impervious Core shall be continuously reworked during moisture conditioning to produce uniformity of moisture content throughout the mass of the material prior to compaction.

Supplemental moisture conditioning shall be restricted to the minimum necessary to adjust the moisture content for minor moisture loss or gain during transportation of the fill and to ensure the compaction of fill materials at the specified moisture content and to the specified density, and to prevent the compacted surface of the embankment fill from losing moisture and drying out.

Supplemental moisture conditioning performed on the required embankments shall include:

i) controlled sprinkling followed by such mixing as is necessary to obtain a uniform moisture content increase throughout the material,

ii) working wet fill material during dry weather to allow the fill material to dry,

iii) removing, spreading, and blending wet material with selected dry fill material, and

Complete removal of wet or dry fill material from the required embankment shall be done if moisture conditioning efforts fail to bring the material within the specified moisture contents.

7.6.3 Processing

It shall be the Contractor's responsibility to devise, furnish, operate and maintain such granular processing plant as is necessary to produce the required quantities of materials, complying with the specified limits from the borrow areas.

Materials excavated for Zone 2 Semi Impervious Core, Zone 3 Fine Filter, Zone 4 Intermediate Filter, Zone 5 Coarse Filter and Zone 6 Downstream Shot Rock Shell shall be processed prior to delivery to the required embankment, to produce fill

materials of the specified gradation. Such processing may require crushing, separation by passing of portions of the materials through washing, screening and classifying plants. Material which is a by-product of the processing of materials for one zone may be incorporated in the fill for another zone provided that it satisfies the specifications for such latter zone either by itself or after it has been blended with other material.

The Contractor shall furnish a granular processing plant of such design, and shall operate his processing equipment in such a manner, as to provide uniformly processed fill materials. The Contractor shall replace or modify equipment and procedures when, in the opinion of the Engineer, equipment or procedures being employed are producing unacceptable segregation or other undesirable characteristics.

At least 30 working days prior to the commencement of any processing operation, other than the simple removal of oversize in the borrow pits, the Contractor shall submit to the Engineer for review a method statement describing the proposed granular processing plant and operations or changes to the proposed granular processing plant and operations.

7.6.4 Fill Placement

7.6.4.1 General

Embankment construction shall be performed in accordance with the best modern practice and with equipment best adapted to the work that is being performed. Embankment materials shall be placed so that each zone is homogeneous, free of stratifications, lenses, pockets, ruts and layers of material of different texture and grading not conforming to the requirements specified herein.

No fill material shall be placed on any part of the foundation area of the required embankments until such part of the foundation has been excavated and prepared by the Contractor to the lines, slopes, and elevations shown on the Drawings and has been approved by the Engineer. The placement of material shall be done so that mixing with adjacent materials in the structure is prevented.

Embankment construction shall not proceed when the work cannot be performed in accordance with the requirements of the specifications. Any part of the embankment which has been damaged by the action of rain and snow or any other cause shall be removed and replaced with material conforming to the requirements specified herein before placement of succeeding layers.

Loading, transporting, dumping and spreading of all materials shall be carried out in such a manner as to avoid segregation. Should segregation occur, the materials shall be removed and replaced to the Engineer's satisfaction with materials meeting the specifications herein. Pockets of stone, particularly at the junction between zones or in contact with the abutments, as well as materials that have fallen in zones of other material shall be removed and replaced by the materials specified for that zone herein.

Unless otherwise authorized by the Engineer, all fill materials shall be placed and spread in continuous and approximately horizontal layers of uniform thickness for the full width and length of the zone by routing the hauling and spreading equipment in a direction parallel to the centerline axis of the Dam. Fill materials shall not be end-dumped into depressions or bladed down slopes. Fill shall be placed and spread in such a manner that no gaps are left between successive loads of materials. The fill shall be leveled prior to compaction by means of dozers or graders to obtain a surface free from depressions.

Fill material that does not meet the specified requirements will be removed and placed in a spoil disposal pile. Fill materials which become contaminated shall be removed to designated spoil disposal areas and replaced with materials meeting the specified requirements for that zone at no cost to the Owner.

Water shall not be allowed to pond on the fill surface of the Dam.

No fill materials, other than in Zone 4 Intermediate Filter, Zone 5 Coarse Filter, Zone 6 Downstream Shell, Zone 7 Over Size Shot Rock Toe Berm and Zone 8 Spillway Riprap, shall be placed in any part of the embankment during periods when the ambient temperatures are such as will result in the placement of frozen fill materials, or in the placement of materials on frozen fill surfaces. Water shall not be used as an aid to compaction of fill materials placed during periods when ambient air temperatures are below 3°C.

Accumulated snow and ice layers formed on fill surfaces shall be removed prior to placement of the next layer of fill material thereon.

7.6.4.2 Specific Zone Requirements

7.6.4.2.1 Zone 1 - Upstream Shell

All Zone 1 material shall be placed and spread in layers of uncompacted thickness not exceeding 1.0 feet, except in locations where special compactors are required and within a 3 foot thick zone measured perpendicular to the abutments where Zone 1 material shall be placed and spread in layers of uncompacted thickness not exceeding 6 inches.

If the surface of the prepared soil foundation or the compacted surface of Zone 1 becomes too dry or too smooth to bond with the layer of Zone 1 material to be placed thereon, the surface material shall be moistened and scarified, to a depth of at least 3 inches to provide a satisfactory bonding surface, before the succeeding layer of material is placed thereon.

If the surface of the prepared soil foundation or the compacted surface of fill material becomes too wet for compaction of the layer of fill material to be placed thereon, the surface material shall be removed and allowed to dry, or shall be scarified to a depth of at least 2 inches until the moisture content is reduced to the specified amount.

Fill material shall not be placed in Zone 1 during periods of rain, snow, or sleet of an intensity which would interfere with the specified moisture conditioning requirements.

All frozen fill materials present in Zone 1 shall be removed and placed in the designated spoil disposal area or shall be removed, allowed to thaw, reconditioned to the specified moisture content, if necessary, replaced and compacted.

7.6.4.2.2 Zone 2 - Semi Impervious Core

All Zone 2 Semi Impervious Core material shall be placed and spread in layers of uncompacted thickness not exceeding 8 inches, except in locations where special compactors are required and within a 3 foot thick zone measured perpendicular to the prepared foundation in the Dam core trench where core material shall be placed and spread in layers of uncompacted thickness not exceeding 6 inches.

Working surfaces shall be maintained free from water, ice and snow. Immediately prior to placing fill, all water shall be removed from depressions. Dry cement may be applied to the foundation when there is excess moisture due to infiltration or precipitation. Fill material shall not be placed in Zone 2 Impervious Core during periods of rain, snow, or sleet of an intensity which would interfere with the specified moisture conditioning requirements.

If the surface of the prepared soil foundation or the compacted surface of core becomes too dry or too smooth to bond with the layer of core material to be placed thereon, the surface material shall be wetted to the specified moisture content range and scarified to a depth of at least 3 inches and allowed to dry to provide a satisfactory and uniformly wetted bonding surface, before the succeeding layer of core material is placed thereon.

If the compacted surface of core material becomes too wet for compaction of the next layer of core material to be placed thereon, the surface material shall be removed and allowed to dry, or shall be scarified to a depth of at least 3 inches until the moisture content is reduced to the specified amount. The over wet fill material shall be removed and placed in a spoil disposal area if these measures fail to decrease the moisture content.

Placement of fill materials shall commence at the lowest elevation of the foundation. Local depressions and undulations in the surface of the prepared foundation in the Dam core trench shall be filled with small quantities of Zone 2 Semi Impervious Core material. Such filling operations will require hand labour and shall only take place during daylight hours. The local depressions and undulations shall be filled starting at the lowest point in that area of the foundation and shall continue in horizontal layers, until all the local depressions are filled and the placing area is large enough to permit the operation of normal construction

equipment. Such fill may be placed simultaneously in depressions at different elevations provided that the normal initial continuous lift of fill is achieved by progressing in horizontal layers from the lowest area upwards.

The Zone 2 Semi Impervious Core material placed in the initial layers against rock foundations, and as instrumentation trench backfill where required, shall be compacted with special compactors. Rock foundations and concrete surfaces shall be moistened prior to placement of the Zone 2 Core material against them. Material adjacent to the rock foundations shall be compacted in such a manner that the fill material is forced into all depressions in the shotcrete or rock surface to form a bond with the prepared rock foundation.

Each layer of core material shall be scarified to a minimum depth of 3 inches following compaction, to ensure a complete bond between that layer and the overlying layer, except in locations where special compactors are required and within a 3 foot wide zone measured perpendicular to the prepared foundation in the Dam core trench where each layer shall be scarified to a minimum depth of 1 inch following compaction. The surface of core shall be maintained in a moist condition by continuous, uniform spraying from a water truck with a spray bar. The sprinkler tank units shall be equipped with positive shutoff valves so that there will be no leakage from the nozzle when the equipment is not operating.

The top surface of each layer of core shall be sloped to drain water from precipitation towards the upstream edge of the zone, away from Zone 3 Fine Filter to prevent contamination with water borne fine soil particles. Immediately prior to periods of heavy precipitation where placing operations must be suspended, the sloped surface of the core shall be made smooth using steel drum rollers to minimize the absorption of water by the surface material and to promote surface runoff in the upstream direction.

Exposed surfaces of core shall be protected from freezing during periods of cold weather by using insulating blankets or a layer of uncompacted sacrificial fill.

Prior to the resumption of fill placement, the protective fill material shall be removed. Any portion of the fill that has suffered a reduction in density due to the action of frost shall be recompacted or removed before the placing of succeeding layers.

7.6.4.2.3 Zone 3, 4 and 5 - Fine, Intermediate and Coarse Filters

The integrity of the dam is dependant on the integrity of the filters. The filters must be unsegregated and uncontaminated so that they are stable under the expected hydraulic gradients and provide proper drainage. End dumping and spreading of the filter material will not be permitted as it promotes segregation.

It is anticipated that water will have to be added to the Zone 3 Fine Filter material in order to reduce segregation during placement and to later aid in compaction.

Rain shall not be considered detrimental to the continuance of placement and compaction in Zone 3, 4 and 5 Filters provided that contamination of these and other zones does not occur and provided that the placed and compacted materials meet the specified requirements for the zone.

All frozen fill materials present in Zone 3 and Zone 4 shall be removed and placed in the designated spoil disposal area or shall be removed, allowed to thaw and replaced and compacted if the moisture content is within the specified limits for that material.

7.6.4.2.4 Chimney Filter

The Chimney Filter materials shall be placed in 1 foot thick lifts. The Zone 3 Fine Filter material may require moisture conditioning prior to compaction.

Three possible methods of Chimney Filter placement are described in the following paragraphs. The inclusion of these three possible methods of filter placement shall not limit the Contractor from suggesting alternative methods of construction. All methods of Chimney Filter placement will involve some inspection and testing by the Engineer to ascertain whether the method is suitable or not. The Engineer's approval of the method of placement is required before Chimney Filter material is placed within the dam cross section. The Engineer may require further testing and re-evaluation of the method of placement should the filter material segregate or experience other difficulties.

It is crucial to ensure that filter material processing and stockpiling operations are done in such a way that prevents segregation.

All methods of placement described below involve crossing the Chimney Filter. The Contractor should schedule his operations in such a manner that the filter crossing locations are minimized if he chooses to use one of these methods. The tires and tracks of all construction and haul equipment which crosses the filter zone shall be kept free of material which could contaminate the Filter zones.

i) Spreader boxes may be used to limit segregation of filter materials. A spreader box is a slip form that delineates three fill zones which allows filter material to be placed in a uniform width and height with a minimum of segregation. An alternative to this approach would be to use spreader boxes for the fine and intermediate filters and place the coarse filter with a belly dump or other method approved by the Engineer.

ii) Belly dump placement can be used to limit segregation provided the speed of the belly dump during placement is not excessive. This method facilitates placement of an even lift of filter material with a minimum amount of haul time.

iii) Scraper placement can be used to limit segregation and control lift thicknesses by ejecting the filter material while slowly driving along the filter zone. The thicknesses of each lift can be controlled by adjusting the height of the belly of the scraper above the ground surface and by adjusting the speed of the scraper and the rate of unloading of the filter material. The scrapers will have to be loaded at the stockpiles by front end loader or excavator.

The surfaces of Zone 3, 4 and 5 Filters downstream of Zone 2 Semi Impervious Core (Chimney Filter shall be protected from contamination by foreign materials at all times. All surface drainage on the surface of Zone 2 Semi Impervious Core shall be directed away from Zone 3 Fine Filter to prevent contamination by water borne fine soil particles. Any section of the Zone 3, 4 and 5 Filters that becomes contaminated with silt or clay size particles during placement, spreading, compaction and constitutes a compromise on the filters ability to perform as required in the dam shall be removed and placed in a designated spoil disposal area and replaced with material meeting the specified requirements for that zone before the next layer is placed on it.

7.6.4.2.5 Blanket Drain

The Zone 3 Fine Filter, Zone 4 Intermediate Filter and Zone 5 Coarse Filter in the Blanket Drain shall each be placed in uncompacted lift thicknesses of 1 foot. The materials should be placed as close as possible to its final resting place to minimize segregation. Water shall be added to Zone 3 Fine Filter material to assist the compaction operations, to minimize segregation and for dust control if necessary.

The Zone 3 Fine Filter, Zone 4 Intermediate Filter and Zone 5 Coarse Filter materials in the Blanket Drain should be placed in such a way that truck traffic on the lift surfaces is minimized, in turn reducing the amount of contamination that may occur. Surface water drainage should be routed away from the Blanket Drain to prevent contamination and clogging of the placed filter materials.

7.6.4.2.6 Riprap Filters

Zone 3, 4 and 5 Filters are required beneath the riprap located on the upstream face, beneath the overflow spillway riprap and beneath the stilling basin at the downstream toe of the Dam. Each of these filters shall be placed individually such that the compacted lift is 1 foot thick.

7.6.4.2.7 Zone 6 - Downstream Shell Shotrock

Zone 6 Shotrock Fill shall be placed and spread in layers not exceeding 3 feet thick and shall contain a range of rock fragment sizes that can be placed into a mass with a minimum of voids, free from pockets of uniformly graded particles and with the larger sized rock fragments well distributed throughout the zone. Rock fragments above the 2 foot size shall be moved during spreading to the Zone 7 Oversize Rock Fill Toe Berm shown on the Drawings.

Rain shall not be considered detrimental to the continuance of placement of Zone 6 Downstream Shotrock provided that contamination of these and other zones does not occur and provided that the placed materials meet the specified requirements for the zone.

7.6.4.2.8 Zone 7 - Over Sized Shotrock Toe Berm

Zone 7 Over Sized Rock Fill material shall be placed and spread in layers of uncompacted thickness not exceeding 6 feet with the larger sized rock fragments well distributed throughout the zone. Special care must be exercised to avoid the formation of voids surrounding rock fragments greater than 1.2 m.

Rain shall not be considered detrimental to the continuance of placement of Zone 7 Over Sized Shotrock Toe Berm provided that contamination of these and other zones does not occur and provided that the placed materials meet the specified requirements for the zone.

7.6.4.2.9 Zone 8 - Spillway and Upstream Face Riprap

Placing riprap, moving individual pieces of rock, dressing the slope and developing of adequate particle interlocking will require the use of excavators equipped with a thumb, clam shells or other equipment that permit the positioning of individual particles. Riprap material shall not be dumped on the slopes and pushed into place. Riprap material shall not be dropped from a height greater than 4 feet.

Individual particles of riprap material that break into two or more particles during loading at a stockpile or at any other time until the riprap is placed and accepted in the Dam or other required embankments shall not be used as riprap material unless it is within the specified particle size range.

Riprap shall be placed in the dry to its full course thickness in one operation and in such a manner as to avoid disturbance or displacement of the underlying bedding material.

Rain shall not be considered detrimental to the continuance of placement of Zone 8 Spillway Riprap provided that contamination of these and other zones does not occur and provided that the placed materials meet the specified requirements for the zone.

7.6.4.2.10 Haul Routes on Working Surface of Dam

Hauling units transporting material on the dam shall have an adequate bearing surface to prevent rutting. Haul roads on the dam shall be located away from the abutments and frequently changed in location except where filter crossing is required. Any haul road no longer in use on the dam shall be worked out to obtain homogeneity with the surrounding embankment material. Haul trucks should be routed over every zone of the dam except Zone 3 Fine Filter and Zone 4 Intermediate Filter and Zone 5 Coarse Filter in such a manner that the tire tracks are spread evenly over the dam section. Whenever and wherever possible, haul routes shall be routed such that they do not cross the filter zones. Any crossing over the Zone 3, 4 and 5 Filter materials must be approved by the Engineer and shall consist of a minimum sacrificial thickness of coarse filter material 1.5 feet thick. A separating layer of nonwoven filter fabric is to be used beneath the filter crossing fill to prevent any contamination of the filter materials. The Engineer is not obliged to approve any such routes if there are feasible alternatives that do not involve crossing the filter zones. Only one filter crossing at any one time will be permitted. The Contractor will maintain the filter crossing throughout its service life and will clean up any spillage of fill materials around which may include excavation and replacement of filter material at no cost to the Owner.

7.6.5 Compaction

7.6.5.1 General

The Contractor shall provide sufficient compaction equipment of the types and sizes as is necessary for compaction of the various fill materials to the required specifications.

Compaction of each layer of fill material shall proceed in a systematic, orderly and continuous manner, so that each portion of the layer receives the compaction specified. The compaction shall be carried out by routing the compaction equipment parallel to the centerline axis of the embankment over all areas of the working surface except within a 3 foot wide zone measured perpendicular to the face of the prepared Dam foundation in the core trench and on the rock and soil

slopes, where special compaction equipment (see below) shall be routed parallel to the slope.

During compacting operations, the method of changing the direction of movement of equipment shall result in uniform compaction. Compaction equipment which is not self propelled shall be pulled, not be pushed, by the towing unit.

A pass shall mean one traverse of a compactor across the surface of a layer in one direction only, and a coverage shall mean the operation by which all parts of any area on the surface of a layer of fill have been traversed at least once by the compacting surfaces of a compactor.

For compaction by a pneumatic tired roller, one coverage shall consist of two passes of the roller with the roller routed so that on the second pass the tires of the roller pass over the areas between the tire tracks of the first pass.

For compaction by a vibratory roller, one coverage shall consist of one pass of the roller. An overlap of 1 foot shall be maintained between the surfaces traversed by adjacent passes of the roller and this overlap shall be maintained even where drums are towed in a multiple arrangement behind a single tractor.

Special compactors include excavator boom mounted vibrating plate tamper, walk behind roller, hand operated vibratory plate compactors and impact plate tampers (jumping jack) One pass with a special compactors shall consist of applying the compactor to all areas of the fill surface to be compacted. These special compactors are to be used in areas where larger compactors (i.e. heavy rollers) can not operate due to space restrictions.

The rolling pattern at all zone boundaries shall be such that the full number of coverages required in each adjacent zone extends completely across the zone boundary.

Should the surface of the fill become rutted or uneven subsequent to compaction, it shall be relevelled and recompacted before the next layer of fill is placed.

All stone particles or lumps of such dimensions that cause interference with compaction in the layer thicknesses specified, shall be removed from the zone in which they are placed prior to compaction as specified.

Each layer of fill material in roller turning areas shall be rolled perpendicular to the normal pattern, to obtain compaction equal to the remainder of the fill in the zone.

Materials which cannot be compacted by the pneumatic tired or vibratory rollers because of the location of such materials, shall be compacted with Special Compactors. Such locations shall include:

i) portions of required embankments adjacent to foundations, and
ii) portions of required embankments at steep and irregular abutments.

Precaution shall be taken when operating compaction equipment to avoid damage to instruments and their leads and to avoid disturbing the prepared foundation. Any such damage or disturbance shall be repaired by the Contractor at no cost to the Owner.

7.6.5.2 Specific Zone Compaction Requirements

7.6.5.2.1 Zone 1 Upstream Shell

The Zone 1 material in each lift shall be mixed and broken down into a homogeneous mass of uniform moisture content and shall be between one and two percent below the optimum moisture content as determined by the Standard Proctor Density Test (and any test strips) after any required moisture conditioning. The Zone 1 material shall be compacted to a dry density equal to or greater than 98 percent of the maximum dry density obtained in the Standard Proctor Compaction Test performed in accordance with ASTM Designation D698. Compaction by special compactors shall be carried out to achieve compacted densities equal to or greater than 98 percent of the maximum dry density obtained in the Standard Proctor compaction test performed in accordance with ASTM Designation D698.

The Contractor will be advised of the optimum moisture contents determined through testing on samples taken from the fill done in the on site laboratory.

7.6.5.2.2 Zone 2 Semi Impervious Core

The requirements of this subsection apply to all Zone 2 Semi Impervious Core material placed in the works. In this section, Zone 2 Semi Impervious Core material will be referred to as core material.

The Contractor will be advised of the optimum moisture contents determined in the laboratory on samples taken from the fill. The frequency will be varied to suit changes in the characteristics of the borrow materials.

The core material in each layer shall be mixed and broken down into a homogeneous mass of uniform moisture content one percent to zero percent below optimum moisture content (as determined from Standard Proctor Density Testing and test strip results) after any required moisture conditioning. The Zone 2 Semi Impervious Core shall be compacted to a dry density equal to or greater than 98 percent of the maximum dry density obtained in the Standard Proctor Density Test performed in accordance with ASTM Designation D698. Compaction by special compactors shall be carried out to achieve compacted densities equal to or greater than 98 percent of the maximum dry density obtained in the Standard Proctor Density Test performed in accordance with ASTM Designation D698.

7.6.5.2.3 Zone 3 Fine Filter, Zone 4 Intermediate Filter and Zone 5 Coarse Filter

The Contractor shall not over compact the filter materials in the Chimney Filter or Blanket Drain and shall modify his compaction methods if excessive particle breakdown is noted at the surface of the lift

7.6.5.2.3.1 Chimney Filter

Each lift of the Zone 3 Fine Filter, Zone 4 Intermediate Filter and Zone 5 Coarse Filter material in the Chimney Filter shall be compacted with at least one coverage of a vibratory roller or special compactor to compact the filter material to 95% of the Maximum Vibrated Density Test performed in accordance with ASTM Designation D4253. Water shall be added to Zone 3 Fine Filter and Zone 4 Intermediate Filter material to assist in compaction operations, to minimize segregation and for dust control. After compaction no construction equipment except the placing and compaction equipment working on the next layer shall pass

along the compacted surface without a haul road crossing that prevents deterioration of the filter due to rutting or addition of fine-grained material from haul truck tires.

The boundary between the inclined Zone 3, 4 and 5 Filters in the Chimney Filter shall be compacted in such a manner that the density of these zones conforms to the respective specified requirements.

7.6.5.2.3.2 Blanket Drain Section

The Zone 3 Fine Filter in the Blanket Drain shall be compacted with at least two coverages of the specified vibratory compactors or special compactors to a dry density of 95 percent. It is anticipated that this material may have to be moisture conditioned to within 1 to 2 percent below Standard Proctor Optimum moisture content as determined in the Standard Proctor Density Test performed in accordance with ASTM Designation D698.

The Zone 4 Intermediate Filter and Zone 5 Coarse Filter material in the Blanket Drain should be wetted prior to compacting the material with at least two passes of a vibratory roller. Care should be taken to prevent erosion of the Zone 3 Fine Filter material during the moisture conditioning operation.

7.6.5.2.3.3 Riprap Filters

The Zone 3 Fine Filter material beneath riprap zones shall be compacted to 95% of the Standard Proctor Density as determined in Standard Proctor Density Test performed in accordance with ASTM Designation D698. It is anticipated that this material may have to be moisture conditioned to within 1 to 2 percent below Standard Proctor Optimum moisture content.

The Zone 4 Intermediate and Zone 5 Coarse Filters shall be moisture conditioned and compacted with two passes of a vibratory roller.

7.6.5.2.4 Zone 6 Downstream Shell and Zone 7 Oversize Rock Fill Toe Berm

Water should be applied to the rockfill mass in Zone 6 and 7 during and after placement in order to facilitate densification of the material through self weight. No

other compaction effort will be required as it is anticipated that the action of the bulldozers spreading the rockfill will be sufficient to achieve the required density.

7.6.5.2.5 Zone 8 Spillway and Upstream Face Riprap

Riprap stones shall be placed using a clam shell and excavator bucket with care taken to ensure that the riprap stones are individually placed in the densest arrangement possible. This operation may require hand placement or wedging of smaller pieces in the riprap mass.

7.6.6 Fill Placement Records

The Contractor shall maintain accurate records of all fill placement operations and at the end of each shift shall provide the Engineer with two copies of the daily record. The following data shall be recorded on forms approved by the Engineer, together with such additional data as the Engineer may request, and shall bear the signatures of the Contractor's and the Engineer's representatives who shall review and certify the information at the end of each shift;

a) Station, offset and elevation at the start and end of fill placement for each zone for each shift.

b) Quantity of material placed for each zone.

c) Station and offset of the start and end of fill placement for each zone that has been spread but has not been compacted.

d) Station and offset of the start and end of areas for each zone that have been compacted and that are approved for further fill placement.

e) Number and classification of men and equipment engaged during the shift.

f) Unusual occurrences including inflows of water, unstable soil conditions, and the use of filter material to blanket seepage conditions.

8.0 SPILLWAY CONSTRUCTION

8.1 Scope

8.1.1 Description of Work

The Work specified in this section comprises the supply of all labour, plant and materials and the performance of all work necessary to construct the preserved wood-geosynthetic clay liner cut off wall and other Work associated with the Overflow Spillway as described herein and as shown on the Drawings. This Work shall include but not be limited to the following;

- excavate trench for preserved wood - geosynthetic clay liner cut off wall
- construct preserved wood - geosynthetic clay liner cut off wall
- backfill and compact trench
- spread geosynthetic clay liner over top of Zone 2 Semi Impervious Core and attach to preserved wood - geosynthetic clay liner cut off wall
- spread and compact Granulite insulation
- place Coarse Filter material over Granulite insulation as indicated on the Drawings (see Section 6.6.5.5.2.4)
- place Spillway Riprap as indicated on the Drawings (see Sections 6.6.4.2.6 and 6.6.6.5.2.5)

8.1.2 Responsibility of Contractor

It is the responsibility of the Contractor to perform the Work as specified within this document and on the Drawings.

8.2 Materials

8.2.1 Preserved Wood

The preserved wood used in the cutoff wall shall consist of pressure treated, CSA approved four by four timbers.

8.2.2 Geosynthetic Clay Liner

The geosynthetic clay liner used in the cut off wall and at the top of the Zone 2 Semi Impervious Core shall consist of a layer of high swelling sodium bentonite sandwiched between two polypropylene or polyester geotextiles. The bentonite shall be bound within the geotextiles in such a manner that the bentonite will not be displaced during handling, transportation, storage and installation, including cutting, patching and fitting.

8.2.3 Granulite Insulation

The Granulite Insulation to be used beneath the Spillway shall be obtained from Inland Cement in Calgary, Alberta and shall be graded between 5 to 40 mm.

8.3 Execution

8.3.1 Trench Excavation

The Contractor may wish to construct the Zone 2 Semi Impervious Core to full height in the Spillway area and then excavate a trench to allow construction on the cut off wall to proceed. The trench shall be excavated in accordance with the Occupational Health and Safety Regulations and any other authority or regulatory body having jurisdiction over the construction site. No worker shall enter any excavation that is greater than 4 feet deep without the sides of the excavation being sloped back from the bottom of the excavation at a slope no steeper than 0.75 horizontal to 1 vertical. Excavated materials must be kept back at least 5 feet from the edge of the excavation and no heavy equipment other than that involved in the excavation is permitted to operate any closer than 10 feet away from the excavation.

