82-461-10370

GEOTECHNICAL STUDIES

at a

POTENTIAL TAILINGS AREA

near

SMITHERS, B.C.

YORKE-HARDY PROPERTY

OMENICA MINING DIVISION

93L/14W

LAT 54°49' LONG 127°18'

Climax Molybdenum Corp. of B.C. Ltd.
Box 696, Smithers, B.C. VOJ 2NO

January 26, 1982

D.A. Davidson M.A.Sc. P.Eng.

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Introduction

The accompanying reports from Golder Associates and Sigma Resource Consultants Ltd., give details of the results of preliminary studies of soil and environmental conditions in an area being investigated as a possible tailings disposal site near Smithers, BC. Figure 1 shows the study area on a BC Government claim map. Specifically, the area is centered on Section 21, Twp 1A, R.5. C.D.

Soil conditions in the area were tested by 17 test pits dug throughout the study area (see Golder report Figure A-2). Soil types were logged and samples were taken to determine the engineering properties of the material.

Several pits were pumped full of water and daily levels were recorded in order to evaluate permiability characteristics.

Studies of the physical and chemical properties of surface and groundwaters entering the area were studied by Sigma Resource Consultants Ltd. under a subcontract with Golder Associates.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. A. DAVIDSON

D. Davidson

D.A. Davidson M.A.Sc. P.Eng.

COST STATEMENT

D. DAVIDSON	Aug 15/Dec 4. Surveying, Pit Location Layout, Access Road Layout, Percolation Measurements Pump Station Setup, Digging Test Pits, Sampling, Creek Flow Measurements Data Compilation	
	143 Hours @ $35.00	$ 5005.00
R. GILBERT	J.D. 350 Backhoe Work	
	Invoice 41 36 1/2 Hrs	
	Invoice 48 8 Hrs	
	Total 44 1/2 Hrs @ 25.00	1112.50
WINDSOR PLYWOOD	Pump and Hose Rentals	
	Invoice 12050R	12.00
	Invoice 12389R	20.00
TRAC & TRAIL	Power Saw Parts	
	Invoice 4587	24.33
TRUCK	4x4 Truck Dodge 200	
	15 days @ 36.00	540.00
GOLDER ASSOCIATES	Invoice 51674 June 1/Aug 31 1981	3847.68
	Invoice 52020 Sept 1/Sept 30 1981	5971.54
	Invoice 52303 Oct 1/Nov 30 1981	17332.51
	TOTAL	$ 33865.56

The value of this work is to be filed on three groups of mineral claims. Disbursements are made on the number of test sites/group basis. (e.g. the Ten Group contains 2 of the total 17 test sites therefore a value of 2/17 x 33865.56 = $3984.18 is applied. Similarily the Twelve Group with 9 test sites and the Thirteen Group with 6 test sites are valued at $17,928.83 and $11,952.55 respectively).

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
D. A. DAVIDSON

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PROFESSIONAL
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D. A. DAVIDSON
BRITISH
COLUMBIA
ENGINEER

D. Davidson

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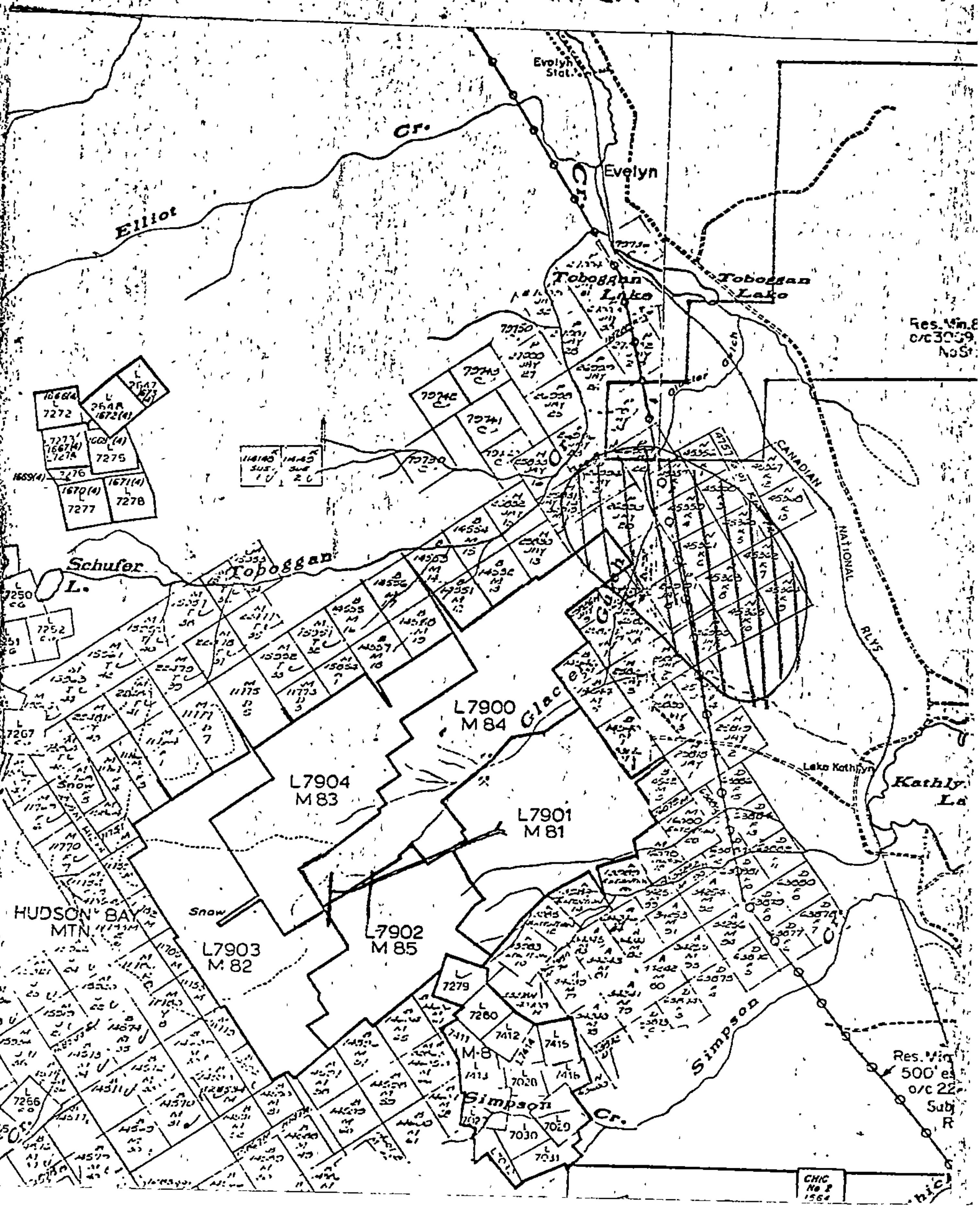
FIGURE 1
CLAIM MAP SHOWING STUDY AREA



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PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
D. A. DAVIDSON

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

DATA REPORT
TO
CLIMAX MOLYBDENUM CORP. LTD. OF B.C.
ON
SOIL TESTING
AT
82-461 YORKE-HARDY

SMITHERS, BRITISH COLUMBIA

DISTRIBUTION:

6 copies - Climax Molybdenum Corporation Limited of B.C.
Golden, Colorado

2 copies - Golder Associates
Vancouver, British Columbia

November, 1981 812-1164

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1.0 INTRODUCTION

The Yorke-Hardy property is a potential molybdenum mine located just northeast of the town of Smithers, B.C., see Figure A1. It was prepared under the terms of contract No. BCS-8 dated June 1981 between Climax Molybdenum Corporation of B.C. and Golder Associates, Vancouver. The ground water conditions were studied by Sigma Engineering of Vancouver, working under the above contract in conjunction with Golder Associates and their report is issued separately.

2.0 TAILING DISPOSAL

Fifteen test pits were excavated on August 25th and 26th, 1981, in the area of the potential tailing pond and tailing retaining embankments within Section 21. The test pits were excavated using a JD350-B backhoe, to depths up to 14 ft. below ground level. The ease of digging with this machine was noted and reported upon. Records of the test pits are presented in Appendix A, and the locations of the test pits are shown on Figure A2. Apart from the sand and gravel found in the southwest of Section 21, the ground is a glacial till overlying bedrock. Bedrock outcrops on the hill to the northeast of Section 21 but it was not encountered in the test pits. The till is of variable hardness, some of it being particularly difficult to excavate. The upper few feet of the material appears to be fissured although the fissures are closed; they can be recognised by their moist blue coloured appearance in contrast to the mat grey appearance of the intact till. The till is, in general, a low plasticity sandy material, very well graded. Grain size distribution tests were carried out on samples of the till and the results are shown in Figure A3. Atterberg limit tests (liquid and plastic limits) were also carried out and the results are shown on Figure A4. These indicate the classification of the material. The in situ moisture content of the material is shown on the test pit records, and it will be noted that in general the material is at or close to the plastic limit. To indicate the compaction properties of the till, a standard Proctor compaction test was carried out on a sample of the material from test pit No. 13. The results are shown on Figure A5 and it can be seen that the optimum moisture content is 12.4 per cent. The plastic limit and natural moisture content of this particular sample were 13.7 and 13.4 per cent, respectively, indicating that in its in situ condition the material would be close to the lower limits of its workability. The material compacts to a moderately high density of 119 lbs/cu.ft., but because of the peaky nature of the curve, it is apparent that compaction would be sensitive to small changes in moisture content.

Drillhole 76-S1 carried out by Climax in the southwest corner of Section 21 indicated sand and gravel over till. Test pit No. 15 was excavated alongside this drillhole to examine the sand and gravel. Test pits Nos. 8, 9 and 10 were also excavated in the sand and gravel. The material appears to be clean and well graded, suitable for tailing embankment construction. In some areas, however, (Test pits Nos. 8 and 15) the water table was encountered at shallow depths. The test pits made large quantities of water indicating that the material is quite permeable. The approximate elevation of the water table in Test pits Nos. 8 and 15 was at elevation 1780 ft.

The sand and gravel could also be used for concrete aggregate and a sample was sent to R.M. Hardy & Associates for testing. A copy of their report is presented in Appendix B. The grain size of the sand and gravel is shown on Figure A3. For compaction purposes maximum and minimum density tests according to ASTM procedures were carried out and the results are as follows: maximum dry density (vibrated) = 135 lbs/cu.ft., minimum dry density = 109 lbs/cu.ft.

3.0 PLANT SITING

Two further test pits were excavated on October 1st, 1981, under the supervision of Don Davidson of Climax Molybdenum Corporation. These test pits were sunk in the area of the potential plant site. They are numbered TP16 and 17, and their locations are shown on Figure 2. The tests pits were excavated using a backhoe to depths of 11-1/2 ft. below ground level. Records of the test pits are presented in Appendix A. Beneath a thin layer of organic topsoil the pits indicate glacial till. However the glacial till appears to be of variable consistency from firm to very stiff. Gradation tests were carried out on the glacial till and the results are shown on Figure A6. Because of the rather soft consistency of the till found in TP16 a series of unconsolidated, undrained triaxial compression tests were carried out on remoulded specimens of the till. The specimens were 2 inches in diameter. The results of the tests are shown on Figures A7 and A8. Figure A7 shows the stress deformation behaviour of the material, indicating that it shows a continuous increase in strength with increasing strain consistent with the plastic feel of the material. At 20 per cent strain, the shear strengths have been plotted in the form of Mohr envelopes on Figure A8. This indicates that the material has undrained shear strength of about 700 lbs/sq.ft.

