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Golder Associates

REPORT ON

PLANS + REPORTS PR-1597

HYDROGEOLOGICAL AND GEOTECHNICAL EVALUATION CAMPBELL MOUNTAIN LANDFILL

PENTICTON, BRITISH COLUMBIA

SUBMITTED TO:

REGIONAL DISTRICT OF OKANAGAN-SIMILKAMEEN
101 MARTIN STREET
PENTICTON, BRITISH COLUMBIA
V2A 5J9

4 Copies - Regional District of Okanagan-Similkameen
Penticton, B.C.

2 Copies - Golder Associates Ltd.
Kelowna, B.C.

September 28, 1994

932-4175

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Golder Associates

September 28, 1994

Our Ref: 932-4175

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101 Martin Street
Penticton, B.C.
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c.c. C. Pryce, MOE
I. Stout City of Penticton
B. Uddlo, " "
for info
Thx.
Dave

Dave
Sept. 30/94
Se

Attention: Mr. Dave Gold, Public Works Manager

RE: COST ESTIMATE FOR PROPOSED RECOMMENDATIONS AT CAMPBELL MOUNTAIN LANDFILL <u>PENTICTON, BRITISH COLUMBIA</u>

Dear Sir:

Golder Associates Ltd. have prepared a cost estimate for the proposed additional work required at the Campbell Mountain Landfill site as recommended in our Hydrogeological and Geotechnical Evaluation report dated September 28, 1994. In review, the recommendations included the following items:

TASK 1 A future monitoring well (P1) be installed west of the existing City of Penticton composting area which is founded south of the north ravine. Two separate monitoring standpipes (50 mm PVC) be installed within the well at various depths. The shallow standpipe should be installed at the bedrock interface with a deeper standpipe established at 10 m depth within the bedrock formation. The purpose of well P1 would be to monitor the extent of possible leachate contamination from the composting together with the offsite migration of gas.

TASK 2 An additional borehole (P2) is recommended within the landfill fire area located at the north ravine. The borehole should be located east of the previously subexcavated area where a large fire was extinguished in 1993. The borehole should extend a minimum depth of 2 to 3 m into the groundwater where a permanent monitoring well will be installed. The monitoring well should also consist of a separate small diameter PVC pipe to allow for the installation of a thermistor to measure the temperature changes at various depths. In addition, another separate screened PVC pipe should be installed to monitor the gas concentrations at varying depths. Together, these results will provide specific information on the contributing mechanism for the creation of the landfill fires in the lower portion of the ravine.

TASK 3 Additional gas concentration data be obtained at regular depth intervals at two or three sites located between BH 102 and BH 103 together with the proposed monitoring wells P1 and P2. Further gas monitoring within the landfill fire area should also be carried out to help further delineate the ravine area affected. As landfill gas concentrations in the ravine area varied with time, it is recommended that additional monitoring be considered in order to establish if temporal trends in concentration occur.

TASK 4 It is recommended that a photogrammetric survey be carried out using old aerial photos to produce a topographic map. This will provide useful information regarding the initial depth of the ravine and the overall slope angle of the west bedrock ridge. Although during earlier conversations with the MOE and RDOS it was proposed that a borehole be drilled in this area, the photogrammetric survey will provide much of this information and will largely preclude the need for a costly monitoring well in this location.

TASK 5 It is recommended that the downgradient monitoring wells BH102, BH103, Randolf Spring and the upgradient monitor at BH104 be sampled on a quarterly basis throughout the first year for the following minimum parameters: Ba, B, Ca, Fe, Mg, Mn, TOC, nitrate/nitrite, TKN, conductivity, pH and Cl. Monthly groundwater measurements should also be carried out at each borehole/augerhole location to establish the seasonal fluctuations and its impact on the groundwater flow directions. At the end of the initial monitoring period, a review of all chemistry results should be carried out to determine a long term monitoring program. In addition it is recommended that toxicity testing be conducted on a one-time basis for samples collected from upgradient and downgradient groundwater monitoring wells and also from ponded water at the Randolf Spring.

In the short term, it is recommended that the aerial photogrammetric mapping, the installation of both monitoring wells P1 and P2 together with additional soil gas monitoring in the north ravine area be carried out. Quarterly groundwater sampling should also be commenced this fall. This additional information is required to fully investigate the cause for the fires and also to provide specific design details to arrest the fires in the ravine area. Based on the above, we have prepared an approximate cost breakdown for the various tasks listed above. The estimated costs are summarized and presented on the attached Table 1 sheet.

We trust the foregoing provides the information you require at this time. Should you have any questions, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

B. Carlsen, P. Eng.
Associate
Encl.

BC/at
Encl.

→TRF

1597

Copy given to Dave Gold Oct 12/94.

Province of British Columbia

Ministry of Environment, Lands and Parks

MEMORANDUM

October 12, 1994

To: File **File(s):** PR-01597

Re: Hydrogeological and Geotechnical Evaluation by Golder Associates Ltd. (dated September 28, 1994)

A review of the above report was undertaken by the undersigned on October 11, 1994. The following comments were relayed at a meeting to Mr. Dave Gold of the Regional District of Okanagan Similkameen.

I. page 5 - AH1, AH2 and AH5 are 50 mm PVC pipes. Require protection (ie: steel casing with concrete ring, a barricade system) and to be highly visible so they are run over by vehicles. All monitoring wells are to have locking caps. For the borehole wells, are the 16.8 cm casings made of steel?

II. page 5 - AH1 and AH 4 were the only wet auger holes.

III. page 14 - "additional monitoring wells required to further delineate the contaminant plume..." If this is in reference to P1 and P2 this is okay. However, it is suggested that the proposed additional work as outlined in the Golder Associates Ltd. letter dated September 28, 1994 be performed prior to any additional wells (other than P1 or P2) being installed. The installation of these wells may not be necessary based upon a review of the additional work.

IV. page 18 - It would be helpful if Golder could provide rationale for the requirement of additional gas monitoring. Is the additional monitoring going to involve shallow or deep probes?

V. page 21 - The NMOC calculation is very close to requiring the landfill to have gas controls. This is close enough that the additional gas monitoring is warranted. However, if the value of t is 23 years (ie: for 1995) the value exceeds 150t and gas control will be mandatory (Section 6.4 Landfill Criteria).

VI. page 21 - 0.3m to 0.5m on the slope where the underground fires occurred. Testing required to meet min. permeability of 10^{-5} cm per second will be required. (As stated later in recommendations). Will have to import this cover or go to a liner. Approval from Regional Waste Manager required on this matter. Would be helpful to have sketch submitted outlining the area to be covered with silt, the gas vents, mon. well P1, etc.

VII. 3:1 design slope to a[redacted]aximum of 70 meters high with a setba[redacted]of 8 to 10 m from the rock ridge. These parameters can be used in the operations plan report. Might want to consider doing visual models to see how different heights of the landfill effect the view (John Voss of the City of Kelowna has done this for the Glenmore landfill).

VIII. Final Cover - Lacustrine Deposits between 10^{-5} and 10^{-6} cm sec. This material should be located, tested and reserved for final cover and fire cover purposes. Where is the location of this material?

IX. E.V. Jensen comments. Wants to have AH4 included in down gradient monitoring program. Would like to see more background wells or auger holes tested for just indicator parameters in the initial 1 year monitoring period.

C.J. Pryce, P.Eng.
Municipal Solid Waste Engineer
Environmental Protection

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TABLES

FIGURES

Golder Associates Ltd.

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Golder Associates

September 28, 1994

Our Ref: 932-4175

Regional District of Okanagan-Similkameen
101 Martin Street
Penticton, B.C.
V2A 5J9

Attention: Mr. Dave Gold, Public Works Manager

**RE: HYDROGEOLOGICAL AND GEOTECHNICAL EVALUATION
CAMPBELL MOUNTAIN LANDFILL
PENTICTON, BRITISH COLUMBIA**

Dear Sir:

Further to your request, Golder Associates Ltd. have carried out a hydrogeological/ geotechnical assessment of the above referenced site. The purpose of the assessment was to evaluate the impact that the landfill operation has had on the local environment together with a review of the existing landfill facilities operated by the Regional District and the City of Penticton as identified by the Ministry of Environment, Lands and Parks (MOELP) Landfill Criteria for Municipal Solid Waste. The following is a brief summary of the study requirements as outlined in your "Request for Proposals" letter dated August 3, 1993 (your File No. 2320-72.25).

- Provide a summary of the geological conditions at the site identifying the surficial deposits, depth to bedrock and groundwater conditions.
- Evaluation of the upgradient and downgradient groundwater quality, quantify the leachate volumes generated by the landfill operation and the extent of leachate migration.
- An evaluation for surface water impacts related to the landfill operation.

- Provide an evaluation of the landfill gas generation together with the potential for off-site gas migration.

- Assessment of the underground fires within the north ravine, recommendations to extinguish the fires and to provide a risk assessment for potential future fires.

- Assessment of the long term landfill slope stability including recommendations for maximum side slopes with acceptable factors of safety.

- Provide an assessment of the impact that the sludge composting facility may create if relocated to the top of the northern portion of the landfill.

1.0 SITE DESCRIPTION

The Campbell Mountain Landfill is located north east of Penticton, B.C. along Spiller Road on District Lot No. 368, S.O.Y.D., as shown on Figure 1. The landfill is operated by the Regional District of Okanagan-Similkameen (RDOS) and serves the Penticton area by providing the following on-site facilities:

- a composting area operated by the City of Penticton

- an evaporation/infiltration site for the disposal of septage and liquid wastes

- metal and acid/lead battery recycling depot

- local bush burning area (woodwaste)

- common refuse dumping area

The present landfill operation covers approximately 10 hectares as shown on Figure 2. The landfill is situated on the side slope of Campbell Mountain which dips downward in a westerly direction towards Okanagan Lake. A prominent bedrock ridge oriented in a north-south direction generally forms the western limits of the landfill except along the southwest corner of the site where a broad base gully is situated. A narrow bedrock ravine is located at the north end of the landfill where recent landfill infilling has been carried out.The infilled ravine area has been subject to several underground fires since the early 1980's.

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Borrowing operations for landfill cover materials have been carried out west of the scale house and along the north east portion of the landfill. The borrow materials are granular and generally consist of gravelly sand grading to a silty sand and gravel. ok for final cover?

Two natural seepage springs were identified downslope and upslope of the active landfill area, as shown on Figure 2. The upslope spring is located about 100 m east of Spiller Road and is currently used for cattle watering purposes. The downslope spring is identified as "Randolph Spring" and located at the west end of an east west gully which is situated south of the landfill property on Lot 1, Plan 36443. A series of chemical laboratory analyses from Randolph Spring on a regular basis for the past few years have been carried out by RDOS. These results have been included in our report for the landfill leachate assessment.

1.1 Site History

It is understood that the landfill operation commenced in 1972 with refuse being placed in an area located south of the north ravine. Infilling within the north ravine commenced in 1975 - 1976. During the early stages of operation, the municipal and industrial solid wastes were commonly placed together with liquid wastes. This placement scheme continued until the mid 1980's when a liquid waste facility was constructed. It is also understood that a sludge compost product was also used as cover material for daily and intermediate purposes. A permanent liquid waste facility has since been completed east of the active landfill operation as shown on Figure 2. Borrow materials for berm construction were selected from excavation Areas "B" and "C".

1.2 Landfill Fire History

It is understood that the landfill has experienced several underground fires since the 1980's. The fires have been limited to the north ravine, near the bottom portion of the slope. In discussion with Mr. D. Gold (RDOS), a fire noted on December 24, 1990 fire was located along the east bedrock side slope near the toe of the ravine where a tree snag ignited within a 4 - 5 m depth of refuse. Additional fires were also noted in the Spring and Fall of 1991 and 1992, with a recent fire noted in January, 1993. The fires were located along the west bedrock face of the ravine at about a third the distance up from the toe. The 1993 fire was

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extinguished by removal of the burning refuse to a depth of about 8 to 9 m. Upon excavation of the fire, observations by the RDOS staff indicate that no daily and/or intermediate cover was present. It is understood that over the past few years, the fire has progressed from east to west across the ravine but is generally limited to the bottom third of the slope. It is understood that the extinguished refuse was placed with two constructed berms at the toe of the ravine and capped with on-site borrow materials. - acceptable? - should this be capped with clay?

2.0 METHODOLOGY

The field investigations were carried out in several stages between October 8, 1993 and April 19, 1994. A summary of the field activities undertaken during this period is presented below. The locations of the various aspects of the field work are shown on the attached site plan (see Figure 2). The augerhole and borehole locations and elevations were surveyed on April 29, 1994 by others.

2.1 Seismic Refraction Survey and Site Reconnaissance (Oct. 8/93 - Nov. 18/93)

A total of twelve hammer seismic refraction surveys were carried out using a signal enhancement seismograph. The inferred soil and bedrock conditions encountered are summarized on Table I. Our site reconnaissance included mapping the exposed bedrock and soil cut areas.

2.2 Ground Conductivity Survey (Oct. 22/93)

Additional seismic refraction surveys were performed using a Geonics EM31 instrument in order to better define the shallow subsurface conditions inferred by the initial seismic refraction survey.

2.3 Landfill Gas Surveys

Shallow gas surveys were carried out on November 15, 1993, February 8, 1994 and May 30, 1994 using temporary gas probes. The objective of the surveys was to make a preliminary assessment of the occurrences of landfill gas in the cover materials on a seasonal basis (fall, winter and spring) in the existing and previous landfill dumping areas, and near the southwest limit of the landfill.

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The gas probes were installed at 42 locations within the landfill as shown on Figures 6 - 9. The survey was extended to include five locations near the southwest boundary on May 30, 1994. The probes were installed by driving hollow steel pipes to a depth of about 1 m and then retracting the pipes a few centimetres prior to measuring gas (oxygen, hydrogen sulfide and methane) concentrations. The gas concentrations were measured with an MSA 361 combustible gas detector. Oxygen was measured as % oxygen, hydrogen sulfide was measured in parts per million (ppm), and methane was measured as % LEL (lower explosive limit). The gas detector was calibrated before and after every survey using certified span gas concentrations for oxygen, hydrogen sulfide and methane. After the readings were taken, the probes were removed from the subsurface.

2.4 Augerhole Drilling

A total of seven augerholes were drilled between December 8 - 10, 1993 at the locations shown on Figure 2. The augerholes were advanced using a CME 750 all terrain drill rig to depths varying between 1.2 and 18.7 m below the existing ground surface. The augerholes were terminated at the bedrock contact except at AH 6 where the testhole was terminated within a gravelly sand at a depth of 18.7 m. Representative samples of the various soil deposits encountered were collected using a 7.5 cm diameter split spoon sampler. Several measurements for explosive gas concentrations were also carried out during the drilling program in the augerholes located near the landfill boundary using the MSA 361 gas detector or Organic Vapour Monitor (OVM) described above. Monitoring wells were installed at AH 1, AH 4 and AH 5 using 50 mm diameter threaded PVC. Details of the well installations together with the soil conditions encountered are summarized on the attached Record of Borehole sheets.

- Protection req'd ?

2.5 Air-Rotary Drilling

A total of five boreholes were put down at the locations shown on Figure 2 using an air-rotary drill rig and advanced using 16.8 cm diameter casing to depths varying between 6.1 and 30.2 m below the existing ground surface. The boreholes were drilled between March 2 - 3 and March 8 - 10, 1994. Four boreholes were located downslope of the existing landfill with one borehole located upgradient and east of Spiller Road. Representative soil samples

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of the various deposits encountered were selected samples were returned to our laboratory for further analysis and testing. Laboratory testing included grain size analyses and organic vapour measurements on samples recovered from BH 101 to BH 104 using an OVM Model No. 580B. Monitoring wells constructed of 50 mm diameter threaded PVC were installed at each borehole location. A summary of the soil and bedrock conditions encountered at each borehole location is presented on the Record of Borehole sheets.

2.6 Groundwater Sampling

Groundwater samples were obtained from monitoring wells BH101 to BH105. Prior to sampling, the monitoring wells were developed and purged using dedicated bailers and Waterra inertial pumps. At BH 101, BH 105 and AH 4 a plastic bailer was used for sampling purposes. At BH 102, BH 103 and BH 104, a Waterra pump was employed for purging and sampling purposes.

The purging and development was carried out on March 28, 1994 prior to groundwater sampling. A minimum 3 to 5 well volumes were purged at the monitoring well locations prior to sampling. It should be noted that purging was not carried out prior to sampling at BH 101 and BH 105 because of the very slow groundwater recovery into these two wells. It is suggested that about a two week purging period be allowed prior to future sampling at these two monitoring locations. Water quality analyses were carried out by Analytical Service Laboratories Ltd. (ASL) in Vancouver, B.C. Analytical parameters tested included physical and organic parameters, dissolved metals, dissolved anions (alkalinity, chloride, sulphate) and nutrients (ammonia nitrogen, total Kjeldahl nitrogen, nitrate nitrogen, nitrite nitrogen, total dissolved phosphate).

Monitoring Well Clause

2.7 Hydraulic Response Testing

Prior to groundwater sampling, the monitoring wells were purged using dedicated bailers and/or dedicated Waterra pump assemblies. Following purging, the recovery of the water levels were monitored and analyzed using the Hvorslev Basic Time Lag method (Hvorslev, 1951) for rising head response testing. The results of the rising head response testing are summarized in Section 3.0.

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3.0 SUBSURFACE CONDITIONS

The results of the field investigation indicate that the landfill site is located within kame/outwash terraces and/or meltwater channel deposits with shallow bedrock subcrops and exposed bedrock outcrops. The predominant deposits consist of the upper loose granular deposits underlain by compact to dense silty sand and gravel overlying bedrock at depth.

The locations of the seismic refraction survey lines and drillhole locations together with the mapped bedrock outcrops are shown on Figure 2. The following presents a summary of the predominant soil strata encountered at the site during our field investigation.

3.1 Upper Granular Deposit

Based on the results of the investigation, the upper granular stratum consists of an interlayered sequence of medium to fine sand and a well graded sand and gravel with a varying cobble content at some locations. These deposits were generally in a loose to compact state.

The granular material was native at all testhole locations except at BH 101, BH 104 and AH 1 where a 1.2 m thick road embankment, a 5.5 m thick construction berm and a 3.7 m thick mineral fill were encountered, respectively. At the augerhole locations, the granular deposits varied in thickness between 8.6 m and 18.4 m at AH 2 and AH 6, respectively. At BH 102, a 4.0 m thick layer of municipal waste was encountered overlying the granular stratum.