Clauses 175 to 177 of the Yukon Occupational Health and Safety Act were used in the above paragraph of this clause. The inclusion of this information does not relieve the Contractor of his duty to review the Occupational Health and Safety Act and to conduct his operations in strict accordance with this act.

8.3.2 Cut Off Wall Construction

The cutoff wall will consist of a geosynthetic clay liner core sandwiched between two rows of preserved wood four by four timbers. The preserved wood four by four timbers shall be held together in such a way that prevents excessive flexing, sagging or separation of the timber wall prior to backfilling. The geosynthetic clay liner shall be held in place between the two rows of preserved wood timbers with a sufficient number of spikes to prevent any sagging of the sandwiched geosynthetic clay liner. The spikes shall penetrate through the geosynthetic clay liner and into the timbers on the opposite side.

8.3.3 Trench Backfill and Compaction

The base of the trench shall be leveled and proofrolled with a jumping jack or vibratory plate compactor at the Engineer's discretion prior to placing a 1 inch thick layer of wetted bentonite pellets on the bottom of the excavation on both sides of the timber-geosynthetic cut off wall.

The trench shall be backfilled with Zone 2 Semi Impervious Core material that has been thoroughly mixed with 5% (by mass) of powdered bentonite and moisture conditioned. The material shall be moisture conditioned so that it is within 2% of Standard Proctor Optimum moisture content. The backfill soil shall be compacted to 98% of the Standard Proctor Density Test in accordance with ASTM D698.

8.3.4 Placement of GeoSynthetic Clay Liner

The subgrade beneath the geosynthetic clay liner at the top of Zone 2 Semi Impervious Core shall be free of angular stones larger than 3/4 inch. The subgrade shall not be placed in the rain, in ponded water or when precipitation is anticipated. Sections of the geosynthetic clay liner will have to be removed and replaced if they have hydrated before the first foot of fill has been placed. Construction joints in the geosynthetic clay liner must have a minimum of a 1 foot overlap. The Contractor shall only place the amount of geosynthetic clay liner that can be covered with backfill by the end of the day. The fill placement operation must be done with care to ensure that the geosynthetic clay liner is not damaged. Damaged sections of the geosynthetic will be removed and replaced at no cost to the Owner.

The geosynthetic clay liner shall extend 4 feet down the upstream face of the Semi Impervious Core and four feet down the downstream face of the Fine Filter in the Chimney Drain. The geosynthetic clay liner shall extend 4 feet up either side of the cut off wall as indicated on the Drawings. The geosynthetic clay liner shall be fastened to the exterior of the timber cut off wall with nails that penetrate through the geosynthetic clay liner and into the timbers. A sufficient number of nails should be used to prevent sagging from occurring prior to backfilling against the timber cut off wall. The geosynthetic clay liner shall be anchored/ballasted in place as soon as possible to prevent wind uplift.

8.3.5 Granulite Placement and Compaction

The Granulite shall be placed in 1 foot lifts and tracked packed with two passes by a bulldozer prior to placing the next lift.

9.0 DAM ACCESS ROAD AND DIVERSION DITCH

9.1 Scope

9.1.1 Description of Work

The Work specified in this section comprises the supply of all labour, plant and materials and the performance of all work necessary to construct the Dam Access Road and Diversion Ditch described herein and as shown on the Drawings. This Work shall include but not be limited to the following;

- constructing the road and diversion ditch cross sections as ground conditions dictate
- lining the ditch with sand, geosynthetic and riprap material

9.1.2 Responsibility of Contractor

It is the responsibility of the Contractor to perform the Work as specified within this document and on the Drawings.

9.2 Materials

9.2.1 Sand Cushion

The sand cushion shall be material passing through a #4 sieve.

9.2.2 Reinforced Polyethylene Liner

The supply and installation of this liner shall be in accordance with the following references;

- ASTM D751-89, Standard Test Methods for Coated Fabrics
- ASTM D3020-89, Standard Specification for Polyethylene and Ethylene Copolymer Plastic Sheeting for Pond, Canal and Reservoir Lining.
- ASTM D4545-86(91), Standard Practice for determining the Integrity of Factory Seams Used in Joining Manufactured Flexible Sheet Geomembranes.
- ASTM D4437-84(88), Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes.
- ANSI/NSF 54-93, Flexible Membrane Liners, Specification Listings and modifications of ASTM test methods to accommodate flexible membrane liners.

The sheeting shall be suitably formed from first quality polyethylene materials. The geomembrane shall consist of a high strength, orientated tape HDPE scrim coated on both sides with an impervious LDPE coating. The sheeting shall be capable of being sealed to itself using heat sealing techniques. The sheeting shall be supplied in the widest widths possible to minimize field seaming. Roll widths shall be not less than 140 inches.

9.2.3 Woven Geotextile

The woven geotextile shall be an LP 200 woven polypropylene (or equivalent) available from Layfield Plastics.

9.2.4 Nonwoven Geotextile

The nonwoven geotextile shall be an LP 1201 (or equivalent) available from Layfield Plastics.

9.2.5 12 Inch Median Riprap Rock

This material is specified in Section 6.3.2.8.

9.3 Execution

9.3.1 Cut and Fill

The Drawings present two typical sections for frozen and unfrozen ground conditions. The ground conditions will be determined through a centerline testpitting program before access road and diversion ditch construction starts. The Contractor will be responsible for balancing the cut and fills and may have to develop borrow pits along the proposed access road and diversion ditch route(s) in order to have adequate fill to complete the Work. These borrow sources are to be developed as per Sections 3.4.1 and 3.4.2 in this document. Testing will be conducted on the proposed fill materials in order to determine the Standard Proctor Density and optimum water content as per ASTM D698. The fill materials shall be compacted to 95% of the Standard Proctor Density. All permafrost soils excavated from the Diversion Ditch cut shall be placed in a spoil disposal pile as per Section 3.4.5.

9.3.2 Ditch Liner Construction

9.3.2.1 Sand Bedding

The ditch bottom shall be lined with 6 inches of bedding sand above and below the 25 mil reinforced polyethylene liner. The ditch slopes shall be lined with a 6 inch layer of bedding sand. The bedding sand in both cases shall be free of sharp rocks or objects.

9.3.2.2 25 mil Reinforced Polyethylene

The 25 mil reinforced polyethylene material shall be placed on the sand bedding layer taking care to incorporate sufficient thermal slack during placement to ensure that harmful stresses do not occur throughout the service life of the liner. Slack wrinkles are to be distributed evenly. All field seams shall be tightly bonded using tape sealing technology. Full contact between the tape and the material will be the standard of acceptance. All field seams shall be non-destructively tested along their entire length using the Air Lance Test (ASTM D4437, 7.2 at reduced pressure). The reinforced polyethylene sheets shall be installed so that the seams are shingled in the direction of the water flow. The backfill should be applied in the direction of flow to prevent applications of stresses to field seams. The geomembrane shall be protected from uplift during installation through the use of sand bags or other suitable weights (such as the 6 inch thick layer of sand to be placed on top of the liner at the base of the Diversion Ditch.

Excavate and backfill anchor trenches at the top of the Diversion Ditch slopes as per the liner manufacturer's specifications. This operation may be done in conjunction with the anchoring of the nonwoven geotextile described below in Section 8.3.2.3 provided the design requirements for anchoring both geosynthetics are met.

The Contractor will ensure that his construction methods are such that damage to the liner is prevented. Any damage to the liner resulting from poor construction practice shall be repaired by the Contractor at no cost to the Owner. Repairs, if necessary, shall utilize the same material as the geomembrane, or a material compatible with the geomembrane, and shall extend a minimum of 1 foot beyond the defect. Repairs shall be accomplished with tape seaming techniques utilizing a tape appropriate to the existing site conditions. All repairs are to be tested using the Air Lance Test (ASTM D4437, 7.2 at reduced pressure).

9.3.2.3 Nonwoven Geotextile

The nonwoven geotextile shall be placed on top of the 25 mil reinforced polyethylene liner on the ditch side slopes. The sheets of nonwoven geotextile shall be installed so that the seams are shingled in the direction of the water flow. An overlap of 3 feet is sufficient as a construction joint.

Excavate and backfill anchor trenches at the top of the Diversion Ditch slopes as per the nonwoven geotextile manufacturer's specifications. This operation may be done in conjunction with the anchoring of the 25 mil reinforced polyethylene liner described above in Section 8.3.2.2 provided the design requirements for anchoring both geosynthetics are met.

9.3.2.4 Woven Geotextile

The woven geotextile shall be placed over the top layer of bedding sand on the Diversion Ditch bottom and shall extend 2 feet up the Diversion Ditch slope on top of the woven geotextile described in Section 8.3.2.3 above and as indicated on the Drawings. The sheets of woven geotextile shall be installed so that the seams are shingled in the direction of the water flow. An overlap of 3 feet is sufficient as a construction joint.

9.3.2.5 12 Inch Median Riprap

The riprap rock shall be placed in a 1.5 foot thick layer on the slopes and bottom of the Diversion Ditch. This material may be end dumped and spread with a bulldozer of D6 size or smaller on the base. Placement of the riprap material on the side slopes shall be performed with a backhoe carefully placing the riprap rock. Dropping the riprap rock or end dumping will not be permitted. The contractor must take care to ensure his placement and spreading methods do not damage the constructed Diversion Ditch liner.

10.0 CONSTRUCTION ACCESS ROAD MAINTENANCE

10.1 Scope

The Work specified in this section shall consist of the provision of all labour, plant and materials and the performance of all the work necessary to maintain the existing construction access roads and to maintain new construction access roads, and to provide access corridors for Other Contractors, as specified herein and as shown on the Drawings.

10.2 Description of Work

The Work shall include, but not necessarily be limited to maintenance of all construction access roads used by the Contractor and Other Contractors on site.

Maintenance of construction and access roads shall not include any temporary roads constructed by the Contractor for his own use.

10.3 Materials

The Contractor will locate and develop any borrow pits for construction access road maintenance as he sees fit provided the pit is located on the Owner's property and provided the excavation methods meet the excavation specifications contained herein. Approval of the pit location and its materials must be received from the Owner and the Engineer respectively before the pit can be developed.

10.4 Execution

Maintenance of existing construction access roads shall include grading, snow removal, sanding, ice removal and repairs required by the Engineer to roadways, ditches, emergency runoff ramps, shoulders, culverts, traffic signs, guardrails, guide posts and other safety devices as necessitated by normal wear and tear, weathering, frost action and breakage.

In summer, the existing construction access roads shall be maintained in a serviceable condition by daily motor patrolling with a bladed machine, to ensure the surface is smooth and free of ruts, wash board and rock particles that may otherwise impede the safe passage of 2 wheel drive pick-up trucks and construction vehicles.

The roads shall be maintained dust free by applying calcium chloride or by alternative treatment, as required and approved by the Engineer.

Roads maintained by the contractor shall be maintained such that all vehicles operated on the roads can negotiate the roads at all times during construction activity.

The Contractor shall schedule his operations such that the existing construction access roads remain in place as long as possible, and any necessary detours are constructed to re-route traffic so as not to interrupt other operations on site.

11.0 INSTRUMENTATION

11.1 Scope

The work specified in this section shall consist of supplying all labour, plant and materials and the performance of all work necessary to assist the Engineer in the installation of instrumentation, as shown on the Drawings and as specified herein.

11.2 Description of the Work

The work shall include, but shall not necessarily be limited to the supply and installation of the following instrumentation, including the supplying and placing of selected backfill in pits, trenches and drill holes:

a) Embankment and foundation pneumatic piezometers, complete with leads
b) Standpipe piezometers
c) Survey hubs
d) Thermistors
e) Painted rocks in spillway

Instrument installation work shall be performed by the Engineer or his representative(s).

11.3 Responsibility of the Contractor

The purpose of the instrumentation is to measure the behaviour and performance of the Dam, its foundation, the excavated and existing slopes, and the rebound of the Spillway excavation during and after construction.

The Contractor shall cooperate with the Engineer in every way possible to ensure that the existing instrumentation and the instrumentation to be installed by the Engineer remains intact and operating. The Contractor will be penalized $1000 per instrument damaged if any of the instruments that have been installed previously by the Engineer or if any of the instruments installed by the Contractor are damaged by his construction equipment. In addition to the penalty, the Contractor shall supply and install a replacement instrument adjacent to each instrument that is damaged by his construction equipment within 7 working days of the damage occurring at no additional cost to the Owner or Engineer. To encourage the Contractor's operators to exercise the care and attention necessary to avoid damaging the instruments, the Contractor will be paid for supplying and using, where

required by the Engineer, wood protection corrals designed to protect the installed instruments during construction.

If the Contractor considers that the wood corral will not be sufficient protection for instruments against damage during construction, he shall provide such additional protection that he deems necessary.

The Contractor shall cooperate with the Engineer to permit continuous observations and recording of the data to be obtained from instruments previously installed and those installed by the Engineer.

11.4 Materials

All materials are to be provided by the Owner or the Engineer.

11.5 Execution

11.5.1 General

The locations of instrumentation and associated works, including instrumentation trenches will be determined by the Engineer.

All work in connection with the installation of instrumentation will be directed and supervised by the Engineer and shall be undertaken by the Engineer or his representatives.

Prior to drilling for, and installation of, instrumentation in the Dam foundation, all foundation preparation, as described in Section 4.0 shall be completed within a radius of not less than 100 feet of such instrumentation, unless otherwise required by the Engineer.

During construction of the Dam, the Engineer will take readings on instruments and survey the installed locations of instruments. In particular he will take an initial set of readings of all instruments immediately after installation and the Contractor will not be permitted to place fill over the instruments or leads until these readings have been taken. To ensure that the Work is being performed as specified and to make a permanent record of the soil properties, the Engineer will take samples of soil from

drillholes and will perform in-situ tests whenever he considers them necessary, and the Contractor shall allow time in his embankment fill placement and installation schedule to enable such tests to be made.

No traffic or equipment other than placing, spreading and compacting equipment required for fill placement shall be allowed to pass over any part of any instrument or connections installed in the fill or foundations until they are covered by at least 1.0 m of fill. All instruments and connections shall be protected from damage and displacement during the progress of the work. Wood protection corrals, markers and barricades shall be provided by the Contractor where required by the Engineer.

11.5.2 Piezometers

Embankment piezometer shall be installed from instrumentation trenches as embankment placing operations progress.

11.5.3 Settlement Instruments

Settlement hubs and foundation settlement gauges shall be installed as shown on the Drawings where required by the Engineer.

11.5.4 Temperature Sensors

Temperature sensors shall be installed by the Engineer to measure the temperature of the rock at the required excavation lines as specified in Section 2-4.6. The location of the temperature sensors will be determined by the Engineer.

11.5.5 Survey Reference Points and Survey Control Monuments

Drillholes for survey reference points shall be cased through the overburden. The casing shall be drilled at least 10 feet into sound, competent bedrock. The 3 inch steel pipe shall be grouted into bedrock using Portland cement grout tremmied into the bottom of the drillhole. The bentonite plug seal shall be placed on the cement grout and backfilled to the bottom of the casing with "frac" sand. The sand backfill shall be placed in such a manner that arching does not occur. Following completion

of the survey reference point the space between the pipe and the casing shall be filled with SAE 90 oil. Holes for survey control monuments shall be drilled with mud. The steel casing shall be grouted into the drillhole using tremmied grout. The stainless steel centering plate shall be supplied to the National Geodetic Survey of Canada specifications. Temporary wooden surveyor's wind shelters capable of opening up on all sides and of a design that is acceptable to the Engineer and the Contractor's surveyors shall be erected over each survey reference point and each survey control monument.

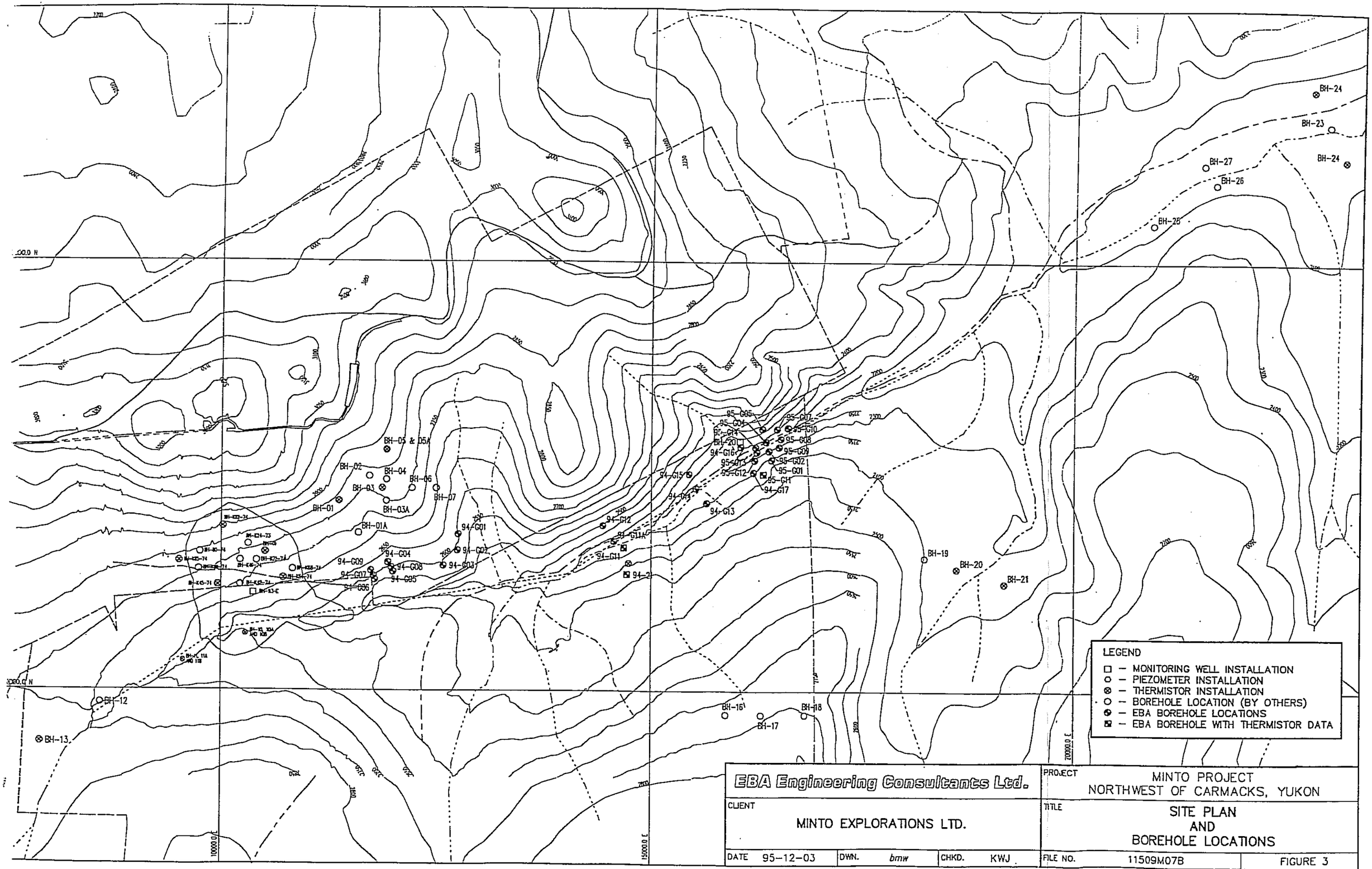
11.5.6 Monitoring

The Contractor shall provide assistance requested by the Engineer for the purpose of monitoring the instruments installed.

Records of instrumentation results will be made available to the Contractor upon request.

During the time that the instruments are being read no construction equipment shall be operated within 150 feet of the section being measured.

The Engineer will endeavour to install, and monitor instruments to minimize disruptions to the Contractors operations. Every attempt will be made to perform the work between shifts and during off-shift periods. Where there is concern about the safety of the work and instrumentation installation and monitoring is required, the Contractor shall assist fully and in a timely manner to install and monitor instruments. There will be no compensation for the disruption of the Contractor's operations for the installation and monitoring of instruments.



EBA Engineering Consultants Ltd.

CLIENT	MINTO EXPLORATIONS LTD.			PROJECT	MINTO PROJECT NORTHWEST OF CARMACKS, YUKON
				TITLE	SITE PLAN AND BOREHOLE LOCATIONS
DATE	95-12-03	DWN.	bmw	CHKD.	KWJ
FILE NO.	11509M07B				FIGURE 3

APPENDIX A

APPENDIX A - SITE INVESTIGATION AND LABORATORY TESTING DATA

Taken from EBA reports;

" Geotechnical Design - Tailings Water Dam - Minto Project, Yukon",
0201 - 95 - 11509, dated December, 1995

and

"Preliminary Geotechnical Design - Tailings/Water Dam - Minto Project, Yukon",
0201 - 95 - 11509, dated July, 1995

4.0 GEOTECHNICAL FIELD INVESTIGATIONS

Over the years, several geotechnical investigations have been carried out over the mine site area. Included in these investigations was work by Golder Associates in 1974 and 1976 and drilling by EBA Engineering Consultants Ltd. (EBA) in 1994. The locations of all the geotechnical boreholes, coreholes and test pits are shown on Figure 3.

The most recent drilling and sampling program was undertaken at the location of the proposed tailings/water dam in the fall of 1995. Caron Diamond Drilling of Whitehorse provided a Longyear 38 diamond drill equipped with an NQ triple tube core barrel. The drilling was conducted between September 23 and October 2, 1995. During this program, a total of 12 boreholes (95-G01, 02, 04, 05, 07, 08, 09, 10, 11, 12, 13, 14) were drilled in the dam foundation or near the tailings/water dam location. Boreholes were not drilled at locations 95-G03 and G06 because of access problems. A thermistor cable was installed in one borehole, (95-G11), to measure ground temperatures at a location immediately upstream of the dam on the north-facing valley wall. Additionally, nine constant head permeability tests were conducted in the bedrock foundations for the dam.

The skid-mounted drilling rig was moved around the site using a D6 Caterpillar dozer which was also used to construct the trails for drill rig access. The benches and trails cut into the valley slopes also afforded an ideal opportunity to visually examine the overburden soils in a relatively undisturbed state.

The locations of the boreholes drilled during the latest (1995) site investigation program, as well as the locations of the access trails, are shown on Figure 4.

Geotechnical investigations conducted by EBA during the 1994 and 1995 investigations as well as work conducted previously by others, have all been utilized to characterize the geotechnical conditions at the site. Borehole logs for the 1995 and 1994 geotechnical investigations are presented in Appendices A.1 and A.2, respectively.

5.0 GEOTECHNICAL CONDITIONS

5.1 SURFICIAL GEOLOGY

In general, the mine site is underlain by bedrock at reasonably shallow depth, with overburden soils consisting of either silty or gravelly sand materials. At some locations, (i.e. near the proposed tailings dam abutments), bedrock outcrops at surface. However, in the vicinity of the open pit, the overburden soils are as much as 85 m (280 feet) thick.

This area of the Yukon was not glaciated during the latest (Wisconsin) glacial period. Therefore, much of the overburden soil has originated from weathering of the native bedrock materials and, in some instances, has been transported by gravity, frost action and/or surface runoff.

5.2 SUBSURFACE CONDITIONS

The various investigations conducted throughout the years indicate that subsurface conditions vary considerably throughout the mine site. However, on the north-facing valley slope, in the area of interest for tailings disposal, the subsurface conditions generally comprise a thin veneer of peat and vegetation mat overlying a fine-grained silt overlying a more coarse-grained sand. The sand is considered to be a residual soil. Generally, there are less fine-grained silts on the south-facing valley slope and in the valley bottom. Over most of the proposed tailings dam location, the sandy residual soils can be found at or near ground surface. Throughout the mine site these residual soils gradually grade with depth into a weathered bedrock that eventually grades into the underlying more competent bedrock. The engineering characteristics of these overburden soils are discussed in detail in the following sections.

5.2.1 Permafrost

The site is located within a region where permafrost is noted to be extensive but discontinuous, being found over an average of 50 to 90% of the area (NRC, 1995). The results of the various drilling programs conducted throughout the years has confirmed that permafrost is discontinuous at the site. The information suggests

that frozen soils exist on the north-facing valley slopes. For the most part, there has been very little frozen soil encountered on the south-facing valley slopes.

Thermistor cables have been installed to measure ground temperatures in several of the boreholes that identified frozen soil.

A thermistor cable was installed in Borehole 95-G11. This cable was installed into permafrost soil comprised mainly of ice-rich silty clay. The cable is located on the north-facing valley slope, slightly upstream of the dam but above the eventual level of water impoundment. Thus, the cable should remain intact following construction and can be used to monitor the long term effects of water impoundment on the permafrost soils present on the north-facing slope. The initial ground temperature profile measured by this cable is presented on Figure 5.

EBA also installed two thermistor cables in the tailings disposal area (Boreholes 94-G11 and 94-G21) during the 1994 investigation. The ground temperature profiles measured by these cables are also presented on Figure 5. It can be seen that slightly colder ground temperatures were encountered higher up the north-facing valley slope. The ground temperature was found to be only -0.3°C in Borehole 94-G11, drilled near the creek in the valley bottom, while a temperature of -1.0°C was measured in Borehole 94-G21, drilled on the north-facing slope.

Frozen soils/rock were not encountered on the north abutment of the tailings/water dam. The excavation of the access roads utilized for drill rig movement at the dam location during the 1995 drilling program necessitated sidehill cuts in the valley slopes which provided an ideal opportunity to determine the extent of the various surficial soils down to depths of approximately 4 metres. The visual observation of the soils exposed in the up-hill cut of these trails proved particularly effective in the determination of the boundaries between the permafrost and non-permafrost soils. These boundaries are shown on Figure 4.

5.2.2 Overburden Soils

5.2.2.1 Surficial Peat and Organic Soils

Surficial soils have been found to consist of very fibrous dark brown peat or organic silts and sands. Surficial peat thicknesses of up to 2.9 m (9.5 feet) were

indicated in several boreholes drilled in the areas of the open pit and waste dumps by Golder in 1976. The drilling conducted by EBA in 1994 encountered a maximum peat thickness in the tailings disposal area of only 0.2 m (0.7 feet). In most locations peat was not found at ground surface. At these locations the surficial soil was typically found to be organic silt and sand.

5.2.2.2 Colluvium

Colluvium is defined as soil transported down-slope from its original source. Typically these soils consist of silt and/or sand. Within the upper 150 mm (6 inches), the colluvium often contains roots and organics from the surface vegetation, and occasionally a thin layer of volcanic ash.

The thickness of the colluvium varied from 0 to 5.5 m (18 feet) on the north-facing valley slope in the area of proposed tailings disposal. At the tailings/water retention dam location colluvium was found to be up to 7.0 m (23 feet) thick.

The silt colluvium typically contains some sand and a trace of gravel, is of compact consistency, is damp, and is brown in colour. The frozen silts from the north-facing valley slope were found to have moisture contents that vary between 25 and 40% and to display visible ice contents of up to 10%. Particle size analyses on two samples of the silty colluvium indicate an average composition of 5% gravel, 11% sand, 72% silt and 12% clay. Individual particle size distribution test results for the silty colluvium are presented in Appendix B.1.

The sand colluvium is generally well-graded, contains some fines, a trace of gravel and occasional cobbles. It is usually of loose to compact consistency. Particle size analyses on three samples of sand colluvium indicate an average of 5% gravel, 66% sand and 29% fines. Although it has a very similar gradation to the in situ residual soils on site (see below), it is differentiated by its disturbed structure and lower density, which indicates that it has been transported to its present location. Individual particle size distribution test results for the sand colluvium are presented in Appendix B.1.

5.2.2.3 Residuum

A layer of residuum (residual soils) is often found directly underlying the surface colluvial deposits. However, in some instances the residuum is found immediately at ground surface. These soils are similar in composition to the colluvial sands, but

were visually distinguished in the field by the resemblance of structure to the underlying parent bedrock.

