Cominco

POLARIS MINE

DECOMMISSIONING AND RECLAMATION PLAN

VOLUME 4 OF 4

2000 ENVIRONMENTAL SITE ASSESSMENT

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Volume 4 of 4
2000 Environmental Site Assessment

Prepared for
Cominco Ltd.

Prepared by:
Gartner Lee Limited

March 2001

Distribution:

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Cominco Polaris Operations – 2000 Contaminant Assessment Program

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GLL 20-930

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1. Introduction

Cominco Ltd. (Cominco) is preparing to close the Polaris Mine located on Little Cornwallis Island in Nunuvut in 2002. The Polaris Mine is situated approximately 100 km northwest of the community of Resolute. In support of the mine closure activities, Cominco commissioned Gartner Lee Limited (GLL) to conduct an assessment of environmental conditions at the mine site and surrounding lands to identify and delineate areas of the mine site requiring remediation to restore the land to a condition suitable for future land use.

The assessment of environmental conditions at the Polaris Mine site was initiated in 1999 with the completion of two phases of environmental site investigation and the initiation of Phase III investigations. The first phase of the program consisted of a review of current and historic mine site operations and a detailed inspection of the facility to identify issues and areas of potential environmental concern. The second phase of the program constituted the initiation of field investigations to characterize the nature, occurrence and approximate extent of contamination in areas of potential environmental concern as identified in the Phase 1 investigation program. The field investigation program was undertaken to provide site specific data on the quality of various environmental media at the Polaris Mine site and surrounding lands, including: soil, groundwater, and vegetation. In addition, a marine environmental sampling program was conducted in 1999 to describe benthic marine conditions and provide current environmental quality data for sediments, seawater and biological tissue in the nearshore marine environment.

To evaluate the environmental quality data obtained during the 1999 site investigation, Cantox Environmental Inc. (Cantox) was commissioned to develop remedial objectives for lead and zinc concentrations in soil using risk assessment principles. The site-specific soil quality remediation objectives (SQRO's) were developed in accordance with protocols set out by the Canadian Council of Ministers of the Environment (CCME, 1996[1]).

On behalf of Cominco Ltd., GLL prepared a report that described the environmental assessment program conducted at the Polaris Mine site in 1999. Cominco presented the information to Federal and Territorial regulatory agencies in May 2000, followed by submission of the report in July 2000. GLL also assisted Cominco with preparation of a Draft Closure Plan for the Polaris Mine site. The Plan was presented and submitted to the regulators in May 2000 for informal review and comment.

This report presents the findings of a follow-up field investigation program conducted at the Polaris Mine site in 2000. The scope of work for the field program in 2000 was developed to address data gaps identified by the environmental site assessment program conducted in 1999, the Draft Closure Plan prepared in May 2000, and initial comments from the regulators on reports prepared to document the 1999 assessment program.

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[1] CCME. 1996. Guidance Manual for Developing Site-specific Soil Quality Remediation Objectives for Contaminated Sites in Canada. The National Contaminated Sites Remediation Program. En 108-4/9-1996E.

The specific tasks carried out during the environmental site investigation field program in 2000 included:

- Step-out soil sampling in areas previously identified as containing petroleum hydrocarbon contaminated soil in order to delineate the distribution and extent of soil contamination requiring remediation;
- Additional and step-out soil sampling to delineate the lateral and vertical extent of lead and zinc contaminated soil in areas of environmental concern as related to mine site operations;
- Additional vegetation and soil sampling in the lands surrounding the active mine site to determine the extent of dust dispersal and expand the database for soil and vegetation tissue quality;
- Collection of additional water samples and water levels in the vicinity of the barge, the landfill, LRD quarry and surface water discharge to North Bay to expand the water quality database;
- Inspection of the oil tank farm liner as requested by the Federal regulators;
- Collection of oil samples from in-service transformers.

