Knight Piésold Ltd.
CONSULTING ENGINEERS

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

RESPONSE TO REVIEW COMMENTS ON TAILINGS EMBANKMENT DESIGN

(REF. NO. 1625/6)

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Knight Piésold Ltd.
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SECTION 1.0 - INTRODUCTION

We are pleased to provide the following responses to the comments made by Mr. C.O. Brawner with respect to his review of the Mt. Polley Tailings Embankment design. Several of the points raised by Mr. Brawner have previously been discussed with Mr. G. Headley of the Ministry of Energy Mines and Petroleum Resources (MEMPR) - Geotechnical Division and have already been included in the detailed design drawings and technical specifications which may not have been made available for Mr. Brawner's review.

SECTION 2.0 - RESPONSES

Mr. Brawner's comments are presented in *italics* and are discussed in the order of his presentation.

General

The plan is to develop three pits. From environmental, volume storage and tailings dam height considerations it is recommended that Imperial Metals be requested to review in detail the potential to mine the pit sequentially and place tailings in them on completion of Pit 1 followed by Pit 2. The stability and environmental benefits are significant. There may also be a cost saving.

The Mt. Polley deposit is a complicated ore body which requires mining from all three pits at various times in order to optimize grade and recovery. The mine plan is being developed by Imperial Metals Mine Engineering staff who are considering various development and waste storage options including in-pit storage of waste and possibly tailings. Knight Piésold consider in-pit tailings disposal to be a viable concept, but this should only be evaluated later on in the mine life, once the open pit development schedule is well defined. Therefore, in-pit tailings disposal is considered to be a possible opportunity for future mine development. We feel it is conservative to ignore this possible option at the present time and continue to plan for secure surface disposal of all tailings solids.

Site Investigation

Only one drill hole appears to have been drilled in the main embankment area. In B.C. valleys there is always the possibility of buried high permeability zones. It is recommended that 2 more boreholes to expand the geotechnical information be drilled and tested.

One hole has been drilled in the Main Embankment area (MP89-234), as noted by Mr. Brawner. It has previously been discussed with Mr. Headley (MEMPR) and it was agreed that three additional holes will be drilled, logged and sampled by a geotechnical engineer during the initial stages of construction as part of the embankment instrumentation and monitoring requirements. The holes are specified in the Technical Specifications and shown on Drawing Nos. 510-77-01-1625.220 and 1625.221. They will be drilled to about 15m depth and will be located in the bottom of the main valley, where significant overburden is known to be present. Lab testing will be conducted on the samples as required and vibrating wire piezometers will be installed in the embankment foundation for long term water pressure monitoring.

Glaciofluvial Sediments in the Tailings Basin

It is noted that obtaining good compaction and density of the till liner over the sediments will be difficult due to poor underlying support of the sediments.

Has removal of the sediments been considered so the liner is not required?

We do not consider total removal of the sediments to be a viable option, as these materials are suspected to underlie the dense low permeability glacial till within the basin. The glacial till materials were deposited when a glacier extended over the area, and it was this glaciation which caused the heavily over consolidated nature of the underlying sediments. Therefore, the basin liner is merely an extension of this natural low permeability glacial till cover and is only required in those areas where the natural glacial till deposit has been removed by recent surface erosion which has locally exposed the glaciolacustrine sequence in the vicinity of the proposed embankment and further downstream.

In early October, 1995, a total of 34 additional test pits were excavated and logged at the Main Embankment area. In addition, 6 test pits were excavated and logged at the Seepage Collection Pond area. This information has previously been submitted to Mr. Headley (MEMPR, Geotechnical Branch) and is included in Appendix A. The investigations are summarized below :

- The test pits were typically 6 m deep.

- Test pit excavations started in the centre of the valley and progressed toward the left (east) abutment at 25 m centres. These test pits encountered 2 to 3 m of dense, moist to wet till overlying stiff to very stiff, overconsolidated silt and silty sand (glaciolacustrine sediments). No sections of loose wet sediments were identified.

- Test pits were then excavated progressively toward the right (west) abutment at a 25 m spacing. Similar stratigraphy was encountered for approx. 125 m. At TPME-15 loose wet sand was encountered below the till. This material extended on the embankment centreline for approx. 125 m, to TPME-20. Over this area, the till cap varied from 1.7 m to 3 m thick, with loose glaciofluvial sediments underlying the till. At the upstream toe of the embankment this zone was approx. 100 m wide. It was approximately 130 m wide at the Stage Ib and Final downstream toe locations.

- The test pits excavated at the Seepage Collection Pond area were required to define the limits of the fine till and glaciolacustrine sediments in which the pond could easily be excavated. It was found that only the southwest corner was underlain by loose sediments. The rest of the pond has stiff silt and silty sand (glaciolacustrine sediments) below a till cap. Both of these materials are suitable for excavation of the pond. The pond will be relocated to avoid construction in any area with loose sediments.

Mr. Brawner has indicated that placement and compaction of the till basin liner will be difficult because of poor underlying support of the sediments and he has suggested that consideration should be given to removing the sediments. However, the test pit excavations have shown that the underlying highly overconsolidated sediments have sufficient strength characteristics to allow placement and compaction of the liner provided that all loose, wet topsoil and glacial till at the topsoil/till contact (a maximum of about 30 cm) is removed prior to fill placement. We feel that it will not be difficult to obtain good compaction and density of the basin liner and do not consider that total removal of the sediments will be necessary. In fact, the additional site investigations have indicated that the extent of the basin liner can be reduced in area due to the excellent low permeability foundation materials encountered throughout most of the tailings basin.

If the liner is placed it is suggested that a seepage cut-off be excavated and backfilled through the sediments near the upstream toe of the main embankment.

The nature and distribution of the geologic units, as described above and as shown on Drawing No. 1623.103, illustrate that it would be extremely difficult to construct a seepage cut-off at the upstream toe of the Main Embankment. In order for the cut-off wall to be effective, it must be extended to low permeability materials both vertically and laterally or else the seepage losses will merely be redirected to a different direction. Therefore, the seepage cut-off would have to be extended completely along the West Embankment. The seepage cut-off wall would be extremely difficult to construct and it is unlikely that it would provide any additional benefit and could actually result in a less efficient seepage control measures than the currently designed system.

Excavate all weak soil to at least 10 m upstream of the upstream toe of the main dam.

Any weak soils which could adversely affect construction activities, embankment stability or could compromise the efficiency of the seepage control measures will be removed and/or treated as specified in the Technical Specifications and as required by the Knight Piésold supervising engineers.

Underdrains

The design of all drain pipe must have sufficient strength to resist full earth load.

All drain lines that exit the dams must be designed so they can be cleaned for distances of about 100 m.

All culverts and drain lines must be designed or protected from icing up in the winter.

The design of the embankment drainage pipeworks is illustrated on Drawing No. 510-14-03-1625.202. The drainage pipeworks consist of CPE embankment foundation drains and DR17 HDPE pipework for the toe drains which pass through the abutments at the Main Embankment. The perforated CPE foundation drains are not required to resist full earth loads as the drains include a gravel surround which provides contingency flow capacity. The HDPE toe drains pass below the core zone and have been designed to withstand full earth loads from the ultimate embankment. The HDPE drains could be cleaned out as recommended by Mr Brawner, and additional toe drains can also be installed during future embankment raises, if necessary.

A series of perforated CPE drain pipes surrounded by gravel and filter fabric were previously included for control of groundwater during construction of the partial basin liner and for long term monitoring. However, the additional site investigation test pits described above and in Appendix A, indicate that the extent of the constructed basin liner will be reduced and the comprehensive drainage network will not be required. Therefore, the basin groundwater drains have been removed from the current Detailed Design Drawings.

All embankment drainage pipes will be covered by a minimum of 1 m of soil to prevent freezing. Buried pipeworks downstream of the embankment also include a cover berm, both for protection from icing and for easy identification and location of the pipes. The outlet pipeworks discharge to a covered drainage sump prior to discharge below the water (or ice) surface of the seepage collection pond.

Sediment control pipeworks, culverts and flow control structures associated with other components of the tailings storage facility also include standard provisions for cold weather operations.

Seepage Collection Pond

In the event that Imperial Metals may find more ore and tailings volume increases, the dam should only be increased in height by the downstream method. To allow for this the seepage collection pond should be located so such change will not encroach on the pond.

The design currently incorporates a buffer zone of approximately 35 m immediately downstream of the toe of the final embankment limits. The storage capacity of the tailings impoundment could be easily expanded to accommodate over 30 million additional tonnes of tailings by raising the final embankment crest by about 17 m using the centreline construction method. Furthermore, it would be a relatively simple exercise to relocate the seepage collection pond further downstream to provide additional space for further extension of the downstream toe of the embankment should this be necessary in the future.

Filter Design

Filter gradation is required to be shown. The design must be conservative.

Filter gradations for construction materials are shown on Drawing No. 510-14-03-1625.212, which is taken from part of the Technical Specifications. The gradation of the tailings is shown on Figure 1 (from Tailings Storage Facility Design Report, Ref. No. 1625/1, May 26, 1995).

The filter materials are considered to be 'non-critical' as defined by Sherard et al (Sherard, J.L., Dunnigan, L.P. and Talbot, J.R., 1984. "Filters For Silts and Clays", ASCE Journal of Geotechnical Engineering, Vol. 110, No. GT6), as they are situated upstream of the core zone. However, the specified filter gradations have been conservatively designed to meet the more rigorous criteria for 'critical' filters. Therefore, the specified filter gradations meet or exceed conventional filter requirements for both the glacial till core zone and for the tailings solids.

Index tests on the bulk tailings sample shown on Figure 1 indicate that the material is non-plastic and fine grained, with 6 percent clay, 64 percent silt and 30 percent fine sand. The operations of the tailings spigotting system will lead to some separation of the tailings adjacent to the embankment, whereby coarser materials will settle out rapidly and finer materials will be transported further out into the pond. The result is that additional filter relationships will be developed between the fine and coarse tailings as well as between the coarser tailings and embankment fill materials. In the event that cracks develop on the embankment from the upstream side, it is anticipated that the tailings will also function as a crack stopping filter medium.

Random Fill

Provide the range of acceptable gradation.

Gradation envelopes for embankment fill materials are also included on Drawing No. 510-14-03-1625.212.

Compaction

Substantial direction is made to the use of vibrating compactors. This method usually develops a moisture profile in the lift and brings fines to the surface. Whenever vibrating compactors are used the surface must be scarified prior to placing the next lift.

Where soils to be compacted contain a moderate clay fraction it is better to use a heavy grid or club foot compactor. The grid roller is the most versatile, being suitable to all soil and gradations and can be pulled at a faster speed than other types for equivalent density.

We disagree with Mr. Brawner' s comments about vibrating compactors and we have specified in the Technical Specifications that a self-propelled 10 ton (minimum) vibratory wedge foot roller be used to compact the glacial till. This compactor is excellent for glacial till as it combines the kneading properties of a sheepsfoot (or club foot) roller with the high compactive energy provided by a vibratory roller. The wedge foot compactor leaves a rough, pitted surface which does not require scarification. Vibratory rollers can produce a "moisture profile" when operating on materials that are significantly wet of the optimum moisture content. However, it is intended that any materials which are so wet as to interfere with proper compaction will not be permitted. The specified wedge foot roller could be operated in the static mode (no vibration) if wet materials were approved for placement in the embankment fill zones. Moisture Content - Density relationships for compaction equipment are discussed further under ***Compaction Tests*** below.

Groundwater Monitoring Wells

Provide the location of these wells. Several must be downstream. List test requirements.

Three permanent groundwater quality monitoring wells have been specified in the detailed design of the Tailings Storage Facility. The locations are shown on Drawing No. 510-12-02-1625.205. Additional monitoring wells will be installed as required during operations and as outlined in "Groundwater Monitoring Design Document" (Knight Piésold Ltd. Ref. No. 1625/5, May 19,1995).

All monitoring wells will be installed in accordance with the industry standards and regulatory requirements, including proper well development and regular sampling and testing. The installation and monitoring requirements are also described in detail in "Groundwater Monitoring Design Document" (Knight Piésold Ltd. Ref. No. 1625/5, May 19,1995).

Compaction Tests

Why is Modified Proctor density used as the reference? Standard Proctor density is more common. A higher moisture content can be tolerated with Standard Proctor criteria. Over-compaction results in a brittle dam structure with limited flexibility to deal with differential settlement.

Mr. Brawner's statements reflect a common misconception within the earthworks construction industry. As indicated on Figure 1, there are different moisture-density relationships depending on the level of compactive effort applied. The Standard Proctor energy is lower than for the Modified Proctor test and, for the given example, the machine compaction energy is still higher.

It is evident from Figure 2 that if one only considers the individual test results, the 'maximum' density decreases as the compaction effort is reduced, and the 'optimum' moisture content also increases as the compactive effort is reduced. However, the theoretical moisture content - density relationship for a soil is defined by the zero air voids line, but we generally find that the 2% air voids line is usually the control in practice. Consequently, if the Standard Proctor moisture density criteria are specified, a lower density fill with a higher permeability and greater compressibility can result. Also, if the contractor attempts to place the fill at the standard proctor optimum moisture content with the heavier compaction equipment, he will sometimes find that excessive rutting, weaving and pore pressure development (or moisture profiles) can occur in fine grained soils. Knight Piésold have therefore used the Modified Proctor test as the reference as it provides a moisture - density relationship which is closer to the relationship expected from the specified compaction equipment.

The glacial till has a fairly low plasticity (PI = 10 to 14) and will be placed at near the optimum moisture content as defined by the Modified Proctor test. Placement at a higher moisture content and a lower density as suggested by Mr. Brawner would result in larger post construction fill settlements and would increase the likelihood of cracks forming in the fill.

Seepage Collection Pond Dam

Consider a low permeability cut-off under the dam.

The seepage collection pond will be constructed by excavation into low permeability glacial till and overconsolidated sediments and does not include a dam. The level of the pond will be maintained below the natural groundwater level and, therefore surrounding groundwater migrates toward the pond creating a hydraulic sink. This will prevent seepage losses downgradient. The Bootjack-Morehead connector road includes a small amount of fill for road subgrade immediately below the seepage collection pond, but is not intended to be a dam. A low permeability cut-off would not provide any additional benefit as discussed previously in "***Glaciofluvial Sediments in the Tailings Basin***".

Stockpile Stabilisation Materials for Urgent Use

Develop stockpiles of artificial membranes, filter cloth, short horizontal drains, filter materials, sand bags etc., for use if unexpected events occur such as:

- ***dam overflow control if massive precipitation or runoff occurs;***
- ***piping or seepage control from the dam slope, toe or valley floor develops;***
- ***tension cracks develop in the dam.***

The design basis for the tailings impoundment includes provisions for storage of the total runoff from the Probable Maximum Precipitation event. Also, the tailings facility will be carefully designed, constructed and closely monitored during initial construction and over its lifetime. If any problems are identified during the course of construction or ongoing monitoring, appropriate remedial actions, contingency plans and materials stockpiles will be implemented.

Modified Centreline Design

The design proposed entails some of the compacted main dam to be constructed over loose to medium dense tailings. With this design variability in consolidation characteristics would be expected. This could lead to tension cracks near the top of the main dam and generally parallel to C.L. Stability analysis should allow for 10 m deep tension cracks filled with water.

Vibratory compaction of the beach should also be considered for the beach zone in the zone downstream of the S.O.L. to ensure low compressibility results.

The modified centreline construction method is illustrated on Drawing 1625.111. As in the centreline construction method, the embankment fill zones extend onto the tailings beaches during each staged expansion. The tailings beaches will be comprised of sandy materials with a very high coefficient of consolidation. The compressibility of these materials will also be low and any settlements which result from on-going expansion of the embankment occur relatively rapidly and are complete during the construction period. In fact, one of the design requirements for each of the staged expansions on to the tailings beaches is for monitoring with vibrating wire piezometers in order to identify the development and dissipation of any excess pore pressures during construction. It has been our experience that any excess pore pressures which develop in the tailings tend to dissipate relatively quickly and the technical specifications include provisions for monitoring to ensure that the pore pressures have dissipated (and consolidation is therefore completed) prior to placement of each successive lift. Vibratory compaction of the first lift typically results in the largest pore pressure response in saturated tailings, after which successive lifts show progressively lower response to loading. The compressibility of the tailings decreases in response to the densification which results from loading and compaction so that compression of the tailings during future staged expansions will not be significant.

Based on our experience with similar construction methods and comparable tailings materials, it is highly unlikely that 10 m deep tension cracks can develop along the crest of the embankment. However, as suggested by Mr. Brawner, stability analyses have been conducted for a 10 m deep tension crack filled with water, as shown on Figure 3. The factor of safety for the water filled tension crack is higher than for the previously reported stability analyses. Therefore, the previously reported minimum factors of safety for the tailings embankment are unchanged even if a 10 m water filled tension crack occurs.

An upstream slip surface for a 10 m water filled tension crack was also evaluated. The results showed that this case is also not critical as the factor of safety is well in excess of 1.5.

Winter Operation

Describe winter operation for disposal.

The supernatant pond is expected to freeze and an ice cover of up to about 500 mm may result. This is a common occurrence for tailings impoundments situated in cold climates, and tailings sedimentation and process water reclaim will continue virtually unaffected by the ice cover. The primary consideration for winter operations is related to tailings deposition by spigotting during extreme cold conditions. The tailings discharge pipeworks will be managed in order to prevent low flows from freezing and glaciating which would result in large volumes of ice becoming entrapped within the tailings mass. Based on our experience at other cold regions tailings disposal operations, we do not feel that winter operations will be particularly difficult at the Mt. Polley site and the only modifications to the summer operating procedures would likely be the operation of fewer spigots in order to concentrate the tailings flows and thus prevent glaciation of the tailings discharge streams.

SECTION 3.0 - CLOSING COMMENTS

In order to ensure that the above listed concerns and all other design objectives are met, all construction activities will be monitored by Knight Piésold geotechnical engineers. As part of the construction supervision program, a detailed Quality Assurance/Quality Control (QA/QC) program will be implemented. The QA/QC program will include Control Tests required for approval of construction materials and Record Tests on placed and compacted materials.

The tailings storage facility has been designed for staged construction over the life of the mine. This allows the on-going performance of the facility to be continually evaluated. The design has flexibility and can be revised as required based on monitoring records, operating experience and updated mine planning.

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UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT No. 1621
SAMPLE No.
DATE

PROJECT : MT. POLLEY TAILINGS GRADATION

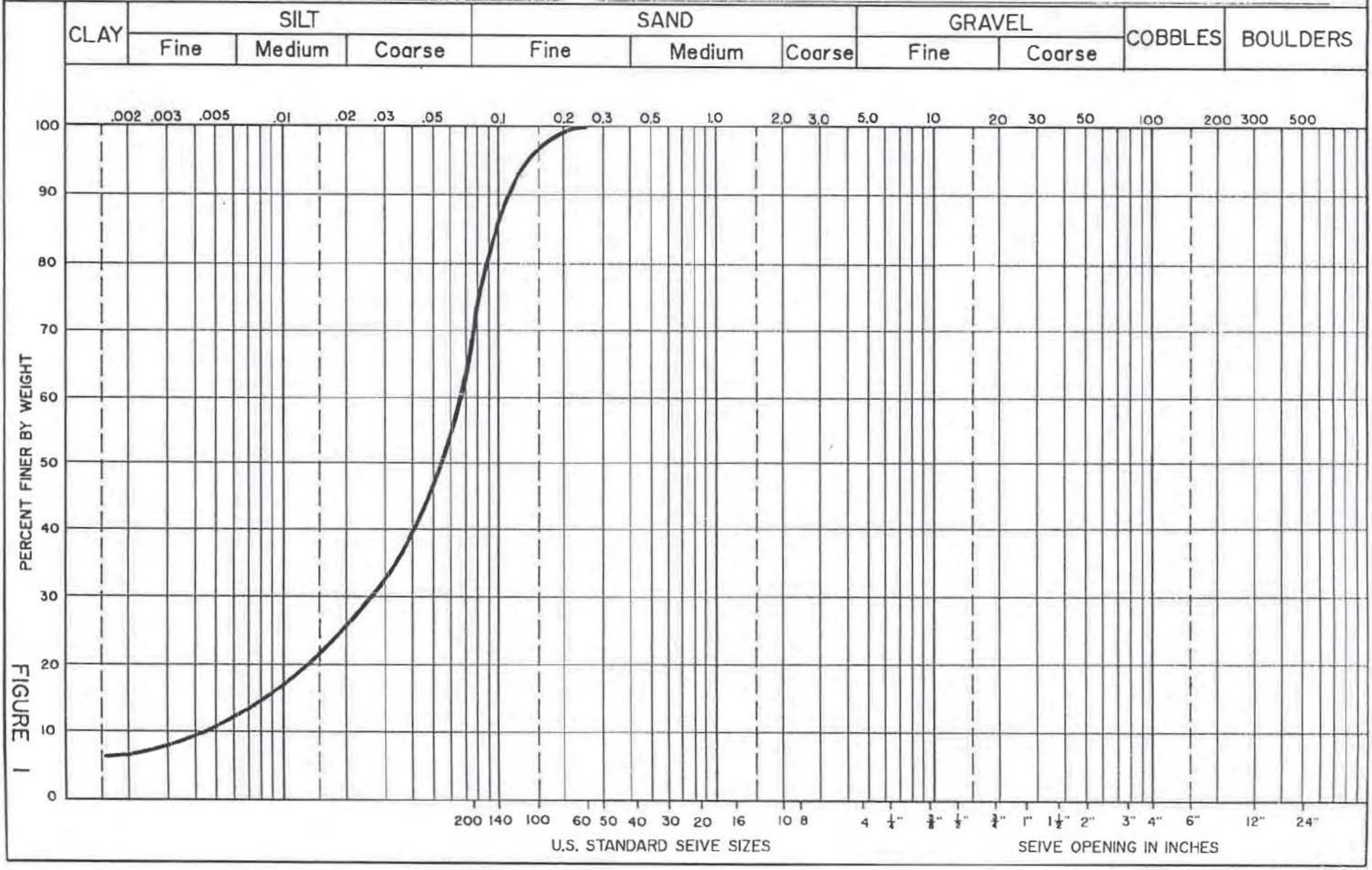

FIGURE 1

I:\JOB\DATA\TILLPROC.XLS Chart1 1/22/96 11:08 AM

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Jan. 19, 1996

MT. POLLEY PROJECT

RELATIONSHIP BETWEEN COMPACTION ENERGY AND MOISTURE CONTENT - DENSITY
(CHARACTERISTIC COMPACTION CURVES FOR GLACIAL TILL)

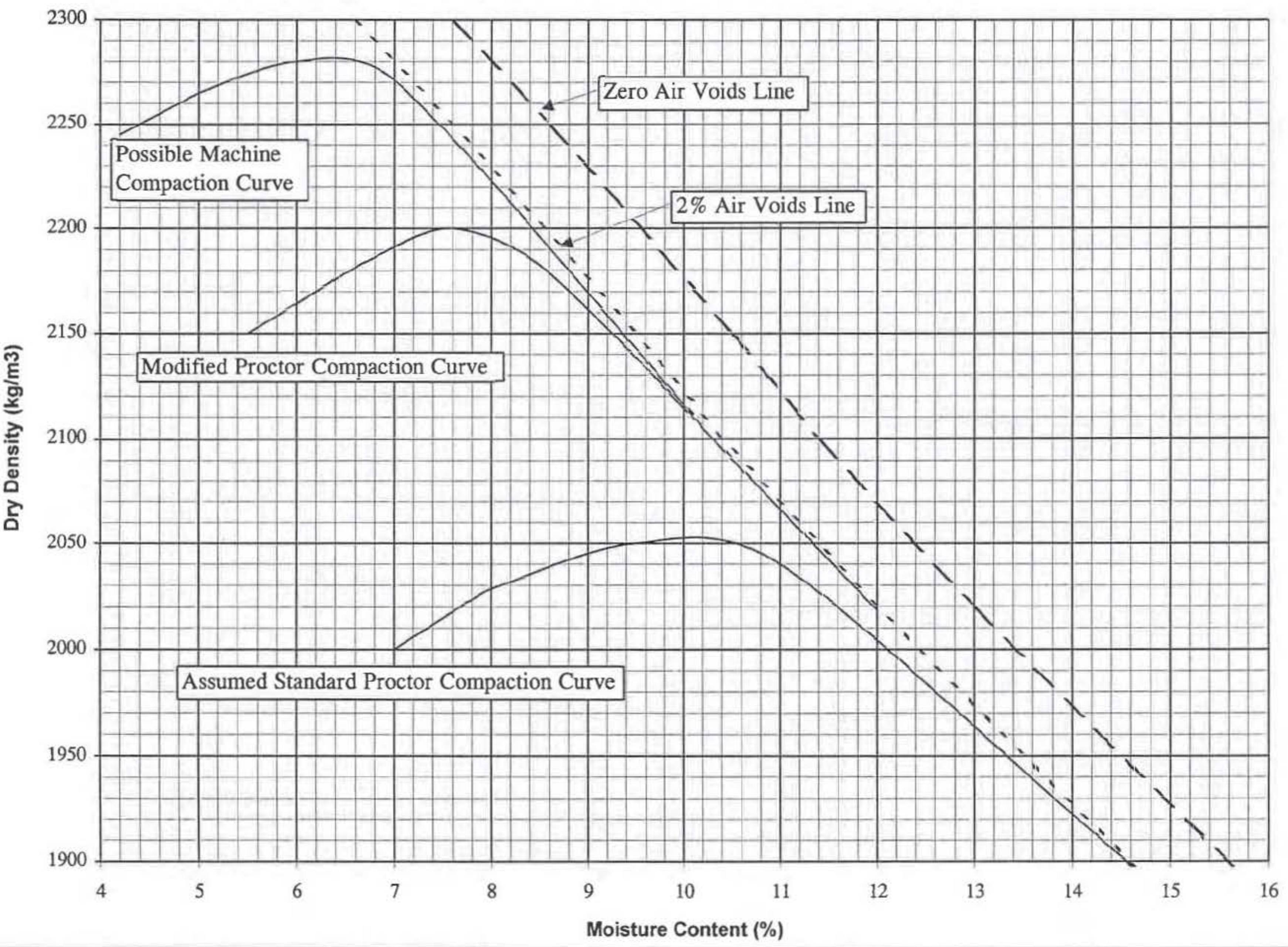
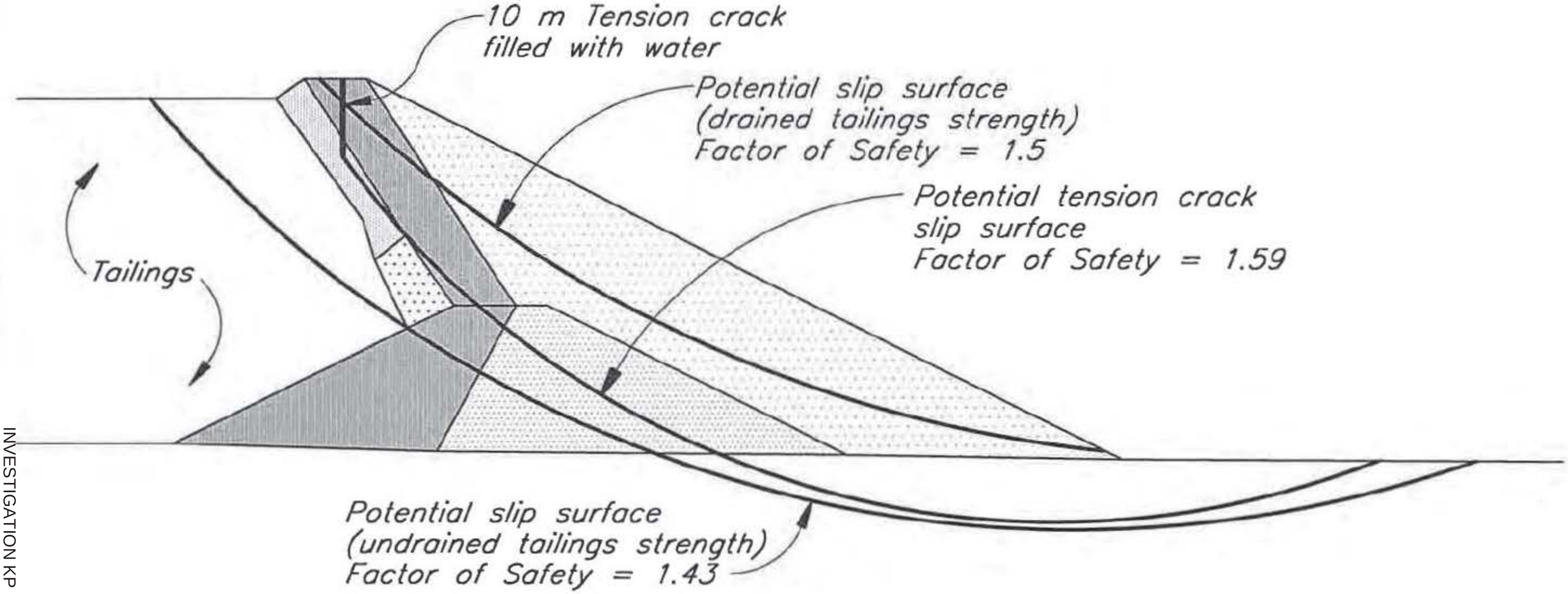


FIGURE 2

CAD FILE: \PROJECT\1625\FIG\A10 Plot scale 1=1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
STATIC STABILITY



Jan. 23, 1996

KNIGHT PIESOLD LTD.
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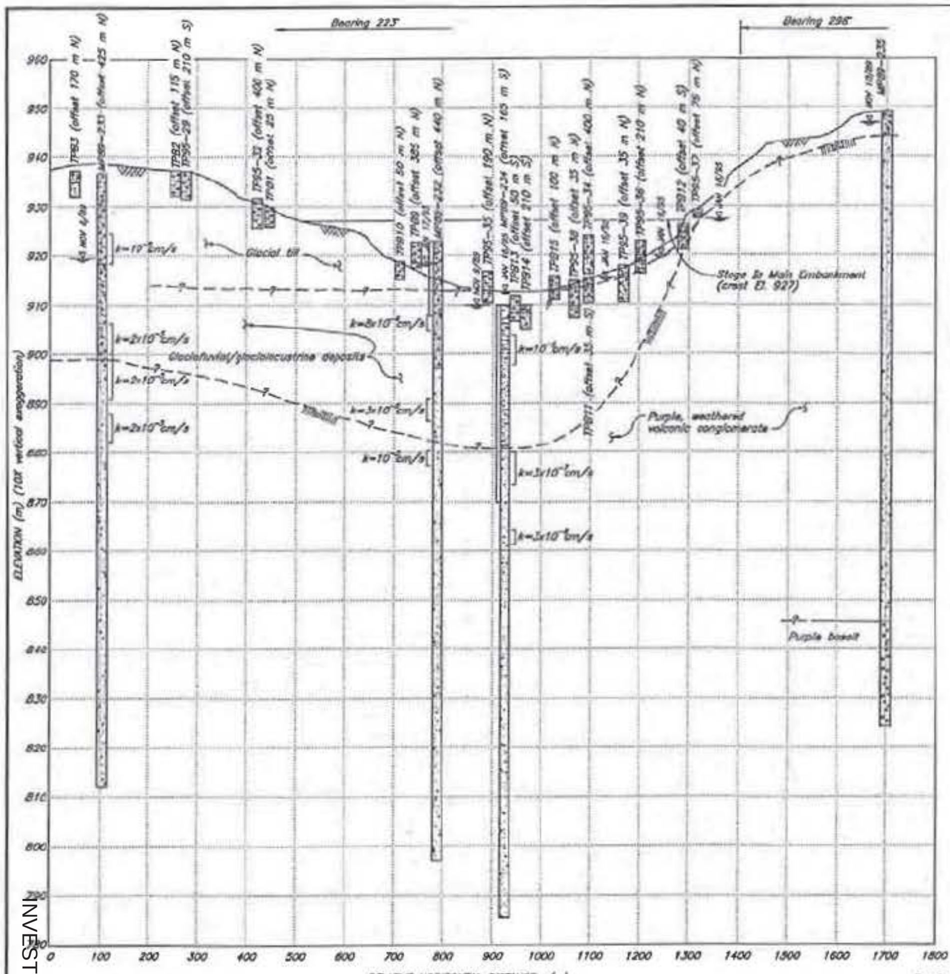
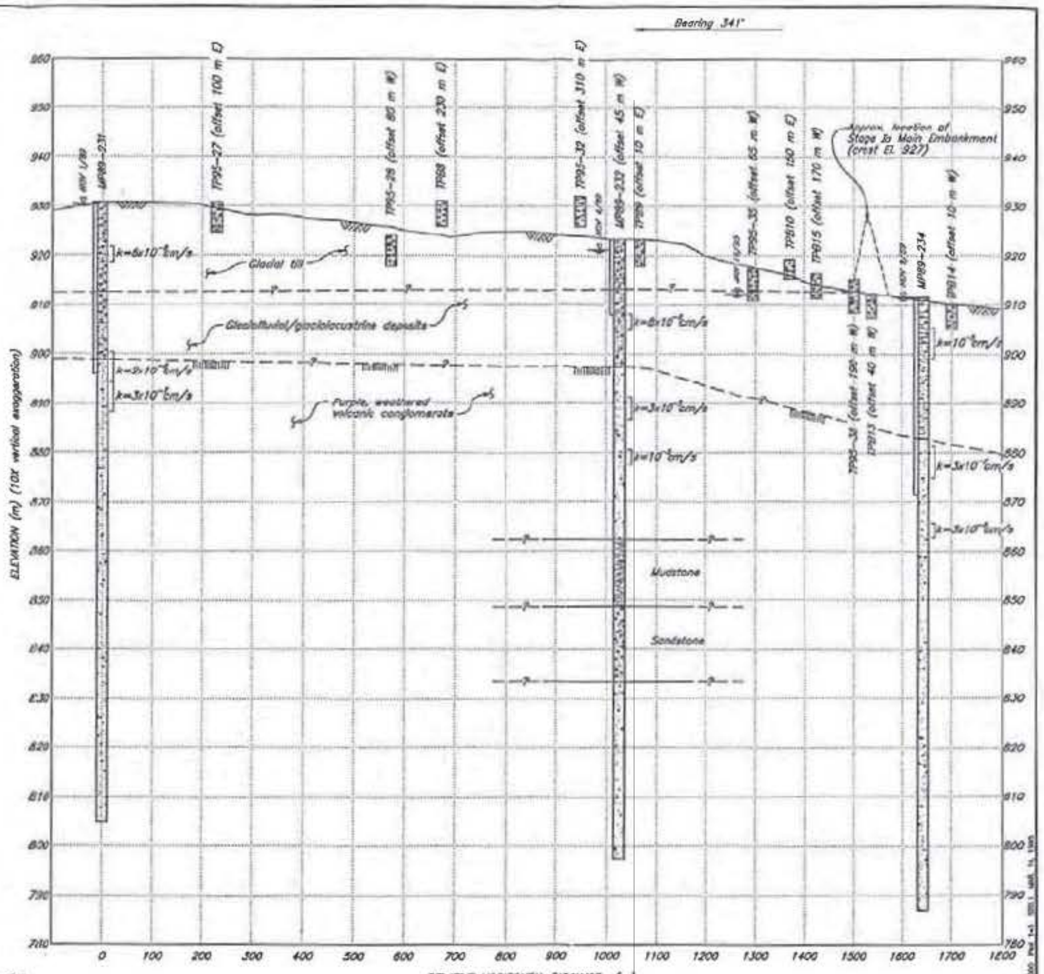
FIGURE 3

1625.A10



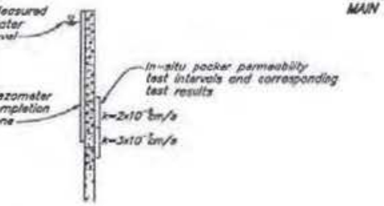
SECTION 2/1623.102
MAIN EMBANKMENT

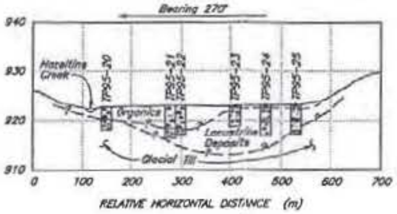


SECTION 3/1623.102
TAILINGS BASIN

Scale 100 0 100 200 300 400 500 Metres

LEGEND:





SECTION 1/1623.100
POLLEY LAKE DAM SITE

DRG. NO.	DESCRIPTION

REFERENCE DRAWINGS

REV.	DATE	DESCRIPTION	APPROVED

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED
0	MAR. 14/95	ISSUED FOR REPORT	KJB

REVISIONS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS - VANCOUVER, B.C.

K. J. BROUWER

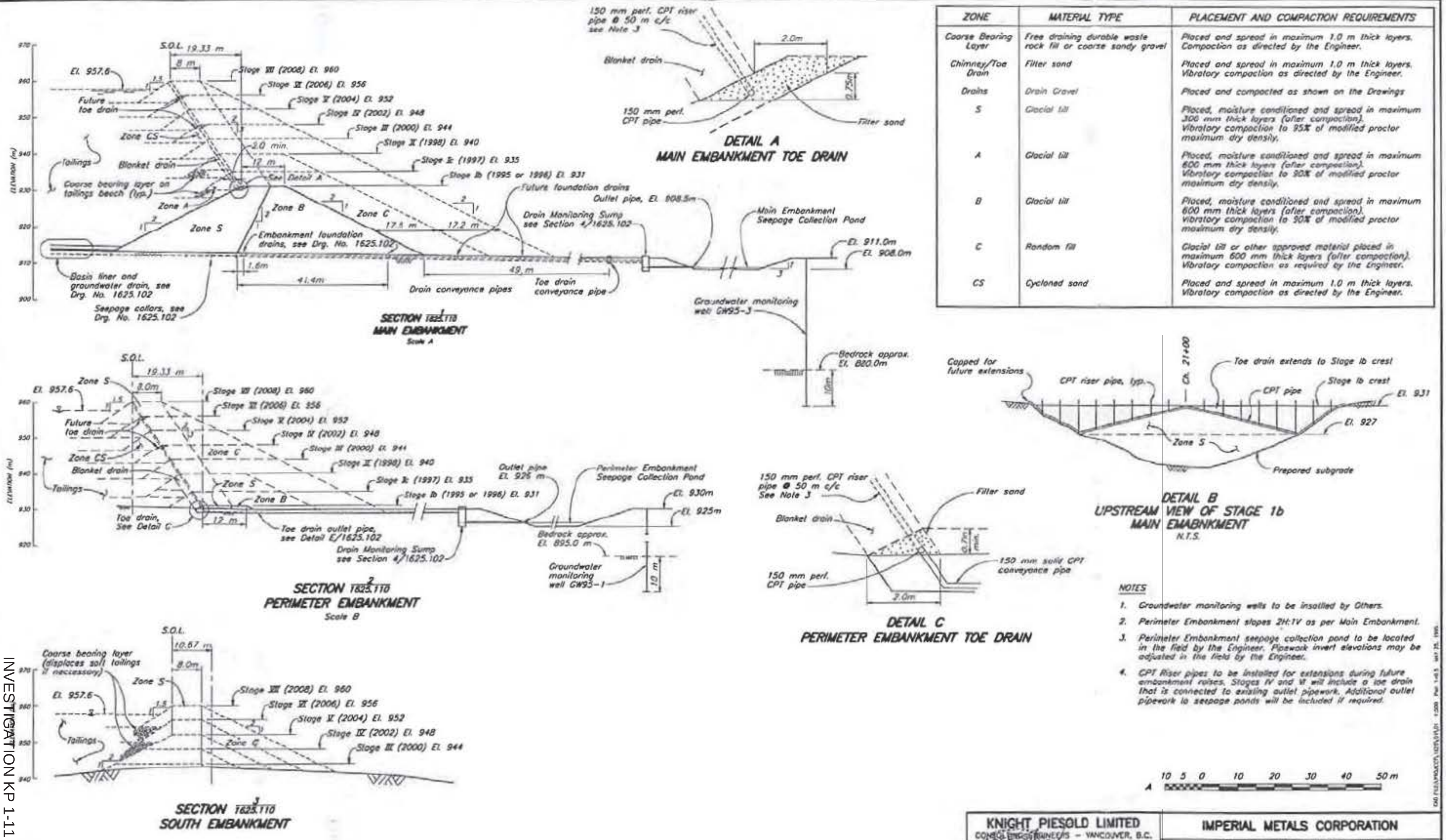
DESIGNED	KGB
DRAWN	NAR/RDT
CHECKED	KGB.
APPROVED	KJB

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY
GEOLOGICAL CROSS-SECTIONS

DATE MARCH 14, 1995 | SCALE AS SHOWN | DRG. NO. 1623.103 | REV. 0



SECTION 1/1625.110
MAIN EMBANKMENT
Scale A

DETAIL A
MAIN EMBANKMENT TOE DRAIN

SECTION 2/1625.110
PERIMETER EMBANKMENT
Scale B

DETAIL C
PERIMETER EMBANKMENT TOE DRAIN

DETAIL B
UPSTREAM VIEW OF STAGE 1b
MAIN EMABNKMENT
N.T.S.

SECTION 3/1625.110
SOUTH EMBANKMENT

ZONE	MATERIAL TYPE	PLACEMENT AND COMPACTION REQUIREMENTS
Coarse Bearing Layer	Free draining durable waste rock fill or coarse sandy gravel	Placed and spread in maximum 1.0 m thick layers. Compaction as directed by the Engineer.
Chimney/Toe Drain	Filter sand	Placed and spread in maximum 1.0 m thick layers. Vibratory compaction as directed by the Engineer.
Drains	Drain Gravel	Placed and compacted as shown on the Drawings
S	Glacial till	Placed, moisture conditioned and spread in maximum 300 mm thick layers (after compaction). Vibratory compaction to 95% of modified proctor maximum dry density.
A	Glacial till	Placed, moisture conditioned and spread in maximum 600 mm thick layers (after compaction). Vibratory compaction to 90% of modified proctor maximum dry density.
B	Glacial till	Placed, moisture conditioned and spread in maximum 600 mm thick layers (after compaction). Vibratory compaction to 90% of modified proctor maximum dry density.
C	Random fill	Glacial till or other approved material placed in maximum 600 mm thick layers (after compaction). Vibratory compaction as required by the Engineer.
CS	Cycloned sand	Placed and spread in maximum 1.0 m thick layers. Vibratory compaction as directed by the Engineer.

NOTES

1. Groundwater monitoring wells to be insalled by Others.
2. Perimeter Embankment slopes 2H:1V as per Main Embankment.
3. Perimeter Embankment seepage collection pond to be located in the field by the Engineer. Pipework invert elevations may be adjusted in the field by the Engineer.
4. CPT Riser pipes to be installed for extensions during future embankment raises. Stages IV and VI will include a toe drain that is connected to existing outlet pipework. Additional outlet pipework to seepage ponds will be included if required.

DRG. NO.	DESCRIPTION
1625.102	TAILINGS STORAGE FACILITY – FOUNDATION PREPARATION AND BASIN LINER – SECTIONS AND DETAILS
1625.110	TAILINGS STORAGE FACILITY – STAGE Ia/Ib TAILINGS IMPOUNDMENT – GENERAL ARRANGEMENT

REFERENCE DRAWINGS

REV.	DATE	DESCRIPTION	APPROVED
1	MAY 26/95	ISSUED FOR DESIGN REPORT	KJB
0	APR. 5/95	ISSUED FOR REVIEW	

REVISIONS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS – VANCOUVER, B.C.

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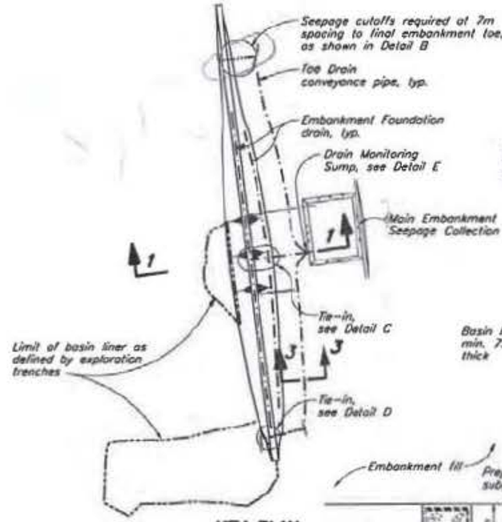
DRAWN KAL/NT
CHECKED MS
APPROVED KJB

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

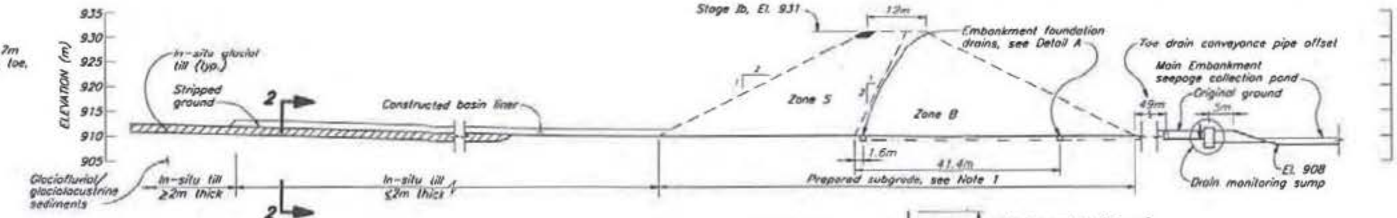
TAILINGS STORAGE FACILITY
TAILINGS EMBANKMENT
SECTIONS AND DETAILS

DATE APRIL 6, 1995
SCALE AS SHOWN
DRG. NO. 1625.111
REV. 1

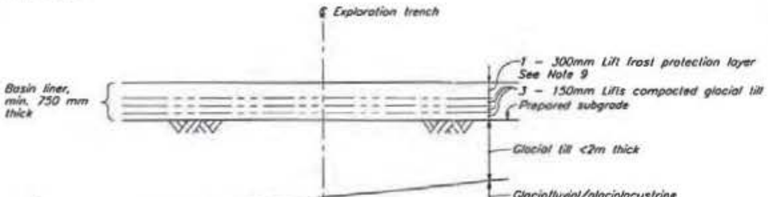


KEY PLAN
Scale A

△2

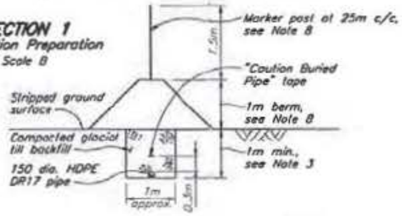


SECTION 1
△2 Foundation Preparation
Scale B



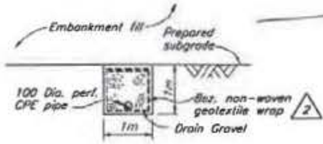
SECTION 2
Basin Liner
Scale D

△2

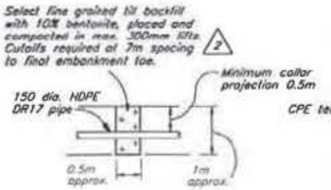


SECTION 3
Toe Drain Conveyance Pipe
Scale D

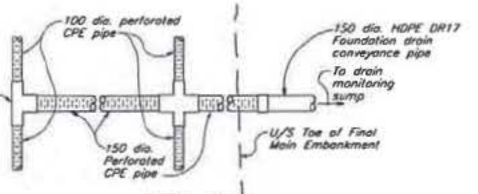
△2



DETAIL A
Embankment Foundation Drain
Scale D

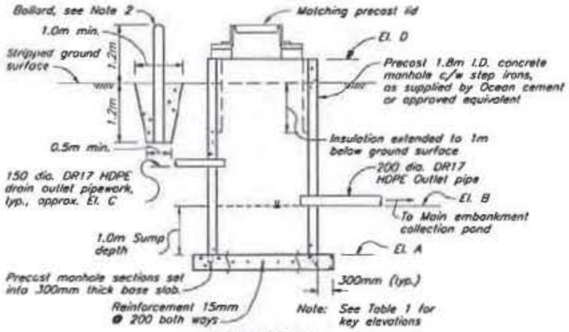


DETAIL B
Seepage Cutoff
Scale D



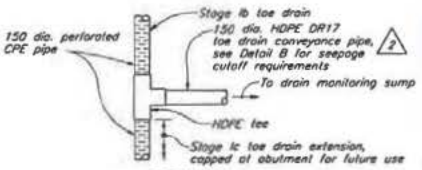
DETAIL C
Embankment Foundation Drain Tie-in
Scale C

△2

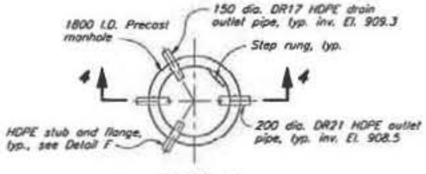


SECTION 4
Scale D

△2

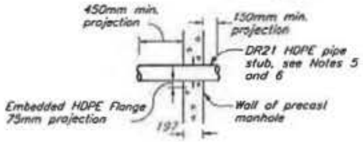


DETAIL D
Toe Drain Tie-in
Scale C



DETAIL E
Drain Monitoring Sump
Scale D

△2



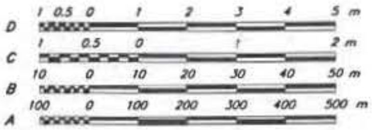
DETAIL F
HDPE Stub and Flange
Scale C

NOTES

1. Subgrade preparation to comprise stripping of topsoil and organics and removing saturated materials to establish a competent, bearing surface for fill placement as directed by the Engineer.
2. Three bollards required at 120°, 1.0m from sump. Bollards to be 200 dia. Std. Weight steel pipe filled with concrete.
3. △2 All pipeworks to have a minimum of 1m of cover for frost protection.
4. HDPE stubs and flanges to be cast into manhole.
5. △2 For Main Embankment drain monitoring sump
   150 dia. pipe stubs @ invert El. 909.3, 3 required.
   200 dia. pipe stub @ invert El. 908.5, 1 required.
6. For Perimeter Embankment drain monitoring sump
   150 dia. pipe stub, 1 required.
   200 dia. pipe stub, 1 required.
7. △2 Drain monitoring sump invert elevations shown on Table 1 may be adjusted in the field by the Engineer.
8. △2 Buried pipework to be covered by a berm and clearly marked by a line of stakes.
9. Frost protection layer to be placed only on right abutment area of basin liner. Not required in valley bottom.
10. △2 All perforated pipe to have drain gravel and geotextile wrap, as shown on Detail A.

Table 1

ELEV.	MAIN EMBANKMENT	PERIMETER EMBANKMENT
A	907.5	924.5
B	908.5	925.5
C	909.3	926.5
D	911.5	930.5



REV.	DATE	DESCRIPTION	APPROVED
2	JAN 18/96	REVISIONS FOR REVIEW COMMENTS	
1	JULY 15/95	FROST LAYER REVISED AND NOTE 9 ADDED	
0	JUNE 2/95	ISSUED FOR TENDER	

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED

REVISIONS

DRG. NO.	DESCRIPTION

REFERENCE DRAWINGS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS – VANCOUVER, B.C.

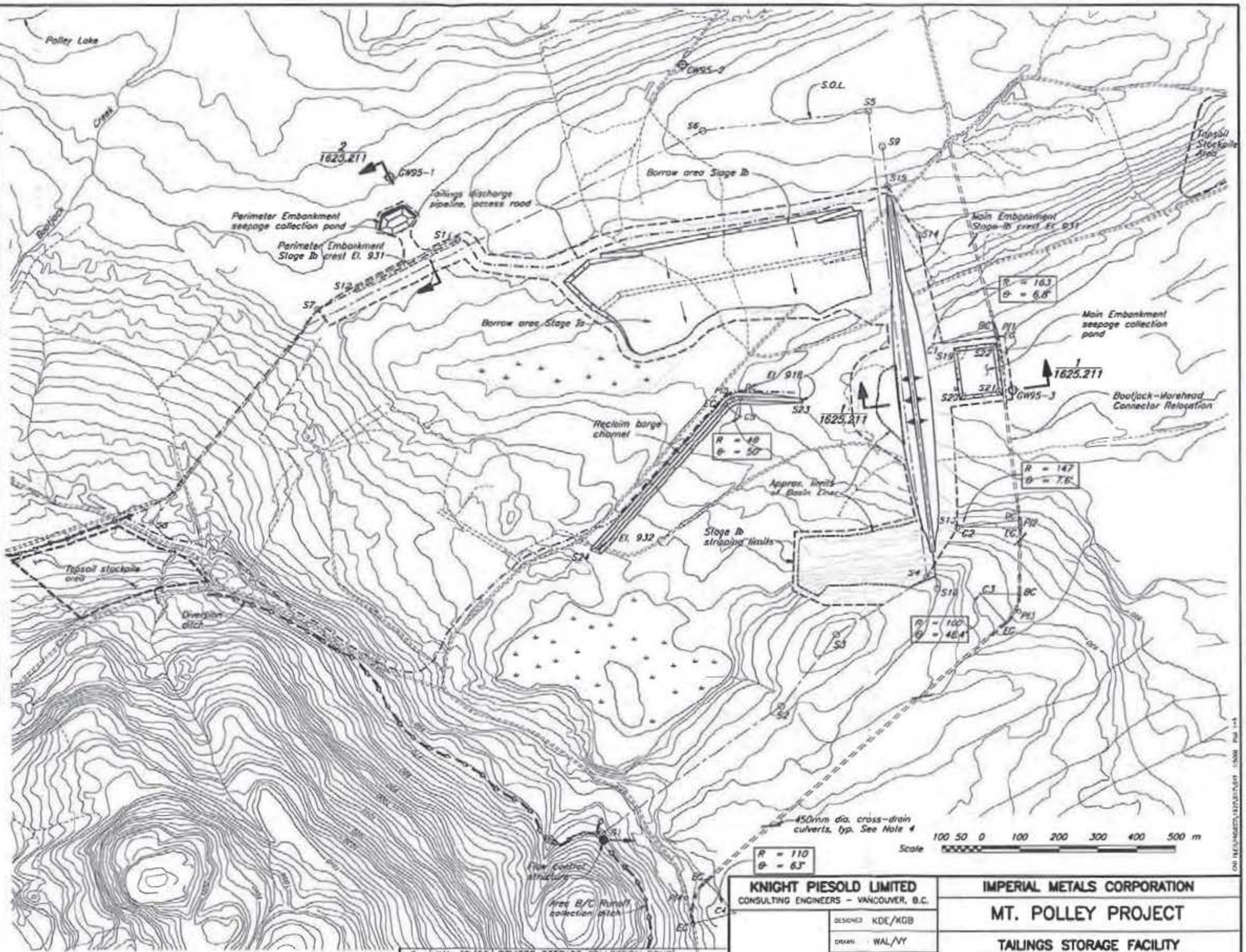
DESIGNED KDE
DRAWN RDT/WAL/NSD
CHECKED
APPROVED

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY
FOUNDATION PREPARATION AND
BASIN LINER
SECTION AND DETAILS

DATE JUNE 2, 1995 | SCALE AS SHOWN | DRG. NO. 510-15-01-1625.202 | REV. 2



SETTING OUT POINTS

Description	Point	Northing	Easting
Setting Out Line (S.O.L.)	S1	5 818 622.590	594 258.688
	S2	5 818 392.402	594 765.778
	S3	5 818 365.375	594 995.246
	S4	5 818 238.539	595 240.350
	S5	5 818 966.983	596 208.866
	S6	5 819 304.035	595 955.881
	S7	5 819 932.340	595 066.670
	S8	5 820 025.632	594 375.061
Stage Ib Main Embankment ℄	S9	5 818 891.014	596 150.000
	S10	5 818 199.059	595 230.000
Perimeter Embankment ℄	S11	5 819 705.338	595 404.339
	S12	5 819 869.082	595 160.766
Stripping Limits	S13	5 818 233.372	595 392.851
	S14	5 818 696.416	595 997.943
	S15	5 818 828.350	596 066.684
Main Embkmnt. Seepage Collection Pond △2	S19	5 818 461.203	595 790.290
	S20	5 818 391.047	595 697.013
	S21	5 818 317.351	595 752.085
	S22	5 818 387.678	595 845.590
Reclaim Barge Channel	S23	5 818 743.870	595 479.103
	C5	5 818 856.841	595 365.834
	BC	5 818 879.675	595 408.055
	EC	5 818 903.862	595 375.481
	PI5	5 818 899.065	595 397.857
	S24	5 818 998.167	594 887.106
△2	C1	5 818 523.688	595 775.212
	BC	5 818 405.938	595 887.923
	EC	5 818 393.421	595 873.189
	PI1	5 818 399.242	595 880.928
△2	C2	5 818 222.184	595 400.960
	BC	5 818 104.704	595 489.320
	EC	5 818 093.995	595 472.909
	PI2	5 818 098.801	595 481.472
Bootjack - Moorehead Connector Relocation △2	C3	5 818 096.998	595 273.949
	BC	5 818 009.797	595 322.894
	EC	5 818 002.473	595 241.322
	PI3	5 817 987.827	595 283.752
	C4	5 818 228.844	594 248.367
	BC	5 818 333.078	594 283.514
	EC	5 818 307.478	594 171.448
	PI4	5 818 354.995	594 220.025

LEGEND:

⊕ GW95-1	- Groundwater monitoring well
C1	- Curve No. 1 (typ.)
BC	- Begin Curve
EC	- End Curve
PI1	- Point of Intersection for Curve No. 1

NOTES

1. Setting Out Line (SOL) is the upstream shoulder of the Stage VII embankment.
2. Stripping and clearing required 5m beyond seepage collection ponds and pipeworks.
3. Perimeter Embankment Seepage Collection Pond to be located in the field by the Engineer.
4. Number and location of cross-drain culverts to be determined in the field by the Engineer.

INVESTIGATION KP 1-11 22 of500

REFERENCE DRAWINGS

DWG. NO.	DESCRIPTION
1625.211	TAILINGS STORAGE FACILITY - TAILINGS EMBANKMENT - SECTIONS AND DETAILS

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED
2	JAN. 18/96	REVISED SEEPAGE COLLECTION POND	
1	JULY 27/95	POINT S16 AND S17 DELETED	
0	JUNE 2/95	ISSUED FOR TENDER	

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS - VANCOUVER, B.C.

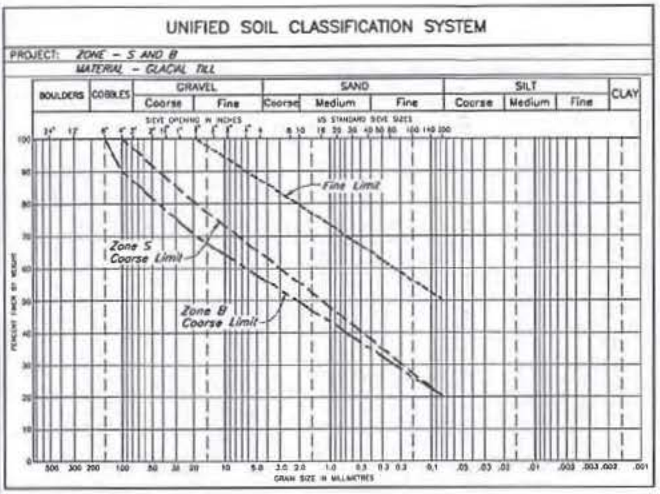
DESIGNED KDE/KGB
DRAWN WAL/VY
CHECKED
APPROVED

IMPERIAL METALS CORPORATION

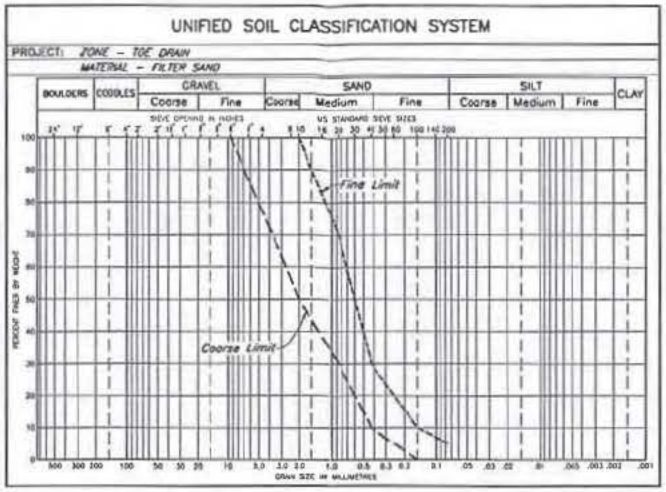
MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY
STAGE Ib TAILINGS IMPOUNDMENT
GENERAL ARRANGEMENT

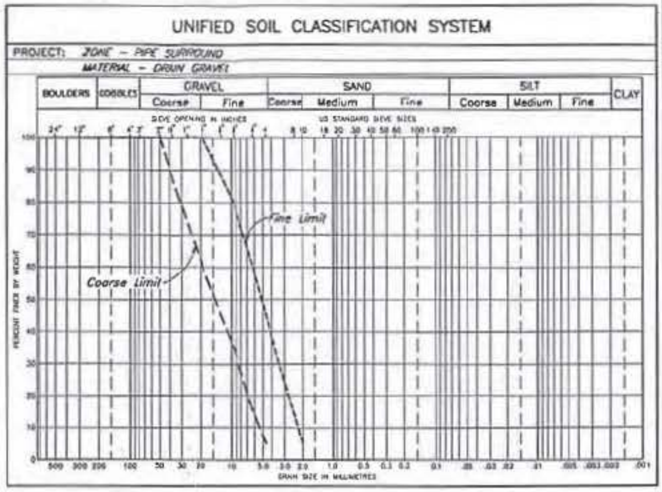
DATE JUNE 2, 1995 SCALE AS SHOWN DRG. NO. 510-12-02-1625.205 REV. 2


UNIFIED SOIL CLASSIFICATION SYSTEM

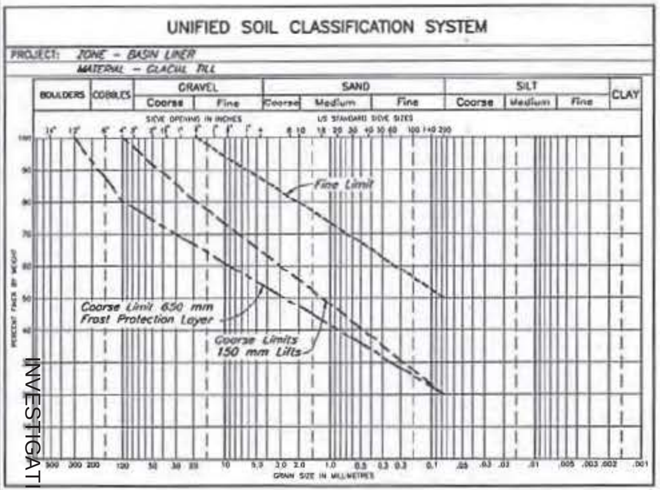
PROJECT: ZONE – S AND B
MATERIAL – GLACIAL TILL


UNIFIED SOIL CLASSIFICATION SYSTEM

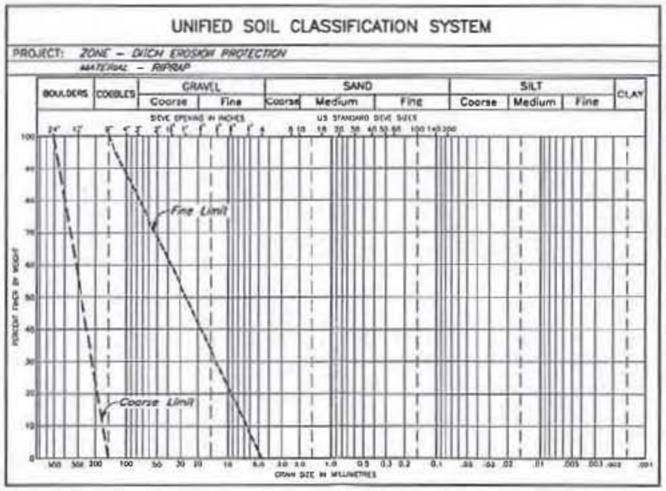
PROJECT: ZONE – TOE DRAIN
MATERIAL – FILTER SAND


UNIFIED SOIL CLASSIFICATION SYSTEM

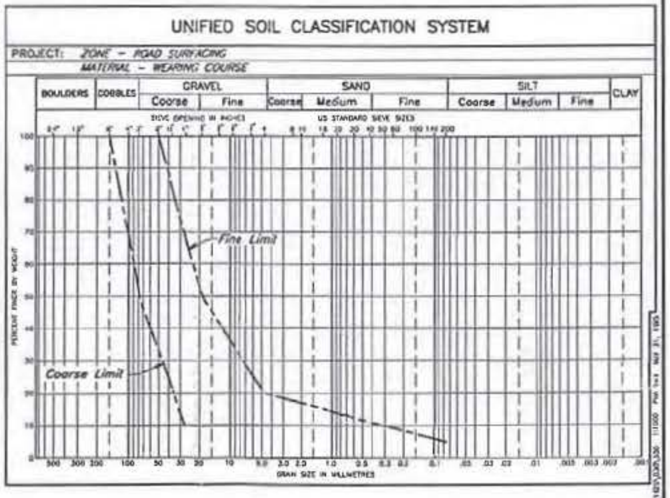
PROJECT: ZONE – PIPE SURROUND
MATERIAL – DRAIN GRAVEL


UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: ZONE – BASIN LINER
MATERIAL – GLACIAL TILL


UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: ZONE – DITCH EROSION PROTECTION
MATERIAL – RIPRAP


UNIFIED SOIL CLASSIFICATION SYSTEM

PROJECT: ZONE – ROAD SURFACING
MATERIAL – WEARING COURSE

NOTES

1. *No more than 10% of Zone S material shall be coarser than the Zone S Coarse Limit and such material shall be finer than the Zone B coarse limit. Zone S material which has a gradation between the Zone S and B coarse limits shall be well spaced out and shall not form continuous layers or sizeable lenses.*
2. *For Filter sand, the portion passing the No. 40 sieve must have a plasticity index (PI) of zero.*

REFERENCE DRAWINGS

DRG. NO.	DESCRIPTION

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED
0	JUNE 2/95	ISSUED FOR TENDER	

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS – VANCOUVER, B.C.

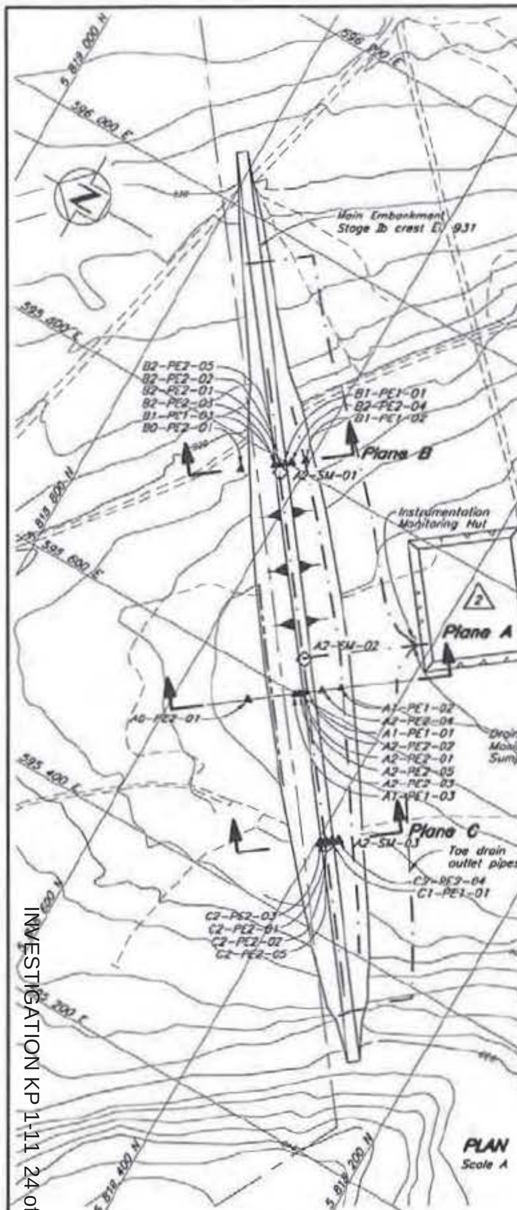
DESIGNED KDE
DRAWN RDT
CHECKED
APPROVED

IMPERIAL METALS CORPORATION

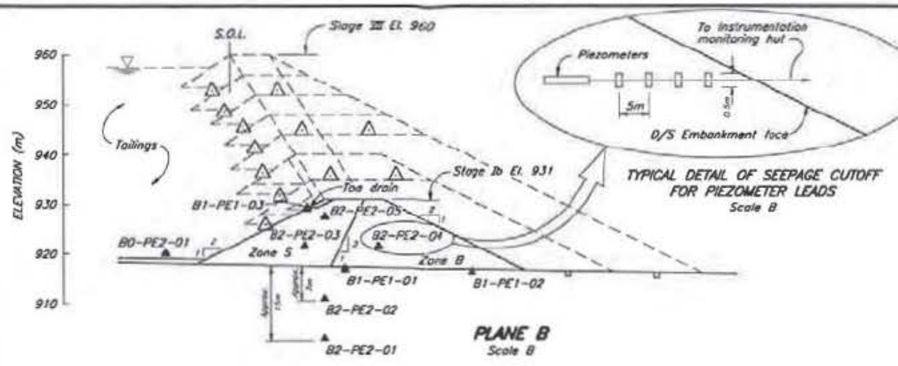
MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY
MATERIAL SPECIFICATIONS

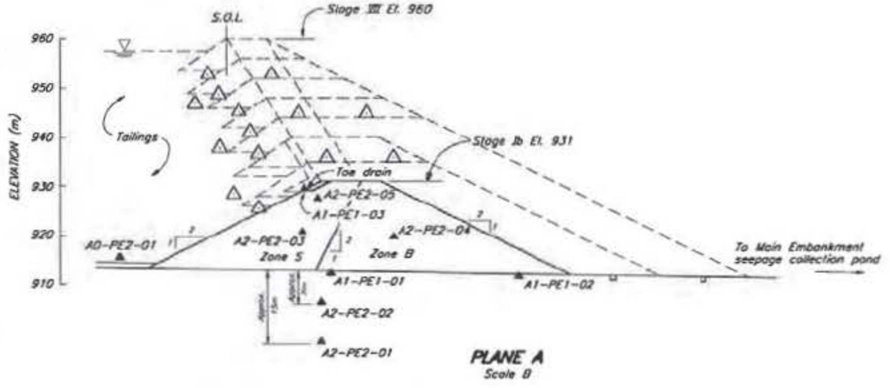
DATE JUNE 2, 1995
SCALE AS SHOWN
DRG. NO. 510-14-03-1625.212
REV. 0



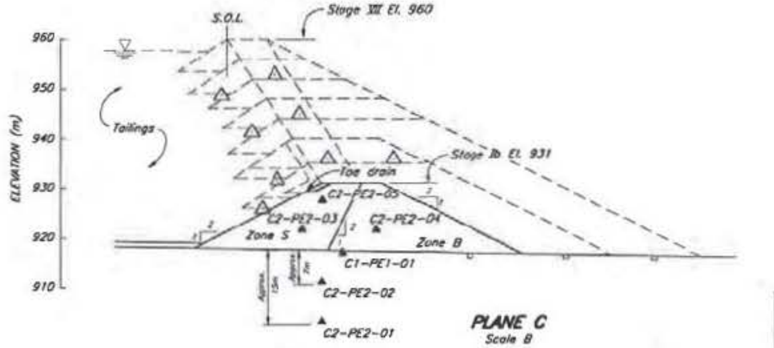
PLAN
Scale A



PLANE B
Scale B



PLANE A
Scale B



PLANE C
Scale B

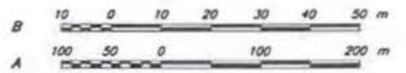
NOTES

1. Piezometers are vibrating type, RST or equivalent, connected to a readout panel via heavy duty direct burial cable.
2. Piezometer leads are to be extended to a prefabricated monitoring hut located downstream of the final embankment toe.
3. A schedule required for piezometer types and lead lengths will be provided in the Technical Specifications.
4. Future survey monuments not shown. A minimum of 2 monuments will be installed for each embankment raise.

LEGEND

A0-PE1-01
- Plane I.D. (A, B etc.)
- Area (0-Tailings, 1-Drain, 2-Embankment)
- Number I.D.
- Pressure Rating (1-Low, 2-High)
- Type of Instrumentation (PE-Piezometer electric, SM-Survey Monument)

A0-PE2-01 ▲	Tailings mass piezometer
A1-PE1-01 ▲	Embankment foundation drain and toe drain piezometer
A2-PE2-01 ▲	Embankment foundation and fill piezometer
A2-SM-01 ◇	Embankment survey monument
△	Future Piezometers



16[illegible]5.221	TAILINGS STORAGE FACILITY – INSTRUMENTATION – SECTIONS AND DETAILS
DRG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

REV.	DATE	DESCRIPTION	APPROVED
2	JAN. 18/96	REVISED SEEPAGE COLLECTION POND	
1	JULY 27/95	BASIN GROUNDWATER DRAINS REVISED	
0	JUNE 2/95	ISSUED FOR TENDER	

REVISIONS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS – VANCOUVER, B.C.

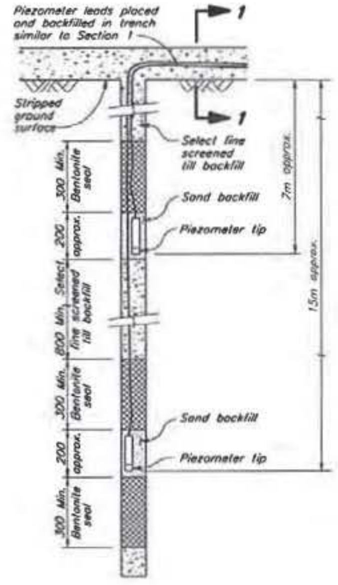
DESIGNED GRC
DRAWN RDT/VY
CHECKED
APPROVED

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

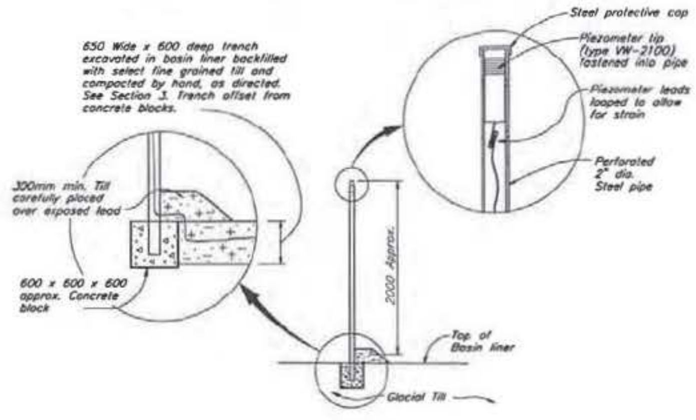
TAILINGS STORAGE FACILITY
INSTRUMENTATION

DATE JUNE 2, 1995 | SCALE AS SHOWN | DRG. NO. 510-77-01-1625.220 | REV. 2



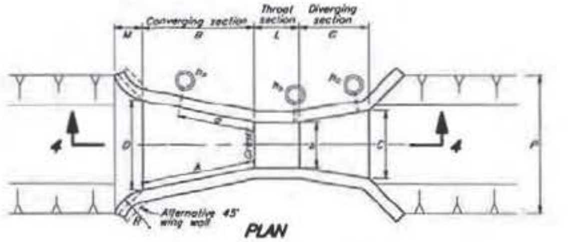
DETAIL A
INSTALLATION OF PIEZOMETERS IN BOREHOLES

N.T.S.

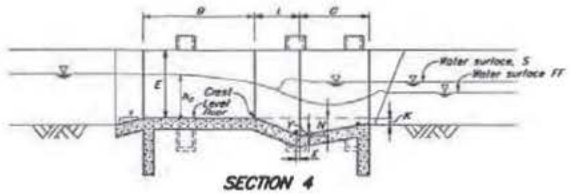


DETAIL B
VERTICAL SUPPORT FOR TAILINGS PIEZOMETERS

N.T.S.

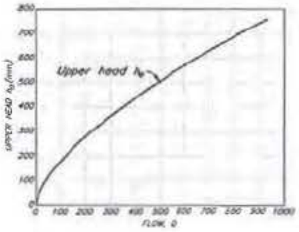


PLAN

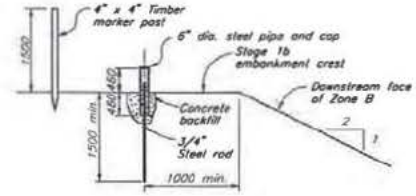


SECTION 4

PARSHALL FLUME (2 FT. SIZE), DETAIL B/1625.215
FLOW MEASUREMENT FOR INFLOWS TO TAILINGS STORAGE FACILITY AREA B RUNOFF COLLECTION AND TAILINGS AREA DIVERSION DITCHES

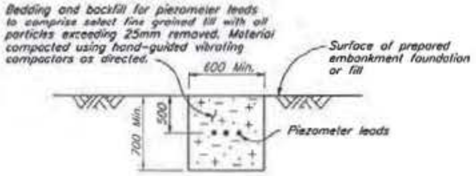


Dimensions for Parshall flume with throat width b_c of 2 feet.	
b_c	609.6
A	1524
a	1016
B	1495
C	914
D	1206
E	914
L	610
G	914
H	–
K	76
M	381
N	229
P	1854
R	508
X	51
Y	76
Z	–



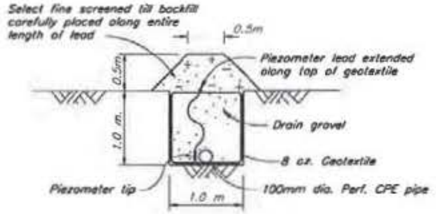
DETAIL OF SURFACE MOVEMENT MONUMENT

N.T.S.



SECTION 1
TYPICAL SECTION THROUGH PIEZOMETER LEAD TRENCH IN PREPARED EMBANKMENT FOUNDATION OR IN ZONE S AND B FILL

N.T.S.



DETAIL C
TYPICAL PIEZOMETER INSTALLATION IN EMBANKMENT FOUNDATION DRAIN OR TOE DRAIN

N.T.S.

Scale 1000 500 0 1000 2000 mm

DRG. NO.	DESCRIPTION
5.220	TAILINGS STORAGE FACILITY – INSTRUMENTATION

REFERENCE DRAWINGS

REV.	DATE	DESCRIPTION	APPROVED

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED
1	JAN. 18/96	GROUNDWATER DRAINS REMOVED	
0	JUNE 2/95	ISSUED FOR TENDER	

REVISIONS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS – VANCOUVER, B.C.

DESIGNED KDE/MBS
DRAWN VY
CHECKED
APPROVED

IMPERIAL METALS CORPORATION

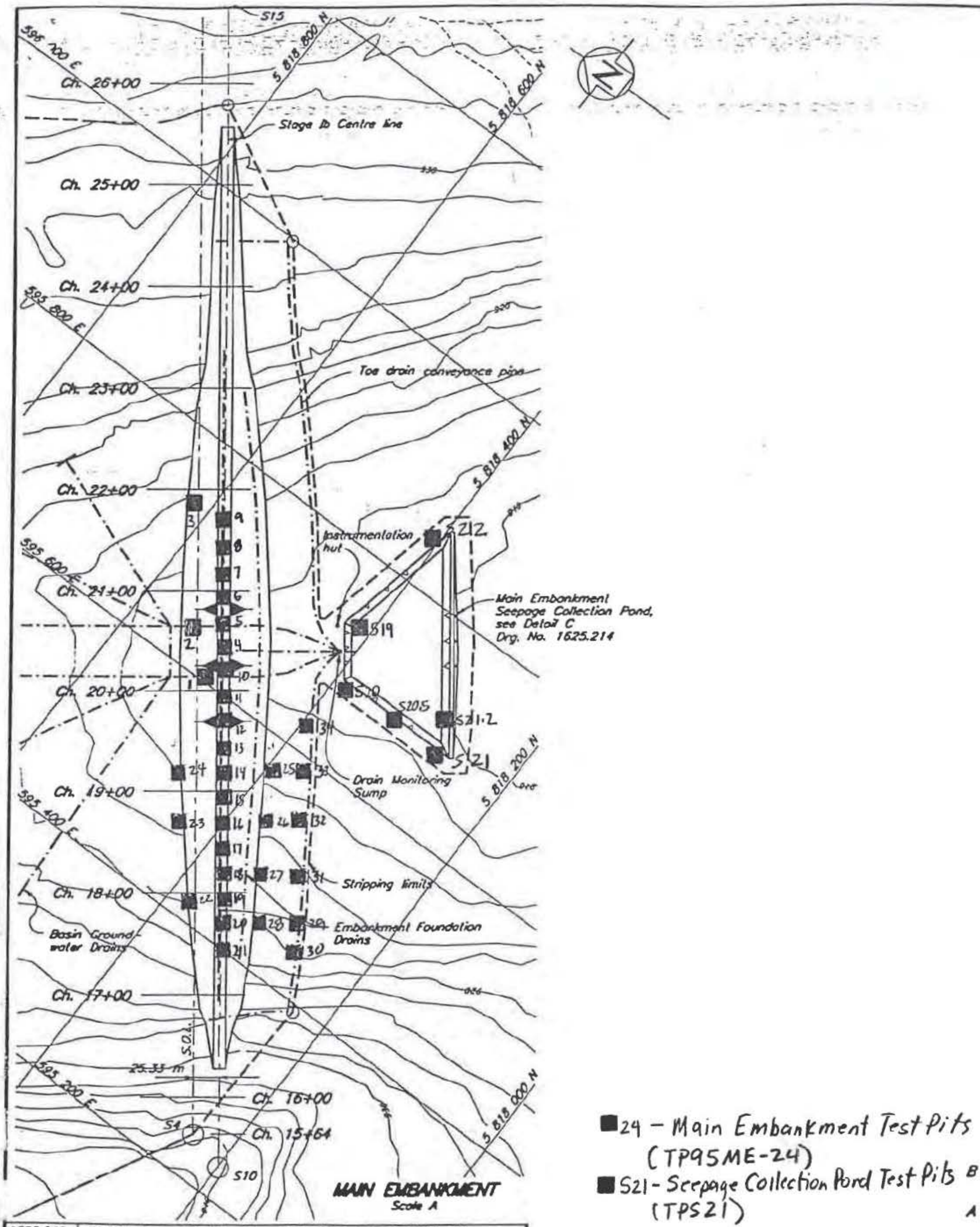
MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY
INSTRUMENTATION
SECTIONS AND DETAILS

DATE JUNE 2, 1995
SCALE AS SHOWN
DRG. NO. 510-77-02-1625.221
REV. 1

APPENDIX A

TEST PIT LOGS FROM 1995
SUPPLEMENTARY INVESTIGATIONS



■ 24 – Main Embankment Test Pits (TP95ME-24)

■ S21 – Seepage Collection Pond Test Pits (TPS21)

DRG. NO.	DESCRIPTION
1625.202	TAILINGS STORAGE FACILITY – FOUNDATION PREPARATION AND BASIN LINER – SECTIONS AND DETAILS
1625.214	TAILINGS STORAGE FACILITY – SEDIMENT CONTROL AND SEEPAGE COLLECTION – SECTIONS AND DETAILS

REFERENCE DRAWINGS

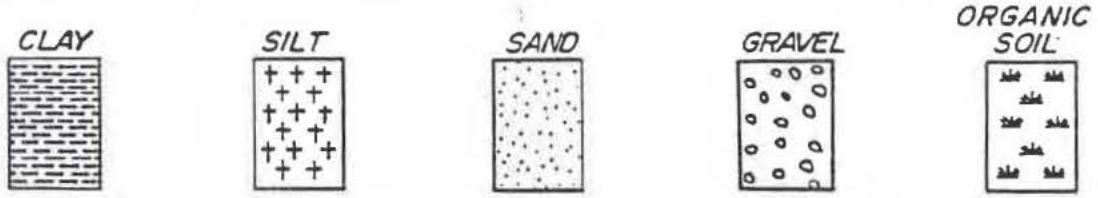
REV.	DATE	DESCRIPTION	APPROVED

REVISIONS

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

SYMBOLS AND TERMS USED IN THE REPORTS

SHEET 1 of 3



The symbols may be combined to denote various soil combinations, the predominant soil being heavier.

RELATIVE PROPORTIONS

TERM	RANGE
Trace	0 - 10%
Some	10 - 20%
"y" or "ey"	20 - 35%
and	35 - 50%

ie. CLAY - silty, trace sand

means : Clay soil with 20% to 35% silt and 0% to 10% sand

CLASSIFICATION BY PARTICLE SIZE

Boulder		Over 8"
Cobble		3" — 8"
Gravel —		
	Coarse	3/4" — 3"
	Fine	#4 — 3/4"
Sand —		
	Coarse	#4 — #10
	Medium	#10 — #40
	Fine	#40 — #200
Silt		#200 -- #0.002 mm
Clay		Finer than 0.002 mm

NOTE

Sieve sizes shown are U.S. standard

DENSITY OF SANDS AND GRAVELS

DESCRIPTIVE TERM	RELATIVE DENSITY	STANDARD PENETRATION TEST
Very loose	0 - 15%	0 - 4 Blows per foot
Loose	15 - 35%	4 - 10 Blows per foot
Medium dense	35 - 65%	10 - 30 Blows per foot
Dense	65 - 85%	30 - 50 Blows per foot
Very dense	85 - 100%	Over 50 Blows per foot

CONSISTENCY OF CLAYS AND SILTS

DESCRIPTIVE TERM	UNCONFINED COMPRESSIVE STRENGTH kPa	UNCONFINED COMPRESSIVE STRENGTH TSF	N VALUE STANDARD PENETRATION TEST	REMARKS
Very soft	< 25	< 0.25	Less than 2	- Can penetrate with fist
Soft	25 - 50	0.25 - 0.5	2 - 4	- Can indent with fist
Firm	50 - 100	0.5 - 1.0	4 - 8	- Can penetrate with thumb
Stiff	100 - 200	1.0 - 2.0	8 - 15	- Can indent with thumb
Very stiff	200 - 400	2.0 - 4.0	15 - 30	- Can indent with thumb-nail
Hard	> 400	> 4.0	Greater than 30	- Cannot indent with thumb-nail

NOTES

1. Relative density determined by standard laboratory tests
2. N Value - blows/ft. of a 140 lb. hammer falling 30 in. on a 2 in. O.D. split spoon
3. Unconfined compressive strength = 2 × Undrained shear strength, C_u

1625 C1

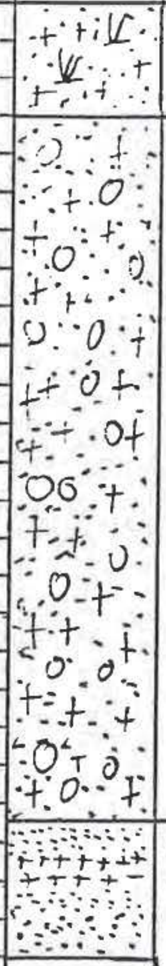
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-1
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment
DATE May 15/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE/MBS

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 Excavator	▽		TOPSOIL- Dark brown/black, moist to wet SILT and SAND with ORGANICS. Slight seep at contact with Till.
	0.5 1.0 1.5 2.0		GLACIAL TILL - moist, brown to grey brown, dense to very dense (increase with depth), overconsolidated SILTY SAND and GRAVEL, occasional COBBLE.
SHELBY TUBE SAMPLE TP95ME-1 ▨ "Sand running" below till.	▽ 2.5		GLACIOFLUVIAL/GLACIOLACUSTRINE SEDIMENTS - Alternating layers fine SAND/SILT/fine SAND/coarse SAND collected in shelby tube. Sand is running in excavation below glacial till. SILT layers show evidence of overconsolidation. Materials liquified while collecting shelby tube sample.
	3.0		

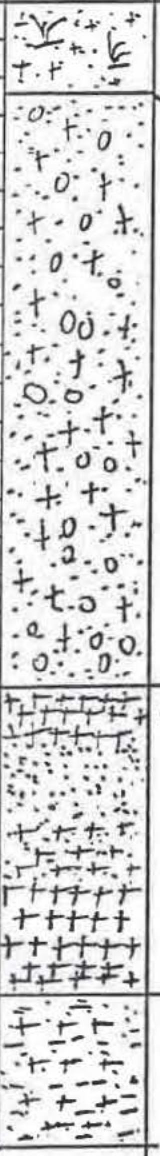
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-2
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment
DATE May 15/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KOE/MES

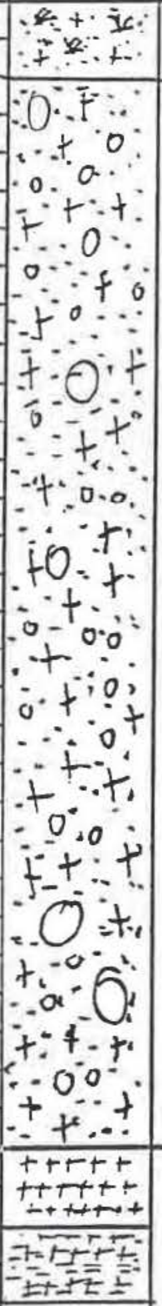
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 Excavator			TOPSOIL— Dark brown/black, moist loose SILT and SAND with ORGANICS. Slight seep at contact with till.
	0.5 1.0 1.5		GLACIAL TILL - moist, brown to grey-brown, medium dense to dense SILTY SAND and GRAVEL, occasional COBBLE.
SHELBY TUBE SAMPLE TP95ME-2A	2.0 2.5		GLACIOFLUVIAL/GLACIOLACUSTRINE SEDIMENTS- Alternating layers of SILT/SAND/SILTY SAND. SILT sections overconsolidated, moist, with minor seep at contact with till. Medium dense to very dense. Shelby tube sample collected in dense SILT. (TP95ME-2A)
-Grab sample TP95ME-2B	3.0		GLACIOFLUVIAL/GLACIOLACUSTRINE SEDIMENTS- - Grey to blue grey SILT/SANDY to CLAYEY SILT. MOIST, very dense, Overconsolidated. Grab sample collected (TP95ME-2B).
	3.5		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-3
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT Main Embankment.
GROUND EL.
DATE May 15/95
LOGGED BY KDE/MES

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (M)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 Excavator			TOPSOIL - Brown, moist SILT and SAND with some ORGANICS.
			GLACIAL TILL - Moist, brown to grey-brown, dense to medium dense, (increase with depth) SILTY SAND and GRAVEL, occasional COBBLE.
	0.5		
	1.0		
NO SAMPLES.			
	1.5		
	2.0		
	2.5		
	3.0		GLACIOFLUVIAL/GLACIOLACUSTRINE SEDIMENTS -From 3.0 to 3.2 : moist, light brown, dense overconsolidated SILT. -From 3.2 to 3.4 : moist, grey brown SILT to CLAYEY SILT, very dense, overconsolidated.
	3.5		

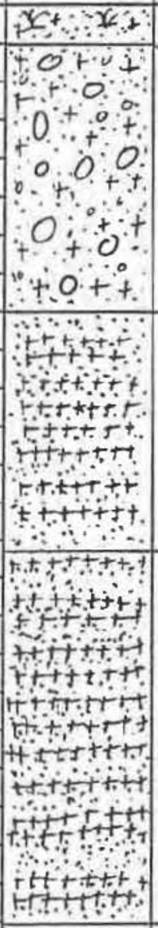
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-4
SHEET 1 of 1

PROJECT Mt Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 3 /95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KOE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown to black, wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greyish green brown SILTY SAND with some GRAVEL and COBBLES. Moist to wet. Medium dense to 1.25m, dense to 2.0m. Slight seep at bottom of till unit
Minor seep. Minor seep in Sand layers.	∇ 2 3		Glaciolacustrine / fluvial Sediments — Greyish green brown interbedded fine SAND and SILT. Silt is stiff, overconsolidated. Sand layers seep slightly, otherwise moist.
Vertical trench walls stable.	4 5 6		Glaciolacustine / fluvial Sediments — Interbedded fine SAND and SILT, as above. Color is greyish blue and unit is stiffer, SILT layers clearly overconsolidated. Moist. TD = 6.0m
Photos 1-4, 1-5	7		

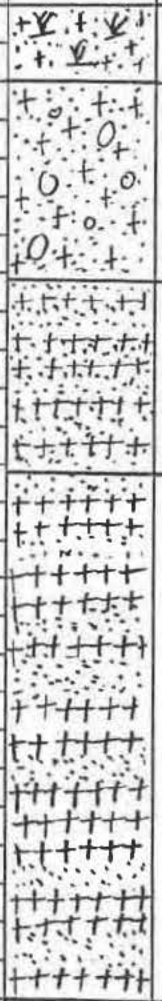
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-5
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct 3/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



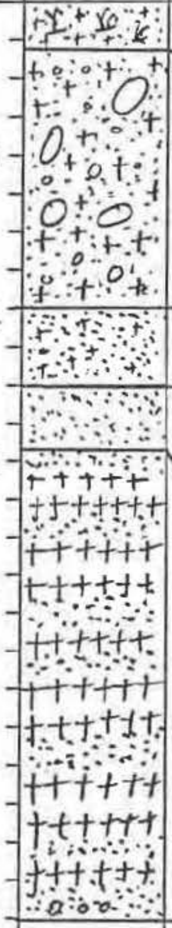
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator	∇		Topsoil – Disturbed, dark brown to black, wet, SILT and fine SAND with ORGANICS
Minor seep from surface runoff at top of till.	1		Glacial Till – Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet. Medium dense at top (to 1.2m), dense to very dense to 1.8m. Slight seep at top of Till.
Minor seep in occ. sand layer.	∇ 2 3		Glacio lacustrine / fluvial Sediments – Greenish grey brown interbedded SILT and fine SAND. Moist, stiff to very stiff. Silt is hard, overconsolidated! Occasional minor seep in sand layers.
Vertical trench walls stable.	∇ 4 5 6		Glacio lacustrine / fluvial Sediments – Interbedded SILT and fine SAND, as above. Color is greyish blue. Unit is very stiff to hard, silt clearly overconsolidated. Occasional minor seep in sand layers. TD = 6.5m
Photos 1-6, 1-7.	7		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-6
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct.3/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

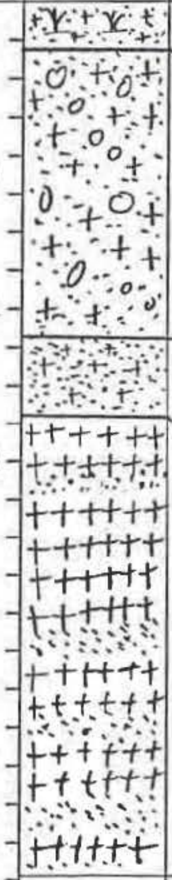
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed dark brown to black wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. moist to wet, medium dense to dense (at 2.0m). Medium loose at top of till.
Minor inflow of water and sand, "running sand."	▽ 2		Glaciofluvial Sediments - SILTY SAND, moist brown, very stiff, overconsolidated.
			Glaciofluvial Sediments - Brown, fine to medium grained SAND. Wet to moist, minor amount of "running sand".
	3		Glaciofluvial Sediments - Bluish grey SILT and fine SAND. moist, very stiff to hard, overconsolidated. Occasional SANDY layer.
	4		
Vertical trench walls stable.	5		
			Trace gravel at bottom of trench.
	6		TD = 6.0m
	7		
Photos 1-8, 1-9, 1-10.			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-7
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 3/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown to black wet SILT and fine SAND with ORGANICS.
	1 2		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. moist, medium loose to 1m, dense to very dense to 2.2m. Till is overconsolidated.
Slight seep.	∇		Glaciofluvial Sediments - Greyish blue SILTY fine SAND with trace GRAVEL. Stiff to hard, overconsolidated. moist.
Vertical trench walls stable	3 4 5		Glaciolacustrine / fluvial Sediments - Greyish brown very stiff to hard SILT with occasional layer of SILTY fine SAND, trace CLAY. Silt and clay are overconsolidated. Slight seep at top of unit (2.7m). TD = 5.7m
No photo.	6 7		

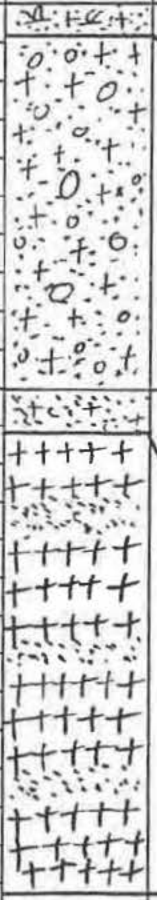
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-8
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 3/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown to black, wet SILT and fine SAND with ORGANICS.
	1 2		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, medium loose to 1.2m, dense to very dense to 2.5m. Till is overconsolidated.
Slight Seep.	▽ 3		Glaciofluvial Sediments - Greyish blue SILTY fine SAND with trace GRAVEL stiff to hard, overconsolidated, moist.
Vertical trench walls stable.	4 5		Glaciolacustrine / fluvial Sediments - Greyish brown very stiff to hard SILT with occasional layer of SILTY fine SAND, trace CLAY. Silt and clay are overconsolidated. TD = 5.8m
	6 7		
Photo 1-11, 1-12			

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-9 SHEET 1 of 1

PROJECT Mt. Polley

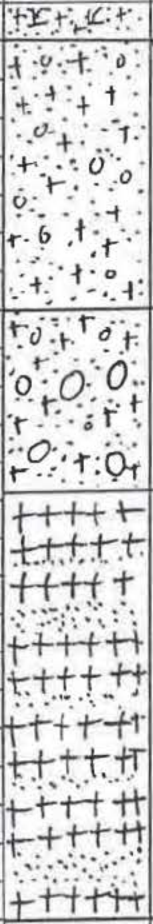
LOCATION OF TEST PIT Main Embankment ℄

DATE Oct. 4/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown to black wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet, medium dense. Dense at bottom of unit.
	2		Glacial Till - As above, with some GRAVEL and COBBLES. Hard, very dense, moist, Overconsolidated.
	3		Glaciolacustrine / Fluvial Sediments - Greyish blue, very stiff to hard, moist SILT and fine SAND with trace GRAVEL / COBBLES. No seeps evident. Overconsolidated.
No seeps evident. Vertical trench walls stable.	4 5		
	6		TD = 6.0m
	7		
Photo 1-15.			

