STATEMENT OF EXPENDITURE

See Claims

Klohn Leonorf

Inv. #	Description	$
CONSULTING FEES:		
10911135	Embankment Design Concepts	$ 202.50
10911206	Review Drilling Program and Assemble Hydrogeology units	6,731.04
10911248	Hydrogeology Field Work Report	31,793.72
10911323	Hydro Geology Report Preparation	$ 18,476.90
		$ 57,204.16
SUPPLIES AND SERVICES:		
10915023	North Central Pump Ground Water Well Preparation	$ 9,624.65
10911248	Dispersements and Equipment	4,276.17
10919042	North General Pump Ground Water Well Preparation 50%	19,117.09
10911323	Dispersements and Services	$ 3,829.61
		$ 35,847.52
	TOTAL KLOHN LEONORF	**$ 93,051.68**

Completed By: R. H. Banner, P. Eng.

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

Part 4 of 7

KLOHN LEONOFF
CONSULTING ENGINEERS

Our File: PB 5616 0101
WP 580

May 16, 1991

Continental Gold Corp.
1500 - 1055 Dunsmuir
Vancouver, British Columbia
V7X 1P1

Mr. J.D. Robertson, P.Eng.
Manager, Environmental Engineering

Mount Milligan Project
Hydrogeology Final Report

Dear Sir:

Regarding the terms of our contract and Purchase Order No. B390-0021 issued to Klohn Leonoff Ltd. by Continental Gold Corp., we are pleased to submit 12 copies of our final report "Mt. Milligan Hydrogeology".

In summary, we have concluded:

1. Most water infiltrating through the waste dumps will be intercepted by the collection ditches and will not enter the groundwater system. Of the small portion of infiltration entering the groundwater system, most will flow into the sediment ponds or the pit. Installed and proposed monitoring wells should detect the small amount of potentially contaminated seepage which does not report to the sediment ponds or the pit.

2. Pit inflows should be minimal.

3. The sediment ponds have potential leakage pathways to King Richard Creek and Alpine Creek but installed and planned monitoring wells should detect potential contamination, which would indicate the necessity for mitigative action.

4. The tailings impoundment has potential for significant leakage through sand and gravel zones past the recycle ponds but installed monitoring wells should detect potential contamination which would indicate the necessity for mitigative action.

We gratefully acknowledge the contributions of Continental Gold Corp. and their consultants in preparing this document. We have enjoyed working with you on this project.

If you have any questions or require further information, please call.

Yours very truly,

KLOHN LEONOFF LTD.

H.R. (Rod) Smith, P.Eng.
Project Manager

HRS:tp
Encl.

FINAL REPORT

PROJECT: MT. MILLIGAN HYDROGEOLOGY

LOCATION: 60 KM SOUTHWEST OF
MACKENZIE, BRITISH COLUMBIA

CLIENT: CONTINENTAL GOLD CORP.
(A SUBSIDIARY OF PLACER DOME INC.)

OUR FILE: PB 5616 0101 APRIL 1991

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLE OF CONTENTS
(continued)

TABLES

TABLE OF CONTENTS
(continued)

TABLES
(continued)

TABLE OF CONTENTS
(continued)

APPENDICES

DRAWINGS

1. INTRODUCTION

1.1 Background

Continental Gold Corp. is developing a copper-gold prospect at the Mt. Milligan property located southwest of MacKenzie, British Columbia (Drawing A-1001). The proposed mill would process nominally 60 000 tonnes of ore per day. The estimated life of the mine is 15 years.

This report is one of several reports to Continental Gold Corp. for inclusion in their Stage I submission to the British Columbia Ministry of Energy, Mines and Petroleum Resources. Others submitting reports include:

- Knight and Piesold Ltd. (geotechnical investigations for tailings and mill);
- Golder Associates Ltd. (waste dump and pit wall stability); and
- Hallam Knight Piesold Ltd. (environmental).

Klohn Leonoff has been retained to provide input on hydrogeologic issues for the project. This has included discussions on siting of mine elements, location of investigations, and methods of investigation.

The request for proposal is included as Appendix I.

1.2 Scope

The scope of this report comprises an evaluation of:

- baseline hydrogeology including groundwater flow rates, groundwater flow directions and groundwater quality;
- impacts of the hydrogeologic regime on the project, including preliminary calculations regarding water balance issues; and
- impacts of the project on the hydrogeologic regime.

This report is based primarily on investigations by Knight and Piesold, and Golder Associates. Available data were augmented by a pump test at the tailings impoundment site and a pressure profile in the northwest pit wall, both supervised by Klohn Leonoff.

The calculations are intended to only identify potential hydrogeologic concerns so that mitigative measures can be included in this stage of design. More complete hydrogeology models will probably be necessary during mine operation so that conformance to expected conditions can be verified and mitigative schemes implemented where necessary.

2. SITE DESCRIPTION

2.1 Physiography

The Mt. Milligan site lies within the northern border of the Nechako Central Plateau, an area of relatively low relief with only an occasional mountain rising 500 m to 800 m above the general plateau elevation (Drawing D-1002). Mt. Milligan is one of several low mountains on a northwest-trending ridge which bounds the western side of a lowland about 30 km wide and at a nominal elevation of about 1100 m. Elevations at the site range from about 900 m to 1500 m. Drainage from the property northward is along Rainbow Creek to the east-flowing Nation River, a tributary to the Peace River Arctic drainage system.

Vegetation consists of lodgepole pine in gravel-covered areas and spruce and balsam in till-covered areas. Extensive timber harvesting by the forest industry has removed virtually all the marketable timber from the minesite area. Timber harvesting in the tailings impoundment area is less extensive.

2.2 Climate[1]

The climate of the Nechako Plateau is characterized by short, cool summers and long, cold winters. The continental nature of the climate is indicated by the range of mean annual temperatures from -15°C to +12°C at the minesite. The rain shadow effect of the Coast Mountains results in annual precipitation of around 500 mm for the Nechako Plateau. An average of 275 mm of rainfall and 269 mm of snowfall (water equivalent) over 157 days per year has been recorded at Germansen Landing. Fort St. James receives an average of 290 mm rainfall and 204 mm snowfall (water equivalent) over 131 days per year, and annual snow pack averages 1295 mm.

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[1] Mount Milligan Project, Revised Stage I Hydrology, Sigma Engineering Ltd., 1991

An analysis of temperature, precipitation and snow pack data from long-term regional stations was used to develop climatic envelopes for comparison with data collected at the Mt. Milligan site (Sigma Engineering Ltd., 1990). This regional information was supplemented with temperature (twice daily recordings), precipitation, snow depth and snow pack data recorded at the Mt. Milligan exploration camp since February 1989.

On the basis of daily temperature data collected over 23 months at the minesite meteorology station, the mean annual temperature averaged 2.13°C. An extreme high of 32°C occurred in August 1990 and extreme low of -45°C occurred in January 1990.

Regionally, mean monthly temperatures range from -15°C in December and January to +14°C in July and August. Extreme temperatures of -45°C and +30°C are given in the regional envelope for December/January and July/August, respectively. Regionally, the months of May to September experience mean temperatures above 0°C, with average minimum to -5°C occurring in May and September and extreme minimums of -10°C possible in any of these five months.

Precipitation data collected at the minesite consisted of daily measurements of rainfall and snowfall which were initiated in February 1989 and have continued to date. Months with the highest total precipitation are December and January and months with the lowest total precipitation are April and May. The remaining months fall within a 2% range of each other in terms of total precipitation. Precipitation measurements collected at the minesite over 11 months in 1989 were approximately 15% below the estimated mean of 586 mm. However, for 1990, an extremely wet year, total precipitation exceeded 858 mm.

A snow depth recording station was established at the minesite on February 12, 1990 and daily measurements were recorded to April 17, 1990. The daily snow depth measurements starting in February 1990 ranged from 600 mm to 840 mm with an average depth of 780 mm to the end of March, after which snow depth began to diminish until the end of recordings on April 17, 1990.

Thirty-year normals data from 1951 to 1980 for the Topley Landing Climate Station (54° 49'N. Lat., 126° 10'W Long.) indicates that 367 mm of calculated lake evaporation occurs annually (Sigma Engineering Ltd., 1990). Using a factor of 7% decrease in lake evaporation for every 300 m of rise in elevation, lake evaporation at Mt. Milligan is expected to be 340 mm at 1000 m elevation and 300 mm at 1500 m elevation.

The mean annual evapotranspiration for the vicinity of the minesite is estimated to be 300 mm according to the Hydrological Atlas of Canada (Sigma Engineering Ltd., 1990).

3. HYDROGEOLOGIC INVESTIGATION

3.1 Introduction

Quantitative and qualitative hydrogeologic data have been extracted from all site investigations completed to date including:

- exploration and condemnation drilling;
- geotechnical drilling and test pitting;
- aggregate test pitting;
- observation well installations;
- monitoring well and piezometer installations;
- pump testing;
- air photo interpretation; and
- groundwater sampling.

3.2 Exploration and Condemnation Drilling

Eight hundred sixty-two exploration and condemnation drill holes were drilled during 1989 and 1990. The holes are located in the pit area, the waste dump areas, and Tailings Area C. Exploration holes in the pit area were drilled on 45° angles while the condemnation holes were vertical. Drawings D-1003 and D-1004 show the locations of the 1991 condemnation drill holes. The drill hole logs and plans showing all drill hole locations are on file at the offices of Continental Gold Corp.

Holes drilled in the southern area of the pit intersected artesian zones, some of which have continued to flow several months after drilling was completed. Table 3.1 summarizes the seven drill holes documented by Knight and Piesold personnel as flowing during the period of January to March 1990.

Table 3.1 - Summary of Flowing Exploration Drill Holes

DRILL HOLE	NORTHING	EASTING	ELEVATION
89-177	9 581.62	13 137.24	1 118.45
89-206	8 202.64	12 599.17	1 186.27
89-214	8 400.59	12 945.83	1 133.40
89-218	8 701.15	13 092.59	1 117.19
89-289	9 750.87	12 679.75	1 126.50
89-344	8 400.27	13 048.59	1 128.37
90-433	9 881.72	13 732.29	1 041.21

Sumps were established in the overburden as a drilling water supply in the southern pit area. Continental Gold Corp. geological staff report that significant quantities of water seeped into one of the sumps from the overburden in the southern pit area.

3.3 Test Pitting

Ninety test pits in the minesite area and 59 test pits in Tailings Area C were excavated by Knight and Piesold and Continental Gold Corp. (Drawings D-1003 and D-1004). The typical depth of the test pits was 3 m. Ten of the test pits in the minesite area and one in Tailings Area C reached bedrock. Test pit logs are included in the reports:

- Minesite Geotechnical Reference Data, Knight and Piesold, April 1991; and
- Tailings Area C Geotechnical Reference Data, Knight and Piesold, April 1991c.

The test pits were located at potential waste dump sites, the millsite, tailings storage areas, and the open pit area. Table 3.2 summarizes those test pits with seepage.

Table 3.2 - Summary of Test Pits with Seepage

AREA	PIT NUMBER	AQUIFER
Minesite	TP89-12	fluvioglacial
	TP90-50	alluvial deposit
	TPM 90-1	sandy till
	TPM 90-2	sandy silt, sand and clay till
	TPM 90-9	alluvial deposit
	TPM 90-10	alluvial deposit
	TPM 90-11	colluvium
	TPM 90-13	silty till
	TPM 90-14	colluvium + organic
	TPM 90-15	colluvium + organic
Tailings Area C	TP90-C5	sand and gravel
	TP90-C7	sand and gravel
	TP90-C9	sandy till
	TP90-C20	sand
	TP91-C12	silty till
	TP91-C14	sandy till
	TP91-C17	sandy till
	TP91-C18	silty till
	TP91-C33	sandy till
	TP91-C35	silty till
	TP91-C36	silty till
	TP91-C38	sandy till
	TP91-C39	silty till

3.4 Observation Well Installation

Knight and Piesold installed observation wells during their Preliminary, Phase 1, and Phase 2 investigations. The Preliminary program investigated Heidi Lake Valley and King Richard Creek, the Phase I program investigated the eastern part of the South Waste Dump and King Richard Creek, and the Phase II program investigated Tailings Area C. A combination of mud rotary and diamond coring drilling was used for the investigations. Observation wells, made of 3.75-cm (1.5-inch) diameter, PVC standpipes perforated over their full length and sealed at the surface, were installed in selected geotechnical drill holes. Table II-1 (Appendix II) summarizes the locations, depths, water elevations, and geology of the observation wells. Drawings D-1003 and D-1004 show the locations of the observation wells. The water level in an observation well reflects a combination of the range of piezometric heads in the aquifers exposed to the well. The water level in an observation well, therefore, represents a weighted average of piezometric heads in the intersected units.

Results of the investigations, which include drill logs, completion details, and groundwater levels, are presented in the Knight and Piesold and Golder Associates reports:

- Minesite Geotechnical Reference Data, Knight and Piesold Ltd., April 1991c; and
- Tailings Area C Geotechnical Reference Data, Knight and Piesold Ltd., April 1991.

3.5 Monitoring Well and Piezometer Installation

Knight and Piesold Ltd. completed geotechnical investigations of Tailings Area A, Tailings Area C, and Millsite Area C in March 1991. Golder Associates Ltd. completed a waste dump foundation investigation and pit wall investigation in February 1991. A combination of mud rotary and diamond coring drilling was used for the investigations. Monitoring wells and/or piezometers were installed in all drill holes. Klohn Leonoff

Ltd., Knight and Piesold Ltd., and Golder Associates Ltd. collaborated on the locations and completion details of the monitoring wells and piezometers.

Five-cm (2-inch) diameter, flush-threaded, schedule 40, PVC monitoring wells with 10-slot or 20-slot screens were installed in most drill holes. The monitoring zones were backfilled with silica sand and sealed with a bentonite plug. Most wells were grouted back to surface with a cement-bentonite slurry. Most installations contain only one standpipe per drill hole.

In holes where a monitoring well was not installed, a 1.9-cm (3/4-inch) diameter piezometer was installed. The monitoring zone was again backfilled with silica sand and sealed with a bentonite plug. Most piezometers were grouted back to surface with a cement-bentonite slurry. The tip consists of a porous plastic Casagrande-type filter or 1.9-cm diameter PVC pipe slotted with a hacksaw. Some piezometers are installed in groups to determine vertical directions of groundwater flow.

The monitoring wells and piezometers have been installed in overburden and bedrock in the pit area, north and south waste rock areas, the till plain east of the minesite, and Tailings Area C. Drawings D-1003 and D-1004 show the locations of the monitoring wells and piezometers. Results of the investigations, which include drill logs, completion details, and groundwater levels, are presented in the Knight and Piesold and Golder Associates reports:

- Minesite Geotechnical Reference Data, Knight and Piesold Ltd., April 1991c;
- Tailings Area C Geotechnical Reference Data, Knight and Piesold Ltd., April 1991; and
- Draft Report to Placer Dome Inc. on Open Pit and Waste Dump Stability Investigations for the Mt. Milligan Project, Golder Associates Ltd., April 1991.

Table II-2 (Appendix II) summarizes the coordinates, elevations of the monitoring zones, diameters, lithology of the layers monitored, and groundwater elevations for the monitoring wells and piezometers.

The monitoring wells and piezometers were developed by a contractor experienced in drilling, well development, and groundwater sampling. All wells and piezometers contained silt and drilling fluids at the start of development but most wells cleaned up by the end of development (North Central Pump and Drilling Ltd., April 1991).

3.6 Drill Stem Packer Testing

Knight and Piesold conducted constant head, rising head, and falling head, wireline-packer permeability tests during drilling in each phase of their investigations. Details of the test results are contained in the reports:

- Minesite Geotechnical Reference Data, Knight and Piesold Ltd., April 1991c; and
- Tailings Area C Geotechnical Reference Data, Knight and Piesold Ltd., April 1991.

Appendix III summarizes the results of the tests.

Klohn Leonoff supervised drilling of drill hole KL91-1, a 137-m (450-ft), HQ diamond core hole drilled on an azimuth of 270° and a dip of 62° in the northwest corner of the pit (Drawing D-1003). The drill hole log, including geologic descriptions and documentation of RQD, recovery, and penetration rate is included as Appendix IV. The hole was drilled to obtain pressure and permeability data vs. depth in the wall of the pit. The data were considered in the calculation of pit inflows and impacts on the groundwater regime surrounding the pit. A through-the-bit packer system was used to shut in a test zone at 6-m intervals, and the pressure response with time was recorded. In cases where a stable pressure was attained during the shut-in test, a pressure was assigned to the zone. A compilation of the pressures gave a pressure profile with depth (Appendix V). The results of the investigation are discussed in Section 5.1.4.

3.7 Rising and Falling Head Tests

Rising head or falling head permeability tests have been performed in some monitoring wells and piezometers. The results are preliminary because the tests were conducted prior to well development and are not, therefore, included in this report. Well development revealed that many monitoring wells and piezometers contained significant quantities of slurry.

Rising head permeability tests will be carried out by Continental Gold Corp. personnel during May 1991 under the direction of Klohn Leonoff Ltd. The test results will be analyzed by Klohn Leonoff and reported at a later date.

3.8 Pump Test

Knight and Piesold installed an 11.4-cm (4.5-inch) diameter pumping well in drill hole KP91-C12 near the South Embankment of the tailings impoundment. The well was completed with 3.0 m of 40-slot, machine-cut, PVC slotted screen in a sand and gravel aquifer (Drawings X-1012 and X-1013).

The well was developed for 24 hours (March 16-17, 1991) and pumped at 100 USgpm for 27 hours (March 17-18, 1991) by North Central Pump of Prince George, B.C. under the supervision of Klohn Leonoff personnel. Recovery was recorded for three hours. The water levels in observation wells 90-676, KP91-C10, and KP91-C13 were recorded during pumping and recovery. The locations of all wells are shown on Drawing D-1004 and the completion details are included in the Knight and Piesold document "Tailings Area C Geotechnical Reference Data."

Logarithmic and semi-logarithmic plots of drawdown vs. time are included as Appendix VI. Maximum drawdown of 4.5 cm was recorded in KP91-C13, 77.5 m from the pumped well. At the end of three hours of recovery measurements, full recovery was achieved in KP91-C10, 50% in 90-676 and 60% in KP91-C13. The majority of the drawdown recorded in the pumping well was due to head losses through the screen.

The estimated transmissivity, based on a Jacob calculation, is 4×10^{-2} m^2/s. The estimated hydraulic conductivity is 4×10^{-1} cm/s with a nominal aquifer thickness of 10 m.

3.9 Air Photo Interpretation

Karl Ricker, FGAC was retained by Continental Gold Corp. to conduct air photo interpretation and compile surficial geology maps of the minesite and tailings impoundment sites. The maps are included in the reports:

- A Preliminary Appraisal of the Surficial Geology of the Mt. Milligan Mine Site with Special Reference to Tailings Impoundment Area "A", Karl E. Ricker, FGAC, January 1991; and
- A Preliminary Appraisal of the Surficial Geology of the Mt. Milligan Mine Site with Special Reference to Tailings Impoundment Area "C", Karl E. Ricker, FGAC, March 1991.

Discussions with Mr. Ricker have assisted Klohn Leonoff in understanding the surficial geology. Locations of springs interpreted from air photos are shown on Drawing D-1003.

3.10 Groundwater Sampling

A baseline groundwater sampling program was initiated in December 1989. Samples were collected from observation well standpipes installed by Knight and Piesold Ltd. in December 1989, March 1990, June 1990 and August 1990. The standpipes are 3.8-cm

(1.5-inch) diameter and are perforated over their full length. Completion details are included in the Knight and Piesold reports:

- Minesite Geotechnical Reference Data, Knight and Piesold, April 1991c; and
- Tailings Area C Geotechnical Reference Data, Knight and Piesold, April 1991.

Drawings D-1003 and D-1004 show the locations of the standpipes used for groundwater sampling so far. With the exception of DH90-695 and DH90-711, which are located in Tailings Area C and sampled only in August 1990, all groundwater samples were collected in the minesite area. Field pH, conductivity and temperature were not recorded at the time of sample collection.

Analytical Services Laboratory of Vancouver analyzed the samples for:

- standard physical properties;
- major ions;
- nutrients;
- total metals;
- total cyanide; and
- dissolved metals.

Appendix VII summarizes the results of the analyses which are complete only for the June 1990 sampling round.

Additional monitoring wells were installed during the 1991 drilling program (as described in Section 3.5), 30 of which have been selected for baseline sampling and analysis. Continental Gold Corp. personnel will sample the 30 wells monthly for one year to establish the groundwater chemistry cycle. Based on the results of these analyses, a sampling program will be designed.

Continental Gold Corp. personnel will collect the groundwater samples in accordance with sampling guidelines developed by Klohn Leonoff. The guidelines comment on:

- equipment storage;
- well purging;
- equipment cleaning;
- field parameter measurement;
- sample transport; and
- field spikes, equipment blanks, and trip blanks.

The sampling guidelines are included as Appendix VIII.

Table 3.3 summarizes the monitoring wells selected for groundwater monitoring (Drawing D-1002).

Table 3.3 - Summary of Monitoring Wells for Groundwater Sampling

STRUCTURE	MONITORING WELL	PURPOSE
North Waste Dump	to be installed	background water quality
	GA91-9 and 10	background water quality prior to start-up
	to be installed	seepage to Swiss Cr.
	to be installed	seepage to North Sediment Pond
	KP91-A8 and A9	seepage to Rainbow Cr.
North Sediment Pond	to be installed	potential seepage through esker gravels in right abutment
South Waste Dump	GA91-5 and 6	background water quality
	GA91-3	seepage to open pit
	GA91-7 and 8	seepage to Minesite Sediment Pond (early in mine life).
	KP91-A12 and A13	seepage to Minesite Sediment Pond
	to be installed	seepage to King Richard Cr. past Minesite Sediment Pond
	KP91-A22	seepage to Rainbow Cr.
Minesite Sediment Pond	KP91-A25 and an additional well to be installed	seepage to King Richard Cr. through sand layers located in right abutment
	KP91-A26	seepage to King Richard Cr. through valley alluvium
	KP91-A1, A4, and A24	seepage to King Richard Cr.
Tailings Area C Main Embankment	KP91-C1 and C5	background water quality
	KP91-C2 and C4	seepage through sand layers
	KP91-C3 and C6	seepage through confined sand and gravel
Tailings Area C Saddle Embankment	KP91-C8 or a well to be installed	seepage through embankment and foundation to Heather Lk.
Tailings Area C South Embankment	KP91-C9	background water quality
	KP91-C10 and C12	seepage through valley sand and gravel
Water Storage Dam	KP91-W1	background water quality

4. GEOLOGY

4.1 Regional Geology[2]

Regional geology is roughly controlled by northwest-southeast trending faults (Drawing A-1005). The two major faults are the Pinchi fault zone about 60 km to the west of the site and the Rocky Mountain Trench fault zone, about 60 km to the east. This faulting trend has brought a variety of rock types into contact in the vicinity of the site.

Rocks of the Proterozoic Wolverine Metamorphic complex are extensive immediately to the west of the Rocky Mountain Trench and are also reported in the mill and tailings areas. Rocks of the Permian Cache Creek group are separated from the site by the Pinchi fault zone to the west and have been reported north of the Nation River.

The Mt. Milligan property lies within the regionally extensive early Mesozoic Quesnel Belt. The rocks in his belt represent a number of volcanic centres that were intruded by stocks of monzonite, syenite and diorite approximately 180 million years ago. Throughout the Quesnel Belt, several of these intrusions are the sites of significant porphyry-style copper-gold mineralization (e.g. Copper Mountain, Afton and Mt. Polley).

In the Mt. Milligan area, the Takla Group of volcanic rocks is dominated by a thick sequence of submarine augite and hornblende porphyritic flows and related pyroclastics of intermediate composition. These volcanic rocks form a tilted, panel-like succession with moderate to steep easterly dips. The Mt. Milligan intrusions comprise biotite monzonite, quartz monzonite, monzonite porphyry, diorite and gabbro compositions. Many of the stocks have intruded along linear trends which are interpreted to reflect fault zones.

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[2] Interim Geological Report, Mt. Milligan Project, Rebagliati Geological Consulting Ltd., April 1990.

Between the minesite and the millsite lies a northwest trending "depression" which may represent a graben, the west side of which is formed by the Great Eastern Fault. Within this graben, sedimentary and volcanic rocks, possibly Tertiary in age, have been intersected by some drill holes.

The region has been extensively glaciated by numerous ice advances. The resulting assemblage of alluvial, colluvial, lacustrine and glacial sediments of various ages is often heterogeneous and complex. Overburden thicknesses range up to 60 m.

4.2 Site Geology - Minesite

Bedrock in the minesite area comprises the Takla Group and Tertiary sedimentary and volcanic sequences. Rocks associated with the Takla Group were encountered west of the Great Eastern Fault and east of the Great Eastern Fault where King Richard Creek meets Meadows Creek.

In the graben on the east side of the Great Eastern Fault, the geology is complex with the presence of volcanic flows, sedimentary point bar deposits and glacial till units which underlie volcanic flows. Material sufficiently hard to be classified as bedrock was not encountered in some holes despite drilling depths of up to 160 m. Interpolation of geologic features between boreholes is difficult.

Significant geological features of the minesite are as follows (bracketed letters represent features on Drawings X-1006 to X-1009):

- The Mt. Milligan ridge (a) (Drawing X-1008) and the pit area are comprised of andesite and basalt flows, tuffs, breccias and agglomerates from the Upper Triassic and Takla Groups. Argillite and conglomerate are associated with the same Mesozoic period. The majority of the mine area, however, is just east of the ridge, which indicates that the mineralized rock may be less resistant to erosion.

- The Great Eastern Fault crosses the mine area (b) (Drawings D-1003, X-1006 and X-1008). The site geology is dominated by related strong northwest and lesser northeast structural trends. The mineral deposits are localized in a zone of extension characterized by these northwest trending fault and fracture systems.
- To the east of the mine area and the Great Eastern Fault is a graben structure infilled with tertiary sandstone, siltstone and basalt (c) (Drawings X-1006 and X-1007). Little is known of the distribution of the Tertiary rocks.
- Most of the pit area and most of the area which extends to Rainbow Creek is covered by intraglacial and interglacial deposits which form a "till" plain. The overburden probably consists of basal tills and ablation tills (d), glaciofluvial and inter-glacial deposits (e) (Drawings X-1006 and X-1009). A large sand and gravel esker swarm overlies the till plain north of the minesite (f) (Drawing X-1009) and a veneer of sand and gravel (g) overlies the balance of the till plain.
- Rainbow Creek and its tributaries have eroded channels into the till plain where the most recent alluvium has been deposited (h)(Drawings X-1006 and X-1008).

4.3 Site Geology - Tailings Area C

Tailings Area C is located on the Wolverine complex, which consists of micaceous, chloritic and garnetiferous schists, quartzite, limestone, and minor granitic gneiss and pegmatite.

At the Main Embankment, the overburden sequence shown on Drawings X-1010 and X-1011 consists of:

- Over-consolidated basal till on rock with a thickness of 0 to 30 m. The bottom of the bedrock channel is at elevation 900 m.
- Over-consolidated lacustrine silt up to elevation 1000 m. The lacustrine silt appears to change facies laterally, possibly a reflection of colluvial and alluvial aprons and fans. Drill holes

have intercepted a sand and gravel bed within the silt with a thickness of about 10 m.

- Overlying the silt is a very dense pre-glacial sand and gravel sequence with a thickness ranging from 0 to 40 m. This sand and gravel unit forms a terrace-like feature on both sides of Limestone Creek Valley. Although not encountered in every drill hole, the sand and gravel is probably adequately prevalent to form a hydrogeologic unit for a significant distance upstream.
- On the top of the sand and gravel terrace is a thin layer of till-like material.
- The modern valley is excavated through these materials to elevation 980 m in the silt.
- Recent alluvial, colluvial and flood plain sediments have been deposited on the present valley floor to depths of 5 m. The current ground elevation of the valley floor at the damsite is 980 m.

At the South Embankment site, the overburden sequence shown on Drawings X-1012 and X-1013 consists of:

- glacial till up to elevation 990 m;
- a sand and gravel zone up to elevation 1000 m; and
- an upper layer of till-like material or loose silt, 10 m thick in places.

5. BASELINE HYDROGEOLOGY - MINESITE

5.1 Hydrogeologic Units

5.1.1 Introduction

The predominant hydrogeologic aquifers in the mine area are:

- alluvial deposits;
- glacial deposits;
- faults and fractures in the Takla volcanics; and
- Tertiary basalt.

Typical sections identifying locations of these units are shown on Drawings X-1006 to X-1009.

5.1.2 Alluvial Deposits

Sand and gravel alluvium deposited in King Richard Creek is probably the result of stream washing of surrounding glacial deposits. Although no permeability tests have been performed, the hydraulic conductivity, based on the description of drill samples and the underfit of the present King Richard Creek, is probably about 10^{-2} cm/s. The approximate thickness of the alluvium is 5 m and the approximate width is 300 m.

5.1.3 Glacial Deposits

Superimposed on the valley bottom bench-land in the vicinity of drill hole GA91-10 is a broad esker swarm which courses out of upper King Richard Valley, then turns across the bench-land to terminate along the south wall of Rainbow Creek Valley. Average relief on the 500-m-wide esker swarm is 20 to 25 m. Comprised of sand and gravel deposits, the eskers are probably very permeable. The minimum thickness of an esker is probably 3 m to 8 m as revealed in drill holes GA91-9 and GA91-10. The base of the esker swarm is formed by the till plain which dips at about 1% to 2% to the east toward Rainbow Creek.

Surficial sands and gravels up to 5 m thick overlie the remainder of the till plain. This material, like the eskers, will probably have bulk hydraulic conductivities of 10^{-3} to 10^{-1} cm/s.

Glacial tills represent a major component of the overburden. Clayey, silty, sandy and gravelly tills are encountered up to 60 m thick in some locations (BH 90-426, 90-440). The composition of a till layer can vary from silty to gravelly with depth. Hydraulic conductivities of the glacial till range from 10^{-8} to 2 X 10^{-6} cm/s according to wireline packer tests and falling head permeability tests performed at depths ranging from 14.9 to 37.5 m. Table 5.1 summarizes the results of the tests.

Table 5.1 - Summary of Hydraulic Conductivity in Glacial Till

CONSTANT HEAD PACKER TEST					
HOLE NO.	ELEVATION (m)		LENGTH (m)	HYDRAULIC CONDUCTIVITY* (cm/s)	GEOLOGY
	From	To			
90-440	1 035.0	1 032.6	2.4	2.3×10^{-7}	gravelly glacial till
90-440	1 032.0	1 029.5	2.5	8.3×10^{-7}	sandy glacial till
90-446	1 058.5	1 056.0	2.5	$<1.5 \times 10^{-7}$	dense clayey glacial till
90-451	1 037.1	1 034.7	2.4	$<5 \times 10^{-8}$	gravely till
90-451	1 034.1	1 031.6	2.5	$<5 \times 10^{-8}$	gravely till
90-459	1 005.1	1 002.6	2.5	$<6 \times 10^{-8}$	gravely till with some clay
90-459	999.0	996.5	2.5	$<4.2 \times 10^{-8}$	gravely till with some clay

FALLING HEAD PACKER TEST					
HOLE NO.	ELEVATION (m)		LENGTH (m)	HYDRAULIC CONDUCTIVITY* (cm/s)	GEOLOGY
	From	To			
KP91-A2	1 017.1	1 009.5	7.6	8×10^{-8}	gravelly till
KP91-A4	1 021.2	1 000.5	18.9	2×10^{-6}	gravelly till

* For a complete listing of hydraulic conductivity tests, see Appendix III.

Inter-till zones of relatively permeable sand and gravel and relatively impermeable clay less than a metre to a few metres thick were encountered. The permeable layers could act as drains or confined aquifers. The inter-till sand and gravel units were encountered in drill holes on both sides of King Richard Creek. Similar units are expected in the pit and waste dump areas. The lateral extent and continuity of these units are uncertain. For calculation purposes, these units are modelled as discrete layers with hydraulic conductivities of 10^{-3} cm/s.

A very dense glacial till unit was encountered under a basalt flow in drill hole 90-446 at a depth of 115 m.

5.1.4 Bedrock

Wireline packer tests performed in the Takla volcanics reveal hydraulic conductivity values ranging from 10^{-8} to 10^{-3} cm/s. Appendix III summarizes all packer test results. The first few metres of bedrock are weathered and usually have hydraulic conductivities between 10^{-6} and 10^{-5} cm/s whereas deeper, more competent rock usually has calculated hydraulic conductivities less than 10^{-7} cm/s. Fractured or highly fractured zones typically have hydraulic conductivities which range from 10^{-5} to 10^{-4} cm/s:

- In Heidi Lake Valley, hydraulic conductivities from 10^{-5} to 10^{-4} cm/s were measured on the east end of the valley down to elevation 1054 m. The hydraulic conductivities estimated for the west end of the valley were less than 10^{-6} cm/s.
- Along King Richard Gully and north of the open pit, hydraulic conductivities between 10^{-7} and 10^{-6} cm/s were measured except in the first 5 m of weathered bedrock or in faulted/fractured zones. Hydraulic conductivities of the heavily fractured zones were between 10^{-5} and 10^{-4} cm/s along lengths ranging from a few metres to 50 m.

Drill hole KL91-1, tested by Klohn Leonoff, penetrated the wall rock in the northwest corner of the pit (Drawing D-1003). In general, rock quality was fair to poor down to 120 m where the rock was noticeably more competent. Joints were infilled with calcite chlorite, pyrite and clays. A significant length of the drill hole encountered sheared and crushed rock. The test results indicated that the majority of the drill hole was of low permeability. Zones of higher permeability were:

- El. 1164.2 m to 1162.9 m, calculated K = $3 X 10^{-8}$ cm/s;
- El. 1139.6 m to 1133.4 m, calculated K = $8 X 10^{-9}$ cm/s; and
- El. 1074.0 m to 1072.7 m, calculated K = $3 X 10^{-9}$ cm/s.

The relatively low permeabilities are substantiated by the relatively high piezometric heads encountered in the drill hole, which would otherwise not be anticipated in a high permeability environment close to a valley wall (Appendix V). The calculated permeabilities in this drill hole were significantly lower than those calculated in other drill holes in the Takla Volcanics.

Bedrock in the mine area is, therefore, generally expected to have low to moderate permeabilities although fractures, especially near fault zones, may have higher permeabilities. For purposes of this assessment, the assumed hydraulic conductivity of the Takla Volcanics is 10^{-6} cm/s. Locally, in open fractures and near the bedrock surface, the assumed hydraulic conductivity is 10^{-4} cm/s.

Little is known about the permeability adjacent to the Great Eastern Fault. However, the hydrogeology of faults generally includes a higher permeability in brittle rocks adjacent to the fault and lower permeability gouge material within the fault. A hydraulic conductivity of 10^{-4} cm/s adjacent and parallel to the fault is, therefore, assumed in this area.

Within the Tertiary rocks, the basalt flows will probably have relatively high hydraulic conductivities. The lateral distribution of the basalt is not known but is assumed to extend east of the Great Eastern Fault. Limited testing indicates that the hydraulic conductivity of the basalt is 5 X 10^{-5} cm/s. Based on experience at other sites, the bulk hydraulic conductivity of the basalt could approach 10^{-3} cm/s.

5.1.5 Summary of Hydrogeologic Parameters

A summary of nominal thicknesses and hydraulic conductivity values is presented in Table 5.2.