Standard Penetration Test (SPT) blow counts in the residuum varied from as low as 7 to well over 100 blows per foot, indicating a wide range of consistency from loose to very dense. Typically, the consistency increases with depth, with the upper 3.0 to 4.5 m (10 to 15 feet) being loose to compact and the deeper residuum being very dense.

Moisture contents measured in the sand residuum ranged from 3 to 15%. These sands did not contain visible ice when encountered in a frozen state (on the north-facing valley slope). The EBA boreholes did not penetrate any frozen residuum on the south-facing valley slope.

Grain size analyses were undertaken on 12 samples of residuum (5 from the area of tailings disposal and 7 from the proposed plant site). These tests indicated an average of 75% sand, 16% silt and clay sizes, and 9% gravel. The percentage of sand sizes varied between 66 and 85%, and the range in fines varied from 3 to 33%. This indicates that there are zones or layers that are relatively "clean" and also ones that are relatively "dirty". In general, the gradations indicate a relatively well-graded sand with some silt and clay. Individual particle size distribution test results for the residuum samples obtained are presented in Appendix B.2.

Additional laboratory testing was undertaken on combined samples of these residuum soils to evaluate their characteristics when used as dam fill. Results of these tests are discussed in Section 6.1.2 and are presented in Appendix B.3.

The thickness of the residuum in the tailings disposal area varied from as little as 1.7 m (5.5 feet) in Borehole 94-G16 to over 7.7 m (44 feet) in Borehole 94-G15. The residuum becomes increasingly more dense with depth, grading gradually into the underlying weathered bedrock, making interpretation of the boundary between the sand and the bedrock difficult. Drilling was terminated prior to encountering bedrock or refusal in several of the boreholes; therefore, the maximum thickness of

the residuum is uncertain. At the dam location the thickness of the residuum varied between 0 and 4.5 m.

5.2.3 Bedrock

The bedrock present at the dam site and throughout the property, consists primarily of granodiorite. This rock is a hard, crystalline, intrusive igneous rock commonly found in the Minto area. Bedrock was cored in 11 of the 12 holes drilled during the 1995 EBA site investigation. In general it is often difficult to determine where the overburden soils (residuum) ends and where the rock begins since the residuum is a result of in situ weathering of the bedrock.

The parent bedrock ranges in composition from predominantly granodiorite to quartz diorite, with minor quartz monzonite. The average mineral constituents are plagioclase feldspar (50%), quartz (20 to 25%), orthoclase feldspar (10 to 15%) and biotite/hornblende 10 to 15%. Orthoclase and plagioclase feldspar make up the primary grains in the sand that results from weathering of the rock, interspersed with quartz and minor biotite hornblende. This sand is considered to be very resistant to future weathering and degradation in it's present state, as most of the biotite/hornblende has already been weathered away to leave behind the more stable minerals.

Core recovery in the bedrock in the dam foundation area varied between 65 and 100 % but averaged over 90 %. The rock quality designation (RQD) was highly variable, ranging from as low as 20 to a high of 80 %. For the most part, the bedrock at the dam location becomes less weathered and less fractured with depth although some highly fractured zones and fractures filled with silts and sands were encountered in a few of the boreholes. For instance a 2.9 metre thick fractured zone (possible shear zone) was encountered in Borehole 95-G04 at a depth of 5.8 metres.

A total of 9 constant head packer tests were carried out in three different boreholes (95-G02, G04 and G14) in the bedrock which would be the foundation for the semi-impervious core. The testing was conducted using a triple packer wireline system obtained from Petur Instruments. The results of this testing are presented in Table 1 and plots of the test results are presented in Appendix A.3.

TABLE 1
PERMEABILITY TEST RESULTS

Borehole No.	Test Depth (metres)	Head ($m H_2O$)	Flow (L/min)	Permeability (cm/sec)
95-G02	7.5 - 10.8	31.2	1.01	1.8×10^{-5}
	7.5 - 10.8	48.5	1.43	1.6×10^{-5}
	7.5 - 10.8	29.8	1.39	2.5×10^{-5}
	5.0 - 8.4	31.2	0.71	1.3×10^{-5}
95-G04	5.6 - 9.0*	24.6	10.5	2.3×10^{-4}
	5.6 - 9.0*	38.7	23.3	3.4×10^{-4}
	5.6 - 9.0*	24.6	12.0	2.7×10^{-4}
95-G14	5.6 - 8.5	31.5	35.2	7.2×10^{-4}
	5.6 - 8.5	21.0	24.1	7.6×10^{-4}

* test conducted in a highly fractured zone (possible shear zone)

EBA 1995 BOREHOLE LOGS
TAILINGS / WATER DAM

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-C01
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945332 E386653	ELEVATION: 720.20 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ⊠ NQ CORE ▤ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						BOULDERS (COLLUVIUM) – some sand, some gravel, trace of silt; clast supported; coarse angular boulders and cobbles; coarse angular sand and gravel; moderately weathered; brown; dry
1.0				GP		
2.0						– casing set to 2.3 m; no recovery above 2.3 m
						SAND (RESIDUUM) – trace of gravel, trace of silt; coarse angular sand; highly weathered; brown; dry
3.0						– becomes less weathered with depth
				SW		
4.0						
						GRANODIORITE (BEDROCK) – moderately weathered; fractured
5.0						– less weathered with depth
6.0				BR		
7.0						
						END OF DRILLHOLE @ 7.6 m
8.0						– 0 to 2.3 m logged by observation of cut bank exposure adjacent to hole
						– all USC's are estimated, based on visual classification and field testing of recovered samples
9.0						MINE GRID COORDINATES (IMPERIAL UNITS)
						Northing – 12694.0
						Easting – 16433.0
10.0						Elevation – 2363.0

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0

EBA Engineering Consultants Ltd.

LOGGED BY: CRH	COMPLETION DEPTH: 7.6 m
REVIEWED BY: CRH	COMPLETE: 95/09/25

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G02
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945364 E386645	ELEVATION: 702.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	PLASTIC / M.C. / LIQUID (20 40 60 80)	PERCENT RECOVERY ■ (20 40 60 80) / PERCENT ROD ◆ (20 40 60 80)	DEPTH(ft)
0.0						BOULDERS AND COBBLES (COLLUVIUM) – some sand, trace of silt; coarse, angular, moderately weathered boulders & cobbles; coarse, angular, highly weathered sand; clast supported; brown			0.0
1.0				GP		– casing set to 2.4 m; no recovery above 2.4 m			2.0
2.0									4.0
3.0									6.0
4.0									8.0
5.0						GRANODIORITE (BEDROCK) – slightly weathered; highly fractured			10.0
6.0									12.0
7.0									14.0
8.0				BR					16.0
9.0									18.0
10.0									20.0
11.0									22.0
12.0									24.0
13.0						END OF DRILLHOLE @ 12.2 m – 0 to 2.4 m logged from observations of cut slope adjacent to drillhole – constant head permeability tests completed in drillhole – static water level approximated at 693.4 m – all USC's are estimated, on visual classification and field testing of recovered samples MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 12798.0 Easting – 16401.0 Elevation – 2303.0			26.0
14.0									28.0
15.0									30.0
16.0									32.0
17.0									34.0
18.0									36.0
19.0									38.0
20.0									40.0
									42.0
									44.0
									46.0
									48.0
									50.0
									52.0
									54.0
									56.0
									58.0
									60.0
									62.0
									64.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: GRH
Eq. No:

COMPLETION DEPTH: 12.2 m
COMPLETE: 95/09/28

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G04
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945398 E386636	ELEVATION: 696.80 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	PLASTIC M.C. LIQUID 20 40 60 80	■ PERCENT RECOVERY ■ 20 40 60 80 ◆ PERCENT RQD ◆ 20 40 60 80	DEPTH(ft)
0.0				SP		COBBLES AND SAND (COLLUVIUM) –			0.0
1.0						– casing set to 1.1 m; no recovery above 1.1 m			2.0
2.0						GRANODIORITE (BEDROCK) – unweathered to slightly weathered; fractured			4.0
3.0									6.0
4.0									8.0
5.0									10.0
6.0				BR		– possibly shear zone between 5.8 to 8.7 m			12.0
7.0									14.0
8.0						– highly weathered at 7.5 to 8.7 m			16.0
9.0						– intact, freshly weathered below 8.7 m			18.0
10.0									20.0
11.0									22.0
12.0						END OF DRILLHOLE @ 11.6 m			24.0
13.0						– constant head permeability test completed between 5.6 m and 8.8 m			26.0
14.0						– static water level approximated at 693.4 m			28.0
15.0						– all USC's are estimated, based on visual classification and field testing of recovered samples			30.0
16.0						MINE GRID COORDINATES (IMPERIAL UNITS)			32.0
17.0						Northing – 12908.0			34.0
18.0						Easting – 16368.0			36.0
19.0						Elevation – 2286.0			38.0
20.0									40.0
									42.0
									44.0
									46.0
									48.0
									50.0
									52.0
									54.0
									56.0
									58.0
									60.0
									62.0
									64.0

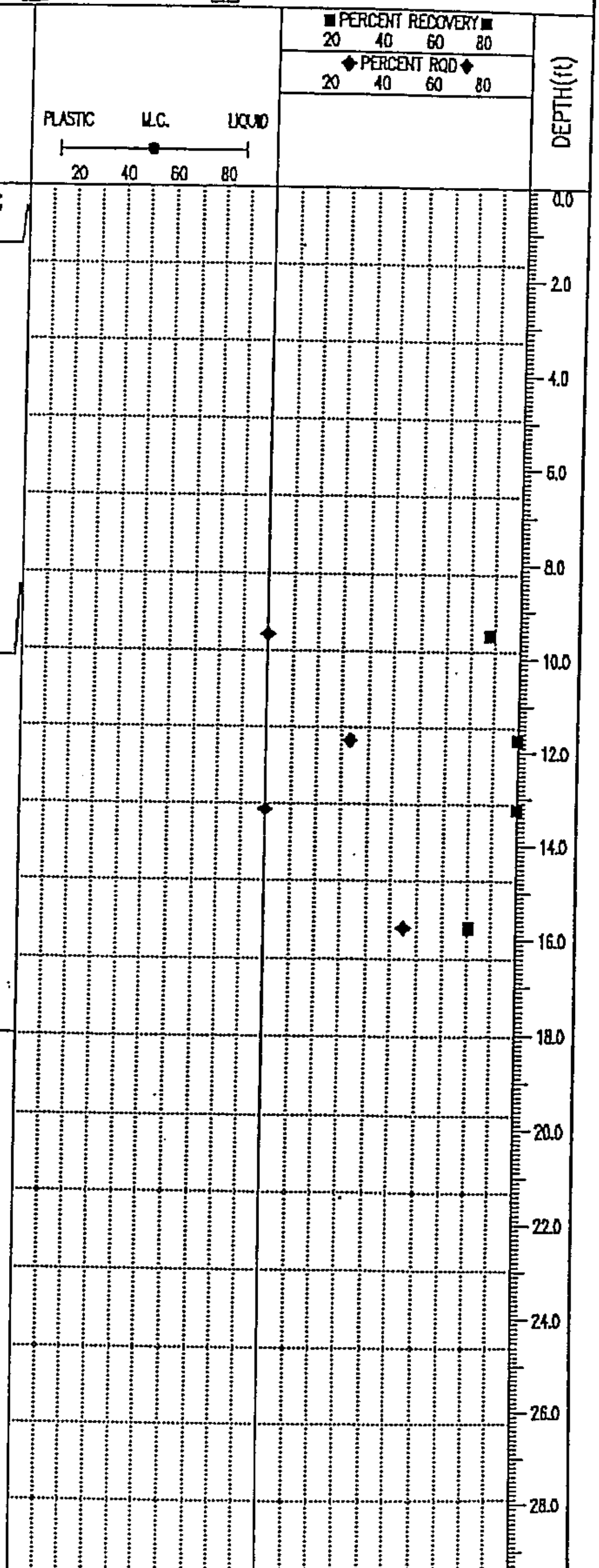
EBA Engineering Consultants Ltd.

LOGGED BY: CRH	COMPLETION DEPTH: 11.6 m
REVIEWED BY: CRH	COMPLETE: 95/09/27

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G05
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945444 E386624	ELEVATION: 723.00 (m)

SAMPLE TYPE: GRAB SAMPLE | NO RECOVERY | NQ CORE | 75 mm SPOON | CRREL BARREL

DEPTH (m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL DESCRIPTION
0.0				OL	ORGANIC SAND & SILT – numerous fine roots; loose; brown; dry
				GW	GRAVEL AND SAND (COLLUVIUM) – some silt; frequent boulders and cobbles; occasional roots; angular well graded gravel and cobbles, moderately weathered; boulders to 0.6 m; matrix supported; dense; dry; brown – casing set to 1.2 m; no recovery above 1.2 m – salt deposits on underside of aggregates from 0.6 m to 1.8 m – becomes coarser with depth – clast supported, trace to some sand or silt by 1.8 m
				BR	GRANODIORITE (BEDROCK) – slightly weathered, intensely broken – more competent below 4.1 m – difficult drilling
5.5					END OF DRILLHOLE @ 5.5 m – overburden profile logged from cut slope adjacent to hole – all USC's are estimated, based on visual classification and field testing of recovered samples MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 13059.0 Easting – 16325.0 Elevation – 2372.0



Depth (m) scale: 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: GRH
Fig. No.

COMPLETION DEPTH: 5.5 m
COMPLETE: 95/09/20
Page 1 of 1

95/11/20 11:14AM (R1/WW)

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G07
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945442 E386677	ELEVATION: 702.90 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0				OL		ORGANIC SILT – some sand, numerous roots, occasional gravel; brown
				SP		SAND – some silt to silty, numerous roots; angular, coarse sand; grey–brown
1.0				GW		GRAVEL AND SAND (COLLUVIUM) – trace of silt, frequent cobbles, occasional roots; medium to coarse, angular, sand; angular gravel – becomes coarse with depth – casing set to 1.5 m; no recovery above 1.5 m
2.0						GRANODIORITE (BEDROCK) – freshly weathered only on fracture/joint faces; moderate fractured with occasional broken zones
3.0				BR		
4.0						END OF DRILLHOLE @ 4.3 m – overburden profile logged from cut slope adjacent to hole; bedrock in cut face approximately 3.0 m to 3.7 m where as at 1.5 m in drillhole – all USC's are estimated, based on visual classification and field testing of recovered samples MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 13057.0 Easting – 16497.0 Elevation – 2306.0
5.0						
6.0						
7.0						
8.0						
9.0						

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0

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Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 4.3 m
REVIEWED BY: CRH	COMPLETE: 95/09/30
Fig. No:	Page 1 of 1

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G08
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945407 E386689	ELEVATION: 694.30 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▯ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						MOSS
1.0						ORGANIC SILT (COLLUVIUM) – numerous roots, wood fibers and organic inclusions, some sand, occasional cobbles and boulders; permafrost Vx,r 10 to 20% ice
2.0	⊠	1		OL		– unsorted slope wash
3.0						– increasing gravel & cobble content below 3.0 m
4.0						– casing set to 1.5 m; no recovery above 1.5 m
5.0						GRAVEL AND SAND (ALLUVIUM) – frequent cobbles
6.0						– sample recovery limited to gravel and cobbles; gravel is rounded and of various rock types; possible alluvial zone
7.0				GW		– boulders @ 5.5 m to 5.9 m
8.0						– coarser below 5.9 m
9.0						
10.0	⊠	2				SAND (RESIDUUM) – silty, occasional cobbles and gravel; coarse, friable, highly weathered sand; friable, highly weathered cobbles; brown; frozen, NbN, Vx< 5% ice
11.0				SW		– less weathering and silt with depth
12.0						– more competent by 10.0 m
13.0				BR		GRANODIORITE (BEDROCK) – slightly weathered, fractured with some intensely broken zones
14.0						END OF DRILLHOLE @ 13.4 m
15.0						– static water level approximated at 690.0 m
16.0						– all USC's are estimated, based on visual classification and field testing of recovered samples
17.0						MINE GRID COORDINATES (IMPERIAL UNITS)
18.0						Northing – 12943.0
19.0						Easting – 16542.0
20.0						Elevation – 2278.0

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft): 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30.0, 32.0, 34.0, 36.0, 38.0, 40.0, 42.0, 44.0, 46.0, 48.0, 50.0, 52.0, 54.0, 56.0, 58.0, 60.0, 62.0, 64.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: CRH
Fig. No:

COMPLETION DEPTH: 13.4 m
COMPLETE: 95/09/29

DETAILED GEOTECHNICAL DESIGN

PROPOSED TAILINGS DAM – MINTO PROJECT

NEAR MINTO CREEK, YUKON

CLIENT: MINTO EXPLORATIONS LTD.

DRILL: LONGYEAR 38, C/W NQ DRILL RODS

UTM ZONE: 8 N6945377 E386682

BOREHOLE NO: 95-G09

PROJECT NO: 0201-95-11509

ELEVATION: 702.90 (m)

SAMPLE TYPE ■ GRAB SAMPLE ☑ NO RECOVERY ☒ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						MOSS
	■	1		SM		SAND AND SILT (COLLUVIUM) – frequent cobbles and boulders, numerous organic inclusions; permafrost
1.0						
						– casing set to 2.1 m; no recovery above 2.1 m
2.0						– becomes coarser with more boulders with depth
				BR		GRANODIORITE (BEDROCK) – fresh to unweathered, moderately broken below 3.5 m
3.0						– fracture filled with frozen silt and sand @ 2.9 m
4.0						
5.0						END OF DRILLHOLE @ 4.6 m
						– grab sample of overburden obtained from cut adjacent to drillhole
						– all USC's are estimated, based on visual classification and field testing of recovered samples
						MINE GRID COORDINATES (IMPERIAL UNITS)
						Northing – 12845.0
						Easting – 16521.0
6.0						Elevation – 2306.0
7.0						
8.0						
9.0						

PLASTIC M.C. LIQUID

20 40 60 80

■ PERCENT RECOVERY ■

20 40 60 80

◆ PERCENT RQD ◆

20 40 60 80

DEPTH(ft)

0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0

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LOGGED BY: CRH

REVIEWED BY: CRH

Fig. No:

COMPLETION DEPTH: 4.6 m

COMPLETE: 95/09/28

5/11/28 11:45AM (TEC/ROB)

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G10
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945445 E386716	ELEVATION: 690.70 (m)

SAMPLE TYPE ■ GRAB SAMPLE ☒ NO RECOVERY ☒ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						SAND (COLLUVIUM) – some gravel, some silt, frequent cobbles and boulders; well graded, angular, friable sand; friable, angular, weathered gravel; brown; compact
1.0						– casing set to 1.5 m; no recovery above 1.5 m
2.0						– more boulders with depth
3.0				SP		
4.0						– recovery limited to cobbles and gravel
5.0						
6.0						
7.0						GRANODIORITE (BEDROCK) – moderately to slightly weathered; intensely broken; fractures up to 51 mm filled with decomposed sand and gravel (granodiorite)
8.0				BR		
9.0						END OF DRILLHOLE @ 9.1 m
10.0						– static water level approximated at 687.3 m
11.0						– all USC's are estimated, based on visual classification and field testing of recovered samples
12.0						MINE GRID COORDINATES (IMPERIAL UNITS)
13.0						Northing – 13070.0
14.0						Easting – 16626.0
15.0						Elevation – 2266.0

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0

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LOGGED BY: CRH
REVIEWED BY: CRH
Dig. No.

COMPLETION DEPTH: 9.1 m
COMPLETE: 95/09/30

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G11
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945281 E386622	ELEVATION: 724.80 (m)

SAMPLE TYPE ■ GRAB SAMPLE ☒ NO RECOVERY ☒ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0	■	1		ML		MOSS, ROOTS
1.0						SILT – some fine sand, numerous organics; wet; firm to soft; mottled brown with black
2.0		2				– frozen by 0.9 m
3.0	☒	3				CLAY AND SILT – medium plastic; wet when thawed; occasional organic fibres; dark grey
4.0		4		CI		– permafrost; Vs, Vx up to 40% ice, ice in thin layers or lens
5.0		5				– becomes lighter grey; Vr,Vx 10 to 20% ice
6.0						– temperature = – 0.14 C at 2.1 m
7.0		6				– temperature = – 0.29 C at 4.3 m
8.0						– becomes less plastic, olive grey, with varved bedding (1 to 2 mm), Vx, 10%< ice
9.0						– temperature = –0.26 C at 5.5 m
10.0						SAND (RESIDUUM) – some silt, occasional gravel; highly weathered, friable, angular coarse sand; friable gravel; rusty brown, frozen; NbN
11.0						
12.0						
13.0						
14.0				SW		
15.0						
16.0						
17.0						
18.0						
19.0						
20.0						END OF DRILLHOLE @ 19.8 m
21.0						– thermister string (EBA #945) installed to 19.5 m below ground surface
22.0						– all USC's are estimated, based on visual classification and field testing of recovered samples
23.0						MINE GRID COORDINATES (IMPERIAL UNITS)
24.0						Northing – 12524.0
25.0						Easting – 16335.0
26.0						Elevation – 2378.0
27.0						

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0 52.0 54.0 56.0 58.0 60.0 62.0 64.0 66.0 68.0 70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0 86.0 88.0

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LOGGED BY: CRH	COMPLETION DEPTH: 19.8 m
REVIEWED BY: CRH	COMPLETE: 95/09/25
Fig. No:	Page 1 of 1

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G12
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945332 E386592	ELEVATION: 705.60 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						SAND (FILL) – some gravel, trace of silt, numerous boulders
1.0				SP		
2.0						– casing set to 2.4 m; no recovery above 2.4 m – core recovery from 2.4 to 3.0 m consisted of a piece of wood and a cobble
3.0				OL		ORGANIC SILT – numerous roots; black; permafrost
4.0	■	1				– Vs; 30 to 40% ice, ice lens to 4 mm, inclined to vertical
5.0				ML		SILT (COLLUVIUM) – some sand, occasional cobbles and boulders; non-plastic; frequent organic inclusions; brown; permafrost, Vx 10% ice
6.0	■	2				– more coarse angular sand with depth; less organics with depth – becomes SILT AND SAND – fine with frequent coarse angular sand grains; permafrost Vx,r,c 40% ice
7.0				SW		
8.0				BR		SAND (RESIDUUM) – trace of gravel; trace of silt; occasional cobbles; angular, friable, coarse sand; permafrost Vr,c; 10% ice
9.0						GRANODIORITE (BEDROCK) – silghtly weathered, fractured but intact
10.0						END OF DRILLHOLE @ 8.2 m – static water level approximated at 698.6 m – all USC's are estimated, based on visual classification and field testing of recovered samples
11.0						MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 12688.0 Easting – 16231.0 Elevation – 2315.0
12.0						
13.0						
14.0						
15.0						

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: GRH
Dig. No:

COMPLETION DEPTH: 8.2 m
COMPLETE: 95/09/20

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G13
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945361 E386601	ELEVATION: 698.00 (m)

SAMPLE TYPE ■ GRAB SAMPLE ☒ NO RECOVERY ⊠ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						GRAVEL AND SAND (ALLUVIUM) – some silt; numerous cobbles and boulders
1.0						
2.0				SW		– casing set to 1.8 m; no recovery above 1.8 m; below 1.8 m recovery limited to gravel and cored cobbles/boulders – some rounded gravel recovered; various rock types observed in the recovery
3.0						
4.0						
5.0		1				SAND – (RESIDUUM) – trace of silt; coarse, angular, friable, highly weahtered sand; frozen Vx, Vc, 10% < ice
6.0						– Nbn below 5.8 m (or unfrozen) – zones of less weathering @ 5.8 to 6.4 m and 8.5 to 8.8 m
7.0				SW		
8.0						
9.0						
10.0				BR		GRANODIORITE (BEDROCK) – freshly weathered, intact bedrock
11.0						END OF DRILLHOLE @ 10.1 m – possible fault or shear zone – static water level approximated at 695.2 m – all USC's are estimated, based on visual classification and field testing of recovered samples MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 12784.0 Easting – 16259.0 Elevation – 2290.0
12.0						
13.0						
14.0						
15.0						

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0

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LOGGED BY: CRH	COMPLETION DEPTH: 10.0 m
REVIEWED BY: CRH	COMPLETE: 95/09/28
Fig. No:	Page 1 of 1

DETAILED GEOTECHNICAL DESIGN	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 95-G14
PROPOSED TAILINGS DAM – MINTO PROJECT	DRILL: LONGYEAR 38, C/W NQ DRILL RODS	PROJECT NO: 0201-95-11509
NEAR MINTO CREEK, YUKON	UTM ZONE: 8 N6945379 E386597	ELEVATION: 698.30 (m)

SAMPLE TYPE ■ GRAB SAMPLE ☑ NO RECOVERY ☒ NQ CORE ☰ 75 mm SPOON ▥ CRREL BARREL

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						SAND (COLLUVIUM) – numerous boulders and cobbles, trace of gravel, trace of silt; angular, weathered sand; angular, weathered gravel, cobbles and boulders
1.0						
2.0				SP/GP		– casing set to 1.8 m; no recovery above 1.8 m; poor recovery above 4.0 m
3.0						– below 3.0 m; possible alluvial sand and gravel, rounded gravel present in recovery
4.0						GRANODIORITE (BEDROCK) – fresh to unweathered, shattered throughout
5.0						
6.0				BR		
7.0						
8.0						
9.0						END OF DRILLHOLE @ 8.5 m – constant head permeability test completed from 5.9 to 8.5 m – static water level approximately 695.0 to 696.5 m – all USC's are estimated, base on visual classification and field test of recovered samples
10.0						MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 12842.0 Easting – 16244.0 Elevation – 2291.0
11.0						
12.0						
13.0						
14.0						
15.0						

PLASTIC M.C. LIQUID
20 40 60 80

■ PERCENT RECOVERY ■
20 40 60 80
◆ PERCENT RQD ◆
20 40 60 80

DEPTH(ft)
0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0

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LOGGED BY: CRH
REVIEWED BY: CRH
Dig. By:

COMPLETION DEPTH: 8.5 m
COMPLETE: 95/09/27

EBA 1994 BOREHOLE LOGS
TAILINGS / WATER DAM AREA

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-C11
TAILINGS DAM (SOUTH CENTRE)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949205 E388804	ELEVATION: 724.17 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▥ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0		1				PEAT – Fibrous; wet; soft; dark brown
1.0	⊠	2	7			ORGANIC SILT (COLLUVIUM) – clayey to some clay, trace of sand, trace of gravel; frequent peat inclusions, occasional cobbles; wet; soft; dark grey
2.0		3				
3.0	▥	4				– permafrost below 3.1 m; Nbe with Vx<5%, some Vr 10% ice in Sample No. 4
4.0						
5.0	▥	5				
6.0	▥	6				– becomes cobbly with depth
7.0	▥	7				SAND AND SILT – trace gravel, frequent cobbles, numerous organic fibres and organic inclusions; angular cobbles and gravel; fine to medium sand; unsorted; frozen Nbe or Nbn; light grey
8.0	▥	8				
9.0	⊠	9	70/120	SM	▤	
10.0		10				SAND (RESIDUUM) – some silt, trace of gravel; unsorted; well graded, quartz and mica rich angular sand; moist; hard; rusty brown
11.0						
12.0	N	11				– slow, hard drilling from 7.8 to 12.2 m
13.0						END OF BOREHOLE @ 12.2 m
14.0						– thermistor string # 944 installed to 12.0 m
15.0						MINE GRID COORDINATES (IMPERIAL UNITS)
16.0						Northing – 11661.21
17.0						Easting – 14675.26
18.0						Elevation – 2375.90
19.0						EBA BOREHOLE NO: 11509-BH13
20.0						
21.0						
22.0						
23.0						
24.0						
25.0						
26.0						
27.0						
28.0						
29.0						
30.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

70/120

DEPTH(ft) 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0 52.0 54.0 56.0 58.0 60.0 62.0 64.0 66.0 68.0 70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0 86.0 88.0 90.0 92.0 94.0 96.0 98.0