The scope of work for the 2000 follow-up assessment of environmental conditions at the Polaris Mine site included a second phase of risk assessment, by Cantox, to support the derivation of site-specific soil quality remediation objectives for lead and zinc. The second phase of risk assessment was conducted to incorporate additional site-specific data on land use patterns as determined from community interviews conducted in Resolute and Grise Fiord. Based on the current and historical land use information provided by the community members, Cantox completed a quantitative screening level human health and ecological risk assessment and derived final concentrations of lead and zinc to be used for the site-specific soil quality remediation objectives.

This report describes the methodology and findings of the 2000 field program. The overall objective of the environmental investigation programs conducted at the Polaris Mine site is to delineate those areas of the property containing levels of petroleum hydrocarbon and /or lead and zinc contamination that require remediation in order to restore the environmental quality of the active mine site as close to pre-mine conditions as possible. Accordingly, this report uses data from both the 1999 and 2000 environmental investigation programs to delineate and describe areas of the Polaris Mine site that require remediation.

A discussion of the regulatory framework used to evaluate the chemical concentration data for soil and water quality is provided that includes a summary of the assumptions used in the Cantox risk assessment for derivation of site specific soil quality remediation objectives. A summary of the Cantox work is appended here and a complete report prepared by Cantox is available under separate cover.

1.1 Summary of 1999 Environmental Site Investigation Program

The objective of the environmental site assessment conducted in 1999 was to identify and assess the significance of potential environmental issues at the Polaris mine site and receiving environment in order to provide direction for future remedial planning.

A Phase 1 environmental site assessment (ESA) and marine environmental survey were conducted in May 1999. The first phase of the environmental site investigation process consisted of a review of available information relating to historic and current mine site operations and a detailed site inspection to identify issues and areas of potential environmental concern. The results of the Phase 1 investigation were then used to assess the data requirements and focus for the Phase 2 environmental assessment program.

The scope of work undertaken for the Phase 2 ESA was intended to provide site specific information on the environmental quality of various media at the Polaris mine site and adjacent lands, including: soil, seepage water and vegetation. The overall objective for the Phase 2 ESA was to define the approximate extent and significance of the potential contaminant sources and issues identified during Phase 1. A limited third phase of surface soil sampling was also undertaken in September 1999, in order to further define the surface soil quality at the mine site.

The Phase 1 ESA identified fourteen areas/issues of potential environmental concern (APEC's) on the basis of the site information review and a detailed site inspection of the Polaris mine site in May 1999. The work plan for the Phase 2 field investigation conducted in July 1999 was developed to provide an assessment of each of these APEC's. The field investigation program consisted of:

- drilling of 14 boreholes
- excavation of 84 test pits
- installation of 25 seepage water monitors
- collection of 145 surface soil samples and 250 samples at depth
- sampling and chemical analysis of soil, vegetation and seepage waters
- collection of representative rock types for testing of acid rock drainage parameters.

Sampling stations were located within the mine site operational area, a background location near the outlet of Frustration Lake and in far-field areas to the east and southeast of the mine site operations.

Chemicals of Concern

On the basis of the Phase 1 site information review, the primary chemicals of concern were identified to be lead and zinc; and, petroleum hydrocarbons from the use, storage and disposal of diesel fuel and hydraulic and lube oils.

Phase 2 Results

The results of sampling and analysis of environmental media at the Polaris mine site and surrounding lands have identified localized areas of the mine site where soil and seepage waters contain contaminants of concern that exceed the Federal and Territorial regulatory guidelines for park land use and the risk-based soil quality remediation objectives[2] (SQRO's). These areas, and other areas of concern to be considered in remedial planning for the Polaris mine site are summarized below.

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[2] The SQRO's developed in 1999 were revised in 2000 to reflect the natural lack of vegetation in the active mine area and to incorporate the results of community interviews held in Resolute and Grise Fiord in 2000.

Rockfill Around the Process Barge – Lead and Zinc

Evaluation of metal concentrations in the rockfill surrounding the barge indicated that lead and zinc concentrations in most of the surface and near surface soil samples exceeded the (1999) SQRO's. Metal contamination of the rockfill attenuated at depths in excess of 1.5 meters with rare exceptions.