Table 5.2 - Summary of Minesite Hydrogeologic Parameters

UNIT	LOCATION	NOMINAL THICKNESS (m)	HYDRAULIC CONDUCTIVITY (cm/s)	
			RANGE TESTED	ASSIGNED VALUE
Alluvium	King Richard Creek	5	-	1 x 10^{-2}
Surficial Gravels (including esker swarm)	Till Plain	5	-	1 x 10^{-2}
Till-Like Deposits	Till Plain	30	1 x 10^{-8} - 2 x 10^{-2}	5 x 10^{-7}
Inter-Till Sand and Gravel	Till Plain	5	-	1 x 10^{-3}
Takla Volcanics	General	-	< 1 x 10^{-8} - 1 x 10^{-3}	1 x 10^{-6}
	Great Eastern Fault		1 x 10^{-7} - 1 x 10^{-3}	1 x 10^{-4}
	Heidi Lake Valley High	20	1 x 10^{-5} - 1 x 10^{-4}	1 x 10^{-4}
Basalt Flow	King Richard Creek	20	5 x 10^{-5}	1 x 10^{-3}

5.2 Piezometric Head Distribution

The water table is generally a subdued image of site topography with the water level generally deeper on ridges and shallower on valley floors. This is modified by local permeability variations and infiltration capacity. The following observations have been reported:

- The standpipes installed in drill hole GA91-7 (Drawing X-1009) at elevation 1065.3 m and 1094.5 m, both in glacial till, indicate a downward gradient.
- In the southern part of the proposed open pit area, drill holes 89-177, 89-206, 89-214, 89-218, 89-289, 89-344, and 90-433 were reported flowing during the period, January 25 to March 3, 1990, indicating an upward gradient from the bedrock.
- The monitoring well installed in drill hole KP91-A12 (Drawing X-1006) in the basalt flow at elevation 1020 m reveals a water level above ground level indicating artesian conditions.
- The monitoring wells installed in drill holes GA91-9 and GA91-10 indicate a downward gradient.

All piezometric heads are based on readings taken prior to well development (Section 3.5). The head distribution may need to be re-evaluated with readings taken after well development. Seasonal variations in the head distribution should also be examined.

5.3 Flow Systems

5.3.1 Introduction

Areas in the vicinity of King Richard Creek and Alpine Creek tributaries are drained directly to the nearest creek. The flow systems at the minesite can otherwise be divided into three areas:

- Mt. Heidi South;
- Till Plain (east and west of King Richard Creek); and
- Mt. Heidi North.

5.3.2 Mt. Heidi South

Along Section B, a typical southwest-northeast section of the minesite, the hydrogeologic regime can be characterized as follows (bracketed numbers represent features on Drawings X-1007 and X-1008):

- Precipitation in recharge zones (1) causes overland runoff, percolation into the top aquifer and infiltration through the underlying aquitard.
- Bedrock which underlies the glacial till is under artesian pressure in the south end of the pit area as indicated by the flowing exploration drill holes (Table 3.1). Bedrock which underlies the till southeast of the pit area may also be under artesian pressure but documentation of flowing drill holes is not available.
- The till plain at the foot of Mt. Heidi South is a recharge zone (2) as indicated by the downward gradients of about 0.4 in GA91-3 and GA91-7 (Drawing X-1009).
- As shown by seepage observed in test pits (Table 3.3), water seeps horizontally through the top aquifer which consists of glacial sand and gravel before discharging to King Richard Creek (3).
- Inter-till sand and gravel or fractured bedrock zones can drain a significant amount of water to King Richard Creek (4). A small quantity will bypass King Richard Creek and discharge directly to Rainbow Creek (5). No assumption can be made on how the faulted zone and the adjacent colluvial and disturbed material interfere with the flow pattern (6).
- The basalt flow intersected by drill holes along King Richard Creek is an aquifer (7). Drill hole data indicate that the basalt probably does not extend down King Richard Creek under the Minesite Sediment Pond Dam.

5.3.3 Till Plain

- The top of the glacial till has a gentle slope dipping northeast. Streams in the sand and gravel reflect this dip direction. King Richard Creek has eroded a valley into the till plain which attracts groundwater from the southwest and the northeast. A piezometric mound has developed between King Richard Creek and Rainbow Creek (Drawings X-1006 and X-1007).

- The esker swarm is a recharge zone as indicated by water levels measured in standpipes GA91-9 and GA91-10. Due to the dip of the top of the till layer, water recharged through the esker swarm is mostly drained northeast towards Rainbow Creek.

- Inter-till layers in the till plain also act as drains and carry water to King Richard Creek, Meadows Creek, and Rainbow Creek.

5.3.4 Mt. Heidi North

- The top of the glacial till has a gentle slope dipping northeast. This slope explains the general trend of surface water flow in this direction and in particular at the foot of Mt. Heidi North where the groundwater flows towards Alpine Creek tributaries rather than towards King Richard Creek (Drawing D-1003). A piezometric mound east of Heidi Lake valley, where the southeast shoulder of Mt. Heidi North and the northeast shoulder of Mt. Heidi South meet, indicates that groundwater flows westward in Heidi Lake valley, and eastward in King Richard Creek valley (Drawing X-1006).

5.4 Groundwater Balance

The two recharge zones close to the pit area are Mt. Heidi South and Mt. Heidi North. The Mt. Heidi South recharge zone covers approximately 600 ha which would infiltrate 5 x 10^5 m^3/yr (15 L/s). The Mt. Heidi North recharge zone covers approximately 120 ha which would infiltrate 9 x 10^4 m^3/yr (3 L/s). The infiltration calculations are based on the assumptions:

- annual precipitation of 586 mm and annual evapotranspiration of 300 mm (Sigma Engineering Ltd., 1991);
- 70% overland runoff net of evapotranspiration; and
- the remainder, about 86 mm, is available for infiltration.

The complete infiltration volume flows through the identified high permeability units, the surficial sand and gravel and the inter-till sand and gravel, and discharges to King Richard Creek, Alpine Creek, and Swiss Creek. Table 5.3 summarizes the flows in the surficial and inter-till aquifers.

Table 5.3 - Summary of Flows in Surficial and Inter-till Aquifers

RECHARGE ZONE	DISCHARGE ZONE	AQUIFER	THICKNESS (m)	FLUX (L/s)
Mt. Heidi South	King Richard Creek	Surficial	2	5
		Inter-till layers	4	10
Mt. Heidi North	Alpine Creek	Surficial	2	2
		Inter-till layers	4	0.5
	King Richard Creek	Inter-till layers	4	0.5
Total				18

An additional flow of up to 0.1 L/s can be expected in the till and bedrock in this area.

The esker swarm forms the second-largest groundwater recharge area in the mine area. With a total covered area of 150 ha, the estimated rate of water percolation through the eskers is 400 000 m^3/yr (13 L/s).

The downward gradients measured by the monitoring wells in the esker swarm indicate downward groundwater seepage. Based on a hydraulic conductivity of 5 x 10^{-7} cm/s for the underlying till and an average gradient of 0.5, the total volume of water flowing to the inter-till layer is estimated to be 1.3 x 10^{5} m^{3}/yr (4 L/s).

The remaining 2.7 x 10^{5} m^{3}/yr (9 L/s) flows along the till layer at the base of the eskers towards Rainbow Creek.

5.5 Hydrochemical Characteristics

Based on chemical analysis of groundwater collected from nine observation wells in December 1989, June 1990 ,and August 1990, the water in the pit area is typically:

- pH neutral (between 6.3 and 7.9);
- calcium carbonate to calcium sulphate;
- high in suspended solids (40 to 9,000 mg/L) (due to insufficient well development);
- low to moderately high in dissolved solids (60 to 480 mg/L); and
- low in dissolved heavy metals (< 0.01 mg/L).

Notable exceptions to the low heavy metals were DH89-383, DH90-435, and DH90-459 which showed levels of iron and/or copper an order of magnitude higher than the other samples. Some of the samples had parameters which were above allowable receiving water concentrations. However, the high metal concentrations may have resulted from lack of filter pack and well development. Appendix VII summarizes the analytical results in tables and summarizes the relative composition of the major ions on Piper plots. The hydrochemical characteristics of the groundwater can be discussed more completely when the one-year monthly baseline groundwater sampling program described in Section 3.10 has been completed.

6. BASELINE HYDROGEOLOGY - TAILINGS AREA C

6.1 Hydrogeologic Units

6.1.1 Introduction

The five predominant hydrogeologic units in Tailings Area C from oldest to youngest are:

- bedrock;
- basal till;
- lacustrine silts and sands;
- sand and gravel; and
- upper till.

6.1.2 Bedrock

Bedrock identified in Tailings Area C comprises two types of rock:

- gabbro/andesite; and
- schist and gneiss.

The gabbro/andesite formations were found mostly in the area of the South Embankment and along the northwest trending ridge on either side of Heather Lake (Drawing D-1002). The schists and gneisses were found mostly in the area of the abutment of the Main Embankment.

Depth to bedrock in the valley bottoms is greater than on the valley slopes and greater than along Heather Lake ridge. Depth to bedrock in the valley bottom is nominally 30 m at the South Embankment and 60 m at the Main Embankment. Depth to bedrock along Heather Lake ridge and on the valley walls is nominally 10 m.

The upper zone of the bedrock is sometimes soft, crumbly, iron-stained, and has clay-infilling along fracture surfaces. The thickness of this zone varies from 3 m to more than 13 m. In some locations, the upper zone of the bedrock is more fractured than the lower zone but is not softer, which results in higher permeability.

The hydraulic conductivity of the bedrock depends on the condition of the rock. Available data do not allow correlation of hydraulic conductivity with rock type. The constant head packer permeability test results can be divided into three bedrock classifications:

- bedrock weathered zone;
- fractured bedrock; and
- competent bedrock.

Appendix III summarizes the test results. Table 6.1 summarizes representative hydraulic conductivities for each bedrock classification.

Table 6.1 - Summary of Tailings Area C Bedrock Hydraulic Conductivities

BEDROCK CLASSIFICATION	NUMBER OF TESTS	HYDRAULIC CONDUCTIVITY (cm/s)	
		RANGE	ASSUMED BULK VALUE
Weathered Zone	4	$<10^{-8}$ to 10^{-6}	10^{-8}
Fractured Bedrock	12	10^{-8} to 10^{-5}	10^{-6} to 10^{-5}
Competent Bedrock	3	$<10^{-8}$ to 10^{-7}	10^{-8}

6.1.3 Basal Till

Very dense basal till, nominally 10 m thick, overlies bedrock in the valley bottoms and along the northwest trending ridge through Heather Lake (Drawings X-1010 to X-1013). The thickness of the basal till ranges up to 35 m in places. The composition of the till ranges from silty to sandy. The results of two constant head wireline packer tests indicate a range of hydraulic conductivity from 10^{-7} to 10^{-6} cm/s.

6.1.4 Lacustrine Silts and Sands

A sequence of lacustrine silts and fine sands up to 60 m thick was deposited in the area of the Main Embankment (Drawings X-1010 and X-1011). Drill holes in Limestone Creek valley intersected the lacustrine deposits over a distance of 800 m. Drill hole KP91-C6 downstream of the Main Embankment and drill holes at the South Embankment did not intersect the lacustrine deposits. Minor lacustrine deposits were encountered in drill hole KP91-W3 on the right abutment of the water storage dam. The deposit is about 1.5 km wide and pinches out at the valley walls. The detailed stratigraphy of this deposit is difficult to delineate, probably because of the distribution of lateral alluvial and colluvial deposits interbedded with the lacustrine deposits. The results of three wireline packer tests indicate the permeability of this unit ranges from 10^{-8} to 10^{-7} cm/s.

6.1.5 Sand and Gravel

Three glaciofluvial sand and gravel units were identified in Tailings Area C. A sand and gravel unit confined within the lacustrine silts and sands nominally 8 m thick and 500 m wide was intersected in four drill holes over 1.5 km along Limestone Creek valley near the Main Embankment (Drawings X-1010 and X-1011). The result of a constant head Hvorslev analysis on flowing well KP91-C3 indicates that the hydraulic conductivity of the unit is 4×10^{-3} cm/s.

A sand and gravel terrace was encountered on the valley walls near the Main Embankment (Drawing X-1010). The sand and gravel intersected in drill holes near the Main Embankment is nominally 10 to 20 m thick and overlays lacustrine silts and sands. Although not all drill holes encountered a clean deposit, the nature and location of these deposits may indicate that the terrace contains sand and gravel over a significant length of Limestone Creek valley. Based on topographic interpretation, the sand and gravel terrace probably extends southeast along Limestone Creek valley along the valley walls. The composition of the terrace feature varies with location.

The sand and gravel intersected in drill holes near the South Embankment is a valley-bottom deposit with a confirmed lateral extent of at least 600 m and a nominal thickness of 10 m (Drawings X-1012 and X-1013). The deposit is nominally 200 to 250 m wide where it pinches out against the valley walls. The hydraulic conductivity of the sand and gravel near the South Embankment is about 4 x 10^{-1} cm/s (based on the 27-hour pump test described in Section 3.8).

Another sand and gravel deposit was identified southwest of Heather Lake (Drawings D-1004 and X-1012). Limited drill hole data preclude delineation of the lateral extent of the unit but a combination of the available drill hole data and topographic relief suggests the deposit could be 2 km long and nominally 500 m wide by 20 m thick. The presence of a southwest-trending stream leading out of the draw close to Heather Lake suggests that the groundwater gradient in the sand channel is slightly less than the topographic gradient, which is 0.01 (Drawing D-1004).

6.1.6 Upper Till

A mantle of silty to sandy till-like material appears to overlie most of the unconsolidated deposits in Tailings Area C (Drawings X-1010 to X-1013). The thickness of the upper till ranges from 0 to 20 m and is generally less dense than the basal till. The hydraulic conductivity of the upper till was not measured but is assumed to range from 10^{-6} to 10^{-5} cm/s.

6.1.7 Recent Alluvial Sand and Gravel

Recent alluvium deposited by Limestone Creek forms a 2-m-thick veneer along the valley bottom (Drawings X-1010). The alluvium includes sands and gravels and organic silt deposits. No permeability tests have been carried out but the bulk hydraulic conductivity is probably about 10^{-3} cm/s.

6.1.8 Summary of Hydrogeologic Parameters

Table 6.2 summarizes the hydrogeologic parameters in Tailings Area C.

Table 6.2 - Summary of Tailings Area C Hydrogeologic Parameters

UNIT	LOCATION	THICKNESS (m)	BULK HYDRAULIC CONDUCTIVITY (cm/s)	
			RANGE	ASSUMED
Weathered Bedrock		3 - 13	$<10^{-8}$ to 10^{-6}	10^{-8}
Fractured Bedrock		-	10^{-8} to 10^{-5}	10^{-5}
Competent Bedrock		-	$<10^{-8}$ to 10^{-7}	10^{-8}
Basal Till		0 - 35	10^{-7} to 10^{-6}	5×10^{-7}
Lacustrine Silts and Sands	Main Embankment	0 - 70	10^{-8} to 10^{-7}	5×10^{-8}
Confined Sand and Gravel	Main Embankment	8	4×10^{-3}	4×10^{-3}
Terrace Sand and Gravel	Limestone Creek Valley	0 - 20	-	10^{-2}
Valley Sand and Gravel	South Embankment	10	4×10^{-1}	4×10^{-1}
Silt/Silty to Sandy Till	South Embankment	2 - 10	-	1×10^{-4}
Sand and Gravel	Heather Lake	20	-	10^{-2}
Upper Till	-	0 - 20	-	10^{-5}
Recent Alluvium	Limestone Creek	2	-	10^{-3}

6.2 Piezometric Head Distribution

Piezometric elevations in Tailings Area C generally reflect the topography. The piezometric elevations recorded in the valley bottoms are lower than those recorded in the valley walls and along the ridge through Heather Lake (Drawings X-1010 and X-1012). Local variations in topography along the ridge, however, are not reflected in the piezometric elevations (Drawing X-1012).

A slough located about 1 km west of the South Embankment is at a nominal elevation of 1000 m and probably forms a groundwater divide in the valley. The groundwater flowing southwest from the divide probably discharges above Rainbow Creek at elevation 980 m. The linear gradient from the slough to Rainbow Creek is 0.01. The groundwater flowing northeast from the divide probably discharges to ground surface about 1 km downstream of the South Embankment site. Piezometric elevations in the sand and gravel near the South Embankment are close to 996 m and the hydraulic gradient to the northeast is about 0.002.

The principal aquifer at the Main Embankment, the confined sand and gravel, has an artesian pressure with a piezometric elevation of about 981.4 m, 3.3 m above ground surface. Based on current piezometric data, the gradient in this aquifer is about 0.02 to the northwest (Drawing X-1011).

Standpipes are installed adjacent to one another, one in bedrock and one in overburden, in several locations: KP91-C1, KP91-C5, and KP91-C7 (Drawings D-1004, X-1010, and X-1012). Water levels recorded in mid-March 1991 indicate downward gradients from the overburden to the bedrock. A downward gradient also exists in the overburden as indicated by the standpipes installed in drill hole KP91-C2 (Drawing X-1010). The downward gradients on the valley walls within the overburden and between the overburden and bedrock indicate that the hillsides and Heather Lake ridge are recharge zones.

The piezometric surface within the bedrock along Heather Lake ridge rises and falls with the bedrock surface.

All piezometric heads are based on readings taken prior to well development (Section 3.5). The head distribution may need to be re-evaluated with readings taken after well development. Seasonal variations in the head distribution should also be examined.

6.3 Flow Systems

The dominant flow systems in Tailings Area C are in the sands and gravels along the valley bottom. Groundwater flows to the sands and gravels as recharge from the upper slopes through overburden and/or bedrock and as infiltration through overlying valley floor materials.

The confined aquifer near the Main Embankment is discharging to the stream through the lacustrine deposits at the Main Embankment site as indicated by the artesian head in the aquifer. The confined aquifer is probably also discharging downstream of the Main Embankment site as indicated by the significant drop in piezometric elevation from KP91-C3 to KP91-C6 (Drawing X-1011). The aquifer is probably recharged through the confining silts and sands upstream of the Main Embankment as well as laterally from bedrock and from valley wall colluvial and alluvial deposits.

The sand and gravel terraces along the valley walls of Limestone Creek are recharged from the upper slopes and from infiltration. Discharge from the sand and gravel terraces is partially into the underlying silt and sand but primarily directly into Limestone Creek and its tributaries.

The sand and gravel beneath the South Embankment site is recharged by infiltration and by flow from the upper slopes. This sand and gravel probably discharges directly into Limestone Creek.

Table 6.3 summarizes the expected flow rates and velocities in the predominant aquifers.

Table 6.3 - Summary of Tailings Area C Groundwater Flows

Aquifer	Location	Flow Rate (L/s)	Velocity (m/yr)
Confined Sand and Gravel	Main Embankment	1	20
Valley Sand and Gravel	South Embankment	4	200
Heather Lake Sand and Gravel	Heather Lake	1	50

Flow within the bedrock is not well-defined but limited seepage is expected because the measured hydraulic conductivities are relatively low. The possibility of permeable flow paths cannot be eliminated, however, because of the significant drill mud losses in bedrock experienced when drilling drill hole KP91-C5 (Knight and Piesold, April 1991).

6.4 Hydrochemical Characteristics

Based on chemical analyses of groundwater from two observation wells in August 1990, the water in Tailings Area C is typically:

- pH neutral (between 7.3 and 7.9);
- calcium carbonate to calcium sulphate;
- high in suspended solids (91 to 9 120 mg/L) (due to incomplete well development);
- low to moderately high in dissolved solids (90 to 410 mg/L); and
- low in dissolved heavy metals.

Some of the samples were above allowable receiving water guidelines for some metals. However, the samples were collected from undeveloped observation wells, which could have caused the high metal concentrations. The hydrochemical characteristics of the groundwater can be discussed more completely when the one-year monthly baseline groundwater sampling program described in Section 3.10 has been completed.

Appendix VII summarizes the analytical results in tables and summarizes the relative composition of the major ions on Piper plots.

7. OPERATING PLAN

Based on conversations with Continental Gold Corp. and Knight and Piesold Ltd. personnel, the operating plan is as follows:

- Ore mined from the pit will be transported by conveyor to the millsite next to Tailings Area C where it will be stockpiled. Waste rock from the pit will be stored in two waste dumps (Drawing D-1003). The South Waste Dump will be used throughout the life of the mine whereas the North Waste Dump will be used only after the fifth year of operation. Both waste dumps will have surface water collection ditches directed into the two sediment ponds (Drawing D-1003).

- The ore will initially be mined from the northern part of the pit, and the southern part of the pit will be started sometime after the first year of operation. Table 7.1 summarizes the pit bottom elevation with time.

Table 7.1 - Summary of Pit Bottom Elevations

YEAR	ELEVATION (m)
1	1040
5	950
10	770
14 (Final)	800

- Water from the pit will be pumped directly to the tailings impoundment.

- The Main and South Tailings Embankments will be centreline-construction, drained structures comprising cycloned tailings with earthfill starter dams. In addition to the Main and South Embankments, a water-retaining saddle dam is required to provide reservoir closure. A water storage dam built in the headwaters of Limestone Creek will create a water reservoir in Limestone Lake. Water from the reservoir will be used as make-up water for the mill. A separate impoundment within the tailings impoundment will contain the sulphide-rich tailings. Drawing D-1004 shows the locations of the various structures and Table 7.2 summarizes the ultimate crest elevations.

Table 7.2 - Summary of Tailings Embankment Crest Elevations

EMBANKMENT		ULTIMATE CREST ELEVATION (m)
Main	Core Dam	1000
	Earthfill Starter Dam	1025
	Tailings	1065
South	Homogeneous Starter Dam	1025
	Tailings	1060
Saddle	Random Earthfill Dam	1065 (max.)
Sulphide	Core Dam	1050
Water Storage	Random Earthfill Dam	1050

- A recycle pond will be constructed at the South Embankment (South Recycle Pond). Groundwater interception wells will be installed and power provided at the South Embankment during construction of the starter dams. The interception wells will be commissioned if groundwater monitoring results show significant contamination (Knight and Piesold, April 1991a).

- A recycle pond and a monitoring pond will also be constructed downstream of the Main Embankment to collect the seepage draining through the Main Embankment (Main Recycle Pond, Monitoring Pond). Groundwater interception wells will be drilled and commissioned if groundwater monitoring results show significant contamination.

Table 7.3 summarizes the pond elevations in and adjacent to the tailings impoundment at start-up and at closure.

Table 7.3 - Summary of Pond Elevations Related to the Tailings Impoundment

TIME	LOCATION	POND ELEVATION (m)
Start-up	Main Impoundment	990
	Sulphide Tailings	1000
	Water Storage	1030
Closure	Main Impoundment	1050
	Sulphide Tailings	1050
	Water Storage	1050

8. IMPACT ASSESSMENT - DURING OPERATION

8.1 Open Pit

The calculation of groundwater flows through bedrock and till to the open pit near the ultimate pit configuration is based on the assumptions:

- surface runoff and groundwater flowing in the upper alluvium is collected by ditches;
- the average piezometric elevation surrounding the pit is 1100 m; and
- the hydraulic conductivity of the bedrock and till of the pit wall rock is 10^{-6} cm/s.

Based on the theory proposed by Polubarinova-Kochina (1962), the estimated steady-state groundwater flow rate from the till layer and the wall rock is 92 000 m^3/yr (3 L/s). Significantly higher inflows will probably occur during initial excavation through the overburden.

If the basalt flow is recharged by the Minesite Sediment Pond and is intercepted during excavation of the pit, a discharge channel from the sediment pond to the open pit could be created. With an expected hydraulic conductivity of 10^{-3} cm/s for the basalt flow and a gradient of 0.05, the estimated inflow is 32 000 m^3/yr (1 L/s) through a 20 x 100 m exposed face.

The walls of the open pit will cut slopes in the overburden and intercept inter-till units on over 40% of its perimeter. These units, which are connected to Mt. Heidi South and Mt. Heidi North recharge zones, could be under high hydraulic pressures in the pit walls and could be sources of significant water inflow to the pit. With an expected conductivity of 10^{-3} cm/s for the inter-till units and a gradient of 0.1, the estimated inflow is 340 000 m^3/yr (11 L/s) through a 4 x 2700 m exposed face.

Excavation in the rock could reveal open fractures which would be sources of water inflow. If the gradient around the pit does not exceed 0.1 during excavation, and a fault zone 2 m wide with a hydraulic conductivity of 10^{-3} cm/s is intercepted on a length of 1000 m, the inflow to the pit will be approximately 63 000 m^3/yr (2 L/s).

On the east end of Heidi Lake valley, near-surface, fractured bedrock may have a hydraulic conductivity between 10^{-4} and 10^{-5} cm/s down to elevation 1055 m. With an expected conductivity of 10^{-4} cm/s for this fractured zone and a gradient of 0.1, the estimated inflow through a 300 x 20 m section is 19 000 m^3/yr (1 L/s).

Heidi Lake valley could be connected to the open pit by a buried canyon which could be present between the lake and the proposed pit. Heidi Lake could then serve as a recharge area with groundwater moving toward the pit. Considering a 5-m-wide and 20-m-deep buried canyon, an estimated flow of 22 000 m^3/year (1 L/s) could be expected, assuming a gradient of 0.1. Table 8.1 summarizes the calculated pit inflows.

Table 8.1 - Summary of Calculated Pit Inflows

AQUIFER	INFLOW	
	(m^3/yr)	(L/s)
Bedrock and Till Overburden	92 000	3
Basalt Flow	32 000	1
Inter-till Layers	340 000	11
Open Fractures, Fault	63 000	2
Fractured Rock and Buried Canyon (Heidi Lake Valley)	41 000	1
Total	568 000	18

8.2 Waste Dumps

The waste rock will have a hydraulic conductivity much higher than the base material. Most precipitation falling on the waste dumps should, therefore, flow into the existing streambeds under the waste dumps and into the runoff collection ditches, both of which are drained to the sediment ponds (Drawing D-1003). The increase in infiltration to the subsurface materials due to the waste dumps should, therefore, be negligible.

Infiltration through the waste dumps into the subsurface materials will be comparable to baseline conditions. Table 8.2 summarizes the seepage paths and infiltration quantities.

Table 8.2 - Summary of Infiltration Through Waste Dumps - Operation

SEEPAGE PATHWAY		ESTIMATED SEEPAGE (L/s)	NOMINAL FLOW PATH LENGTH (m)	ESTIMATED TRAVEL TIME (yr)
FROM	TO			
South Waste Dump	Minesite Sediment Pond	3	400	4
	Pit	3	-	-
	King Richard Creek Downstream of Minesite Sediment Pond	1	400	4
North Waste Dump	Pit/Minesite Sediment Pond	0.5	1000	10
	North Sediment Pond	0.5	1200	10
	Swiss Creek	0.2	1000	10

8.3 Minesite Sediment Pond

Located downstream of the open pit on King Richard Creek, the Minesite Sediment Pond will operate at a nominal elevation of 1030 m but could rise to elevation 1035 m during freshet (Knight and Piesold, April 1991b) (Drawing D-1003).

Seepage rates from the Minesite Sediment Pond estimated by Knight and Piesold (Knight and Piesold, April 1991b) through the dam core and through the foundation total 0.062 m^3/hr. The left abutment of the Minesite Sediment Pond embankment is adjacent to drill hole KP91-A25 where significant sand and gravel layers were identified (Knight and Piesold, April 1991c). Similar sand and gravel layers could also reasonably exist in the right abutment. If the surficial materials down to elevation 1025 m are cut off per the dam design (Knight and Piesold, April 1991b), the drill hole data indicate that approximately 5 m of sand and gravel will remain as a potential flow path through the abutments into King Richard Creek. Calculated seepage through the left abutment sand and gravel materials is 1 m^3/hr (3 L/s) based on a hydraulic conductivity of 10^{-3} cm/s. The potential impact of abutment seepage is significantly greater than seepage through the engineered structures. Table 8.3 summarizes all estimated seepage from the Minesite Sediment Pond.

Table 8.3 - Summary of Seepage from Minesite Sediment Pond

SEEPAGE PATH	ESTIMATED SEEPAGE (m^3/hr)
Dam Core	0.027
Foundation	0.035
Abutments	1
Total	1.062

If mitigative measures are taken, the seepage quantities into King Richard Creek could be reduced. An installed monitoring well and an additional monitoring well to be installed will monitor for potentially contaminated seepage through the left abutment.

The upstream limit of the Minesite Sediment Pond is located where the basalt flow was identified at elevation 1025 m. The basalt underlies alluvial deposits and 3 m of glacial till. If the sediment pond is connected to the basalt flow during excavation of the pit, a seepage path to the open pit could develop. The estimated inflow to the pit through such seepage was detailed in Section 8.1.

Based on existing drill hole information, the basalt does not extend downstream along King Richard Creek past the Minesite Sediment Pond embankment.

8.4 North Sediment Pond

The North Sediment Pond, located next to the overburden storage, will raise the water level of the existing pond by 3 m (Drawing D-1003). Since the pond is located in a depression, the change of piezometric level will not have a significant impact on the groundwater regime.

Knight and Piesold estimated that the total seepage from the north sediment pond under full pond loading is about 0.02 m^3/hr (Knight and Piesold, April 1991b).

Seepage from the North Sediment Pond through the eskers on the east side of the embankment could be significant. Surficial geology mapping indicates that the existing pond is entrenched into till materials just below the base of the adjacent sand and gravel eskers. Seepage in the order of 0.1 m^3/hr could result if the pond elevation exceeds the elevation of the sand and gravel base. Table 8.4 summarizes the seepage from the North Sediment Pond.

Table 8.4 - Summary of Seepage from North Sediment Pond

SEEPAGE PATH	ESTIMATED SEEPAGE (m^3/hr)
Dam Core	0.01
Foundation	0.01
Abutments	0.1
Total	0.12

8.5 Millsite

Continental Gold Corp. will be taking preventive measures to isolate oil, grease, and other potential contaminants inside the buildings (see Stage 1 submission, Volume 3, Section 5).

8.6 Tailings Impoundment

The seepage paths at the South Embankment will be through the tailings to the sand embankment and through the tailings to the underlying sand and gravel aquifer (Drawings X-1012 and X-1013). A portion of the seepage in the sand and gravel aquifer and all of the seepage from the embankment materials should report to the South Recycle Pond. The balance of the seepage in the sand and gravel aquifer, about 30 m^3/hr, will continue southwest in the valley aquifer. The estimated velocity of the seepage is 400 m/yr. The water quality will be monitored in installed monitoring wells, and seepage collection wells will be commissioned if the water quality is unacceptable. Table 8.5 summarizes the components of seepage near the South Embankment estimated by Knight and Piesold.

If seepage collection wells are commissioned, they will collect seepage from the impoundment as well as regional groundwater from the southwest, which will result in an increased quantity of water to the tailings impoundment. This additional quantity of water should be tentatively considered in the water balance.

Seepage past the Main Embankment will be predominantly through embankment materials, terrace sands and gravels and the confined sand and gravel in the valley bottom (Drawings X-1010 and X-1011). The terrace sand and gravel upstream of the embankment will be excavated and used in construction, which will reduce seepage through this unit. Knight and Piesold estimates seepage to the Main Recycle Pond will be 50 m^3/hr, 46 m^3/hr through the drains and 4 m^3/hr through the terrace sand and gravel via a diversion ditch excavated in silt. An additional 1 m^3/hr is estimated to flow past the relief wells through the sand and gravel aquifer confined in the lacustrine silt in the valley bottom. The estimated velocity of the seepage in the confined sand and gravel is 10 m/yr. Table 8.5 summarizes the seepage estimates calculated by Knight and Piesold (Knight and Piesold, April 1991a) past the respective embankments of the tailings impoundment.

Table 8.5 - Summary of Seepage from Tailings Impoundment During Operation

SEEPAGE PATH		ESTIMATED SEEPAGE RATE (m^3/hr)
FROM	TO	
Tailings Impoundment Near Main Embankment	Main Recycle Pond	50
	Monitoring Pond	1
Tailings Impoundment Near South Embankment	South Recycle Pond	15
	Southwest Valley Aquifer	30
Saddle Dam	Heather Lake	1
Water Storage Dam	Sulphide Tailings	3

Seepage through the Main Embankment will be easy to collect because of the thick sequence of lacustrine silt and sand underlying the embankment and the impoundment. Monitoring wells in the area (Drawing D-1002) will be sampled regularly and should allow identification of potentially contaminated seepage both in the terrace sand and gravel and in the confined sand and gravel aquifer.

The pond elevation within the tailings impoundment will increase from 995 m to 1050 m during operation. This pond will decrease the recharge from Heather Lake ridge and tend to reverse the flow direction in the ridge to the southwest. Drilling fluid losses described in the drill log for KP91-C5 indicate there may be significant bedrock fractures, but if no high-permeability fractures exist in the bedrock, seepage through the ridge should be small.

Leakage from the Recycle Ponds should be evaluated when the design has been finalized.

9. CLOSURE PLAN

Per conversations with Continental Gold Corp. personnel, the closure plan includes:

- flooding the pit to elevation 1055 m, the nominal elevation of King Richard Creek, to minimize the effects of potentially acid-producing wall rock. The diversion ditches will be re-directed into the open pit to accelerate its filling;
- grading and covering the waste dumps if they prove to be acid-generating;
- breaching the sedimentation ponds when the water meets the discharge standards; and
- submergence of the sulphide-rich tailings. Seepage from the impoundment will be monitored and recirculated until sample analysis data show that no contamination is present.

10. IMPACT ASSESSMENT - AFTER CLOSURE

10.1 Open Pit

The post-closure groundwater level surrounding the pit will likely be close to pre-mining conditions given the flowing exploration drill holes in the southern pit area and the ground surface piezometric level in KL91-1. The pit water levels will generally be lower than current groundwater levels, which will result in the pit's acting as a groundwater discharge zone. All water leaving the pit will leave as surface water. Evaporation from the pit pond will exceed the evapotranspiration prevailing prior to excavation, which will decrease the annual flow of King Richard Creek. The hydrology of the minesite will be affected by the artificial lake.

10.2 Waste Dumps

Water from precipitation will rapidly percolate through the north and south waste dumps and evapotranspiration will be low. Post-closure groundwater conditions will probably be close to pre-mining conditions. Table 10.1 summarizes the infiltration through the waste dumps.

Table 10.1 - Summary of Infiltration Through Waste Dumps - Closure

SEEPAGE PATHWAY		ESTIMATED SEEPAGE (L/s)	NOMINAL FLOW PATH LENGTH (m)	ESTIMATED TRAVEL TIME (yr)
FROM	TO			
South Waste Dump	King Richard Creek	4	400	4
	Open Pit	3	-	-
North Waste Dump	Open Pit/King Richard Creek	0.5	1000	10
	Alpine Creek	0.5	1200	10
	Swiss Creek	0.2	1000	10

Overland runoff will prevail on the overburden storage area, creating small creeks discharging to King Richard Creek or Alpine Creek.

10.3 Sediment Ponds

Since the ponds will be breached after mine closure is completed, they will not have a lasting impact on the groundwater regime. Post-operation flow paths after breaching will be towards the valley from both sides. Both pond sites are surrounded by natural groundwater mounds. Post-breaching mound dissipation due to the removal of the sediment ponds should, therefore, be insignificant.

10.4 Millsite

Diversion ditches from the millsite will direct surface runoff to the tailings impoundment. If the ditches are properly lined or excavated in low-permeability till per the intended design (Knight and Piesold, April 1991b), the impact on the groundwater regime will be negligible.

10.5 Tailings Impoundment

Knight and Piesold estimates that the steady-state seepage from the tailings impoundment after closure will total 40 m^3/hr, one-quarter of which is estimated to pass through the South Embankment and three-quarters of which is estimated to pass through the Main Embankment (Knight and Piesold, April 1991a). Table 10.2 summarizes the components of Knight and Piesold's seepage estimate.

Table 10.2 - Summary of Seepage from Tailings Impoundment After Closure

SEEPAGE PATH		ESTIMATED SEEPAGE (m^3/hr)
FROM	THROUGH	
Surface Pond	Main Embankment	0.10
	South Embankment	0.18
Infiltration	Main Embankment	30
	South Embankment	10

Some seepage from the tailings impoundment will also discharge through the sand and gravel underlying the South Embankment and to the confined sand and gravel underlying the Main Embankment. Monitoring wells in each area will be sampled and analyzed for potential contamination.

Leakage from the Recycle Ponds should be evaluated when the design has been finalized.

11. CONCLUSIONS

11.1 Baseline Conditions

11.1.1 Minesite

- Most rocks in the open pit area appear to have low permeability with hydraulic conductivity in the order of 10^{-8} to 10^{-6} cm/s. Possible exceptions to the low permeability of the rocks are:

  a) basalt (10^{-3} cm/s);

  b) bedrock high in Heidi Lake valley (10^{-4} cm/s); and

  c) brittle-fracture faults.

- Significant aquifers in the open pit area recharged from Mt. Heidi South and Mt. Heidi North are inter-till sands and gravels and surficial sands and gravels. The estimated groundwater flow towards King Richard Creek is 15 L/s and towards Alpine Creek is 3 L/s.

- The groundwater in the minesite area is characteristically calcium carbonate to calcium sulphate. Some dissolved and total metals exceed the receiving water quality guidelines. However, since non-standard wells and sampling procedures were used, conclusions regarding the background hydrochemical characteristics of the groundwater should be confirmed after one year of monthly sampling data have been compiled.