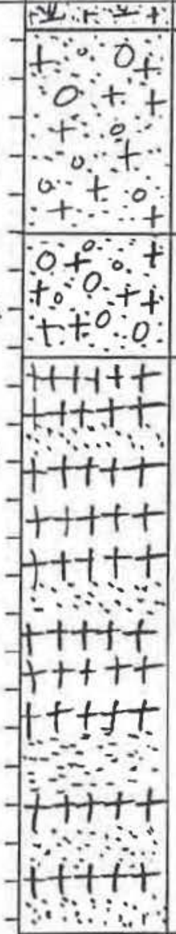
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-10
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 4 /95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200 LC Excavator			Topsoil - Disturbed dark brown to black, wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet, medium loose to dense. Slight seep at 1.5 m
	▽ 2		Glacial Till - As above, with mottled grey blue SANDY planes. Very dense.
Occ. minor seep on sandy horizons.	3 4 5		Glaciolacustrine / fluvial Sediments - Grey brown interlayed SILT and SANDY SILT with trace CLAY. SILT layers are medium brown color and SAND is grey brown. Unit is moist, stiff, overconsolidated. Occasional minor seep on sandy horizons.
Vertical trench walls stable.	6		TD = 6.0m
	7		
Photos 1-16, 1-17, 1-18, 1-19.			

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-11 SHEET 1 of 1

PROJECT Mt. Polley

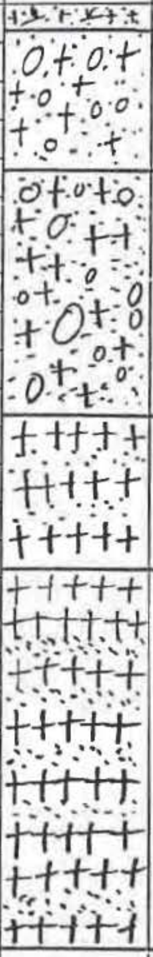
PROJECT NO. 1625

LOCATION OF TEST PIT Main Embankment ℄

GROUND EL.

DATE Oct. 4/95

LOGGED BY KOE



NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown moist to wet SILT and fine SAND with ORGANICS.
	▽ 1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES - Moist to wet, medium loose.
Slight seep at top and bottom of dense till.	2		Glacial Till - As above, with blue mottled appearance. Blue mottles are SANDY horizons. Dense to very dense, moist. Overconsolidated. Slight seep at top and bottom of unit.
	▽ 3		Glaciolacustrine/fluvial Sediments - Greyish blue SILT, SILTY SAND. Moist, stiff to very stiff. Overconsolidated. Occasional wet sand seam to 10 cm.
Vertical trench walls stable.	4 5 6		Glaciolacustrine/fluvial Sediments - Brownish green interlayered SILT and fine SAND. Silt layers are muddy brown color, overconsolidated. Sandy layers are green brown color. Layers typically to 5mm. Moist (drier than upper unit), very stiff.
			TD=6.2m
Photo 1-20.	7		

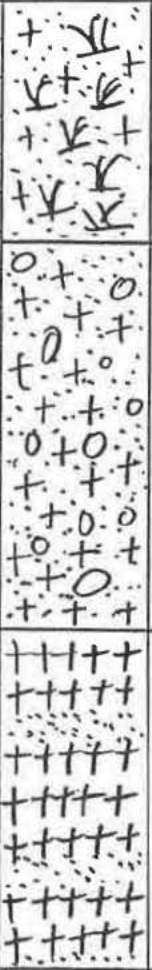
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-12
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 4/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

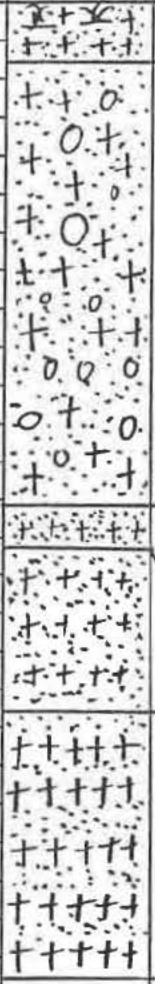
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator.	1		Topsoil - Disturbed topsoil and roots for nearby burn pile. Topsoil not 1.6m thick originally.
	2 3		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, dense to approx. 2.5m and very dense to 4.1m. Slight seep at bottom of till unit.
Slight seep at bottom of till. Vertical trench walls stable.	▽ 4 5 6		Glaciolacustrine/fluvial Sediments - Greyish blue to green brown SILT and SILTY SAND. Fine, brown muddy SILT layers typically 2cm thick; SILTY SAND layers 2 to 3mm. Moist, very stiff to hard. Over-consolidated.
Photo 1-21	7		TD = 6.3m

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP.95ME-13
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT Main Embankment ℄
GROUND EL.
DATE Oct.4/95
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed, dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1 2 3		Glacial Till – Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, very dense, overconsolidated.
	4		Glaciolacustrine / fluvial Sediments – Grey brown, moist SILT and SANDY SILT. Medium stiff to stiff, overconsolidated.
			As above, but grey blue color, very stiff to hard. Moist, overconsolidated.
No seeps evident. Vertical trench walls stable.	5 6		As above, sediments with more pronounced interlayering of SILT and SANDY SILT. Very stiff to hard, moist, overconsolidated. TD = 6.4m
Photo 1-22.	7		

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-14 SHEET 1 of 1

PROJECT Mt. Polley

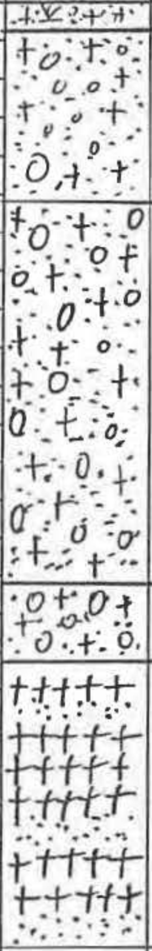
LOCATION OF TEST PIT Main Embankment ℄

DATE Oct.4/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator.			Topsoil - Disturbed dark brown, moist to wet SILT and fine SAND with ORGANICS.
Slight seep at bottom of till.	1 ▽		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. moist to wet, medium dense. Seep at bottom of till.
	2 3		Glacial Till - As above, with blue mottled appearance. Blue grey mottles are sandy horizons. Very dense, moist, overconsolidated. Mottled sandy horizons are thin (to 2mm), wet.
	4		Glacial Till - As above, bluish grey color, medium dense, moist to wet.
	5 6		Glaciolacustrine / Fluvial Sediments - Light brown, moist SILT and SANDY SILT. Stiff to very stiff (almost hard). Mottled appearance near bottom. TD=6.2m
Photo 1-23	7		

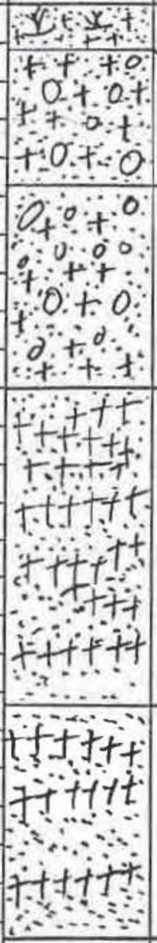
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-15
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 4 /95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Top Soil - Disturbed dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Medium loose, moist to wet.
	2 ▽		Glacial Till - As above, with bluish grey mottled appearance. Mottled horizons are wet SAND, to 2mm. Very dense, moist overall.
	3 4 ▽		Glaciofluvial / lacustrine Sediments - Highly irregular, intermixed layers of light brown fine to medium SAND and SILT. Unit is moist, stiff to very stiff. Silt is overconsolidated. Seep at top of unit.
Some "running sand".	5 6		Glaciofluvial / lacustrine Sediments - As above, with more SAND (SILTY SAND). Sand is loose, some pockets are making water and running. Seep at top of unit. TD = 6.1m
Photo 1-24, 1-25.	7		

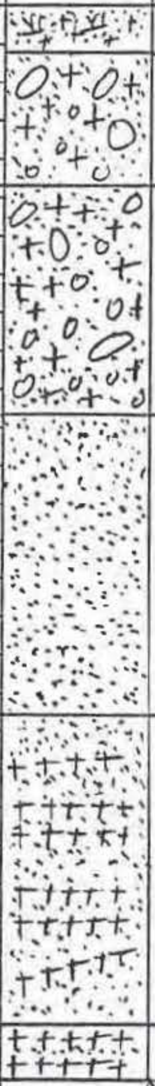
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-16
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 4 /95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



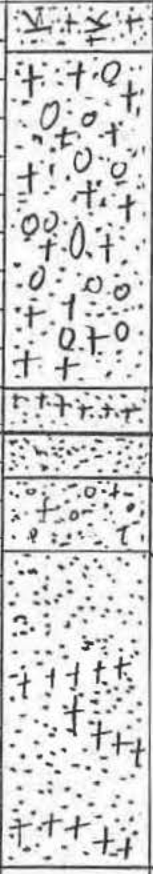
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200 LC Excavator			Topsoil- Disturbed dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till- Greenish grey brown SILTY SAND with trace GRAVEL and COBBLES. Medium loose, moist to wet.
	2		Glacial Till- As above, with bluish grey mottled appearance. Mottled horizons are wet SAND, to 2mm. Moist, dense to very dense. Seep at base of till.
Seep <1gpm. "Running Sand".	∇ 3 4		Glaciofluvial /lacustrine Sediments - Brown, medium grained, loose, wet SAND. Seep at 2.7m, with inflow <1gpm and running SAND.
Total Inflow 1-2 gpm.	5 ∇ 6		Glaciofluvial /lacustrine Sediments - Interlayered, brown moist SILTY SAND, Stiff, overconsolidated. Occ. Sand layer loose and seeping
	7		Glaciofluvial /lacustrine Sediments - As above, more regularly layered SILT and SANDY SILT. Moist, stiff. TD = 7.0m
Photo 2-2, 2-3, 2-4.			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-17
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT Main Embankment ℄
GROUND EL.
DATE Oct. 4/95
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Disturbed dark brown, moist to wet SILT and fine SAND with ORGANICS.
Till quite soft.	1 ▽ 2		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet, medium loose/dense to 1.5m. Dense to 2.5m. Slight seep at 1.5m
"Running Sand"	▽		Glaciolacustrine/fluvial Sediments - Interlayered light brown, stiff, moist SILT and SILTY SAND.
	3		Glaciofluvial/lacustrine Sediments - Brown, loose, wet sand. Seep at top, running.
"Running Sand", est. water inflow, approx. 2gpm	▽		Glaciofluvial Sediments - Brown, wet, SILTY SAND and GRAVEL.
Trench collapsing in Sand layers.	4 5		Glaciolacustrine/fluvial Sediments - Brown, irregular layers of medium grained, loose wet SAND and some SILT. Water seeping in sand, which is "running". TD=5.7M
Photo 2-5, 2-6.	6 7		

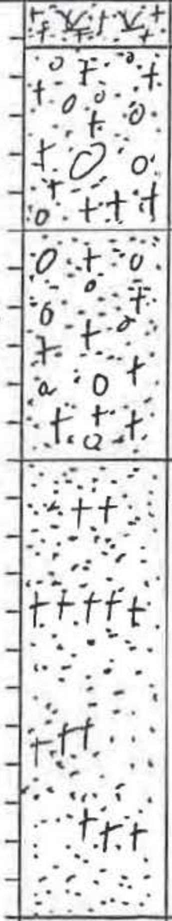
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-18
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct 4/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200LC Excavator			Topsoil - Disturbed, dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace GRAVEL and COBBLES. Moist to wet, medium loose/firm to 1.5m
Till quite wet, loose.	2		Glacial Till - As above, with bluish grey mottled appearance. Moist to wet, medium loose to firm. Seep at base of till
Seep at base of till.	∇ 3		Glaciofluvial Sediments - Light brown, wet, fine to medium SAND with occasional irregular layer of stiff, overconsolidated SILT. SAND is loose, entire unit is seeping, with "running sand". Trench sides collapsing
"Running Sand"	4		
Trench walls collapsing.	5		
	6		TD=6.0m
	7		
Photo 2-7.			

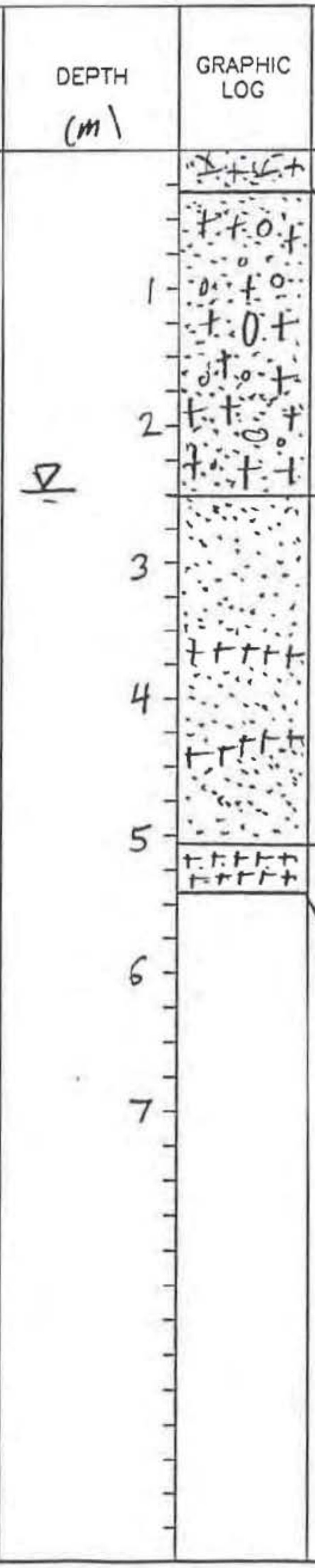
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-19
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct 4/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



NOTES Groundwater level difficulty in digging, equipment used, etc.	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator	Topsoil - Dark brown, moist to wet SILT and fine SAND with ORGANICS-
	Glacial Till - Greenish grey brown, SILTY SAND with trace to some GRAVEL and COBBLES. wet, medium dense/loose. Slightly drier, medium dense at 2.2m
Seeping throughout SAND. "Running SAND"	Glaciofluvial Sediments - Brown, fine to medium SAND with occasional thin layer (to 2.5 cm) of stiff, over-consolidated SILT. Wet, loose, seeping throughout unit.
Trench collapsed.	Glaciolacustrine Sediments - Light brown, moist, stiff to very stiff (almost hard) SILT. TD=5.4m

No photo

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-20 SHEET 1 of 1

PROJECT Mt. Polley

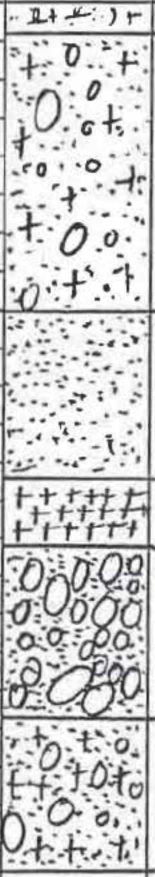
LOCATION OF TEST PIT Main Embankment ℄

DATE Oct. 4 /95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Dark Brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Medium dense, moist.
Random Seeps in Sand	∇ 2		Glaciofluvial Sediments - Brown, medium grained loose wet SAND. Seep at bottom, also randomly within unit.
	∇ 3		Glaciolacustrine Sediments - Light brown, moist very stiff overconsolidated SILT with occasional SAND seam
-Strong seep at base of gravelly unit -	4 ∇		Glaciofluvial Sediments - Wet, brown SANDY GRAVEL and COBBLES, Very dense, seep at base of unit 2-3 gpm.
-very hard to dig in red till	5		Glacial Till - Red brown, very dense, moist SILTY SAND with some GRAVEL and COBBLES, overconsoliated. Basal till? TD = 5.7m
	6		
	7		
Photos 2-8, 2-9.			

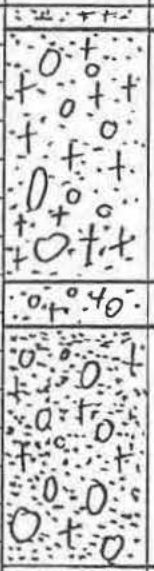
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-21
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Main Embankment ℄
DATE Oct. 4/95

PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

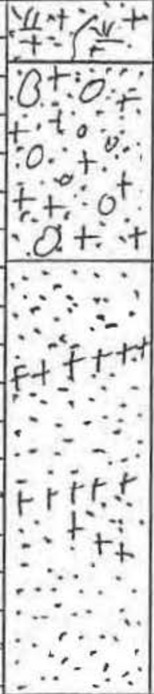
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil – Dark brown, moist SILT and fine SAND with ORGANICS.
	1 ∇		Glacial Till – Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. medium dense to dense, moist to wet. Seep at bottom.
	2		Glacial Till – Intermixed brown till and reddish Basal till. Moist, very dense.
Difficult to dig in.	3		Glacial Till – Reddish brown SAND and SILT with some GRAVEL and COBBLES. Moist to wet, very dense, SANDY till TD = 3.7m
	4		
	5		
	6		
	7		
Photo 2-10			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-22
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT U/S Toe Main Embankment
DATE Oct. 4/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

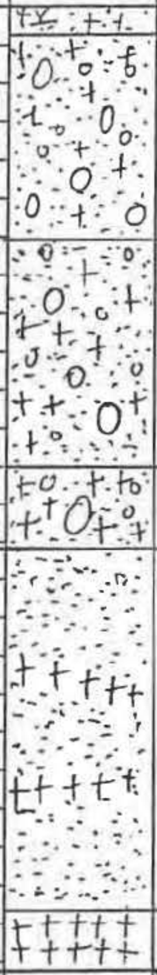
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200LC Excavator			Topsoil - Disturbed dark brown SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES - Medium dense, moist to wet.
Seep in sand.	▽ 2 3		Glaciofluvial / lacustrine Sediments - Brown, fine to medium, loose, wet SAND with occasional thin layer (to 1 cm) of light brown, v. stiff, overconsolidated SILT. Water seeping in SAND unit.
Hole collapsed	4		TD = 4.6m
No photo.	5 6 7		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-23
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT U/S Toe Main Embankment
GROUND EL.
DATE Oct. 4/95
LOGGED BY KOE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200LC Excavator			Topsoil - Brown, moist to wet SILT and fine SAND with ORGANICS.
Slight Seep at base of till.	1 ▽		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Medium dense, moist to wet. Slight Seep
	2		Glacial Till - As above with bluish grey mottled horizons. Very dense, moist to wet (esp. on mottling).
	3 ▽		Glacial Till - Content as above, greyish blue color, very dense, moist.
Vertical trench walls stable.	4 5		Glaciofluvial / Glaciolacustrine Sediments - Brown, medium grained wet SAND with occasional thin, very stiff overconsolidated SILT layer. Random seeps in wet SAND.
	6 7		Glaciolacustrine Sediments - Light brown, moist, very stiff SILT with occasional SAND layer. TD = 6.3m
Photo 2-10			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-24
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT U/S Toe Main Embankment
DATE Oct 4/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator.	1		Glacial Till- Greenish grey brown, SILTY SAND with trace to some GRAVEL AND COBBLES- Medium dense, moist to wet.
Minor seep at base of looser till unit.	∇ 2 3 4		Glacial Till- As above, with bluish grey mottled horizons; moist, dense to very dense.
			Glacial Till - As above, bluish grey color, moist, very dense.
Vertical trench walls stable.	5		Glaciolacustrine /Fluvial Sediments- Brown SILTY SAND. very stiff, moist.
	6		Glaciolacustrine /fluvial Sediments - Greyish Brown SILT and SILTY SAND, wet to moist, stiff to very stiff. TD = 6.3m.
Phot 2-12.	7		

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-25 SHEET 1 of 1

PROJECT Mt. Polley

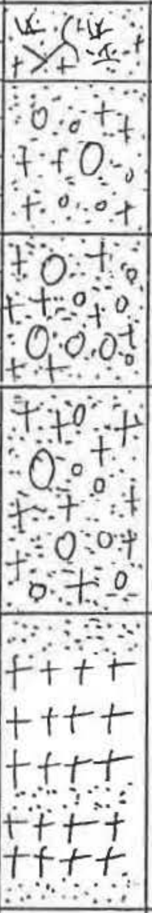
LOCATION OF TEST PIT D/S Toe Stage 1b Main Embankment

DATE Oct 5/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Dark brown, disturbed, wet to moist SILT and fine SAND with ORGANICS.
Slight seep at base of till.	1 ∇		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Dense to medium dense, moist, slight seep at base of unit
	2		Glacial Till - As above, but very dense.
	3		Glacial Till - As above, but bluish grey color, moist, very dense.
	4 5		Glaciolacustrine / fluvial Sediments - Light brown moist, stiff SILT. Overconsolidated. Occasional layer of loose wet fine SAND. (NOT running). TD=5.9m
	6 7		
Photo 2-13..			

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TD95ME-26 SHEET 1 of 1

PROJECT Mt. Polley

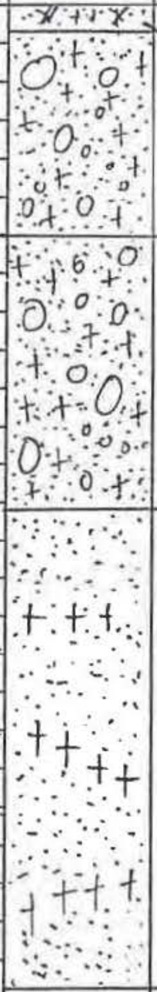
LOCATION OF TEST PIT D/S Toe

DATE Oct. 5/95 Stage Ib Main Embankment

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

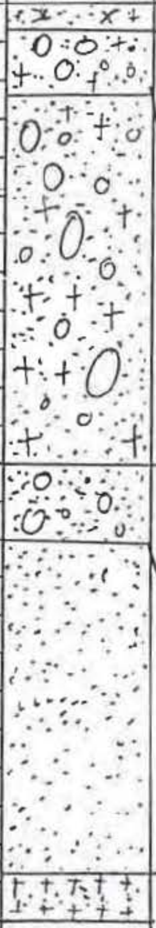
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed dark brown, wet to moist SILT and fine SAND with ORGANICS.
	1		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Medium dense/loose, moist to wet.
	2 3		Glacial Till- As above, except drier (moist) and dense.
Slight seep in SAND unit.	4 ▽ 5 6		Glaciolacustrine/fluvial Sediments - Light brown, wet, fine to medium grained interlayered SAND and SANDY SILT. Occasional minor seep in sand (≈5m). Wet, loose but not running; although sand is collapsing. TD=6.4m
No photo.	7		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-27
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT D/S Toe Stage 1b Main Embankment
GROUND EL.
DATE Oct. 5/95
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200 LC Excavator			Topsoil- Disturbed dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till- Greenish grey brown with greyish mottled horizons. SILTY SAND with trace to some GRAVEL and COBBLES. Medium Dense, moist.
	2		Glacial Till- As above, but moist to wet, medium dense to loose.
Seeping gravelly unit	3 ▽		Glaciofluvial Sediments - brown, wet SAND with some GRAVEL. Medium dense to loose; seep in gravelly sections.
"Running Sand" Not as much water as embankment centre line.	4 5		Glaciofluvial Sediments - Medium grained, loose, wet brown SAND. Water seeping in, causing SAND to collapse and "run". Sand collapsing.
Trench collapsing	6		Glaciolacustrine Sediments - Light brown, moist, stiff interlayered SILT and SANDY SILT. TD = 6.0m
Photos 2-16, 2-17, 2-18.	7		

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-28 SHEET 1 of 1

PROJECT Mt. Polley

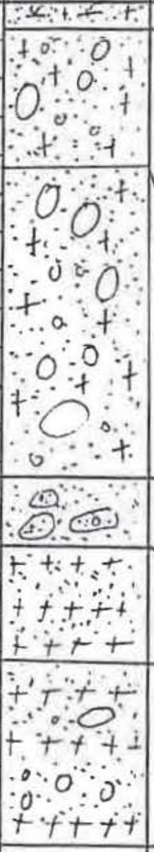
LOCATION OF TEST PIT D/S toe Stage 1b Main Embankment

DATE Oct5/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

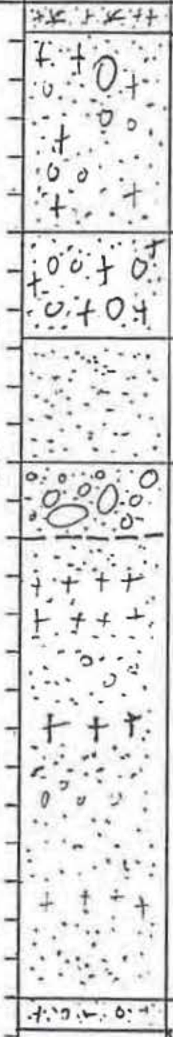
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed dark brown, moist lower SILT and fine SAND with ORGANICS.
	1		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, medium dense.
	2		Glacial Till- As above, with blue-grey mottled horizons (sandy coatings on rocks). Moist, very dense.
Seep in sand.	3 ∇		Glaciofluvial/lacustrine Sediments - Brown/greenish grey wet SAND with irregular patches of Brown and red glacial till. Rusty color.
	4		Glaciolacustrine/fluvial Sediments - Light brown, moist, very stiff to hard SILT and fine SAND.
Vertical trench walls stable.	5		Glaciolacustrine/Fluvial Sediments - Light brown SILT and fine SAND with some GRAVEL and COBBLES. Moist, very stiff to hard TD=5.5 m
	6		
	7		
photo 2-19.			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-29
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT D/S toe Final Main Embankment
DATE Oct 5/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



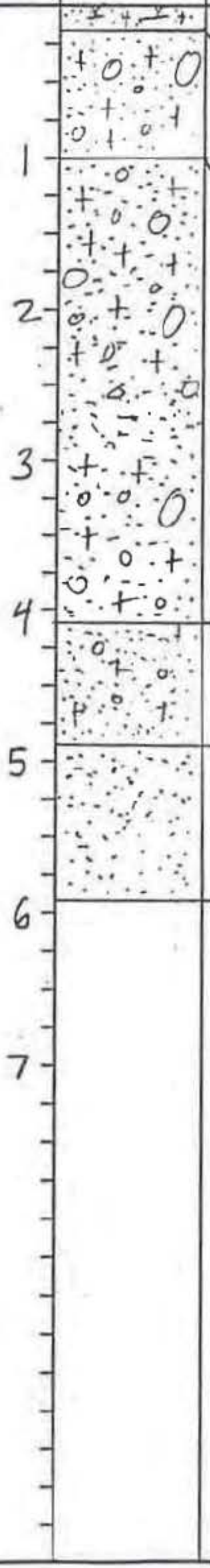
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Dark brown, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Medium dense, moist.
	2		Glacial Till. As above, with blue-grey mottling. Moist, very dense (overconsolidated).
			Glaciofluvial Sediments - Brown, wet, medium 100% medium grained SAND.
Strong seep in coarse sediments.	∇ 3 4 5 6 ∇		Glaciofluvial Sediments - Brown, wet SAND, GRAVEL and COBBLES. Dense to very dense. Strong seep, approx. 2-3 gpm. Coarse material extends to approx 3.5m. Below 3.5m, SAND with some SILT, GRAVEL.
	7		Brown, moist SILTY SAND and GRAVEL. Dense to very dense. Probably glacial till TD=6.7m
photo 2-20.			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-30
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT D/S Toe Final Main Embankment
DATE
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



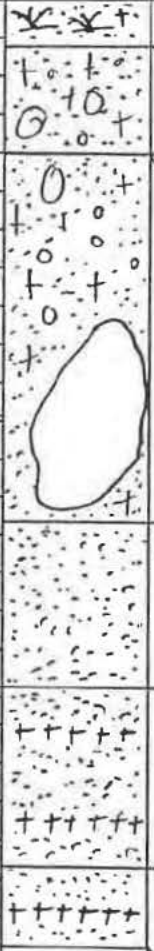
NOTES Groundwater level difficulty in digging, equipment used, etc.	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator	Topsoil - Dark brown, moist to wet SILT and fine SAND with ORGANICS. Lots of Roots -
	Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist; medium dense
	Glacial Till - As above, but moist, dense to very dense. Occasional SAND LENS.
	Glaciofluvial Sediments - Green brown SILTY SAND with trace GRAVEL. Wet, medium dense to loose.
Trench staying open.	Glaciofluvial Sediments - Brown, loose wet SAND with water seeping, minor "running SAND" TD > 5.9 m
Photo 2-21	

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-31
SHEET 1of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT D/S Toe Final Main Embankment
DATE Oct.5/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

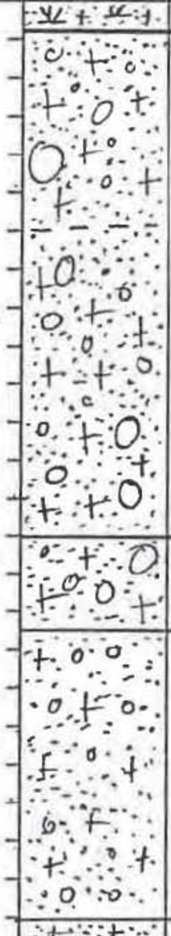
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil - Black, wet SILT and fine SAND with lots of ORGANICS (peat).
	1		Glacial Till - Bluish grey SILTY SAND with trace to some GRAVEL and COBBLES. Wet, firm (color due to overlying organics).
	2 3		Glaciall Till - Greenish grey brown. Composition as above. Medium dense to dense, moist to wet. One boulder 1.5m diameter.
Water seeping in sand horizon.	∇ 4		Glaciofluvial Sediments - Brown, medium loose, wet SAND. Water seeping in, Sand collapsing badly.
	5		Glaciofluvial Sediments - Brown, loose wet SAND with occasional layer (1 to 2cm) of overconsolidated SILT.
	6 7		Glaciolacustrine Sediments - Interlayered light brown fine SILTY SAND and muddy brown overconsolidated SILT. Wet, stiff. TD = 6.2m
Photo 2-22			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95ME-32
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT D/S Toe Final Main Embankment
DATE Oct 5/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200LC Excavator			Topsoil - Dark brown, moist to wet SILT and fine SAND with ORGANICS.
Slight Seep in till	1 ∇ 2 3		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet, medium dense to dense (at bottom). Slight seep in till approx 1.5m (denser)
	4		Glacial Till - As above, blue grey color, SANDY, wet, medium dense.
	5		Glacial Till - Greenish grey brown color, as above. SILTY SAND with trace GRAVEL, over-consolidated. (maybe sediments), Moist to wet, dense. Slight seep.
Seep in sand.	∇ 6		
	7		Glaciolacustrine Sediments - Interlayered light brown fine SILTY SAND and muddy brown overconsolidated SILT. Moist, stiff. TD=6.2m.
Photo 2-23			

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-33 SHEET 1 of 1

PROJECT Mt. Polley

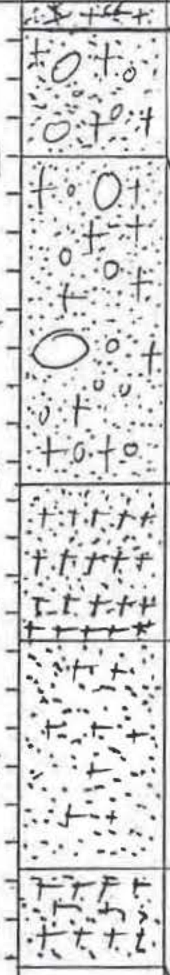
LOCATION OF TEST PIT D/S Toe Final Main Embankment

DATE Oct 5/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed dark brown moist to wet SILT and fine SAND with ORGANICS
	▽ 1		Glacial Till - Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, dense. Minor seep.
Minor seep at base of looser till.	2 3		Glacial Till - As above. Moist, very dense.
	4		Glaciolacustrine / fluvial Sediments - Interlayered, brown, moist SILT and SILTY SAND. Very stiff.
	5		Glaciofluvial / lacustrine Sediments - Brown, wet, medium grained SAND with trace SILT. Medium dense to loose. Water held in Sand, not seeping or running.
	6		Glaciolacustrine Sediments - Light brown, moist SILT and SILTY SAND. Stiff / very stiff. TD = 6.3m
	7		
Photo Z-24			

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95ME-34 SHEET 1 of 1

PROJECT Mt. Polley

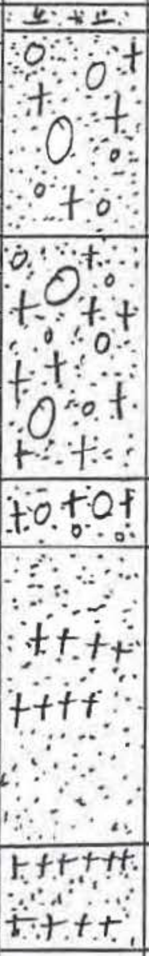
LOCATION OF TEST PIT D/S Toe Final Main Embankment

DATE Oct 5/95

PROJECT NO. 1625

GROUND EL.

LOGGED BY KDE



NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed brown/black, moist to wet SILT and fine SAND with ORGANICS
	1		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist to wet, medium dense to dense at bottom.
	2 3		Glacial Till- As above, with bluish grey mottled horizons, which are sandy coatings. Moist to wet, very dense.
Slight Seep	∇		Glacial Till- as above, bluish grey with some COBBLES and GRAVEL. Moist, very dense.
	4 5		Glaciofluvial / lacustrine Sediments- Brown, wet, medium grained SAND with trace SILT. Occasional silt pocket- Medium loose.
Slight Seep.	∇		Glaciolacustrine Sediments - Light brown, moist SILT and SILTY SAND Stiff to very stiff TD=6.2m
	6		
	7		
Photo 2-25			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP-S19
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Seepage Pond, NE corner (S.O.P. S19)
DATE Sept 21/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

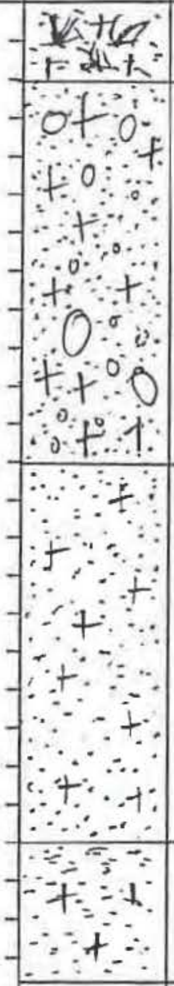
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
JD-690D LC Excavator	▽		Dark brown, wet, loose SILT and fine SAND with ORGANICS. (TOPSOIL).
Occ. seep, >>1gpm.	1 ▽		Bluish grey to brown, moist to wet, dense to very dense SILTY SAND with some GRAVEL, occ. COBBLE. Over-consolidated. (GLACIAL TILL)
	2 3 4		Grey-green to green brown, moist, very stiff SILT with trace fine SAND. Uniform, glaciofluvial / glaciolacustrine sediments. Occasional seep. Over consolidated
	5		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TPS20
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT NO. 1625
LOCATION OF TEST PIT Seepage Collection Pond 15m west of S20
GROUND EL.
DATE Oct. 5/95
LOGGED BY KDE



NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil- Disturbed darkbrown, black moist to wet SILT and fine SAND with ORGANICS.
Slight Seep.	∇ 1 2		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Has bluish grey mottled horizons which are wet. Overall, moist to wet, medium dense to 1.5m and medium dense to dense at bottom. Slight seep on mottled surfaces
Hole almost dry.	3 4 5		Glaciolacustrine/Fluvial Sediments — Brown, moist to wet SAND and SILTY SAND. Stiff to firm.
Vertical trench walls stable.	6		Glaciolacustrine/Fluvial Sediments - As above, but greyish brown color. moist, stiff. TD=6.4m
Photo 3-1	7		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TPS20.5
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Seepage Collection Pond Between S20/S21.
DATE Oct 5/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

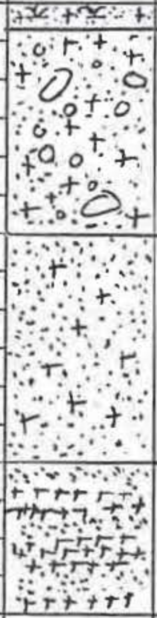
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC200LC Excavator			Topsoil – Disturbed brown/black, moist to wet SILT and fine SAND with ORGANICS.
	1		Glacial Till – Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES. Moist, dense
Minor seep on sandy crack in till	2 3 4		Glaciolacustrine / Fluvial Sediments – Interlayered light brown SILT and SILTY SAND. moist to wet (at sandy horizons).
Vertical trench walls stable	5 6		Glaciolacustrine / Fluvial Sediments – As above, greyish color. TD=6.5m
Photo 3-2	7		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP-521
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Seepage Pond, SW corner
DATE Sept 21/95 (S.O.P. 521)
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE



NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
JD 690D-LC excavator			Dark brown, moist, loose SILT and fine SAND with ORGANICS. (TOPSOIL)
	1		Brownish grey, moist and dense SILTY SAND / SILT with trace to some GRAVEL, trace COBBLES, occ. BOULDER (GLACIAL TILL)
Waterseeping in sandy sediments.	▽ 2		Brown, loose, very wet medium grained SAND with trace SILT (Binds together). Unstable, sides of trench collapsing. Waterseeping in. (Glacio fluvial / Glaciolacustrine sediments.)
Entire trench collapsed. No samples, no photos.	3		Brown, medium dense, moist to wet layered SILT and fine SAND, trace CLAY. Over-consolidated. (Glaciofluvial/Glaciolacustrine sediments).
	4		
	5		

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TPS21.2
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Seepage Collection Pond East of S21
DATE Oct 5/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

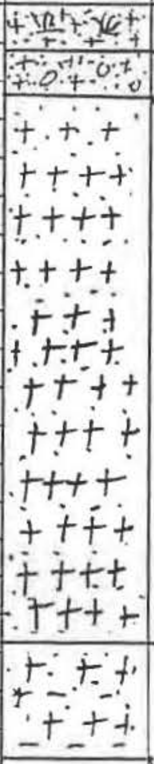
NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Komatsu PC 200 LC Excavator			Topsoil- Disturbed dark brown SILT and fine SAND with ORGANICS. WET to MOIST
	1		Glacial Till- Greenish grey brown SILTY SAND with trace to some GRAVEL and COBBLES, moist to wet, medium dense.
	2		Glaciolacustrine/Fluvial Sediments- brown, moist to wet fine SAND and SILT, Firm to stiff.
	3 4 5		Glaciolacustrine/fluvial Sediments- Blue grey interlayered SAND (fine) and SILT. Occasional seam of muddy brown stiff overconsolidated SILT/CLAY. Moist to wet, firm to stiff.
Vertical trench walls stable.	6		Glaciolacustrine Sediments - Light brown, interlayered SILT and fine SAND. moist, stiff TD = 6.0m
	7		
Photo 3-3			

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP-S22
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Seepage Pond, SE corner (S.O.P. S22)
DATE Sept 21/95
PROJECT NO. 1625
GROUND EL.
LOGGED BY KDE

NOTES Groundwater level difficulty in digging, equipment used, etc.	DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
JD 690D-LC Excavator	▽		Darkbrown, wet, loose SILT and fine SAND with ORGANICS (TOPSOIL).
	1		Greenish-grey to brown, moist, medium dense SILT/SILTY SAND with trace to some GRAVEL. (GLACIAL TILL).
Occ. small seep in bluish layer >> 1gpm.	▽ 2 ▽ 3 4		Mottled green grey to brown SILT and SILTY fine SAND. Very stiff, moist. mottled appearance due to the presence of randomly oriented grey-blue layers of fine SILT and CLAY with trace SAND and GRAVEL. Layers seep a small amount of water. Dense, over-consolidated GLACIOFLUVIAL/GLACIOLACUSTRINE SEDIMENTS.
	▽ 5		Greyish Blue, moist, very stiff SILT and CLAY with trace SAND. Over-consolidated. Minor seep. Similar to above glaciofluvial/glaciolacustrine sediments.

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
CONTRACT NO.

TAILINGS STORAGE FACILITY
AND ANCILLARY WORKS
(REF. NO. 1625/3)

PART 10 - TECHNICAL SPECIFICATIONS

MARCH 25, 1996

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
CONTRACT NO. ____

TAILINGS STORAGE FACILITY
AND ANCILLARY WORKS

PART 10 - TECHNICAL SPECIFICATION
(REF. NO. 1625/3)

TABLE OF CONTENTS

TECHNICAL SPECIFICATIONS

SECTION 1 - GENERAL TECHNICAL REQUIREMENTS

1.1 Scope

The general technical requirements specified in this Section shall, except as specifically excluded in the sections following, apply to all activities and operations relating to carrying out the Work as shown on the Drawings or as required by the Company Representative and/or the Engineer.

The Work to be carried out under the Contract shall consist of supply of all labour, Plant and materials and performing all things necessary to construct the entire Work as defined in these Technical Specifications, on the Drawings or required by the Company Representative and/or the Engineer.

A listing of the advance notice periods required of the Contractor is given on Table I, Page 1-73.

1.2 Clearing, Stripping, Grubbing and Topsoil Removal

The Contractor shall clear, strip, grub and remove topsoil from all ground surfaces prior to excavation in any area, in areas which are not excavated but in which fill is to be placed, and over remaining areas of the tailings basin to the limits shown on the Drawings.

In order to reduce erosion and contamination of the surface runoff to a minimum at all times, clearing, stripping, grubbing and topsoil removal shall be scheduled to be performed only as and when required to enable each portion of the Work to be carried out.

1.2.a Clearing

Clearing the areas of the Site so designated on the Drawings or in the Technical Specifications shall consist of the felling of all trees, shrubs and vegetation to within eighteen inches of the ground.

Felling of timber and removal from site of all merchantable timber will be carried out by Others under the direction of the Company Representative.

As Work of this Contract, all non-merchantable timber and vegetation shall be disposed of by burning to reduce it to ashes or as otherwise approved by the Company Representative. Care shall be taken in burning debris to prevent the fire from spreading. Prior to starting any fires the Contractor shall notify the Company Representative and the governmental authority having jurisdiction with regard to fires and shall obtain written permission to proceed.

General requirements regarding prevention and control of fires are covered in the General Conditions. At all times during which burning takes place, the Contractor shall have available in working order to control the fire, sufficient fire fighting equipment and personnel to operate such equipment.

Any clearing which the Contractor elects to perform for his own purposes shall be subject to the approval of the Company Representative and shall be performed in accordance with the requirements of this Clause. Prior to the clearing of any area which is not required for the Work, the Contractor shall submit to the Company Representative for approval, full details of the proposed clearing. Clearing in any such area shall not be commenced prior to receipt of written approval by the Company Representative.

1.2.b Stripping and Grubbing

Stripping and grubbing of the selected areas of the Site shown on the Drawings shall consist of the complete removal of all vegetation and organic matter and grubbing to remove all roots and stumps.

All vegetable matter, roots and stumps so produced shall be disposed of in the same manner as that specified for non-merchantable debris in (a) above. Muskeg or material which cannot be burned shall be stockpiled in the designated topsoil stockpile area.

1.2.c Removal of Topsoil

After an area has been cleared, stripped and grubbed and the debris removed, the Contractor shall remove the surface topsoil and stockpile this material in the areas shown on the Drawings. Organic matter shall be stockpiled separately from the oxidized rooting layer of mineral soil.

The material is to be stockpiled in a neat workmanlike manner approved by the Company Representative such that it will be stable and protected from erosion.

Areas of standing water and swampy ground which are of sufficient extent to prevent topsoil removal by normal construction methods will not require topsoil removal. These areas will be defined in the field by the Company Representative.

1.3 Open Excavation

1.3.a Classification

Material excavated in open cut for the Work will be classified as follows:

1.3.a.i Class 1 Excavation

Class 1 excavation shall be in material excavated within the specified excavation limits which can be removed by hand or accepted mechanical excavation methods up to and including removal by ripping and bulldozing using a track mounted tractor, at least equivalent to a Caterpillar D9L in weight and horsepower and equipped with a single tooth articulated ripping attachment or, in confined areas, by a mechanical hydraulic shovel at least equivalent to a Caterpillar 225 fitted with a rock bucket of 1 cubic yard capacity.

1.3.a.ii Class 2 Excavation

Class 2 excavation shall be in material excavated within the specified excavation limits which cannot be removed by the methods specified in Sub-clause (i) of this Clause, and which would normally require recognized quarrying methods such as drilling and blasting.

In the event of a dispute as to the classification of any excavated material, the decision of the Engineer will be final.

1.3.b General

The Contractor shall develop its excavation methods, techniques and procedures with due consideration of the nature of the materials to be excavated and shall take such precautions as are necessary to preserve in an undisturbed condition all materials outside the lines and grades shown on the Drawings. The Contractor will be permitted to carry out excavation, shaping etc. by whatever method it considers most suitable, providing it is consistent with producing an acceptable end result as determined by the Engineer. The Contractor shall be solely responsible for the safety and adequacy of the methods employed.

The Contractor shall also notify the Engineer after clearing, stripping and grubbing, and removing topsoil from an area, and obtain the Engineer's approval of the adequacy of the exposed surface prior to excavating below or placing material on the surface.

The Contractor, in its scheduling of the Work, shall allow sufficient time in its construction schedule for the Company Representative's proper consideration thereof prior to his authorization to proceed with excavation in any area.

Furthermore, in areas where the Contractor is excavating both Class 1 and Class 2 materials, as hereinbefore defined, the Contractor shall obtain the Company Representative's written authorization to proceed with excavation of each Class before excavation begins.

The Contractor shall not excavate beyond the lines and grades shown on the Drawings without the prior written approval of the Company Representative. Any additional excavation which is performed by the Contractor for any purpose or reason whatsoever, other than in compliance with a specific request from the Company Representative, shall be carried out at the expense of the Contractor. If such additional excavation, as defined herein, should in the opinion of the Company Representative, require backfilling in order to satisfactorily complete the Work, such backfilling shall be done by and at the expense of the Contractor to the satisfaction of the Company Representative and with material supplied by the Contractor at its own cost, and approved by the Company Representative.

Where pipe, drain or culvert trenches are to be excavated in fill, excavation shall not commence until the elevation of the compacted fill exceeds the nominal crown elevation of the conduit by at least 30 centimetres.

The Contractor shall provide, maintain and operate any temporary drainage and/or pumping facilities required to control ground and surface water in order to keep the excavations dry and in a stable condition. The Contractor's dewatering operations shall be accomplished in a manner that will not adversely affect the stability of the excavated slopes and will not cause erosion and softening of adjacent materials.

The discharge from any dewatering system shall be directed to sediment ponds.

When a section of excavation has been completed to the required lines and grades, the Contractor shall notify the Engineer who will inspect the Work. Excavated surfaces shall not be covered with pipe bedding, fill or concrete until the surface has been approved in writing by the Engineer. The Contractor shall uncover at its own expense, any excavated surface which has been covered prior to inspection and approval by the Engineer.

The Contractor shall protect and maintain all excavations until completion of the Work or until such time as the adjacent placement of material has been completed.

Material from the excavations, which meets, or can be processed to meet, the requirements for the construction materials specified in the Contract Documents, shall be either stockpiled for later use, or used directly for construction of the Work. In the event that the Contractor elects to stockpile fill material prior to placing it directly into the fill, the cost of double handling shall be at the Contractor's expense.

Excavated materials not suitable for use in construction shall be disposed of in spoil disposal areas as shown on the Drawings and as approved by the Company Representative.

1.3.c Class 2 Excavation

If the Contractor proposes to perform open excavation of Class 2 materials using drill and blast techniques, the Contractor's methods, techniques and procedures shall be such that, by controlling the relationship among such factors as: the location, dimensions and sequence of excavation of various benches, lifts and rounds; the burden; 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, the peripheral surfaces of all completed excavations shall be smooth, sound and to the specified lines of excavation.

Not less than 7 days prior to commencing Class 2 excavation for each part of the Work, and at any time it proposes to alter his methods for such excavation, the Contractor shall submit to the Engineer for authorization to proceed with the Work, complete details of the proposed plan for such excavation. Such plans shall include drawings and statements on all of the factors noted in the first paragraph of this Sub-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 sound, smooth, excavated rock surfaces.

If the methods, techniques and procedures of excavation adopted by the Contractor for any part of the Work are unsatisfactory in that they fail to conform to the Contractor's proposal as previously authorized by the Engineer or that they result in an excessive amount of excavation or overbreak beyond the specified lines or result in excavated rock surfaces which are not sound and smooth, then, notwithstanding the Engineer's prior authorization to proceed with the Work, the Contractor shall adopt at it's own expense such revised methods, techniques and procedures as are necessary to achieve the required results.

Except as otherwise specified, each bench of excavation in rock shall not exceed 6 m or such lesser height as may be directed by the Engineer in order to obtain satisfactory results.

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

The Contractor will not be permitted to blast within 30 m of any concrete, grout or shotcrete which has been in place less than 2 days. Blasting within 30 m of concrete, grout or shotcrete that has been in place 2 days or more will be permitted only after submission by the Contractor and authorization to proceed with the Work has been granted by the Engineer of the Contractor's proposed blasting procedures together with an outline of precautions to be taken.

The Contractor shall use non-electric blasting methods when conditions so require.

Except as otherwise specified or directed by the Engineer, the Contractor shall use pre-shearing, cushion blasting or other smooth wall drilling and blasting techniques as approved by the Engineer to excavate rock surfaces in open excavation.

Pre-shearing shall consist of drilling a line of holes not less than 38 mm in diameter in the plane of the required rock excavation surface and charging them with the minimum amount of high velocity explosive which will shear the rock in a plane along the line of the drill holes without shattering the rock. The charging rate for these holes shall not exceed 360 gm of 75 percent Gelignite or equivalent per square metre of pre-sheared area. In the event that higher velocity powder is used the charging rate shall be decreased on a pro-rated basis. The distance between the drill holes for pre-shearing shall not be greater than 0.6 m and such holes shall be drilled at closer spacings if the rock is being excessively shattered by the pre-shear blasting.

All holes in a pre-shear plane shall be drilled, charged and detonated simultaneously prior to drilling the production blast holes and at least 24 hours prior to detonating the production blast. The first row of production blast holes adjacent to the pre-sheared plane shall be lightly charged to ensure that the pre-sheared face will not be damaged when the main production blast is detonated.

The maximum practical amount of unexcavated burden shall be maintained between the pre-shear line and the open face. The bottoms of pre-shear holes shall not be positioned at a higher elevation than the bottoms of adjacent primary blast holes.

Where the unexcavated burden is considered to be insufficient for pre-shearing, "cushion blasting" shall be utilized. Cushion blasting is defined as the technique of carefully drilling a line of closely spaced holes, as for pre-shearing, in the plane of the minimum line of excavation, lightly loading the holes with well distributed, completely stemmed charges and firing them after the production blast in groups of not more than 25 holes per delay.

1.3.d Class 2 Surface Clean-Up

The Contractor shall completely remove all loose, shattered and disintegrated rock, gravel or other deleterious material preparatory to placement of any earthfill, concrete, shotcrete or against rock surfaces.

Such cleaning shall be done by the use of air and water jetting or by other methods approved by the Engineer for all surfaces beneath concrete, shotcrete or grout. Air and water jetting is defined as the use of such jets for the purpose of cleaning rock surfaces, removal of incompetent material and cleaning out of seams, cracks, fissures and other depressions.

Air and water jetting equipment shall be capable of delivering air and/or water jets at variable pressures up to 100 psi and shall be complete with a selection of nozzle sizes. Air and water jetting equipment shall be capable of delivering air, water or both air and water at the required pressure through one nozzle.

In all areas of open excavation of rock, other than those intended for the placement of concrete, shotcrete or grout, the rock surface shall be cleaned and scaled using regular excavating equipment to achieve a surface which is in compliance with the provisions of this Clause. The use of hand tools will not be required for such clean-up except in cases where hand scaling is necessary to provide safe working conditions.

1.3.e Tolerances in Class 2 Excavation

The Contractor will be permitted to leave projections of solid rock inside the required lines of excavation provided that such projections cover an area not greater than 0.5 square metres, occur at not less than 3 metre centres at the planes of the required lines of excavation and do not project more than 10 centimetres inside such plane.

1.3.f Revisions to Lines and Grades

In the event that the Company Representative should in his sole discretion require the Contractor to excavate any part of the Work to lines or grades other than specified, previously directed by the Company Representative, or shown on the Drawings then:

(i) if the Contractor is advised of such requirements before excavation to the lines and grades specified, previously directed by the Company Representative, or shown on the Drawings, such required excavation will be paid for as per the applicable L.S. price entered for the excavation in The Schedule of Estimated Quantities and Prices; or

(ii) if the Contractor is advised of such requirements after excavation to the lines and grades specified, previously directed by the Company Representative, or shown on the Drawings, all additional excavation so required will be paid for in accordance with "Changes in the Work" of the General Conditions.

1.3.g Stability and Protection of Excavated Surfaces

The Contractor shall be solely and completely responsible, until completion of the Work, for the safety, stability, maintenance, support and protection of all Class 1 and Class 2 excavated surfaces, the excavation of which is carried out under the Contract, and for the safety of his work force and the forces of Others while they are in the Contractor's working areas including areas in the immediate vicinity of the excavations. The Contractor shall supply and install rock reinforcement and provide all temporary supports, bulkheads, canopies, sheeting and bracing, divert surface water, remove water from the excavations, and shall provide and maintain such drainage and pumping facilities as are necessary to stabilize and protect the excavations. Except as otherwise approved by the Company Representative, such temporary support and facilities shall be removed by the Contractor on completion of the Work.

Immediately following each blast the Contractor shall scale and remove all loose or unstable material from surfaces exposed by the blast, including such material beyond the required line of excavation, and shall at all times maintain such surfaces free of loose, unstable and potentially dangerous materials.

The Contractor shall, wherever necessary, remove by scaling or other means all loose, overhanging or otherwise dangerous material situated on existing slopes that are located above excavations to be performed under this Contract.

1.4 Embankments and Berms

1.4.a General

The words "embankment fill", "fill materials", "fill" and "rockfill" shall be regarded as being interchangeable when used in the context of referring to the various zones of material comprising embankments and road fills. Similarly the words "backfill" and "bedding" shall be regarded as interchangeable when used in the context of referring to the various zones of materials comprising trench fill.

At least 7 days prior to the scheduled commencement of fill placement the Contractor shall submit to the Engineer for authorization to proceed with the Work, complete details of the various stages, materials, equipment, methods and procedures he proposes to use for such operations. Notwithstanding that the Engineer has given the Contractor authorization to proceed with such procedures, the Contractor shall be completely responsible for the planning and execution of such procedures.

The Contractor shall be liable for any damage whatsoever to property, caused by or resulting from his operations in performing the Work, including dewatering and/or drainage of embankment foundations. Such damage shall be fully repaired by and at the expense of the Contractor.

The Contractor shall prepare the foundation for and construct the various zones of fill of embankments and berms to the lines and grades shown on the Drawings within the tolerances specified herein. Fill materials shall not be placed on any part of foundations until all required excavation, dewatering and foundation preparation has been completed and written approval has been granted by the Engineer.

1.4.b Supply and Production of Fill Materials

Fill material for constructing the embankments and berms and for trenches shall be supplied by the Contractor and will be obtained from:

- excavations required for the Work
- borrow areas
- other sources which may be proposed by the Contractor and approved by the Company Representative and Engineer

The borrow areas and excavations contain sufficient material to complete the Work. However, the disposition of the material is random and heterogeneous in the borrow areas and excavations will require proper planning and operation to obtain suitable materials which meet the specified requirements for the various zones.

The Contractor shall be wholly responsible for supplying materials which conform to the specified requirements for each class of material and shall take whatever measures and precautions are necessary to achieve this objective. Such measures shall include, but not be limited to, planned operation, drainage and selective excavation in the borrow areas and excavations, sorting, blending, screening, etc.

In the event that the Contractor wishes to obtain any materials from sources other than those stipulated above, then it shall carry out, at it's own expense, investigations to show that the material contained in the alternate area are suitable for the intended purpose. Such investigations shall be sufficient, to establish that the material is suitable. Details of the investigations and the results thereof shall be submitted to the Company Representative and Engineer at least twenty-one (21) days before the Contractor intends to commence production in the alternate area. Approval by the Company Representative and Engineer for the Contractor to obtain construction materials from alternative sources shall not relieve the Contractor of it's responsibility to produce materials which conform with the specified requirements.

All borrow areas and excavations shall be cleared, stripped and grubbed prior to commencement of material production.

1.4.c Material Requirements

The Contractor shall provide all fill materials required for the Work and shall ensure that such materials meet the requirements specified herein or shown on the Drawings. The acceptability of such fill materials will be determined by the Engineer on the basis of quality control tests which will be made frequently on each material after it has been placed and spread in the embankments and berms.

Wherever the terms "rock", "rock fragments" or "rockfill" are used in this Section to denote a fill material, they shall mean rock obtained from Class 2 excavation or natural talus either directly from such sources or from stockpiles. The term "sand and gravel", when used in this Section includes naturally occurring cobble and boulder content in the sand and gravel where such material meets the gradation requirements shown on the Drawings.

Fill materials shall be durable, shall not, except as otherwise specified, contain more than a small proportion of thin, flat or elongated particles and shall be free from organic and other deleterious material. Except as otherwise specified, the particles shall be hard and resistant to breakdown during handling.

Fill materials shall be well graded within the specified gradation limits, that is, they shall contain a good distribution of all sizes of particles from the coarsest to the finest. The specified gradation limits shall apply to the materials when they are dumped and spread on embankments and berms or placed in trenches prior to any required compaction.

Drain gravel shall be free of organic materials and other deleterious substances. The materials shall be uniformly graded and the gradation shall fall entirely within the specified gradation limits for each class of filter materials. The drain gravel shall be placed to form the zones shown on the Drawings in a manner such that segregation is avoided. Drain gravel shall be compacted as directed by the Engineer. Moisture conditioning will not be required when placing drain gravel.

The required gradation envelopes for the various zones of fill and drain gravel are specified on the Drawings.

The Contractor shall, as and when necessary, process materials to produce fill materials which meet the requirements specified for the various zones. Such processing shall, where necessary, include, but not be limited to, separating material into various sizes, blending one material with another, scalping off oversize material, screening and/or washing to remove fines, crushing or selective excavation of the materials.

All oversize material shall be removed from the fill material either prior to its being placed in embankments, trenches or berms or after it is dumped and spread but before compaction operations are started. 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.

Stockpile locations shall be as approved by the Company Representative. The Contractor shall stockpile fill material such that excessive segregation will not occur. Before any area is used for stockpiling, it shall be cleared and stripped as necessary to prevent contamination of the material. Stripping and topsoil removal shall be carried out in accordance with the provisions of Clause 1.2.

1.4.d Fill Placement

The Contractor's operations and procedures for placing fill shall be subject to the approval of the Engineer in accordance with the provisions of Clause 1.4.a. Furthermore, no fill materials shall be placed in embankments, berms or trenches until all foundation preparation in the fill area has been completed to the requirements of the appropriate section in this Technical Specification and has been approved in writing by the Engineer.

The Contractor shall construct the zones of the embankments and berms only with materials meeting the specified requirements for such zones. The fill in each zone shall be free from lenses, pockets and layers of materials which are substantially different in gradation from the surrounding material in the same zone.

Fill material shall be excavated, transported, placed and spread in such a manner that segregation is avoided. Any material placed which does not meet the specified requirements shall be removed or remixed, blended, disced, or otherwise reworked by and at the expense of the Contractor to produce a material which does satisfy the specified requirements of the zone, whether or not such material has been covered by other fill material. Except as otherwise specified, the Contractor shall construct each zone by placing spreading and levelling; and, where required, compacting the specified fill material in continuous lifts of the specified thickness. The surface of each lift shall be sloped only at such grades as are necessary to ensure at all times that adequate surface drainage is provided.

Fill shall not be placed against concrete until a minimum of seven (7) days have elapsed after concrete placement.

Except as otherwise specified in the Technical Specification fill shall be dumped and spread in such a manner that no gaps are left between adjacent dumped loads of materials. The fill shall be levelled prior to compaction using a motor grader to obtain a smooth surface free from depressions. Except in areas where space is limited or as otherwise specified, fill shall be placed by routing the hauling and spreading units approximately parallel to the axis of the embankment and, within practical limits, the hauling units shall be so routed that they do not follow in the same paths but spread their tracks evenly over the surface of the fill. The equipment used for placing fill shall be such that it does not cause segregation of the material.

For trench backfill or working around or near pipes, valves, instrumentation or structures, the Contractor shall exercise particular care in fill placement to avoid damage to the Work. Should the Engineer for any reason wish to reinspect components previously authorized for backfilling, the Contractor shall excavate and re-expose such Work to the satisfaction of the Engineer. If any fault in the Work is uncovered the Contractor shall make the fault good to the satisfaction of the Engineer and replace the backfill. Such excavation, repairs and backfilling shall be done at the expense of the Contractor.

The Contractor shall have available during all working hours, sufficient heavy rubber tired graders or other equipment, approved by the Engineer in accordance with Clause 1.4.a., to level, re-level and otherwise maintain the uncompacted fill surfaces in a smooth and workmanlike manner.

In earthfills which require moisture conditioning, the Contractor shall condition the material to the moisture content designated by the Engineer prior to placing the material on the fill zone. The Contractor shall adopt all measures necessary to achieve a moisture content within one percent of that designated, distributed uniformly throughout the layer of material being placed, immediately prior to compaction. The Contractor shall adopt whatever measures are necessary to ensure that the designated moisture content is preserved after compaction, until the succeeding layer is placed.

Wherever necessary, after a layer of fill has been placed, the moisture content of the fill material shall be modified to ensure that it is within the range specified.

If after placing, spreading and levelling any fill material which becomes too wet for proper compaction as determined by the Engineer, it shall be either removed from the embankment or berm or the moisture content reduced to a value acceptable to the Engineer by discing or other approved methods. Suitable disc harrows or other approved equipment shall be available during all working hours for use if required.

Equipment used by the Contractor to apply water to fill material shall be designed to apply water uniformly and at sufficient rates to achieve the designated moisture content. Water tank trucks shall be equipped with positive shut-off valves so that no leakage will result from the nozzles when the equipment is not operating. In the event that leaks do occur, they shall be repaired immediately.

Moisture conditioning shall be carried out in a manner that will avoid flow of water between zones.

All zones in the embankments and berms are to be constructed in near horizontal lifts with each lift being completed over the full length and breadth of the zone before material is placed in the next lift.

The maximum difference in elevation between adjacent zones in the embankments, permitted at any time during construction, shall be equal to the larger of the two lift thicknesses for the two adjacent zones. Except for this requirement, the Contractor will not be permitted to form any construction joints in the embankments without the approval of the Engineer.

1.4.e Compaction

All fill material, after placing, spreading and levelling to the appropriate layer thickness, shall be compacted in accordance with the requirements of this Sub-clause and to the requirements of the appropriate section in this Technical Specification.

Filter and drain materials shall be compacted with a minimum of 4 passes of the specified compaction equipment appropriate to the zone under construction. Core material, Zone S, and basin liner fill shall be compacted to at least 95% of Modified Proctor maximum dry density. Random fill, Zone B, shall be compacted to at least 90% of Modified Proctor maximum dry density.

Compaction of each lift of fill shall proceed in a systematic, orderly and continuous manner such as to ensure that all of each lift receives the compaction specified. The compaction shall be carried out by routing the compaction equipment parallel to the axis of the embankment or berm, except that where such routing is impracticable, such as in roller turning areas, in areas adjacent to the foundations or at the lower elevations of the fill, in areas adjacent to concrete, and in trenches, the compaction equipment may be routed in any direction provided that all of each lift receives the compaction specified.

Hand guided vibratory compactors shall be used to compact materials which cannot be compacted by the specified vibratory rollers because of location near pipes, valves, instrumentation, structures or accessibility.

The Contractor shall take every precaution, when operating compaction equipment, to avoid damage to adjacent structures and instrumentation devices and their leads, and to avoid disturbing the foundation. Any such damage or disturbance shall be repaired or remedied by the Contractor at its own expense.

The rolling pattern at all zone boundaries or construction joints shall be such that the full number of roller passes required in one of the adjacent zones or on one side of the construction joint extends completely across the boundary or joint.

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

All particles of dimensions such that they interfere with compaction in the layer thicknesses specified, shall be removed from the zone in which they were placed, either prior to or during compaction.

The Contractor shall provide sufficient compaction equipment of the types and sizes specified herein as is necessary for compaction of the various fill materials. If the Contractor wishes to use alternative equipment, it shall submit to the Engineer for approval complete details of such equipment and the methods proposed for its use. The Engineer's approval of the use of alternative equipment will be dependent upon the Contractor's demonstrating, by constructing suitable test fills, to the satisfaction of the Engineer, that such alternative equipment will compact the fill materials to a density not less than that which would be produced by the equipment and number of coverages specified herein.

Compaction equipment shall have sufficient power for the most adverse conditions to be encountered during compaction of the fill and when the compaction equipment is ballasted to the maximum weight specified for compaction of the fill.

When vibratory rollers are operated in a multiple arrangement, all of the rollers shall be similar and similarly ballasted.

Compaction equipment shall be maintained in good condition at all times to ensure that the amount of compaction obtained is a maximum for the equipment. The Contractor shall immediately make adjustments to the equipment to achieve this end whenever such are necessary.

The Contractor shall, prior to shipping compaction equipment to the Site, submit to the Engineer, manufacturer's data giving all dimensions, weights and complete technical data, including descriptions and calculations of applied forces.

Unless approved under the prior provisions of this clause all fill material shall be compacted using the following specified equipment:

1.4.e.i Smooth Drum and Wedge-Foot Drum Vibratory Rollers

Smooth drum and wedge-foot drum vibratory rollers shall be equipped with a suitable cleaning device to prevent the accumulation of material on the drum during rolling. Each roller shall have a total static weight of not less than 9 tonnes at the drum when the roller is standing on level ground. The drum shall be not less than 1.5 m in diameter and not more than 2 m in width. The vibration frequency of the roller drum during operations shall be between 1100 and 1500 vibrations per minute and the centrifugal force developed by the roller at 1250 vibrations per minute shall not be less than 17 tonnes.

The power of the motor driving the vibrator shall be sufficient to maintain the specified frequency and centrifugal force under the most adverse conditions which may be encountered during compaction of the fill.

Propulsion equipment for the roller shall be adequate to propel the roller at speeds up to 6 km/h.

For compaction by the vibratory roller, 1 coverage shall consist of 1 pass of the roller. A minimum overlap of 12 inches shall be maintained between the surfaces traversed by adjacent passes of the roller drum. During compaction the roller shall be propelled at 3 km/h.

1.4.e.ii Hand-Guided Vibratory Compactors

The Contractor shall adopt special compaction measures consisting of hand guided vibratory compactors to compact fill in trenches, around structures and in other confined areas which are not accessible to the larger vibratory roller. Such compaction shall be capable of compacting the material to the same density as that achieved by the larger vibratory roller. The number of passes of the hand guided vibratory compactors shall be determined by the Engineer.

1.4.f Quality Control

The Engineer will take samples of fill materials and perform gradation and moisture content tests and will carry out field density tests on the compacted fill and any other tests that he considers necessary to ascertain that the fill being placed or already placed meets the Contract requirements. The results of the tests carried out by the Engineer will be final and conclusive in determining compliance with the Technical Specifications.

Samples for quality control will be excavated by the Engineer. Sample pits by the Engineer shall be backfilled by the Contractor using fill material similar to that excavated and compacted using special compactors.

The Contractor shall give the Engineer full co-operation in sample taking or making tests and shall render such assistance as is necessary to enable sampling and testing to be carried out expeditiously. Each lift of embankment fill will need to be approved by the Engineer prior to placement of further fill. The Contractor shall allow sufficient time for the Engineer to carry out the required test work in order to determine the acceptability of each lift. The making of such tests by the Engineer or the time taken to interpret their results shall not constitute grounds for a claim by the Contractor for additional compensation or an extension of time.

Tests carried out by the Engineer will be performed in accordance with the principles and methods prescribed by the American Society for Testing and Materials (ASTM) and other such recognized authorities, such methods being modified to the extent necessary to take into account local conditions and the large particle sizes of the materials specified.

Notwithstanding any quality control testing carried out by the Engineer, the Contractor shall be responsible for performing such tests as are necessary to control the quality of the materials prior to delivery to, and after incorporation in embankments and berms.

Separate payment will not be made to the Contractor for any work involved in carrying out the tests specified herein or for backfilling the test pits excavated by the Engineer.

Tests carried out by the Engineer for the purposes of quality control defined above will be as follows:

1.4.f.i Control Tests on Fill Materials Prior to Compaction

Tests for gradation, and for moisture content where applicable, will be made on samples of fill materials taken from test pits after spreading and prior to compaction, at frequencies sufficient to ensure that the fill materials adopted for use are in full compliance with the Technical Specifications.

The results of these tests will be made available to the Contractor on request as soon as the necessary computations have been completed and checked.

1.4.f.ii Record Tests on Fill After Compaction

Tests for density will be made on the fill compacted in place and samples of the fill will be obtained for related laboratory testing, at such frequency as the Engineer considers necessary for the proper evaluation of the properties of the fill materials after compaction.

1.4.g Suspension and Resumption of Operations

In planning and implementing suspension and resumption of fill placement operations, the Contractor shall take into account the requirements for foundation preparation.

The Contractor shall not place fill materials at such times that conditions for such operations are unsatisfactory due to excess rain, low temperatures or any other reason. The Contractor will be permitted to place fill at atmospheric temperatures less than 0°C only if it can be placed and compacted to densities equal to those which would be achieved in the same material if freezing conditions did not prevail. Free draining sand and gravel, cobbles and boulders, and rockfill may be placed during freezing weather and on frozen fill surfaces provided that the materials in such surfaces were compacted as required by the Engineer before they became frozen and that the surface is free of snow and ice.

If placement of fill is suspended because of precipitation or impending precipitation or for any other reason, the surface shall be graded and rolled smooth to seal the surface and to avoid unnecessary absorption of moisture. In order to achieve this, the Contractor may at his option, provide cross or crown slopes of up to 5 percent for drainage control. The runoff from fills in progress shall be directed to sediment control facilities to the satisfaction of the Company Representative.

Where operations have been suspended, the effects of rain or other adverse conditions will be assessed by the Engineer before approval is given to resume placing. Equipment shall not be allowed to travel on the fill until the fill has dried sufficiently to prevent excessive rutting and to allow the equipment to be operated satisfactorily.

1.4.h Protection and Maintenance

The Contractor shall maintain any placed fill in a neat and workmanlike condition until completion of the Work. The Contractor shall take such steps as are necessary to avoid ponding of water on the fill or contamination of the fill by traffic or other causes, and he shall at all times keep the surface and slopes of the embankment free from rubbish, rejected or unsuitable fill, or waste materials.

The Contractor shall do whatever is necessary to prevent surface runoff or water from any other source from eroding fill materials placed for the Work, and shall, at its own expense, immediately repair any damage resulting from such erosion. Any repairs shall be carried out using the same standards for quality and workmanship as defined in the Contract Documents for the portion of the Work being repaired.

Should any slide, including all movements of earth, rock, debris, or other material occur within or onto any part of the embankments or berms, the Contractor shall remove such materials and all other materials affected as directed by the Engineer, and any portions of the embankments or berms so removed shall be rebuilt in accordance with the Contract Documents.

Unless shown otherwise on the Drawings buried pipework shall not be crossed by motorized vehicles until the specified backfill has been compacted to a depth of at least 30 cm above the crown of the pipe. In embankments or roadways subject to compacting equipment or high wheel loads the depth of cover shall be at least 60 cm above the crown of the pipe. Temporary crossings shall be adequately flagged.

1.5 Plain and Reinforced Concrete

1.5.a Code Requirements

Concrete to be incorporated in the work shall conform in all respects with the requirements of ACI Standard 318, ACI 304R, ACI 211.1 and ACI 214, except in the case of conflict arising between the requirements of the Technical Specifications and those of ACI Standard, in which case the requirements of the Technical Specifications shall take precedence.

1.5.b Concrete Composition

1.5.b.i General

Concrete shall be composed of Portland cement, water, fine and coarse aggregate, water reducing agent and air entraining agent. Concrete shall be designed to give a practical combination of materials which will produce the required durability and strength in the hardened concrete.

The strength requirements of all concrete to be used in the Work shall be a minimum strength of 30 MPA at 28 days. Lean concrete for blinding ("mud-slab") shall attain a minimum strength of 20 MPS at 28 days.

1.5.b.ii Concrete Workability

Concrete delivered for placing shall, at the time of placing, have a maximum slump limit not exceeding 75 mm.

The Engineer reserves the right to require a lesser slump wherever it is practical for concrete of such lesser slump to be transported, placed and consolidated.

Where concrete is being placed by pump, the slump at the receiving hopper of the pump will be permitted to be 25 mm more than that specified above.

1.5.b.iii Mix Design

The responsibility for the design of all concrete mixes to be used in the work will rest entirely with the Contractor. The concrete supplied shall be in accordance with ASTM C94 Standard Specifications for Ready-Mixed Concrete.

The Contractor shall cooperate with, and provide assistance to the Engineer in obtaining samples of aggregates and concrete and in maintaining quality control of all aspects of concrete production at the batch plant and at the point of placement of concrete.

The entrained air content of the mortar fraction of the concrete at the point of placement shall be maintained at six (6) percent and shall not vary by more than one (1) percent from this value.

1.5.c Materials

Except as specified otherwise or approved by the Engineer, Portland cement shall be Type IIA, conforming to ASTM Designation C150.

Fine aggregate shall be processed natural sand. Coarse aggregate may be natural gravel or a mixture of natural and crushed gravel. All concrete aggregates shall be sound, free of harmful materials and non-reactive with the alkali that may be contained in the cement. Aggregates shall be properly graded and shall comply with ASTM Specifications C33, C131 and C136. The Contractor shall be responsible for the quality of all such materials used in the Work.

Water used in mixing, clean-up and curing of concrete, as well as water used for spraying concrete aggregates, shall be fresh, clean and free from deleterious amounts of silt, organic matter, alkali, acids, salts and other impurities.

Unless otherwise specified herein or directed by the Engineer, the following admixtures shall be employed:

(i) An air-entraining agent, confirming to the requirements of ASTM Designation C260.

(ii) A water reducing agent. The water reducing agent shall be "Pozolith 300N" manufactured by the Master Builders Company or equivalent conforming to ASTM C494.

1.5.d Sampling and Testing

During the concreting operations the Engineer will sample and test all classes of concrete in accordance with ACI Recommended Practice 311.4R-5.

Tests carried out by the Engineer for the purposes of quality control will be as follows:

(i) Coarse and fine aggregates properties

Grading ASTM C136, C117
Abrasion (coarse aggregate) ASTM C131
Specific gravity and absorption ASTM C127, C128
Friable particles ASTM C142

(ii) Field Tests of Concrete

Slump ASTM C143
Temperature
Air content ASTM C231
Compression tests on cylinders ASTM C31, C39

The Contractor shall provide and maintain at no separate cost to the Owner sufficient testing of the above parameters for its own quality control to ensure the aggregates and concrete continue to meet the requirements of the Technical Specification and shall make the results of such tests available to the Engineer.

1.5.e Transport of Concrete

The time elapsed between completion of the mixing of the concrete at the batch plant and its discharge at the forms shall not exceed 90 minutes for concrete properly agitated while in transit. Under no circumstances shall water be added to concrete during transit where such concrete has previously been batched with mixing water at the batch plant.

If these basic limits cannot be met for concrete mixed at the batch plant consideration will be given to dry-mix batching with water and air-entraining admixture added in the transit mix truck prior to discharge. Extreme care shall be taken to ensure that only sufficient water and air-entraining admixture is added to provide the required slump and air content.

1.5.f Forms

All formwork shall be in accordance with ACI 347 - "Recommended Practice for Concrete Formwork".

A bond-breaking compound shall be used on all forms.

1.5.g Construction Tolerances

Except as specified elsewhere in this Clause formwork shall be erected and braced and the concrete placed such that the dimensions of the completed concrete structure fall within the following tolerances:

Elevation	6 mm maximum deviation
Variation in plumb	6 mm in 13 m
Variation in all structural dimensions	-6 mm to +12 mm
Variation in location of inserts openings, embedded metalwork	-6 mm to +6 mm

Concrete work and embedded metal that exceeds the specified tolerance limits shall be remedied or removed by and at the expense of the Contractor.

1.5.h Preparation for Placement of Concrete

1.5.h.i General

Before the beginning of any concrete placement, the Contractor shall prepare the place of deposit in accordance with all requirements specified herein and elsewhere in the Contract Documents and obtain authorization from the Engineer, at least 24 hours in advance, for placement of concrete.

1.5.h.ii Subgrade Preparation

Earth or granular foundations shall be thoroughly compacted and dampened prior to placing concrete.

All rock surfaces against which concrete is to be placed shall be clean and sound.

Construction joints, bedrock and earth subgrade against which concrete is to be placed shall be damp.

Wetting of hardened concrete or bedrock shall begin 24 hours prior to the placement of concrete unless otherwise directed by the Engineer.

Concrete shall not be placed on frozen surfaces or into pooled water.

1.5.h.iii Final Clean-Up and Check-Out Inspection

Final clean-up shall comprise the removal of all mud, grease, snow, debris, wire, paper and other foreign matter from the surfaces on and against which fresh concrete is to be placed, by means of air or water jets or hand retrieval. Free-standing water shall then be removed so as to leave the subgrade or joint in a saturated surface dry condition.

Final clean-up shall be completed before the Engineer will make his check-out inspection for authorization to place concrete.

1.5.i Placement of Concrete

1.5.i.i General

The Contractor shall provide the Engineer with 24 hours notice stating when and where concrete is to be placed. Final check-out inspection for approval of concrete placement will be undertaken by the Engineer only after the setting of forms, placement of reinforcement and embedded metal and final clean-up have been completed.

Concrete shall be placed only in the presence of the Engineer.

1.5.i.ii Placing Procedure

Concrete shall be deposited as closely as practicable in its final position in horizontal lifts not more than 50 mm deep. Lateral movement of the concrete by means of vibrators will not be permitted.

Concrete shall be dropped vertically without lateral movement into formwork and without interference. Unconfined free fall shall be limited to 1.5 metres unless otherwise required or approved by the Engineer.

Methods and equipment used for the concrete consolidation shall be in accordance with the report of ACI Committee 309 - "Consolidation of Concrete".

1.5.i.iii Supply of Concrete

Concrete for the work shall be supplied by the Contractor. It is the responsibility of the Contractor to ensure that the concrete meets all of the above requirements.

1.5.j Repairs to Concrete

Repair of imperfections in formed concrete shall be completed as soon as possible after removal of forms. The Contractor shall keep the Engineer advised as to when repairs of concrete will be performed, and repairs shall be performed in the presence of the Engineer unless inspection is waived in each specific case.

1.5.k Curing and Protection

During the period when concrete is protected by forms, the exposed surfaces of all concrete built up in lifts shall be initially water cured. After finishing operations have been completed, water curing shall be continued.

1.5.1 Edge Bevels

Exposed edges of finished concrete which will not be subsequently covered with fill shall be provided with 45 degree bevels in all directions. The bevels shall be constructed using bevel forming strips of 25 mm by 25 mm by 45 degree size.

1.5.m Steel Reinforcement

1.5.m.i General

All bars employed for the Work shall be deformed bars conforming to ASTM A615 grade 60 unless otherwise specified on the Drawings.

Reinforcement fabric shall be welded steel wire fabric complying with the provisions of ASTM A185.

At the time concrete is placed, reinforcement shall be free from loose rust, scale, oil, salt or other coating which could impair the bond to concrete.

Minimum concrete protective cover for reinforcement, unless otherwise shown on the Drawings, shall be 50 mm.

1.6 Pipework

1.6.a General

All materials furnished by the Contractor shall be new, suitable and the best of their respective kind and shall be subject to approval by the Engineer. They shall comply with the latest applicable standards for the American National Standard Institute (ANSI) American Society of Mechanical Engineers (ASME), American Society for Testing and Materials (ASTM), American Water Works Association (AWWA) and the American Association of State Highway and Transportation Officials (AASHTO). Any contradictions between standards shall be submitted to the Engineer for decision.

1.6.b Manufacturer's Information

When specified, 2 copies of manufacturer's catalogues shall be provided at least 14 days prior to installation of the pipework. For pipe fittings and related pipework components, catalogues shall include detailed information on material specifications, dimensions and pressure ratings, storage and handling requirements, installation and joining procedures, name and location of manufacturers representative, corrosion protective coatings. For valves, gates and accessories the required information shall include, in addition, a replacement parts lists by catalogue number, operating and maintenance instructions and warranty documentation.

1.6.c Pipe, Fittings and Couplings

1.6.c.i High Density Polyethylene (HDPE) Pipe

HDPE pipe and fittings shall be made from polyethylene resin compound qualified as Type III, Category 5, Class C, Grade P34 in accordance with ASTM D1248.

Approved HDPE pipe material includes but is not limited to:

- Driscopipe 8600, with cell classification PE355434C or Driscopipe 1000 with cell classification PE345434C by Phillips Driscopipe.
- Poly pipe, with cell classification PE345434C by Poly Pipe Industries.
- Sclairpipe with cell classification PE345434C by KWH Pipe (Canada) Ltd.
- Plexco PE3408 with cell classification PE345434C by Chevron.

Cell classification shall be as defined in ASTM D3350 for PE3408 materials.

Catalogues shall be provided in accordance with Clause 1.6.b.

Fabricated HDPE fittings shall have a pressure rating equal to the pipe in which they are installed. Pipe used to fabricate fittings shall have dimensions in accordance with ASTM F714.

1.6.c.ii Corrugated Polyethylene (CPE) Drainage Tubing and Culvert Pipe

Pipework shall be manufactured from virgin material Type III or IV, Class C, Category 5, Grade P33 in accordance with ASTM D1248. Pipework, including couplings and fittings, shall meet or exceed all requirements of AASHTO M-252.

Catalogues shall be provided in accordance with Clause 1.6.b.

Perforations for CPE tubing, where specified, shall be slotted and shall be in accordance with the requirements of AASHTO M-252 except that total inlet areas shall not be less than 85 cm^2/linear metre for tubing of diameter 20 cm or less.

Couplings shall be split, snap-on or screw-on type, as supplied by the manufacturer of the pipework. Self coupling pipework may be supplied.

Pipework in diameters of 15 cm and under may be supplied in continuous coils.

1.6.c.iii Steel Pipe

Steel pipe shall be AWWA C200 manufactured to meet the requirements of ASTM A139 Grade A or B. Wall thickness shall be standard weight (Schedule 40) unless shown otherwise on the Drawings. Pipe ends shall be butted if couplings are required bevelled if to be welded, or grooved if Victaulic type couplings are required.

Steel pipe if indicated on the Drawings, shall be corrosion protected in accordance with Clause 1.6.c.xii or Clause 1.6.e.i for buried or exposed conditions, respectively or as otherwise indicated.

Steel pipe fitting dimensions for welding shall meet ANSI B16.9 or as otherwise approved. Fabricated fittings and specials shall be in accordance with ANSI/AWWA C208.

1.6.c.iv Plastic Discharge Hose

Plastic discharge hose shall be Kanaflex Series 170 R or approved equivalent. 150 mm diameter hose shall have a minimum 100 psi working pressure rating and 250 mm diameter hose a minimum 50 psi working pressure rating. The hose shall be provided with a standard weight steel, hose nipple, rubber lined and secured with two "King" Double Bolt Clamps or similar. The hose nipple shall be grooved for attachment to a Class 150 flange with a Victaulic Style 741 "Vic-Flange" or similar. Hose diameters and lengths shall be as shown on the Drawings or required by the Engineer.

Catalogues shall be provided in accordance with Clause 1.6.b for hose specifications and dimensions only.

1.6.c.v Pipe Fittings and Couplings

Grooved pipe fittings and couplings shall be ASTM A536 ductile iron, or steel, as supplied or recommended by Victaulic Company of America, or approved equal. Gaskets and seals for grooved pipe where required shall be EPDM. All components including bolts and lubricants shall be provided by the coupling manufacturer. All units shall be shop prime painted.

Catalogues shall be provided in accordance with Clause 1.6.b.

"Dresser" type compression couplings shall consist of a cylindrical sleeve with conical inner surfaces at each end, two wedge shaped resilient gaskets, two ring shaped followers and a set of high strength, low alloy, track-head, oval-neck rolled-thread bolts with heavy hex nuts. Sleeve lengths shall be 100 mm for pipe under 127 mm IPS, 127 mm for pipe up to 355 mm IPS and 178 mm for pipe over 355 mm IPS. Couplings for pipe over 355 mm IPS shall accommodate a total angular deflection at the joint of not less than 4 degrees.

Flanged coupling adapters shall combine the features of a flexible compression coupling with a flange to create a compact flexible fitting to connect plain end pipe to flanged fittings.

Compression couplings and flanged coupling adapters shall be shop primed and rated for a working pressure of not less than 150 psi.

Where indicated on the Drawings couplings shall be provided with a harness assembly, to prevent the pipe pulling out of the coupling, while maintaining full joint flexibility.

All components including harness assembly and bolts shall be supplied or approved by the fitting manufacturer.

Catalogues shall be provided in accordance with Clause 1.6.b.

1.6.c.vi Corrugated Steel Pipe (CSP) Culvert

CSP shall be fabricated with helical 68 x 13 mm corrugations from galvanized steel sheets meeting all requirements of ASTM A444 and shall conform to the requirements of AASHTO M-36.

Unless otherwise shown on the Drawings, wall thickness shall be 2 mm for culvert pipe of diameter 0.91 m or less and 2.77 mm for culvert pipe of larger diameter. Unless shorter lengths are required for installation, CSP shall be supplied in 6 m lengths.

Catalogues shall be provided in accordance with Clause 1.6.b.

Couplings for CSP shall be the hugger type (Armtec H500 or approved equivalent) with rubber O-ring gaskets as supplied by the pipe manufacturer. Couplers shall be galvanized, of similar gauge to or heavier than the pipe being joined and shall be supplied by the pipe manufacturer.

Fittings and sections and specials for CSP shall be shop fabricated from galvanized CSP conduits of similar or heavier gauge or as otherwise shown on the Drawings or approved by the Engineer.

Seepage collars or diaphragms shall be galvanized corrugated steel sheet cut to fit snugly and symmetrically about CSP culvert. Collar dimension shall be at least 0.6 m greater than the culvert diameter on all sides.

All fasteners shall be galvanized, cadmium plated in accordance with ASTM B766, or stainless steel.

Half-round culvert shall be manufactured, nestable, flanged or nonflanged galvanized corrugated steel pipe. Field cut culvert will not be acceptable for permanent installations.

Half-round culvert shall be provided with sufficient 38 mm diameter x 1830 mm long sharpened galvanized pipe stakes complete with caps and clip brackets, or equal as approved by the Engineer, for anchoring of the half section at 3 m intervals both sides.

1.6.c.vii Precast Concrete Manholes

Pre-cast reinforced concrete sections including lids and bases for use as valve chambers, wet wells or manholes shall be in accordance with ASTM C789, ASTM C850 or ASTM C478 for the installed conditions shown on the Drawings. Joints between sections, lids and bases shall be rubber gasketed in accordance with ASTM C443 or mastic sealed tongue and groove. Cut-outs may be factory formed or field located. Cut-out location and diameter is the responsibility of the Contractor.

Manhole step-iron rungs shall be 19 mm galvanized iron, or equal, 300 mm wide with a 50 mm drop, protruding 150 mm from the wall and spaced 300 mm vertically. Locations shall be as shown on the Drawings.

Manhole access frames shall be cast iron or ductile iron, 510 mm diameter minimum opening, H20 rated, for embedding in pre-cast lids c/w cast iron cover.

Access hatches shall be by Bilco as approved by the Engineer.

Vents, where required, shall be standard weight galvanized steel pipe with 180^o goose neck and heavy duty galvanized bird screen. Vents shall be attached to a flanged or grooved standard weight galvanized steel section embedded in the pre-cast lid or as otherwise shown on the Drawings. Vent heights and diameters shall be as shown on the Drawings.

1.6.c.viii Tapping Sleeves

Tapping sleeves for installation on HDPE pipelines shall be shop modified, Style 6626 stainless steel tapping sleeves by Robar Industries or as otherwise approved. All metallic components including fasteners, shall be Type 304 stainless steel except the flange which may be ASTM A536 ductile iron. The branch shall be supplied without a test plug and shall be fully lined with rubber integrally bonded to the body gasket. The body gasket shall be a one piece rubber mat of grid pattern, fully lining the sleeve shell. The flange face shall be bare metal, flat faced, drilled to Class 150 pattern.

Tapping sleeve and offtake sizes shall be as shown on the Drawings or specified elsewhere.

Tapping sleeves shall be rated for at least 75 psi.

1.6.c.ix Flanges, Gaskets and Bolts

Unless otherwise specified or shown on the Drawings, steel flanges shall be Class 150 in accordance with ANSI/ASME B16.5 and cast iron flanges shall be Class 125 in accordance with ANSI/ASME B16.1. Class 25 flanges shall be in accordance with AWWA C207. Flange gaskets shall be full face, 1/16 in, fabric reinforced rubber or compressed asbestos. Flange assembly bolts shall meet requirements of ASTM A307 Grade A or Grade B, for cast iron flanges. Bolts shall be square or hex head. Nuts shall be heavy hex in accordance with ASTM A307.

It shall be the Contractor's responsibility to ensure compatibility between flanges used for the work.

All bolts and fasteners for intermittent or total submergence, or buried service or for embedment in concrete shall be type 304 stainless steel. All other bolts and fasteners shall be galvanized in accordance with ASTM A394 or cadmium plated in accordance with ASTM B766 unless otherwise approved.

1.6.c.x Rubber Lining of Steel Pipe and Fittings

Where required, rubber lining of pipes and fittings, shall be Linatex natural rubber, Shore 40, Durometer A in accordance with ASTM D2240, of thickness 6.5 mm for pipe of 150 mm IPS or less and of thickness 9.5 mm for pipe of larger diameter unless otherwise shown on the Drawings.

1.6.c.xi Lining and Coating of Steel Pipe

If indicated on the Drawings buried steel pipework shall be externally protected with Shaw polyethylene "Yellow Jacket", Specification No. 1, in accordance with AWWA/ANSI C215. Joints and couplings in buried steel pipe or damaged protective coating shall be wrapped with "Canusa" heat shrink sleeves in accordance with AWWA/ANSI C216 or a petrolatum tape system (eg. Denso T-1), or as otherwise in accordance with AWWA C217 and approved by the Engineer.

Lining of steel pipe as required shall be in accordance with AWWA C210 or as otherwise approved by the Engineer.

Catalogues shall be provided in accordance with 1.6.b.

1.6.c.xii Pipeline Guide Posts

Unless otherwise indicated pipeline guide posts shall be vertical 2.4 m lengths of firmly embedded 64 mm diameter standard weight steel pipe c/w screw on cap, both hot dip galvanized. Posts shall either be concrete embedded to a depth of 1 m or sharpened and driven at least 1 m to firm embedment. At least a 1 m length of pipe shall remain above ground.

1.6.c.xiii Pipe and Valve Supports and Hangers

All pipes and valves shall be properly supported and anchored in accordance with normal practice and the

Drawings. Standard above ground hangers shall be of the clevis or clamp type, Wyatt Figure 124 or Figure 133. Chain or strap hangers shall not be used. Saddles shall be the adjustable pipe stanchion type with u-bolt yoke, Grinnell Figure 259/264 or similar.

1.6.c.xiv PVC Pipe Well Screens and Casings

PVC pipe shall be Schedule 40 or Schedule 80 in accordance with ASTM D1785, pressure rated pipe (SDR Series) in accordance with ASTM D-2241, or Drain Waste and Vent (DWV) Pipe in accordance with ASTM D-2665 as shown on the Drawings. Fittings for PVC pipe shall be in accordance with ASTM D-2466 for Schedule 40 fittings, ASTM D-2467 for Schedule 80 fittings and ASTM D-2665 for DWV pipe.

Well casing pipe and couplings shall be Schedule 40 PVC in accordance with ASTM F-480. Threads shall be ACME type. Slots for well screens shall be sized as indicated on the Drawings and shall be 25 mm minimum in length, with 6 mm spacing between slots. Slots shall be aligned in five vertical rows for pipe of 12 mm OD.

Locking lids for wells shall be water tight PVC with 'O' ring compression seal and including pivot and hinge and hasp with snap latch. Lids shall be "Snap Cap" by Monitoring Wells Sale and Service or approved equivalent. Wells shall be complete with concrete collar surround, approved valve box or manhole c/w lid.

1.6.d Valves and Accessories

Valve types and accessories shall be as shown on the Drawings and as listed below. Catalogues shall be provided with all valves and accessories in accordance with Clause 1.6.b.

1.6.d.i Slide Gates

Slide gates shall be Armco Model 5-00 galvanized steel slide gate or approved equivalent, handwheel operated, with mounting frame, suitable for flush mounting on a concrete headwall. Frame extensions and stem extensions shall be as shown on the Drawings. Where required, stem extensions shall be encased in oil filled 50 mm or 62 mm diameter standard weight galvanized steel pipe with upper and lower oil seals, suitable for prolonged exposure to sub-zero conditions and of lengths as shown on the Drawings or required to suit actual lengths in the field. The length of stem that will move through the seal packings shall be Type 304 stainless steel. Stem sections shall be joined by welded and pinned couplings acting as guides inside the casing pipe. Stem couplings shall have well rounded edges and be free of protruding components and slide freely inside the casing pipe. Stem couplings shall be located clear of joints in the casing pipe. Casing pipe lengths shall be joined with threaded galvanized couplings.

1.6.d.ii Pinch Valves

Manually operated, full metal body c/w back-up flanges, working pressure to 75 psi, double acting pinch mechanism, port area 100 percent of full pipe area, reinforced pure gum rubber sleeve with integral flanges drilled to ANSI B16.5 Class 150 standard, hand wheel operated, 4:1 ratio bevel gears on valves 8 inch diameter and above. Suitable for service with mine tailings slurry. Red Valve Series 75, RKL Series LHW or approved equal.

1.6.d.iii Knife Gate Valves

Manually operated, full port flow, all wetted parts Type 304 stainless steel or ultrahigh molecular weight (UHMW) polymers, working pressure to 100 psi, heavy duty frame, UHMW body liner and replaceable wear seal rings, flanges drilled to ANSI B16.5 Class 150 standard, hand wheel operated, 4:1 ratio bevel gear on valves 8 inch diameter and above. Suitable for service with mine tailings slurry. Clarkson KGA valve, L&M M-100, Rovalve ARL17 or approved equal. Valves above 450 mm nominal size shall be provided with a hydraulic actuator. Valve supplier will provide one only portable power pack suitable for installation in a pick-up truck for operation of the hydraulic actuator.

1.6.d.iv Butterfly Valves

Manually operated, AWWA/ANSI C504 quality, wafer or lug type as shown on the Drawings for installation between ANSI Class 125/150 flanges. Suitable for buried or exposed outdoor application under sustained sub-zero conditions on pipelines carrying storm water drainage and mine tailings supernatant, which will contain suspended solids. Non-corroding bearings, heavy duty service. Butterfly valves will be required in the applications set out below and as shown on the Drawings. Where shown on Drawings valves shall include geared operator.

1.6.d.v Vacuum Breaker

Vacuum Breaker valves for tailings slurry pipeline shall be Tech-Taylor Style T1 F4R-A3.

1.6.d.vi Pressure Sensor Assembly

Pressure Sensor for installation in HDPE slurry pipeline shall be Red Valve Series 42S, 1" diameter c/w good quality 3 1/2" glycol filled pressure gauge with 1 to 200 psi range as approved by sensor supplier. Ball valves shall be supplied both above and below the gauge.

Sensor body shall be PGR. Valves, bushings, nipples, plug and sensor body shall be stainless steel.

1.6.d.vii Plug Valves

Plug valves shall be DeZurik Series 100 for water service or as approved by the Engineer. Valves shall be completed with electric actuator and manual override.

1.6.e Workmanship

1.6.e.i General

Wherever possible, pipelines shall be installed parallel to or at right angles to surface structures and roadways.

The Contractor shall set the grade for every pipe length and shall ensure that the bed on which piping is to be laid is solid, well compacted and free of any dips, hollows, boulders or hard and sharp protrusions.

Installation of buried or ongrade pipework shall not commence until bedding conditions have been approved by the Engineer.

Pipe and couplings shall be laid in accordance with this specification and the manuals of instructions issued by the manufacturers of the pipe or coupling in accordance with Clause 1.6.b.

Pipe and fittings shall be checked before installation for defects or cracks that might prevent proper jointing or operation of the pipeline and shall be clean and free of foreign matter. All pipe, couplings and fittings etc., shall be lowered into place in such a manner as to prevent damage to the pipework. End hooks of any kind shall not be used.

Damaged or defective pipe components shall not be used in the work unless repairs or modifications have been carried out with the approval of and to the satisfaction of the Engineer.

Care shall be taken to ensure that no water, muck, silt, gravel or other foreign material enters the pipework at any time. Care shall be taken to properly align and support the pipe before joints are completed.

Pipe shall be adequately supported during construction and on completion to prevent abnormal stresses being imposed on items of equipment such as pumps, flanges, valves etc.

Whenever work is suspended for any reason all open ends of piping shall be plugged or otherwise suitably closed. Should any pipe become either partially or wholly clogged before final acceptance of the Work, it shall be cleaned out by the Contractor or it shall be replaced by the Contractor at the Contractor's expense.

1.6.e.ii HDPE Pipework

Joining of HDPE pipe lengths shall be by thermal butt fusion or by Victaulic type Hugger couplings or flanges as shown on the Drawings or where otherwise required.

Thermal butt fusion of HDPE shall be carried out by experienced technicians supplied by, or approved by, the pipe supplier or manufacturer and in general accordance with ASTM D2657 and the recommended procedures provided with the manufacturer's catalogue information. The Engineer may require fusion operators to perform test welds for destructive testing, prior to commencing work on any permanent component of the facility.

Butt fusion equipment shall be in good repair and of appropriate size for the job, complete with all necessary clamps, controls, gauges, supports, ancillary equipment and operation/maintenance manuals.

The Owner reserves the right to have non-destructive testing of all thermally butt fused HDPE pipe welds carried out at any time during the Work and to reject those that are unsatisfactory for any reason. Such joints shall be cut out and repaired at the Contractor's expense.

If the Contractor elects to drag HDPE pipework into place all stub ends, flanges or offtakes and other components must be supported above ground on suitable skids or as otherwise necessary to avoid damage. The Contractor shall provide all necessary temporary guide posts and equipment to ensure pipework is not dragged across areas of completed earthworks susceptible to damage. If damage occurs to pipeline components or to completed earthworks during pipeline installation, the damage shall be made good at the expense of the Contractor. Gouges, holes or abrasion of HDPE pipework such that the wall thickness is reduced to less than 80 percent of its manufactured thickness shall be sufficient grounds for rejecting the pipe. Damaged sections of HDPE may be cut out and the pipe rejoined by butt fusion at the expense of the Contractor.