The results of the shallow seismic refraction survey indicate that the upper granular deposits are loose to compact with seismic velocities ranging between 307 and 460 m/sec, indicating a well graded gravelly sand. It is inferred that the thickness of the granular deposit along the northern portion of the site and east of the north ravine varies between 2.0 and 4.4 m.

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Organic vapour concentrations were measured on all the recovered granular borehole samples using an Organic Vapour Monitor (OVM) Model No. 580M. Organic vapour concentrations were only detected on the samples recovered at BH 102. The concentrations ranged between 17.7 ppm beneath the municipal wastes to 4.8 ppm at depth. In addition, a Gastech monitor Model No. 1238 was used to monitor the methane gas within the augerholes located near the landfill wastes. The Gastech monitor was calibrated using a methane gas concentration of 1.3 percent for an equivalent 26 percent LEL reading (lower explosive limit). Monitoring was carried out at AH 1 and AH 6. At AH 1, a 3 percent LEL reading was recorded within the augers through the upper mineral fill to a depth of 2.7 m. A Gastech reading of 3 percent LEL was detected along the outside of the augers when drilling at AH 6 with a reading of 1 percent LEL noted within the recovered sample at a depth of about 12.2 m. Methane concentrations were not detected within the remaining augerhole locations.

3.2 Lower Granular Deposit

Underlying the upper granular deposit was a compact to dense well graded gravelly sand with some silt sizes grading to a silty sand and gravel. This deposit was encountered at each testhole location except at AH 1 and AH 4 and varied in thickness between 0.7 m and 9.4 m at BH 101 and BH 102, respectively. This deposit was generally found overlying bedrock.

The seismic refraction velocities ranged between 480 and 610 m/sec at SL 112 and SL 106, respectively. At SL 106, the stratum is inferred to be about 14.0 m thick.

Organic vapour concentrations using an OVM monitor model No. 580M on samples collected at BH 102, between depths of 16.5 m and 25.6 m, ranged between 8.0 and 1.6 ppm, respectively. No vapour concentrations were detected within the samples at the remaining borehole locations.

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3.3 Bedrock Geology

Available geological information from Geological Survey of Canada Maps indicates that the Campbell Mountain Landfill site is located in the Monashee Group within the Shuswap terrane, which consists predominantly of layered gneiss (paragneiss) together with local zones of less-metamorphosed sedimentary bedrock.

The bedrock surface generally dips in a south and westerly direction except along the north portion of the site where a narrow ravine is bounded by steep sided bedrock slopes. The bedrock ridge generally extends about 30 m higher than the base of the ravine at the north property line. A thin silty sand and gravel veneer was observed overlying the bedrock surface east of the ravine within the proposed Cover Material Excavation Area "A" as shown on Figure 2 and as discussed in Section 3.1. Similar veneer and bedrock conditions exist east of Spiller Road. Bedrock exposure was also noted south of the scale house and west of Spiller Road. The exposed bedrock locations are presented on Figure 2. Based on the above bedrock information, a bedrock contour plan has been plotted as shown on Figure 4, indicating a bedrock trough which dips south along the west limits of the landfill.

The results of the seismic refraction survey indicate that the bedrock exhibits seismic velocities ranging between 2360 and 3330 m/sec. In general, the bedrock becomes marginally rippable using a D9G Caterpillar Tractor at seismic velocities up to about 2500 m/sec.

The air rotary boreholes were terminated within a relatively hard bedrock formation except at BH 102, where highly fractured bedrock was encountered. Difficult drilling conditions at BH 102 resulted in the termination of the borehole within the fractured bedrock zone. At BH 104, the uppermost 2.0 m of bedrock was also fractured. Moderate groundwater seepage was encountered at these borehole locations during the drilling activity. No seepage was noticed within the bedrock at the remaining air rotary borehole locations. A 2.75 m thick, soft, weathered and fractured bedrock zone was encountered at BH 105 underlying a 0.3 m thick moist gouge layer. No detectable groundwater seepage was encountered within BH 105, at the time of drilling.

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3.4 Hydraulic Conductivity Values

Hydraulic conductivity testing was carried out within all screened sections of the wells founded within bedrock using a rising head test method. The following table presents a summary of the test results for weathered/fractured and hard/competent bedrock zones.

BOREHOLE NO.	SCREEN DEPTH (m)	BEDROCK CONDITION	HYDRAULIC CONDUCTIVITY (cm/sec)
BH 101	4.3 - 5.8	Competent	9.0×10^{-8}
BH 102	26.4 - 29.5	Fractured	*
BH 103	6.5 - 9.6	Soil/Bedrock Interface	7.0×10^{-5}
BH 104	10.7 - 13.7	Fractured	1.1×10^{-4}
BH 105	5.5 - 8.5	Competent	6.9×10^{-8}

*Note: An hydraulic conductivity value was not determined because of very rapid water level recovery, during the rising head test. However, it is estimated that the hydraulic conductivity may range between 10^{-1} and 10^{-2} cm/sec.

4.0 GROUNDWATER CONDITIONS

Water levels in the monitoring wells were measured on a periodic basis during the field investigation. A summary of the recorded groundwater levels is presented in Table II.

During the initial augerhole drilling investigation, groundwater was only encountered at two locations, AH 1 and AH 4, and the remaining augerholes were dry. The depth to water in the overburden soils at AH 1 and AH 4 was approximately 5 to 6 m below ground surface. Following the completion of the second stage of the investigation, groundwater was encountered in the boreholes drilled to bedrock at varying depths, ranging from approximately 4 to 27 m below ground surface. The water was typically found at or within the upper 1 to 2 metres of the bedrock surface.

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5.0 CLIMATIC CONDITIONS

5.1 Available Climatic Data

We have utilized the climatic information from Environment Canada based on records from the Penticton Airport. This station commenced recording in 1941 and contains the data base for the analysis of climatic conditions. Three other climatic stations in the area were also used in the analysis of climatic data. These stations are 1) Summerland CDA, 2) Peachland Brenda Mines and 3) Okanagan Falls 2S. The details of all four climatic stations are summarized on the following table.

Station	Latitude/Longitude/Elevation	Period of Continuous Records
Penticton Airport	49 28 N 119 36 W 344 m	1941 - Present
Summerland CDA	49 34 N 119 39 W 454 m	1916 - Present
Peachland Brenda Mines	49 52 N 120 0 W 1463 m	1968 - 1993
Okanagan Falls 2S	49 19 N 119 33 W 335 m	1970 - 1982

These stations are operated by Environment Canada and are equipped with precipitation gauges and temperature recorders.

5.2 Temperature

The mean annual temperature for the period of record for the Penticton Airport station is 8.9°C. The lowest mean monthly temperature occurs in January and was recorded at -2.7°C. The highest mean monthly temperature occurs in July and was recorded at 20.3°C. The extreme minimum temperature on record is -27.2°C, while the maximum temperature on record is 40.6°C.

5.3 Precipitation

The annual precipitation for the period of record at the Penticton Airport station is a mean of 282.9 mm. The mean annual snowfall is 76.0 mm. The two months of the year when the precipitation is at maximum are December and January with a total of 31.2 and 32.0 mm, respectively. The months of the year with the minimum precipitation are March and October, with a total of 17.3 and 15.3 mm, respectively.

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The annual precipitation from 1971 to 1992 for the Penticton Airport and the Summerland CDA are illustrated in Figure 10. The precipitation at the Penticton Airport is slightly less variable and exhibits less rainfall approximately 52% of the time than at the Summerland CDA station.

The maximum precipitation on record for the Penticton Airport is 469.5 mm in 1983. The driest year on record was 1970, with 199.9 mm of precipitation. These extreme conditions for the Summerland CDA station occurred in 1990 with 485.2 mm of precipitation, while the driest period was 1985 with 205.8 mm of precipitation.

6.0 DISCUSSION

Based on the results of the investigation we have carried out a study of the geotechnical and hydrogeological conditions at the landfill. The details of the conditions, the impacts of the landfill and our recommendations are presented in the following paragraphs.

6.1 Groundwater Regime and Chemistry

6.1.1 Groundwater Flow Patterns

Elevations for the May 29, 1994 water levels are plotted on Figure 5 and contoured to show inferred directions of groundwater flow. As shown, groundwater flow generally follows the topography, with flow to the southwest and west at a gradient of approximately 0.18. Based on the inferred flow pattern, leachate impacted groundwater, if present, should be detected at BH 102, BH 103 and AH 4, while background conditions should be present at BH 101, BH 104 and BH 105. Due to the proximity of AH 1 to the waste it may or may not show landfill related impacts. The groundwater quality is discussed in the following section.

6.1.2 Groundwater Chemistry

The chemical analyses for samples collected from the monitoring wells is summarized in Tables IV to X. Copies of the laboratory reports for confirmatory sampling at BH 101 and BH 105 and previous sampling of the Randolf Spring are included in Appendix A. Where possible, the data from the Randolf Spring have been included in Table X in a similar format to the monitoring well data.

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Based on the inferred groundwater flow patterns, background conditions are expected at BH 101, BH 104 and BH 105. The chemical analyses for these wells showed a wide range in concentration for parameters frequently used as indicator parameters at landfills, such as chloride and electrical conductivity. Chloride levels at BH 104 were 7.8 mg/L, as compared to 80 to 389 mg/L at BH 101 and BH 105, respectively. Similarly, the conductivity level of 695 umhos/cm at BH 104 is considerably lower than those at BH 101 and BH 105, with levels of 1280 and 1960 umhos/cm, respectively. To confirm that the elevated levels at BH 101 and BH 105 were valid, these locations were resampled and analyzed for pH, conductivity, chloride and sulphate. The results for this analysis (Appendix A) showed similar results, indicating that the elevated nature of these parameters was valid.

The reason for the variation in background quality is uncertain considering that all three wells were installed in the bedrock, but may be due to different bedrock units. This would suggest that the bedrock has a natural variability and has naturally elevated levels of chloride and conductivity and a number of other parameters (sulphate, nitrate and possibly aluminum, bismuth, iron, molybdenum, phosphorus, potassium, sodium and zinc).

Parameters which appear to show a more definite contrast between leachate impacted groundwater and background conditions include barium, boron, calcium, iron, magnesium, manganese and total organic carbon. In most instances, samples collected from BH 102, BH 103 and AH 4 found these parameters to be present at concentrations above those at background wells. Chloride and conductivity levels at these locations also appear elevated but cannot be definitively linked to the landfill leachate for the reasons given above.

The level of impact to groundwater appears to be highest at BH 102, although for many indicator parameters BH 103 shows equal levels of impact. For comparison purposes the B.C. Environment Approved and Working Criteria For Water Quality (1994) are included in Tables IV to X. While the groundwater quality does show evidence of landfill impacts, the levels of most parameters are within the applicable guidelines, with the exception of chloride at BH 105, and iron, manganese and sodium at most locations. The guidelines for chloride, iron and manganese are aesthetic objectives only and are not related to human health, except for individuals sensitive to sodium. In fact, the elevated levels of these

..../14

parameters in the background wells shows that they occur naturally at elevated concentrations.

The water quality for the Randolf Spring suggests that the water has possibly been impacted, although the source is uncertain. The conductivity and chloride concentrations are elevated above BH 104 but are less than the levels at background wells in the bedrock. As such, it is difficult to determine if the water at this location has been impacted by the landfill. The other parameters showing elevated concentrations are COD and nitrate. The elevated COD may be landfill related or may be related to some other source. The nitrates level at the Randolf Spring is above the health related drinking water guideline, however, the nitrate levels in monitoring wells downgradient of the landfill were present at relatively low concentrations. This would suggest that the elevated nitrate is related to another source such as animal wastes. This could occur if the spring is frequently used for drinking water by the local fauna and/or domestic animals.

6.1.3 Assessment of Impacts

Although landfill related impacts are apparent at BH 102, BH 103 and AH 4, the elevated nature of indicator parameters does not result in exceedances of health related drinking water standards or livestock watering criteria, where they are more restricting than drinking water standards. Aesthetic related guidelines are exceeded for iron, manganese, sodium and chloride, however, there are no known water wells immediately downgradient of the landfill and these parameters also occur at naturally elevated levels. While the presence of a contaminant plume has been identified, the lateral and downgradient extent of the plume has not been determined. Additional monitoring wells would be required to further delineate the contaminant plume. One of these wells should be drilled on the west side of the bedrock ridge which is adjacent to the new City composting area. This well will monitor whether any leachate impacted groundwater is flowing to the west.

The present monitoring data does not clearly suggest that the Randolf Spring has been impacted by the landfill, and in fact suggests that the spring may be impacted by other sources such as animal waste. This could occur if local fauna, the domestic and/or domestic animals use the spring for drinking water. Additional monitoring of the water quality at the

.... /15

spring is required to determine if the spring shows ongoing impacts and to help identify the source.

6.2 Landfill Leachate

6.2.1 Climate

The climate of the Okanagan Valley is dry due to its location in the rain shadow of the Coast Mountains. It typically has hot dry summers and crisp winters with a minimal amount of snowfall.

Long term meteorological data, based on 30 year normals, for the Penticton Airport meteorological station, located about 10 km to the south, was used to prepare a water budget for the Campbell Mountain Landfill basin.

6.2.2 Water Balance Calculation

The following table presents the mean temperature and precipitation for the Penticton Airport, as well as evapotranspiration rates and a water balance, based on a yearly basis.

WATER BALANCE CALCULATIONS FOR THE PENTICTON AIRPORT				
Month	**Mean Temperature (C)**	**Mean Precipitation (mm)**	**Actual Evapotranspiration (mm)**	**Actual Water Balance (mm)**
Jan	-2.7	32.0	3	29
Feb	0.6	19.8	6	13.8
Mar	3.9	17.3	18	-0.7
Apr	8.6	21.4	35	-13.6
May	13.4	29.1	59	-29.9
Jun	17.2	27.6	50	-22.4
Jul	20.3	21.1	34	-12.9
Aug	19.5	26.5	29	-2.5
Sept	14.7	17.7	18	-0.3
Oct	8.7	15.3	15	0.3
Nov	3.0	23.9	11	12.9
Dec	-0.4	31.2	5	26.2
YEAR	8.9	282.9	283	-0.1

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Thus, the water balance for the site shows that there is a complete balance between precipitation and evapotranspiration. This indicates that there is very little infiltration, which would result in minimal generation of leachate. However, it is anticipated that during heavy rainfall events and the spring thaw that some infiltration occurs and this would contribute to the generation of leachate. Estimating the amount of such infiltration is difficult, although overall values are expected to be low. Therefore, the following alternative estimate of leachate generation is provided.

Justification for using in situ soil for final cover?

6.2.3 Flux of Leachate Impacted Groundwater

We have estimated the flux of leachate impacted groundwater leaving the landfill using the information obtained in this investigation and Darcy flux calculations. The groundwater flow pattern indicates that the groundwater, including that impacted by the landfill, flows toward the southwest. Knowing the groundwater gradient, assuming a "window" through which groundwater flow occurs and using the hydraulic conductivity information, the Darcy flux exiting the landfill can be calculated. It is inferred that the major portion of the leachate is generated in the former gully along the west edge of the landfill.

As the hydraulic conductivity of the competent bedrock is very low it is expected that flow to the southwest will be restricted by the bedrock outcropping and directed through a "window" roughly between BH 103 and AH 4. A length of 150 m was used for this "window" and a height of 3.0 m was used to correspond to the active saturated zone encountered at BH 103. The hydraulic conductivity of BH 103 was used for the calculations. Based on the above assumptions, the flux of leachate impacted groundwater leaving the landfill is estimated at 3.4 L/min or 4,900 L/day. It should be noted that this is only an estimate and that the actual flux will be better defined by the installation of additional monitoring wells at the site. It should also be noted that this flux represents a combination of groundwater and leachate, thus leachate volumes only represent a fraction of the estimated flow.

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6.3 Landfill Gas

It is our understanding that over the past number of years, difficulties with the spontaneous combustion of refuse have been experienced at the Penticton landfill as previously discussed in Section 1.2. The area in which the landfill fires have occurred contains between 10 - 20 m of municipal refuse. The future plans include placement of an additional 10 - 15 m of refuse at this location. During previous years, sewage compost has been used as a source of cover material for the municipal refuse. Current operations of the landfill utilize a cover material comprised mainly of coarse sands and gravel materials.

do we have an estimate how much / how long?

6.3.1 Landfill Gas Monitoring

The results of the landfill gas surveys expressed as % oxygen, ppm hydrogen sulfide and % LEL methane are presented in Table III. The distributions of methane and hydrogen sulfide on selected dates are shown on Figures 6 and Figure 7.

6.3.2 Seasonal Patterns

The concentration data for methane show no distinct seasonal variations. The concentrations at many individual probe locations varied significantly on the three survey dates while the concentrations at the remaining locations showed little or no variation. There was no seasonal relationship as to when the highest concentrations occurred, although all of the concentrations that exceeded 100% LEL occurred in either November, 1993 or May, 1994.

The concentration data for hydrogen sulfide also do not show distinct seasonal variations although the highest concentrations tended to occur in November, 1993 and May, 1994. All of the highest concentrations (e.g., greater than 100 ppm) occurred in November, 1993. Similar to the methane results, the concentrations of hydrogen sulfide at many individual locations varied significantly on the three survey dates while the concentrations at the other locations showed little or no variation.

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6.3.3 Locational Patterns

The distributions of the highest concentrations of methane and hydrogen sulfide that were recorded at each probe site are shown on Figure 8 and Figure 9, respectively. Elevated concentrations of methane (e.g., greater than 10% LEL) were recorded in all areas of the landfill. Elevated concentrations of hydrogen sulfide (e.g., greater than 10 ppm) were recorded primarily in the north and east-central areas, which are the oldest areas of the landfill.

The distributions of the methane and hydrogen sulfide concentrations recorded in the probes in May, 1994 are shown on Figures 6 and 7, respectively. The patterns noted above for the highest concentrations are also evident in the May, 1994 data, that is, elevated methane concentrations occurred in all areas of the landfill and elevated hydrogen sulfide concentrations occurred in the north and east-central areas.

Measurements of methane and hydrogen sulfide concentrations were made at five additional probe sites located adjacent to the western limit of the landfill, in four of the monitoring wells (see Table III) and in select soil samples (see Record of Borehole sheets). At the sites of the five additional probes, methane and hydrogen sulfide were not detected. Methane was detected in BH 102 on May 30, 1994 at a concentration of 3% LEL; in BH 103, located downgradient (west) of BH 102, methane was not detected on that date. At AH 6 located adjacent to BH 102, methane was detected in soil samples during drilling at concentrations of 1% and 3%.