- Artesian conditions exist in the bedrock underlying the till at the south end of the pit area.

- A groundwater mound in the till plain east of King Richard Creek divides the flow in the till plain between King Richard Creek and Rainbow Creek.

11.1.2 Tailings Area C

- Primary aquifers at Tailings Area C are a confined sand and gravel aquifer in Limestone Creek valley, a terrace sand and gravel along the valley walls of Limestone Creek, and a valley bottom sand and gravel in the South Embankment area. Lateral gradients in the confined sand and gravel and in the valley bottom sand and gravel indicate that flow is directed down Limestone Creek.

- The hydrochemical characteristics of the groundwater at Tailings Area C are based on two groundwater samples. The groundwater in the Tailings Area C is characteristically calcium carbonate. Some dissolved and total metals exceed the receiving water quality guidelines. However, since non-standard wells and sampling procedures were used, conclusions regarding the background hydrochemical characteristics of the groundwater should be confirmed after one year of monthly sampling data have been compiled.

11.2 Impacts During Operation

11.2.1 Minesite

- Estimated total pit inflows are 65 m^3/hr (18 L/s).

- Seepage losses from the Minesite Sediment Pond to King Richard Creek estimated by Knight and Piesold are 1 m^3/hr (0.3 L/s). The majority of the losses are through the sandy layers identified in the abutment of the embankment.

- Groundwater inflows and pressures will require thorough consideration during design and excavation of overburden slopes.

- Probable groundwater pathways from the waste dumps to the environment comprise:
    - infiltration through the South Waste Dump to the Minesite Sediment Pond (11 m^3/hr (3 L/s), estimated travel time four years);
    - infiltration through the South Waste Dump to King Richard Creek downstream of the Minesite Sediment Pond (4 m^3/hr (1 L/s), estimated travel time four years);
    - infiltration through the North Waste Dump to Swiss Creek (0.7 m^3/hr (0.2 L/s), estimated travel time 10 years);
    - infiltration through the North Waste Dump to the North Sediment Pond (2 m^3/hr (0.5 L/s), estimated travel time 10 years).

11.2.2 Tailings Area C

- The estimated seepage through the valley sand and gravel past the South Embankment and the South Recycle Pond is 30 m^3/hr. The estimated seepage velocity is 400 m/yr.

- The seepage through and under the Saddle Dam will enter Heather Lake.

- The estimated seepage through the confined sand and gravel unit at the Main Embankment which bypasses the Main Recycle Pond is 1 m^3/hr. The estimated seepage velocity is 10 m/yr.

- Environmental impacts at the tailings area are controllable, particularly with the acid-producing tailings stored upstream in a flooded impoundment. If the supernatant water quality is adequate, the seepage water will also be adequate.

- If recovery pumping is necessary at the South Embankment, large quantities of regional groundwater may be pumped back into the tailings impoundment. This additional quantity of water should be tentatively included in the water balance.

- Although losses past the Main Embankment recycling system are possible, the installed groundwater monitoring network should adequately define seepage losses in time to install any necessary mitigative measures.

11.3 Impacts After Closure

11.3.1 Minesite

- The abundance of groundwater currently surrounding the pit (as indicated by high piezometric levels in KL91-1 and flowing drill holes in the southern pit area) suggests that the pit will fill with water after closure. The expected pond elevation in the pit is 1055 m which is the elevation of King Richard Creek on the east side of the pit wall.

- The piezometric surface surrounding the pit after closure will probably be similar to pre-mining conditions. The pit will act as a groundwater discharge zone.

- The infiltration rate to the natural soils under the waste dumps will be somewhat greater after closure than under pre-mining conditions. However, the groundwater mounds developed under the waste rock piles will be minimal. Probable groundwater pathways from the waste dumps to the environment comprise:

  - infiltration through the South Waste Dump to King Richard Creek (4 L/s, estimated travel time four years);
  - infiltration through the North Waste Dump to Swiss Creek (0.2 L/s, estimated travel time 10 years); and

  - infiltration through the North Waste Dump to Alpine Creek (0.5 L/s, estimated travel time 10 years).

- The sedimentation ponds will not significantly impact on the groundwater regime after they are breached.

11.3.2 Tailings Area C

- Losses past the South Recycle Pond through the valley sand and gravel are probable. Monitoring wells in the area of the South Embankment will be sampled and analyzed for potential contamination.

- If recovery pumping is necessary at the South Embankment, large quantities of groundwater may be pumped back into the tailings impoundment. This quantity of water should be tentatively included in the water balance.

- Losses past the Main Recycle Pond through the confined sand and gravel are probable. Groundwater monitoring for a sufficient period after closure should adequately define seepage losses in time to install any necessary mitigative measures.

- Environmental impacts at the tailings area are controllable, particularly with the acid-producing tailings stored upstream in a flooded impoundment. If the supernatant water quality is adequate, the seepage water will also be adequate.

12. RECOMMENDATIONS

- Additional monitoring wells should be installed to monitor seepage from the North Waste Dump, South Waste Dump, and North Sediment Pond. Drawing D-1002 shows the proposed locations of these wells.

- The 30 selected monitoring wells shown on Drawing D-1002 should be sampled monthly for background water quality for one year starting in May 1991. The samples should be collected in accordance with the sampling guidelines in Appendix VIII. A sampling program based on the collected data should be designed in May 1992.

- Water levels should be recorded every two weeks in all piezometers and monitoring wells.

- Additional surface water monitoring points should be established in Alpine Creek, downstream of the North Sediment Pond, and on Esker Lake Creek, downstream of Esker Lakes (Drawing D-1003).

- Additional drill holes to identify overburden conditions for the pit walls should be considered for final design of the excavation. Tests for estimating groundwater pressures and inflows should be included.

- Data being collected over the next year should be incorporated into the hydrogeology model as part of the final design process. These data would include groundwater chemistry, groundwater levels, rising head test results, and any additional drilling and testing that is carried out.

KLOHN LEONOFF LTD.

H. RODNEY SMITH

H.R. (Rod) Smith, P.Eng.
Project Manager

HMcCreadie.

H. McCreadie, EIT
Project Engineer

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APPENDIX I

TERMS OF REFERENCE

PLACER DOME INC.

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December 21, 1990

Klohn Leonoff Ltd.
10200 Shellbridge Way
Richmond, B. C.
V6X 2W7

Attention: Mr. Rod Smith

Dear Sir:

Re: Mount Milligan Project - Hydrological and Hydrogeological Studies

Further to our recent telephone conversations with Peter McCreath and yourself, we request your proposal to provide engineering services for the referenced study as further described below.

Placer Dome Inc. recently assumed controlling interest in the Mount Milligan Project and has continued the environmental and feasibility studies that are necessary to advance the project to a production decision. Of particular concern is the satisfactory completion of all programs and studies necessary to prepare the Stage 1 Report required by the Ministry of Energy, Mines and Petroleum Resources for their Mine Development Review Process. It is our intention to fulfil this requirement and to submit our Stage 1 Report in April 1991.

As lead geotechnical consultant, Knight and Piesold has been instrumental in the preparation of several related studies that have been completed to date. As appropriate, these reports will be available, to you. In addition, a surface hydrology study has been conducted by Sigma Engineering Ltd. and a copy of their report is being sent to your office. Topographic mapping is also available of the property and surrounding vicinity.

The specific tasks required for the present study by generic area will include the following items:

A. Hydrology

1. A review of the study prepared by Sigma will be required. The intent is to become familiar with the work performed to date and the current level of understanding of the surface hydrology.

2. An investigation and report will be required that addresses the hydrological considerations and design concepts that will be necessary for water management of the following project areas:

a. Plantsite

This will include:

- a drainage plan to intercept and divert runoff away from the site,
- a drainage plan to collect and convey site runoff to a plantsite pond that has been conceptually located and designed by Knight and Piesold,
- a preliminary design specification for an emergency spillway for the pond, and
- the flood and storm event criteria that have been used for the foregoing tasks.

b. Waste Dump

This will include a drainage plan for control of sediments. No settling pond has been designed to date for this purpose. If recommended, a conceptual design, design criteria and location will be required.

c. Open Pit

This will include:

- a drainage plan to collect and divert runoff away from the pit,
- a plan for pit water management that may include collection and routing to a water treatment facility, and
- the flood and storm event criteria that have been used for the foregoing tasks.

d. Construction Sediment Control

The Mount Milligan site is situated adjacent to valuable fisheries habitat and as a result it is imperative that sediment control measures are implemented at the commencement of construction activities. It is contemplated that water diversion and/or collection ditches and settling pond(s) will be required as well as other sediment control procedures. It would be desirable if these facilities could be integrated wherever possible into the permanent plant facilities.

e. Report

To complete the study a report will be required that provides a general overview of the pre-development and existing hydrology of the drainage area that will be affected by the project. The report will then discuss the impact of development upon the hydrological regime and the mitigative effect of the various measures and treatments discussed above. The report should also include an order-of-magnitude estimate of the costs of construction of any works proposed. The report will be required by March 8, 1991.

B. Hydrogeology

1. A review is required of the reports prepared by Knight and Piesold. The objective is to become familiar with the work conducted to date from phases 1 and 2 and the present general understanding of the local groundwater conditions. Required early January 1991.

2. A review is required of the work proposal by Knight and Piesold and the specific objectives of the work for phase 3, which will commence in early January 1991. Comments and recommendations are required on the proposed program to ensure that all objectives are clear and all of the necessary work is performed. Required early January 1991.

3. The following reports are required for the preparation of the Stage 1 report which Placer Dome plans to submit on April 1, 1991.

   a. A general overview of the preproduction groundwater status and dynamics around the proposed mine, waste dump areas, plantsite, tailings area (Limestone Creek) and the overall Rainbow Creek basin extending down to the Nation River. This report is required by February 15, 1991.

   b. A general overview of the expected performance of the groundwater at the various stages of operation from year 1, 5, 10 and 15 and for each area of the mine and tailings disposal areas. The following information which may be integrated with this evaluation will be as follows:

      - The quantities of seepage from the various dams will be provided by Knight and Piesold.
      - The water quality information from operations and the receiving water systems will be estimated by Hallam Knight and Piesold.
      - The surface water flows will be estimated by a report prepared by Sigma which is enclosed. Additional work on the surface water management will become available during the next two months from the hydrological work to be conducted, above.
      - The hydrogeological report will be required by March 8, 1991.

   c. A Ministry of Environment document entitled "Resource Development Environmental Impact Assessments Suggested Framework for a Hydrogeologic Study" which describes the requirements of the B.C. government for hydrogeological studies is enclosed for your reference.

Discussions with Knight and Piesold, and Sigma Engineering personnel will be expected for all of the above work and a cooperative approach will be encouraged.

The results from the surface and groundwater assessments must be integrated to ensure that the overall water management plan is consistent. To ensure this a series of meetings will be needed to provide additional information to you and to track the progress in fulfilling the overall objectives.

Your confirmation that the above completion dates can be met should be provided to us together with your estimate of the cost of performing the work described not later than January 3, 1991.

If you have any questions please call me.

Yours truly,

PLACER DOME INC.

J D Robertson

J.D. Robertson, P. Eng.
Manager - Environmental Engineering

cc: W.A. Trythall
T.J. Smolik

JDR/mlb
90-12-21

APPENDIX II

SUMMARY OF OBSERVATION WELLS, MONITORING WELLS, AND PIEZOMETERS

Table II-1 - Summary of Observation Wells

HOLE NO.	COORDINATES		ELEVATION (m)	GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	NORTH	EAST			ELEVATION (m)	DATE*
HEIDI LAKE VALLEY						
90-411	9 002.52	11 704.15	1 098.28	sand and gravel, clay and boulders on andesite and monzonite	1 089.75	Jan. 1990
90-421	8 939.79	10 030.88	1 083.16	sand and gravel on bedrock	1 075.54	Jan. 1990
KING RICHARD GULLY						
90-435	10 067.54	14 495.55	1 052.18	sand and gravel, till, on trachitic flow	1 033.89	Feb. 1990
90-446	9 317.42	13 972.12	1 073.42	till on basalt	1 049.80	Feb. 1990
90-451	7 774.92	14 842.03	1 055.14	till on syenogabro, latitic augite porphyry flow, monzonite	1 051.03	Feb. 1990
90-459	7 939.02	15 246.93	1 020.03	till on latitic augite porphyry flow	1 015.46	Feb. 1990
TAILINGS AREA C						
90-676	10 950	22 981	1 007.33	sand and gravel, till on gabbro	998.19	Jun. 1990
90-695	14 575	20 450	976.04	clay and fine sand on mafic bedrock	972.69	Jul. 1990
90-711	10 800	22 675	1 005.14	till, sand and gravel on gabbro	997.82	Jul. 1990

* Depth to groundwater determined during and shortly after completion of drilling. "Minesite Geotechnical Reference Data", "Tailings Area C Geotechnical Reference Data", Knight and Piesold, May 1991 and May 1991c.

Table II-2 - Summary of Monitoring Wells and Piezometers

HOLE	COORDINATES		TIP	ELEVATION TOP PVC (m)	DIA. (in)	MONITORING ELEVATION		GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	EAST	NORTH				FROM (m)	TO (m)		ELEV. (m)	DATE
KP91-A1	16 338.9	8 143.3	P1	1 004.38	2	991.6	994.3	andesite	1 003.12	Feb.19/91
KP91-A2	16 498.6	7 573.5	P1	1 037.52	2	1 009.0	1016.6	till	1 012.91	Feb.19/91
KP91-A3	16 044.1	6 834.4	P1	1 035.88	2	1 003.6	1 020.6	till/bedrock	1 032.63	Feb.19/91
			P2	1 035.88	0.75	1 031.6	1 033.5	sand and gravel	1 035.12	Feb.19/91
KP91-A4	16 246.9	8 307.0	P1	1 037.98	2	1 001.7	1 020.6	till	1 012.23	Feb.19/91
KP91-A5	16 633.1	9 264.7	P1	1 035.19	2	1 006.1	1 010.5	sand	1 029.28	Feb.19/91
			P2	1 035.12	2	1 022.1	1 025.9	sand	1 030.3	Feb.19/91
			P3	1 035.1	0.75	1 030.2	1 033.9	sand	dry	Feb.19/91
KP91-A6	16 789.4	9 780.4	P1	1 024.46	2	998.2	1 002.5	sand and gravel	1 024.46	Feb.19/91
			P2	1 024.56	2	1 014.4	1 018.7	till	1 017.64	Feb.19/91
KP91-A8	15 534.5	10 404.2	P1	1 033.38	2	1 003.0	1 006.7	till	1 029.71	Mar.17/91
			P2	1 033.37	0.75	1 025.5	1 028.8	till	1 032.47	Mar.17/91
			P3	1 033.4	0.75	1 029.7	1 032.3	sand and gravel	1 032.76	Mar.17/91
KP91-A9	15 228.8	10 096.5	P1	1 044.88	2	986.4	995.5	till	1 037.95	Mar.17/91
KP91-A10	14 920.4	9 847.3	P1	1 046.85	2	999.3	1 006.1	till	1 030.74	Feb.19/91
KP91-A12	14 246.1	9 403.9	P1	1 031.2Y	2	1 016.7	1 021.6	basalt	frozen	Mar.17/91
KP91-A13	14 148.9	9 105.1	P1	1 047.79	2	1 038.2	1 040.6	till	1 046.27	Mar.17/91

HOLE	COORDINATES		TIP	ELEVATION TOP PVC (m)	DIA. (in)	MONITORING ELEVATION		GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	EAST	NORTH				FROM (m)	TO (m)		ELEV. (m)	DATE
KP91-A14	15 073.2	6 340.9	P1	1 066.28	2	1 053.5	1 056.5	till	1 057.87	Feb.19/91
			P2	1 066.20	0.75	1 062.1	1 064.3	sand and gravel	1 064.09	Feb.19/91
			P3	1 066.73	2	1 012.5	1 017.1	till	1 057.81	Feb.19/91
KP91-A15	15 581.2	6 578.1	P1	1 059.20	2	1 001.3	1 005.6	sand	1 047.68	Feb.19/91
			P2	1 059.2	0.75	1 040.6	1 049.9	sand	1 049.84	Feb.19/91
KP91-A16	16 302.8	7 404.1	P1	1 040.91	2	1 010.5	1 020.1	till	1 031.08	Feb.19/91
KP91-A17	16 974.9	8 105.6	P1	1 006.98	2	978.1	982.1	till	997.82	Feb.19/91
			P2	1 007.0	2	996.5	999.5	gravel	1 006.22	Feb.19/91
KP91-A21	17 114.1	7 675.9	P1	1 012.88	2	965.1	972.2	silt and sand	999.58	Feb.19/91
KP91-A22	16 213.3	6 737.7	P1	994.91	2	977.2	982.8	volcanic rock	994.61	Feb.19/91
KP91-A24	15 799.0	8 020.2	P1	1 040.69	2	1 012.9	1 017.4	sand	1 017.76	Feb.19/91
KP91-A25	15 304.7	8 023.1	P1	1 033.34	2	997.0	1001.1	clay	1 028.48	Feb.23/91
			P2	1 033.3	0.75	1 012.4	1 019.2	sand and gravel	1 022.12	Feb.23/91
KP91-A26	15 077.9	7 904.6	P1	1 019.39	2	1 003.8	1 010.2	sand and gravel	1 018.46	Mar.31/91
GA91-1	13 678.7	9 902.8	P1	1 042.63	0.75	989.0	1026.5	till, silt and sandstone	frozen	Mar.19/91
GA91-3	12 973.5	8 647.8	P1	1 126.41	2	1 103.5	1 106.2	bedrock	1 122.1	Mar.19/91
			P2	1 126.41	0.75	1 112.6	1 114.4	till	frozen	Mar.19/91
GA91-4	13 264.0	10 203.1	P1	1 095.29	0.75	1 008.9	1 012.3	volcanic rock	1 088.9	Mar.17/91

HOLE	COORDINATES		TIP	ELEVATION TOP PVC (m)	DIA. (in)	MONITORING ELEVATION		GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	EAST	NORTH				FROM (m)	TO (m)		ELEV. (m)	DATE
GA91-5	12 447.3	7 895.9	P1	1 237.65	2	1 232.3	1 234.6	till	frozen	Mar.18/91
			P2	1 237.65	0.75	1 223.4	1 227.4	weathered rock	1 235.42	Mar.18/91
GA91-6	12 196.5	8 190.5	P1	1 252.87	2	1 240.1	1 242.4	till	1 243.01	Mar.18/91
			P2	1 252.87	0.75	1 242.8	1 250.7	sand	dry	Mar.18/91
GA91-7	13 966.2	8 014.4	P1	1 101.58	2	1 062.9	1 066.8	till	1 086.18	Mar.19/91
			P2	1 101.58	0.75	1 091.3	1 096.6	till	1 096.49	Mar.19/91
GA91-8	13 799.2	8 625.4	P1	1 092.60	2	1 069.9	1 075.9	till	1 083.85	Mar.19/91
GA91-9	14 251.9	10 718.8	P2	1 055.28	0.75	1 034.3	1 038.5	till	1 035.75	Mar.19/91
			P1	1 055.28	2	1 047.7	1 050.1	sand and gravel	1 047.81	Mar.19/91
GA91-10	14 573.0	10 561.7	P1	1 044.04	2	1 039.2	1 041.9	sand and gravel	1 039.73	Mar.19/91
			P2	1 044.04	0.75	1 022.7	1 027.3	till	1 033.49	Mar.19/91
KL91-1	12 147.64	9 597.04		1 176.20	0.75	1 055.1	1 077.9	fractured rock	1 176.20	Apr.9/91
KP91-C1	21 593.0	15 002.0	P1	1 041.36	2	1 021.61	1 032.16	weathered limey bedrock	1 037.84	Mar.17/91
			P2	1 041.39	2	1 033.28	1 036.12	gravelly sand	1 039.61	Mar.17/91
KP91-C2	21 024.3	14 381.6	P1	1 014.11	2	955.59	960.16	silty sand and gravel	981.97	Mar.17/91
			P2	1 014.08	2	987.26	993.05	fine sand	992.88	Mar.17/91
KP91-C3	20 707.7	14 251.6		978.66	2	920.57	959.50	sand and gravel	981.4	Apr.10/91

HOLE	COORDINATES		TIP	ELEVATION TOP PVC (m)	DIA. (in)	MONITORING ELEVATION		GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	EAST	NORTH				FROM (m)	TO (m)		ELEV. (m)	DATE
KP91-C4	20 514.9	14 038.5	P1	1 006.27	2	946.83	953.23	v. dense sandy gravel	990.43	Mar.17/91
			P2	1 006.37	2	991.74	996.31	sand and gravel	1 006.37	Mar.17/91
KP91-C5	20 123.4	13 520.5	P1	1 057.64	2	1 032.25	1 036.18	bedrock	1 035.35	Mar.17/91
			P2	1 057.39	2	1 040.50	1 044.50	silty to gravelly till	1 046.18	Mar.17/91
KP91-C6	20 118.9	15 288.1		968.77	2	942.98	963.16	dense uniform sand	959.89	Mar.17/91
KP91-C7	21 018.9	12 706.5	P1	1 075.94	2	1 064.27	1 068.66	bedrock-sandy till contact	1 064.98	Mar.17/91
			P2	1 075.74	2	1 056.54	1 061.72	weathered, fractured, schist	1 064.73	Mar.17/91
KP91-C8	21 448.3	11 585.1		1 037.42	2	1 021.02	1 027.61	sand and gravel	1 036.41	Mar.7/91
KP91-C9	22 593.1	11 426.8		1 064.40	2	1042.91	1 052.67	banded volcanic	1 055.42	Mar.17/91
KP91-C10	23 017.3	11 112.9		1 001.90	2	987.38	993.49	sand and gravel	996.12	Mar.15/91
KP91-C11	23 320.9	10 949.8		1 054.02	2	1044.51	1 048.53	slt fn sand and fn gravel till	1 048.19	Mar.16/91
KP91-C12	22 820.9	10 882.7		1 007.64	4.5	979.90	1 007.64	sand and gravel	996.7	Mar.14/91
KP91-C13	22 787.8	10 952.8		1 005.12	2	987.62	998.81	gravelly sand	996.48	Mar. 14/91
KP91-C14	23 133.3	11 107.0		999.85	2	985.04	996.80	sand	996.14	Mar.15/91
KP91-W1	25 137.4	12 699.8		1 041.40	2	992.94	1 006.04	sand and gravel	frozen	Mar.15/91
KP91-W2	25 089.8	12 564.0	P1	1 007.16	0.75	995.10	998.39	sand and gravel	frozen	Mar.15/91

HOLE	COORDINATES		TIP	ELEVATION TOP PVC (m)	DIA. (in)	MONITORING ELEVATION		GEOLOGY OF MONITORING ZONE	GROUNDWATER LEVEL	
	EAST	NORTH				FROM (m)	TO (m)		ELEV. (m)	DATE
			P2	1 007.2	0.75	1001.71	1 004.79	fine sand	frozen	Mar.15/91
KP91-W3	25 320.0	13 102.7		1 059.8	2	1 045.78	1 048.83	clay-bedrock contact	frozen	Mar. 15/91

KLOHN LEONOFF

APPENDIX III

PACKER TEST RESULTS

PACKER TEST RESULTS

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
89-361	1 053.7	1048.2	5.5	3.7×10^{-5}	fractured and oxidized zone with limonite and hematite staining
	1 047.6	1 039.1	8.5	8.0×10^{-7}	competent
	1 038.5	1 029.9	8.5	1.1×10^{-6}	
	1 029.3	1 020.8	8.5	2.2×10^{-6}	
	1 020.2	1 011.7	8.5	1.3×10^{-6}	
	1 011.0	1 002.5	8.5	7.7×10^{-7}	
	1 001.9	993.4	8.5	1.4×10^{-5}	
	992.8	984.2	8.5	7.0×10^{-6}	
	983.6	975.1	8.5	1.4×10^{-5}	
	974.5	965.9	8.5	1.5×10^{-5}	competent volcanic rock with some fractures, chlorite, and slickensides
	965.3	956.8	8.5	1.2×10^{-6}	sightly fractured (good RQD)
	956.2	947.6	8.5	5.5×10^{-6}	slightly fractured (good RQD)
	947.0	938.5	8.5	1.3×10^{-5}	heavily fractured, hole making some water, prior to test, but water dropped during test
	937.9	929.4	8.5	2.3×10^{-5}	heavily fractured, monzonite with low RQD, minor rubble, no clay, and extensive fracturing in upper three meters
	928.8	920.2	8.5	2.2×10^{-5}	heavily fractured, hole making water
	919.6	911.1	8.5	6.6×10^{-7}	competent (Good RQD)
	910.5	901.9	8.5	1.5×10^{-5}	heavily fractured, extensive water loss, unstable test pressure
	873.9	865.4	8.5	2.1×10^{-7}	competent rock (Good RQD)
	892.2	865.4	26.8	4.4×10^{-7}	competent
	864.7	847.1	17.7	$<1 \times 10^{-7}$	competent
	855.6	847.1	8.5	$<1 \times 10^{-7}$	competent

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
89-370	1 037.5	1 029.0	8.5	9.6×10^{-5}	heavily fractured
	1 028.4	1 019.9	8.5	3.6×10^{-6}	fault zone, monzonite/intrusive breccia (low RQD)
	1 001.0	992.4	8.5	9.0×10^{-7}	less fractured rock
	979.6	971.1	8.5	4.5×10^{-6}	competent (Good RQD)
	947.3	931.5	15.8	5.6×10^{-6}	
	932.4	916.2	16.2	1.4×10^{-6}	competent
	917.2	901.0	16.2	2.3×10^{-7}	slightly fractured
	902.2	885.8	16.5	1.4×10^{-7}	competent
	885.8	870.5	15.2	3.9×10^{-7}	competent
	870.5	855.3	15.2	1.0×10^{-4}	heavily fractured
	856.5	840.0	16.5	6.4×10^{-5}	moderately fractured
	841.3	824.8	16.5	5.6×10^{-5}	moderately fractured
89-383	1 132.6	1 126.5	6.1	4.6×10^{-6}	
	1 126.5	1 117.4	9.1	2.6×10^{-6}	slightly fractured
	1 108.3	1 099.1	9.1	9.4×10^{-7}	competent
	1 099.1	1 090.0	9.1	1.3×10^{-4}	moderately fractured
	1 089.4	1 080.8	8.5	9.2×10^{-5}	slightly fractured monzonite with calcite veins (good RQD)
	1 080.2	1 071.7	8.5	1.8×10^{-4}	competent monzonite with calcite veins (excellent RQD)
	1 071.1	1 062.5	8.5	6.4×10^{-4}	competent monzonite (excellent RQD)
	1 061.9	1 053.4	8.5	5.2×10^{-6}	competent monzonite (excellent RQD)
	1 052.8	1 044.2	8.5	7.7×10^{-6}	competent monzonite with some calcite and dolomite (excellent RQD)
	1 043.6	1 035.1	8.5	1.1×10^{-3}	fault zone from 327 to 328.5 and from 332 to 337 with chlorite coating on fractures
	1 034.5	1 026.0	8.5	3.4×10^{-4}	fault zone at top of interval then competent monzonite (Good RQD)
	1 025.4	1 016.8	8.5	6.4×10^{-4}	heavily fractured and breccia monzonite and volcanic tuff with calcite veins and chlorite coating

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
	1 016.2	1 007.7	8.5	7.1×10^{-5}	moderately fractured, calcite with abundant pyrite and volcanic tuff with calcite veining (moderate RQD)
	1 007.1	998.5	8.5	8.1×10^{-5}	no drilling returns, water disappearing downhole, (moderately RQD)
	997.9	989.4	8.5	8.8×10^{-6}	slightly fractured
	988.8	980.2	8.5	2.8×10^{-4}	moderately fractured
	979.6	971.1	8.5	9.3×10^{-6}	competent
	970.5	962.0	8.5	3.6×10^{-7}	competent
	961.3	952.8	8.5	8.3×10^{-7}	competent
89-390	1 019.2	1 010.7	8.5	2.5×10^{-5}	fractured
	1 000.9	992.4	8.5	2.3×10^{-5}	heavily fractured rock with chlorite and minor gouge (low RQD)
	991.8	983.3	8.5	6.8×10^{-5}	heavily fractured rock with chlorite,talc and minor gouge (low RQD)
	982.7	974.1	8.5	3.5×10^{-6}	moderately fractured rock with some chlorite and little gouge (RQD improving)
	973.5	965.0	8.5	5.4×10^{-6}	moderately fractured, with some pyrite (RQD improving)
	955.2	946.7	8.5	1.9×10^{-6}	competent rock, hole making water
	946.1	937.5	8.5	4.1×10^{-7}	competent rock with chloritic fractures
	936.9	928.4	8.5	3.0×10^{-7}	competent monzonite, minor alteration
	927.8	919.3	8.5	5.1×10^{-7}	competent rock with some fractures (good RQD)
	918.6	910.1	8.5	2.7×10^{-6}	competent rock (excellent RQD)
	909.5	901.0	8.5	8.1×10^{-8}	competent rock (excellent RQD)
	900.4	891.8	8.5	2.6×10^{-6}	slightly fractured competent monzonite with pyrite and calcite veinlets (moderate RQD)
	891.2	882.7	8.5	4.4×10^{-6}	chloritic, heavily fractured volcanics, with calcite stringers (low RQD)
	882.1	873.5	8.5	1.8×10^{-7}	competent volcanics (good RQD)
	872.9	864.4	8.5	1.7×10^{-7}	very competent rock

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
90-409/411	1 083.1	1 082.1	1.0	2.7×10^{-5}	clayey silt (erratic readings)
	991.0	986.4	4.6	1.2×10^{-6}	highly fractured rock
	985.8	980.3	5.5	2.2×10^{-7}	highly fractured rock
	979.7	974.6	5.1	1.8×10^{-5}	competent bedrock
90-412	1 079.9	1 077.5	2.4	1.0×10^{-8}	very competent hard rock,
	1 076.9	1 071.4	5.5	4.8×10^{-6}	competent rock (good RQD)
	1 070.8	1 062.2	8.6	5.6×10^{-7}	competent rock (good RQD)
	1 061.6	1 050.1	11.5	1.6×10^{-5}	competent rock with some fractures
90-414	1 035.2	1 029.7	5.5	5.1×10^{-7}	very competent hard rock (good RQD)
	1 029.1	1 023.7	5.4	1.3×10^{-6}	competent rock (good RQD)
	1 023.0	1 014.5	8.5	7.5×10^{-7}	competent rock (good RQD)
	1 013.9	1 005.4	8.5	1.9×10^{-6}	competent rock with some fractures
90-415	1 084.2	1 080.2	4.0	2.1×10^{-5}	competent rock
	1 081.1	1 072.6	8.5	1.9×10^{-4}	competent rock moderately jointed
	1 072.0	1 063.4	8.6	7.8×10^{-5}	competent rock moderately jointed
	1 062.8	1 054.3	8.5	1.3×10^{-5}	competent rock moderately jointed
90-417	1 082.3	1 078.4	3.9	1.5×10^{-4}	heavily fractured bedrock (rubble)
	1 076.2	1 070.7	5.5	2.0×10^{-5}	faulted rock
90-421	1 031.7	1 026.2	5.5	1.2×10^{-6}	bedrock
	1 025.6	1 017.1	8.5	3.0×10^{-7}	bedrock
	1 016.4	1 007.9	8.5	1.0×10^{-6}	bedrock
	1 007.3	998.8	8.5	1.9×10^{-6}	bedrock
90-426	989.4	984.0	5.4	1.8×10^{-5}	fractured sandstone
	983.4	974.8	8.6	5.8×10^{-7}	moderately competent argilite
	974.2	965.7	8.5	1.0×10^{-6}	soft argilite
90-435	962.0	956.5	5.5	3.7×10^{-6}	heavily fractured and oxidized rock
	955.9	946.4	9.5	2.1×10^{-5}	heavily fractured fault zone (slickensides)
	945.8	937.3	8.5	1.7×10^{-6}	heavily fractured rock

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
90-440	1 035.0	1032.6	2.4	2.3×10^{-7}	gravelly glacial till (cored with thin mud)
	1 032.0	1 029.5	2.5	8.3×10^{-7}	sandy glacial till (cored with thin mud)
	928.3	922.9	5.4	3.2×10^{-8}	moderately competent weakly cemented coal, clay and sand
	922.2	913.7	8.5	1.2×10^{-7}	moderately competent weakly cemented coal, clay and sand
90-445	1 013.7	1 011.2	2.5	5.9×10^{-7}	competent bedrock
	1 010.6	1 005.1	5.5	1.9×10^{-7}	competent bedrock
	1 001.5	996.3	5.2	1.2×10^{-6}	moderately fractured rock
	995.4	986.8	8.6	6.9×10^{-6}	xoidized and fractured vesicular volcanic rock
90-446	1 058.5	1 056.0	2.5	$<1.5 \times 10^{-7}$	dense, competent very clayey, gravel, with trace sand and cobbles (glacial till)
	1 003.6	998.1	5.5	1.1×10^{-5}	moderately competent rock
	997.5	992.0	5.5	3.8×10^{-6}	competent rock (good RQD)
	988.4	981.0	7.4	9.0×10^{-7}	moderately competent rock (broken rock in top 5.2 m)
	979.2	970.7	8.5	1.3×10^{-6}	competent rock (good RQD)
90-451	1 037.1	1 034.7	2.4	$<5 \times 10^{-8}$	gravely till (cored with thin mud)
	1 034.1	1 031.6	2.5	$<5 \times 10^{-8}$	gravely till (cored with thin mud)
	973.1	970.7	2.4	2.0×10^{-7}	competent rock (good RQD)
	960.9	952.4	8.5	5.0×10^{-7}	competent rock (good RQD)
	951.8	943.2	8.6	4.9×10^{-7}	competent rock (good RQD)
90-459	1 005.1	1 002.6	2.5	$<6 \times 10^{-8}$	gravely till with some clay (cored with thin mud)
	999.0	996.5	2.5	$<4.2 \times 10^{-8}$	gravely till with some clay (cored with thin mud)
	980.7	975.2	5.5	$<2.2 \times 10^{-7}$	competent rock (good RQD)
	971.5	966.1	5.4	2.4×10^{-6}	moderately competent rock (good RQD)
	962.7	957.2	5.5	$<5.4 \times 10^{-8}$	competent rock (good RQD)

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
90-676	995.4	994.5	0.9	$<7 \times 10^{-8}$	competent till
	992.4	991.4	1.0	5.0×10^{-6}	sand and gravel
	986.3	985.3	1.0	4.0×10^{-3}	gravel and sand
	966.1	964.0	2.1	3.0×10^{-7}	competent rock
	957.0	954.8	2.2	$<2 \times 10^{-8}$	competent rock
90-681	1 007.5	1 005.1	2.4	$<6 \times 10^{-8}$	sand and silt, trace of clay
	998.4	995.9	2.5	$<6 \times 10^{-8}$	competent rock
	979.8	977.6	2.2	1.0×10^{-6}	slightly fractured rock
90-682	1 007.1	1 004.7	2.4	$<9 \times 10^{-8}$	competent rock
	1 001.0	998.6	2.4	2.0×10^{-5}	fractured rock
	995.5	993.1	2.4	3.0×10^{-5}	fractured rock
	989.1	986.7	2.4	1.0×10^{-6}	slightly fractured rock
	983.3	980.9	2.4	6.0×10^{-6}	slightly fractured rock
90-685	1 013.8	1 011.4	2.4	5.0×10^{-4}	pebbles, clay and silt
	1 006.2	1 003.7	2.5	6.0×10^{-4}	coarse sand and silt
	1 000.1	997.6	2.5	6.0×10^{-8}	clay silt and sand
	997.0	994.6	2.4	$<9 \times 10^{-4}$	clay silt and sand
	983.3	980.9	2.4	$<1 \times 10^{-4}$	pebbles, clay and sand till
	968.1	965.6	2.5	2.0×10^{-6}	clay, pebbles, sand till
	959.2	956.8	2.4	$<1 \times 10^{-4}$	clay, pebbles and silt till
90-690	1 023.6	1 019.0	4.6	$<4 \times 10^{-5}$	clay pebble till
	995.5	993.1	2.4	4.0×10^{-7}	sandy clay till
	980.3	978.1	2.2	9.0×10^{-7}	slightly fractured rock
	971.1	968.7	2.4	3.0×10^{-8}	competent bedrock
90-695	962.6	960.1	2.5	$<2 \times 10^{-8}$	clay
90-698	986.0	983.5	2.5	2.0×10^{-8}	competent bedrock
	979.9	977.4	2.5	1.0×10^{-7}	fractured rock
90-700	1 003.2	1 000.8	2.4	8.0×10^{-7}	clay