Natural bends in HDPE pipelines shall not exceed 50 pipe diameters in radius. Pipelines shall not be bent to such radius until at least 6 hours after completion of any fused joints in the section of pipeline to be bent.

1.6.e.iii Flanged Joints

Flanged joints shall be made with gaskets accurately centred in the joint. Bolts, studs and nuts shall be lubricated with flange bolt lubricant so that the nuts can be run up by hand. Care shall be taken to prevent excessive initial tensioning of bolts and studs, and to ensure that tension is applied uniformly. Rust preventive compound applied to the faces of flanges before shipment shall be removed before installation. Acid or tools that may damage finished surfaces shall not be used for cleaning flanges.

1.6.e.iv Welded Joints

Welded joints in steel piping shall be made by the electric arc process in accordance with ASME/ANSI B31.1, Chapter V and AWWA C206. Welding shall be performed only by welders holding current, valid, welding tickets issued by the relevant Alaska authority. Prior to assembly and welding operations, pipe ends and all welding fittings shall be thoroughly cleaned and be free of foreign matter. Special precautions, including the provision of adequate protective shelters shall be taken when welding in cold or wet weather to avoid undue chilling of weld metal within the zone of welding influence. No welding shall be done without adequate preheating when the temperature of the metal is below 50°F. Approved shop fabricated or butt welding fittings shall be used for all bends and connections. Stub-ins for branch connections will not be permitted without the prior approval of the Engineer.

1.6.e.v Backfilling

Before final acceptance of pipework and before backfilling is completed the Contractor shall clean and flush all pipework and carry out hydrostatic pressure testing as required in accordance with Clause 1.6.e.vi.

Pipe backfill materials and procedures shall be in accordance with Clause 1.4.d. and shall meet the gradation requirements shown on the Drawings. Movement of the pipe after the joint is made shall be minimized.

1.6.e.vi Hydrostatic Pressure Testing of Pipework

All steel and HDPE pipework and joints shall be pressure tested prior to backfilling or final acceptance. CSP corrugated polyethylene, PVC and Profile Wall HDPE will not require pressure testing.

Before testing is performed, the Contractor shall place sufficient backfill, pipe anchors and thrust blocks at bends in underground pipework or as otherwise required to prevent displacement of the pipe during testing. Pipe anchors and thrust blocks at bends shall be left exposed during the test.

The Engineer shall be present during pressure testing of pipework and shall approve each length of pipe after it meets the requirements specified herein. Testing shall be performed on valved or capped sections of the pipeline so that each valve (except where specifically excluded) in the system is tested for leakage in the fully closed position. Unvalved sections of the pipeline shall be adequately plugged prior to pressure testing. The Contractor shall supply the test pump, pressure gauges and all equipment necessary for filling and draining the pipeline and for carrying out the pressure testing, including end caps and 12 mm or 19 mm valves for venting excess air and for filling the pipe.

Pinch valves, air release valves, check valves, gate valves, tapping sleeves and other items of pipework which in the opinion of the Engineer cannot be satisfactorily tested (eg. decant inlets) or could be damaged by testing shall be excluded from the test.

The procedure for testing shall be as follows. The section of pipework to be tested shall be slowly filled and all air expelled. The pressure at the lowest point in the pipe section shall then be raised to the required pressure listed below. The quantity of water pumped into the test section to maintain the specified pressure over the period of the test shall be considered to be the leakage. The duration of the test shall not be less than 2 hours after initial filling and stabilization.

Test pressure shall be as follows:

Steel Pipe - 150 psi (minimum)
- 300 psi (maximum)
HDPE Pipe - 1.5 times the rated pressure of the pipe

Pipe shall be tested in lengths such that no section of steel pipe sees less than the minimum test pressure and that no section of HDPE pipe sees more than the test pressure or less than 75 percent of the test pressure. Particular care to avoid overpressure must be exercised when testing HDPE pipeline placed on steep grades.

No leakage will be allowed in steel pipework or HDPE pipework.

Air pressure testing of pipework will not be permitted.

In the event of leakage of the Contractor shall make good the faulty joint or coupling and re-test the pipe all at his own expense.

It is the responsibility of the Contractor to supply all water and equipment necessary for pipe flushing, cleaning and pressure testing and to dispose of the water after the completion of such work in a manner compatible with Clause 1.10.e.

1.6.e.vii Corrugated Polyethylene Drainage Tubing

Installation of corrugated polyethylene pipework shall be in general accordance with ASTM D2321 and the manufacturer's instructions, with specific requirements as shown on the Drawings.

Pipework shall be laid to the maximum extent, in long lengths to minimize the number of couplings required.

Jointing of corrugated polyethylene pipework to other pipework shall be carried out as shown on the Drawings.

1.6.e.viii Corrugated Steel Culvert Pipe (CSP)

Joining of CSP to other pipework shall be as shown on the Drawings.

Localized areas in which the zinc coating has been damaged by welding or other fabrication procedures shall be repaired by careful wire brushing followed by two applications of a zinc rich paint as specified in AASHTO M36, or approved equal. CSP or fittings with gross uncoated or damaged areas shall be removed from the Work and replaced at the Contractor's expense.

1.7 Miscellaneous Metalwork

1.7.a General

The Contractor is advised that all the items of metalwork are not detailed on the Tender Drawings. The Contractor shall prepare complete shop and erection drawings of all miscellaneous metalwork to be supplied by him, showing in detail the sizes of each component part, type and grade of metal, connection and welding details, method of assembly, hardware and anchorage or connections with other work. Each of such Drawings shall be submitted to the Engineer for review at least 30 days prior to fabrication or ordering of any item shown thereon.

Before commencing fabrication, the Contractor shall verify the location and obtain all necessary measurement of adjacent work and structures which might affect the work.

Design, fabrication and installation of miscellaneous metalwork shall be in accordance with the AISC Manual of Steel Construction, AISC Code of Standard Practice and ASTM A36, except as otherwise specified.

All work shall be equal to the best modern practice in the manufacture and fabrication of materials of the type described herein or shown on the Drawings. All metalwork shall be carefully assembled in the most substantial manner to carry out the design called for, and reinforced where required. Built-up work shall be completely assembled in the shop and match marked for correct field erection. All frames shall be suitably braced to maintain alignment during shipment and erection. All work shall be rigid and true to line and grade. Individual members shall not be spliced except where shown on the Drawings.

All embedded metalwork shall be accurately set in place before concrete is placed or, where shown on the Drawings, recesses shall be left in the concrete and the metalwork placed, anchored and mortared in place after the concrete has set.

Where it is impractical to place anchors or anchor bolts by either of the foregoing methods, holes shall be drilled in the concrete and anchors shall be installed by the Contractor as directed by the Engineer.

Anchor bolts shall be installed within the following tolerances unless otherwise shown on the Drawings:

Variation of alignment	-1/8 inch ±
Variation of bolt projection	-1/4 inch±

Exposed welds shall be ground smooth on all bearing surfaces where prominent welds would prevent proper seating or bearing of two members. Welding of galvanized steel will not be permitted except where shown on the Drawings.

Shop connections shall be welded. Field connections shall be welded or bolted. Bolted connections shall be made with either standard bolts or high strength bolts, as indicated on the Drawings.

Concrete stud anchors shall be welded to the steel as shown on the Drawings in accordance with the stud manufacturer's instructions.

1.7.b Materials

Except as otherwise specified or shown on the Drawings, materials shall conform to the following standard specifications:

1.	Structural steel shapes, bar plates	ASTM A36 and ASTM A6
2.	Floor plates	ASTM A36
3.	Cast iron	ASTM A48, Class 25
4.	Steel pipe	ASTM A53 Grade A or B, Black, Schedule 40
5.	Bolts, nuts and washers	
	- High strength	ASTM A325 Type 1
	- Standard strength	ASTM A307 Grade A or Grade B
	- Threads	Coarse thread
	- Washers, hardened	ASTM A325

	- Washers, standard strength	Standard commercial quality
	- Bevel washers	Malleable iron or steel
6.	High strength threaded studs	ASTM A449

All bolts and fasteners for total or intermittent submergence shall be stainless steel.

Unless otherwise shown on the Drawings, all exposed fastenings shall be of the same material, colour and finish as the metal to which they are attached.

1.8 Painting and Galvanizing

1.8.a Painting

All metal surfaces to be painted shall be free of sharp edges or protrusions, solvent cleaned to SSPC-SP1, blast cleaned to SSPC-SP6, vacuum cleaned and shall be prime painted in the shop with inorganic zinc primer, except for galvanized surfaces, surfaces to be encased in concrete. Shop painting shall be performed in accordance with the provisions of the Steel Structures Painting Council.

Finish coat shall be 2 part epoxy applied to miscellaneous metalwork in the field as specified on the Drawings or elsewhere herein.

Field Painting of Welded Areas of Primed Steelwork

The welded areas shall be cleaned of all rust, scale and weld flux by chipping and power wire brushing.

Immediately after surface preparation is completed, the area to be treated shall be coated with one coat of an approved primer applied by brush or spray. The primer shall be overlapped onto the previous coating to the extent of about 20 mm on each side of the weld.

1.8.b Galvanizing

All galvanizing shall conform to the following requirements:

1. Galvanizing shall be hot dip in accordance with ASTM A385 and ASTM A153 unless otherwise specified.

2. The coating shall be clean and smooth and free from defects. Repair of damaged hot dip galvanized coatings shall be in accordance with ASTM A780.

3. Material shall be galvanized after all fabrication, machining and shop work is completed, except as otherwise specified herein.

4. The galvanizing of bolts, nuts and washer shall be in accordance with ASTM A394. Nuts shall be tapped after being galvanized and the threads of nuts left bare.

1.9 Geosynthetics

1.9.a Filter Fabric

The filter fabric required to be incorporated into the Work shown on the Drawings shall be non-woven needle punched polyester geotextile fabric at least equal to the following specifications:

Property	**Test Method**	**Filter Fabric Type 1**
Weight	ASTM D-3776	8 oz/sq.yd.
Grab strength	ASTM D-1682	255 lbs.
Elongation at break	ASTM D-1682	65 percent

Mullen burst strength	ASTM D-3786	450 psi
Permeability	Constant Head	0.25 cm/s
EOS	CW-02215	80 micron
Puncture	ASTM D-751	140 lbs.
Trapezoidal tear strength	ASTM D-1117	140 lbs.
UV Resistance		Not required

The filter fabric type shall be Supac 8 NP as manufactured by Phillips Fibers Corporation or approved equal.

1.9.a.i Shipment and Storage

Fabric shall be packaged and shipped in standard roll lengths and widths. The geotextile shall be kept dry and wrapped such that it is protected from the elements during shipping and storage. At no time shall the geotextile be exposed to ultraviolet light for a period exceeding fourteen days. The fabric shall be labelled as per ASTM D4873.

1.10 Contractor's Construction Schedule

The Contractor shall complete the various items of the Work within the mandatory time requirements and dates specified in the Contract Documents.

Key Dates

The Contractor's Construction Schedule submitted with the Tender shall be based on the times specified herein and shall be used by the Contractor for planning, organizing and directing the construction of the Work and for reporting progress. The Construction Schedule shall be a detailed critical path method (CPM) schedule showing all principal activities relating to construction of the Work. Such activities shall include the items of principal value in the Form of Tender.

In accordance with the provisions of the General Conditions and of the Special Conditions the Contractor shall upgrade its Construction Schedule as necessary after commencement of and throughout the Work to meet the requirements of those Clauses as specified.

1.11 Contractor's Plant

1.11.a General

Except as otherwise specifically provided for in the Tender Documents, the Contractor shall make all necessary arrangements for the provision, operation, security, maintenance and subsequent demolition, disposal or removal on completion of the Work of all Plant, including stationary construction facilities, of whatsoever nature required for the complete and satisfactory execution of the Work.

Omission in the Tender Documents of specific requirements for any particular items of Plant shall in no way be construed to relieve the Contractor from its obligations under the first paragraph of this Clause.

The Contractor shall give the Company Representative at least seven (7) days notice in writing of its intention to remove any particular item of Plant or any part thereof.

1.11.b Site Arrangement Plans

Within seven (7) days of award of the Contract the Contractor shall prepare and submit to the Company Representative and Engineer for authorization to proceed with the Work, detailed site arrangement plans showing the layout and details of all services and other construction facilities which it proposes to install in its working areas. These plans shall include, but shall not necessarily be limited to, the following:

(i) Construction access to the various work areas on the Site, including road connections to public roads.

(ii) Contractor's administrative office, workshop, warehouse and storage facilities.

(iii) Water supply, sewerage and waste disposal facilities.

(iv) Borrow areas, spoil areas and stockpile areas.

(v) Groundwater and/or surface water handling and sediment control facilities.

Acceptance by the Company Representative and Engineer of the site arrangement plans shall in no way be construed to relieve the Contractor of its duties and responsibilities for the provision, operation and maintenance of adequate and suitable Plant.

Whenever the Contractor proposes to make any additions or revisions to its roads and other stationary construction facilities, they shall be shown on relevant drawings and re-submitted to the Company Representative and Engineer for review before the additions or revisions are made.

In considering the proposed location of stationary construction facilities, the Company Representative will, amongst other things, make due allowance for the requirements of others who shall be working on the Site from time to time.

Site arrangement plans shall be kept up to date by the Contractor at all times.

1.12 Availability and Use of the Site

1.12.a General

The Contractor is advised that the construction equipment, materials and labour forces of Others may be present on the Site during the course of the Work. The Contractor shall not locate any portion of its Plant where it will interfere with the work of Others and shall remove and relocate any such plant, at the Contractor's cost, should it interfere with the work of Others at any time during the course of the work of Others. Therefore, the Contractor shall not be entitled to exclusive use of any portion of the Site and shall cooperate with the forces of others as may be required by the Company Representative. Should the Contractor desire to make use of or occupy any land which lies outside of the working areas, a proposal for use and occupancy of such land shall be submitted for acceptance by the Company Representative.

Without limiting the generality of any of the provisions contained elsewhere in the Contract Documents, the Contractor shall protect the property of the Owner and Others from damage as a result of its operations, to the satisfaction of the Company Representative. In the event of damage to the property of the Owner and Others resulting from the Contractor's operations, the Contractor shall immediately notify the Company Representative. The Company Representative may exercise an option to:

(i) Either direct the Contractor to immediately repair such damage, or

(ii) notify the Contractor that such damage will be repaired by the forces of others.

Any such repairs shall be made to the Owner's satisfaction and at the Contractor's expense and, if made by the forces of Others, the cost therefore shall be paid by the Contractor.

1.12.b Site Roads

The Contractor shall be responsible for constructing and maintaining all roads on and to the Site as required under the Contract as well as constructing and maintaining any additional construction roads as deemed necessary by it for the performance of the Work.

All roads on the Site, including those that may be constructed by the Contractor shall be available for use by the Owner, the Company Representative and the Engineer and by others having permission from the Company Representative to do so.

At the completion of the Work all site roads and culverts used by the Contractor shall be left in a safe condition, with a reasonably smooth, well drained surface.

1.12.c Contractor's Site Office

During the performance of the Work, the Contractor shall provide and maintain at the Site an office which shall be the headquarters of the Contractor's Project Manager.

1.12.d Landscape Preservation and Restoration

The Contractor shall preserve the natural landscape except where clearing and/or earthwork is required by the Contract or permitted by the Company Representative in writing, and shall so conduct the operations and equipment such that the destruction, scarring or defacing of trees, the native shrubbery and the natural surroundings are kept to a minimum.

On completion of the Work, all working areas shall be smoothed and graded to conform to the natural appearance of the landscape. In the event that, in contravention of the requirements of this Clause, or for any other reason, the Contractor's operations result in destruction, scarring, damage, or defacing of trees, shrubbery, or landscape outside the limits of the Contractor's working areas, all trees or shrubbery so destroyed, scarred, damaged or defaced shall be removed as soon as possible thereafter and the landscape shall be restored and reseeded with the natural vegetation to the satisfaction of the Company Representative at no additional cost to the Owner.

1.12.e Prevention of Water Pollution

The Contractor shall comply with all Federal and Provincial laws and regulations with respect to disposal of pollutants and all additional requirements specified in the Contract Documents.

The Contractor's construction activities shall be performed in a manner such as to prevent solid matter, contaminants, debris and other objectionable pollutants and wastes from entering streams, flowing or dry water courses, lakes and underground water sources. Such pollutants and wastes include, but are not limited to, refuse, garbage, cement, concrete, sewage effluent, industrial waste, oil and other petroleum products, aggregate processing tailings, mineral salts and silty or muddy water. Sanitary wastes shall be disposed of by methods approved by the Company Representative.

The Contractor is expressly warned that the groundwater and/or surface water runoff from all areas disturbed by the Contractor's operations must be directed to sediment ponds. Accordingly, the Contractor shall construct intercepting ditches, sumps, bypass channels, barriers, and/or other means to direct all muddy water and eroded materials to such sediment ponds after it leaves his working areas and all roads on the Site and prior to its entry into existing streams or water courses or permanent installations. Except as otherwise specified, excavated materials shall not be deposited or stored in, or alongside of, water courses where they could be washed away by high water, storm or normal surface runoff.

Any waters discharged from the Site shall be essentially free of material in suspension. For the purpose of this Sub-clause, material in suspension in waters released to the environment shall not exceed 25 mg/l or as otherwise required by law.

1.12.f Construction Facilities of Others

The Contractor is advised that temporary construction facilities of others such as, but not limited to roads, power and water lines and communication lines have been or will be constructed by others during the course of the Work. The Contractor shall not disrupt the continuance of use of such facilities until the Contractor is advised by the Company Representative that they are no longer required. Should the Contractor at any time wish to relocate these temporary construction facilities to facilitate the Work, prior written approval shall be obtained from the Company Representative.

1.13 Spoil Disposal Area and Stockpile Areas

Except as otherwise specified, the Contractor shall dispose of unsuitable and surplus materials from the excavations in the spoil disposal area and stockpile areas as shown on the Drawings or as otherwise directed by the Company Representative. Spoil and topsoil shall be placed to the height and slopes as shown on the Drawings or as otherwise required by the Company Representative.

Each spoil fill and/or stockpile shall be developed in an orderly manner and in such a way that it does not interfere harmfully with the natural drainage in the area. The Company Representative reserves the right to limit the amount of material which can be placed in spoil disposal areas and/or stockpile areas and to control the method of construction, height and slopes to which the material can be placed. Spoil fills and/or stockpiles shall be stable within themselves, shall not cause instability of adjacent natural slopes or any parts of the Work and shall be graded to provide free draining surfaces which do not detract from the general appearance of the area.

Stockpiles should be developed in such a manner as to limit segregation. All surface water runoff from spoil areas and stockpile areas shall be directed to sediment ponds.

1.14 Dewatering and Drainage

Except as otherwise provided for by the Contract Documents, the Contractor shall investigate, design, construct, operate, maintain and subsequently remove such temporary cofferdams, dikes, fills, surface and sub-surface dewatering and drainage facilities as are necessary for control and removal of all water entering the work areas including seepage and leakage water, precipitation and water resulting from the operations of the Contractor. Cofferdams, dikes, fills and dewatering and drainage facilities provided by the Contractor shall be safe and stable, and shall be such as to permit the Work to be performed in an orderly and efficient manner under dry conditions. Water removed from the excavations shall be disposed of in such a manner as will not endanger the environment, the stability of existing slopes, or the Work, and shall be directed to sediment ponds.

The Contractor will not be permitted to use the permanent drainage facilities installed for the Work without the prior approval of the Engineer.

Construction and maintenance of all groundwater and/or surface water facilities shall be subject to the approvals of the Company Representative and Engineer prior to construction and shall be carried out in accordance with the provisions of Clauses 1.9.b. and 1.10.e.

The Contractor shall obtain written approval from the Engineer before discontinuing the operation of any dewatering system.

1.15 Borrow Areas

The Contractor shall give the Company Representative and Engineer not less than 14 days notice of its intention to develop any potential borrow area.

Prior to developing any borrow area other than the borrow areas designated on the Drawings or in the Specifications, the Contractor shall carry out such sub-surface investigation and obtain and submit such samples as are required by the Engineer to enable the Engineer to assess the suitability of the materials in the area for the intended use.

The Contractor shall keep accurate exploration records of a type approved by the Engineer of any test pit, trench or drill hole which is excavated for the purpose of investigating construction materials, and a copy of such records shall be submitted to the Engineer within 7 days of the completion of the test pit, trench or drill hole. Samples recovered from test pits, test trenches and drill holes and submitted to the Engineer for approval will be tested by the Engineer.

The Contractor's borrow pit operations shall be such as to avoid waste of any suitable construction material therein. The Contractor shall clear, strip and grub borrow areas, windrow all topsoil or, as directed by the Engineer, stockpile all topsoil which, in the opinion of the Engineer, can be salvaged. Borrow areas shall be developed with due consideration for drainage and runoff from the excavated surfaces so as not to cause erosion of the adjacent terrain. Borrow areas shall be excavated in such a manner that water will not collect and stand therein. For materials sensitive to overwetting, the borrow areas shall be developed to minimize the exposure of the material to precipitation. In till borrow areas all excavated faces shall be vertical. Before being abandoned, the sides of any borrow areas outside the final limits of the tailings storage facility shall be brought to stable slopes with slope intersections rounded and shaped to provide a natural appearance. All rubbish, Contractor's equipment and structures shall be removed from these areas. Waste piles shall be levelled, trimmed and shaped to regular lines to prevent the occurrence of ponding or of concentrations of surface runoff and to provide a neat appearance. All surface water runoff shall be directed to sediment ponds.

Waste material from an excavation for the Work or from a processing operation in a borrow area shall be disposed of in a spoil area or in an area approved by the Company Representative and set aside for this purpose within the borrow area.

1.16 Setting Out the Work

1.16.a General

The Owner has established at the Site, survey reference points and a bench mark. The Contractor shall use such reference points and bench mark as the basis for setting out the Work and shall be responsible for their preservation insofar as they are affected by his operations.

The Contractor shall set out the Work efficiently and accurately and shall be solely responsible therefor. The Contractor shall provide, fix and be responsible for the maintenance of all monuments, stakes, templates, batter boards, bench marks and other reference marks, and shall take all necessary precautions to prevent their removal or disturbance and shall be responsible for the consequences of any such removal or disturbance and for the accurate reinstatement of all such marks. The Contractor shall provide the Company Representative with drawings showing the locations and details of his monuments and control bench marks immediately after establishing of such monuments and shall submit updated drawings after making any changes, additions or deletions.

The Work shall be set out to meet the requirements of the Drawings and tolerance limits specified in the Contract Documents in all respects. At the request of the Company Representative the

Contractor shall at all times, without charge, provide qualified personnel, equipment, tools and materials to assist the Company Representative in checking the setting out of the Work. No payment will be made for any expense incurred by the Contractor as a result of any work performed in the establishment of lines and grades, or in the checking of these and the taking of any other surveys or measurements.

If at any time during the progress of the Work any error should become evident or occur in the location, grades, dimensions or alignment of any part of the work, the Contractor, upon such error occurring or becoming evident, shall forthwith inform the Company Representative and shall at the Contractor's own expense rectify such error to the satisfaction of the Company Representative, unless such error is based on incorrect data supplied in writing by the Company Representative, in which case the expense of rectifying the error will, as between the Contractor and the Owner, be borne by the Owner.

The Company Representative reserves the right to use the Contractor's setting out monuments to perform occasional check surveys at times agreeable to both parties.

1.16.b Survey Accuracy

The accuracy of control surveys shall be subject to the approval of the Engineer. The Contractor shall present data and calculations to establish the following standards of accuracy relative to the benchmark and reference points provided by the Owner.

- Points on the Setting Out Line (S.O.L.) and the Contractor's temporary control points for embankment construction shall be established to a horizontal standard deviation of less than 20 mm and a vertical standard deviation of less than 40 mm, both with a 95% confidence interval, taking into account the limits of accuracy of the survey instruments as provided by the manufacturer.

- As-Built locations of pipework and culverts shall be established to horizontal and vertical standard deviations of less than 100 mm with a confidence interval of 95%.

1.16.c Field Notes and Calculations

Field notes shall be recorded in securely bound field books of high quality with a table of contents and each page numbered sequentially. The field books shall be made available for inspection by the Engineer upon request. Traverse adjustments shall be clearly indicated in the notes. A log listing all field note books by number shall be maintained.

Calculations including computer printouts shall be maintained in binders and shall be neat, orderly, and cross referenced as applicable.

Cross-sections shall be plotted on approved translucent cross section drafting sheets and submitted to the Engineer together with the appropriate survey notes and calculations.

The original and one copy of all field notes and calculations shall be submitted upon completion of the work. Disk copies of computer calculations shall be submitted.

1.17 Drawings Submitted by Contractor

The Contractor shall submit to the Company Representative and Engineer for review, one (1) reproducible and two (2) print copies of such drawings as may be required by the Company Representative and Engineer. Such submissions shall give complete details and information and contain sufficient views and be to such suitable scales as will show clearly the work or item. Each drawing shall be prepared on bordered D size sheets (56 mm x 86 mm), shall include north arrow and scale bars as appropriate and shall in every case include a title block in the lower right corner stating the subject of the drawings, a drawing number, the current revision and dates of all revisions. Each drawing shall be carefully checked and signed by the Contractor prior to submission. On completion of the Work the Contractor shall submit a drawing showing the as-built locations and elevations of all major components of the work.

The review by the Company Representative and Engineer of drawings and schedules submitted by the Contractor shall not be construed as indicating any checking of the drawings and schedules, and shall not relieve the Contractor of responsibility for adequacy and accuracy of detail of the work shown on such drawings and schedules or for any errors therein or of any other of the Contractor's responsibilities under the Contract.

1.18 Standard Specifications

Specific codes and standard specifications referred to in these Technical Specifications and the Drawings shall, to the extent of such reference only, form part of the Technical Specifications and Drawings. Where a particular standard is referred to, that standard shall, unless otherwise stated, be the edition in effect thirty (30) days prior to the closing date for submission of tenders.

Where no specific standards are referred to, material, equipment and articles furnished by the Contractor shall comply with the applicable provisions of the American Society for Testing and Materials (ASTM).

1.19 Daily Reports

The Engineer will maintain in detail a daily report to record progress of the Work, the number of personnel of all categories at the Site, the materials delivered to the Site, and all other items which he deems necessary to record.

This daily report will be kept in the Engineer's site office and the Contractor's representative shall be required to read and sign this document daily. In case of differences of opinion between the Engineer and the Contractor regarding the facts stated in the daily report, the Contractor shall, within twenty-four (24) hours, give notice in writing to the Engineer regarding any such difference.

1.20 Provisional Sums

Every provisional sum, if any, set out in the Schedule of Estimated Quantities and Prices for work to be executed by the Contractor, which has not been specified in detail when the Contract is entered into, shall be deducted from the Contract Price and in lieu thereof subject to the provisions below, there shall be added to the Contract Price the value of the work so executed, valued in accordance with the provisions of the General Conditions entitled "Changes in the Work".

Work under provisional sums shall be executed by the Contractor only at the discretion and written direction of the Company Representative.

The Owner at all times reserves the right to have any part, or all, of the work covered under provisional sum items in the Schedule of Estimated Quantities and Prices performed by Others without any reimbursement to the Contractor by reason thereof.

1.21 Payment - General

The provisions of this Clause shall apply to each and every other Section contained in the Technical Specifications as if such provisions were specifically contained in each such Section.

Payment for the Work required by the Contract Documents for which Items have been included in the Schedule of Estimated Quantities and Prices shall be made in accordance with the lump sum prices and provisional sums entered in the Schedule of Estimated Quantities and Prices. The work to be performed by the Contractor for such prices and provisional sums shall include doing everything necessary to complete such Items in accordance with the Contract Documents.

Except as otherwise provided for elsewhere in the Tender Documents, the lump sum prices and provisional sums included in the Schedule of Estimated Quantities and Prices shall be deemed to include all of the cost of doing everything necessary to complete all work required, shown, enumerated or described in the Tender Documents and on the Drawings whether or not such work is specifically shown or described as part of the work of any specific item in the Schedule of Estimated Quantities and Prices.

TABLE 1

SUMMARY OF TECHNICAL AND SAFETY ADVANCE NOTICE PERIODS REQUIRED OF CONTRACTOR

Clause	Subject	Notice Period
1.3.c.	Class 2 excavation	7 days
1.4.a.	First fill placement	7 days
1.4.b.	Alternate borrow areas	21 days
1.4.d.	Fill placement against concrete	7 days
1.5.h.(i)	Concrete placement	24 hours
1.6.b.	Pipe and fittings catalogues	14 days
1.9.a.	Removal of plant	7 days
1.9.b.	Site arrangement and sediment control plans	7 days
1.13	Borrow area development	14 days
1.17	Daily reports	24 hours

SECTION 2 - MOBILIZATION AND DEMOBILIZATION

2.1 Scope of Work

The Work in this section comprises the establishment on the Site of all the temporary accommodation, Plant and equipment necessary for the successful performance and completion of the Work and shall include, but not be limited to:

2.1.a Assemble all necessary Plant and equipment and transport it to the Site.

2.1.b Establish all the Contractor's maintenance facilities, temporary workshops, office accommodation and sanitation facilities on the Site.

2.1.c Provide and maintain the Engineer's field office and testing laboratory on the Site.

2.1.d Maintain all Plant and services for the duration of the Work.

2.1.e On completion of the Work, remove all Plant, temporary facilities and the Engineer's field office and laboratory from the Site and clean up and leave the Site in a clean and tidy condition to the satisfaction of the Company Representative.

2.2 Use of Site

The area designated for the Contractor's temporary facilities is shown on the Drawings. The Tenderer shall submit with its Tender a sketch showing clearly how it would utilize this area and what temporary facilities would be constructed.

The Tenderer shall also submit with its Tender a detailed layout showing all temporary haul roads and any other areas which it may wish to utilize in performing the Work.

The Contractor shall plan its operations in a manner such that there is minimum disturbance to the natural terrain outside the limits of the work areas shown on the Drawings.

SECTION 3 - TAILINGS BASIN

3.1 Scope of Work

The Work to be completed in this Section shall include, and not be limited to the following:

3.1.a Strip and grub all roots and stumps in the tailings basin as shown on the Drawings or as otherwise instructed.

3.1.b Burn all non-merchantable timber and dispose of material from the stripping and grubbing by burning. Dispose of material which cannot be burned in the designated spoil area.

3.1.c Remove and stockpile all topsoil from the areas which have been stripped and grubbed.

3.1.d Excavate exploratory trenches in the lower part of the tailing basin and install the basin groundwater drains.

3.1.e Develop, operate and maintain the borrow areas required to supply fill materials for the Work.

3.1.f Construct the basin liner in the lower part of the tailings basin.

3.1.g Excavate the reclaim barge channel.

3.2 Stripping, Grubbing and Topsoil Removal

Stripping, grubbing and topsoil removal shall be carried out as defined in Clause 1.2 within the tailings basin to the limits shown on the Drawings. Swampy and wet areas which are inaccessible to construction equipment will not require stripping. The limits of accessibility shall be agreed between the Company Representative and the Contractor in the field, with the objective of optimizing recovery of topsoil.

The Contractor shall assume an average depth of stripping equal to 0.30 m.

Stripping, grubbing and topsoil removal shall be scheduled to work progressively uphill in the tailings basin to minimize the area requiring sediment control until the basin liner is completed and the Main Embankment has been constructed to El.918 metres.

In all areas which the Contractor is required to carry out further work, the stripped ground surface shall be established by survey in accordance with the General Technical Requirements.

3.3 Basin Groundwater Drains

The Contractor shall excavate exploratory trenches in the lower portion of the tailings basin at the locations shown on the Drawings for the purpose of determining the limits of the glacial till in place which is at least 2 m thickness after topsoil removal. These trenches shall be excavated under the direction of the Engineer.

The exploratory trenches shall be excavated in an uphill direction at 0.25% minimum grade from temporary dewatering sumps near the upstream toe of the main embankment. In all locations where the trenches exceed 1.0 m in depth the trenches shall be excavated with benches at 1.0 m from the base of the trench to facilitate installation of the basin groundwater drain geotextile surround.

The basin groundwater drains shall be constructed in each trench immediately upon completion of excavation. The Contractor shall clean out all material which has caved into the trench, extend the specified geotextile and perforated CPT and backfill with drain gravel to 1 m depth in 2 - 0.5 m lifts, each levelled and compacted with 2 passes of the hand-guided vibratory compactors. After closing the geotextile, the trench shall be backfilled with glacial till compacted in 0.35 m maximum thickness lifts as shown on the Drawings.

The Contractor shall install the non-perforated HDPE connecting pipe between the two basin groundwater drains.

The Contractor shall maintain the basin groundwater drains in a dewatered condition by pumping temporary sump(s) until such time as gravity drainage is established through the permanent drain conveyance pipe to be constructed as part of the Main Embankment works.

3.4 Basin Liner

3.4.a General

After completion of basin groundwater drain construction in an area of the tailings basin, the Engineer will designate the limits of the basin liner, to be constructed of compacted glacial till, placed and compacted in 3 lifts and covered with a frost protection layer as shown on the Drawings.

3.4.b Subgrade Preparation

The Contractor shall regrade the stripped ground surface and compact using the smooth drum vibratory roller with a minimum of 2 passes to "proof-roll" the basin liner foundation. Areas which are pumping, rutting or weaving shall be subexcavated and replaced with glacial till backfill or scarified and recompacted. At the completion of subgrade preparation the basin liner subgrade shall be a smooth, firm surface without isolated low spots, draining to the upstream toe of the main embankment.

3.4.c Grade Control

The Contractor shall establish the limits of the prepared subgrade by survey and shall measure the elevations of a 10 m x 10 m grid of points to be progressively extended over the entire basin liner area as subgrade preparation and basin liner construction advance. The Contractor shall prepare a drawing showing the elevations of the grid points measured within the completed portion and along the limits of the prepared subgrade and shall submit a copy to the Engineer for approval. When signed and dated, the subgrade approval will form the basis for control of the thickness of basin liner placed and compacted in the permanent work.

The Contractor shall check the elevations at the grid points after compaction of the second of the three lifts of glacial till and shall direct placement of the final lift accordingly to achieve the required final thickness upon completion. The Contractor shall plot the measured elevations of the top of the compacted third lift of basin liner at each grid point to prove that there exists at each point the 450 mm minimum required thickness of compacted glacial till.

In case of a shortfall, the Contractor may elect to check the thickness of the basin liner by excavating small test pits at selected grid points to confirm the survey results. However, it is the responsibility of the Contractor to provide proof to the satisfaction of the Engineer, that the basin liner has been placed in all required areas to the minimum thickness shown on the Drawings.

After acceptance of each part of the basin liner by the Engineer, the Contractor shall place the frost protection layer.

3.4.d Basin Liner Construction

The glacial till basin liner shall be placed, levelled, moisture conditioned if required and compacted in 3 equal lifts of at least 150 mm compacted thickness to cover the lower portion of the tailings basin with a low permeability glacial till blanket which connects the compacted till core zone of the main embankment to the natural existing glacial till blanket in the upper portions of the tailings basin.

The Contractor shall supply glacial till meeting the gradation requirements specified on the Drawings and meeting the moisture content requirements designated by the Engineer.

The material shall be placed and spread and shall be levelled with a motor grader. Prior to compaction all rocks larger than 100 mm and all roots or sticks larger than 10 mm dia by 200 mm long shall be removed from the material.

Compaction of the individual lifts of the basin liner shall be carried out using the designated number of passes of the smooth drum vibratory roller operated as specified in Clause 1.4.

The upper edges of the basin liner shall be feathered out to meet the natural ground to prevent ponding of surface runoff. Temporary construction joints formed in the basin liner shall be stepped back by at least 2 m from lift to lift to allow good bonding of the material and to prevent penetration of more than one lift of the basin liner by vertical construction joints.

The Contractor shall protect and maintain the completed surfaces of each lift of the basin liner against disturbance by construction traffic and softening or erosion by runoff until such time as the Engineer accepts the work based on results of testing and instructs the Contractor to proceed. The Engineer will make every effort to expedite testing and to provide the results in a timely manner, however, it is the Contractor's responsibility to schedule the work to avoid delays.

When a portion of the basin liner has been accepted by the Engineer as completed, the Contractor shall cover the accepted area with the specified frost protection layer of glacial till and shall seal the surface thereof with the smooth drum vibratory roller. This upper surface shall be graded to shed runoff until such time as the embankment fill is raised above the level of the top of the basin liner.

3.5 Borrow Areas, Spoil Areas and Topsoil Stockpile

The primary borrow areas, spoil areas and topsoil stockpile for the Work are shown on the Drawings. Development of these facilities and any other borrow sources which the Contractor may choose to utilize shall in all respects conform to the requirements of the applicable Clauses of the General Technical Requirements.

Stripping of borrow areas shall in all cases be carried out progressively ahead of the excavation to minimize the area open to erosion and to minimize sediment loading in surface runoff. Borrow floors shall be sloped to drain, with runoff directed to sediment ponds.

Waste piles and sediment ponds may be located in worked out sections of the borrow areas upon presentation of evidence to the satisfaction of the Engineer to show that no further quantities of suitable material which might be required in the Work would become inaccessible as a result. The preferred spoil area is located in the swamp adjacent to the borrow area in the tailings basin.

The development, maintenance, and operation of the borrow areas, haul roads and all sediment control ponds shall be the responsibility of the Contractor. The Contractor may employ methods and means of procedure of its own choosing, subject to compliance with the requirements of the General Technical Requirements. Approval by the Company Representative and/or Engineer of the Contractor's proposed methods shall in no way be construed to relieve the Contractor of his responsibility for the safety, adequacy or efficacy of his operations.

3.6 Reclaim Barge Channel

The reclaim barge channel shall be excavated to the lines and grades shown on the Drawings. The Contractor shall excavate test pits along the length of the reclaim barge channel for the purpose of classifying the soils in advance of excavation. The Engineer will designate the excavated material as suitable for use in basin liner or embankment fills or for haulage to spoil based on its gradation and moisture content characteristics. A 6 m wide access road shall be constructed parallel to the reclaim barge channel in native material as shown on the Drawings.

SECTION 4 - EMBANKMENTS AND SEEPAGE COLLECTION PONDS

4.1 Scope of Work

The Work to be carried out under this Section shall include, and not necessarily be limited to, the following:

4.1.a Strip and grub and remove topsoil from the foundation area for the Main and Perimeter embankments and seepage collection ponds.

4.1.b Excavate and prepare the foundation areas for the embankments, including subexcavation and backfill as directed by the Engineer.

4.1.c Dewater and maintain the foundation excavations by employing any temporary measures as are necessary to keep the excavations properly dewatered.

4.1.d Install foundation and toe drains.

4.1.e Install drain conveyance pipework and monitoring sumps.

4.1.f Supply, place and compact all earthfill materials in the Main and Perimeter embankments and pond berms.

4.1.g Excavate the seepage collection ponds and install the seepage recycle sumps.

4.2 Stripping, Grubbing and Topsoil Removal

All stripping and grubbing, and removal of topsoil in the embankment foundation and seepage collection pond areas will be carried out as specified in Clause 1.2.

The Contractor shall assume an average depth of stripping equal to 0.3 m.

4.3 Foundation Preparation and Excavation

Embankment foundation preparation following the completion of topsoil removal will include shaping and compacting the exposed surface to ensure adequate drainage and suitable erosion protection as directed by the Engineer. Embankment foundation preparation will be carried out progressively, working up both abutments only enough to stay ahead of the fill.

Excavation in the embankment foundation areas to the lines and grades shown on Drawings will generally be carried out in silty sand or glacial till and will terminate at an elevation which exposes bedrock, competent silty sand or glacial till. It is not anticipated that excavation in bedrock will be required.

Any soft and saturated materials which are encountered in the embankment foundations and are not acceptable to the Engineer will require treatment. Treatment may include, but is not limited to, subexcavation and replacement with suitable coarse grained backfill, the extension of foundation drains, or the placement of extra fill to act as a buttress. The extent, including depth, of any required treatment will be determined by the Engineer. Any areas treated by subexcavation and replacement will require shaping and compaction, as above, prior to fill placement.

Materials excavated from the embankment foundation and seepage collection pond areas which satisfy the requirements for use as fill material will be used to construct the various zones of the embankment or pond berms. In order to implement this, the Contractor shall carry out the foundation excavation in a strictly selective manner such that the silty sands are not mixed with the glacial till.

The Contractor shall be responsible for maintaining and preserving the final excavated surfaces and shall keep them free of water to the maximum practical extent by constructing diversion drains, sumps, temporary berms etc. to divert and control surface runoff. The Contractor shall have adequate pumping capacity available at all times to ensure that the excavations are properly dewatered. The Contractor shall determine the actual locations of all dewatering facilities in order to fulfil his responsibility for control of water in all excavations to the satisfaction of the Engineer. The Contractor must recognise that foundation preparation and dewatering may prove to be difficult and shall make any and all provisions necessary to ensure a satisfactory completion of the works as required by the Engineer.

The Contractor shall operate and maintain the dewatering facilities until the Main Embankment is raised to El. 918 metres (sufficient to store the 1 in 100 year 24 hour storm) and the Engineer gives approval to commence impounding water on the basin liner.

Particular attention shall be devoted to protecting the final excavated surfaces of the glacial till. The Contractor shall avoid tracking equipment over these surfaces as much as possible and shall place the first layer of glacial till fill over the final surfaces as soon as possible in order to protect them. In the event that any final excavated surface of the glacial till deteriorates due to the Contractor's failure to protect it, then the softened, saturated or deteriorated material shall be removed and replaced with competent material at the Contractor's expense.

Prior to placing any fill materials or concrete on excavated surfaces, the surfaces shall be prepared as follows:

(i) Surfaces of excavations in glacial till, sloping at less than 4H:1V, shall be kept clean of any loose debris and compacted with 4 passes of a 10 ton vibratory roller. In the event that the moisture content of these surfaces is too high to permit 4 passes of a vibratory roller and the surface tends to rut and weave, then the compaction shall be reduced to 2 passes of a 10 ton static roller or as required by the Engineer.

(ii) Surfaces of excavations in sands and gravels sloping at less than 4H:1V shall be trimmed to the required lines and grades and compacted with 4 passes of a 10 ton vibratory roller.

(iii) For excavated surfaces sloping at steeper than 4H:1V, the fill shall be keyed in to the native soil by cutting vertical steps into the slope equal in height to the lift thickness of fill being placed.

After completion of foundation preparation in any area the Contractor shall measure such area and delineate the area on a Drawing showing the embankment outlines and shall submit this Drawing to the Engineer for approval. When signed and dated by the Engineer the approved area shall be covered immediately with one lift of fill appropriate to the zones of the embankment and shall be compacted as specified.

All requirements for installing basin and foundation instrumentation shall be met prior to placing fill in or above the instrumented areas.

4.4 Foundation Drains and Conveyance Pipework

The Main Embankment foundation drains shall be installed after the foundation preparation has been completed and before the commencement of embankment fill placement. Drainage pipework, filter fabric and granular backfill shall be placed at the locations and to the lines and grades shown on the Drawings.

Conveyance pipework for the basin groundwater and embankment foundation drains at the Main Embankment shall also be installed after the foundation preparation has been completed and before the commencement of embankment fill placement. Conveyance pipework and glacial till backfill with bentonite enriched seepage cutoffs shall be placed at the locations and to the lines and grades shown on the Drawings.

Conveyance pipework for the toe drain at the Perimeter Embankment shall be installed after the foundation preparation has been completed and before the commencement of embankment fill placement. Conveyance pipework and glacial till backfill shall be placed at the locations and to the lines and grades shown on the Drawings.

All pipework shall be supplied and the Contractor's installation methods shall be in conformance with the General Technical Requirements.

4.5 Materials of Construction

4.5.a General

The embankments shall be constructed by placing and compacting the material in the various zones in successive near horizontal layers which extend from one abutment to the other and do not contain any construction joints normal to the axis of the embankment.

All traffic on the embankment surface shall be routed to traverse the entire surface and avoid being concentrated on any particular route.

All zones of the embankment shall be constructed concurrently and no zone will be permitted to lag behind, or be constructed ahead of, its adjacent zone by more than one layer thickness, unless prior approval is given by the Engineer. In addition, the placing, spreading and compaction shall be scheduled in a manner such that all runoff from precipitation falling on the embankment shall drain towards the upstream face of the embankment. The purpose of this is to reduce the discharge of suspended solids and sediment downstream of the embankment.

4.5.b Material Requirements

Requirements for materials placed in the various zones of the embankment are as follows:

4.5.b.i Zone S - Core Zone Glacial Till

Glacial till required for Zone S shall conform to the gradation limits shown on the Drawings.

Excavation and handling of the glacial till shall be carried out in a manner such that it is well blended and well graded. Lenses of sand and gravel which may occur in or at the boundaries of the in-situ glacial till shall be removed unless the Contractor can demonstrate that it can be blended into the glacial till to produce a blend which conforms with the specified gradation limits for Zone S.

From time to time the Engineer shall designate the moisture content at which the glacial till is to be placed and compacted in the embankment. The Contractor will be required to moisture condition the material prior to delivering it to the embankment to obtain a moisture content which is within plus or minus one percent of the designated moisture content. In the event that the moisture content of the glacial till delivered to the embankment falls outside these prescribed limits then the Engineer may require that it be removed and replaced with material which complies with the prescribed limits. In some instances, the Engineer may permit the Contractor to adjust the moisture content on the embankment.

4.5.b.ii Zone B - Glacial Till

Glacial till required for Zone B shall conform to the gradation limits shown on the Drawings. The excavation, handling and moisture conditioning requirements are identical to those for Zone S.

4.5.b.iii Toe Drain - Filter Sand

Toe Drain pipework and filter sand shall be placed at the locations and to the lines and grades shown on the Drawings. The toe drain filter sand material shall meet the gradation requirements shown on the Drawings. The material shall be sound, durable and resistant to breakdown during handling.

4.5.b.iv Foundation Drains - Drain Gravel

Geotextile, CPT and HDPE pipework and drain gravel shall be installed or placed at the locations and to the lines and grades shown on the Drawings. The drain gravel shall meet the gradation requirements shown on the Drawings. The material shall be sound, durable and resistant to breakdown during handling.

4.6 Fill Placement

All material placed in the embankments shall be loaded, placed and spread in a manner such that segregation is avoided. All lenses of segregated material shall be removed or be reworked on the embankments to maintain the specified gradation in each zone.

The placing, spreading, and levelling of all material on the embankments shall generally be carried out with the equipment travelling parallel to the embankment axis. Spreading and compaction along abutments, or in confined areas, shall be carried out by routing the equipment in a manner best suited to the circumstances in accordance with the provisions of Clause 1.4.

After spreading, and prior to compaction, all material in Zones S and B shall be levelled with a motor grader to provide a regular surface free of oversize cobbles and segregated rock pockets.

Requirements for placement of materials in the various zones in the embankments are shown on the Drawings and are described as follows:

4.6.a Zone S - Core Zone Glacial Till

The glacial till in the embankment core, Zone S, shall be placed and spread to form layers which will not exceed 300 millimetres after compaction, and compacted using the specified vibratory roller.

The moisture content immediately after levelling shall be within one percent of that designated by the Engineer. No fill shall be placed on dried out surfaces. If the moisture content is wetter than that designated by the Engineer, additional measures such as disking of the fill materials may be required prior to compaction.

4.6.b Zone B - Glacial Till

The glacial till in the Zone B, shall be placed and spread to form layers which will not exceed 600 millimetres after compaction, and compacted using the specified vibratory roller.

The moisture content immediately after levelling shall be within one percent of that designated by the Engineer. No fill shall be placed on dried out surfaces. If the moisture content is wetter than that designated by the Engineer, additional measures such as disking of the fill materials may be required prior to compaction.

4.6.c Foundation Drains and Toe Drains

All material in the foundation drains and toe drains shall be placed to the lines and grades shown on the Drawings. Drainage pipework shall be installed as shown on the Drawings.

The Contractor shall submit the details of his proposed method of constructing the embankment toe drain to the Engineer for review 2 weeks prior to starting to work on the toe drain.

Compaction of drain gravel and outlet conveyance pipe backfill shall be carried out using 2 passes of the hand guided vibratory compacts. Compaction of the filter sand will not be required.

4.6.d Compaction

All compaction shall be carried out immediately after the material has been levelled using a motor grader.

All fill placed shall be compacted as specified in Clause 1.4.e. using the appropriate type of compaction equipment specified herein or on the Drawings.

The number of passes required shall at all times be determined by the Engineer and shall be varied to achieve the compaction objectives shown on the Drawings.

4.6.e Protection and Maintenance

The Contractor shall maintain any fill placed in the embankment in a condition which satisfies the requirements of Clause 1.4.e. until the completion of the Work. The Contractor shall take such steps as are necessary to avoid ponding of water on the fill, or contamination of the fill by traffic or other causes and shall at all times keep the surface and slopes of the embankment and foundations free from rubbish, rejected or unsuitable fill, waste materials and unnecessary equipment. Furthermore, the Contractor shall protect all buried pipework in accordance with Clause 1.6.e.

4.7 Seepage Collection Ponds

The seepage collection ponds are located downstream of the Main Embankment and Perimeter Embankment as shown on the Drawings.

The Contractor shall, after completion of topsoil removal and staking of the excavation limits, excavate test pits or trenches in the presence of the Engineer to determine the nature and extent of the soils within the excavation limits. The Engineer will carry out Control Tests on samples of the soil and will, through the Company Representative, issue an instruction to the Contractor designating the soils for use as fill or for removal to spoil.

The Main Embankment seepage collection pond excavation is expected to comprise predominantly saturated silty sands. The Perimeter Embankment seepage collection pond excavation is expected to comprise competent glacial till.

The Contractor, prior to commencing excavation in an area, shall submit his proposed excavation method complete with details of haul routes, dewatering measures and sediment control plan to the Company Representative for approval. The proposed excavation method shall in all cases be in conformance with the General Technical Requirements.

The seepage recycle sumps each comprise a cast-in-place concrete base slab, a vertical CSP sump riser and a CSP intake pipe as shown on the Drawings. The Contractor shall supply and place the base slab and shall supply and install the CSP riser and intake pipe. Materials supplied and methods of installation shall conform to the General Technical Requirements.

The seepage collection pond berms shall be constructed of fill placed, spread and compacted in 0.3 m lifts. The Engineer will select material from the seepage pond excavations for use in the pond berm at the perimeter embankment. The main embankment seepage collection pond berm will be constructed of glacial till from the borrow area in the tailings basin.

4.8 Construction Tolerances

The Contractor shall prepare the foundations for and construct the various zones of fill of the embankment to the lines and grades shown on the Drawings, within the tolerances specified below.

4.8.a The maximum permissible horizontal and vertical deviation of the boundaries between the zones of the embankments from the lines and grades shown on the Drawings, shall be plus or minus 600 millimetres.

4.8.b The maximum permissible horizontal and vertical deviation of the sloping outer faces of the embankments from the lines and grades shown on the Drawings shall be plus or minus 1000 millimetres provided that the average line of the final dressed slopes shall not fall inside the required slope line.

4.8.c The crest width of the embankments shall not be less than the dimensions shown on the Drawings at any station along the crest.

4.8.d The final surfaces of embankment crests shall be graded to and finished within plus or minus 100 millimetres of the elevations shown on the Drawings.

SECTION 5 - SITE ROADS AND DIVERSION DITCHES

5.1 Scope of Work

The Work to be completed in this Section shall include, and not be limited to, the following:

5.1.a Construct, operate and maintain all sediment control facilities for the Work.

5.1.b Strip, grub and burn all non merchantable timber, vegetation, stumps and roots in the areas designated on the Drawings or as otherwise instructed.

5.1.c Remove and windrow or stockpile all topsoil from the areas which have been stripped and grubbed.

5.1.d Construct the Bootjack-Morehead Connector Road relocation complete with drainage culverts and with a decant structure at Edney Creek tributary.

5.1.e Construct the Area B runoff collection ditch complete with flow control structures and overflow culverts.

5.1.f NOT USED

5.1.g NOT USED

5.1.h Construct the tailings area diversion ditch.

5.1.i Upgrade and connect the reclaim access road.

5.1.j Replace windrowed topsoil on fill slopes along roads and ditches.

5.2 Sediment Control

The Contractor shall schedule his construction activities to provide control of suspended sediment in surface runoff from areas disturbed by the Work in accordance with subclause 1.10.e of the General Technical Requirements.

The primary sediment control facility for the tailings area will be the sediment pond formed by the Bootjack-Morehead Connector relocation. Ditches, roads and other construction activities outside the tributary catchment of this primary sediment control facility will require care to limit sediment concentrations in receiving waters. Methods to be employed by the Contractor may include, but are not limited to, terracing, silt fences, hay bales and careful supervision of work near streamcourses.

5.3 Stripping, Grubbing and Topsoil Removal/Replacement

Stripping and grubbing shall be carried out as defined in Clause 1.2 within the limits of the Work shown on the Drawings.

For the Work of this Section 5, comprising site roads and diversion ditches, topsoil shall be windrowed along the downhill edges of the cleared, stripped and grubbed corridors for the Work. The Contractor shall remove the topsoil a minimum of 1 m past the line of fill stakes and shall take care not to push the windrow of topsoil into standing timber. In cases of conflict, the Contractor shall immediately notify the Company Representative of the requirement for additional clearing. In no case shall fill be placed on unstripped ground or supported on topsoil windrows.

Upon the completion of the site roads and diversion ditches in each area of the Work, the Contractor shall compact the fill slopes by track walking with a bulldozer and shall spread the windrow of topsoil onto the fill slope using bulldozer(s) and/or backhoe(s) distributing the available organic material to achieve an even coverage on the slope. Haulage of topsoil along roads and ditches will not be required.

5.4 Bootjack-Morehead Connector Relocation

The Bootjack-Morehead Connector Relocation shall be built in the location shown on the Drawings to provide a 6m wide roadway generally to B.C. Forest Service Class 4 standards.

Sidehill portions of the road shall be built in local cut to fill with drainage ditches and culverts to suit local conditions. The embankment section of the road located south east of the Main Embankment of the tailings area shall be built to El.911 as shown on the Drawings using glacial till from the designated borrow area in the S.E. corner of the tailings basin. The embankment fill shall be placed, spread and compacted in lifts of 0.30 m maximum thickness.

All culverts shall be supplied and installed in accordance with the requirements of the General Technical Specifications.

The outlet culvert and decant structure shall be supplied and installed as shown on the Drawings.

The Contractor shall place a wearing course of rockfill in a single lift of 200 mm minimum thickness to complete the Bootjack-Morehead Connector Relocation. The wearing course shall be loaded and hauled from the Owner's stockpile, located approximately 1 km distant from the millsite in the open pit area. The wearing course shall be graded and compacted to form a durable surface as shown on the Drawings.

The Contractor is advised that the Bootjack Morehead Connector is a public road. The Contractor shall at all times maintain access through or around the site on the existing or relocated portions of this road. Delays of not more than one half hour to traffic will be permitted. The Contractor shall provide suitably equipped flagpersons at any location where, and at all times when, construction activities require that public access along the road be temporarily restricted. A prominent sign stating CONSTRUCTION AHEAD, SLOW TO 30 km/h shall be erected and maintained by the Contractor, to the satisfaction of the Company Representative, at each end of the affected portion of the road.

5.5 Area B Runoff Collection Ditch

The Area B runoff collection ditch and the associated flow control structures shall be constructed above the Bootjack Morehead Connector Road at the locations shown on Drawing No. 1625.215. Sections and details are given on Drawing Nos. 1625.216 and 1625.217.

After windrowing of topsoil to the lower edge of the cleaned area, the contractor shall set out the ditch alignment and the locations of the flow control structures in conjunction with the Engineer to allow adjustment relative to existing topography and existing stream course locations. The Area B runoff collection ditch shall be located sufficiently distant from the existing road to allow construction of the ditch without closure of the road, and to avoid interference of the ditch cuts and fills with the existing road section.

The ditch shall be constructed entirely in cut, as shown on the Drawings and the excavated material shall be placed to form a maintenance access road along the ditch. All cut slopes shall be dressed and trimmed to stable, neat lines and grades. All fill slopes shall be dressed, trackwalked for compaction and covered with topsoil as specified in Clause 5.3.

The culverts, slide gates and concrete headwalls which comprise the flow control structures shall be supplied, constructed and installed in accordance with the General Technical Requirements.

Riprap shall be placed at culvert exits and at other locations designated by the Engineer for erosion protection. Riprap shall be mine waste rock from the Owners stockpile in the open pit area, selected during loading and placement to avoid pockets of fines and boulders of average dimension greater than 500 mm. The rip-rap shall be predominantly 75 mm to 300 mm in size, averaging 150 mm in size.

5.6 Tailings and Reclaim Access Roads

The tailings access road and pipe containment channel shall be constructed in the locations and to the lines, grades and dimensions shown on the Drawings or instructed by the Manager.

After windrowing of topsoil to the lower edge of the cleared, stripped and grubbed area, the Contractor shall set out the road by survey. The final location of the Bootjack Creek crossing will require the approval of the Manager. The Contractor shall not carry out any instream work at Bootjack Creek without the specific written approval of the Manager. The schedule key dates set forth in Clause 1.8 shall be used to plan this work.

The tailings access road shall be constructed by placement of material from required cuts in 0.5 m lifts compacted with 4 passes of the heavy vibratory roller. Fill slopes shall be staked and constructed at 2H:1V and shall be trackwalked for compaction upon completion to grade, followed by respreading of the windrowed topsoil onto the fill slopes. Cut slopes shall be dressed to remove loose and overhanging material.

The tailings and reclaim pipelines shall be supplied and installed as specified in Section 6.0 of this Technical Specification.

The Contractor shall supply and install drainage culverts in the locations shown on the Drawings or directed by the Engineer. The pipe arch culvert shall be supplied and installed in Bootjack Creek. Temporary diversion of the creek will be required to place and compact a sound, level bedding pad for the pipe arch culvert. Special care shall be used in compacting material into the haunches of the pipe arch culvert. An air actuated "pogo" compactor is the preferred method of compaction into the culvert corrugations. Manual compaction using shovel handles will be acceptable as directed by the Engineer.

The tailings access road earthworks are described and specified starting at the millsite and proceeding to the tailings area as follows:

5.6.a Millsite to Bootjack Creek

The Contractor shall excavate the pipeline trench as shown on the Drawings. In locations where the bottom of the pipeline trench is not in glacial till as determined by the Engineer, the Contractor shall subcut the trench and place glacial till to provide the required 0.3 m of select fine grained till as specified on the Drawings. The base of the completed pipeline trench shall be compacted with 2 passes of the heavy vibratory roller and shall be free of sharp projecting rocks, soft or pervious areas, and shall grade continuously without sharp changes in grade or isolated low spots. The Contractor shall protect and maintain the pipeline trench until the pipelines are installed and backfilled. Pipe backfill shall be select fine grained glacial till obtained from required road cuts, spread in 150 mm lifts and compacted with the hand guided vibratory compactor.

Riprap shall be placed and compacted with the bucket of an excavator to form interlocking erosion protection, well bedded in the pipe backfill. Riprap shall be obtained from the Owners waste rock stockpile in the open pit area.

The Contractor shall carefully consider his options for surface runoff control to prevent erosion damage to work in progress.

The tailings access road shall be completed with safety berms and road wearing course as shown on the Drawings.

5.6.b Bootjack Creek Crossing

The elevation of final road grade at the Bootjack Creek crossing will be determined based on the requirement for continuous free drainage grade on the pipelines. A 4 m wide bench for the pipe sleeves will be required at final road grade in addition to the 8 m wide roadway.

5.7 Tailings Area Diversion Ditch

The tailings area diversion ditch shall be excavated along the west side of the tailings area, graded to discharge into flow control structure #3 at the SW corner of the tailings area.

The ditch, for the most part, will follow an existing logging road and will be constructed in local cut to fill.

Cut slopes shall be trimmed to neat and stable lines and fill slopes shall be trackwalked and the available stripped and windrowed topsoil spread as specified in Clause 5.3. Riprap will not be required in this ditch.

SECTION 7 - INSTRUMENTATION AND MONITORING FACILITIES

7.1 Scope of Work

The Work to be carried out under this Section shall include, but not necessarily be limited to, the following:

7.1.a Grouting and decommissioning of existing boreholes and standpipes.

7.1.b Supplying and installing piezometers in the basin groundwater and embankment foundation drains, embankment foundation, fill zones and in the tailings upstream of the embankment. The piezometers will be located on two vertical planes, identified as planes A and B, as shown on the Drawings.

7.1.c Constructing a monitoring hut, supplying and installing a piezometer terminal station in the hut and connecting instrumentation to the terminal station.

7.1.d Supplying and installing a Parshall flume.

7.1.e Supplying and installing survey monuments.

7.1.f Drilling and geotechnical sampling for Main Embankment foundation piezometers.

7.2 Grout Existing Boreholes

The Contractor shall grout selected existing boreholes and standpipes shown on the Drawings prior to commencing work which might lead to crushing or burial of the collars of such existing boreholes and standpipes. The grout shall be an expanding cement grout as approved by the Engineer. Any drillholes which are lost due to construction disturbance prior to grouting shall be relocated by survey, dug out and grouted or backfilled at the Contractors expense.

7.3 Piezometers

7.3.1 Materials and Supplies

A total of eighteen (18) piezometers shall be installed during Stage Ia and Ib construction, as shown on Drawing No. 1625.220. The piezometers shall be RST Model VW-2100, or approved equivalent, electric vibrating wire type rated for 25 and 100 psi as shown on the Drawings. The piezometers shall be connected to a 24 channel Terminal Station located in a monitoring hut via RST Model VW-2323 standard heavy duty, PVC jacketed direct burial cable (non-vented). An RST Model VW-2102 manual readout box, or approved equivalent, shall be provided to facilitate the reading of the piezometric data directly from the terminal station.

A barometer shall be installed in the monitoring hut as the reading is necessary for barometric compensation. A summary of required materials and supplies and a schedule of the required piezometers and lead lengths for Planes A and B during Stage Ia and Ib construction are presented on Dwg. No. 1625.221.

7.3.2 Installation Procedures

Piezometers shall be installed in the basin groundwater drains, embankment foundation drains, embankment foundation, fill zones and in the tailings upstream of the embankment as shown on Drawing No. 1625.220 under the direct supervision of the Engineer. Installation details are shown on Drawing No. 1625.221. The location of each piezometer shall be accurately surveyed by the Contractor immediately upon installation.

Basin groundwater and embankment foundation drain piezometers shall be placed in the granular backfill adjacent to the perforated CPE pipework. The leads shall be extended through the embankment foundation in the conveyance pipework trenches and then to the terminal station at the monitoring hut in trenches along the route shown on the Drawings. They shall be carefully placed in a shallow trench which shall be bedded and backfilled with a fine uniform sand as shown on the Drawings.

Foundation piezometers shall be installed in boreholes drilled after the installation of the basin groundwater and embankment foundation drains piezometers. The boreholes shall be a minimum of 50 millimetres in diameter. Following installation of the foundation piezometers, each borehole shall be backfilled with uniformly graded sand, bentonite and native till free of +25mm diameter particles. The leads shall be carefully placed in a shallow trench which shall be bedded and backfilled with a fine uniform sand and extended to the terminal station at the monitoring hut as shown on the Drawings.

Embankment fill piezometers shall be placed in shallow trenches excavated in the compacted till fill and backfilled with native till. The till in the trenches shall be compacted by hand using a jumping jack or other approved compactor. Embankment piezometers located in the toe drain shall be placed in shallow trenches excavated in the compacted filter sand and compacted by hand, as above. The leads shall be carefully placed in a shallow trench which shall be bedded and backfilled with a fine uniform sand and extended to the terminal station at the monitoring hut as shown on the Drawings.

Tailings piezometers shall be installed in vertical 50 mm diameter perforated steel pipes set in concrete base blocks. The tailings piezometer leads shall be extended through the Zone S fill in narrow hand-dug trenches as shown on the Drawings and backfilled with select fine grained till and compacted as directed by the Engineer.

Each lead shall have the piezometer number securely affixed to it at intervals not exceeding 10 metres along the lead. Splice connections shall be made with field splice kits supplied by the cable/piezometer supplier.

Extreme care shall be taken to protect and maintain all piezometer leads. Prior to burial all piezometer lead trenches shall be adequately staked and flagged. All repairs and splices required as a result of damage attributable to the Contractor's operations shall be to the account of the Contractor, up to and including complete replacement of the piezometers.

7.4 Terminal Station and Readout Box

The terminal station shall be supplied and installed and the readout box shall be supplied as shown on the Drawings. Extreme care shall be taken to protect these facilities both during and after construction. Any repairs required as a result of damage attributable to the Contractor's operations shall be to the account of the Contractor, up to and including complete replacement of the facilities.

7.5 Monitoring Hut

A monitoring hut shall be supplied and erected adjacent to the drain monitoring sump at the seepage collection pond downstream of the Main Embankment to house the piezometer terminal station. The monitoring hut structure shall be Lumberland garden shed model #SWG 108C, code #SKU584060 (8 ft x 10 ft) or approved equivalent, as shown on the Drawings, and shall be positioned and erected to the satisfaction of the Engineer. Electric power for the monitoring hut will be provided by Others.

7.6 Flow Monitoring

The Contractor shall supply and install a Parshall flume for flow measurement in the location shown on the Drawings and shall provide such survey control as the Engineer may require from time to time. The Parshall flume shall be a "2 ft" model as supplied by __________, or approved equivalent.

7.7 Survey Monuments

The survey monuments shall comprise a steel rod grouted into a drilled or excavated hole and protected with a surface casing and cover, all as shown on the Drawings. Locations will be selected to provide long term settlement record points and control points for setting out of future work.

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

GROUNDWATER MONITORING PROGRAM
(REF. NO. 1624/2)

JUNE 3, 1996

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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

GROUNDWATER MONITORING PROGRAM
(REF. NO.1624/2)

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Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

GROUNDWATER MONITORING PROGRAM
(REF. NO. 1624/2)

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Association of Consulting Engineers of Canada
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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

GROUNDWATER MONITORING PROGRAM
(REF. NO. 1624/2)

SECTION 1.0 - INTRODUCTION AND SCOPE OF WORK

1.1 GENERAL DESCRIPTION

The Mt. Polley Project is located approximately 56 kilometres northeast of Williams Lake, British Columbia (Figure 1.1). The project will include open pit mining of copper and gold bearing ore, storage of waste rock in dumps adjacent to the open pits, processing of the ore to produce mine concentrate and transport of tailings slurry via a gravity feed pipeline to the tailings storage facility. No discharge of process solutions is required or anticipated at any time.

Development of the Mt. Polley Project will comprise three interconnected open pits, waste dumps, overburden stockpiles and a mill site all located on the Mt. Polley ridge. The tailings storage area will be located in a relatively flat area south of the Mt. Polley ridge. The overall site plan is shown on Figure 1.2 and the proposed drainage plan of the mine site is shown on Figure 1.3.

The British Columbia Ministry of Environment, Lands and Parks (MELP), Environmental Protection Branch has requested that a Groundwater Monitoring Program be designed and implemented for the Mt. Polley Project. The Groundwater Monitoring Program will be used prior to the commencement of the site preparation construction program, during operations and after closure. This document has been prepared in response to the MELP request. Information provided in this report includes selection of the monitoring well locations, well construction procedures, monitoring protocols, and a summary of results to date. The specific goals of this report are as follows :

- To determine the direction and volume of groundwater flow from the mine site and other disturbed areas to receiving waters.

- To identify the locations of all surficial and deep groundwater aquifers underlying the mine site and their points of discharge to surface waters.

- To establish background groundwater quality in aquifers prior to mine development.

- To calculate seepage and groundwater contaminant dilution ratios in surface receiving waters in order to ensure no exceedances of the British Columbia environmental water quality criteria.

- To locate seepage collection ponds and recovery wells to ensure optimal recycling of seepage from the tailings pond during operations and to provide background data to evaluate the efficiency and integrity of the seepage recovery systems.

Other requirements of the Ground Water Monitoring Program, as requested by MELP, include:

- Groundwater Monitoring Program to be developed and evaluated by a qualified hydrogeologist.

- "... establish monitoring wells downgradient from the pit, waste rock piles, and tailings pond dams, and to sample aquifers in both surficial deposits and bedrock below. Establishment of control wells in appropriate locations will be required where feasible, as part of the hydrogeological study mentioned above."

- "General field and lab QA/QC requirements for blanks, determination of accuracy and precision and data acceptability are similar to that outlined for collection of surface water quality data. Additionally, the proponent is

HKP

asked to submit a groundwater monitoring protocol incorporating procedural QA/QC concerns specific to groundwater quality monitoring for approval by Environmental Protection, Williams Lake prior to implementation."

- "Dedicated samplers for each well are required. When measuring dissolved metals in groundwater it is desirable to use an "in-line" filter to prevent precipitation of dissolved metals, upon exposure to air. Well casings must be constructed of materials that will not leach metals and artificially contaminate the groundwater samples collected for metals analysis."

1.2 REFERENCE INFORMATION

The Mt. Polley Project groundwater regime has previously been studied by Knight Piésold Ltd., who have prepared a number of reports which contain information relevant to the Groundwater Monitoring Program. These documents include an evaluation of the groundwater regime as described in "Report on Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility, February 19, 1990" and in "Mount Polley Project, Stage I Environmental and Socio-Economic Impact Assessment, January 1991". Additional information about surface water hydrology is also presented in "Report on Project Water Management (Ref. No. 1624/1), February 6, 1995" and "Tailings Storage Facility Design Report (Ref. No. 1625/1) May 26, 1995.". In addition, a groundwater sampling protocol is provided in "Manual on Sampling and Handling Guidelines for Determination of Groundwater Quality, (Ref. No. 1625/5)" which has been updated and is included in its entirety in Appendix A.

SECTION 2.0 - SITE INFORMATION SUMMARY

2.1 PREVIOUS INVESTIGATIONS

2.1.1 General

Hydrogeological investigations at the Mt. Polley site were initiated in 1989 by Knight Piésold and Imperial Metals as part of the geotechnical evaluation of the open pits, waste dumps and tailings storage facility. Hydrogeologic investigations were conducted by advancing drill holes through overburden soils into the underlying bedrock. Bedrock permeabilities were evaluated using in-situ pump-in packer tests at the open pit site and the tailings storage area. Overburden permeabilities in the tailings storage area were evaluated using a combination of in-situ pump-in packer tests and falling head tests conducted in standpipes. Laboratory hydraulic conductivity testing was also conducted on representative samples of the overburden materials.

2.1.2 General Site Geology and Hydrogeology

The Mt. Polley project is located in an alkali intrusive complex in the Quesnel Trough, a 35 kilometre wide northwest trending regional volcanic - sedimentary belt. Rock units are segmented in blocks by several faults, including an inferred northwesterly trending normal fault which extends along Polley Lake. Geological structures of the region are predominately northwest trending, dipping steeply to the northeast as shown on Figure 2.1.

Topography is generally subdued and the area has been glaciated. Surficial deposits of well graded dense glacial till are common throughout the area and are typically present in greater thickness in topographic lows. Bedrock exposures are common at higher elevations.

The Mt. Polley ridge extends over parts of four watersheds. The two main watersheds are the Polley Lake watershed to the east and the Bootjack Lake watershed to the west. The north side of the ridge drains into the 6K Creek watershed and the south side of the ridge drains into the Bootjack Creek watershed. The west and a portion of the north and central pits, several overburden stockpiles and part of the mill site will be located in the Bootjack Lake watershed. The remaining portion of the north and central pits, most of the north and southeast waste dumps, some overburden stockpiles and the remaining portion of the mill site will be located in the Polley Lake watershed. In addition to the two main watersheds there will be a small portion of the north waste dump located in the 6K Creek watershed and a small portion of the southeast waste dump located in the Bootjack Creek watershed (Figure 1.2).

The tailings storage area will be located in the Northeast Edney Creek Tributary. Due to construction of the embankment along the ridge tops and subsequent filling of the tailings facility, there is the potential for seepage into the two adjacent watersheds, Hazeltine Creek and Southwest Edney Creek Tributary.

Previous investigations have shown that the groundwater aquifers at the Mt. Polley Project site consist of unconfined fractured bedrock zones at the open pit, waste dump and mill site areas and a confined glaciofluvial/alluvial deposit at the tailings storage area. Static groundwater tables were determined to be relatively near surface for both areas, as shown on Figures 2.2 and 2.3.

2.1.3 Open Pits

The open pits are situated in an area of irregular topography with moderate to steep relief. Surface water ponding and stream flows in the pit area are ephemeral. Overburden, where present, in the open pit area consists of a thin veneer of colluvium, glacial till and forest litter. Bedrock consists of intrusion breccia, syenodiorite and monzonite with lesser occurrences of dyke rock. Several fault and fracture zones have been identified with occasional clayey or sandy fault gouge zones.

Geological structures trend in a north-south direction, parallel to the orientation of the Mt. Polley ridge. Several east-west oriented fault zones have been identified in the open pit areas, as shown on Figure 2.1. The rock quality is variable, with highly fractured zones up to 100 metres long encountered in several exploration and condemnation drill holes. Zones of very weak and highly altered rock up to 100 metres in thickness were also encountered. These zones are usually associated with geological contacts between rock units and faulting. The dominant joint set has a strike of 167 degrees and dips 74 degrees to the northeast. A weaker orthogonal joint set strikes 030 degrees and dips at 18 degrees to the northwest. Discontinuities are generally rough and often healed with calcite and chlorite.

The hydrogeology of the open pits was previously evaluated, with a summary provided in the Imperial Metals Corporation January 1991 document "Stage I Environmental and Socio-Economic Impact Assessment, Responses to Comments by the Agencies". The groundwater table was found to be near surface, running parallel to the surface topography. Groundwater flows originate from the Mt. Polley ridge and flow toward Polley and Bootjack Lakes, as shown on Figure 2.2. Piezometric measurements indicate that groundwater within the ridge is under hydrostatic conditions. In-situ hydraulic conductivity measurements obtained for the bedrock strata were generally low, less than 1×10^{-5} cm/s. In the fractured bedrock zones hydraulic conductivities were measured at 1×10^{-4} cm/s to 1×10^{-3} cm/s.

2.1.4 Waste Dumps and Overburden Stockpiles

Current mine plans include the development of two waste dumps and several overburden stockpiles, as shown on Figure 1.3. The Southeast waste dump provides storage for all waste rock generated from the Central and West Pits. It will be activated at the start of mine development. The North Waste Dump may be developed later in the mine life in order to provide additional storage for waste rock generated from the North Pit.

Existing surface water ponding and stream flows in the waste dump and overburden stockpile areas are ephemeral. Overburden, where present, in the waste dump areas consists of a thin veneer of colluvium, glacial till and forest litter. Predominant bedrock types consist of monzonite porphyry, syenodiorite and various volcanic units including lapilli tuff and breccias. Geological structures are projected to be conformable with the open pit area.

The groundwater table is expected to be near surface, running parallel to the surface topography, with groundwater flows originating from the centre of the Mt. Polley ridge towards Polley and Bootjack Lakes, as for the open pit areas. Bedrock permeabilities are also expected to be similar to the open pit areas, generally less than 1×10^{-5} cm/s.

2.1.5 Mill Site

The mill site is located on a relatively flat and undulatory section of the topographic ridge between Polley and Bootjack Lakes. Surface water ponding and stream flows are ephemeral. Overburden at the mill site is generally similar to the open pit and waste dump areas. A swampy area with a thick organic horizon recharged by surface runoff and shallow groundwater flows has been excavated from the southern half of the mill site area. Bedrock types and geological features are also similar to the open pit and waste dump areas.

The hydrogeology of the mill site area was previously evaluated and a summary has been presented in the Imperial Metals Corporation document, "Stage I Environmental and Socio-Economic Impact Assessment, Responses to Comments by the Agencies, January, 1991". The groundwater table was reported to be parallel to the surface topography, with groundwater flows migrating from the Mt. Polley ridge towards Polley and Bootjack Lakes, as shown on Figure 2.2. Piezometric measurements indicated that groundwater within the ridge was under hydrostatic pressure conditions.

In-situ hydraulic conductivity testing has not been conducted at the mill site. However, bedrock hydraulic conductivity is likely to be similar to that measured in the adjacent open pit area, typically less than 1 x 10^{-5} cm/s. Fractured high hydraulic conductivity bedrock zones identified in the open pit area are also likely to be present at the mill site.

2.1.6 Tailings Storage Area

The tailings storage area is located south of the Mt. Polley ridge, in a relatively flat topographic area located within the Northeast Edney Creek watershed. A small pond and two swampy areas exist within the tailings storage area. Surface discharges from these areas are ephemeral and are considered to be the result of groundwater discharges.

Subsurface stratum at the site consists of a 5 to 30 metre thick veneer of dense grey glacial till that is underlain by a glaciofluvial/alluvial deposit at the bottom of the catchment. The glacial till is locally overlain by wet organic rich deposits in localized topographic lows. Bedrock consists of a volcanic conglomerate which is heavily fractured and weathered. This unit becomes harder and more competent with depth and is underlain by a competent basalt. Some sedimentary sequences were identified in the conglomerates along the east ridge of the tailings basin.

The hydrogeology of the tailings storage area has been previously evaluated and it was determined that the tailings area groundwater table is sub-parallel to the surface topography, with groundwater flows directed east - southeast northeast towards Northeast Edney Creek Tributary, as shown on Figure 2.3. Groundwater flows occurred predominantly in the sandy glaciofluvial/alluvial deposit and at the bedrock contact. A slight upward gradient was encountered in the lower topographic areas.

In-situ hydraulic conductivity measurements have been obtained for both the overburden and bedrock strata. Bedrock hydraulic conductivities were found to range from 9×10^{-8} cm/s to 5×10^{-4} cm/s, with a geometric mean of 4×10^{-6} cm/s. The lower values were measured in competent bedrock, while the higher values were associated with highly fractured rock. In addition, hydraulic conductivities generally decreased with depth as weathering and fracturing diminish. Falling head hydraulic conductivities ranging from 1×10^{-6} to 2×10^{-5} cm/s were measured. A mean in-situ hydraulic conductivity of 9×10^{-6} cm/s was obtained for the grey surficial till. Samples of this material were also tested with an air entry permeameter, which produced a hydraulic conductivity of 2×10^{-8} cm/s.

2.2 1989 MONITORING WELL PROGRAM

A total of nine (9) groundwater monitoring wells were installed in selected NQ diamond drillholes during the 1989 investigations by Knight Piésold, as shown on Figure 2.4. Three of the wells (MP-89-107, MP-89-146 and MP-89-151) were installed in the open pit area and the remaining six wells (MP-89-231, MP-89-232, MP-89-233, MP-89-234, MP-89-235 and MP-89-236) were installed at the tailings area. The 1989 monitoring wells were not constructed in complete accordance to current industry procedures. The wells consisted of 40 mm PVC well pipe with screened sections constructed with a hacksaw that extend from approximately 3 metres below ground surface to the end of the well string. In the tailings storage area, the monitoring wells range in depth from 15 to 40 metres. Bentonite seals were installed below the well string and at the ground surface. Natural sand backfill was placed around the screened interval (Appendix B). The three open pit wells were extended the full length of the exploration drill holes, approximately 150 metres, and seals were not installed below the well string for these installations. The surface seals consist of a 1 metre concrete plug overlain by two metres of bentonite that was installed just below the bedrock surface.

One set of groundwater quality samples was collected in 1989 from all nine recently installed wells. In the spring of 1990, a second sample set was obtained from the three open pit wells. Sampling of the installations was terminated ~~stopped~~ in 1990 and resumed again in January, 1995. Deep snow cover and unmarked monitoring well locations limited the water quality sampling to only two wells (MP89-234, MP89-236) and water levels were limited to three locations (MP89-232, MP89-234, MP89-236). Wells MP89-234 and MP89-236 exhibited artesian conditions and had a static groundwater table of approximately 15 cm above the existing ground surface. The third well MP89-232 was found to have a water table located at the surface.

2.3 1995 MONITORING WELL PROGRAM

In August, 1995 seven additional groundwater wells (R-95-1 to R-95-7) were installed in the vicinity of the open pits and mill site (Figure 2.4). The wells were constructed with 110 mm PVC well pipe in 150 mm holes advanced with air rotary drilling methods. Well casings were installed over the full length of the holes, which ranged from 80 to 170 metres. Screened zones were installed at various levels, where high recharge was encountered during drilling (Appendix B). The well casings were sealed in accordance with standard BC water well practices.

During the Knight Piésold site inspection in September, 1995, water quality samples were collected from all 1995 wells (R-95-1 to R-95-7). The sampling was conducted in part to supply additional background groundwater data and in part to determine the sampling requirements that which will be required for the Mt. Polley Project Groundwater Monitoring Program.

During the 1995 site visit, no existing users of either groundwater resource were identified with the exception of the anticipated future use of the fractured bedrock aquifers by the mine for make-up and potable water supply.

Drilling records produced by the well drillers for the open pit area (Appendix C) indicate fractured bedrock zones were encountered at various depths and that these zones were the primary sources of groundwater in each well. Groundwater levels measured in wells 95-R-1 and 95-R-7 in September, 1995, indicate the groundwater table is relatively shallow, occurring at depths of 12 to 19 metres. These depths are within several metres of the projected 1991 groundwater contour plan provided on Figure 2.3. The drilling information from the 1995 investigation has therefore reaffirmed the earlier work done in the report, "Mount Polley Project, Stage I Environmental and Socio-Economic Impact Assessment, January 1991".

SECTION 3.0 - GROUNDWATER IMPACTS

3.1 MILL SITE AREA

3.1.1 Baseline

Mining hydrogeology is a complex process and is difficult to model since it has to deal with natural systems after they have been disturbed by mining processes. As a result, there will always be large uncertainties when reporting the results for mine hydrology studies. In general, the average volume of deep percolation to the groundwater table is a portion of the average annual precipitation (Brown, 1988). Recorded precipitation data for the site is limited and precipitation records for climatologically similar stations in the Mt. Polley area have therefore been used to estimate a mean annual site precipitation of 755 mm and a mean annual evaporation of 423 mm. Using these numbers it has been suggested by Brown that for medium precipitation (0.5-1.5 m/y) and low evaporation (0-0.5 m/y), a 25 percent portion be used to estimate the annual recharge contribution to the groundwater system.

As a result, 25 percent of the annual precipitation has been used to calculate baseline groundwater recharge rates at the proposed open pits, waste dumps, overburden stockpiles, and the mill site as shown on Table 3.1. Using this value, existing groundwater recharge at the proposed open pit area range from 0.0007 to 0.0034 m^3/s with dilution ratios ranging from 22 to 273. Typical recharge rates at the proposed waste dump areas range from 0.0002 to 0.0075 m^3/s with dilution ratios of 27 to 296. Typical recharge rates at the proposed mill site area range from 0.0005 to 0.0007 m^3/s with dilution ratios of 106 to 392. Finally typical recharge rates at the proposed overburden stockpile areas range from 0.0004 to 0.0009 m^3/s with dilution ratios ranging from 211 to 231.

As shown on Figure 3.1, the groundwater table on the Mt Polley ridge is shallow and runs parallel to surface topography. The watershed/ groundwater divide is centred near the Mt Polley summit.

To date, baseline groundwater quality for wells 95-R-1 to 95-R-7 meet the 1994 BC Environmental Potable Water Criteria with the exception of iron in 95-R-5, 95-R-6 and 95-R-7 and manganese in 95-R-5, and 95-R-7 (shown in Appendix D). Baseline groundwater quality generally exceeds the 1994 British Columbia Environmental Aquatic Life Criteria for several total metals (aluminium, cadmium, chromium, copper, iron, lead, selenium, silver and zinc).

3.1.2 Operational

As shown on Figure 3.2, the groundwater seepage into the open pits will result in the establishment of a watershed/groundwater divide centred around the open pits. Precipitation infiltration and runoff occurring within this watershed will be collected as either groundwater seepage or surface runoff by the pit sump and added to the mill circuit process system. The divide will gradually increase in extent as the pits are developed to deeper depths and groundwater seepage gradients into the pits will be maximized. Groundwater flows to the various watersheds are expected to be reduced by an average flow of 15 l/s.

In addition, pumping water from the groundwater supply wells will also result in a reduction of groundwater flow into the Polley and Bootjack Lakes and will cause drawdown of the water table. The flow reduction resulting from the pumping has not been quantified, but Table 3.2 indicates the potential maximum rates and average annual recharge quantities. These maximum pumping rates are not safe yields, however, and pumping at these rates may result in depletion of stored water within the fractured unconfined aquifers. The net result will be a reduction in the groundwater table around the mine site area. The maximum pumping rates may decrease with time until the pumping rate equals the recharge rate of the local system.

As a result, the overall impact to the Bootjack and Polley Lake watersheds due to mine development will be a slight decrease in groundwater flows relative to the baseline flows as groundwater will be collected in the open pit and in the recently installed groundwater pumping wells. Ongoing infiltration of precipitation during mine operations may result in slight modifications to groundwater chemistry, particularly for higher nitrogen levels due to flushing of blasting residues from the waste dumps. However, some of these infiltrating waters will be recovered in the open pit and pumping well systems. No adverse groundwater chemistry impacts are projected for the open pit development during operations as unaffected groundwater will flow into the excavation rather than affected groundwater flowing out of the excavation.

The downstream water quality impacts due to groundwater affected by the mine development are projected to be insignificant. Groundwater quality is not expected to be significantly degraded, and may actually be improved due to open pit dewatering practices. Also, the receiving water bodies will provide extensive dilution which is projected to be better than for the baseline conditions presented on Table 3.1 which are due to the interception and recycling of all the open pit infiltration and a significant proportion of the waste dumps infiltration.

3.1.3 Post-Closure

After mine closure, each pit will be permitted to flood. It is anticipated that the ultimate pit water level will be approximately 1090 metres, based upon the lowest pit wall elevation in the west corner of the West Pit and the existing shallow groundwater table. During spring runoff conditions and wet periods it is possible that surface water may runoff from the pits into Bootjack Lake watershed. Based upon average precipitation and groundwater recharge rates, it is estimated that this may commence about 50 years after closure. The post-closure flow paths to Bootjack and Polley Lakes are expected to return back to the baseline flow paths once pit flooding is complete (Figure 3.3). As flooding progresses, the groundwater divide formed around the pits will be reduced in size. The final configuration will be dependent upon localized geological conditions such as the hydraulic conductivity, heterogeneity, anisotropy and orientation of the fractured zones.

3.2 TAILINGS STORAGE AREA

3.2.1 Baseline

At the tailings area, the baseline groundwater quality is poor. Aluminium, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, silver and zinc are generally not in compliance with the 1994 British Columbia Environmental Aquatic Life Criteria (Appendix D).

3.2.2 Operational

The construction of the tailings storage facility will modify the existing groundwater flow quantities and direction. The construction of the embankment will eventually result in the formation of hydraulic gradients and seepage flows into the Hazeltine Creek, Southwest Edney Creek and the Northeast Edney Creek watersheds. In addition to this, all surface water in the upper reaches of the Northeast Edney Creek watershed will be retained in the tailings storage facility instead of recharging the Northeast Edney Creek Tributary.

Groundwater seepage flows at the tailings storage facility have been calculated using a conventional Darcy seepage model. To calculate these groundwater seepage flows and their corresponding dilution ratios for the surrounding three watersheds three assumptions have been made. First, it has been assumed that the seepage through the dam will remain constant throughout the year (steady state flow). Secondly, it assumes average monthly flow conditions in the surrounding creeks. Finally, it is assumed that no loss of solute will occur in the flow system (steady state solute transport). The dam seepage has been calculated using the SEEP/W finite element modelling program as part of the water balance analysis included in "Report on Project Water Management, Ref. No. 1624/1". As shown in Table 3.3, a conservative estimate of dilution ratios are presented and they range from 15 to 244 for the various watersheds.

3.2.3 Post-Closure

Groundwater conditions around the tailings storage facility will be permanently changed from the baseline conditions due to the new topographic high point of the tailings storage facility. Groundwater flow from the tailings storage facility will flow into all of the three adjacent watersheds. It is anticipated, however, that as tailings consolidation occurs, groundwater quality from the tailings impoundment will ~~improve~~ return to levels ~~better~~ similar to than baseline values.

?

Surface water conditions will also be permanently changed. The surface water from the upper reaches of the Northeast Edney Creek watershed will be detained in the tailings storage facility and will be released by a spillway, installed at closure, into the Southwest Edney Creek Tributary. As a result, the flows along the Northeast Edney Creek Tributary will be permanently reduced and these surface flows will be redirected into the Southwest Edney Creek Tributary.

SECTION 4.0 - GROUNDWATER MONITORING PROGRAM

In response to MELP requests, a site inspection of the Mt. Polley Project was conducted by Mr. David Machin September 20 to 22, 1995. Mr. Machin is a registered Professional Engineer (Ontario) who specializes in hydrogeology, geology and environmental engineering. While on site, Mr. Machin reviewed the existing groundwater monitoring installations and collected water quality samples from all accessible installations.

The groundwater regime at the Mt. Polley site results from infiltration of precipitation through the ground surface into the underlying overburden and bedrock strata. Infiltration migrates through the pore spaces in the overburden and through joints/fractures in the bedrock and flows downgradient to topographic depressions. Infiltration at the site occurs predominately on the Mt. Polley ridge (the recharge zone) with discharge of the infiltrated water into Bootjack and Polley Lakes, as well as ephemeral stream courses. Hydrogeological impacts resulting from development of the Mt. Polley Project will likely consist of modification of the existing groundwater tables and infiltration rates. The potential exists for the modification of groundwater quality as either a direct result of mine activities or as a result of the modified infiltration rates.

The groundwater quality monitoring program will include sampling conducted by Imperial Metals Corporation on a quarterly basis during 1996 prior to the start of mining activities. The samples collected from the existing groundwater wells will be used to establish baseline water quality. During operations, quarterly sampling is recommended. Sampling will be conducted in mid-fall and mid-spring in order to obtain flows during high precipitation or recharge periods and in late summer and winter to obtain groundwater flow conditions during low precipitation or discharge periods. At closure the groundwater monitoring program will be continued on a quarterly basis for a minimum period of two years. At this point, the results of the two year monitoring period will be reviewed and the program will be modified as required. A proposed sampling schedule is provided on Figure 4.1.

Current mine plans entail the development of only the southeast waste dump. The two proposed monitoring wells, P_6 and P_7, will therefore not be constructed downgradient of the north waste dump until later in the mine life when the north waste dump is to be constructed. The monitoring wells will be constructed in accordance with the procedures outlined in the "Groundwater Quality Monitoring Manual" and equipped with dedicated inertia lift devices. The proposed location for each installation is shown on Figure 2.4.

A detailed description of the monitoring protocol that will be utilized during groundwater sampling and data collection is provided in Appendix A. The protocol provides a consistent methodology that permits the temporal comparison of data and helps to minimize the occurrence of erroneous data. Groundwater sampling and data collection will be conducted by an individual who has been trained in environmental procedures and the sample and preservation procedures will be strictly followed.

During mining operations and for 2 years after closure, groundwater conditions will be monitored in the mill site area from the groundwater sump located within the pit and from water supply wells 95-R-1, 95-R-4 and 95-R-7. Water well 95-R-3 was to be included in the monitoring program, but due to blockage in the completed well at a depth of 50 metres it has been omitted from the program. Wells MP89-107, MP89-146, and MP89-151 are being used for baseline groundwater monitoring but they will likely be destroyed during pit stripping operations. No replacement wells are proposed at the mill site area because it is believed that the 1995 water supply wells will provide adequate coverage of the three 1989 wells that will be lost in the open pit area.

During mining operations and for 2 years after closure, two background groundwater monitoring wells will exist in the mill site area (95-R-5 and 95-R-6). Well 95-R-5 is located on the east side of the Mt. Polley ridge in an area that is not downgradient of either the waste dumps or the open pits. Well 95-R-6 is located on the southwest corner of Mt. Polley in the projected Polley Lake groundwater recharge zone. This portion of the Polley Lake watershed will not be impacted by mining activities, except for the possibility of the shifting of the Polley and Bootjack Lake groundwater as a result of groundwater seepage into the open pits (Figure 3.2). Should the groundwater divide shift sufficiently that 95-R-6 is contained within the Bootjack Lake watershed, it will still remain upgradient of any impact zones. These two wells will therefore give additional information to the baseline groundwater quality established prior to construction in that they will help show the natural fluctuations of the baseline values throughout the operation of the mine life. Therefore during mining operations, baseline and background water quality data will be compared with values obtained from water wells 95-R-1, 95-R-4 and 95-R-7. If water quality levels indicate significant deviations from the baseline values and background wells 95-R-5 and 95-R-6 have remained constant over the time period in question, then further monitoring wells will be installed as appropriate to investigate any potential groundwater impacts.

During mining operations and for 2 years after closure, groundwater conditions will also be monitored in the tailings storage area. Monitoring will initially consist of the existing 1989 wells and three replacement wells, P_1 1996, P_2 1996, P_3 1996, which will be installed in 1996 as shown on Figure 2.4. (It is anticipated that MP89-232 and MP89-235 will be lost during the construction and early operations of the facility.) Wells MP89-231, MP89-233 and MP89-234 are located immediately outside the perimeter of the facility and every effort will be made to preserve them. In addition to all this, well P_4 will be installed at a later date when the tailings pond elevation will rise high enough to cause potential seepage into the Southwest Edney Creek Tributary.

During mining operations and for 2 years after closure, MP89-236 will be used as a background groundwater monitoring well. MP89-236 is located upgradient of the tailings storage facility, as evident by the artesian conditions observed during the September, 1995 site visit. This well intercepts groundwater flows from the recharge zone located near the watershed divide positioned to the north. MP89-236 will be lost during the later stages of the mine life due to the filling of the tailings storage facility. When this occurs, the well will be replaced with a new background well, P_5, constructed further upgradient of the tailings storage facility as shown in Figure 2.4. As at the mill site area, the tailings storage area background well MP89-236 along with the established baseline values for the area will be used to detect any potential groundwater impacts. If water quality levels indicate significant deviations from the baseline values and the background well MP89-236 has remained constant over the time period in question, then further monitoring wells will be installed as appropriate to investigate any potential groundwater impacts.

During the September, 1995 site visit it was discovered that wells MP89-233 and MP89-234 had been damaged. The stick-up at MP89-233 was broken off below the ground surface with no visual indication of the well location. This site is considered to be lost for future data collection. The stick-up of MP89-234 was also broken off, apparently during clearing operations along the main embankment foundation. The well did however, retain a stick-up of approximately 15 cm, which will permit the repair of the installation for continued monitoring. Well MP89-236 will also require minor repair work. The stick-up, which is broken off several centimetres above the ground surface, must be extended and a steel protective casing must be installed. All of the above mentioned monitoring wells will be installed in accordance to the procedures provided by MELP and will be equipped with dedicated inertia lift devices.

To eliminate the possibility of cross-contamination between monitoring wells and to permit the use of in-line filtering systems during the collection of dissolved metal samples, all of the remaining 1989 wells will each be supplied with a dedicated inertia lift pump system. For each of the 1995 wells and 1996 proposed replacement wells, a dedicated submersible pump to preventing cross-contamination will be installed. For the submersible pumps, a sampling port will be provided at the well head to eliminate possible contamination by a water distribution pipe network.

When taking water samples the screened interval of the well will be significant but the method in which the wells were completed (more than one screened interval per well) will not be considered adverse since the purpose of the groundwater monitoring is to detect process impacts upon the environment. Due to the anticipated local depression of the groundwater table around the open pit, the long screen length will become beneficial because the impacted wells will continue to provide groundwater data at consistent reference points. If contaminants are detected or suspected in a well, it will be possible to determine which permeable bedrock aquifer is affected by using very low flow rate sampling, with the sampler intake set at the middle of the screened interval in question. This method will obtain a sample representative of the screened interval and not a composite sample of the entire well casing.

SECTION 5.0 - SUMMARY AND CONCLUSIONS

This report presents the current understanding of the Mt. Polley Project site hydrogeological conditions and the anticipated impacts that will result from the project development. The Groundwater Monitoring Program has been designed on this basis and will fulfil the following objectives:

- Provide data for the establishing baseline groundwater quality levels.
- Detect groundwater contamination and identify the potential source.
- Estimate baseline groundwater flows and dilution ratios in receiving surface water bodies.

Existing monitoring facilities are adequate for the establishment of a baseline groundwater database and will be used to evaluate potential impacts on the groundwater system during mining operations. Additional monitoring installations will be required only at the tailings storage facility where three groundwater monitoring wells will be constructed in full accordance of the MELP groundwater monitoring procedures. If the North waste dump is constructed at a later date, downgradient wells will be installed by Imperial Metals Corporation at that later time.

Imperial Metals Corporation proposes to conduct a groundwater monitoring schedule as provided on Figure 4.1. This schedule can be adjusted as deemed necessary by both Imperial Metals Corporation and governing agencies. As indicated on the groundwater monitoring schedule, the data collected will be summarized and evaluated on an annual basis and a report will be submitted to the government agencies for review. The annual report will contain recommendations for the improvement of the Groundwater Monitoring Program, which will be adjusted to suit specific site conditions or to address any concerns that may be identified in the future.

SECTION 6.0 - REFERENCES

Brown, A., "Groundwater Evaluation and Control for Gold Mining Projects," *Second International Conference on Gold Mining*, ed. C.O. Brawner (Littleton, Colorado: Society of Mining Engineers, 1988), pp. 219-233.