6.3.4 Assessment of Gas Migration

Based on the geologic setting of the landfill site (i.e., granular deposits overlying bedrock) and the results of the landfill gas surveys, landfill gas appears to be migrating from the waste by upward venting through the top of the landfill cells. The detection of methane at the sites of BH 102 and AH 6 located near the western limit of the landfill, but not at the sites of BH 103, AH 4 and the four probe sites located adjacent to the western limit of the landfill, suggests that landfill gas may not be migrating horizontally away from the landfill site to the west. However, it is recommended that additional gas concentration data be obtained at

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regular depth intervals at two or three sites located between BH 102 and BH 103 to confirm this interpretation. yes agree!

In evaluating the results of the gas surveys, it is important to note that the data obtained from the probes represent the methane and hydrogen sulfide concentrations at the time the measurements were made. Gas conditions at the probe sites will vary with time of day due to variations in atmospheric temperature and pressure. Also, gas conditions will change with variations in soil moisture conditions caused by precipitation events, drying periods and frozen ground conditions. Therefore, the occurrences of gas at the landfill could vary from the occurrences determined on the three survey dates and additional monitoring should be considered. yes agree!

6.3.5 Calculation of Non-Methanogenic Organic Compounds (NMOCs) Value

Schedule 2 in the Landfill Criteria for Municipal Solid Waste indicates that for landfills with a capacity of greater than 100,000 tonnes require a calculation to estimate NMOCs. If their calculated NMOC emissions are greater than 150 tonnes/year, then landfill gas collection and control equipment is required.

It is understood that the landfilling operation at the Campbell Mountain Landfill began in 1972, and the total refuse accepted between 1972 and 1993 was 696,314 tonnes and therefore ✓ requires calculation of NMOCs. NMOCs are calculated using the following equation supplied in the Landfill Criteria for Municipal Solid Waste:

$$M_{NMOC} = 2L_oR(1-e^{-kt})(C_{NMOC})(3.595 \times 10^{-9})$$

where:

M_{NMOC} = mass emissions rate of NMOC, tonnes/year

L^o = refuse methane generation potential, m3/tonne of refuse

R = average annual refuse acceptance rate, tonne/year

k = landfill gas/methane generation rate constant, $year^{-1}$

t = age of landfill, years

C_{NMOC} = concentration of NMOC in landfill gas, ppmv as hexane

3.595×10^{-1} = conversion factor

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In the absence of site-specific data, the following default values are given:

k	$= 0.02\ year^{-1}$
L_o	$= 230\ m^3$/tonne of refuse
C_{NMOC}	= 8000 ppmv as hexane

and site-specific data indicate that:

R	= 696,314 tonnes/22 years = 31,650 tonnes/year
t	= 22 years

Therefore, the M_{NMOC} value is calculated as follows:

$$M_{NMOC} = 2(230)(31,650)(1-e^{-(0.02)(22)})(8000)(3.595 \times 10^{-9})$$
$$= 149.05 \text{ tonnes/year}$$

The calculated value of 149.05 tonnes/year is less than the 150 tonnes/year guideline, at which point gas collection and control are required, and therefore such a system is not required for the Campbell Mountain Landfill.

6.4 Landfill Fires

6.4.1 General Causes

When considering landfill fires it is important to recognize that they require a source of oxygen in order to burn. In general, the use of a thick, good quality, fine grained soil for earth cover, which is compacted over the refuse on a frequent basis, will prevent most landfill fires from occurring. It is suspected that the fires at the landfill are occurring as a result of chemical reactions within the refuse, with oxygen travelling to the fire through the refuse and porous sands and gravels used for cover materials at the landfill. It is also possible that seasonal variations in the groundwater levels in the base of the gully could adversely affect the generation of combustible landfill gases.

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6.4.2 Prevention of Fires

The flow of oxygen down through the cover soils and into the refuse can be minimized through the construction of an impervious, compacted silt/clay cover over the top and around the perimeter of the problem areas within the ravine. Ideally, this silt/clay cover would be approximately 1 m in thickness, constructed in lifts and compacted at moisture contents above optimum. As it is unlikely that a clay cover material is available in the area of the site, it is considered that local deposits of silt will provide a sufficient barrier to the flow of oxygen into the landfill, assuming that the cover is properly placed and compacted. Based on observations, discussions with RDOS staff members and results of the landfill gas survey, it is estimated that approximately 2200 m^2 in area has been affected with fires as outlined on Figure 2.

It is understood that it is planned to place an additional 15 m of refuse in the area of the past fires and temporary cover will be required prior to further landfilling. To this end, we recommend a cover of silt approximately 0.3 to 0.5 m thick be properly placed and compacted prior to placing additional waste in this area. The area requiring temporary cover is also shown on Figure 2 and corresponds to the area affected with fires. A temporary cover system consisting of a synthetic liner could also be considered if construction of a silt cover is economically impractical. Regardless of which temporary cover is selected, the effect this will have on slope stability will require evaluation. This evaluation can be conducted once final design details are known.

Because the north ravine area of the landfill which is prone to fires is going to be covered with up to 15 m of additional refuse, it is suggested that the installation of a gas venting system below the silt/clay cover be considered. The stability of the final slope should be evaluated if this consideration is implemented once the final design details are known for the venting scheme.

As discussed above, the occurrence of landfill fires can be minimized through the selection and use of effective cover materials. However, we have not been able to reach a conclusion regarding the origin of the fires. It is recommended that additional gas monitoring be

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carried out to help further delineate the ravine area affected. Installation of a gas monitoring well in the area of concern should also be considered.

6.5 Composting

It is understood that the RDOS is concerned about the relocating of the City of Penticton composting area from the east side of the landfill to the west side of the landfill, near the bedrock ridge defining the landfill's western limit. It is our opinion that such relocation should not result in different impacts to the subsurface than occurred by composting on the east side. As discussed above, leachate generation at the site is minimal, primarily due to climatic conditions. In addition, groundwater flow patterns are such that any leachate generated will ultimately be discharged near BH 102, whether the composting occurs on the east side or the west side of the landfill. The recommended additional monitoring well on the west side of the bedrock ridge near the new City composting area will be used to confirm this.

6.6 Landfill Stability Analyses

The stability of the landfill under static and seismic load conditions was evaluated using Golder Associates' CSlope computer program for Sarma's method of slope stability analyses. In order to determine the minimum critical failure zone, a variety of trial circular slip surfaces were analyzed.

The analyses was carried out for an assumed ultimate landfill configuration. Based on our experience and review of the site conditions we have selected the final slope of the landfill constructed at angles of 3 horizontal to 1 vertical for a total vertical height of 70m.

Strength parameters for the landfill together with the unit weight of the refuse used in the calculations was obtained from several studies we have conducted in B.C. and Alberta. A friction angle and cohesion of 20 degrees and 15kPa, respectively together with a unit weight of 12 kN/m^3 were selected in the stability calculations. Based on the site conditions the stability calculations for the landfill were carried out in a drained condition.

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In our seismic risk analyses for the landfill, we have used available information from Kelowna. A peak ground acceleration of 0.08 g was used in the stability calculations. This corresponds to the 1 in 1000 year earthquake event.

The results of the analyses indicate that under static load conditions the minimum factor of safety is 1.55. Under earthquake load conditions, the factor of safety reduces to 1.21. These results demonstrate that the landfill slopes will remain stable even under earthquake load conditions.

The final landfill toe along the west limits of the landfill should not extend to within 8-10 m of the crest of the bedrock ridge or steep overburden slopes as shown on Figure 2. This setback can also provide future road access for long term maintenance and monitoring of the landfill. IMP. NOTE

6.7 Cover Materials

The results of the site investigation indicate that there are suitable materials for the construction of daily and intermediate landfill covers. The available materials are founded along the north east corner of the site (identified as Cover Material Excavation Area "A" in Figure 2) and along the southwest corner of the landfill (Elevation Area "B").

In general, the excavation volume of the borrow areas will be determined by the depth of the bedrock, particularly along the Excavation Area "A". Assuming a sideslope of 2 horizontal to 1 vertical for the final pit slopes with a 5 m setback from the property lines and an average cover depth of 2.0 m, it is estimated that about 45,000 m^3 of materials are available. This material is generally granular and varies from a gravelly sand to a silty sand and gravel, as shown on the Grain Size Distribution Sheets (Figure 13).

Along the Excavation Area "B", it is estimated that a borrow volume of about 230,000 m^3 of granular material is available. Calculations are based assuming that the excavation progresses along the crest of the current borrow face at Area "B" and extends westerly at 2 horizontal to 1 vertical to a base elevation of about 532 m along the toe of the existing

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slope near AH 4. Exposed granular materials along the slope face vary from a sand and gravel thickness of about 2 - 3 m at surface with an underlying medium to fine sand deposit as presented on Figure 14. A summary of the intermediate cover placed along a portion of the slope face at the north ravine is shown on Figure 15. The grain size analysis indicates that the material generally consists of a gravelly sand.

An indication / justify a good clay/silt to require

A 5 m setback to the crest of the 2 horizontal to 1 vertical cut slope face from all affected property boundaries was used in our volume calculations. This setback will provide a buffer for long term erosion of the borrow slope faces. However, it is also recommended that the borrow slope faces be hydro-seeded to help minimize the potential for the development of erosion channels across the slope and for aesthetic purposes.

The final cover should consist of 1 m of compacted fine grained soil. This cover should be graded to promote runoff, then covered with topsoil and seeded. Fine grained materials have not been encountered within the area of the landfill. It may be required to import these materials or use alternative final cover materials.

IMP. NOTE

7.0 RECOMMENDATIONS

Based on the results of the investigation together with our interpretation of the groundwater flow patterns and chemical analyses, our comments for the future development and monitoring of the landfill operation are as follows:

- It is recommended that a future monitoring well be installed west of the existing City of Penticton composting area which is founded south of the north ravine. Monitoring well P1, as shown on Figure 2, should be located outside of the active landfill areas within the bottom of the small gully at an elevation of about 605 m. Two separate monitoring standpipes (P1 shallow and P1 deep) constructed of 50 mm PVC should be installed within the well at various depths. The shallow standpipe should be installed at the bedrock interface with a deeper standpipe established at 10 m depth within the bedrock formation. This well installation will help monitor the effect that the composting activity will have on groundwater quality downgradient of the north-south bedrock formation.

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- It is recommended that the downgradient monitoring wells BH102, BH103, the upgradient monitor at BH104 and the Randolf Spring be sampled on a quarterly basis throughout the first year (commencing fall 1994) for the following minimum parameters:
  Ba, B, Ca, Fe, Mg, Mn, TOC, nitrate/nitrite, TKN, conductivity, pH and Cl.

- Monthly groundwater measurements should also be carried out at each borehole/augerhole location as listed on Table 2 to establish the seasonal fluctuations and its impact on the groundwater flow directions.

- A minimum of three well volumes should be purged prior to sampling using the existing dedicated waterra pumps and bailers. The samples should be kept cool during storage and transportation to a qualified testing facility. At the end of the initial monitoring period, a review of all chemistry results should be carried out to determine a long term monitoring program.

- In addition it is recommended that toxicity testing (Microtox) be conducted on a one-time basis for samples collected from upgradient and downgradient groundwater monitoring wells and also from ponded water at the Randolf Spring. It was suggested by Dr. J. Bryan of the Ministry of Environment that upgradient and downgradient samples be collected as composite samples; i.e. BH 104 and 105 composited for the upgradient sample and BH102 and BH103 composited for the downgradient sample.

With regard to problems of landfill fires in the area of the ravine, we provide the following recommendations:

- As it is understood that it is planned to place an additional 15 m of refuse in the area of the past fires, we recommend that a ~~temporary~~ cover of silt approximately 0.3 to 0.5 thick be properly placed and compacted prior to placing additional waste in this area. Such a cover would limit the flow of oxygen into the landfill and would reduce the potential for further fires. A temporary cover system consisting of a

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synthetic liner could also be considered if construction of a silt cover is economically impractical. It is also recommended that the installation of a gas venting system below the temporary cover be considered.

- An additional borehole, P2 is also recommended within the landfill fire area located at the north ravine as shown on Figure 2. The borehole should be located east of the previously subexcavated area where a large fire was extinguished in 1993. The borehole should extend a minimum depth of 2 to 3 m into the groundwater where a permanent monitoring well will be installed. The monitoring well should also consist of a separate small diameter PVC pipe to allow for the installation of a thermistor to measure the temperature changes at various depths. In addition, another separate screened PVC pipe should be installed to monitor the gas concentrations at varying depths. Together, these results will provide specific information on the contributing mechanism for the creation of the landfill fires in the lower portion of the ravine.

- As landfill gas concentrations in the ravine area varied with time, it is recommended that additional monitoring be considered in order to establish if temporal trends in concentration occur.

With regard to the assessment of landfill gas migration, we provide the following recommendations:

- Additional gas concentration data should be collected at regular depth intervals at two or three sites located between BH102 and BH103 to confirm that landfill gas is not migrating horizontally away from the landfill site to the west. The proposed monitoring well P1 should also be used for gas monitoring purposes.

With regard to the uncertainty surrounding the bedrock surface topography, particularly in the former gully along the west side of the landfill, we provide the following recommendation:

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- An aerial photograph search through the various local Government archives has resulted in the discovery of low level stereo sets of the Campbell Mountain Landfill site in 1964. It is suggested that a photogrammetric survey be carried out using these aerial photos to produce a topographic map. This will provide useful information regarding the initial depth of the ravine and the ~~overall slope angle of~~ the west bedrock ridge. For what purpose? Although during earlier conversations with the MOE and RDOS it was proposed that a borehole be drilled in this area, the photogrammetric survey will provide much of this information and will largely preclude the need for a costly monitoring well in this location. Preliminary cost estimates to produce the topographic maps for the landfill site from the 1964 airphotos are in the order of about $1,500.

With regard to landfill closure, we provide the following recommendations:

- When the life of the landfill has come to term, it is recommended that a final impervious silt/clay cap be placed over the pan area of the landfill. The final cover should consist of a minimum 1.0 m thick compacted silt/clay material. Compaction should be carried out to a minimum of 95 percent Standard Proctor maximum dry density (ASTM D968). It is also recommended that the silt/clay material is at/near optimum moisture during placement to minimize the migration of air through the cover into the landfill. A tight seal to the bedrock edges should also be ensured especially within the north ravine area. Local lacustrine deposits may be considered for use for construction of the cover. Typical permeability values for lacustrine deposits generally vary between 10^{-5} and 10^{-6}cm/sec. The cover should be graded to increase surface runoff and minimize infiltration. Consideration should be given to using similar materials for the intermediate cover in the north ravine where fires have occurred.

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We trust the foregoing provides the information you require at this time. Should you have any questions, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

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TABLE I
SUMMARY OF SEISMIC SURVEY RESULTS

November 25, 1993 — 932-4175

Seismic Survey Line No.	Average Depth (m)	Average Velocity (m/sec)	Inferred Soil and Bedrock Conditions
SL 101	0.0 - 8.3(south), 10.4(north)	413	Loose gravelly **SAND** to a **SAND**.
	@8.3(south), 10.4(north)	5880	**BEDROCK**.
SL 102	0.0 - 2.8(south), 5.4(north)	368	Loose gravelly **SAND** to a **SAND**.
	@2.8(south), 5.4(north)	4705	**BEDROCK**.
SL 103	0.0 - 5.3(north), 14.9(south)	460	Loose to compact gravelly **SAND**.
	@5.3(north), 14.9(south)	3545	**BEDROCK**.
SL 104	0.0 - 3.2(east), 11.2(west)	324	Loose **SAND**.
	@3.2(east), 11.2(west)	3330	**BEDROCK**.
SL 105	0.0 - 3.4(north), 9.1(south)	307	Loose **REFUSE FILL/SAND**.
	@3.4(north), 9.1(south)	3330	**BEDROCK**.

TABLE I SUMMARY OF SEISMIC SURVEY RESULTS November 25, 1993			932-4175
Seismic Survey Line No.	Average Depth (m)	Average Velocity (m/sec)	Inferred Soil and Bedrock Conditions
SL 106	0.0 - 2.8 2.8 - 16.8 @16.8	353 610 2440	Loose gravelly SAND. Compact silty gravelly SAND. **BEDROCK**
SL 107	0.0 - 9.3 @9.3	408 3330	Loose gravelly SAND to a SAND. **BEDROCK**
SL 108	0.0 - 2.0 @2.0	330 2540	Loose gravelly SAND. **BEDROCK**
SL 109	0.0 - 2.5 @2.5	326 3125	Loose gravelly SAND. **BEDROCK**
SL 110	0.0 - 4.4 @4.4	333 2360	Loose gravelly SAND. **BEDROCK**
SL 111	0.0 - 1.0 1.0 - 5.4 @5.4	327 812 2710	Loose sandy SILT. Compact to dense silty gravelly SAND. **BEDROCK**
SL 112	0.0 - 3.3 @3.3	480 2406	Compact silty gravelly SAND. **BEDROCK**

TABLE II
GROUNDWATER LEVEL SUMMARY

GROUNDWATER MONITORING (depth below ground surface, m) May 31, 1994							932-4175
DATE Ground Surface Elevations (m)	**AH 1** (592.82)	**AH 4** (530.81)	**BH 101** (569.60)	**BH 102** (565.67)	**BH 103** (529.24)	**BH 104** (587.03)	**BH 105** (612.54)
1993							
Dec 10	dry	6.00					
Dec 24	dry	5.81					
1994							
Feb 8	5.24	5.78					
Feb 10	5.44	5.86					
Mar 2	4.30	5.79	5.99				
Mar 8	-	-	5.38				
Mar 9	-	5.86	5.32		6.83	10.70	
Mar 10	4.39	5.87	5.25	27.55	6.82	10.95	
Mar 17	5.03	5.87	5.09	27.61	6.83	10.93	8.33
Mar 23	5.29	5.90	4.97	27.62	6.81	10.92	7.98
Mar 28	5.43	5.85	4.89	27.64	6.81	11.03	7.62
Apr 19	5.44	5.96	4.66	27.65	6.82	10.92	6.79
Apr 29	5.44	5.99	-	27.65	6.83	10.66	-
May 26	5.47	5.98	4.23	27.61	6.80	10.94	6.52
May 29	5.43	5.96	4.13	27.58	6.81	10.94	6.49