Yours very truly,

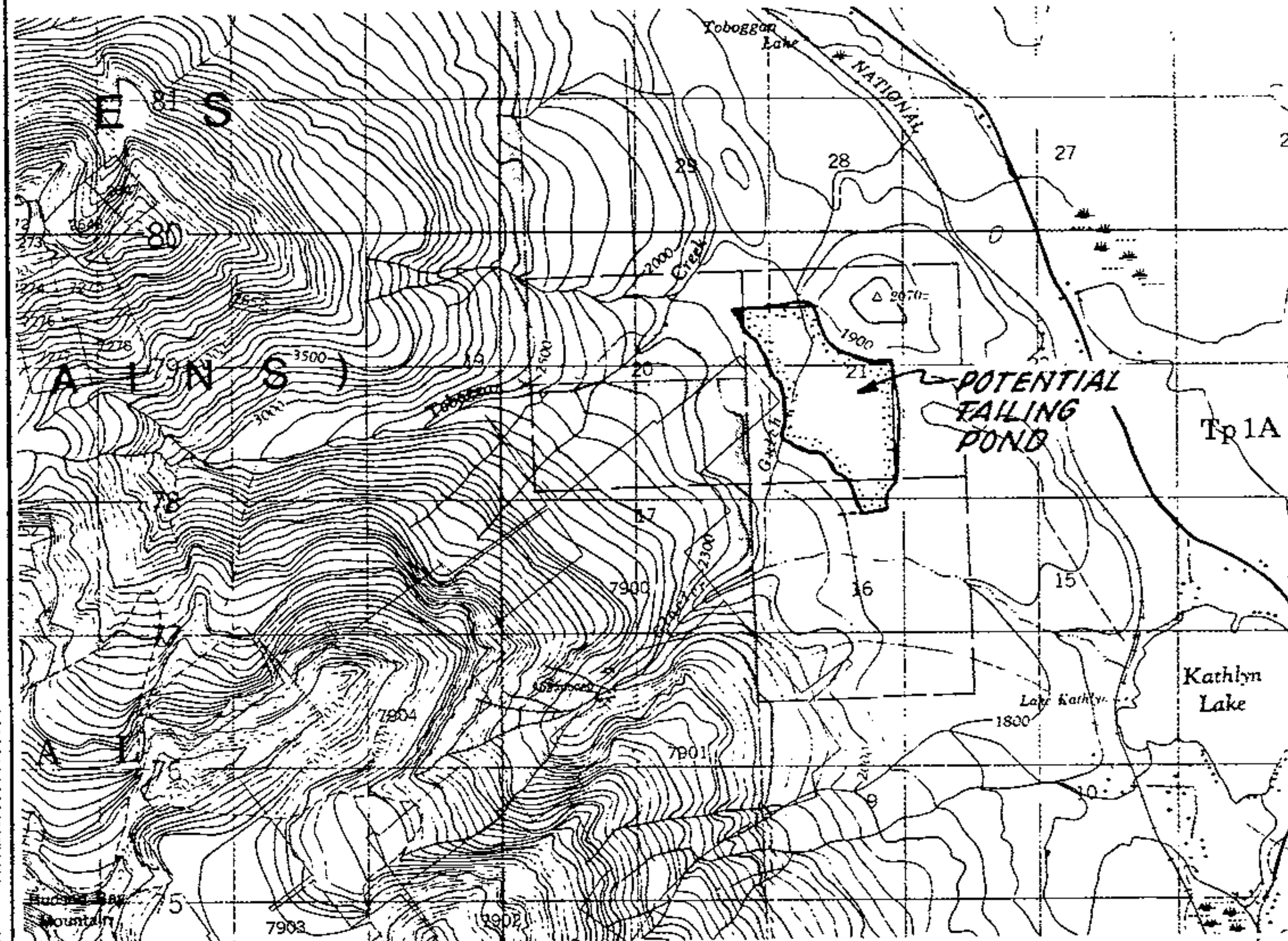
GOLDER ASSOCIATES

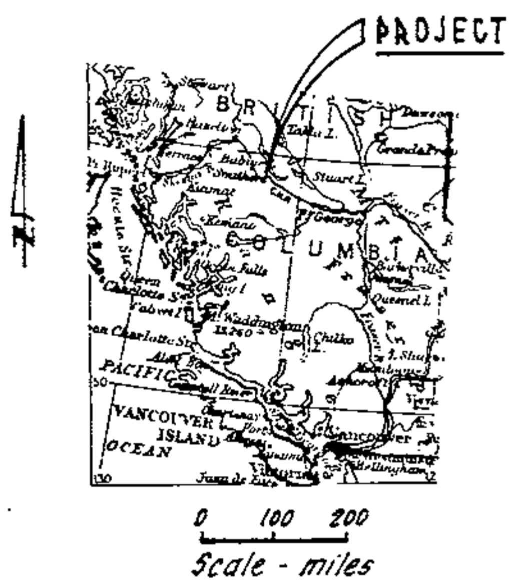
N.A. Skermer, P. Eng.

NAS/bjh
812-1164

LOCATION OF PROJECT

Figure **A1**

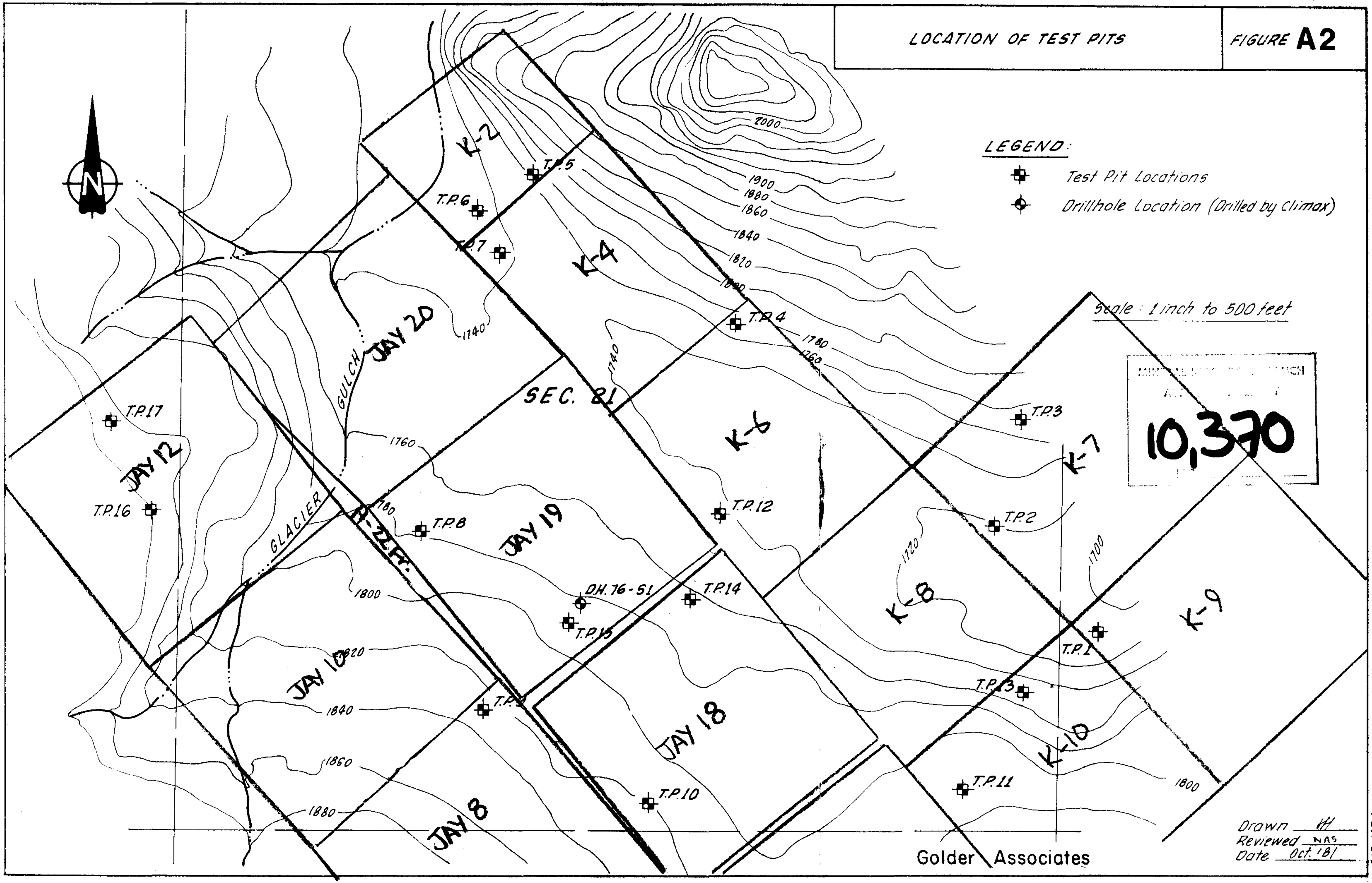




Scale 1: 50,000
From Sheet 93L/14
Smithers B.C.

Golder Associates

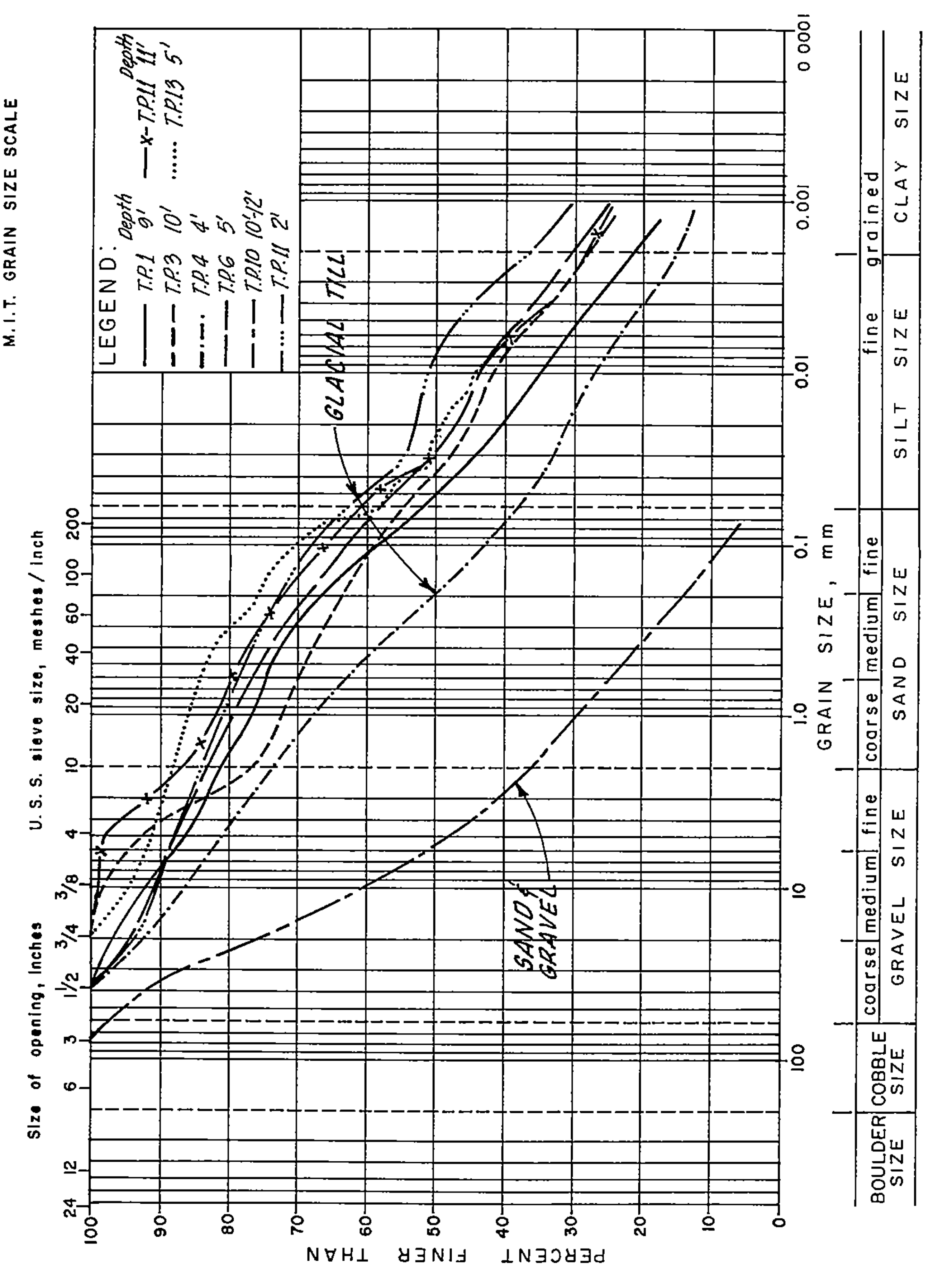
PROJECT NO. 812-1164 DRAWN REVIEWED NAS DATE Sept '81



LOCATION OF TEST PITS — FIGURE A2

GRAIN SIZE DISTRIBUTION
POTENTIAL TAILING SITE

Figure **A3**



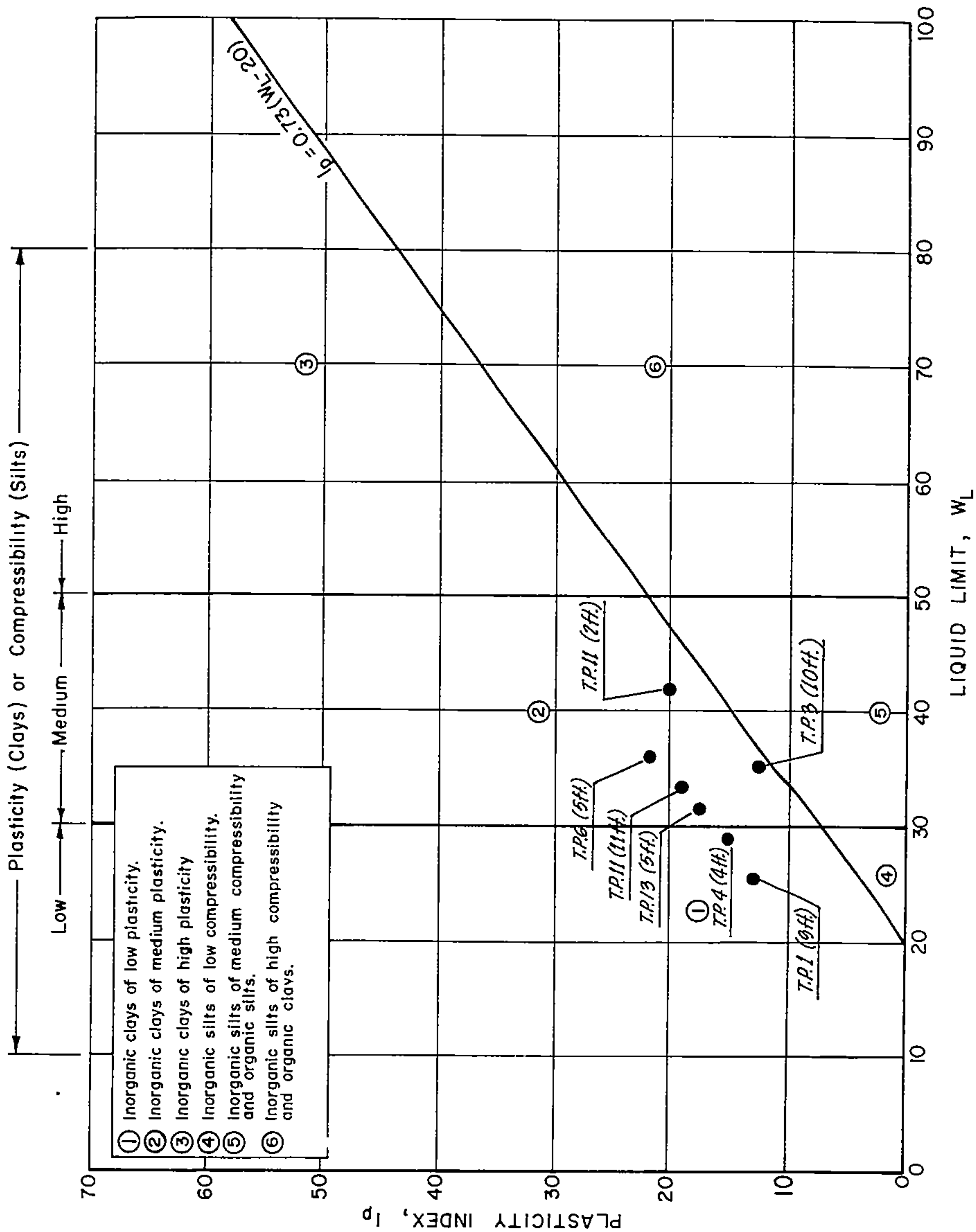
PROJECT NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Sept '81