TABLE 3.1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

ESTIMATED BASELINE GROUNDWATER FLOWS AND DILUTION RATIOS OPEN PITS ,WASTE DUMPS, OVERBURDEN STOCKPILES AND MILL SITE

J:\JOB\DATA\1624\WATERBAL\TABLE.XLS

Last Revision : 29-May-96

Precipitation (mm/yr) = 755
Evaporation (mm/yr) = 432
Infiltration as a % of Precipitation = 25

Watershed	Proposed Mining Component	Catchment Area (ha)	Watershed Average Annual Flows (m^3/s)	Average Groundwater Flows (m^3/s)	Dilution Ratio (1) (m^3/s)
Polley Lake Watershed (Hazeltine Creek Weir)	North Waste Dump Area	24.5	0.1995	0.00147	136
	Southeast Waste Dump Area	132.5	0.1995	0.00793	25
	Overburden Stockpile Areas	14.4	0.1995	0.00086	231
	Open Pit Areas	12.2	0.1995	0.00073	273
	Mill Site Area	8.5	0.1995	0.00051	392
	TOTAL	**192.1**	**0.1995**	**0.01150**	**17**
Bootjack Lake Watershed (Morehead Creek Weir)	Southeast Waste Dump Area	4.2	0.0744	0.00025	296
	Overburden Stockpile Areas	5.9	0.0744	0.00035	211
	Open Pit Areas	57	0.0744	0.00341	22
	Mill Site Area	11.7	0.0744	0.00070	106
	TOTAL	**78.8**	**0.0744**	**0.00472**	**16**
6K Creek Watershed (6K Creek)	North Waste Dump Area	3.2	0.0493	0.00019	257

Notes:

1) Dilution Ratio = Watershed Average Annual Flow / Average Groundwater Flow; For existing (baseline) conditions.
2) Average Groundwater Flows = 25% Precipitation * Catchment Area / (31536000 sec/year)

TABLE 3.2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

PROJECTED GROUNDWATER PRODUCTION FROM 1995 WELLS

J:\JOB\DATA\1624\WATERBAL\TABLE.XLS

Last Revision : 17-May-96

		Well Identification No.				
		95-R-1	95-R-2 & 95-R-7	95-R-4	95-R-5	95-R-6
OUTFLOWS	Maximum Pump Rate, m^3/hr	10.36	67.37	33.28	1.09	1.91
	Annual Volume Pumped, m^3	90,754	590,161	291,533	9,548	16,732
INFLOWS	Recharge Area, m^2	126000	283000	283000	80000	31500
	Annual Precipitation, mm	755	755	755	755	755
	Infiltration coefficient	25	25	25	25	25
	Annual Recharge, m^3	23,783	53,416	53,416	15,100	5,946
NET DIFFERENCE (1)	m^3	(66,971)	(536,745)	(238,117)	5,552	(10,786)

Note:

1) Net difference = Annual Volume Pumped - Annual Recharge.

TABLE 3.3

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

ESTIMATED BASELINE GROUNDWATER FLOWS AND DILUTION RATIOS
TAILINGS STORAGE AREA

J:\JOB\DATA\1624\WATERBAL\TABLE.XLS Last Revision : 17-May-96

Watershed	Seepage Flow Through Dam Structure (1) (m^3/s)	Average Annual Weir Flow (m^3/s)	Dilution Ratio
Hazeltine Creek	0.00210	0.1995	95
Northeast Edney Creek	0.00218	0.0317	15
Southwest Edney Creek (2)	0.00013	0.0317	244

Notes:

1) Seepage through Dam structures has been obtained from Case 2, Table 7.2 of the Knight Piesold Design Report 1625/1. Case 2 assumes the permeability of the foundation glacial till = $1x10^{-6}$ cm/sec.
2) Flows for the Southwest Edney Creek are unavailable. Dilution ratios have been calculated assuming similar flows to Northeast Edney Creek Tributary.

1624.A1

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

PROJECT LOCATION MAP

CAD FILE: \PROJECT\1624\FIG\A1 Plot scale 1=1 MAY 8, 1996

MAY 8, 1996

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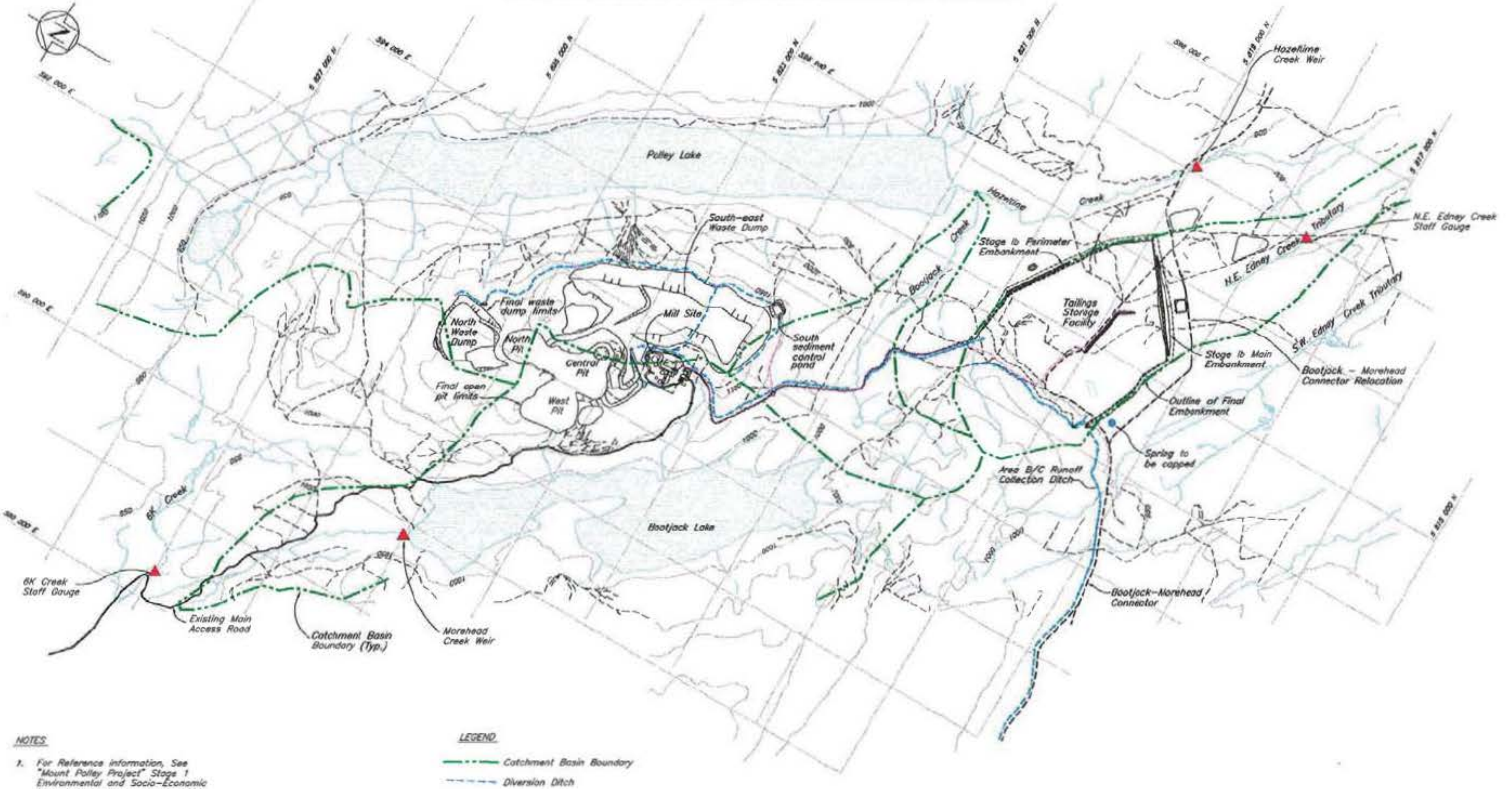
FIGURE 1.1

1624.B12COLOR

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER ARRANGEMENT AND CATCHMENT BASINS MAP



NOTES

1. For Reference information, See "Mount Polley Project" Stage 1 Environmental and Socio-Economic Impact Assessment, January 1991.
2. Contour interval is 50 metres.
3. Mill site layout as per CSFM Engineering.

LEGEND

- Catchment Basin Boundary
- Diversion Ditch
- Tailings/Reclaim Pipline
- ▲ Watershed Montoring Point

Scale 1000 500 0 1000 2000 m

April 30, 1996
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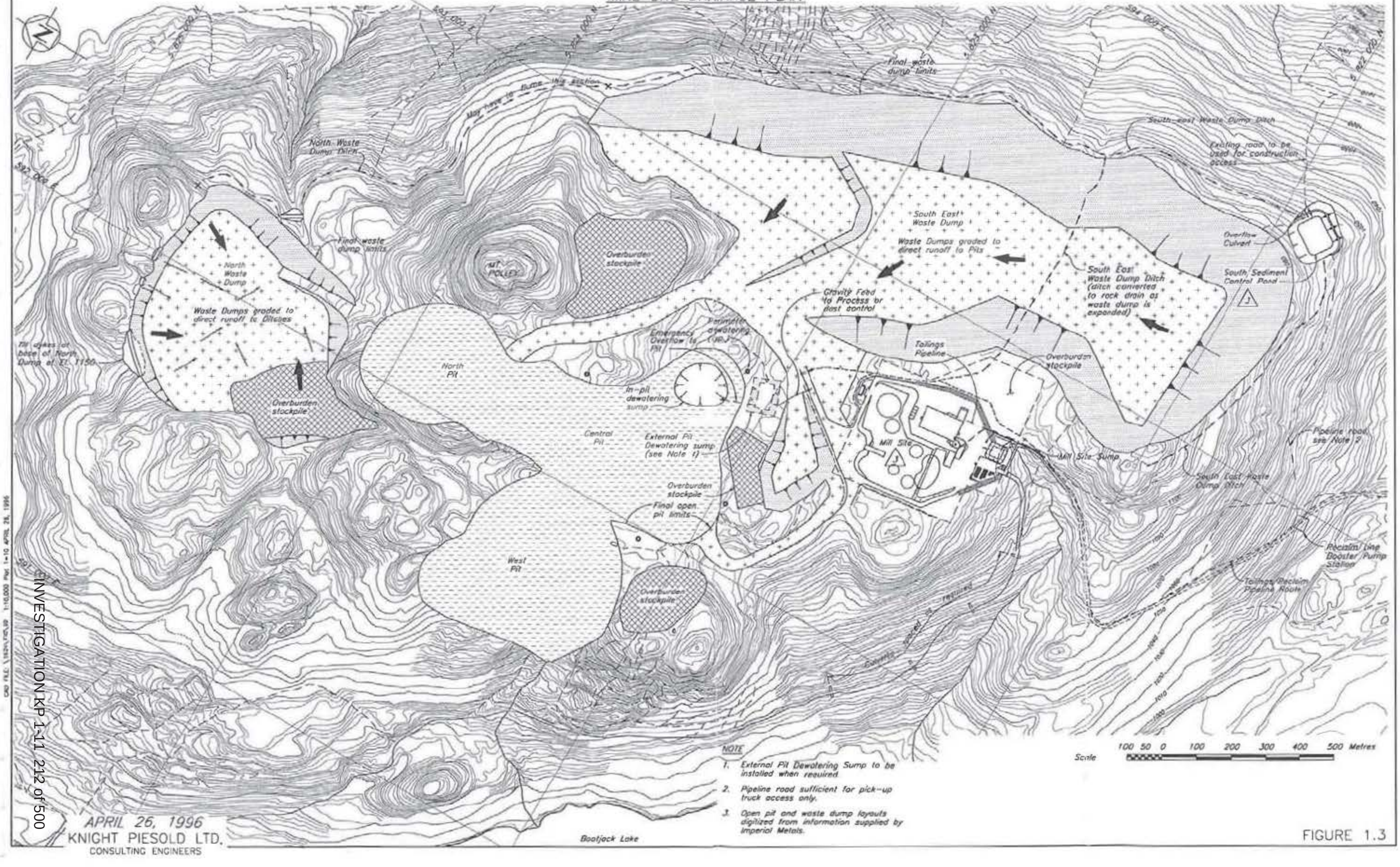
FIGURE 1.2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
MINE SITE DRAINAGE PLAN



NOTE

1. External Pit Dewatering Sump to be installed when required.
2. Pipeline road sufficient for pick-up truck access only.
3. Open pit and waste dump layouts digitized from information supplied by Imperial Metals.

APRIL 26, 1996

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FIGURE 1.3

CAD FILE: \1624\1624.09 1:10,000 Plot 1=10 APRIL 26, 1996

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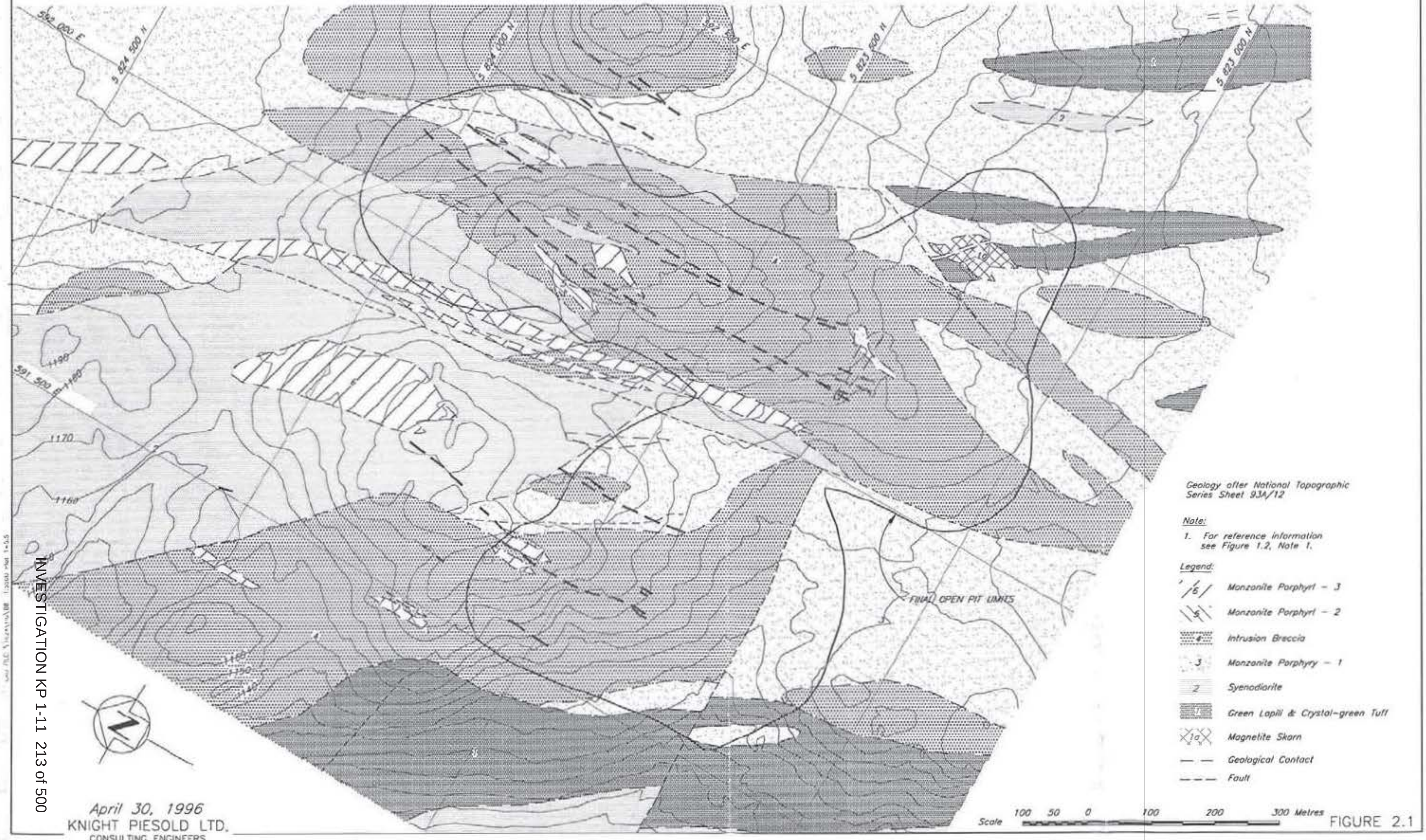
IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GEOLOGICAL PLAN OF OPEN PIT AREA



Geology after National Topographic Series Sheet 93A/12

Note:

1. For reference information see Figure 1.2, Note 1.

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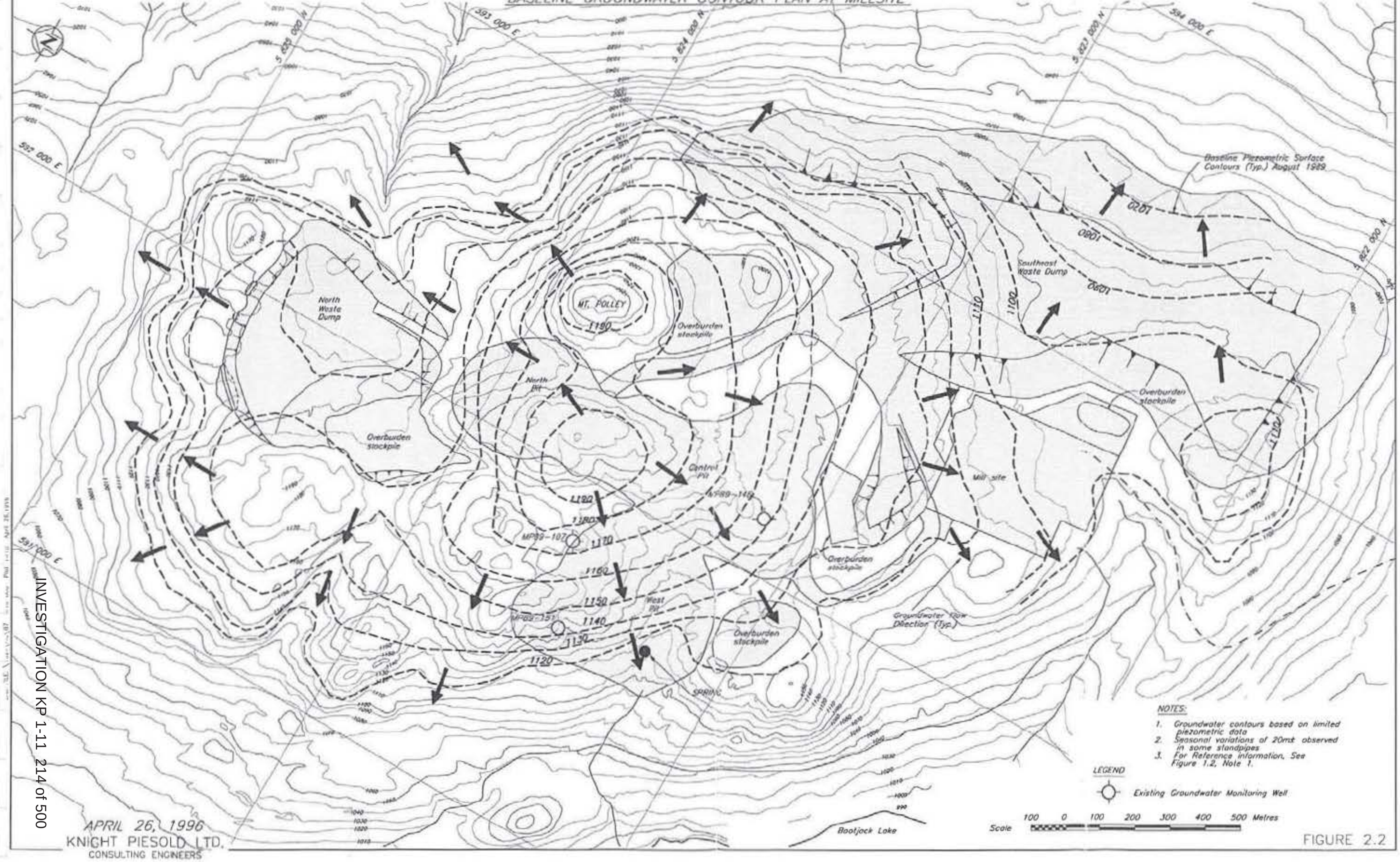
FIGURE 2.1

IMPERIAL METALS COPORATION

MT. POLLEY PROJECT

BASELINE GROUNDWATER CONTOUR PLAN AT MILLSITE



NOTES:

1. Groundwater contours based on limited piezometric data
2. Seasonal variations of 20m± observed in some standpipes
3. For Reference information, See Figure 1.2, Note 1.

LEGEND

○ Existing Groundwater Monitoring Well

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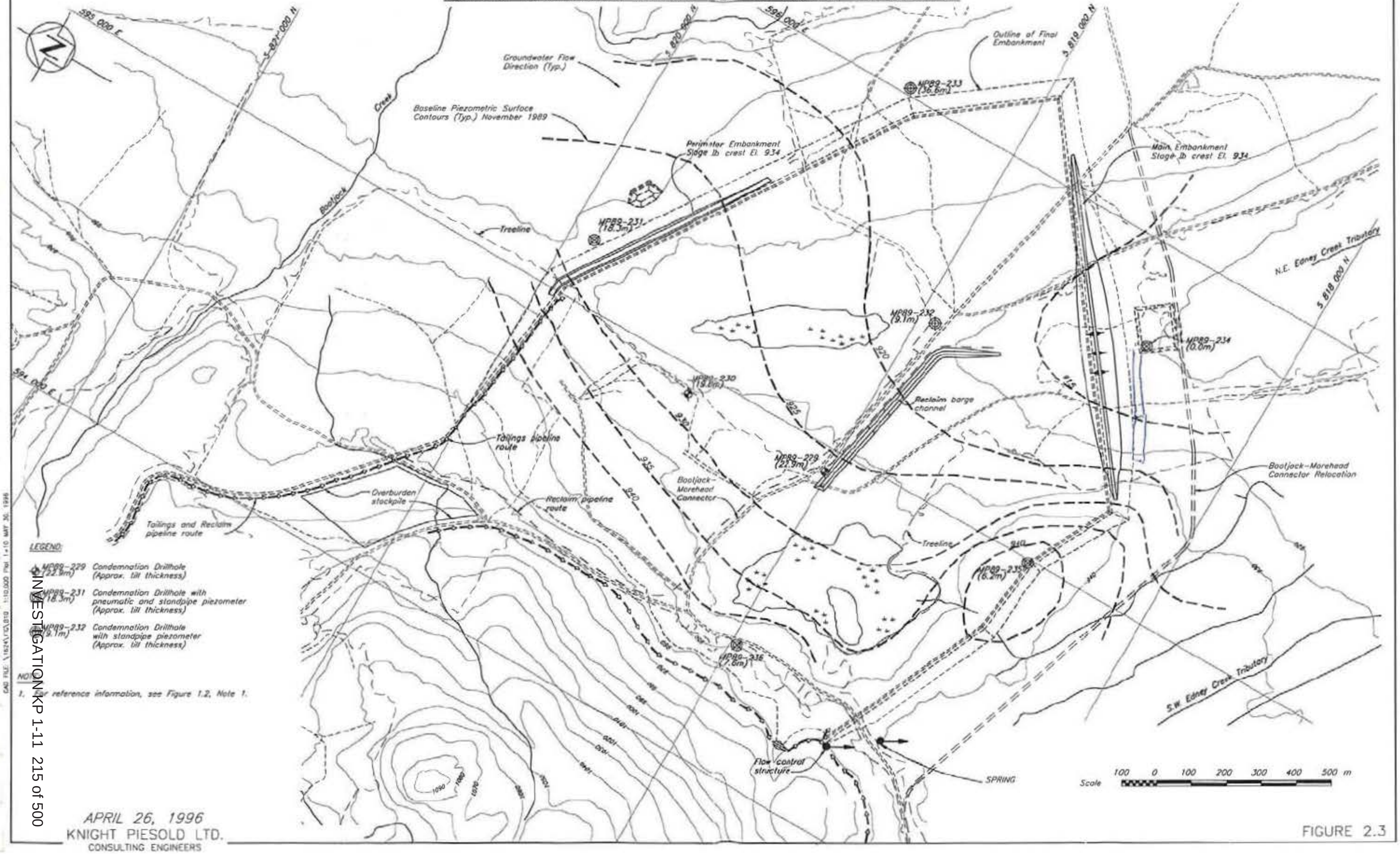
FIGURE 2.2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
BASELINE GROUNDWATER CONTOUR PLAN AT TAILINGS STORAGE AREA



LEGEND:

MP89-229 (22.9m) Condemnation Drillhole (Approx. till thickness)

MP89-231 (18.3m) Condemnation Drillhole with pneumatic and standpipe piezometer (Approx. till thickness)

MP89-232 (9.1m) Condemnation Drillhole with standpipe piezometer (Approx. till thickness)

NOTE:

1. For reference information, see Figure 1.2, Note 1.

APRIL 26, 1996

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FIGURE 2.3

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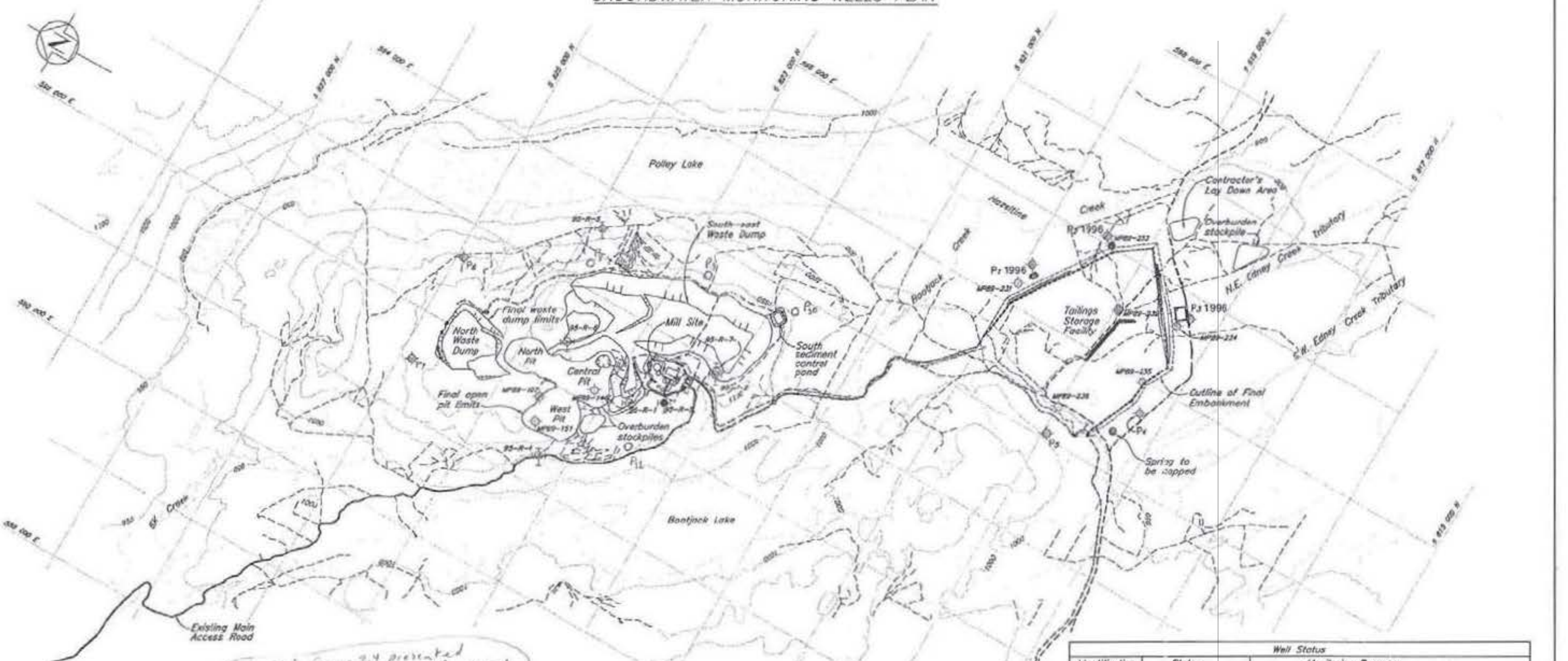
IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING WELLS PLAN



original figure 2.4 presented in Report Ref. No. KLY/2, dated June 3, 1996

Well Status		
Identification	Status	Monitoring Purpose
95-R-1	Good	Open pit and mine site, flows to Bootjack Lake.
95-R-2	Good	Mill site flows to Bootjack Lake.
95-R-3	Blocked	
95-R-4	Good	Open pit, flows to Bootjack Lake.
95-R-5	Good	South waste rock dump, flows to Polley Lake.
95-R-6	Good	Background.
95-R-7	Good	Mill site flows to Bootjack Lake.
MP89-107	Unknown	Open pit, background, will be lost.
MP89-148	Unknown	Open pit, background, will be lost.
MP89-151	Unknown	Open pit, background, will be lost.
MP89-231	Unknown	Tailings storage may flow to Hazeltine Creek.
MP89-232	Good	Tailings storage and background, will be lost.
MP89-233	Broken	
MP89-234	Broken, repairable	Tailings storage facility, flow to Northeast Edney Lake.
MP89-235	Unknown	Tailings storage facility, flow to Southwest Edney Lake.
MP89-236	Broken, repairable	Background for tailings storage facility.

NOTES:

This figure is a revised version of the

1. ~~For general notes, see Figure 1.2~~
2. Monitoring installations 95-R-X consist of 110mm I.D PVC well pipe installed primarily as a water supply source. Wells are screened at multiple intervals.
3. Monitoring installations MP89-X consist of 30 mm I.D PVC which have slotted screens.
4. Monitoring installation MP89-233 has been lost due to breakage of the stickup PVC below the ground surface. No evidence of well location remains.
5. Monitoring installation 95-R-3 has been blocked at a depth of approximatly 70 metres below the collar. ~~This installation is inoperatable as a screen interval is not accessable.~~

LEGEND

- ◇ MP89-107 Existing Groundwater Monitoring Well (1989)
- ◇ P1 Proposed Groundwater Monitoring Well (1996)
- ● Damaged Groundwater Well
- ◇ 95-R-1 Existing Groundwater Supply Well (1995)
- ● Spring to be capped

Scale 1000 500 0 1000 2000 m

April 30, 1996

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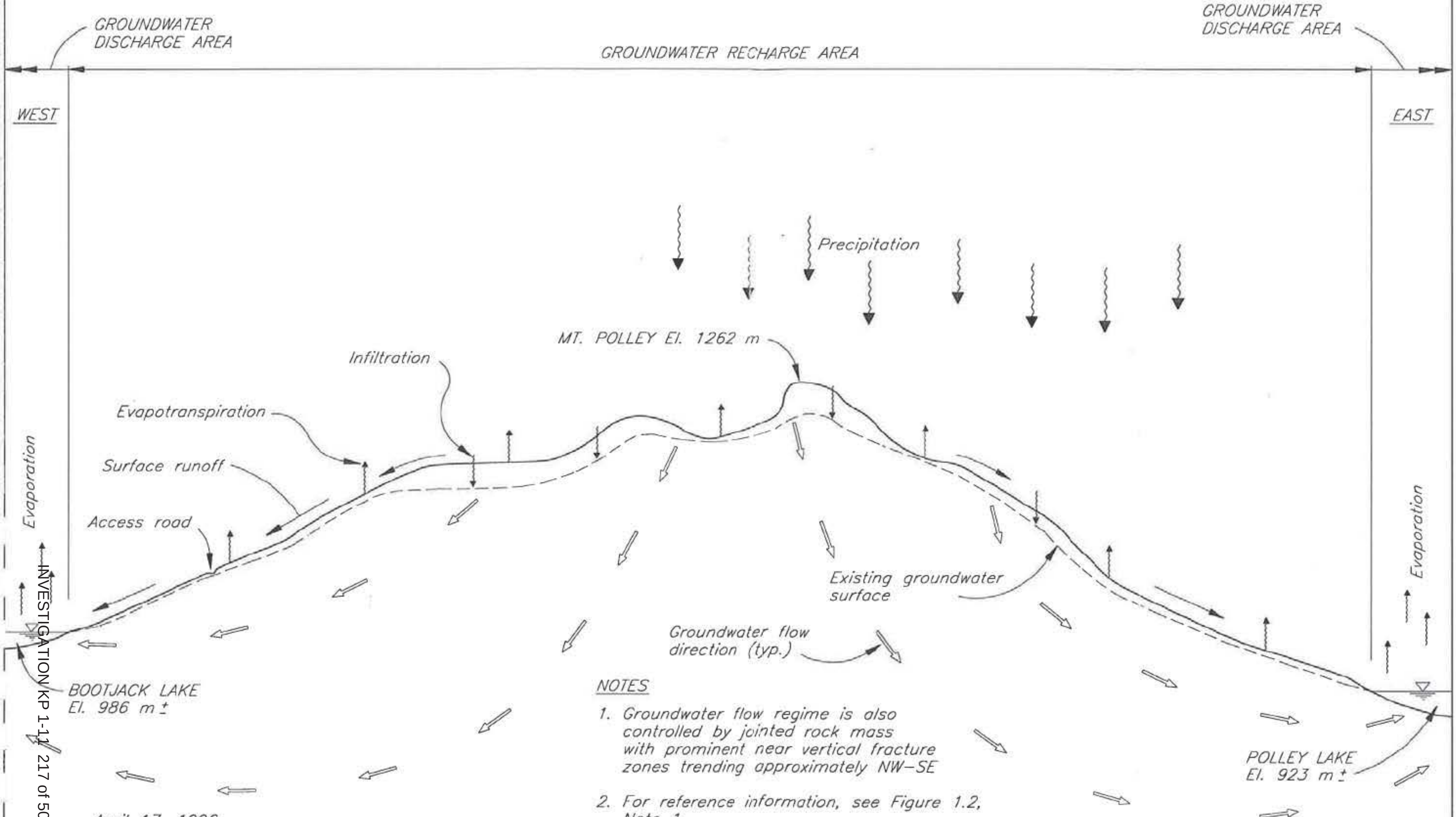
Revised August 3, 1996

FIGURE ~~2.4~~ 1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
BASELINE MINE SITE HYDROGEOLOGY



NOTES

1. Groundwater flow regime is also controlled by jointed rock mass with prominent near vertical fracture zones trending approximately NW–SE
2. For reference information, see Figure 1.2, Note 1.

April 17, 1996
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FIGURE 3.1

1624.B5

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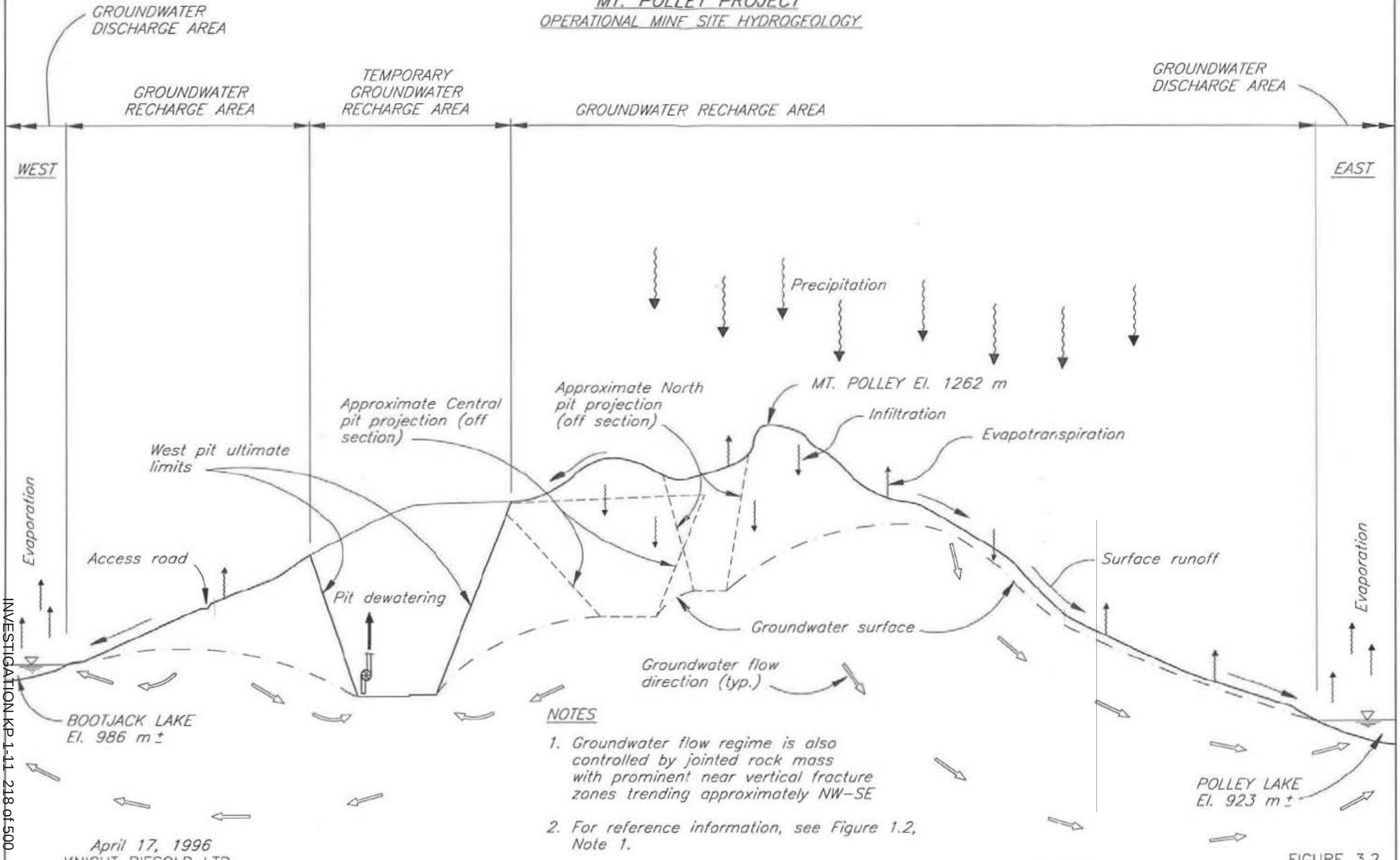
MT. POLLEY PROJECT

OPERATIONAL MINE SITE HYDROGEOLOGY



NOTES

1. Groundwater flow regime is also controlled by jointed rock mass with prominent near vertical fracture zones trending approximately NW–SE
2. For reference information, see Figure 1.2, Note 1.

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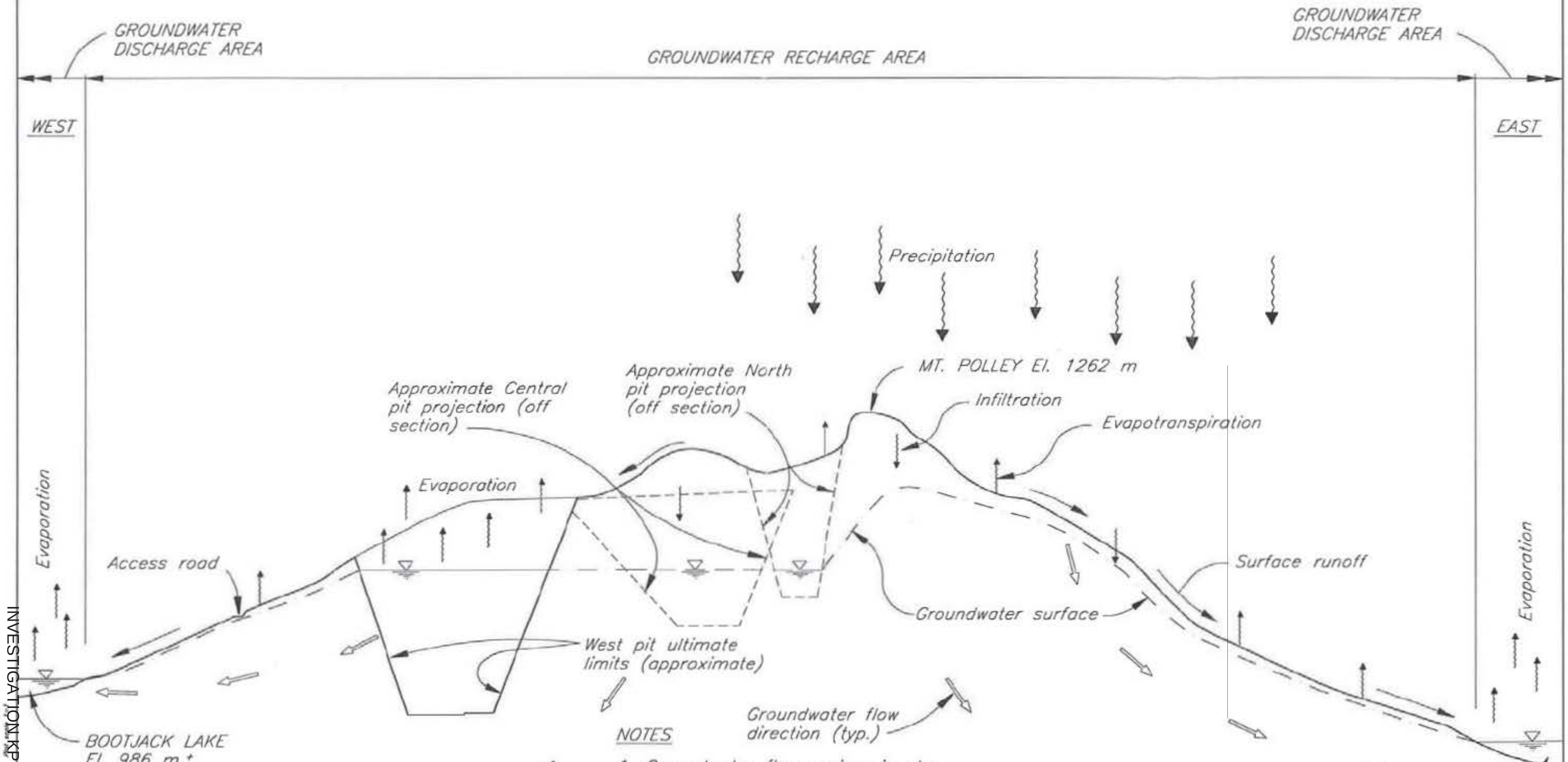
FIGURE 3.2

1624.B6

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
POST-CLOSURE MINE SITE HYDROGEOLOGY



NOTES

1. Groundwater flow regime is also controlled by jointed rock mass with prominent near vertical fracture zones trending approximately NW-SE
2. For reference information, see Figure 1.2, Note 1.

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FIGURE 3.3

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING SCHEDULE

5/7/96
J:\JOB\DATA\1624\SCHEDULE.XLS

Installation No.	Monitoring Sites	Pre-mining Monitoring for Establishment of Baseline Data												Construction											Mining
		1996												1997											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
95-R-1	Mill Site, Open Pits					■				■		■			■			■				■		■	
95-R-7	Mill Site, Waste Dump					■				■		■			■			■				■		■	
95-R-4	Open Pits					■				■		■			■			■				■		■	
MP89-107	Open Pits					■				■		■			■			Assumed lost							
MP89-146	Open Pits					■				■		■			■			Assumed lost							
MP89-151	Open Pits					■				■		■			■			Assumed lost							
P_6	Waste Dump																								
P_7	Waste Dump																								
MP89-231	Tailings Storage Area					■				■		■			■			Assumed lost							
MP89-232	Tailings Storage Area					■				■		■			■			Assumed lost							
MP89-234	Tailings Storage Area					■				■		■			■			☒				■		■	
MP89-235	Tailings Storage Area					■				■		■			■			Assumed lost							
P_1 1996	Tailings Storage Area									■		■			■			■				■		■	
P_2 1996	Tailings Storage Area									■		■			■			■				■		■	
P_3 1996	Tailings Storage Area									■		■			■			■				■		■	
P_4	Tailings Storage Area																								
95-R-5	Background					■				■		■			■			■				■		■	
95-R-6	Background					■				■		■			■			■				■		■	
MP89-236	Background					■				■		■			■			☒				■		■	
P_5	Background																								
	Review of yearly data annual report													■											
	Review of post- mining data and monitoring program adjustment																								

Installation No.	Monitoring Sites	Mining																							
		1998												1999											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
95-R-1	Mill Site, Open Pits		■			■				■		■			■			■				■		■	
95-R-7	Mill Site, Waste Dump		■			■				■		■			■			■				■		■	
95-R-4	Open Pits		■			■				■		■			■			■				■		■	
MP89-107	Open Pits																								
MP89-146	Open Pits																								
MP89-151	Open Pits																								
P_6	Waste Dump																								
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MP89-231	Tailings Storage Area																								
MP89-232	Tailings Storage Area																								
MP89-234	Tailings Storage Area		■			■				■		■			■			■				■		■	
MP89-235	Tailings Storage Area																								
P_1 1996	Tailings Storage Area		■			■				■		■			■			■				■		■	
P_2 1996	Tailings Storage Area		■			■				■		■			■			■				■		■	
P_3 1996	Tailings Storage Area		■			■				■		■			■			■				■		■	
P_4	Tailings Storage Area																								
95-R-5	Background		■			■				■		■			■			■				■		■	
95-R-6	Background		■			■				■		■			■			■				■		■	
MP89-236	Background		■			■				■		■			■			■				■		■	
P_5	Background																								
	Review of yearly data annual report	■												■											
	Review of post- mining data and monitoring program adjustment																								

Installation No.	Monitoring Sites	Mining																						
		2000								2007			2008											
		J	F	M	A	M	J	J		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
95-R-1	Mill Site, Open Pits		■			■					■			■			■				■		■	
95-R-7	Mill Site, Waste Dump		■			■					■			■			■				■		■	
95-R-4	Open Pits		■			■					■			■			■				■		■	
MP89-107	Open Pits																							
MP89-146	Open Pits																							
MP89-151	Open Pits																							
P_6	Waste Dump										■			■			■				■		■	
P_7	Waste Dump										■			■			■				■		■	
MP89-231	Tailings Storage Area																							
MP89-232	Tailings Storage Area																							
MP89-234	Tailings Storage Area		■			■					■			■			■				■		■	
MP89-235	Tailings Storage Area																							
P_1 1996	Tailings Storage Area		■			■					■			■			■				■		■	
P_2 1996	Tailings Storage Area		■			■					■			■			■				■		■	
P_3 1996	Tailings Storage Area		■			■					■			■			■				■		■	
P_4	Tailings Storage Area										■			■			■				■		■	
95-R-5	Background		■			■					■			■			■				■		■	
95-R-6	Background		■			■					■			■			■				■		■	
MP89-236	Background		■			■					■			■			■				■		■	
P_5	Background										■			■			■				■		■	
	Review of yearly data annual report	■											■											
	Review of post- mining data and monitoring program adjustment																							

Installation No.	Monitoring Sites	Post-mining Monitoring																										
		2009												2010												2011		
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
95-R-1	Mill Site, Open Pits		■			■				■		■			■			■				■		■				
95-R-7	Mill Site, Waste Dump		■			■				■		■			■			■				■		■				
95-R-4	Open Pits		■			■				■		■			■			■				■		■				
MP89-107	Open Pits																											
MP89-146	Open Pits																											
MP89-151	Open Pits																											
P_6	Waste Dump		■			■				■		■			■			■				■		■				
P_7	Waste Dump		■			■				■		■			■			■				■		■				
MP89-231	Tailings Storage Area																											
MP89-232	Tailings Storage Area																											
MP89-234	Tailings Storage Area		■			■				■		■			■			■				■		■				
MP89-235	Tailings Storage Area																											
P_1 1996	Tailings Storage Area		■			■				■		■			■			■				■		■				
P_2 1996	Tailings Storage Area		■			■				■		■			■			■				■		■				
P_3 1996	Tailings Storage Area		■			■				■		■			■			■				■		■				
P_4	Tailings Storage Area		■			■				■		■			■			■				■		■				
95-R-5	Background		■			■				■		■			■			■				■		■				
95-R-6	Background		■			■				■		■			■			■				■		■				
MP89-236	Background																											
P_5	Background		■			■				■		■			■			■				■		■				
	Review of yearly data annual report	■												■												■		
	Review of post- mining data and monitoring program adjustment																									■	■	■

Note: *P = Monitoring installations will be installed during mining as required.*

FIGURE 4.1

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APPENDIX A

MANUAL ON SAMPLING AND HANDLING GUIDELINES FOR DETERMINATION OF GROUNDWATER QUALITY

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

MANUAL ON SAMPLING AND HANDLING GUIDELINES FOR DETERMINATION OF GROUNDWATER QUALITY
(REF. NO. 1625/5)

MAY 19, 1995

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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

MANUAL ON SAMPLING AND HANDLING GUIDELINES FOR DETERMINATION OF GROUNDWATER QUALITY
(REF. NO. 1625/5)

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Knight Piésold Ltd.
CONSULTING ENGINEERS

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

MANUAL ON SAMPLING AND HANDLING GUIDELINES FOR DETERMINATION OF GROUNDWATER QUALITY
(REF. NO. 1625/5)

SECTION 1.0 - INTRODUCTION

This document presents the groundwater sampling procedures recommended for the monitoring wells at the Mt. Polley Project. The plan sets out numerous guidelines, but specific procedures, data sheets and management techniques may be refined by the staff members responsible for sampling. The objective is to standardize procedures and techniques for sample collection, preservation and shipment, thereby ensuring that incidental errors are not introduced and allowing for continued comparison of results with on-going sampling.

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

SECTION 2.0 - EQUIPMENT

2.1 LIST

Equipment required for sampling, preparation and preservation of samples and shipment to laboratory is outlined below:

2.1.1 Sample Collection

- Tarp to lay down around well, used to keep all equipment clean.
- Plastic coated water level probe with incremental depth markings.
- Measuring tape.
- Wash bath of about 2 - 3 l size for decontaminating the water level probe.
- Disposable latex gloves.
- Deionized water (2 - 3 l for each well).
- Well log with monitoring well completion diagram.
- Data forms for documenting the sampling details.
- Appropriate sampling bottles (2 - 1 l, 1 - 500 ml, 2 - 250 ml for each well).
- Commercially purchased bailer for 2 inch monitoring wells, which can be disassembled for decontamination, or disposable bailers to be dedicated to each well.
- Non-contaminating bailer line (e.g. fishing line, stainless steel or teflon-coated stainless steel) of sufficient strength to prevent breakage.
- Bailer retrieval system such as fishing reel or down rigger.
- Volumetric measurement devices (e.g. 20 l bucket and 1 l graduated cylinder).
- Indelible marker.
- Wash bottle.
- Large brush for cleaning inside and outside of bailer.
- Clean rags.

- Paper towels.
- Clipboard or binder for sampling forms.

2.1.2 Sample Preparation and Preservation

- Deionized water.
- Spare sample bottles.
- Wash bottles.
- Paper towels.
- Disposable latex gloves.
- Protective eye glasses.
- Vacuum filtration apparatus.
- 0.45 micron filter papers.
- Tweezers.
- Nitric acid (HNO_3) and pipettes (2 ml required in each of three bottles per well). Concentration is 15 normal.
- NaOH pellets (provided by laboratory in total cyanide sample bottle).

2.1.3 Sample Shipment

- Cooler for shipping samples.
- Tape for sealing sample bottles and cooler.
- Indelible marker and address labels.
- Max-min thermometer.

2.2 MAINTENANCE AND STORAGE

Procedures for handling and storage of sampling equipment should be consistent with those for analytical laboratories. For example:

- Equipment should be stored in sealed containers in a clean room dedicated to sampling.
- Equipment should be repaired or replaced if it is malfunctioning.

- Equipment should be transported to the sampling site in sealed containers.
- Equipment should be cleaned with deionized water between collecting each sample.

SECTION 3.0 - SAMPLE COLLECTION

3.1 STEP 1 - PREPARE FOR SAMPLING

Wear a fresh pair of disposable latex gloves throughout the sampling process.

Prior to taking any measurements or samples, sample bottles and identification labels should be prepared. The bailer should be checked for any leaks or weaknesses. Equipment such as the water level probe and field parameter metres should be tested. Also, all pertinent information must be documented in the upper portion of the field sampling record sheet, an example of which is included in Appendix A.

Table 3.1 gives details of the groundwater samples to be collected from each well, including the sample size and preservative required. The procedures involved are described in Steps 2 and 8 below.

3.2 STEP 2 - DETERMINE GROUNDWATER LEVEL AND WELL VOLUME

- Immerse tip of the water level probe in water to confirm that it is operating.
- Check that the tape length is correct.
- Decontaminate the water level probe by rinsing it in a deionized water bath.
- Measure the depth to water from the top of the PVC to within at least 0.01 m.
- Measure the total depth of the well from the top of the PVC to within at least 0.01 m.
- Calculate the volume of the water column in the well.
- Fill in section on sampling record sheet titled "Groundwater Level and Well Volume".

3.3 STEP 3 - PURGE WELL

The water standing in a well prior to sampling is not representative of in-situ groundwater quality and must be removed (the well purged), so that formation water can replace the stagnant water.

The steps for purging the well include:

- Rinse tubes, bailer line and anything else lowered into the well with deionized water to prevent cross-contamination.
- Gently bail three well volumes from the well.
- Dispose of the purged water in an environmentally acceptable manner.
- Fill in section on sampling sheet titled "Well Purging".

3.4 STEP 4 - MEASURE FIELD PARAMETERS

Near the end of the well purging, the field parameters (temperature, conductivity and pH) should be measured because they are subject to change once the groundwater is removed from the well. To measure:

- Rinse the metres with deionized water and blot dry with clean paper towels.
- Rinse the field parameter sample container (1 l vol.) and blot dry with clean paper towels.
- Calibrate the field parameter metres in the standard solutions (the standard solutions should be comparable to the values expected in the field).
- Fill the field sample container immediately after the well has been purged.
- Immediately measure the parameters in order:
    - temperature
    - conductivity
    - pH
- Fill in section on sampling record sheet titled "Field Parameters".

3.5 STEP 5 - COLLECT SAMPLES

Since purging of the well will assist in "pre-cleaning" the equipment, the same equipment should be utilized for sampling. The sampling should be carried out in the following order using the correct bottles:

- Field parameters (Bottle No. 1)	1 l
- Total metals (T.M.) (Bottle No. 2)	250 ml
- Total mercury (T.Hg) (Bottle No. 3)	500 ml
- Dissolved metals (D.M.) (Bottle No. 4)	250 ml
- Total cyanide (T.CN) (Bottle No. 5)	1 l

The sampling procedure should comprise the following:

- Take precautions to prevent dirt and dust from contaminating the samples.
- Before filling the sample bottles, rinse out twice using water being collected from the well, except for total cyanide bottle (No. 5). In this bottle, add 7 to 10 NaOH pellets, if not already added.
- Fill the containers almost full, but in bottles No. 2, 3 and 4 leave room to add the HNO_3 (2 ml) preservative and allow for shaking.
- Cap the sample containers tightly.
- Complete the sample label before moving to the next sampling site.
- Store the samples in a protective container for protection during transportation to camp.

3.6 STEP 6 - FILTRATION OF SAMPLES

Upon returning to camp, the dissolved metals ~~and total mercury~~ sample~~s~~ must be filtered before the preservative is added. Consequently, these samples have the greatest potential for becoming contaminated and care must be taken to avoid touching the filter or sample. Filtering procedures are as follows:

- Rinse the inside of the vacuum filter apparatus (base and funnel) with deionized water and shake out excess water.
- With the tweezers, place a filter on the base of the filter funnel. Handle the filter only on the edges. Screw the top portion of the vacuum filter apparatus on carefully so as to avoid wrinkling the filter paper.
- Pour the sample into the top of the filter apparatus and secure the lid. Attach the bottom section and hand held suction pump, making sure the airline is properly secured.
- Using the hand held pump, filter the sample into the bottom of the apparatus. (Note: If the sample is silty, this procedure may take some time).
- Rinse the original sample bottle with deionized water before returning the sample. Return sample and fasten cap on bottle.
- After each sample, rinse filter apparatus with deionized water and be sure to replace filter.

3.7 STEP 7 - PRESERVE SAMPLES

Many of the chemical constituents and physicochemical parameters that are to be measured or evaluated in groundwater monitoring programs are not chemically stable so preservation is required to prevent sample degradation.

Preservation methods are generally limited to pH control, chemical addition, refrigeration and protection from light and are intended to retard biological action and hydrolysis and to reduce sorption effects.

Table 3.1 summarizes the sample preservation methods required for each bottle. All bottles should be kept at 4°C. In bottles 2, 3 and 4, add 2 ml of HNO_3. In bottle 5, NaOH pellets were added prior to sampling.

Complete the section on the sampling record sheet titled "Sampling, Filtration and Preservation".

3.8 STEP 8 - SHIP SAMPLES TO LABORATORY

3.8.1 Sample Labels

The labels should be sufficiently durable to remain legible even when wet and should include:

- Sample identification number (Well No. and Bottle No.)
- Name of collector
- Date and time of collection
- Place of collection
- Parameter(s) requested, i.e. Total Metals, Total Mercury, Dissolved Metals, Total Cyanide or Field Parameters

3.8.2 Packing

- Seal and carefully pack the sample bottles in an upright position to ensure that they are not disturbed during shipping.
- Pack ice in properly sealed, water-tight plastic bags around the sample bottles.
- Position the shipping (max-min) thermometer so that it is not against the ice.
- Use newspaper or equivalent as a packing material. Styrofoam chips should not be used.
- Seal the shipping container.

3.8.3 Chain-of-Custody Record

A chain-of-custody record should be filled out and should accompany every shipping container sent to the laboratory. The record should include:

- Sample number
- Signature of collector
- Date and time of collection
- Sample type
- Identification of well
- Number of sample bottles
- Signature of person(s) involved in the chain of possession
- Inclusive dates of possession
- Internal temperature of shipping container when samples were sealed into the shipping container
- Maximum temperature recorded during shipment
- Minimum temperature recorded during shipment; and
- Internal temperature of shipping (refrigerated) container upon opening in the laboratory.

The chain-of-custody record sheet is included in Appendix A.

SECTION 4.0 - QUALITY CONTROL AND DATA REVIEW

4.1 INTRODUCTION

In order to document the condition of the well and verify the accuracy of the sampling and handling program, some quality control measures must be taken. Quality control includes the following categories:

- Field parameters
- Preliminary data review
- Annual well evaluation

If quality control locates a source of error, the source should be identified and documented. Corrective action, including re-sampling, should then be initiated.

4.2 FIELD PARAMETERS

Quality control for determination of field parameters simply includes calibration of all field measurement equipment prior to use and re-calibration in the field before measuring each sample.

4.3 PRELIMINARY DATA REVIEW

On receipt of the laboratory data, the results should be compared with previous data from the well and with data from any adjacent wells. Should anomalous data be present, the possible reasons should be assessed and resampling initiated to verify or discount any anomalies.

4.4 ANNUAL WELL EVALUATION

Annual evaluation of the wells provides documentation of the well condition and, therefore, the quality of the data. Complete records of the tests should be filed. These include:

(i) Sedimentation

The quantity of sediment in each well should be documented by measuring the total depth of the monitoring well. Any sediment should be removed from the well, described (sand, silt, organic matter, etc.), and documented.

(ii) Rising Head Test

An annual rising head test is required to verify the performance of each well. Following a similar procedure every year, data should be collected from 5 percent recovery to 95 percent recovery. Thirty to forty reading should be taken, where possible. The rising head test data collection form included in Appendix A should be completed in full. The time data should be measured to the second for wells which recover 95 percent in less than an hour. The data should be analyzed by qualified personnel and compared to earlier results to determine whether or not the well response has changed.

TABLE 3.1
IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SAMPLE AND PRESERVATION PROCEDURES FOR GROUNDWATER MONITORING[1]

Bottle No.	Parameter Group	Specific Analysis	Bottle Type	Preservative	Maximum Holding Time
1	Field Parameters	Suspended Solids, Turbidity, Conductivity, pH, Colour, Dissolved Solids, Hardness	1 l plastic[2]	4°C	Conductivity and pH are field determined but sample should be shipped ASAP to minimize pH shift[3]
	Major Ions	Bicarbonate, Sulphate, Chloride, Fluoride			28 days
	Nutrients	O-Phosphate, D- Phosphorus, T-Phosphorous, Nitrate, Nitrite, Ammonia			48 hours
2	Total Metals	Al, Sb, As, Ba, Be, Bi, Bo, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, Se, Si, Ag, Sr, U, V, Zn	250 ml plastic	2 ml HNO_3 4°C	6 months
3	Total Mercury		500 ml plastic	2 ml HNO_3 4°C	6 months
4	Dissolved Metals	Al, Sb, As, Ba, Be, Bi, Bo, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Si, Ag, Na, Sr, U, V, Zn	250 ml plastic	Field filtration (0.45 micron), 2 ml HNO_3 4°C	6 months
5	Total Cyanide		1 l plastic	7 to 10 NaOH pellets, sodium arsenite if oxidizing agents are present, 4°C	14 days, 24 hours if sulphide is present

1. References: Test Methods for Evaluation Solid Waste - Physical/Chemical Methods, U.S. EPA SW-846 (2nd Edition, 1982).
Methods for Chemical Analysis of Water and Wastes, U.S. EPA-600/4-79-020.
Standard Methods for the Examination of Water and Wastewater, 16th Edition (1985).
Collection and Preservation of Environmental Samples, Analytical Service Laboratories, December, 1986.
2. Plastic Polyethylene
3. Conductivity and pH field measurements are not always required but should be carried out whenever equipment is available on site

APPENDIX A

RECORD SHEETS

Knight Piesold Ltd.
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MT. POLLEY PROJECT
GROUNDWATER SAMPLING QUALITY CONTROL
CHAIN OF CUSTODY RECORD

PROJECT NO.: ____________________

(ONE PER SHIPPING CONTAINER)
Month and Year of Sampling Round ________
Page ________ of ________

DESCRIPTION OF CONTENTS

SAMPLE NO.		SAMPLING METHOD	SAMPLING DATE	INITIALS
Well No.	Bottle No.			

BOTTLE NO.	VOLUME	PARAMETER
1	1000 ml	Field Parameters (F.P.)
2	250 ml	Total Metals (T.M.)
3	500 ml	Total Mercury (T.Hg)
4	250 ml	Dissolved Metals (D.M.)
5	1000 ml	Total Cyanide (T.CN)

Temperature: Initial ________ Max. ________ Min. ________ Final ________

CHAIN OF CUSTODY

Date		Location	Signature
From	To		

J:\JOB\DATA\0019\GWATER3.XLS

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MT. POLLEY PROJECT
GROUNDWATER SAMPLING QUALITY CONTROL
RISING HEAD TEST

PROJECT NO.: ____________________

WELL NO.: ____________________
DATE: ____________________
Page ______ **of** ______

PRE-TEST WATER LEVELS

- Day Before: Date ____________ Depth to Water ____________
- Day Tested: Date ____________ Depth to Water ____________

PURGING

- Purging Method ____________
- Time Purging Started (h:m:s) ____________
- Time Purging Ended (h:m:s) ____________
- Total Volume Purged ____________
- Comments ____________

Well Inner Diameter ____________
PVC Stickup ____________
Total Depth ____________
Air Temp. ____________
Probe Serial No. ____________
Tested By ____________

WELL CONDITION ____________________

RECOVERY DATA:

Date	Time (h:m:s)	Depth to Water From Top of PVC	Comments

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MT. POLLEY PROJECT
GROUNDWATER SAMPLING QUALITY CONTROL RECORD SHEET

PROJECT NO.: ____________________

WELL NO.: ____________________

DATE SAMPLED: ____________________

WEATHER: ____________________

COMMENTS: ____________________

GROUNDWATER LEVEL AND WELL VOLUME

	Time	Depth	Comments
a) Depth to Water from top of PVC			
b) Depth to bottom of Test Zone from top of PVC			
c) Length of Standing Water Column, L (b - a)			

Volume of Standing Water Column ($0.8 \times L \times D^2$) = ____________________

- where D = inner diameter of PVC pipe

WELL PURGING

Volume to purge (3 x volume of standing water column) = ____________________

Purging Duration: from ____________________ to ____________________

	Purge Well with Bailer		Purge Well with Grundfos Pump
Bailer Volume		Container Volume	
Number of Bails		Number of Containers	
Volume Bailed		Volume Pumped	

Well Yield (high, medium, low) ____________________ (high = recharge as fast as purging)
(low = >24 hrs to recover from purging)

Comments: ____________________

FIELD PARAMETERS

	Time	Calibration Standard		Groundwater Sample
		Stated	Measured	
Temperature				
pH				
Conductivity				

SAMPLING, FILTRATION AND PRESERVATION

Description ____________________

	Time	Filtration		Preservation		Container No. and Volume
		(Y / N)	Method	(Y / N)	Type	
Field Parameters						1 (1000 ml)
Total Metals (T.M.)						2 (250 ml)
Total Mercury (T.Hg)						3 (500 ml)
Dissolved Metals (D.M.)						4 (250 ml)
Total Cyanide (T.CN)						5 (1000 ml)

SIGNATURE ____________________

J:\JOB\DATA\0019\GWATER1.XLS

APPENDIX B

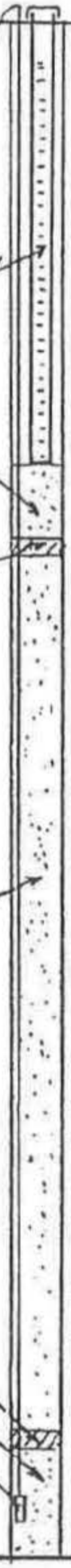
1989 AND 1995 MONITORING WELL INSTALLATIONS LOGS

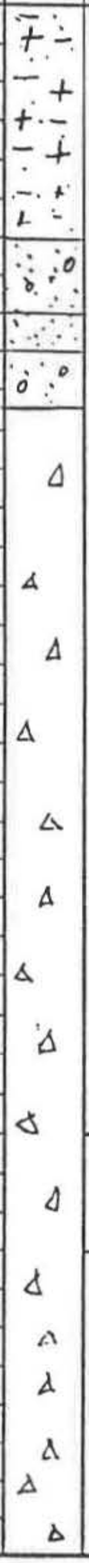
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. MP89-231
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST HOLE Tailings Area B
DATE BEGUN Oct. 31, 1989 DATE FINISHED Nov. 1, 1989
PROJECT No. 1621
GROUND ELEVATION 927.
LOGGED BY RNK + KMcN





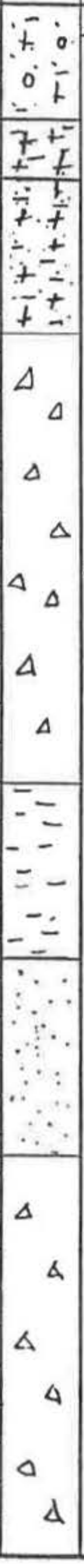
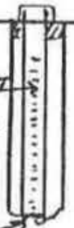
NOTES Water loss, type and size of hole, drilling method, groundwater level, etc. ∇	CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY $(\times 10^{-6}$ cm/s$)$	DEPTH (feet)	DESCRIPTION AND CLASSIFICATION OF MATERIAL ∇
pneumatic leads						s-water table at surface - dense, grey, silty till with abundant rounded pebbles
water table at surface	10			6.4		
1 1/2" Ø PVC standpipe piezometer slotted to surface					50	
	20					- reddish brown coarse sand and gravel (weathered K-spar rich intrusive)
	50					- fine beach sand with minor clay binder
	0					- reddish brown coarse sand and gravel (weathered K-spar rich intrusive)
	85				100	
sand backfill	100	70	10	1.6		
	100	70				
bentonite seal	90	50		.29		- purple weathered volcanic conglomerate with rough planar joints infilled with clay, hematite, or calcite (decreasing weathering down hole)
	90	20	<3			
	100	30			150	
		50				
		65	10			
		50				
		50			200	
		40				
		40				
Sand backfill		35				
		50				
		60			250	
		70	30			
		70	30			
		20	<3			
		70	20			
		20	<3		300	- Conglomerate strained to sandy clay gouge
		0	<3			
		20	<3			
entonite seal		40	30			
		95				
and ackfill		65				
		70			350	
		40	10			
neumatic ezometer tip at 385'		40	10			
		75	30			
	80	50	10			EOH

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No mP89-232
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST HOLE Tailings Area 1
DATE BEGUN Nov. 1, 1989 DATE FINISHED Nov. 4, 1989
PROJECT No. 1621
GROUND ELEVATION 919.4
LOGGED BY RNK + K McN

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY ($\times 10^{-6}$ cm/s)	DEPTH (feet)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
							▽ water table at 7'
1½" ø PVC standpipe piezometer 	15						dense, grey silty glacial till
	30						-clay rich silt, becoming coarser graind down hole
	40			7.7	50		-layered clay rich very fine sands and silts.
hole sloughed in at 50'	0						
	15						
	30	0	<3				
	45	0					-purple weathered, soft, clayey volcanic conglomerate with abundant cobbles and gravel
	90	20			100		
	40	0		3.2			← sand and clay rich volcanic mud
	90	25	10				(dominant fractures at 90° and 45° to core axis, tight, rough and planar, with calcite infilling)
	95	75	30				
	100	25	<3	10	150		sandy clay gouge
		80	30				
		80					
		65					
		75					
		40	10				
		25	<3		200		-well strained purple mudstone with calcite infilled rough planar joints
		35					
		0					
		35	10				
		10	<3		250		-well strained purple sandstone with clay matrix
		0					
		0					
		10					
		70	30				
		60					
		60			300		-volcanic conglomerate (as above)
		70					
		40	10				
		10	<3				
		10			350		
		25					
		80	30				
		100					
		100					
		98					EOH

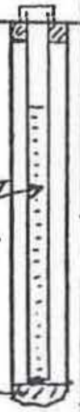
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. MP89-233
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST HOLE Tailings Area C
DATE BEGUN Nov. 5, 1989 DATE FINISHED Nov. 6, 1989
PROJECT No. 1621
GROUND ELEVATION 933.9
LOGGED BY RNK + K McN

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.



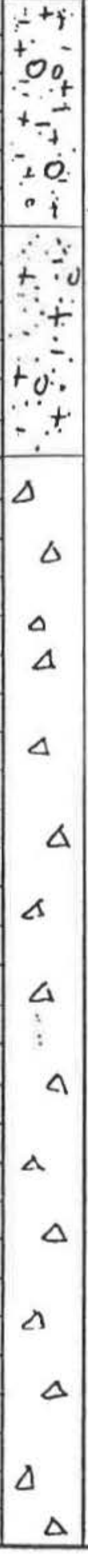
1 1/2" Ø PVC standpipe piezometer

bentonite seal

hole sloughed in at 100'

CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY (x 10^{-6} cm/s)	DEPTH (feet)
5				
15			11	50
0				
10				100
50	0	< 3	22	
15	↓	↓		
15			16	
25				
70				150
70				
75	40		17	
75	40	10		
60	0	< 3		
95	90	10		200
55	10	< 3		
70	20	< 3		
100	35	10		
100	45	10		
90	30	10		250
90	0	< 3		
100	↓	↓		
100				
95				
80				300
70				
40				
40				
10				350
40				
70	25	10		
30	10	10		
20	0	< 3		
20	0	< 3		

GRAPHIC LOG



DESCRIPTION AND CLASSIFICATION OF MATERIAL

- dense, grey silty glacial till with abundant pebbles (recovery mostly pebbles and silty clay)

∇ water table at 56'

- grey sandy glacial till with some pebbles (recovery mostly pebbles)

- heavily weathered volcanic conglomerate, with matrix leached to leave sand and gravel

EOH

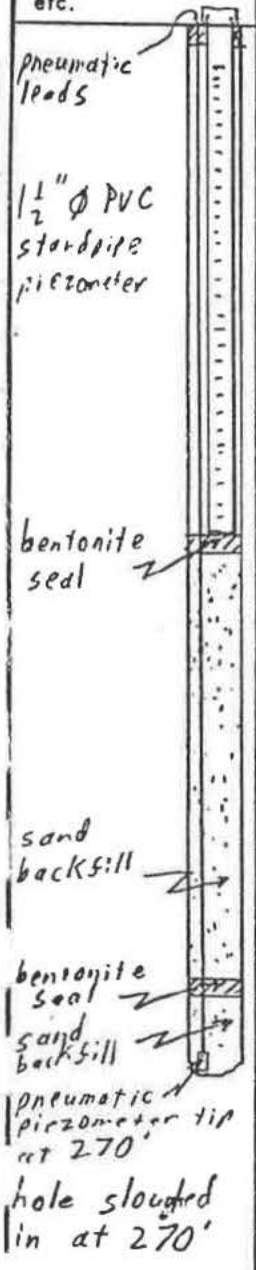
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

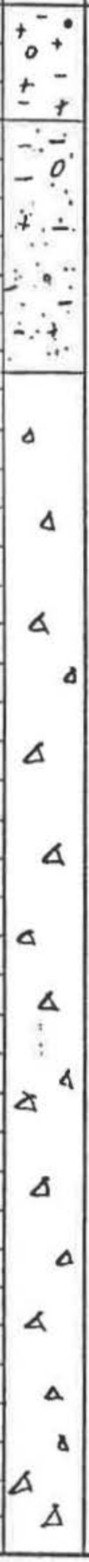
TEST HOLE : MP89-234
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST HOLE Tailings Area B
DATE BEGUN Nov 7, 1989 DATE FINISHED NOV. 7, 1989
PROJECT No. 1621
GROUND ELEVATION 909.3
LOGGED BY RNK + K McN

NOTES
Water loss, type and size of hole, drilling method, groundwater level, etc.



hole sloughed in at 270'



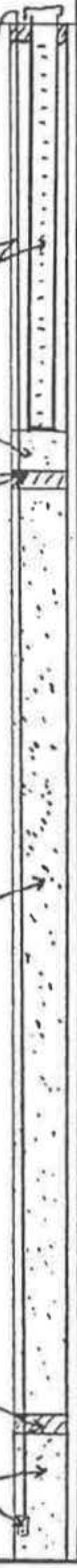
CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY (x 10⁻⁶ cm/s)	DEPTH (feet)	DESCRIPTION AND CLASSIFICATION OF MATERIAL
					▽ - water table at surface
50			14		- dense grey clay and silt with a trace of pebbles, and rare 5cm bands of clean san
1				50	- grey clayey sand with some pebble
20					
0					
85				100	
100	35	10			
	40	10	.32		- weathered purple volcanic conglomerate (altered to sand and gravel) defects oriented 60° and 90° to core axis
	65	30			
	85	30			
	70	30			
	20	<3	3.3	150	
↓	50	50			
10	0	<3			
90	70	30			
100	90	30			- decreasing degree of weathering with depth
90	15	<3		200	
95	25				
70	0				
100	30				
	40	↓			
	80	10		250	
	80	10			
	80	10			
	10	<3			
	10				
	0			300	
	0				
	25	↓			
	80	30			
	20	10		350	
	30	30			
	80				
	60				
	80				
↓	70	↓			EOH

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. MP89-235
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1621
OCATION OF TEST HOLE Tailings Hrn B
GROUND ELEVATION 946.2
ATE BEGUN Nov. 9, 1989 DATE FINISHED Nov. 10, 1989
LOGGED BY RNK + KMcN



NOTES 'ater loss, type and size of hole, drilling method, roundwater level, tc.	CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY (x 10⁻⁶ cm/s)	DEPTH (feet)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
oneumatic 'ads						▽	▽ - water table at 6' ← dense grey sandy glacial till
	80	20	<3				
	100	40	10			△	
		70	10	510			
" ϕ PVC		90	30			△	- very weathered purple volcanic conglomerate with rough, wavy, thin clay filled fractures
standpipe		70		.086	50		
ezometer		85				△	
		95					
		70	10	.40		△	
sand ckfill		60			100		
		60				△	
bentonite al		60					
		50		11		△ △	
		65					
		65			150		
		85				△	
		90	30				
		70				△	
		30					
		90			200	△	
		85					
s nd		75				△	
backfill		70					
		85				x	
		60			250	△	
		70	10				← healed shear zone
		75	30			△	
		85					
		90				△	
		60			300	△	
	90	60	10				
	100	60				△	
	90	50					
	95	50				x	
	100	80	30		350	x	- purple basalt
b tonite s al		40	10			x	
nd		60	10			x	
b ksill		100	30				
p matic		70	30			x	
piezometer, tip at 370'		60	10			x	EOH

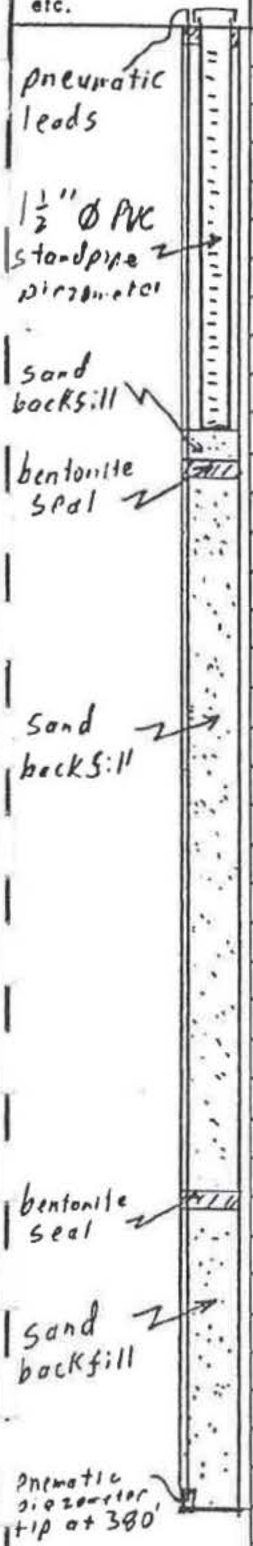
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. MP89-236
SHEET 1 of 1

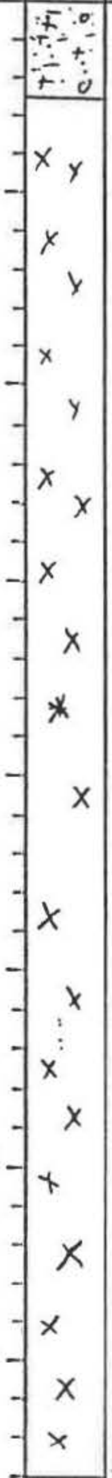
PROJECT Mt. Polley
LOCATION OF TEST HOLE Tailings Area ?
DATE BEGUN Nov. 10, 1989 DATE FINISHED Nov. 11, 1989
PROJECT No. 1621
GROUND ELEVATION 944.4
LOGGED BY RNK + K McN

NOTES
Water loss, type and size of hole, drilling method, groundwater level, etc.



CORE RECOVERY %	RQD	DEFECT SPACING (cm)	PERMEABILITY (× 10⁻⁶ cm/s)	DEPTH (feet)
5				
10				
10	0	<3		
40	0	↓	27	
60	0			50
80	10			
40	10		2.7	
70	20			
70	10	10		
95	30	↓	2.0	100
80	25			
100	25	<3		
60	30	10		
90	15	↓	.77	
100	60			150
80	60			
100	50			
80	20	<3		
100	35	<3		
100	45	10		200
90	20	<3		
90	15	<3		
100	40	10		
45	10	<3		
80	25	10		250
60	5	10		
70	10	<3		
80	15	↓		
80	0			
50	0			300
30	0			
45	10			
40	0			
70	0			
90	30			350
95	45	10		
100		10		
100		<3		

GRAPHIC LOG



DESCRIPTION AND CLASSIFICATION OF MATERIAL

▽
- water table at surface.
- dense grey silty till with some pebbles

- weathered golfball syenite with thin calcite and chlorite filled tight planar, smooth fractures. Defects at 20° and 70° to core axis

? EOH

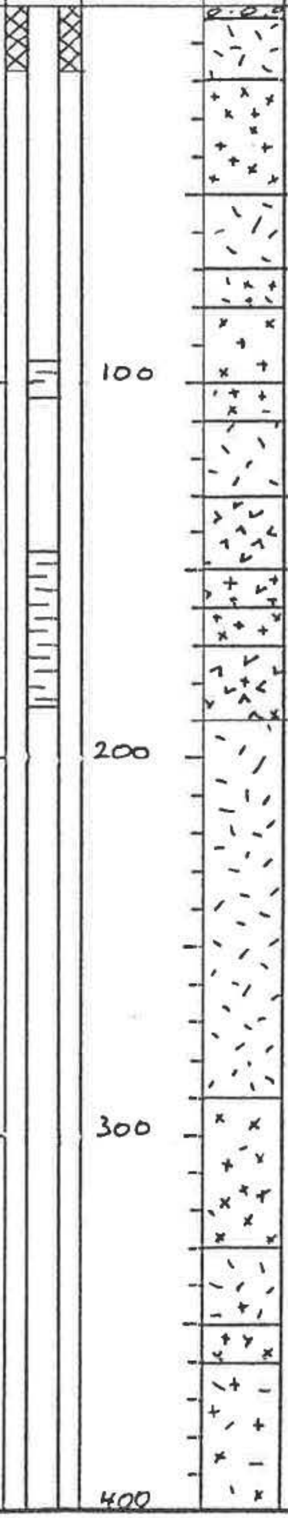
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. 95-R-1
SHEET 1 of 2

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
							0-3' overburden
							3-20' syenodiorite, green chloritic, minor to some monzonite porphyry
							20-50' monzonite porphyry, pink, K-spar rich
							50-70' syenodiorite,grey, prophyritic
							70-80' 50/50 syenodiorite and monzonite porphyry
90-100' 1 gpm							80-100' monzonite porphyry, pink, K-spar rich
					100		100-110' 70% monzonite porphyry, 30% syenodiorite
							110-130' syenodiorite, light grey, prophyritic
							130-150' dk. green basaltic volcanics
							150-160' monzonite porphyry, 30% basaltic volcanics
150'-180' 20+ gpm							160-170' monzonite porphyry, buff, K-spar rich
175' fractured							170-190' dk. green basaltic volcanics, minor to some monzonite porphyry
					200		190-290' syenodiorite, light grey, prophyritic
					300		290-330' monzonite porphyry, buff, K-spar rich, 10% syenodiorite
							330-350' syenodiorite, light grey, prophyritic, 10% monzonite porphyry
							350-360' monzonite porphyry, pink, K-spar rich
							360-460' 50/50 syenodiorite and monzonite porphyry, possible intrusive breccia
					400		



KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-1
SHEET 2 of 2

PROJECT MT Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
405-440' 20+ gpm 415-440' fractured							360-460' 50/50 syenodiorite and monzonite porphyry, possible intrusive breccia
							E.O.H. = 460'
					500		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-2
SHEET 1 of 1

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

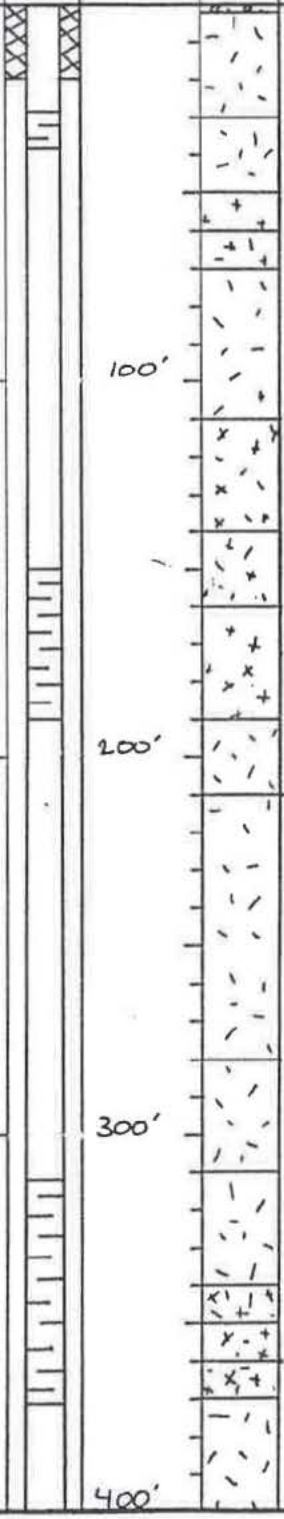
NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
							0-4' overburden
							4-20' syenodiorite, weathered beige to light brown
							20-40' syenodiorite, lightly weathered beige to light brown
							40-70' syenodiorite, light grey
							70-100' syenodiorite, dk. grey, highly pyritic
							100-110' syenodiorite, light grey, oxidized
							110-120' syenodiorite, light grey
122-138' 80 gpm							120-130' syenodiorite, light grey, limonite coated
122-138' fractured							130-170' syenodiorite, light grey
							170-230' syenodiorite, light grey, fractured
202-250' 100+ gpm							
							230-240' syenodiorite, light grey
							240-295' syenodiorite, light grey, fractured
							E.O.H. = 295'

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. 95-R-3
SHEET 1 of 2

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY



NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL	
							0-2'	overburden
							2-30'	syenodiorite, grey-green, weathered
							30-50'	syenodiorite, rusty limonite coated fractures, highly oxidized
							50-60'	monzonite porphyry, pink
							60-70'	50/50 syenodiorite and monzonite porphyry
							70-110'	syenodiorite, light brown minor pink monzonite porphyry
							110-140'	60% monzonite porphyry, 40% syenodiorite
							140-160'	40% monzonite porphyry, 60% syenodiorite
140-190' 2 gpm 140-190' fractured							160-190'	monzonite porphyry, beige
							190-210'	syenodiorite, grey-green
							210-280'	syenodiorite, light brown, oxidized pyrite, abundant pyrite
							280-310'	syenodiorite, green
							310-340'	syenodiorite, light brown
							340-350'	50/50 syenodiorite and monzonite porphyry
310-370' 7 gpm 310-370' fractured							350-360'	70% monzonite porphyry, 30% syenodiorite
							360-370'	50/50 syenodiorite and monzonite porphyry
							370-420'	syenodiorite, grey-green

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. 95-R-3
SHEET 2 of 2

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
							370-420' syenodiorite, grey-green
							420-500' syenodiorite, grey-pink
					500'		E.O.H. = 500'

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-A-4
SHEET 1 of 1

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
							0-20' overburden, glacial till
							20-90' monzonite porphyry, reddish maroon
85-105' 10 gpm					100'		90-140' monzonite porphyry, reddish maroon, oxidized
140-170' 12 gpm							140-160' syenodiorite, grey-green
							160-190' syenodiorite, grey-green, slightly oxidized
					200'		190-200' syenodiorite, grey-green
							200-230' syenodiorite, grey-green, slightly oxidized
210-222' 100+ gpm 210-222' fractured							
							230-240' syenodiorite, grey-green
							240-270' mafic tuff
							270-320' monzonite porphyry, grey and pink
					300'		
313-320' possible water 312-320' fractured							320-330' dk. green basaltic volcanic, minor monzonite porphyry
							330-360' syenodiorite, grey and pink
350-380' possible water 350-380' fractured							360-380' syenodiorite, grey and pink, trace mafic volcanic
							380-400' syenodiorite, grey and pink
					400'		E.O.H. = 400'

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

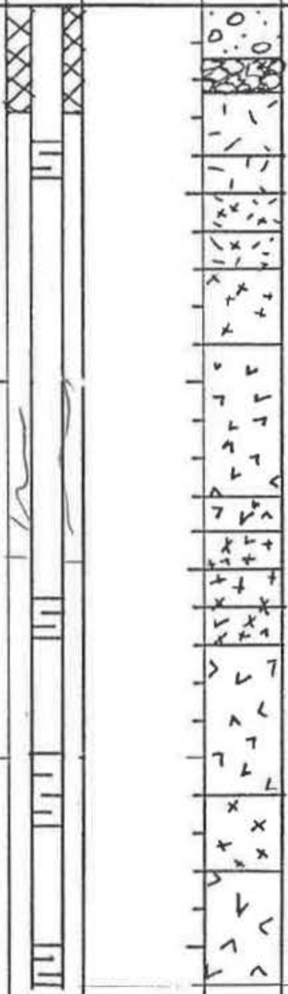
TEST HOLE No 95.A.5
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.