TABLE III
SOIL GAS MONITORING
PENTICTON LANDFILL

31 May 1994 **932-4175**

REFERENCE LOCATION	% OXYGEN			H_2S (ppm)			% LEL (calibrated to methane)		
	Nov. 15/93	Feb. 8/94	May 30/94	Nov 15/93	Feb. 8/94	May 30/94	Nov. 15/93	Feb. 8/94	May 30/94
A1	17.9	18.9	0.5	0	0	5	1	1	2
B1	0.3	-	20.4	4	-	0	3	-	2
C1	9.3	19.9	15.0	1	0	0	3	0	0
A2	0.3	20.8	20.5	2	0	0	5	0	0
B2	0.2	-	17.5	56	-	0	2	-	0
C2	0.4	9.1	20.6	4	1	0	3	2	1
A3	15.5	0.8	0.8	1	2	2	3	9	1
B3	0.9	2.9	1.7	3	1	1	5	22	12
C3	8.3	19.6	12.2	1	0	1	2	2	7
A4	0.3	0.7	8.9	258	5	2	>100	3	72
B4	0.2	0.5	0.5	44	5	30	4	2	2
C4	0.3	9.0	15.5	308	0	0	0	2	1
A5	0.5	5.5	0.3	19	0	6	4	42	6
B5	4.2	10.7	8.6	0	0	1	32	32	6
C5	0.4	6.6	0.6	0	0	3	3	25	0
A6	0.3	9.2	0.7	2	0	12	3	59	8
B6	0.4	5.3	0.8	210	3	3	1	46	5
C6	0.7	6.0	0.7	2	1	6	1	71	7
A7	7.7	11.4	0.6	1	1	1	48	45	6
B7	0.4	0.8	1.1	4	3	1	3	7	8
C7	1.0	6.0	0.4	0	3	4	4	42	6
A8	1.0	1.2	0.8	1	1	1	2	11	5
B8	0.4	1.2	0.5	0	17	3	1	11	5
C8	1.3	0.4	1.0	1	1	0	5	4	6
A9	0.8	-	0.6	0	-	3	3	-	2
B9	15.1	0.6	0.7	0	0	2	84	4	2
C9	0.4	-	7.0	0	-	0	>100	-	53
D9			20.8		0				0
A10	0.4	-	4.7	8	-	7	1	-	>100
B10	9.8	-	1.2	0	-	42	61	-	>100
C10	0.4	-	1.0	0	-	22	>100	-	1
A11	3.9	2.7	4.8	0	0	0	3	12	5
B11	2.2	5.0	0.6	0	1	0	12	45	1
C11	0.1	0.4	0.8	6	14	5	>100	11	>100

TABLE III SOIL GAS MONITORING PENTICTON LANDFILL 31 May 1994									932-4175
REFERENCE LOCATION	% OXYGEN			H_2S (ppm)			% LEL (calibrated to methane)		
	Nov. 15/93	Feb. 8/94	May 30/94	Nov 15/93	Feb. 8/94	May 30/94	Nov. 15/93	Feb. 8/94	May 30/94
A12	0.4	-	1.1	0	-	0	2	-	>100
B12	0.6	1	0.7	1	80	15	>100	8	>100
C12	0.5	-	4.8	11	-	6	1	-	24
D12			20.0			0			0
A13	1.4	-	0.9	0	-	0	6	-	0
B13	1.8	2.5	2.1	0	5	1	4	27	>100
C13	0.9	6.5	2.7	2	2	1	2	60	16
A14	9.0	17.2	12.1	1	0	0	52	9	4
B14	0.8	0.4	-	0	3	-	1	2	-
C14	4.1	1.2	-	1	1	-	>100	14	-
D14			19.6			0			0
A15			20.8			0			0
A16			20.2			0			0
AH1			2.9			0			1
AH4			20.1			0			0
BH 101			19.2			0			0
BH 102			0.3			0			3
BH 103			10.6			0			0
BH 104			20.4			0			0

Table IV
Summary of Chemical Analyses
Background Well - BH 101
Campbell Mountain Landfill

Parameter	Sample Date	Drinking Water Guidelines
	03/28/94	
Physical Tests		
Conductivity	1280	
pH	7.71	6.5-8.5[2]
Dissolved Anions		
Alkalinity	518	
Chloride	80.3	250[2]
Sulphate	96.0	500[2]
Nutrients		
Ammonia Nitrogen	0.009	
Total Kjeldahl Nitrogen	0.55	
Nitrate Nitrogen	0.217	10.0[3]
Nitrite Nitrogen	0.011	1.0[3]
Total Dissolved Phosphate	0.084	
Organic Parameters		
Chemical Oxygen Demand	23	
Total Organic Carbon	13.4	
Dissolved Metals		
Aluminum	1.95	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.138	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	0.11	
Boron	<0.10	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	107	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	0.011	0.300[4]
Iron	1.92	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.042	5.0[4]
Magnesium	46.6	500[2]
Manganese	0.812	0.05[2]
Molybdenum	0.031	0.25[5]
Nickel	<0.020	0.200[3]
Phosphorous	1.59	
Potassium	22.9	
Selenium	<0.20	0.01[3]
Silicon	9.57	
Silver	<0.015	
Sodium	140	200[2]
Strontium	3.95	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	0.026	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	0.105	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related or Health Related.

Table V
Summary of Chemical Analyses
Downgradient - BH 102
Campbell Mountain Landfill

Parameter	Sample Date 03/28/94	Drinking Water Guidelines
Physical Tests		
Conductivity	2520	
pH	6.75	6.5 - 8.5[2]
Dissolved Anions		
Alkalinity	1340	
Chloride	158	250[2]
Sulphate	3.6	500[2]
Nutrients		
Ammonia Nitrogen	0.410	
Total Kjeldahl Nitrogen	1.50	
Nitrate Nitrogen	<0.005	10.0[3]
Nitrite Nitrogen	0.007	1.0[3]
Total Dissolved Phosphate	0.005	
Organic Parameters		
Chemical Oxygen Demand	120	
Total Organic Carbon	41.2	
Dissolved Metals		
Aluminum	<0.20	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.545	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	0.24	
Boron	0.18	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	220	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	<0.010	0.300[4]
Iron	48.1	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.068	5.0[4]
Magnesium	124	500[2]
Manganese	3.23	0.05[2]
Molybdenum	<0.030	0.25[5]
Nickel	<0.020	0.200[3]
Phosphorous	<0.30	
Potassium	12.3	
Selenium	<0.20	0.01[3]
Silicon	21.1	
Silver	<0.015	
Sodium	80.9	200[2]
Strontium	8.05	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	<0.010	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	0.018	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related Or Health Related.

Table VI
Summary of Chemical Analyses
Downgradient - BH 103
Campbell Mountain Landfill

Parameter	Sample Date 03/28/94	Drinking Water Guidelines
Physical Tests		
Conductivity	2530	
pH	7.20	6.5 - 8.5[2]
Dissolved Anions		
Alkalinity	1180	
Chloride	220	250[2]
Sulphate	20.8	500[2]
Nutrients		
Ammonia Nitrogen	0.006	
Total Kjeldahl Nitrogen	0.66	
Nitrate Nitrogen	0.060	10.0[3]
Nitrite Nitrogen	0.006	1.0[3]
Total Dissolved Phosphate	0.101	
Organic Parameters		
Chemical Oxygen Demand	-	
Total Organic Carbon	21.4	
Dissolved Metals		
Aluminum	<0.20	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.094	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	0.28	
Boron	0.28	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	211	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	0.014	0.300[4]
Iron	0.036	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.044	5.0[4]
Magnesium	135	500[2]
Manganese	0.996	0.05[2]
Molybdenum	<0.030	0.25[5]
Nickel	0.025	0.200[3]
Phosphorous	<0.30	
Potassium	14.1	
Selenium	<0.20	0.01[3]
Silicon	9.66	
Silver	<0.015	
Sodium	235	200[2]
Strontium	5.44	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	<0.010	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	0.011	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related or Health Related.

Table VII
Summary of Chemical Analyses
Background Well - BH 104
Campbell Mountain Landfill

Parameter	Sample Date 03/28/94	Drinking Water Guidelines
Physical Tests		
Conductivity	695	
pH	7.68	6.5-8.5[2]
Dissolved Anions		
Alkalinity	368	
Chloride	7.8	250[2]
Sulphate	34.5	500[2]
Nutrients		
Ammonia Nitrogen	<0.005	
Total Kjeldahl Nitrogen	0.27	
Nitrate Nitrogen	0.080	10.0
Nitrite Nitrogen	<0.001	
Total Dissolved Phosphate	0.147	
Organic Parameters		
Chemical Oxygen Demand	-	
Total Organic Carbon	3.6	
Dissolved Metals		
Aluminum	<0.20	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.068	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	<0.10	
Boron	<0.10	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	74.6	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	<0.010	0.300[4]
Iron	<0.030	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.023	5.0[4]
Magnesium	34.5	500[2]
Manganese	0.263	0.05[2]
Molybdenum	<0.030	0.25[5]
Nickel	<0.020	0.200[3]
Phosphorous	<0.30	
Potassium	7.6	
Selenium	<0.20	0.01[3]
Silicon	11.7	
Silver	<0.015	
Sodium	26.1	200[2]
Strontium	1.71	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	<0.010	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	<0.005	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related or Health Related.

Table VIII
Summary of Chemical Analyses
Background Well - BH 105
Campbell Mountain Landfill

Parameter	Sample Date 03/28/94	Drinking Water Guidelines
Physical Tests		
Conductivity	1960	
pH	7.55	6.5-8.5[2]
Dissolved Anions		
Alkalinity	360	
Chloride	389	250[2]
Sulphate	95.5	500[2]
Nutrients		
Ammonia Nitrogen	<0.005	
Total Kjeldahl Nitrogen	0.34	
Nitrate Nitrogen	0.225	10.0
Nitrite Nitrogen	0.007	
Total Dissolved Phosphate	0.077	
Organic Parameters		
Chemical Oxygen Demand	-	
Total Organic Carbon	3.7	
Dissolved Metals		
Aluminum	<0.20	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.041	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	0.17	
Boron	<0.10	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	109	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	<0.010	0.300[4]
Iron	0.176	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.020	5.0[4]
Magnesium	62.4	500[2]
Manganese	0.061	0.05[2]
Molybdenum	0.112	0.25[5]
Nickel	<0.020	0.200[3]
Phosphorous	<0.30	
Potassium	11.8	
Selenium	<0.20	0.01[3]
Silicon	6.78	
Silver	<0.015	
Sodium	215	200[2]
Strontium	2.19	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	<0.010	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	<0.028	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related Or Health Related.

Table IX
Summary of Chemical Analyses
Downgradient - AH 4
Campbell Mountain Landfill

Parameter	Sample Date 03/28/94	Drinking Water Guidelines
Physical Tests		
Conductivity	1520	
pH	7.85	6.5 - 8.5[2]
Dissolved Anions		
Alkalinity	676	
Chloride	108	250[2]
Sulphate	12.0	500[2]
Nutrients		
Ammonia Nitrogen	0.019	
Total Kjeldahl Nitrogen	1.66	
Nitrate Nitrogen	<0.005	10.0
Nitrite Nitrogen	0.025	
Total Dissolved Phosphate	0.012	
Organic Parameters		
Chemical Oxygen Demand	-	
Total Organic Carbon	12.4	
Dissolved Metals		
Aluminum	<0.20	
Antimony	<0.20	
Arsenic	<0.20	0.050[3]
Barium	0.229	1.0[3]
Beryllium	<0.005	0.100[4]
Bismuth	0.19	
Boron	0.11	5.0[3]
Cadmium	<0.010	0.005[3]
Calcium	102	1000[4]
Chromium	<0.015	0.05
Cobalt	<0.015	1.0[4]
Copper	<0.010	0.300[4]
Iron	<0.030	0.3[2]
Lead	<0.050	0.01[3]
Lithium	0.066	5.0[4]
Magnesium	83.3	500[2]
Manganese	1.98	0.05[2]
Molybdenum	0.039	0.25[5]
Nickel	0.023	0.200[3]
Phosphorous	<0.30	
Potassium	15.6	
Selenium	<0.20	0.01[3]
Silicon	9.73	
Silver	<0.015	
Sodium	93.9	200[2]
Strontium	3.92	
Thallium	<0.10	0.013[3]
Tin	<0.30	
Titanium	<0.010	0.100[5]
Tungsten	<0.10	
Vanadium	<0.030	0.1[5]
Zinc	0.058	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related or Health Related.

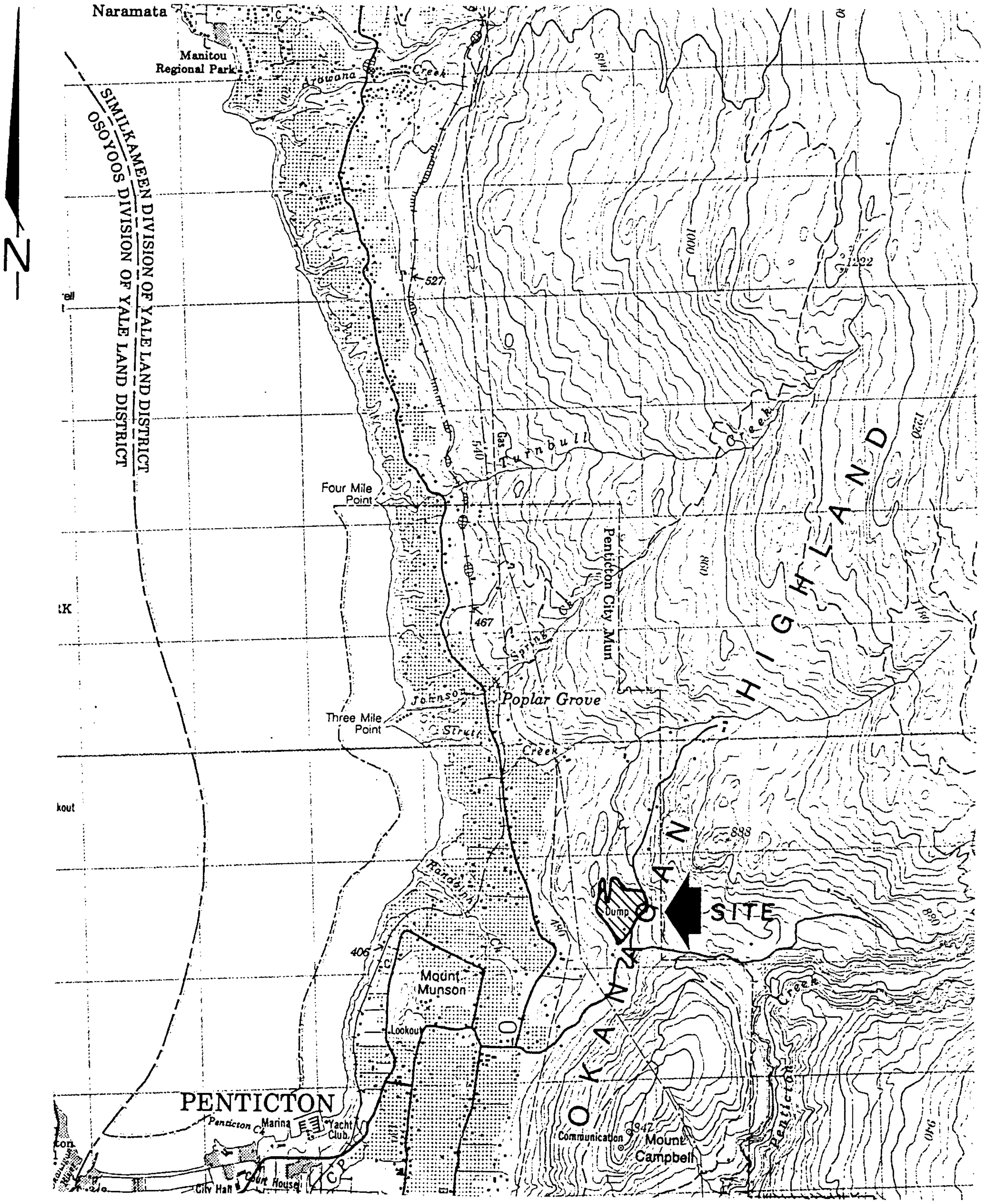
Table X
Summary of Chemical Analyses
Randolf Springs
Campbell Mountain Landfill

Parameter	Sample Date 06/29/93	Drinking Water Guidelines
Physical Tests		
Conductivity	1260	
pH		6.5-8.5[2]
Dissolved Anions		
Alkalinity		
Chloride	54	250[2]
Sulphate		500[2]
Nutrients		
Ammonia Nitrogen	0.07	
Total Kjeldahl Nitrogen	1.25	
Nitrate Nitrogen	13	10.0[3]
Nitrite Nitrogen	0.01	1.0[3]
Total Dissolved Phosphate	0.08	
Organic Parameters		
Chemical Oxygen Demand	355	
Total Organic Carbon		
Dissolved Metals		
Aluminum		
Antimony		
Arsenic	<0.01	0.050[3]
Barium		1.0[3]
Beryllium		0.100[4]
Bismuth		
Boron		5.0[3]
Cadmium	<0.001	0.005[3]
Calcium		1000[4]
Chromium		0.05
Cobalt	0.006	1.0[4]
Copper		0.300[4]
Iron		0.3[2]
Lead	<0.011	0.01[3]
Lithium		5.0[4]
Magnesium		500[2]
Manganese		0.05[2]
Molybdenum	0.002	0.25[5]
Nickel	0.002	0.200[3]
Phosphorous		
Potassium		
Selenium	0.002	0.01[3]
Silicon		
Silver		
Sodium		200[2]
Strontium		
Thallium		0.013[3]
Tin		
Titanium		0.100[5]
Tungsten		
Vanadium		0.1[5]
Zinc	0.048	5.0[2]

1. B.C. Environment Approved And Working Criteria for Water Quality, 1994.
2. Aesthetic Related Drinking Water Guideline.
3. Health Related Drinking Water Guideline.
4. Livestock Watering Guideline.
5. Drinking Water Guideline Not Specified As Either Aesthetic Related Or Health Related.