Based on the occurrence and concentrations of lead and zinc found in the soil samples collected in the vicinity of the process barge and shiploading dock, two major sources of metal contamination were identified: concentrates from dryer emissions, spillage, vehicle tracking, and conveyor transfer and, mineralized rockfill materials which are the source of elevated metal concentrations at depth.

Potential migration pathways for metal contamination include: particulate emissions and windborne dispersion of concentrates, seasonal leaching of dissolved metals into the soil column, ground disturbance during snow removal activities and vehicle tracking.

Rockfill Around the Process Barge – Petroleum Hydrocarbons

Concentrations of light extractable petroleum hydrocarbons (LEPH) exceeded the Yukon Territorial CSR standards for industrial land use in soils sampled from several borehole and test pit locations in the vicinity of the barge, the vehicle fuelling station, and the day tank. The gas chromatograph patterns of samples containing elevated concentrations of LEPH indicated that the source of the petroleum is diesel.

Observations during test pit excavation and the results of soil sample analysis indicated that petroleum hydrocarbon contamination was restricted to the active layer, measured to be approximately 1.1 to 1.5 meters below ground level in the area surrounding the process barge in July 1999. Due to differential heating of the permafrost adjacent to the barge walls, the thickness of the active zone and, therefore, the zone of petroleum hydrocarbon contamination in the rockfill and seepage water increased to over 3 meters at test hole locations directly adjacent to the barge walls.

The hydrocarbon contamination is attributed to various sources of diesel fuel storage and use in the vicinity of the barge and dock, including: diesel fuel stored under the barge, the above ground vehicle fuelling tank, and the day tank located on the west side of the barge. Infiltration of hydrocarbons from frequent small volume spillage during vehicle fuelling and accidental releases through the ventilation ports during filling of the under-barge tank represent the major pathways for migration to the subsurface. Oil products are lighter than water and therefore tend to float on the water table. Given that the surface of the permafrost layer within the rockfill layer occurs at a lower elevation adjacent to and beneath the barge, migration of oil contaminated seasonal melt water would be toward the barge and away from the ocean.

The results of seepage water analysis indicate that, due to the limited thickness of the saturated zone, the concentrations of chemicals in seepage or melt waters tend to correlate closely with concentrations in soils. Accordingly, dissolved zinc concentrations exceeded the CCME water quality guideline in all of the water samples tested and concentrations of petroleum hydrocarbon components were found to exceed the applicable regulatory limits in 8 of the 9 seepage water samples analyzed. One water sample, collected from the water level control sump, contained ammonia and nitrite concentrations that exceeded the CCME water quality guidelines for the protection of aquatic life. This is attributed to the short-term effects of activities in the area.

The restriction of summer season melt water to the active layer overlying permafrost and the localized occurrence of contaminants suggests that potential pathways for contaminant migration such as groundwater flow are likely not present.

Concentrate storage building, concentrate conveyors and area to the south

Lead and zinc concentrations in soil samples were found to exceed the (1999) SQRO's in all test pit and surficial sampling locations in the vicinity of the concentrate storage building and conveyors, with the exception of the southwest side of the shiploading conveyor, and the southern section of the outdoor bulk chemical storage. Lead and zinc concentrations in the soil samples collected in the vicinity of the concentrate storage building and the outdoor chemical storage ranged from 51 ug/g to 1.58% for lead and from 144 ug/g to 16.8% zinc. The highest concentrations of lead and zinc were found in soil samples collected in the direct vicinity of metal sources such as: the concentrate conveyor at the rear of the barge, the open doorways of the concentrate storage building (lead concentrate is stored at the north end and zinc at the south end), conveyor loading areas and the outdoor storage of copper and zinc sulfate used in the mill process.

Potential migration pathways for metal contamination originating in the area of the mine site include: particulate emissions and windborne dispersion of concentrates, seasonal leaching of dissolved metals into the soil column, ground disturbance during snow removal activities and vehicle tracking.

Tailings Line and Tailings Spill Areas

Surface soil samples collected along the tailings pipeline in previous spill areas and in the vicinity of a large spill that occurred at the thickener building indicated that zinc concentrations exceeded the (1999) SQRO's in all the samples tested, with the exception of two soil samples downslope of the thickener building. Lead concentrations were elevated in only 1 of the soil samples tested.