150-170' 1 gpm
160-170' fractured

197-210' 3 gpm
197-210' fractured



DESCRIPTION AND CLASSIFICATION OF MATERIAL

0-14'	overburden, glacial till
14-23'	broken rock
23-40'	syenodiorite, light grey and beige, weathered
40-50'	syenodiorite, grey-green
50-60'	50/50 syenodiorite and monzonite porphyry
60-70'	30% monzonite porphyry, 70% syenodiorite
70-90'	monzonite porphyry, brick red
90-130'	mafic tuff
130-140'	mafic tuff, 5-10% pink monzonite porphyry
140-150'	80% monzonite porphyry, 20% mafic tuff
150-160'	monzonite porphyry, pink
160-170'	80% monzonite porphyry, 20% mafic tuff
170-210'	mafic tuff
210-230'	monzonite porphyry, brick red
230-260'	mafic tuff

E.O.H. = 260'

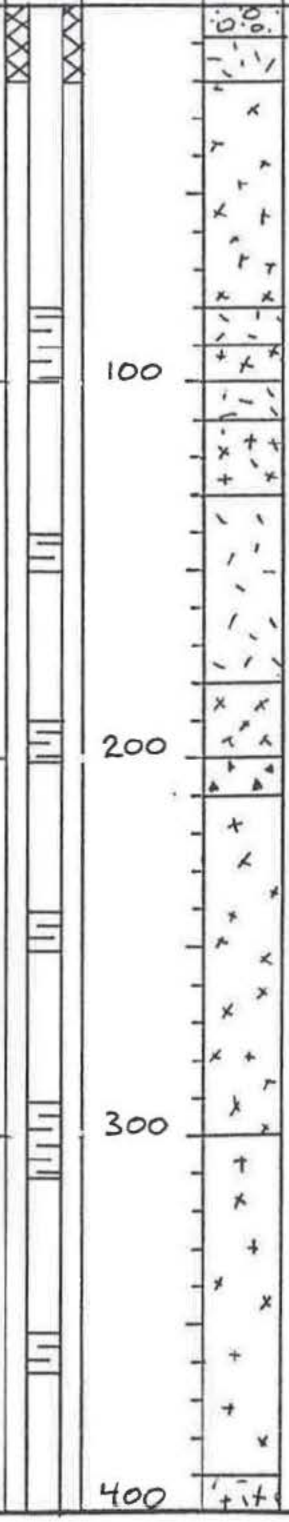
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-6
SHEET 1 of 2

PROJECT MT Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
9-88' 3 gpm 9-88' fractured							0-9' overburden 9-20' syenodiorite, light grey, weathered 20-80' fine grained monzonite, pink
					100		80-90' syenodiorite, light grey 90-100' fine grained monzonite, pink 100-110' syenodiorite, light grey 110-130' fine grained monzonite, pink, 10% syenodiorite
150-175' 2 gpm 150-175' fractured							130-180' syenodiorite, grey-green, minor monzonite
					200		180-200' fine grained monzonite, pink, minor syenodiorite 200-210' Augite porphyry dike, dk. grey 210-300' fine grained monzonite, pink
300-310' 1 gpm 300-310' fractured					300		300-390' fine grained monzonite, pink
					400		390-400' 50/50 syenodiorite and monzonite porphyry

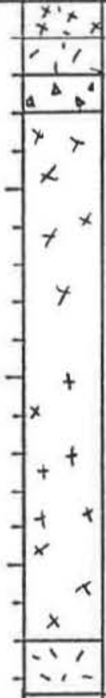


KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-6
SHEET 2 of 2

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY



NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
410-417' 1 gpm 410-417' fractured							400-410' 80% monzonite porphyry, 20% syenodiorite 410-420' syenodiorite, grey-green, minor monzonite porphyry 420-430' Augite porphyry dike, dk. grey 430-570' monzonite porphyry, pink, minor grey syenodiorite
505-570' some fractures					500		
570-580' fractured							570-584' syenodiorite, grey-green
					600		E.O.H. = 584'

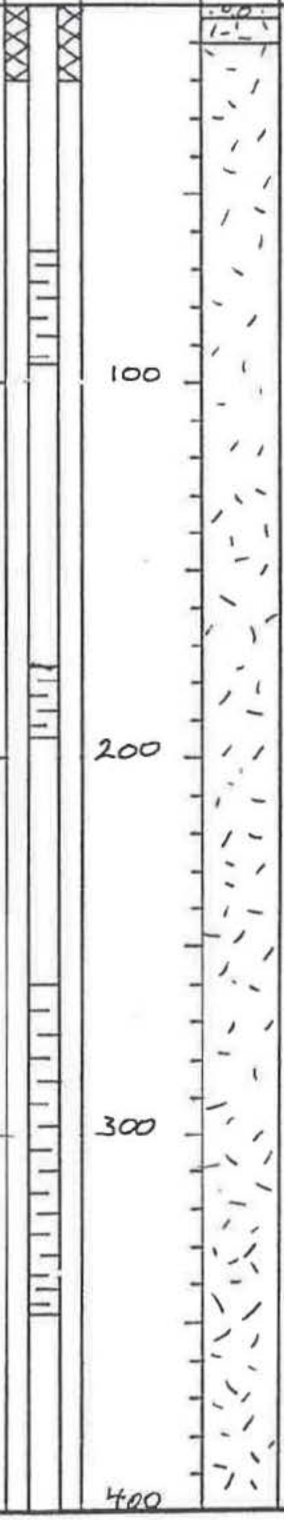
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-7
SHEET 1 of 2

PROJECT MT. Polley
PROJECT No. 1624
LOCATION OF TEST HOLE
GROUND ELEVATION
DATE BEGUN
DATE FINISHED
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
70-85' 2 gpm 70-85' fractured 160-200' 15 gpm 160-200' fractured 250-310' 50 gpm 250-310' fractured 340-455' fractured							0-3' overburden 3-10' syenodiorite, light brown, oxidizes, fractured 10-400' syenodiorite, grey-green



KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No 95-R-7
SHEET 2 of 2

PROJECT MT Polley
LOCATION OF TEST HOLE
DATE BEGUN
DATE FINISHED
PROJECT No. 1624
GROUND ELEVATION
LOGGED BY

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS / FOOT	MOISTURE CONTENT %	MONITORING INSTALLATION	DEPTH	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
340-455' fractured							400-430' Augite porphyry dike, dk. grey
							430-560' syenodiorite, light grey-green
					500		
							E.O.H. = 560'
					600		

Knight Piésold Ltd.
CONSULTING ENGINEERS

APPENDIX C

BOREHOLE LOGS

DRILL RECORD

IMPERIAL METALS CORPORATION

	Property:	Mount Polley		Location:				Correct Dip:	-90°			
	Hole No.:	95R-1		Equipment:				True Brg.				
	Commenced:	July 8,1995		Elevation:	1137. 24m.			Survey at:				
	Completed:	July 14, 1995		Size:	6"			% Recovery:				
	Coordinates:	2550.61 N /	2212.35E	Core Stored:				Length:	460ft			
	Date:	July 14, 1995		Logged By:	Rad Pesall			Unusual Feat.:				
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.	Feet			%	Oz/T	ppm	ppm	%
0	10		syenodiorite, green chloritic, abundant epitdote, minor monzonite porphyry #1						0.003	887		
10	20		70% syenodiorite, 30% monzonite porphyry #1,						0.004	1320		
20	30		monzonite porphyry, pink, K-spar rich, magnetic						0.001	179		
30	40		• visible py						<001	75		
40	50		•						0.002	112		
50	60		syenodiorite, grey, porphyritic						0.004	584		
60	70		•						0.002	420		
70	80		50/50 syenodiorite and monzonite porphyry, magnetic						0.002	722		
80	90		monzonite porphyry #1 as above at 20 ft., magnetic						<001	225		
90	100		•						<001	330		
100	110		70% monzonite porphyry #1, 30% syenodiorite						<001	158		
110	120		syenodiorite, light grey, porphyritic, white plagioclase phenos						<001	34		
120	130		•						<001	140		
130	140		dark green basaltic volcanic, local epidote + magnetite						<001	195		
140	150		•						<001	90		
150	160		80% monzonite porphyry, 30% basaltic volcanic as at 130 ft.						<001	127		
160	170		monzonite porphyry # 1, buff, white plagioclase phenos 2-3 mm.						<001	295		
170	180		90% basaltic volc as above @ 130'; 10% mpp#1						<001	144		
180	190		90% basaltic volc as above @ 130'; 30% mpp#1						<001	26		
190	200		sydr; lt grey matrix, wht plag phenos 2-3mm.						<001	25		
200	210		•						<001	94		
210	220		•						<001	79		
220	230		•						<001	54		
230	240		sydr; lt grey matrix, white plag phenos 2-3mm						<001	57		
240	250		•						<001	124		
250	260		•						<001	270		
260	270		•						<001	210		
270	280		•						<001	126		
280	290		•						0.002	579		
290	300		90%pk mpp#1; 10 % sydr as above at 190', poss. bx						0.005	1120		
300	310		• few malachite grains						0.003	1535		
310	320		• few malachite grains						0.014	1690		
320	330		•						0.003	872		
330	340		10%pk mpp#1 as above, 90% grey porph. sydr						<001	122		
340	350		•						0.004	572		
350	360		mpp#1 pk, white plag phenos						0.001	450		
360	370		50/50 pk mpp#1 and grey sydr, poss intr. breccia						0.002	298		
370	380		•						<001	418		
380	390		•						0.002	513		
390	400		•						0.003	487		
400	410		•						0.002	828		
410	420		• visible cp						0.008	1375		
420	430		• visible cp						0.004	753		
430	440		•						0.007	1605		
440	450		•						0.002	912		
450	460		•						0.003	1360		
			–END OF HOLE–									

95R-2

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-2		Equipment:			True Brg.:					
	Commenced:	14-Jul-95		Elevation:	1100 m.		Survey at:					
	Completed:	31-Jul-95		Size:	6"		% Recovery:					
	Coordinates:	2185N/2850E		Core Stored:			Length:	295 Ft.				
	Date:	10-Aug-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
0	10		syenodiorite, limonite coated cuttings, weathered beige to light brown						<.001	179		
10	20		"						0.001	295		
20	30		syenodiorite, grey disseminated pyrite visible, minor weathered syenodiorite as above						0.001	566		
30	40		"						<.001	277		
40	50		syenodiorite, light grey, slightly bleached, minor epidote and pyrite						<.001	292		
50	60		"						<.001	160		
60	70		"						0.001	257		
70	80		syenodiorite, dark grey, highly pyritic; pyrite 8-10%						<.001	368		
80	90		"						<.001	651		
90	100		"						<.001	363		
100	110		syenodiorite, light grey, 10% of oxidized cuttings						<.001	353		
110	120		as above, no oxidation, slightly bleached						<.001	231		
120	130		" limonite coated, disseminated magnetite and pyrite abundant						<.001	119		
130	140		syenodiorite, light grey, fresh, disseminated pyrite, epidote, minor disseminated magnetite						<.001	200		
140	150		"						<.001	319		
150	160		"						<.001	231		
160	170		"						<.001	165		
170	180		" Fragments, 2-3 cm fault						<.001	88		
180	190		" Fragments, 2-3 cm fault						<.001	188		
190	200		" Fragments, 2-3 cm fault						<.001	165		
200	210		" Fragments, 2-3 cm fault						<.001	149		
210	220		" Fragments, 2-3 cm fault	fault					<.001	241		
220	230		" Fragments, 2-3 cm fault						<.001	192		
230	240		syenodiorite, light grey, fresh, disseminated pyrite abundant, minor magnetite						<.001	198		
240	250		" Fragments, 2-3 cm fault						<.001	183		
250	260		" Fragments, 2-3 cm fault						<.001	118		
260	270		" Fragments, 2-3 cm fault						<.001	139		
270	280		" Fragments, 2-3 cm fault						<.001	207		

NVESTIGATION KP 1-11 264 of 500

95R-2

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-2		Equipment:			True Brg.:					
	Commenced:	14-Jul-95		Elevation:			Survey at:					
	Completed:	31-Jul-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	295 Ft.				
	Date:	10-Aug-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
280	290		" Fragments, 2-3 cm fault						<.001	291		
290	295		" Fragments, 2-3 cm fault						<.001	454		
			End of Hole									

	Property:	Mt. Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-3		Equipment:			True Brg.:					
	Commenced:	01-Aug-95		Elevation:	1121.69m.		Survey at: ,					
	Completed:	02-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	2416.59N/2460.16E		Core Stored:			Length:	505 Ft.				
	Date:	11-Aug-95		Logged by:	R. Pesall		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
0	10		syenodiorite, grey-green, weathered, trace limonite on fractures						<.001	483		
10	20		"						<.001	433		
20	30		"						<.001	450		
30	40		syenodiorite, rusty limonite coated fractures, highly oxidized						<.001	243		
40	50		"						<.001	330		
50	60		monzonite porphyry #1, salmon pink, iron oxides on fractures						<.001	581		
60	70		50/50 syenodiorite and monzonite porphyry #1 rusty coloured cuttings						<.001	588		
70	80		syenodiorite, light brown, minor pink monzonite porphyry #1						<.001	433		
80	90		"						<.001	141		
90	100		"						<.001	195		
100	110		"						<.001	178		
110	120		60% monzonite porphyry #1; 40% syenodiorite, light brown and pink						<.001	517		
120	130		"						<.001	224		
130	140		"						<.001	272		
140	150		40% monzonite porphyry #1, 60% syenodiorite, limonite coating on fracture						<.001	160		
150	160		"						<.001	176		
160	170		monzonite porphyry #1, beige fine grained matrix, white plagiocase laths 2-3 mm long						<.001	192		
170	180		"						<.001	14		
180	190		"						<.001	89		
190	200		syenodiorite, grey-green, chloritic, some epidote, trace disseminated pyrite						<.001	257		
200	210		"						<.001	638		
210	220		syenodiorite, light brown, oxidised disseminated pyrite 2-3%, abundant limonite						<.001	284		
	Property:	Mt. Polley		Location:			Correct Dip:	-90				

	Hole No.:	95R-3		Equipment:			True Brg.:					
	Commenced:	01-Aug-95		Elevation:			Survey at:					
	Completed:	02-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	2440N/2700E		Core Stored:			Length:	505 Ft.				
	Date:	11-Aug-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
220	230		"						<.001	213		
230	240		"						<.001	298		
240	250		"						<.001	257		
250	260		"						<.001	161		
260	270		"						<.001	238		
270	280		"						.001	748		
280	290		syenodiorite, green, chloritic, non-oxidised disseminated pyrite 5-6%						.001	818		
290	300		"						<.001	381		
300	310		"						0.002	479		
310	320		syenodiorite, light grey and pink, slightly oxidised, disseminated pyrite 1%						<.001	185		
320	330		"						.001	281		
330	340		"						<.001	446		
340	350		50/50 syenodiorite and monzonite porphyry #1, slightly oxidised, disseminated pyrite 3%						<.001	423		
350	360		70/30 monzonite porphyry #1 and syenodiorite, slightly oxidised, disseminated pyrite <1%						.001	251		
360	370		50/50 " "						0.003	259		
370	380		syenodiorite grey-green, non-oxidised, chloritic, disseminated pyrite 5%						0.001	369		
380	390		"						<.001	370		
390	400		"						0.001	348		
400	410		"						0.001	348		
410	420		"						<.001	665		
420	430		syenodiorite grey and pink, feldspathised, abundant epidote, <1%pyrite						<.001	328		
430	440		"						<.001	220		
440	450		"						<.001	295		
450	460		"						<.001	226		
	Property:	Mt. Polley		Location:			Correct Dip:	-90				

	Hole No.:	95R-3		Equipment:			True Brg.:					
	Commenced:	01-Aug-95		Elevation:			Survey at:					
	Completed:	02-Aug-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	505 Ft.				
	Date:	11-Aug-95		Logged by:	R. Pesall		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
460	470		syenodiorite grey-pink, feldspathised, abundant epidote, disseminated <1%pyrite						<.001	327		
470	480		"						<.001	212		
480	490		"						<.001	266		
490	500		"						<.001	254		
			End of Hole									

95R-4

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-4		Equipment:			True Brg.:					
	Commenced:	03-Aug-95		Elevation:	1050.43 m.		Survey at:					
	Completed:	05-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	3250.26 N/1304.90E		Core Stored:			Length:	405Ft.				
	Date:			Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
0	10		brown glacial till, minor fragments of monzonite porphyry #1						0.003	247		
10	20		monzonite porphyry #1 reddish-maroon ground mass, white plaglocase phenos						<.001	261		
20	30		"						<.001	242		
30	40		"						<.001	343		
40	50		"						<.001	292		
50	60		"						<.001	383		
60	70		"						<.001	56		
70	80		"						<.001	33		
80	90		"						<.001	40		
90	100		monzonite porphyry #1 as above, abundant limonite, well oxidised						<.001	50		
100	110		monzonite porphyry #1 as above but less oxidised, reddish-maroon						<.001	35		
110	120		"						<.001	70		
120	130		"						<.001	87		
130	140		"						<.001	118		
140	150		syenodiorite, grey-green, chloritic, disseminated pyrite 5-6%, unoxidised						<.001	105		
150	160		"						0.002	138		
160	170		syenodiorite as above but slightly oxidised, minor monzonite porphyry #1						<.001	55		
170	180		"						<.001	112		
180	190		"						<.001	158		
190	200		syenodiorite grey-green, chloritic, unoxidised, disseminated pyrite 2-3%						<.001	113		
200	210		" slightly oxidised						<.001	158		
210	220		"						<.001	155		
220	230		"						<.001	162		
230	240		syenodiorite, green-grey, chloritic, unoxidised, disseminated pyrite 3-5%						0.019	255		

'e No.: 95R

95R-4

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-4		Equipment:			True Brg.:					
	Commenced:	03-Aug-95		Elevation:			Survey at:					
	Completed:	05-Aug-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	405Ft.				
	Date:			Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
240	250		mafic tuff, green, chlorite and epidote alteration, disseminated pyrite 3-5%						<.001	160		
250	260		"						<.001	162		
260	270		"						0.001	171		
270	280		monzonite porphyry #1, pink and grey, unoxidised, disseminated pyrite 2-3%						<.001	574		
280	290		"						0.001	699		
290	300		"						0.002	720		
300	310		"						0.001	557		
310	320		"						0.002	514		
320	330		dark green very fine grain basaltic volcanic, minor monzonite porphyry #1						0.002	650		
330	340		syenodiorite grey and pink, feldspathised, trace disseminated pyrite						0.001	306		
340	350		"						0.001	451		
350	360		"						<.001	415		
360	370		syenodiorite as above, trace fragments of mafic volcanic						0.002	766		
370	380		"						0.001	474		
380	390		syenodiorite pink and grey, highly feldspathised, trace pyrite						0.002	536		
390	400		"						0.003	649		
			End of Hole									

	Hole No.:	95R-5		Equipment:			True Brg.:					
	Commenced:	08-Aug-95		Elevation:			Survey at:					
	Completed:	09-Aug-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	260Ft.				
	Date:	11-Aug-95		Logged by:	R. Pesalj		Unusual Feat.:					
From Feet	To	Syb	Description	Sample No.	From	To	Lgth.	Rec. %	Au Oz/T	Total Cu ppm	Oxide Cu ppm	Ratio %
230	240		mafic tuff, green, chloritic, abundant epidote, disseminated pyrite 5%						<.001	62		
240	250		"						<.001	68		
250	260		"						<.001	96		
			End of Hole									

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-6		Equipment:			True Brg.:					
	Commenced:	10-Aug-95		Elevation:	1190 m.		Survey at:					
	Completed:	13-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	3640N/2360E		Core Stored:			Length:	584Ft.				
	Date:	02-Oct-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To		-	Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
0	10		syenodiorite, light grey, weathered, slightly oxidised surfaces						0.002	729		
10	20		"						0.003	1175		
20	30		pink fine grain monzonite, 1-2%fine grain disseminated pyrite						0.001	891		
30	40		"						<.001	540		
40	50		"						<.001	505		
50	60		"						<.001	351		
60	70		"						<.001	348		
70	80		"						<.001	589		
80	90		syenodiorite, light grey, unoxidised, porphyritic, minor monzonite						<.001	485		
90	100		pink fine grained monzonite as above at 20'						<.001	392		
100	110		syenodiorite, light grey, unoxidised, porphyritic, minor monzonite						<.001	352		
110	120		monzonite , pink, fine grain 10% syenodiorite as above at 100'						<.001	403		
120	130		"						<.001	419		
130	140		syenodiorite, grey-green, chloritic, minor monzonite as above						<.001	249		
140	150		"						<.001	378		
150	160		"						<.001	386		
160	170		"						<.001	404		
170	180		"						<.001	477		
180	190		monzonite, pink, fine grain minor grey syenodiorite, 2-3% pyrite						<.001	433		
190	200		"						<.001	659		
200	210		Augite porphyry dyke, dark grey, unoxidised						0.003	557		
210	220		monzonite porphyry, pink, fine grain, 3-5% disseminated pyrite						0.002	670		
220	230		"						0.001	833		
	Property:	Mount Polley		Location:			Correct Dip:	-90				

	Hole No.:	95R-6		Equipment:			True Brg.:					
	Commenced:	10-Aug-95		Elevation:			Survey at:					
	Completed:	13-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	--		Core Stored:			Length:	584Ft				
	Date:	02-Oct-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
230	240		monzonite porphyry, pink, fine grain 3-5% disseminated pyrite						<.001	767		
240	250		"						0.001	942		
250	260		"						0.004	1185		
260	270		"						0.005	1360		
270	280		"						0.005	2020		
280	290		"						0.003	1350		
290	300		syenodiorite, green-grey, chloritic, disseminated pyrite 2-4%						0.002	909		
300	310		monzonite porphyry, pink fine grain, 3-5% disseminated pyrite						0.002	1400		
310	320		"						0.001	3320		
320	330		"						0.003	1200		
330	340		"						0.002	1470		
340	350		"						<.001	1025		
350	360		"						0.003	1950		
360	370		"						0.002	1240		
370	380		"						0.003	1700		
380	390		"						<.001	1455		
390	400		50/50 syenodiorite and monzonite porphyry						0.001	1980		
400	410		20/80 syenodiorite and monzonite porphyry						0.005	1765		
410	420		syenodiorite grey-green, minor monzonite porphyry						0.003	1725		
420	430		augite porphyry dyke, dark green, unaltered						0.002	579		
430	440		monzonite porphyry, pink, minor grey syenodiorite						<.001	636		
440	450		"						0.001	718		
450	460		"						<.001	707		
460	470		"						0.002	804		
470	480		"						0.001	651		
480	490		"						<.001	777		
490	500		"						0.002	1160		
500	510		"						0.003	1250		
	Property:	Mount Polley		Location:			Correct Dip:	-90				

	Hole No.:	95R-6		Equipment:			True Brg.:					
	Commenced:	10-Aug-95		Elevation:			Survey at:					
	Completed:	13-Aug-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	584Ft.				
	Date:	02-Oct-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
510	520		monzonite porphyry, pink, minor grey syenodiorite						0.002	624		
520	530		"						0.005	1110		
530	540		"						0.008	1860		
540	550		"						0.006	1435		
550	560		"						0.006	1285		
560	570		"						0.008	1475		
570	580		syenodiorite, grey-green, chloritic, disseminated pyrite 1-2%						0.012	2330		
580	584		"						0.009	4280		
			End of Hole									

95R-7

	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-7		Equipment:			True Brg.:					
	Commenced:	14-Aug-95		Elevation:	1113.89m.		Survey at:					
	Completed:	19-Aug-95		Size:	6"		% Recovery:					
	Coordinates:	2189.20N/2964.25E		Core Stored:			Length:	560Ft.				
	Date:	02-Oct-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
0	10		syenodiorite, light brown, oxidised						0.002	326		
10	20		syenodiorite, grey-green, chloritic, disseminated pyrite 3-5%						<.001	360		
20	30		"						<.001	411		
30	40		"						<.001	579		
40	50		"						<.001	561		
50	60		"						<.001	270		
60	70		"						0.004	335		
70	80		"						0.01	199		
80	90		"						0.005	402		
90	100		"						<.001	208		
100	110		"						<.001	144		
110	120		"						0.002	187		
120	130		"						0.001	210		
130	140		"						<.001	241		
140	150		"						<.001	731		
150	160		"						<.001	150		
160	170		"						<.001	489		
170	180		"						<.001	156		
180	190		"						<.001	358		
190	200		"						<.001	294		
200	210		"						<.001	545		
210	220		"						<.001	228		
220	230		"						<.001	215		
230	240		"						<.001	260		
240	250		"						<.001	287		
250	260		"						<.001	251		
260	270		"						<.001	374		
270	280		"						<.001	255		
280	290		"						<.001	295		

290	300		"						<.001	365		
300	310		"						<.001	217		
310	320		"						<.001	392		
	Property:	Mount Polley		Location:			Correct Dip:	-90				
	Hole No.:	95R-7		Equipment:			True Brg.:					
	Commenced:	14-Aug-95		Elevation:			Survey at:					
	Completed:	19-Aug-95		Size:	6"		% Recovery:					
	Coordinates:			Core Stored:			Length:	560Ft.				
	Date:	02-Oct-95		Logged by:	R. Pesalj		Unusual Feat.:					
From	To			Sample	From	To	Lgth.	Rec.	Au	Total Cu	Oxide Cu	Ratio
Feet		Syb	Description	No.				%	Oz/T	ppm	ppm	%
320	330		syenodiorite, grey-green, chloritic, disseminated pyrite 3-5%						<.001	308		
330	340		"						<.001	214		
340	350		"						<.001	284		
350	360		"						<.001	275		
360	370		"						<.001	462		
370	380		"						<.001	213		
380	390		"						<.001	212		
390	400		"						<.001	277		
400	410		Augite porphyry dyke, dark grey and black, unaltered						<.001	252		
410	420		"						<.001	229		
420	430		"						<.001	115		
430	440		syenodiorite, pale grey-green, disseminated pyrite 3-5%						<.001	119		
440	450		"						<.001	514		
450	460		"						<.001	805		
460	470		"						<.001	405		
470	480		"						<.001	331		
480	490		"						<.001	173		
490	500		"						<.001	184		
500	510		"						<.001	310		
510	520		"						<.001	262		
520	530		"						<.001	239		
530	540		"						<.001	197		
540	550		"						<.001	224		
550	560		"						<.001	270		

Knight Piésold Ltd.
CONSULTING ENGINEERS

APPENDIX D

BASELINE GROUNDWATER QUALITY DATA
TO THE END OF 1995

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

Knight Piésold Ltd.
CONSULTING ENGINEERS

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

OPEN PIT/MILLSITE BASELINE GROUNDWATER QUALITY

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Last Update: 7 May 96

		1994 BC Environment Water Quality Criteria		MP89-107 Nov 25/89	MP89-107 Apr 5/90	MP89-146 Nov 25/89	MP89-146 Apr 5/90	MP89-151 Nov 25/89	MP89-151 Apr 5/90	95-R-1 Sept 20/95	R-95-4 Sept 21/95	R-95-4d Sept 21/95	R-95-5 Sept 21/95	R-95-6 Sept 20/95	R-95-7 Sept 22/95
		Freshwater Aquatic Life	Drinking Water												
Physical Tests															
Conductivity (umhos/cm)		----	----	380	153	81	70.9	150	335	207	206	206	331	322	191
Total Dissolved Solids		----	----	----	----	----	----	----	----	144	146	148	241	236	133
Hardness	CaCO3	----	----	167	78.7	30.6	27.0	71.2	73.0	102	72	70.6	171	167	87.8
pH		----	----	7.83	7.26	6.97	6.92	7.50	7.25	7.79	7.89	8.07	8.23	7.67	7.42
Total Suspended Solids		----	----	----	----	----	----	----	----	8	13	11	28	44	5
Turbidity (NTU)		----	----	----	----	----	----	----	----	1	5.3	5.8	9.8	11.7	3.7
Dissolved Anions															
Alkalinity	Total CaCO3	----	----	----	----	----	----	----	----	124	99.3	101	155	145	60.4
Chloride	Cl	----	----	----	----	----	----	----	----	<0.5	<0.5	<0.5	<0.5	0.5	<0.5
Fluoride	F	----	----	----	----	----	----	----	----	0.19	0.21	0.2	0.41	0.99	0.6
Sulphate	SO4	----	----	----	----	----	----	----	----	2	18.2	18.3	36.4	42.2	38.3
Nutrients															
Ammonia Nitrogen	N	----	----	----	----	----	----	----	----	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate Nitrogen	N	----	----	----	----	----	----	----	----	0.014	<0.005	<0.005	<0.005	0.008	<0.005
Nitrite Nitrogen	N	----	----	----	----	----	----	----	----	0.001	<0.001	0.001	0.001	0.007	0.002
Dissolved ortho-Phosphate	P	----	----	----	----	----	----	----	----	0.021	0.01	0.01	0.004	0.001	0.18
Total Dissolved Phosphate	P	----	----	----	----	----	----	----	----	0.021	0.01	0.01	0.004	0.001	0.18
Total Phosphorus	P	----	----	----	----	----	----	----	----	0.027	0.021	0.022	0.021	0.013	0.279
Cyanides															
Total Cyanide	CN	----	0.2	----	----	----	----	----	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Metals															
Aluminum	T-Al	0.005-0.1	----	***0.14***	***0.50***	***0.37***	***1.57***	***0.74***	***0.66***	***0.029***	***0.308***	***0.244***	***0.502***	***1.31***	***0.05***
Antimony	T-Sb	----	----	----	----	----	----	----	----	<0.0001	<0.0001	0.0002	0.0001	0.0001	0.0008
Arsenic	T-As	0.05	0.025	0.0004	0.0014	0.0015	0.0018	0.0013	0.0010	0.0008	0.0048	0.0049	0.0021	0.0049	0.0047
Barium	T-Ba	----	1	----	----	----	----	----	----	0.02	<0.010	<0.010	0.012	0.027	<0.010
Beryllium	T-Be	----	----	----	----	----	----	----	----	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth	T-Bi	----	----	----	----	----	----	----	----	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Boron	T-B	----	5	----	----	----	----	----	----	<0.10	0.27	0.26	<0.10	<0.10	<0.10
Cadmium	T-Cd	0.0002-0.0018	0.005	<0.0002	***0.0012***	***0.0002***	***0.0005***	<0.0002	***0.0003***	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	***0.001***
Calcium	T-Ca	----	----	----	----	----	----	----	----	32.3	25.7	24.7	61.2	45	21.7
Chromium	T-Cr	0.002-0.02	0.05	0.001	***0.002***	0.001	***0.006***	***0.003***	***0.002***	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Cobalt	T-Co	----	----	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Copper	T-Cu	0.002-0.004	1	***0.018***	***0.050***	***0.26***	***0.41***	***0.13***	***0.072***	***0.002***	***0.002***	***0.002***	***0.002***	***0.009***	<0.001
Iron	T-Fe	0.3	0.3	<0.03	0.07	0.28	***1.33***	***1.80***	***0.37***	<0.030	0.234	0.201	***0.627***	***0.785***	***0.529***
Lead	T-Pb	0.001-0.007	0.01	<0.001	***0.002***	***0.003***	***0.009***	***0.010***	***0.004***	<0.001	<0.001	<0.001	<0.001	***0.001***	<0.001
Magnesium	T-Mg	----	----	----	----	----	----	----	----	5.5	3.14	3.03	8.58	14.1	8.78
Manganese	T-Mn	----	0.05	1.24	1.67	0.011	0.025	0.038	0.030	0.013	0.043	0.041	0.1	0.027	0.64
Mercury	T-Hg	0.0001	0.001	0.00005	0.00006	0.00005	<0.00005	0.00007	<0.00005	<0.00001	<0.00001	<0.00001	<0.00001	0.00002	<0.00001
Molybdenum	T-Mo	----	----	0.005	0.002	0.010	0.002	0.009	0.009	0.01	0.038	0.039	0.031	0.028	0.004
Nickel	T-Ni	0.025-0.15	----	<0.001	<0.001	0.001	0.003	0.004	<0.001	<0.001	0.001	<0.001	0.002	0.004	0.002
Selenium	T-Se	0.001	0.01	----	----	----	----	----	----	<0.0005	0.0007	0.0006	<0.0005	<0.0005	***0.0018***
Silicon	T-Si	----	----	----	----	----	----	----	----	8.43	9.27	9.02	10.9	16.5	23.2

Notes 1) Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Turbidity (NTU).

2) Italic bold shaded values indicate exceedance of the BC Environmental freshwater aquatic life criteria. (Approved and Working Criteria for Water Quality - 1994, BC Environment, Victoria)

3) The letter d after the monitoring well identification name means that it is a duplicate sample, eg R-95-4d

4) A < sign mean that the value is less than the detection limit stated.

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

OPEN PIT/MILLSITE BASELINE GROUNDWATER QUALITY (con't)

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Last Update: 7 May 96

		1994 BC Environment Water Quality Criteria		MP89-107 Nov 25/89	MP89-107 Apr 5/90	MP89-146 Nov 25/89	MP89-146 Apr 5/90	MP89-151 Nov 25/89	MP89-151 Apr 5/90	95-R-1 Sept 20/95	R-95-4 Sept 21/95	R-95-4d Sept 21/95	R-95-5 Sept 21/95	R-95-6 Sept 20/95	R-95-7 Sept 22/95
		Freshwater Aquatic Life	Drinking Water												
Total Metals															
Silver	T-Ag	0.0001	----	***0.0002***	<0.0001	<0.0001	***0.0001***	<0.0001	***0.0001***	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Strontium	T-Sr	----	----	----	----	----	----	----	----	0.117	0.066	0.065	0.186	0.466	0.043
Titanium	T-Ti	----	----	----	----	----	----	----	----	<0.010	0.013	0.012	0.024	0.011	<0.010
Uranium	T-U	----	0.1	----	----	----	----	----	----	0.00054	0.00031	0.00031	0.00046	0.00089	0.00007
Vanadium	T-V	----	----	----	----	----	----	----	----	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc	T-Zn	0.03	5	<0.005	<0.005	<0.005	0.015	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	***0.066***
Dissolved Metals															
Aluminum	D-Al	----	----	0.010	0.018	0.065	0.22	0.058	0.096	0.019	0.016	0.027	0.043	0.03	0.01
Antimony	D-Sb	----	----	----	----	----	----	----	----	<0.0001	0.0001	0.0001	0.0002	<0.0001	0.0006
Arsenic	D-As	----	----	0.0002	0.0012	0.0010	0.0012	0.0003	0.0009	0.001	0.0044	0.0045	0.0015	0.0041	0.0047
Barium	D-Ba	----	----	----	----	----	----	----	----	0.02	<0.010	<0.010	<0.010	0.023	<0.010
Beryllium	D-Be	----	----	----	----	----	----	----	----	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth	D-Bi	----	----	----	----	----	----	----	----	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Boron	D-B	----	----	----	----	----	----	----	----	<0.10	0.27	0.26	<0.10	<0.10	<0.10
Cadmium	D-Cd	----	----	<0.0002	0.0010	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0009
Calcium	D-Ca	----	----	54.8	26.0	10.4	9.05	23.9	24.3	31.9	23.8	23.3	55.7	44.1	21.1
Chromium	D-Cr	----	----	<0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	----	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Copper	D-Cu	----	----	0.013	0.018	0.21	0.24	0.025	0.021	0.002	<0.001	<0.001	<0.001	0.004	<0.001
Iron	D-Fe	----	----	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.030	<0.030	<0.030	0.051	<0.030	0.407
Lead	D-Pb	----	----	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium	D-Mg	----	----	7.08	3.26	1.10	1.05	2.73	2.91	5.44	3.03	3	7.83	13.8	8.56
Manganese	D-Mn	----	----	1.17	1.17	0.007	0.015	<0.005	0.030	0.012	0.036	0.035	0.069	0.023	0.617
Mercury	D-Hg	----	----	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	----	----	----	----	----	----
Molybdenum	D-Mo	----	----	0.002	0.002	0.003	0.002	0.006	0.008	0.011	0.038	0.038	0.031	0.028	0.004
Nickel	D-Ni	----	----	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Potassium	D-K	----	----	0.60	0.70	0.59	0.61	0.42	0.56	0.51	0.33	0.3	1.19	0.38	0.75
Selenium	D-Se	----	----	----	----	----	----	----	----	<0.0005	0.0008	0.0008	<0.0005	<0.0005	0.002
Silicon	D-Si	----	----	----	----	----	----	----	----	8.3	8.88	8.83	9.73	13.4	22.6
Silve	D-Ag	----	----	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	----	----	2.44	2.15	4.64	3.51	2.24	2.28	4.61	16.9	16.9	5.08	7.18	3.58
Strontium	D-Sr	----	----	----	----	----	----	----	----	0.115	0.063	0.062	0.179	0.462	0.042
Titanium	D-Ti	----	----	----	----	----	----	----	----	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium	D-U	----	----	----	----	----	----	----	----	0.00052	0.00027	0.00029	0.0004	0.00044	0.00005
Vanadium	D-V	----	----	----	----	----	----	----	----	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc	D-Zn	----	----	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.057
Organic Parameters															
Total Organic Carbon	C	----	----	----	----	----	----	----	----	1.2	<0.5	<0.5	0.9	1	0.9

Notes 1) Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Turbidity (NTU).
2) Italic bold shaded values indicate excedance of the BC Environmental freshwater aquatic life criteria. (Approved and Working Criteria for Water Quality - 1994, BC Environment, Victoria)
3) The letter d after the monitoring well identification name means that it is a duplicate sample, eg R-95-4d
4) A < sign mean that the value is less than the detection limit stated.

Knight Piésold Ltd.
CONSULTING ENGINEERS

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

TAILINGS STORAGE FACILITY BASELINE GROUNDWATER QUALITY

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Last Update: 7 May, 96

		1994 BC Environment Water Quality Criteria		MP89-231 Nov 25/89	MP89-232 Nov 25/89	MP89-233 Nov 25/89	MP89-234 Nov 25/89	MP89-234 Sept 22/95	MP89-235 Nov 25/89	MP89-236 Nov 25/89	MP89-236 Jan 17/95	MP89-236 Sept 22/95	MP89-236d Sept 22/95
		Freshwater Aquatic Life	Drinking Water										
Physical Tests													
Conductivity (umhos/cm)		—	—	1226	289	393	422	399	4280	574	511	460	473
Total Dissolved Solids		—	—	—	—	—	—	330	—	—	323	336	335
Hardness	CaCO3	—	—	182	96.7	197	80.2	154	432	177	187	227	229
pH		—	—	7.73	7.40	7.65	8.0	7.89	7.28	8.24	7.87	7.71	7.74
Total Suspended Solids		—	—	—	—	—	—	548	—	—	373	240	74
Turbidity (NTU)		—	—	—	—	—	—	113	—	—	250	105	23.8
Dissolved Anions													
Alkalinity	Total CaCO3	—	—	—	—	—	—	250	—	—	284	301	298
Chloride	Cl	—	—	—	—	—	—	1.3	—	—	2.0	1.2	0.6
Fluoride	F	—	—	—	—	—	—	0.13	—	—	0.13	0.11	0.11
Sulphate	SO4	—	—	—	—	—	—	14.4	—	—	12.3	3.8	4.5
Nutrients													
Ammonia Nitrogen	N	—	—	—	—	—	—	0.014	—	—	<0.005	<0.005	<0.005
Nitrate Nitrogen	N	—	—	—	—	—	—	<0.005	—	—	0.007	0.028	0.028
Nitrite Nitrogen	N	—	—	—	—	—	—	0.001	—	—	0.005	0.001	0.001
Dissolved ortho-Phosphate	P	—	—	—	—	—	—	0.022	—	—	0.003	0.002	0.002
Total Dissolved Phosphate	P	—	—	—	—	—	—	0.022	—	—	0.003	0.002	0.002
Total Phosphorus	P	—	—	—	—	—	—	0.553	—	—	0.500	0.333	0.070
Cyanides													
Total Cyanide	CN	—	0.2	—	—	—	—	<0.001	—	—	<0.001	<0.001	<0.001
Total Metals													
Aluminum	T-Al	0.005-0.1	—	***7.88***	***34.1***	***15.4***	***4.77***	***13.1***	***5.84***	***9.80***	***4.49***	***1.23***	***0.619***
Antimony	T-Sb	—	—	—	—	—	—	—	0.0001	—	0.0024	0.0003	0.0006
Arsenic	T-As	0.05	0.025	0.0085	0.0004	0.0088	***0.073***	0.0079	0.0346	0.014	0.0068	0.0042	0.0039
Barium	T-Ba	—	1	—	—	—	—	—	0.292	—	0.114	0.023	0.02
Beryllium	T-Be	—	—	—	—	—	—	—	<0.005	—	<0.005	<0.005	<0.005
Bismuth	T-Bi	—	—	—	—	—	—	—	<0.10	—	<0.10	<0.10	<0.10
Boron	T-B	—	5	—	—	—	—	—	0.25	—	<0.10	<0.10	<0.10
Cadmium	T-Cd	0.0002-0.0018	0.005	<0.0002	***0.015***	***0.0003***	<0.0002	***0.0003***	***0.0008***	***0.0003***	***0.0002***	<0.0002	<0.0002
Calcium	T-Ca	—	—	—	—	—	—	—	63.6	—	57.6	56.2	55.4
Chromium	T-Cr	0.002-0.02	0.05	***0.005***	***0.047***	***0.040***	***0.007***	***0.029***	***0.012***	***0.012***	***0.007***	0.001	0.001
Cobalt	T-Co	—	—	0.006	0.013	0.009	0.002	0.010	0.008	0.007	0.006	0.001	0.001
Copper	T-Cu	0.002-0.004	1	***0.030***	***0.069***	***0.048***	***0.019***	***0.052***	***0.068***	***0.075***	***0.129***	***0.061***	***0.133***
Iron	T-Fe	0.3	0.3	***11.9***	***29.3***	***20.9***	***4.47***	***14.0***	***6.63***	***15.3***	***9.95***	***4.86***	***5.26***
Lead	T-Pb	0.001-0.007	0.01	***0.003***	***0.013***	***0.009***	***0.004***	***0.006***	***0.013***	***0.011***	***0.008***	***0.001***	***0.002***
Magnesium	T-Mg	—	—	—	—	—	—	—	22.2	—	23.7	23.9	23.7
Manganese	T-Mn	—	0.05	0.99	0.72	0.45	0.14	0.66	0.590	0.45	0.670	0.182	0.200
Mercury	T-Hg	0.0001	0.001	0.00008	***0.00020***	***0.00012***	***0.00013***	***0.00012***	<0.00001	***0.00013***	0.00009	<0.00001	<0.00001
Molybdenum	T-Mo	—	—	0.005	0.002	0.012	0.003	0.010	<0.001	0.005	0.003	0.001	<0.001
Nickel	T-Ni	0.025-0.15	—	0.015	***0.062***	***0.036***	0.005	0.023	0.019	0.011	0.007	0.001	0.002
Selenium	T-Se	0.001	0.01	—	—	—	—	—	<0.0005	—	0.0009	<0.0005	<0.0005
Silicon	T-Si	—	—	—	—	—	—	—	17.7	—	14.5	10.4	9.55

Notes 1) Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Turbidity (NTU).
2) Italic bold shaded values indicate exceedance of the BC Environmental freshwater aquatic life criteria.
(Approved and Working Criteria for Water Quality - 1994, BC Environment, Victoria)
3) The letter d after the monitoring well identification name means that it is a duplicate sample, eg R-95-4d
4) A < sign mean that the value is less than the detection limit stated.

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TAILINGS STORAGE FACILITY BASELINE GROUNDWATER QUALITY (con't)

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Last Update: 7 May, 96

		1994 BC Environment Water Quality Criteria		MP89-231 Nov 25/89	MP89-232 Nov 25/89	MP89-233 Nov 25/89	MP89-234 Nov 25/89	MP89-234 Sept 22/95	MP89-235 Nov 25/89	MP89-236 Nov 25/89	MP89-236 Jan 17/95	MP89-236 Sept 22/95	MP89-236d Sept 22/95
		Freshwater Aquatic Life	Drinking Water										
Total Metals													
Silver	T-Ag	0.0001	---	***0.0003***	***0.0003***	***0.0005***	<0.0001	<0.0001	***0.0004***	***0.0002***	***0.0020***	<0.0001	<0.0001
Strontium	T-Sr	---	---	---	---	---	---	0.841	---	---	2.06	2.07	2.03
Titanium	T-Ti	---	---	---	---	---	---	0.07	---	---	0.031	0.011	<0.010
Uranium	T-U	---	0.1	---	---	---	---	0.00122	---	---	0.00106	0.00103	0.00104
Vanadium	T-V	---	---	---	---	---	---	0.031	---	---	<0.030	<0.030	<0.030
Zinc	T-Zn	0.03	5	***0.044***	***0.066***	***0.078***	0.024	0.026	***0.064***	***0.039***	***0.049***	0.01	0.008
Dissolved Metals													
Aluminum	D-Al	---	---	0.045	0.13	0.027	0.029	0.024	0.015	0.014	0.035	0.023	0.015
Antimony	D-Sb	---	---	---	---	---	---	<0.0001	---	---	0.0017	0.0003	0.0003
Arsenic	D-As	---	---	0.0018	0.0024	0.0015	0.066	0.0231	0.0008	0.0008	0.0006	0.0002	0.0001
Barium	D-Ba	---	---	---	---	---	---	0.069	---	---	0.023	<0.010	<0.010
Beryllium	D-Be	---	---	---	---	---	---	<0.005	---	---	<0.005	<0.005	<0.005
Bismuth	D-Bi	---	---	---	---	---	---	<0.10	---	---	<0.10	<0.10	<0.10
Boron	D-B	---	---	---	---	---	---	0.25	---	---	<0.10	<0.10	<0.10
Cadmium	D-Cd	---	---	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Calcium	D-Ca	---	---	---	33.4	46.6	16.1	32.9	128	39.7	43.0	53.1	53.5
Chromium	D-Cr	---	---	0.002	0.002	0.001	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	---	---	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001
Copper	D-Cu	---	---	0.006	0.007	0.001	<0.001	<0.001	0.009	<0.001	<0.001	0.004	<0.001
Iron	D-Fe	---	---	2.08	0.35	<0.03	<0.03	0.037	<0.03	<0.03	<0.030	0.068	<0.030
Lead	D-Pb	---	---	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Magnesium	D-Mg	---	---	14.0	3.15	19.2	9.50	17.4	26.6	18.6	19.2	23	23.1
Manganese	D-Mn	---	---	0.78	0.21	0.13	0.036	0.037	0.43	0.066	0.011	<0.005	<0.005
Mercury	D-Hg	---	---	<0.00005	<0.00005	<0.00005	<0.00005	---	<0.00005	0.00005	---	---	---
Molybdenum	D-Mo	---	---	0.005	0.002	0.009	0.003	<0.001	0.006	0.003	0.003	0.003	<0.001
Nickel	D-Ni	---	---	0.006	0.013	0.007	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001
Potassium	D-K	---	---	4.00	1.13	1.10	1.78	2.21	4.27	2.05	1.97	2.55	2.63
Selenium	D-Se	---	---	---	---	---	---	<0.0005	---	---	0.0009	<0.0005	<0.0005
Silicon	D-Si	---	---	---	---	---	---	8.77	---	---	6.60	7.73	7.8
Silve	D-Ag	---	---	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	---	---	180	7.97	8.30	66.0	32.4	686	42.9	44.0	14.0	14.7
Strontium	D-Sr	---	---	---	---	---	---	0.651	---	---	1.68	1.96	1.98
Titanium	D-Ti	---	---	---	---	---	---	<0.010	---	---	<0.010	<0.010	<0.010
Uranium	D-U	---	---	---	---	---	---	0.00069	---	---	0.00078	0.00092	0.00098
Vanadium	D-V	---	---	---	---	---	---	<0.030	---	---	<0.030	<0.030	<0.030
Zinc	D-Zn	---	---	0.025	0.011	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Organic Parameters													
Total Organic Carbon	C	---	---	---	---	---	---	---	1.0	---	1.1	1.0	0.8

Notes 1) Results are expressed as milligrams per litre except for pH, Conductivity (umhos/cm), and Turbidity (NTU).
2) Italic bold shaded values indicate exceedance of the BC Environmental freshwater aquatic life criteria, (Approved and Working Criteria for Water Quality - 1994, BC Environment, Victoria)
3) The letter d after the monitoring well identification name means that it is a duplicate sample, eg R-95-4d
4) A < sign mean that the value is less than the detection limit stated.

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

REPORT ON GEOTECHNICAL INVESTIGATIONS AND DESIGN OF OPEN PITS AND WASTE DUMPS
(REF. NO. 1628/1)

JULY 5, 1996

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REPORT ON GEOTECHNICAL INVESTIGATIONS AND DESIGN OF OPEN PITS AND WASTE DUMPS

(REF. NO. 1628/1)

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IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

REPORT ON
GEOTECHNICAL INVESTIGATIONS AND DESIGN OF OPEN PITS AND WASTE DUMPS

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Appendix B	Drill hole data and point load test results
Appendix C	Test pit logs - 1995

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

REPORT ON GEOTECHNICAL INVESTIGATIONS AND DESIGN OF OPEN PIT AND WASTE DUMPS

SECTION 1.0 - INTRODUCTION

1.1 GENERAL OVERVIEW

The Mt. Polley Project is located in central British Columbia approximately 56 kilometres north-east of Williams Lake, as shown on Figure 1.1. The nearest settlement is the community of Likely, which is located on the northern tip of Quesnel Lake.

The project derives its name from Mt. Polley, a low mountain with a peak elevation of 1260 metres, approximately 300 metres above the surrounding terrain. Mt. Polley is situated between Polley Lake to the east, and Bootjack Lake to the south-west. The site is accessible by paved road from Williams Lake to Morehead Lake, near Likely, and then by gravel forestry road for the final 10 kilometres to the site.

The project involves open pit mining of an estimated 82.3 million tonnes of copper and gold ore contained in three adjacent orebodies, at a nominal rate of 17,800 tonnes per day. Approximately 92.6 million tonnes of waste rock will be stored in waste rock dumps adjacent to the open pit.

After processing of the ore to produce a copper/gold concentrate, the tailings will be discharged as a slurry into a tailings storage facility designed to provide environmentally secure storage of the solids waste, with collection and recycling of all process solutions. No discharge of process solutions from the site is required.

This report is an updated version of the 1990 Knight Piésold report "Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility" prepared for Imperial Metals Corporation. Details related to the tailings storage facility have been omitted. New information concerning modified waste rock dump sites, geotechnical investigations throughout the site, project water management plans, proposed reclamation program, pit bench design, and proposed pit dewatering plans have been incorporated in this report. All new or revised information has been derived from the following documents by Knight Piésold Ltd:

- March 1995 "Report on Geotechnical Investigations for Mill Site and Tailings Storage Facility" (Ref. No. 1623/1).
- February 1995 "Report on Project Water Management" (Ref. No. 1624/1).
- March 1996 "Hallam Knight Piésold Reclamation Plan Report"
- June 1996 "Groundwater Monitoring Program" (Ref. No. 1624/2).

1.2 SCOPE OF REPORT AND ACKNOWLEDGEMENTS

This report summarizes the design for the open pit and waste dumps with a brief discussion on the project water management plans. It is based on the results of field investigations and laboratory testwork. Specific design items which are addressed in the report are:

- Site characteristics including hydrometeorology, regional geology and seismicity.
- The results of geotechnical investigations carried out in the open pit and waste dump areas.
- Assessment of open pit geology, rock mass characteristics, hydrogeology, and dewatering requirements.

- New layout of the waste rock dumps and an assessment of the hydrogeologic impacts.

- Water management plans.

These items are discussed in the following sections of the report and are intended to provide input towards a Work Systems Approval.

All field geotechnical work was carried out under the direction of Knight Piésold Ltd. personnel with active involvement of Imperial Metals Corporation field personnel.

A comprehensive review of geotechnical data pertaining to the open pit design was carried out by Mr. C.O. Brawner, P. Eng. Results of this review with recommendations for open pit slope design are summarized in Section 4.0 of the 1990 Knight Piésold "Report on Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility, Ref. No. 1621/1", and are included in this report as Appendix A.

SECTION 2.0 - SITE CHARACTERISTICS

2.1 HYDROMETEOROLOGY

Long and short term climate records are available for a number of locations in the area, as shown on Figure 2.1. Two recently established stations (Likely with 12 years of record and Horsefly with 17 years) are located within 40 km of the site in similar terrain. The project area is subjected to a relatively temperate climate with warm summers and cool winters. The precipitation is well distributed throughout the year.

Detailed climatological summaries from 1984 to 1990 for weather stations from within the project area are included in Appendix A of the 1990 Knight Piésold report, Ref. No. 1621/1. Site specific data collected from July 1995 to January 1996 is available in the 1996 Hallam Knight Piésold "Reclamation Plan" report.

The mean annual temperature at Likely, the nearest station to the site, is 4.0°C with an extreme maximum of 33.9°C and an extreme minimum of -37°C. At Quesnel, with approximately 76 years of record, extremes are 40.6°C and -46.7°C. Frost free days in the area range from 199 at Horsefly Lake (elevation 788 m) to 244 at Barkerville (elevation 1244 m).

A preliminary estimate of the total annual and monthly distribution of precipitation for the site has been made using data from a number of stations in the area. The mean annual precipitation at Likely is 699.7 mm and at Barkerville (with over 76 years of record) is 1043.9 mm. Precipitation for the site can be expected to fall within this range. The 1996 Knight Piésold "Groundwater Monitoring Program" report gives a mean annual site precipitation of 755mm. Data for Likely, Barkerville and the site are presented in Table 2.1.

Short term storm intensity, duration, and return period curves have been plotted using data obtained from the rainfall frequency atlas for Canada, and are shown on Figure 2.2. Probable maximum precipitation for the site has also been calculated from data contained in this atlas and is shown on Table 2.2.

Evaporation data and estimated evaporation for the site have been computed using potential evapotranspiration by AES using the Thornwaite model and available data for Quesnel and Williams Lake. This data is shown in Table 2.3. Canadian Climate Normals, Volume 9 contains lake evaporation data for Mica Creek and Blue River which are at similar latitude to the mine site but are judged to be too distant to be relevant.

2.2 REGIONAL GEOLOGY

The Mt. Polley site is located in an alkalic intrusive complex in the Quesnel Trough, a 35 km wide north-west trending volcanic sedimentary belt.

The rock units are segmented into blocks by several faults, including an inferred north-westerly trending normal fault which extends along Polley Lake. The predominant structural orientation of the region is north-west trending and dipping steeply to the north-east. Localized geology in the vicinity of the open pit is shown on Drawing 1628.101.

The topography is generally subdued and has been glaciated. Surficial deposits of well graded, dense glacial till material are common throughout the region and are typically present in greater thicknesses in topographic lows. Bedrock exposures are common at high elevations.

2.3 SEISMICITY

The Mt. Polley site is situated within an area of very low seismic activity. A seismic risk calculation based on a Cornell type probabilistic model has been developed by the Pacific Geoscience Centre. The results for the Mt. Polley site are included as Table 2.4 and are summarized as follows:

Return Period (yrs)	Probability of Exceedence in 50 years (%)	Peak Ground Acceleration (g)	Peak Ground Velocity (m/s)
100	40	.021	.043
475	10	.037	.077
1000	5	.046	.094

The project is located in a NBCC Acceleration Zone 0, and Velocity Zone 1 for structural design requirements.

SECTION 3.0 - GEOTECHNICAL INVESTIGATIONS AND TESTING

3.1 GENERAL

Geotechnical investigations have been carried out to provide design criteria for the proposed open pit and waste dumps facilities. Investigative work consisted of field mapping, test pit excavations, installation of ground water monitoring wells, and diamond drilling with permeability testing. The following provides a summary of the investigation work:

- 1989 - A diamond drilling program and hydrogeologic investigation was conducted by Imperial Metals Corporation, in conjunction with exploration drilling. A total of thirty-nine geotechnical drill holes, including three holes with oriented drill core, were completed in the open pit areas, as shown on Figure 3.1. Details from the oriented drill holes are included as Appendix B. Nine groundwater monitoring wells were also completed, as shown on Figure 3.1.

- 1995 - A geotechnical investigation program consisting of thirty-nine test pits was completed by Knight Piésold throughout the project area. Test pit logs are included as Appendix C. Seven groundwater monitoring wells were completed in the vicinity of the open pits and mill site.

Evaluation of site conditions and geotechnical design criteria were based on the following:

(i) Open Pit

- Detailed logging of rock mass discontinuity data in oriented drill core from angled drill holes, and non-oriented drill core from vertical exploration holes (1989).

- Selected laboratory testing of fault gouge material (1990).

- Permeability testing in vertical drill holes (1989)

- Installation of three pneumatic and standpipe piezometers (1989), and installation of groundwater wells monitoring flow from the pit to Bootjack Lake (1995).

(ii) Waste Dumps

- Laboratory studies on the acid generation potential of waste rock (1990).

- Condemnation drilling in the vicinity of the proposed waste dumps (1989).

- Groundwater well monitoring flow from the south-east dump to Polley Lake (1995).

3.2 OPEN PIT

3.2.1 General Description

The open pit will consist of three interconnecting pits, namely the Central, North and West Pits as shown on Drawing 1625.230. The Central and North Pits will extend approximately 1,100m in a north-south direction and the Central and West pits approximately 1,100m in an east-west direction. The total area of the open pits at the conclusion of the operation will be approximately 70 ha. Mining is scheduled to commence in the Central Pit. Development of the North and West Pits will follow.

3.2.2 Geotechnical Drilling

The exploration program conducted by Imperial Metals Corporation in 1989 was expanded to provide additional information on the rock structure within the proposed open pit areas. Geotechnical drill logs were developed in addition to the geologic logs for 39 drill holes. The drill hole locations are shown on Figure 3.1. The following parameters were routinely recorded:

- RQD (rock quality designation)
- Discontinuity spacing and description of surface conditions
- Discontinuity orientation with respect to the core axis
- Discontinuity infilling materials
- Point load test results

Three inclined geotechnical drill holes, MP89-152, MP89-153 and MP89-154 were drilled in 1989 to provide true orientation of the rock discontinuities.

Stereonet plots of the joint and fracture orientations measured in each of the three inclined holes have been developed by the Schmidt contouring method and are presented in Figures 3.2, 3.3 and 3.4. A combined plot of all discontinuity data is included in Figure 3.5. A summary of rock types, RQD, fracture index and unconfined compressive strength data for the three inclined geotechnical drill holes is included as Appendix B.

The predominant rock types encountered were intrusion breccia, syenodiorite and monzonite, with minor occurrence of mafic dykes. Several fracture zones were identified and occasional clayey to sandy zones of fault gouge were encountered in the drill core. Two samples of fault gouge were analyzed in the laboratory as follows:

Drill Hole	MP89-143	MP89-152
Depth	38 m (125 ft)	90 m (245 ft)
Gradation		
Gravel	6 percent	7 percent
Sand	28 percent	16 percent
Silt	46 percent	23 percent
Clay	20 percent	54 percent
Atterberg Limits		
L.L.	57 percent	86 percent
P.L.	26 percent	36 percent
P.I.	31 percent	50 percent
Pocket Penetrometer	disturbed	4.5 tons/ft^2
Natural Moisture Content	23.5 percent	26.5 percent

In general, the rock mass quality comprising the proposed open pit walls was found to have variable conditions, ranging from strong and fresh to weak and altered rock. The uniaxial compressive strength of intact core samples ranged from very high (>200 MPa) to very low (<5 Mpa). Zones of very weak and highly altered rock were identified at localized intervals in most drill holes. Highly fractured zones up to 100 metres in thickness were encountered in several drill holes. Zones of increased fracturing, more intense alteration and lower rock mass quality are recognized to be generally associated with large scale structural features such as faults and contacts between the intrusive geologic units.

Discontinuities in the rock mass generally reflect the regional structural trend, as the dominant joint set was observed to strike 170 degrees and dip 75 degrees to the north-east. A secondary joint set was found to be approximately orthogonal to the main set, striking 30 degrees and dipping 20 degrees to the north-west. Discontinuities observed in the core were generally rough, and contained calcite and chlorite cementation. However, smooth, polished and slickensided joints were also identified. It should be noted that these orientations are based on the results of oriented core from three drill holes. Information on rock mass structure from the other cored drill holes supports these general orientations, however a more comprehensive model of the rock mass structure will be established with the initial development of the open pit.

3.2.3 Permeability Testing

Permeability testing was completed in five vertical exploration holes in 1989 as shown on Figure 3.1. The test apparatus consisted of an NQ double packer wireline system with a flow meter and pressure gauge for accurate monitoring of test conditions.

The test results are included in Table 3.1. In general, the measured rock formation permeabilities were less than about 1 x 10^{-5} cm/s, but occasional higher permeability zones (approximately 10^{-4} cm/s to 10^{-3} cm/s) were encountered, often associated with zones of intensely fractured bedrock. The geometric mean of all the permeability tests is 8.4 x 10^{-6} cm/s.

3.2.4 Groundwater Monitoring

Groundwater instrumentation installed in 1989 in the open pit area included three 40 mm diameter standpipe piezometers for water level measurement and groundwater sampling. These wells are still operational. Two multiple port pneumatic piezometers were installed for measurement of water levels and hydraulic gradients, but their status is unknown. Water level measurements were also obtained in open drill holes at the site. In August 1995, three groundwater monitoring wells were installed in the vicinity of Bootjack Lake to monitor the groundwater flow from the open pit and the mill site. An additional monitoring well was installed to monitor the groundwater flow from the east waste dump to Polley Lake. These are discussed in the 1996 Knight Piésold groundwater monitoring report, Ref.

No. 1624/2. This report reviews past well monitoring programs and presents the results of the 1995 wells. It serves as a compilation of the current understanding of the site's hydrogeological conditions and the anticipated impacts that will result from the project development.

In general, groundwater levels around the project area were measured at depths in the order of 30 metres at higher elevations, and 3 to 10 metres at lower elevations, as summarised in Table 3.2. Hydraulic gradients measured in the multiple port installations appeared to be approximately hydrostatic, however, temporary artesian flows were encountered in a few holes during drilling.

3.2.5 Pit Dewatering

Water inflow into the open pits results from groundwater seepage and surface runoff. While groundwater seepage is assumed to be relatively constant over the life of the mine, surface water inflows can be more variable depending on open pit area, precipitation levels and surface water diversions surrounding the pit perimeters. Groundwater flow is difficult to predict accurately, but experience at other mines suggests that the inflow will be in the order of 0.005 m^3/s to 0.025 m^3/s. These rates may be temporarily higher if permeable fracture systems are intersected, but short term dewatering of these fracture zones should occur.

Surface water inflow due to direct precipitation will vary according to rainfall intensity, and is expected to average about 0.01 m^3/s to 0.02 m^3/s on an average annual basis depending on the undiverted catchment area of the pit(s). These values are based on an average annual precipitation of 755 mm/yr (as discussed in Section 2.1), a runoff coefficient of 75% and initial and final pit areas of 41 ha and 90 ha respectively.

Water accumulating in the pit bottom will be transferred to an in-pit sump located on the East side of the Central Pit, about 60 metres above the ultimate base. From there, it will be pumped to the mill for use as process water or discharged into the tailings basin. However, during storm events considerable water will accumulate in the pit bottom where it will be temporarily stored in a bottom sump until it is transferred to the higher sump. Pumping requirements will be determined during initial operations and the pumping capacity will be selected to accommodate increased pumping requirements during and after storm events.

If additional water storage capacity is required, a separate external pit sump may be installed during later mine operations.

Perimeter dewatering wells, and/or horizontal drains may be installed in and around the pits to draw down groundwater levels should it be necessary to control seepage and enhance pit slope stability. These requirements will be progressively determined during mine development.

In the later years of mine operation, the Central Pit may be used for waste rock disposal while the West Pit is mined. Groundwater and surface runoff could then accumulate in the Central Pit and may result in increased lateral seepage rates into the West and North Pits. The West Pit is about 50 metres deeper than the Central Pit and seepage would occur through a bench approximately 150 m high which separates the two pits. The permeability of the bedrock throughout the pit area has been determined to be less than approximately 1×10^{-5} cm/s, but may range from 1×10^{-4} cm/s to 1×10^{-3} cm/s in zones of fractured bedrock (natural geologic fracture zones and/or blast damaged zones). There are three geologic contacts in the vicinity of the bench which have been identified as zones of weak and highly altered rock. These discontinuities could serve as relatively high permeability seepage paths into the West Pit and will be evaluated during initial and ongoing pit development.

The North and Central Pits are separated by a larger bench, approximately 100 m high. Both pits are of the same depth. A north-south trending fault has been found which cuts the west side of the bench and could be a zone of high permeability which will be evaluated during future pit development. It is unlikely that seepage from the Central to North Pits will be a significant consideration due to long seepage path lengths and low seepage gradients.

3.3 WASTE DUMPS

3.3.1 Waste Characterisation

A detailed program of acid/base accounting was completed in 1989 and 1990 on potential waste rock materials from the open pit. This program involved the collection of random samples of drill core and subsequent analyses for:

- total sulphur
- neutralization potential
- total acid generation potential (calculated on the basis of total sulphur)

These tests were carried out by Envirochem Services Ltd. and Coastech Research, both of North Vancouver, B.C. The results of the waste characterization tests for the 94 samples tested are included in Appendix C of the 1990 Knight Piésold report, Ref. No. 1621/1. The testwork indicates that the waste rock will not be acid generating. ARD tests are discussed extensively in the 1996 Hallam Knight Piésold "Reclamation Plan Report".

3.3.2 Surficial Materials

The revised waste dump sites are shown on Drawing No. 1625.230. In general, the sites are characterized by gently undulating topography. The Central pit may be used for waste rock disposal when development of the west pit proceeds during the later stages of operation.

The North dump is situated on a relatively flat area with bedrock knobs and ridges. Colluvium, glacial till and forest litter were encountered along the flat area to a maximum thickness of approximately 20 metres. The North dump has a capacity for 16 million tonnes and will likely be used during the mining of the North Pit later on in the mine life.

The South-East dump is situated along the crest of a broad ridge. The topography is relatively flat and undulating. A veneer of colluvium, glacial till and forest litter is present over most of the area. Bedrock was encountered in drill holes at depths ranging from approximately 3 to 7.6 metres.

Groundwater in the vicinity of the waste dumps is generally shallow with flow directions governed by the surface topography.

SECTION 4.0 - OPEN PIT SLOPE DESIGN

4.1 GENERAL

This section provides a revised summary of Section 4.0 of the 1990 Knight Piésold "Report on Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility" authored by Mr. C.O. Brawner. A proposed blasting program and details of anticipated groundwater inflow and pumping requirements can be found in the original report, which is included as Appendix A.

4.2 FACTORS WHICH INFLUENCE PIT SLOPE STABILITY AND SLOPE ANGLE

Factors which influence rock slope stability of open pit mines include geologic structure, groundwater conditions and dynamic acceleration forces generated during blasting.

The potential for pit slope instability is generally related to the presence of adversely oriented geologic discontinuities in the pit slopes. Typical slope failure mechanisms include circular, planar, block, wedge, and toppling modes as shown in Figure 4.1.

The presence of groundwater in the pit slopes influences stability by reducing rock mass shear strength due to reduced effective stress, creating seepage forces towards the pit slopes, creating hydrostatic forces in tension cracks, and increasing hydrodynamic shock due to blasting below the water table. Consequently, it is important that low water levels and groundwater pressures be maintained in the pit slopes. The most effective way to develop this control is with the installation of horizontal drains. Drainage requirements can most effectively be determined during initial development of the open pit by inspection of bench faces for seepage, and through the drilling of exploratory drain holes.

Dynamic acceleration forces due to blasting must be reduced at the final pit face to allow the steepest practical slopes to be developed, thereby minimizing the waste to ore ratio. This requires controlled blasting techniques to maintain the design pit slope angles.

Slope movements, reflecting instability of the pit slopes, are typically indicated by the development of tension cracks along the pit or bench crests. Periodic inspections along the pit crest and bench locations will identify areas which may require further scaling and/or monitoring.

4.3 STRUCTURAL GEOLOGY

Three inclined boreholes, MP89-152 to MP89-154 were drilled using the clay imprint procedure to orient the rock mass structure. Stereographic plots are shown in Figures 3.2 to 3.5. The overall plots indicate a predominant joint set with an average strike of 170 degrees and an average dip of 75 degrees east. A secondary joint set was revealed striking on average 30 degrees and dipping 20 degrees north west. These geologic structures are the features which will influence slope stability throughout the pit walls, and potentially lead to certain types of instability in each pit face depending on the face orientation. The pit slope design must accommodate these potential failure mechanisms.

Generally, the rock strength is moderate to high so that stability will be controlled by the geologic structures. In addition to the joint sets described above, several localized zones featuring very closely spaced fractures, development of clayey gouge material and low compressive strength were noted. These localized zones may require additional design requirements, such as reduction of bench face angles, or installation of steel mesh and/or shotcrete to control bench face stability, which will be evaluated during development of the pit.

Details of the rock mass discontinuity data (R.Q.D. and joint frequency), together with unconfined compressive strength data, are provided in Appendix B.

4.4 EVALUATION AND CONTROL OF GROUNDWATER

The groundwater table is generally close to the ground surface, ranging from 30 metres depth in topographically higher areas, to 3 metres depth in lower elevations around the project area. In some cases, artesian conditions were encountered in exploration drill holes. Drainage measures will be developed in the pit allowing for pit walls to be excavated at the steepest slopes possible and to prevent potential bottom heaving of the pit floor. Drainage measures to control seepage into the pit and improve stability of the pit walls will include the installation of horizontal drain holes, as determined from observed conditions in the initial pit development.

4.5 PIT SLOPE AND BENCH DESIGN

Design of initial pit slopes is based on a relatively steep bench face of 70 degrees, with inter-ramp slope angles of 52 degrees, shown as Design I in Figure 4.2. This design is based on the available structural information, and assumes drained conditions in the pit slopes. Where favourable interaction of rock mass structure and pit wall geometry are revealed during initial pit development, Design II will be utilized to optimize pit slope angles. These two pit slope designs are included to accommodate the different combinations of geologic conditions and pit slope orientations. A summary of the proposed design geometry for pit slopes is presented in Table 4.1. It should be highlighted that pit slope design will be modified based on updated geology and on additional geotechnical information obtained during early pit development.

For final pit design, controlled blasting will be used to develop the relatively steep bench face angles. Bench faces will be scaled to reduce ravelling and reduce width requirements for catch berms. The most recent pit design was completed using Mintec's MEDSYSTEM software.

SECTION 5.0 - WASTE DUMP LAYOUTS

5.1 WASTE DUMP LOCATIONS AND CONSTRUCTION

Waste dump sites are shown on Drawing No. 1625.230. Selection of waste dump sites has included consideration of environmental and economic factors, in addition to optimization of waste rock haulage.

The waste dumps are generally situated on relatively flat topography and will be underlain by glacial till and bedrock. Sufficient quantities of suitable topsoil and glacial till will be stripped and stockpiled for reclamation of the dumps. The ultimate waste dumps, as shown on Drawing No. 1625.230 include final reclaimed slopes of 2h:1v. During operations, the waste rock will be placed in individual benches as required to control surface erosion.

Drainage ditches will be used to control surface runoff from the North and South-East waste dumps. The dumps will be graded to direct runoff from the tops of the dumps into the open pit areas. The ditches will collect runoff from the dump slopes and will transfer the water to sediment control ponds as shown on Drawing No. 1625.230. The water will then be discharged into the tailings basin. There will be three main perimeter drainage ditches, as follows:

- The first drainage ditch will run north to south along the eastern end of the South East waste dump.

- The second drainage ditch will run west to east along the southern end of the final limit of the South-East dump.

- The third drainage ditch will run south between the South-East waste dump and the mill site. It is then directed east and will connect to the first drainage ditch. This ditch will cut across the southern end of the South-East waste dump, to be used later in the mine life. As the dump advances, the ditch will be converted to a rock drain so that drainage can continue as the dump is developed. It is anticipated that natural segregation of coarser material will occur during waste rock placement. The coarser material will fall to the base of the advancing dump and the ditch will be filled with durable, coarse material. In the event that coarse, durable material is not available to fill the ditch, suitable material will be selected and placed in the ditch prior to covering it with the waste dump. This requirement will be evaluated as the waste dump develops.

Existing groundwater levels at the waste dump sites have been observed to be within a few metres of the ground surface, with a phreatic surface similar to the general topographical features. Due to the segregation of waste rock during placement, coarser particles will collect along the base of the dump providing free draining conditions within the waste dump materials.

5.2 STABILITY ANALYSES

Stability analyses of the waste dump have been carried out for a range of natural ground conditions and maximum dump height. A typical stability analysis is shown on Figure 5.1.

Strength parameters for the rockfill have been assumed from published information on the shear strength of rockfill by Leps (1970), and recommended values from the US Forest Service Intermountaine Region, Dump Stability Performance Objectives and Evaluation Criteria. These are summarized in Figure 5.2. Strength parameters for the foundation material are based on an in-situ layer of till, as stripping of topsoil and organic debris will be implemented.

The stability analyses were carried out for base translational failure along the waste rock/foundation contact using a non-circular analysis. The analyses were completed for the final reclaimed slopes of 2h:1v, using a maximum dump elevation of 1170 metres, as shown in Figure 5.1. The calculations take into account the maximum natural slope of the terrain in the waste dump area which does not exceed 38°. Previous stability analyses, outlined in the 1990 "Report on Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility" (ref 1621/1) indicated that for the final reclaimed dump slopes, a minimum factor of safety of 1.3 can be achieved for all terrain on site, regardless if topsoil is stripped.

However, topsoil stripping will be implemented in the waste dump locations, creating a factor of safety against failure greater than 1.5 on all terrain, as indicated in Figure 5.3. The topsoil will be used for reclamation, as discussed below.

5.3 RECLAMATION

Areas designated for waste rock storage will be logged, grubbed and cleared prior to mining. Topsoil, overburden and coarse woody debris will be removed and stockpiled. These materials will be removed in a staged manner so that material removed from each succeeding raise is replaced on the previously completed raise. This leapfrog pattern will reduce the need for large soil stockpiles, will minimize haul costs, and will accelerate the recolonization of reclaimed areas by native materials from soil seed banks, bud banks, and rooted offsets. Most importantly, reclamation of completed raises of the waste dumps will commence almost immediately instead of being deferred until the end of mining.

Waste rock dumps will be constructed by end dumping, re-contoured to an ultimate slope of 2h:1v, covered with a layer of overburden/topsoil and re-vegetated. Individual dumps will not exceed 50 m in height. The top surfaces of the stockpiles will drain toward the open pits, but will be designed to have ridges and depressions, to blend in with the surrounding topography and to create habitat diversity. The final surfaces will be covered with a layer of overburden and topsoil, then re-vegetated. Final reclamation of the waste dumps will involve spreading of topsoil and glacial till and seeding or planting as required.

For further discussion on proposed reclamation plans, refer to the 1996 Hallam Knight Piésold "Reclamation Plan Report".

SECTION 6.0 - WATER MANAGEMENT PLAN

An overview of all water associated with the Mt. Polley Project is provided in the 1995 Knight Piésold "Report on Project Water Management". An overall project water balance was completed by integrating the water balances for the mine site, including the open pits, waste dumps and mill site with the tailings facility and the undisturbed catchment areas immediately upgradient from it. The @RISK Analysis and Modelling program was used to describe the effects of the statistical nature of precipitation over the entire life of the project.

The report demonstrated that the tailings facility and open pit can and will be operated so that no surface discharge of excess water will be required and that make-up water requirements from Polley Lake will be minimized by addition and use of surface runoff from waste dumps and undisturbed catchment areas. Included in the report is the most recent hydrometeorological information obtained, including precipitation, snowmelt, evaporation and runoff. The report discusses assumptions made and presents conclusions and recommendations concerning make-up water supply and the project water management plan.

SECTION 7.0 - REFERENCES

Brown, Adrian., 1988. "Groundwater Evaluation and Control for gold Mining Projects," *Second International Conference on Gold Mining*, ed. C.O. Brawner (Littleton, Colorado: Society of Mining Engineers), pp. 219-233

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Imperial Metals Corporation, 1990. "Stage I Environmental and Socioeconomic Impact Assessment, Volume I of II".

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Knight Piésold Ltd., 1995. "Mt. Polley Project, Report on Project Water Management, Ref. No. 1624/1".

Knight Piésold Ltd., 1996 "Groundwater Monitoring Program, Ref. No. 1624/2"

TABLE 2.1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

MEAN MONTHLY AND ANNUAL PRECIPITATION

Location:	Likely, B.C.		Mine Site		Barkerville	
Elevation:	724 m		1000 m		1265	
Location:	52° 36'N 121° 32'W		52° 30'N 121° 35'W		53° 4'N 121° 31'W	
	Mean (mm)	Std. Dev. (mm)	Mean (mm)	Std. Dev. (mm)	Mean (mm)	Std. Dev. (mm)
Jan	74.2	27.0	75.5	27.0	103.0	44.4
Feb	60.2	27.7	58.1	27.7	85.6	42.5
Mar	37.8	13.5	44.5	13.5	85.3	29.1
Apr	42.2	20.9	43.1	20.9	61.8	24.5
May	36.6	15.4	50.6	15.4	65.9	28.9
June	66.3	29.7	81.5	29.7	89.2	28.8
July	47.0	27.4	65.7	27.4	81.7	31.0
Aug	82.0	35.7	83.1	35.7	102.3	53.0
Sept	50.4	27.1	60.4	27.1	85.4	39.9
Oct	61.6	42.3	60.4	42.3	88.4	37.4
Nov	58.4	18.8	57.3	18.8	86.6	28.2
Dec	83.0	36.9	74.8	36.9	108.7	42.5
Annual	699.7	116.4	755	116.4	1043.9	112.7

Source :

Canadian Climate Normals, 1951-1980, Temperature and Precipitation Atmospheric Environment Service, Environment Canada.

TABLE 2.2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

PROBABLE MAXIMUM PRECIPITATION

1 hour PMP = 78 mm = 78 mm/hour
6 hour PMP = 88 mm = 14.6 mm/hour
24 hour PMP = 163.3 mm = 6.8 mm/hour

Source :

Rainfall Frequency Atlas for Canada, W.D. Hogg, D.A. Carr, Supply and Services Canada 1985.

TABLE 2.3

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

ESTIMATED PAN EVAPORATION AT SITE

	Quesnel	Williams Lake	Site
May	98	88	93
June	130	124	127
July	151	144	148
August	131	129	130
September	81	77	79
October	39	38	38
Total	630	600	615

Source:

Based on computed potential evapotranspiration data by AES using Thornthwaite model, increased by an empirical factor of 1.25 to bring into line with pan evaporation data.

TABLE 2.4

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SEISMIC RISK CALCULATION

ENERGY, MINES AND RESOURCES CANADA GEOLOGICAL SURVEY OF CANADA	ENERGIE, MINES ET RESSOURCES CANADA COMMISSION GEOLOGIQUE DU CANADA
SEISMIC RISK CALCULATION *	CALCUL DE RISQUE SEISMIQUE *

REQUESTED BY/ DEMANDE PAR Jeremy Haile / Knight & Piesold Ltd. mj

SITE Mt. Polley, B.C.

LOCATED AT/ SITUE AU 52.55 NORTH/NORD 121.63 WEST/OUEST

PROBABILITY OF EXCEEDENCE PER ANNUM/ PROBABILITE DE DEPASSEMENT PAR ANNEE	0.010	0.005	0.0021	0.001
PROBABILITY OF EXCEEDENCE IN 50 YEARS/ PROBABILITE DE DEPASSEMENT EN 50 ANS	40 %	22 %	10 %	5 %
PEAK HORIZONTAL GROUND ACCELERATION (G) ACCELERATION HORIZONTALE MAXIMALE DU SOL (G)	0.021	0.028	0.037	0.046
PEAK HORIZONTAL GROUND VELOCITY (M/SEC) VITESSE HORIZONTALE MAXIMALE DU SOL (M/SEC)	0.043	0.056	0.077	0.094

* REFERENCES

1. NEW PROBABILISTIC STRONG SEISMIC GROUND MOTION MAPS OF CANADA: A COMPILATION OF EARTHQUAKE SOURCE ZONES, METHODS AND RESULTS. P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY EARTH PHYSICS BRANCH OPEN FILE NUMBER 82-33, OTTAWA, CANADA 1982.

2. ENGINEERING APPLICATIONS OF NEW PROBABILISTIC SEISMIC GROUND-MOTION MAPS OF CANADA. A.C. HEIDEBRECHT, P.W. BASHAM, J.H. RAINER, AND M.J. BERRY CANADIAN JOURNAL OF CIVIL ENGINEERING, VOL. 10, NO. 4, P. 670-680, 1983.

3. NEW PROBABILISTIC STRONG GROUND MOTION MAPS OF CANADA. P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY, BULLETIN OF THE SEISMOLOGICAL SOCIETY OF AMERICA, VOL. 75, NO. 2, P. 563-595, 1985.

4A. SUPPLEMENT TO THE NATIONAL BUILDING CODE OF CANADA 1985, NRCC NO. 23178. CHAPTER 1: CLIMATIC INFORMATION FOR BUILDING DESIGN IN CANADA. CHAPTER 4: COMMENTARY J: EFFECTS OF EARTHQUAKES.

4B. SUPPLEMENT DU CODE NATIONAL DU BATIMENT DU CANADA 1985, CNRC NO. 23178F. CHAPITRE 1: DONNEES CLIMATIQUES POUR LE CALCUL DES BATIMENTS AU CANADA. CHAPITRE 4: COMMENTAIRE J: EFFETS DES SEISMES.

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Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

TABLE 2.4 (Continued)

SEISMIC RISK CALCULATION

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SITE                                                   Mt. Polley, B.C.

     ZONING FOR ABOVE SITE/ ZONAGE DU SITE CI-DESSUS

     1985 NBCC/CNBC:   ZA = 0;   ZV = 1;   V = 0.05 M/S

  ACCELERATION ZONE/ ZONE D'ACCELERATION      ZA=0
  ZONAL ACCELERATION/ ACCELERATION ZONALE   0.00 G

  VELOCITY ZONE/ ZONE DE VITESSE              ZV=1
  ZONAL VELOCITY/ VITESSE ZONALE            0.05 M/S


                 1985 NBCC/CNBC **
   SEISMIC ZONING MAPS/ CARTES DU ZONAGE SEISMIQUE

             PROBABILITY LEVEL: 10% IN 50 YEARS
       NIVEAU DE PROBABILITE: 10% EN 50 ANNEES

         ------------------------------------
          G OR M/S    ZONE      ZONAL VALUE/
                               VALEUR ZONALE
         ------------------------------------
            0.00
                       0           0.00
            0.04
                       1           0.05
            0.08
                       2           0.10
            0.11
                       3           0.15
            0.16
                       4           0.20
            0.23
                       5           0.30
            0.32
                       6*          0.40
         ------------------------------------

   * ZONE 6:  NOMINAL VALUE/ VALEUR NOMINALE  0.40;
     SITE-SPECIFIC STUDIES SUGGESTED FOR IMPORTANT PROJECTS/
     ETUDES COMPLEMENTAIRES SUGGEREES POUR DES PROJETS D'IMPORTANCE.

  ** FOR NBCC APPLICATIONS, CALCULATED ZONE VALUES AT A SITE SHOULD BE
     REPLACED BY EFFECTIVE ZONE VALUES [ZA(EFF) OR ZV(EFF)] AS SHOWN BELOW/
    POUR APPLICATIONS SELON LE CNBC, ON DOIT REMPLACER LES VALEURS ZONALES
     CALCULEES POUR UN SITE PAR LES VALEURS EFFECTIVES [ZA(EFF) OU ZV(EFF)]
     COMME MONTRE CI-DESSOUS:

      1.   IF/SI (ZA - ZV) > 1,          ===>  ZA(EFF) = ZV + 1.
  OR/OU
      2.   IF/SI (ZA - ZV) < 1,          ===>  ZA(EFF) = ZV - 1.
  OR/OU
      3.   IF/SI ZV=0. AND/ET ZA > 0,    ===>  ZV(EFF) = 1.

       (SEE REFERENCE 2 CITED ABOVE, PAGE 677)
       (VOIR PAGE 677 DE LA REFERENCE 2 CI-DESSUS)

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TABLE 3.1

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SUMMARY OF PERMEABILITY TESTING IN OPEN PIT

Hole No.	Depth Interval (ft)	Measured Permeability (cm/s)
MP89-145	40-60	1.0×10^{-6}
	70-90	4.6×10^{-6}
	100-120	5.0×10^{-7}
	130-150	3.5×10^{-6}
	160-180	1.3×10^{-5}
	190-210	$< 3.0 \times 10^{-6}$
	220-240	8.7×10^{-7}
MP89-146	60-80	8.8×10^{-6}
	90-110	$5.0 \times 10\text{-}^{7}$
	120-140	6.9×10^{-7}
	150-170	3.1×10^{-6}
	180-200	1.5×10^{-5}
	210-230	5.7×10^{-6}
	240-260	2.2×10^{-6}
	270-290	3.7×10^{-6}
	300-320	1.1×10^{-5}
	330-350	1.6×10^{-4}
	360-380	1.5×10^{-6}
	390-410	$< 1.5 \times 10^{-6}$
	420-440	6.9×10^{-7}

TABLE 3.1 (Continued)

Hole No.	Depth Interval (ft)	Measured Permeability (cm/s)
MP89-146 (Con't)	460-480	9.8×10^{-7}
	480-520	1.0×10^{-6}
	520-560	2.5×10^{-6}
	600-640	4.8×10^{-6}
	640-700	2.0×10^{-6}
MP89-147	20-50	3.2×10^{-4}
	50-80	6.8×10^{-6}
	80-120	2.6×10^{-6}
	120-160	4.0×10^{-5}
	160-200	1.4×10^{-4}
	200-240	1.8×10^{-5}
	240-280	6.2×10^{-6}
	280-320	1.8×10^{-5}
	320-360	7.5×10^{-7}
	360-400	7.5×10^{-7}
MP89-148	20-60	1.0×10^{-4}
	60-100	6.6×10^{-4}
	100-140	3.0×10^{-3}
	140-180	4.2×10^{-4}
	180-220	4.8×10^{-5}
	220-260	3.0×10^{-5}
	260-300	7.2×10^{-6}
	300-340	4.9×10^{-4}

TABLE 3.1 (Continued)

Hole No.	Depth Interval (ft)	Measured Permeability (cm/s)
MP89-155	20-50	2.8×10^{-5}
	50-90	1.6×10^{-5}
	90-130	3.4×10^{-4}
	130-170	4.7×10^{-6}
	170-210	$< 1.0 \times 10^{-7}$
	210-250	$< 1.0 \times 10^{-7}$
	250-290	1.0×10^{-7}
	290-330	1.7×10^{-6}
	330-370	9.4×10^{-7}
	370-410	4.5×10^{-6}
	410-450	1.5×10^{-7}
	450-490	6.8×10^{-3}
	490-530	1.4×10^{-4}
	530-570	3.6×10^{-5}
	570-610	2.7×10^{-4}
	610-650	$< 1.0 \times 10^{-7}$
	650-700	$< 1.0 \times 10^{-7}$
Geometric Mean of all tests:		8.4×10^{-6} cm/s

TABLE 3.2

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

GROUNDWATER LEVELS IN PROPOSED OPEN PIT AREA

DEPTH TO GROUNDWATER TABLE (m) IN MONITORING WELLS

Date	MP89-107	MP89-146	MP89-151
August 16, 1989	28.0	14.7	35.5
November 8, 1989	10.0	10.5	31.0

DEPTH TO PHREATIC SURFACE (m) IN MULTIPLE PNEUMATIC PIEZOMETERS

	MP89-147A	-147B	-147C	MP89-155A	-155B
Tip Depth (m)	27.6	59.0	88.8	7.8	157.7
Date					
August 2, 1989	3.2	2.6	4.5	-	-
August 15, 1989	3.5	2.4	4.6	-	-
November 12, 1989	2.2	1.6	9.2	2.7	*

* Reading beyond capacity of read-out box.

TABLE 4.1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

PRELIMINARY SLOPE DESIGN

DESIGN SECTOR	PIT SLOPE ORIENTATION	BENCH FACE ANGLE	BENCH HEIGHT (m)	BENCH WIDTH (m)	INTER-SLOPE ANGLE
I	All slopes	70°	20	8.5	52°
II	Favourable conditions	75°	20	8.5	55°

Notes: 1. Pit slope design based on fully drained slope conditions.

2. Pit slope design to be reviewed during initial development of pit, as actual conditions are encountered.

1628.A3

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
PROJECT LOCATION PLAN

CAD FILE: \ 1628\FIG\A3 Plot 1=1

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FIGURE 1.1

1625.A16

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
LOCATION OF WEATHER STATIONS

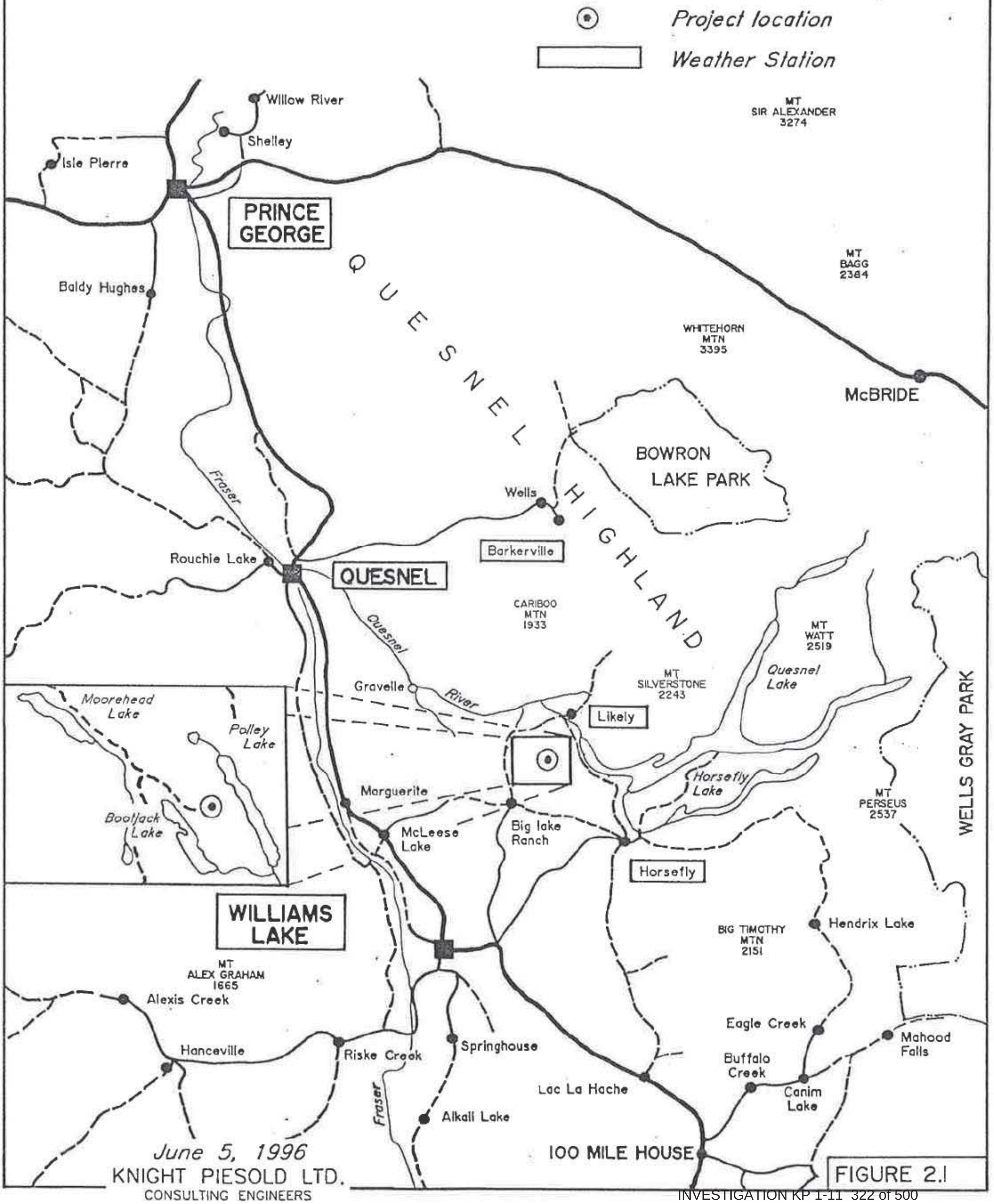

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FIGURE 2.1

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SHORT DURATION RAINFALL INTENSITY – DURATION – FREQUENCY DATA FOR MINE SITE

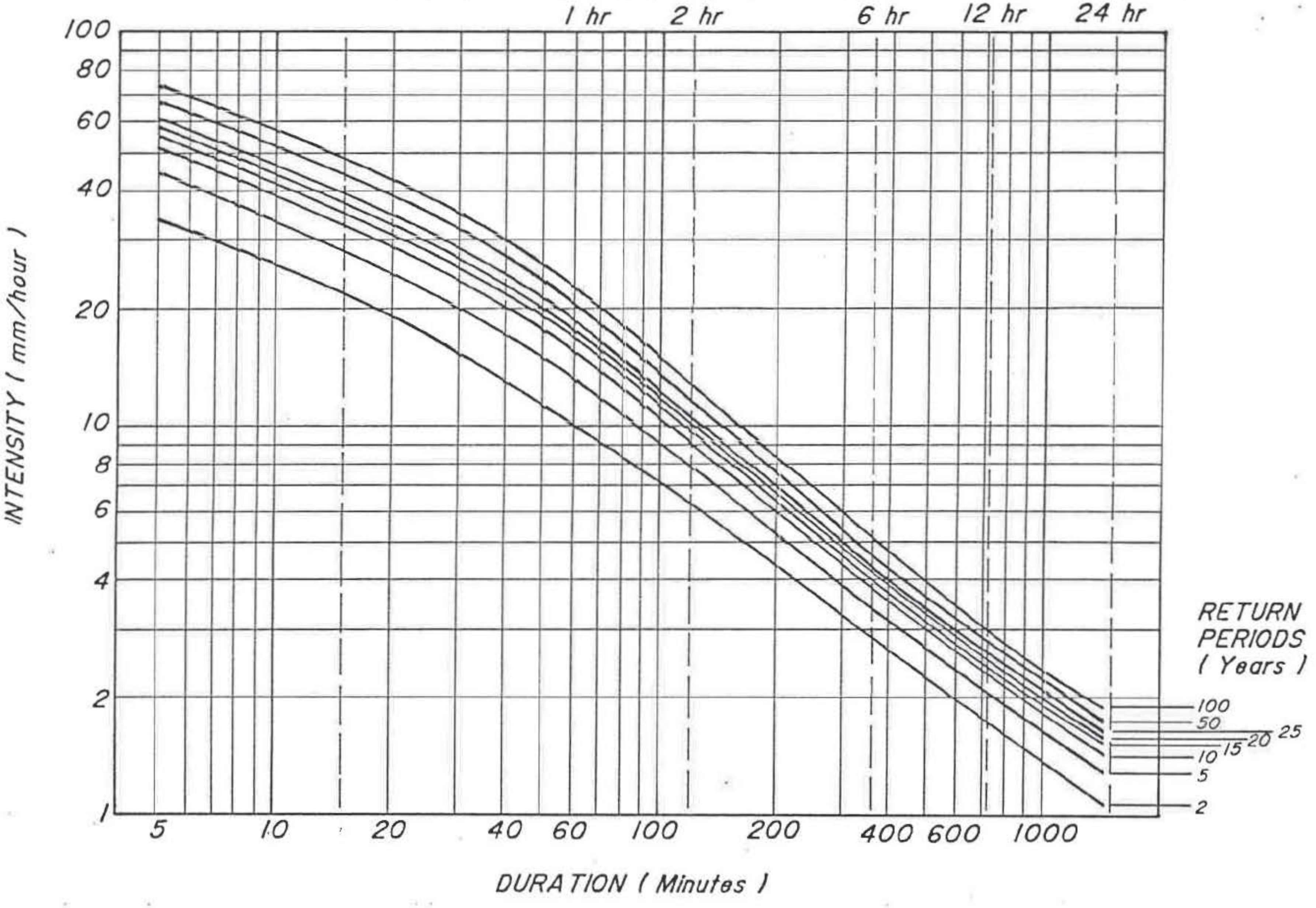

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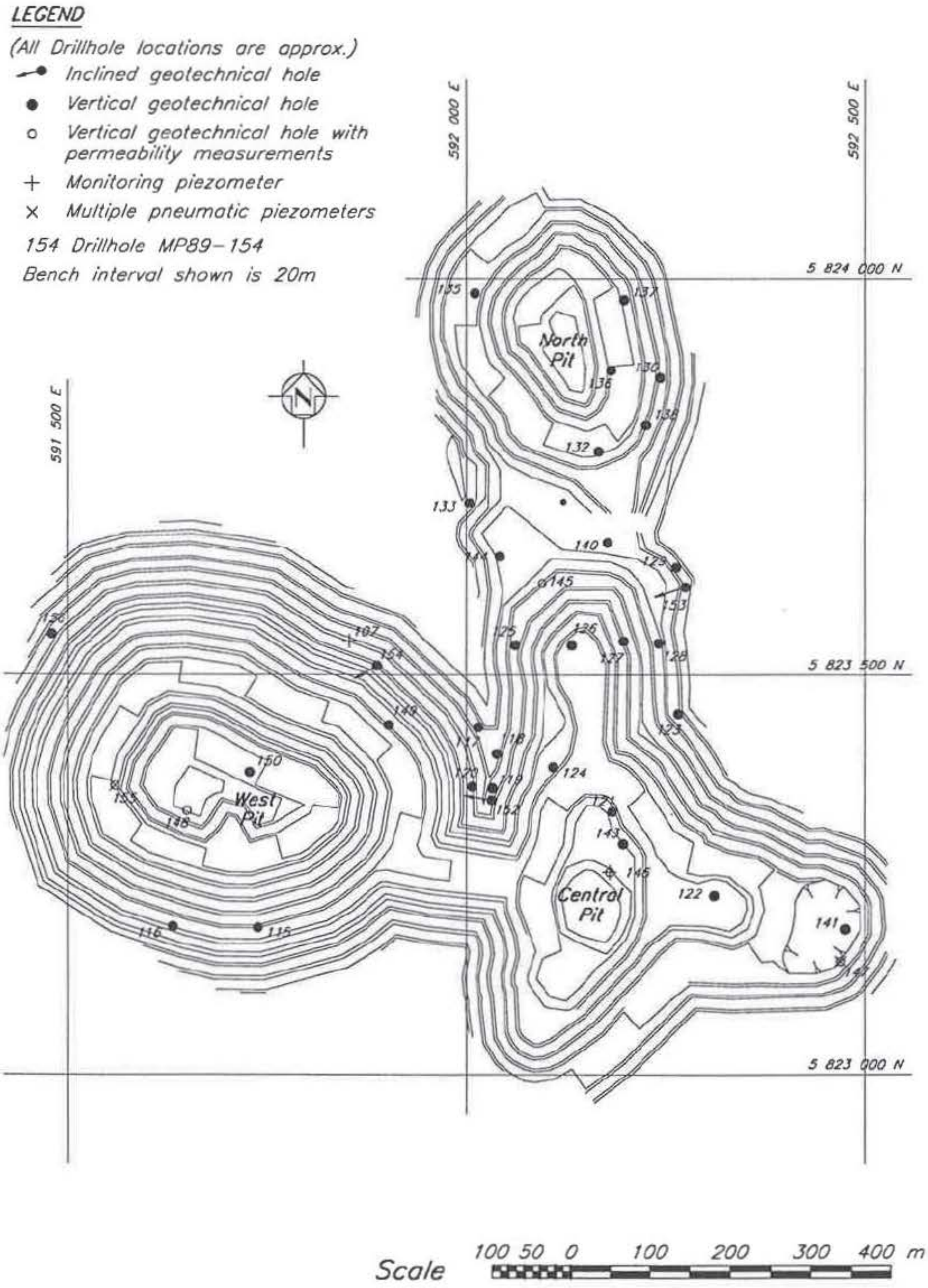
FIGURE 2.2

1625.A1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
OPEN PIT LAYOUT AND
GEOTECHNICAL DRILL HOLE LOCATIONS



LEGEND

(All Drillhole locations are approx.)