Golder Associates

Project No. 812-1164

PLASTICITY CHART

FIGURE **A4**



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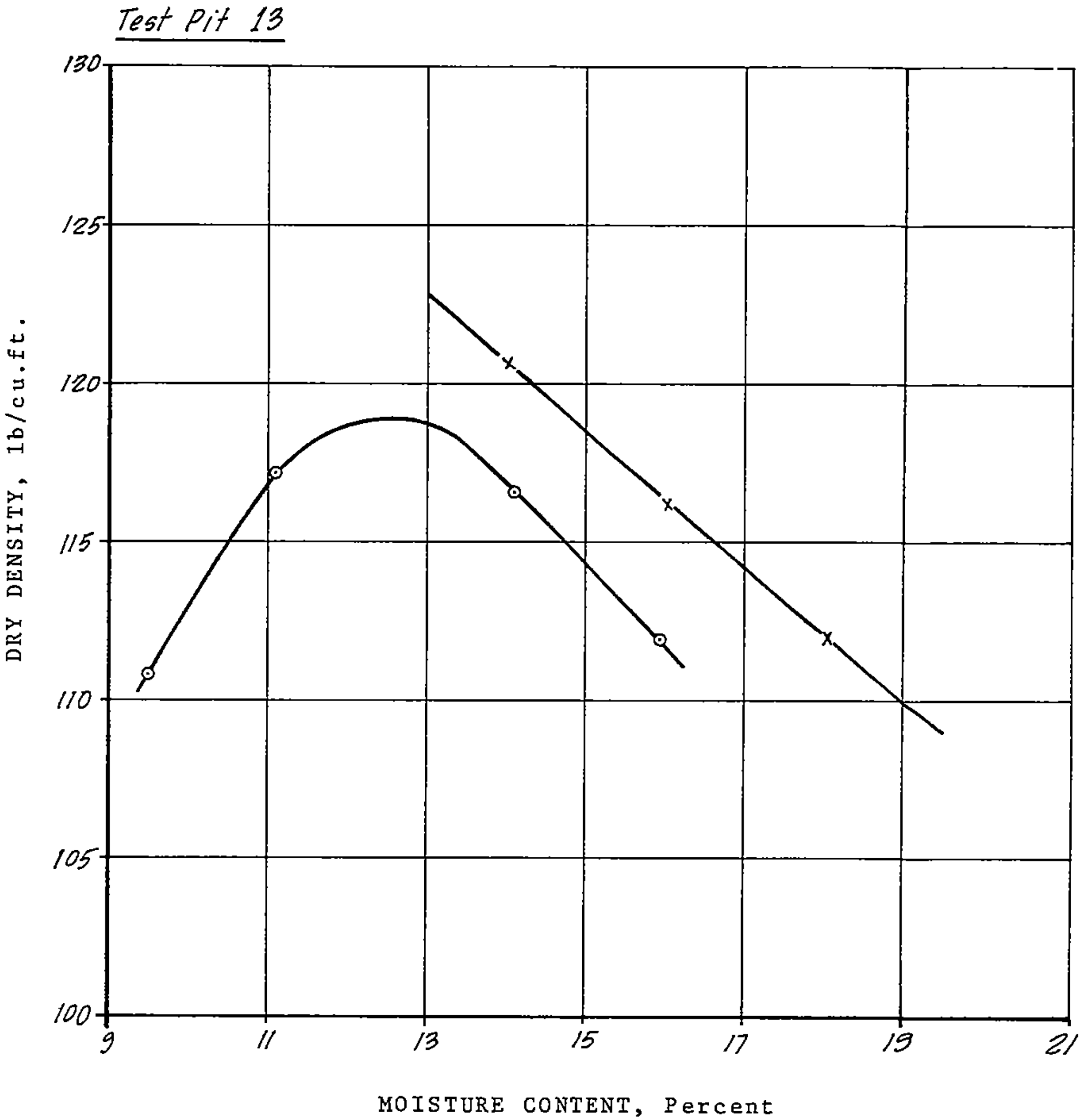
Date Oct 81

COMPACTION TEST

FIGURE **A5**

Project No. 8_1164



MAXIMUM DRY DENSITY 118.9 lb/cu.ft.

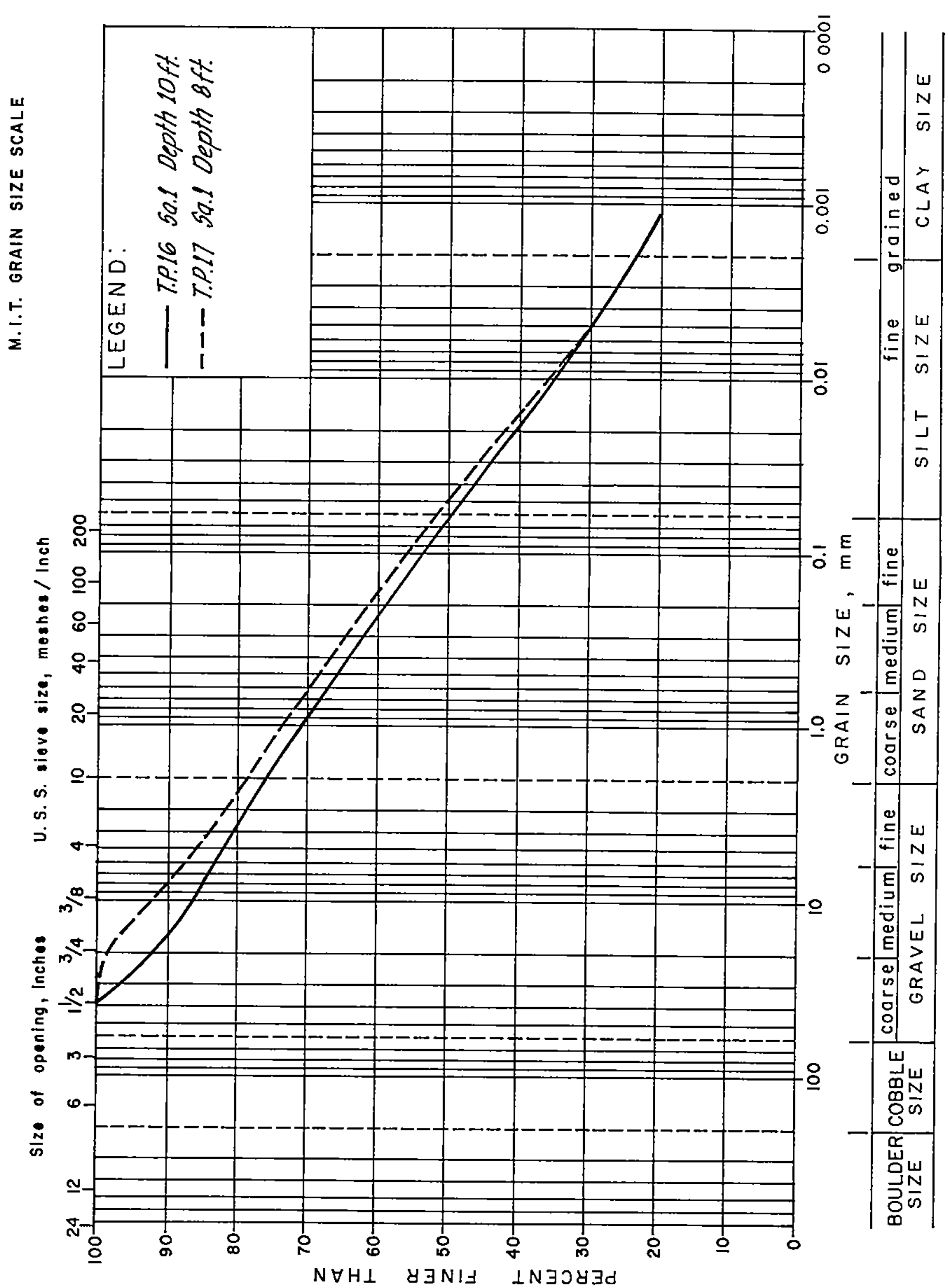
OPTIMUM MOISTURE CONTENT 12.4 %

Golder Associates

Drawn
App'd NAS
Date Sept./81

GRAIN SIZE DISTRIBUTION
POTENTIAL PLANTSITE

Figure **A6**



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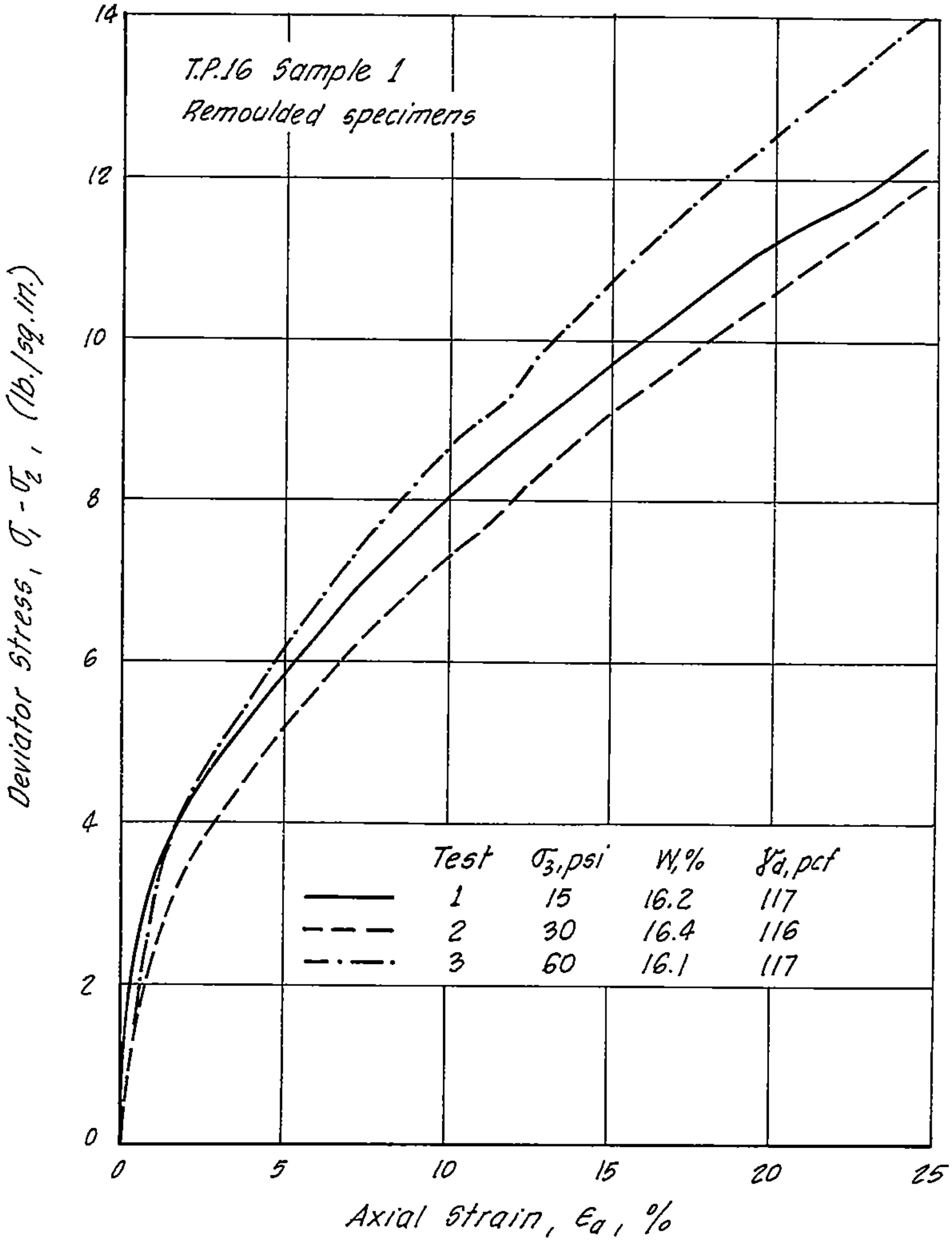
UNDRAINED TRIAXIAL COMPRESSION TEST
STRESS STRAIN CURVES