Tailings residuals represent the source of the elevated metal concentrations. Potential pathways for contaminant migration would include wind dispersion, soil creep and surface runoff; however, analysis of soil samples collected downslope of the tailings spill at the thickener building indicated that the metal concentrations in the tailings residuals have not impacted downslope locations. Therefore, there appears to be limited potential for contaminant migration from tailings spill residuals in this area.

Operational and Construction Landfills

Metals analysis of soil samples collected at the toe of the operational landfill indicated that only one surficial soil sample contained a zinc concentration in excess of the (1999) SQRO. Levels of lead measured in all the samples were less than the (1999) SQRO.

Petroleum hydrocarbon analysis was conducted on soil samples collected from the area downslope of the operational landfill due to concerns regarding the use of waste oil for open burning of garbage. Observations during test pit excavation did not reveal the presence of petroleum hydrocarbon contamination at any of the sampling locations, with the exception of a slight hydrocarbon odor at one test pit located at the toe of the operational landfill. The results of extractable petroleum hydrocarbon analysis of a soil sample collected from this test pit indicated the presence of a trace level of LEPH; however, the concentrations were less than the NWT remediation guideline for TPH and the Yukon CSR standard for industrial land use. The results of EPH analysis for the five other soil samples tested were less than the detection limit.

The results of seepage water testing in monitors installed in upgradient and downgradient locations within the landfills indicated that levels of ammonia and nitrite that exceeded the CCME water quality guidelines for protection of aquatic life were found in 2 monitors locations at the toe of the operational landfill and two monitor locations at the toe of the construction landfill. Each of the downgradient monitor locations tested for cyanide, also exceeded the CCME guideline for this parameter although the nutrient and cyanide levels did not exceed the Yukon CSR standards.

Dissolved concentrations of zinc exceeded the CCME water quality guideline in water samples collected from all monitor locations installed at the landfills although the water samples did not contain dissolved metal concentrations that exceeded the Yukon CSR standards for protection of aquatic life. Petroleum hydrocarbon concentrations did not exceed the applicable standards in any of the monitors installed at the landfill.

The results of seepage water analysis indicated that, due to the limited thickness of the saturated zone, the concentrations of chemicals in seepage or melt waters correlated closely with the soil contaminant levels. The seasonal restriction for the presence of subsurface melt waters and the localized occurrence of dissolved contamination suggests that potential pathways for contaminant migration such as groundwater flow are likely not significant. Surface runoff would constitute another potential migration pathway; however, although erosion channels were noted, water flow was not observed during the field investigation conducted in July 1999. Surface runoff also represents a seasonally restricted pathway for contaminant migration.

Although the analytical program did not identify areas of significant environmental concern with respect to contaminant migration from the landfill areas, the landfills are identified as an area targeted for remediation on the basis of the requirement to develop and implement a suitable remedial program for closure.

Former Oil Bladder Storage Area

Six test pits were excavated to the top of the permafrost layer to determine the presence, severity and approximate extent of petroleum hydrocarbon contamination resulting from a historic oil spill in this area. Contaminant observations indicated that evidence of hydrocarbon contamination was present in 5 of the 6 test pits with the strongest hydrocarbon odours encountered within the saturated interval of the active layer, generally at 0.4 to 0.6 metres below ground level. The results of soil sample analysis showed that concentrations of LEPH in excess of the NWT guidelines and Yukon CSR standards for industrial land use were present in soils sampled from three of the test pits. Additional test pits were recommended (in 1999) to delineate the full extent of the oil contamination for remediation (these test pits were completed in 2000).

Former and current fuel tank installations at the CRF plant, Firehall, Foldaways and Quonset Huts

Targeted sampling of soils within the former and current location of above ground fuel storage tanks revealed contamination with petroleum hydrocarbons at the CRF plant, the Firehall, and the Foldaways. Areas of hydrocarbon stained soils were observed within the Quonset Hut, where refuelling facilities consisting of hand pumps attached to fuel drums were located.