- ⊸● Inclined geotechnical hole
- ● Vertical geotechnical hole
- ○ Vertical geotechnical hole with permeability measurements
- \+ Monitoring piezometer
- × Multiple pneumatic piezometers

154 Drillhole MP89–154

Bench interval shown is 20m

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FIGURE 3.1

CAD FILE: \1628\FIG\A1 1:6000 Plot 1=8

NCI-763

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SUMMARY OF JOINT DATA FOR MP89-152

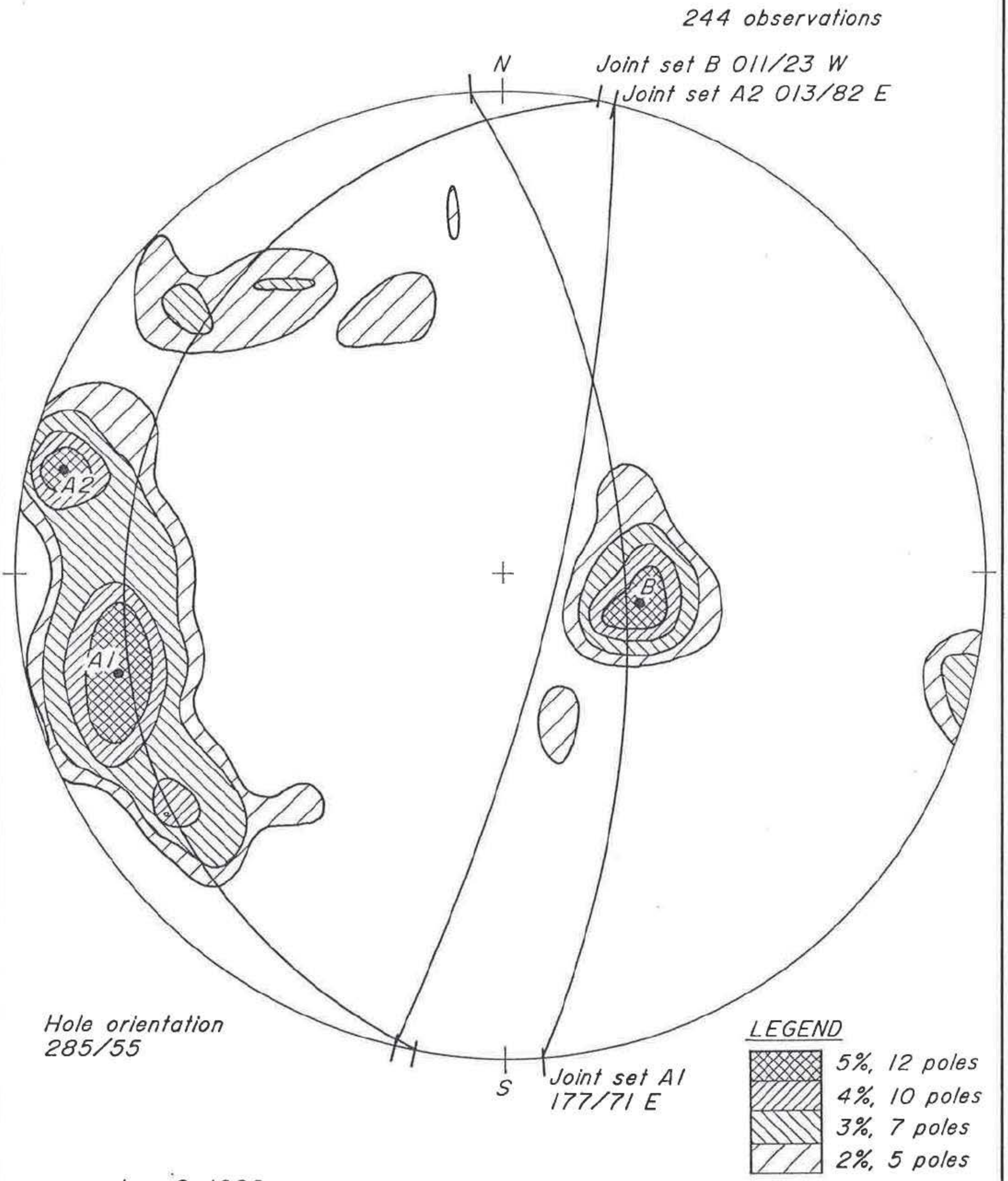

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FIGURE 3.2

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SUMMARY OF JOINT DATA FOR MP89-153

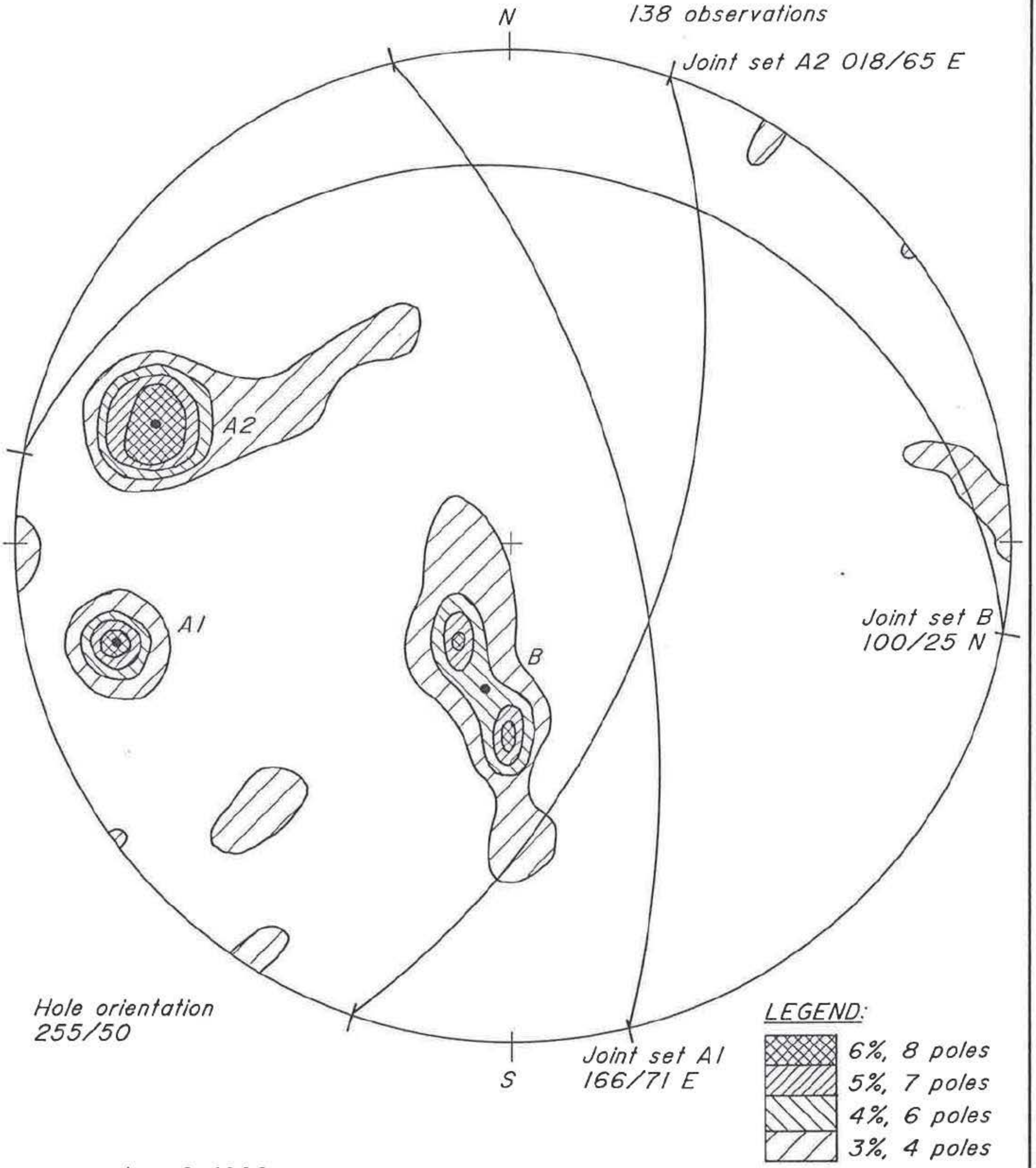

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FIGURE 3.3

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SUMMARY OF JOINT DATA FOR MP89-154

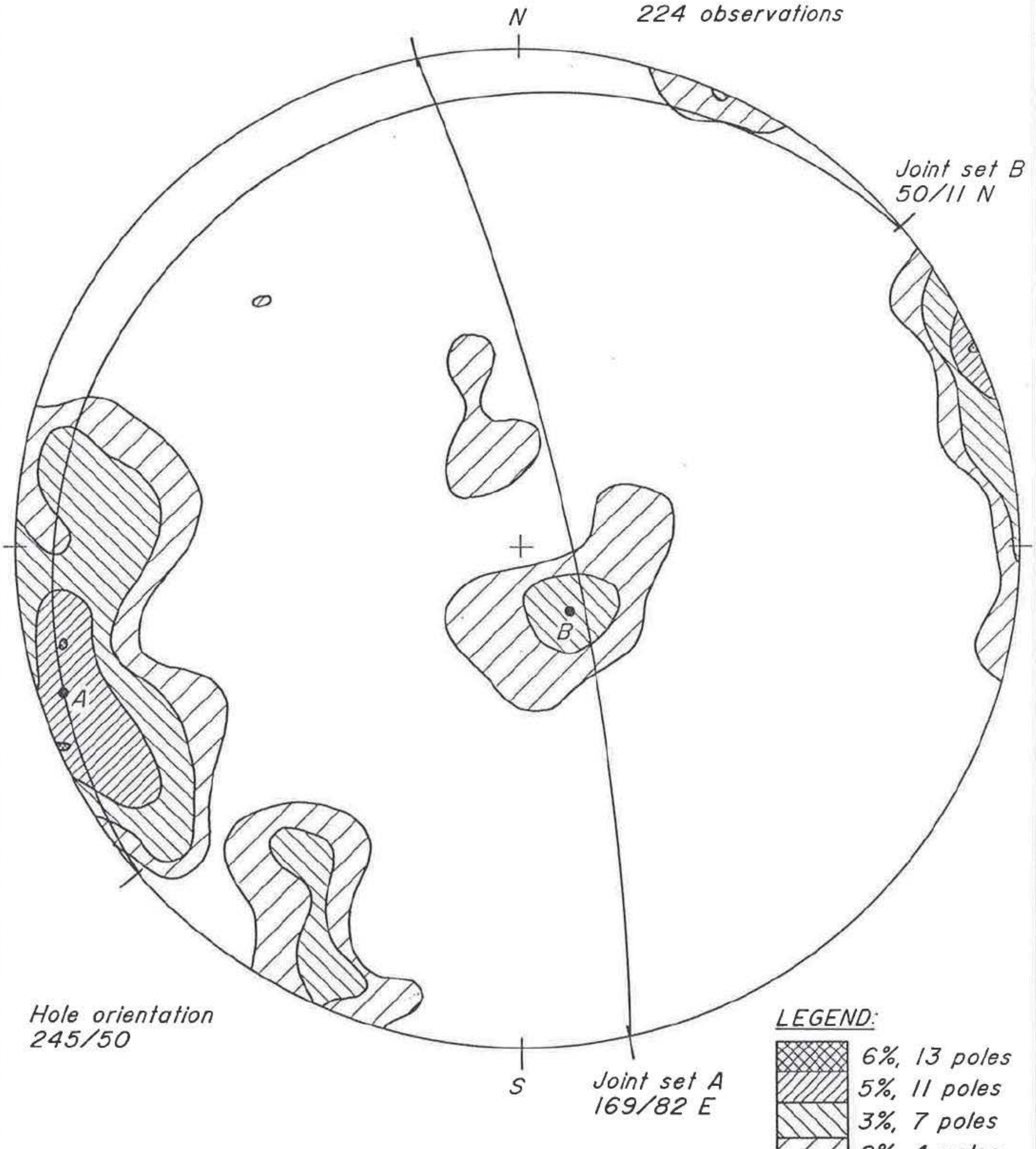

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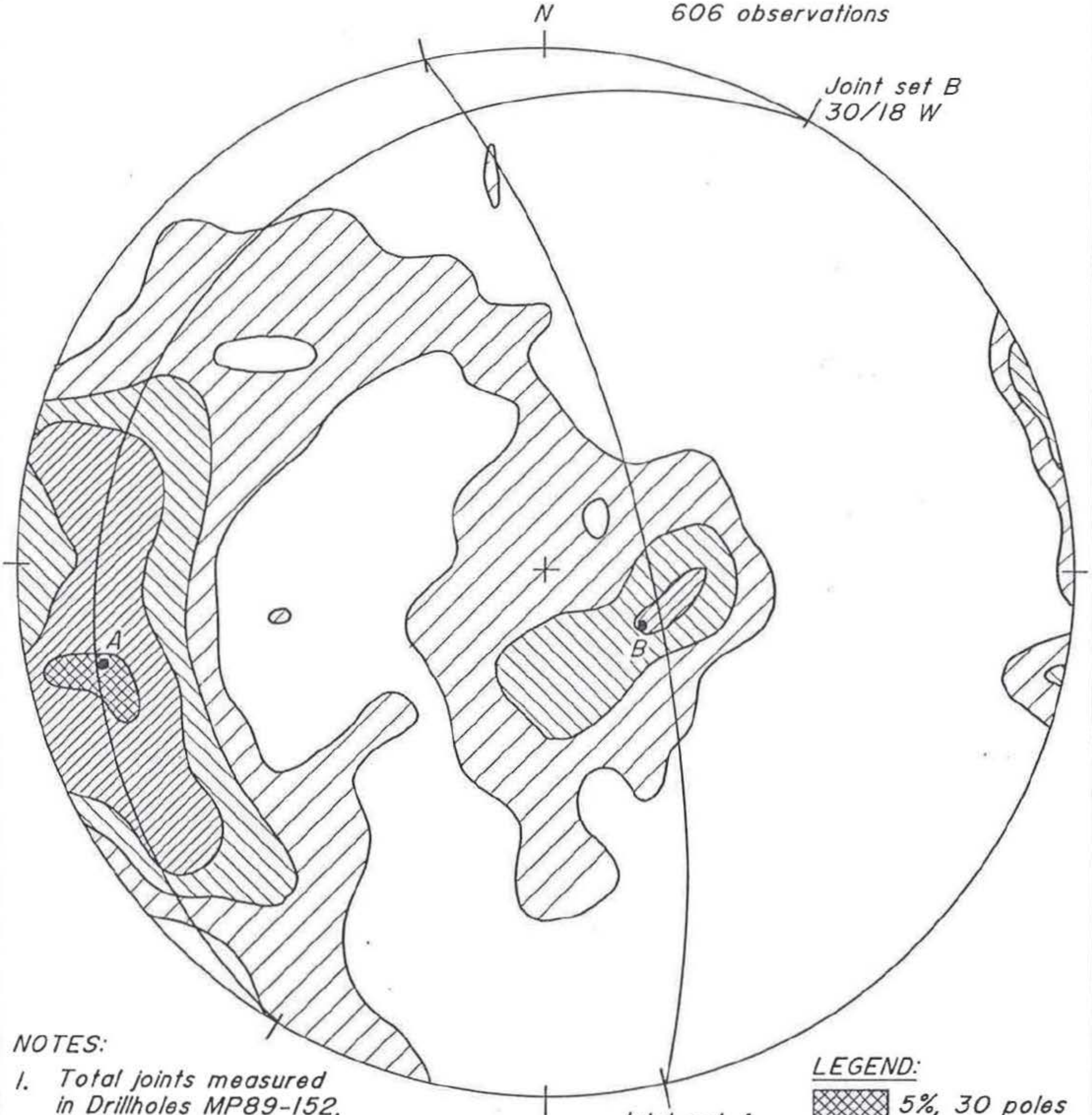
FIGURE 3.4

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
SUMMARY OF JOINT DATA



NOTES:

1. Total joints measured in Drillholes MP89-152, MP89-153 and MP89-154.
2. Uncorrected for directional bias.

LEGEND:

- ▩ 5%, 30 poles
- ▨ 3%, 18 poles
- ▧ 2%, 12 poles
- ▨ 1%, 6 poles

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FIGURE 3.5

1628.A5

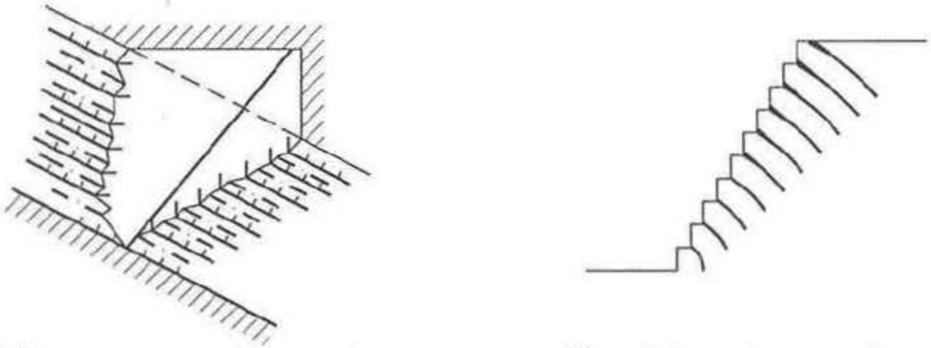
IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
OPEN PIT
TYPICAL FAILURE MODES

(a) *Failure geometry in homogeneous rock or rock with random localized jointing*

(b) *Failure combining movement along discontinuous joints and through intact rock*

(c) *Failure on the plane of a continuous fault, shear zone or joint*

(d) *Failure as a block on a weak layer bounded at the back by a joint or tension crack*



(e) *Failure as a wedge on two or more intersecting discontinuities*

(f) *Failure by toppling. Most frequent where major structure dips steeply*

CAD FILE: \1628\FIG\A5 Plot 1=1

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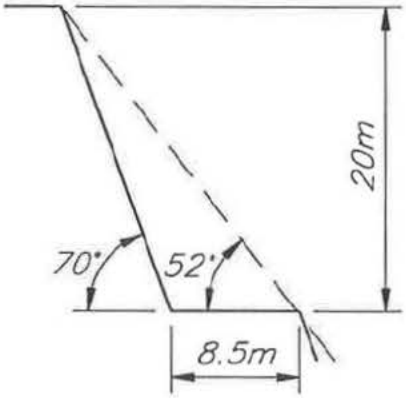
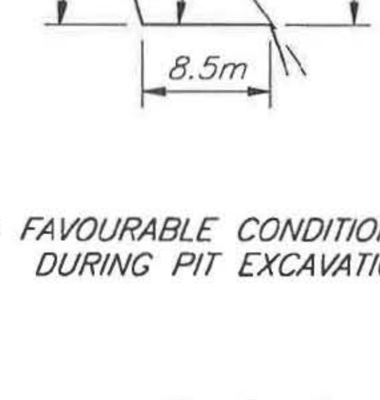
FIGURE 4.1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
OPEN PIT – PRELIMINARY DESIGN
SLOPE ANGLES AND BENCH DESIGN



DESIGN I – ALL INITIAL PIT SLOPES



DESIGN II – FAVOURABLE CONDITIONS ENCOUNTERED DURING PIT EXCAVATION

CAD FILE: \1628\FIG\A4 Plot 1=1

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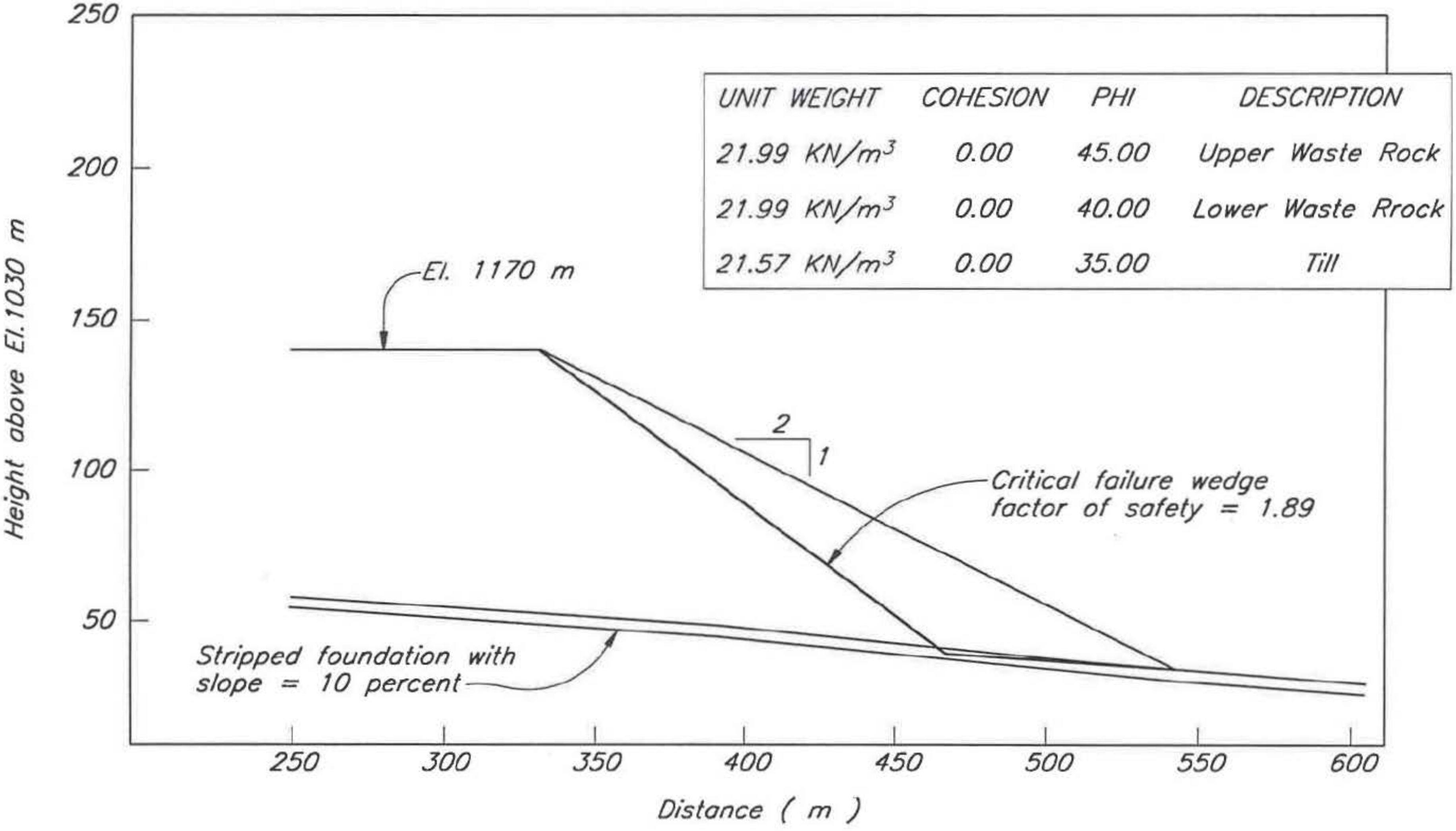
FIGURE 4.2

CAD FILE: \1625\FIG\A38 Plot 1=1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
TYPICAL STATIC WEDGE FAILURE ANALYSIS



UNIT WEIGHT	COHESION	PHI	DESCRIPTION
21.99 KN/m^3	0.00	45.00	Upper Waste Rock
21.99 KN/m^3	0.00	40.00	Lower Waste Rrock
21.57 KN/m^3	0.00	35.00	Till

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FIGURE 5.1

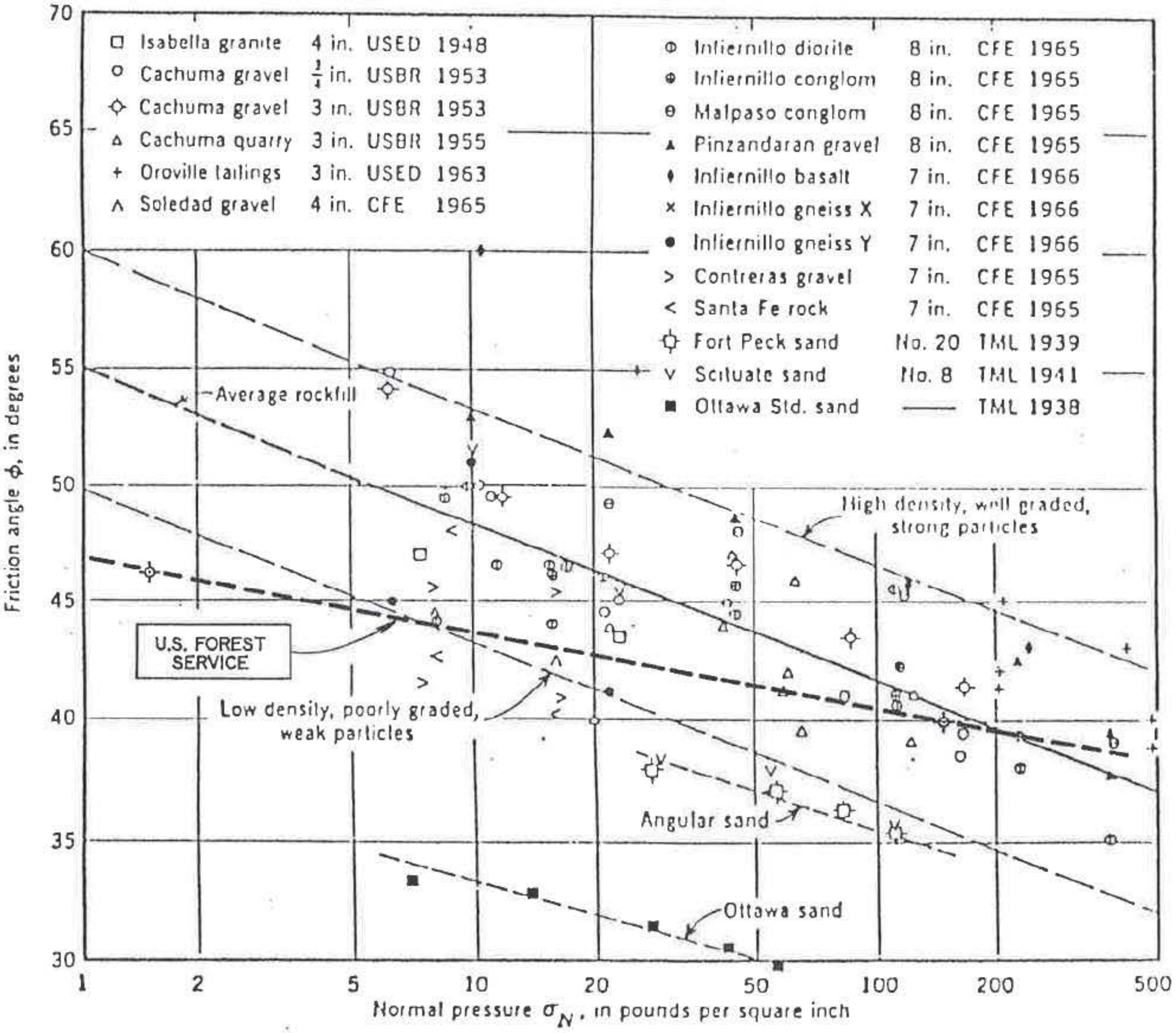
1625.A38

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

WASTE DUMPS

SHEAR STRENGTH OF ROCKFILL



Information taken from :

REVIEW OF SHEARING STRENGTH OF ROCKFILL
By Thomas M. Leps, F. ASCE
July , 1970

BCIL7733 xP

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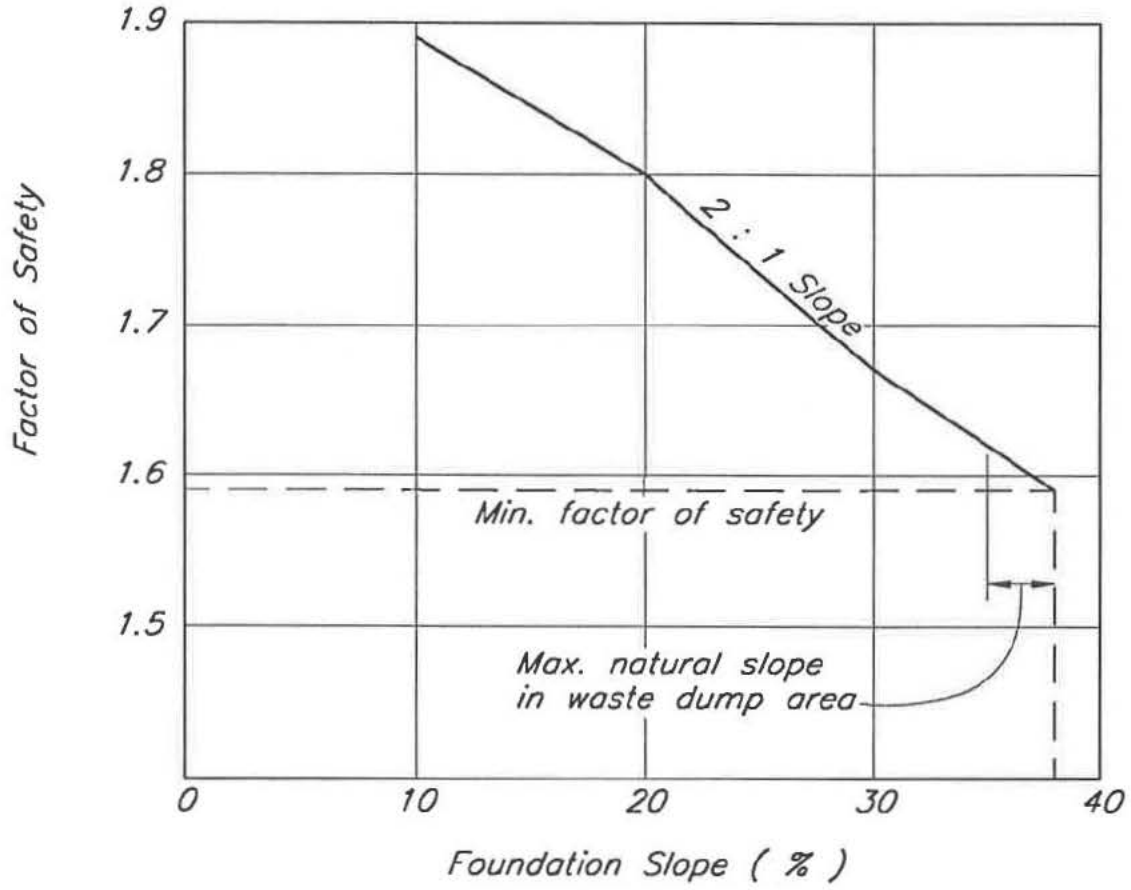
FIGURE 5.2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
WASTE DUMPS – STABILITY CHART



NOTE: Foundation will be stripped with φ' = 35°.

CAD FILE: \1625\FIG\A39 Plot 1=1

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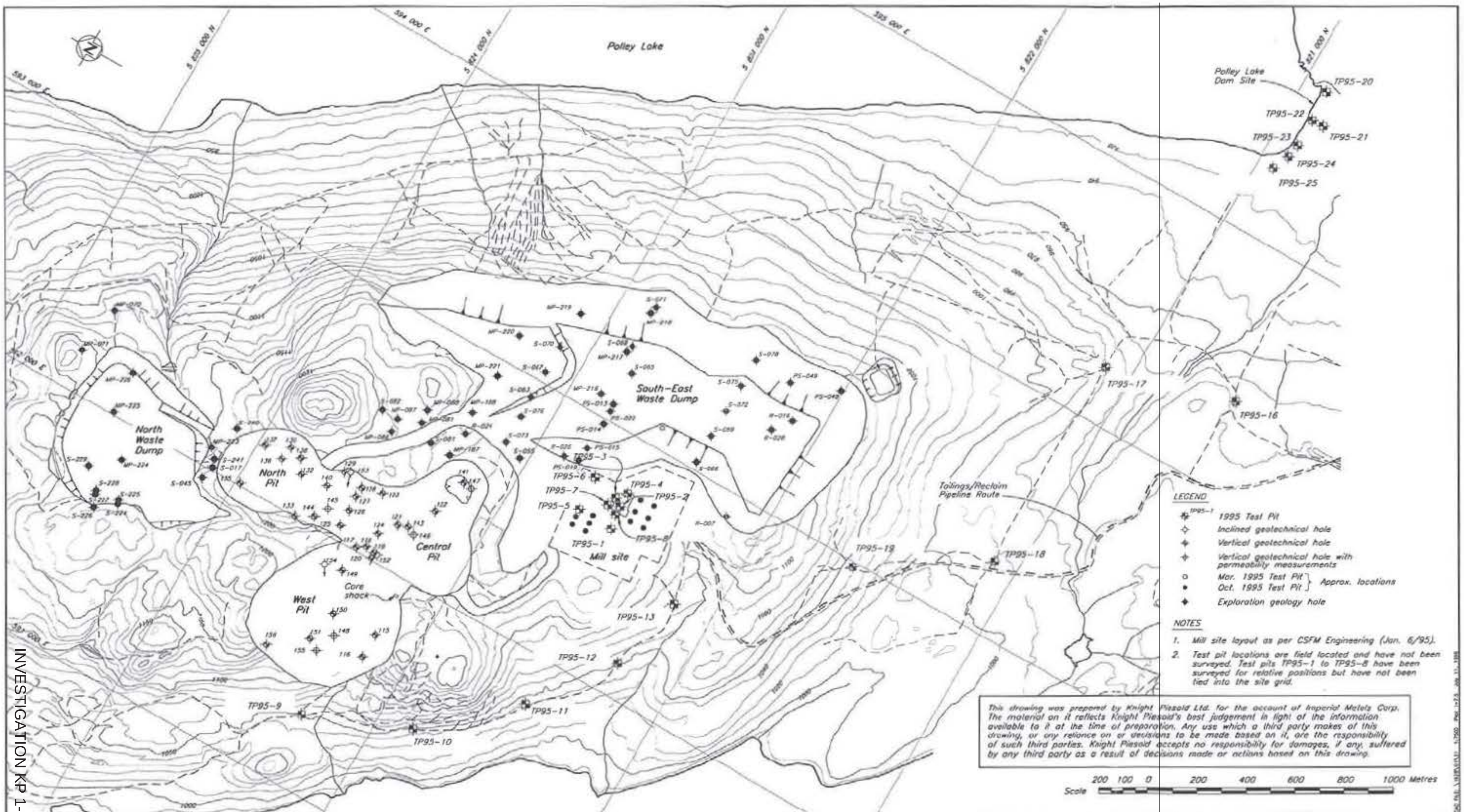
FIGURE 5.3



LEGEND

- ✢ TP95-1 1995 Test Pit
- ✧ Inclined geotechnical hole
- ✦ Vertical geotechnical hole
- ✧ Vertical geotechnical hole with permeability measurements
- ○ Mar. 1995 Test Pit } Approx. locations
- ● Oct. 1995 Test Pit } Approx. locations
- ◆ Exploration geology hole

NOTES

1. Mill site layout as per CSFM Engineering (Jan. 6/95).
2. Test pit locations are field located and have not been surveyed. Test pits TP95-1 to TP95-8 have been surveyed for relative positions but have not been tied into the site grid.

This drawing was prepared by Knight Piesold Ltd. for the account of Imperial Metals Corp. The material on it reflects Knight Piesold's best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this drawing, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Knight Piesold accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this drawing.

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DESIGNED EM/TS
DRAWN VY/ND
CHECKED
APPROVED

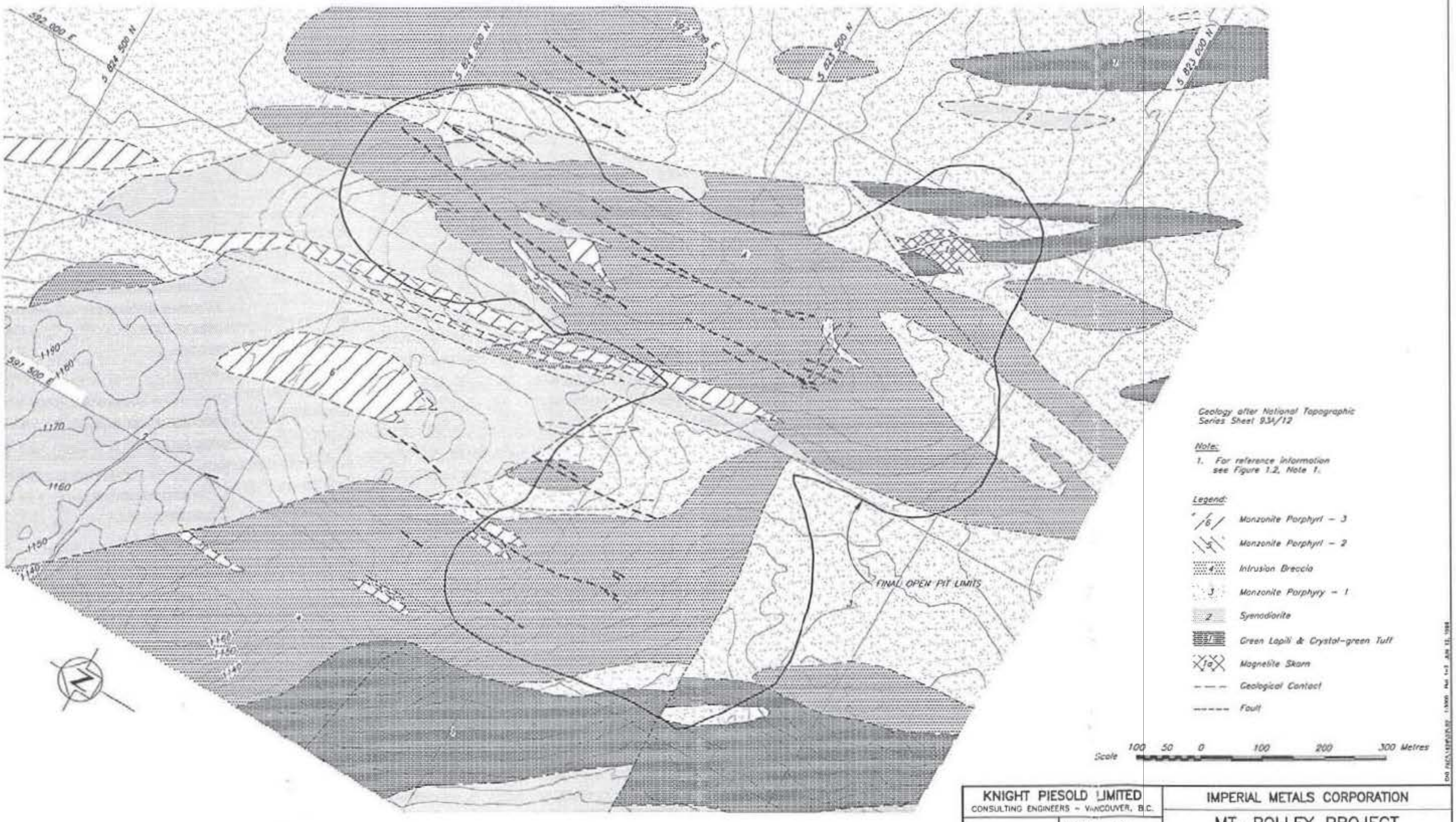
IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

SITE PLAN
GEOTECHNICAL INVESTIGATION PROGRAM

DATE JULY 11, 1996
SCALE AS SHOWN
DRG. NO. 1628.100
REV. A

DRG. NO.	DESCRIPTION	REV.	DATE	DESCRIPTION	APPROVED	REV.	DATE	DESCRIPTION	APPROVED
REFERENCE DRAWINGS		REVISIONS				REVISIONS			



Geology after National Topographic Series Sheet 93A/12

Note:

1. For reference information see Figure 1.2, Note 1.

Legend:

6	Monzonite Porphyrl – 3
5	Monzonite Porphyrl – 2
4	Intrusion Breccia
3	Monzonite Porphyry – 1
2	Syenodiorite
1	Green Lapili & Crystal-green Tuff
1a	Magnetite Skarn
– – –	Geological Contact
------	Fault

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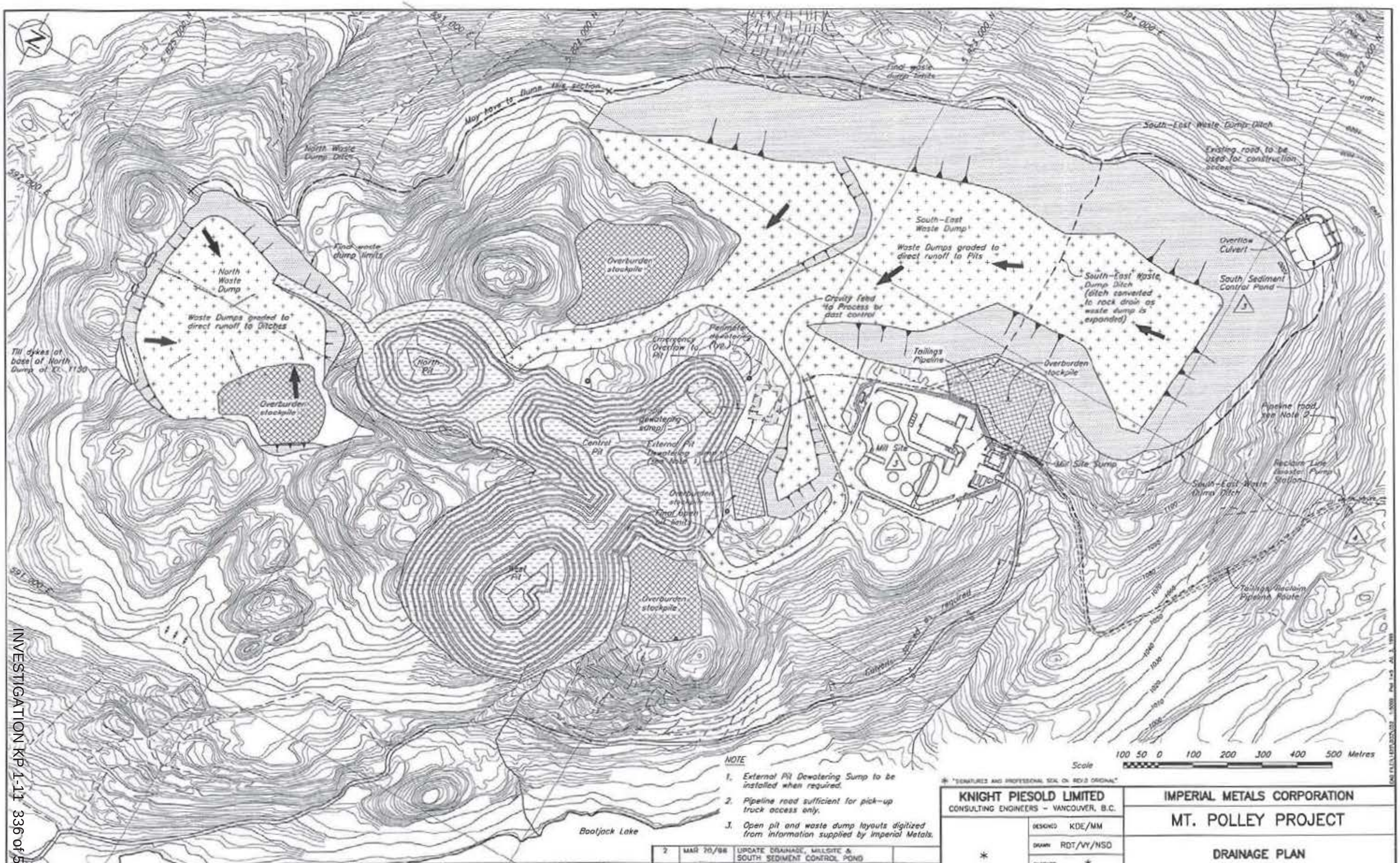
IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

GEOLOGICAL PLAN OF OPEN PIT AREA

DATE JUNE 12, 1996 SCALE AS SHOWN DRG. NO. 1628.101 REV. A

DRG. NO.	DESCRIPTION	REV.	DATE	DESCRIPTION	APPROVED	REV.	DATE	DESCRIPTION	APPROVED
REFERENCE DRAWINGS		REVISIONS				REVISIONS			



NOTE

1. External Pit Dewatering Sump to be installed when required.
2. Pipeline road sufficient for pick-up truck access only.
3. Open pit and waste dump layouts digitized from information supplied by Imperial Metals.

Scale 100 50 0 100 200 300 400 500 Metres

* "SIGNATURES AND PROFESSIONAL SEAL ON REV.0 ORIGINAL"

25.232	DRAINAGE PLAN - SECTIONS AND DETAILS
DRG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

REV.	DATE	DESCRIPTION	APPROVED
4	JULY 3/96	RELOCATE BOOSTER PUMP STATON	
3	APRIL 1/96	MILLSITE AND CONTROL POND REVISED	

REVISIONS

REV.	DATE	DESCRIPTION	APPROVED
2	MAR 20/96	UPDATE DRAINAGE, MILLSITE & SOUTH SEDIMENT CONTROL POND	
1	MAR 14/96	UPDATED OPEN PITS,WASTEDUMPS,SITE DRAINAGE	
0	AUG 24/95	ISSUED FOR CONSTRUCTION	

REVISIONS

KNIGHT PIESOLD LIMITED
CONSULTING ENGINEERS - VANCOUVER, B.C.

*

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DRAWN RDT/VY/NSD
CHECKED *
APPROVED *

IMPERIAL METALS CORPORATION

MT. POLLEY PROJECT

DRAINAGE PLAN
MINE SITE

DATE AUGUST 24, 1995
SCALE AS SHOWN
DRG. NO. 1625.230
REV. 4

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CONSULTING ENGINEERS

APPENDIX A

REVIEW OF OPEN PIT DESIGN
BY
C.O.BRAWNER, P.ENG.

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

1628/1

July 5, 1996

SECTION 4.0 - OPEN PIT SLOPE DESIGN

4.1 FACTORS WHICH INFLUENCE PIT SLOPE STABILITY AND SLOPE ANGLE

The most important factors which influence rock slope stability of open pit mines are geologic structure, groundwater conditions and seismic acceleration forces due to blasting.

Where geologic discontinuities, (joints, bedding planes, foliation, shears, faults, etc.) singly or in combination dip out of the slope at angles near or in excess of the angle of friction of the discontinuities, a potential for failure exists. It is essential that the geologic model of discontinuities around the pit be determined and the kinematic potential for failure evaluated. Typical failure models are shown in Figure 4.1. They include circular, planar, wedge, block and toppling modes.

Where multiple bench failures can occur along discontinuities, it is normally necessary to obtain samples to perform direct shear tests along these discontinuities. The surface roughness and waviness along the discontinuity must be evaluated in the direction of sliding. This may increase the effective angle of friction by ten degrees or more. Both conditions require assessment in order to evaluate the safety factor for that portion of the slope.

The presence of groundwater in the slopes may influence stability in a number of ways:

a. Reduction in the frictional shear strength due to buoyancy.

b. Reduction in cohesion of clay gouge or clayey rock with increasing moisture content.

Revised: February 15, 1990

c. Development of seepage forces during drainage towards the pit slope.

d. Creation of hydrostatic forces in tension cracks during heavy rainfall or snow melt (this pressure increases as the square of the depth).

e. An increase in hydrodynamic shock due to blasting below the water table.

As a result, it is important that the water table and groundwater pressures be maintained low in the pit slopes. The most effective way to develop this control is with the installation of horizontal drains. Any tension cracks that develop should be monitored and filled in to prevent the build up of water pressures.

Seismic acceleration forces due to blasting must be reduced at the final pit face to allow the steepest practical slopes to be used to minimize the waste to ore ratio. This will usually comprise using controlled blasting for the line holes, angled line holes, buffer holes adjacent to the line holes, numerous delays and blasting to a free face. Photographs of representative conditions are enclosed in Figure 4.2. The relationship between distance from the blast, pounds per delay and particle velocity (related to damage) is given in Figure 4.3.

4.2 STRUCTURAL GEOLOGY

Three boreholes, MP89-152 to MP89-154 were drilled on an inclination and the core was oriented using the clay imprint procedure as discussed in Section 3. Stereographic plots are shown in Figures 3.2 to 3.5. The overall plots indicate the major joint set has an average strike of 167 degrees and an average dip of 75 degrees E. The strike variation is about ± 20 degrees and the dip variation about ± 10 degrees. A second set of joints strikes 30 degrees ± 20 degrees and dips 18 degrees W ± 10 degrees. These geological structures are the major features which will influence pit slope stability for all walls.

This structure will lead to certain types of potential instability in each pit face depending on the face direction. The pit slope design must accommodate this potential.

East facing slopes	-	planar failure along shears, faults and contacts
North facing slopes	-	shallow wedges along joint intersections or fault contacts
South facing slopes	-	local wedges adjacent to fault contacts
West facing slopes	-	toppling

Rock joint continuity data (R.Q.D. and Joint Frequency) is shown in Appendix B, together with unconfined compressive strength data. Generally the rock strength is moderate to high so that stability will be controlled by the geologic structure. Several local zones of high fracturing and low strength were noted, i.e. - hole MP89-152, depth 180-350 feet. When the preliminary pit design has been developed, it will be necessary to evaluate rock strength data where drill holes intersect the pit walls to determine if any special design modification would be required. The west facing slopes must be evaluated in particular. If weak zones dip into these slopes, stress relief and high stress could cause subsidence and over stress the overlying rock to initiate toppling movement.

4.3 EVALUATION AND CONTROL OF GROUNDWATER

Groundwater is generally reasonably shallow below the ground surface. In some drill holes it was artesian. Consideration must be given to developing drainage of the pit walls to allow steep slopes and drainage in the pit floor to prevent pit bottom heaving. Wet blast holes will also require the use of more expensive explosives than the standard ANFO.

Revised: February 15, 1990

The projected open pit dewatering requirements have been estimated from the permeability test results and by a general water balance incorporating climatic data and hydrogeologic information. The volume of recoverable groundwater stored in the bedrock fractures and fissures has been estimated by assuming a specific yield of 0.005. Open pit dewatering systems will be required to remove this water from storage. Additional open pit inflows will include direct precipitation and groundwater recharge from the area of influence. The hydrometeorologic data presented in Section 2.1 has been adjusted for runoff and transpiration losses to enable a prediction of annual recharge to the groundwater system.

The rate of groundwater inflow is controlled by the permeability of the bedrock. The bedrock permeability is expected to be anisotropic due to structural features. Rock structure provides a barrier to groundwater movement across relatively intact formations and low permeability clay gouge but also results in preferential flow parallel to fractured rock zones. The site investigation program outlined in Section 3.2 identified zones with a broad range of permeabilities.

It is anticipated that the principal directions of groundwater inflow will be parallel to the dominant structural features which trend roughly north and south. This groundwater flow trend is advantageous in the later years of operation, when the ultimate depth of the west pit is below the surface elevation for Bootjack Lake. In general, the rock structure provides a natural barrier to flow from Bootjack Lake into the bottom of the ultimate pit. However the approximately east-west trending fault structure in the west zone, as shown on Figure 2.3, may provide a high permeability conduit for groundwater flow. On-going evaluation of pit geology during operations will enable accurate predictions to be made prior to final development.

It is estimated that the average, steady state pumping requirements for open pit groundwater control over the life of the project will be approximately 15 L/s (200

Igpm). This estimate does not include for removal of direct precipitation which will average approximately 13 L/s (175 Igpm) annually. The actual pit dewatering rate will be higher in the early stages of the operation when groundwater is removed from storage, and during periods of high rainfall.

Generally the most effective ways of controlling seepage into the pit is to install horizontal drain holes. They should be 20 to 30 metres (60 to 100 ft) long, drilled at a +2 to +3 degree slope and spaced about 12 metres (40 ft) apart at the toe of each double bench where seepage is encountered. In order to locate seepage zones, all blast holes which have water in them along the line holes and buffer holes should be plotted on blasting plans. The horizontal drain holes are only installed in areas where seepage is indicated.

If wet holes become a problem, a program to drill every tenth to twelfth blast hole an additional 6 to 9 metres (20 to 30 ft) deep and blast to that lower depth will provide a groundwater sink and help to lower the water table in the blast area. If this procedure is not successful, pumping wells at a number of locations around the pit may be required.

In order to continue to monitor the groundwater level conditions, a percentage of future drill holes should have piezometers installed to monitor the water table.

4.4 BLASTING CONTROL NEAR THE FINAL WALLS

Where the pit slope design angle will not be controlled by the structural geology the use of controlled blasting at the final face will normally allow an increase of 5 to 7 degrees in the slope angle. This involves the use of controlled blasting, with reasonably small diameter blast holes detonated as a pre-shear line in the harder massive rock or as a cushion or post shear line in weak or heavily fractured rock. The line holes should not be larger than 15 cm (6 inches) in diameter and spaced

1.5 to 2 m (5 to 6 ft) apart. It is preferable if this pre-shear line is drilled at an angle of 70-75 degrees below the horizontal rather than vertical. It is also desirable to drill the line holes double bench depth to do away with a small bench lip which could develop half way up a double benched slope. To minimize wall damage it is preferable that the explosive in the line holes be decoupled laterally and/or air decked to spread the explosive more throughout the length of the hole. Rock excavation should be to the line holes and not beyond.

Two or three lines of buffer holes are recommended, drilled in front of the line holes with the spacing equal to about one-half that between the production holes. The first line of buffer holes should be angled. The others may be vertical. They should use the same diameter as the line holes. In order to drill the angle holes, it will be necessary to purchase or lease a drill which drills this size of hole and can be angled at angles up to about 25 degrees. Tamrock have drills with angled capacity. The amount of explosives per buffer hole will be approximately one-quarter that in the production holes. All buffer holes should be delayed.

Production holes may use larger diameter drills. Every hole of a production blast within one hundred feet of the final wall must be delayed singly.

Blasting should be developed towards a free face with that free face perpendicular to the wall. A typical trial blast pattern is shown in Figure 4.4. Figure 4.2 shows an excellent blast control program at Gortrum Mines in Ireland. Figure 4.3 is a plot of damage to rock, related to the weight of charge per delay, and the blast distance to the final wall. This graph emphasizes the utmost importance of using delays to reduce seismic acceleration forces to minimize wall damage.

The best blast design will result from trial test blast patterns in the field. The most beneficial program will develop where the open pit will be developed initially as a small pit and a subsequent set back will be developed. This initial pit can be developed with variable test slopes and test blast patterns to develop the best blast design for the final wall. Test trial blasts will be required wherever the rock conditions change substantially.

It is recommended that double benching be used at the final wall. In order for this procedure to be successful, the upper bench face must be scaled prior to drilling the buffer holes on the next lower bench elevation. It is also important that blast holes be staggered so the bottom of the hole does not intercept the crest of the bench below. Otherwise, very fragmented bench crests will develop leading to considerable ravelling and a greater berm width.

It is recommended that the operators of front-end loaders or shovel loaders who excavate this final face be given a seminar on structural geology, particularly the identification of small planar blocks and small wedges which could fail. By recognizing these in advance, they can dig them out so that ravelling at a later date will be reduced. By minimizing this ravelling the bench width can be narrowed to increase the overall slope angle.

Do not place piles of loose rock at the outer side of berms to catch ravelling rock. This requires an excessive bench width and results in overall flatter slope angles. Berms are to catch ravelled rock. They are not intended for later access.

4.5 MONITORING

The development of slope movement will be indicated by the development of a tension crack or cracks. It is most important that periodic inspections along the crest and bench locations be performed periodically to locate such cracks.

When tension cracks are observed the initial monitoring program requires the installation of surface movement hubs or gages which will allow measurement of both vertical and horizontal displacement. This is required to evaluate the type of movement that is occurring - circular, planar, toppling etc.

If larger scale movements appear to be developing, an electronic distance measuring (EDM) prism monitoring system should be developed. Three or four prisms should be installed on a line down the center of the slide with readings taken daily from a fixed station across the pit. Movement records should be plotted daily to determine if there is an acceleration of the movement. Plots should be made of a total movement vs time. At this point in time a decision as to whether the slide will be stabilized or whether it will simply be monitored and allowed to fail will then be made. If it is to be allowed to fail, continued monitoring of the acceleration will allow the date of failure to be predicted several days in advance. Mining would be discontinued at this time.

From a practical standpoint, where failure volumes involve 500,000 cubic yards or more, experience is that a failure will not occur within the next 24 hours if the amount of daily movement is less than about three inches.

Any failures involving one or more benches should be back analyzed. The location, structural geology, face failure geometry, failure surface roughness, seepage and blasting details etc. should be recorded. This allows the most accurate evaluation of the shear strength along the failure surface to be determined, to be used in re-design. Photographs should be taken and described.

4.6 BENCH DESIGN

For final pit wall bench design it is proposed that controlled blasting be used to develop a relatively steep bench face (70 to 75 degrees) which should be scaled with excavating equipment and a drag chain or equivalent from the top. Double benching is recommended. The scaling will reduce subsequent ravelling and reduce the catch width required for berms. Where the rock face stands up well, a 6 metre (20 foot) wide bench is suggested. If the rock is very fractured and considerable ravelling occurs the bench will have to be widened to about 8 metres (25 feet).

If areas of heavily fractured rock or faulted rock are encountered in the final slopes, more stable bench faces can frequently be developed using bulldozers and rippers rather than blasting along the final line holes. By utilizing this procedure the slope angles at Bougainville, in Papua New Guinea, for example, were steepened some 8 degrees.

4.7 PRELIMINARY PIT SLOPE DESIGN

East Facing Slope - A revised geological interpretation provided by Imperial Metals Corporation indicates the geologic structure is reasonably uniform over all three pits. Planar failures will occur locally where the structure dip is flatter than the bench face angle.

The slope angle can be developed with bench face angles of 70 degrees. The overall angle will depend on berm width, bench height and whether single or double benching will be used. See Table 4.1 and Figures 4.5 and 4.6.

West Facing Slopes - Based on existing structural geologic data the structure dips into the west facing slopes at about 45 to 75 degrees. Where the structure dip is less than about 60 degrees and does not cross major faults the bench faces can be developed at 75 degrees. The overall angle will depend on berm width, bench height and single or double benching. Where the dip angle is steeper than about 60 degrees the potential for toppling failure exists. The bench faces should be flattened to 70 degrees and berm widths should be increased by 2.0 metres.

The overall slope angles for various conditions are shown in Table 4.1 and Figures 4.5 and 4.6.

It is very important that these slopes be drained.

South Facing Walls - The fault structures generally dip N-S and will not materially influence slope stability. The joints dip into the slope which is a stable condition. Accordingly bench faces can be developed at 75 degrees with minimum berms widths. The overall slope angle will depend on the use of single or double benches. See Table 4.1 and Figures 4.5 and 4.6.

North Facing Walls - The fault structures will have similar influence as in the south facing walls. The two joint sets prevalent at the site will intersect to form shallow wedges. Some local bench size failures can be expected. Bench faces should be developed at 70 degrees with wider catch berms. The overall slope angles for various conditions are given in Table 4.1 and Figures 4.5 and 4.6.

Note that the slope angles recommended do not include haul roads.

Pit Noses - The preliminary design of the west pit and central pit has created a north and a south nose. Such noses usually suffer from excessive ravelling and instability. It is recommended the overall slopes in any such area be flattened 10 degrees by using wider catch benches.

Ramps - It is desirable to locate haul roads on the most stable pit wall - in this instance along the west facing slopes.

Fault Intersections - Where faults intersect the walls at shallow angles (<30 degrees) local wedge failures will occur. Extra scaling will be required.

Revised: February 15, 1990

Knight Piésold Ltd.
CONSULTING ENGINEERS

APPENDIX B

DISCONTINUITY DATA AND POINT LOAD TEST RESULTS

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

1628/1

July 5, 1996

APPENDIX B

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

DISCONTINUITY DATA AND POINT LOAD TEST RESULTS

DRILLHOLE MP89-152 (285/55)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE	COMP.STRENGTH	
from	to				(psi)	(psi)	(MPa)
10	20	DIORITE	60	2.0	3200	36188	250
20	30		82	2.0	3200	36188	250
30	40		83	1.0	3500	39581	273
					2900	32796	226
40	50		68	1.5	3500	39581	273
					2800	31665	218
50	60		95	1.2			
60	70		80	2.0	1000	11309	78
70	80		88	1.0	2000	22618	156
					4000	45235	312
80	90		93	1.5	2900	32796	226
90	100		68	3.0	2000	22618	156
100	110		93	1.0	1000	11309	78
110	120		100	1.2	2200	24879	172
120	130		65	2.7			
130	140		80	1.0	2800	31665	218
140	150		80	1.2	3000	33926	234
150	160		75	1.3	3000	33926	234
160	170		97	1.7	1900	21487	148
170	180		75	1.7	2600	29403	203
180	190		80	High	400	4524	31
190	200		20	High			
200	210		40	High	1800	20356	140
220	230		20	V.High			
220	230	SYENO	40	High	400	4524	31
230	240		60	2.5	1500	16963	117
240	250		35	3.0	1000	11309	78
250	260		18	High			
260	270		35	High	200	2262	16
270	280		25	High	200	2262	16
280	290		10	High	900	10178	70
290	300		7		100	1131	8
300	310		5	High			
310	320		3	High	700	7916	55

APPENDIX B (Continued)

DRILLHOLE MP89-152 (285/55)

	DEPTH	ROCK	R.Q.D.	FRACTURE	GAUGE	COMP.STRENGTH	
from	to	TYPE		INDEX (jt/ft)	(psi)	(psi)	(MPa)
320	330		0	High			
330	340		15	High	700	7916	55
340	350		-	1.5	600	6785	47
					800	9047	62
350	360		85	1.8	1700	19225	133
					2200	24879	172
360	370		99	0.7	1100	12440	86
370	380		95	1.5	2700	30534	211
380	390		95	1.2	2600	29403	203
390	400		80	4.0	1200	13571	94
					2000	22618	156
400	410		80	1.0	2100	23748	164
410	420		80	3.3	1800	20356	140
					2600	29403	203
420	430		65	3.3	1200	13571	94
430	440		70	3.0	700	7916	55
440	450		15	High	1200	13571	94
450	460		83	1.7	1200	13571	94
					1000	11309	78
460	470		94	1.4	1600	18094	125
470	480		90	1.0			
480	490		85	1.1	2800	31665	218
					400	4524	31
490	500		80	2.0			
500	510		65	1.0	700	7916	55
510	520		40	3.0	900	10178	70
520	530		70	1.6	1800	20356	140
530	540		75	0.8			
540	550		85	0.8	700	7916	55
					1200	13571	94
550	560		45	High	900	10178	70
560	570		45	High	600	6785	47
570	580		35	High	400	4524	31
			35	High	600	6785	47
580	590		30	High	2800	31665	218
590	600		15	High	700	7916	55
					1500	16963	117
600	610		92	0.4	2100	23748	164
610	620		98	0.5	1900	21487	148
620	630		73	1.6			

APPENDIX B (Continued)

DRILLHOLE MP89-152 (285/55)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH	
from	to					(psi)	(MPa)
630	640		92	1.0	2000	22618	156
640	650		92	0.8	800	904	762
650	660		35	1.2	300	3393	23
660	670		98	0.5	200	2262	16
					900	10178	70
670	680	IB	95	0.8	1700	19225	133
					1600	18094	125
680	690		95	0.7	400	4524	31
					1000	11309	78
690	700		87	1.3	3000	33926	234
					2000	22618	156
					1700	1922	133
700	710	DYKE	95	1.2	1200	13571	94
		IB			1000	11309	78
710	720		100	0.6	2800	31665	218
720	730		85	1.1	600	6785	47
730	740		90	1.0	1900	21487	148
740	750		50	1.0	300	3393	23
					100	1131	8
750	760		100	0.4	1300	14701	101
					1200	13571	94
760	770		90	0.6	300	3393	23
					700	7916	55
770	780		40	High	50	565	4
780	790		35	1.5	1900	21487	148
790	800		25	High	1500	16963	117
800	810		-	0.9	3200	36188	250
810	820		92	0.9	1100	12440	86
					3200	36188	250
820	830		87	1.1	2500	28272	195
830	840		80	1.1	900	10178	70
					2100	23748	164
840	850		50	High	600	6785	47
					1600	18094	125
850	860		90	1.1	2300	26010	179
					1500	16963	117
860	870		95	1.1	1100	12440	86
870	880		25	1.2	800	9047	62
880	890		96	0.5	200	2262	16
					500	5654	39

APPENDIX B (Continued)

DRILLHOLE MP89-152 (285/55)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH	
from	to					(psi)	(MPa)
890	900		94	0.7	300	3393	23
900	910		90	1.7	800	9047	62
910	920		55	3.0	300	3393	23
920	930		45	2.0	200	2262	16
					400	4524	31
930	940		30	High	100	1131	8
940	950		87	1.4	3500	39581	273
950	960		70	2.0	1200	13571	94
960	970		90	1.5	1500	16963	117
970	980		93	1.4	2500	28272	195
					200	2262	16
980	990		85	1.3	1500	16963	117
990	1000			1.5	2300	26010	179

DRILLHOLE MP89-153 (253/50)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH	
from	to					(psi)	(MPa)
30	40		25	High	1000	11309	78
40	50		15	High			
50	60		35	High	500	5654	39
60	70		70	High	1000	11309	78
70	80	DYKE	35	High	2500	28272	195
		IB			600	6785	47
80	90		15	High	100	1131	8
90	100		35	High	100	1131	8
100	110		18	3.0	800	9047	62
110	120		50	2.2	2300	26010	179
120	130		15	3.0	1700	19225	133
130	140		12	4.0	1200	13571	94
140	150		95	1.1	400	4524	31
150	160		95	0.9	1300	14701	101
160	170		91	1.0	2000	22618	156
170	180		35	2.6	1200	13571	94
180	190		65	2.4	100	1131	8
					300	3393	23
190	200		87	1.3	2700	30534	211
200	210		99	0.8	3600	40712	281
210	220		94	1.2	1800	20356	140
					2500	28272	195
220	230		97	0.7	3800	42973	296
230	240		92	1.1	2900	32796	226

APPENDIX B (Continued)

DRILLHOLE MP89-153 (253/50)

DEPTH from	to	ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH (psi)	(MPa)
240	250		100	0.6	2500	28272	195
250	260		80	1.4	1100	12440	86
260	270		100	0.4	1000	11309	78
			100	0.4	1400	15832	109
270	280		100	0.4	3000	33926	234
			100	0.4	1500	16963	117
280	290		80	1.2	2600	29403	203
290	300		96	0.7	1700	19225	133
300	310		89	1.1	1400	15832	109
310	320		96	0.9	2400	27141	187
320	330		50	2.7	1300	14701	101
330	340	DYKE	80	1.2	600	6785	47
		IB			400	4524	31
340	355		83	1.0	2200	24879	172
350	360		98	0.6	1500	16963	117
360	370		100	0.6	1400	15832	109
370	380		80	1.6	1000	11309	78
380	390		100	0.4	1600	18094	125
390	400		98	0.9	2200	24879	172
400	410		100	0.3	2000	22618	156
410	420		100	0.5			
420	430		100	1.0	1300	14701	101
430	440		100	0.5	2000	22618	156
					1200	13571	94
440	450		91	0.4	1900	21487	148
450	460		96	0.6	1800	20356	140
460	470		100	0.5			
470	480		100	0.7	1200	13571	94
480	490		100	0.3	1200	13571	94
490	500		100	0.0	1200	13571	94
					1000	11309	78
					4000	45235	312
500	510		100	0.4	2500	28272	195
510	520		98	0.7	1500	16963	117
520	530		97	0.7	3000	33926	234
530	540		90	0.8	2200	24879	172
540	550		100	0.3	2200	24879	172
550	560		100	0.7	2300	26010	179
560	570		65	1.8	800	9047	62
570	580		50	2.6	300	3393	23

APPENDIX B (Continued)

DRILLHOLE MP89-153 (253/50)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH	
from	to					(psi)	(MPa)
					700	7916	55
580	590		20	2.0	500	5654	39
					2800	31665	218
590	600		75	1.5	1100	12440	86
600	610		40	3.0	50	565	4
					100	1131	8
610	620		82	1.3	800	9047	62
620	630		97	0.6	1000	11309	78
630	640		95	0.3	2400	27141	187
640	650		80	1.2	2000	22618	156
650	660		100	0.3	2800	31665	218
660	670		100	0.1	500	5654	39
					1000	11309	78
670	680		98	0.4	2700	30534	211
					700	7916	55
680	690		95	1.1	100	1131	8
				1.1	700	7916	55
690	700		96	0.8	1000	11309	78
700	710		89	0.9	2200	24879	172
710	720		92	0.7	900	10178	70
720	730	DYKE	70	1.4	1000	11309	78
730	740		75	0.8	1500	16963	117

DRILLHOLE MP89-154 (245/50)

10	20	IB	20	2.5	2000	22618	156
					2800	31665	218
20	30		30	2.5	1400	15832	109
30	40		50	1.8	400	4524	31
40	50		30	1.8			
50	60	DYKE	70	1.7	100	1131	8
		IB			300	3393	23
60	70		25	3.0	1100	12440	86
70	80		95	High	400	4524	31
80	90		45	High	400	4524	31
90	100		7	High	1100	12440	86
100	110		45	1.9	600	6785	47
110	120		55	1.9	2600	29403	203
120	130	DYKE	55	2.1	600	6785	47
130	140	IB	30	High	350	3958	27

APPENDIX B (Continued)

DRILLHOLE MP89-154 (245/50)

DEPTH		ROCK	R.Q.D.	FRACTURE	GAUGE	COMP.STRENGTH	
from	to	TYPE		INDEX (jt/ft)	(psi)	(psi)	(MPa)
140	150		25	3.0	350	3958	27
150	160		55	1.7	150	1696	12
160	170		55	1.0	300	3393	23
170	180		35	High			
180	190		30	High	300	3393	23
190	200		60	High			
200	210	DYKE	12	High	300	3393	23
210	220	IB	3	High	250	2827	19
220	230		3	High	50	565	4
230	240		15	High			
240	250		40	High	1100	12440	86
250	260		30	High			
260	270		45	High			
270	280		14	High			
280	290			High			
290	300	DYKE	18	High	500	5654	39
300	310	IB	5	High			
310	320		18	High	300	3393	23
320	330		45	7.5	700	7916	55
					900	10178	70
330	340		75	1.5	4100	46366	320
340	350		95	1.2	5000	56544	390
350	360		85	1.6			
360	370		94	0.9	3000	33926	234
370	380		91	1.1	2600	29403	203
380	390		40	2.2	3400	38450	265
390	400		97	1.2	4100	46366	320
					3600	40712	281
400	410		93	1.3	3000	33926	234
410	420		93	1.2	1400	15832	109
420	430		92	1.4	3500	39581	273
430	440		83	2.3			
440	450	SYENO	85	1.6	2900	32796	226
450	460		90	1.1	2800	31665	218
460	470		95	0.8			
470	480		87	1.0			
480	490		95	1.1			
490	500		94	1.2			
500	510		96	1.2			
510	520		91	1.0			

APPENDIX B (Continued)

DRILLHOLE MP89-154 (245/50)

DEPTH		ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH	
from	to					(psi)	(MPa)
520	530		92	1.4			
530	540		100	0.4			
540	550		98	0.7			
550	560		92	0.9			
560	570	IB	87	1.3	2400	27141	187
570	580		95	1.1	2000	22618	156
580	590	DYKE	82	0.8	3400	38450	265
				25	High		
600	610	SYENO	100	0.1	3600	40712	281
610	620	IB	97	1.2	1400	15832	109
620	630	DYKE	95	0.7	1600	18094	125
630	640	SYENO	90	0.9	900	10178	70
640	650		92	1.3	3700	41843	289
650	660		85	1.4	1600	18094	125
660	670		90	1.3	1700	19225	133
670	680		96	0.7			
680	690		99	1.0	1400	15832	109
690	700		95	1.0	3500	39581	273
700	710	IB	87	1.0	500	5654	39
710	720		80	1.3	100	1131	8
					1500	16963	117
720	730		30	2.0	900	10178	70
730	740		40	2.0	500	5654	39
740	750		30	High	500	5654	39
750	760		20	High	0	0	0
760	770		25	V.High			
770	780		10	V.High	0	0	0
780	790		18	V.High	50	565	4
790	800		15	V.High			
800	810		34	High	50	565	4
810	820		23	High	300	3393	23
					0	0	0
820	830		6	V.High	150	1696	12
830	840		40	High			
840	850	IB	68	1.4	600	6785	47
850	860		53	1.4	1300	14701	101
860	870		50	1.2			
870	880		85	1.1	150	1696	12
880	890		70	1.3	800	9047	62
890	900		100	1.0	300	3393	23

APPENDIX B (Continued)

DRILLHOLE MP89-154 (245/50)

DEPTH from	to	ROCK TYPE	R.Q.D.	FRACTURE INDEX (jt/ft)	GAUGE (psi)	COMP.STRENGTH (psi)	(MPa)
900	910		100	0.4	800	9047	62
910	920		97	0.7	400	4524	31
920	930		65	1.0	1200	13571	94
930	940		100	0.6	800	9047	62
940	950		89	0.8	500	5654	39
950	960		98	0.7	1400	15832	109
960	970		90	1.4	200	2262	16
970	980		18	1.5	400	4524	31
980	990		70	1.2	2000	22618	156
990	1000		93	1.6	300	3393	23
1000	1010		15	High	100	1131	8
1010	1020		15	High			
1020	1030		85	1.5	1100	12440	86
1030	1040		85	1.5	1500	16963	117

APPENDIX C

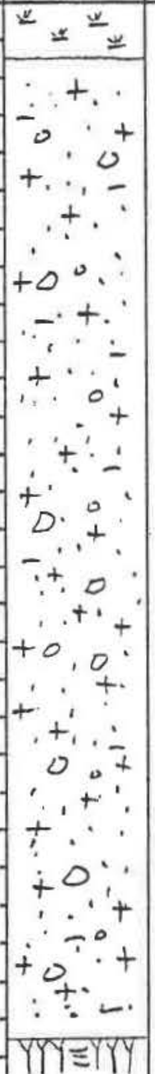
TEST PIT LOGS

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-1
SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,550N, 592,610E
GROUND ELEVATION ~1112 m
DATE Jan 11/95 Fine Ore Stockpile
LOGGED BY KGB



NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200hoe.	0		Dark brown / black ORGANICS
Moderate digging conditions.	1		
	2		Brown, dense, slightly moist, fine-grained sandy SILT with some fine-grained gravel and clay. Well graded, poorly sorted. Becomes denser at depth (dense, cohesive chunks are ripped from in-situ material).
	3		→ Sandy Silt Glacial Till
Sample TP95-1 from 4 to 5.5m depth	← 4		
Seep encountered at ± 5.2 m depth.	▽ 5		saturated till below 5.2m.
		EO.P	Bedrock encountered at 5.5m. Too deep to excavate any further.
	6		
	7		
	8		

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-2 SHEET 1 of 1

PROJECT Mt Polley

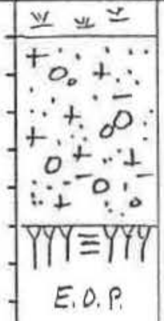
PROJECT No. 1623

LOCATION OF TEST PIT Approx 5822,560 N, 592,730 E Concentrator

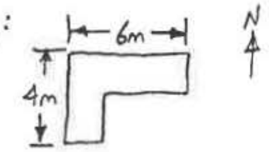
GROUND ELEVATION ~ 1110 m

DATE Jan 11/95

LOGGED BY KGB

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe Water table encountered at 1.2 m No samples taken.	0 1 ▽ 2		Dark brown/black, saturated, ORGANICS. Orange brown/brown, dense, moist to very moist, fine-grained sandy SILT with some gravel and clay. Organics sometimes encountered to 1m depth. Sandy SILT Glacial Till Bedrock encountered at 1.2m depth. Angular fragments, typically 10cm dia. Wet due to water table.

Note: This trench was excavated approx. 10m long:



- The north-south portion typically had 1m of organics, a thin layer of till overlying bedrock.
- The east-west portion is described above.
- Both limbs encountered bedrock at shallow depths.

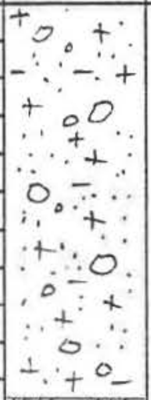
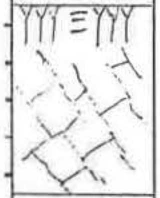
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-3
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Approx 5,822,560 N, 592,745 E
Concentrator
DATE Jan 11/95

PROJECT No. 1623
GROUND ELEVATION ~1110 m
LOGGED BY KGB

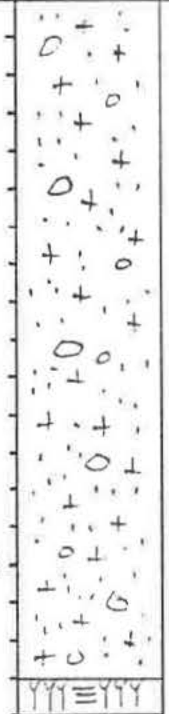
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe Moderate digging conditions No samples taken!	0 1		Brown, dense, fine-grained sandy SILT with some gravel and clay. Slightly moist to moist. Similar to material encountered in TP95-1 Sandy Silt Glacial Till
Water table encountered. at 2.1 m Water ponded in pit to 2m depth after 18hrs.	∇ 2 3	 E.O.P.	Bedrock encountered at 2.1 m. Angular fragments 10 to 20 cm dia. typically. Very broken at surface, and becomes more competant with depth. Backhoe rips through 1m of bedrock, and could continue, indicating the contact is very fractured.
	4		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-4
SHEET 1 of 1

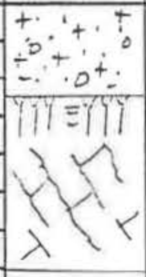
PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,510N, 592,765E
South end of Concentrator
GROUND ELEVATION ~ 1109 m
DATE Jan 11/95
LOGGED BY KSB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe	0		Orange-brown (near surface) to brown, dense fine-grained sandy SILT with some gravel and clay (similar to TP95-1). slightly moist. Cohesive in-situ, especially at depth where chunks of material is ripped from pit. Fine to moderate-grained gravel.
Moderate digging conditions	1		
Sample TP95-4 taken 2 to 3.6m	2 ∇		Sandy Silt Glacial Till
	3		↓ Basal till
Water table encountered at 3.6m. water ponded to approx 2 to 2.5m depth after 18hrs	∇ 4	E.O.P.	Bedrock encountered at 3.6m depth. Angular fragments encountered.

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	# TEST PIT LOG	TEST PIT No. TP95-5 SHEET 1 of 1

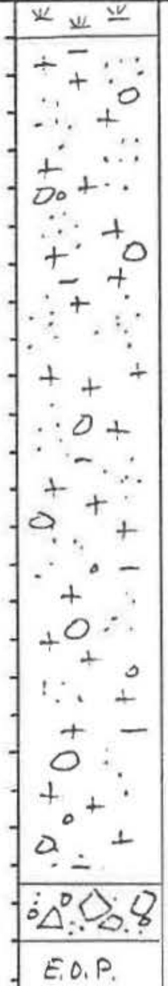
PROJECT Mt Polley
LOCATION OF TEST PIT Approx 5,822,720 N , 592,600E
Crusher
DATE Jan 12/95

PROJECT No. 1623
GROUND ELEVATION ~1120 m
LOGGED BY KGB

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Oxidized silty SAND with some gravel, trace clay. Coarser grained than tills in TP95-1, 3 and 4. Lots of roots throughout. Silty Sand Glacial Till
No seeps encountered.	1	E.O.P.	Bedrock encountered at 0.5m. Lapilli Tuff (volcanics). Oxidized (iron stained) on exposed outcrop. Fractured.
No samples taken.	2		Note: Test pit is 10 m long, and varies in depth up to 1.4m.

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-6 SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,320 N; 592,740 E
Coarse Ore Stockpile.
GROUND ELEVATION ~1117 m.
DATE Jan 12/95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		ORGANICS
Moderate digging conditions Sample TP95-6 from 0 to 4m ←	1 2 3		Brown, dense, fine-grained sandy SILT with some fine-grained gravel, trace to some clay. Slightly moist. Becomes very dense (hard) near bottom of pit as backhoe rips chunks of till (very cohesive, acts like gravelly clay with some sand and silt. Probably a local till layer). Sandy Silt Glacial Till
Digging becomes more difficult.	4		Till becomes oxidized at 4 m.
No seeps encountered.	5	E.O.P.	Oxidized coarse-grained sand and angular rock fragments encountered. No large rock fragments or visible outcrop encountered.
	6		

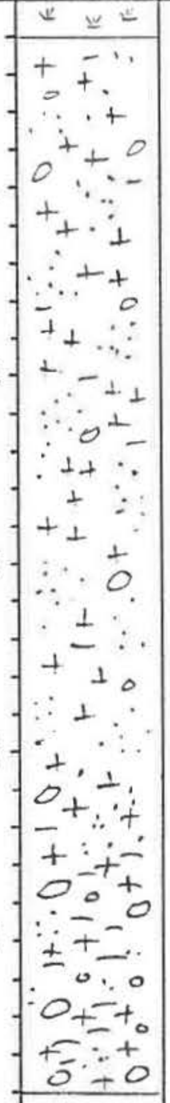
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-7
SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,510N; 592,730E.
" Concentrator
GROUND ELEVATION ~1112 m
DATE Jan 12/95
LOGGED BY KGB

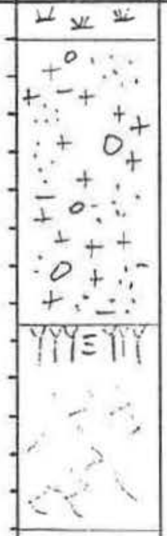
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics
Moderate digging conditions.	1 2 3		Brown, dense, slightly moist, fine-grained sandy SILT with some gravel, clay. Similar to material encountered in surrounding test pits. Hard, grey coloured till encountered at depth (~4.4m). Rips in extremely [illegible], no [illegible] samples from pit. Gravel is round and fine to medium-sized. Typically, the more dense till is encountered near the till/bedrock contact in previous test pits. Sandy Silt Glacial Till
Seep encountered at 4.4m.	4		
Sample TP95-7 (4.4 to 5.8m)	5		
Difficult digging conditions	6	E.O.P.	



KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-8 SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Approx 5,822,560 N ; 592,690 E.
" Concentrator
DATE Jan 12/95

PROJECT No. 1623
GROUND ELEVATION ~1110 m
LOGGED BY KGB.

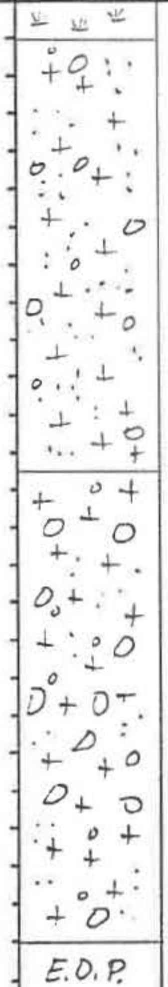
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics, black + brown colour.
Moderate digging conditions.	1		Dense, brown, fine-grained sandy SILT with some fine-grained gravel and clay. Loose once excavated. Similar till as majority of mill site pits. No hard basal till encountered. Sandy Silt Glacial Till
Water quickly ponding at bottom of hole.	∇ ? 2		Bedrock encountered at 1.7 m. Lapilli Tuff (volcanics). Angular fragments up to 30 cm dia. Backhoe tears through approx 1.1m with difficulty. Becomes extremely difficult to excavate at 2.8 m depth.
No samples taken.	3	E.O.P	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-9
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Apprx 5,823,280 N; 591,300 E
" East side Bootjack Lake
GROUND ELEVATION ~1052m
DATE Jan 12/95
LOGGED BY KGB.

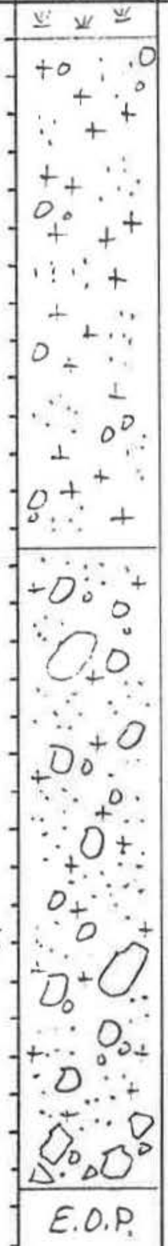
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics.
			Brown, dense, moist, sandy gravelly SILT with trace to some clay. Medium sized gravel. Poorly sorted, well graded. Coarser than till at mill site.
Moderate digging conditions	1		
Sample TP95-9A ← (0.2 to 2.5m)			Sandy Gravelly Silt Glacial Till
	2		
			Grey, slight to moderately dense (firm), very moist → sat'd, (sticky and cohesive) sandy SILT with some clay, trace to some gravel, trace cobbles. Gravel is fine to coarse grained. Moderate resistance when indented with finger. Very plastic. Backhoe creates suction when excavating material. This is very wet material!
Sample TP95-9B ← (2.5 to 5.0m)	3		
Seep @ 4m.	∇ 4		
			Sandy Silt Glacial Till
	5	E.O.P.	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-10
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,850 N ; 551 480 E
GROUND ELEVATION ~1048 m
DATE Jan 12/95 (East side Bootjack Lake)
LOGGED BY KGB.

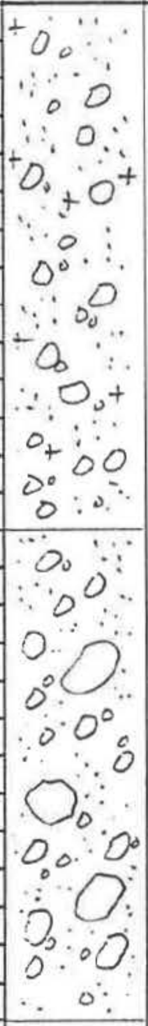
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics.
			Oxidized, dense sandy SILT with some gravel and clay. Slightly moist. Same material as encountered at mill site. Loose once excavated. Sandy Silt Glacial Till
Moderate digging conditions.	1		
	2		
	3		Brown, dense, moist, silty gravelly SAND with trace cobbles and clay. Non-plastic. Loose once excavated. moderate to coarse gravel. Denser material at bottom of pit. Coarser than till encountered in TP95-9. Silty Gravelly Sand Glacial Till
Sample TP95-10 ←			
	4		
More difficult digging (due to coarse rocks)	5		
No seeps encountered.			
	6		Rock fragments encounted (up to 20 cm dia.) at base of pit -- possible bedrock ?
	7		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-11
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5,822,500 N; 581,800 E (East side of Bootjack Lake)
GROUND ELEVATION ~1040 m
DATE Jan 12/95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe. Moderate digging conditions Sample TP95-11 ←	0 1 2		Brown, dense, slightly moist (near surface) to very moist (to 2.8m depth), gravelly SAND with some silt. Non-plastic. Poorly sorted, moderately graded. Slightly oxidized near surface. Gravelly Sand Glacial Till
Seep encountered @ 2.8m. Difficult digging due to coarse material.	▽ 3 4 5		Saturated sandy GRAVEL with some cobbles, trace to some silt. Moderately dense. Angular cobbles and gravel. Very coarse material. Noticable water in material when excavated. Sandy Gravel Glacial Till
	6	E.O.P.	

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-12 SHEET 1 of 1

PROJECT Mt. Polley

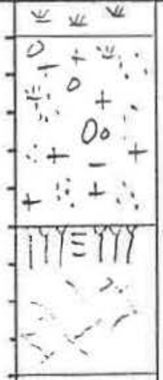
LOCATION OF TEST PIT Appr. 5 822 250 N ; 592 140 E (East side of Bootjack Lake)

DATE Jan 13/95

PROJECT No. 1623

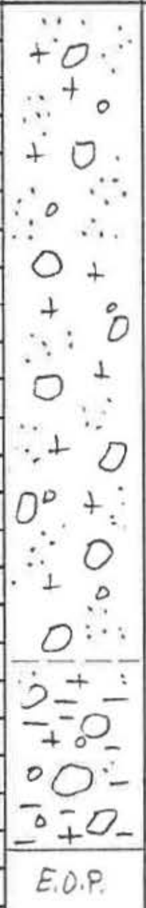
GROUND ELEVATION ~1050 m

LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe. Sample TP95-12 ← Moderate digging to 2m.	0 1 2 3	 E.O.P.	Organics Brown, moderately oxidized, moist to very moist, moderately dense, fine-grained sandy SILT with some fine-grained gravel and clay, trace organics. Poorly sorted, moderately graded. Slightly plastic. Sandy Silt Glacial Till Bedrock encountered at ~2m depth. Fractured, typically 20 cm dia pieces. Slightly wet at contact.

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-13 SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5 822 170 N; 592 470 E
GROUND ELEVATION ~1076 m
DATE Jan 13/95 (East side of Bootjack Lake)
LOGGED BY KGB.

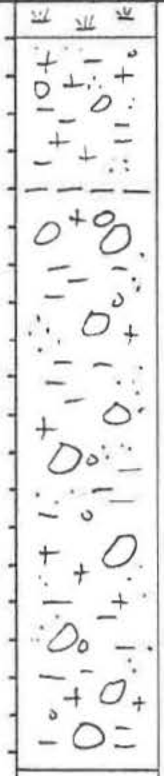
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		
	1		Brown, dense, moist, silty SAND with some gravel, trace to some clay. Gravel is typically medium sized. Well graded, poorly sorted. Slightly plastic. Coarser than material encountered at millsite. Good construction material. Silty Sand Glacial Till
Moderate digging conditions			
Sample TP95-13 ← (0 to 3.5m)	2		
	3		
Difficult digging conditions	4		Till becomes denser and more difficult to excavate. Grey-brown, hard, slightly moist sandy SILT with some gravel and clay. Rounded gravel; variable sizes. Extremely cohesive (rips in chunks from pit). Looks like a basal till. Sandy Silt Basal Till
No seeps.	5		
	6		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-14
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Appx 5 825 000N; 589 230E (7.1km along Main Access Road)
GROUND ELEVATION ~975m
DATE Jan 13/95
LOGGED BY KGB.



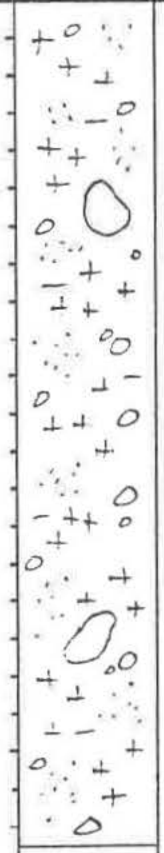
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe	0		Organics
Moderate digging conditions	1		Oxidized-brown near surface (becoming grey-brown coloured with depth), dense, slightly moist, sandy SILT and CLAY with some gravel and trace cobbles. Gravel and cobbles are rounded. Material becomes denser below 1m:
Sample TP95-14. ←	2		Hard, slightly moist, sandy SILT with some gravel and clay. Moderate to well graded, poorly sorted. Plastic when wet.
No seeps.			Good construction material.
Difficult digging with depth.	3		Sandy Silt Glacial Till
	4	E.O.P.	
	5		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-15
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Apprx 5826 300 N; 587 500 E (4.35 km along Main Access Road)
GROUND ELEVATION ~930 m
DATE Jan 13/95
LOGGED BY KGB.

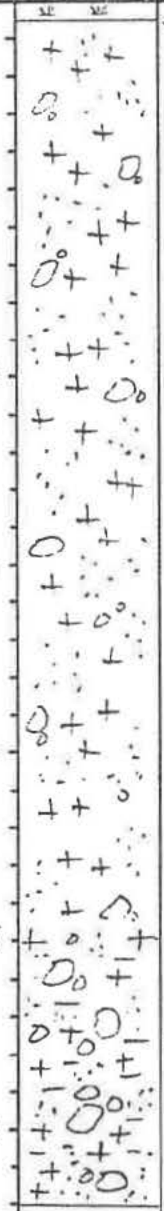
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe	0		No organics (on top of clear-cut hill).
Moderate digging conditions.	1		Brown, dense, slightly moist, sandy gravelly SILT with trace to some clay, trace cobbles. Poorly sorted, well graded. Rounded cobbles and gravel. Dense basal-till like appearance when excavated in hard chunks, although majority of material is loose once excavated. Good construction material. (similar till as TP95-14, only coarser.)
Sample TP95-15 ←	2		
No seeps.	3		Sandy Gravelly Silt Glacial Till
	4		
		E.O.P.	
	5		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-16
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5 820 580N; 594 370E (TSF Access Road)
GROUND ELEVATION ~980m
DATE Jan 13/95
LOGGED BY KGB.

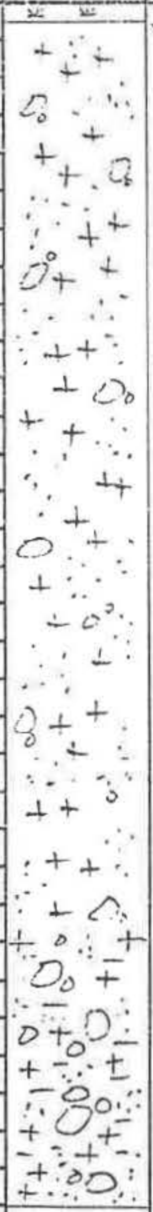
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics
Easy to moderate digging conditions.	1		Brown, dense, slightly moist, sandy SILT with trace to some gravel and clay. Occasional rounded cobble or boulder. Moderately graded, poorly sorted. Plastic. No oxidation evident. In-situ material is 'very stiff'. Sandy Silt Glacial Till
Sample TP95-16 ← (0 to 5m)	2		
	3		
	4		
Seep at 5.0m.	∇ 5		Grey, hard, slightly moist sandy SILT with some gravel and clay, trace cobbles. Material is ripped from ground in extremely cohesive chunks. Slightly moist. Note: Some local coarse areas of gravel and sand exist and water seeps through.
Very difficult digging conditions.	6	E.O.P.	
	7		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-16
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5820 580N: 594 370E
GROUND ELEVATION ~980m
DATE Jan 13/95 (TSF Access Road)
LOGGED BY KSB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics
Easy to moderate digging conditions.	1		Brown, dense, slightly moist, sandy SILT with trace to some gravel and clay. Occasional rounded cobble or boulder. Moderately graded, poorly sorted. Plastic. No oxidation evident. In-situ material is 'very stiff.'
Sample TP95-16 ← (0 to 5m)	2		Sandy Silt Glacial Till
	3		
	4		
Seep at 5.0m.	▽ 5		Grey, hard, slightly moist sandy SILT with some gravel and clay, trace cobbles. Material is ripped from ground in extremely cohesive chunks. Slightly moist.
Very difficult digging conditions.	6		Note: Some local coarse areas of gravel and sand exist and water seeps through.
		E.O.P.	
	7		

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	# TEST PIT LOG	TEST PIT No. TP95-17 SHEET 1 of 1

PROJECT Mt. Polley

PROJECT No. 1623

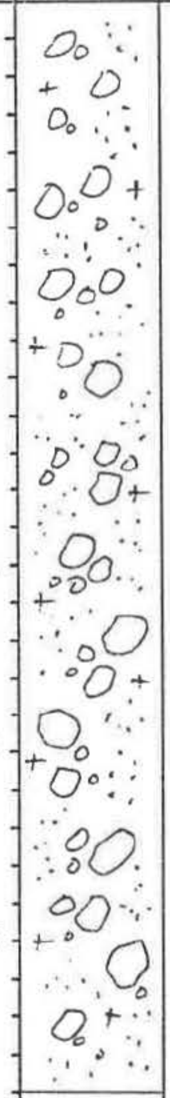
LOCATION OF TEST PIT Approx 5 821 110 N; 594 230 E (TSF Access Road).

GROUND ELEVATION ~980 m

DATE Jan 13/95

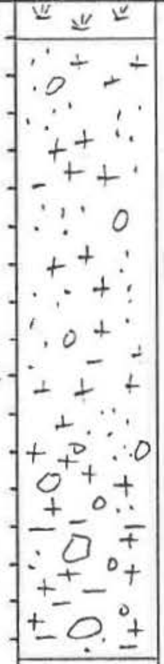
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		
	1		Brown, moderately dense, moist, GRAVEL and SAND with some fine cobbles and silt. Poorly sorted, moderately graded. Non-plastic. Sub-angular gravel and cobbles.
Moderate digging conditions.	2		Gravel and Sand Glacial Till
Sample TP95-17	←		
Water level rises to 3m depth after 15 hrs.	▽ 3 ↑		
	4		
Water table encountered at 4.3 m.	▽		Material is saturated below 4.3 m.
	5		
	6	E.O.P.	



KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-18 SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5821100N; 593 295E
GROUND ELEVATION ~992m
DATE Jan 14/95 (Along tailings/reclaim pipeline route)
LOGGED BY KGB.

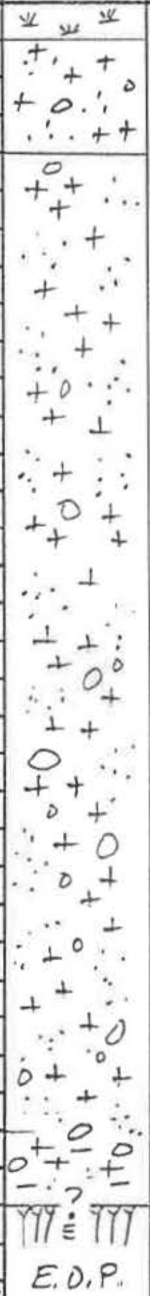
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		Organics
Moderate digging conditions. Sample TP95-18	1 ←		Brown, dense, slightly moist sandy SILT with some gravel and trace clay. Occasional rounded cobble. Plastic. Poorly sorted, moderately graded. Approx. top 20cm is oxidized; the remainder is fresh. Sandy Silt Glacial Till
	2		
Difficult digging conditions. No seeps encountered.	3		Gray-brown, hard, slightly moist sandy SILT with some gravel and clay, and trace cobbles. Very dense and cohesive (rips out of pit in chunks). Poorly sorted, well graded. Gravel and cobbles are round to sub-rounded.
		E.O.P.	
	4		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-19
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5821 600 N; 592 980 E
(Along tailings / reclaim pipeline route)
GROUND ELEVATION ~1042 m
DATE Jan 14/95
LOGGED BY KGB.

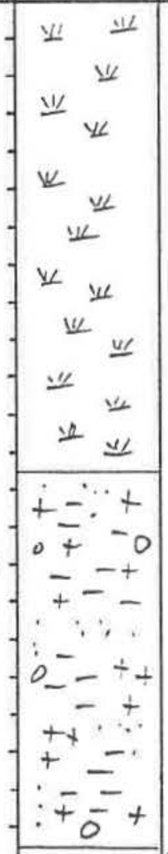
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe. *Seepage from 0.2 to 0.8m only.	▽* 0		Organics.
	1		Brown, dense, moist gravelly SAND and SILT with trace cobbles and clay. Oxidized near surface. Plastic. Very well graded, poorly sorted. Sub-angular to sub-rounded particles. Visible seepage. Gravelly Sand and Silt Till (Note: This may be a layer of material developed from road construction.)
Moderate digging conditions	2		
Sample TP95-19 (0.8 to 6.0m)	← 3		Brown, dense, slightly moist, silty fine-grained SAND with some gravel, trace cobbles (with depth). Plastic. Poorly sorted, moderately graded. Becomes moister with depth. Material becomes sandy SILT with some gravel and clay, trace cobbles. All gravel is sub-round to sub-angular. Silty Sand / Sandy Silt Glacial Till
	4		
	5		approximate depth.
Difficult digging conditions.	6		Becomes grey and hard. Rounded gravel and cobbles.
	7		Note: Angular rock fragments encountered at bottom of hole. Fine-grained, mafic with white (~2mm) flecs. (Possible bedrock contact?)

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-20
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5 820 900N; 585 670 E (South-east corner of Polley Lake)
GROUND ELEVATION ~ 922 m
DATE Jan 14/95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	∇* 0		Black/brown ORGANICS. Completely saturated. Side walls continuously slough into pit. Very smelly! Very soft. Water continuously seeps into pit.
* Perched water table above dense till.	1		
Very easy digging (0-2.5m)	2		
More difficult digging conditions.	3		Grey, very stiff → hard, slightly moist → moist, sandy SILT with some gravel and clay. Plastic. Poorly sorted, moderately graded. Very cohesive. Looks like basal till encountered in local pits, only more in-situ moisture. Sandy Silt Basal Till
Sample TP95-20 ←			
	4		
		E.O.P.	Approximate depth. Difficult to measure due to pit constantly collapsing and filling with water.
	5		

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-21
SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5 820 840N; 595 540E
GROUND ELEVATION ~922 m
DATE Jan 14/95 (60m south of Polley Lake)
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL

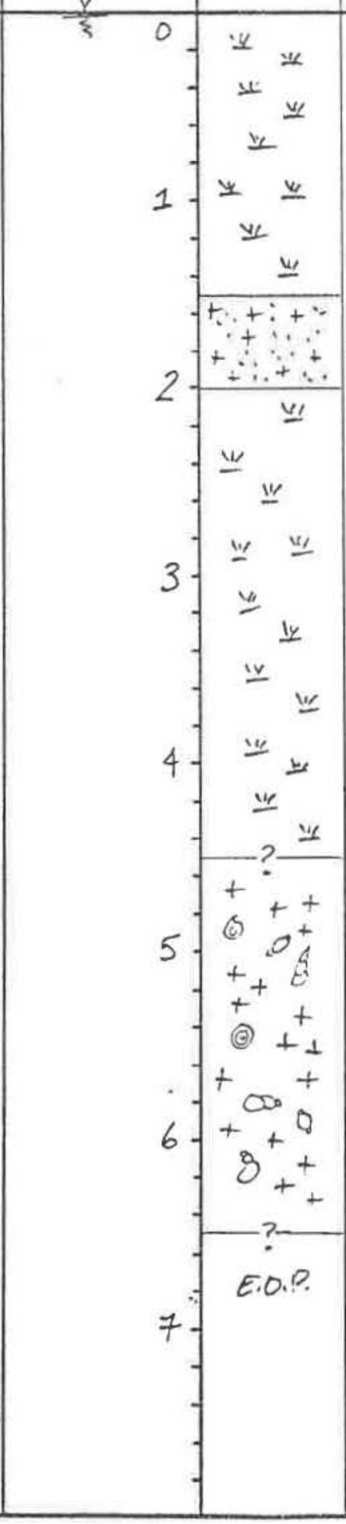
NOTES

Hitachi 200 hoe.

Visible seeps from peat from 0 to 1m depth. Pit is saturated.

Very soft digging throughout.

No samples taken.



DESCRIPTION AND CLASSIFICATION OF MATERIAL

Black/brown, saturated, very soft ORGANICS. Very strong odour. Minimal strength.

Layer of gray, saturated, very soft, silty fine-grained SAND. Varves of grey and brown colours. Easily indented with finger.

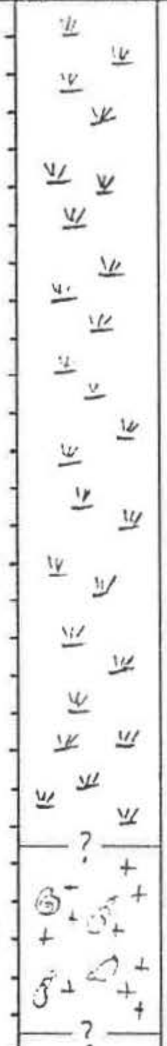
Tan and grey, saturated, very soft SILT and ORGANICS. Varved silt layers. Tan layers contain yellow grass and small (up to 1cm; ave 0.5cm long) white fresh water shells. Well sorted, poorly graded. Very plastic and cohesive. Strong odour.

SILT and ORGANICS

Note: Depths are approximate only due to pit constantly collapsing and filling with water.

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-22 SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5820 890 N; 595 540 E (South end of Polley Lake)
GROUND ELEVATION ~522m
DATE Jan 14/95
LOGGED BY KGB

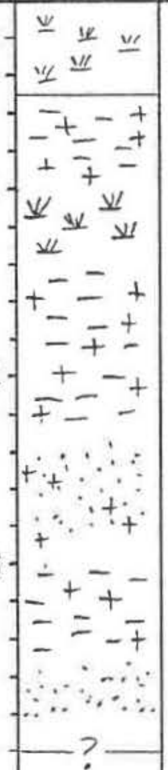
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe	∇ 0		
Visible seeps from peat layer. Pit is saturated	1		Black/brown, saturated, very soft ORGANICS. Side walls continuously collapse into pit. Very strong odour. Minimal strength.
Very easy digging throughout test pit.	2		
No samples taken.	3		
	4	?	
	5	?	Tan/grey, saturated, very soft SILT and ORGANICS. Varved layers. Same material as encountered in TP95-21. SILT and ORGANICS
	6	E.O.P.	
			Note: Depths are approximate only due to pit walls continuously collapsing and pit filling with water.

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-23
SHEET 1 of 1

PROJECT Mt Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5820 890 N; 555 420 E (South west corner of Polley Lake)
GROUND ELEVATION ~922m
DATE Jan 14/95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	∇ 3 0		Black/brown, saturated, very soft ORGANICS.
Soft digging conditions.	1		Grey, saturated, very soft CLAY and SILT. Well sorted, poorly graded. Varved. Very plastic. Strong odour. Very cohesive.
Pit is saturated.	2		
No samples taken.	3		Layers of darkgrey/black, saturated, very soft fine-grained SAND and SILT. Some sand is coarse grained and of quartz composition. Cohesive. LACUSTRINE LAYERS
	4	E.O.P.	
			Note: Depths are approximate only due to pit walls continuously collapsing and the pit filling with water.

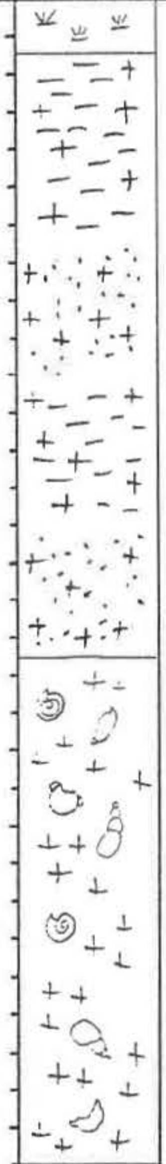
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-24
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Approx 5 820 800 N; 595 360 E
DATE Jan 14/95 (south-west corner of Polley Lake)

PROJECT No. 1623
GROUND ELEVATION ~922 m
LOGGED BY K&B.

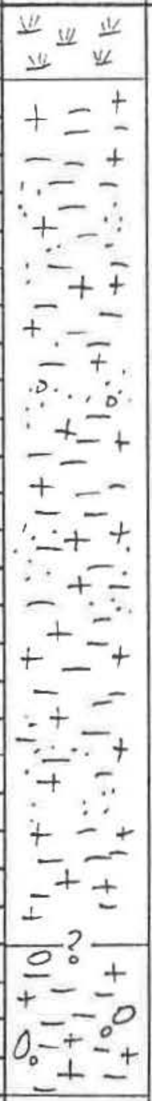
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	▽ 0		Black-brown, saturated, very soft ORGANICS.
Very soft digging conditions. Pit walls are more competent than in earlier test pits (TP95-20 to 23) No samples taken.	1 2 3		Lacustrine sequences of the following: • Dark grey, very soft, saturated CLAY and SILT with some organics. Varved. Well sorted, poorly graded. • Dark grey, very soft, saturated silty fine-grained SAND. Both are plastic due to high silt/clay content. Strong odour. LACUSTRINE LAYERS
	4 5 6		Tan/grey, saturated, very soft SILT and ORGANICS. Varved layers containing white fresh-water shells and yellow grass. Well sorted, poorly graded. Very plastic and cohesive. Strong odour. SILT and ORGANICS
	7	E.O.P.	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-25
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Approx 5 820 930 N; 595 250 E (On access road to Polley Lake)
GROUND ELEVATION ~922
DATE Jan 14 /95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe	▽ 0		Black/brown, saturated, very soft ORGANICS.
Very soft digging conditions. Sample TP95-25 ← (0.4 to 5m)	1 2 3 4		Dark grey, saturated, very soft (and sticky) CLAY and SILT with some sand, coarsening with depth to sandy CLAY and SILT with trace gravel. Very plastic. Strong odour. Moderate to well sorted, poorly graded. Layers of sand and gravel at local intervals. LACUSTRINE LAYERS
Difficult digging conditions at 5 to 5.8m	5		Brown, hard, slightly moist, sandy SILT with some gravel and clay, trace cobbles. Very dense chunks are ripped from pit. Poorly sorted, well graded. Plastic (when wet). Looks similar to basal till encountered locally, only brown in colour. Sandy Silt Basal Till
	6	E.O.P.	