KEY PLAN

Figure 1



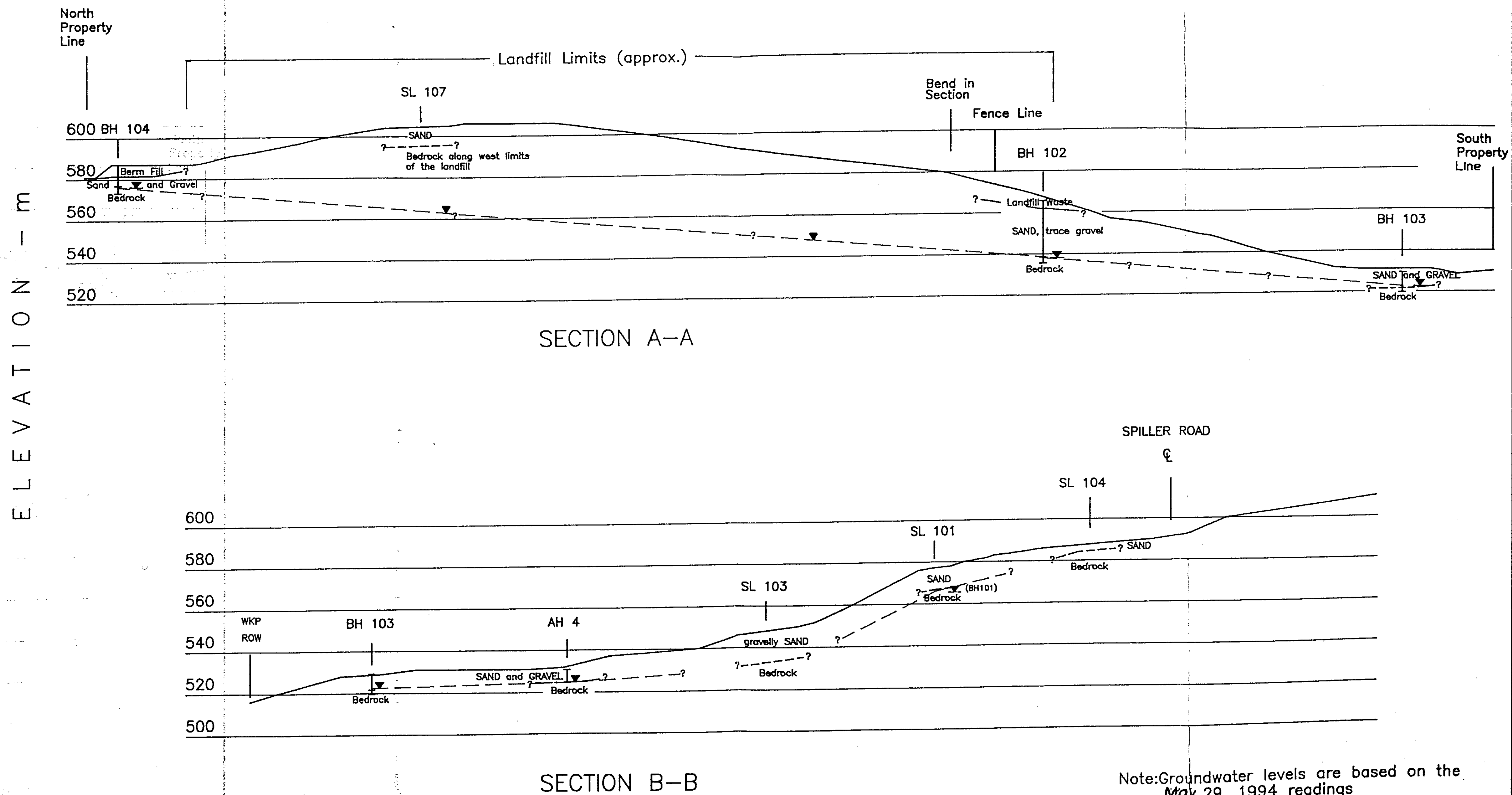
Scale- 1:50,000

PROJECT No. 932-4175 DRAWN rt REVIEWED bc DATE June/94

Golder Associates

TYPICAL SECTIONS

FIGURE: 3

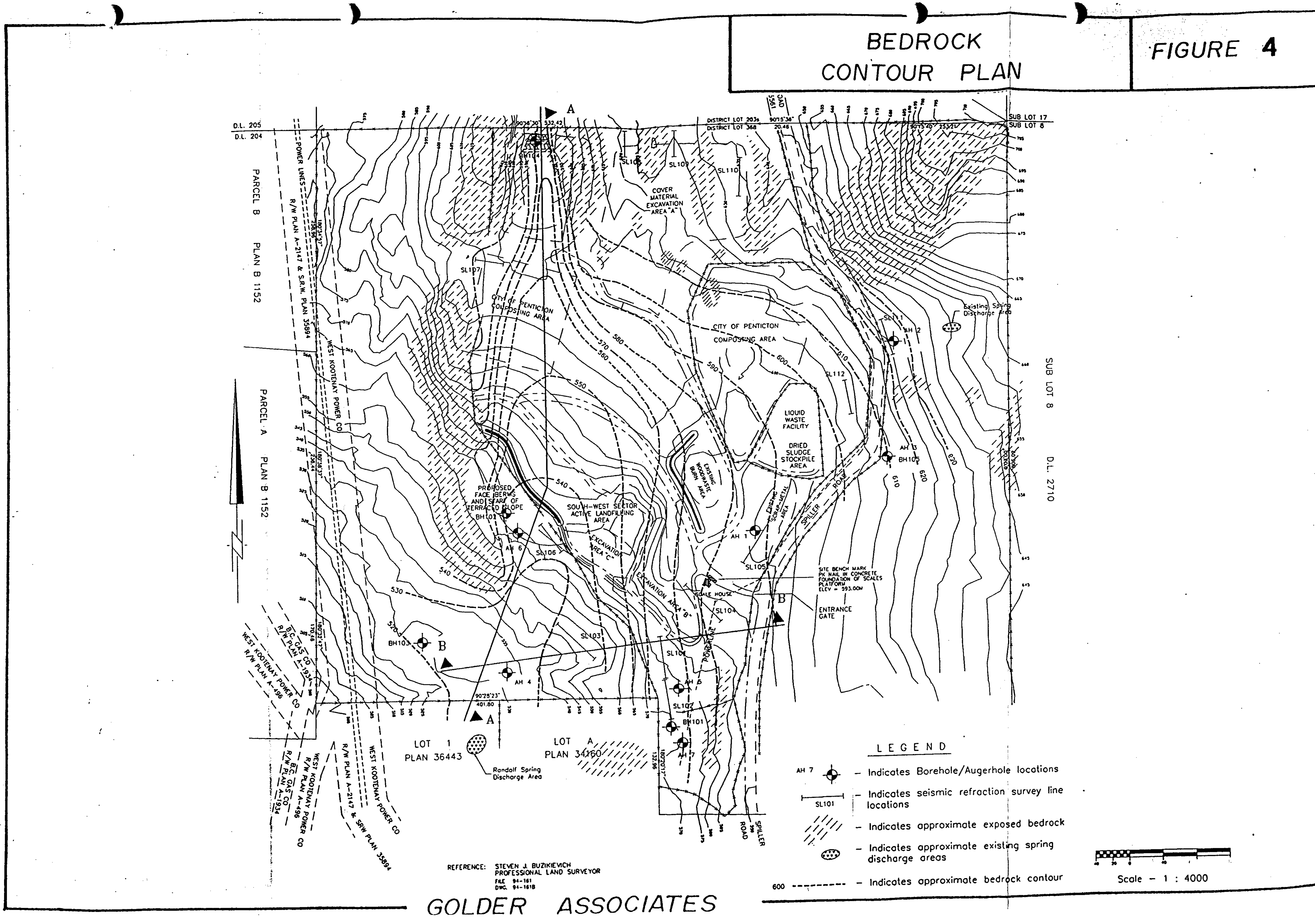


Note: Groundwater levels are based on the May 29, 1994 readings

SCALE – 1:2000

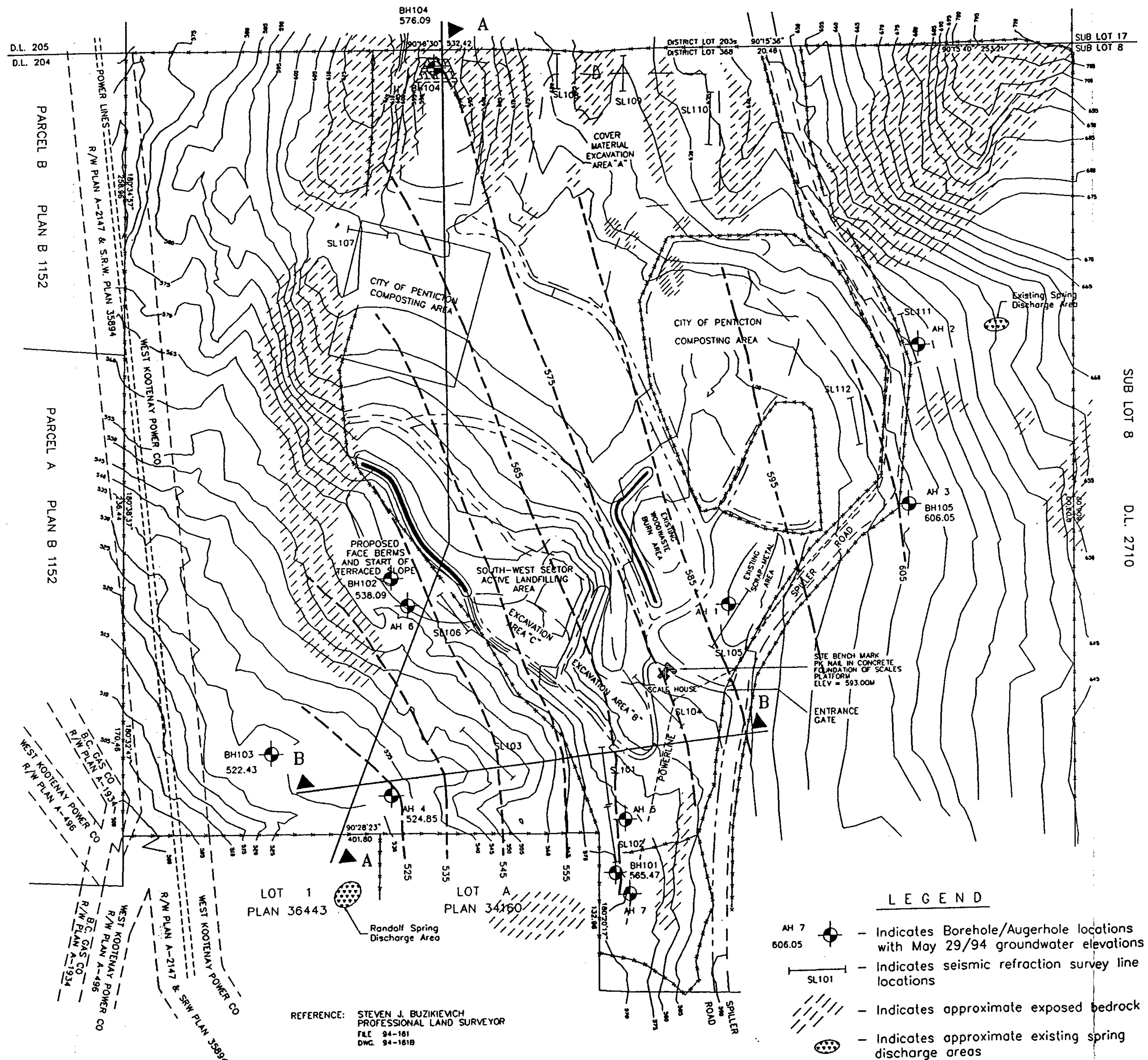
GOLDER ASSOCIATES

PROJECT NO. 932-4175 DRAWN rt REVIEWED .... DATE May/94


BEDROCK CONTOUR PLAN
FIGURE 4
PARCEL B PLAN B 1152
PARCEL A PLAN B 1152
D.L. 205
D.L. 204
POWER LINES
R/W PLAN A-2147 & S.R.W. PLAN 35894
WEST KOOTENAY POWER CO
CITY OF PENTICTON COMPOSTING AREA
COVER MATERIAL EXCAVATION AREA "A"
LIQUID WASTE FACILITY
DRIED SLUDGE STOCKPILE AREA
PROPOSED FACE BERMS AND START OF TERRACED SLOPE
SOUTH-WEST SECTOR ACTIVE LANDFILLING AREA
EXCAVATION AREA "C"
EXCAVATION AREA "B"
SPILLER ROAD
SCALE HOUSE
ENTRANCE GATE
SITE BENCH MARK PK NAIL IN CONCRETE FOUNDATION OF SCALES PLATFORM ELEV = 593.00M
Existing Spring Discharge Area
SUB LOT 17
SUB LOT 8
D.L. 2710
LOT 1 PLAN 36443
LOT A PLAN 34160
Randolf Spring Discharge Area
B.C. GAS CO R/W PLAN A-1934
WEST KOOTENAY POWER CO R/W PLAN A-496
R/W PLAN A-2147 & SRW PLAN 35894
LEGEND
AH 7 – Indicates Borehole/Augerhole locations
SL101 – Indicates seismic refraction survey line locations
– Indicates approximate exposed bedrock
– Indicates approximate existing spring discharge areas
600 – Indicates approximate bedrock contour
Scale – 1 : 4000
REFERENCE: STEVEN J. BUZIKIEVICH PROFESSIONAL LAND SURVEYOR FILE 94-161 DWG. 94-161B
GOLDER ASSOCIATES
Project No. 932-4175 Drawn rt Reviewed bc Date June/94

GROUNDWATER CONTOUR PLAN

FIGURE: 5



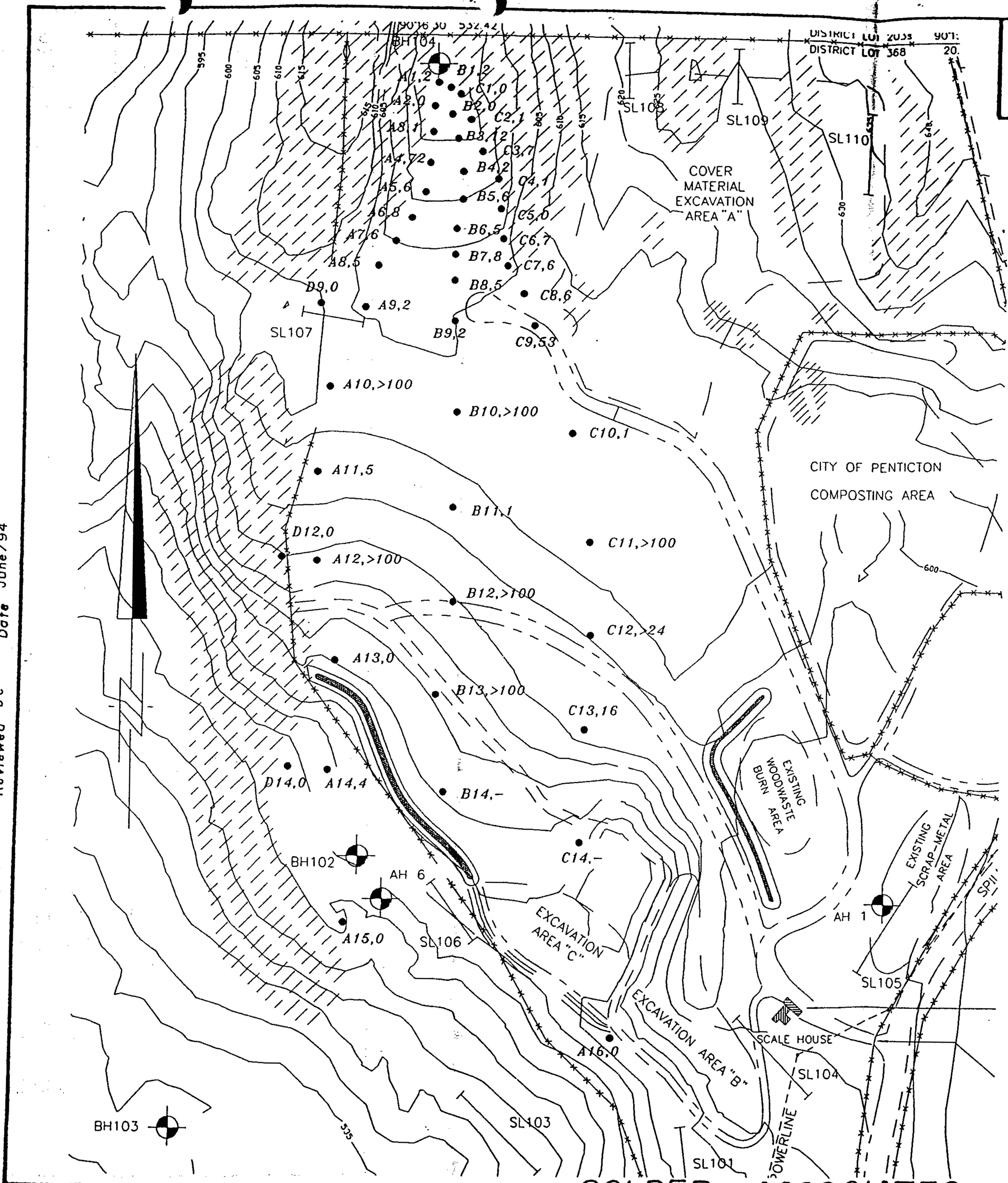
LEGEND

- AH 7 606.05 – Indicates Borehole/Augerhole locations with May 29/94 groundwater elevations
- SL101 – Indicates seismic refraction survey line locations
- Indicates approximate exposed bedrock
- Indicates approximate existing spring discharge areas
- 600 – Indicates approximate groundwater contour

GOLDER ASSOCIATES

METHANE CONCENTRATIONS (May 30, 1994)

FIGURE 6



GOLDER ASSOCIATES

LEGEND

AH 7 – Indicates Borehole/Augerhole locations

SL101 – Indicates seismic refraction survey line locations

– Indicates approximate exposed bedrock

• C11,72 – Indicates approximate soil gas monitoring location, reference number and methane concentrations in percent LEL