The petroleum hydrocarbon observed in the vicinity of these fuel tank installations appears to be limited to the saturated interval of the active layer. The full extent of the contaminated zones in the vicinity of the source areas was not delineated; however, based on the contaminant observations during test pit excavations, the contamination appeared to localized.

Surface over active mining area and old crusher and surface ore stockpiles

Sources of metal contamination in the surface over the active mining area include: air emissions from ventilation raises, the occurrence of mineralized soils, the drilling of the raised bores, the crusher area and stockpiles of specialized ore located outside the north portal.

Due to the continued activity and level of ground disturbance in this area of the mine site, only a limited program of test pit excavation (three test pits) was conducted. The results of soil testing revealed the presence of lead and zinc concentrations that exceeded the federal guidelines.

This area has been targeted for remediation on the basis of the closure activities that will take place to regrade and recontour the surface to restore this area of the mine site.

Snowdumps

Four main areas of the mine site are used to store snow from clearing activities. These are located: west of the firehall (Firehall snow dump), near the foldaway buildings (Foldaway snowdump), south of Loon Lake (Loon Lake snow dump) and at the southern tip of the mine site peninsula (Main snowdump). The snow dumps represent areas of potential environmental concern due to the inclusion of potentially contaminated particulates that may dissolve into melt waters during the summer season.

On the basis of the analytical results, the snow dump areas represent sources of metal contamination with respect to concentrations of lead, zinc and possibly cadmium in particulates. Step-out soil samples were recommended in 1999 to delineate the extent of potential metal contamination in the surrounding soils (and these were completed in 2000). Given the potential for migration of contaminated melt waters, the snowdumps should not be located in close proximity to the foreshore.

Acid Rock Drainage

Representative rock samples were tested to determine acid rock drainage characteristics. The results of analysis showed that the samples were not potentially acid generating and that significant leaching of metals was unlikely.

Vegetation Quality

Metal concentrations were determined in representative plant species collected near the mine site and up to 5 kilometers away in order to evaluate potential impacts from deposition of wind borne particulates transported from the mine operations to the surrounding lands. The results of metal analysis in plant samples indicated the following:

- Lead and zinc concentrations were highest in plant tissues collected from sampling stations located nearest the mine site.
- Comparison of the current metal concentration data in plant tissue with the 1975 BC Research data showed that higher concentrations of zinc were present in grasses and lichens at the four sampling stations. Lead concentrations in plant tissues measured in the present study were significantly higher than the BC Research results, which did not contain detectable concentrations at any of the sampling stations.

The field program conducted in 2000 expanded the sampling area for vegetation and soil quality assessment.

Marine Environmental Survey

A marine environmental survey was conducted at 12 sampling stations located in Garrow Bay, Polaris Bay and Crozier Strait. A dive survey was conducted to document benthic conditions and to conduct sampling of sediments and biota at selected stations. Seawater sampling was also carried out at several of the sampling stations.

The dive survey was videotaped to provide a permanent record of the observations. Generally, the sea bottom appeared clean and virtually free of debris at most sampling sites. At sites where debris was observed, it was limited to one or two items such as cable, a hard hat or a tire. There were no problematic accumulations of debris at any of the sites where diving took place.

Sea life (e.g., clams, anemones, urchins, shrimp) was evident at all sites although abundance appeared to vary among sites. Shrimp or "krill" were found in abundance immediately under the ice at all stations and generally throughout the water column. The shrimp were especially abundant near the sewage outfall in Crozier Strait. *Mya* clams were observed at all sites with the exception of stations in Crozier Strait, where sea urchins were encountered in greater numbers.

Owing to natural differences in water depths, current velocities, substrate composition and slope, it was difficult to attribute differences in marine life distribution and abundance among sampling sites to the activities of the Polaris Mine. Some of the sites near the dock appeared to have been affected by recent rip-rap addition (used to repair storm damage) which will take some time to colonize, and by the sewage discharge which attracts shrimp and (in previous years) sculpins.