EBA ENGINEERING CONSULTANTS LTD.
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LOGGED BY: CRH	COMPLETION DEPTH: 12.2 m
REVIEWED BY: CRH	COMPLETE: 94/06/25
Fig. No:	Page 1 of 1

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD	BOREHOLE NO: 94-G11A
TAILINGS DAM (NORTH CENTRE ABUTMENT)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949227 E388768	ELEVATION: 724.91 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▥ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						ORGANIC SILT – some sand, numerous roots; occasional cobbles and boulders; damp; firm; brown
1.0						SAND (COLLUVIUM) – some silt, some gravel, occasional cobbles and boulders; unsorted; well graded, angular sand; angular, friable gravel; damp; compact; brown
2.0						– becomes olive grey
3.0						
4.0		1				– water table @ 4.1 m
5.0	⊠	2	55			SAND (RESIDUUM) – some silt, trace of gravel, frequent cobbles, unsorted; matrix supported; angular, quartz and mica rich sand; angular friable gravel; damp; dense; rusty brown
6.0	⊠	3	40/150			– slow, hard drilling, 45 seconds for 25 mm
7.0						
	⊠	4	50/40	SM		
8.0						END OF BOREHOLE @ 7.7 m – water table @ 4.1 m MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 11734.87 Easting – 14559.28 Elevation – 2378.30 EBA BOREHOLE NO: 11509-BH15
9.0						
10.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

40/150

50/40

DEPTH(ft) 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0

EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: CRH

COMPLETION DEPTH: 7.7 m
COMPLETE: 94/06/26

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G12
TAILINGS DAM (NORTH ABUTMENT)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949280 E388727	ELEVATION: 759.44 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▯ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						ORGANIC SAND – silty, some gravel; moist; loose; dark brown, – frequent root fibers
		1				
1.0						SAND (COLLUVIUM) – some gravel; some silt; frequent cobbles; angular, quartz and mica rich sand; angular friable gravel; damp; dense; rusty brown – becomes light grey–brown below 1.5 m – difficult, rough drilling 1.8 to 2.4 m
	⊠	2	43/150			
2.0						
3.0	⊠	3				
	⊠	4	40			SAND (RESIDUUM) – some gravel – rough, hard drilling – drilling refusal @ 4.1 m
4.0	⊠	5	50/60			END OF BOREHOLE @ 4.1 m
5.0						MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 11915.79 Easting – 14429.77 Elevation – 2491.60 EBA BOREHOLE NO: 11509–BH14
6.0						
7.0						
8.0						
9.0						
10.0						

■ STANDARD PENETRATION ■ 20 40 60 80

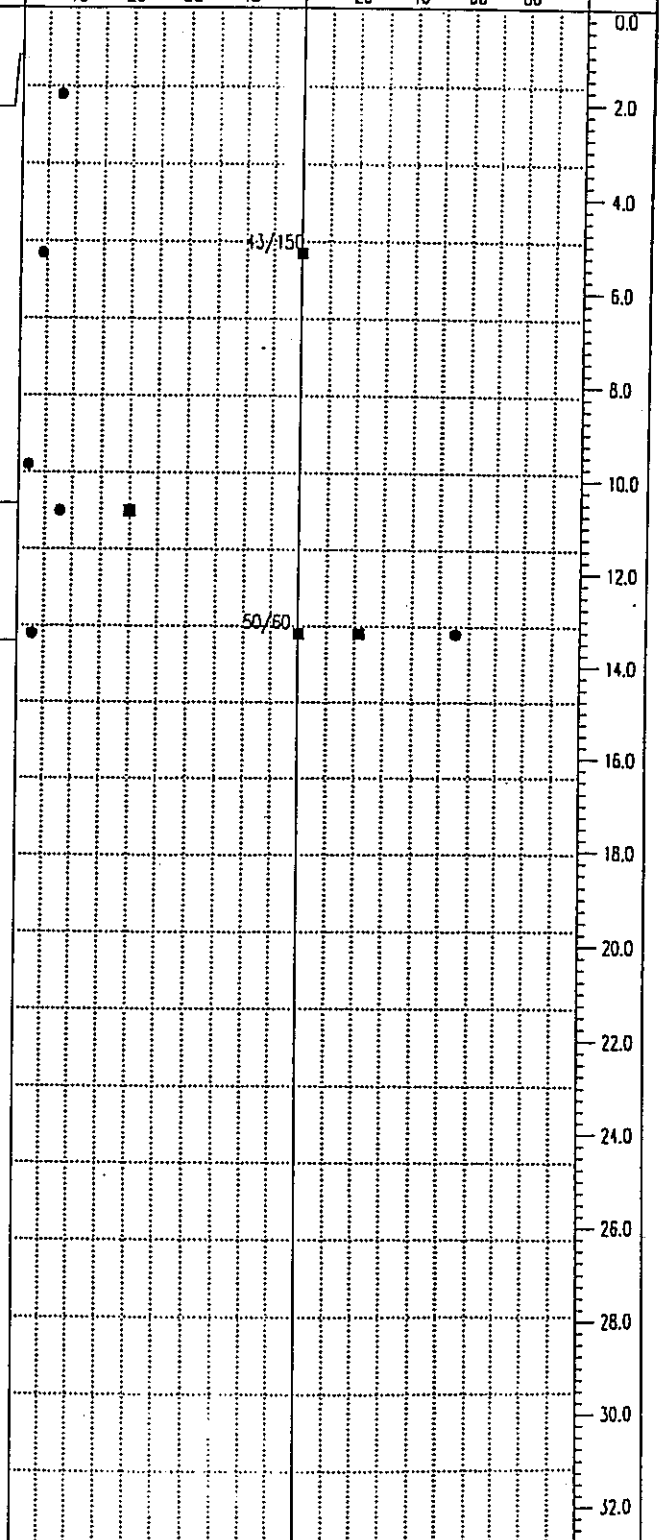
PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80



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LOGGED BY: CRH	COMPLETION DEPTH: 4.1 m
REVIEWED BY: CRH	COMPLETE: 94/06/26
Fig. No:	Page 1 of 1

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G13
WATER RETENTION DAM (SOUTH ABUTMENT)	DRILL: LONGYEAR 38, 3 7/8 TRICONE, HW	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949376 E389101	ELEVATION: 714.85 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▥ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0		1				SURFACE – willows, alders, moss and organics (driller noted clear ice @ base of organics)
1.0		2				
2.0						SILT (COLLUVIUM) – sandy, trace of organics, olive brown, frozen – easy drilling – all cuttings washed out – sampling not possible
3.0		3				
4.0						
5.0						SAND (RESIDUUM) – trace of silt and organics, olive brown to brownish – all cuttings washed out – sampling not possible grey, frozen
6.0		4				
7.0						
8.0						BEDROCK – grandorite – grinding @ 8.0 m – lost circulation from top of casing (washed out from below) – intact bedrock @ 8.5 m – continued drilling to 12.2 m
9.0						
10.0						
11.0						
12.0						
13.0						END OF BOREHOLE @ 12.2 m
14.0						NOTE: hole @ toe of solifluction lobe
15.0						MINE GRID COORDINATES (IMPERIAL UNITS)
16.0						Northing – 12186.02
17.0						Easting – 15667.50
18.0						Elevation – 2345.30
19.0						EBA BOREHOLE NO: 11509-BH17
20.0						
21.0						
22.0						
23.0						
24.0						
25.0						
26.0						
27.0						
28.0						
29.0						
30.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

DEPTH(ft) 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0 52.0 54.0 56.0 58.0 60.0 62.0 64.0 66.0 68.0 70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0 86.0 88.0 90.0 92.0 94.0 96.0 98.0

EBA ENGINEERING CONSULTANTS LTD
Whitehorse, Yukon

LOGGED BY: JRT
REVIEWED BY: CDH
Dg Dh

COMPLETION DEPTH: 12.2 m
COMPLETE: 94/08/22

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G14
WATER RETENTION DAM (CENTRE)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YT	UTM ZONE: 8 N6949427 E389062	ELEVATION: 708.45 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▯ CRREL BARREL ▮ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL
0.0					
1.0		1			
2.0	⊠	2	9		
3.0	⊠	3	16		
4.0	⊠	4	67		
5.0		5			
6.0					
7.0					
8.0					
9.0					
10.0					

SOIL DESCRIPTION

ORGANIC SILT – 100 mm thick

cobbles; unsorted; matrix supported; angular to subangular well graded sand; fine to coarse angular to subangular gravel; angular to subangular cobbles; moist; loose; brown

SAND – gravelly, some silt, frequent

– becomes moister with depth

– cobbles or boulders from 2.0 to 3.0 m

– water table @ 2.75 m

– SAND (RESIDUUM) – some gravel, trace to some silt, occasional silt inclusions; unsorted; angular well graded sand; angular friable fine gravel; quartz and mica rich; moist to wet; very dense; rusty brown

– drilling much harder from 3.1 m to 4.5 m

– very hard slow drilling from 4.6 m to end of hole (60 seconds+ per 25 mm)

END OF BOREHOLE @ 5.8 m

– no sloughing

– water @ 2.75 m

NOTE BH: in cut bench 0.5 m deep

MINE GRID COORDINATES (IMPERIAL UNITS)

Northing – 12357.83

Easting – 15544.19

Elevation – 2324.30

EBA BOREHOLE NO: 11509-BH11

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID

10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

DEPTH(ft)

0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0

EBA ENGINEERING CONSULTANTS LTD.

Whitehorse, Yukon

LOGGED BY: CRH

REVIEWED BY: CRH

Fig. No:

COMPLETION DEPTH: 5.8 m

COMPLETE: 94/06/24

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G15
WATER RETENTION DAM (NORTH ABUTMENT)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949477 E389034	ELEVATION: 724.05 (m)

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▥ HQ CORE

SOIL DESCRIPTION

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL
0.0					
		1			
1.0					
	⊠	2	66	SM	
2.0					
3.0	⊠	3	30/75		
4.0		4			
5.0		5			
6.0					
7.0		6			
	N	7	30		
8.0					
9.0					
10.0					

SAND (RESIDUUM) – gravelly, some silt, occasional cobbles; well graded angular sand; fine angular gravel; unsorted; compact; olive grey

– becomes dense and siltier with depth

– gravelly or cobbly zone from 1.8 to 2.4 m

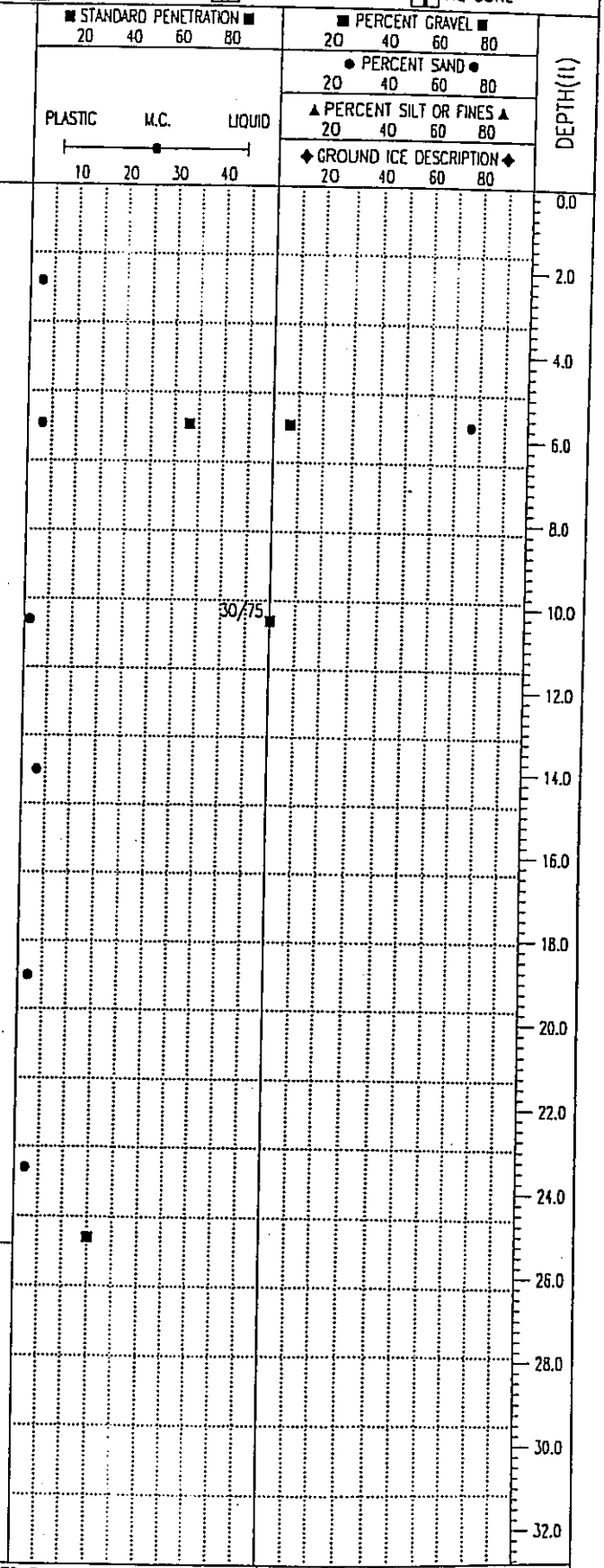
– centre bit coated in rock powder @ 4.5 m
– from 4.6 to 6.1 m drilling very slow (10 to 20 seconds per 25 mm)

– 6.1 to 7.6 m, very slow hard drilling (10 to 15 s per 25 mm), some rough sections

END OF BOREHOLE @ 7.7 m
– no sloughing
– no water
– no permafrost

NOTE: BH located on a cut bench roughly 2 m below natural ground;

MINE GRID COORDINATES (IMPERIAL UNITS)
Northing – 12525.58
Easting – 15458.62
Elevation – 2375.50



EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

LOGGED BY: CRH
REVIEWED BY: CRH
COMPLETION DEPTH: 7.7 m
COMPLETE: 94/06/24

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G16
ALT. RETENTION DAM (NORTH CENTRE)	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-1-1509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949582 E389217	ELEVATION: 705.15 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▯ CRREL BARREL ▯ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						SAND – gravelly, silty, numerous cobbles; angular to subangular well graded sand; angular to subangular gravel; unsorted; moist to wet; loose; dark brown
1.0						
		1				– less cobbles below 1.2 m
2.0						
						– becomes darker brown below 2.4 m; some ice crystals Nbe
		2	55			SAND (RESIDUUM) – some fine gravel, some to trace of silt; angular, fine gravel; unsorted; damp; compact; light brown
4.0						
		3	40/150			– becomes very dense by 4.0 m
5.0						GRANODIORITE (BEDROCK) – hard REFUSAL @ 4.6 – minor seepage @ 4.6 – no well installed
						END OF BOREHOLE @ 4.6 m MINE GRID COORDINATES (IMPERIAL UNITS) Northing – 12847.49 Easting – 16069.55 Elevation – 2313.50 EBA BOREHOLE NO: 11509-BH16
6.0						
7.0						
8.0						
9.0						
10.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

40/150

DEPTH(ft): 0.0, 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0, 22.0, 24.0, 26.0, 28.0, 30.0, 32.0

EBA ENGINEERING CONSULTANTS LTD.

LOGGED BY: CRH	COMPLETION DEPTH: 4.6 m
REVIEWED BY: CRH	COMPLETE: 94/06/27

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-G17
ALTERNATE RETENTION DAM (SOUTH ABUTMENT)	DRILL: LONGYEAR 38, 3 7/8 TRICONE, HW	PROJECT NO: 0201-11509
(SOUTH ABUTMENT) MINTO CREEK, YUKON	UTM ZONE: 8 N6949491 E389265	ELEVATION: 713.81 (m)

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▥ CRREL BARREL ▥ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						MOSS AND ORGANICS – black
1.0		1				– permafrost @ 0.2 m
2.0						SAND – silty, trace of quartz gravel, sizes to 75 mm diameter, Vs, Vr 25%
3.0		2				– occasional organic seams and pockets throughout
4.0						– organics throughout, frozen
5.0						– cobble or boulder @ 4.0 m
6.0						SAND – lighter colour (to light brown) at 4.9 m
7.0						– no sampling possible below 4 m depth
8.0						
9.0						
10.0						– difficult drilling to 9.8 m
11.0						– silty sand and gravel on bit at 9.8 m (frozen sandy gravel)
12.0						– put on new bit, drill to 12.8 m
13.0						– still frozen, some gravel
14.0						– hole abandoned due to difficult drilling
15.0						END OF BOREHOLE @ 12.8 m
16.0						MINE GRID COORDINATES (IMPERIAL UNITS)
17.0						Northing – 12545.57
18.0						Easting – 16219.65
19.0						Elevation – 2341.90
20.0						EBA BOREHOLE NO: 11509-BH18
21.0						
22.0						
23.0						
24.0						
25.0						
26.0						
27.0						
28.0						
29.0						
30.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

DEPTH(ft) 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0 34.0 36.0 38.0 40.0 42.0 44.0 46.0 48.0 50.0 52.0 54.0 56.0 58.0 60.0 62.0 64.0 66.0 68.0 70.0 72.0 74.0 76.0 78.0 80.0 82.0 84.0 86.0 88.0 90.0 92.0 94.0 96.0 98.0

EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

LOGGED BY: JRT
REVIEWED BY: CRH

COMPLETION DEPTH: 12.8 m
COMPLETE: 94/08/22

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: GH 94-20
TAILINGS DAM CENTRE HOLE	DRILL: CME-75 C/W HOLLOW STEM AUGERS	PROJECT NO: 0201-11509
MINTO CREEK, YT	UTM ZONE: 8 N - E -	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ⊘ NO RECOVERY ⊠ STANDARD PEN. ▤ 75mm SPLIT SP. ▯ CRREL BARREL ▯ HQ CORE

DEPTH(m)	SAMPLE TYPE	SAMPLE NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION
0.0						ORGANIC SILT – some sand, numerous roots, occasional cobbles and boulders; damp; Blah; brown
		1				
1.0						SAND (COLLUVIUM) – some silt; some gravel; occasional cobbles; unsorted; well graded, angular sand, angular friable gravel; damp; compact; brown
	⊠	2	17			– becomes olive grey
2.0						
3.0	⊠	3	40			END OF BOREHOLE @ 3.1 m – boulder @ 3.1 m – drilling refusal @ 3.1 m
4.0						
5.0						
6.0						
7.0						
8.0						
9.0						
10.0						

■ STANDARD PENETRATION ■ 20 40 60 80

PLASTIC M.C. LIQUID 10 20 30 40

■ PERCENT GRAVEL ■ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

▲ PERCENT SILT OR FINES ▲ 20 40 60 80

◆ GROUND ICE DESCRIPTION ◆ 20 40 60 80

DEPTH(ft) 0.0 2.0 4.0 6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0 28.0 30.0 32.0

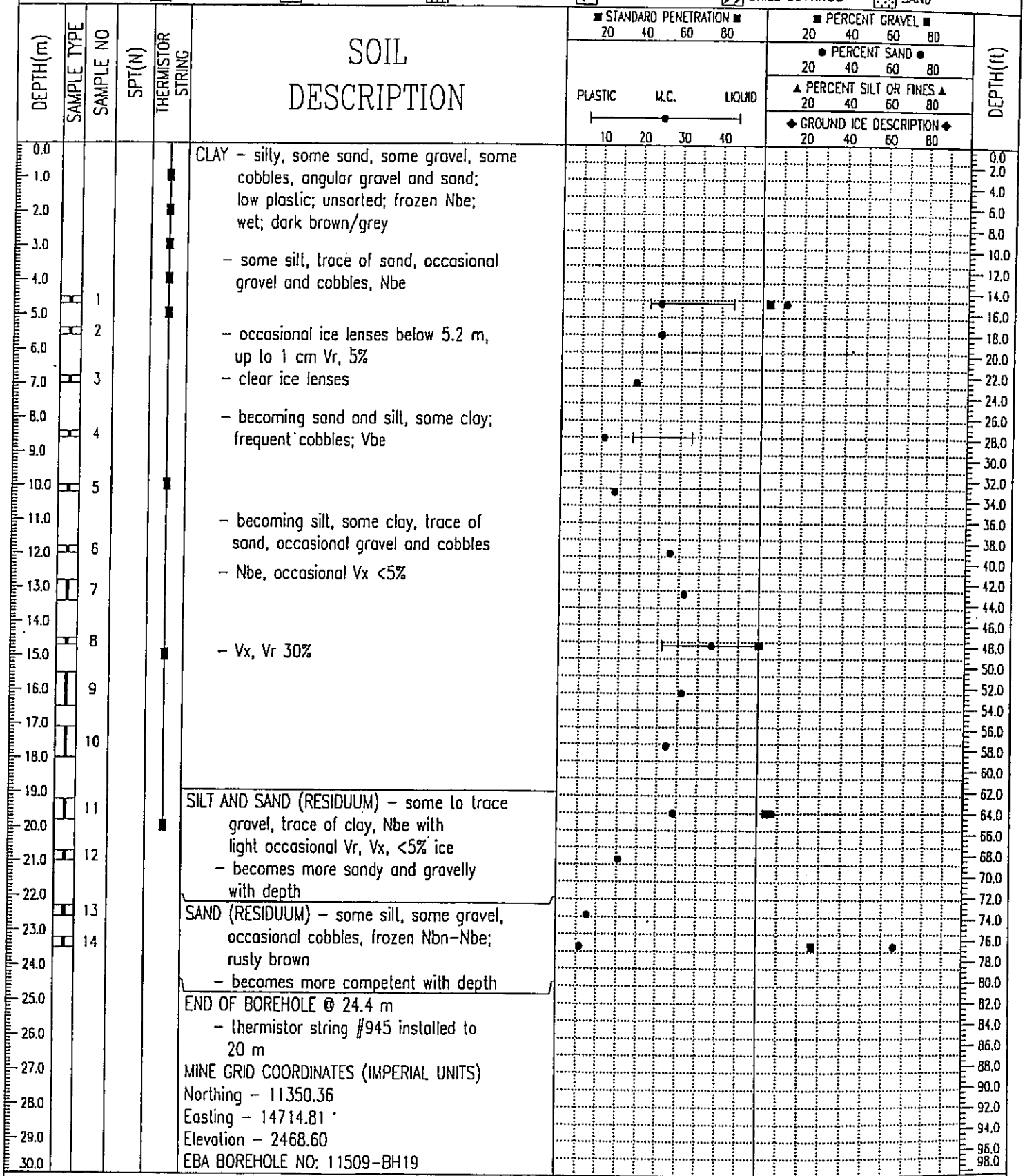
EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 3.1 m
REVIEWED BY: CRH	COMPLETE: 94/06/24

PROPOSED COPPER MINE DEVELOPMENT	CLIENT: MINTO EXPLORATIONS LTD.	BOREHOLE NO: 94-21
TAILINGS DAM (SOUTH ABUTMENT)	DRILL: LONGYEAR 38, 3 7/8 TRICONE, HW	PROJECT NO: 0201-11509
MINTO CREEK, YUKON	UTM ZONE: 8 N6949111 E388820	ELEVATION: 752.43 (m)

SAMPLE TYPE: GRAB SAMPLE | NO RECOVERY | STANDARD PEN. | 75mm SPLIT SP. | CRREL BARREL | HQ CORE

BACKFILL TYPE: BENTONITE | PEA GRAVEL | SLOUGH | GROUT | DRILL CUTTINGS | SAND



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: CRH	COMPLETION DEPTH: 24.4 m
	REVIEWED BY: CRH	COMPLETE: 94/08/22
	Fig No	Page 1 of 1

GOLDER 1976 BOREHOLE LOGS

RECORD OF BOREHOLE #1 Plantsite Area

LOCATION (See Figure 2) N 12,200; E 11,945 BORING DATE May 6, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) +3 -2 -1 0 +1 +2 / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss & Topsoil							
1.0'	Weathered granodiorite bedrock crumbles to angular sand and gravel, slightly silty		1	CB				
			2	"				
5.2'	Rock		3	"				
5.8'	End of Borehole at 5.8 ft. below surface. Auger cannot advance in relatively sound rock.							

Piezometer

Thermister

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE # 1A — Plantsite Area

LOCATION (See Figure 2) N 11,825 E 11,572 — BORING DATE May 6, 1976

BOREHOLE TYPE Permafrost Core Barrel — BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P — W — W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss & Topsoil							
1.0'	Weathered granodiorite bedrock crumbles to angular sand and gravel, slightly silty		1	C.B.				
4.7'	Rock		2	"				
5.3'	End of Borehole at 5.3 ft. below surface. Auger cannot advance in relatively sound rock.		3	"				

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE #2 Plantsite Area

LOCATION (See Figure 2) N 12,490 E 11,700 BORING DATE May 5, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

Project No. 1-7[illegible]

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss & Topsoil							
1.0'	Weathered granodiorite bedrock. Near surface crumbles to sand and gravel to ½ in. size. Less weathered and more competent with increasing depth.		1	C.B.				
			2	"				
			3	"				
			4	"				
7.5'	End of Borehole at 7.5 ft. depth. Permafrost core barrel cannot advance in relatively sound bedrock.							

VERTICAL SCALE
1 inch to 2 feet

Golder Associates

DRAWN [illegible]

RECORD OF BOREHOLE #3 *Plantsite Area*

LOCATION (See Figure 2) *N 12,350 E 11,850* BORING DATE *May 9, 1976*

BOREHOLE TYPE *Permafrost Core Barrel* BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -3 -2 -1 0 +1 +2 / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	*Moss*							
0.5'								
1.0'	*Topsoil - silty ...*		1	C.B.				
	Weathered rock grades from sand and gravel near surface to relatively sound rock at 7.5 ft. depth.		2	"				
			3	"				*Thermistor*
7.5'	*End of Borehole.*							

VERTICAL SCALE

DRAWN 44

RECORD OF BOREHOLE #4 Plantsite Area

LOCATION (See Figure 2) N12,540 E 11,900 BORING DATE May 3, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'								
0.5'	Moss & Topsoil		1	A.S.				
	Sand & gravel, trace of silt, brown		2	C.S.				
3.5'	Weathered granodiorite bedrock		4	"				
5.8'	Sound granodiorite bedrock		5	"				
6.3'	End of borehole at 6.3 ft. depth. Permafrost core barrel cannot advance below 6.3 ft. below.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE # 5+5A Plantsite Area

LOCATION (See Figure 2) N12,800 E 11,900 BORING DATE May 3 & 9, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -3 -2 -1 0 +1 +2 / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'								
1.0'	Silty topsoily red Sand & gravel brown with cobbles		1	C.B.				Piezometer / Thermister
			2					
			3					
5.0'	Granodiorite bedrock, hard							
6.3'	End of Borehole.							

Note: Hole 5 cannot be advanced beyond 5ft. depth. Hole 5A drilled 2' east and 5' south of hole 5. Permafrost auger could not be advanced below 5' depth. A-size diamond drill core 5' to 6.3'.

VERTICAL SCALE

DRAWN HH

RECORD OF BOREHOLE #6 Plantsite Area

LOCATION (See Figure 2) N12,350 E, 12,200 BORING DATE May 5, 1976.

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P — W — W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss & Topsoil							
1.0'	Sand and gravel, brown slightly silty		1	C.B.				
			2	"				
6.0'	Weathered rock							
6.5'	Bedrock slightly weathered, harder with depth.		3	"				
			4	"				
9.0'	Borehole could not be advanced below 9' depth.							

Note: At 7.5' depth, two thin ice lenses noted, each 1 to 2 mm thick.

VERTICAL SCALE

Golder Associates

DRAWN

RECORD OF BOREHOLE #7 Plantsite Area

LOCATION (See Figure 2) N 12,350 E 12,480 BORING DATE May 5, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Topsoil - brown, silty							
1.0'	Sand and gravel to 3 in. size		1	C.B.				
4.5'	Weathered bedrock, thin ice layers on boundaries of mineral grains.		2	"				
5.8'	Borehole could not be advanced below 5.8 ft. depth.							