HOLE NO.	Elevation (m)		Length (m)	K (cm/s)	Comments
	From	To			
90-707	967.0	964.6	2.4	$<5 \times 10^{-8}$	clay
90-711	964.5	962.1	2.4	$<2 \times 10^{-8}$	competent rock
KP91-A12	1021.8	1019.6	2.2	10^{-5}	vesicular basalt, low RQD
	1017.2	1014.1	3.1	10^{-5}	vesicular basalt, highly fractured, very low RQD
	1016.3	1009.3	7	5×10^{-5}	vesicular basalt, highly fractured from 1016.2 to 1011.8 m, very low RQD
	1009.3	1002.3	7	8×10^{-6}	vesicular basalt, high RQD
	1003.2	996.1	7.1	10^{-5}	vesicular basalt, high RQD
KP91-C7	1059.7	1056.7	3	10^{-6}	bedrock, quartz biotite schist, poor RQD
KP91-C8	1016.2	1012.9	3.3	10^{-7}	bedrock, competent gabbro
KP91-C9	1049.2	1046.1	3.1	10^{-7}	bedrock, competent gabbro, moderate RQD
	1046.1	1042.8	3.3	10^{-7}	bedrock, competent gabbro
KP91-W2	992.9	988.9	4	10^{-5}	bedrock, quartz biotite schist, moderate RQD

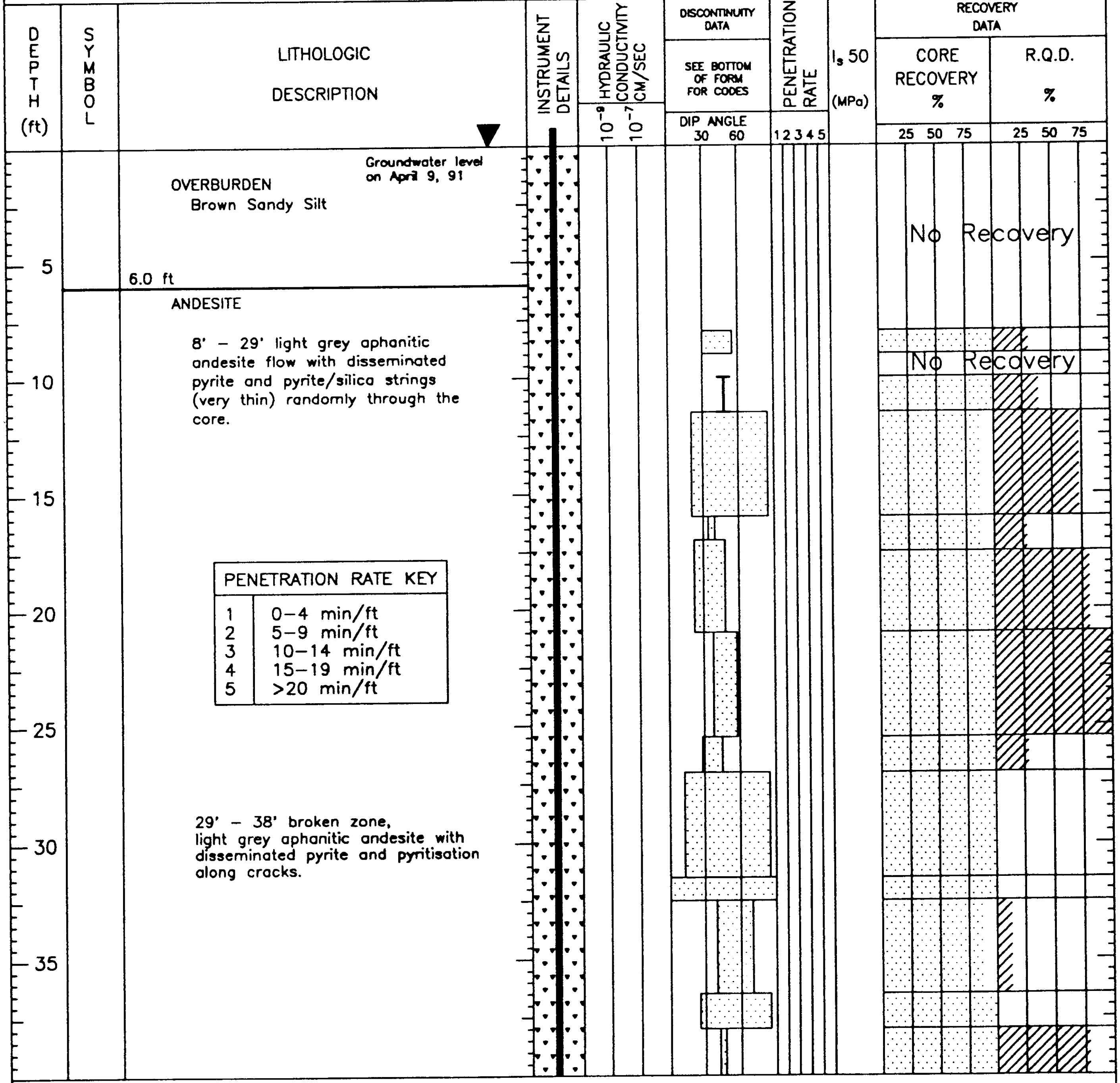
APPENDIX IV

DRILL HOLE LOG KL91-1

SHEET 1 OF 10

KLOHN LEONOFF LTD. GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

CLIENT: Continental Gold Corporation	JOB NO.: PB 5616 0102
PROJECT: Mt. Milligan	DATE HOLE STARTED: Mar 11, 1991 FINISHED: Mar 19, 1991
LOCATION: 70 km west of McLeod Lk.	DATUM: Ground Surface
DIRECTION AZIMUTH: 270 degrees DIP (from horiz): 62 degrees	ELEV. COLLAR: 1176.20 m
CO-ORDINATES E.: 12,147.64 m N.: 9,597.04 m	ELEV. TOP OF ROCK: 1174 m
TOTAL DEPTH OF HOLE: 450 ft	ELEV. BOTTOM OF HOLE: 1055 m
MANUFACTURER'S DRILL DESIGNATION: HT-1000 Nodwell	DRILLING METHOD SOIL: Tri-cone ROCK: HQ Coring
DRILLING CONTRACTOR: Foundex Exploration Ltd.	FLUID: Water CASED TO: 64 ft
LOGGED BY: KGB/PMG/JCC/CGP DATE: March 1991	ANGLE OF DISCON.: MEASURED FROM CORE AXIS ☒ TRUE DIP ☐



OVERBURDEN
Brown Sandy Silt

6.0 ft

ANDESITE

8' – 29' light grey aphanitic andesite flow with disseminated pyrite and pyrite/silica strings (very thin) randomly through the core.

PENETRATION RATE KEY	
1	0–4 min/ft
2	5–9 min/ft
3	10–14 min/ft
4	15–19 min/ft
5	>20 min/ft

29' – 38' broken zone, light grey aphanitic andesite with disseminated pyrite and pyritisation along cracks.

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM51

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft) | SYMBOL | LITHOLOGIC DESCRIPTION

45
50
55
60
65
70
75
80
85

ANDESITE

Light grey aphanitic andesite with disseminated pyrite and pyritization along cracks. Silicification on joint surfaces.

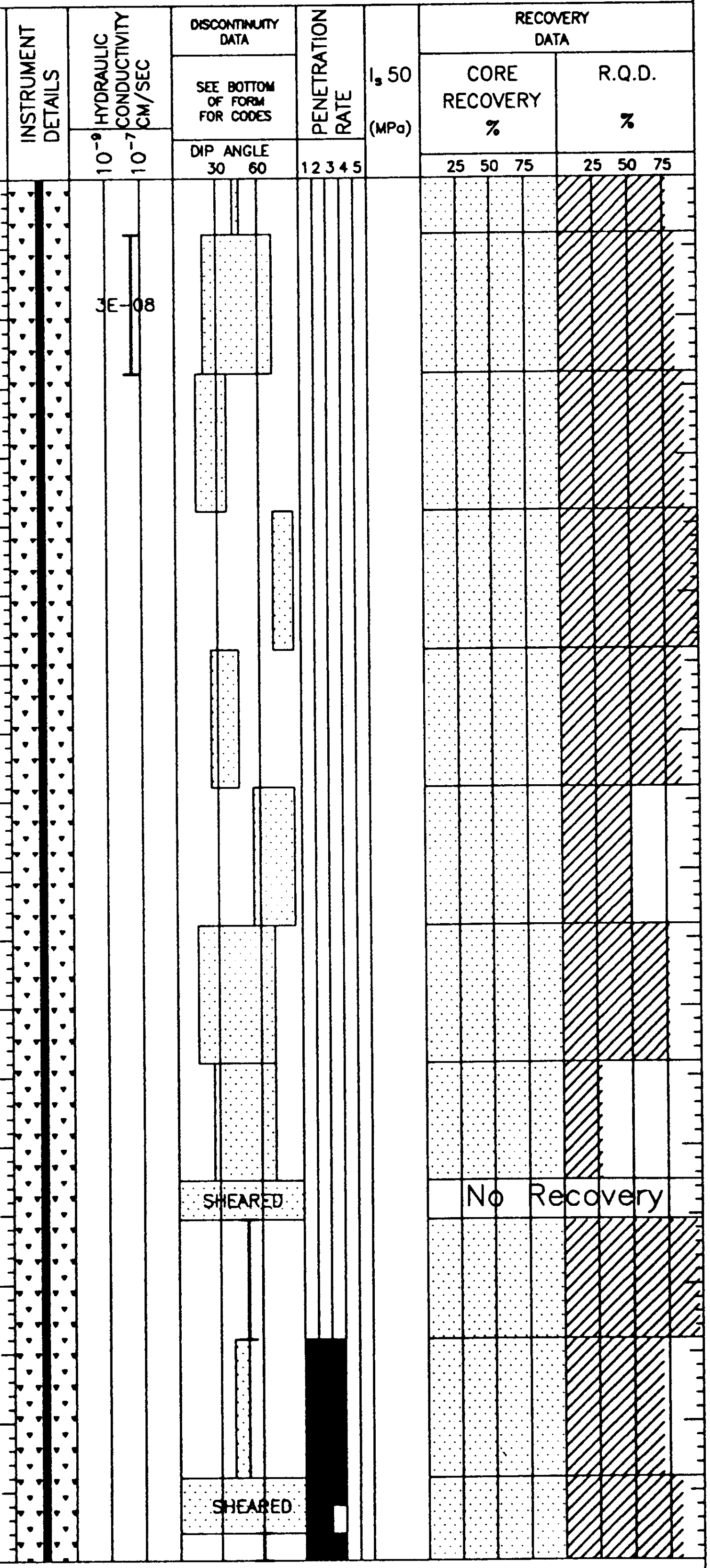
56' – 59' highly pyritized and silicified zone

72' – 78'2" Shear zone, gougy shear highly pyritized

78'2" – 82' moderately weathered, light grey andesite. Closed joints with calcite infill, no pyrite.

82' – 87' slightly weathered light grey andesite. Closed joints with calcite infill

87' – 89' shear zone, calcite, pyrite, blue powdery coating (copper?). Quartz intrusion at 88.5'.



DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft) | SYMBOL | LITHOLOGIC DESCRIPTION | INSTRUMENT DETAILS | HYDRAULIC CONDUCTIVITY CM/SEC 10^{-9} 10^{-7} | DISCONTINUITY DATA: SEE BOTTOM OF FORM FOR CODES; DIP ANGLE 30 60 | PENETRATION RATE 1 2 3 4 5 | I_s 50 (MPa) | RECOVERY DATA: CORE RECOVERY % 25 50 75; R.Q.D. % 25 50 75

ANDESITE

94.5' -96.5' moderately weathered andesite, calcite infill.
Slight quartz intrusion at 98'

96.5' - 105' light grey, weathered andesite, closed joints, traces of pyrite.

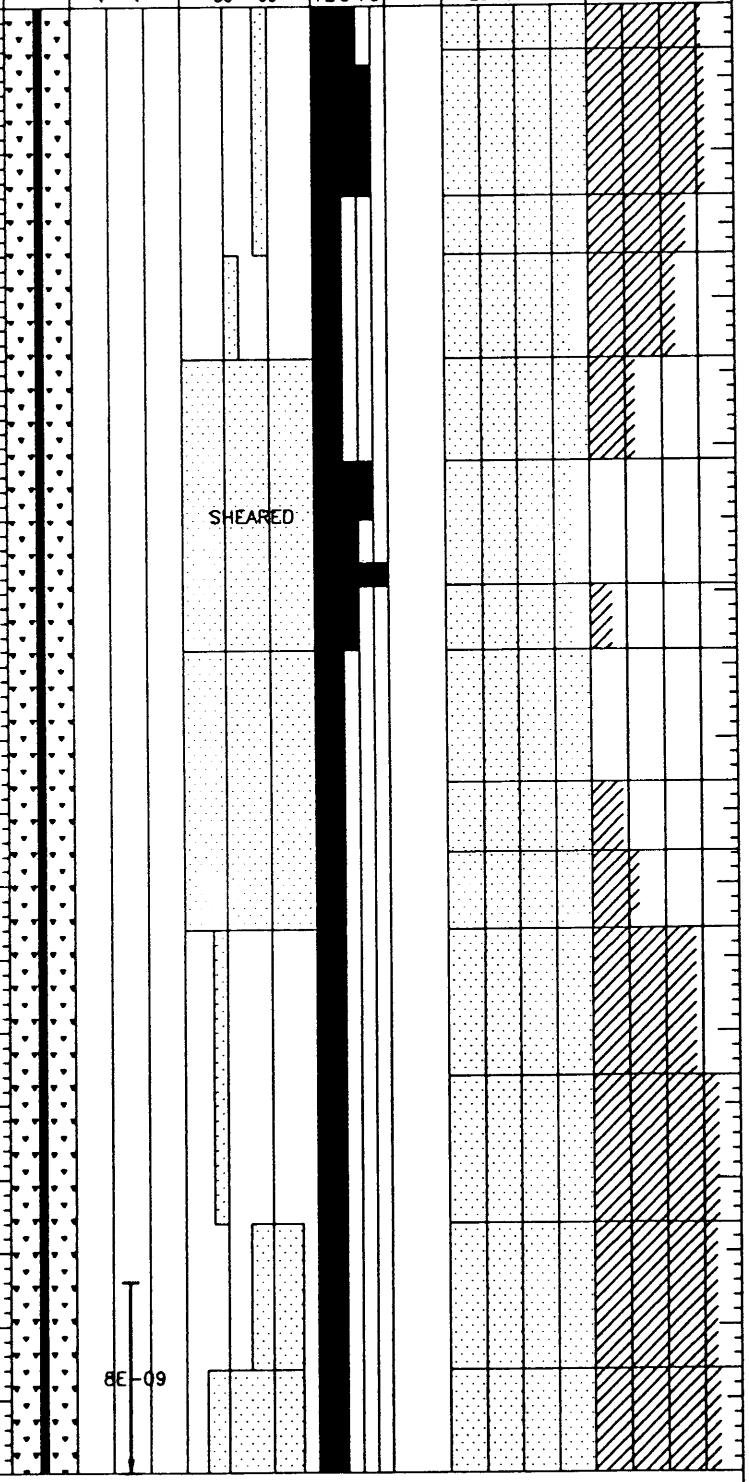
105' - 110' highly weathered andesite, green, pyrite, calcite. Quartz intrusion at 109'. Shear zone.

ANDESITE

110' - 119.8' shear zone, crushed andesite. Slickensided joints with chlorite and calcite.

119.8' - 120.2' breccia (andesite chunks in calcite matrix)
120.2' - 121' healed fractures with calcite and pyrite infill.
121' - 121.7' brocken core with calcite, chlorite and pyrite in fractures.
121.7' - 124.6' Massive sulfides, chlorite and calcite.

124.6 - 146.5' dark green andesite with calcite veining. Sulfides in fractures.



DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft) | SYMBOL | LITHOLOGIC DESCRIPTION

ANDESITE

146.5' – 150.5' light grey andesite

150.5' – 153.5' weathered, soft, light green chlorite/andesite

153.5' – 157' light grey andesite closed joints with calcite,pyrite and chlorite infill.

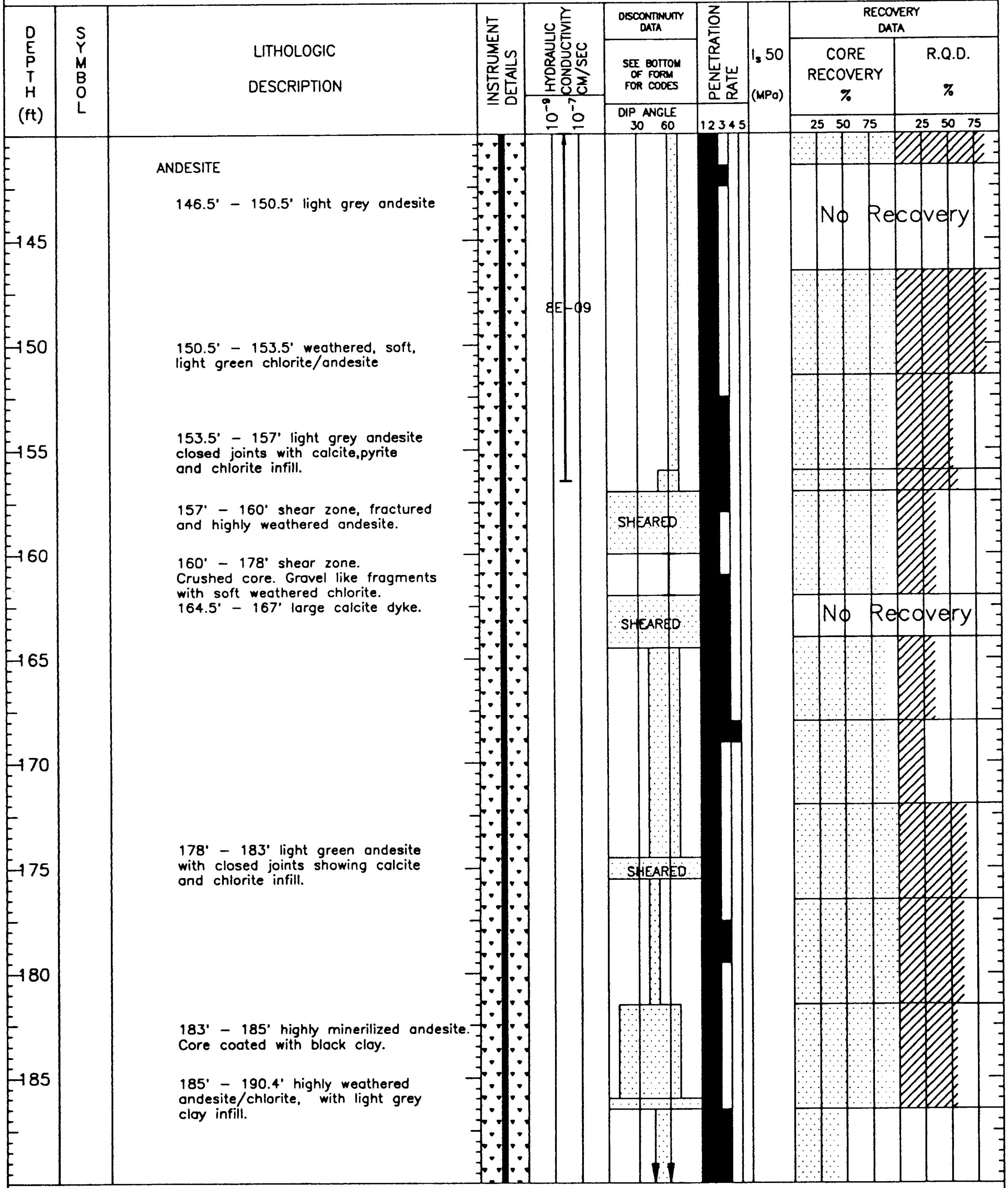
157' – 160' shear zone, fractured and highly weathered andesite.

160' – 178' shear zone.
Crushed core. Gravel like fragments with soft weathered chlorite.
164.5' – 167' large calcite dyke.

178' – 183' light green andesite with closed joints showing calcite and chlorite infill.

183' – 185' highly minerilized andesite. Core coated with black clay.

185' – 190.4' highly weathered andesite/chlorite, with light grey clay infill.



DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

SHEET 5 OF 10

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft) | SYMBOL | LITHOLOGIC DESCRIPTION | INSTRUMENT DETAILS | HYDRAULIC CONDUCTIVITY CM/SEC 10^{-9} 10^{-7} | DISCONTINUITY DATA SEE BOTTOM OF FORM FOR CODES DIP ANGLE 30 60 | PENETRATION RATE 1 2 3 4 5 | I_s 50 (MPa) | RECOVERY DATA CORE RECOVERY % 25 50 75 | R.Q.D. % 25 50 75

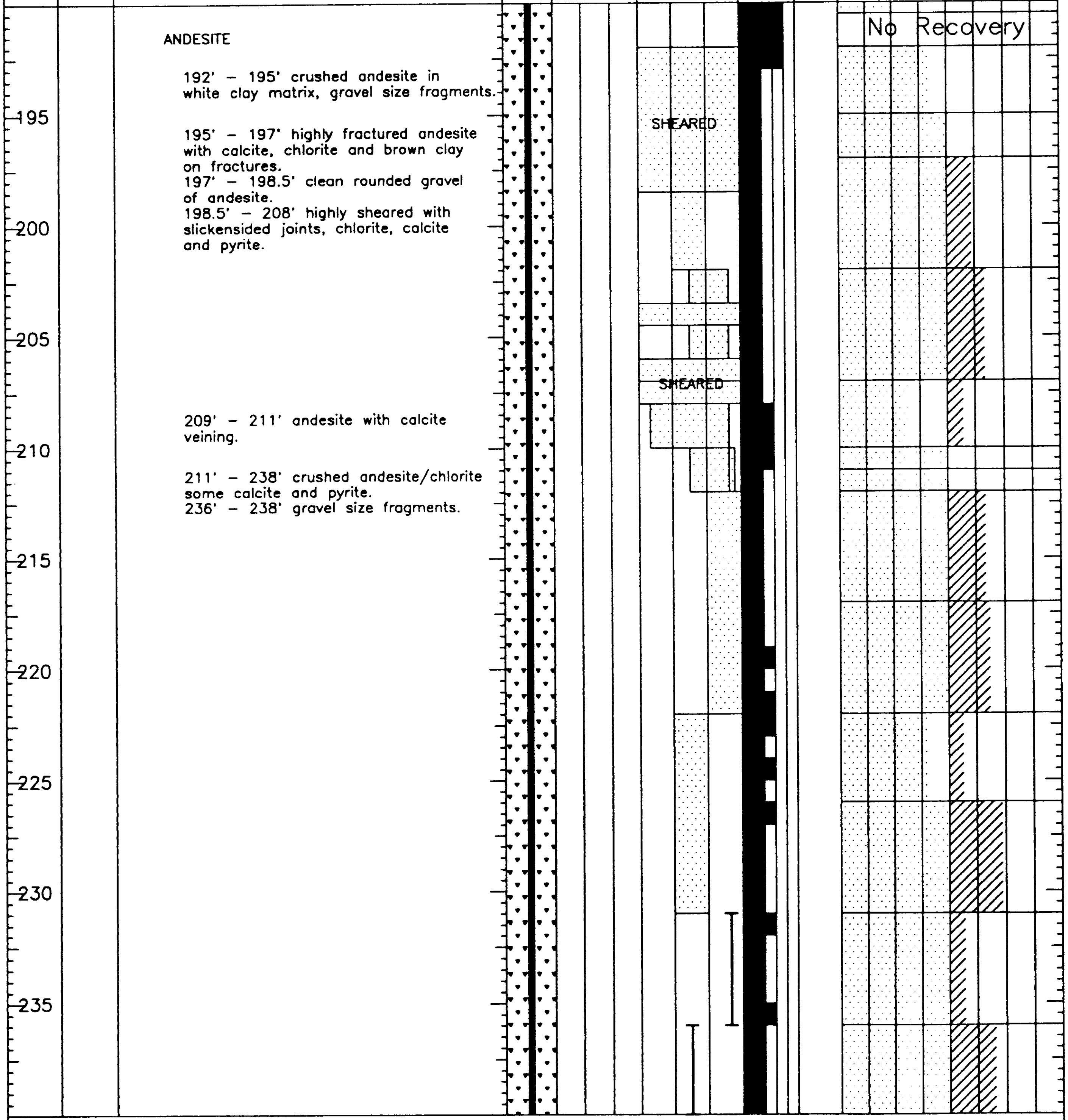
ANDESITE

192' – 195' crushed andesite in white clay matrix, gravel size fragments.

195' – 197' highly fractured andesite with calcite, chlorite and brown clay on fractures.
197' – 198.5' clean rounded gravel of andesite.
198.5' – 208' highly sheared with slickensided joints, chlorite, calcite and pyrite.

209' – 211' andesite with calcite veining.

211' – 238' crushed andesite/chlorite some calcite and pyrite.
236' – 238' gravel size fragments.



DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

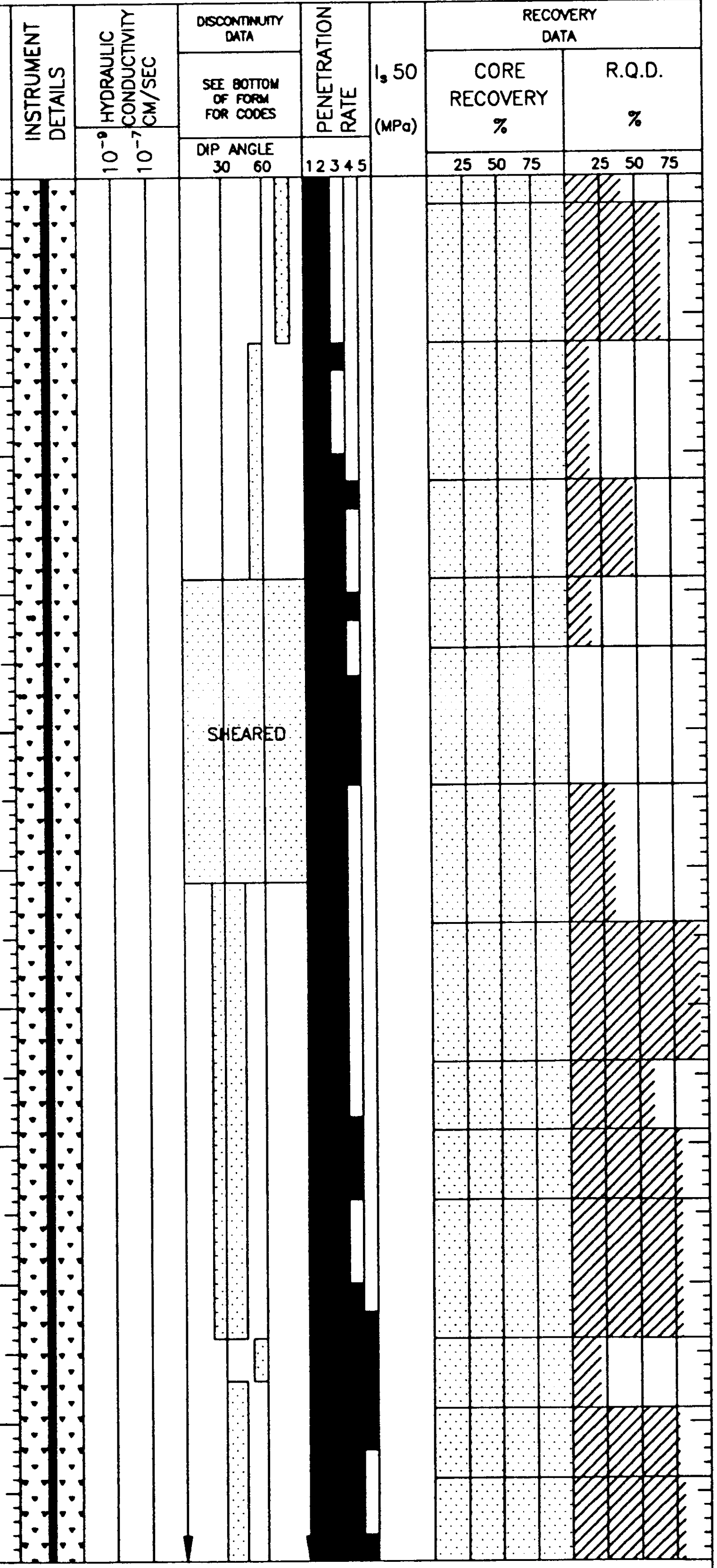
INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

SHEET 6 OF 10

KLOHN LEONOFF LTD. **GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1**

DEPTH (ft)	SYMBOL	LITHOLOGIC DESCRIPTION
245 250 255 260		ANDESITE 238' - 250' light grey andesite with chlorite. Joints show chlorite, iron-oxyde and bluish-grey powdery coating. 250' - 252' non fractured, light grey andesite. 252' - 253' crushed with angular shaped fragments. 253' - 260' shear zone, weathered andesite with slickensided joints at 30 degrees. Healed fractures filled with talc-like powder and chlorite.
260 265 270 275 280 285		PORPHYRY Hard green porphyry with chlorite, pyrite and hematite.



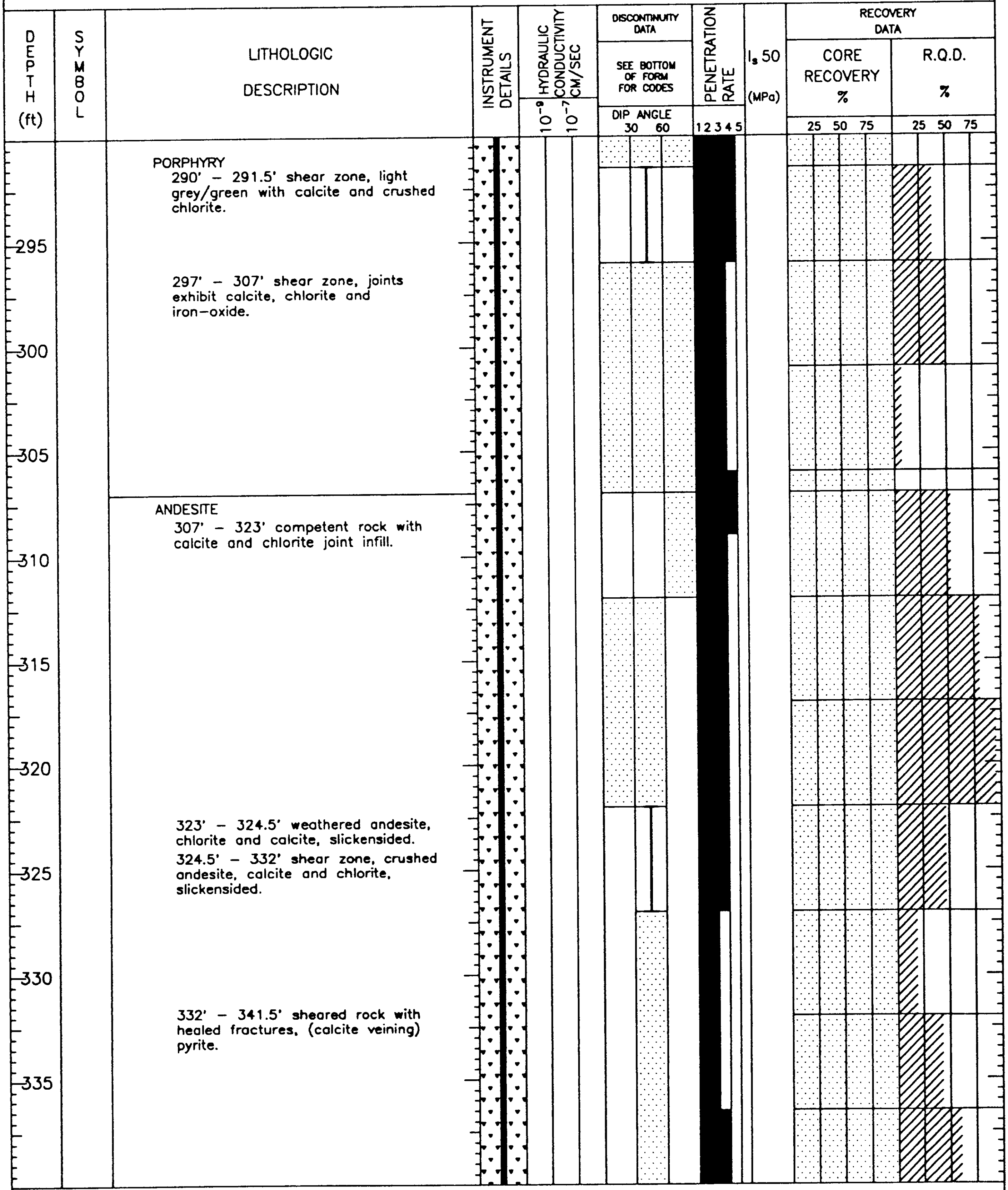
DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1



PORPHYRY

290' – 291.5' shear zone, light grey/green with calcite and crushed chlorite.

297' – 307' shear zone, joints exhibit calcite, chlorite and iron-oxide.

ANDESITE

307' – 323' competent rock with calcite and chlorite joint infill.

323' – 324.5' weathered andesite, chlorite and calcite, slickensided.

324.5' – 332' shear zone, crushed andesite, calcite and chlorite, slickensided.

332' – 341.5' sheared rock with healed fractures, (calcite veining) pyrite.

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft) | SYMBOL | LITHOLOGIC DESCRIPTION | INSTRUMENT DETAILS | HYDRAULIC CONDUCTIVITY CM/SEC 10^{-9} 10^{-7} | DISCONTINUITY DATA: SEE BOTTOM OF FORM FOR CODES; DIP ANGLE 30 60 | PENETRATION RATE 1 2 3 4 5 | I_s 50 (MPa) | RECOVERY DATA: CORE RECOVERY % 25 50 75; R.Q.D. % 25 50 75

Depth marks: 345, 350, 355, 360, 365, 370, 375, 380, 385

ANDESITE

341.5' – 346' light grey andesite with calcite veining. Sheared zone, crushed at 345' with chlorite and pyrite.

346' –365' light grey andesite with calcite and chlorite veining. Whole core with longitudinal fractures.