Seawater

The results of seawater analysis indicated that dissolved metals, cyanide, organic chemical parameters, petroleum hydrocarbons, PAH and PCB were either not present in detectable concentrations or the concentrations were below the CCME guidelines for protection of aquatic life.

Sediments

Lead, zinc and cadmium concentrations in sediments collected from Garrow Bay in 1999 were equivalent to background concentrations, based on pre mine development studies conducted by BC Research in 1975[3]. Lead, zinc and cadmium concentrations in sediments collected from Polaris Bay in 1999 were slightly greater than the 1995 background concentrations but remained generally less than the Federal regulatory guidelines. Sediment samples collected (in 1999) from sampling stations adjacent to the landfill site contained levels of lead and zinc that slightly exceeded the CCME guidelines.

The concentrations of cadmium, lead, and zinc in sediment samples collected in the immediate vicinity of the dock area in Crozier Strait were the highest concentrations reported in both the 1999 and 1981 studies. However, these metal concentrations were similar to those reported by Fallis (1984)[4] for data collected in 1981, prior to mine development. Therefore, naturally occurring mineralization is considered to be the most likely source for the observed metal levels in the sediments. The Crozier Strait sediment quality data also suggests that metal concentrations have increased in upcurrent areas from the levels reported prior to full-scale development of the mine site.

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[3] B.C. Research, 1975. Environmental Study of Polaris Mine, Little Cornwallis Island. Submitted to Cominco Ltd., Project No. 1642. Prepared by Division of Applied Biology, B.C. Research.

[4] Fallis, B.W. 1984. Trace elements in sediments and marine biota collected from the vicinity of the Polaris Mine, Little Cornwallis Island, N.W.T. Department of Fisheries and Oceans, Winnipeg, Manitoba. Unpublished Data.

Tissue Quality

The results of clam tissue analysis indicated that metal concentrations found in the present study were similar to the values reported by B.C. Research (1975, 1978[5]) and Fallis (1984) at most of the sampling stations. The highest concentrations of metals were found in clam tissue collected from the vicinity of the shiploading dock. Therefore, the historically higher concentrations of metals in the area of the dock in Crozier Strait are reflected in the tissue quality data for Mya clams. On the basis of the sediment quality information, the elevated levels of cadmium, lead and zinc in the tissue samples at the shiploading dock area are also considered to be representative of naturally occurring mineralization.

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[5] B.C. Research. 1978. Polaris Mine Aquatic Environmental Studies, 1977. Prepared for Cominco Ltd., Trail, B.C.

2. 2000 Field Investigation Program

The field investigation program at the Polaris Mine site was conducted from July 28th to August 3rd, 2000. Polaris staff members continued the monitoring of groundwater levels in wells located in the barge area for a period of 10 days following departure of GLL personnel.

The field investigations consisted of the excavation of 149 shallow test pits, the collection of 338 soil samples, the collection of three species of vegetation and soil samples at 13 stations, and collection of 13 surface water and groundwater samples. Other tasks completed during the field investigation program in July and August 2000 included a detailed inspection of the liner at the tank farm and the collection of oil samples from in-service transformers (completed by D. Almack, Polaris electrician).

In general, sampling locations for the field investigations conducted in the active mine site area were focussed on previously investigated areas where additional data was required to delineate the extent of soil contamination with petroleum hydrocarbons or lead and zinc. The number of sampling stations established for the collection of vegetation and soil samples in the surrounding lands was increased from the 8 stations sampled in 1999 to 13 stations in 2000. The distance of the vegetation sampling stations from the active mine site was also extended to encompass the area east of Garrow Lake and northeast to above Frustration Lake. Groundwater samples were collected from monitors that were installed in the vicinity of the barge and the landfill during the 1999 field program. The surface water sampling program was expanded to include active seepage areas identified at the landfill, surface water in the LRD quarry and the Loon Lake discharge to North Bay.

Figure 2 illustrates the location of the test pits, surface soil samples, vegetation sampling stations and water sample collection points. The sampling points for the field investigations conducted in 1999 are also shown in Figure 2.