Figure **A7**



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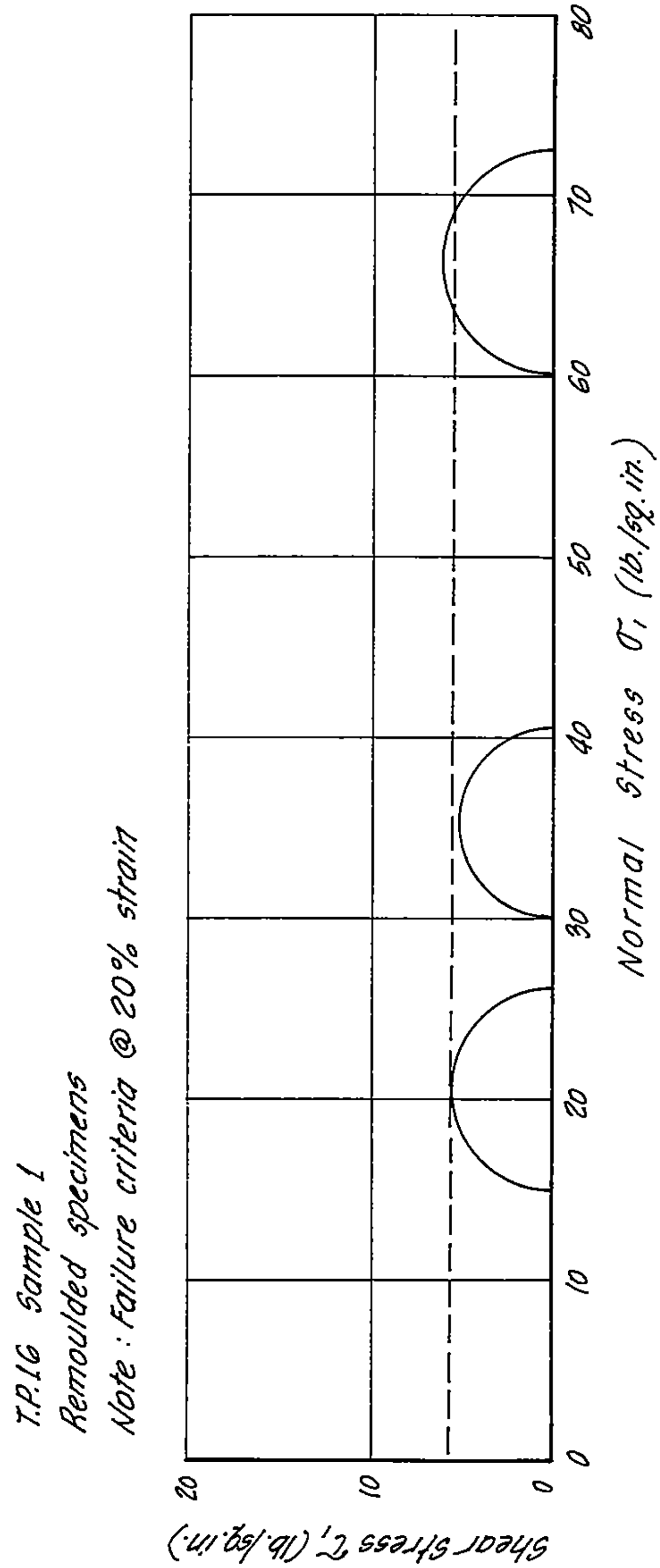
UNDRAINED TRIAXIAL COMPRESSION TEST
MOHR ENVELOPE

Figure **A8**



PROJECT NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Oct. '81

Golder Associates

APPENDIX A

RECORDS OF TEST PITS

RECORD OF TEST PIT #1

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 26, 1981*

Datum

Project *Smithers Yorke-Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_p — W — W_L) 10 20 30 40	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	*Stiff light brown silty TILL*					*Pit dry. Pit left open. Percolation test in pit.*
2.5'	*Hard grey fissured silty gravelly TILL with occ. cobbles and boulders. More sandy at depth*					
9.5'	*End of Test Pit.*					

Vertical Scale
1 inch to *2* feet

Sheet *1* of *1*

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PROJ. NO. *812-1164* DRAWN *M* REVIEWED *NAS* DATE *Sept. '81*

RECORD OF TEST PIT #2

Location (See Figure 2)

Date August 25, 1981

Datum

Method of Excavation Backhoe

Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % W_P W W_L	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Stiff dry light brown silty TILL					
2.0'	Very stiff brown silty cobble TILL					
4.0'	Hard grey silty TILL with gravel and cobble. Blue fissures. Easier digging. (This till would compact).					
9.5'	End of Test Pit.					

Vertical Scale
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ. NO. 812-1164 DRAWN ... REVIEWED NAS DATE Sept. 1 '81

RECORD OF TEST PIT #3

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 25, 1981*

Datum

Project *Smithers Yorke-Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P — W — W_L) 10 20 30 40	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	*Hard dry becoming moist, friable light brown silty gravelly TILL. Occ. cobbles and large boulders.*					*Pit dry. Pit backfilled.*
8.5'	*Hard grey silty gravelly TILL*					
10.0'	*End of Test Pit.*					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ NO. 812-1164 DRAWN ... REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #4

Location (See Figure 2)

Date August 25, 1981

Datum

Method of Excavation Backhoe

Project Smithers Yorke - Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (Wp, W, WL) 10 20 30 40	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	Stiff light brown dry sandy gravelly SILT					Till here is too hard and dry for embankment construction without moisture conditioning. Very hard digging. Pit dry. Pit backfilled.
1.5'	Hard brown gravelly silty TILL with odd cobbles					
8.5'	End of Test Pit.					

Vertical Scale 1 inch to 2 feet

Sheet 1 of 1

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PROJ NO. 812-1164 DRAWN ... REVIEWED NAS DATE Sept./81

RECORD OF TEST PIT #5

Location (See Figure 2)

Date August 25, 1981

Datum

Method of Excavation Backhoe

Project Smithers Yorke - Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P W W_L)	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Stiff brown silty sandy gravelly TILL					Pit dry. Pit backfilled.
4.5'	Very stiff grey silty sandy gravelly TILL with occ. boulder. Blue fissures (tight)					
11.5'	End of Test pit.					

Vertical Scale:
1 inch to 2 feet

Sheet 1 of 1

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PROJECT NO. 812-1164 DRAWN M. REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #6

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 25, 1981*
Datum
Project *Smithers Yorke-Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P, W, W_L) 10 20 30 40	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Firm brown silty SAND & GRAVEL (TILL)					No water in pit. Pit left open. Easy digging.
4.0'	Firm to stiff blue grey silty stoney TILL					
5.0'	Stiff blue grey silty stoney TILL with blue fractures					
10.0'	End of Test Pit.					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

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PROJECT NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #7

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 25, 1981*
Datum
Project *Smithers Yorke-Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P W W_L)	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	*Firm brown silty sandy stoney TILL*					*Pit dry. Pit left open.*
5.0'	*Very stiff grey silty sandy gravelly TILL with blue fissures. Till is blocky. Lens of very dense grey silt at 7 ft.*					
10.0'	*End of Test Pit.*					

Vertical Scale
1 inch to 2 feet

Sheet 1 of 1

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PROJECT NO. 812-1164 DRAWN ____ REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #8

Location (See Figure 2) | Date August 26, 1981
Datum
Method of Excavation Backhoe | Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT – % (W_P, W, W_L)	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Compact light brown SILT with some gravel					Unable to dig beyond 6 ft. Pit making water very fast and collapsing.
2.0'	Brown well graded SAND, GRAVEL & COBBLES					
6.0'	End of Test Pit					

Vertical Scale. 1 inch to 2 feet

Sheet 1 of 1

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PROJ. NO. 812-1164 DRAWN [initials] REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #9

Location (See Figure 2)

Date August 26, 1981

Datum

Method of Excavation Backhoe

Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P — W — W_L)	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Brown well graded SAND, GRAVEL & COBBLES (no boulders). Some seams 2"-3" thick of silty sand.					Pit dry. Pit backfilled. Easy digging.
11.0'	End of Test Pit.					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

PROJ. NO. 812-1164 DRAWN ... REVIEWED NAS DATE Sept. '81

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RECORD OF TEST PIT #10

Location (See Figure 2)

Method of Excavation Backhoe

Date August 26, 1981

Datum

Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P, W, W_L)	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	Compact light brown SILT with occ. gravel					Pit dry. Pit backfilled. Easy digging.
2.5'	Compact brown SAND, GRAVEL & COBBLES. Seams of sand.					
14.0'	End of Test Pit					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

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PROJECT NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Sept./81

RECORD OF TEST PIT #11

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 26, 1981*

Datum

Project *Smithers Yorke-Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P, W, W_L) 10 20 30 40	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	*Black organic TOPSOIL*					
1.0'	*Stiff light brown grey mottled silty gravelly TILL, occ. cobbles. Some tight grey fissures.*		1			*Pit dry. Pit backfilled. Comparatively easier digging.*
5.5'	*Very stiff grey silty gravelly TILL with cobbles & boulders. Blue fissures. Some fissures wet.*		2			
11.5'	*End of Test Pit.*					

Vertical Scale.
1 inch to 1 feet

Sheet 1 of 1

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PROJECT NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Sept. 1981

RECORD OF TEST PIT #12

Location (See Figure 2)

Method of Excavation Backhoe

Date August 26, 1981

Datum

Project Smithers Yorke - Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P W W_L)	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	Soft brown sandy SILT					
1.25'	Soft to firm grey sandy SILT					Pit collapsing at 9ft., unable to dig deeper. Gravel may be a glacial channel.
5.6'	Grey water bearing SAND, GRAVEL & COBBLE					
9.0'	End of Test Pit.					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ NO. 812-1164 DRAWN [initials] REVIEWED NAS DATE Sept.

RECORD OF TEST PIT # 13

Location (See Figure 2)

Method of Excavation *Backhoe*

Date *August 26, 1981*

Datum

Project *Smithers Yorke - Hardy*

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT – % (W_P — W — W_L) 10 20 30 40	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	Hard dry light brown silty gravelly TILL with cobbles					Pit dry. Pit backfilled. Disturbed sample at 5 ft.
2.0'	Hard grey friable- crumbly silty gravelly TILL with cobbles and occ. boulders. Not fissured. Becoming harder and more intact with depth. Easier digging.					
10.0'	End of Test Pit.					

Vertical Scale. 1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ. NO. 812-1164 DRAWN [illegible] REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #14

Location (See Figure 2)

Date August 26, 1981

Datum

Method of Excavation Backhoe

Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P — W — W_L)	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Dry brown gravelly SILT (TILL)					Pit dry. Pit backfilled.
2.0'	Stiff to hard grey silty, gravelly TILL with wet pocket of sand & gravel at 7.5ft.					
9.0'	End of Test Pit.					

Vertical Scale:
1 inch to 2 feet

Sheet 1 of 1

PROJ. NO. 812-1164 DRAWN [initials] REVIEWED NAS DATE Sept. 18/81

Golder Associates

RECORD OF TEST PIT #15

Location (See Figure 2)
Method of Excavation Backhoe

Date August 26, 1981
Datum
Project Smithers Yorke-Hardy

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_P W W_L)	GROUNDWATER CONDITIONS / REMARKS
	Ground Surface					
0.0	Firm brown SILT					Unable to excavate beyond 5 ft. Pit making water very fast and collapsing.
2.5'	Compact brown SAND, GRAVEL & COBBLES.					
5.0'	End of Test Pit.					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ. NO. 812-1164 DRAWN M. REVIEWED NAS DATE Sept. '81

RECORD OF TEST PIT #16

Location (See Figure A2) Potential Plantsite

Date Oct. 1st, 1981

Datum 1880 ft. approx.

Method of Excavation Backhoe

Project

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_p, W, W_L) 10 20 30 40	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Dark brown organic clayey SILT					Perched water table at base.
4.0'	Firm grey, plastic, silty sandy, gravelly, cobbly CLAY with sandy lenses - TILL		1	TX		Cobbles well-rounded Hazelton and Bowser rocks.
11.5'	End of Test Pit					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ. NO. 812-1169 DRAWN REVIEWED NAS DATE Oct. '81

RECORD OF TEST PIT #17

Location (See Figure A2) Potential Plantsite | Date Oct. 1st, 1981
Datum 1870 ft. approx.
Method of Excavation Backhoe | Project

ELEV. / DEPTH (feet)	DESCRIPTION	STRATIGRAPHY PLOT	SAMPLE NUMBER	ADDITIONAL LAB. TESTING	WATER CONTENT - % (W_p — W — W_L) 10 20 30 40	GROUNDWATER CONDITIONS REMARKS
	Ground Surface					
0.0	Dark brown organic clayey SILT					
0.5'	Stiff to very stiff brown sandy, gravelly TILL. Lenses of grey clay. Some sandy lens at 6ft. Friable.					
-6.0'	Very stiff grey sandy silty TILL. Friable.		1		o├──┤	
11.5'	End of Test Pit.					

Vertical Scale.
1 inch to 2 feet

Sheet 1 of 1

Golder Associates

PROJ. NO. 812-1164 DRAWN [initials] REVIEWED ..... DATE Oct. '81

APPENDIX B

CONCRETE AGGREGATE TESTING

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

File No P-3657 October 28, 1981.

Golder Associates,
224 W. 8th Ave.,
VANCOUVER, B.C.
V5Y 1N5

Attention: Mr. Nigel Skirmer

Dear Sirs:

Re: Concrete Aggregate Evaluation.

We have examined the suitability of an aggregate sample submitted to us, by you, for use in making concrete. The results of:

(i) Specific Gravity and Absorption.

(ii) Sieve Analysis.

(iii) Soundness Test.

have been previously reported to you verbally and are detailed in a separate report to you by our Mr. P. Joshi, C.E.T.

Attached to this letter are the results of a Partial Petrographic Analysis conducted on 3/8", 1/2", 3/4", and 1" fractions of the aggregate sample.

Pertinent observations with respect to the suitability of the aggregate for use in concrete are given below:

1) The aggregate has a very high fines content, with 11.5 percent of the total sample passing the No. 200 sieve. CAN3 - A23.1 - M77 limits the maximum amount of material passing the No. 200 in the sand fraction (passing the No. 4 sieve) to 3.0 percent. Clearly very significant washing operations would have to be instituted to make this sand suitable for use in concrete.