365' – 368' light grey andesite with few fractures and calcite veining

368' – 371' light grey andesite, brocken up, with much chlorite and calcite. Some iron-oxide (red)

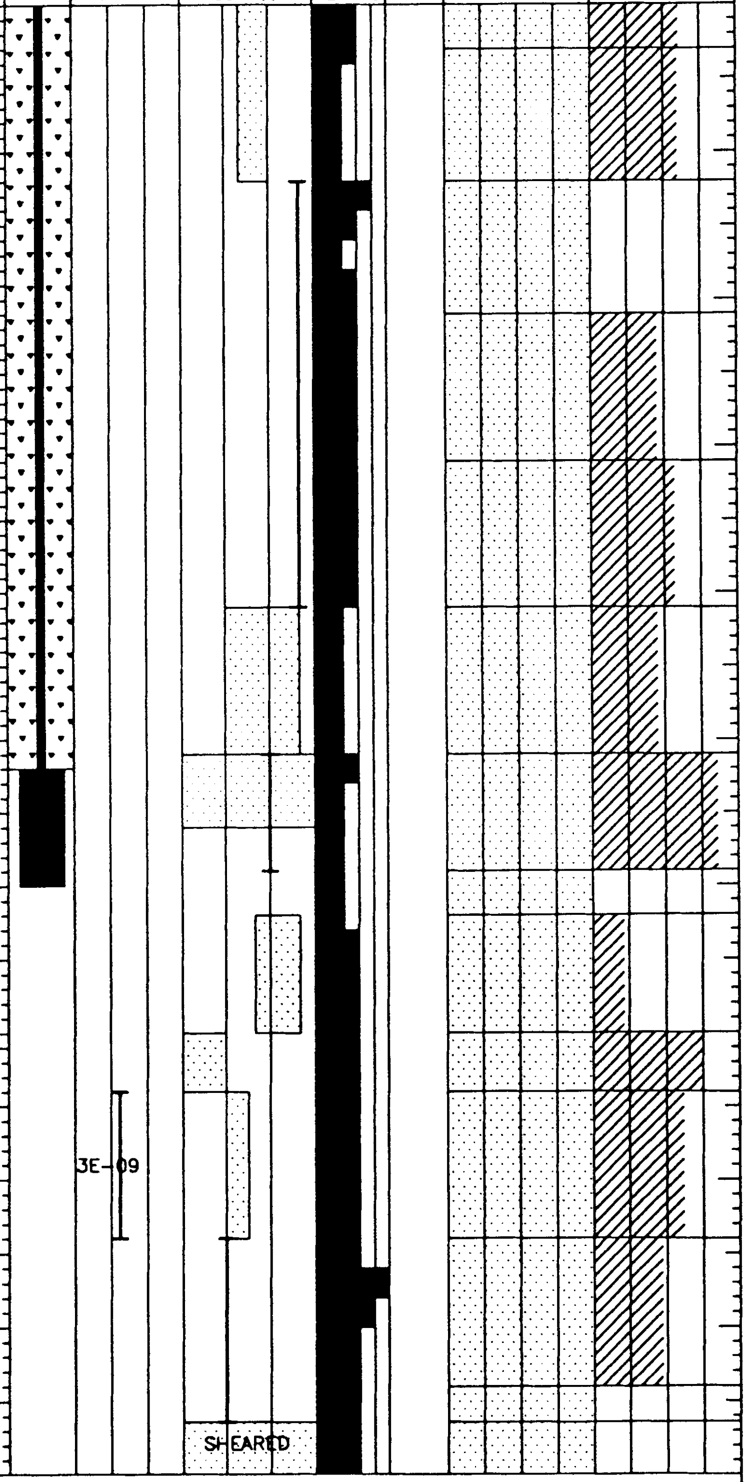
371' – 374.5' light grey andesite with chlorite and calcite.

374.5' – 375' crushed soft chlorite vein.

PORPHYRY

375' – 388.2' fractured rock with calcite and pyrite veining. Calcite and chlorite on joints.

388.2' – 394.5' sheared zone, crushed rock. Calcite, pyrite and chlorite.



DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

SHEET 9 OF 10

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft)	SYMBOL	LITHOLOGIC DESCRIPTION	INSTRUMENT DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC 10^{-9} 10^{-7}	DISCONTINUITY DATA SEE BOTTOM OF FORM FOR CODES DIP ANGLE 30 60	PENETRATION RATE 1 2 3 4 5	I_s 50 (MPa)	RECOVERY DATA CORE RECOVERY % 25 50 75	RECOVERY DATA R.Q.D. % 25 50 75
395 400 405 410 415 420 425 430 435		PORPHYRY 394.5' – 397' fractured rock, calcite, chlorite and pyrite. 397' – 397.5' crushed rock 397.5' – 403' porphyry with large calcite vein with some pyrite at 400'. 403' – 407' highly fractured rock with calcite and trace of chlorite. 407' – 440' very competent rock with low fracturation, some calcite. No joints from 435' to 438.5'.							

DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

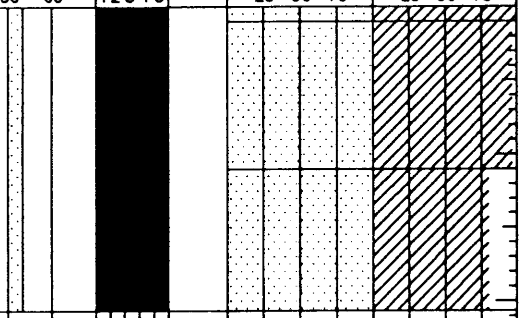
KLOG FORM: KLM52

SHEET 10 OF 10

KLOHN LEONOFF LTD.

GEOLOGIC LOG OF DRILL HOLE NO.: KL 91-1

DEPTH (ft)	SYMBOL	LITHOLOGIC DESCRIPTION	INSTRUMENT DETAILS	HYDRAULIC CONDUCTIVITY CM/SEC 10^{-9} 10^{-7}	DISCONTINUITY DATA SEE BOTTOM OF FORM FOR CODES DIP ANGLE 30 60	PENETRATION RATE 1 2 3 4 5	I_s 50 (MPa)	RECOVERY DATA CORE RECOVERY % 25 50 75	RECOVERY DATA R.Q.D. % 25 50 75
445 450		PORPHYRY very competent rock, hard to drill (25 min/ft). Slickensided joints with calcite, pyrite and chlorite.							
455 460 465 470 475 480 485		END OF HOLE 450.33ft NOTES: 1. Drilling fluid: Water. 2. Water return continuous during drilling, apparently 100%. 3. Standpipe installation: a) Packer set at 366 ft. b) Backfilled with grout in two stages. c) Open hole below 370 ft.							



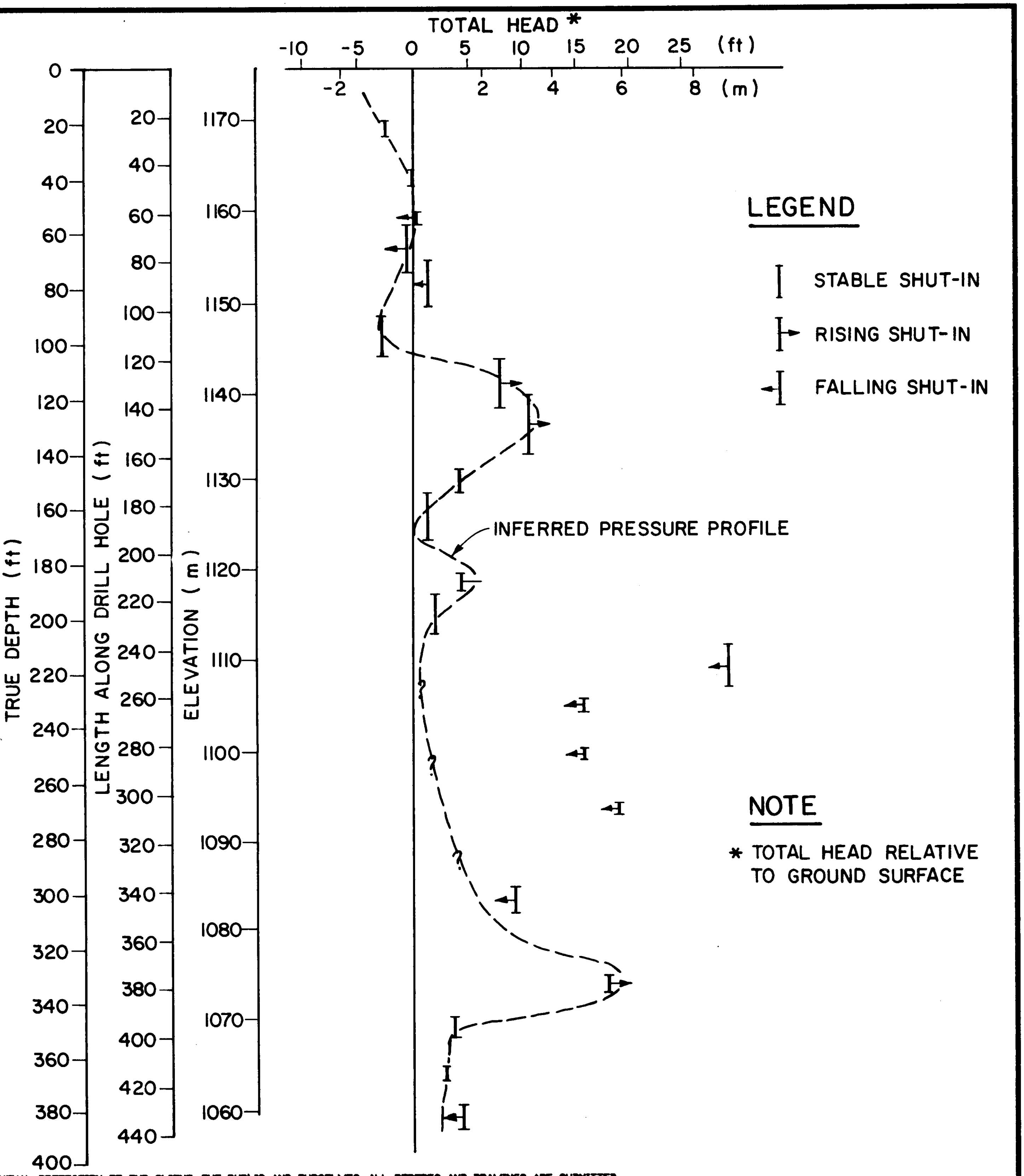
DISCONTINUITY CODES: B: BEDDING D: DRILL BRK F: FAULT G: GNEISS'TY J: JOINT M: SCHIST'TY S: SHEAR T: TENSION CRK

INFILL CODES: A: CARBONACEOUS C: CARBONATE K: CLAY O: IRON OXIDE Q: QUARTZ Z: ZEOLITE

KLOG FORM: KLM52

APPENDIX V

PRESSURE PROFILE KL91-1



NOTE

* TOTAL HEAD RELATIVE TO GROUND SURFACE

SCALE

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TOTAL HEAD PROFILE OF
DRILL HOLE KL91-1

CLIENT
CONTINENTAL GOLD CORP.

DATE OF ISSUE

APPROVED

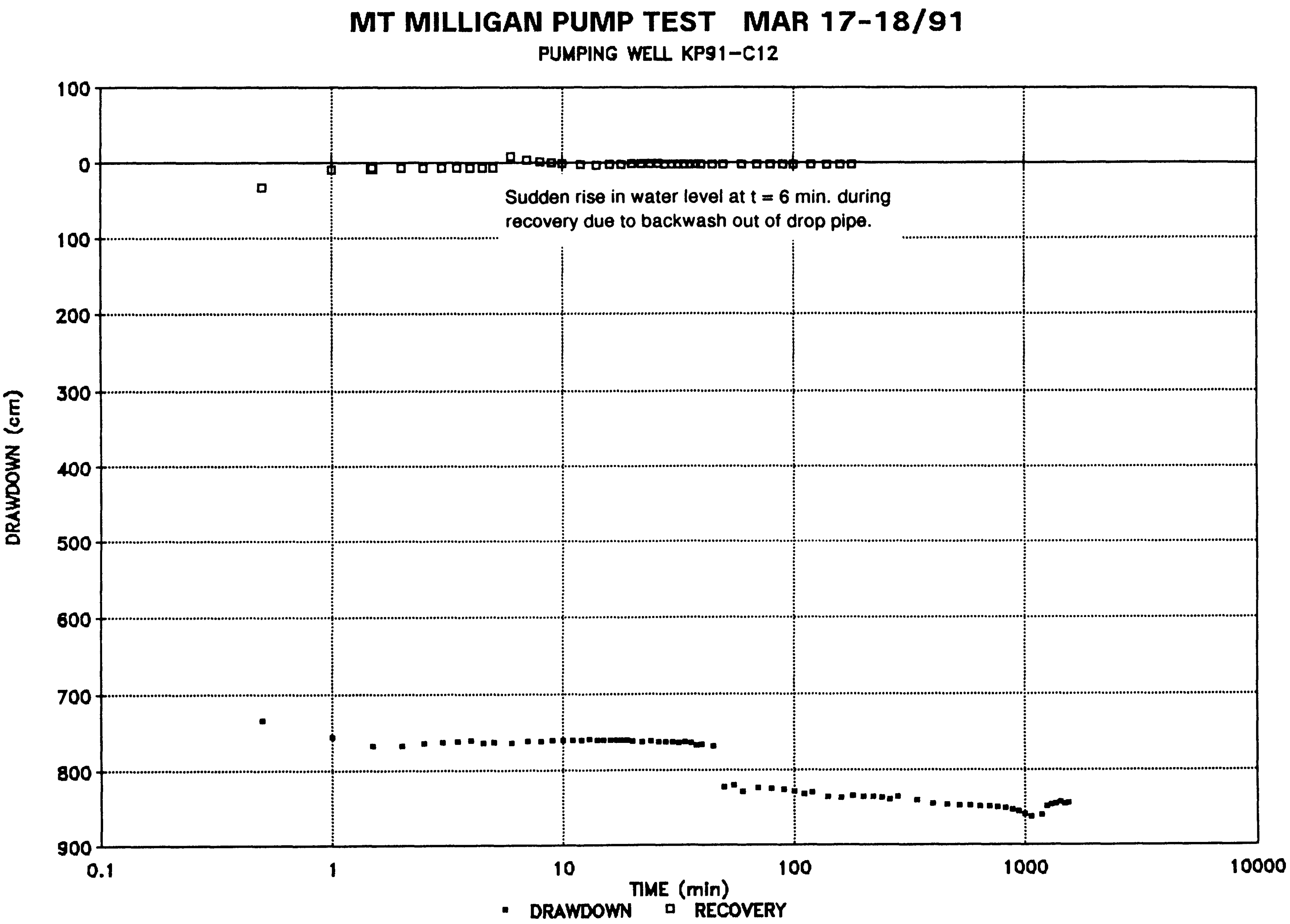
PROJECT No.
PB 5616 01

DWG. No.
APP. V-1

REV.

APPENDIX VI

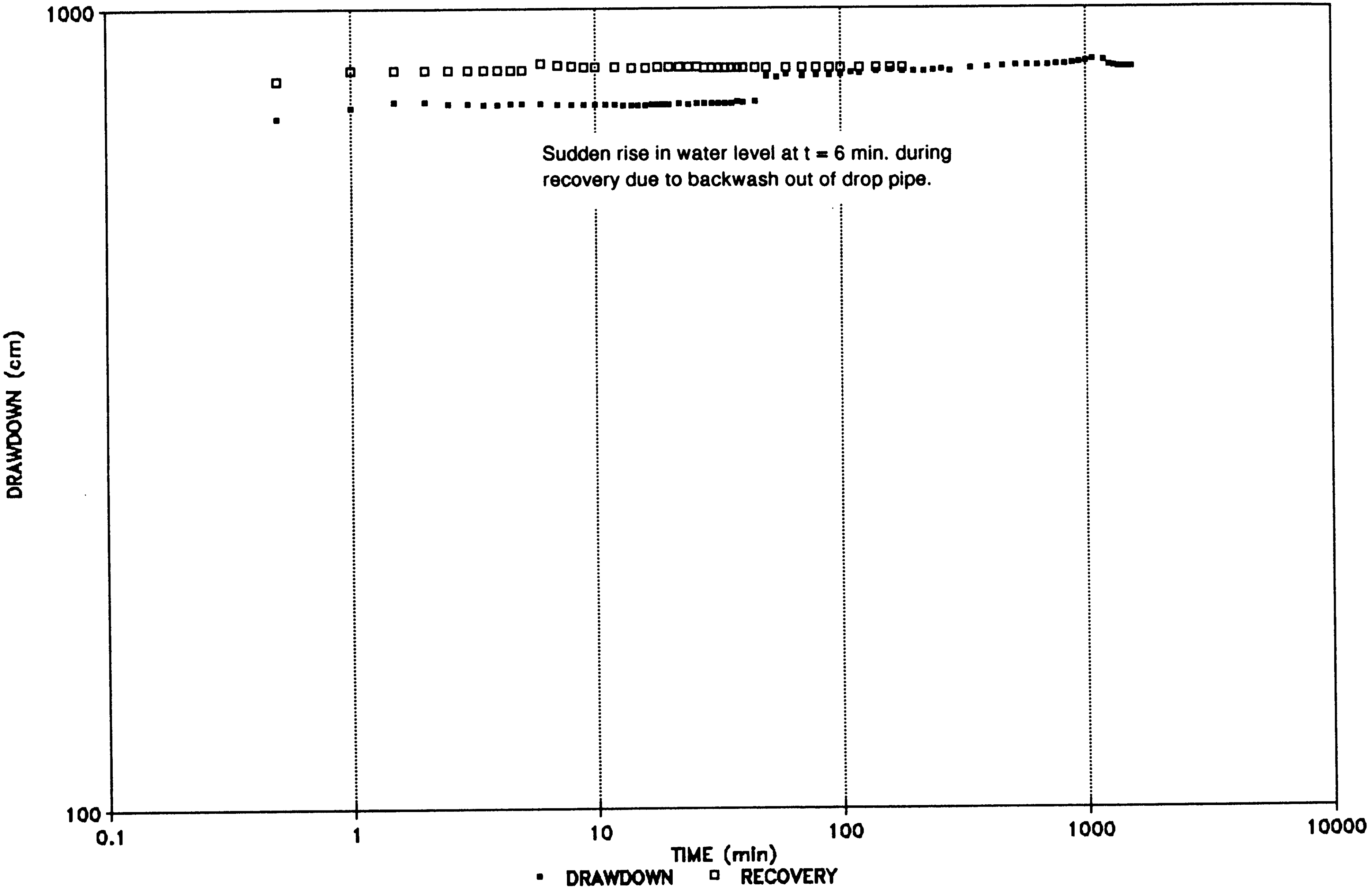
PUMP TEST PLOTS



Sudden rise in water level at t = 6 min. during recovery due to backwash out of drop pipe.

MT MILLIGAN PUMP TEST MAR 17-18/91

PUMPING WELL KP91-C12



Sudden rise in water level at t = 6 min. during recovery due to backwash out of drop pipe.

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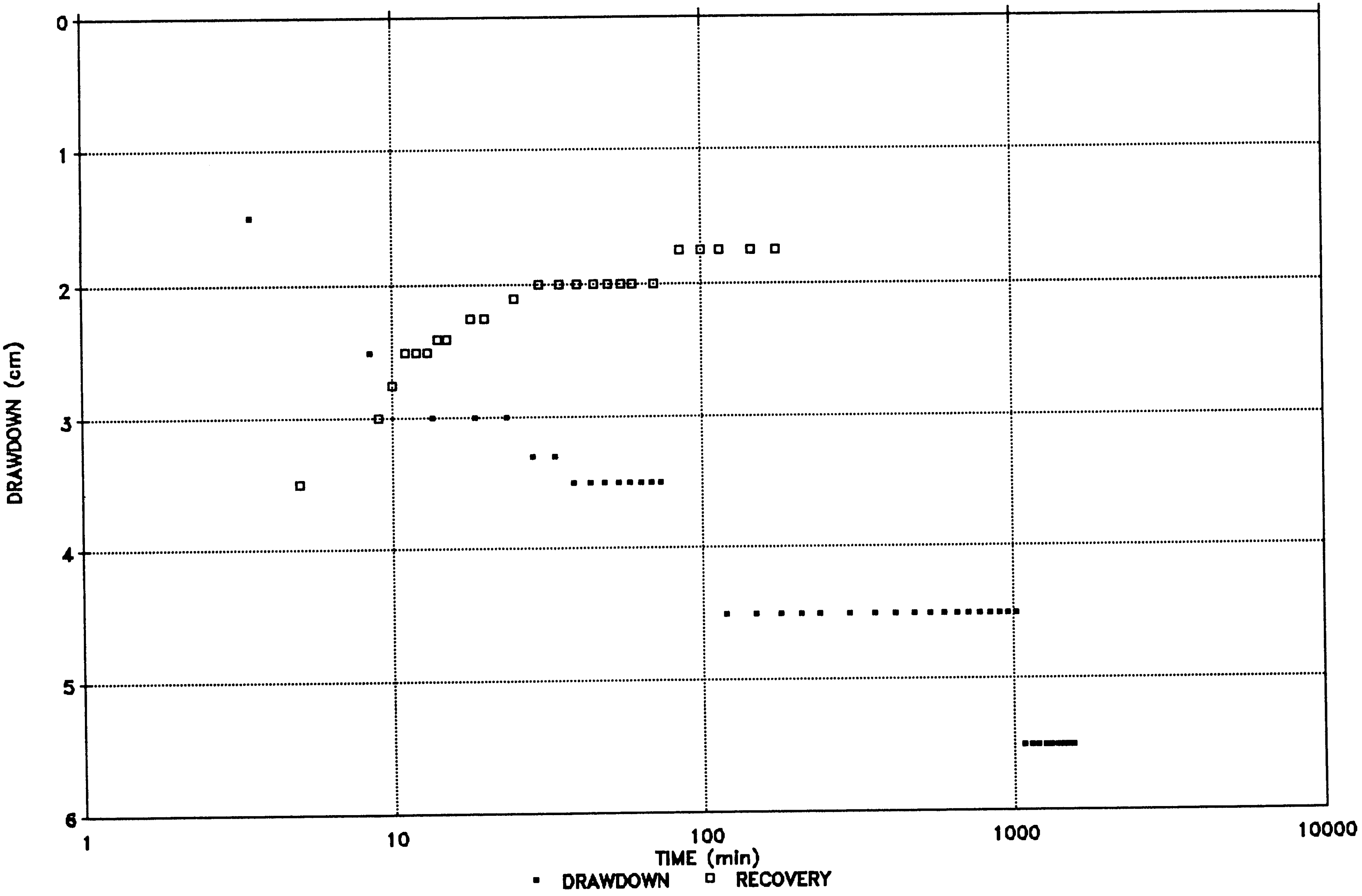
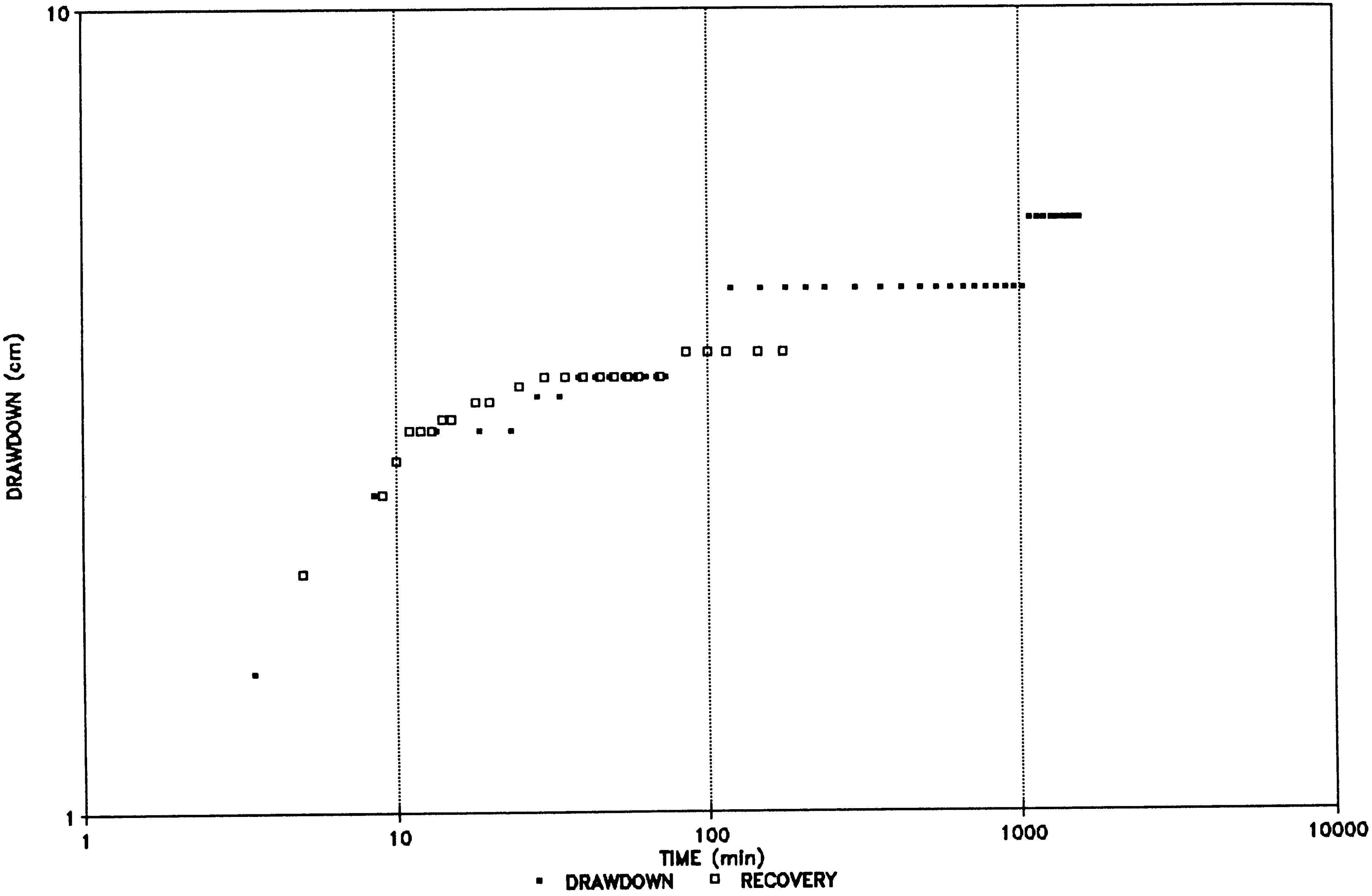
MT MILLIGAN PUMP TEST MAR 17-18/91