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-26 SHEET 1 of 1

PROJECT Mt. Polley

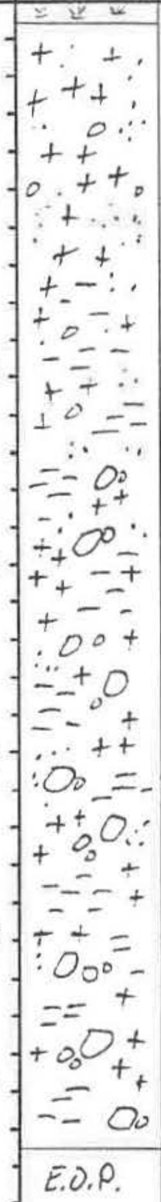
PROJECT No. 1623

LOCATION OF TEST PIT Approx 5819 150 N; 594 645 E (Tailings Basin)

GROUND ELEVATION ~938m

DATE Jan 15/95

LOGGED BY KGB.

NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe.	0		ORGANICS
	1		Brown, dense, slightly moist → moist, sandy SILT with some fine gravel and clay, trace cobbles. Very plastic. Poorly sorted, well graded. With depth, material becomes grey coloured and increases in gravel content. Looks very much like a typical basal till.
Moderate digging conditions	2		Very cohesive, hard chunks of material is ripped out of pit. This material is more moist than usually encountered.
No seeps encountered.	3		Sandy Silt Glacial Till
Sample TP95-26 ←			
	4		
	5		Material at approx 5.5m becomes very plastic due to higher moisture content (behaves like plasticene when remoulded). Material remains the same well graded nature, only more moist.
	6	E.O.P.	
	7		

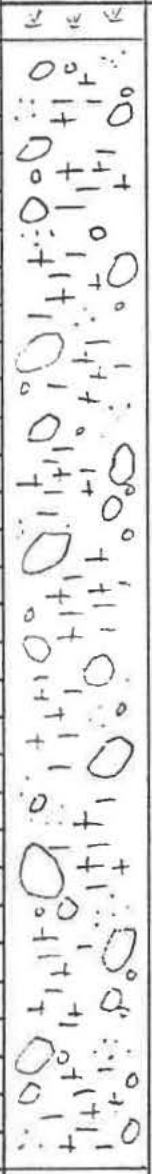
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-27
SHEET 1 of 1

ROJECT Mt Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 819 740 N; 595 350E (North embankment alignment)
GROUND ELEVATION ~530 m
DATE Jan 15/95
LOGGED BY KGB.

NOTES roundwater level, difficulty in digg-ing, equipment sed, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe	0		ORGANICS
	1		Brown (grey at depth), hard, slightly moist sandy SILT with some gravel and clay, trace cobbles. Poorly sorted, well graded. Very cohesive (rips in dense chunks from pit). Gravel and cobbles are sub-rounded. Cobble content increases with depth to "some cobbles." Top 0.5m of material is oxidized. Plastic when wetted.
*ocal seeps ~ 2.7m and 4m only. The mainder of he pit is dry.	2		
	▽*		**Sandy Silt Basal Till**
	3		
ample TP95-27 ←	▽* 4		
Moderate to difficult digging onditions.	5		
	6		
		E.O.P.	
	7		

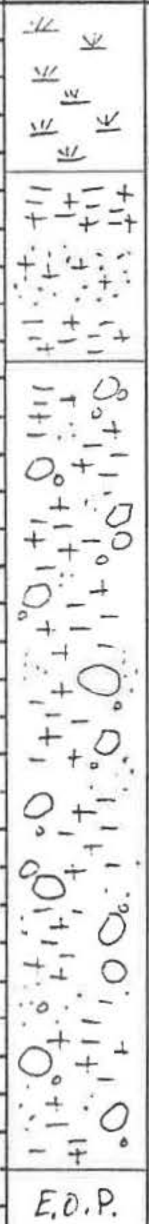


KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-28
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
LOCATION OF TEST PIT Appox 5819 360 N ; 595 285 E " (Tailings Basin)
GROUND ELEVATION ~ 923.4m
DATE Jan 15/95
LOGGED BY KGB.

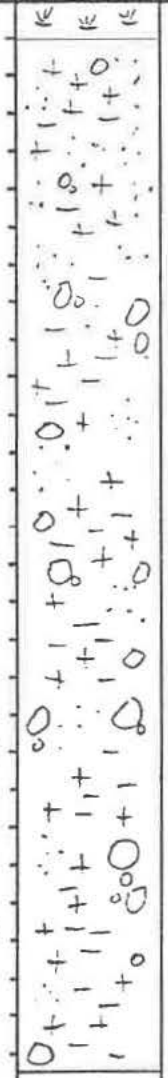
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe Ponded water at surface.	▽ 0		Brown, soft, saturated ORGANICS.
Easy digging conditions (0 to 1.5m)	1		Grey-green, soft, very moist layers of CLAY and SILT and silty SAND. Well sorted, poorly graded layers. Clay and silt are very plastic due to high moisture. Sand layer is visibly wet on pit walls.
Moderate to difficult digging conditions (1.5 to 6.2m). Sample TP95-28 ← (5 to 6.2m)	2 3 4 5 6		Brown-gray, hard, slightly moist, sandy SILT with some gravel and clay, trace cobbles. Very cohesive, dense chunks of material. Plastic when wet. Poorly sorted, well graded. Sandy silt Glacial Till Material becomes moist at 5m depth. Clay and silt matrix materials become sticky and are easily remoulded (like plasticene). Bedrock and possible water table nearby.
	7	E.O.P.	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-29
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5818 745 N; 596 270E (Potential East Ridge Borrow Area)
GROUND ELEVATION ~ 936m
DATE Jan 15/95
LOGGED BY KGB.

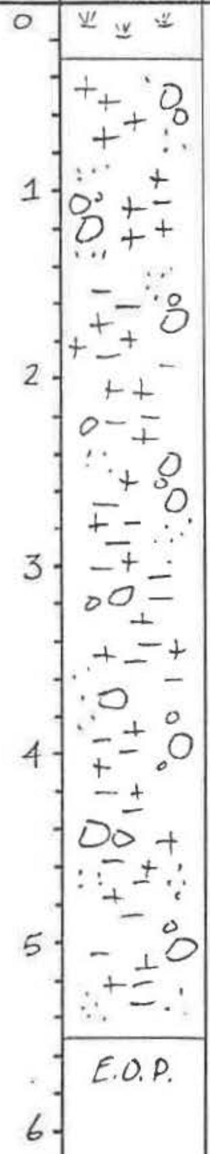
NOTES roundwater level, difficulty in digg-ing , equipment sed , etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe. ery soil to 'm depth! Moderate gging conditions lo seeps. Sample TP95-29 ←	0 1 2 3 4 5 6	 E.O.P.	ORGANICS. Brown, dense (firm to hard), dry to slightly moist, sandy SILT with some gravel, trace clay and cobbles. Material is drier than usually encountered. Poorly sorted, well graded. Plastic when wet, otherwise at plastic limit with natural moisture content. Becomes very hard with depth, and excavates in dense, cohesive chunks. Good construction material. Sandy Silt Glacial Till

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-30
SHEET 1 of 1

PROJECT Mt. Polley
LOCATION OF TEST PIT Approx 5818 495N; 596 560 E (Potential East Ridge Borrow Area)
DATE Jan 15/95
PROJECT No. 1623
GROUND ELEVATION ~ 938m
LOGGED BY KGB.

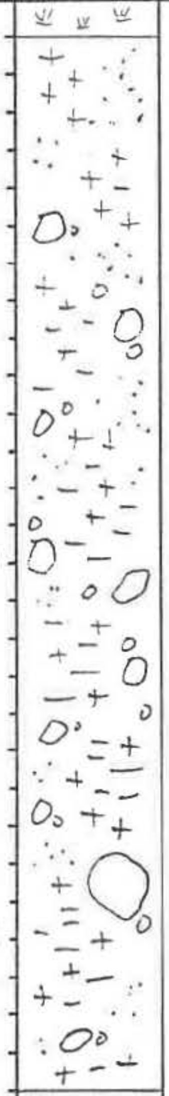
NOTES Groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
Hitachi 200 hoe. No seeps encountered. Moderate digging conditions Sample TP95-30 ←	0 1 2 3 4 5 6		Bright orange ORGANICS (rotten wood). Brown, dense (firm to hard), slightly moist, sandy SILT with some gravel, trace clay and cobbles. Poorly sorted, well graded. Becomes more cohesive, grey coloured and hard with depth as material is ripped out of pit in chunks. Gravel and cobbles are sub-rounded to round. Good construction material (similar to TP95-29). Sandy Silt Glacial Till

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-31
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 816 955 N; 596 470 E (Potential East Ridge Borrow Area)
GROUND ELEVATION ~939 m.
DATE Jan 15/95
LOGGED BY KGB.

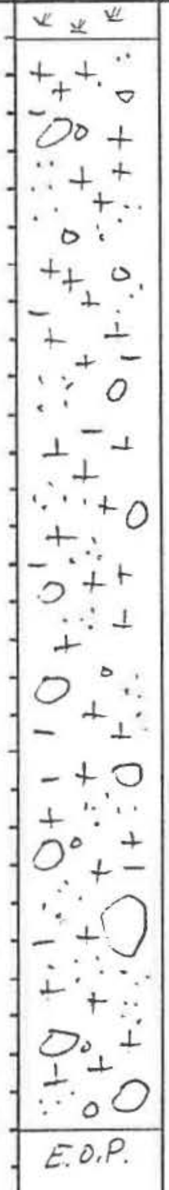
NOTES roundwater level, difficulty in digg- ng , equipment sed , etc .	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
itachi 200 hoe	0		ORGANICS.
No seeps ncountered.	1		Brown, dense (firm to hard), slightly moist, sandy SILT with some gravel, trace clay and cobbles. Occasional boulder at depth. Poorly sorted, well graded. Same material as encountered in TP95-29 and 30 (same natural moisture content as TP95-30). Good construction material. Sandy Silt Glacial Till
oderate igging conditions			
ample TP95-31 ←	2		
	3		
	4		
	5		
	6	E.O.P.	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-32
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 819 140 N; 595 780E (East Tailings Basin)
GROUND ELEVATION ~932m
DATE Jan 16/95
LOGGED BY KGB.

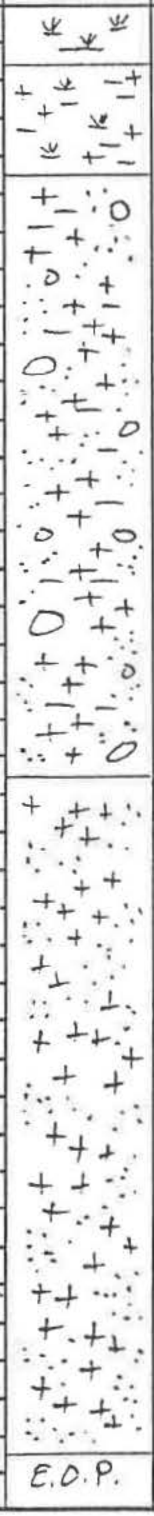
NOTES roundwater level, difficulty in digg-g, equipment sed, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe	0		ORGANICS, black/brown/orange
derate to ifficult digging. o seeps ncountered	1 2 3		Brown, dense (very stiff), slightly moist, sandy SILT with some gravel and clay, trace cobbles. Becomes grey in colour and increases in density to "hard" with depth. Poorly sorted, well graded. No oxidized zone near surface. Gravel and cobbles are sub-round to round. Becomes very basal-like with depth. Very low permeability. Sandy Silt Glacial Till
mple TP95-32 ←	4 5 6	E.O.P.	

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-33
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1673
OCATION OF TEST PIT Approx 5818750N; 594 820E (SW Tailings Basin)
GROUND ELEVATION ~932m
DATE Jan 16/95
LOGGED BY KGB.



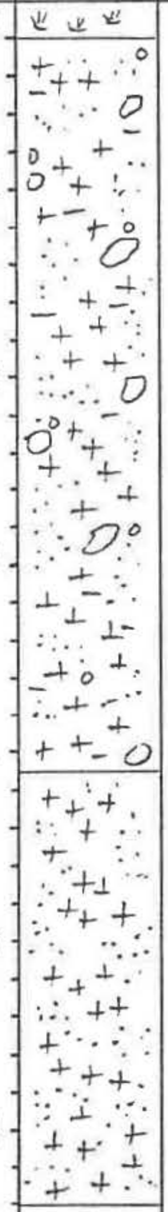
NOTES oundwater level, difficulty in digg- g, equipment ed, etc.	DEPTH (metres)	DESCRIPTION AND CLASSIFICATION OF MATERIAL
achi 200 hoe	▽ 0	Black, soft, saturated ORGANICS. Swamp. Willows + swamp spruce.
ded water surface (perched water ble).	1	Grey-black, oxidized, stiff, moist SILT and CLAY with some organics (grass and roots). Very plastic. Well sorted, poorly graded. Low permeability SILT and CLAY
ooth, easy igging (0 to 0.9m) erate igging (0.9 to 4.1m)	2 3 4	Brown, dense (v. stiff), slightly moist sandy SILT with some gravel and clay, trace cobbles. Poorly sorted, well graded. Oxidized at contact with overlying silt + clay. Slightly plastic. Low permeability Sandy Silt Glacial Till
mooth, easy igging (4.1 to 7.7m) ple TP95-33 (4.1 to 7.7m) ←	5 6 7 8	Grey, stiff to very stiff, moist, SILT and fine-grained SAND. Very thin laminated layers (<<1mm) which can be carefully peeled apart by hand. Plastic. Well sorted, poorly graded. No varves evident. Low permeability. Cohesive. SILT and SAND

KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-34
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 818 730 N; 595 250 E (South Basin)
GROUND ELEVATION ~ 824 m.
DATE Jan 16/95
LOGGED BY KGB

NOTES Groundwater level, difficulty in digg- g, equipment ed, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe	0		Black, soft ORGANICS.
oderate digging nditions. mple TP95-34A ← 2 to 4.1m) Only local, w flow seeps ible at ntact.	1 2 3 4 ▽*		Brown, dense (hard), slightly moist, sandy SILT with some gravel and clay, trace cobbles. Top 30cm is oxidized. Rounded gravel and cobbles. Material is just below plastic limit. Poorly sorted, well graded. Similar material as encountered in TP95-33. Low permeability. Sandy Silt Glacial Till.
ooth, easy ging (4.1 to 6.4m) ple TP95-34B ← 4.1 to 6.4m)	5 6		Dark grey / black, stiff → very stiff, slightly moist, SILT and fine-grained SAND. Well sorted, poorly graded. Does not have layering like TP95-33 did. At plastic limit. Cohesive. Low permeability. Drier than TP95-33 Silt and sand layers. SILT and SAND
	7	E.O.P.	

KNIGHT AND PIESOLD LTD. CONSULTING ENGINEERS	TEST PIT LOG	TEST PIT No. TP95-35 SHEET 1 of 1

PROJECT Mt. Polley

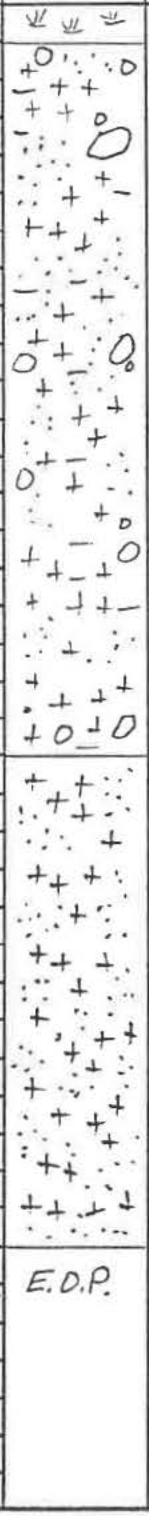
PROJECT No. 1623

OCATION OF TEST PIT Approx 5818 690 N; 595 535 E.
" (South Basin).

GROUND ELEVATION ~917m

DATE Jan 16/95

LOGGED BY KGB

NOTES roundwater level, difficulty in digg- ig , equipment sed , etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe	0		ORGANICS, black / orange.
derate digging nditions. (0.2 to 4.0m). * Seep at contact. j localized and low flow rate.	1 2 3 ∇ * 4		Brown, dense (v. stiff → hard), slightly moist sandy SILT with some gravel and clay, trace cobbles. Poorly sorted, well graded. Slightly plastic (at P.L.) Rounded gravel + cobbles. Dense, very cohesive chunks of material encountered with depth when ripped out of pit. Becomes grey-colour with depth. Very low permeability. Sandy Silt Glacial Till
ooth, easy ligging (4.0 to 6.6m) ple TP95-35 .0 to 6.6m)	5 ← 6		Dark grey, slightly moist, stiff, SILT and fine-grained SAND. Sand is visible as white qtz. flecks in silt. Well sorted, poorly graded. Below plastic limit. Cohesive chunks when excavated, and cohesive overall. Low permeability. Same material as encountered in TP95-34 pit. Silt and Sand.
	7	E.O.P.	

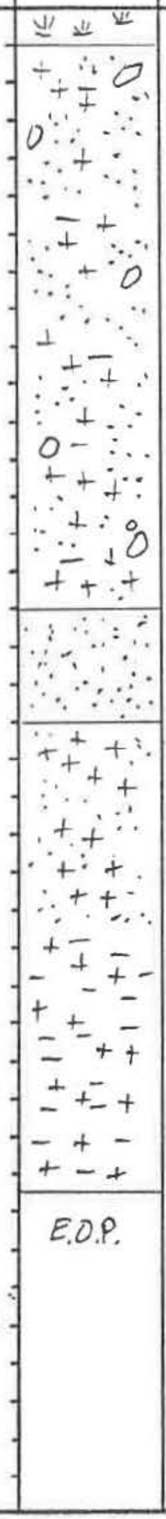
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-36
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 818 520 N; 595 275 E (South Basin)
GROUND ELEVATION ~924 m
DATE Jan 16/95
LOGGED BY KGB.

NOTES roundwater level, difficulty in digg-g, equipment ed, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe.	0		ORGANICS.
oderate digging. des slough into pit. Sample TP95-36A ← (.2 to 3.2m)	1 2		Brown to grey, very stiff → hard, moist, silty SAND with trace to some gravel and clay. No coarse gravel or cobbles in this material. Poorly sorted, moderately graded. Moister than most tills. Rounded gravel. Cohesive. Coarser than most tills, also. Silty Sand Glacial Till
derate flow from sand yer.	3 ▽		Black, medium to coarse-grained SAND with trace (to none) of silt. Not cohesive. Well sorted, poorly graded. Saturated. Approx 60 cm thick. SAND
ooth digging (3.2 → 6.3m) Sample TP95-36B ← (B to 6.3m)	4 5		Creamy brown, very stiff → hard, slightly moist SILT and CLAY. No coarse material. Layered. Well sorted, poorly graded. Very cohesive. Low permeability. SILT and CLAY
	6 7	E.O.P.	Brown, soft, moist to very moist SILT and fine-grained SAND. Well sorted, poorly graded. Slightly cohesive (probably due to high moisture content). Sides of pit continuously cave-in. Difficult to tell where this layer exists due to instability of test pit walls. SILT and SAND

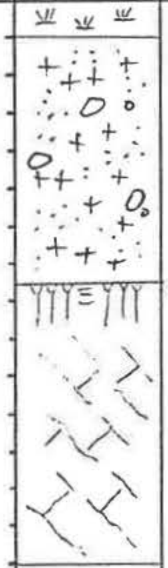


KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-37
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 818 345 N; 595 260 E (SW Tailings Basin).
GROUND ELEVATION ~938m
DATE Jan 16/95
LOGGED BY KGB.

NOTES . oundwater level, difficulty in digg- 1, equipment ed, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
'tachi 200 hoe	0		ORGANICS.
Moderate digging (to 1.5m)			Brown, very stiff, moist sandy SILT with some gravel and clay. Poorly sorted, well graded. Plastic. Contains more moisture than usual (probably due to close proximity to surface and bedrock).
Sample TP95-37 ←	1		Sandy Silt Glacial Till
ep below till/ bedrock contact.			
	2		Bedrock encountered at 1.5m depth. Very fractured, purple volcanic conglomerate (friable). Fragments are typically 30cm size. and very angular.
Difficult digging ock.	▽		
	3	E.O.P.	

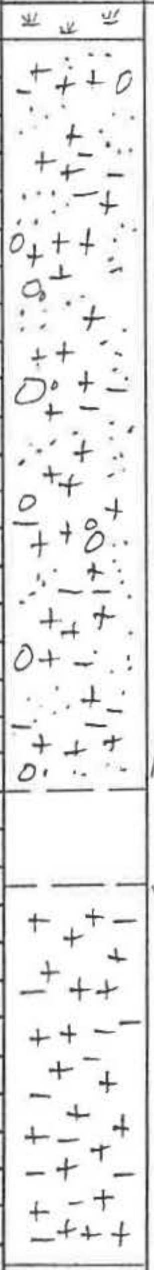
KNIGHT AND PIESOLD LTD.
CONSULTING ENGINEERS

TEST PIT LOG

TEST PIT No. TP95-38
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 818 460 N; 595 495E
GROUND ELEVATION ~915m
DATE Jan 16/95
LOGGED BY KGB.

NOTES groundwater level, difficulty in digging, equipment used, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
tachi 200 hoe.	0		ORGANICS.
oderate digging (0 to 4.7m) No seepage encountered.	1 2 3		Brown to grey, hard, slightly moist sandy SILT with some gravel and clay. Poorly sorted, well graded. Rounded gravel. Very dense, cohesive chunks ripped out of pit. Plastic. Grey colour on face of some chunks (along cracks in till?). Occasional cobble near surface and becoming "trace cobbles" with depth. Low permeability. Sandy Silt Glacial Till
	4		Dark gray, stiff to very stiff, moist SILT with some clay, trace to some sand, trace gravel. Very plastic. Looks like above till, although some material is layered (and peels apart on layers). (Probable transition where till has been mixed with underlying layers)
Moderate, yet smooth digging (4.5 to 6.7m) Sample TP95-38 ←	5 6		Creamy brown to grey, very stiff → hard, slightly moist SILT with some clay. Very cohesive and dense. Well sorted, poorly graded. Obvious layers in grey silt. Till-like feel for density of this material. Similar to silt/clay encountered in TP95-36. Low permeability. SILT and CLAY
	7	E.O.P.	



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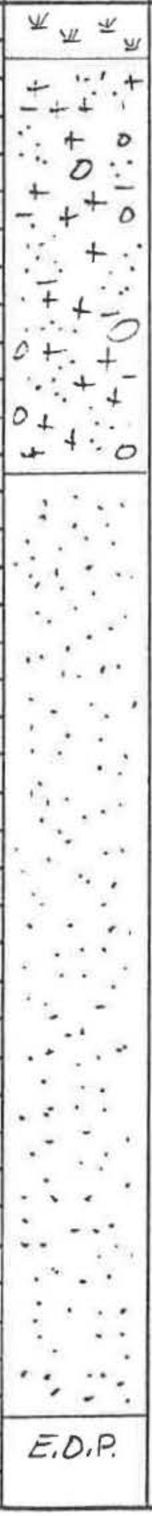
TEST PIT LOG

TEST PIT No. TP95-39
SHEET 1 of 1

PROJECT Mt. Polley
PROJECT No. 1623
OCATION OF TEST PIT Approx 5 818 405 N; 595 405 E
" (south tailings basin)
GROUND ELEVATION ~918 m
DATE Jan 16/95
LOGGED BY KGB.

NOTES Groundwater level, difficulty in digg- g, equipment ied, etc.	DEPTH (metres)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
itachi 200 hoe.	0		Black, saturated, soft ORGANICS.
oderate gging (0 to 2.5m)	1 2		Brown to grey, hard, slightly moist → moist, sandy SILT with some gravel and clay. Poorly sorted, well graded. More moist on surface of dense, cohesive chunks of till (from surface inflow?). Typical till. Sandy Silt Glacial Till
ter table at act. Easy digging 5 to 7.5m) ides of pit itinuously slough.	$\underline{\nabla}$ 3 3 4 5 6		Brown, soft, saturated, fine-grained SAND and SILT. No cohesion (pit walls continuously cave-in). Very well sorted, poorly graded. Becomes more dense with depth. Sand and Silt
de TP95-39 ← (at bottom of pit).	7 8		Note: Bottom of pit is estimated only as continuous sloughing of side walls made accurate measurements impossible.

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

RESPONSE TO REVIEW COMMENTS ON GROUNDWATER MONITORING PROGRAM

(REF. NO. 1625/7)

SEPTEMBER 12, 1996

IMPERIAL METALS CORP.
MT. POLLEY PROJECT

RESPONSE TO REVIEW COMMENTS ON GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/7)

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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

RESPONSE TO REVIEW COMMENTS ON GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/7)

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FIGURES

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

RESPONSE TO REVIEW COMMENTS ON GROUNDWATER MONITORING PROGRAM

(REF. NO. 1625/7)

SECTION 1.0 - GENERAL

The following is a response to the review comments submitted by Mr. Joe Negraeff of the Ministry of Environment on July 22, 1996, with respect to the Environmental Baseline Report 1995 and related Groundwater Monitoring Documents. This document specifically contains only the relevant responses to the review comments pertaining to the groundwater monitoring program as originally documented in the following:

- "Imperial Metals Corporation Mount Polley Project Environmental Baseline Report 1995", by Hallam Knight Piesold Ltd. (Section 7.0 only);
- "Manual on Sampling and Handling Guidelines for Determination of Groundwater Quality (Ref. No. 1625/5)", dated May 19, 1995, by Knight Piesold Ltd.; and
- "Groundwater Monitoring Program (Ref. No. 1624/2)", dated June 3, 1996, by Knight Piesold Ltd.

This document is organized in a manner whereby the review comment is listed followed by the response. Reference numbers are provided as per the original Environmental Baseline Report (1995) submitted for review. In some instances the response may take the form of a reference or clarification of information originally submitted for agency review.

The groundwater wells installed at the proposed minesite in 1995 were installed by Imperial Metals Corporation (IMC) for the primary purpose of investigating open pit dewatering and water supply for mill process requirements. The 1995 wells were installed without the direction or supervision of Knight Piesold Ltd. The details of installation were provided to Knight Piesold Ltd. by IMC and were included in the Report Ref. No. 1624/2.

IMC has recently provided further details on the 1995 installations. Specifically, the wells comprise 5 inch diameter, flush jointed PVC pipe which were grouted inside 6 inch diameter steel casings to a minimum depth of 5 m or to bedrock. The PVC included slotted sections in the aquifers to maximize water recovery. The use of the 1995 wells as groundwater monitoring wells was considered to be a secondary objective and will be decommissioned in early 1997 once the new 1996 monitoring wells have been installed and sampling has commenced.

Subsequent to the review comments and consideration of the importance of groundwater quality sampling and associated monitoring of potential hydrogeologic impacts on surrounding surface drainages, the 1996 groundwater monitoring program has been revised. Provisions have been included for the installation of a total of eight (8) additional wells (three new wells in the minesite area in addition to the five wells proposed for the tailings facility area, originally proposed in Report Ref. No. 1624/2) dedicated for the purpose of monitoring groundwater quality. The 1996 groundwater monitoring wells will be used to collect baseline groundwater quality and for monitoring groundwater quality during operations and at closure. Details on the proposed groundwater monitoring wells are included in the "Requirements and Specifications for the 1996 Groundwater Monitoring Program (Ref. No. 1625/8)" which accompanies this document.

SECTION 2.0 - RESPONSES TO REVIEW COMMENTS

The following are responses to review comments made by the Ministry of Environment, as documented on July 22, 1996, specifically relating to the groundwater monitoring program.

A. Imperial Metals Corporation Mount Polley Project Environmental Baseline Report 1995.

Section 7.0 Groundwater Sampling

Section 7.1 Introduction

Comment: *"Please note that the Guidelines for Minimum Standards in Water Well Construction for the Province of B.C. are directed at production wells i.e. for development of water supplies. Optimal construction of monitoring wells differs somewhat from production wells in choice of well drilling machinery, well casing diameter, materials, and well development prior to sampling".*

Response: Additional groundwater monitoring wells will be installed in 1996 in accordance with accepted standard practice for groundwater monitoring wells, as per EPA, CCME and ASTM criteria (see accompanying Report Ref. No. 1625/8 for details).

Section 7.2 Methods and Materials

Comment: *"Are joins in the PVC well casings in the 1995 wells welded or threaded? Weld materials can contribute to metals contamination. PVC casing and screens should be threaded not welded to avoid potential for contamination from the weld compounds".*

Response: The 1995 wells included 5 inch diameter Schedule 40 flush jointed, threaded PVC casing and screens, as per recent information provided by Imperial Metals Corporation. All PVC casing and screens for the 1996 wells will also to be flush jointed and threaded.

Comment: *"Groundwater samples should be free of particulates and kept anaerobic as they would be in-situ in the ground (i.e. no air or head space in the sample container). It is desirable to collect dissolved metals samples in groundwater without exposure to air by using "in-line" filtration methods to ensure no oxidation of iron etc. to ferric iron, which in turn precipitates as particulate ferric hydroxide or oxyhydroxides scavenging other dissolved metals species such as arsenic, cadmium, lead and vanadium with it in the process. This will lead to underestimation of the dissolved concentration of any metal".*

Response: Agree that groundwater samples should be kept free of particulates and kept anaerobic. In-line filtration will be adopted in the future for the collection of dissolved metals samples.

Comment: *"If there are lots of suspended solids in a groundwater sample as is the case of the '89 series wells around the tailings pond, this means either the well has not been properly developed prior to sampling i.e. (a) the fines present after well development were not flushed or cleaned out of the well, (b) that regular maintenance is not performed prior to sampling or (c) that precipitates (particulate matter) have formed in the sample due to exposure to air during the sampling process".*

Response: Agree. All proposed 1996 monitoring wells will be developed following installation to remove all fine-grained sediment that may cause clogging. The wells will be re-developed if sediment is observed during operations. All remaining (1989 and 1995) wells which are scheduled to be re-sampled for a period of time in later 1996 and early 1997 will be re-developed if necessary prior to sampling.

Comment: *"We insist that the monitoring wells to be constructed in 1996 around the tailings pond and elsewhere as described below, meet acceptable* *monitoring well specifications as detailed in numerous EPA and CCME publications on groundwater sampling methodology e.g. EPA/625/6-87/016, EPA/625/6-90/016b, EPA/625/R-93/003a; and CCME EPC-NCSRP-48/e (March 1994) etc.".*

Response: The specifications for the 1996 groundwater monitoring wells will meet the necessary EPA and CCME criteria and shall be consistent with ASTM D5092 for groundwater monitoring wells. Details of the proposed 1996 installations are included in the accompanying Report Ref. No. 1625/8. This revised installation procedure will mean that the wells cannot be converted to groundwater pumpback wells as originally intended for the tailings impoundment.

Comment: *"It would be worthwhile contacting some industry experts with practical field experience in groundwater sampling for metals, to gain from their experience with pumps, well maintenance, sampling equipment, in-line filtration etc. for the objective of obtaining good quality groundwater chemistry result especially for dissolved metals".*

Response: Knight Piesold Ltd. has experience in groundwater monitoring well installation, groundwater sampling and well development. The monitoring well locations, installation methodology and sampling procedures have also been reviewed by Mr. Leslie Smith, Ph.D. of the University of British Columbia (see attached letter report).

Section 7.3.1 Open Pit / Mill Site

Comment: *"Please note in this and subsequent sections i.e. 7.3.2 etc., that there is no B.C. Water Quality Criteria (BCWQC) for "total aluminum for aquatic life. The only BCWQA for aluminum for aquatic life is for the "dissolved" form of aluminum.*

Response: Comment noted. Response under separate cover by Mr. Dan Royea of Hallam Knight Piesold Ltd.

B. Imperial Metals Corporation Mt. Polley Project Groundwater Monitoring Program (Ref. No. 1624/2), June 3, 1996.

Section 2.1.6 Tailings Storage Area

Comment: *"At the bottom of the page it says the groundwater flows northeast towards NE Edney Creek Tributary. From the contours shown in Figure 2.3, it would seem that the groundwater flows would be to the east-southeast. Please clarify".*

Response: Correction noted. Groundwater flows do indeed flow east-southeast toward NE Edney Creek Tributary (as suggested) and not northeast as initially reported.

Section 2.3 1995 Monitoring Well Program

Comment: *"The 110 mm diameter PVC well installations sited around the pit area are ideal for production i.e. dewatering, but not necessarily for monitoring. They will take considerable effort to purge prior to collection of water quality samples when they are not in use for dewatering. By having multiple screened zones in one casing or borehole, there will be a lot of mixing and diluting of groundwater from the different aquifer zones intercepted by the one casing. The drill logs indicate there are very significant aquifers at different levels in the same boreholes. Multiple small diameter casings each sealed in the different aquifers in each borehole would give more valuable information as to groundwater quality, its source and potential problem in the discharge area if known".*

Response: The 1995 wells installed around the minesite area are suitable for dewatering as this was the primary intent with these wells. Although the use of these wells for groundwater monitoring is not ideal as mixing and dilution of groundwater from the different aquifers may occur, they may still function as monitoring wells to identify any changes in groundwater quality. Notwithstanding this, it has been decided by IMC that only the new (1996) wells will be used to monitor initial baseline and long-term groundwater quality. Some of the 1989 and 1995 wells will continue to be monitored in late 1996 and early 1997 to provide overlap with the 1996 wells. In addition, IMC reserves the option of continuing to monitor wells 95-R-5 and 95-R-6 to provide additional long-term monitoring of background water quality in the minesite area. The proposed schedule for monitoring is shown on Table 1 of Report Ref. No. 1625/8.

The proposed 1996 monitoring wells in the minesite area will be located below the groundwater table in relatively pervious fracture zones in bedrock to provide initial baseline and on-going groundwater quality information during operations. During drilling the hole will be water tested to determine the most permeable zone for the installation of the well. If a significant fracture zone is encountered at a shallower depth during the installation of the first well, then a separate hole will be drilled to enable a second monitoring well to be installed. The installation of multiple wells in one hole is not practical since the diameter of the hole must be very large to facilitate multiple installations of the minimum 50 mm diameter wells complete with the necessary filter pack and seal backfill materials. All attempts will be made during the 1996 groundwater monitoring program to locate the completion zones in the most permeable fracture systems, based on the geologic information and the conditions encountered during drilling. Additional details on the 1996 program are discussed in the accompanying Report Ref. No. 1625/8.

Comment: *"Again please explain the rationale for the siting of two groundwater monitoring wells almost side by side (95-R-2 and 95-R-7) as indicated in Figure 2.4. It is assumed that these wells are situated and constructed primarily for dewatering purposes, with monitoring a secondary consideration. We would like to see installation of an additional well designed strictly for monitoring purposes, to be located between the central pit and Bootjack Lake, possibly off the main road below the most south-westerly corner of the central pit in the "draw" that is apparent from the* *contours in Fig. 1.3. The siting of this well should be done in consultation with a qualified hydrogeologist to ensure it is optimally located for detection of contaminated groundwater migrating from the pit area to Bootjack Lake. This should be done as soon as possible so that baseline data may be collected prior to mining".*

Response: Groundwater wells 95-R-2 and 95-R-7 were constructed primarily for dewatering purposes, as suggested. Well 95-R-7 was drilled as a second well since 95-R-2 was lost during drilling. One additional groundwater monitoring well, designated P_8, will be installed between the central pit and Bootjack Lake as part of the 1996 program, as suggested. This well will be located in the draw and adjacent to the access road, as shown on the attached Figure 1.

Comment: *"We are also concerned that only one monitoring well (95-R-5) was installed along the entire basal perimeter of the southeast waste rock dump (which is some 2.5 km in length) and that it is located at the extreme north end of the dump. We will require the installation of 2-3 additional wells designed specifically for monitoring purposes to monitor contaminant migration in groundwater flow down-gradient from the waste rock dump towards Polley Lake and Bootjack Creek. Again the siting of these wells should be done in consultation with a qualified hydrogeologist to ensure they are optimally located for the above mentioned purpose".*

Response: Two additional monitoring wells, designated P_6 and P_7, will be installed east and south of the southeast waste dump between the dump and Polley Lake as part of the 1996 program. The approximate locations of the proposed wells are shown on the attached Figure 1.

Comment: *"What was the groundwater level in the '95 series wells at the time of completion? This is not indicated in the Appendix B well log or the Appendix C borehole information. Please provide this information in writing to this office".*

Response: Static groundwater levels for the 1995 wells, measured inside the well following completion and prior to sampling are as follows: 95-R-1, 20.1m; 95-R-4, 10.7m; 95-R-5, 1.3m; 95-R-6, 3.9m; 95-R-7, 12.2m. This information was collected by Knight Piésold Ltd. during groundwater sampling.

Section 3.2 Tailings Storage Area

Section 3.2.1 Baseline

Comment: *"This section states that the tailings area baseline groundwater quality is poor, however the poor quality of the groundwater in this area may be exaggerated by poor well construction and development technique, as recognized in Section 2.2 of this report and as documented by Marc Zubel, Senior Groundwater Engineer, Water Management Branch, Victoria, B.C., in his Feb. 4, 1991 comments to A.P. Kohut on the Mt. Polley Copper/Gold Project Stage I Addendum Report (Oct. 1990)".*

Response: Some of the 1989 wells at the tailings area will be plugged and abandoned during construction of the tailings facility. The remaining wells will be decommissioned in early 1997 following a period of overlap with the new 1996 monitoring wells. The proposed 1996 wells will be installed in accordance with accepted standards for monitoring well installation and will be developed prior to sampling.

Section 3.2.2 Operational

Comment: *"One of the objectives of the Mt. Polley groundwater monitoring program as required by BCMELP and identified on page 2 of this report was to locate the seepage collection pond and recovery wells to ensure optimal recycling of seepage from the tailings pond during operations. This objective does not appear to be addressed in this report. Please respond as to whether the seepage pond has been optimally located for tailings pond seepage recovery? Does it capture all of the potential "discharge" in the* *sandy area in the vicinity of the main tailings embankment, identified during the initial drilling in the tailings pond area"?*

Response: The seepage collection pond at the main tailings embankment has been located at the low point in the valley to intercept runoff and near surface seepage from the embankment. A system of embankment foundation drains, which are also interconnected with foundation pressure relief holes, drain by gravity into the seepage collection pond. The primary function of the seepage collection pond is to provide a reservoir for seepage monitoring and containment prior to recycling to the tailings embankment as necessary. The geological sequence of glaciofluvial and glaciolacustrine sediments which underlie the glacial till materials in the valley are complex and it is highly unlikely that all groundwater will report directly to the seepage collection pond. However, an extensive groundwater recovery well system has not been incorporated into the design since the tailings water is projected to be of good quality and no adverse water quality impacts are anticipated.

IMC had previously intended that all new groundwater monitoring wells downgradient of the tailings impoundment comprise 5 inch diameter wells which could be converted to pump back wells if required to supplement any requirements for make-up water for the milling operation. However, the current groundwater monitoring program has been modified to be consistent with MOE requirements for monitoring well installations only. Therefore, any provisions for seepage recovery by pump-back wells will be addressed during operations. Pump-back wells will be installed if additional make-up water is required or if on-going groundwater quality monitoring indicates that groundwater chemistry is being adversely affected by excessive seepage from the tailings impoundment.

Comment: *"I do not have a copy of the Report referred to in this section i.e. Report on Project Water Management, Ref. No. 1624/1. Could you please provide me with a copy".*

Response: Copy of "Report on Project Water Management (Ref. No. 1624/1)" included with this document, as requested.

Section 3.2.3 Post-Closure

Comment: *"What is the basis for stating that the groundwater quality from the tailings impoundment will improve to levels better than baseline values? Is this due to a reduction in recharge for the drainage area due to change in permeability of surface material compared to pre-tailings pond conditions? or to better monitoring well installations, where the suspended sediment content, will be reduced or eliminated and therefore enhance the quality of the groundwater samples collected"?*

Response: This statement should be modified from "improve to levels better than baseline values" to "return to levels similar to baseline values". During operations and for a period of time after closure, seepage from the impoundment will comprise process water which originates from the supernatant pond and from consolidation of the tailings mass. In the long-term, the closure pond will contain surface runoff water. Once consolidation of the tailings mass is complete and the seepage from the surface water pond reaches steady state conditions all groundwater impacts due to process water will cease. On-going seepage to the groundwater system would then be of similar water quality to the final surface runoff pond.

Section 4.0 Groundwater Monitoring Program

Comment: *"The person who collects the groundwater samples, should not only be trained in environmental procedures, but be trained in and very familiar with proper groundwater quality monitoring procedures".*

Response: Agree. IMC are currently relying on Hallam Knight Piesold Ltd., who have suitably qualified personnel trained in proper procedures in groundwater quality monitoring and sampling. Also, IMC are presently in the process of identifying a suitably qualified individual to assist with environmental monitoring, including on-going water quality monitoring and sampling during operations. The procedures and protocol for groundwater sampling and handling are included in Report Ref. No. 1625/5.

Figure 1.2

Comment: *"How will the spring in the southwest corner of the tailings pond be capped off"?*

Response: The spring, located in the southwest corner of the tailings facility, will be capped with a 50 mm diameter PVC pipe at surface to provide an additional permanent installation for groundwater quality monitoring. The pipe will be installed by excavating a shallow hole and installing a slotted PVC screen section complete with a filter sand pack and a bentonite seal at surface in order to facilitate regular water quality sampling of the spring. The spring in designated S_1 and is shown on the attached Figure 1.

C. Imperial Metals Corporation Mt. Polley Project: Manual on Sampling and Handling Guidelines for Determination of Groundwater Quality (Ref. No. 1625/5), May 19, 1995.

Note: Responses to other comments in Section C are addressed by Mr. Dan Royea of Hallam Knight Piesold Ltd. under separate cover.

Section 2.1.2 Sample Preparation and Preservation

Comment: *"In-line filtration methods such as the Gelman high capacity filter should be employed for filtration of dissolved metals samples to ensure there is no exposure to air which oxidizes iron in the samples which in turn scavenges dissolved metals, thereby underestimating the dissolved portion of the metals. In groundwater situations there should be very little to no particulate in the water samples unless the well has not been properly* *developed or if oxidation occurs allowing precipitates to form on the inside of the well casing and immediate aquifer material around the well casing. Wells susceptible to such precipitate formation or sediment accumulation should be cleaned and pumped 2 to 3 weeks prior to sampling to remove the precipitates/sediment from the well prior to actually collecting samples".*

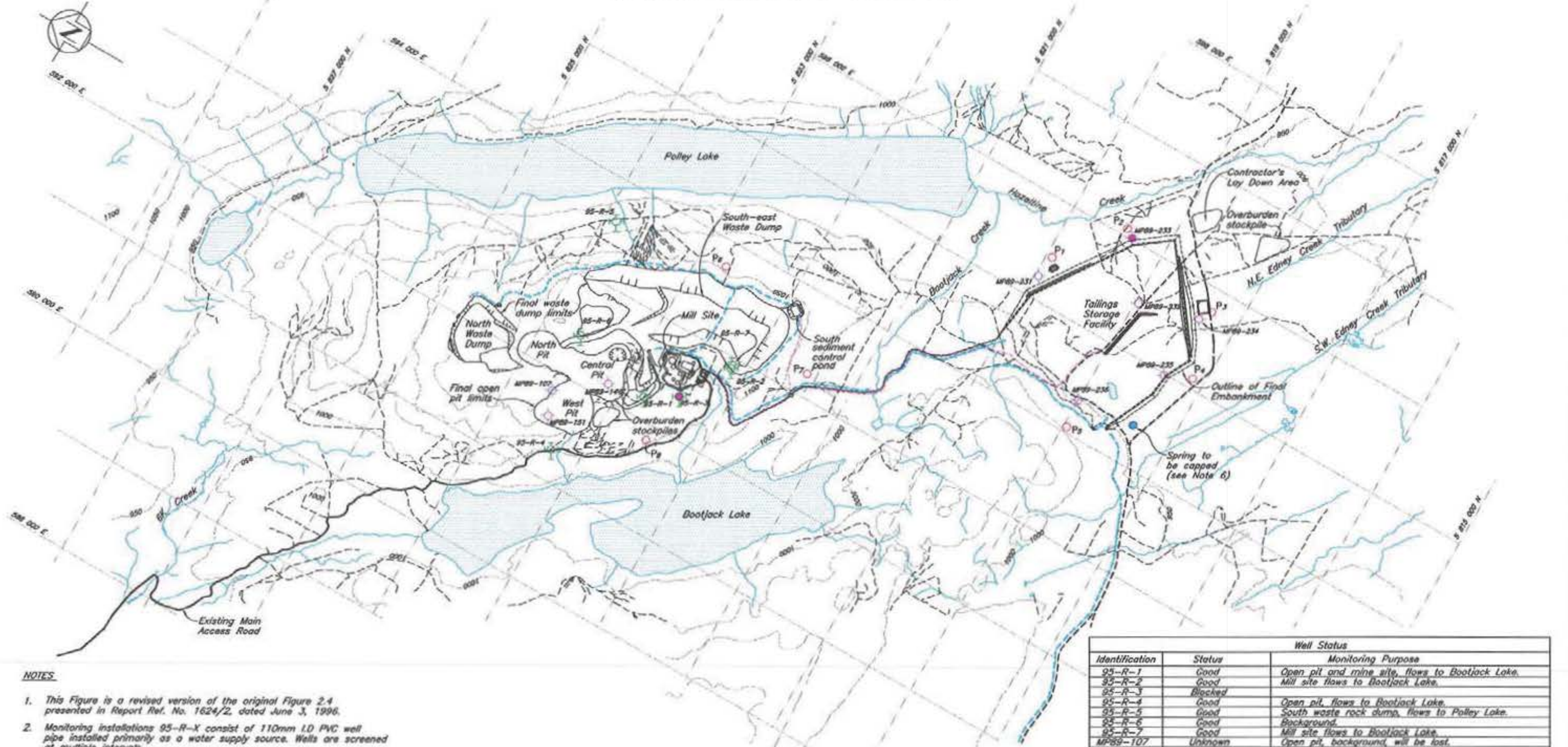
Response: In-line filtration methods will be used in the future to collect the dissolved metals samples. All wells will be developed following installation and at least 2 to 3 weeks prior to sampling to remove any sediment or precipitates, as suggested.

Appendix D: Baseline Groundwater Quality Data to the End of 1995

Note: Details on the results of the baseline groundwater quality program are included by Mr. Dan Royea of Hallam Knight Piesold Ltd. under separate cover.

1625.B37COLOR

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING WELLS PLAN



NOTES

1. This Figure is a revised version of the original Figure 2.4 presented in Report Ref. No. 1624/2, dated June 3, 1996.
2. Monitoring installations 95-R-X consist of 110mm I.D PVC well pipe installed primarily as a water supply source. Wells are screened at multiple intervals.
3. Monitoring installations MP89-X consist of 30 mm I.D PVC which have slotted screens.
4. Monitoring installation MP89-233 has been lost due to breakage of the PCV riser below the ground surface. No evidence of well location remains.
5. Monitoring installation 95-R-3 has been blocked at a depth of approximatly 70 metres below the collar. This installation is no longer operable as a screen interval is not accessible.
6. Groundwater spring to be capped with slotted PCV and filter sand pack for groundwater quality monitoring.

LEGEND

MP89-107 ◇ Existing Groundwater Monitoring Well (1989)

○ P7 Proposed Additional Groundwater Monitoring Well (1996)

◆ Damaged Groundwater Well

95-R-4 ◇ Existing Groundwater Supply Well (1995)

Well Status

Identification	Status	Monitoring Purpose
95-R-1	Good	Open pit and mine site, flows to Bootjack Lake.
95-R-2	Good	Mill site flows to Bootjack Lake.
95-R-3	Blocked	
95-R-4	Good	Open pit, flows to Bootjack Lake.
95-R-5	Good	South waste rock dump, flows to Polley Lake.
95-R-6	Good	Background.
95-R-7	Good	Mill site flows to Bootjack Lake.
MP89-107	Unknown	Open pit, background, will be lost.
MP89-146	Unknown	Open pit, background, will be lost.
MP89-151	Unknown	Open pit, background, will be lost.
MP89-231	Unknown	Tailings storage may flow to Hazeltine Creek.
MP89-232	Good	Tailings storage and background, will be lost.
MP89-233	Broken	
MP89-234	Broken, repairable	Tailings storage facility, flow to Northeast Edney Lake.
MP89-235	Unknown	Tailings storage facility, flow to Southwest Edney Lake
MP89-236	Broken, repairable	Background for tailings storage facility.

Scale 1000 500 0 1000 2000 m

Sept. 11, 1996

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

FIGURE 1

1625.A40

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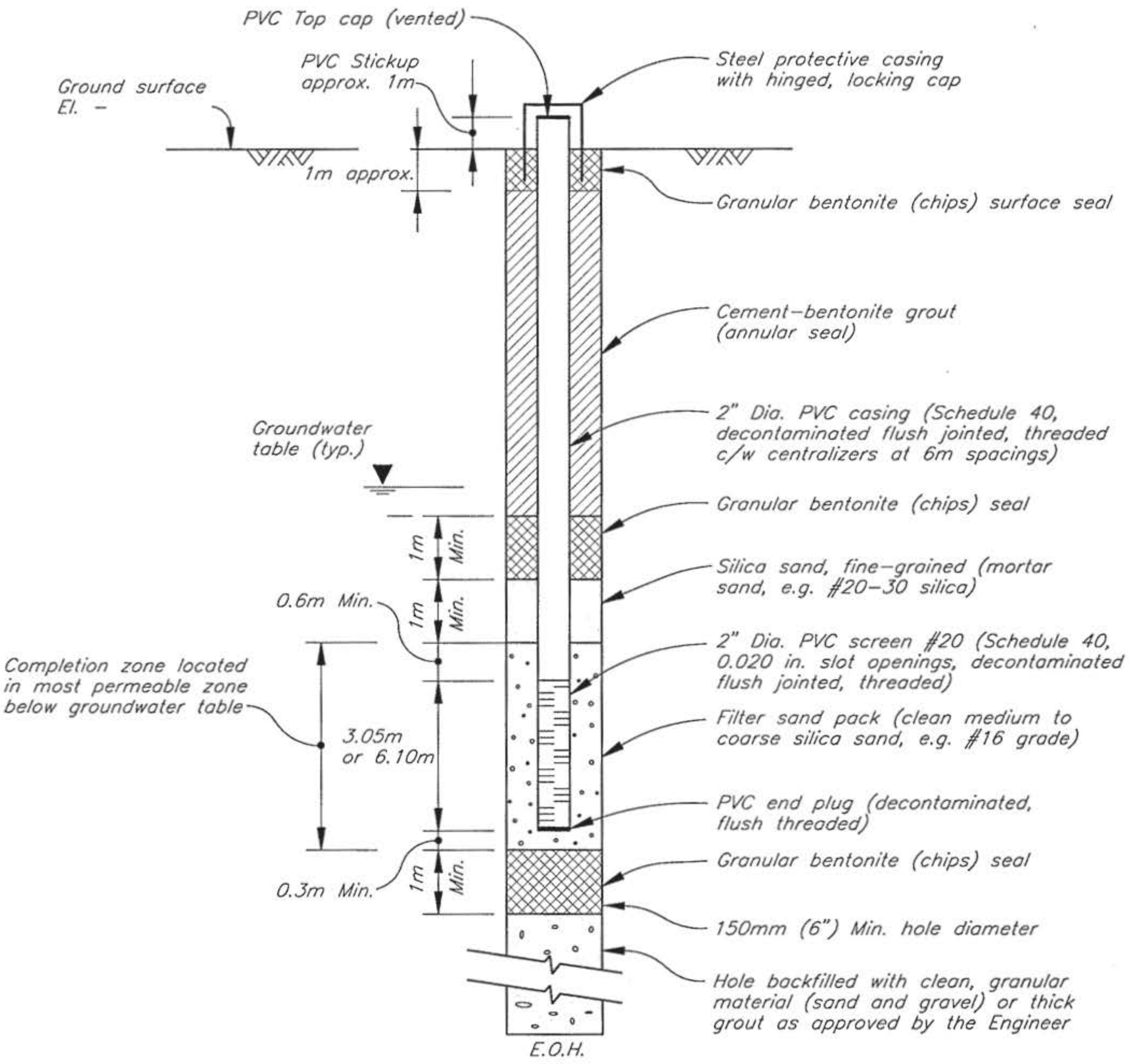
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: E:
COMPLETION DATE

PROJECT No. *1628*
HOLE No.
GROUND ELEVATION

PROPOSED 1996 GROUNDWATER MONITORING WELLS

SCHEMATIC DIAGRAM



NOTES

1. *Depths of hole, PVC and all backfill materials to be recorded.*
2. *All backfill materials to be installed using tremmie pipe to prevent bridging.*

CAD FILE: \1625\FIG\A40 Plot scale 1=1

FIGURE 2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

REQUIREMENTS AND SPECIFICATIONS
FOR THE 1996
GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/8)

SEPTEMBER 12, 1996

DRAFT

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IMPERIAL METALS CORP.
MT. POLLEY PROJECT

REQUIREMENTS AND SPECIFICATIONS FOR THE 1996 GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/8)

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MT. POLLEY PROJECT

REQUIREMENTS AND SPECIFICATIONS FOR THE 1996 GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/8)

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APPENDICES

Appendix A "Mt. Polley Project - Groundwater Monitoring Program", by Mr. Leslie Smith, Ph.D., U.B.C.

Knight Piésold Ltd.
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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

REQUIREMENTS AND SPECIFICATIONS FOR THE 1996 GROUNDWATER MONITORING PROGRAM
(REF. NO. 1625/8)

SECTION 1.0 - GENERAL

The following is a summary of the recommendations and requirements for the installation of additional (1996) groundwater monitoring wells for the Mt. Polley Project. The objective of the wells is to provide high quality installations for the collection of groundwater samples for the evaluation of initial baseline conditions and groundwater quality during operations and at closure. The monitoring wells will also be used to monitor fluctuations in groundwater levels resulting from seasonal effects as well as to monitor any influences resulting from mine development. It is the intent to install the new 1996 groundwater monitoring wells sometime in September, 1996 to allow for the collection of the initial set of (baseline) samples as soon as possible.

Specific details on the monitoring well supplies, installation procedures and drilling methods are provided along with recommendations for well development and sampling procedures. The locations of the proposed 1996 groundwater monitoring wells in addition to the existing wells are shown on the attached Figure 1. This figure is revised from the original Figure 2.4 previously submitted in the "Groundwater Monitoring Program (Ref. No. 1624/2)". The completion details and requirements for the 1996 groundwater monitoring wells are also shown on the attached Figure 2. The proposed schedule for groundwater monitoring is shown on Table 1.

The proposed groundwater monitoring program has been reviewed by Mr. Leslie Smith, Ph.D. of the University of British Columbia. His review comments and suggestions are presented in his attached letter report "Re: Mt. Polley Project -

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

Groundwater Monitoring Program". Mr. Smith's recommendations have been included in this document and are supported by Imperial Metals Corporation.

This document should be read in conjunction with the "Response to Review Comments on Groundwater Monitoring Program (Ref. No. 1625/7)", dated September 11, 1996 which also accompanies this document.

SECTION 2.0 - WELL LOCATIONS

The 1996 groundwater monitoring wells will be installed in selected intervals and geologic units to characterize the groundwater quality at the minesite and tailings facility areas. The wells will be installed as dedicated wells for the sole purpose of groundwater quality sampling. The wells will be installed and developed as per standard practice and as outlined herein and will be maintained over the life of the project.

it is planned to install a
~~A~~ total of eight (8) monitoring wells ~~will be installed~~ during the 1996 program, including five (5) at the tailings facility area, designated P_1 to P_5, and three (3) at the minesite area, designated P_6 to P_8. The monitoring wells will be located outside the various development areas to provide initial baseline and background groundwater quality as well as for long-term groundwater quality monitoring. The locations of the proposed monitoring wells are shown on Figure 1.

SECTION 3.0 - COMPLETION ZONES

The completion zones for the monitoring wells will be located in the saturated zone below the groundwater table and below the groundwater surface predicted during operations. This will ensure that groundwater samples may be collected at any time during the year and at any time during operations and at closure. The wells will be installed in relatively pervious zones in overburden and bedrock, as these zones will provide the preferential paths for groundwater flow in addition to providing greater recoveries for well development and sampling.

The monitoring wells in the tailings facility area will be completed in the relatively permeable glaciofluvial sandy unit which underlies the glacial till, and in the heavily fractured bedrock (conglomerate) at the base of the overburden. Two holes will be drilled at each site for the installation of one well per hole in each of the relatively pervious overburden, and fractured bedrock zones.

The monitoring wells in the minesite area will be installed in relatively permeable fracture zones within bedrock. The actual locations of the completion zones (screened intervals) will be assessed based on the geologic conditions intersected during drilling. Specifically, zones of high water take or flow will be targeted as completion zones for the wells. A target depth of approximately 30 to 40 metres will be selected for each hole. Water tests will be carried out progressively during drilling to determine the most permeable zone for the completion zone. Specifically, the location of the most permeable intervals in each borehole will be selected by observations of changes in water production rates and water levels as the borehole is drilled. The most permeable zone, consisting of either a small fracture zone, or a highly fractured zone within a fractured interval will then be selected for the monitoring interval. An air rotary system will be used to drill the borehole. If it is determined that the most permeable zone is at some depth above the bottom of the borehole, then either a local sand and gravel or a thick grout mixture will be installed as backfill prior to the installation of the well. In addition, if a second significant fracture zone is intersected at a shallower depth, then an additional well will be installed (in a separate hole) at the same site.

The thickness of the completion zone will depend largely on the permeability and water production rate of the fracture zone. In general, approximately 3 metre thick completion zones will be used for the high permeability zones, while approximately 6 metre thick completion zones will be used for the less permeable zones. The larger completion zones are preferred in low permeability zones to allow for more flow into the well during well development and purging, and to provide a more representative sample for the low yield producing zones. In no case will the completion zone exceed 6 metres.

Completion details for the proposed 1996 groundwater monitoring wells is shown on Figure 2.

SECTION 4.0 - DRILLING METHODS

Appropriate drilling methods will be utilized to prevent contamination of the surrounding formation water and to allow for the collection of representative groundwater samples. No drilling fluids or additives will be used for the drilling of the monitoring well holes as the fluids may affect the groundwater samples. Dry methods will be utilized for the drilling of all boreholes.

Potential drilling methods for the monitoring well holes in overburden in the tailings facility area include hollow stem auger, air-rotary with casing advancer, or dual-wall (reverse circulation) air rotary. Samples may be retrieved from auger flights, or from split-spoon or thin-walled sampling methods to identify permeable water-bearing zones for the selection of the screened intervals for the wells. No mud-rotary drilling will be permitted nor air-rotary utilizing the down-hole hammer as this method requires lubricating oil which may contaminate the hole.

Drilling methods for the monitoring well holes in bedrock in the minesite area include air-rotary or reverse circulation (air only). The completion zones for these wells will be determined by observation of water production rates and water levels measured progressively at select intervals during drilling. No mud-rotary or down-hole hammer methods shall be used for the monitoring well holes at the minesite.

SECTION 5.0 - INSTALLATION DETAILS

The groundwater monitoring wells will be installed in pre-drilled holes with a minimum diameter of ~~150~~ mm (~~6~~ 4 inches). Dry drilling methods only (i.e. no drilling fluids) will be used for the drilling of the monitoring well holes. Details of the well installations are described below. A schematic diagram showing the typical completion details for the groundwater monitoring wells and record information required for installation are shown on Figure 2.

The groundwater monitoring wells will comprise decontaminated 50.8 mm (2 inch) diameter, flush jointed, threaded Schedule 40 PVC tubing. This will facilitate the installation of submersible pumps for groundwater sampling and pump systems for the development of the wells. Centralizers will be installed at designated spacings (approximately 6 metres) along the PVC to help centre the casing inside the borehole. Well screens will be installed at the bottom of the well and will be 3.05 or 6.10 metres (10 or 20 feet) long with #20 (0.020 in. or 0.25 mm wide) slots. The screens will also be decontaminated, flush jointed, threaded Schedule 40 PVC as per the solid riser. Suitable slip caps, slip couplers and end plugs are also required, as shown on Figure 2.

Backfill materials will include a uniform silica sand, such as #16 (0.40 mm diameter) required as the filter pack around the well screens. Such sand shall be no coarser than #10 mesh and no finer than #40 mesh. The sand will be bounded by a low permeability seal zone comprised of approximately 1 metre minimum of fine (3/8" diameter or less) bentonite chips. The materials will be backfilled from the bottom up with a delivery (tremmie) pipe to prevent any bridging of backfill materials during installation. A sand and gravel or cement-bentonite grout backfill may be required, particularly for the minesite wells, in order to isolate the completion zone and support the groundwater well installation above the bottom of the borehole.

Following the installation of the top bentonite seal, the holes will be backfilled with a cement-bentonite grout mixture around the annulus between the PVC casing and the wall of the borehole. The grout will be mixed to a thick consistency and pumped down the hole with a delivery pipe from the bottom up to ensure a proper seal. The grout seal is required to prevent surface water from entering the well. Under no circumstances will the boreholes be grouted by pouring grout into the open hole from surface to a depth greater than 3 metres inside the hole.

Following grouting, a surface bentonite seal and protective steel casing, complete with locking cap will be set in concrete around the PVC casing for protection and ease of sampling.

These methods are consistent with EPA, CCME and ASTM D5092 requirements and specifications.

SECTION 6.0 - WELL DEVELOPMENT

The groundwater monitoring wells will be developed following installation to remove fine particulate matter, including fine silts and clays which may originate from the geologic formation or from cuttings generated during drilling. Well development techniques include pumping water down the well under positive and negative (suction) pressures to remove foreign matter and particulates from the filter sand pack around the screen. The result is clear and non-turbid water which is more representative of the in-situ groundwater conditions. This also makes it easier to filter the water samples (by in-line filtration methods) for the dissolved metals samples. Air-surging methods will not be permitted as this may disturb and significantly reduce the effectiveness of the filter sand pack.

Subsequent well development will also be carried out if the water is found to be turbid or contain foreign matter.

SECTION 7.0 - SAMPLING PROCEDURES

Groundwater samples will be recovered by the use of submersible pump systems. The pump system is advantageous in decreasing the sampling time, minimizing labour costs and allowing for direct sampling from the screened interval and therefore is strongly recommended.

Bailers will also be available in the event that the pump system breaks down or is not available. Only one bailer will be dedicated to each well for sampling purposes. Bailers will not be utilized for more than one well as this will result in potential contamination of the samples.

Sampling procedures generally involve the removal of stagnant water from the well prior to collecting the sample. It is recommended that the equivalent of three borehole volumes of water be removed from the well prior to collecting the sample. This is achieved by measuring the static water level inside the well and calculating the volume of water inside the well and borehole, then pumping (or bailing) three times this volume from the well prior to sampling. This ensures that the sample is representative of the in-situ baseline groundwater within the formation. In addition, during the purging of the wells (prior to sampling), chemical, or field, parameters such as pH and/or electrical conductivity will also be checked to ensure these values are stable (within acceptable limits) prior to collecting the groundwater sample. In the event that the recovery of the well is very slow and three borehole volumes cannot practically be removed from the well then the well should be pumped once and allowed to recover prior to collecting the sample.

The groundwater sampling program previously prescribed in the "Groundwater Monitoring Program (Ref. No. 1624/2)" indicates that groundwater samples will be collected on a quarterly basis (i.e. once every 3 months). This will allow any natural variations in the baseline or background water quality to be assessed. Rising head type slug tests will also be performed in each well, once at the completion of well development, and once per year thereafter in order to assess the on-going performance of the well and to provide information on the hydraulic conductivity and response of the geologic formation. The proposed schedule for groundwater monitoring is included in Table 1.

Details on the groundwater sampling methods and protocol, including sampling and chain of custody forms for sample collection as well as forms for rising head tests, are included in the "Manual on Sampling and Handling Guidelines for Determination of Groundwater Quality (Ref. No. 1625/5)" previously issued on May 19, 1995. A revised copy of this manual will be prepared prior to continuing with the groundwater sampling program in the fall of 1996.

TABLE 1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING SCHEDULE

5/7/96
J:\JOB\DATA\1634\SCHED1.XLS

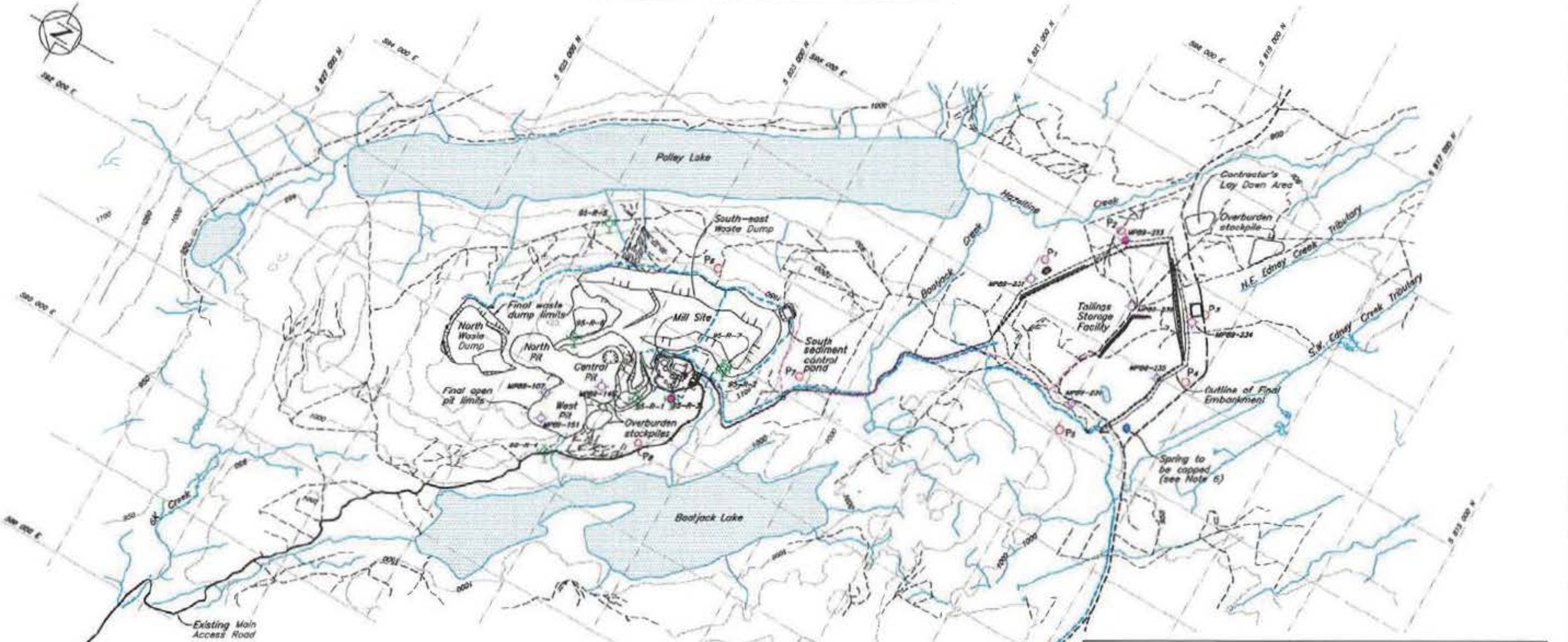
Installation No.	Monitoring Sites	Pre-mining Monitoring for Establishment of Baseline Data											Construction											Mining																																															Post-mining Monitoring																									
		1996											1997											1998											1999											2000							2007			2008											2009											2010											2011		
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J		O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
95-R-1	Mill Site, Open Pits					■				■		■			■			■																																																																																	
95-R-7	Mill Site, Waste Dump					■				■		■			■			■																																																																																	
95-R-4	Open Pits					■				■		■			■			■																																																																																	
MP89-107	Open Pits					■				■		■			■			Assumed lost																																																																															
MP89-146	Open Pits					■				■		■			■			Assumed lost																																																																															
MP89-151	Open Pits					■				■		■			■			Assumed lost																																																																															
P_8 (1996)	Open Pits									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_6 (1996)	Waste Dump									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_7 (1996)	Waste Dump									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
MP89-231	Tailings Storage Area					■				■		■			■			Assumed lost																																																																															
MP89-232	Tailings Storage Area					■				■		■			■			Assumed lost																																																																															
MP89-234	Tailings Storage Area					■				■		■			■			■																																																																																	
MP89-235	Tailings Storage Area					■				■		■			■			Assumed lost																																																																															
P_1 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_2 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_3 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_4 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
P_5 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
S_1 (1996)	Tailings Storage Area									■		■			■			■				■		■			■			■				■		■			■			■				■		■			■			■				■		■				■			■			■			■				■		■			■			■				■		■			■			■				■		■				
95-R-5	Background					■				■		■			■			■																																																																																	
95-R-6	Background					■				■		■			■			■																																																																																	
MP89-236	Background					■				■		■			■			■																																																																																	
	Review of yearly data annual report													■											■											■											■									■											■											■											■	
	Review of post- mining data and monitoring program adjustment																																																																																																■	■	■

Notes:

1. P_i = Groundwater monitoring wells to be installed during fall of 1996.
2. S_i = Monitoring well to be installed at groundwater seep location during fall of 1996.
3. Groundwater quality monitoring data will be reviewed as soon as practical following each sampling round. The results will also be reviewed and documented in an annual report to be issued each January.

1625.B37COLOR

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING WELLS PLAN



NOTES

1. This Figure is a revised version of the original Figure 2.4 presented in Report Ref. No. 1624/2, dated June 3, 1996.
2. Monitoring installations 95-R-X consist of 110mm I.D PVC well pipe installed primarily as a water supply source. Wells are screened at multiple intervals.
3. Monitoring installations MP89-X consist of 30 mm I.D PVC which have slotted screens.
4. **Monitoring installation MP89-233 has been lost due to breakage of the PCV riser below the ground surface. No evidence of well location remains.**
5. **Monitoring installation 95-R-3 has been blocked at a depth** of approximatly 70 metres below the collar. This installation is no **longer operable as a screen interval is not accessible.**
6. Groundwater spring to be capped with slotted PCV and filter sand pack for groundwater quality monitoring.

LEGEND

- MP89-107 ◇ Existing Groundwater Monitoring Well (1989)
- ○ P7 Proposed Additional Groundwater Monitoring Well (1996)
- ◆ Damaged Groundwater Well
- 95-R-4 ◇ Existing Groundwater Supply Well (1995)

Well Status		
Identification	Status	Monitoring Purpose
95-R-1	Good	Open pit and mine site, flows to Bootjack Lake.
95-R-2	Good	Mill site flows to Bootjack Lake.
95-R-3	Blocked	
95-R-4	Good	Open pit, flows to Bootjack Lake.
95-R-5	Good	South waste rock dump, flows to Polley Lake.
95-R-6	Good	Background.
95-R-7	Good	Mill site flows to Bootjack Lake.
MP89-107	Unknown	Open pit, background, will be lost.
MP89-146	Unknown	Open pit, background, will be lost.
MP89-151	Unknown	Open pit, background, will be lost.
MP89-231	Unknown	Tailings storage may flow to Hazeltine Creek.
MP89-232	Good	Tailings storage and background, will be lost.
MP89-233	Broken	
MP89-234	Broken, repairable	Tailings storage facility, flow to Northeast Edney Lake.
MP89-235	Unknown	Tailings storage facility, flow to Southwest Edney Lake.
MP89-236	Broken, repairable	Background for tailings storage facility.

Scale 1000 500 0 1000 2000 m

Sept. 11, 1996

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

FIGURE 1

0000 Plot 1=40

1625.A40

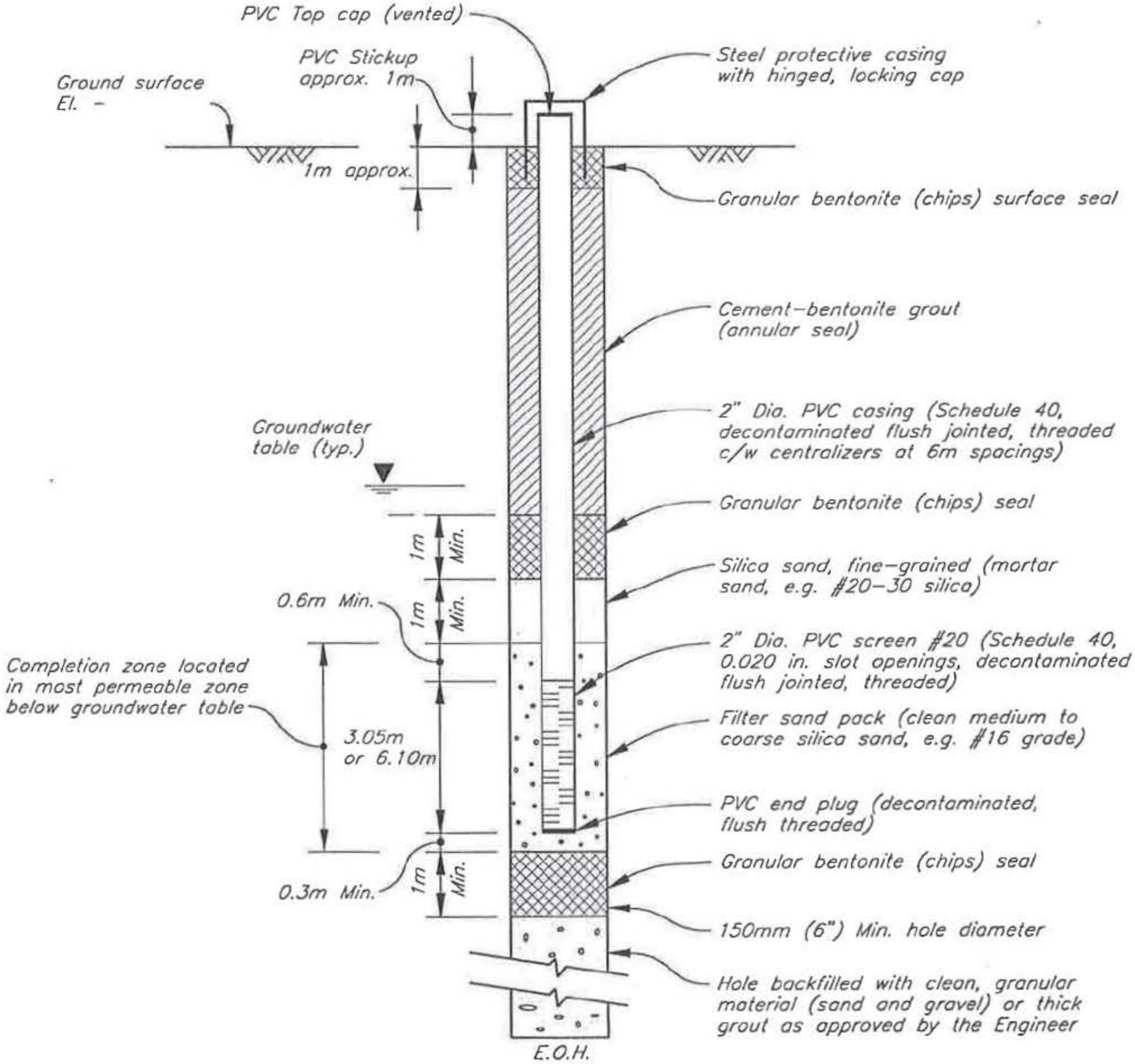
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: ____________ E: ____________
COMPLETION DATE ____________
PROJECT No. *1628*
HOLE No. ____________
GROUND ELEVATION ____________

PROPOSED 1996 GROUNDWATER MONITORING WELLS

SCHEMATIC DIAGRAM



CAD FILE: \1625\FIG\A40 Plot scale 1=1

NOTES

1. *Depths of hole, PVC and all backfill materials to be recorded.*
2. *All backfill materials to be installed using tremmie pipe to prevent bridging.*

FIGURE 2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SPECIFICATION FOR DRILLING, MONITORING WELL INSTALLATIONS AND RELATED SERVICES
(REF. NO. 1628/3)

SEPTEMBER 18, 1996

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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SPECIFICATION FOR DRILLING, MONITORING WELL INSTALLATIONS AND RELATED SERVICES
(REF. NO. 1628/3)

This report was prepared by Knight Piésold Ltd. for the account of Imperial Metals Corporation. The material in it reflects Knight Piésold's best judgement in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Knight Piésold accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

Association of Consulting Engineers of Canada
Association des Ingénieurs-Conseils du Canada

AND DEVELOPMENT

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SPECIFICATION FOR DRILLING, MONITORING WELL INSTALLATIONS AND RELATED SERVICES
(REF. NO. 1628/3)

TECHNICAL SPECIFICATION

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

Appendix A Test Procedure for [illegible]
Packer Pump Test

Appendix B Test Procedure for [illegible] Head
Packer Test

[illegible]

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

SPECIFICATION FOR DRILLING, MONITORING WELL INSTALLATIONS AND RELATED SERVICES
(REF. NO. 1628/3)

TECHNICAL SPECIFICATION

SECTION 1.0 - GENERAL

1.1 SCOPE OF WORK

The Work of this Contract includes the supply of all personnel, equipment and materials and the performance of all things required in connection with the installation of groundwater monitoring wells for the Mt. Polley Project, as described in this Specification, including the following major items of work:

1. Mobilizing and setting up one drill rig and any necessary support equipment.
2. Drilling through overburden using a dry drilling method, casing, and recovering soil samples in selected holes.
3. Drilling through bedrock using a dry drilling method.
4. Monitoring changes in down-hole water production and measuring standing water levels during drilling operation.
5. Providing monitoring well materials and installing monitoring wells.
6. Providing specified backfill materials and backfilling holes using these materials.
7. Cleaning up the drill sites and the temporary staging area.

The following work and services will be provided by Imperial Metals Corporation (the Owner) or by Knight Piésold (the Engineer) at the site:

1. Establishing and marking all monitoring well sites.
2. Assisting in the preparation of all monitoring well sites including clearing where necessary.
3. Maintaining site access routes.
4. Supervising all drilling activities and monitoring well installations.
5. Surveying locations and reference elevations of all monitoring well holes.

1.2 COMPLETION TIME

The Tender shall be returned to the Owner on or before September 25, 1996. The Contractor shall commence mobilization immediately upon written notification to the designated staging area and shall be prepared to commence drilling on or before October 1, 1996.

1.3 QUALITY OF WORK

In order to ensure efficient and satisfactory performance of the work in accordance with the requirements of this Contract, the Contractor shall employ competent and experienced foremen and drillers at all times.

The Engineer can, if in his opinion the work is not being carried out to acceptable standards, order the Contractor to stop work. The work will start again when, in the Engineer's opinion, the fault has been corrected. All payment for that work will stop while the fault is being corrected. No payment shall be made for work improperly performed.

1.4 CONTRACT ADMINISTRATION

Upon award of the Contract, a Purchase Order will be issued to the Contractor by the Owner. Technical direction of the work, including site supervision, and contract administration will be carried out by Knight Piésold's Resident Engineer (the Engineer).

The Contractor shall assign, and make available for the duration of the Work, a designated representative (Contractor's Representative) authorized to carry out the work in all respects and authorized to agree upon and sign for the quantities of the Work on a daily basis.

The Contractor's Representative shall present the daily quantities each day to the Engineer for agreement and signature by Noon of the following day. The signed daily time and quantity sheets, when summarized in a monthly invoice, shall form the sole basis for payment under the Contract.

1.5 PROVISIONAL SUMS

Provisional sums have been established for various items of Work to be carried out and for materials to be supplied by the Contractor. Written authorization from the Engineer is required prior to any expenditure, purchase or work under Provisional Sum items.

1.6 TERMINATION

The Engineer reserves the right to terminate the Work on any hole or for the entire site upon providing at any time reasonable advance notice to the Contractor. In the event of such termination, the Owner's sole obligation to the Contractor shall be limited to payment for Contractor services performed to that time in accordance with the payment items in the Schedule.

SECTION 2.0 - MOBILIZATION/DEMOBILIZATION AND SITE PROVISIONS

2.1 MOBILIZATION

The Contractor shall mobilize one drill rig, plus all down-hole accessories, consumable down-hole supplies, tools and testing equipment to the Mt. Polley Project. Mobilization shall include setting up at the staging area and preparation of the drill rigs, tools and accessories at the first drill site.

Mobilization shall commence immediately upon written notification by the Engineer.

Additional drill rigs, tools, etc. shall be mobilized when and as required by the Engineer.

2.2 DEMOBILIZATION

Demobilization of any drill rig shall proceed only upon written notification of the Engineer.

2.3 STAGING AREA

A staging area will be designated by the Owner for the Contractor's temporary use during the course of the work. The Contractor shall comply with all requirements regarding proper disposal of waste oils, rubbish, sewage, etc. to the Owner's satisfaction and as directed by the Engineer. During the course of the work, the staging area shall be maintained in an orderly condition. Upon final demobilization, the Contractor shall leave the staging area in an orderly and clean condition, to the Owner's satisfaction, as directed by the Engineer.

2.4 DRILLING SITE ACCESS AND PREPARATIONS

The Owner will be responsible for providing access to the drill sites for a truck-mounted drill rig and for clearing the drill sites where necessary. The Owner will provide the necessary personnel and equipment for preparing the drill sites. The

Contractor shall be responsible for the timely and efficient completion of the Work including the provision of any staging and/or other supports for the rig and its equipment. The Owner shall assist the Contractor in constructing staging/supports using available equipment, where necessary. After removal of the drill rig, each site shall be cleaned up to the satisfaction of the Owner, as directed by the Engineer.

SECTION 3.0 - MONITORING WELL DRILLING STRATEGY

In general, one deep and one shallow monitoring well will be installed at each of the eight (8) drill sites at the Mt. Polley Project. The locations of the drill sites, designated P_1 to P_8, are shown on the attached Figure 1. Monitoring wells will be installed at five (5) sites, designated P_1 to P_5, at the tailings facility area and at three (3) sites, designated P_6 to P_8, at the minesite area.

(1½ inch)

Each monitoring well will consist of 50.8 mm (2 inch) diameter PVC tubing (screens and risers) installed in a pre-drilled borehole. The monitoring well holes should be 150 mm (6 inch) in diameter since it is generally recommended that a minimum annular space of 2 inches be maintained between the inside diameter of the borehole and the outside diameter of the monitoring well (ref. ASTM Standard D5092, subsection 6.6.2). The holes may be drilled to a minimum diameter of 125 mm (5 inches) provided that there will be sufficient annular space between the outside of the monitoring well and the inside of the borehole/casing for the insertion of a tremmie pipe large enough to deliver the backfill materials to the required depth.

At the minesite area, both deep and shallow monitoring well holes will be terminated within bedrock as the overburden in the area is generally very thin. The holes for the deep monitoring wells will be advanced to a target depth of between 30 and 40 metres, to be determined by the Engineer at the time of drilling. For costing purposes, a target depth of 40 m can be assumed for each of the deep minesite holes, as indicated in Table 1. After completion of the deep monitoring well, a shallow well may also be installed at the drill site, at the discretion of the Engineer. For costing purposes, it can be assumed that a second monitoring well hole will be drilled to a maximum depth of 10 m at each of the three minesite locations.

At the tailings facility area, the deep monitoring well holes will be terminated at a distance of 10 to 15 metres into bedrock. At Locations P_1 to P_3, the expected thickness of the overburden ranges from approximately 30 m to 35 m, through which soil sampling will be conducted using standard penetration testing (SPT) methods and split spoon equipment. Sampling will be generally carried out at 3 m (10 ft) intervals for the first 15 m (50 ft) and at 6 m (20 ft) intervals thereafter. At Locations P_4 and P_5 the expected overburden thickness is expected to be much less and, therefore, no soil sampling will be required. After completion of the deep monitoring well at each location, a shallower hole will be drilled and terminated within the overburden at a depth determined by the Engineer at the time of drilling. For costing purposes, the maximum depth of the shallower monitoring well holes can be assumed to be the depth of the bedrock surface, as indicated in Table 1.

The monitoring wells shall be installed in a manner similar to that shown on Figure 2. For the monitoring well holes in the minesite area, the depth of the completion zone for each well will be determined based on cuttings retrieved from the hole; down-hole groundwater inflow rates, to be estimated during drilling at approximate 3 m (10 ft) intervals; and periodic water level readings. In all cases, the completion zones will target the most permeable zones encountered during drilling and will be determined on site by the Engineer.

For the monitoring well holes in the tailings area, the depth of the well completion zones will be determined based on the results of SPT testing and overburden sampling as well as cuttings samples retrieved from the bedrock, down-hole groundwater inflow rate estimates and periodic water level readings. In general, one well will be installed in the most permeable soil unit and one in the fractured bedrock near the overburden-bedrock contact.

SECTION 4.0 - EQUIPMENT, MATERIALS AND LABOUR

4.1 GENERAL

The Owner will provide a bulldozer, backhoe and any miscellaneous support equipment which is currently on site, as necessary. The Contractor may obtain water necessary for mixing grout and concrete at the Mt. Polley plant site. The Contractor must have a means of retrieving and storing sufficient water for use at each monitoring well site.

The Contractor shall supply all other equipment, materials, supervision and facilities required for the performance of the work. The Contractor shall also maintain a good supply of spare parts, casing, rods and consumables. Subject to the approval of the Engineer, the Contractor may use equipment and materials of his own preference, except for items which are specifically required in this Specification. Items of equipment or materials which, in the opinion of the Engineer, do not meet the specified requirements shall be replaced by the Contractor, at his own expense, with equipment and materials meeting the specified requirements.

4.2 DRILLING AND SAMPLING EQUIPMENT

The Contractor shall mobilize and have in operation one drill rig capable of penetrating overburden and bedrock until the work is complete. The Contractor shall employ a dry drilling method as described below and shall have available split spoon sampling equipment. A method of estimating down-hole groundwater inflow rates shall be provided by the Contractor and shall be submitted to the Engineer for approval prior to carrying out the Work. The Contractor shall supply a means of periodically measuring down-hole water levels during drilling unless provisions are made for the Engineer to supply such equipment.

Dry drilling methods must be used for the drilling of all monitoring well boreholes. Drilling fluids or additives are strictly prohibited as they could contaminate the groundwater samples. For the monitoring well holes in overburden (in the tailings facility area), acceptable drilling methods include hollow-stem auger, air-rotary with casing advancer, or dual-wall (reverse circulation) air-rotary. The drilling method selected should allow for temporary support of the borehole walls both during drilling and during backfilling operations since cohesionless alluvial deposits may be encountered at the tailings facility area. For the monitoring well holes in bedrock (in the minesite area), acceptable drilling methods include air-rotary or reverse circulation. No mud-rotary drilling or air-rotary drilling using a down-hole hammer will be permitted.

4.3 MONITORING WELL INSTALLATION

Monitoring wells will be installed as shown on Figure 2. An estimation of the quantities of supplies and materials required for the monitoring wells, which the Contractor must supply, is provided in Table 2. Since the actual monitoring well completion zone depths will not be determined until the drilling of each hole is complete, the estimates given in Table 2 are based on maximum quantities expected.

The monitoring wells should consist of 50.8 mm (2 inch) diameter, decontaminated, flush-jointed and threaded Schedule 40 PVC tubing (includes both riser pipe and screen). For each well, the Engineer will select either a 3.05 m or 6.10 m (10 ft or 20 ft) long well screen, depending on the relative permeability of the surrounding geologic zone. The screen shall comprise #20 (0.020 in. or 0.25 mm wide) slot, or similar, section of PVC. The Contractor shall have available sufficient screen lengths to install 6.10 m of screens at each monitoring well. The Contractor shall also supply sufficient centralizers to attach to the tubing at 6 m spacings as well as end plugs, top caps and slip couplers for all wells.

A uniform sand, such as #16 silica sand (or 0.40 mm min. diameter), will be required for the filter pack around the well screens. Such sand shall be no coarser than #10 mesh and no finer than #40 mesh. The sand will be bounded by a low permeability seal zone comprised of at least 1 m of fine (3/8" dia or less) bentonite chips. Above the top seal, the annulus between the PVC casing and the wall of the hole will be backfilled with a cement-bentonite grout mixture. Below the lower bentonite seal, where necessary, the hole will be backfilled using either a cement-bentonite grout mixture or a clean sand and gravel, to be approved by the Engineer. A surface bentonite seal will also be installed along with a protective steel casing complete with locking cap set in concrete around the top of the PVC casing for protection.

The grout shall consist of water, Normal Portland Cement and high-yield milled bentonite (unaltered), mixed to a thick consistency. The recommended mixing ratio is 30 USgal water : 3 bags cement : 1/2 to 1/3 bag bentonite.

All backfill materials placed to a depth greater than 3 m below the ground surface must be installed from the bottom up using a delivery (e.g. tremmie) pipe to prevent bridging of the backfill materials inside the hole during installation.

SECTION 5.0 - RECORD KEEPING

During the drilling, the Contractor shall keep a running log of the drilling operation. This log shall be signed by the driller and foreman and the original copy given to the Engineer at the end of each shift. The log shall include a general description of the overburden and bedrock, measured groundwater inflow rates, water level readings, and general comments on drilling conditions and unusual rises or drops in the water levels during drilling. The locations of the water inflow tests and water level readings will be determined by the Engineer.

All the time spent drilling versus testing shall be recorded whether to the account of the Engineer or to the Contractor.

The Contractor's Representative and the Engineer shall agree on quantities for payment on a daily basis. The signed daily quantity forms, when summarized in a monthly invoice, shall form the sole basis for payment for the Work.

SECTION 6.0 - MEASUREMENT AND PAYMENT

6.1 MOBILIZATION/DEMOBILIZATION

Payment for mobilization shall include for all costs of mobilizing and establishing the Contractor's presence at the designated staging area. Mobilization will be considered complete when the drill is fully functional and actively drilling its first hole. Payment for demobilization shall include for all costs of final cleanup and removal from the site of the work of all equipment, materials and waste as directed by the Engineer.

Payment for mobilization and demobilization will be made at the lump sum rates negotiated between the Owner and the Contractor.

6.2 SITE PREPARATION AND DRILL MOVES

Measurement for payment of drill moves will be made on the basis of an hourly rate for the drill moves and shall include tear down, move and rig set-ups required for the work.

Payment for drill moves will be made at the rate negotiated between the Owner and the Contractor.

6.3 DRILLING AND TESTING PAYABLE ON AN HOURLY BASIS

Drilling operations shall be carried out at the locations and to the depths directed by the Engineer. Measurement for payment for drilling will be made on the basis of the actual time taken to drill the holes and perform the tests, as prescribed by the Engineer. Payment will be made at the rates negotiated between the Owner and the Contractor and shall include for all costs of the drilling operations required to advance the hole. Payment for the installation of the monitoring wells will be made at a separate rate to be negotiated between the Owner and the Contractor.

6.4 STANDBY FOR UNANTICIPATED WORK STOPPAGES

Standby time shall be deemed to occur when, in the opinion of the Engineer, the Contractor is delayed for short periods through no fault of the Contractor.

Payment for standby time, up to a maximum of 8 hours per shift, will be made at the rate negotiated between the Owner and the Contractor.

6.5 CONSUMABLE ITEMS

Unit rates for the consumable items shall be established based on the values included in the attached Table 2, to be completed by the Contractor.

Consumable items required by the Engineer and not included on Table 2 will be made at the actual and necessary net cost, including handling and freight, for delivery of the materials to the site. All items and materials to be claimed as consumables must be approved by the Engineer prior to being used in the Work.

TABLE 1

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

1996 GROUNDWATER MONITORING PROGRAM
SUMMARY OF DRILLING PROGRAM

F:\JOB\REPORT\1628\GDWWELL.XLS

Well Site	Approximate Expected Overburden Thickness (m)	Deep Well Hole		Shallow Well Hole	
		Maximum Expected Hole Depth (m)	Split Spoon Sampling	Maximum Expected Hole Depth (m)	Split Spoon Sampling
1. Tailings Area					
P_1	30	45	Yes	30	No
P_2	35	50	Yes	35	No
P_3	30	40	Yes	30	No
P_4	5	20	No	5	No
P_5	10	20	No	10	No
2. Minesite Area					
P_6	Minimal	40	No	10 (Optional)	No
P_7	Minimal	40	No	10 (Optional)	No
P_8	Minimal	40	No	10 (Optional)	No

TABLE 2

IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

1996 GROUNDWATER MONITORING PROGRAM
MONITORING WELL SUPPLIES

F:\JOB\REPORT\1628\GDWWELL.XLS

Item	Quantity	Unit	Unit Rate ($CDN)	Total Cost ($CDN)
1. 2 in. dia. Schedule 40 PVC solid riser (flush jointed, threaded, decontaminated, c/w centralizers at 6 m spacings).	1270	ft.		
2. 2 in. dia. shedule 40 PVC screen (#20 slot, flush jointed, threaded, decontaminated).	320	ft.		
3. Bentonite chips ("Enviroplug" or similar).	50	50 lb. bags		
4. Portland normal cement (Type 1)	110	88 lb bags		
5. High yield unaltered bentonite drill mud	25	50 lb bags		
6. Silica sand (#16 or similar)	130	50 lb. bags		
7. Silica sand (#20/#30 or similar)	25	50 lb. bags		
8. Concrete stone mix	15	55 lb. bags		
9. 2 in. dia. PVC slip couplers, bottom plugs and J-type top caps.	16	each		
10. Steel protective casings	16	each		
TOTAL COST				

Notes:

- Quantities of materials were estimated assuming that all wells will be installed at the maximum target depth
- Quantities of cement and high-yield bentonite were calculated based on a mix ratio of 30 USgal of water : 3 bags cement : 1/2 bag bentonite.
- If unit sizes of materials supplied by the Contractor differ from those indicated above, quantities should be adjusted accordingly.

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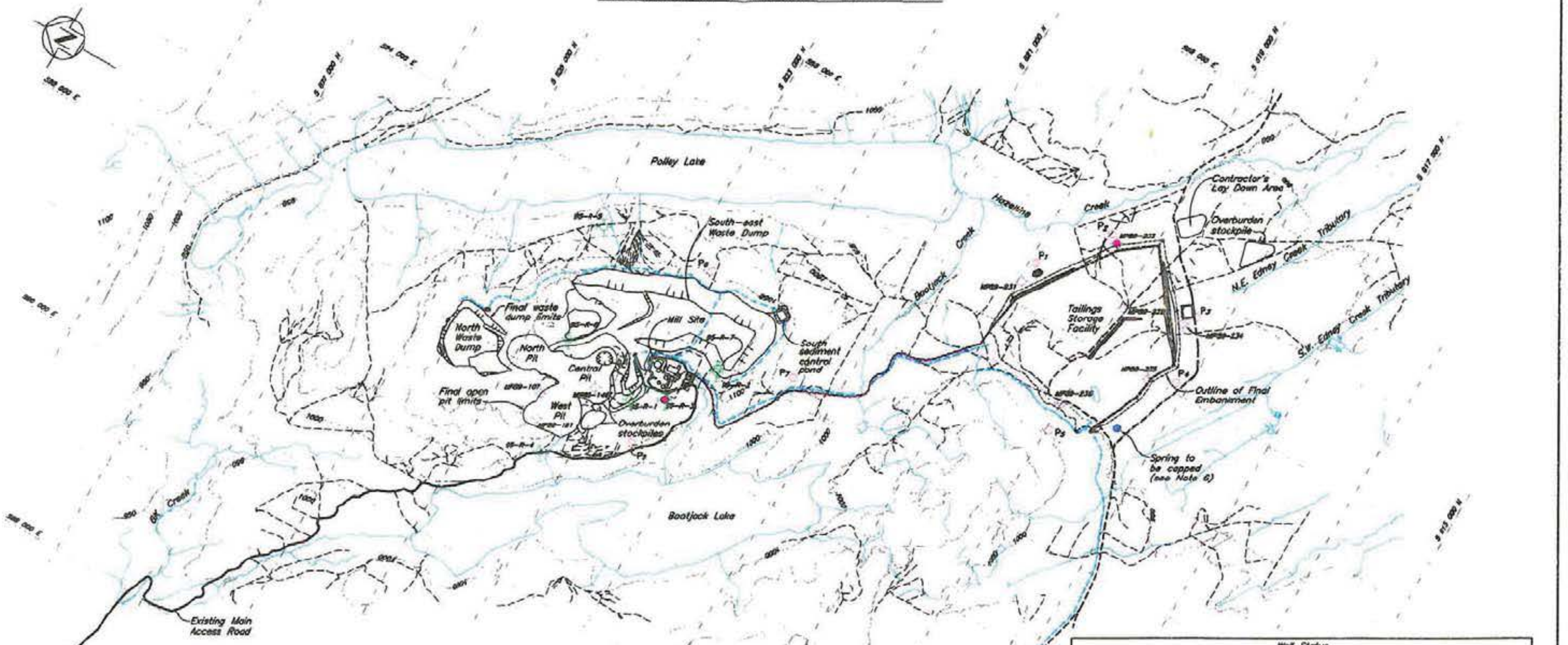
IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT
GROUNDWATER MONITORING WELLS PLAN



NOTES

1. This Figure is a revised version of the original Figure 2.4 presented in Report Ref. No. 1624/2, dated June 3, 1996.
2. Monitoring installations 95-R-X consist of 110mm I.D PVC well pipe installed primarily as a water supply source. Wells are screened at multiple intervals.
3. Monitoring installations MP89-X consist of 30 mm I.D PVC which have slotted screens.
4. Monitoring installation MP89-233 has been lost due to breakage of the PCV riser below the ground surface. No evidence of well location remains.
5. Monitoring Installation 95-R-3 has been blocked at a depth of approximatly 70 metres below the collar. This installation is no longer operable as a screen interval is not accessible.
6. Groundwater spring to be capped with slotted PCV and filter sand pack for groundwater quality monitoring.

LEGEND

MP89-107 Existing Groundwater Monitoring Well (1989)

P7 Proposed Additional Groundwater Monitoring Well (1996)

◆ Damaged Groundwater Well

95-R-4 Existing Groundwater Supply Well (1995)

Well Status

Identification	Status	Monitoring Purpose
95-R-1	Good	Open pit and mine site, flows to Bootjack Lake.
95-R-2	Good	Mill site flows to Bootjack Lake.
95-R-3	Blocked	
95-R-4	Good	Open pit, flows to Bootjack Lake.
95-R-5	Good	South waste rock dump, flows to Polley Lake.
95-R-6	Good	Background.
95-R-7	Good	Mill site flows to Bootjack Lake.
MP89-107	Unknown	Open pit, background, will be lost.
MP89-146	Unknown	Open pit, background, will be lost.
MP89-151	Unknown	Open pit, background, will be lost.
MP89-231	Unknown	Tailings storage may flow to Hazeltine Creek.
MP89-232	Good	Tailings storage and background, will be lost.
MP89-233	Broken	
MP89-234	Broken, repairable	Tailings storage facility, flow to Northeast Edney Lake.
MP89-235	Unknown	Tailings storage facility, flow to Southwest Edney Lake.
MP89-236	Broken, repairable	Background for tailings storage facility.