..... 2

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GEOTECHNICAL, MATERIALS & METALLURGICAL ENGINEERING - ENVIRONMENTAL, MATERIALS & CHEMICAL SCIENCES
CALGARY DAWSON CREEK EDMONTON FORT McMURRAY LETHBRIDGE MEDICINE HAT PRINCE GEORGE RED DEER SASKATOON VANCOUVER WINNIPEG

2) If the total aggregate sample is adequately washed, then approximately 50 percent of the sample would be coarse aggregate (in the 2 in. to No. 4 sieve sizes) and approximately 50 percent of the sample sand (passing the No. 4 sieve). The coarse aggregate could be used with minimal wasteage as a natural 1½ in. max. size material. Substantial crushing would however be required if all the coarse aggregate were to be used as 3/4 in. max. size material.

3) Both the coarse aggregate and sand fractions readily meet the requirements of the Sulphate Soundness Test. i.e. the aggregate is generally strong and not susceptible to breakup during processing or in concrete during, mixing transporting and placing.

4) The Bulk Relative Density (S.S.D.) of the coarse aggregate is typical of good quality concrete aggregates. The value for the sand fraction, at 2.475, is however very low. This is possibly attributable to the very high percent material passing the No. 200 sieve. We would expect a higher value for a suitably washed sample.

5) The partial Petrographic analysis indicates that the coarse aggregate is comprised predominantly of strong basic and intermediate volcanics, tuff and agglomerate and quartzite. Minor strong components include granite and argillite. There are however, some only fair quality weathered quartzite and granite particles which display substantial iron oxide coatings. These weathered particles could give rise to localized surface deficiencies in concrete, such as pop-outs, spalls and staining, which could be objectionable in architectural concrete, or exposed flatwork (e.g. floor slabs, bridge decks etc.)

Also there is some chert present in the coarse aggregate. Some species of chert are known to be alkali-reactive in Portland cement concrete. Consequently, we recommend that this aggregate be evaluated for potential alkali reactivity as recommended in CAN3 - A23.1 - M77, appendix B, section B 3.3. (Chemical Method). If this test was borderline, or positive then we recommend that consideration be given to performing the test in section B 3.4 (Mortar - Bar Method).

..... 3

In summary, the petrographic numbers for the 3/8", 1/2", 3/4" and 1" size fractions are 124, 115, 114, and 136 if the chert proves to be non-reactive and 147, 133, 198 and 136 if the chert proves to be reactive.

Conclusions

We consider that the aggregate evaluated by us in this test program could be suitable for use in the production of concrete provided:

a) The chert component of the aggregate proved to be non alkali reactive.

b) The potential for some minor localised pop-outs, spalls and staining which could arise from the weathered, iron oxide coated quartzite and granite particles is recognized e.g. this item could be of concern in architectural concrete or flatwork, but may be acceptable in mass concrete, foundations, footings, piles, etc.

c) The aggregate would require substantial washing to remove excess material passing the No. 200 sieve. Aggregate gradation of processed material would have to conform to the requirements of CAN3 - A23.1 - M77.

We would be pleased to conduct any further testing which maybe required for this aggregate, or perform any concrete trial mixes, and supply concrete mix designs, should you wish to retain us for this purpose.

Please call if you have any queries regarding this report.

Yours truly,

HARDY ASSOCIATES (1978) LTD.,

Per: D. R. Morgan

D.R. Morgan, Ph.D., P. Eng.,
Manager - Materials Engineering Division.

DRM:nmd
Enclosures.

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

PETROGRAPHIC ANALYSIS

FILE: P-3657 CLIENT: Golder Associates

DATE: 81-10-20 PREPARED: F.S. CHECKED:

Not according to CSA or ASTM procedure (Partial Petrographic)

SAMPLE: SIEVE: 3/8" PARTICLE COUNT:

PARTICLE SHAPE

ANGULAR: SUB-ROUNDED:
SUB-ANGULAR: ROUNDED:

PARTICLE SPHERICITY

N/A ISOMETRIC: FLAT: RODLIKE:

PARTICLE SURFACE

CLEAN, POLISHED:
CLEAN, SMOOTH :
CLEAN, ROUGH :
COATED :

PETROLOGIC/MINERALOGICAL TYPES DESCRIPTION	WEIGHT (GRAMS)	PERCENT OF TOTAL	PN FACTOR	PN CONTRIBUTI(
Basic Volcanics - strong	38.38	23.6	1	23.6
Intermediate Volcanics -strong	12.11	7.5	1	7.5
Tuff & Agglomerate - strong	12.51	7.7	1	7.7
Granite - strong	1.77	1.1	1	1.1
Quartzite - strong	67.62	41.6	1	41.6
Argillite - good	3.18	2.0	1	2.0
Weathered Quartzite & Granite - iron oxide throughout & as coatings.	19.50	12.0	3	36.0
Chert - strong; potentially deletorious	7.27	4.5	1;6*	4.5;27
	162.34g	100%		124

Assuming Chert is Alkali - reactive. 146.5 ≈ 147

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CONSULTING ENGINEERING & PROFESSIONAL SERVICES

PETROGRAPHIC EXAMINATION

FILE: P-3657 CLIENT: Golder Associates

DATE: 81-10-19 PREPARED: F.S. CHECKED: ______

METHOD: Not to CSA or ASTM specifications (partial Petrographic)

SAMPLE: ______ SIEVE: ½" PARTICLE COUNT: ______

PARTICLE SHAPE

ANGULAR: SUB-ROUNDED:
SUB-ANGULAR: ROUNDED:

PARTICLE SPHERICITY

N/A ISOMETRIC: FLAT: RODLIKE:

PARTICLE SURFACE

CLEAN, POLISHED:
CLEAN, SMOOTH :
CLEAN, ROUGH :
COATED :

PETROLOGIC/MINERALOGICAL TYPES DESCRIPTION	WEIGHT (GRAMS)	PERCENT OF TOTAL	PN FACTOR	PN CONTRIBUTI
Basic Volcanics - strong	225.60	43.1	1	43.1
Intermediate Volcanics - strong	31.51	6.0	1	6.0
Tuff - strong	28.39	5.4	1	5.4
Granite - strong	9.73	1.9	1	1.9
Quartzite - strong	169.69	32.5	1	32.5
Quartzite - heavy iron oxide coating	40.01	7.6	3	22.8
Chert - strong; potentially deleterious	18.28	3.5	1;6*	3.5;21.(
	523.21g	100%		115.2≈115
				132.7≈133

*Assuming Chert is Alkali Reactive.

PETROGRAPHIC ANALYSIS

FILE: P-3657 CLIENT: Golder Associates

DATE: 81-10-20 PREPARED: F.S. CHECKED:

Not according to CSA or ASTM specs (partial petrographic).

SAMPLE: SIEVE: 3/4" PARTICLE COUNT:

PARTICLE SHAPE

ANGULAR:
SUB-ANGULAR:
SUB-ROUNDED:
ROUNDED:

PARTICLE SPHERICITY

N/A ISOMETRIC: FLAT: RODLIKE:

PARTICLE SURFACE

CLEAN, POLISHED:
CLEAN, SMOOTH :
CLEAN, ROUGH :
COATED :

PETROLOGIC/MINERALOGICAL TYPES DESCRIPTION	WEIGHT (GRAMS)	PERCENT OF TOTAL	PN FACTOR	PN CONTRIBUTIC
Basic Volcanics - strong	164.59	39.9	1	39.9
Intermediate Volcanics - strong	49.83	12.1	1	12.1
Quartzite - strong	85.47	20.7	1	20.7
Argillite - good	15.21	3.7	1	3.7
Weathered Quartzite & Granite - substantial iron oxide content	28.20	6.8	3	20.4
Chert - strong; potentially deleterious	69.33	16.8	1;6*	16.8;100.8*
	412.63g			113.6≈114
				197.6≈198*

* Assuming Chert is alkali-reactive.

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

PETROGRAPHIC EXAMINATION

FILE: P-3657 CLIENT: Golder Associates

DATE: 81-10-19 PREPARED: F.S. CHECKED:

METHOD: Not according to CSA or ASTM specifications (partial Petrographic).

SAMPLE: SIEVE: 1" PARTICLE COUNT:

PARTICLE SHAPE

ANGULAR: SUB-ROUNDED:
SUB-ANGULAR: ROUNDED:

PARTICLE SPHERICITY

N/A

ISOMETRIC: FLAT: RODLIKE:

PARTICLE SURFACE

CLEAN, POLISHED:
CLEAN, SMOOTH :
CLEAN, ROUGH :
COATED :

....

PETROLOGIC/MINERALOGICAL TYPES DESCRIPTION	WEIGHT (GRAMS)	PERCENT OF TOTAL	PN FACTOR	PN CONTRIBUTI
Gneiss, Granite - strong	128.85	13.1	1	13.1
Basic Volcanics - strong	306.30	31.1	1	31.1
Tuff & Agglomerate - strong	110.22	11.2	1	11.2
Quartzite - strong	260.50	26.5	1	26.5
Basic Volcanics - strong - heavy iron oxide coating	63.32	6.4	3	19.2
Weathered Quartzite - disseminated pyrite weathered to iron oxides throughout	114.95	11.7	3	35.1
	984.14 g	100%		136.2≃136 (PN

HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

File No P-3657 October 28, 1981.

Golder Associates,
224 W. 8th Ave.,
VANCOUVER, B.C.
V5Y 1N5

Dear Sirs:

Re: Soil Testing.

As requested we have carried out tests on the sample delivered to our labratory on 19th September, 1981.

The attached technical report contains results for the following tests:

(i) Maximum & Minimum Relative Density.
(ii) Specific Gravity & Absorption.
(iii) Sieve Analysis.
(iv) Soundness Test.

Please do not hesitate to call us if you require any further information.

Yours truly,

HARDY ASSOCIATES (1978) LTD.,

Per: Joshi

P. Joshi, C.E.T.

Per: D. Pridy

D. Pridy, P. Eng.,
Manager - Inspection & Testing Division.

PJ:DP:nmd

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HARDY ASSOCIATES (1978) LTD.

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SIEVE ANALYSIS REPORT

OFFICE VANCOUVER
FILE P-3657
DATE 81-10-28
CLIENT P.O.
C.C.

TO Golder Associates,
224 W. 8th Ave.,
VANCOUVER, B.C.
V5Y 1N5

PROJECT

SOURCE

TYPE OF SAMPLE Gravely sand

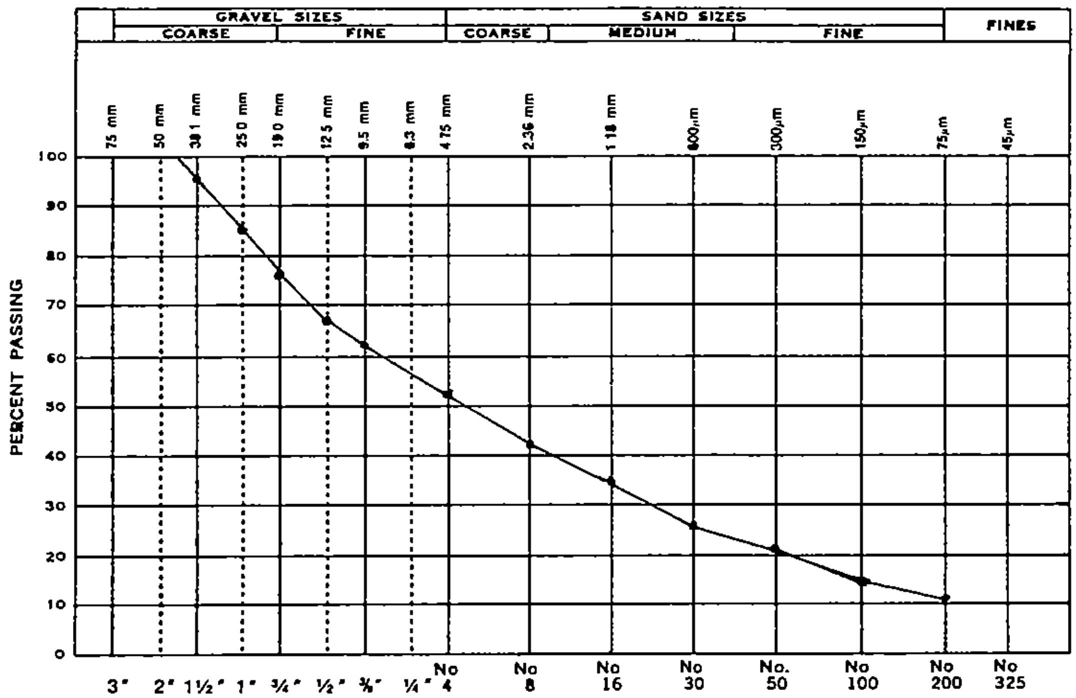
SAMPLED BY client

DATE SAMPLED

DATE REC'D 81-09-17

DATE TESTED 81-09-22

TEST NO.



SIEVE SIZE	PERCENT PASSING
75 mm (3")	
50 mm (2")	100.00
38.1 mm (1½")	96.8
25.0 mm (1")	85.3
19.0 mm (¾")	77.9
12.5 mm (½")	68.5
9.5 mm (⅜")	62.2
6.3 mm (¼")	
4.75 mm (No. 4)	51.1
2.36 mm (No. 8)	41.5
1.18 mm (No. 16)	34.7
600μm (No 30)	27.8
300μm (No. 50)	21.5
150μm (No. 100)	15.4
75μm (No. 200)	11.5
45μm (No. 325)	

COMMENTS

CERTIFIED LABORATORY*

REPORT CERTIFIED P. Joshi, C.E.T.