OBSERVATION WELL KP91-C13



MT MILLIGAN PUMP TEST MAR 17-18/91

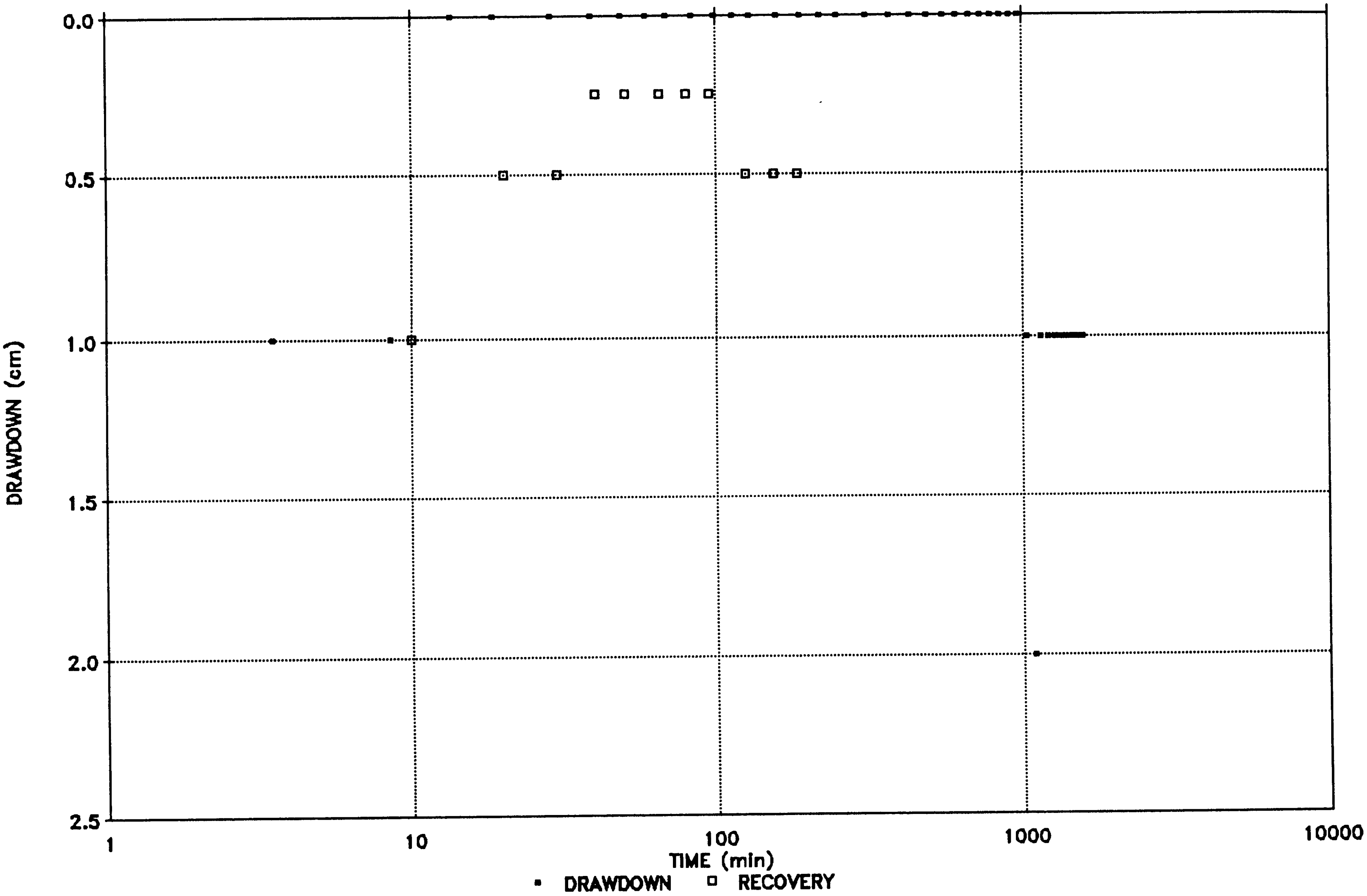
OBSERVATION WELL KP91-C13



KLOHN LEONOFF

MT MILLIGAN PUMP TEST MAR 17-18/91

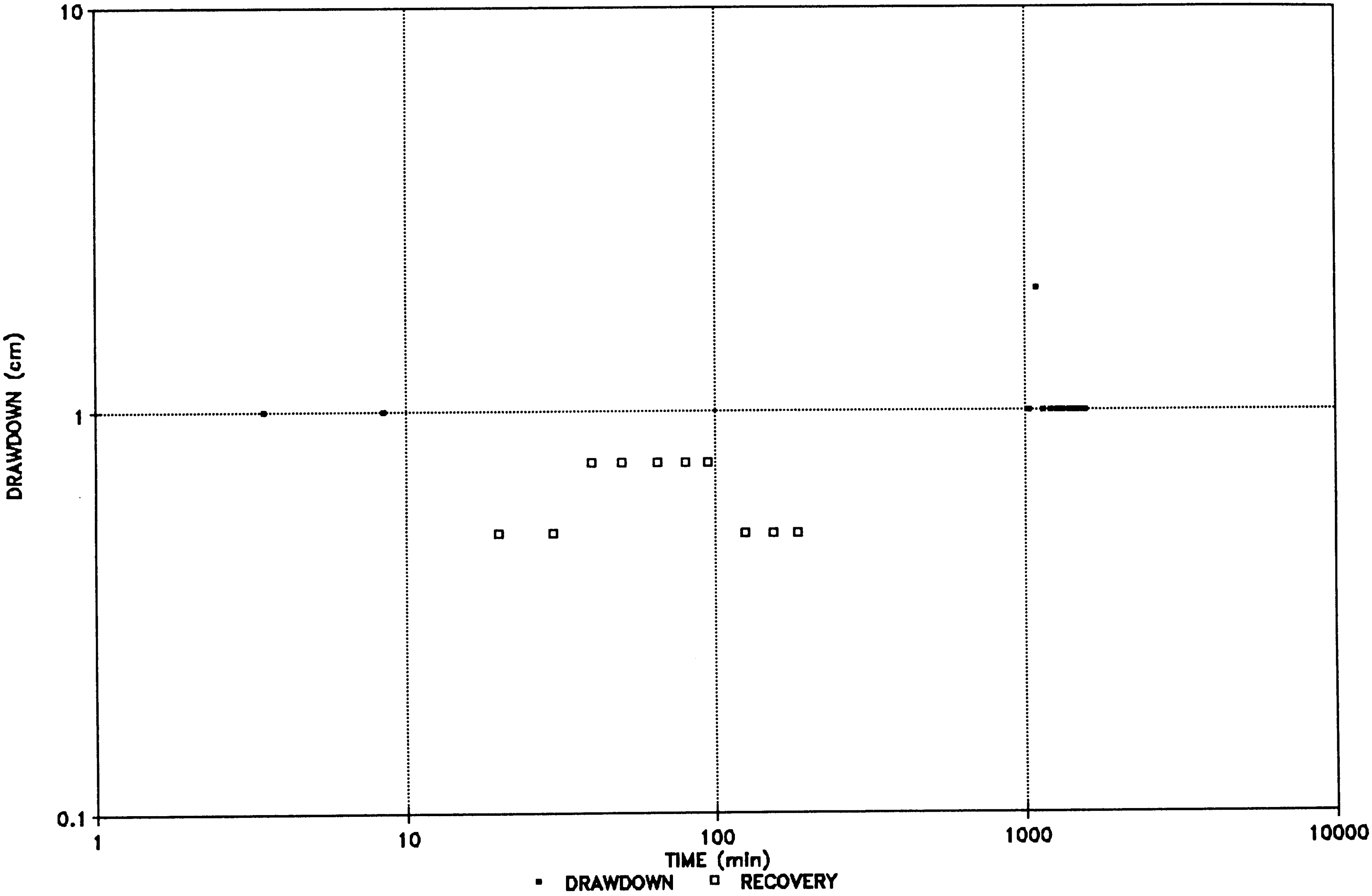
OBSERVATION WELL 90-676



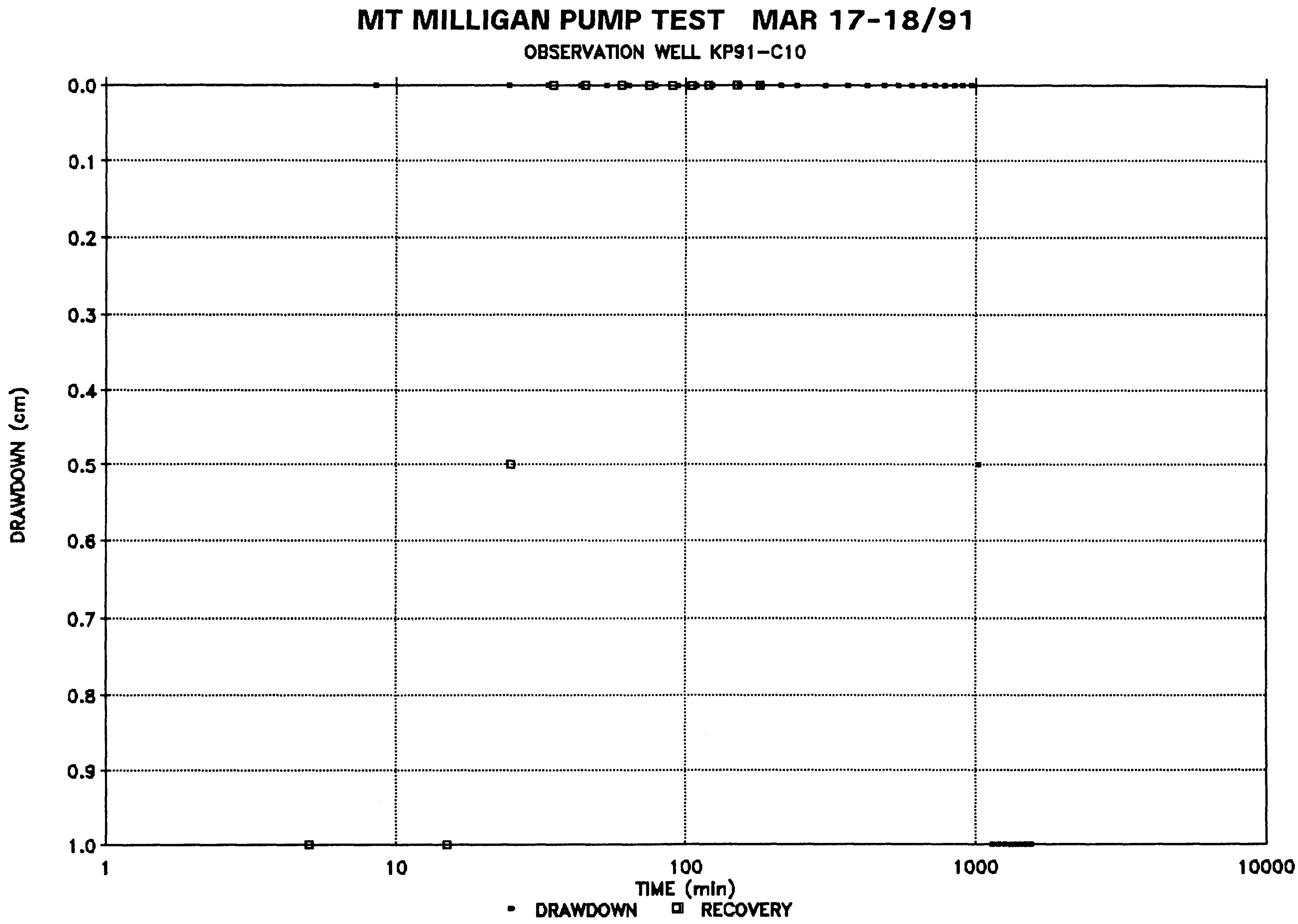
KLOHN LEONOFF

MT MILLIGAN PUMP TEST   MAR 17-18/91

OBSERVATION WELL 90-676



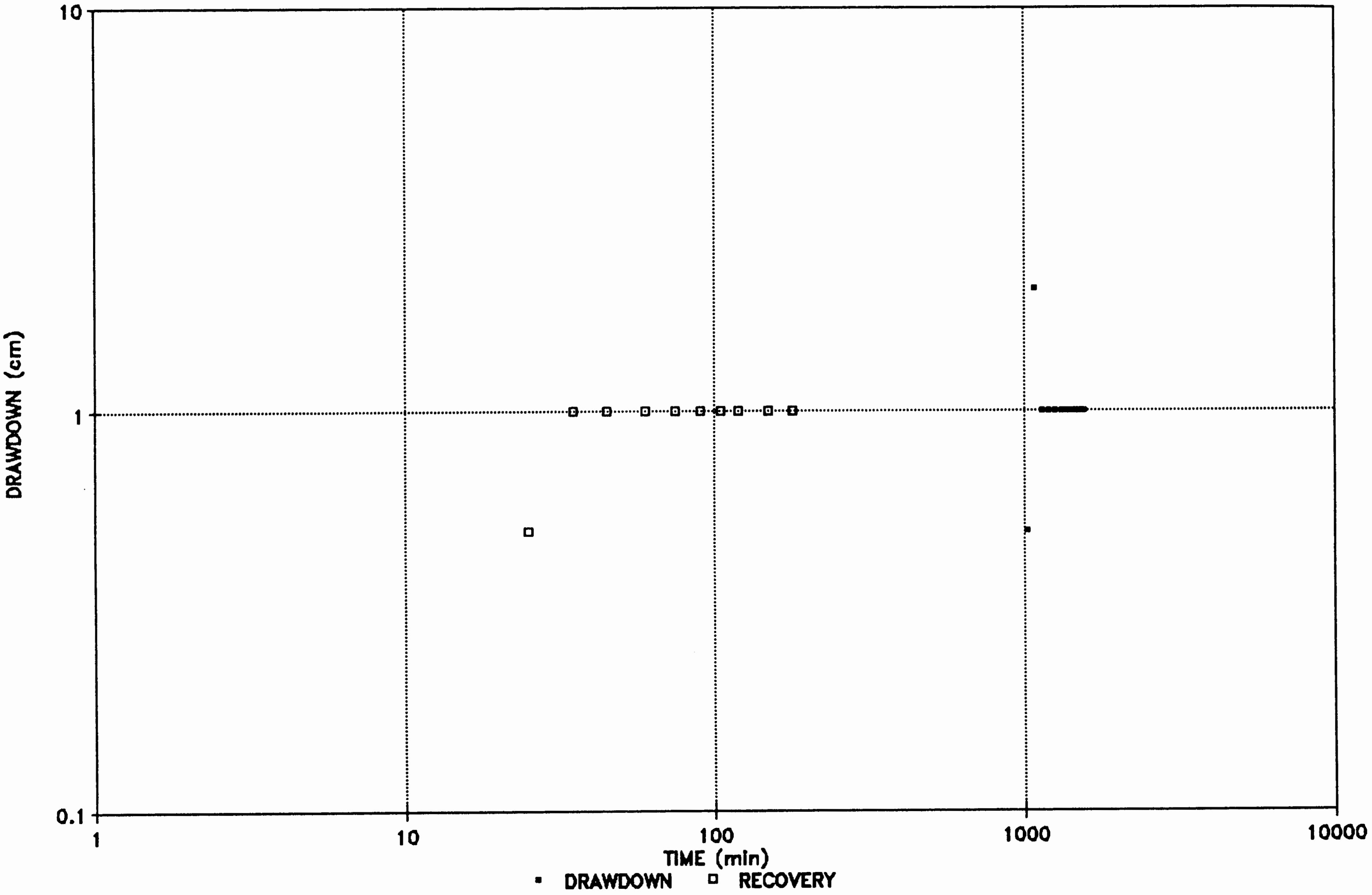
KLOHN LEONOFF



KLOHN LEONOFF

MT MILLIGAN PUMP TEST MAR 17-18/91

OBSERVATION WELL KP91-C10



KLOHN LEONOFF

APPENDIX VII

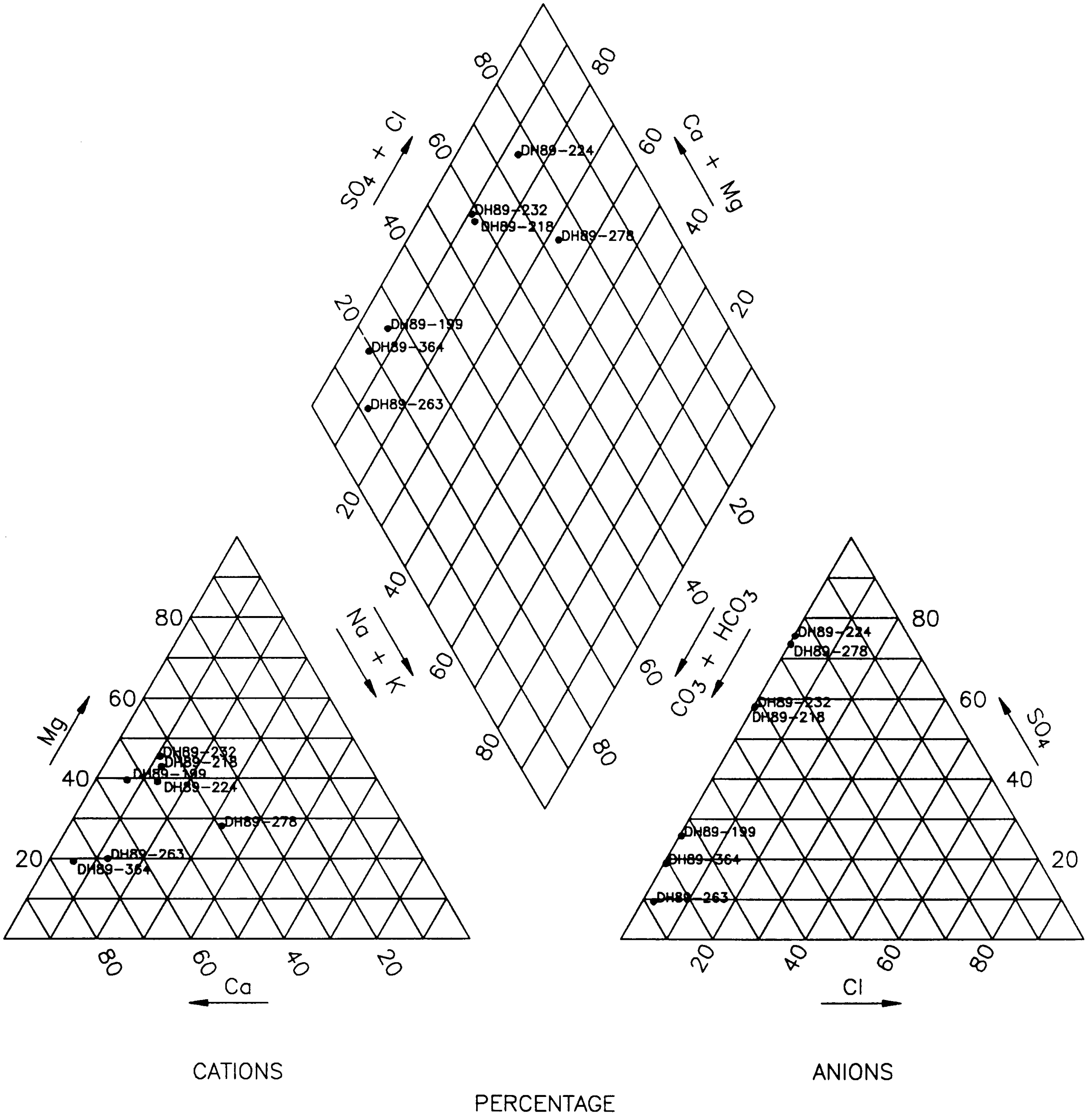
GROUNDWATER CHEMISTRY

CONTINENTAL GOLD CORP.
MOUNT MILLIGAN PROJECT

GROUNDWATER QUALITY
MINESITE
APR & DEC 1989

PARAMETER	DH89–106 APR 04 1989	DH89–199 DEC 08 1989	DH89–218 DEC 08 1989	DH89–224 DEC 08 1989	DH89–232 DEC 08 1989	DH89–263 DEC 08 1989	DH89–278 DEC 08 1989	DH89–364 DEC 08 1989
Physical Tests								
pH	7.7	6.97	6.93	7.02	7.29	7.02	7.54	7.8
Conductivity umhos	494	338	523	711	550	59.3	523	309
Turbidity NTU	20	1160	283	14.2	2060	46.1	38.4	68.9
Suspended Solids	37.3	2700	477	112	1870	58	52	117
Dissolved Solids	316	265	375	520	420	41.7	387	244
Hardness CaCO3	182	165	238	334	250	24.7	180	153
Anions								
Alkalinity CaCO3	96.6	135	107	84.9	123	24.7	68.1	132
Chloride Cl		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Fluoride F								
Sulphate SO4	141	45.2	142	254	165	2.5	184	29.5
Nutrients								
O–Phosphate O–P								
D–Phosphorous D–P	0.015	0.037	0.038	0.073	0.047	0.096	0.061	0.017
T–Phosphorous T–P								
Nitrate N	< 0.005	< 0.005	< 0.005	< 0.005	0.048	< 0.005	< 0.005	0.18
Nitrite N	< 0.001	< 0.001	< 0.001	< 0.001	0.063	0.003	0.005	0.005
Ammonia N	< 0.005	< 0.005	< 0.005	< 0.005	0.017	< 0.005	0.008	< 0.005
Cyanide								
Total Cyanide T CN	0.004	0.56	0.025	0.008	0.091	< 0.001	< 0.001	< 0.001
Total Metals								
Aluminum T Al	0.69	16.1	54	1.01	15.8	0.76	0.6	0.07
Antimony T Sb	0.009	0.0014	0.0012	0.0003	0.0008	0.0002	0.0024	< 0.0001
Arsenic T As	0.013	0.013	0.032	0.001	0.004	0.0007	0.0016	0.0004
Barium T Ba	0.17	0.25	0.53	0.021	0.13	0.014	0.032	< 0.01
Beryllium T Be								
Bismuth T Bi								
Boron T Bo								
Cadmium T Cd	< 0.0002	0.0003	0.0006	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium T Ca								
Chromium T Cr								
Cobalt T Co								
Copper T Cu	0.039	0.26	0.73	0.028	0.099	0.011	0.008	0.001
Iron T Fe	3.26	26.4	79.1	1.93	56.5	1.09	1.1	0.12
Lead T Pb	0.034	0.013	0.051	0.046	0.006	0.005	0.003	< 0.001
Magnesium T Mg								
Manganese T Mn								
Mercury T Hg	< 0.00001	0.00034	< 0.00001	< 0.00001	0.00023	< 0.00001	< 0.00001	< 0.00001
Molybdenum T Mo	0.019	0.019	0.013	0.008	0.013	0.002	0.006	0.007
Nickel T Ni	0.005	0.022	0.068	0.005	0.035	0.001	0.002	0.001
Selenium T Se	< 0.0005	0.0005	0.0017	< 0.0005	0.0012	< 0.0005	< 0.0005	< 0.0005
Silicon T Si								
Silver T Ag	< 0.0001	0.0001	0.0001	< 0.0001	0.0003	< 0.0001	< 0.0001	0.0001
Strontium T Sr								
Uranium T U								
Vanadium T V								
Zinc T Zn	0.017	0.071	0.24	0.017	0.03	0.012	0.015	< 0.005
Dissolved Metals								
Aluminum D Al	< 0.005	0.03	0.018	0.014	0.022	0.019	0.014	0.01
Antimony D Sb	0.0084	0.0009	0.0001	0.0002	0.0002	0.0002	0.0003	< 0.0001
Arsenic D As	0.0064	0.0004	0.0007	0.0002	< 0.0001	< 0.0001	0.0008	0.0003
Barium D Ba	0.082	0.055	0.034	< 0.01	< 0.01	< 0.01	0.018	< 0.01
Beryllium D Be								
Bismuth D Bi								
Boron D Bo								
Cadmium D Cd	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium D Ca		37.8	48	72.5	48.4	7.61	41.7	48.6
Chromium D Cr								
Cobalt D Co								
Copper D Cu	0.033	0.001	0.001	0.001	< 0.001	0.001	< 0.001	< 0.001
Iron D Fe	1.03	< 0.03	0.09	0.13	< 0.03	< 0.03	< 0.03	< 0.03
Lead D Pb	0.034	< 0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	< 0.001
Magnesium D Mg		16.9	28	36.4	30.6	1.36	18.1	7.55
Manganese D Mn								
Molybdenum D Mo	0.019	0.019	0.012	0.008	0.009	0.001	0.006	0.007
Nickel D Ni	0.001	< 0.001	< 0.001	0.001	0.001	< 0.001	0.002	0.001
Potassium D K		0.71	0.77	2.94	2.67	0.41	0.33	0.69
Selenium D Se	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Silicon D Si								
Silver D Ag	< 0.0001	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sodium D Na		5.01	14.7	21.7	12.1	1.36	39.4	3.63
Strontium D Sr								
Uranium D U								
Vanadium D V								
Zinc D Zn	0.014	< 0.005	< 0.005	0.005	0.011	< 0.005	< 0.005	< 0.005

MT. MILLIGAN HYDROGEOLOGY
PIPER PLOT
DECEMBER 1989 GROUNDWATER SAMPLES



CONTINENTAL GOLD CORP.
MOUNT MILLIGAN PROJECT

GROUNDWATER QUALITY
MINESITE
MAR 1990

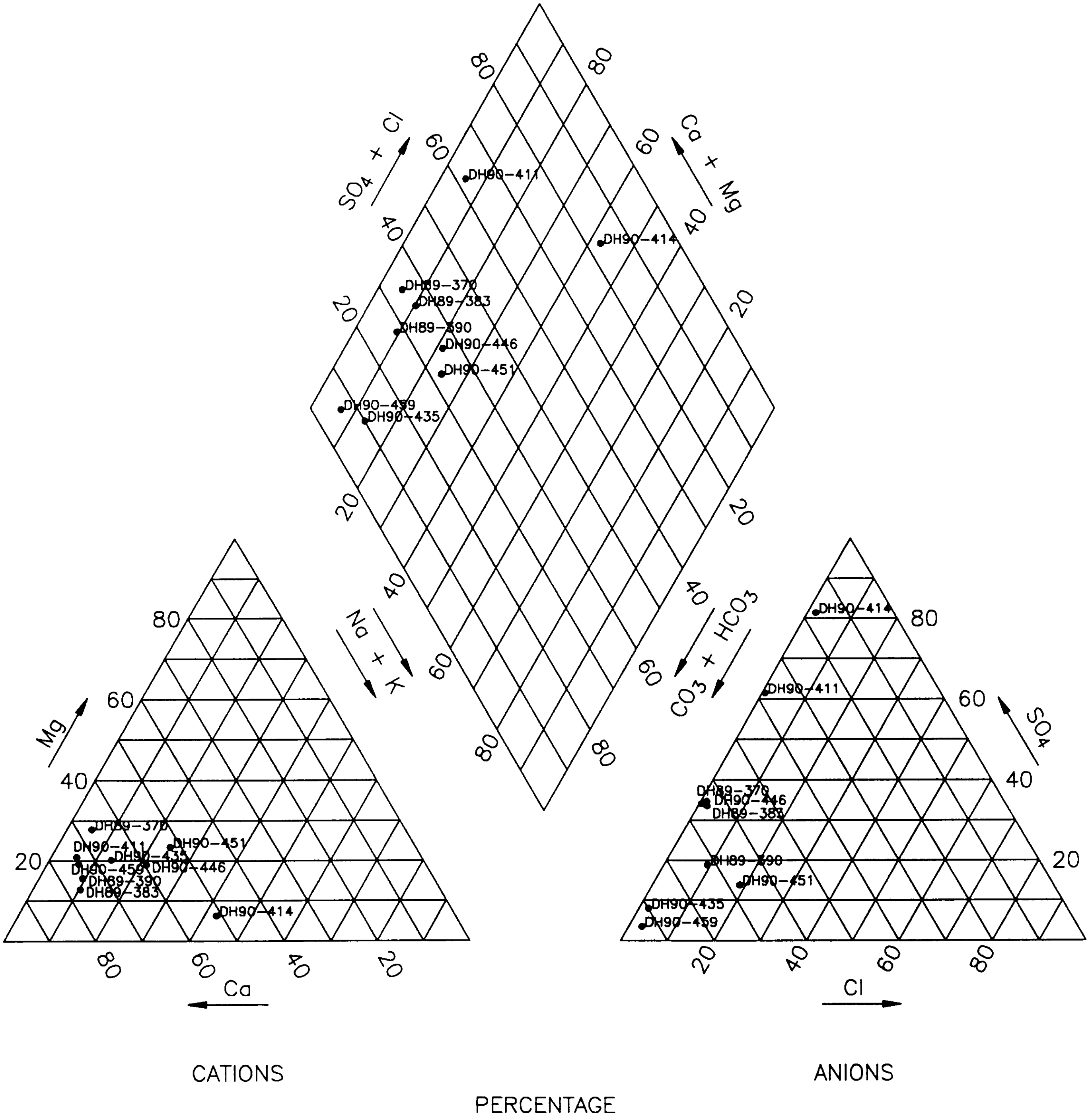
PARAMETER	DH89–370 MAR 03 1990	DH89–383 MAR 03 1990	DH89–390 MAR 03 1990	DH90–411 MAR 03 1990	DH90–414 MAR 03 1990	DH90–435 MAR 03 1990	DH90–446 MAR 03 1990	DH90–451 MAR 03 1990	DH90–459 MAR 03 1990
Physical Tests									
pH	7.08	6.92	7.35	7.4	7.25	7.28	7.66	7.45	6.64
Conductivity umhos	258	264	198	248	454	66.1	335	232	134
Turbidity NTU	654	54	1430	93.7	35.6	47.5	187	26.5	32.3
Suspended Solids	342	625	1860	305	247	117	67.3	62	67.3
Dissolved Solids	197	208	140	174	320	49	171	193	207
Hardness CaCO3	102	113	68.5	68.8	113	26.3	25.5	106	63.3
Anions									
Alkalinity CaCO3	86.7	93.2	76	100	47.6	29.8	102	105	53.6
Chloride Cl									
Fluoride F									
Sulphate SO4	41.4	38.2	15	19.8	176	1.4	31.4	17.5	96
Nutrients									
O–Phosphate O–P									
D–Phosphorous D–P	0.098	0.015	0.099	0.011	0.033	0.022	0.094	0.023	0.028
T–Phosphorous T–P									
Nitrate N	< 0.005	< 0.005	0.027	< 0.005	0.006	0.008	0.05	< 0.005	< 0.005
Nitrite N	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.019	< 0.001	< 0.001
Ammonia N	0.031	0.015	0.89	0.059	0.025	0.017	0.019	0.087	0.061
Cyanide									
Total Cyanide T CN	0.024	0.003	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
Total Metals									
Aluminum T Al	23.4	0.6	261	81.7	6.85	4.41	14.2	4.12	3.33
Antimony T Sb	0.0021	0.0027	0.0017	0.0027	0.0027	0.0022	0.0008	0.001	0.0016
Arsenic T As	0.015	0.0014	0.12	0.081	0.0035	0.0029	0.0049	0.0022	0.0017
Barium T Ba	0.22	0.69	2.12	0.84	0.11	0.061	0.13	0.059	0.042
Beryllium T Be									
Bismuth T Bi									
Boron T Bo									
Cadmium T Cd	0.0006	0.0004	0.0027	0.0017	< 0.0002	0.0003	0.0002	0.0003	0.0002
Calcium T Ca									
Chromium T Cr									
Cobalt T Co									
Copper T Cu	0.34	0.017	3.82	0.88	0.049	0.038	0.036	0.029	0.021
Iron T Fe	35.4	2.74	504	165	7.29	4.8	11.4	4.53	4.36
Lead T Pb	0.026	0.012	0.15	0.16	0.028	0.022	0.047	0.016	0.031
Magnesium T Mg									
Manganese T Mn									
Mercury T Hg	0.00002	0.00001	0.00002	0.00006	< 0.00001	0.00001	0.00002	0.00002	0.00001
Molybdenum T Mo	0.013	0.016	0.008	0.022	0.02	0.001	0.03	0.008	0.001
Nickel T Ni	0.031	0.003	0.61	0.34	0.005	0.005	0.012	0.006	0.004
Selenium T Se	0.001	< 0.0005	0.0018	0.006	< 0.0005	0.0008	0.0005	< 0.0005	< 0.0005
Silicon T Si									
Silver T Ag	0.0005	< 0.0001	0.0025	0.0012	< 0.0001	< 0.0001	0.0004	< 0.0001	0.0001
Strontium T Sr									
Uranium T U									
Vanadium T V									
Zinc T Zn	0.18	0.041	1.33	0.43	0.064	0.036	0.035	0.029	0.026
Dissolved Metals									
Aluminum D Al	0.19	0.06	0.05	0.08	0.085	0.044	0.06	0.068	0.095
Antimony D Sb	0.0004	0.0008	0.001	0.0016	0.0025	0.0012	0.0008	0.0006	0.0016
Arsenic D As	0.0003	0.0005	0.0014	0.0072	0.0013	0.0006	0.0024	0.0005	0.0003
Barium D Ba	0.036	0.69	0.025	0.029	0.027	0.011	0.023	0.023	0.014
Beryllium D Be									
Bismuth D Bi									
Boron D Bo									
Cadmium D Cd	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium D Ca									
Chromium D Cr									
Cobalt D Co									
Copper D Cu	0.004	0.003	0.008	0.052	0.002	0.002	0.005	0.005	0.005
Iron D Fe	0.54	0.88	0.078	0.3	0.11	0.085	0.016	0.28	0.1
Lead D Pb	0.008	0.004	0.004	0.05	0.002	0.003	0.01	0.002	0.005
Magnesium D Mg									
Manganese D Mn									
Molybdenum D Mo	0.012	0.016	0.006	0.014	0.02	0.001	0.012	0.008	< 0.001
Nickel D Ni	0.002	0.002	0.003	0.007	< 0.001	< 0.001	0.003	< 0.001	< 0.001
Potassium D K									
Selenium D Se	< 0.0005	< 0.0005	0.0009	< 0.0005	< 0.0005	< 0.0005	0.0005	< 0.0005	< 0.0005
Silicon D Si									
Silver D Ag	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sodium D Na									
Strontium D Sr									
Uranium D U									
Vanadium D V									
Zinc D Zn	0.011	0.023	< 0.005	0.011	< 0.005	0.01	< 0.005	0.007	0.013

CONTINENTAL GOLD CORP.
MOUNT MILLIGAN PROJECT

GROUNDWATER QUALITY
MINESITE
JUN 1990

PARAMETER	DH89–370 JUN 09 1990	DH89–383 JUN 09 1990	DH89–390 JUN 09 1990	DH90–411 JUN 09 1990	DH90–414 JUN 09 1990	DH90–435 JUN 10 1990	DH90–446 JUN 09 1990	DH90–459 JUN 09 1990	DH90–451 JUN 10 1990
Physical Tests									
pH	7.59	7.24	7.67	7.65	7.28	6.99	7.49	7.72	6.32
Conductivity umhos	374	226	180	282	523	68.5	273	206	74.4
Turbidity NTU	124	27	6930	239	13.8	79.5	39.3	36.3	112
Suspended Solids	295	40	8220	806	35.3	158	138	48.7	303
Dissolved Solids	340	190	160	260	480	60	230	180	60
Hardness CaCO3	152	96.5	56.4	131	140	29.1	104	98.3	25.1
Anions									
Alkalinity CaCO3	143	71.8	60.9	57.5	46.8	31.4	98	107	22.9
Chloride Cl	0.7	1.5	5.6	0.7	3.5	0.5	1.4	2.3	4.5
Fluoride F	0.27	0.14	0.07	0.09	0.06	0.03	0.11	0.04	0.07
Sulphate SO4	71.7	35.9	15.3	89.5	217	2.7	51	3.9	4.5
Nutrients									
O–Phosphate O–P	0.042	0.006	0.31	0.056	0.004	0.05	0.023	0.011	0.024
D–Phosphorous D–P	0.09	0.019	0.42	0.12	0.007	0.09	0.03	0.021	0.08
T–Phosphorous T–P	0.19	0.029	9.92	0.53	0.038	0.24	0.076	0.035	0.19
Nitrate N	< 0.005	< 0.005	0.009	< 0.005	< 0.005	0.013	< 0.005	< 0.005	< 0.005
Nitrite N	0.002	0.004	0.004	0.002	0.002	0.005	< 0.001	< 0.001	< 0.001
Ammonia N	0.062	0.11	0.14	0.007	0.1	0.03	< 0.005	0.015	0.036
Cyanide									
Total Cyanide T CN	0.001	0.012	0.007	0.002	0.002	0.004	< 0.001	0.018	0.002
Total Metals									
Aluminum T Al	7.83	0.7	56.7	4.57	0.67	1.13	4.62	1.44	2.75
Antimony T Sb	0.0012	0.0006	0.0024	0.0008	0.0008	0.0014	0.001	0.0006	0.0007
Arsenic T As	0.0047	0.0008	0.044	0.005	0.001	0.0014	0.0031	0.0027	0.0017
Barium T Ba	0.2	0.068	0.56	0.081	0.039	0.064	0.16	0.036	0.1
Beryllium T Be	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Bismuth T Bi	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Boron T Bo	< 0.1	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium T Cd	0.0004	0.0019	0.0013	0.0005	0.0005	0.0004	0.0005	0.0003	0.0003
Calcium T Ca	40.5	31	47.1	43.4	50.5	9.05	32.3	32.7	8.71
Chromium T Cr	0.034	0.005	0.13	0.017	0.004	0.006	0.01	0.005	0.008
Cobalt T Co	0.01	0.003	0.062	0.043	0.006	0.002	0.002	0.004	0.005
Copper T Cu	0.19	0.015	0.6	0.055	0.014	0.015	0.048	0.031	0.032
Iron T Fe	17.3	1.23	96.6	7.69	0.94	1.77	5.25	2.19	4.27
Lead T Pb	0.042	0.011	0.022	0.025	0.009	0.017	0.05	0.013	0.024
Magnesium T Mg	13.3	3.6	35.3	9.09	4.02	2.03	7	5.35	3.25
Manganese T Mn	0.45	0.69	1.66	0.31	0.077	0.051	0.1	2.41	0.24
Mercury T Hg	0.00005	< 0.00001	0.00007	0.00006	< 0.00001	0.0001	< 0.00001	< 0.00001	0.00007
Molybdenum T Mo	0.02	0.012	0.007	0.003	0.023	< 0.001	0.009	0.003	0.001
Nickel T Ni	0.02	0.005	0.11	0.016	0.01	0.004	0.007	0.007	0.006
Selenium T Se	0.0007	< 0.0005	0.0008	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Silicon T Si	22.9	4.9	93.8	17.3	8.38	9.44	14.9	8.36	11.3
Silver T Ag	< 0.0001	< 0.0001	0.0006	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Strontium T Sr	0.25	0.08	0.26	0.15	0.49	0.03	0.22	0.12	0.059
Uranium T U	0.00008	< 0.00005	0.00032	0.00005	0.00015	< 0.00005	0.00027	0.00014	< 0.00005
Vanadium T V	< 0.03	< 0.03	0.21	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Zinc T Zn	0.072	0.018	0.26	0.031	0.024	0.033	0.025	0.011	0.035
Dissolved Metals									
Aluminum D Al	0.14	0.045	0.093	0.06	0.086	0.056	0.1	0.17	0.13
Antimony D Sb	0.0002	0.0002	0.0002	< 0.0001	0.0005	0.0007	0.0004	0.0002	0.0002
Arsenic D As	0.0005	0.0001	0.0018	0.0011	0.0007	0.0005	0.0016	0.0017	0.0003
Barium D Ba	0.041	0.056	0.012	0.022	0.032	0.023	0.083	0.029	0.05
Beryllium D Be	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Bismuth D Bi	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Boron D Bo	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium D Cd	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0003	0.0003
Calcium D Ca	42.8	33	18.6	40.7	49.8	8.88	31.4	31.1	6.91
Chromium D Cr	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001
Cobalt D Co	0.002	0.003	0.001	0.001	0.002	< 0.001	0.002	0.005	0.002
Copper D Cu	0.004	0.007	0.003	0.007	0.004	0.004	0.012	0.021	0.006
Iron D Fe	0.27	0.093	0.12	0.12	0.1	0.079	0.15	0.64	0.17
Lead D Pb	0.002	0.003	0.002	0.005	0.007	0.002	0.007	0.005	0.003
Magnesium D Mg	10.8	3.33	2.35	6.99	3.73	1.63	6.05	4.9	1.87
Manganese D Mn	0.22	0.65	0.028	0.18	0.064	0.016	0.038	2.33	0.079
Molybdenum D Mo	0.018	0.01	0.002	0.002	0.018	< 0.001	0.007	0.003	0.001
Nickel D Ni	0.002	0.001	0.001	< 0.001	< 0.001	0.002	0.001	0.006	0.001
Potassium D K	4.25	3.73	0.82	1	1.6	0.5	3.1	0.97	0.74
Selenium D Se	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Silicon D Si	2.85	4.14	5.68	11.1	8.45	5.76	5.85	5.98	5.02
Silver D Ag	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sodium D Na	1.47	2.89	2.21	2.94	46.6	1.75	11.1	2.7	3.24
Strontium D Sr	0.24	0.08	0.058	0.13	0.54	0.027	0.22	0.11	0.043
Uranium D U	< 0.00005	< 0.00005	0.00019	< 0.00005	0.00014	< 0.00005	0.00027	0.00012	< 0.00005
Vanadium D V	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Zinc D Zn	< 0.005	0.007	< 0.005	< 0.005	0.01	0.006	< 0.005	0.006	0.01