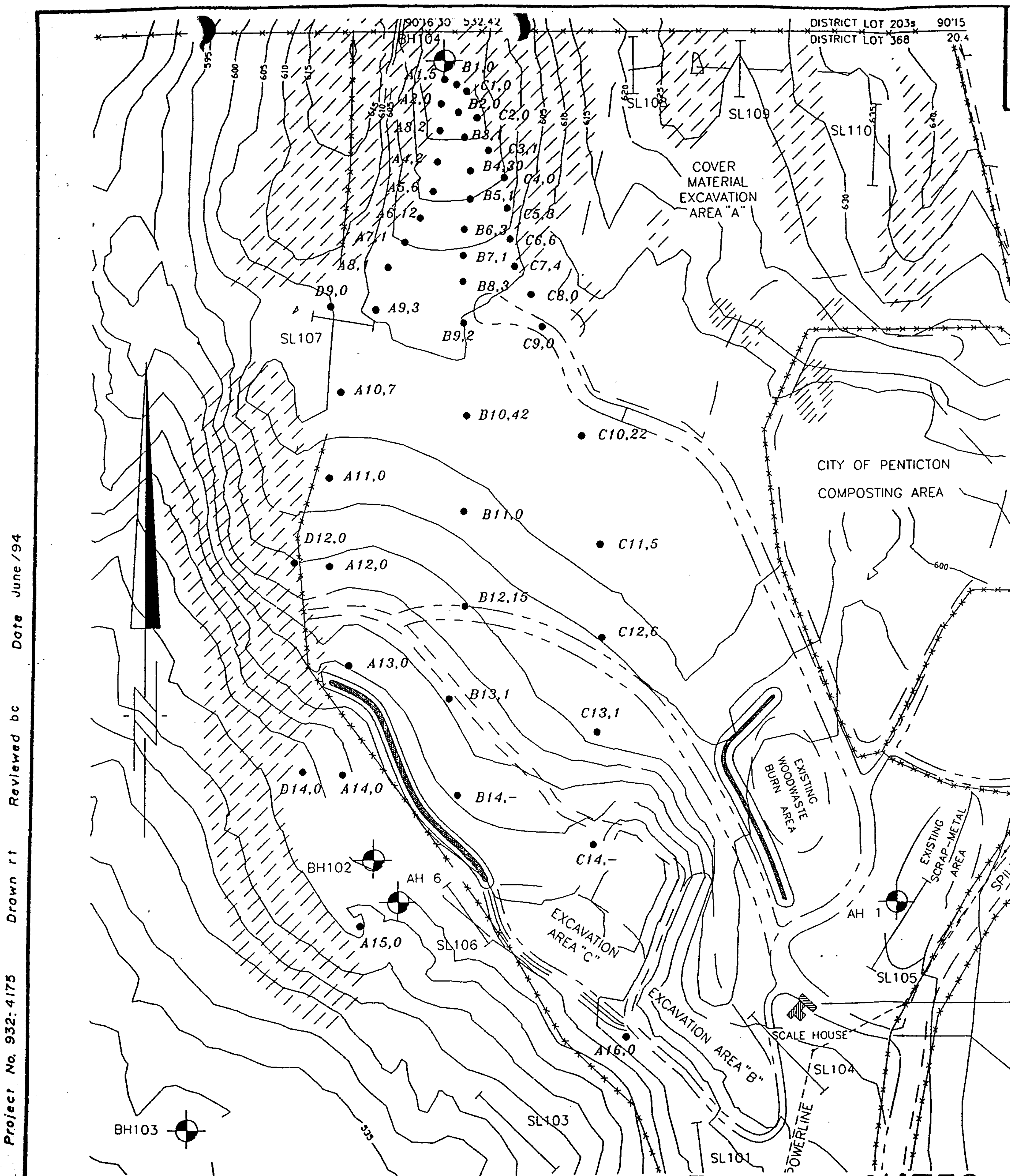
40 20 0 40

Scale – 1 : 2500

Project No. 932-4175 Drawn rt Reviewed bc Date June/94

HYDROGEN SULFIDE CONCENTRATION (May 30,1994)

FIGURE 7



Project No. 932-4175 Drawn rt Reviewed bc Date June/94

L E G E N D

AH 7 — Indicates Borehole/Augerhole locations

SL101 — Indicates seismic refraction survey line locations

— Indicates approximate exposed bedrock

• C11,5 — Indicates approximate soil gas monitoring location, reference number and hydrogen sulfide concentrations in ppm

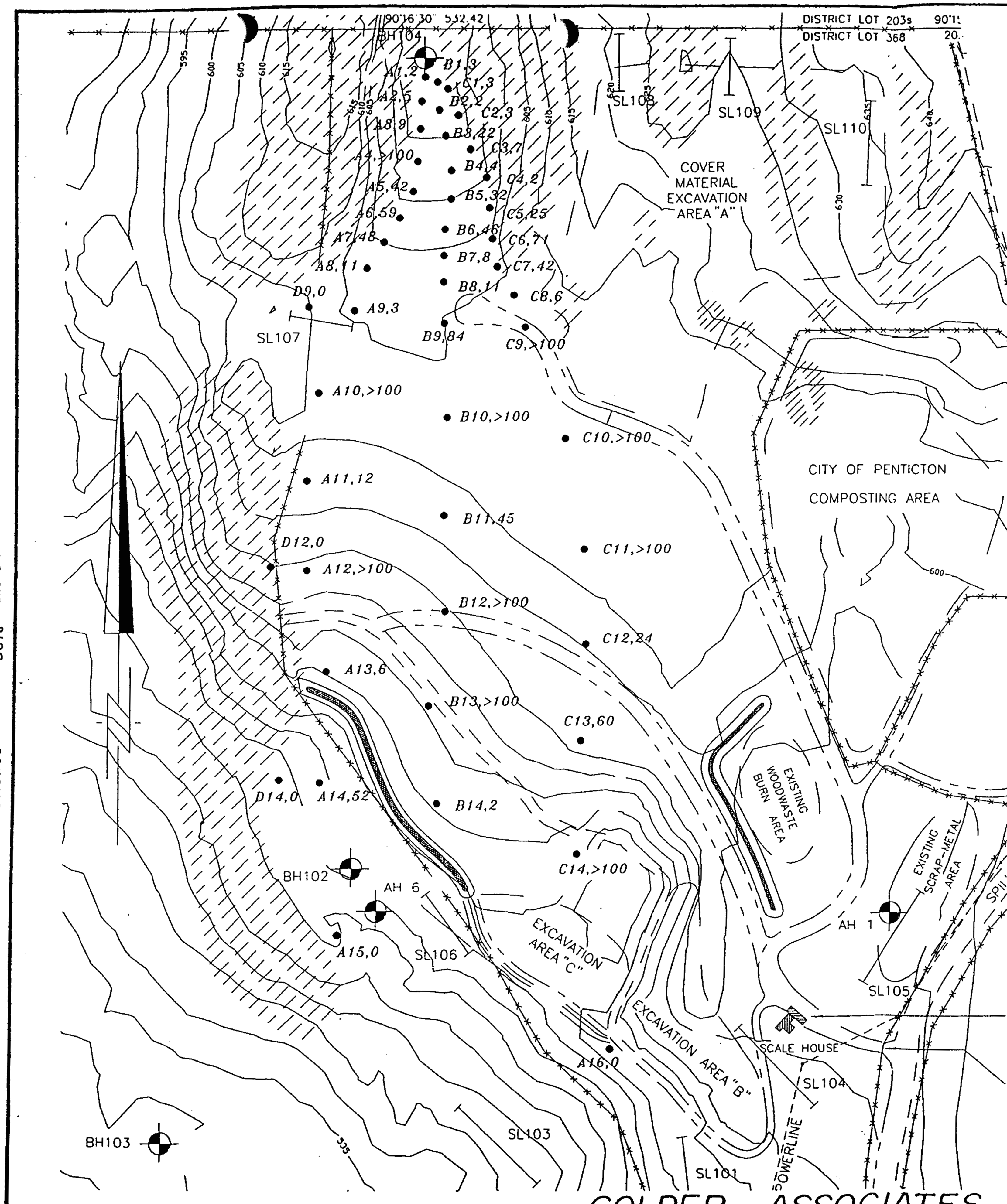
40 20 0 40

Scale – 1 : 2500

GOLDER ASSOCIATES

MAXIMUM METHANE CONCENTRATIONS

FIGURE 8



GOLDER ASSOCIATES

LEGEND

AH 7 – Indicates Borehole/Augerhole locations

SL101 – Indicates seismic refraction survey line locations

– Indicates approximate exposed bedrock

• C11,72 – Indicates approximate soil gas monitoring location, reference number and methane concentrations in percent LEL

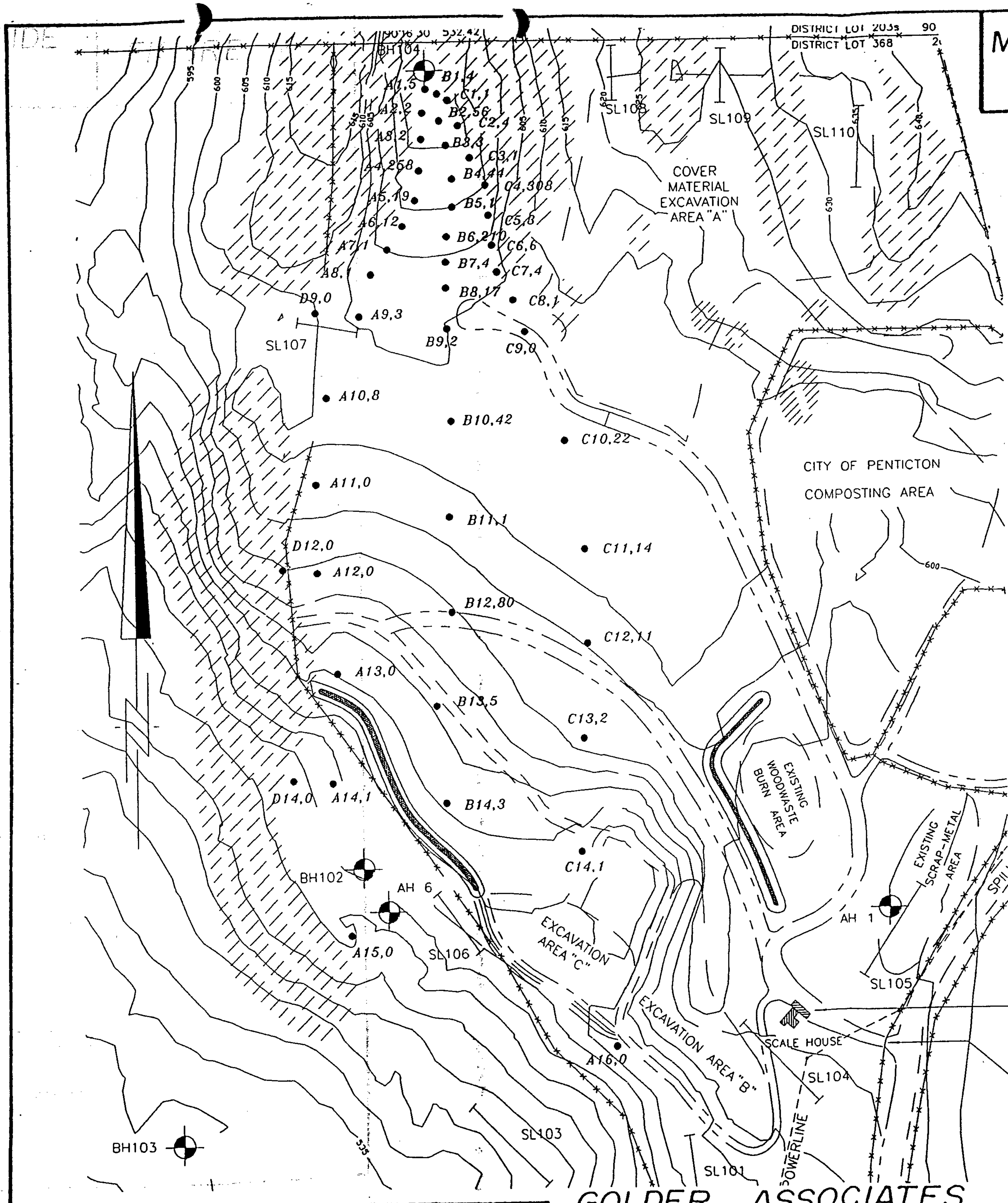
40 20 0 40

Scale – 1 : 2500

Project No. 932-4175 Drawn rt Reviewed bc Date June/94

MAXIMUM HYDROGEN SULFIDE CONCENTRATIONS

FIGURE 9



GOLDER ASSOCIATES

LEGEND

AH 7 — Indicates Borehole/Augerhole locations

SL101 — Indicates seismic refraction survey line locations

— Indicates approximate exposed bedrock

• C11,5 — Indicates approximate soil gas monitoring location, reference number and hydrogen sulfide concentrations in ppm