TECHNICIAN S.S.

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

SOUNDNESS OF AGGREGATE SULPHATE TEST REPORT

TO: Golder Associates,
224 W. 8th Ave.,
VANCOUVER, B.C.
V5Y 1N5

FILE: P-3657
DATE: 81-10-28
CLIENT P.O.
C.C.

PROJECT

SOURCE
DATE SAMPLED

TYPE OF SAMPLE
DATE RECEIVED 81-09-19

SAMPLED BY Client
DATE TESTED 81-09-28

SOLUTION — NUMBER OF CYCLES

COARSE AGGREGATE

SIEVE SIZE PASSING	SIEVE SIZE RETAINED	ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
3 IN	2 IN		
2 IN	1 - ½ IN		
1 - ½ IN	1 IN	25.1	0.0
1 IN	¾ IN	16.2	0.0
¾ IN.	½ IN	20.5	0.7
½ IN	3/8 IN	13.9	0.1
3/8 IN	NO 4 IN	24.3	0.1
TOTALS		100.0	0.9

FINE AGGREGATE

SIEVE SIZE PASSING	SIEVE SIZE RETAINED	ORIGINAL GRADING PERCENT	WEIGHED AVERAGE PERCENT LOSS
3/8 IN	NO 4		
NO 4	NO 8	32.3	0.0
NO. 8	NO 16	33.0	0.2
NO 16	NO 30	23.3	0.4
NO 30	NO 50	21.4	0.6
NO 50	NO 100		
NO 100			
TOTALS		100.0	1.2

SIZE FRACTION	NO PARTICLES		QUALITATIVE EXAMINATION OF PLUS ¾" MATERIAL
3" - 2"	ORIGINAL		
	FINAL		
2" - 1½"	ORIGINAL		
	FINAL		
1½" - 1"	ORIGINAL	20	
	FINAL	20	
1" - ¾"	ORIGINAL	25	(No noticeable change in appearance in aggregate)
	FINAL	25	

COMMENTS

REPORT CERTIFIED Prakash Joshi, C.E.T. TECHNICIAN S.S.

TESTED IN ACCORDANCE WITH ASTM C88

HARDY ASSOCIATES (1978) LTD.
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

TECHNICAL REPORT

FILE P-3657
DATE 81-10-07
CLIENT P.O.
C.C.

To: Golder Associates,
224 W. 8th Ave.,
VANCOUVER, B.C.
V5Y 1N5

PROJECT:

SUBJECT: (1) Maximum & minimum relative density of complete sample.

(2) Specific gravity & absorption of coarse and fine portion of sample.

DATA:

TEST METHOD	ASTM D049.78			CAN3 - 23.2 - M77		
Sample	Maximum Relative Density kg/m3	Minimum Relative Density kg/m3	Average Absorption %	Bulk Relative Density (S.S.D. Basis)	Apparent Relative Density	Bulk Relative Density
Entire	2164.1	1750.8	-	-	-	-
Fine Portion	-	-	5.63	2.4752	2.6559	2.3433
Coarse Portion	-	-	0.20	2.700	-	2.6950

Comments: The high percent material passing the No. 200 sieve made it difficult to establish the S.S.D. condition of the sand. This probably also accounts for the high absorption of the fine fraction.

Certified: Prakash Joshi, C.E.T. Technician: I.W./S.S.

CALGARY DAWSON CREEK EDMONTON FORT McMURRAY LETHBRIDGE PRINCE GEORGE RED DEER VANCOUVER WINNIPEG

A falling head test was performed in backhoe pit #1, located as shown in Figure 2. The test results are presented in Figure 3. The percolation test indicated that up to 20 inches of water per day seeped from the test pit. Test pit #7, excavated near Glacier Gulch, was found to infiltrate with approximately 5 feet of water in less than 15 days.

3. TAILINGS CHARACTERISTICS

What data is available on the ore indicates that sulphide oxidation and hence acid production may be a possibility, as the ore contains iron sulphide as pyrite (1%). Although the mine drainage water indicates a moderate alkalinity, carbonates or other alkali materials to buffer the acid production may not occur in acceptable concentrations because of the volcanic nature of the area. Further tests on acid production characteristics are required.

The tailings also contain .03 to .06 percent copper as chalcopyrite and smaller amounts of zinc, chromium and lead.

4. SEEPAGE DURING OPERATION

The quality of the potential seepage during operation is difficult to predict as it depends on decant composition and alkalinity, tailings composition, and tailings depth. During operation, the oxygen available for sulphide oxidation and hence pH depression is limited to that dissolved in the decant (provided that adequate decant depth is maintained to minimize oxygen transfer from the atmosphere). If the decant alkalinity is high (from addition of process chemicals), then the pH will often stay within acceptable levels for metal precipitation. However, other soluble species such as cyanide and organic flotation reagents could remain soluble. It is therefore recommended that seepage control measures be considered.

Alternatively, seepage control may not be required if:

1) cyanide or organic chemicals are destroyed prior to entering ponds;
2) alkalinity of the waste will balance acid generation;
3) potentially harmful chemicals are in a stable form.

5. SEEPAGE AFTER ABANDONMENT

The possible seepage after abandonment differs from that during operation in that the water available for leaching must come from natural sources. These sources include precipitation, groundwater, and surface runoff.

5.1 RAINWATER

Rainwater can be characterized as "aggressive" water. It tends to be extremely low in dissolved solids, with a relatively low pH and no buffering capacity. It, by itself, is able to dissolve significant quantities of metals. When coupled with a pH drop due to sulphide oxidation, high concentrations of metals in resultant seepages could occur.

Therefore, it is advisable to either cap the top of the pond and/or seal the bottom of the pond, thus preventing the described flow from occurring. Alternatively, mixing high alkalinity materials in the upper layer of the tailings upon abandonment may add enough alkalinity to prevent problems from developing.

5.2 GROUNDWATER FLOWS

Groundwater can enter the potential tailings area from recharge, from the Glacier Gulch fan and from migration from the mine area.

5.2.1 Recharge from the Fan

Samples of the Glacier Gulch fan sediments indicate that the groundwater from this source is not likely to be alkaline and may be capable of dissolving previously deposited minerals.

In general, groundwater is limited in its ability to produce acid conditions because of its limited oxygen content. However, if the groundwater levels fluctuate, thus exposing the tails first to moist air, then to water, groundwater/metal interactions could occur.

Mitigative procedures should be aimed at preventing a varying phreatic level, and at preventing a groundwater flux through the tailings.

5.2.2 Groundwater from the Mine Area

A water sample collected inside the mine adit (sample #7) indicated that the groundwater surrounding the mine area was quite alkaline (pH 7.90) and contained significant buffering capacity (alkalinity 75.4 mg/l as $CaCO_3$). It is unlikely that acid generation problems would evolve with the mine groundwater because there is sufficient buffering capacity in the water to neutralize any pH changes even if oxygen was to make contact with deposited minerals.

5.3 SURFACE WATER

Surface water would react in a similar fashion to direct precipitation, except that its flushing rates would be much higher. The surface water in the vicinity is generally soft and without buffering. (Results from surface water sampling are given in Appendix 1).

Surface water should, therefore, be isolated from the ponds upon abandonment. This could be done by performing dyking and other river engineering works on the creeks, thus preventing the creeks from wandering back over the deposited tails at some time in the future.

As shown in Figure 1, samples were taken from six locations as follows:

1. Toboggan Creek at road crossing
2. Glacier Gulch at road crossing
3. Glacier Gulch at railway
4. Old Glacier Gulch Channel at Kathlyn Lake
5. Drainage flowing east from site
6. Small creek on powerline right-of-way.

The water in the area is low in hardness and alkalinity and generally contains very low concentrations of all background substances.

5.3.1. pH Alkalinity-Hardness

The pH of the samples varied between 6.7 and 7.1 with corresponding alkalinities varying from 10.6 to 27.3 mg/l as $CaCO_3$. The highest alkalinity (27.3 mg/l) was measured in the previous channel of Glacier Gulch near Kathlyn Lake.

Hardness varied from 11 mg/l to 28 mg/l, being lowest in upper Glacier Gulch and highest in the old Glacier Gulch channel.

5.3.2 Anions

All anion values were low, but some important relative differences exist. Sulphate levels were higher in the easterly site drainage, whereas nitrate was elevated (0.25 mg/l) in the old Glacier Gulch channel. Phosphate was below 0.03 mg/l in all locations.

The elevated nitrate level in the old channel should be monitored to show pre-development conditions. It is common to blame explosive residues from mining operations as the cause of elevated nitrogen concentrations. Regular sampling of location 4 would establish background conditions.

5.3.3 Metals

No metals were detected in significant concentrations with the exception of iron found in both the easterly drainage and the old Glacier Gulch channel.

The iron concentration in the easterly site drainage was 1.16 mg/l and in the old Glacier Gulch channel was 2.81 mg/l. The iron concentrations in Glacier Gulch were low but increased by a factor of 10 below the site.

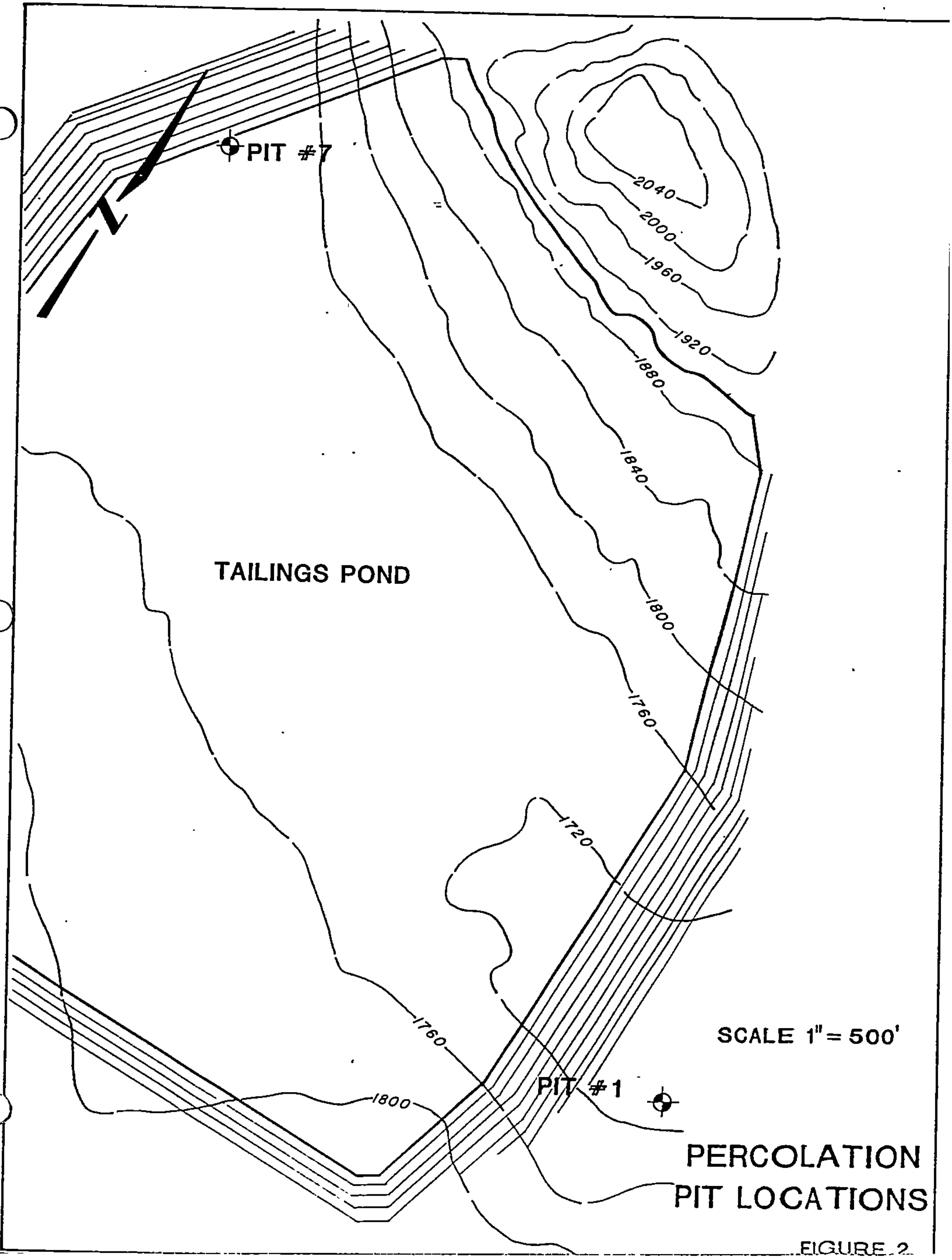
Elevated iron concentrations are common in the groundwaters and surface waters of British Columbia Coast Range. However, the level of 2.81 mg/l measured in the old Glacier Gulch channel is high relative to other waters.

As iron is a potential constituent of seepage from abandoned or active tailings areas, a regular sampling of iron-rich streams is warranted to establish background conditions.