VERTICAL SCALE

Golder Associates

DRAWN

RECORD OF BOREHOLE #9 Area of Proposed Open Pit

LOCATION (See Figure 2) N 11,600 E 10,504 BORING DATE May 2, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Sand and gravel brown, slightly silty. Trace of silt, loose to compact, grading to dense at 19 ft. depth. (Probably insitu intensely weathered bedrock)		1	AS.				
			2	"				
			3	"				
			4	"				
			5	"				
			6	"				
19.0'	Granodiorite bedrock - weathered grey. One 1/8 in. thick ice lense noted on the fracture.		7	"				
			8					
22.0'	End of Borehole							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN CHECKED

RECORD OF BOREHOLE #10 Area of Proposed Open P.

LOCATION (See Figure 2) N 10,650 E 10,285 BORING DATE May 9, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L (0 20 40 60 80 100)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	Ground Surface							
0.5'	Moss							
	Silt and fine sand, laminated with scattered organic. Occ. seams of gravel and coarse sand. Frozen throughout with zones containing segregated ice crystals. Layers of clear ice.		1	C.B				
			2	"				
9.0'	Thin peat layer		3	"			45.8, 45.4	
10.0'	Ice with minor silt (see photo Appendix B)							
14.0'								
16.5'	Ice with minor silt (See photo Appendix B.)							
17.5'			4	"				
20.5'	End of Borehole.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN CHECKED

RECORD OF BOREHOLE #10A Area of Proposed Open Pit

LOCATION (See Figure 2) N 10,652 E 10,285 BORING DATE May 9, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Silt and fine sand, laminated with scattered organic. Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals. Layers of clear ice.							
8.5'	Ice with minor silt.							
14.8'	End of Borehole.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN CHECKED

RECORD OF BOREHOLE #108 Area of Proposed Open Pit

LOCATION (See Figure 2) N 10,656 E 10,291 BORING DATE May 9, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

Project No. [illegible]

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -3 -2 -1 0 / WATER CONTENT PERCENT W_P W W_L 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Silt and fine sand, laminated with scattered organic. Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals. Layers of clear ice.							
~~16.8'~~ 17.1'	Ice							
18.5'	Ice with minor silt							
~~20.2'~~ 20.5'	Ice							
23.0'			1	C.B.				
			2	"				
			3	"				
31.0'	End of Borehole.							

Thermistors

VERTICAL SCALE

DRAWN

RECORD OF BOREHOLE #11 Area of Proposed Open Pit

LOCATION (See Figure 2) N. 10,340 E. 9,600

BORING DATE May 6, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P — W — W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Peat, frozen, fibrous to amorphous;		1	C.B.				
2.5'	Sand and gravel, frozen		2	"				
3.5'	Could not advance hole below 3.5 ft. depth. See log for hole 11A.							

VERTICAL SCALE 1 inch = 5 feet

Golder Associates

DRAWN CHECKED

Project No. 160-22

RECORD OF BOREHOLE #11A Area of Proposed Open Pit

LOCATION (See Figure 2) N10,340 E 9,555 BORING DATE May 6, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Peat, fibrous to amorphous with- ice lenses 1.5 to 4.0 ft.		1	C.B.				
4.0'	Silt and fine sand; laminated with scattered organic; Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		2	"				
7.3'	End of Hole		3	"				

VERTICAL SCALE

Golder Associates

DRAWN

Project No. V-2---5

RECORD OF BOREHOLE # 11 B Area of Proposed Open Pit

LOCATION (See Figure 2) N 10,340 E 9,550 BORING DATE May 7, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -3 -2 -1 0 +1 +2 / WATER CONTENT PERCENT W_P W W_L 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Peat, black, amorphous, frozen; occ. thin layers of wood; layers of silt and fine gravel; separated ice crystals throughout.							
9.5'	Silt; Sand and angular to subangular gravel to 3 in. size		1 2					
12.0'	Silt; clayey, with thin seams of coarse sand.		3				31.5 31.6	
14.5'	Gravel							
15.0'	Could not advance hole below 15 ft. depth.							

Thermistors

VERTICAL SCALE 1 inch to 20 feet

Golder Associates

DRAWN CHECKED

Project No. 1-76023

RECORD OF BOREHOLE #12 Foundation Area of Proposed Western Waste Dump

LOCATION (See Figure 2) N. 9,850 E. 8,580

BORING DATE May 7, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Peat; black, amorphous, frozen; ice lenses to 1/8 in. thick; occasional seams of sand, fine gravel and wood.		1	C.B.				
			2	"				
9.0'	Silt, sand and gravel		3	A.S.				
11.0'	Could not advance hole below 11 ft. depth.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE #13 Foundation Area of Proposed Western Waste Dump

LOCATION (See Figure 2) N. 9,390 E. 7,900

BORING DATE May 8, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -2 -1 0 +1 / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Peat - black, amorphous, ice lenses to 1/8 in. thick; scattered gravel.		1	C.B.				
3.5'	Sand - silty with scattered fine gravel; seggregated ice throughout		2	"				
			3	"				Thermister
9.5'	Cobbles or Bedrock ? could not advance hole below 9.5 ft. depth.							

VERTICAL SCALE

Golder Associates

DRAWN

RECORD OF BOREHOLE #16 Alternative Plantsite Area

LOCATION (See Figure 2) N. 9,730 E. 15,900

BORING DATE May 10, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Peat - black, frozen, amorphous							
0.7'			1	C.B.				
	¼ in. thick ice lenses.							
	Silt and fine sand; laminated with scattered organic; Occasional seams of gravel and coarse sand. Frozen throughout with zones containing segregated ice crystals. Layers of clear ice.		2					
10.0'			3					
11.0'	Brown sand & gravel, trace of silt							
	End of Borehole.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

CHECKED

RECORD OF BOREHOLE #17 Alternative Plantsite Area

LOCATION (See Figure 2) N. 9,730 E. 16,317

BORING DATE May 10, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Sand; Gravel; trace of Silt (not frozen)		1	C.B.				
			2	*				
3.5'	Could not advance hole below 3.5 ft.							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

CHECKED

Project No. 11-76055

RECORD OF BOREHOLE #18 Alternative Plantsite Area

LOCATION (See Figure 2) N. 9,730 E. 16,830

BOREHOLE TYPE Permafrost Core Barrel

BORING DATE May 10, 1976

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
0.0'	Ground Surface Moss							
	Sand and gravel; trace of silt.		1	C.B.				
2.1'	Bedrock		2	A.S.				

Note: Six separate holes yielded rock chips; refusal at 2ft. below surface.

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN dt

RECORD OF BOREHOLE #19 Scheme I Tailing Dam

LOCATION (See Figure 2) N. 11,550 E. 18,240

BORING DATE May 11, 1976

BOREHOLE TYPE Permafrost Core Barrel

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Silt and fine sand; laminated with scattered organic. Occasional seams of gravel and coarse sand. Frozen below 2.5 ft. depth with numerous ice lenses approx. 1/8 in. thick.		1	C.B.				
2.5'			2	"				
6.5'	Sand; slightly silty with Gravel to 1 in. size.		3	"				
7.5'	Hole could not be advanced through gravel layer.							

VERTICAL SCALE 1 inch = 5 feet

Golder Associates

DRAWN CHECKED

RECORD OF BOREHOLE *20 Scheme I Tailing Dam

LOCATION (See Figure 2) N. 11,425 E. 18,625

BOREHOLE TYPE Permafrost Core Barrel

BORING DATE May 10, 1976

BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -2 -1 0 +1 / WATER CONTENT PERCENT W_P W W_L 20 40 60 80	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Peat - black with wood and segregated ice.		1	C.B.				
1.5' / 2.0'	Clear ice - with silt, fine sand and scattered gravel; approximately 50% ice.							
3.8'	Ice							
4.5'	Silt - grey, clayey; trace of fine sand and organic.		2	"				
7.0'	Silt - with fine sand and scattered gravel; ice lenses.		3	R.C.				Thermister
			4	"				
			5	"				
			6					
			7	"				
18.0'	End of Hole							

4 in. Diamond Core

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE #21 Scheme I Tailing Dam

LOCATION (See Figure 2) N. 11,225 E. 19,175 · BORING DATE May 11, 1976

BOREHOLE TYPE Permafrost Core Barrel · BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	Temperature (°C) -2 -1 0 +1 / WATER CONTENT PERCENT W_P W W_L	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'								
1.0'	Silt and fine Sand; laminated with scattered organics; Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		1					
			2					
7.5'	Sand and fine gravel Could not advance hole below 7.5 ft. depth.							Thermister

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN CHECKED

RECORD OF BOREHOLE #22 Scheme 2b Damsite

LOCATION (See Figure 2) N. 16,200 E. 23,100

BOREHOLE TYPE Permafrost Core Barrel

BORING DATE May. 12, 1976

BOREHOLE DIAMETER

DATUM

Project No. V-76035

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE
	Ground Surface					
1.0'	Moss Peat					
			C.B.			
11.0'	Sand and fine gravel Fine gravel		2	1		
	Silt and fine Sand; laminated with scattered organic; Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		3	1		
			4	1		
			5	1		
	Occasional ice lenses at inclination 45° to vertical.		6	1		
54.0	End of Hole					
	See also photo record of frozen core recovered from this hole.					

Temperature (°C) ⊡ -4 -3 -2 -1 0

WATER CONTENT PERCENT W_P W W_L 20 40 60 80

NO 33.6 W_P 33.9

PIEZOMETER OR STANDPIPE INSTALLATION

ADDITIONAL LAB. TESTING

Thermisters

VERTICAL SCALE

Project No. 11-76055

RECORD OF BOREHOLE #23 Scheme 2b Damsite

LOCATION (See Figure 2) N. 16,600 E. 22,910 BORING DATE May 13, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L (20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Peat layer with ice							
1.0'	Silt and fine sand; laminated with scattered organic; occassional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		1	C.B.				
			2	"				
11.0'	Ice							
12.0'	Silt- grey with wood and ice.							
14.5'	Sand and gravel.		3	"			0	
16.5'	Silt-grey with organic, ice and sand and gravel.							
18.5'	Sand and gravel to 1 in. max. size.		4	"				
21.5'	End of Hole							

VERTICAL SCALE 1 inch to 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE #24 Scheme 2b Domsite

LOCATION (See Figure 2) N. 17,000 E. 22,720

BOREHOLE TYPE Permafrost Core Barrel

BORING DATE May 13, 1976

BOREHOLE DIAMETER

DATUM

Project No. 17-76-02

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L (-5 -4 -3 -2 -1 0; 20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Moss							
0.5'	Peat - black, fibrous							
1.5'	Silt and fine Sand; laminated with scattered organic; Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		1	C.B.			o	thermisters
			2	RC				
			3	"				
26.5'	End of Hole							

VERTICAL SCALE

Cold ...

DRAWN

RECORD OF BOREHOLE #26 Scheme 2a Damsite

LOCATION (See Figure 2) N. 15,920 E. 21,630 BORING DATE May 14, 1976

BOREHOLE TYPE Permafrost Core Barrel BOREHOLE DIAMETER

DATUM

Project No. 7-76055

ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L (20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'	Sand and gravel- silty with peat and segregated ice.							
4.0'	Peat - black with wood and ice.							
6.5'	Silt and fine sand- laminated with scattered organic. Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals.		1	CB			o	
			2	11			o	
14.5'	Peat, Wood and Ice							
16.5'			3	11			146.0 o	
			4	4			o	
30.0'	End of Hole							

VERTICAL SCALE 1 inch = 5 feet

Golder Associates

DRAWN

RECORD OF BOREHOLE #27 Scheme 2a Damsite

LOCATION (See Figure 2) N.16,140 E.21,490

BORING DATE May 14, 1976

BOREHOLE TYPE Permafrost Core Barrel.

BOREHOLE DIAMETER

DATUM

SOIL PROFILE ELEV. / DEPTH	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	SAMPLE TYPE	BLOWS / FOOT	ELEVATION SCALE	WATER CONTENT PERCENT W_P W W_L (20 40 60 80)	PIEZOMETER OR STANDPIPE INSTALLATION / ADDITIONAL LAB. TESTING
	Ground Surface							
0.0'								
0.3'	Moss							
1.0'	Peat - silty with ice and wood.		1					
5.0'	Silt and fine sand; laminated with scattered organic; Occasional seams of gravel and coarse sand; Frozen throughout with zones containing segregated ice crystals; Layers of clear ice.		2				135.3 o	
	Gravel layer							
26.0'	End of Hole							

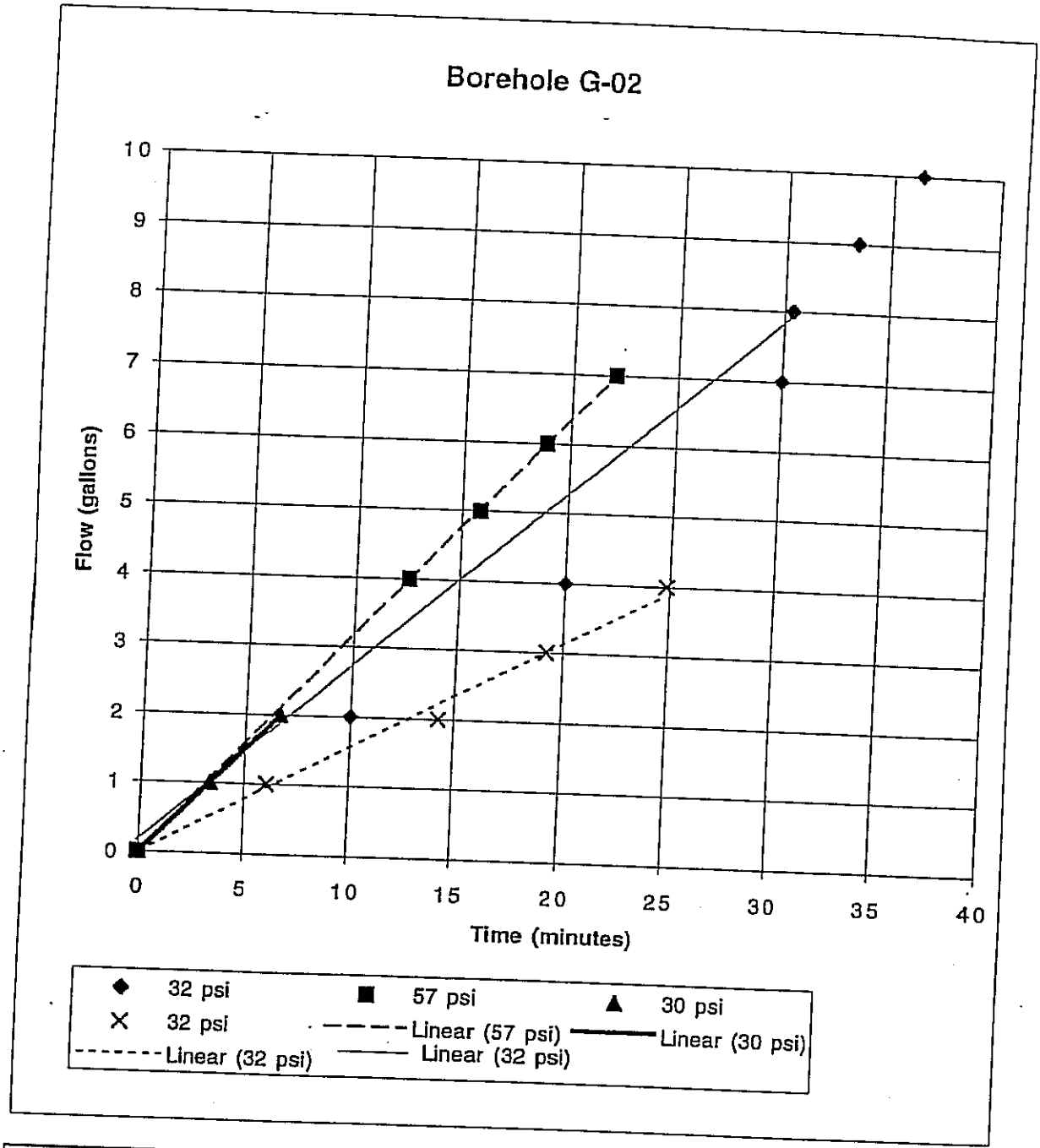
VERTICAL SCALE 1 inch to 5 feet

Golder Associates

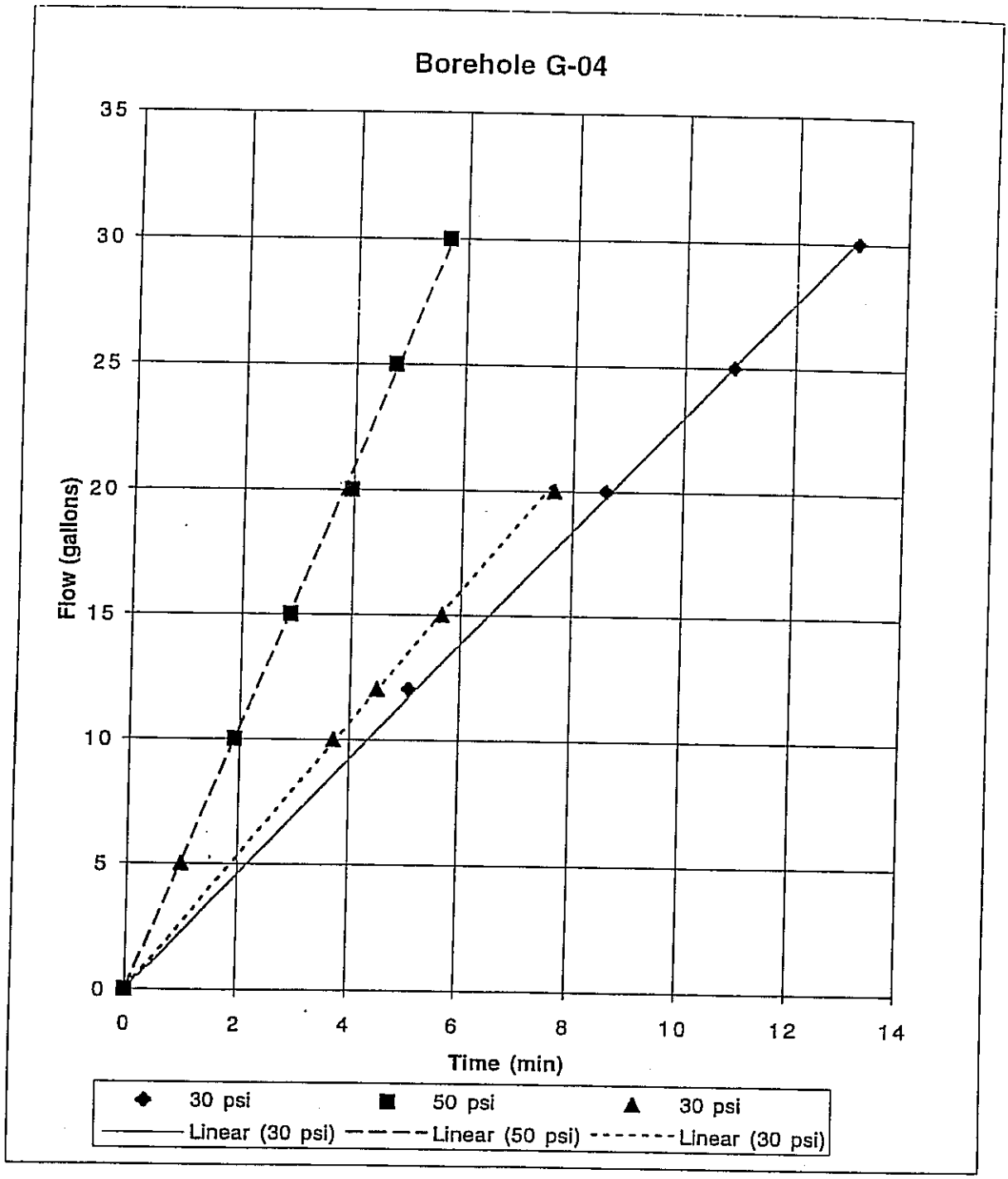
DRAWN

CHECKED

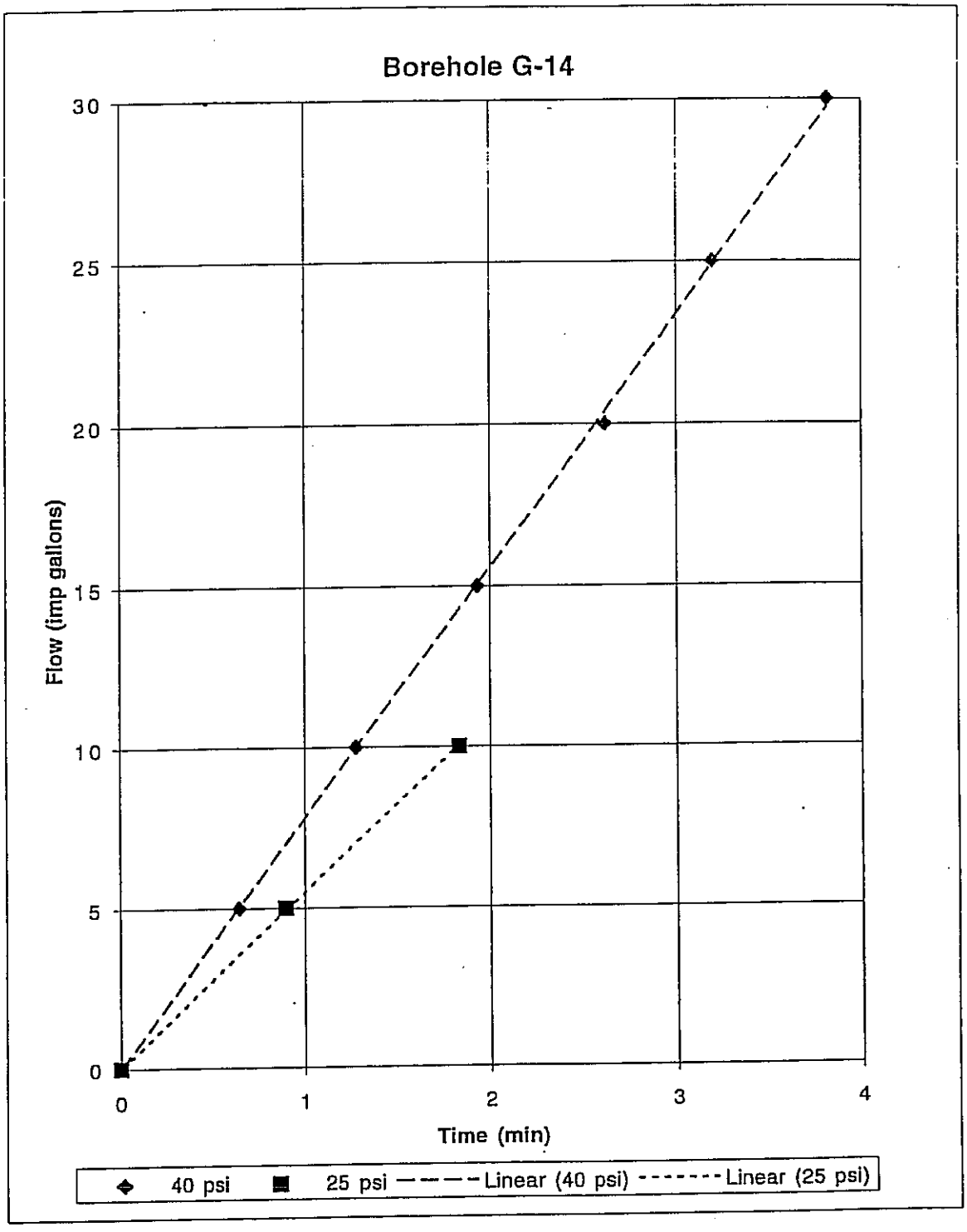
EBA 1995 PACKER TESTS



Pressure (psi)	Q (imp gal/min)	Q (usgpm)	he (m H2O)	L (m)	k (m/s)	Interval Tested (m)
32	0.22	0.27	31.2	3.35	1.8E-07	7.5-10.8
57	0.32	0.38	48.8	3.35	1.6E-07	7.5-10.8
30	0.30	0.36	29.8	3.35	2.5E-07	7.5-10.8
32	0.16	0.19	31.2	3.35	1.3E-07	5.0-8.4



Pressure (psi)	Q (imp gal/min)	Q (usgpm)	he (m H2O)	L (m)	k (m/s)	Interval Tested (m)
30	2.23	2.68	24.6	3.35	2.3E-06	5.6-9.0*
50	5.22	6.27	38.7	3.35	3.4E-06	5.6-9.0*
30	2.64	3.18	24.6	3.35	2.7E-06	5.6-9.0*



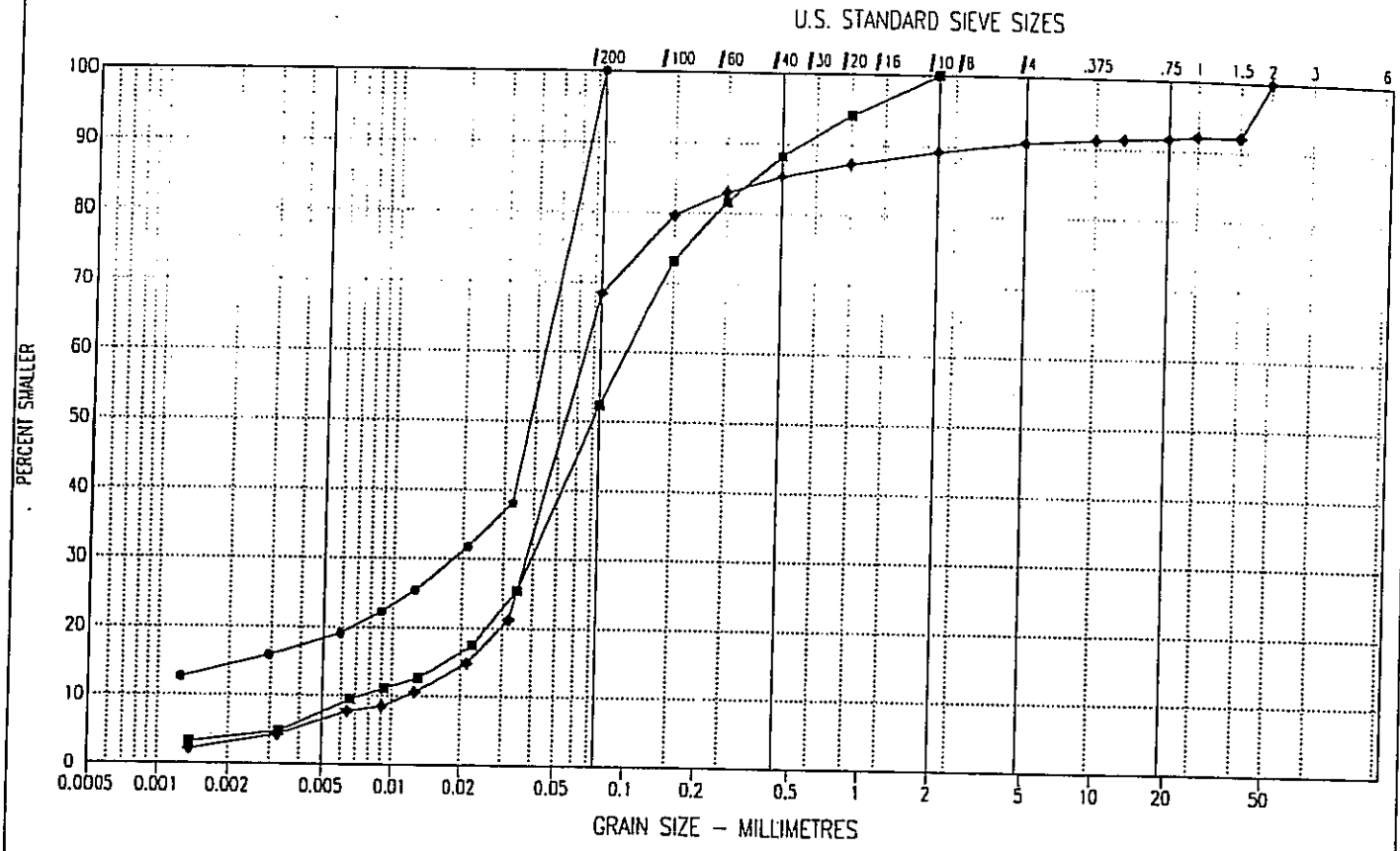
Pressure (psi)	Q (imp gal/min)	Q (usgpm)	he (m H2O)	L (m)	k (m/s)	Depth Interval (m)
40	7.79	9.36	31.5	2.90	7.2E-06	5.6-8.5
25	5.47	6.57	21	2.90	7.6E-06	5.6-8.5