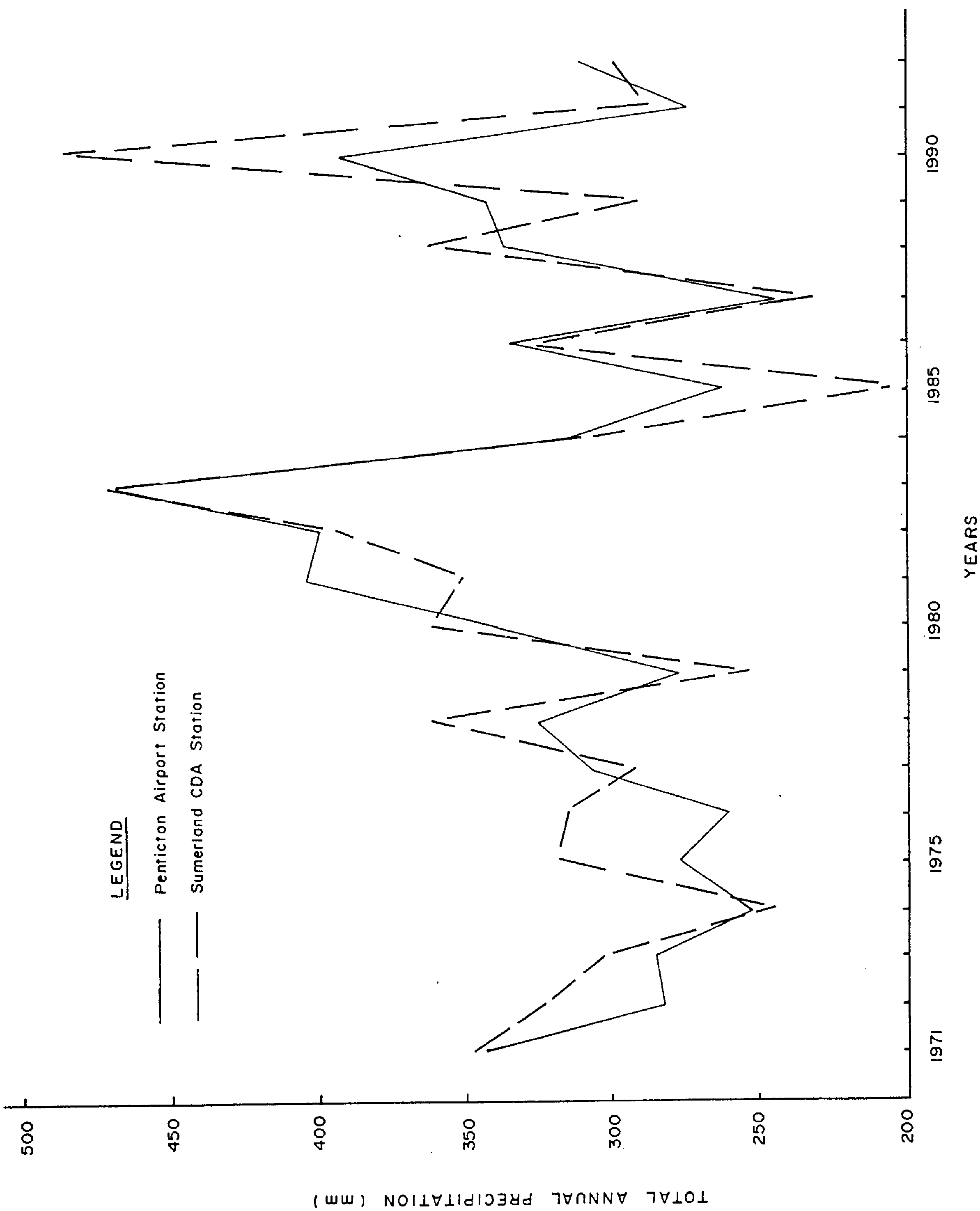
40 20 0 40

Scale – 1 : 2500

Project No. 932-4175 Drawn rt Reviewed bc Date June/94

ANNUAL PRECIPITATION 1971 - 1992

Figure 10

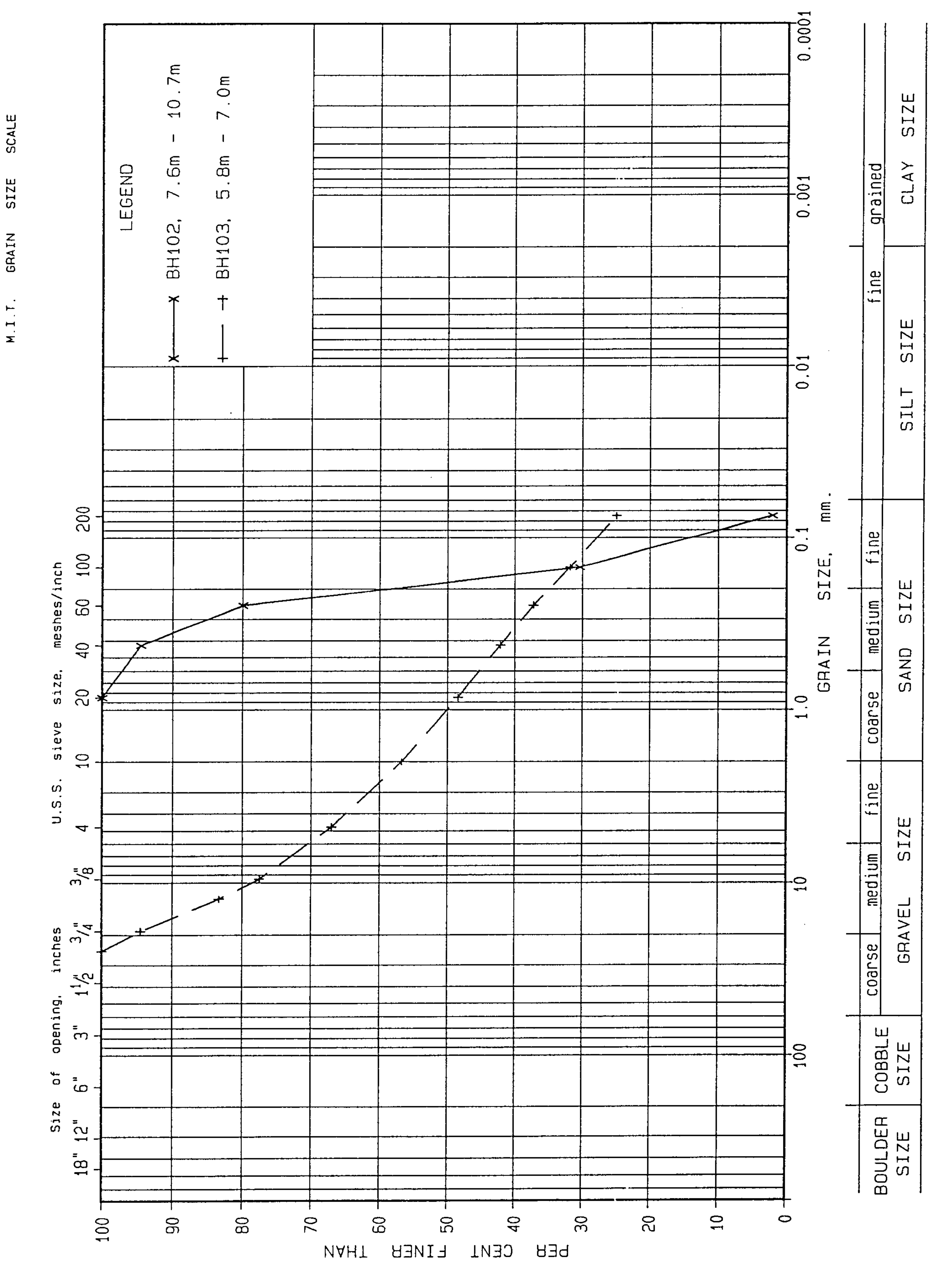


PROJECT No. 932-4175 DRAWN JDF REVIEWED DATE JUNE/94

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure: **11**

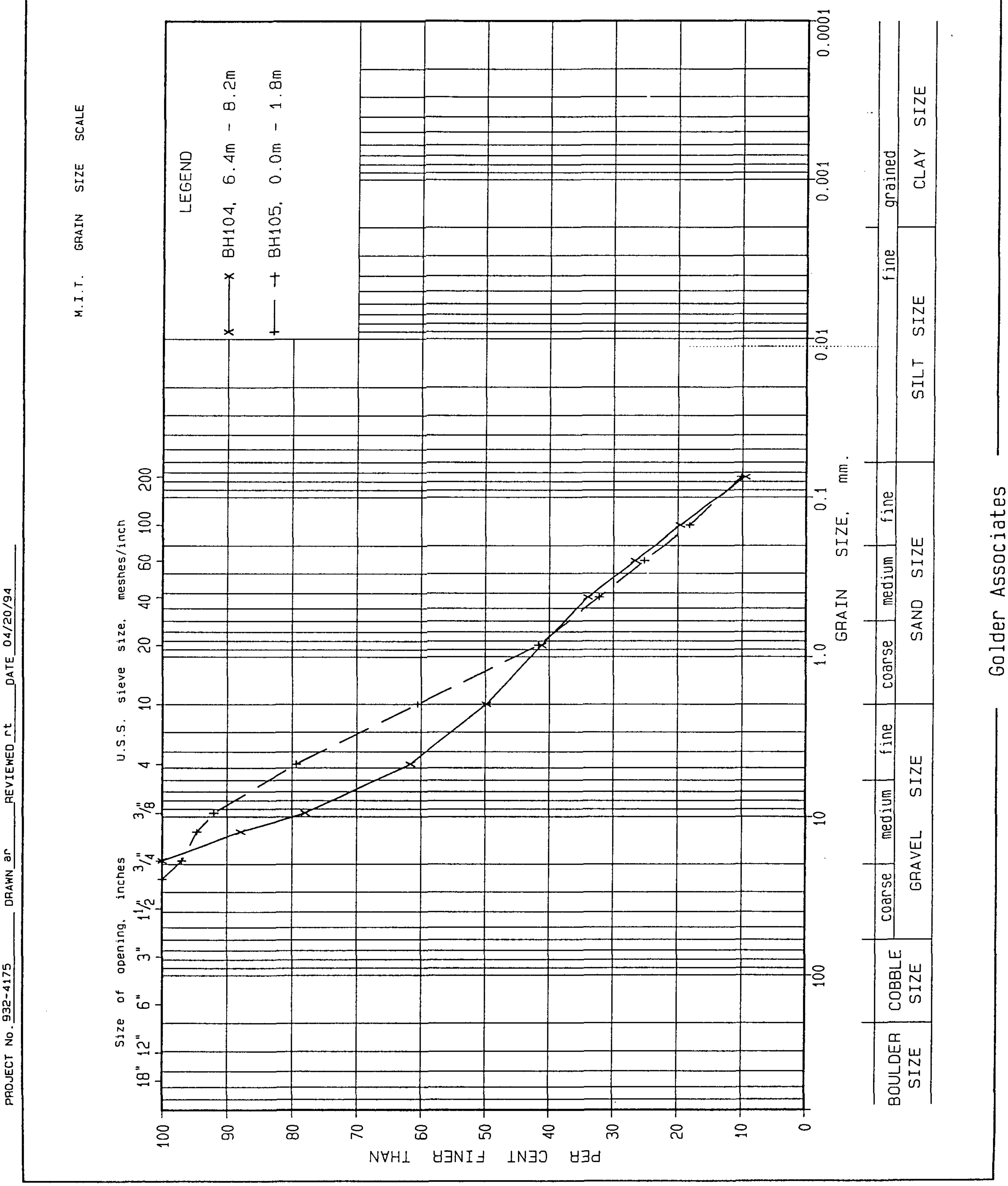


PROJECT No. 932-4175 DRAWN ar REVIEWED rt DATE 04/20/94

Golder Associates

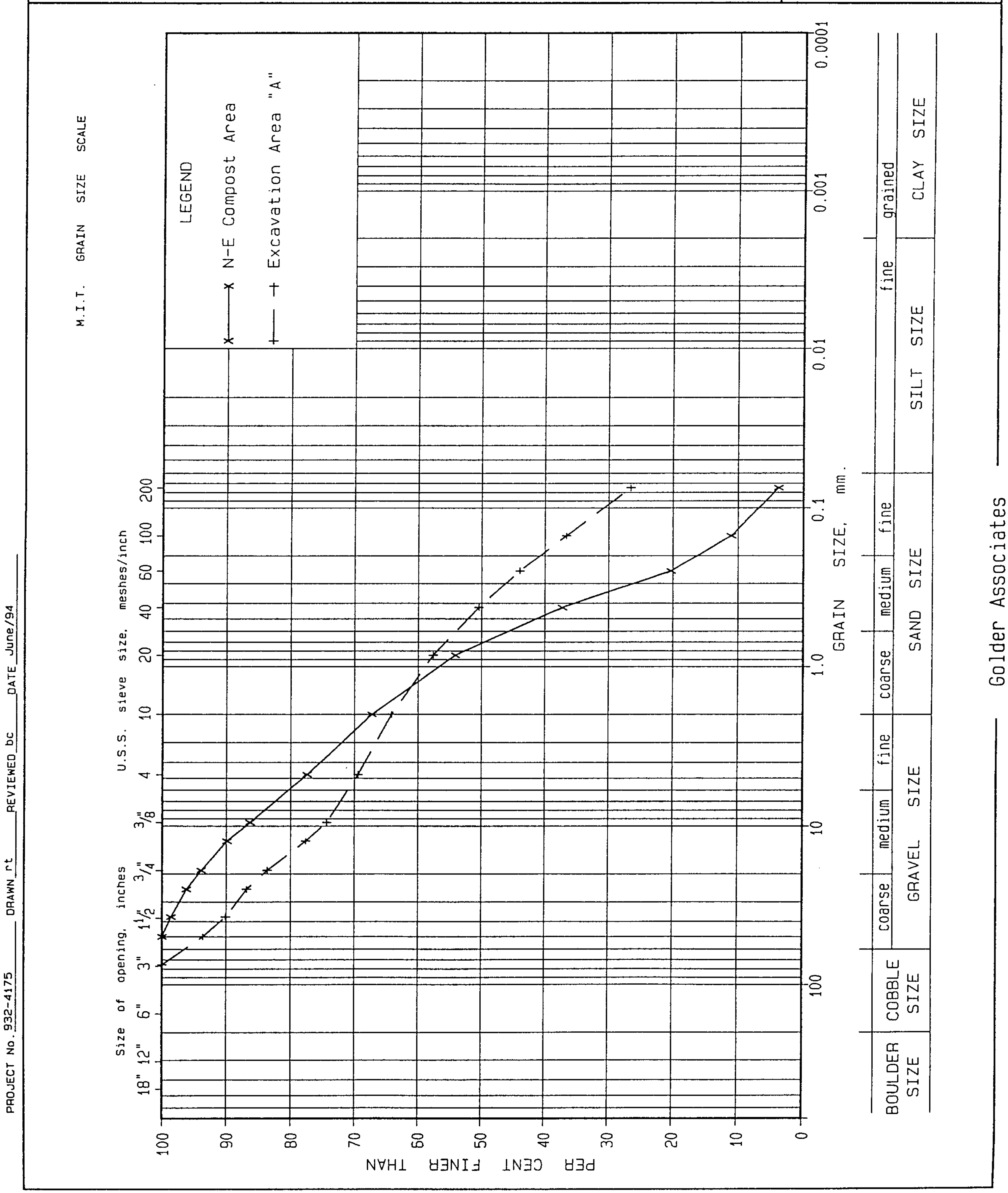
GRAIN SIZE DISTRIBUTION

Figure: 12



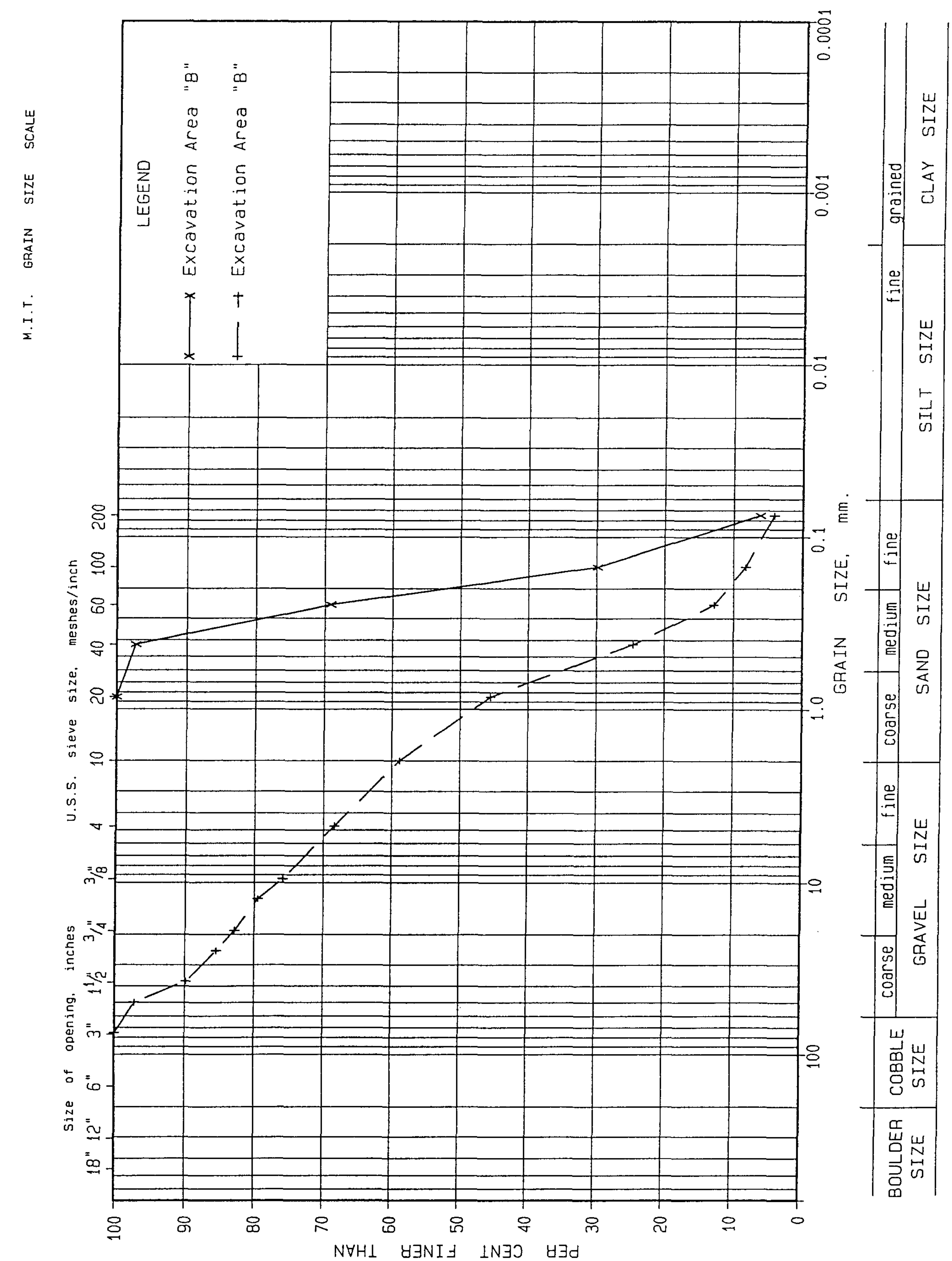
GRAIN SIZE DISTRIBUTION

Figure: **13**



GRAIN SIZE DISTRIBUTION

Figure: **14**

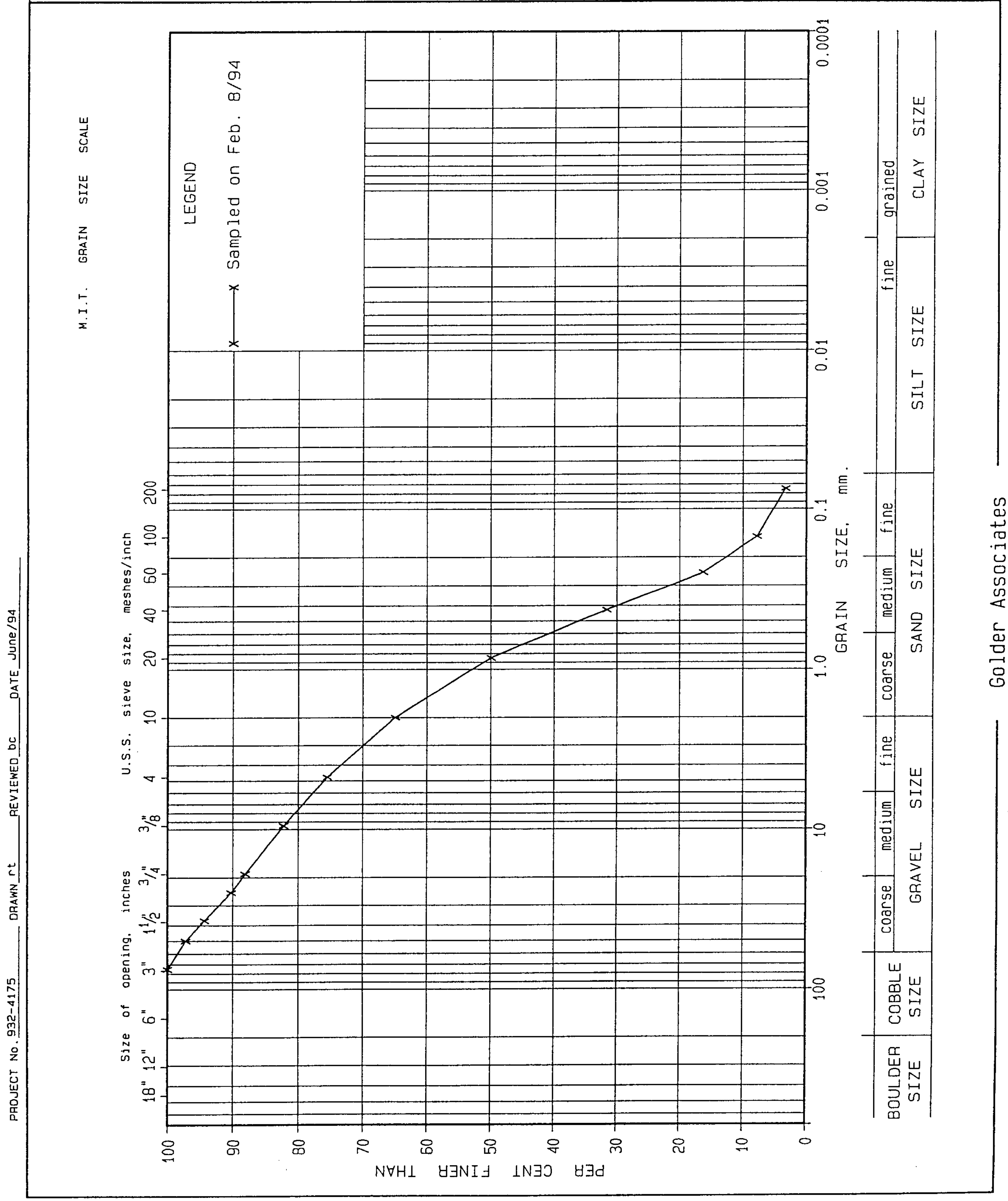


Golder Associates

PROJECT No. 932-4075 DRAWN rt REVIEWED bc DATE June/94

GRAIN SIZE DISTRIBUTION
NORTH RAVINE COVER MATERIAL

Figure: **15**



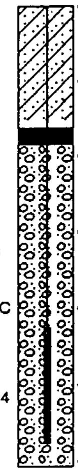
RECORD OF BOREHOLE - BH 1[illegible]

PROJECT: Landfill
PROJECT LOCATION: Penticton
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: March 2,1994
BORING LOCATION: See Figure 1

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp —o W— Wl	PIEZOMETER OR STANDPIPE INSTALLATION
	Ground Surface		569.60							
0–1	Compact brown gravelly SAND with occasional cobbles. (FILL)		0.00 – 568.40	1	CS					Cuttings
1–2	Compact brown cobbly sandy GRAVEL.		1.20 – 567.15	2	CS					Bentonite Seal
2–3	Dense brown SAND and GRAVEL with a trace of silt and occasional cobbles.		2.45 – 566.40	3	CS					Sand and Gravel
3–6	Hard competent BEDROCK.		3.20 – 563.50	4	CS					50mm PVC Slotted; ∇ April 19/94
6	END OF BOREHOLE		6.10							



Depth scale: 0 to 20 m.