MT. MILLIGAN HYDROGEOLOGY
PIPER PLOT
JUNE 1990 GROUNDWATER SAMPLES

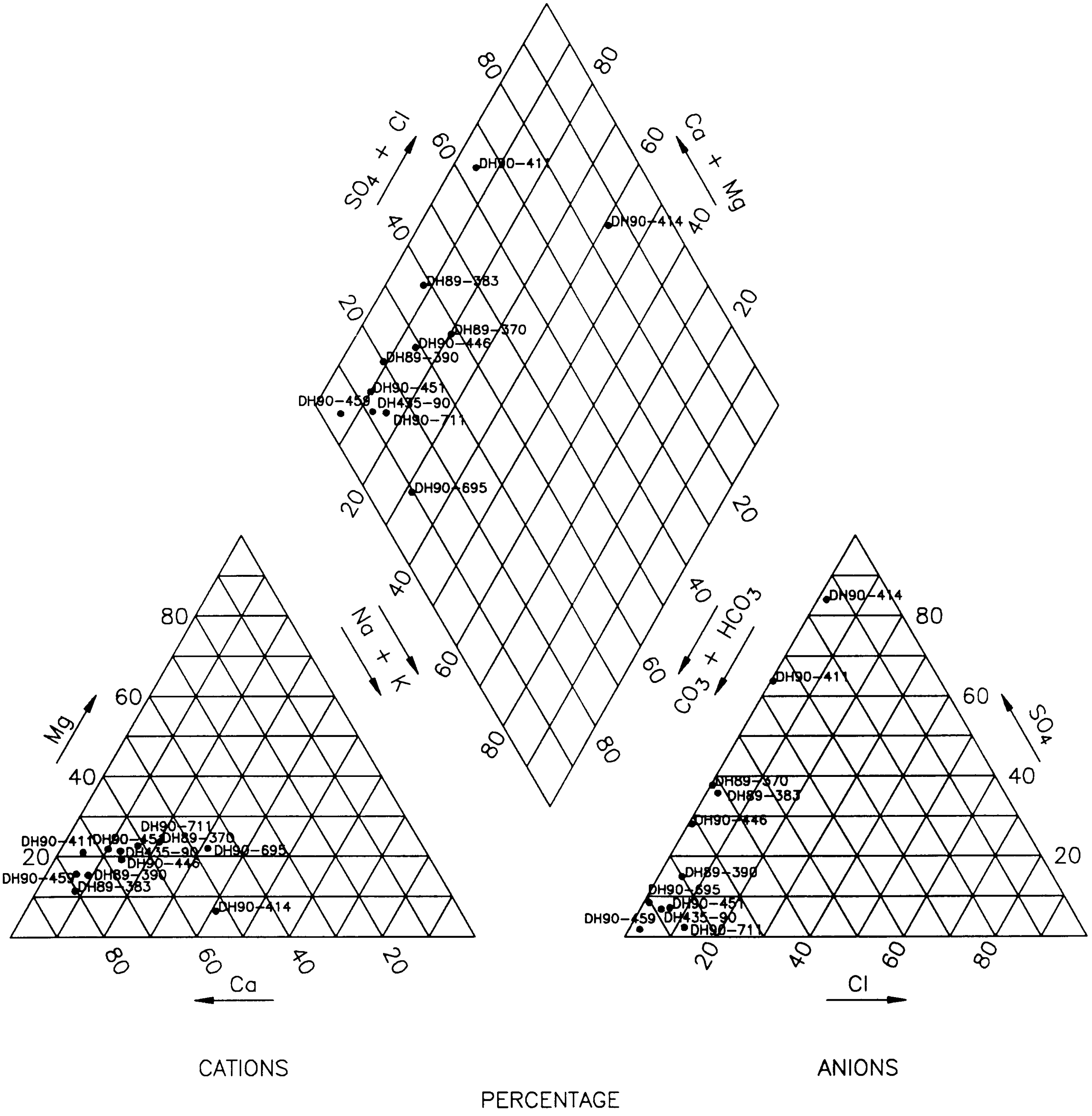


CONTINENTAL GOLD CORP.
MOUNT MILLIGAN PROJECT

GROUNDWATER QUALITY
MINESITE AREA AND TAILINGS AREA C
AUG 1990

PARAMETER	DH89-370 AUG 01 1990	DH89-383 AUG 01 1990	DH89-390 AUG 01 1990	DH90-411 AUG 01 1990	DH90-414 AUG 01 1990	DH435-90 AUG 01 1990	DH90-446 AUG 01 1990	DH90-451 AUG 01 1990	DH90-459 AUG 01 1990	DH90-695 AUG 01 1990	DH90-711 AUG 01 1990
Physical Tests											
pH	7.52	7.47	7.32	7.51	7.17	7.31	7.66	7.37	7.18	7.87	7.34
Conductivity umhos	350	353	233	310	515	69.4	250	117	178	423	98.3
Turbidity NTU	112	508	697	92.1	39.3	23.1	15.9	286	17.2	49.5	1900
Suspended Solids	225	326	307	364	107	66	42.7	991	80.7	91.3	9120
Dissolved Solids	350	350	230	210	500	60	240	110	170	410	90
Hardness CaCO3	160	109	66.9	140	144	32.4	115	58.4	92.9	159	46
Anions											
Alkalinity CaCO3	128	73.9	52.7	56.5	38.5	29.8	94.3	50.4	95.8	221	37.8
Chloride Cl	0.5	2.1	2.4	0.5	3.4	1.1	0.7	2.6	1.7	2.1	3.7
Fluoride F	0.29	0.16	0.06	0.11	0.16	0.05	0.11	0.05	0.06	0.1	0.06
Sulphate SO4	75.1	41.2	9.4	96.6	218	2.2	35.6	4	1.8	19.8	< 1
Nutrients											
O-Phosphate O-P	0.02	0.006	0.018	0.007	0.005	0.006	0.006	0.02	0.008	0.038	0.37
D-Phosphorous D-P	0.02	0.006	0.018	0.007	0.005	0.006	0.006	0.023	0.008	0.038	0.37
T-Phosphorous T-P	0.1	0.01	0.69	0.05	0.035	0.015	0.02	0.09	0.025	0.05	0.56
Nitrate N	0.01	0.012	< 0.005	0.009	0.011	0.039	0.008	0.009	0.011	0.012	0.76
Nitrite N	< 0.001	< 0.001	< 0.001	0.003	0.003	0.001	0.002	0.005	0.009	< 0.001	< 0.001
Ammonia N	0.11	0.15	0.028	0.14	0.19	0.037	< 0.005	0.092	0.015	0.53	0.065
Cyanide											
Total Cyanide T CN	< 0.001	0.002	0.007	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.018	0.003	0.017
Total Metals											
Aluminum T Al	5.58	3.98	123	4.53	4.52	3.28	1.42	12	1.1	1.34	206
Antimony T Sb	0.0011	0.0023	0.0014	0.0007	0.0012	0.0029	0.0006	0.0009	0.0004	0.001	0.0002
Arsenic T As	0.0029	0.0022	0.08	0.0041	0.0021	0.0019	0.0018	0.0064	0.011	0.017	0.058
Barium T Ba	0.11	0.15	1.02	0.077	0.077	0.07	0.042	0.15	0.041	0.14	1.56
Beryllium T Be	< 0.005	< 0.005	< 0.01	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.01
Bismuth T Bi	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2
Boron T Bo	< 0.1	< 0.1	< 0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2
Cadmium T Cd	0.0003	0.0015	0.0026	0.0004	0.0004	0.0003	< 0.0002	0.0006	0.0003	0.0004	0.0042
Calcium T Ca											
Chromium T Cr	0.027	0.016	0.49	0.015	0.011	0.013	0.005	0.028	0.007	0.006	0.58
Cobalt T Co	0.005	0.004	0.076	0.004	0.005	0.004	< 0.001	0.011	0.006	0.002	0.11
Copper T Cu	0.17	0.063	1.23	0.04	0.044	0.05	0.012	0.074	0.027	0.016	0.78
Iron T Fe	14.3	7.33	218	7.42	5.63	4.59	1.31	14.7	3.39	1.57	298
Lead T Pb	0.044	0.09	0.096	0.026	0.176	0.048	0.024	0.043	0.02	0.096	0.31
Magnesium T Mg											
Manganese T Mn	0.43	0.44	3.63	0.28	0.15	0.097	0.053	2.37	5.54	0.11	7.85
Mercury T Hg	0.00002	0.00005	0.00004	0.00002	0.00003	< 0.00001	< 0.00001	0.00003	0.00003	0.00002	0.0005
Molybdenum T Mo	0.028	0.019	0.004	0.002	0.027	0.002	0.011	0.004	0.008	0.015	0.009
Nickel T Ni	0.012	0.008	0.182	0.01	0.006	0.006	0.002	0.016	0.004	0.006	0.029
Selenium T Se	< 0.0005	< 0.0005	0.0017	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0005	< 0.0005	< 0.0005	0.0016
Silicon T Si	13.8	14.2	29.2	17.6	16.2	11.5	8.44	26.9	8.96	13.2	11
Silver T Ag	< 0.0001	< 0.0001	0.0012	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	0.002
Strontium T Sr	0.24	0.1	0.52	0.15	0.49	0.047	0.18	0.13	0.11	0.33	1
Uranium T U	0.00024	0.00008	0.00009	< 0.00005	0.00011	< 0.00005	0.00034	< 0.00005	0.00042	0.00157	0.0000
Vanadium T V	< 0.03	< 0.03	0.51	< 0.03	< 0.03	< 0.03	< 0.03	0.041	< 0.03	< 0.03	0.81
Zinc T Zn	0.063	0.069	0.64	0.043	0.054	0.056	0.008	0.035	0.02	0.037	0.61
Dissolved Metals											
Aluminum D Al	0.085	0.42	0.099	0.16	0.28	0.29	0.17	0.069	0.13	0.066	0.12
Antimony D Sb	0.0003	0.0005	0.0005	0.0001	0.0006	0.0017	0.0004	0.0002	0.0002	0.0006	< 0.0001
Arsenic D As	0.0004	0.0005	0.0071	0.0013	0.0009	0.0009	0.0015	0.0004	0.011	0.017	0.0034
Barium D Ba	0.037	0.077	0.02	0.02	0.037	0.041	0.042	0.011	0.028	0.13	0.035
Beryllium D Be	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Bismuth D Bi	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Boron D Bo	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium D Cd	< 0.0002	0.0003	< 0.0002	< 0.0002	< 0.0002	0.0003	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium D Ca	44.6	38.1	22.2	43.4	51.3	9.73	35.7	17.6	30.9	43	13.4
Chromium D Cr	0.002	0.003	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001	< 0.001	0.002
Cobalt D Co	< 0.001	0.003	< 0.001	< 0.001	0.002	0.001	< 0.001	< 0.001	0.005	0.001	< 0.001
Copper D Cu	0.001	0.014	0.006	0.005	0.008	0.016	0.005	0.005	0.012	0.007	0.007
Iron D Fe	0.29	0.88	0.14	0.33	0.45	0.46	0.19	0.07	1.28	0.044	0.063
Lead D Pb	0.005	0.009	0.001	0.002	0.005	0.01	0.003	0.002	0.002	0.062	0.075
Magnesium D Mg	11.3	3.26	2.72	7.47	3.76	1.91	6.23	3.42	3.73	12.3	3
Manganese D Mn	0.26	0.36	0.15	0.15	0.084	0.037	0.042	0.13	5.15	0.081	0.023
Molybdenum D Mo	0.023	0.016	0.003	0.002	0.021	0.001	0.008	0.001	0.006	0.012	0.001
Nickel D Ni	0.001	0.002	< 0.001	0.001	0.002	0.003	0.001	0.001	0.002	0.003	0.002
Potassium D K	3.57	3.05	1.06	0.9	1.88	0.8	2.72	0.94	1.4	2.8	0.75
Selenium D Se	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Silicon D Si	3.59	5.75	5.91	10.9	7.69	5.76	5.96	6.58	7.61	8.26	7.16
Silver D Ag	< 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	16.3	2.65	2.42	2.94	44.7	1.73	7.17	2.43	2.06	31.7	3.58
Strontium D Sr	0.22	0.087	0.068	0.14	0.48	0.043	0.18	0.073	0.11	0.33	0.065
Uranium D U	0.00024	0.00006	0.00007	< 0.00005	0.0001	< 0.00005	0.00034	< 0.00005	0.00036	0.00152	< 0.0000
Vanadium D V	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
Zinc D Zn	< 0.005	0.023	< 0.005	< 0.005	0.016	0.035	< 0.005	< 0.005	< 0.005	0.024	< 0.005

MT. MILLIGAN HYDROGEOLOGY
PIPER PLOT
AUGUST 1990 GROUNDWATER SAMPLES



APPENDIX VIII

GROUNDWATER SAMPLING GUIDELINES

SAMPLING AND HANDLING GUIDELINES
FOR BACKGROUND GROUNDWATER QUALITY
MT. MILLIGAN PROJECT

OUR FILE: PB 5616 0102

APRIL 1991

TABLE OF CONTENTS

1. INTRODUCTION

This document constitutes the groundwater sampling procedures recommended by Klohn Leonoff Ltd. for sampling monitoring wells at the Mt. Milligan site for the parameters presently chosen for analysis. This plan comprises only general procedures and techniques for sample collection, sample preservation and shipment, field analytical procedures, and chain-of-custody control. Specific procedures, data sheets and management techniques should be developed by the staff members responsible for sampling.

Some common problems noted by U.S. EPA for groundwater sampling are:

- Owners/operators have not prepared sampling and analysis (S&A) plans or do not keep plans on site.
- Plans contain very little information or do not adequately describe the S&A program that the owner/operator is employing at his facility.
- Field sampling personnel are not following the written plan or are not aware that it exists.
- Improper well evacuation techniques are used.
- Sampling equipment is used that may alter chemical constituents in groundwater.
- Sampling techniques are used that may alter chemical composition of samples.
- Facility personnel are not using field blanks, chemical standards, and chemically spiked samples to identify changes in sample quality after collection.
- Field personnel do not properly clean non-dedicated sampling equipment after use.
- Field personnel place sampling equipment (rope, bailer, tubing) on the ground where it can become contaminated prior to use.

- Field personnel do not document their field activities adequately (e.g. keep sampling logs).
- Field personnel are not following proper chain-of-custody procedures.
- Little attention is paid to reporting data errors or anomalies.
- Quality Assurance/Quality Control (QA/QC) protocol is inadequate (field and/or laboratory).

The purpose of these guidelines is to avoid these problems.

2. EQUIPMENT

2.1 Maintenance and Storage

Procedures for handling and storing sampling equipment should be consistent with those for analytical laboratory equipment, since the sampling equipment will be included in the process of analyzing parameters at very low concentrations. For example:

- equipment should be stored in sealed containers in a clean room dedicated to water sampling;
- equipment should be repaired or replaced if it is malfunctioning;
- equipment should be transported to the sampling site in sealed containers; and
- equipment should be cleaned with deionized water between each sample.

2.2 List

Equipment for sampling includes:

- plastic-coated water level probe with incremental depth markings of 0.01 m;
- wash bath of about 10 L size for decontaminating the water level probe;
- disposable surgical latex gloves;
- deionized water;
- well log and monitoring well completion diagram with surveyed reference elevation;
- data forms for documenting the sampling details;
- discharge line to volumetric measurement device;
- in-line filter holder (Milli-pore or equivalent);

- 0.45 micron filter papers;
- appropriate sample bottles;
- pH meter, conductivity meter, and thermometer;
- Brainard-Kilman pump;
- commercially purchased bailer for 2-inch monitoring wells, which can be disassembled for decontamination and is fitted for in-line pressure filtering;
- non-contaminating bailer line (e.g. fishing line, teflon-coated stainless steel) of sufficient strength to prevent breakage;
- volumetric measurement devices (e.g. 10-L pail and 1-L graduated cylinder);
- tweezers (for filter paper);
- indelible marker;
- wash bottle(s);
- large bottle-type brush for cleaning bailer and/or sampling pump if necessary;
- large bottle-type brush and threaded 19-mm (3/4-inch) diameter PVC pipe for cleaning the monitoring well if necessary;
- hangman and pulley/reel assembly for lowering and raising the bailer;
- clean rags;
- paper towels;
- tape for sealing sample bottles;
- small screwdriver for calibrating field pH and conductivity meters;
- container(s) for field parameter measurements; and
- clipboard or binder for sampling forms.

3. 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, prepare and test:

- sample bottles;
- sampling pump;
- in-line filtration apparatus;
- field parameter standard solutions;
- field parameter sample container;
- field parameter meters; and
- water level probe.

Also start the field sampling form, which documents:

- well number;
- well depth;
- water level depth;
- well yield - high, medium or low;
- purge volume and pumping rate;
- time well purged;
- collection method;
- well evacuation procedure/equipment;
- sample withdrawal procedure/equipment;
- date and time of collection;
- sampling sequence;
- types of sample bottles used;
- preservative(s) used;
- parameters requested for analysis;

- field observations of sampling event;
- name of sample collector; and
- climatic conditions including air temperature.

An example of a sampling record is included.

MT. MILLIGAN PROJECT
GROUNDWATER SAMPLING QUALITY CONTROL
SAMPLING RECORD

WELL NO.: ____________

DATE OF SAMPLING: ____________

COMMENTS: ____________

WEATHER: ____________

DECONTAMINATION AND EQUIPMENT CHECK (Y/N)

Sampling Apparatus ______ Water Level Probe ______

WATER DEPTH AND TOTAL DEPTH

Probe Serial No.:

	Time	Depth	Comments
Depth to Water from Top of PVC			
Depth to Bottom from Top of PVC			

VOLUME OF STANDING WATER COLUMN = 0.8 D^2 L = ____________

WELL PURGING

Pumping Method ____________

Measuring Device ____________ Well yield (High, Med., Low): ____________

Pumping Record

High=recharge as fast as pumping, Low= >24 hrs to recover from purging

Intake Depth	Time		Volume	Description of Water/Comments
	From	To		

FIELD PARAMETERS

	Time	Calibration Standard		Groundwater Sample
		Stated	Measured	
Temperature				
pH				
Conductivity				

SAMPLING

Method ____________

	Time	Filtration		Preservation		Container Type
		(Y/N)	Method	(Y/N)	Type	
Total Metals (T.M.)						
Total Mercury (T.Hg)						
Dissolved Metals (D.M.)						
Total Cyanide (T.CN)						
Major Anions (M.A.)						

SIGNATURE ____________

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3.2 Step 2 - Measure Static Water Level and Total Depth

a) Dip the water level probe in water to confirm that it is operating.

b) Check that the tape length is correct.

c) Decontaminate the water level probe by rinsing it in a deionized water bath.

d) Measure the depth to water from the top of the PVC to within at least 0.01 m.

e) Measure the total depth of the well from the top of the PVC to within at least 0.01 m.

f) Calculate the volume of the water column in the well.

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 so that formation water can replace the stagnant water. Table 3.1 summarizes the recommended pumping methods.

Table 3.1 - Recommended Pumping Method

High Water Level (<15 m)*	Brainard-Kilman
Low Water Level (>15 m)	Bailer

* Can be extended to 30 m

a) Rinse all tubes, pump parts, bailer line and anything else to be lowered into the well with deionized water to prevent cross contamination.

b) If a pump is used, lower the pump intake to a point just below the standing water level in the well; ensure that the well water is not agitated. The intake should be maintained near the water surface to maximize the purging action. Deeper submergence will result in ineffective purging because the flow into the pump will come from the screen.

c) Gently pump or bail three well volumes from the well. Lower the intake during pumping, if necessary.

e) Dispose of the purged water in an environmentally acceptable manner.

3.4 Step 4 - Measure Field Parameters

Near the end of 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:

a) Rinse the meters with deionized water and blot dry with clean paper towels.

b) Rinse the field parameter sample container and blot dry with clean paper towels.

c) Calibrate the field parameter meters in the standard solutions (the standard solutions should be comparable to the values expected in the field).

d) Rinse the meters with deionized water and blot dry with clean paper towels.

e) Fill the field sample container immediately after the water has been extracted from the well.

f) Immediately measure the parameters in order:

    - temperature;
    - conductivity; and
    - pH.

3.5 Step 5 - Withdraw Sample

The sample withdrawal method is dependent on the well characteristics, and the method used for purging. Since the purging will assist in "pre-cleaning", this same equipment, where possible, should be utilized for sampling. The sampling should be carried out in order:

- total metals (T.M.);
- total mercury (T.Hg);
- dissolved metals (D.M.);
- total cyanide (T.CN); and
- major anions (M.A.).

To sample:

a) Take precautions to prevent dirt and dust from contaminating the samples.

b) Filter the dissolved metals sample as a pressure filtering operation in the discharge line. Samples transferred directly from the sampling equipment through the filter to the sample bottle have less opportunity to become contaminated. If a bailer is used for sampling, it should have fittings appropriate for in-line pressure filtering.

c) Before filling, rinse the sample bottles out twice with the water being collected (unless the preservative is already in the container).

d) Fill the containers almost full but leave room to add the preservative and allow shaking.

e) Add preservative according to Step 6. Shake the container to dissolve and/or mix the preservative.

f) Cap the sample containers tightly.

g) Complete the sample label before moving to the next sampling site. Ensure that the dissolved metals and total metals samples are not mixed up.

h) Store the sample in its shipping container (typically a cooler). Tape for keeping dust out of the cooler and ice-packs for keeping the samples cool will probably be necessary during the summer months.

3.6 Step 6 - 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. Sample preservation mitigates the effects of sample degradation.

Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light, and are intended to:

1) retard biological action;
2) retard hydrolysis; and
3) reduce sorption effects.

Table 3.2 summarizes the appropriate sample bottle types and sample preservation measures.

Table 3.2 - Sampling and Preservation Procedures for Groundwater Monitoring(1)

PARAMETER GROUP	SPECIFIC ANALYSIS	BOTTLE TYPE	PRESERVATIVE	MAXIMUM HOLDING TIME
Physical Parameters	Suspended Solids, Turbidity, Conductivity, pH, Colour, Dissolved Solids, Hardness	1-L plastic(2)	4°C	Conductivity and pH are field-determined but samples should be shipped ASAP to minimize pH shift
Major Anions	Bicarbonate, Sulphate, Chloride, Fluoride			28 days
Nutrients	O-Phosphate, D-Phosphorous, T-Phosphorous, Nitrate, Nitrite, Ammonia.			48 hours
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
Total Mercury		500-mL plastic	2 mL HNO_3, 4°C	6 months
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
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 Evaluating 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

The nitric acid and sodium hydroxide used for preserving the samples can cause severe burns and should be handled with care.

Metallic ions that migrate through the unsaturated (vadose) and saturated zones and arrive at a groundwater monitoring well may be present in the well. Particles (e.g. silt, clay), which may be present in the well even after well evacuation procedures, may absorb or adsorb various ionic species which would lower the dissolved metal content in the well water. Groundwater samples on which metals analysis will be conducted should be split into two portions. One portion should be filtered through a 0.45-micron membrane filter, transferred to the sample bottle, preserved with nitric acid, and analyzed for dissolved metals. The remaining portion should be transferred to a bottle, preserved with nitric acid, and analyzed for total metals. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and any sorption of ions to the particles.

3.7 Step 7 - Ship Samples to Laboratory

3.7.1 Sample Labels

The labels should be sufficiently durable to remain legible even when wet and should include:

- sample identification number;
- 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 Major Anions.

3.7.2 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 thermometer so that it is not against the ice.
- Use newspaper or equivalent as a packing material. The analytical laboratory requests that styrofoam chips not be used since the styrofoam is messy and can possibly contaminate the samples.
- Seal the shipping container.

3.7.3 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.

An example of a chain-of-custody record is included.

MT. MILLIGAN PROJECT
GROUNDWATER SAMPLING QUALITY CONTROL
CHAIN OF CUSTODY RECORD

(ONE PER SHIPPING CONTAINER)

Month & Year of Sampling Round ______

Page   of

DESCRIPTION OF CONTENTS

SAMPLE NO.	SAMPLE TYPE *	SAMPLING DATE	INITIALS

* 250–mL T.M. (Total Metals), 250–mL D.M. (Dissolved Metals), 1–L T.CN (Total Cyanide), 500–mL T.Hg (Total Mercury), 1–L M.A. (Major Anions)

TEMPERATURE: Initial: ______ Max.: ______ Min.: ______ Final: ______

CHAIN OF CUSTODY

DATE		LOCATION	SIGNATURE
FROM	TO		

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4. FIELD QUALITY CONTROL (QC)

4.1 Introduction

The field quality control program should document the condition of the monitoring well and verify the adequacy of the sampling and handling program. If the QC program identifies a source of error, the QC should not be used to correct the groundwater data. Instead, the source of the error should be identified and documented, and corrective action, including resampling, should be initiated.

The QC steps can be divided into four categories:

- field parameters;
- blanks and spikes;
- preliminary data review; and
- annual well tests.

4.2 Field Parameters

All field measurement equipment must be calibrated prior to field use and recalibrated in the field before measuring each sample. This includes temperature, pH, and EC measurement systems.

4.3 Blanks and Spikes

4.3.1 Trip Blank

Have the laboratory fill one of each type of sample bottle with deionized water, transport it to the site, handle it like a sample (except for running it through the sampling equipment), and return it to the laboratory for analysis for dissolved metals. A sampling record with a dummy sample number should be completed. One trip blank per sampling round is recommended.

4.3.2 Equipment Blank

To ensure that non-dedicated sampling devices have been effectively cleaned (in the laboratory and field), have the laboratory provide one equipment blank (deionized water) for each piece of equipment (e.g. Brainard Kilman pump, bailer). All sampling and handling steps must be followed to ensure that procedures and equipment are tested by this blank. A sampling record with a dummy sample number should be completed. One equipment blank for each sampling round is recommended for each set of equipment. The blank should be analyzed for dissolved metals.

4.3.3 Field Spike

To ensure that the field and transportation procedures are not creating changes in water chemistry, have the laboratory provide two unacidified samples with known concentrations of metals comparable to the expected field conditions (field spike). Two spikes are recommended so that the difference between natural sample degradation and sample degradation due to the sampling and handling procedures can be documented. Follow all sampling and handling steps with one of the spikes to ensure that procedures and equipment are tested. With the other spike, simply transfer the contents to another bottle and acidify. Sampling records with dummy sample numbers should be completed. The analytical chemist should retain a sample of the spike in the laboratory and analyze for dissolved metals at the same time as the field sample for comparison.

4.4 Preliminary Data Review

On receipt of the laboratory data, all results should be compared with previous data from the well and with data from adjacent wells to identify anomalous data. Possible reasons for identified anomalies should be assessed and resampling initiated to verify any anomalies.

4.5 Annual Well Tests

4.5.1 General

Annual well tests provide documentation of the well condition and, therefore, the quality of the data. Complete records of the tests should be filed.

4.5.2 Sedimentation

The quantity of sediment in each well should be documented by measuring the total depth of the monitoring well. Any sediment should be bailed or educted out of the well, described (sand, silt, organic matter, etc.), and documented.

4.5.3 Hydraulic Integrity

The hydraulic integrity of the well should be checked by establishing a packer immediately above the well screen and filling the well with clean water. On completion, the test water must be removed from the system. This test should follow sampling.

4.5.4 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% recovery to 95% recovery. Thirty to forty readings should be taken, where possible. The rising head test data collection form included in these guidelines should be completed in full. The time data should be measured to the second for wells which recover 95% 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.

MT. MILLIGAN RISING HEAD TEST

PRE-TEST WATER LEVELS

Day Before
- Date ____________________
- Depth to Water ____________________

Day Of
- Date ____________________
- Depth to Water ____________________

PUMPING DATA

Pumping Method ____________________
Time Pumping Started (h:m:s) ____________________
Time Pumping Ended (h:m:s) ____________________
Total Volume Pumped ____________________
Comments ____________________

WELL CONDITION ____________________
____

WELL NO.: ____________

DATE: ____________

PAGE _____ OF _____

WELL INNER DIA.: ____________

PVC STICKUP: ____________

TOTAL DEPTH: ____________

AIR TEMP.: ____________

PROBE SERIAL NO.: ____________

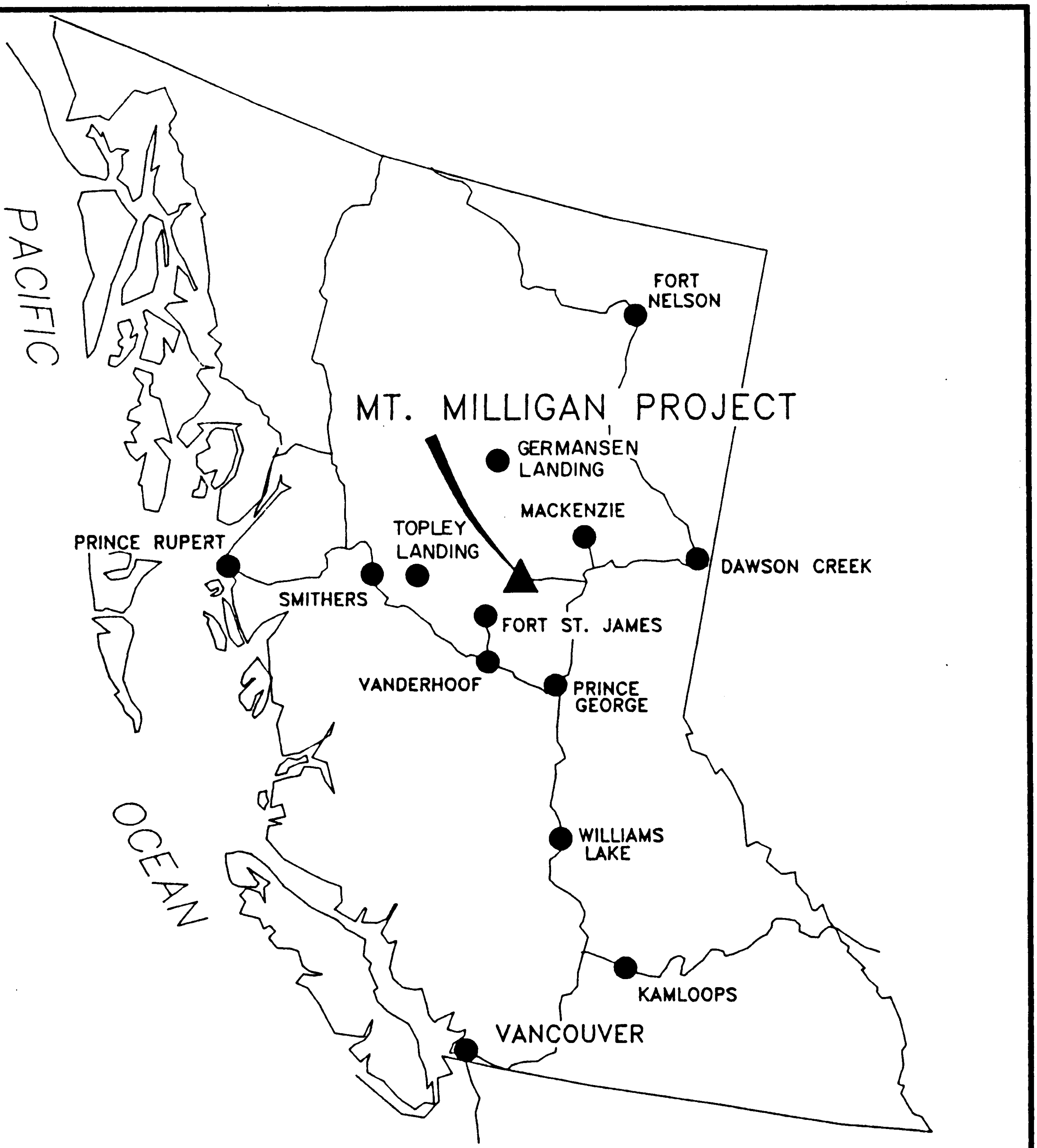
TESTED BY: ____________

RECOVERY DATA

DATE	TIME (h:m:s)	DEPTH TO WATER BELOW TOP OF PVC (m)	COMMENTS

KLOHN LEONOFF

DRAWINGS



SCALE

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT MT. MILLIGAN HYDROGEOLOGY

TITLE LOCATION PLAN

CLIENT: CONTINENTAL GOLD CORP.

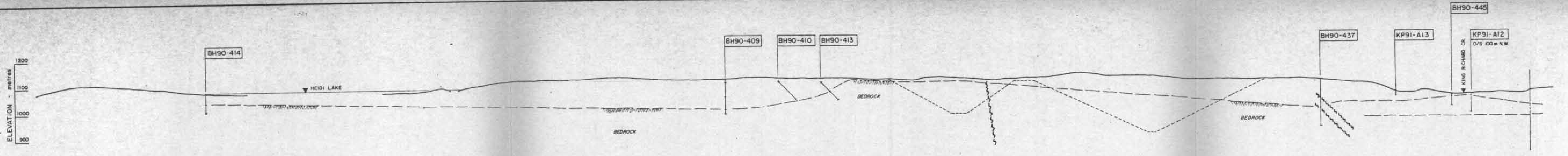
DATE OF ISSUE APR. 23, 1991

APPROVED

PROJECT No. PB 5616 01

DWG. No. A-1001

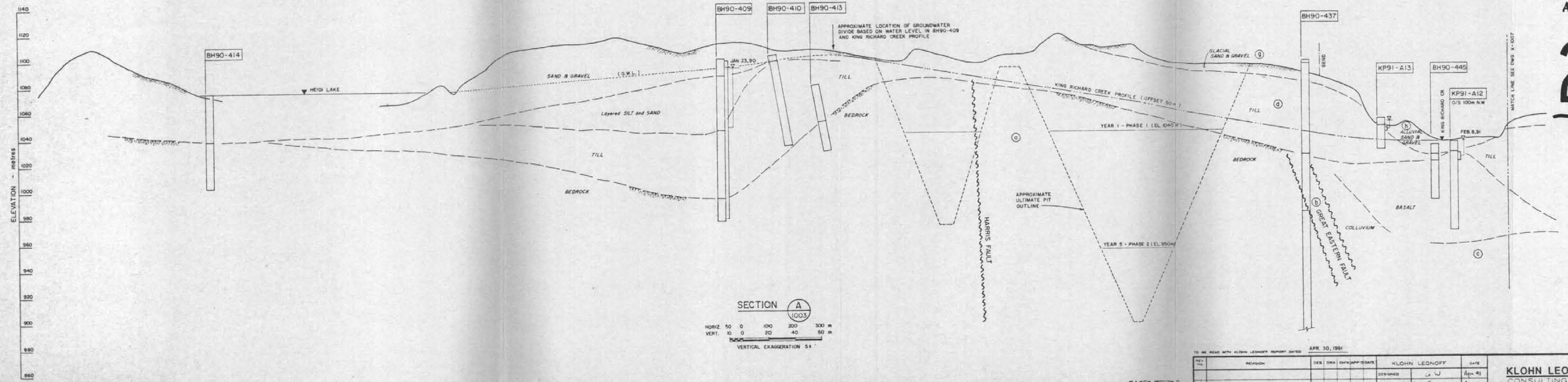
REV.



SECTION A 1003

50 0 100 200 300 m

NO VERTICAL EXAGGERATION



SECTION A 1003

HORIZ. 50 0 100 200 300 m

VERT. 10 0 20 40 60 m

VERTICAL EXAGGERATION 5X

LEGEND

- WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)
- COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL
- ③→ FLOW DIRECTIONS (referred in text)
- ⓓ HYDROGEOLOGIC UNIT (referred in text)
- — — — INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

PART 4 OF 7

NOTE

TOPOGRAPHY AND BOREHOLE LOCATION FOR WEST END OF SECTION FROM "MINESITE GEOTECHNICAL REFERENCE DATA", KNIGHT AND PIESOLD, APR. 1991.

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV. No.	REVISION	DES	DRN	CHK'D	APP'D	DATE
A	ADDED NOTE		Jk	1/4/91		4/4/91

KLOHN LEONOFF		DATE
DESIGNED	G.W.	Apr. 91
DRAWN	Jk.	Apr. 91
CHECKED	G.W.	Apr. 91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

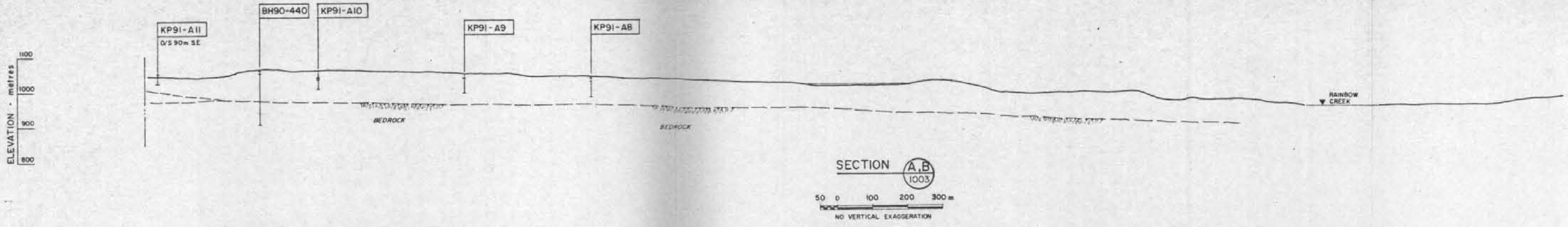
CLIENT
CONTINENTAL GOLD CORP.

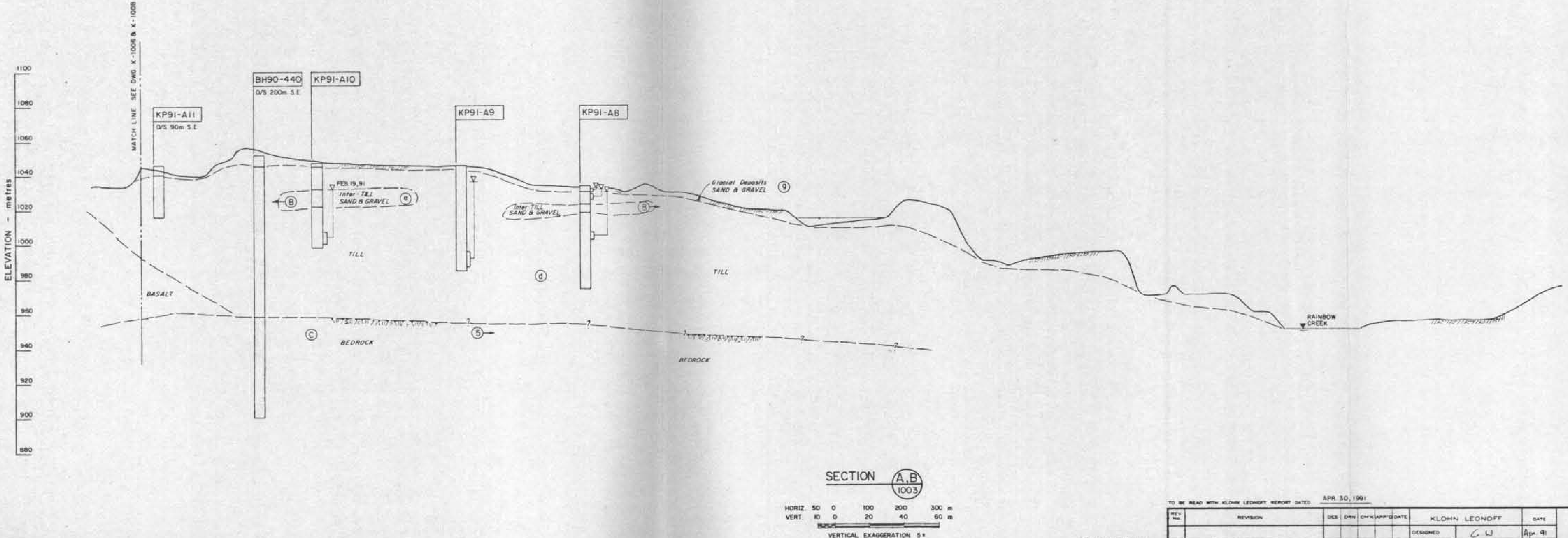
PROJECT
MT. MILLIGAN HYDROGEOLOGY

SCALE

TITLE
MINESITE
SECTION A WEST HALF
HEIDI LAKE AND OPEN PIT

DATE OF ISSUE: APR. 23, 1991
PROJECT No.: PB 5616 01
DWG. No.: X-1006
REV.: A





LEGEND

- WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)
- COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL
- ③→ FLOW DIRECTIONS (referred in text)
- ⓓ HYDROGEOLOGIC UNIT (referred in text)
- ------ INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

part 4 of 7

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV. No.	REVISION	DES.	DRN	CH'K	APP'D	DATE

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DESIGNED	G.W.	Apr. 91
DRAWN		Apr. 91
CHECKED	G.W.	Apr. 91
RECOMMENDED		
APPROVED		

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CONSULTING ENGINEERS

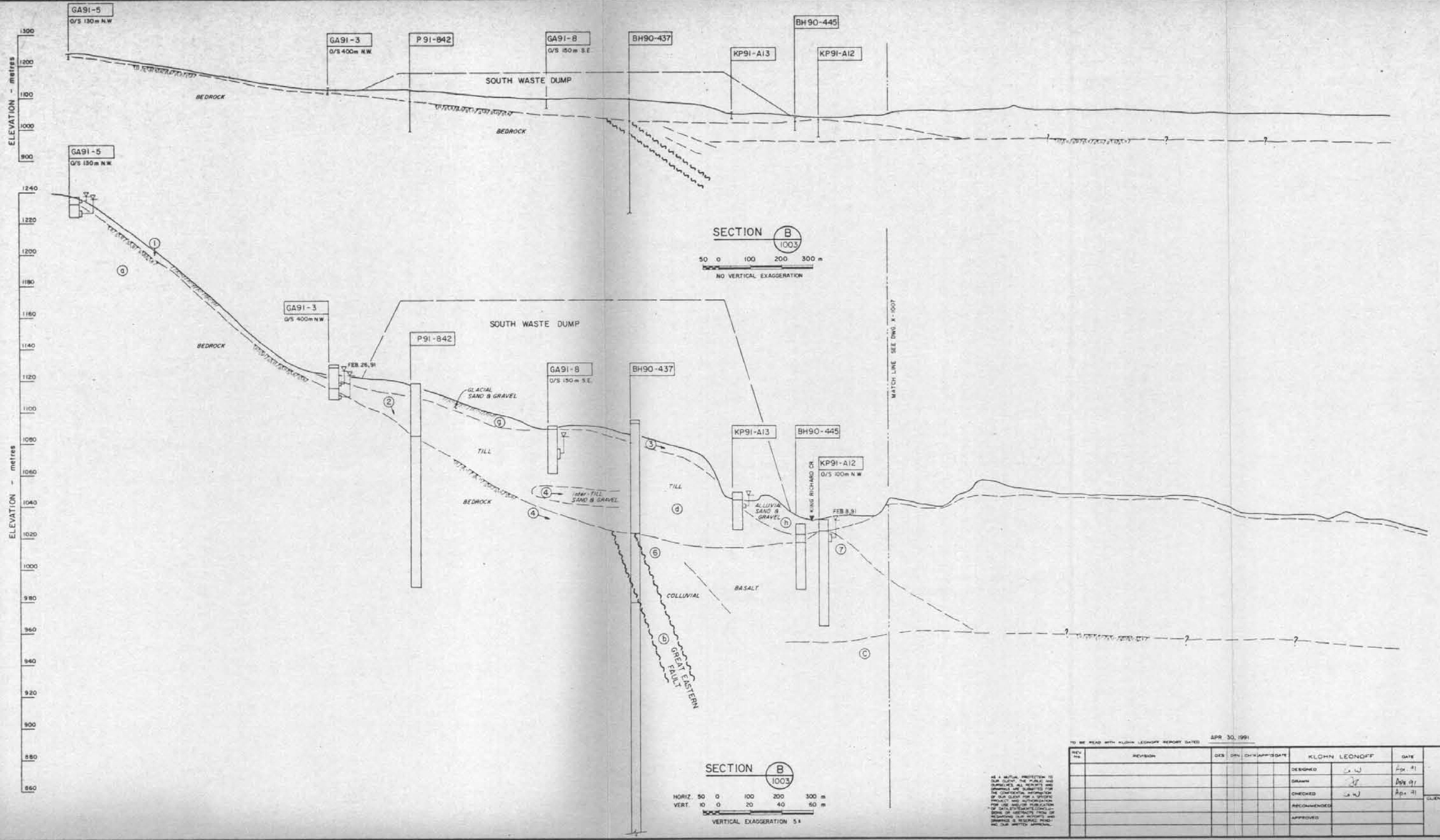
CLIENT
CONTINENTAL GOLD CORP.