LABORATORY TEST RESULTS
COLLUVIUM

EBA Engineering

PARTICLE SIZE - ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION CLAY %	SILT %	SAND %	GRAVEL %	Cu	Cc	U.S.C
●——●	94-G11	1.20 - 1.65	18.0	82.0	0.0	0.0	-	-	
◆——◆	94-G13	0.70 - 0.90	6.2	62.2	22.2	9.4	5.8	2.0	
■——■	94-G17	0.90 - 1.10	7.2	45.1	47.7	0.0	13.9	2.3	

SILTY COLLUVIUM

Project: 0201-11509

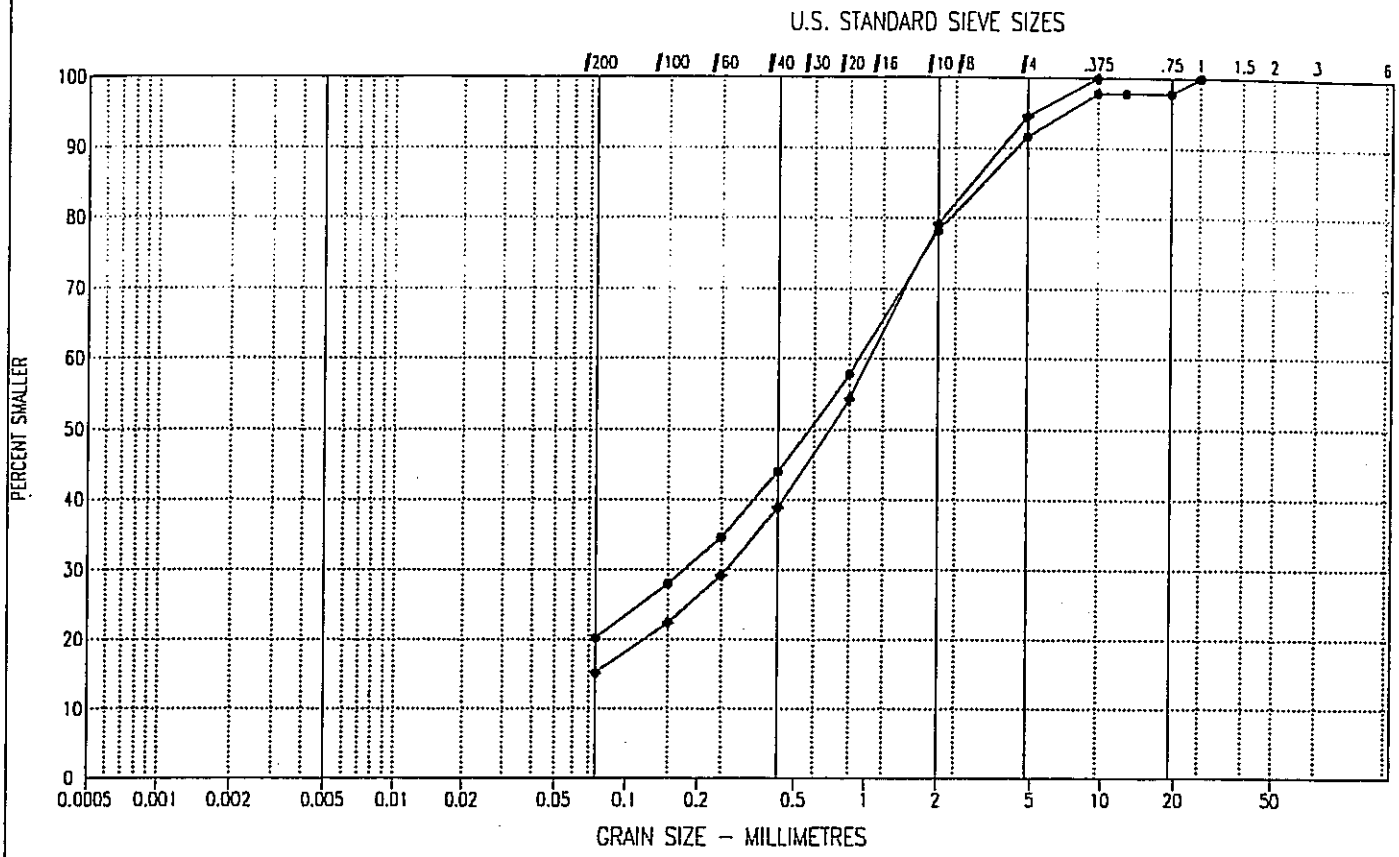
Date Tested: 94/08/05 BY: FRS

Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●	94-G04	2.60 – 2.90	20.1	71.4	8.5	26.1	0.9	SM
◆	94-G06	2.60 – 3.00	15.2	79.3	5.5	22.5	1.3	SM

SANDY COLLUVIUM

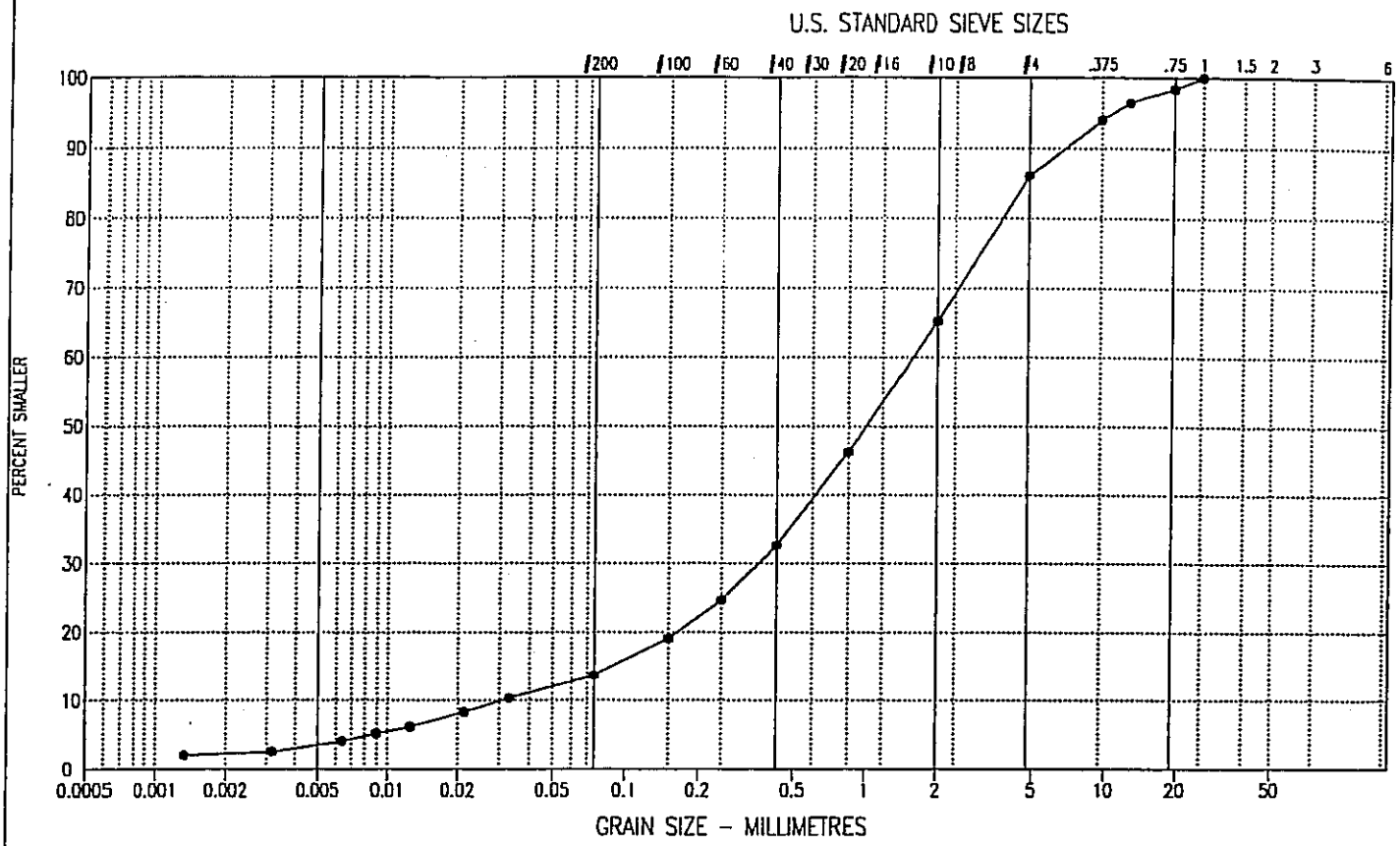
Project: 0201-11509 Date Tested: 94/06/20 BY: FRS

Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION				Cu	Cc	U.S.C
			CLAY %	SILT %	SAND %	GRAVEL %			
●——●	2187	0.00	3.4	10.2	72.4	14.0	54.5	2.6	SM

Project: 201-11509 Date Tested: 94/11/29 BY: IS

Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering

MOISTURE-DENSITY RELATIONSHIP
(ASTM Designation D 698, D 1557)

Project: MINTO COPPER MINE

Address: MINTO CREEK, YUKON

Project No.: 201-11509

Date Tested: 94 11 24

Client: MINTO EXPLORATIONS

Attention: MR. LUTZ KLINGMANN

Sample No.: 2187

Date Sampled: UNKNOWN

Sample Location:

Sample Description: SAND, SOME SILT, GRAVEL (25mm MAX), LIGHT BROWN

Maximum Dry Density: 2125 kg/m³

Optimum Moisture Content: 9.0 %

Natural Moisture Content: 3.4 %

☒ Standard Proctor (ASTM D 698)

☐ Modified Proctor (ASTM D 1557)

Hammer Weight: 2.494 kg

Hammer Drop: 304.8 mm

No. of Layers: 3

No. of Blows/Layer: 56

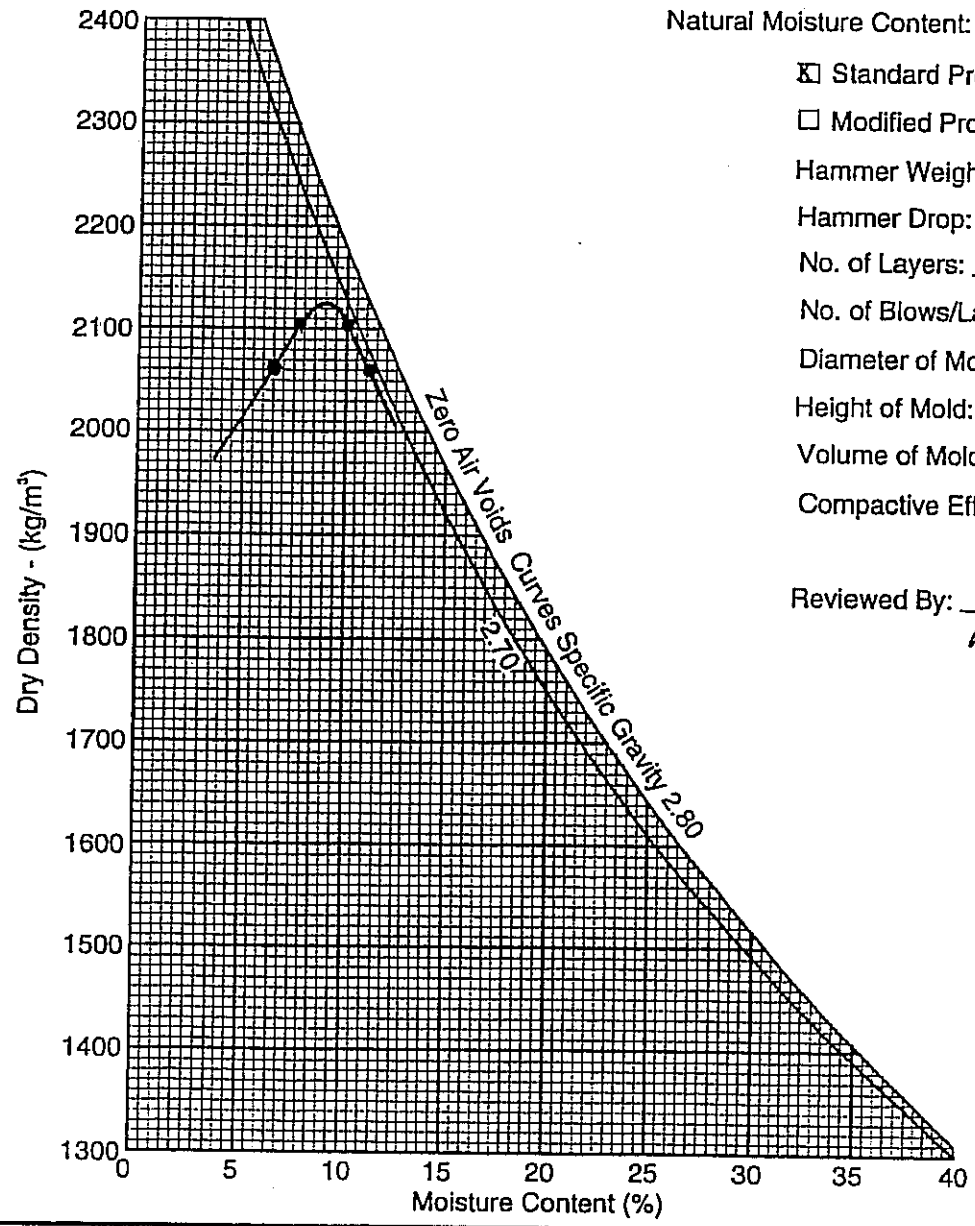
Diameter of Mold: 152.3 mm

Height of Mold: 116.5 mm

Volume of Mold: 0.00212 m³

Compactive Effort: 590.3 kJm³

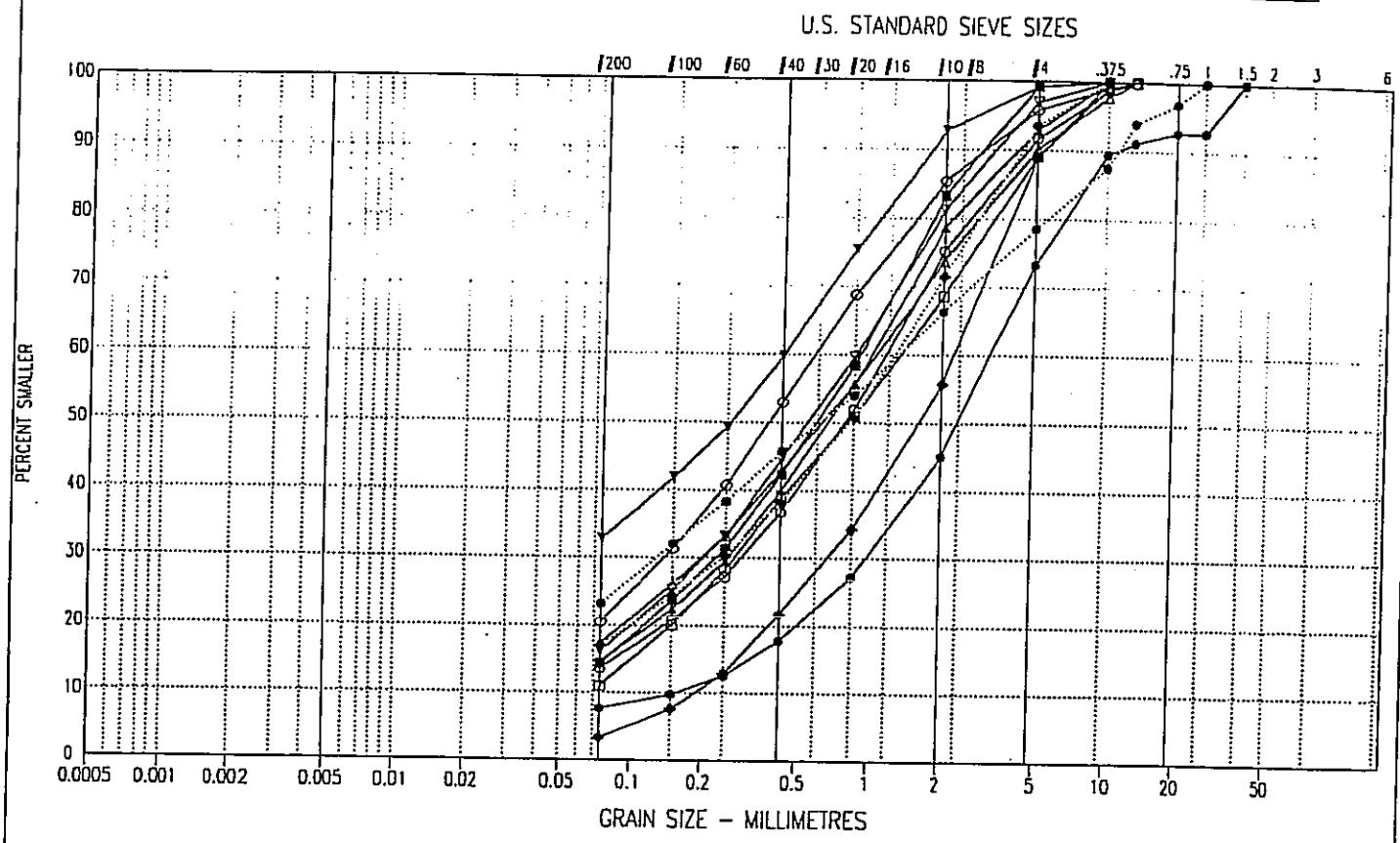
Reviewed By: A. Ruban P.Eng.



EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●	94-21	23.20 – 23.50	7.6	65.7	26.7	21.9	1.9	SW-SM
◆	94-G01	0.40 – 0.80	3.2	85.6	11.2	12.0	1.1	SW
■	94-G02	4.50 – 5.00	14.3	85.0	0.7	17.6	1.1	SM
▲	94-G05	6.95 – 7.40	14.5	78.4	7.1	20.7	1.2	SM
▼	94-G06	10.40 – 10.50	32.8	66.3	0.9	18.7	0.5	SM
⊕	94-G07	4.40 – 4.85	13.6	77.9	8.5	22.6	1.3	SM
⊖	94-G08	9.10 – 9.20	20.5	75.3	4.2	16.8	0.9	SM
⊡	94-G09	1.30 – 1.80	11.0	78.0	11.0	21.1	0.8	SP-SM
△	94-G11	9.00 – 9.30	17.3	72.7	10.0	25.9	0.9	SM
▽	94-G11A	7.60	16.2	80.8	3.0	18.6	1.1	SM
●	94-G12	4.00 – 4.10	23.1	55.4	21.5	43.6	0.4	SM
◆	94-G15	1.50 – 1.95	17.0	76.5	6.5	30.9	1.0	SM

NATURAL RESIDUUM

Project: 0201-11509

Date Tested: 94/09/22

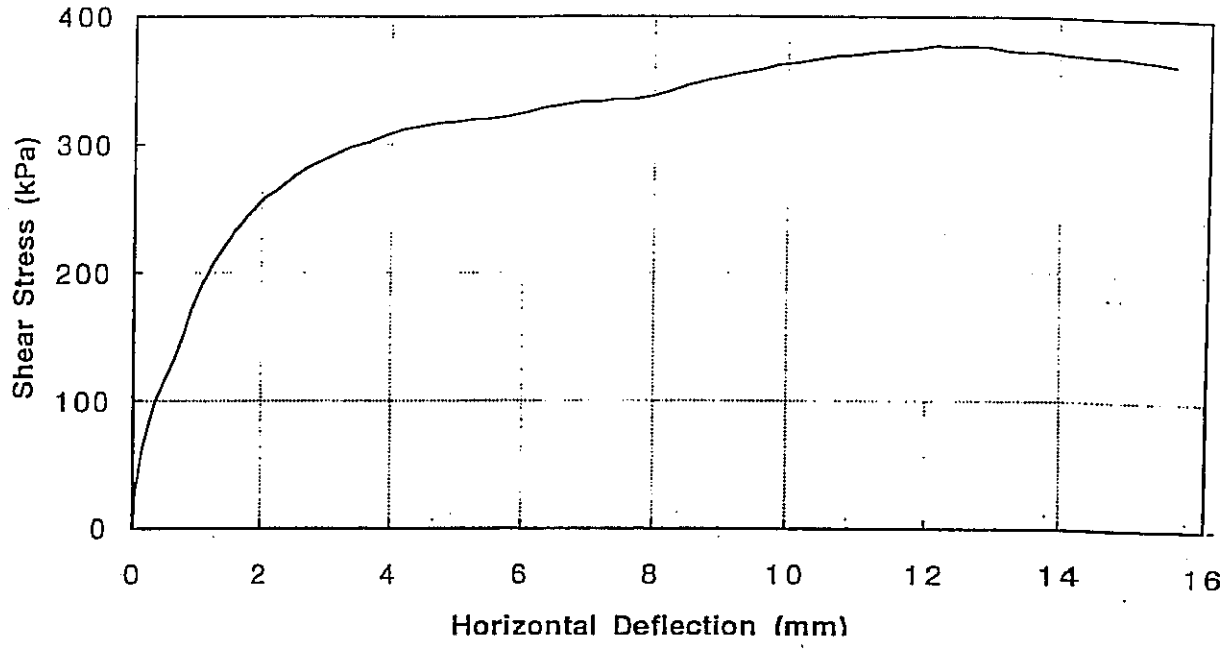
BY: ATM

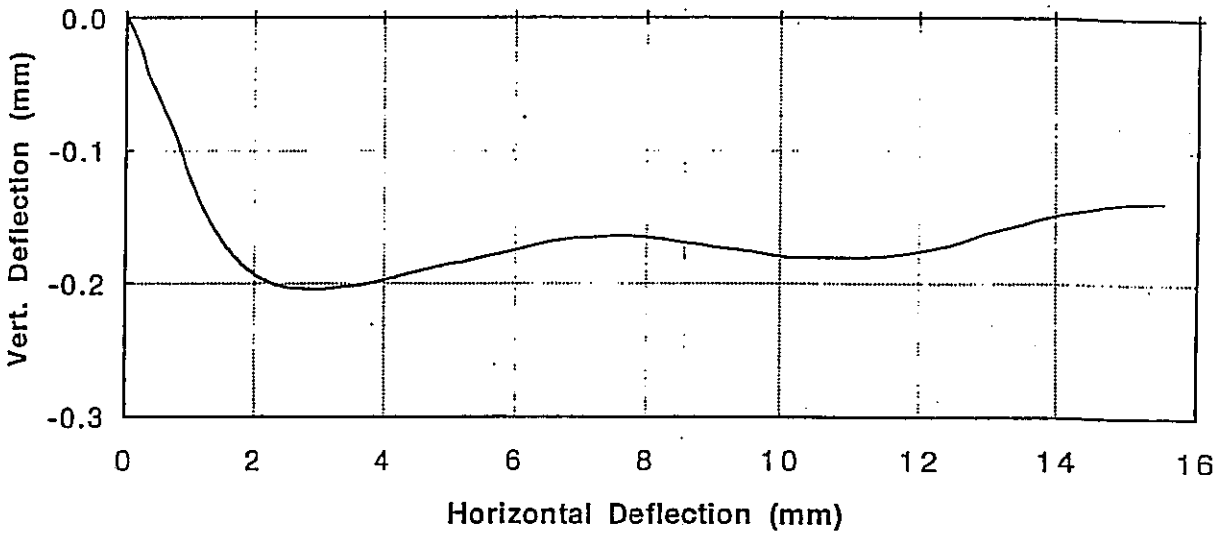
Tested in accordance with ASTM D422 unless otherwise noted.

EBA Engineering Consultants Ltd.

Direct Shear Test

Peak Stress= 377 kPa





Test Hole Number: Sa.#2187
Depth:
Normal Stress(kPa): 480
Displ. Rate(mm/min.): 0.24
Test No.: DS-1

eba

EBA Engineering Consultants Ltd.