DRILL RIG: Cyclone TH-60
DRILLING CONTRACTOR: Cascade Drill.
DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT
CHECKED: RT
DATE: March 14/94

RECORD OF BOREHOLE - BH 1

PROJECT: Landfill
PROJECT LOCATION: Penticton
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: March 2-3,9/94
BORING LOCATION: See Figure 1

SHEET: 1 OF 2
DATUM: Geodetic
BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS (ppm)	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
	Ground Surface	565.67							
0–3.96	Landfill Refuse Wastes. (FILL)	0.00							Cuttings; Bentonite Seal
3.96–5.18	Compact dark grey cobbly SAND and GRAVEL.	561.71 / 3.96	1	CS			17.7	OTHER TESTS summarizes the Organic Vapor Concentrations detected using the OVM #580M monitor.	
5.18–6.40	Compact light grey SAND and GRAVEL with occasional cobbles grading to a gravelly SAND.	560.49 / 5.18	2	CS			11.2		
6.40–13.41	Compact light grey to brown medium to fine SAND with a trace of gravel grading to a light brown medium to fine SAND at depth.	559.27 / 6.40	3	CS			14.5		50mm Solid PVC
			4	CS			4.8		
			5	CS			4.8		
13.41–14.94	Compact light brown fine SAND with a trace of silt.	552.26 / 13.41	6	CS			4.8		
14.94–16.46	Compact light brown medium to fine SAND with a trace to some gravel.	550.73 / 14.94	7	CS			4.8		Cuttings
16.46–19.20	Dense brown to grey gravelly SAND with some silt and occasional cobbles.	549.21 / 16.46	8	CS			8.0		
19.20–		546.47 / 19.20	9	CS			4.8		

DRILL RIG: Cyclone TH-60
DRILLING CONTRACTOR: Cascade Drill.
DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT
CHECKED: RT
DATE: March 21/94

RECORD OF BOREHOLE - BH 10[illegible]

PROJECT: Landfill
PROJECT LOCATION: Penticton
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: March 2-3,9/94
BORING LOCATION: See Figure 1

SHEET: 2 OF 2
DATUM: Geodetic
BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT (Wp, W, Wl)	PIEZOMETER OR STANDPIPE INSTALLATION
20 – 25.90	Dense grey gravelly fine SAND with a trace to some silt.	539.77 / 25.90	10	CS			1.6		Top of Casing
25.90 – 27.43	Dense COBBLES and BOULDERS.	538.24 / 27.43						Bottom of casing shoe set at a depth of 27.43m.	Bentonite Seal
27.43 – 30.18	Soft highly fractured and weathered BEDROCK.	535.49 / 30.18	11	CS			-		Apr. 29/94
			12	CS			-		#2/12 Frac Sand; Hole Cave
30.18	END OF BOREHOLE								

Depth scale: 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40

DRILL RIG: Cyclone TH-60
DRILLING CONTRACTOR: Cascade Drill.
DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT
CHECKED: RT
DATE: March 21/94

PROJECT: Landfill
PROJECT LOCATION: Penticton
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

RECORD OF BOREHOLE - BH 1

BORING DATE: March 8,1994
BORING LOCATION: See Figure 1

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
	Ground Surface		529.24							
0	Loose dark brown SAND and SILT with root fibres throughout. (TOPSOIL)		0.00 / 528.79 / 0.45	1	CS					
1–2	Compact brown SAND and GRAVEL with occasional cobbles grading to a sandy GRAVEL with some cobbles.		526.79 / 2.45	2	CS					
3–5	Compact to dense light brown to grey gravelly silty SAND with occasional cobbles.		524.04 / 5.20	3	CS					Cuttings
	Loose brown SAND with a trace to some gravel.		523.44 / 5.80	4	CS					
6–7	Dense light brown to grey gravelly SAND with some silt and occasional thin sand layers throughout.		521.64 / 7.60	5	CS					Bentonite Seal; Apr. 29/94
8–9	Soft to hard BEDROCK.		519.64 / 9.60	6	CS					#2/12 Frac Sand; 50mm PVC Slotted
10	END OF BOREHOLE									

DRILL RIG: Cyclone TH-60
DRILLING CONTRACTOR: Cascade Drill.
DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT
CHECKED: RT
DATE: March 14/94

PROJECT: Landfill

PROJECT LOCATION: Penticton

PROJECT NUMBER: 932-4175

Sampler Hammer: 63.5 kg., Drop 0.76m.

RECORD OF BOREHOLE - BH 1[illegible]

BORING DATE: March 9,1994

BORING LOCATION: See Figure 1

SHEET: 1 OF 1

DATUM: Geodetic

BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	587.03 / 0.00							
0–5.50	Compact light brown gravelly SAND with occasional cobbles grading to a SAND with a trace of gravel at depth. (Berm Construction FILL)	581.53 / 5.50	1	CS					
5.50–5.80	Loose dark brown silty SAND, some gravel and root fibres. (Original Ground Surface)	5.80	2	CS					
5.80–6.40	Compact brown gravelly silty SAND with occasional root fibres.	580.63 / 6.40	3	CS					Cuttings
6.40–8.50	Compact to dense light brown gravelly SAND with a trace of silt and occasional cobbles.	578.53 / 8.50	4	CS					
8.50–10.20	Dense brown cobbly SAND and GRAVEL with occasional boulders.	576.83 / 10.20	5	CS					Bentonite Seal
10.20–12.20	Soft fractured BEDROCK.	574.83 / 12.20	6	CS					Apr. 29/94; #2/12 Frac Sand
12.20–13.72	Hard BEDROCK.	573.31 / 13.72	7	CS					50mm PVC Slotted
13.72	END OF BOREHOLE								

DRILL RIG: Cyclone TH-60

DRILLING CONTRACTOR: Cascade Drill.

DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT

CHECKED: RT

DATE: March 14/94

RECORD OF BOREHOLE - BH [illegible]5

PROJECT: Landfill

PROJECT LOCATION: Penticton

PROJECT NUMBER: 932-4175

Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: March 10,1994

BORING LOCATION: See Figure 1

SHEET: 1 OF 1

DATUM: Geodetic

BOREHOLE TYPE: 168mm Casing

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
	Ground Surface	612.54							
0–1.85	Compact brown SAND and GRAVEL with some silt, occasional cobbles and boulders.	0.00 / 610.69	1	CS					Bentonite Seal; Cuttings
1.85–3.35	Hard competent BEDROCK.	1.85 / 609.19	2	CS					Bentonite Seal; Sand and Gravel
3.35–3.65	Compact brown gravelly SAND with a trace of silt.	3.35	3	CS					
3.65–6.40	Soft weathered and fractured BEDROCK.	3.65 / 606.14	4	CS					#2/12 Frac Sand
6.40–8.53	Hard competent BEDROCK.	6.40 / 604.01	5	CS					Apr. 19/94; 50mm PVC Slotted
	END OF BOREHOLE	8.53							

DRILL RIG: Cyclone TH-60

DRILLING CONTRACTOR: Cascade Drill.

DRILLER: Doug/ Rocky

Golder Associates

LOGGED: RT

CHECKED: RT

DATE: March 21/94

RECORD OF BOREHOLE - AH 1

PROJECT: RDSO Landfill
PROJECT LOCATION: Penticton B.C.
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: Dec. 8/93
BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: Auger

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	592.82 / 0.00							
0–2.10	Loose brown sandy SILT with a 0.3m diameter boulder encountered at 0.6m. (FILL)	590.72 / 2.10							Cuttings Backfill
2.10–2.70	Loose dark brown SILT with some root matter. (FILL)	590.12 / 2.70						Gastech reading of 3% LEL inside augers.	
2.70–3.70	Compact brown SAND and GRAVEL with a trace, piece of glass, paper and wood. (FILL)	589.12 / 3.70	1	DO	16,12,5	17			Bentonite Seal
3.70–4.10	Loose brown SAND with a trace of gravel.	588.72 / 4.10							#2/12 Frac Sand
4.10–4.90	Compact to dense brown SAND and GRAVEL.	587.92 / 4.90							Slotted 50mm PVC
4.90–5.50	Weathered BEDROCK.	587.32 / 5.50							▽ 3/17/94; ▽ 4/29/94
	AUGER REFUSAL WITHIN BEDROCK.								

DRILL RIG: CME 750
DRILLING CONTRACTOR: Thorman Drill.
DRILLER: C.MacKenzie

LOGGED: RE
CHECKED: RE
DATE: Dec. 8/93

Golder Associates

PROJECT: RDSO Landfill

RECORD OF BOREHOLE - AH

SHEET: 1 OF 1

PROJECT LOCATION: Penticton B.C.

BORING DATE: Dec. 8/93

DATUM: Geodetic

PROJECT NUMBER: 932-4175

BORING LOCATION: Penticton B.C.

BOREHOLE TYPE: Auger

Sampler Hammer: 63.5 kg., Drop 0.76m.

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		625.94							
	Loose brown sandy SILT, some cobbles. (TOPSOIL)		0.00 625.64							
	Compact brown SAND and GRAVEL with a trace of silt and occasional cobbles.		0.30 625.04							
1	Dense silty gravelly SAND. (GLACIAL TILL)		0.90 623.54							
2										
	Refusal of carbide tipped auger. (Inferred Bedrock) (A second augerhole was drilled approximately 10m north of AH2 with refusal encountered at 2.4m)		2.40							
3										
4										
5										
6										
7										
8										
9										
10										

DRILL RIG: CME 750

DRILLING CONTRACTOR: Thorman Drill.

DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE

CHECKED: RE

DATE: Dec. 8/93

PROJECT: RDSO Landfill
PROJECT LOCATION: Penticton B.C.
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

RECORD OF BOREHOLE - AH

BORING DATE: Dec. 8/93
BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: Auger

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		612.50							
	Loose to compact brown SAND and GRAVEL with some silt and some cobbles.		0.00							
1			611.30							
	Refusal of carbide tipped auger. (Inferred Bedrock/Boulder)		1.20							
2										
3										
4										
5										
6										
7										
8										
9										
10										

DRILL RIG: CME 750
DRILLING CONTRACTOR: Thorman Drill.
DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE
CHECKED: RE
DATE: Dec. 8/93

RECORD OF BOREHOLE - AH

PROJECT: RDSO Landfill
PROJECT LOCATION: Penticton B.C.
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: Dec. 9/93
BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: Auger

DEPTH SCALE (m)	DESCRIPTION	ELEV / DEPTH	NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m / WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	530.81							
	Loose dark brown sandy SILT, some cobbles. (TOPSOIL)	0.00							
	Loose brown gravelly sandy SILT with some cobbles and boulders.	530.51 / 0.30							Cuttings Backfill
1–4	Compact brown gravelly SAND with some cobbles and boulders grading to a compact brown cobbly SAND and GRAVEL with a trace of silt and occasional boulders.	529.91 / 0.90	1	DO	20/0.15m			Bouncing on cobble/boulder	Bentonite Seal; #2/12 Frac Sand
5	Compact brown brown to grey gravelly SAND.	526.21 / 4.60	2	AS					Slotted 50mm PVC; Feb. 8/94; 4/29/94
6	Refusal of carbide tipped auger. (Inferred Bedrock)	524.71 / 6.10							

DRILL RIG: CME 750
DRILLING CONTRACTOR: Thorman Drill.
DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE
CHECKED: RE
DATE: Dec. 9/93

RECORD OF BOREHOLE - AH

PROJECT: RDSO Landfill
PROJECT LOCATION: Penticton B.C.
PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

BORING DATE: Dec. 9/93
BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: Auger

PENETRATION RESISTANCE BLOWS/0.3m
WATER CONTENT, PERCENT Wp W Wl

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE	572.63 / 0.00						
0 – 4.30	Compact grey-brown fine SAND and SILT to a dense fine sandy SILT with a trace of gravel and occasional cobbles.		1	DO	12,14,15	29		Cuttings Backfill
								Bentonite Seal
								#2/12 Frac Sand
								Slotted 50mm PVC
4.30 – 4.90	Dense to very dense brown SAND and GRAVEL with some silt. (GLACIAL TILL)	568.33 / 4.30	2	DO	43,50/0.08m			Dry Hole
4.90	Refusal of carbide tipped auger. (Inferred bedrock)	567.73 / 4.90						

DRILL RIG: CME 750
DRILLING CONTRACTOR: Thorman Drill.
DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE
CHECKED: RE
DATE: Dec. 9/93

PROJECT: RDSO Landfill | PROJECT LOCATION: Penticton B.C. | PROJECT NUMBER: 932-4175
Sampler Hammer: 63.5 kg., Drop 0.76m.

RECORD OF BOREHOLE - AH

BORING DATE: Dec. 10/93
BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1
DATUM: Geodetic
BOREHOLE TYPE: Auger

DEPTH SCALE (m)	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp W Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		562.87 / 0.00							
0–1.50	Compact brown cobbly sandy SILT with occasional cobbles.		561.37 / 1.50							
1.50–1.80	Compact brown SAND and GRAVEL with occasional cobbles and boulders.		1.80							
1.80–3.40	Compact brown SAND with a trace to some gravel and occasional cobbles.		559.47 / 3.40	1	DO	6,10,11	21			
3.40–9.30	Compact brown gravelly SAND grading to a SAND and GRAVEL with occasional cobbles.		553.57 / 9.30	2	DO	5,11,17	28			
9.30–11.00	Compact brown medium to fine SAND.		551.87 / 11.00							
11.00–18.40	Dense brown to grey SAND and GRAVEL with a trace of silt.			3	DO	13,20,20	40		Gastech reading of 3% LEL detected on outside of augers. Reading of 1% LEL detected within sample no. 3.	
			544.47							
18.40–18.70	Very dense grey fine gravelly SAND with some silt.		544.17 / 18.70	4	DO	26,40,68	108			
	END OF BOREHOLE.									

DRILL RIG: CME 750
DRILLING CONTRACTOR: Thorman Drill.
DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE
CHECKED: RE
DATE: Dec. 10/93

PROJECT: RDSO Landfill

PROJECT LOCATION: Penticton B.C.

PROJECT NUMBER: 932-4175

Sampler Hammer: 63.5 kg., Drop 0.76m.

RECORD OF BOREHOLE - AH

BORING DATE: Dec. 10/93

BORING LOCATION: Penticton B.C.

SHEET: 1 OF 1

DATUM: Geodetic

BOREHOLE TYPE: Auger

DEPTH SCALE (m)	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH	SAMPLES: NUMBER	TYPE	BLOWS / 0.15m.	N	OTHER TESTS	PENETRATION RESISTANCE BLOWS/0.3m; WATER CONTENT, PERCENT Wp — W — Wl	PIEZOMETER OR STANDPIPE INSTALLATION
0	GROUND SURFACE		569.30							
	Loose dark brown cobbly SILT.		0.00 / 569.00							
	Compact brown SAND with a trace of silt and occasional cobbles.		0.30 / 568.70							
1–2	Loose brown COBBLES and BOULDERS with occasional sand layers throughout.		0.60 / 567.00							
	Refusal of carbide tipped auger. (Inferred bedrock)		2.30							

DRILL RIG: CME 750

DRILLING CONTRACTOR: Thorman Drill.

DRILLER: C. MacKenzie

Golder Associates

LOGGED: RE

CHECKED: RE

DATE: Dec. 10/93

APPENDIX A

CHEMAC

CHEMAC ENVIRONMENTAL SERVICES
(A DIVISION OF CARO ENTERPRISES INC.)

932-4175.

#1 - 368 Industrial Avenue, Kelowna, British Columbia, Canada V1Y 7E8 • Telephone (604) [redacted]
763-5090
Fax 763-4810

April 27, 1994

Golder Associates
#243 - 1889 Springfield Road
KELOWNA, BC
V1Y 5V5

Attention: Mr. Scott Orth

Dear Sir:

Following are the results of the analysis of water samples identified as shown:

Project: 932-4175

Received April 20, 1994

Parameters	Units	BH 101	BH 105
pH	pH units	7.1	7.0
Conductivity	umhos/cm	1290	1270
Dissolved Chloride	mg/L	87.5	165
Dissolved Sulphate	mg/L	115	67.5

Yours truly,
CHEMAC ENVIRONMENTAL SERVICES

Janice M. Fraser, B.Sc.
Lab Manager

enclosure

FAX: 860-9874

THE INFORMATION CONTAINED IN THIS REPORT IS THE CONFIDENTIAL PROPERTY OF THE CLIENT. ANY LIABILITY ATTACHED THERETO IS LIMITED TO THE FEE CHARGED.

CHEMAC™

CHEMAC ENVIRONMENTAL SERVICES
(A DIVISION OF CARO ENTERPRISES INC.)

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July 21, 1993

Regional District of Okanagan - Similkameen
101 Martin Street
PENTICTON, B.C.
V2A 5J9

Attention: Mr. Dave Gold

Dear Sir,

Following are the results of the laboratory analysis performed on samples taken from Randolf Spring on June 29, 1993:

Parameter	Units		Randolf Spring
TEH Total Extractable Hydrocarbons	mg/L as diesel		<0.01
PAH's			
Naphthalene	ug/L		<0.5
Acenaphthylene	ug/L		<0.5
Acenaphthene	ug/L		<0.5
Fluorene	ug/L		<0.5
Phenathrene	ug/L		<0.5
Anthracene	ug/L		<0.5
Floroanthene	ug/L		<0.5
Pyrene	ug/L		<0.5
Benzo(a)anthracene/ Chrysene	ug/L	*	1.7
Benzo(b)fluoranthene/ Benzo(k)fluoranthene	ug/L	*	<1.0
Benzo(a)pyrene	ug/L		<0.5
Indeno(1,2,3-cd)pyrene	ug/L		<0.5
Dibenzo(ah)anthracene	ug/L		<0.5
Benzo(ghi)perylene	ug/L		<0.5

* overlapping peaks on chromatogram
Note: units for PAH's are ug/L.

PCB's	mg/L	<0.0003

Diagnostic Pesticide Scan as per Zenon Environmental Lab.
All pesticides below minimum detectable concentration
(complete list of parameters available on request)

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Regional District of Okanagan Similkameen
July 21, 1993 (cont)

Parameter	Units	Randolf Spring
Zinc	mg/L	0.048
Arsenic	mg/L	<0.01
Cobalt	mg/L	0.006
Molybdenum	mg/L	0.002
Cadmium	mg/L	<0.001
Mercury	mg/L	<0.0005
Nickel	mg/L	<0.002
Lead	mg/L	<0.011
Selenium	mg/L	<0.002
Specific Conductance	umhos/cm	1260
Nitrate	mg/L as N	13.0
Nitrite	mg/L as N	0.01
Ammonia	mg/L as N	0.07
Total Kjeldahl Nitrogen	mg/L as N	1.25
Total Nitrogen	mg/L as N	14.26
Total Phosphorus	mg/L as P	0.25
Total Diss. Phosphorus	mg/L as P	0.08
Ortho phosphate	mg/L as P	0.06
Chloride	mg/L	54
BOD	mg/L	<10
COD	mg/L	355
Acidity to pH 8.3	mg/L as CaCO3	515
Total Coliform.	Colonies/100mL	43
Fecal Coliform	Colonies/100mL	38

Microtox Bioassay % EC 50 * >100

* EC 50 - The concentration of sample causing a 50 % reduction in bioluminescence of a selected bacteria.

Yours truly,
CHEMAC ENVIRONMENTAL SERVICES

Janice M. Fraser, B.Sc.
Lab Supervisor

Enclosure