PROJECT
MT. MILLIGAN HYDROGEOLOGY

SCALE

TITLE
MINESITE
SECTION A AND B EAST HALF
TILL PLAIN

DATE OF ISSUE APR. 23, 1991
PROJECT No. PB 5616 01
DWG. No. X-1007
REV.



LEGEND

- WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)
- COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL
- ③→ FLOW DIRECTIONS (referred in text)
- ⓓ HYDROGEOLOGIC UNIT (referred in text)
- — — — INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

Part 4 of 7

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR 30, 1991

REV. No.	REVISION	DES	DRN	CH'K	APP'D	DATE	KLOHN LEONOFF		DATE
							DESIGNED	G.W	Apr. 91
							DRAWN	JT	Apr. 91
							CHECKED	G.W	Apr. 91
							RECOMMENDED		
							APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

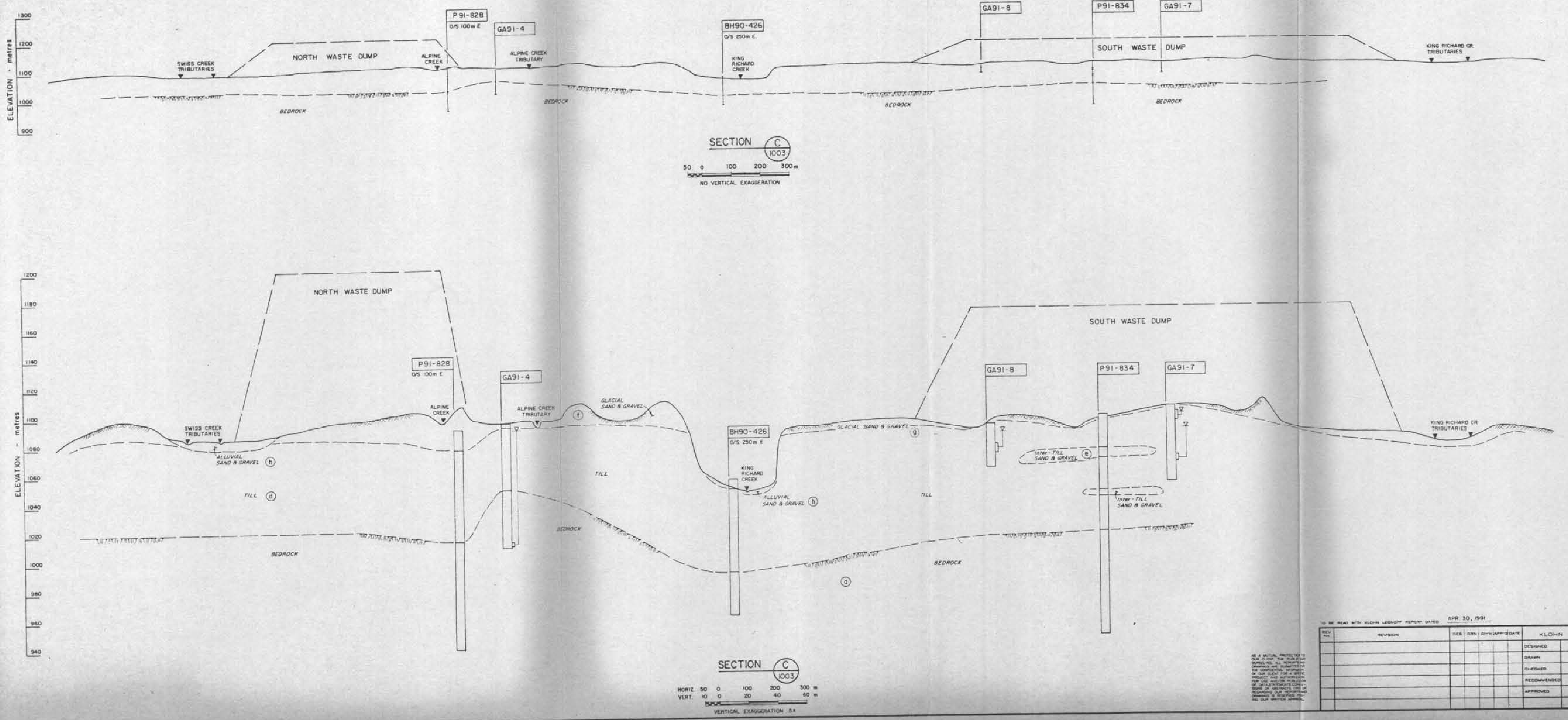
CLIENT
CONTINENTAL GOLD CORP.

SCALE

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
MINESITE
SECTION B WEST HALF
MT. HEIDI SOUTH

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APR. 30, 1991	PB 5616 01	X-1008	



LEGEND

- ▽ WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)
- COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL
- ③→ FLOW DIRECTIONS (referred in text)
- ⓓ HYDROGEOLOGIC UNIT (referred in text)
- — — — INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH ASSESSMENT REPORT

21,488

PART 4 OF 7

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR 30, 1991

REV No.	REVISION	DES	DRN	CH'K	APP'D	DATE	KLOHN LEONOFF		DATE
							DESIGNED	G.W	Apr. 91
							DRAWN	JC	Apr. 91
							CHECKED	G.W.	Apr. 91
							RECOMMENDED		
							APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

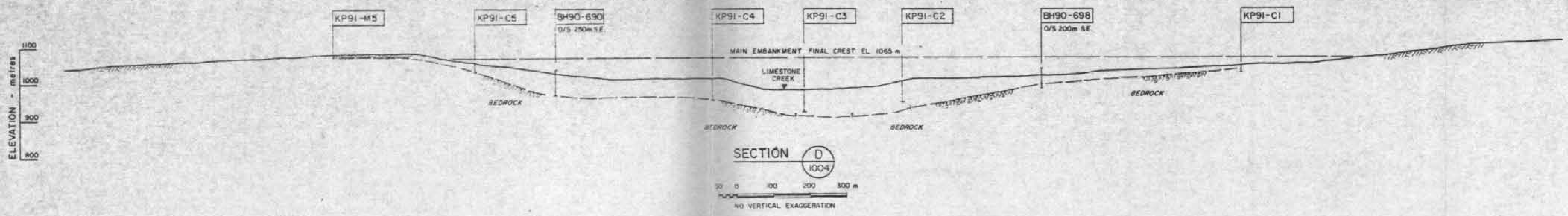
CLIENT
CONTINENTAL GOLD CORP.

PROJECT
MT. MILLIGAN HYDROGEOLOGY

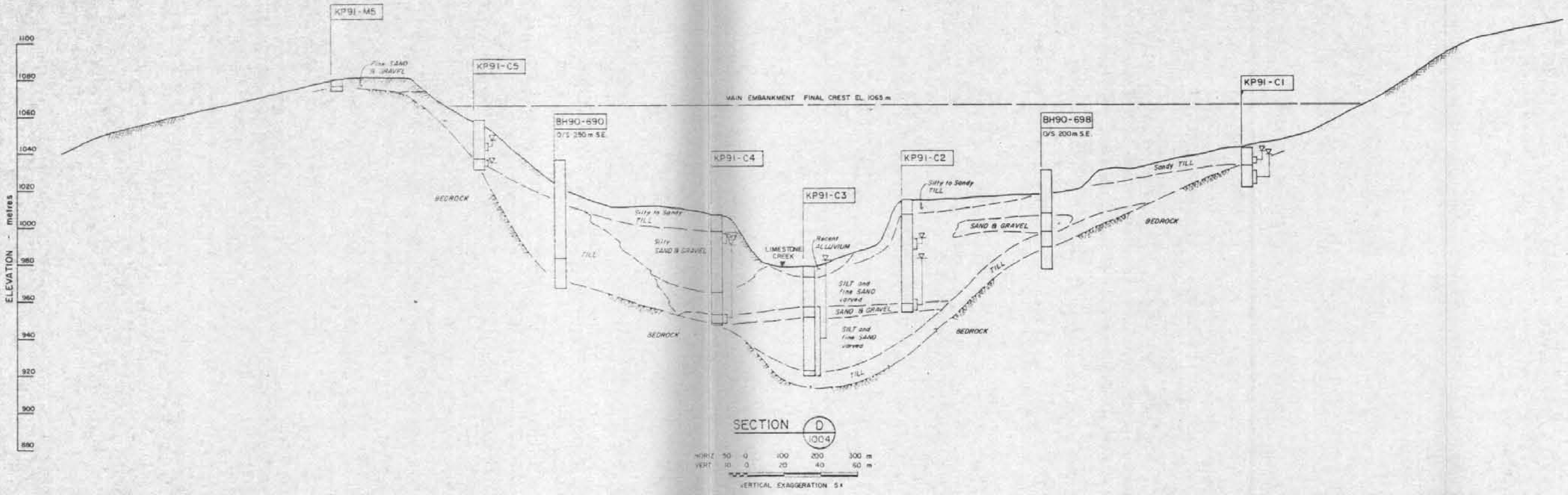
SCALE

TITLE
MINESITE
SECTION C
WASTE DUMPS

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APR. 23, 1991	PB 5616 01	X-1009	



SECTION D 1004



SECTION D 1004

LEGEND

WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)

COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL

INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH ASSESSMENT REPORT

21,488

PART 4 OF 7

NOTE

APPROXIMATE EMBANKMENT LOCATION FROM KNIGHT AND PIESOLD LTD. DRAWING 1673.007.

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV No.	REVISION	DES	DRN	CH'K	APP'D	DATE
A	ADJUSTED BEDROCK SURFACE		JC	HM		APR/91

KLOHN LEONOFF		DATE
DESIGNED	HMcC	APR./91
DRAWN	JC	APR./91
CHECKED	HMcC	APR./91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

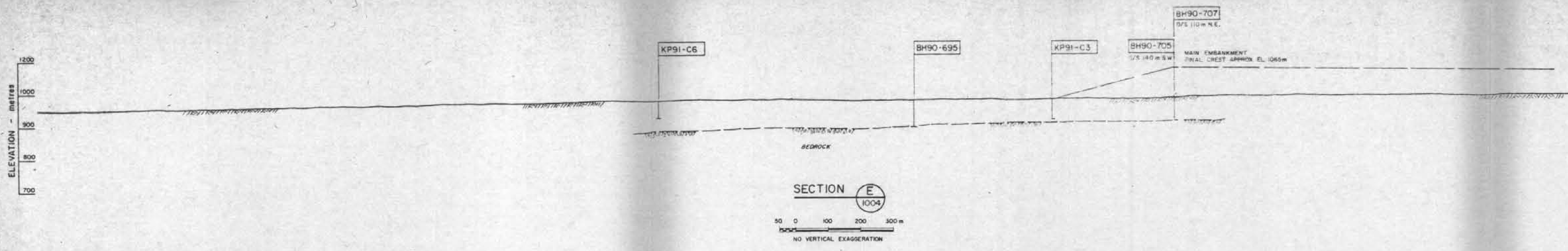
CLIENT
CONTINENTAL GOLD CORP.

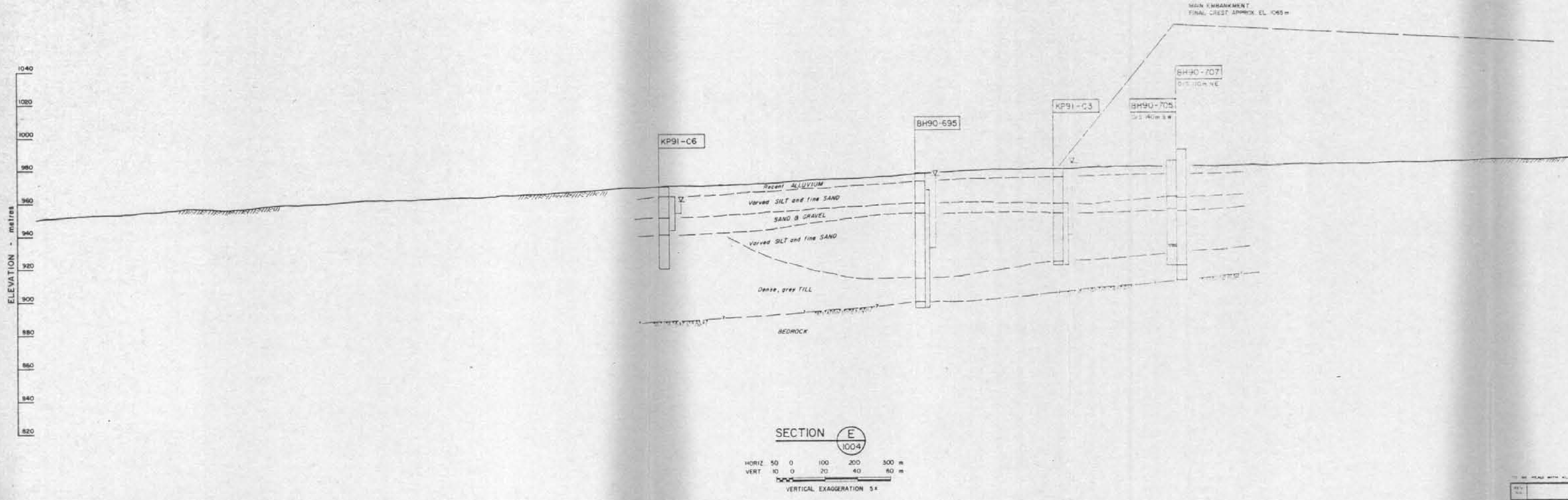
PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TAILINGS AREA C
SECTION D
ACROSS LIMESTONE VALLEY

SCALE

DATE OF ISSUE: APR. 23, 1991
PROJECT No.: PB 5616 01
DWG. No.: X-1010
REV: A





LEGEND

▽ WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)

COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL

— — — INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

PART 4 OF 7

NOTES

1. APPROXIMATE EMBANKMENT LOCATION AND TAILINGS FINAL ARRANGEMENT FROM KNIGHT AND PIESOLD LTD. DRAWINGS 1675.105 AND 1675.122.
2. TOPOGRAPHY FOR NORTHWEST END OF SECTION IS FROM 1:50 000 NATIONAL TOPOGRAPHIC MAPPING.

TO BE READ WITH KLOHN LEONOFF REPORT DATED

REV. No.	REVISION	DES.	DRN	CH'K	APP'D	DATE
A	ADDED BH90-705, BH90-707 & NOTE 2					APR/91

KLOHN LEONOFF		DATE
DESIGNED	MWC	APR/91
DRAWN	E	JAN 91
CHECKED	MWC	APR/91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

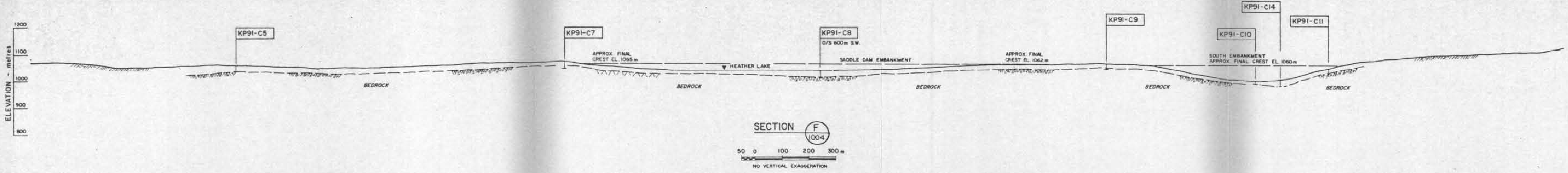
CLIENT
CONTINENTAL GOLD CORP.

SCALE

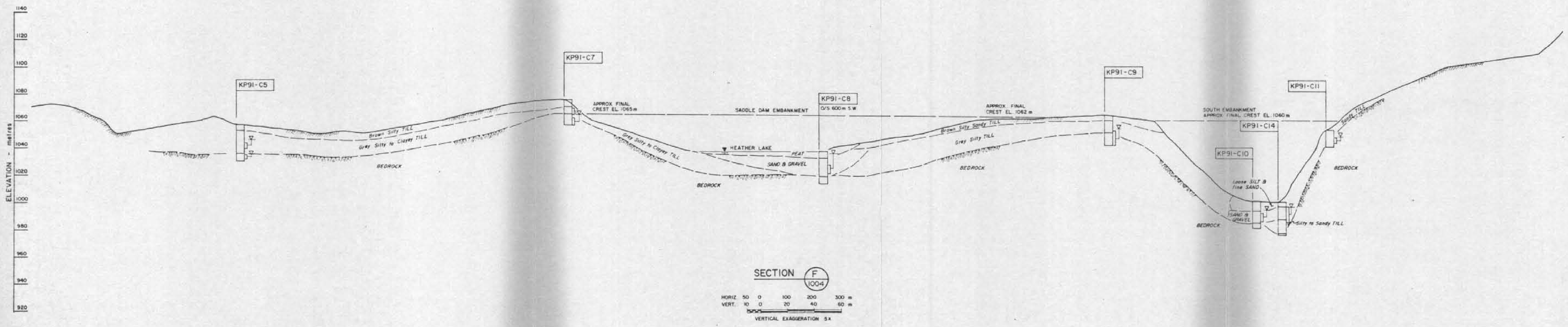
PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TAILINGS AREA C
SECTION E
ALONG LIMESTONE VALLEY

DATE OF ISSUE APR. 23, 1991
PROJECT No. PB 5616 01
DWG. No. X-1011
REV. A



SECTION F 1004



SECTION F 1004

LEGEND

- WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)
- COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL
- — — — INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH ASSESSMENT REPORT

21,488

PART 4 OF 7

NOTE

APPROXIMATE EMBANKMENT LOCATIONS FROM KNIGHT AND PIESOLD DRAWINGS 1675.108 AND 1675.111.

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV. No.	REVISION	DES	DRN	CH'K	APP'D	DATE

KLOHN LEONOFF		DATE
DESIGNED	HMcC	APR/91
DRAWN	JJ	APR 91
CHECKED	HMcC	APR/91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

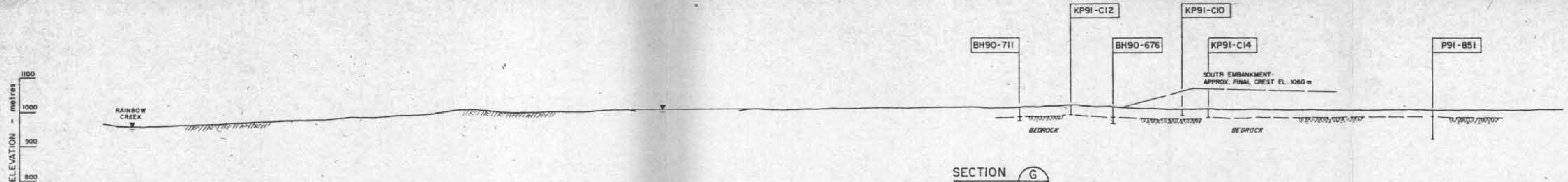
CLIENT
CONTINENTAL GOLD CORP.

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TAILINGS AREA C
SECTION F
ACROSS SOUTH EMBANKMENT VALLEY

SCALE

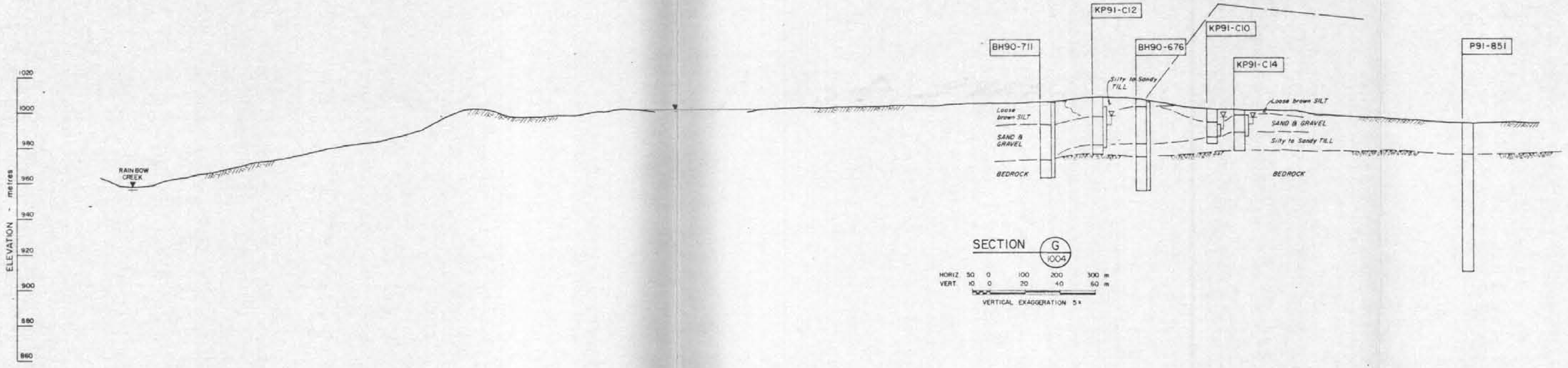
DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APR. 25, 1991	PB 5616 01	X-1012	



SECTION G 1004

50 0 100 200 300m

NO VERTICAL EXAGGERATION

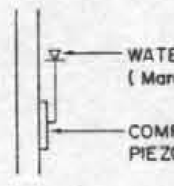


SECTION G 1004

HORIZ. 50 0 100 200 300 m
VERT. 10 0 20 40 60 m

VERTICAL EXAGGERATION 5×

LEGEND



WATER LEVEL MEASURED IN STANDPIPE (March 14-19, 1991 unless otherwise noted)

COMPLETION ZONE IN MONITORING WELL, PIEZOMETER OR OBSERVATION WELL

INFERRED GEOLOGIC CONTACT

GEOLOGICAL BRANCH ASSESSMENT REPORT

21,488

Part 4 of 7

NOTE

APPROXIMATE EMBANKMENT LOCATION AND TAILINGS FINAL ARRANGEMENT FROM KNIGHT AND PIESOLD LTD. DRAWINGS 1675.110 AND 1675.122.

TO BE READ WITH KLOHN LEONOFF REPORT DATED ________

REV. No.	REVISION	DES	DRN	CHK	APP	DATE	KLOHN LEONOFF		DATE
							DESIGNED	WMcC	APR/91
							DRAWN	JR	APR 91
							CHECKED	WMcC	APR/91
							RECOMMENDED		
							APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

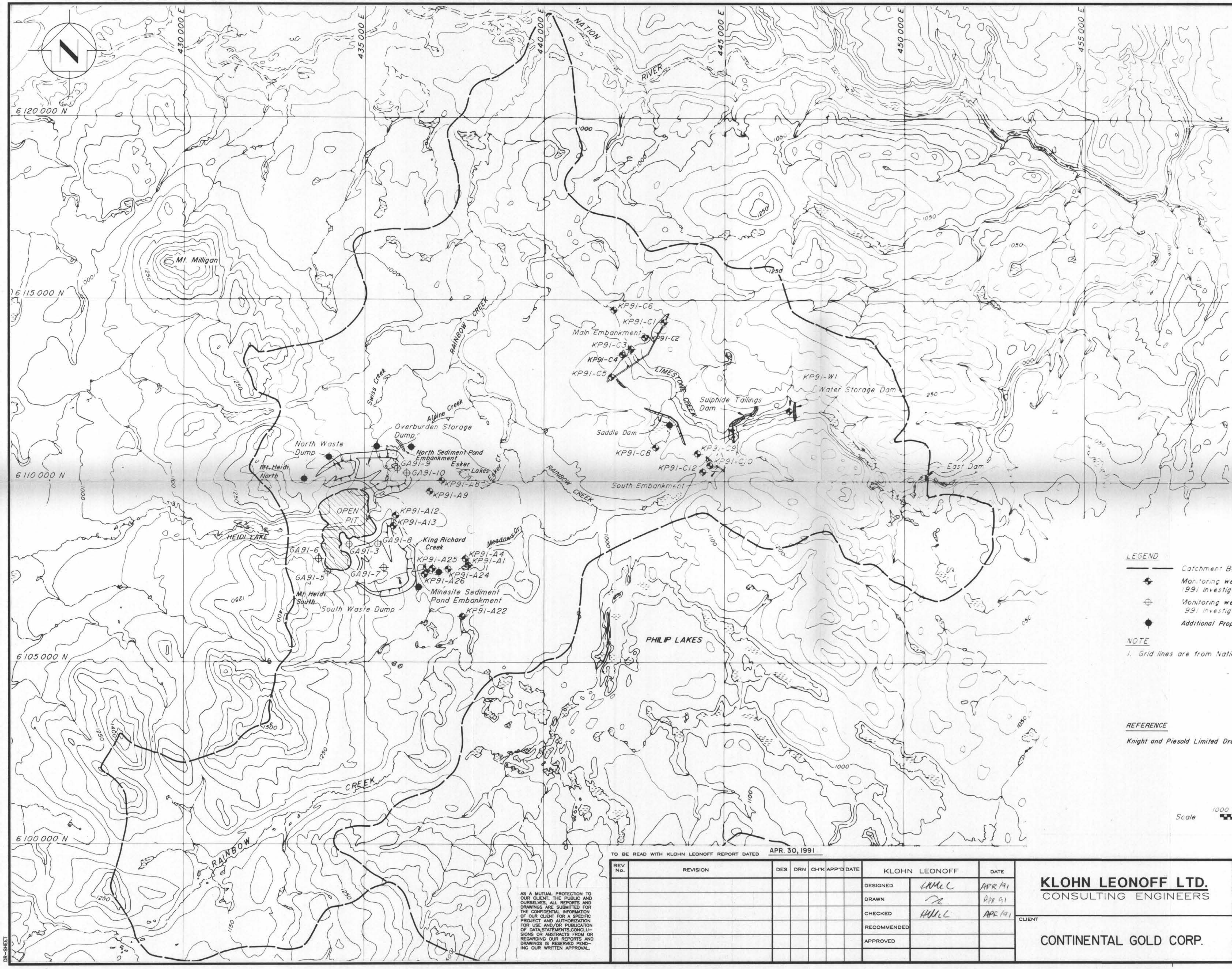
CLIENT
CONTINENTAL GOLD CORP.

SCALE

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TAILINGS AREA C
SECTION G
ALONG SOUTH EMBANKMENT VALLEY

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
	PB 5616 01	X-1013	



LEGEND

- ▬ ▬ Catchment Boundary
- ⊕ Monitoring wells installed by Knight and Piesold Ltd. 1991 Investigation Program
- ⊕ Monitoring wells installed by Golder Associates Ltd. 1991 Investigation Program
- ● Additional Proposed Monitoring Wells

NOTE

1. Grid lines are from National Topographical Mapping.

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

PART 4 OF 7

REFERENCE

Knight and Piesold Limited Drawing No. 1675.050 Rev. A.

Scale 1000 500 0 1000 2000 3000 4000 5000 m

SCALE

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV No.	REVISION	DES	DRN	CH'K	APP'D	DATE

KLOHN LEONOFF		DATE
DESIGNED	HMcC	APR /91
DRAWN	[illegible]	APR 91
CHECKED	HMcC	APR /91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT
CONTINENTAL GOLD CORP.

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
REGIONAL PLAN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APR. 23, 1991	PB 5616 01	D - 1002	

LEGEND

— → — → —	Waste Dump Runoff Collection Ditch
- - - → - · -	Rock Drain
● ~	Spring (interpreted from aerial photos ref. report by K.E. Ricker, Jan. 1991)
BH89-361	Preliminary Geotechnical Site Evaluation
TP89-1 to 35	Preliminary Geotechnical Site Evaluation
BH90-440	Report on Phase I Geotechnical Investigations
TP90-36 to 74	Mt. Milligan Test Pit Program
GBH90-527	1990 Site Investigation Program
GS-CA-1 TPM90-1 to 15	Report on Phase II Geotechnical Investigations for Mill Site Area
KL91-1 GA91-1 to 10	1991 Site Investigation Program
TPGA91-1 to 3	1991 Site Investigation Program
KP91-A1 to A26	1991 Site Investigation Program
P91-826	1991 Condemnation Drill Holes

Scale

200 0 200 400 600 800 1000 1200 Metres

REFERENCE

Knight and Piesold Limited Drawing No. 1673.001 Rev. D.

GEOLOGICAL BRANCH
ASSESSMENT REPORT

21,488

SCALE

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

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REV No.	REVISION	DES	DRN	CH'K	APP'D	DATE
A	ADDED BH90-421		JR	Hall		MAY/91

KLOHN LEONOFF		DATE
DESIGNED	G.W.	Apr. 91
DRAWN	JR	Apr 91
CHECKED	G.W.	Apr. 91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT
CONTINENTAL GOLD CORP.

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
MINESITE
TEST LOCATION PLAN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV.
APR. 23, 1991	PB 5616 01	D - 1003	A

DR-SHEET

LEGEND:

90-681	Report on Phase II geotechnical investigations for Area C
P91-851	Condemnation drill hole
KP91-C1 to C14 KP91-WSD1 to WSD3 KP91-CM3 to CM5	1991 Investigation program
TP91-C18	Test Pit with seepage

REFERENCE

- Knight and Piesold Limited Drawing No. 1673.002 Rev. B.
- Recycle Pond locations from Knight and Piesold Drawings 1675.104 Rev. B and 1675.110 Rev. B.

Scale 500 0 500 1000 1500 Metres

GEOLOGICAL BRANCH ASSESSMENT REPORT

21,488

Part 4 of 7

TO BE READ WITH KLOHN LEONOFF REPORT DATED APR. 30, 1991

REV No.	REVISION	DES	DRN	CH'K	APP'D	DATE
A	ADDED RECYCLE PONDS					

KLOHN LEONOFF		DATE
DESIGNED	HMcC	APR/91
DRAWN		APR 91
CHECKED	HMcC	APR/91
RECOMMENDED		
APPROVED		

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

CLIENT
CONTINENTAL GOLD CORP.

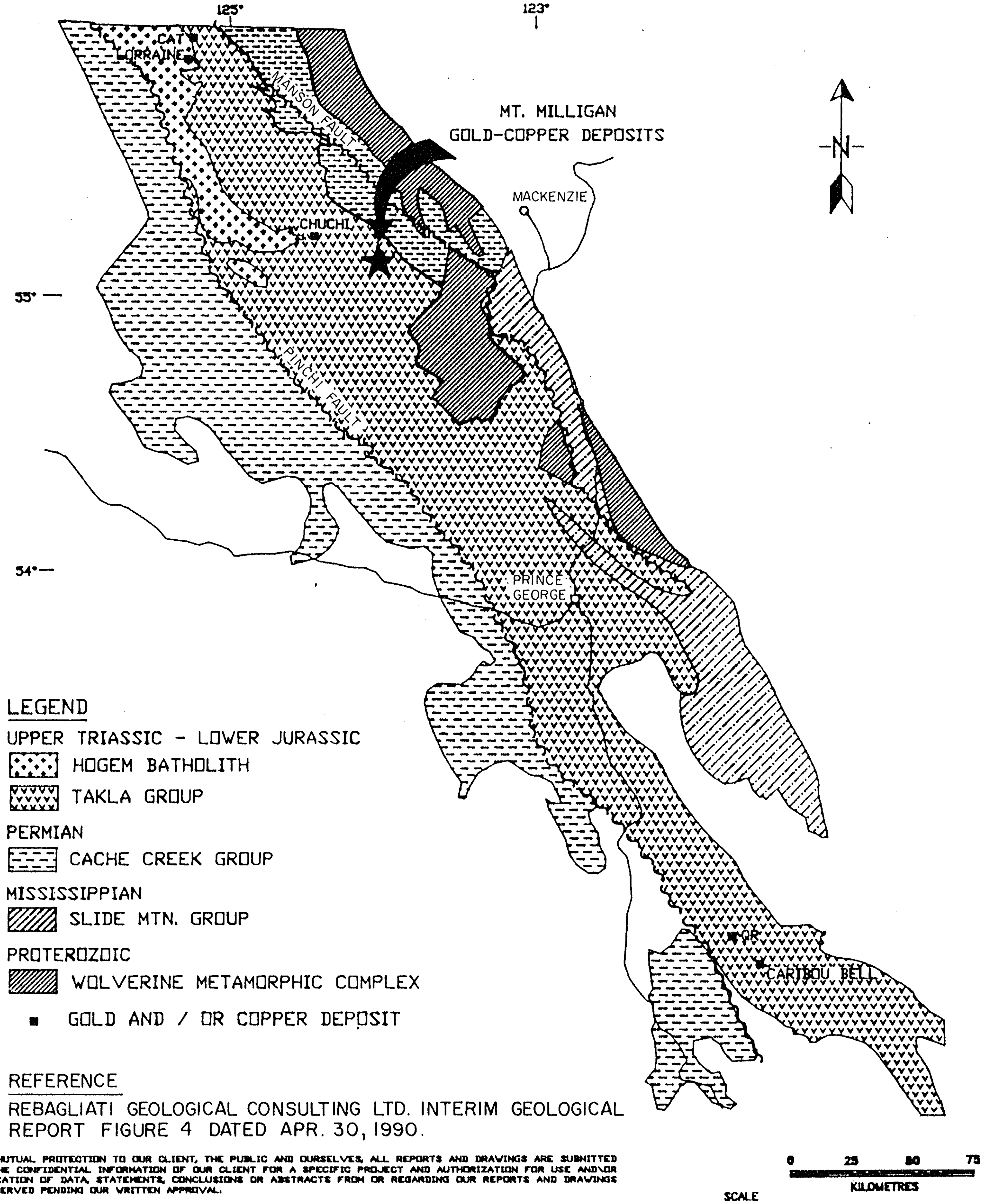
SCALE

PROJECT
MT. MILLIGAN HYDROGEOLOGY

TITLE
TAILINGS AREA C
TEST LOCATION PLAN

DATE OF ISSUE APR. 23, 1991
PROJECT No. PB 5616 01
DWG. No. D - 1004
REV. A

DR-SHEET



REFERENCE

REBAGLIATI GEOLOGICAL CONSULTING LTD. INTERIM GEOLOGICAL REPORT FIGURE 4 DATED APR. 30, 1990.

KLOHN LEONOFF LTD.
CONSULTING ENGINEERS

PROJECT MT. MILLIGAN HYDROGEOLOGY

TITLE REGIONAL GEOLOGY

CLIENT: CONTINENTAL GOLD CORP.

DATE OF ISSUE APR. 23, 1991

APPROVED HMcC

PROJECT No. PB 5616 01

DWG. No. A-1005

REV.