Direct Shear Test

Project No.: 0201-11509
Date Tested: 95-01-18

Test Hole No.: Sa.#2187
Depth (m):
Test Number: DS-1

Initial Sample Conditions

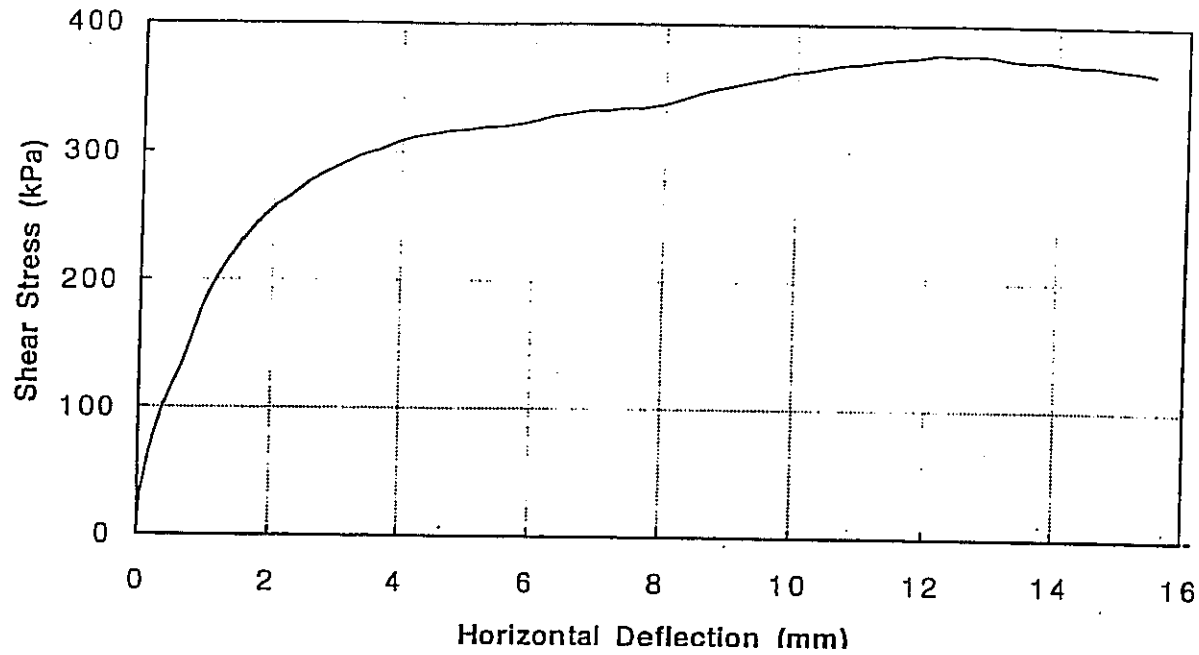
Moisture Content (%): 10.0
Wet Density (Mg/m3): 2.011
Dry Density (Mg/m3): 1.828

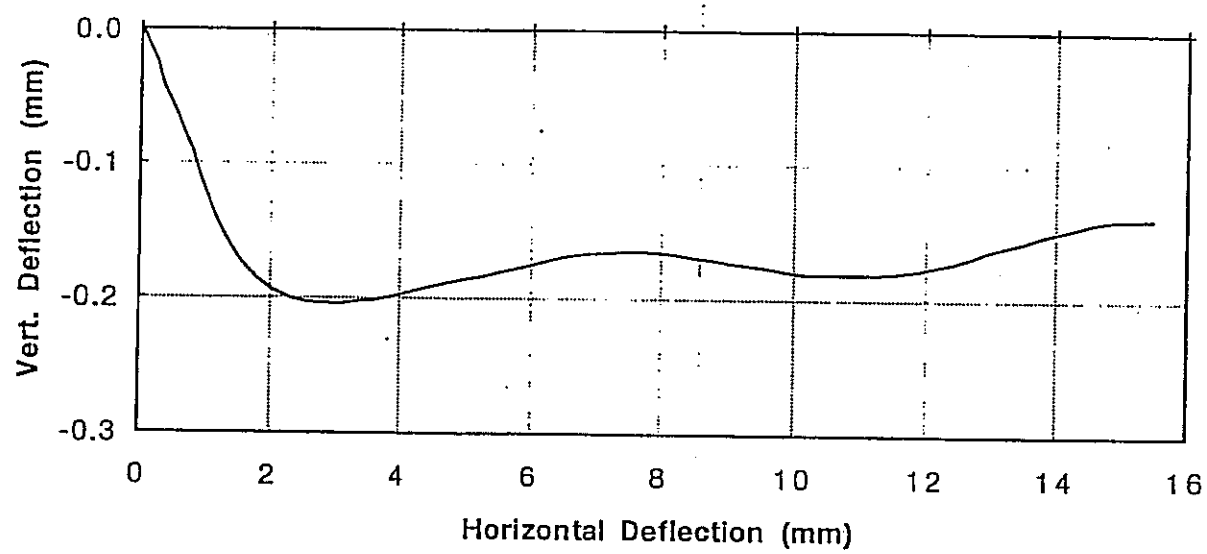
Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)	Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)
0.00	0.000	0.0	7.43	-0.165	335.5
0.04	-0.002	31.1	7.70	-0.164	335.3
0.13	-0.012	60.9	7.97	-0.166	337.9
0.24	-0.024	81.5	8.23	-0.167	341.8
0.34	-0.042	101.2	8.50	-0.169	346.5
0.64	-0.074	133.8	8.76	-0.171	349.6
0.78	-0.091	154.7	9.03	-0.173	352.2
0.92	-0.112	175.0	9.30	-0.174	355.3
1.07	-0.130	192.0	9.60	-0.177	358.4
1.21	-0.146	205.3	9.87	-0.179	362.2
1.36	-0.159	217.5	10.14	-0.181	363.8
1.54	-0.173	230.6	10.42	-0.181	366.0
1.78	-0.186	245.1	10.69	-0.181	368.7
2.04	-0.195	257.6	10.97	-0.181	370.0
2.29	-0.201	266.4	11.27	-0.181	372.3
2.55	-0.203	275.9	11.54	-0.180	373.5
2.80	-0.204	283.5	11.85	-0.178	374.8
3.06	-0.205	290.2	12.14	-0.175	377.2
3.35	-0.203	297.1	12.41	-0.172	376.4
3.62	-0.202	301.3	12.68	-0.168	376.7
3.91	-0.199	307.1	12.95	-0.163	376.5
4.18	-0.196	311.5	13.26	-0.159	373.4
4.44	-0.192	314.4	13.53	-0.156	372.5
4.71	-0.189	316.7	13.80	-0.152	372.8
4.97	-0.186	317.6	14.08	-0.148	370.6
5.24	-0.184	319.6	14.35	-0.145	369.5
5.51	-0.181	320.4	14.62	-0.142	369.4
5.80	-0.178	322.3	14.90	-0.140	367.4
6.06	-0.175	325.4	15.21	-0.139	365.8
6.33	-0.171	328.8	15.49	-0.139	363.4
6.60	-0.169	330.8			
6.88	-0.167	333.2			
7.15	-0.166	333.2			

EBA Engineering Consultants Ltd.

Direct Shear Test

Peak Stress= 377 kPa





Test Hole Number: Sa.#2187
Depth:
Normal Stress(kPa): 480
Displ. Rate(mm/min.): 0.24
Test No.: DS-1

EBA Engineering Consultants Ltd.

Direct Shear Test

Project No.: 0201-11509
Date Tested: 95-01-19

Test Hole No.: Sa.#2187
Depth (m):
Test Number: DS-2

Initial Sample Conditions

Moisture Content (%): 9.9
Wet Density (Mg/m3): 1.974
Dry Density (Mg/m3): 1.795

Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)	Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)
0.00	0.000	0.0	7.65	-0.404	693.0
0.07	-0.002	46.3	7.92	-0.402	696.2
0.13	-0.007	87.4	8.18	-0.400	696.3
0.28	-0.027	134.4	8.44	-0.400	697.6
0.38	-0.046	172.3	8.71	-0.400	698.9
0.51	-0.075	209.8	8.99	-0.401	698.0
0.64	-0.091	239.3	9.25	-0.402	698.4
0.81	-0.133	274.6	9.52	-0.402	697.0
1.09	-0.176	309.1	9.79	-0.406	697.2
1.34	-0.206	349.9	10.05	-0.411	705.9
1.60	-0.240	384.0	10.32	-0.415	713.6
1.85	-0.263	412.4	10.59	-0.419	720.6
2.10	-0.286	442.4	10.88	-0.423	727.1
2.35	-0.306	468.9	11.15	-0.426	733.0
2.60	-0.322	493.4	11.44	-0.429	739.4
2.86	-0.336	513.6	11.71	-0.430	744.6
3.11	-0.348	532.1	11.99	-0.431	747.7
3.38	-0.359	549.9	12.25	-0.431	751.2
3.64	-0.367	565.8	12.54	-0.431	754.7
3.90	-0.375	580.3	12.81	-0.430	759.1
4.16	-0.383	593.9	13.08	-0.428	760.6
4.42	-0.390	607.4	13.35	-0.427	761.5
4.68	-0.395	620.2	13.62	-0.425	763.4
4.95	-0.400	632.4	13.95	-0.423	766.6
5.23	-0.404	642.9	14.29	-0.422	767.7
5.50	-0.407	651.9	14.65	-0.420	768.0
5.76	-0.409	659.9	14.86	-0.420	767.6
6.03	-0.410	665.3	15.14	-0.420	767.6
6.30	-0.410	672.5	15.42	-0.419	767.4
6.56	-0.410	677.2			
6.82	-0.410	680.5			
7.11	-0.409	686.2			
7.38	-0.407	689.5			

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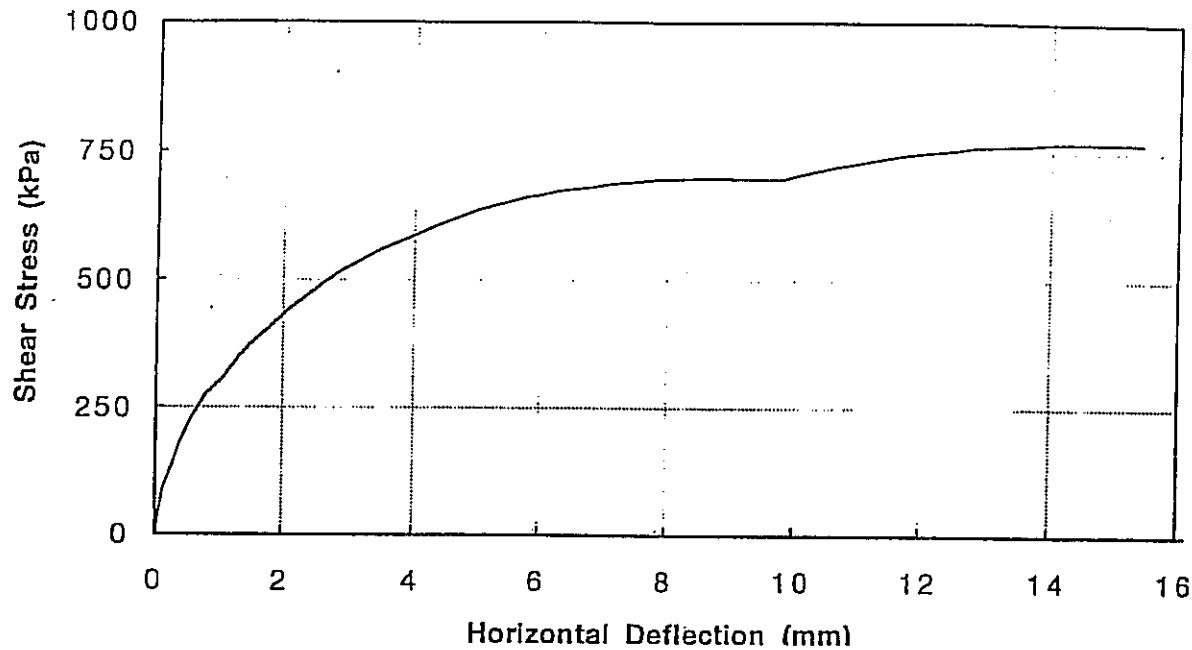
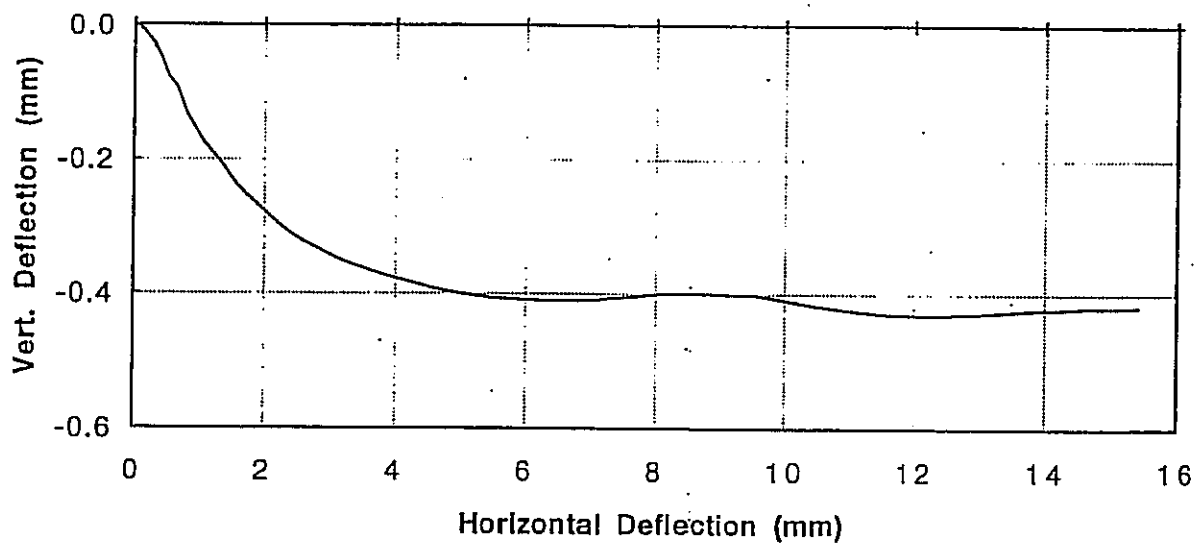
Direct Shear Test

Peak Stress= 768 kPa





Test Hole Number: Sa.#2187
Depth:
Normal Stress(kPa): 960
Displ. Rate(mm/min.): 0.24
Test No.: DS-2

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EBA Engineering Consultants Ltd.

Direct Shear Test

Project No.: 0201-11509
Date Tested: 95-01-20

Test Hole No.: Sa.#2187
Depth (m):
Test Number: DS-3

Initial Sample Conditions

Moisture Content (%): 10.1
Wet Density (Mg/m3): 1.982
Dry Density (Mg/m3): 1.800

Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)	Horiz. Disp. (mm)	Vert Disp. (mm)	Shear Stress (kPa)
0.00	0.000	0.0	8.34	-0.416	1077.8
0.13	-0.004	78.4	8.60	-0.413	1082.6
0.31	-0.018	167.1	8.87	-0.410	1084.3
0.41	-0.033	230.4	9.16	-0.410	1086.8
0.58	-0.069	302.2	9.42	-0.411	1090.1
0.80	-0.111	371.5	9.69	-0.411	1095.5
1.07	-0.156	430.5	9.95	-0.411	1099.7
1.30	-0.187	486.6	10.22	-0.411	1102.8
1.55	-0.223	542.9	10.49	-0.412	1104.3
1.87	-0.264	606.7	10.76	-0.415	1102.0
2.13	-0.294	654.7	11.06	-0.418	1101.0
2.38	-0.320	696.4	11.33	-0.422	1097.9
2.67	-0.346	737.1	11.60	-0.425	1093.9
2.92	-0.365	770.7	11.87	-0.430	1090.1
3.16	-0.382	803.0	12.19	-0.437	1099.9
3.42	-0.397	834.1	12.40	-0.441	1109.9
3.70	-0.410	865.2	12.70	-0.448	1115.2
3.97	-0.418	886.7	12.96	-0.453	1116.1
4.26	-0.426	912.9	13.23	-0.455	1118.1
4.50	-0.431	931.2	13.50	-0.458	1126.2
4.76	-0.436	949.0	13.77	-0.463	1132.2
5.07	-0.440	969.8	14.03	-0.467	1138.1
5.32	-0.442	986.4	14.31	-0.471	1143.3
5.60	-0.444	1000.9	14.60	-0.476	1146.7
5.88	-0.444	1014.4	14.88	-0.480	1150.8
6.15	-0.444	1025.6	15.15	-0.484	1153.3
6.43	-0.442	1037.6	15.43	-0.487	1155.2
6.71	-0.439	1045.6			
6.99	-0.435	1055.4			
7.28	-0.431	1059.5			
7.54	-0.428	1066.7			
7.80	-0.423	1069.9			
8.12	-0.418	1074.9			

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EBA Engineering Consultants Ltd.

CONSTANT HEAD PERMEABILITY TEST

Job Number: 0201-11509
Test Hole: Sa.#2187 Depth:

Date: 95-02-14
Test No: P-9

Time	Buret (cc)	Elap. (min)	Outflow (cc)
10:36	40.6	0	0.0
10:47	45.4	11	4.8
10:58	49.7	22	9.1
11:10	54.2	34	13.6
11:28	61.0	52	20.4
11:42	66.3	66	25.7
12:04	74.1	88	33.5
12:30	83.0	114	42.4
12:59	92.7	143	52.1
13:29	81.7	173	63.1
13:56	72.7	200	72.1
14:27	62.4	231	82.4
14:54	53.3	258	91.5
15:22	44.2	286	100.6

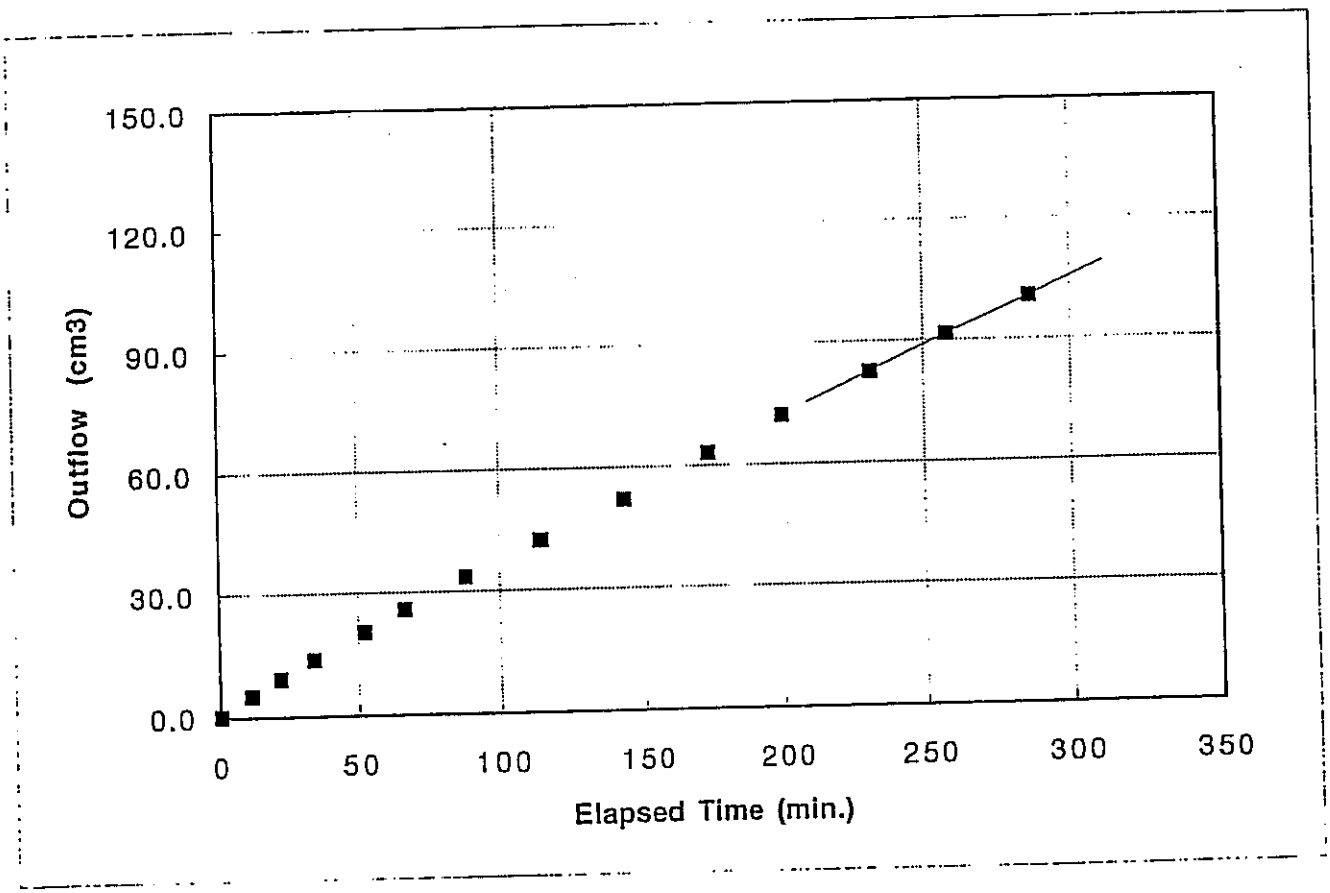
Diameter= 89.7 mm
Height= 72.5 mm

Volume= 458.16 cm3

Head Diff.= 3.9 psi

Q= 0.0055152 cm3/sec
i= 37.84
A= 63.19 cm2

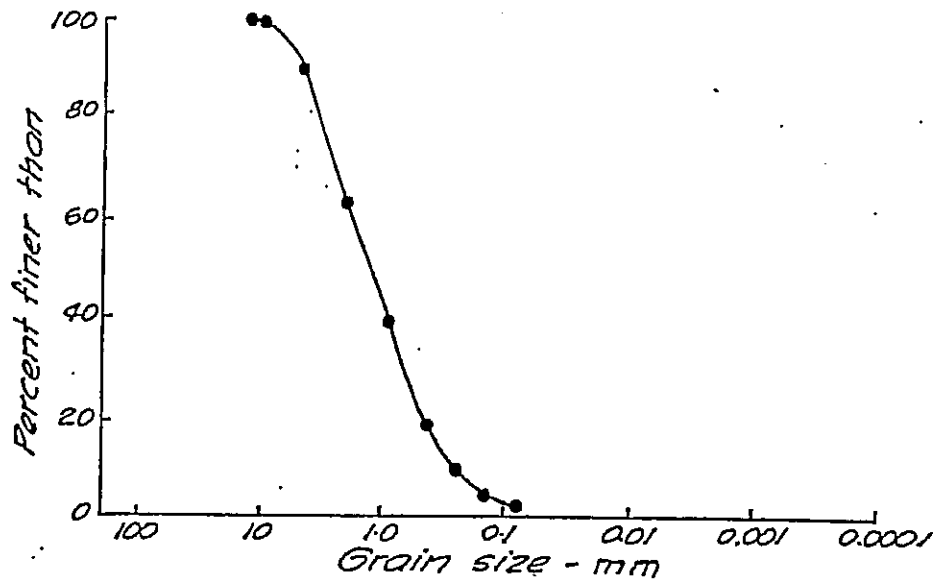
K= 2.31E-06 cm/sec



RESIDUAL SOIL TEST RESULTS
SAMPLE RS-1

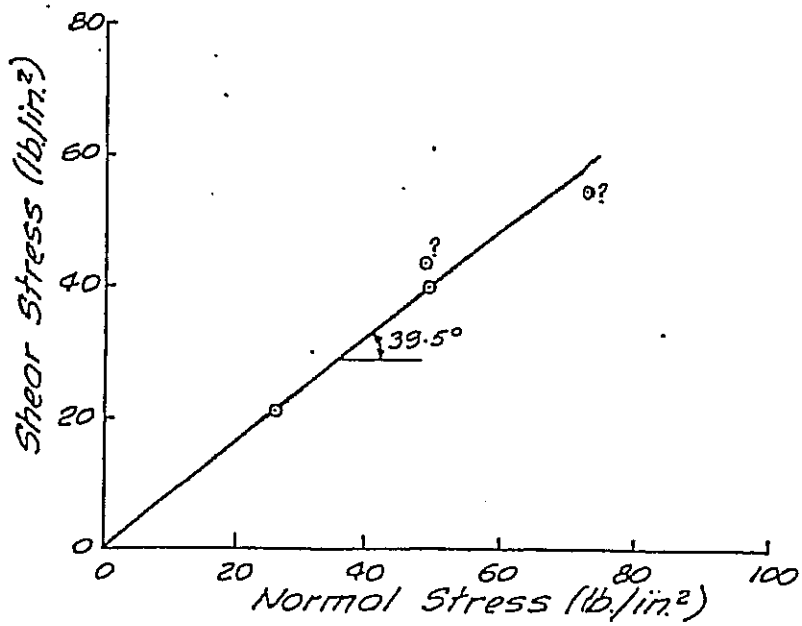
FIGURE VIb - 1

GRAIN SIZE DISTRIBUTION



Cobble	Gravel	Sand	Silt	Clay

SHEAR TEST CHARACTERISTICS



MOISTURE CONTENT = 4·2 %

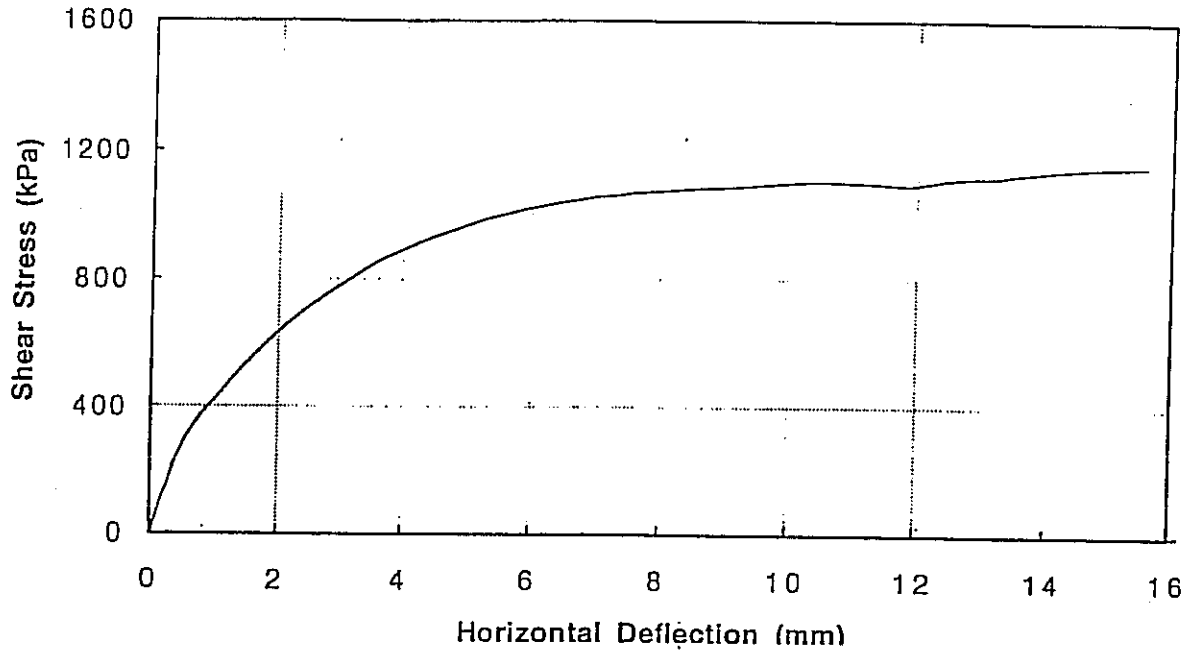
Golder Associates

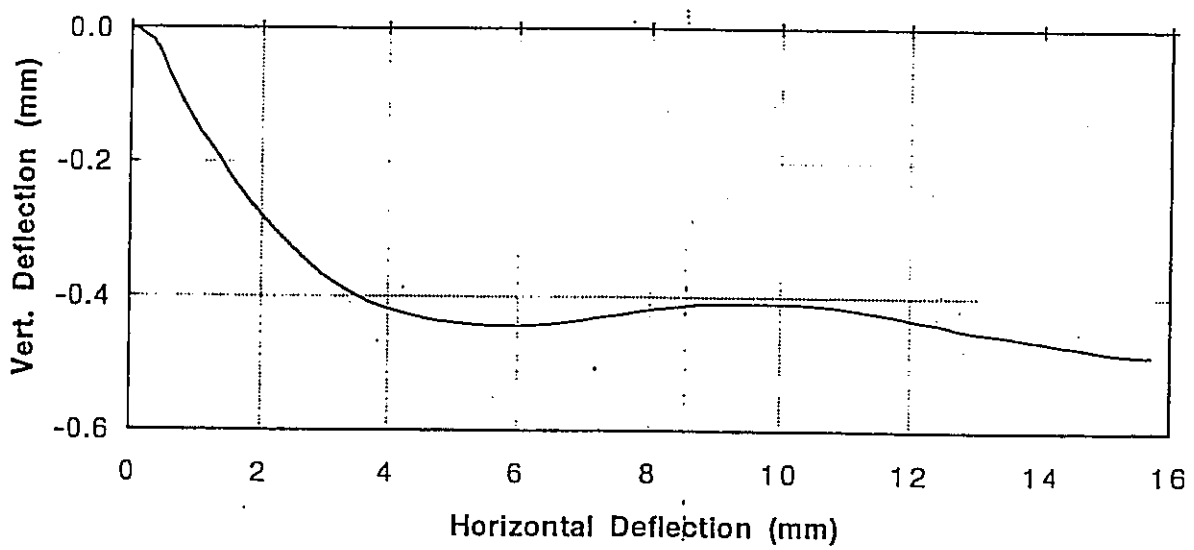
Drawn S.H.
Approved
Date

EBA Engineering Consultants Ltd.

Direct Shear Test

Peak Stress= 1155 kPa





Test Hole Number: Sa.#2187
Depth:
Normal Stress(kPa): 1440
Displ. Rate(mm/min.): 0.24
Test No.: DS-3

eba

EBA Engineering Consultants Ltd.