5.3.4 Other Pollutants

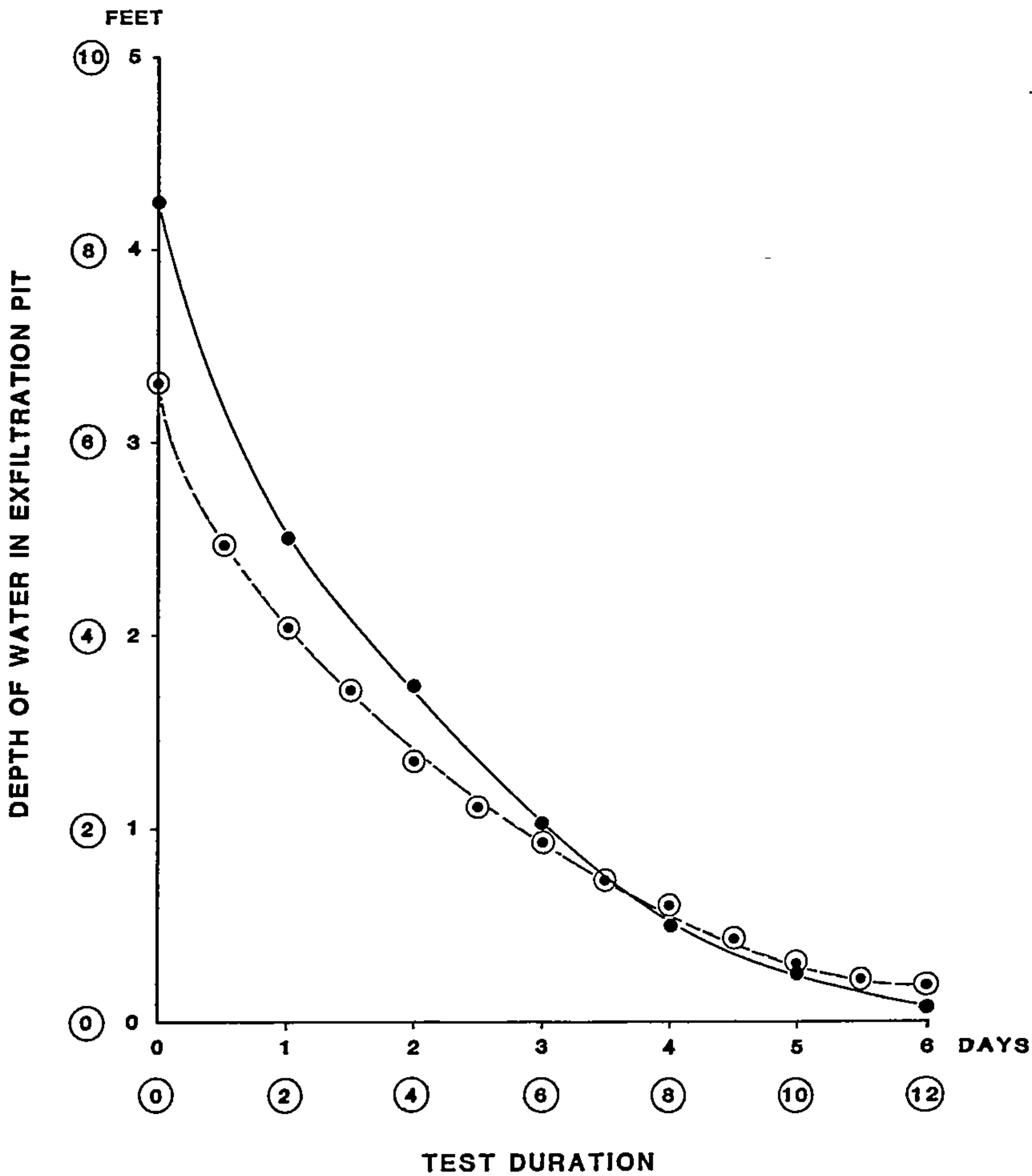
No significant quantities of other pollutants were found on site; however, some relative differences should be noted.

The concentrations of total organic carbon were slightly elevated in the old Glacier Gulch channel and the levels of total Kjeldahl nitrogen were slightly elevated in all samples except for the upper reaches of Glacier Gulch and Toboggan Creek. The elevated concentrations were very low (0.765 mg/l maximum), but the relative difference should be documented prior to mine operation.



PERCOLATION PIT LOCATIONS

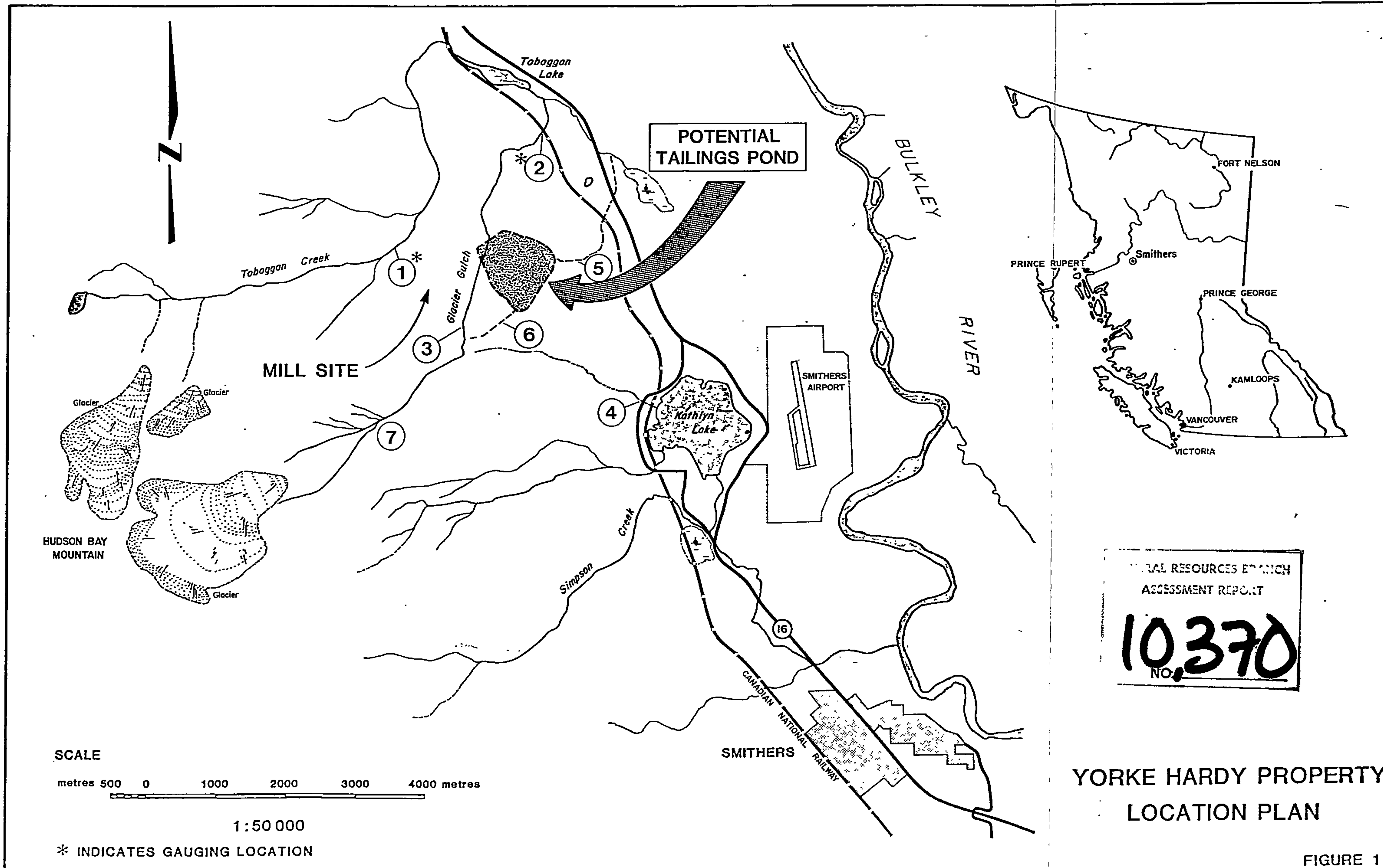
FIGURE 2



EXFILTRATION PIT FALLING HEAD TEST

TEST RESULTS

FIGURE 3



YORKE HARDY PROPERTY
LOCATION PLAN

FIGURE 1

APPENDIX

1. PURPOSE

This report presents the results of a flow measurement and water quality sampling program at the Yorke Hardy Property in Smithers, B C.

2. WATER QUALITY

Water quality samples were collected in July (Locations 1 through 6) and October (Locations 1, 3, and 7) 1981. The sampling locations are identified on Figure 1. The results of testing are presented in the attached tables.

All samples were field filtered prior to laboratory analysis. The analyses were carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater (14th Edition)" published by the American Public Health Association, 1975 and the "Laboratory Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Materials (2nd Edition)" published by the Government of B C, Ministry of the Environment, Water Resources Services, 1976.

The metals were determined by using Inductively Coupled Plasma Spectrographic analysis, direct or graphite furnance atomic absorption spectrophotometry, or hydride generation. Mercury was determined using a Pharmacia Mercury Monitor (flameless atomic absorption spectrophotometry) after controlled digestion of the sample.

The streams in the vicinity contained very soft, low alkalinity water showing typical background levels in almost all potentially harmful substances.

3. FLOW MEASUREMENT

Flow measurements were taken at the mine adit flume, Toboggan Creek and Glacier Gulch between October 1 and 2, 1981. Cross section locations for Toboggan Creek and Glacier Gulch are shown in Figure 1. The flume measurement was surveyed approximately 150 m inside the mine adit. On Toboggan Creek and Glacier Gulch, average velocity (measured at 0.66 of total depth) and depth measurements were taken at 25 cm intervals across the stream width. Staff gauges were installed at both these sites.. Velocity (measured at 0.2 and 0.8 of total depth) and depth measurements were taken at 10 cm intervals across the mine adit flume. All velocity measurements were made using a Weather Measure digital flow meter.

The results for these measurements are as follows:

SITE	DATE	DISCHARGE
Mine Adit Flume	October 1, 1981	0.54 CFS (240 gpm)
Toboggan Creek	October 1, 1981	22.0 CFS
Glacier Gulch	October 2, 1981	12.0 CFS

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RESULTS OF TESTING:

SAMPLE #		1	2	3
CLIENT SAMPLE I.D.		GLACIER GULTCH#1	TOBOG CREEK #1	TRIBUTARY #1
SAMPLE # ON FIGURE 1		(3)	(1)	(5)
PHYSICAL TESTS				
pH		6.70	7.05	7.10
Conductivity (micromhos/cm)		31.9	36.6	63.8
Turbidity (JTU)		4.6	0.40	9.0
Hardness (mg/L)		11.0	14.5	24.
SOLIDS (mg/L)				
Total Suspended		< 0.5	< 0.5	1.0
Total Dissolved		15.	24.	18.
Total Total		16.	25.	19.
DISSOLVED ANIONS (mg/L)				
Alkalinity: Bicarbonate	HCO3	10.6	12.5	14.8
Alkalinity: Carbonate	CO3	Nil	Nil	Nil
Alkalinity: Hydroxide	OH	Nil	Nil	Nil
Chlorides	Cl	0.50	0.92	< 0.5
Sulfates	SO4	< 5.	< 5.	11.0
Nitrates	N	0.020	0.039	0.009
Nitrites	N	0.001	0.008	< 0.001
Ortho Phosphates	o-PO4	< 0.030	< 0.030	< 0.030
Fluorides	F	0.064	0.040	0.14
DISSOLVED METALS (mg/L)				
Aluminum	Al	0.05	0.08	0.03
Antimony	Sb	< 0.001	< 0.001	< 0.001
Arsenic	As	< 0.001	0.002	0.001
Barium	Ba	0.007	0.007	0.015
Beryllium	Be	< 0.003	< 0.003	< 0.003
Bismuth	Bi	< 0.5	< 0.5	< 0.5
Boron	B	< 0.01	0.010	0.010
Cadmium	Cd	< 0.001	< 0.001	< 0.001
Calcium	Ca	3.80	4.89	7.70
Chromium	Cr	0.005	0.004	0.005
Cobalt	Co	< 0.005	< 0.005	< 0.005
Copper	Cu	0.006	0.002	0.003
Iron	Fe	0.046	< 0.030	0.20
Lead	Pb	< 0.001	< 0.08	< 0.001
Magnesium	Mg	0.36	0.52	0.92
Manganese	Mn	0.009	< 0.003	< 0.003
Molybdenum	Mo	0.06	0.01	0.020
Nickel	Ni	< 0.005	< 0.005	< 0.005
Phosphorus	PO4	< 0.4	< 0.4	< 0.4
Potassium	K	0.34	0.17	0.23
Silicon	SiO2	2.68	4.01	6.36
Silver	Ag	< 0.001	< 0.001	< 0.001
Sodium	Na	1.08	1.31	2.92
Strontium	Sr	0.014	0.017	0.026
Tin	Sn	< 0.03	< 0.03	< 0.03
Titanium	Ti	< 0.006	< 0.006	< 0.006
Vanadium	V	< 0.005	< 0.005	< 0.005
Zinc	Zn	< 0.010	< 0.010	< 0.010

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RESULTS OF TESTING: (CON'T)