Scale 1000 500 0 1000 2000 m

Sept. 11, 1996

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

FIGURE 1

1625.A40

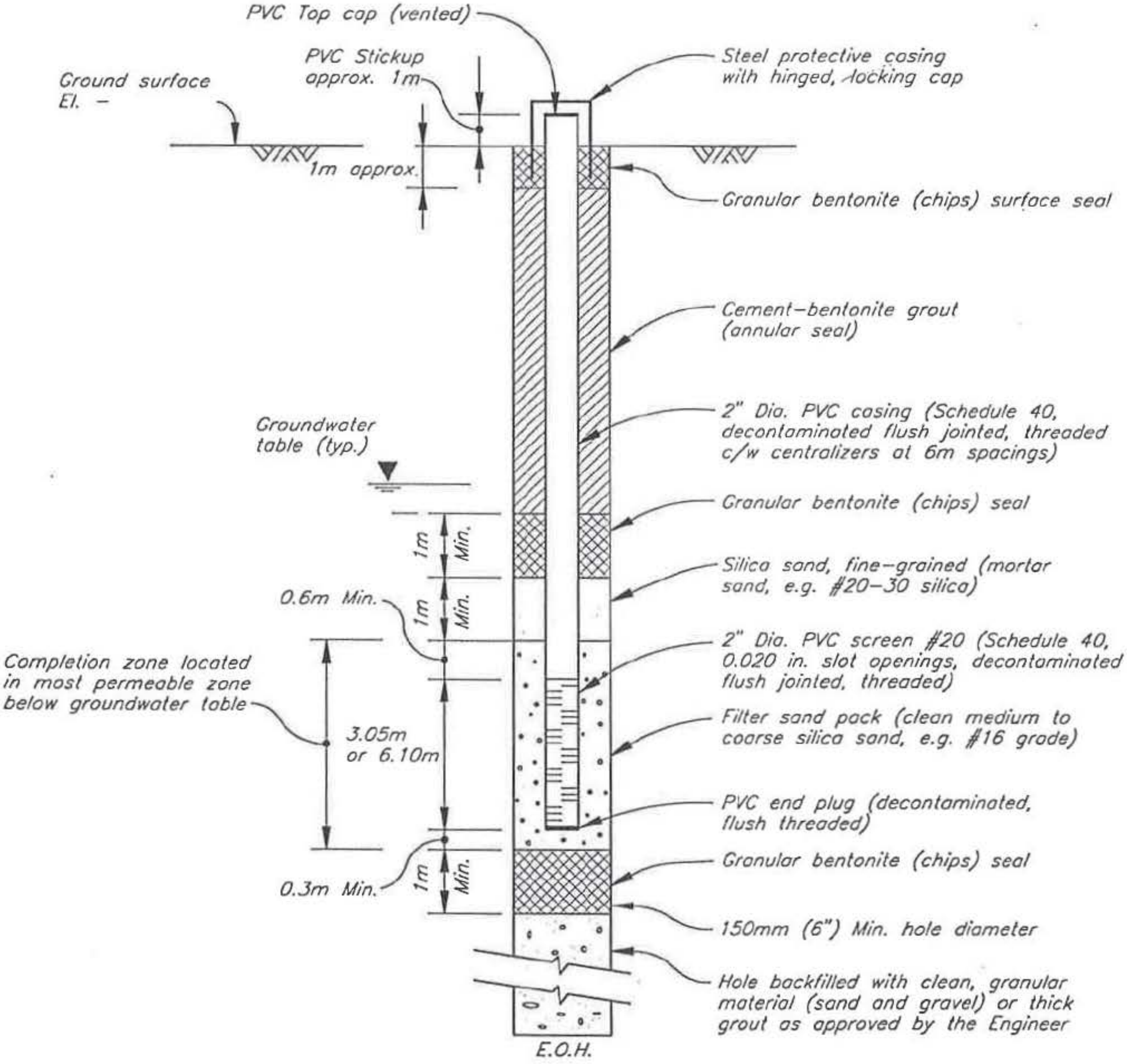
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N:________ E:________
COMPLETION DATE ________
PROJECT No. *1628*
HOLE No. ________
GROUND ELEVATION ________

PROPOSED 1996 GROUNDWATER MONITORING WELLS

SCHEMATIC DIAGRAM



NOTES

1. *Depths of hole, PVC and all backfill materials to be recorded.*
2. *All backfill materials to be installed using tremmie pipe to prevent bridging.*

CAD FILE: \1625\FIG\A40 Plot scale 1=1

FIGURE 2

MOUNT POLLEY MINING CORPORATION
MOUNT POLLEY PROJECT

1996 GROUNDWATER MONITORING WELL INSTALLATION PROGRAM
(REF. NO. 1628/4)

FEBRUARY 7, 1997

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IMPERIAL METALS CORPORATION
MT. POLLEY PROJECT

1996 GROUNDWATER MONITORING WELL INVESTIGATION PROGRAM
(REF. NO. 1628/4)

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MOUNT POLLEY MINING CORPORATION
MOUNT POLLEY PROJECT

1996 GROUNDWATER MONITORING WELL INSTALLATION PROGRAM
(REF. NO. 1628/4)

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MOUNT POLLEY PROJECT

1996 GROUNDWATER MONITORING WELL INSTALLATION PROGRAM
(REF. NO. 1628/4)

SECTION 1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Mount Polley Project is located in central British Columbia approximately 56 kilometres north-east of Williams Lake, as shown on Figure 1.1. The nearest settlement is the community of Likely, on the northern tip of Quesnel Lake.

The Mount Polley Mine has reserves of 82.3 million tonnes of copper and gold ore contained in three ore bodies. Ore will be hauled to the crusher and then it will be processed in the mill by selective flotation to produce a copper-gold concentrate at a production rate of approximately 17,800 tonnes per day (6.5 million tonnes per year). Approximately 92.6 million tonnes of waste rock will be stored in waste rock dumps adjacent to the open pit.

After processing the ore to produce the copper/gold concentrate, the tailings will be discharged as a slurry into the tailings storage facility which will provide environmentally secure storage of the tailings solids. As the solids settle out of the slurry, process fluids are collected and recycled back to the mill for re-use in the milling process. No surface discharge of any process solution from the tailings facility is required or anticipated.

In 1996, the British Columbia Ministry of Environment, Lands and Parks (MELP), Environmental Protection Branch requested that a Groundwater Monitoring Program be designed and implemented for the Mount Polley Project. One of the requirements of the program was to "... establish monitoring wells down-gradient from the pit, waste rock piles, and tailings pond dams, and to sample aquifers in both surficial deposits and bedrock ...", including the establishment of background wells up-gradient of any potential impacts by mining activities. The 1996 Groundwater Monitoring Well Installation Program was undertaken to fulfil this requirement. This report presents the details of the 1996 Groundwater Monitoring Well Installation Program, procedures followed during the work and results of the program.

1.2 PREVIOUS WORK

In 1989 Knight Piésold Ltd. was retained by Imperial Metals Corporation to conduct a geotechnical evaluation of the open pits, waste dumps and tailings storage facility for the proposed development of the Mount Polley Project. Monitoring wells were installed as part of this program. The 1989 Monitoring Well Program is summarized as follows:

1989 MONITORING WELL PROGRAM

- A total of nine (9) groundwater monitoring wells were installed in selected NQ diamond drillholes during the 1989 investigations by Knight Piésold, as shown on Figure 1. The 1989 monitoring wells were not installed in complete accordance to current industry practices. They were constructed using 38 mm diameter PVC well pipe with screened sections extending from approximately 3 metres below ground surface to the end of the well string. The screened sections were made using a hacksaw to cut the slots in the PVC pipe.

- Three wells (MP-89-107, MP-89-146 and MP-89-151) were installed in the open pit area. These wells were extended the full length of the exploration drill holes, approximately 150 metres. Bentonite seals were not installed below the well string. The surface seals consisted of a 1 metre concrete plug covered by two metres of bentonite that was installed just below the bedrock surface.

- Six wells (MP-89-231, MP-89-232, MP-89-233, MP-89-234, MP-89-235 and MP-89-236) were installed at the tailings facility. These monitoring wells varied from 15 to 40 metres in depth. Bentonite seals were installed below the well string and at the ground surface. Natural sand backfill was placed around the screened interval.

Additional groundwater wells were completed in the vicinity of the open pits and mill site with an air rotary water well drill rig in 1995. The program was co-ordinated and supervised by Imperial Metals Corporation. The 1995 Monitoring Well Program is summarized as follows:

1995 MONITORING WELL PROGRAM

- In August, 1995 seven groundwater wells (R-95-1 to R-95-7) were installed in the vicinity of the open pits and mill site, as shown on Figure 1. The wells were primarily for groundwater supply and were constructed with 110 mm PVC well pipe in 150 mm holes advanced with air rotary drilling methods. Well casings were installed over the full length of the holes, which ranged from 80 to 170 metres. Screened zones were installed at various levels, where high recharge was encountered during drilling. The well casings were sealed in accordance with standard BC water well practices.

1.3 REFERENCE INFORMATION

Prior to starting the 1996 Groundwater Monitoring Well Installation Program, a report containing detailed specifications for the drill program was issued, "Imperial Metals Corporation, Specification for Drilling, Monitoring Well Installations and Related Services, (Ref. No. 1628/3), September 18, 1996".

A summary of previous work on groundwater monitoring wells is presented in the Knight Piésold report "Imperial Metals Corporation, Groundwater Monitoring Program, Ref. No. 1624/2, June 3, 1996". This report is a compilation of the hydrogeological conditions at the site and the anticipated impacts that will result from the project development.

Knight Piésold Ltd. has prepared a number of reports which contain information relevant to the Groundwater Monitoring Program, as summarized below:

i) Imperial Metals Corporation, Report on Geotechnical Investigations and Design of Open Pit, Waste Dumps and Tailings Storage Facility, February 19, 1990.

ii) Imperial Metals Corporation, Mount Polley Project, Stage I Environmental and Socio-Economic Impact Assessment, January 1991.

iii) Imperial Metals Corporation, Report on Project Water Management (Ref. No. 1624/1), February 6, 1995.

iv) Imperial Metals Corporation, Tailings Storage Facility Design Report (Ref. No. 1625/1), May 26, 1995.

v) Imperial Metals Corporation, Manual on Sampling and Handling Guidelines for Determination of Groundwater Quality, (Ref. No. 1625/5), May 19, 1995.

A number of geotechnical investigations were conducted during construction of the Stage Ia tailings embankment in 1996. Detailed geologic and hydrogeologic information obtained from these investigations and the 1996 Groundwater Monitoring Well Installation Program will be presented in the report, "Mount Polley Mining Corporation, Mount Polley Project, Updated Design Report, Ref. No. 1627/2".

1.4 SCOPE OF WORK

The 1996 Groundwater Monitoring Well Installation Program was conducted between October 30 and December 6, 1996. The drill Contractor (Drillwell Enterprises Ltd.) was responsible for the following:

- Mobilization of one drill rig (air rotary) and support equipment.
- Overburden drilling, using a dry drilling method.
- Standard penetration testing (SPT) and associated sampling in overburden.
- Bedrock drilling, using a dry drilling method.
- Monitoring changes in down hole water production and measuring water levels during drilling operations.
- Installation of groundwater monitoring wells in permeable zones and backfilling of drill holes. (Well pipe and supplies were provided by Mount Polley Mining Corporation.)
- Well development.
- Clean up of drill sites.

Access to the drill sites and drill site construction were the responsibility of Mount Polley Mining Corporation. The monitoring well locations were surveyed by the Mount Polley Mining Corporation survey crew.

The following services were provided by Knight Piésold for the 1996 Groundwater Monitoring Well Installation Program:

- Selection of location for drill sites.
- Supervision of drill activities and monitoring well installations.
- Logging of the drill holes, including SPT samples and drill cuttings. Detailed drill logs are included in this report.
- Laboratory testing of selected samples.
- Selection of completion zones for the groundwater monitoring wells. The monitoring well completion details are included in this report.
- Supervision of well development.
- Training and supervision of monitoring well sampling.

SECTION 2 - 1996 MONITORING WELL INSTALLATIONS

2.1 GENERAL

The 1996 groundwater monitoring well installation program was conducted between October 30 and December 6, 1996. The 1996 groundwater monitoring wells were designed to serve as permanent groundwater monitoring points for the project. They will be utilized prior to operations, during the life of the mine and after mine closure.

A total of nine sites were selected for well installations, as follows:

- Six sites around the perimeter of the tailings storage facility (GW96-1, GW96-2, GW96-3, GW96-4, GW96-5, GW96-9).
- Three sites around the perimeter of the mine (GW96-6, GW96-7, GW96-8).

The locations of the drill sites are shown on Figure 1.

A total of 15 monitoring wells were installed at the nine locations. Most sites were targeted for one deep and one shallow well. Only GW96-6, GW96-7 and GW96-9 had a single well completed. If two wells were targeted for a site, the geologic formations and hydrogeologic conditions observed during drilling of the first (deep) hole were used to select the well completion zone for the second (shallow) hole. The completion zones of the monitoring wells were selected to target preferential groundwater flow pathways near surface and at depth.

A summary of the monitoring wells, their locations and completion zone details is provided on Table 2.1.

2.2 DRILLING

The drilling was conducted with an air-rotary rig, provided by Drillwell Enterprises Ltd., of Duncan B.C. The holes were advanced with a 149.2 mm (5 7/8 inch) O.D.

Geologic descriptions and observations of moisture conditions, in-hole water levels and down-hole water production rates are provided on the drillhole logs in Appendix A.

2.3 GROUNDWATER MONITORING WELL INSTALLATIONS

After drilling and logging of the first (deep) drillhole was completed at each site, the zones of greatest groundwater yield within each of the overburden and bedrock units were selected for completion of the monitoring wells. If two wells were required, a second hole was then drilled for installation of the shallow well. At GW96-6 and GW96-7, bedrock was encountered at surface or beneath a very thin veneer of overburden and the bedrock permeability was relatively consistent. Therefore, only one well was installed at these locations. GW96-9 was a supplemental well specifically targeted for a near surface aquifer in the vicinity of GW96-3 and GW96-4 and only one well was considered necessary.

Each monitoring well consists of 50.8 mm (2 inch) diameter, decontaminated, flush-jointed, threaded Schedule 40 PVC tubing (screens and risers) installed within a hole approximately 150 mm (6 inch) in diameter. Screen lengths from 1.8 m (6 ft) to 6.1 m (20 ft) were selected in the field, as required to capture the extent of the target zone. The screens were provided with #20 (0.020 inch or 0.25mm) slots. The screens were surrounded by a filter pack of uniformly graded #16 silica sand. The well completion zone was hydraulically isolated by an upper and, where necessary, lower bentonite chip seal. In most cases, the upper seal was separated from the #16 filter sand pack by a layer of fine-grained (#20-#30) silica sand in order to prevent downward migration of gelled bentonite into the primary filter pack. Above the upper seal, the hole was backfilled with a combination of bentonite chips and/or cement-bentonite grout (installed using a tremmie pipe) and/or washed gravel (19 mm to 37 mm). Each well installation was completed with a bentonite chip surface seal and a steel protective casing with locking cap at surface.

Monitoring well completion details are provided in Appendix B.

2.4 IN-SITU TESTING

In-situ testing was limited to Standard Penetration Tests (SPT's) within the overburden in GW96-1A, GW96-2A and GW96-3A for the purpose of collecting further information on foundation conditions at the tailings embankments. Uncorrected SPT blow counts are included on the drillhole logs in Appendix A.

2.5 LABORATORY TESTING

Soil samples collected during Standard Penetration Testing in the 1996 groundwater monitoring well drillholes were sealed up and are in storage at the Mount Polley site. To date, no laboratory testing has been carried out on these samples.

SECTION 3 - SUMMARY AND CONCLUSIONS

During the 1996 Groundwater Monitoring Well Installation Program, a total of 15 monitoring wells were installed at 9 different sites, 6 of which were located around the perimeter of the tailings storage facility and 3 of which were located around the perimeter of the mine. Monitoring wells were completed in overburden and in bedrock.

Groundwater quality sampling from the monitoring wells is required on a quarterly basis. Monitoring will be conducted prior to commencement of mining operations, in order to establish baseline water quality, during mining operations and for a period of at least 2 years after mine closure. The groundwater monitoring program will be administered and conducted by Mount Polley Mining Corporation.

TABLE 2.1

MOUNT POLLEY MINING CORPORATION
MOUNT POLLEY PROJECT

SUMMARY OF 1996 MONITORING WELL INSTALLATIONS

J:\JOB\REPORT\1628\[4-tbl-21.xls]Sheet1

6-Feb-97

Monitoring Well No.	General Location	Coordinates Northing	Coordinates Easting	Ground El. (m)	Completion Zone (m below ground surface)	Geologic Unit
GW96-1A	Tailings Facility	5 819 939.06	595 415.82	927.89	52.4 - 60.1	Bedrock
GW96-1B	Tailings Facility	5 819 935.22	595 416.16	927.81	32.6 - 39.0	Overburden
GW96-2A	Tailings Facility	5 819 449.92	596 065.40	931.42	50.9 - 55.2	Bedrock
GW96-2B	Tailings Facility	5 819 447.08	596 074.73	931.42	29.7 - 35.7	Overburden
GW96-3A	Tailings Facility	5 818 308.97	595 768.75	912.06	47.0 - 53.0	Bedrock
GW96-3B	Tailings Facility	5 818 306.52	595 765.16	912.06	15.4 - 20.0	Overburden
GW96-4A	Tailings Facility	5 818 164.58	595 147.94	940.56	19.2 - 25.0	Bedrock
GW96-4B	Tailings Facility	5 818 162.87	595 151.26	940.46	2.7 - 7.3	Overburden
GW96-5A	Tailings Facility	5 819 626.68	594 330.34	973.55	13.8 - 19.7	Bedrock
GW96-5B	Tailings Facility	5 819 629.64	594 329.79	973.44	3.0 - 7.1	Overburden
GW96-6	Minesite Area	5 822 851.66	593 659.21	1058.53	34.4 - 43.0	Bedrock
GW96-7	Minesite Area	5 821 520.53	592 983.23	1021.32	9.9 - 14.3	Bedrock
GW96-8A	Minesite Area	5 822 468.46	591 861.59	1050.10	35.2 - 40.1	Bedrock
GW96-8B	Minesite Area	5 822 469.40	591 859.31	1050.09	11.0 - 15.7	Overburden/Bedrock
GW96-9	Tailings Facility	5 818 277.14	595 503.89	916.18	3.4 - 6.1	Overburden

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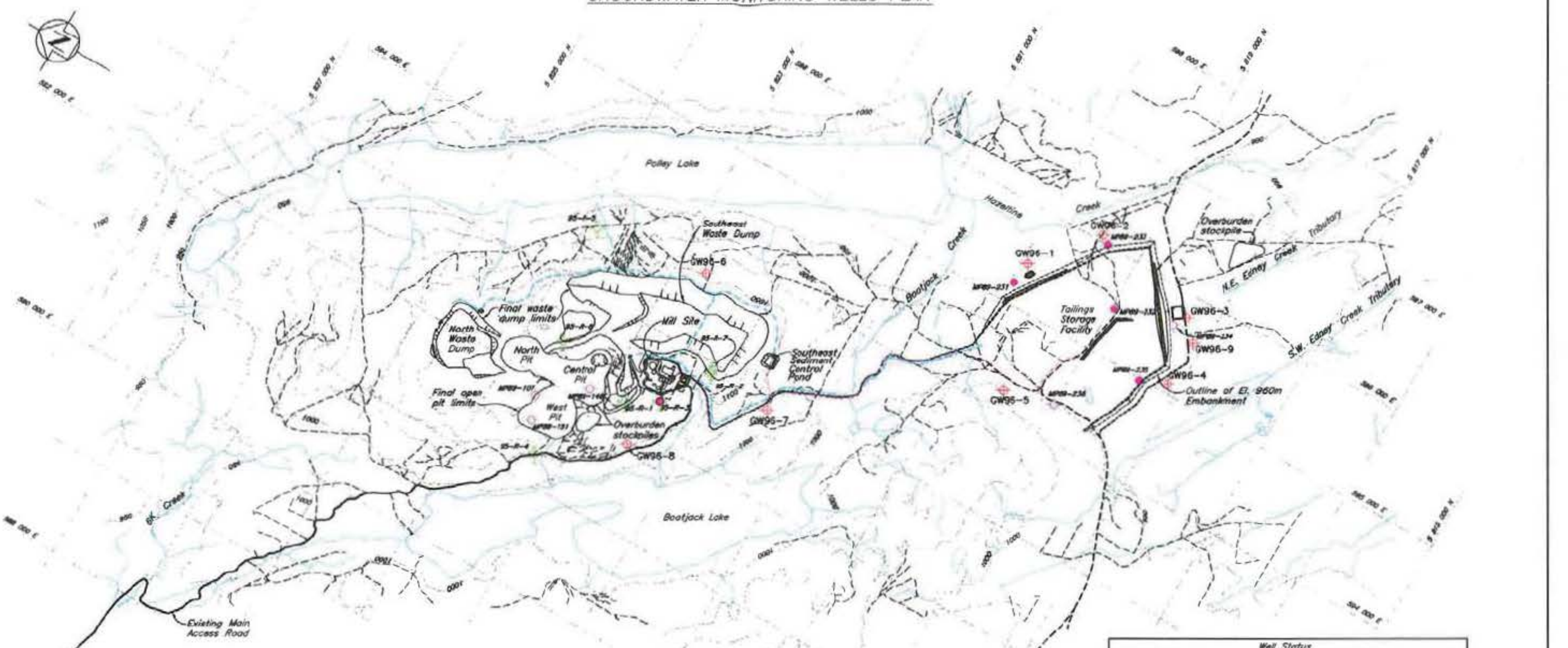
MOUNT POLLEY MINING CORPORATION
MOUNT POLLEY PROJECT
GROUNDWATER MONITORING WELLS PLAN



NOTES

1. Open Pits and Waste Dumps are shown in their final configurations.
2. 1989 Monitoring Wells consist of 38 mm PVC with slotted screens.
3. 1995 Monitoring Wells consist of 110mm PVC well pipe installed primarily as a water supply source. Wells are screened at multiple intervals.
4. Monitoring installation 95-R-3 has been blocked at a depth of aporoximatly 70 metres below the collar. This installation is no longer operable as a screen interval is not accessible.
5. 1996 Monitoring Wells consist of 50 mm PVC with one slotted screen section.
6. Location of Southeast Sediment Control Pond to be finalized at the construction.

LEGEND

MP89-107 ○ 1989 Groundwater Monitoring Well

GW95-1 ⊕ 1996 Groundwater Monitoring Well

● Decommissioned / Lost Groundwater Well

95-R-4 ✛ 1995 Groundwater Supply Well

Well Status

Identification	Status	Identification	Status
MP89-107	Unknown	GW96-1A	Good
MP89-146	Unknown	GW96-1B	Good
MP89-151	Unknown	GW96-2A	Good
MP89-231	Lost/Decommissioned	GW96-2B	Good
MP89-232	Decommissioned	GW96-3A	Good
MP89-233	Lost/Decommissioned	GW96-3B	Good
MP89-234	Good	GW96-4A	Good
MP89-235	Lost/Decommissioned	GW96-4B	Good
MP89-236	Broken, Repairable	GW96-5A	Good
95-R-1	Good	GW96-5B	Good
95-R-2	Good	GW96-6	Good
95-R-3	Blocked	GW96-7	Good
95-R-4	Good	GW96-8A	Good
95-R-5	Good	GW96-8B	Good
95-R-6	Good	GW96-9	Good
95-R-7	Good		

Scale 1000 500 0 1000 2000 m

Feb. 6, 1997
KNIGHT PIESOLD LTD.
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FIGURE 1

Knight Piésold Ltd.
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APPENDIX A

DRILLHOLE LOGS

Association
of Consulting
Engineers
of Canada

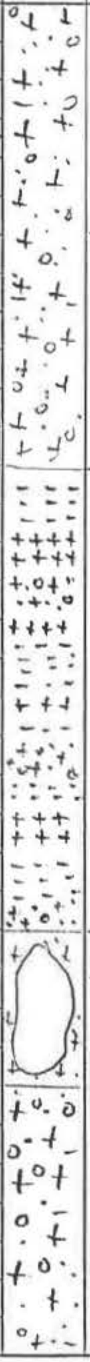
Association
des Ingénieurs-
Conseils
du Canada

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

TEST HOLE LOG

TEST HOLE No. GW96-1A/1B
SHEET 1 of 4

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE TSF 1A N5819939.06, E595415.82 / 1B N5819935.22, E595416.16
GROUND EL. 1A: 927.89 / 1B: 927.81
DATE BEGUN Nov. 29/96
DATE FINISHED DEC 6/96
LOGGED BY PJP



NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel/casing							
Note: * GW's A+B installed in separate drill holes. (3m appart)					0		SILT (TILL) - sandy, some gravel (20%) and clay, rare cobbles, very stiff to stiff, well graded, low permeatlity, very moist to wet, brown, masive.
					1.2		- becoming very stiff to hard and very moist.
GEOLOGY inferred from cuttings and SPT samples.	16"/24" = 67%	SPT 9 19 16 14 n= 35			3.3		- becoming some gravel to gravelly and moist to very moist.
					3.9		
					5.1		CLAY and SILT (Glaciolacustrine) - poor recovery from cuttings as wet and softer - see SPT ⓐ 6.0m.
	24"/24" = 100%	SPT 2 2 4 4 n= 6			6.0		CLAY and SILT (GLACIOLACUSTRINE) - lesser silt and fn silty sand laminations 1mm to 100 mm thick, firm, well sorted, bedded, low permeability as no sand only laminations observed. Contains 20 to 100 mm thick well graded fill-like texture layers, high to mod plasticity to non plastic coarse silt layers, wet to saturated, grey.
					8.5		- hit 0.3m ϕ boulder believed to be top of glacial till unit - see SPT ⓐ 8.8m.
Likely pushed gravel in split spoon! →	4"/24" = 17%	SPT 9 15 11 13 n= 26			8.8		SILT and SAND (TILL) - some gravel to gravelly, trace clay and rare cobbles, med dense to dense, massive, low permeability moist to very moist, brown.
					9.4		- possibly weathered top of till → softer
					9.5		- becoming dense to very dense

CAD FILE: [illegible] Plot scale 1=1

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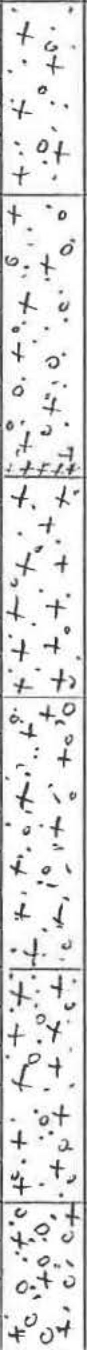
TEST HOLE LOG

TEST HOLE No. GW96-1A/1B
SHEET 2 of 4

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov.29/96 DATE FINISHED DEC.6/96
LOGGED BY PJP



NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing							
NOTE: * GW's A+B installed in separate drill holes.					10.7		- becoming very dense, moist and grey-brown → BASAL Till-like, slightly coarser
	15"/24" = 63%	SPT 22 40 } n= 39 } 79			12.1		SAND (TILL) - silty (25% to 30%), gravelly (30% to 35%), trace clay, very dense, well graded, massive, low permeability, moist, grey to grey-brown.
					12.55		- last 1" of sample silt w some fn sand (thin layer of glacio-lacustrine?)
					12.8		- cont'd gravelly silty sand till
					13.7		- becoming fine grained to SILT (TILL) w some sand (20%) and some fine gravel "Fine Till", very stiff, low permeability, moist, grey-green.
					15.2		SAND (TILL) - gravelly and silty, trace clay, very dense, well graded, massive, low perm, moist brown to orange-brown at times
					17.3		- becoming gravelly and only some silt.
	6"/10" -60%	21 50 (4") n=>100			18.0		SILT and SAND (TILL) - gravelly, trace clay, very stiff to hard, well graded, massive, low permeability, moist, brown to red-brown.
					18.25		
					21.3		SAND (TILL) - gravelly, some silt, trace clay and cobbles, very dense, well graded, massive, low permeability, damp to moist, brown.
					27.7		

CAD FILE: \CAD\FIG\A1 Plot scale 1=1

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TEST HOLE LOG

TEST HOLE No. GW96-1A/1B
SHEET 3 of 4

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov. 29/96 DATE FINISHED DEC 6/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel/casing							
NOTE: * GW's A+B installed in separate drill holes.					27.7		SILT (GLACIOLACUSTRINE) - trace fine sand (10%) and clay (5-10%), mostly coarse silt, very stiff, likely low permeability unit, non plastic, massive?, moist, grey to grey-green. - may be periodic fine gravel and better graded layers.
	24"/24" =100%	45 43 } n= 62 } >100			30.2 30.65		SAND (GLACIOFLUVIAL) - trace coarse silt, fine grained, silt laminations rare and thin, very dense, poorly graded, layered, saturated, grey.
NOTE: Upon start-up in AM, wtr at 60' below grade inside casing. →					30.7		SILT (TILL) - sandy, some gravel, very stiff, well graded, trace clay (10%), massive, lower permeability, moist, grey
NOTE: Begins making water -31.9m - 2 gall/min -32.6m - 5 gall/min -36.6m - 15 gall/min -38.1m - 50 gall/min -41.1m - 2 gall/min -42.4m - 0 gall/min					31.9		SAND (GLACIOFLUVIAL) - gravelly, trace silt (5-10%) resulting in dirty water, dense, periodic thin layers of silt/sand (fine) <50mm as brought up w̄ sand & gravel. - unit grades back and forth between medium to coarse grained sand w̄ some gravel to sandy gravel w̄ 10% fines as dirty. - clean water and coarsest gravel
Steel Casing + Shoe cut-off and left in ground from 47.3 to 48.5m					42.4		SILT and SAND (TILL) - some gravel (20%), trace clay, very stiff to hard, well graded, massive, low permeability, moist, brown to red-brown.

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TEST HOLE LOG

TEST HOLE No. GW96-14/1B
SHEET 4 of 4

PROJECT Mt. Polley - Hydrological Investigation
LOCATION OF TEST HOLE
DATE BEGUN
DATE FINISHED
PROJECT NO. 1627.300
GROUND EL.
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel/casing							
NOTE: ✻ GW'S A+B installed in separate drill holes.					47.6	✓	Volcanic Conglomerate (BEDROCK) - "fragments" of hematitically altered, weathered sediment composed primarily of volcanic clasts. - periodic moist rock chips but density and moisture content primarily constant. - no fault, fracture, water bearing zones intercepted.
					61.3 (201ft)		

CAD FILE: \CAD\FIG\A1 Plot scale 1=1

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST HOLE LOG	TEST HOLE No. GW96-2A/2B SHEET 1 of 4

PROJECT Mt. Polley - Hydrological Investigation

PROJECT NO. 1627.300

LOCATION OF TEST HOLE (TSF) 2A: N5819449.92, E596065.86 / 2B N5819447.08, E596074.73

GROUND EL. 2A: 931.42 / 2B: 931.42

DATE BEGUN Nov 10/96 DATE FINISHED Nov. 17/96

LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing							
NOTE: * GW's A+B installed in separate drill holes.							0-5.5m - GLACIAL TILL 0-3m - SOFT, WET 3-5.5m - VERY DENSE, MOIST
GEOLOGY INFERRED FROM CUTTINGS AND SPT SAMPLES	4"	/ ? n= ≈50	- PUSHED ROCK				5.56m - SPT SS. 2" O.D. 4" RECOVERY - PUSHED ROCK SILT/SAND TILL - GREY-BROWN, VERY DENSE, WELL GRADED, MOIST, TRACE CLAY, GRAVELLY, MASSIVE 5.5m - 7.01m - TILL MOIST, GRAVELLY, OLIVE GREEN-GREY 7.01m - 8.5m - TILL SILT/SAND, BROKEN UP GRAVEL, OCCASIONAL COBBLES.
- SPT @ 11.8m	24"/24"	15 25 32 38	N=58		11m (36')		GLACIOLACUSTRINE SILT, GREY-GREEN, TRACE FINE SAND <5%, SOME CLAY (10-15%) VERY MOIST - MAY CONTAIN THIN FINE SAND LAMINATIONS AS MATRIX IS VERY MOIST TO WET AND MINOR WATER BUILDS UP WHEN STOP DRILLING.

CAD FILE: \CAD\PGS\A1 Plot scale 1-1

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST HOLE LOG	TEST HOLE No. GW96-2A/2B SHEET 2 of 4

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov. 10/96 DATE FINISHED Nov. 17/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	SPT BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ⌀ tricone bit - 6" steel casing							
NOTE: * GW's A+B installed in separate drill holes.					11.8		SPT - S.S. 2" O.D @ 11.8m (38'9") ↳GLACIOLACUSTRINE SILT - VERY STIFF, OLIVE GREEN - LIGHT BROWN, THINLY TO IRREGULAR LAMINATED (2-10mm THICK), FINE SAND LAYERS, CONTAINS ONE 30mm THICK FINE - MED. GRAINED SAND LAYER - DAMP, VARIABLE SILT CONTENT (PRIMARILY MD-CS GRAINED), LOW VERTICAL K, POTENTIALLY MODERATE HORIZONTAL K ALONG SEAMS (DISCONTINUOUS?). LOW TO SOME CLAY IN THIN LAYERS.
SPT 2" o.d. SS @ 14.9m	24"/24"	18 30 36 45	N=66				TO 14.9m - SAME UNIT, SEE SPT @ 14.9 14.9 - SPT - S.S. 2" O.D. (49') ↳GLACIOLACUSTRINE ↳V. STIFF, OVERCONSOLIDATED, GENERALLY FN-MED. GRAINED SILT WITH LAMINATIONS (VARVES?) OF MORE CLAY RICH LAYERS 1-2mm, OCCASIONAL 2-3cm LAYERS OF TILL-LIKE, POORLY SORTED BETTER GRADED SAND/SILT LAYERS WITH FINE GRAVEL (UP TO 10mm ⌀). LOW PLASTICITY IN GENERAL, LOW PERMEABILITY, HORIZONTAL STRATIFICATION LT. BROWN FN-MED GRAIN SAND SEAM (UP TO 2cm THICK), DENSE, UNSATURATED, MOIST
- WATER TABLE APPROX. @ 5.76 m. (55') - WATER FILLING 2-4' @ EOH WHEN STOP DRILLING.				60ft	18.28		- cuttings indicate coarsening to well graded till-like unit → Possibly SAND (TILL) w̄ silty, gravelly (fn.gr) matrix. - Driller indicates unit drills smooth and is very dense. Good returns.

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST HOLE LOG	TEST HOLE No. GW96-2A/2B SHEET 3 of 4

PROJECT *Mt. Polley - Hydrological Investigation* PROJECT NO. *1627.300*

LOCATION OF TEST HOLE ______ GROUND EL. ______

DATE BEGUN *Nov. 10/96* DATE FINISHED *Nov. 17/96* LOGGED BY *PJP*

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel/casing		SPT			22.87		- becomes fine grained to Sandy Silt, some fine gravel, trace clay, no cobbles, moist to very moist, brown, likely low permeability
	6½"/6½" = 100%	45→6" 10→½" n= 75 to 100			24.24		SAND AND SILT (Glaciolacustrine) - fine grained sand and coarse grained silt with 1 to 2 mm thick laminations of saturated silt. Also contained 1 to 3 cm thick fine to medium grained, saturated sand layer. Very stiff, lower permeability - Last 3" SILT (till-like) - sandy, trace fine gravel, massive, very stiff, grey, moist.
					24.24 to 26.83		- cuttings returned indicate continued fine grained till-like SILT - sandy with trace fine gravel
			Does not make much water while drilling. Once drilling stopped for 10 minutes → 15' to 20' of water in bottom of hole.		26.83		SAND and GRAVEL (Glaciofluvial) - believed to be saturated stratified sands and gravels with alternating "cleaner and dirtier" layers due to variable fines content. Washed coarse fraction (i.e. medium to coarse gravel) is rounded to subrounded.
					32.0		- sandy gravel, rounded to subrounded, medium to coarse grained. Produces ≈ 80 l/minute
					32.6		- thin silt (Glaciolacustrine) layer
					32.9		- back to Glaciofluvial GRAVEL - some coarse sand, trace fines (10%), contains trace cobbles. Continues making water at 80 l/min.
					35.2		- water test 20-25 l/min

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TEST HOLE LOG

TEST HOLE No. GW96-2A/2B
SHEET 4 of 4

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov. 10/96 DATE FINISHED Nov. 17/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY W/O WATER - 5 7/8" φ tricone bit - 6" steel casing					36.0		- continued Glaciofluvial GRAVELS and coarse SANDS, water test → 50-55 l/min contains 10% fines
					40.2		- becoming less fines (<5%) and cleaner water and higher water flow rates. water test → 200-225 l/min
					40.5		SILT (Basal Till) - sandy, some gravel to gravelly, trace clay, rare cobbles, slightly weathered, moist to very moist, no water produced, grey.
41.1m Note: Upon start up. No water in bottom of hole					41.1		- becoming very stiff to hard, moist, low permeability, massive, grey.
							- continued grey till, gravel fragments are multilithic,
					50.3		- GRAVEL (weathered bedrock?) - some coarse sand, no fines matrix, clasts subrounded to angular and ~~a~~ not so multilithic, generally clasts are erosional resistant qtz and cherts, likely weathered conglomerate.
					51.2 to 51.4		- making water at 10 - 12 l/min
BEDROCK - not making any water					52.4		CONGLOMERATE BEDROCK - very competent, smooth drilling, clasts composed of erosional resistant quartz, cherts and occasional intrusive.
					61.6m		EOH

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TEST HOLE LOG

TEST HOLE No. GW96-3A/3B
SHEET 1 of 3

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE (TSF) 3A: N5818308.97, E595768.75 / 3B: N5818306.52, E595765.16
GROUND EL. 3A: 912.06 / 3B: 912.06
DATE BEGUN Nov. 4/96
DATE FINISHED Nov. 9/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing					0		SILT (FILL) — fill composed of silt till - sandy, some gravel (10-15%), some clay (10%), low prm, very moist, brown
					3.0		- fill is mixture of silt till and glaciolacustrine silt
		SPT			4.95		
	14"/18" =78%	2 8 } n= 12 } 20					SILT (Glaciolacustrine) - some clay, trace fine sand, weakly interbedded stiff to very stiff, low permeability, coarse silt - fine sand laminations, light grey to brown.
5.2m Note: 20min wait, 2 to 3' of standing water in bottom of hole.					5.2		- primarily coarse silt and trace very fine sand, stiff, saturated, grey
					6.7		- predominantly well graded silt with up to some clay, <2% fine sand, low permeability.
8.2m Note: water at pond elevation in bottom of hole overnight.		SPT			8.2		
	24"/24" =100%	6 9 } n= 13 } 22 18					SILT (Glaciolacustrine) - some clay to clayey, very stiff, irregular layers of slight composition change and color change, grey to grey - brown, moist, moderate plasticity, natural m/c >> PL.
					9.8		- becoming SILT/CLAY (Glaciolacustrine) laminated with rare fn sand/coarse silt layers 1mm.
	24"/24" =100%	8 13 } n= 19 } 32 22			11.6		- continued laminated SILT and CLAY (1 to 3mm) as above for 1st 12" - 2nd 12" → Coarse silt (sensitive) as quickens under viabration. Note: same unit as tested with CPT investigation earlier in year., saturated, grey, massive.
					11.6 to 14.7		- continued coarse silt unit as above.

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TEST HOLE LOG

TEST HOLE No. GW96-3A/3B
SHEET 2 of 3

PROJECT Mt Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov. 4/96 DATE FINISHED Nov. 9/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT SPT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing	24"/24" = 100%	0 0 } n = 1 1 4			14.7		SILT (Glaciolacustrine) - coarse silt primarily with trace fn sand, saturated, Note: Low blow counts due to loss of confinement and disturbance causing quickening of silt (non-plastic) unit. (CPT data showed unit was very stiff), grey, massive, saturated.
					17.1		- becoming coarse grained with gravel returning with washings as now generating water, water test → 50 to 60 l/min, likely glaciofluvial sandy gravel unit.
	20"/24" = 83%	SPT 15 55 } n = 108 53 60			17.5		SAND (Glaciofluvial) - dense to very dense, medium to coarse grained, massive, saturated, grey, medium to high permeability.
					17.65		SAND and SILT (TILL) - some gravel, trace to some clay, well graded, very dense, gravel up to 1" ϕ, massive, low perm, - likely Basal Till, no water produced. - continued grey very dense Basal till from 17.5 to 19.8 m.
					19.8 m		- becoming red brown at times believed to be due to drilling through red-brown volcanic conglomerate clast caught up in till unit.
	10"/10" = 100%	23 80/4" n = 75			23.6		SILT and SAND (TILL) - continued, very dense, massive, low permeability. - occasional cobbles to 25 m
25 m Note: Approx. 10 m of water in bottom of hole overnight					25		- becoming slightly more gravelly, silty sand, trace clay, likely continued cobbles, grey to red-brown, massive, low permeability likely, moist 25 m to 35 m - cont'd glacial till - red brown to grey, moist.

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TEST HOLE LOG

TEST HOLE No. GW96-3A/3B
SHEET 3 of 3

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE
GROUND EL.
DATE BEGUN Nov. 4/96 DATE FINISHED Nov. 9/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY W/O WATER - 5 7/8" ϕ tricone bit - 6" steel casing					35		Volcaniclastic Conglomerate-(Bedrock) - "fragments" of hematically altered, weathered sediment comprised of volcanic clasts, drilled with tricone bit → soft - rock chips generally damp to dry with return dusty.
Note: Contact between till and bedrock is dry. Wait 20 minutes but no water, drilled dry to dusty w/ occasional damp zones.					52.1		- possible fracture (wet) zone as material comes out as clumps and damp for 0.5 to 1.0 m.
					54.9		EOH (180ft)
							- wait 20 minutes, no water in bottom of hole. - Pull rods and remeasure → 1' of water in bottom of hole.

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TEST HOLE LOG

TEST HOLE No. GW96-4A/4B
SHEET 1 of 1

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE (TSF) 4A: N5818164.58, E595147.94 4B: N5918162.87, E595151.26
GROUND EL. 4A: 940.56 ; 4B: 940.46
DATE BEGUN Nov. 18/96 DATE FINISHED Nov. 20/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing					0		SAND (TILL) - gravelly, some silt to silty, trace clay, very dense, well graded, low permeability, moist, medium brown. -(Ablation till)
					4.0		SAND (Glaciofluvial) - some gravel to gravelly, trace silt (10%), dense, clasts rounded to subrounded, saturated, moderate permeability, cohesionless, grey-brown
4.5 m Waited 20 minuts, wtr at 10' below grade.					4.5		- becoming slightly cleaner (less fines) and still saturated but not making any water.
					7.0		SAND (TILL) - silty, some gravel, trace clay, rare cobbles, very dense, well graded, low permeability, moist, grey-brown.
					9.8		Volcaniclastic Conglomerate (Bedrock) - fragments of hematically altered volcanic in sediment matrix, red-brown, hard, dry. No observable fracture zones.
Not: 20' of wtr in bottom of hole overnight.					16.7		- making dribble of water
					25.0		EOH

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TEST HOLE LOG

TEST HOLE No. GW96-5A/5B
SHEET 1 of 1

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE (TSF) 5A: N5819626.68, E594330.34 / 5B: 9.64, E594329.79
GROUND EL. 5A: 973.55 / 5B: 973.44
DATE BEGUN Nov. 21/96 DATE FINISHED
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing					0		SILT (Ablation Till) - sandy, some gravel and clay, stiff, moderately well graded, low permeability, wet to saturated, dark brown.
					2.1		- becoming very stiff, moist to very moist, light to medium brown.
No water generated in overburden or bedrock during drilling.					4.9		- hit 0.6 m ϕ boulder
Note: 5.5m: left for 1 week, water at surface upon re-startup.					6.0		- becoming gravelly and dense
					6.7		- becoming very dense, moist and grey, still low permeability and no water generated
					10.4		SYENITE INTRUSIVE (Bedrock) - coarse grained to pegmatitic, massive, - no observable fractures, dry to damp
					15.2		- narrow zone damp chips, no dust for 1m, water bearing?
					25.5		EOH

KNIGHT PIESOLD LTD. CONSULTING ENGINEERS	TEST HOLE LOG	TEST HOLE No. GW96-6 SHEET / of /

PROJECT Mt. Polley - Hydrological Investigation
LOCATION OF TEST HOLE (Millsite) - N5822851.66, E593659.21
DATE BEGUN Oct. 30/96 DATE FINISHED Oct. 31/96
PROJECT NO. 1627.300
GROUND EL. 1058.53
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT		DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing				0		Intermediate Volcanic (Bedrock) - fn grained, dark grey, andesite to basalt, minor epidote alteration, drills quickly, moderately competent, dry ; dusty, no indication of water
				9.1		- becoming slightly coarser grained to micro diorite composition, epidote + k-spar alteration, dry, relatively massive, no water produced
				12.8		- let hole stand for 20 minutes, upon restart, 2ft of water in bottom of hole,
				15.2		- trace pyrite and minor chalcopyrite for 1m only, no water → dusty continued.
				24.4		- let hole stand for 20 minutes, upon start-up, rock chips moist initially only, then dusty again. - continued microdiorite intrusive, tight, no fractures observed.
				36.6		- becoming harder to drill → No water produced during drilling.
				43.8		EOH

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TEST HOLE LOG

TEST HOLE No. GW96-7
SHEET 1 of 1

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE (Millsite): N5821520.53, E592983.23
GROUND EL. 1021.32
DATE BEGUN Nov. 7/96 DATE FINISHED Nov. 7/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT			DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY W/O WATER - 5 7/8" ϕ tricone bit - 6" steel casing					0		SILT (TILL) - sandy, some gravel and clay, dense to very dense, massive, low permeability, moist to very moist, brown.
					2.4		Diorite (Bedrock) - fn grained → microdiorite or plagioclase feldspar volcanic (intermediate) - epidote, magnetite and calcite altered, weak chlorite alteration?, fractured and weathered
					3.0		- begins making water at 5 to 10 l/min
					6.0		- water tst at 16 l/min
					9.0		- becoming highly fractured with blue-grey fault gauge returns in water, water produced at 19 l/min.
					10.7		- large fragments of rock breaking off forming pocket inside hole. Rock fragments contain numerous calcite stringers → fault zone. → still producing water → hole caving in.
					15.5		EOH (51')

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TEST HOLE LOG

TEST HOLE No. GW96-8A/8B
SHEET 1 of 1

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE (Millsite) 8A: N5822468.46, E591861.59
8B: N5822469.40, E591859.31
GROUND EL. 8A: 1050.10
8B: 1050.09
DATE BEGUN Nov.1/96
DATE FINISHED
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT		DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing				0		SILT (FILL) - fill composed of reworked sandy silt fill with some gravel, stiff, wet to saturated, fill formerly pull-out for road construction, trace organics mixed in, grey, low permeability.
				2.4		SILT and SAND (TILL) - gravelly, some clay, trace cobbles, very moist, low permeability, not producing water, brown.
				4.5		- becoming dense to very dense, moist to very moist,
				7.6		- becoming very dense and moist.
				12.2		GRAVEL (Glaciofluvial) - sandy, dense, subrounded clasts, very moist to wet but not producing water, high permeability. → let stand for 20 minutes and 5ft of water in bottom of hole.
				12.8		Diorite (Bedrock) - medium grained, massive, somewhat weathered, weak chlorite alteration. → begins to make 15 l/min
				27.4		- becomes much harder to drill and continues to produce 15 l/min.
				36.9		- hit fractured zone (softer) and now produces 60 to 70 l/min. - continuing in fracture zone with high flow rates to EOH.
				40.1		EOH

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TEST HOLE LOG

TEST HOLE No. GW96-9
SHEET 1 of 1

PROJECT Mt. Polley - Hydrological Investigation
PROJECT NO. 1627.300
LOCATION OF TEST HOLE TSF: N5818277.14, E595503.89
GROUND EL. 916.18
DATE BEGUN Nov. 21/96 DATE FINISHED Nov. 21/96
LOGGED BY PJP

NOTES Water loss, type and size of hole, drilling method, groundwater level, etc.	CORE RECOVERY %	BLOWS/FOOT		DEPTH (m)	GRAPHIC LOG	DESCRIPTION AND CLASSIFICATION OF MATERIAL
DRILLWELL - AIR ROTARY w/o WATER - 5 7/8" ϕ tricone bit - 6" steel casing				0		SILT (TILL) - sandy, some gravel and clay, trace cobbles, stiff to very stiff, low permeability, well graded, very moist to wet, grey to brown
				≈2		- becoming very stiff and moist to very moist
				3.9		SAND (Glaciofluvial) - fine grained with some fine gravel, trace to some silt, moderate permeability, saturated, grey-brown. - contains alternating more gravel rich layers 0.2 to 0.3m thick - producing only dribble of water with saturated cuttings.
				5.1		SILT (Glaciolacustrine) - layered silt with lesser thin fn sand and silt laminations, as well as silt & clay layers, appears irregular, stiff to very stiff, low permeability, grey, moist to very moist.
				6.0		EOH

CAD FILE: \CAD\TC\AT Plot scale 1=1

APPENDIX B

GROUNDWATER MONITORING WELL COMPLETION DETAILS

1625.A42

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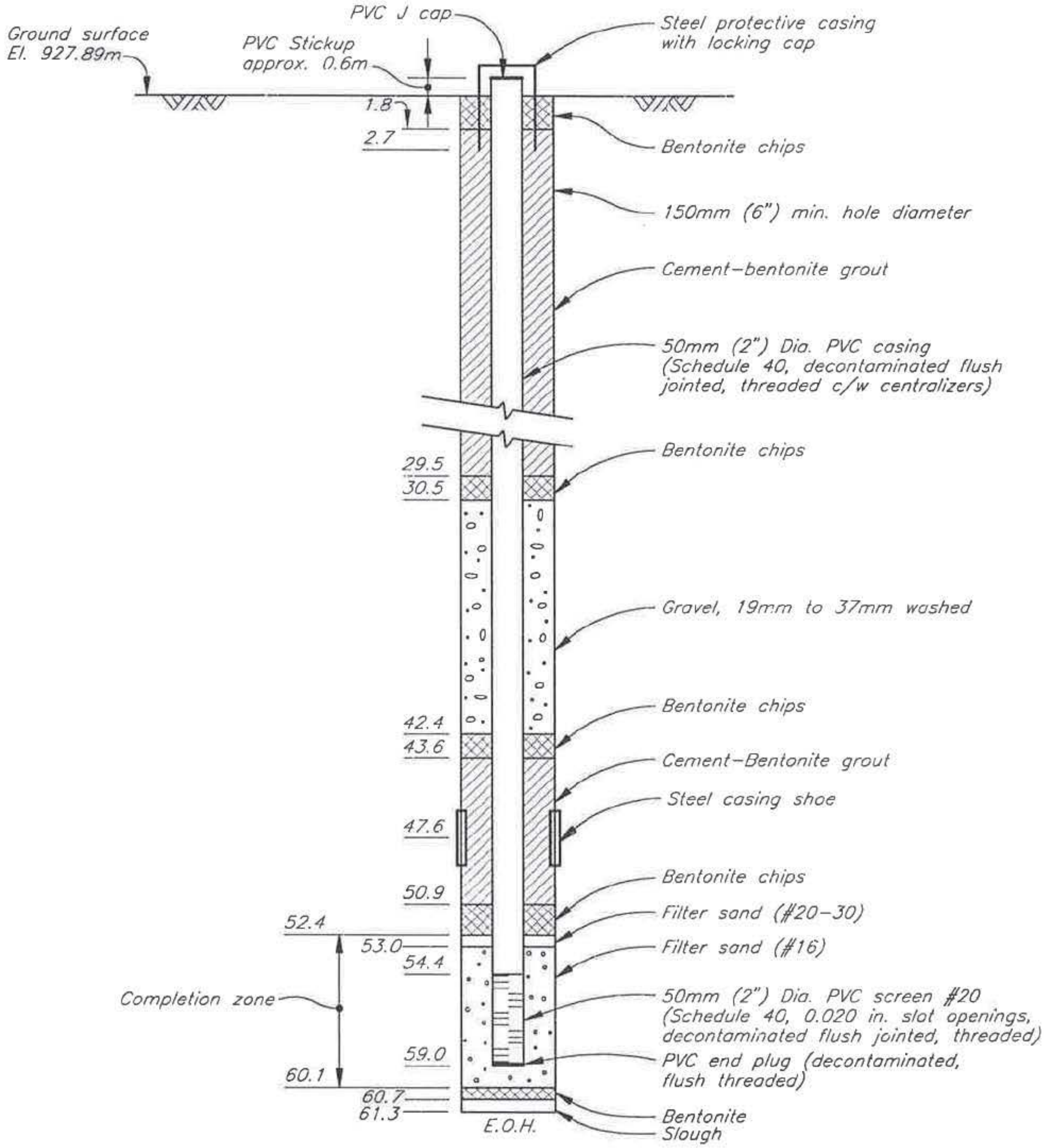
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 819 939.06* E: *595 415.82*
COMPLETION DATE *Dec. 2/96*

PROJECT No. *1628*
HOLE No. *GW96-1A*
GROUND ELEVATION *927.89m*



NOTES

1. Cement-grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

CAD FILE: \1625\FIG\A42 Plot scale 1=1

FIGURE B.1

1625.A43

KNIGHT PIESOLD LTD.
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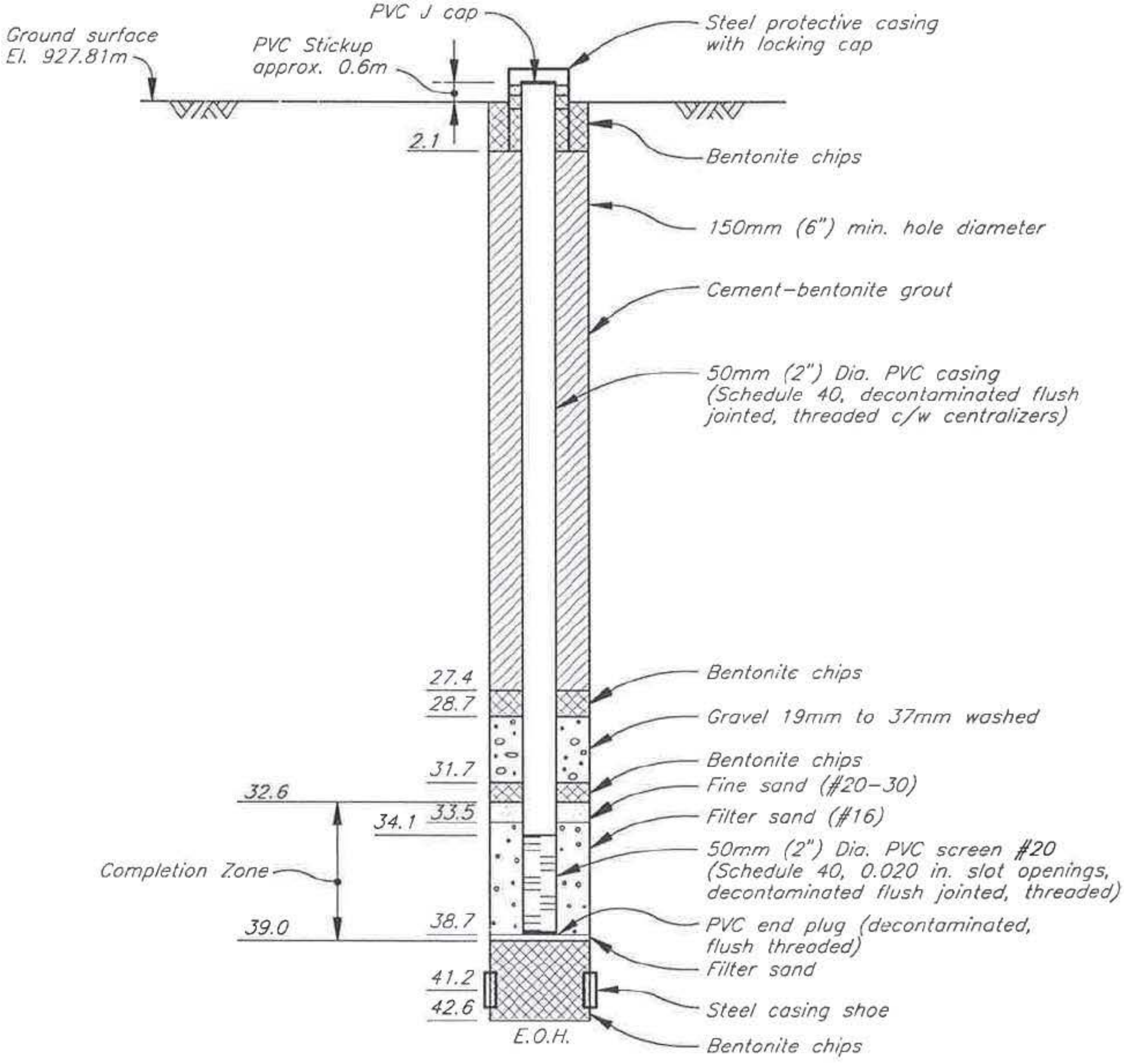
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 819 935.220* E: *595 416.160*
COMPLETION DATE *Dec. 5/96*

PROJECT No. *1628*
HOLE No. *GW96-1B*
GROUND ELEVATION *927.81*



NOTES

1. *Cement-grout mixture installed using tremmie pipe.*
2. *Depths shown from surface in metres.*

CAD FILE: \1625\FIG\A43 Plot scale 1=1

FIGURE B.2

1625.A49

KNIGHT PIESOLD LTD.
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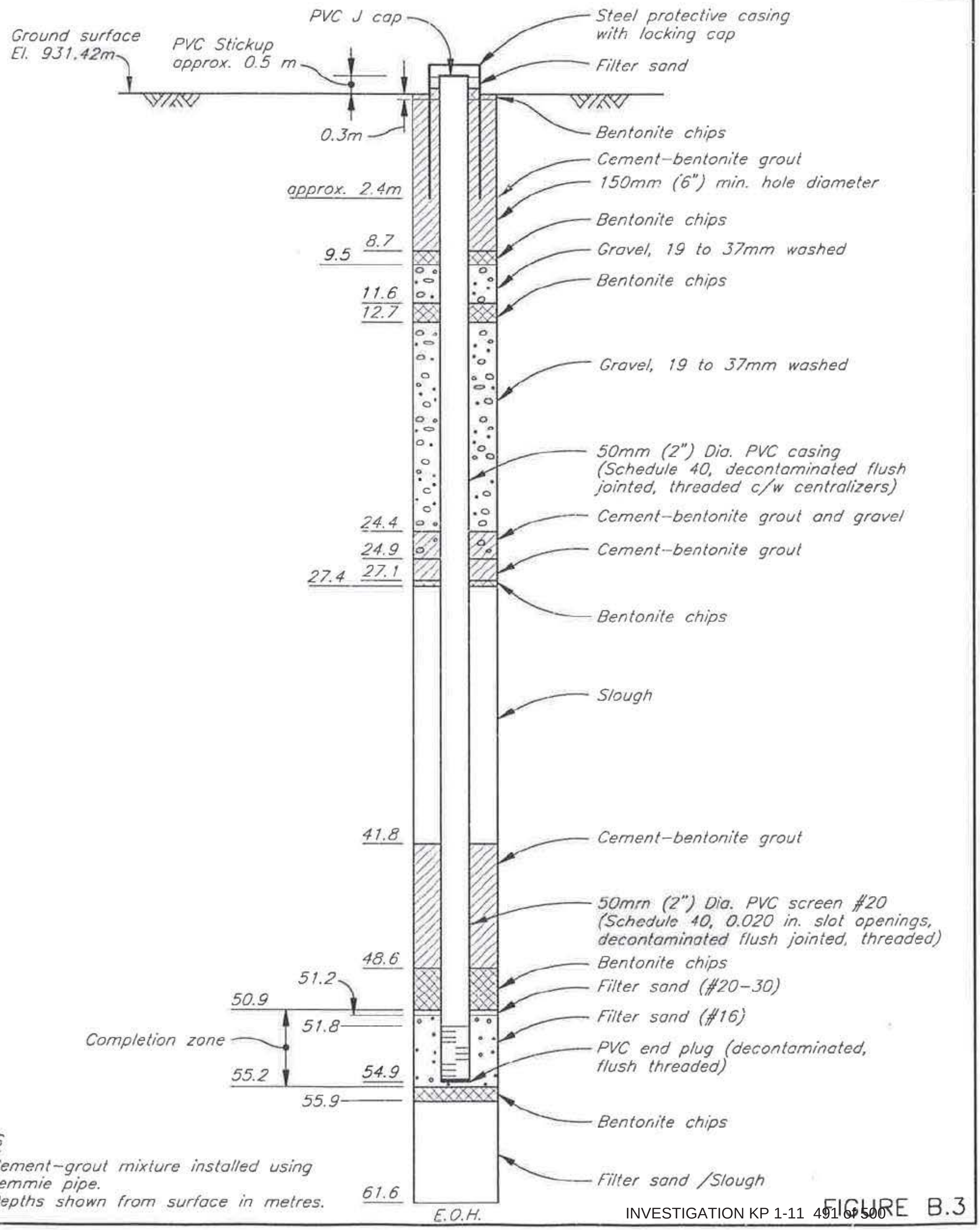
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 819 449.92* E: *596 065.40*
COMPLETION DATE *Nov. 17/96*

PROJECT No. *1628*
HOLE No. *GW96-2A*
GROUND ELEVATION *931.42*



NOTES

1. Cement-grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

FIGURE B.3

CAD FILE: \1625\FIG\A49 Plot scale 1=1

1625.A50

KNIGHT PIESOLD LTD.
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GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*

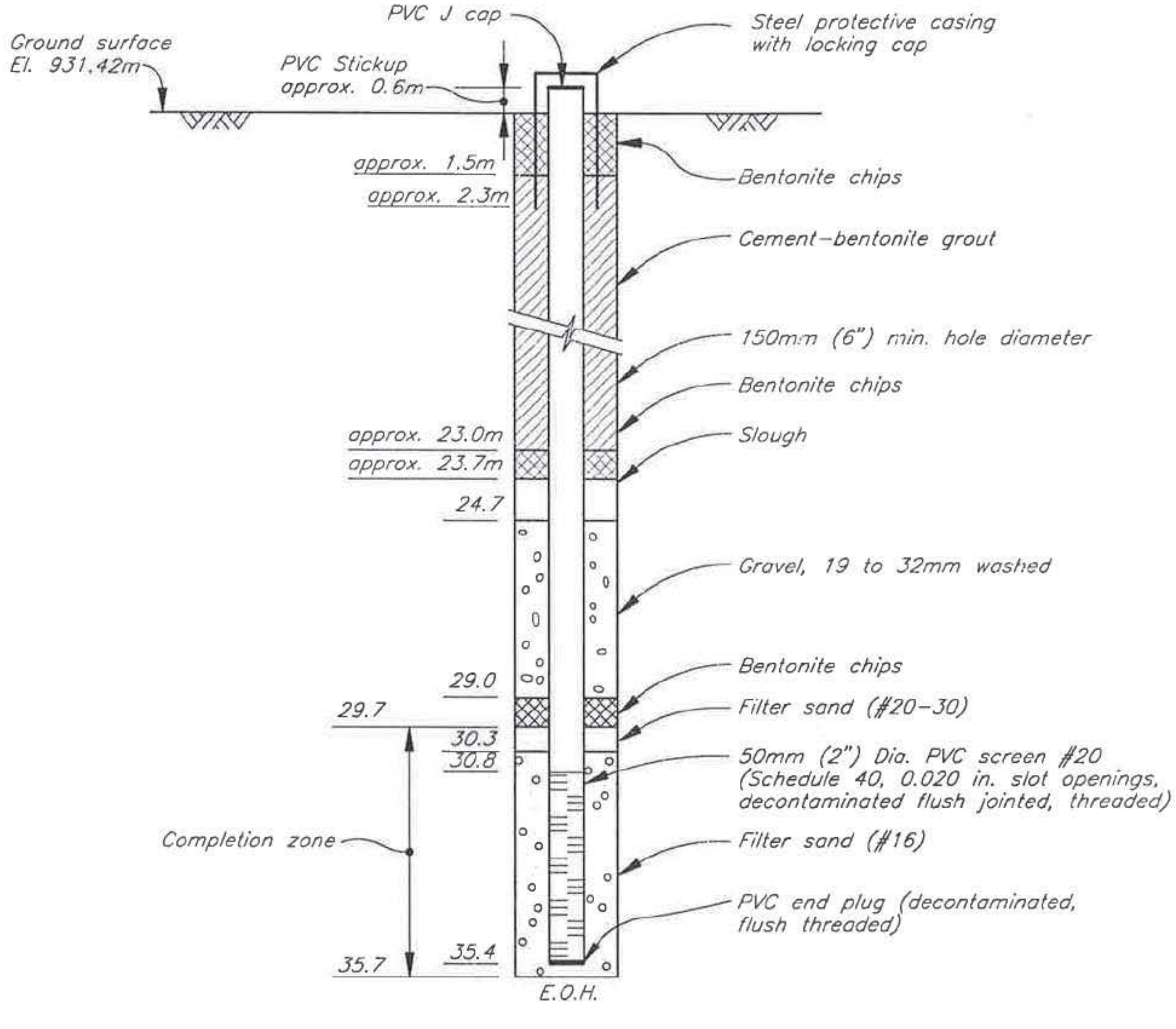
LOCATION N: *5 819 447.08* E: *596 074.73*

COMPLETION DATE *Nov. 16,17/96*

PROJECT No. *1628*

HOLE No. *GW96-2B*

GROUND ELEVATION *931.42*



NOTES

1. *Cement-grout mixture installed using tremmie pipe.*
2. *Depths shown from surface in metres.*

FIGURE B.4

1625.A51

KNIGHT PIESOLD LTD.
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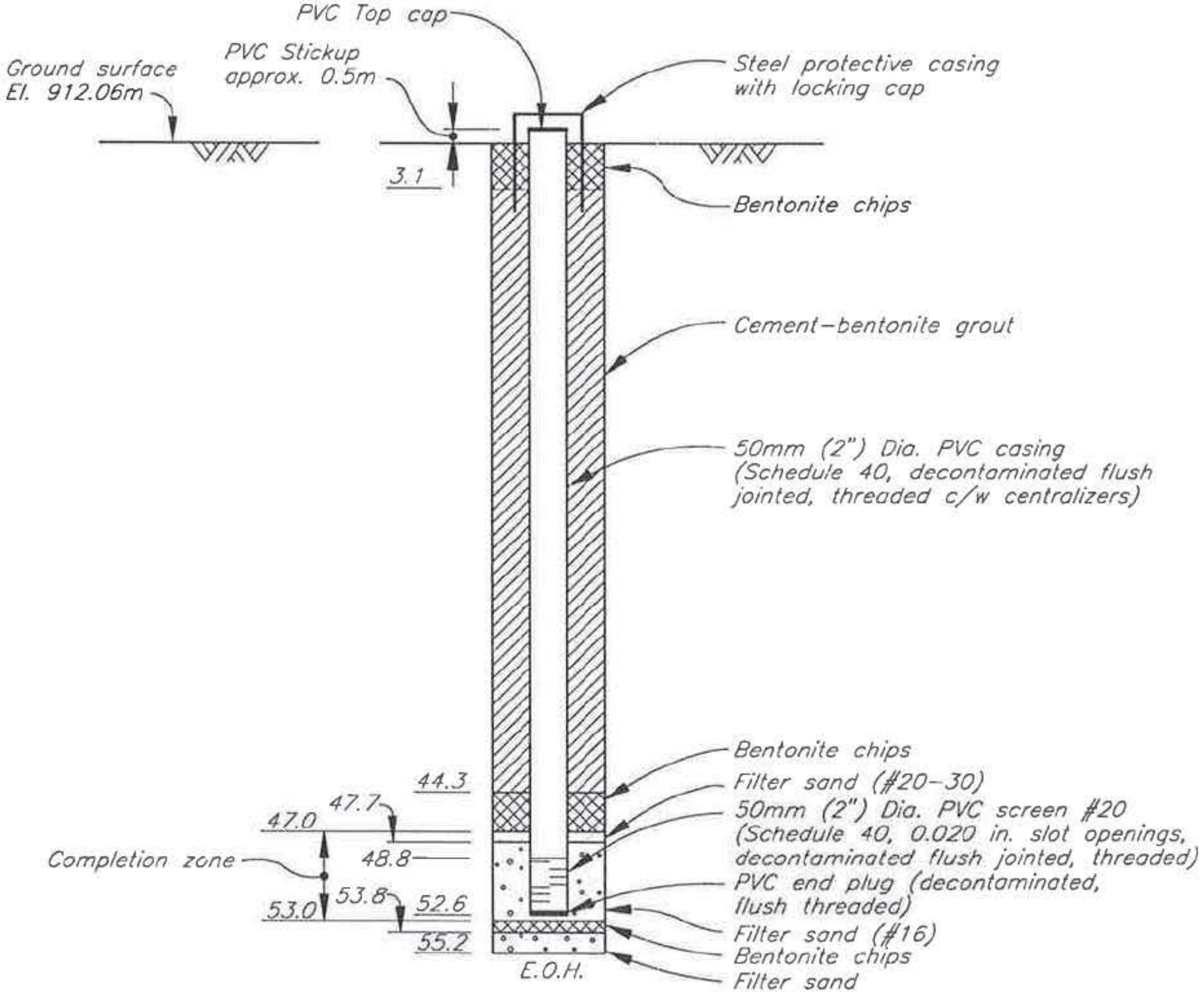
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*	PROJECT No. *1628*
LOCATION N: *5 818 308.97* E: *595 768.75*	HOLE No. *GW96-3A*
COMPLETION DATE *Nov. 7,8/96*	GROUND ELEVATION *912.06*

PROPOSED 1996 GROUNDWATER MONITORING WELLS

SCHEMATIC DIAGRAM



NOTES

1. *Cement-grout mixture installed using tremmie pipe.*
2. *Depths shown from surface in metres.*

CAD FILE: \1625\FIG\A51 Plot scale 1=1

FIGURE B.5

1625.A52

KNIGHT PIESOLD LTD.
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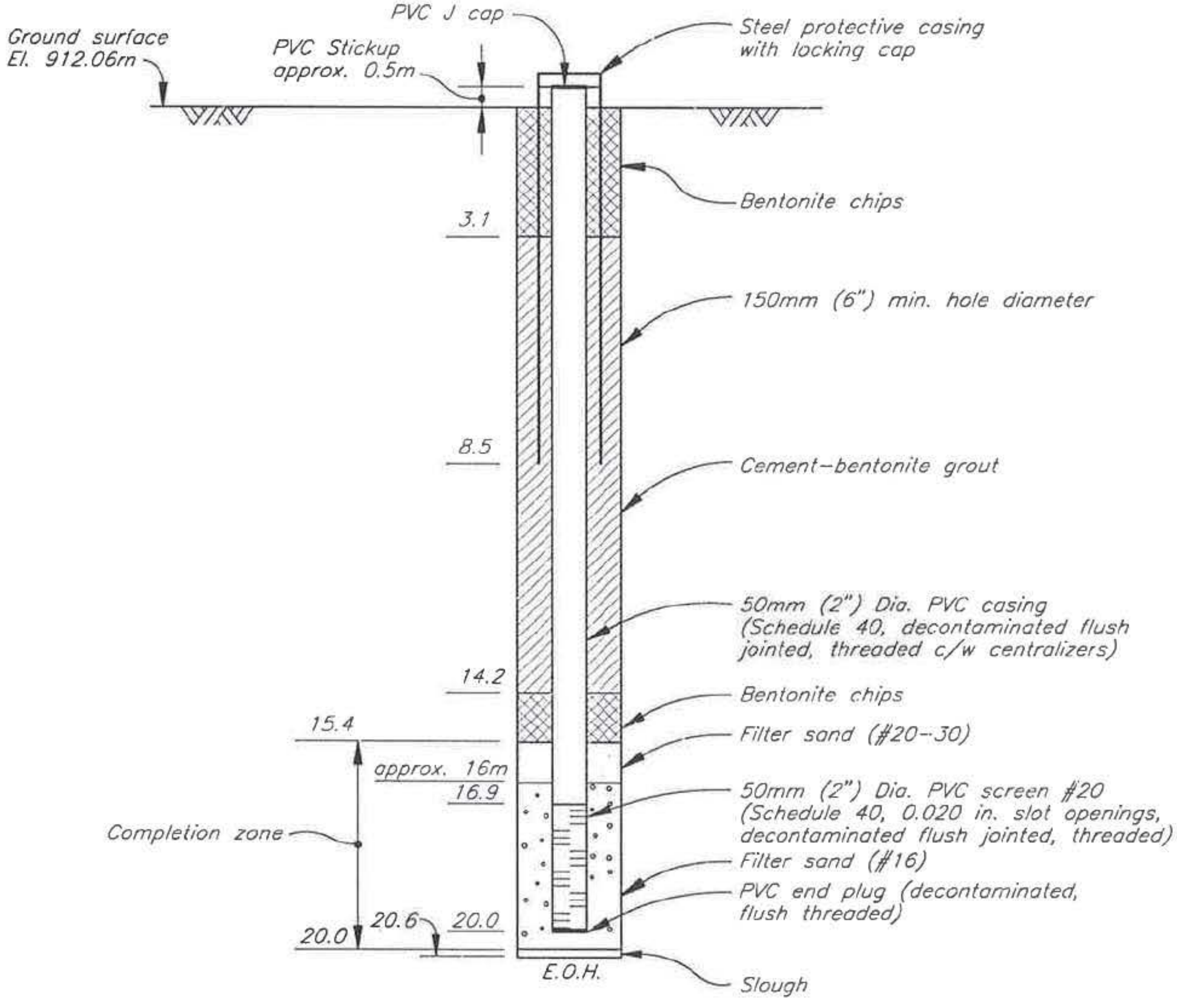
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 818 306.52* E: *595 765.16*
COMPLETION DATE *Nov. 9/96*

PROJECT No. *1628*
HOLE No. *GW96-3B*
GROUND ELEVATION *912.06*



NOTES

1. Cement-grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

CAD FILE: \1625\FIG\A52 Plot scale 1=1

FIGURE B.6

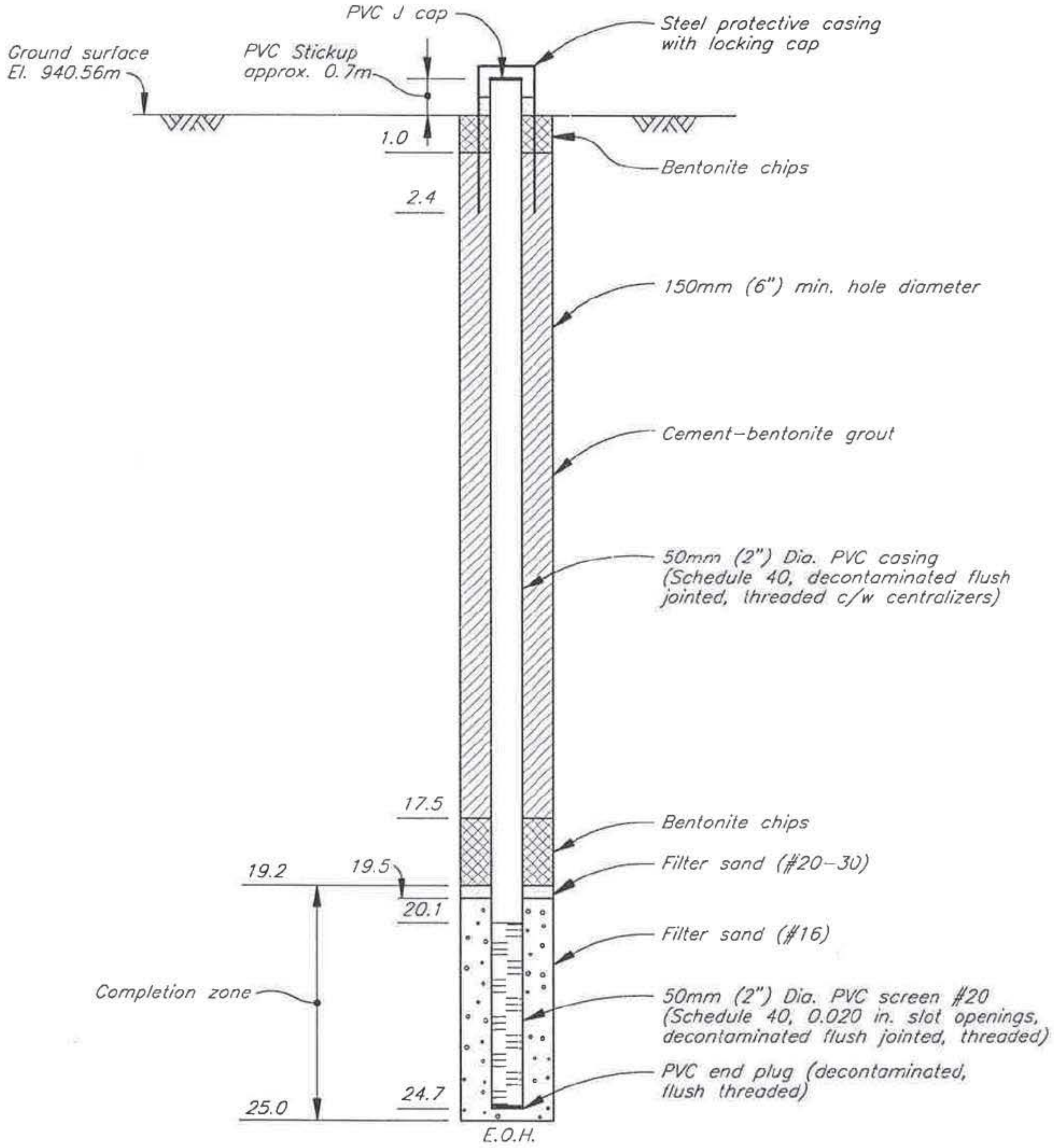
KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

1625.A48

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 818 164.58* E: *595 147.94*
COMPLETION DATE *Nov. 19/96*

PROJECT No. *1628*
HOLE No. *GW96-4A*
GROUND ELEVATION *940.56*



NOTES

1. *Cement–grout mixture installed using tremmie pipe.*
2. *Depths shown from surface in metres.*

CAD FILE: \1625\FIG\A48 Plot scale 1=1

FIGURE B.7

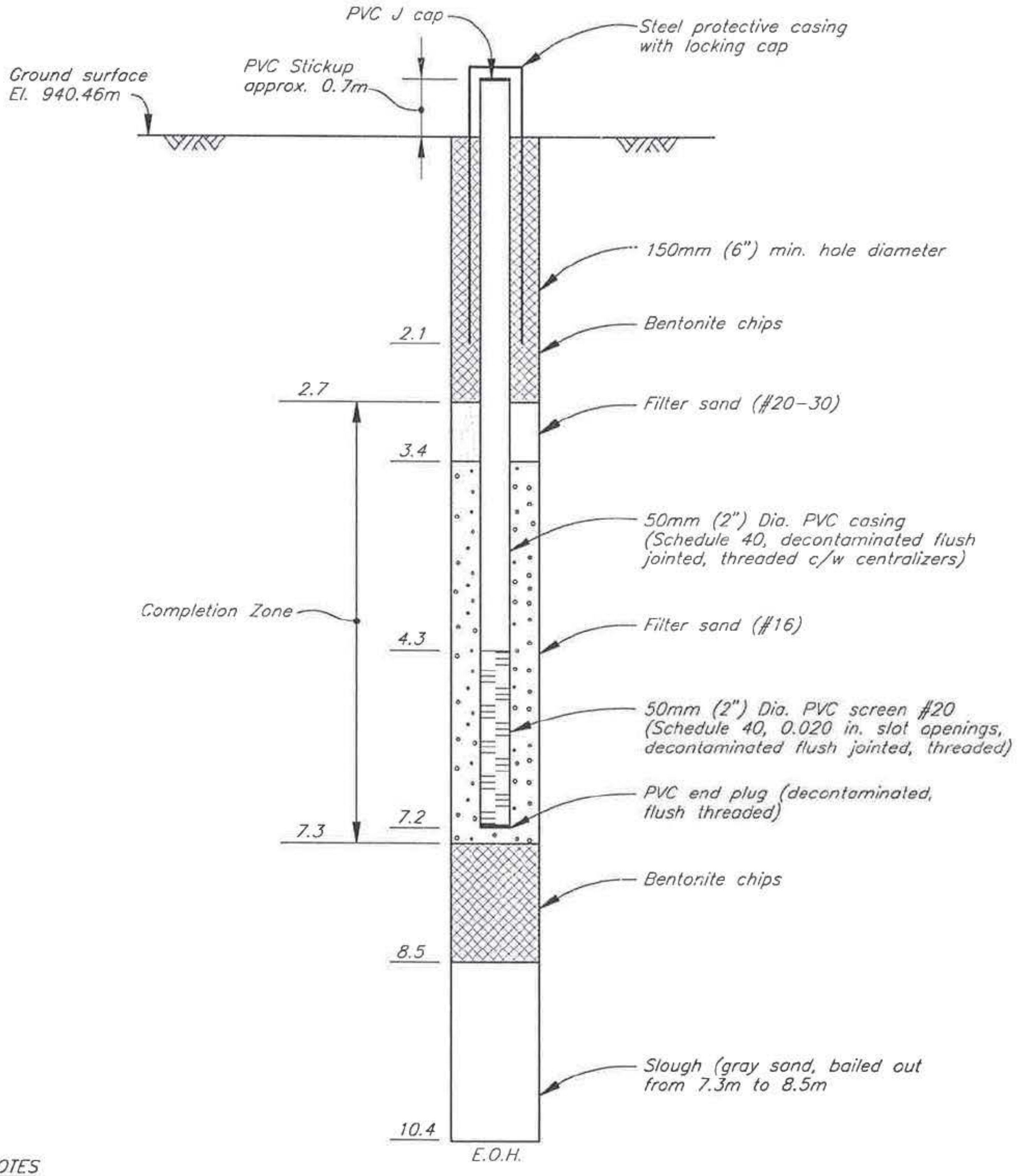
1625.A47

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT MT. POLLEY PROJECT
LOCATION N: 5 818 162.87 E: 595 151.26
COMPLETION DATE Nov. 20/96

PROJECT No. 1628
HOLE No. GW96-4B
GROUND ELEVATION 940.46



NOTES
1. Cement-grout mixture installed using tremmie pipe.
2. Depths shoen from surface in metres.

CAD FILE: \1625\FIG\A47 Plot scale 1=1

FIGURE B.8

1625.A45

KNIGHT PIESOLD LTD.
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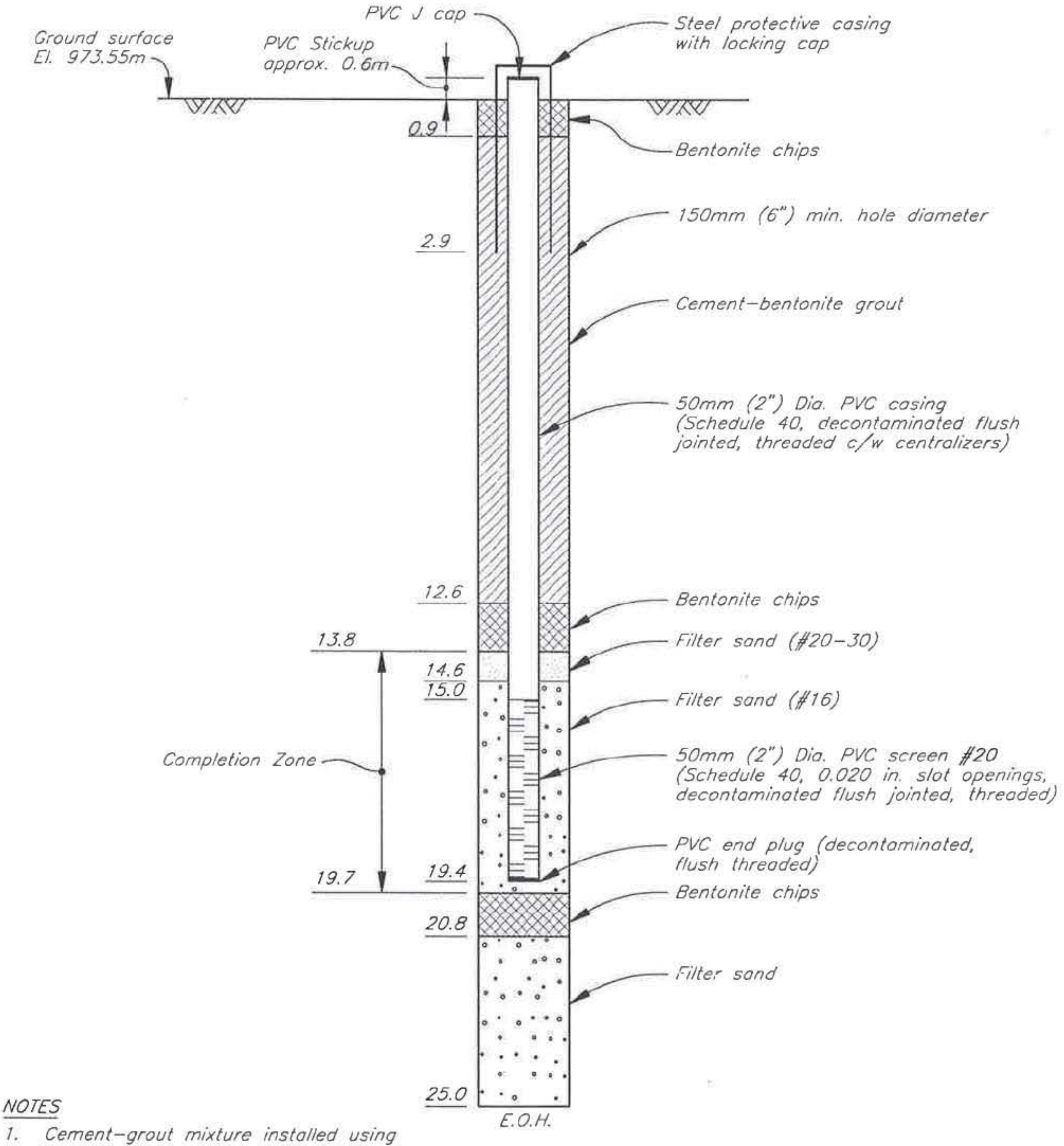
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT MT. POLLEY PROJECT
LOCATION N: 5 819 626.68 E: 594 330.34
COMPLETION DATE Nov. 28/96

PROJECT No. 1628
HOLE No. GW96-5A
GROUND ELEVATION 973.55



NOTES

1. Cement–grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

CAD FILE: \1625\FIG\A45 Plot scale 1–1

FIGURE B.9

1625.A44

KNIGHT PIESOLD LTD.
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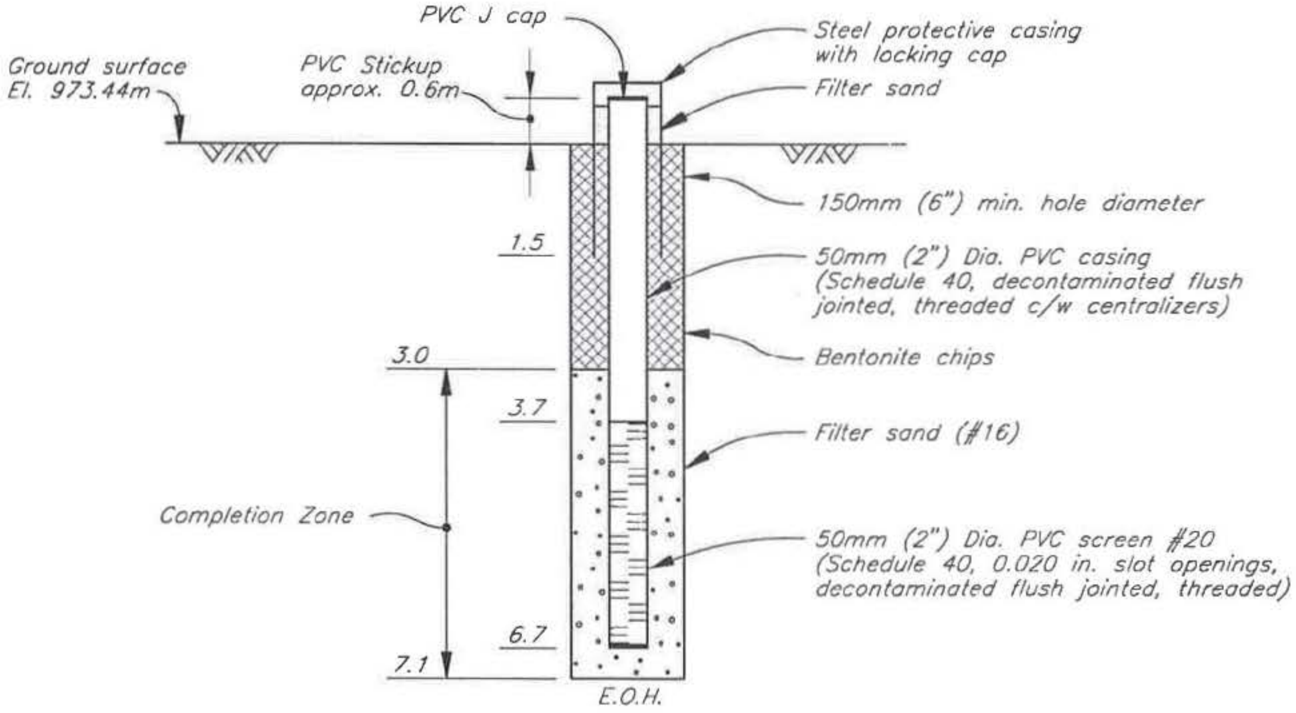
GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT MT. POLLEY PROJECT
LOCATION N: 5 819 629.64 E: 594 329.79
COMPLETION DATE Nov. 29/96

PROJECT No. 1628
HOLE No. GW96-5B
GROUND ELEVATION 973.44



NOTES

1. Cement-grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

CAD FILE: \1625\FIG\A44 Plot scale 1=1

FIGURE B.10

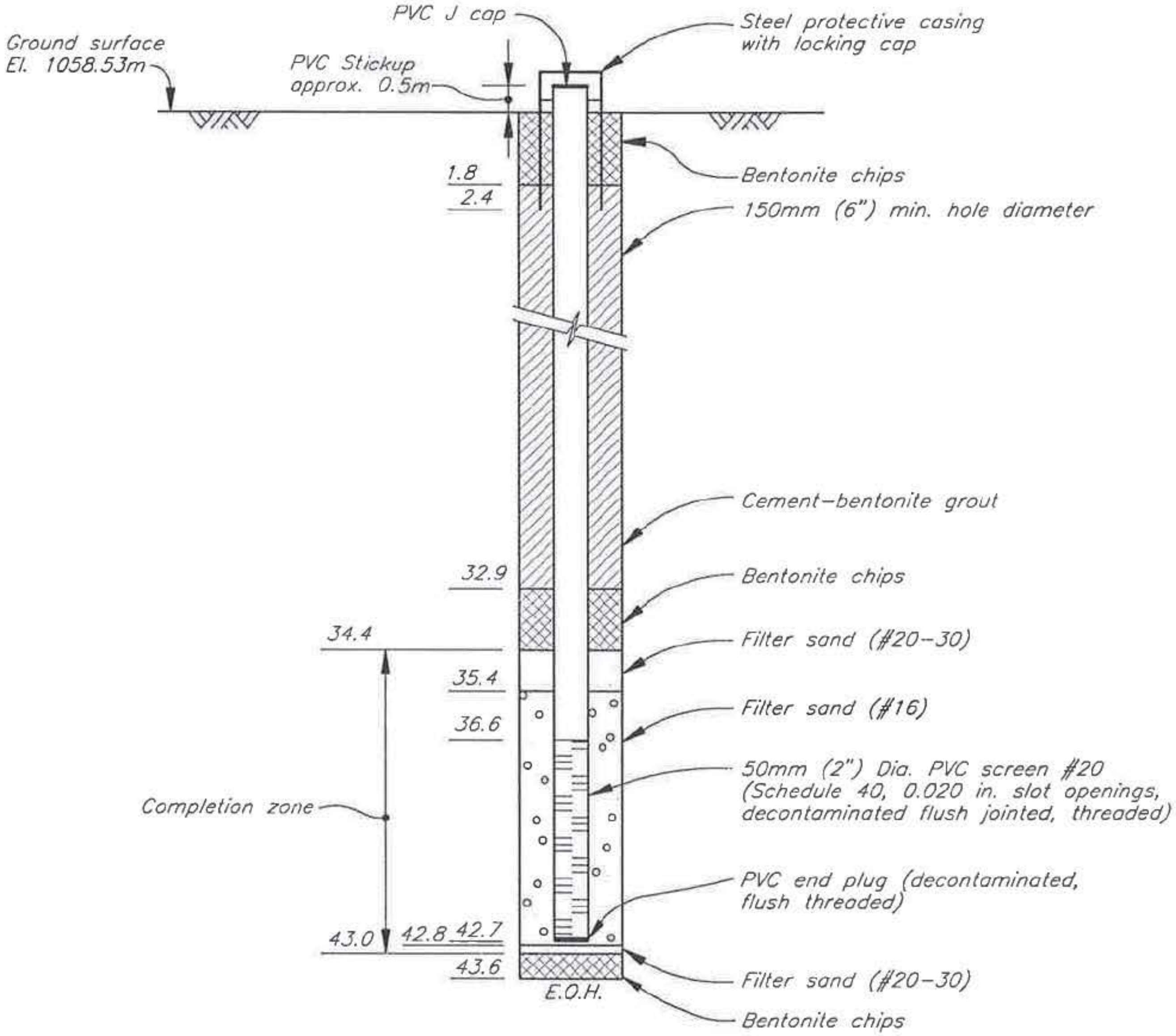
1625.A54

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 822 851.66* E: *593 659.21*
COMPLETION DATE *Oct. 31/96*

PROJECT No. *1628*
HOLE No. *GW96-6*
GROUND ELEVATION *1058.53*



NOTES

1. Cement–grout mixture installed using tremmie pipe.
2. Depths shown from surface in metres.

CAD FILE: \1625\FIG\A54 Plot scale 1=1

FIGURE B.11

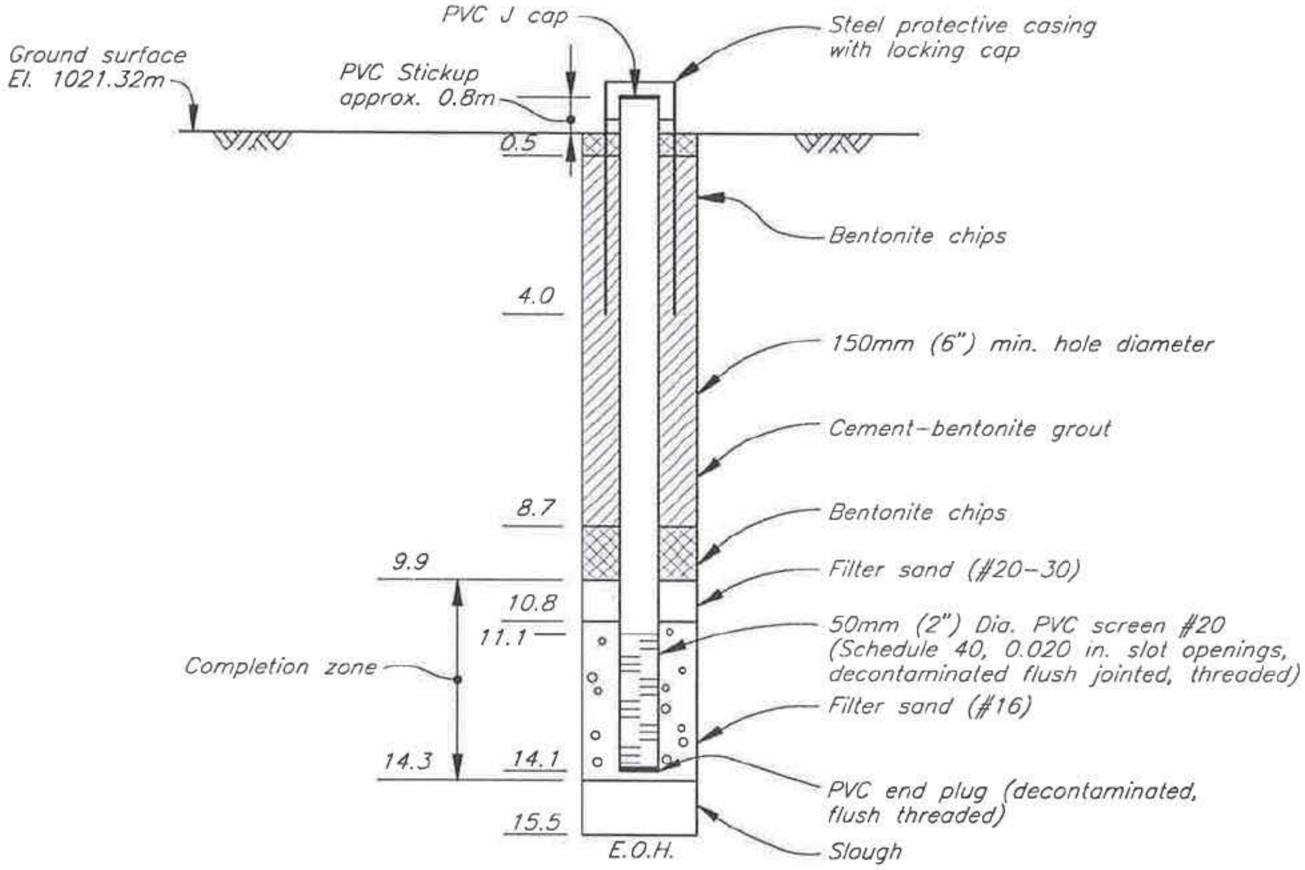
1625.A53

KNIGHT PIESOLD LTD.
CONSULTING ENGINEERS

GROUNDWATER MONITORING WELL COMPLETION DETAILS

PROJECT *MT. POLLEY PROJECT*
LOCATION N: *5 821 520.53* E: *592 983.23*
COMPLETION DATE *Nov. 4/96*

PROJECT No. *1628*
HOLE No. *GW96-7*
GROUND ELEVATION *1021.32*



NOTES

1. *Cement-grout mixture installed using trremmie pipe.*
2. *Depths shown from surface in metres.*

CAD FILE: \1625\FIG\A53 Plot scale 1=1

FIGURE B.12