CONSTANT HEAD PERMEABILITY TEST

Job Number: 0201-11509
Test Hole: Sa.#2187 Depth:

Date: 95-02-14
Test No: P-9

Time	Buret (cc)	Elap. (min)	Outflow (cc)
10:36	40.6	0	0.0
10:47	45.4	11	4.8
10:58	49.7	22	9.1
11:10	54.2	34	13.6
11:28	61.0	52	20.4
11:42	66.3	66	25.7
12:04	74.1	88	33.5
12:30	83.0	114	42.4
12:59	92.7	143	52.1
13:29	81.7	173	63.1
13:56	72.7	200	72.1
14:27	62.4	231	82.4
14:54	53.3	258	91.5
15:22	44.2	286	100.6

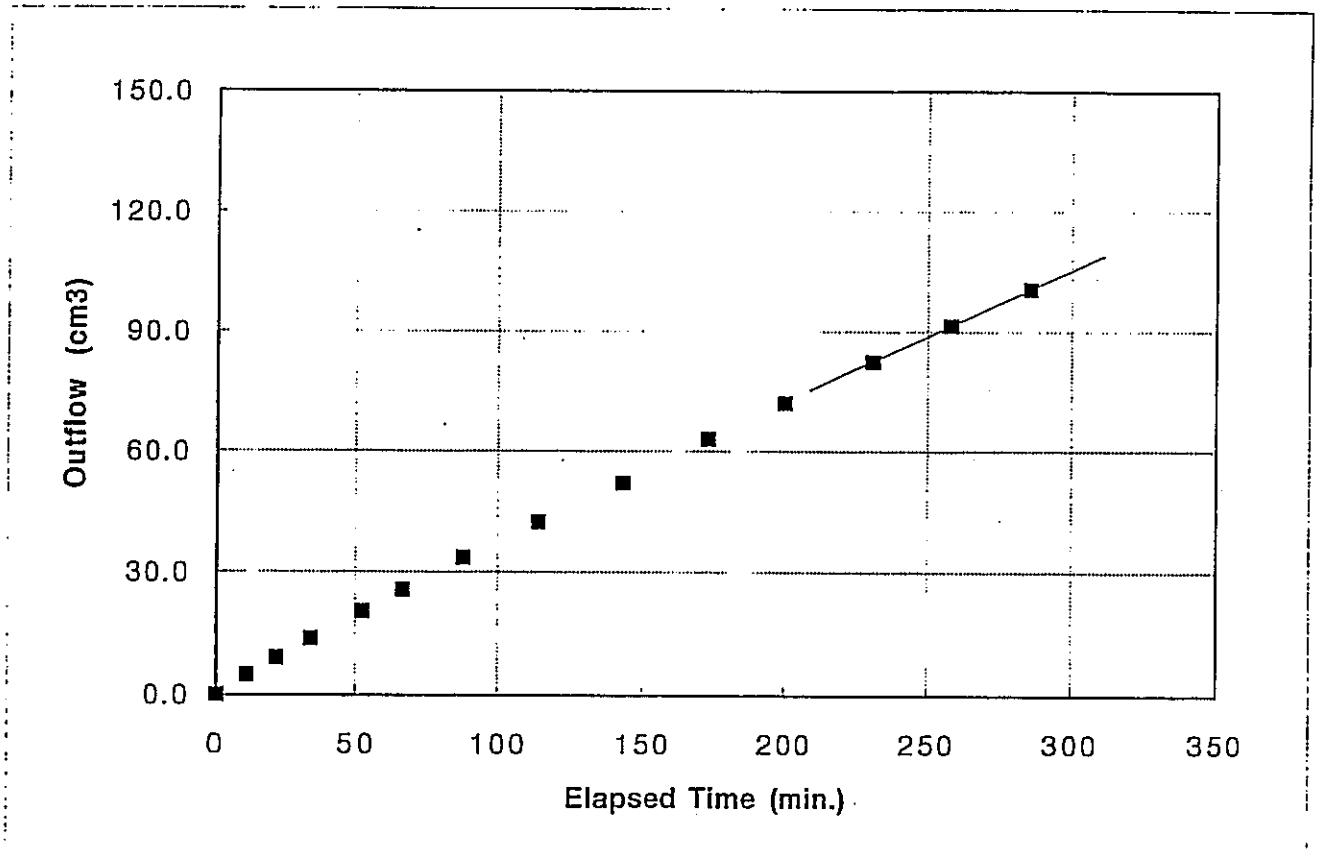
Diameter= 89.7 mm
Height= 72.5 mm

Volume= 458.16 cm3

Head Diff.= 3.9 psi

Q= 0.0055152 cm3/sec
i= 37.84
A= 63.19 cm2

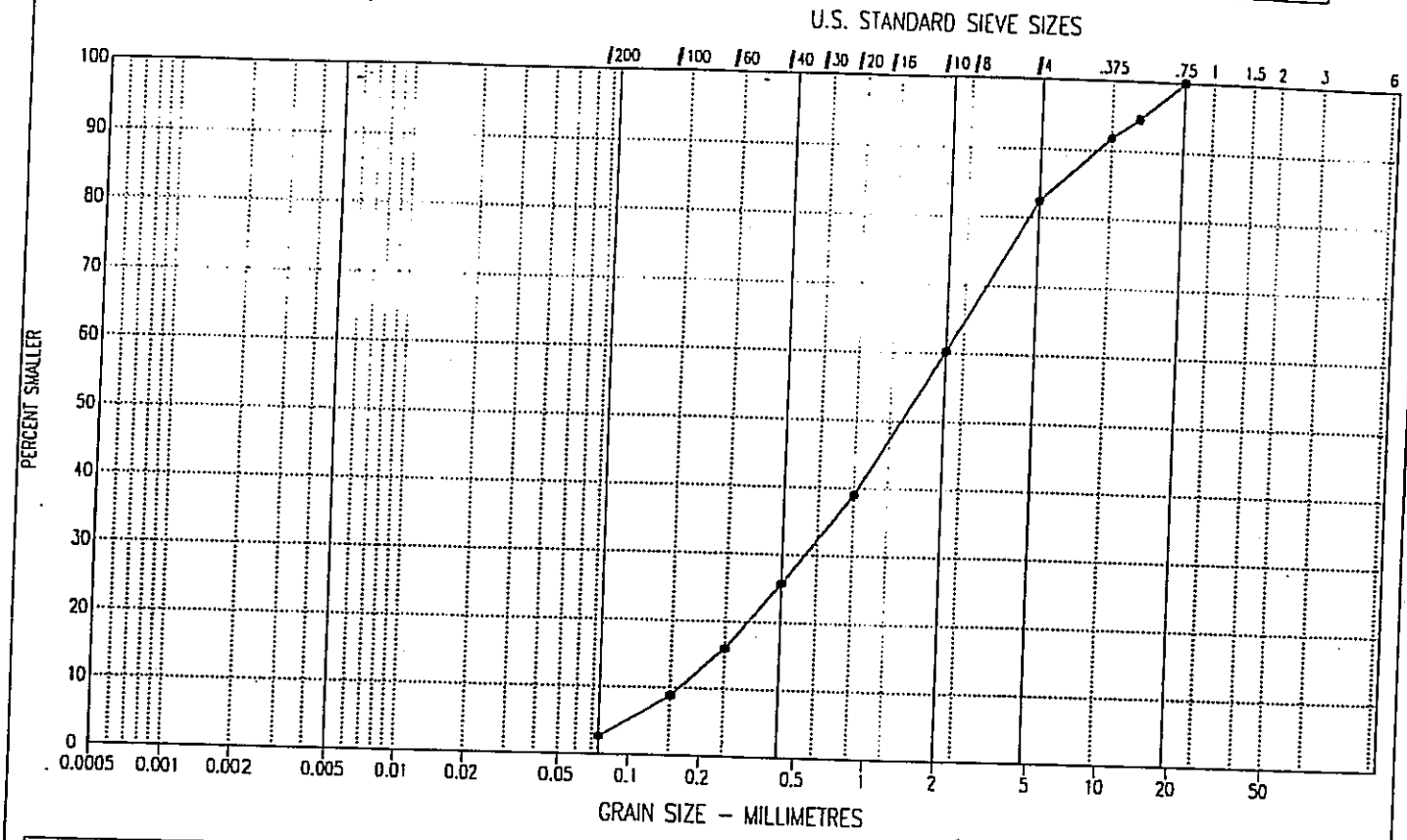
K= 2.31E-06 cm/sec



EBA Engineering

PARTICLE SIZE – ANALYSIS OF SOILS

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●——●	S-2187	0.00	2.6	79.8	17.6	12.0	1.0	SP

WASHED RESIDUUM

Project: 201-11509

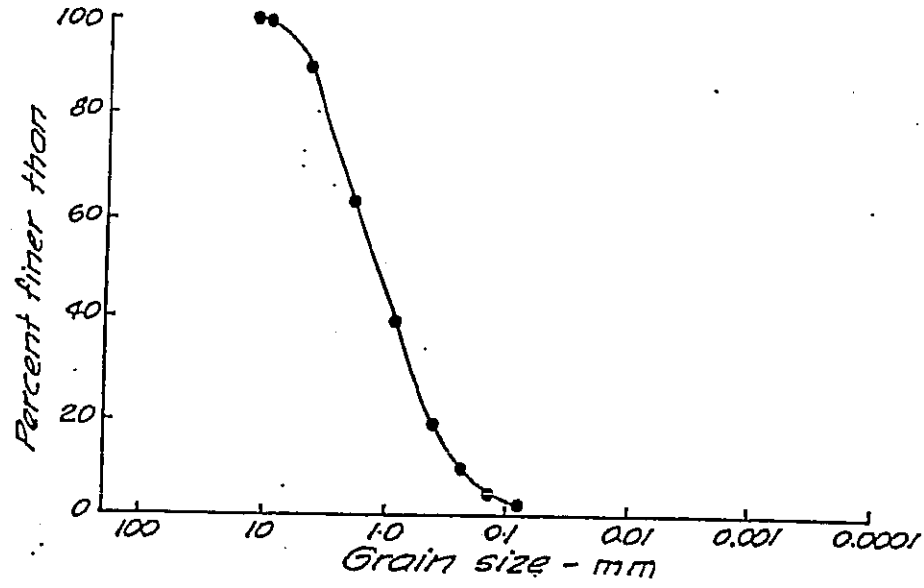
Date Tested: 95/02/17 BY: IS

Tested in accordance with ASTM D422 unless otherwise noted.

RESIDUAL SOIL TEST RESULTS
SAMPLE RS-1

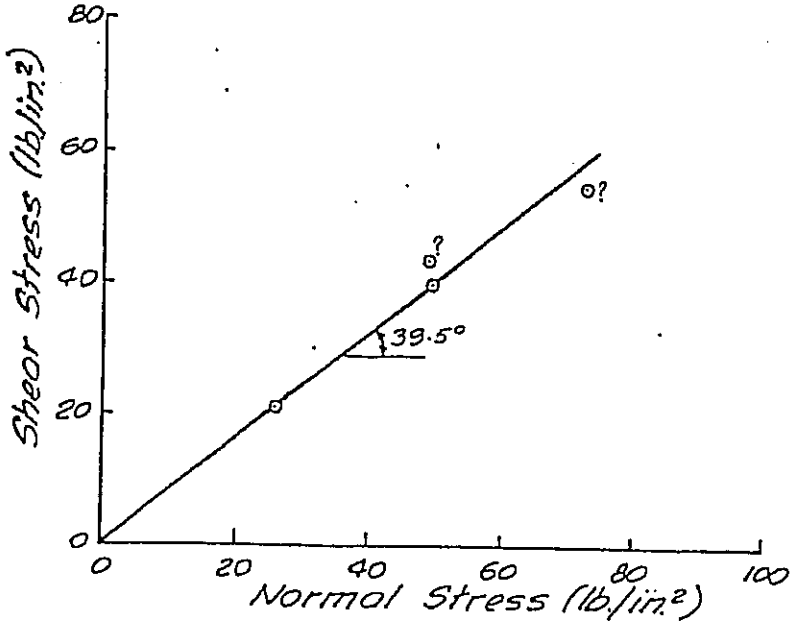
FIGURE VIb - 1

GRAIN SIZE DISTRIBUTION



Cobble	Gravel	Sand	Silt	Clay

SHEAR TEST CHARACTERISTICS



MOISTURE CONTENT = 4.2%

Drawn S.H.
Approved

EBA Engineering Consultants Ltd.

CONSTANT HEAD PERMEABILITY TEST

Job Number: 0201-11509
Test Hole: Sa.#2187 Depth:

Date: 95-02-16
Test No: P-10

Time	Buret (cc)	Elap. (min)	Outflow (cc)
14:32	7.5	0.0	0.0
14:32	10.5	0.5	3.0
14:33	13.5	1.0	6.0
14:33	16.5	1.5	9.0
14:34	19.0	2.0	11.5
14:34	22.0	2.5	14.5
14:35	25.0	3.0	17.5
14:35	27.5	3.5	20.0
14:36	30.0	4.0	22.5
14:36	32.5	4.5	25.0
14:37	35.5	5.0	28.0
14:37	38.5	5.5	31.0
14:38	41.5	6.0	34.0
14:38	44.0	6.5	36.5
14:39	47.0	7.0	39.5

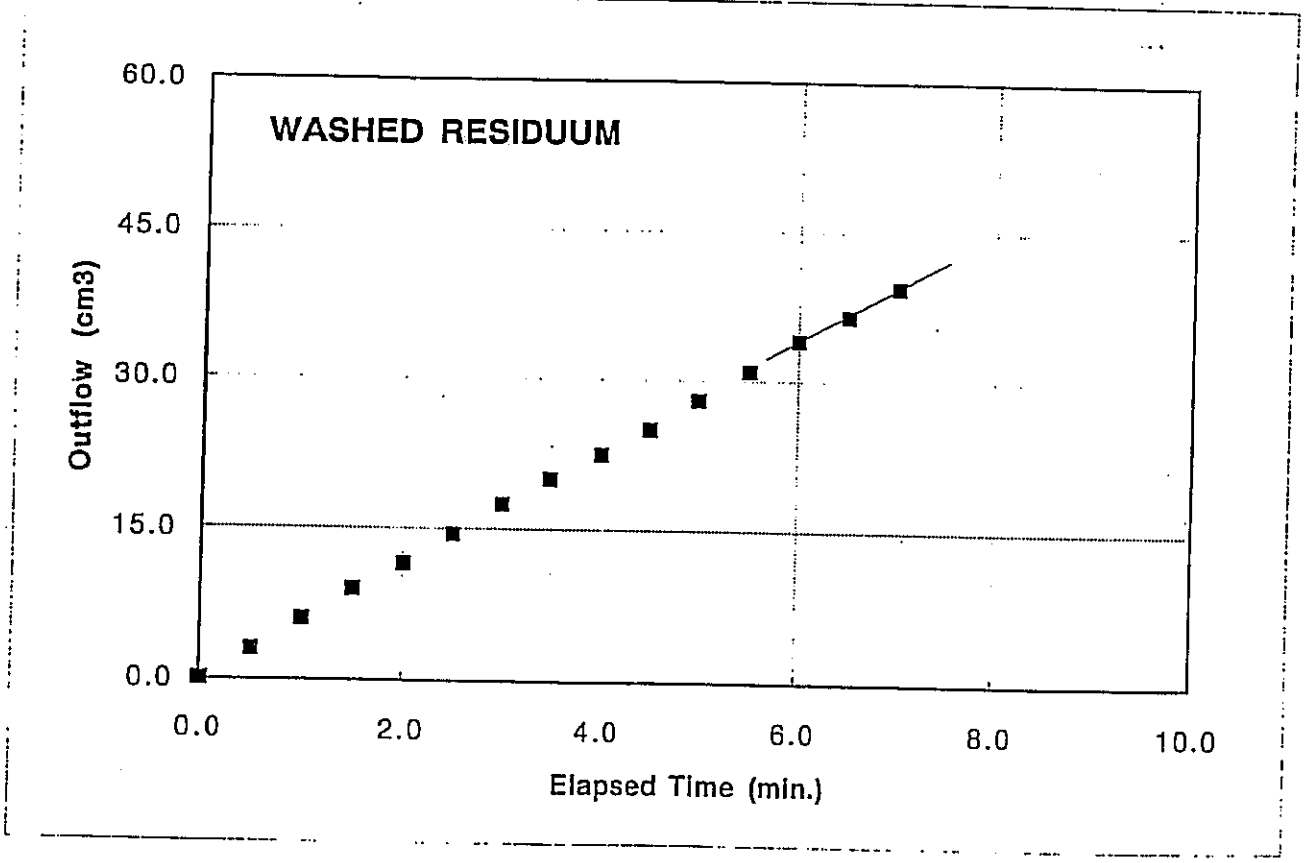
Diameter= 89.7 mm
Height= 62.1 mm

Volume= 392.43 cm3

Head Diff.= 0.47 psi

Q= 0.1 cm3/sec
i= 5.32
A= 63.19 cm2

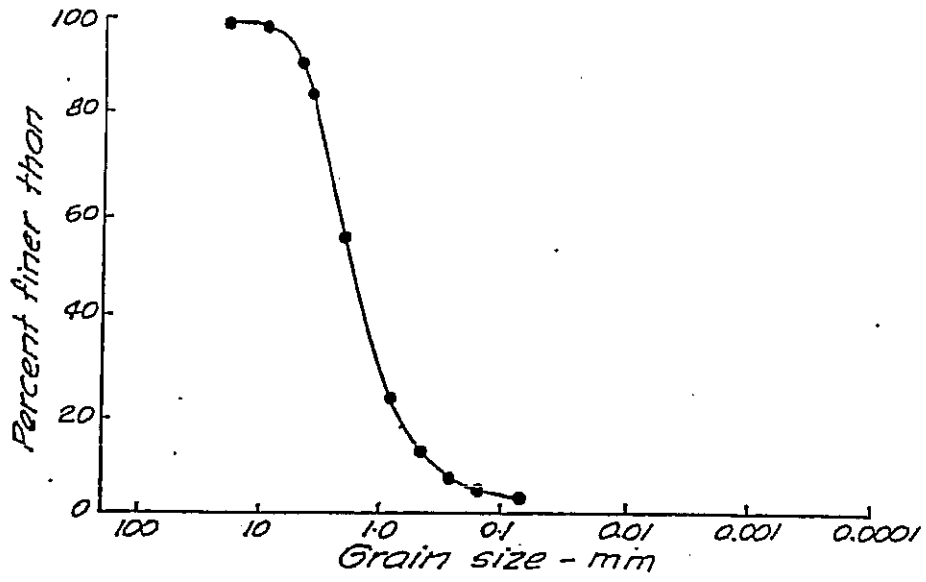
K= 2.97E-04 cm/sec



RESIDUAL SOIL TEST RESULTS
SAMPLE RS-2

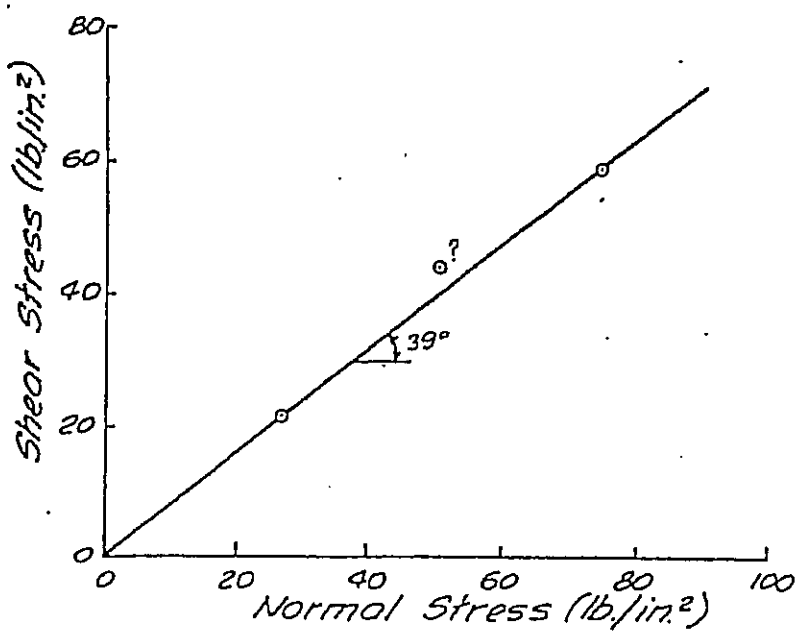
FIGURE VIb - 2

GRAIN SIZE DISTRIBUTION



Cobble	Gravel	Sand	Silt	Clay

SHEAR TEST CHARACTERISTICS



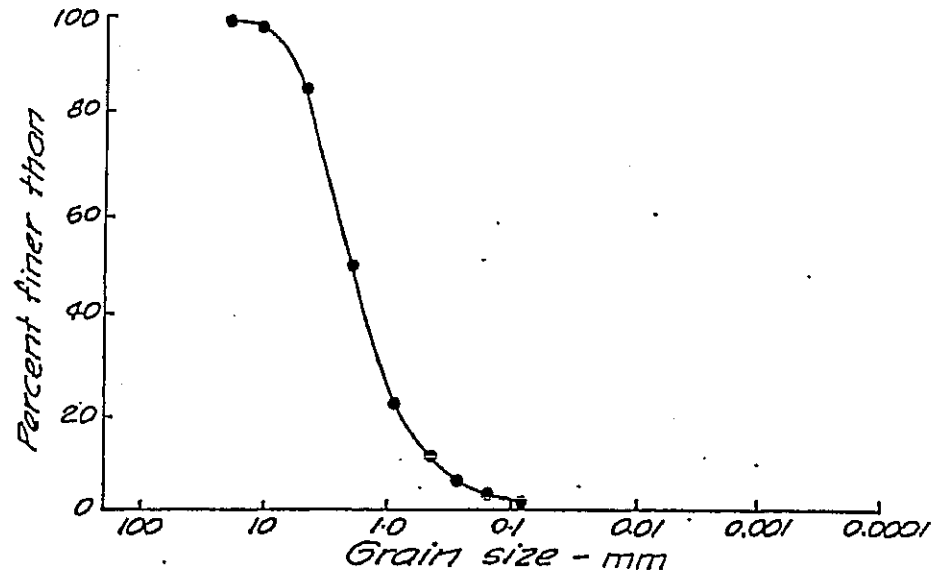
MOISTURE CONTENT = 4.4 %

Drawn S.H.
Approved

RESIDUAL SOIL TEST RESULTS
SAMPLE RS-3

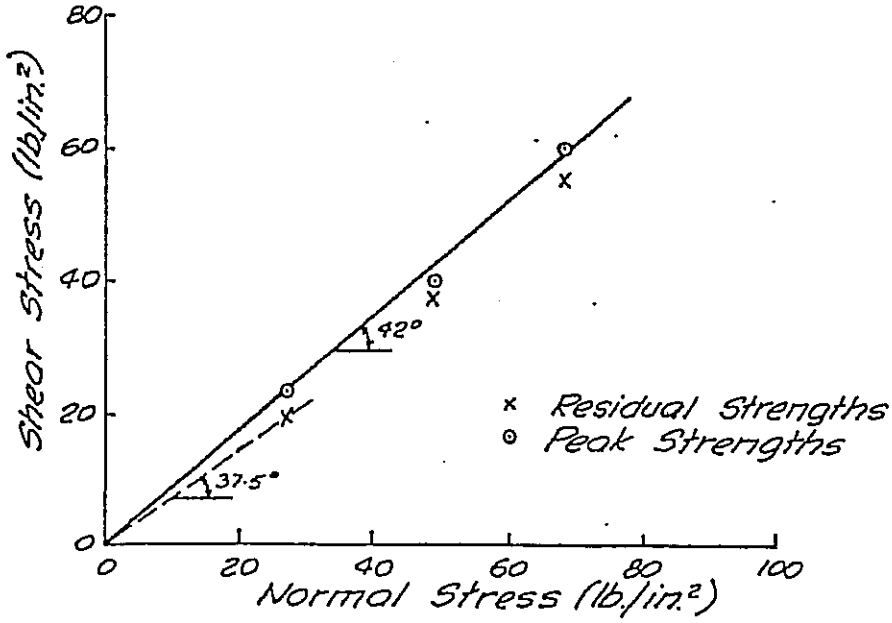
FIGURE VIb - 3

GRAIN SIZE DISTRIBUTION



Cobble	Gravel	Sand	Silt	Clay

SHEAR TEST CHARACTERISTICS



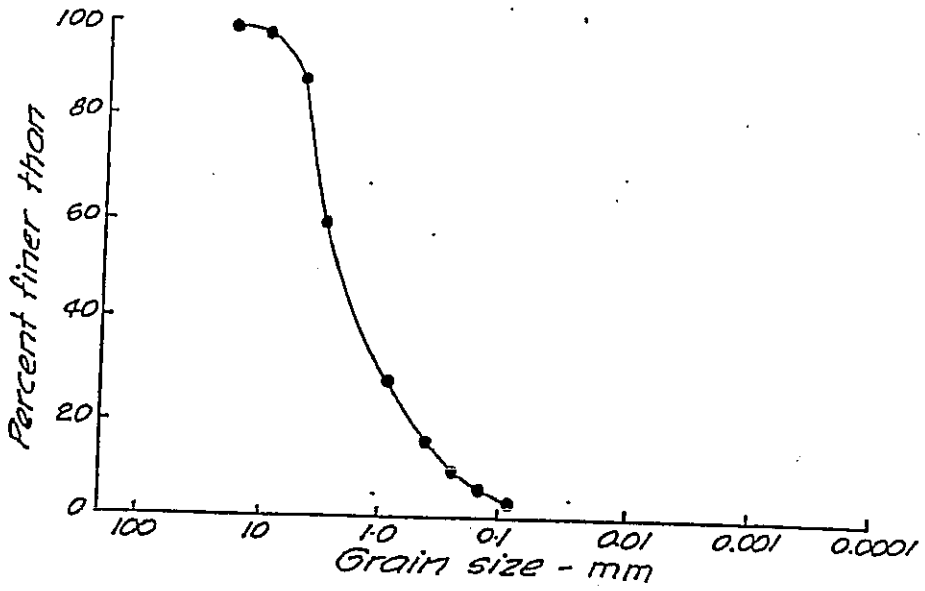
MOISTURE CONTENT = 3·2 %

Drawn S.H.
Approved

RESIDUAL SOIL TEST RESULTS
SAMPLE RS-4

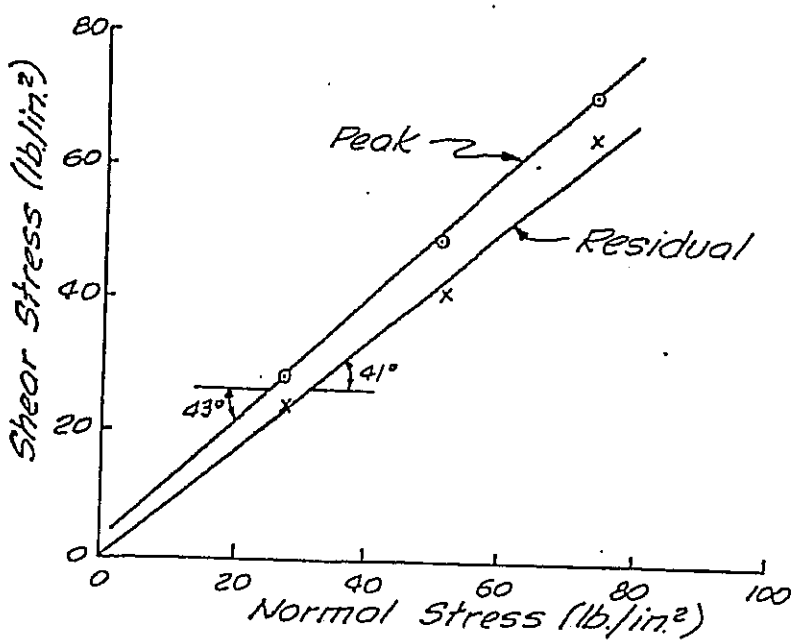
FIGURE VIb - 4

GRAIN SIZE DISTRIBUTION



Cobble	Gravel	Sand	Silt	Clay

SHEAR TEST CHARACTERISTICS



MOISTURE CONTENT = 3·2%

Drawn S.H.
Approved B.

Project No. 176055

GRAIN SIZE DISTRIBUTION
SAND AND GRAVEL - RESIDUAL OVERBURDEN

FIGURE 6