SAMPLE #		1	2	3
CLIENT SAMPLE I.D.		GLACIER GULTCH#1	TOBOG CREEK #1	TRIBUTARY-#1
SAMPLE # ON FIGURE 1		(3)	(1)	(5)
TOTAL METALS (mg/L)				
Aluminum	Al	1.13	0.19	0.08
Antimony	Sb	< 0.001	< 0.001	< 0.001
Arsenic	As	0.001	0.001	0.001
Barium	Ba	0.068	0.007	0.015
Beryllium	Be	< 0.003	< 0.003	< 0.003
Bismuth	Bi	< 0.5	< 0.5	< 0.5
Boron	B	0.027	0.036	0.015
Cadmium	Cd	< 0.001	< 0.001	< 0.001
Calcium	Ca	4.06	4.93	7.92
Chromium	Cr	0.009	0.007	0.006
Cobalt	Co	< 0.005	< 0.005	< 0.005
Copper	Cu	0.016	0.003	0.003
Iron	Fe	Nil	0.048	1.16
Lead	Pb	< 0.001	< 0.001	< 0.001
Magnesium	Mg	0.55	0.52	0.93
Manganese	Mn	0.026	< 0.003	0.081
Mercury	Hg	0.0001	0.0001	0.0001
Molybdenum	Mo	0.06	0.01	0.02
Nickel	Ni	< 0.005	< 0.005	< 0.005
Phosphorus	PO4	< 0.4	< 0.4	< 0.4
Potassium	K	0.59	0.19	0.25
Silicon	SiO2	7.60	4.55	6.98
Silver	Ag	< 0.001	< 0.001	< 0.001
Sodium	Na	1.14	1.13	2.31
Strontium	Sr	0.015	0.016	0.026
Tin	Sn	< 0.03	< 0.03	< 0.03
Titanium	Ti	0.052	< 0.006	< 0.006
Vanadium	V	< 0.005	< 0.005	< 0.005
Zinc	Zn	0.013	< 0.010	< 0.010
POLLUTANT TESTS (mg/L)				
Total Organic Carbon	C	< 2.	< 2.	< 3.
Total Phosphate	PO4	< 0.030	< 0.030	< 0.030
Ammonia Nitrogen	N	< 0.05	< 0.05	< 0.05
Total Kjeldahl Nitrogen	N	0.063	0.063	0.279
Total Phenolics as Phenol		< 0.001	< 0.001	< 0.001

Key to Table
mg/L = milligrams per liter
< = signifies that the parameter in question was NOT DETECTED. The number signifies the detection limit

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RESULTS OF TESTING: (CON'T)

SAMPLE #		4	5	6
CLIENT SAMPLE I.D.		GLACIER GULTCH#2	POWER LINE CREEK	BRANCH E GL TO K
SAMPLE # ON FIGURE 1		2	6	4
PHYSICAL TESTS				
pH		6.7	7.0	7.10
Conductivity(mhos/cm)		42.0	60.4	66.0
Turbidity(JTU)		3.5	0.55	15.0
Hardness(mg/L)		16.	22.	28.
SOLIDS(mg/L)				
Total Suspended		< 0.5	< 0.5	< 0.5
Total Dissolved		12.	19.	23.
Total Total		13.	20.	23.
DISSOLVED ANIONS(mg/L)				
Alkalinity: Bicarbonate	HCO3	13.6	10.8	27.3
Alkalinity: Carbonate	CO3	Nil	Nil	Nil
Alkalinity: Hydroxide	OH	Nil	Nil	Nil
Chlorides	Cl	< 0.5	0.5	< 0.5
Sulfates	SO4	< 5.	16.5	< 5.
Nitrates	N	0.039	0.019	0.25
Nitrites	N	< 0.001	< 0.001	< 0.001
Ortho Phosphates	o-PO4	< 0.030	< 0.030	< 0.030
Fluorides	F	0.068	0.080	0.10
DISSOLVED METALS(mg/L)				
Aluminum	Al	0.15	0.07	0.02
Antimony	Sb	< 0.001	< 0.001	< 0.001
Arsenic	As	0.001	< 0.001	0.002
Barium	Ba	0.007	0.013	0.011
Beryllium	Be	< 0.003	< 0.003	< 0.003
Bismuth	Bi	< 0.5	< 0.5	< 0.5
Boron	B	< 0.01	< 0.01	< 0.01
Cadmium	Cd	< 0.001	< 0.001	< 0.001
Calcium	Ca	5.22	7.47	8.37
Chromium	Cr	0.005	0.005	0.003
Cobalt	Co	< 0.005	< 0.005	< 0.005
Copper	Cu	0.007	0.019	0.004
Iron	Fe	0.077	0.069	1.11
Lead	Pb	< 0.001	< 0.001	< 0.001
Magnesium	Mg	0.56	0.69	1.14
Manganese	Mn	0.007	0.012	0.004
Molybdenum	Mo	0.04	0.02	0.03
Nickel	Ni	0.005	< 0.005	< 0.005
Phosphorus	PO4	< 0.4	< 0.4	< 0.4
Potassium	K	0.33	0.37	0.53
Silicon	SiO2	4.30	8.14	8.06
Silver	Ag	< 0.001	< 0.001	< 0.001
Sodium	Na	1.61	2.77	3.28
Strontium	Sr	0.019	0.022	0.032
Tin	Sn	< 0.03	< 0.03	< 0.03
Titanium	Ti	< 0.006	< 0.006	< 0.006
Vanadium	V	< 0.005	< 0.005	< 0.005
Zinc	Zn	< 0.010	< 0.010	< 0.010

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RESULTS OF TESTING: (CON'T)

SAMPLE #		4	5	6
CLIENT SAMPLE I.D.		GLACIER GULTCH#2	POWER LINE CREEK	BRANCH E GL TO
SAMPLE # ON FIGURE 1		(2)	(6)	(4)
TOTAL METALS (mg/L)				
Aluminum	Al	0.45	0.14	1.50
Antimony	Sb	< 0.001	< 0.001	< 0.001
Arsenic	As	0.001	0.001	0.001
Barium	Ba	0.014	0.013	0.016
Beryllium	Be	< 0.003	< 0.003	< 0.003
Bismuth	Bi	< 0.5	< 0.5	< 0.5
Boron	B	0.032	0.020	0.034
Cadmium	Cd	< 0.001	< 0.001	< 0.001
Calcium	Ca	5.51	7.40	8.72
Chromium	Cr	0.007	0.005	0.0012
Cobalt	Co	< 0.005	< 0.005	< 0.005
Copper	Cu	0.008	0.006	0.008
Iron	Fe	0.58	0.42	2.81
Lead	Pb	< 0.001	< 0.001	< 0.001
Magnesium	Mg	0.64	0.68	1.19
Manganese	Mn	0.030	0.015	0.087
Mercury	Hg	0.0001	0.0002	0.0002
Molybdenum	Mo	0.04	0.03	0.04
Nickel	Ni	< 0.005	< 0.005	< 0.005
Phosphorus	PO4	< 0.4	< 0.4	< 0.4
Potassium	K	0.37	0.37	0.53
Silicon	SiO2	5.65	8.71	9.10
Silver	Ag	< 0.001	< 0.001	< 0.001
Sodium	Na	1.42	2.19	3.07
Strontium	Sr	0.020	0.021	0.032
Tin	Sn	< 0.03	< 0.03	< 0.03
Titanium	Ti	0.013	< 0.006	< 0.006
Vanadium	V	< 0.005	< 0.005	< 0.005
Zinc	Zn	< 0.010	< 0.010	< 0.010
POLLUTANT TESTS (mg/L)				
Total Organic Carbon	C	< 2.	< 2.	4.
Total Phosphate	PO4	< 0.030	< 0.030	< 0.030
Ammonia Nitrogen	N	< 0.05	< 0.05	< 0.05
Total Kjeldahl Nitrogen	N	0.765	0.180	0.382
Total Phenolics as Phenol		< 0.001	< 0.001	< 0.001

mg/L = milligrams per liter
(See page 3 - key to table)

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Elaine McLellan (pi)
Judi M. Mitchell, B.Sc.,
Chemist

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RESULTS OF TESTING:

		1	2	3
SAMPLE #		1	2	3
CLIENT SAMPLE I.D.		FLUME	GLACIER CREEK	TOBOGAN CREEK
SAMPLE # ON FIGURE 1		7	1	3
PHYSICAL TESTS				
pH		7.90	7.20	7.15
Conductivity (micro mhos/cm)		272.	50.6	38.5
Turbidity (JTU)		0.37	2.4	1.3
Hardness (mg/L)	CaCO3	197.	-	-
SOLIDS (mg/L)				
Total Suspended		< 0.5	2.0	< 0.5
Total Dissolved		296.	-	-
Total Total		300.	-	-
DISSOLVED ANIONS (mg/L)				
Alkalinity: Bicarbonate	HCO3	75.4	13.3	14.0
Alkalinity: Carbonate	CO3	Nil	Nil	Nil
Alkalinity: Hydroxide	OH	Nil	Nil	Nil
Chlorides	Cl	2.19	< 0.5	< 0.5
Sulfates	SO4	119.	8.5	6.0
Nitrates	N	< 0.001	0.012	0.14
Nitrites	N	< 0.001	0.017	0.003
Ortho Phosphates	o-PO4	0.15	< 0.030	< 0.030
Fluorides	F	1.30	0.045	< 0.030
DISSOLVED METALS (mg/L)				
Aluminum	Al	0.016	-	-
Antimony	Sb	0.013	-	-
Arsenic	As	0.16	-	-
Barium	Ba	0.007	-	-
Beryllium	Be	< 0.003	-	-
Bismuth	Bi	< 0.5	-	-
Boron	B	0.039	-	-
Cadmium	Cd	< 0.001	-	-
Calcium	Ca	71.8	-	-
Chromium	Cr	0.002	-	-
Cobalt	Co	< 0.005	-	-
Copper	Cu	< 0.001	-	-
Iron	Fe	< 0.030	-	-
Lead	Pb	< 0.001	-	-
Magnesium	Mg	4.38	-	-
Manganese	Mn	0.022	-	-
Molybdenum	Mo	< 0.005	-	-
Nickel	Ni	< 0.005	-	-
Phosphorus	PO4	< 0.4	-	-
Potassium	K	0.42	-	-
Silicon	SiO2	10.0	-	-
Silver	Ag	< 0.001	-	-
Sodium	Na	11.1	-	-
Strontium	Sr	0.39	-	-
Tin	Sn	< 0.03	-	-
Titanium	Ti	< 0.006	-	-
Vanadium	V	< 0.010	-	-
Zinc	Zn	< 0.010	-	-

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File No: 3693E

RESULTS OF TESTING: (CON'T)

SAMPLE #		1	2	3
CLIENT SAMPLE I.D.		FLUME	GLACIER CREEK	TOBOGAN CREEK
SAMPLE # ON FIGURE 1		7	1	3
TOTAL METALS (mg/L)				
Aluminum	Al	0.016	0.17	0.070
Antimony	Sb	0.014	< 0.001	< 0.001
Arsenic	As	0.19	0.001	0.001
Barium	Ba	0.007	0.02	0.008
Beryllium	Be	< 0.003	< 0.003	< 0.003
Bismuth	Bi	< 0.5	< 0.5	< 0.5
Boron	B	0.04	< 0.01	< 0.01
Cadmium	Cd	0.006	0.003	0.005
Calcium	Ca	67.4	5.66	5.49
Chromium	Cr	< 0.001	< 0.001	< 0.001
Cobalt	Co	< 0.005	< 0.005	< 0.005
Copper	Cu	0.006	0.009	0.002
Iron	Fe	0.037	0.70	0.11
Lead	Pb	< 0.001	< 0.001	< 0.001
Magnesium	Mg	4.10	0.76	0.67
Manganese	Mn	0.023	0.053	< 0.003
Molybdenum	Mo	3.80	0.038	< 0.005
Nickel	Ni	0.006	< 0.005	< 0.005
Phosphorus	PO4	< 0.4	< 0.4	< 0.4
Potassium	K	0.43	0.42	0.22
Silicon	SiO2	9.26	6.24	4.85
Silver	Ag	< 0.001	< 0.001	< 0.001
Sodium	Na	10.4	1.64	1.46
Strontium	Sr	0.36	0.03	0.02
Tin	Sn	< 0.03	< 0.03	< 0.03
Titanium	Ti	< 0.006	0.021	< 0.006
Vanadium	V	< 0.010	< 0.010	< 0.010
Zinc	Zn	0.021	< 0.010	< 0.010
POLLUTANT TESTS (mg/L)				
Total Organic Carbon	C	16.	-	-
Total Phosphate	PO4	< 0.060	-	-
Ammonia Nitrogen	N	0.12	-	-
Total Kjeldahl Nitrogen	N	0.12	-	-
Total Phenolics as Phenol		< 0.001	-	-

Key to Table

mg/L = milligrams per liter
< = signifies that the parameter in question was NOT DETECTED. The number signifies the detection limit

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per Judi M. Mitchell, B.Sc.,
Chemist

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ENVIRONMENTAL INVESTIGATIONS OF POTENTIAL YORKE HARDY TAILINGS DISPOSAL SYSTEM

SECL 839

NOVEMBER 1981

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CLIMAX MOLYBDENUM CORP BC LTD

ENVIRONMENTAL INVESTIGATION OF POTENTIAL YORKE HARDY TAILINGS DISPOSAL SYSTEM

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CONTENTS

1. PURPOSE

This study examines the potential tailings storage scheme at the Yorke Hardy property at Smithers, British Columbia. The oject of the study is to suggest appropriate measures to ensure an environmentally sound tailings disposal system.

2. SITE DESCRIPTION

The Yorke Hardy property is located 5 miles north of Smithers, B C on the flanks of the Hudson Bay Mountain (see Figure 1). The property is an underground molybdenum prospect which could require tailings storage for up to 70 million tons.

2.1 SURFACE CONDITIONS

The potential tailings storage area is a saddle located at the 1700 foot elevation directly northeast of the proposed minesite. The saddle drains to the Toboggan Creek system. Glacier Gluch, which is a glacier fed creek, crosses the north side of the proposed site flowing north prior to joining the Toboggan Creek drainage system. At one time, Glacier Gulch flowed east and joined the Kathlyn Lake system. An old creek bed is still visible; however, water in the channel is limited to localized drainage immediately above Kathlyn Lake.

2.2 SUBSURFACE CONDITIONS

The soils in the tailings area consist of a glacial till overlain by a gravel fan associated with Glacier Gulch. High groundwater tables in he fan indicated high, but probably seasonally variable, groundwater recharge from the water source.