2.1 Test pit excavation and Soil Sampling

Test pits were excavated in several areas of the mine site using a tracked excavator supplied by Polaris Mine. The excavation of test pits allowed observation of subsurface soil conditions, visual and olfactory evidence of petroleum hydrocarbon contamination, depth to permafrost and collection of soil samples for chemical analysis.

Soil samples were collected from test pits on the basis of stratigraphy and, in the case of investigating hydrocarbon contamination, visual and olfactory observations. Soil samples for investigation of metals contamination were generally collected over thin intervals (0.05m) near the ground surface in order to determine the contribution of metals from airborne particulates. Test pits were generally excavated until permafrost was encountered, at depths ranging from 0.8 to 1.2 meters.

A limited number of surficial soil samples were collected along the hillside between the Accommodations Building and the barge. The surface samples were collected using a trowel and included the upper 0.1 meters of the soil surface.

Soil samples to be analyzed for petroleum hydrocarbon parameters were collected into clean, laboratory certified 250 mL glass jars or 125 mL glass jars with teflon-lined lids. Soil samples to be analyzed for metals were placed in plastic ziploc bags. The soil samples were kept cool until delivery to the analytical laboratory. Standard chain-of-custody forms were completed for each sample and the form accompanied the samples to the laboratory.

2.2 Surface Water and Groundwater Sampling

Surface water samples were collected from several areas of the mine site to provide a general characterization of the quality of surface drainage. As shown in Figure 2, surface water samples were collected from the following areas of the mine site:

- areas of ponded water in the vicinity of the process barge (ROSUMP and ROPOND);
- water discharging from an active groundwater seep located at the toe of the operational landfill (LF1);
- the Loon Lake surface water discharge;
- creek flowing into the North Bay;
- Little Red Dog Quarry Pit

Each of the groundwater monitors installed in 1999 was checked to determine the presence of free water. Water within the majority of the monitor installations was frozen and not accessible for sampling. To provide additional groundwater quality data, test pits excavated at the landfill during the 2000 field program were left open for up to several days to allow water seepage to accumulate for subsequent sampling. A sufficient volume of water for sampling was available from only two of the test pits, TP132 and TP 140. Monitors and test pits which contained free water were sampled and included:

- In the vicinity of the process barge: BH1, BH5, BH6, BH7, TP5, and the water level control sump;
- In the vicinity of the landfill: TP61, TP132, TP140.

Prior to sampling groundwater, the monitors were purged to remove stagnant water. The monitors were allowed to recover to near static levels (75% of static) prior to collection of the groundwater samples. Where low volumes of water were available or recharge rates were slow, sampling took place in stages that, on occasion, spanned two days.

The water samples were collected using dedicated Waterra tubing and foot valves. Conductivity, temperature and pH of the groundwater was measured in the field. Groundwater samples to be analysed for dissolved metals were filtered in the field using in-line disposable filters. Samples were preserved in the field as appropriate for the various analytical parameters. The water samples were stored in a cooler and shipped to the analytical laboratory within one week of collection. Standard chain-of-custody forms accompanied all samples submitted to the laboratory.

2.3 Vegetation and Soil Sampling

The location of the 13 sampling stations for vegetation and soils were based on the vegetation sampling units and stations previously established by BC Research (1975) prior to mine development, as described in the 1999 ESA. As shown in Figure 3, the sampling stations were located within the active mine area and at distances progressively farther extending to the northern and eastern slopes above Garrow Lake. Eight of the sampling stations had also been sampled during the 1999 field program.

Three plant species were sampled at each of the vegetation sampling stations: *Thamnolia subuliformis* (an abundant lichen), *Alopecurus alpinus* (a grass species), and *Salix arctica* (the Arctic willow). Plant sampling for each of the species involved clipping the current season's growth of leaves and stalk from the Arctic willow and the Alopecurus grass by hand. The entire vegetative body of the lichen species was collected. Roots of the Arctic willow were also collected into separate sample bags. Soil adhering to the plants was removed to the greatest extent possible prior to placing the plants into paper bags.

The plant samples were dried at room temperature prior to shipment to the analytical laboratory. Standard Chain-of Custody Forms accompanied all samples shipped to the analytical laboratory in Vancouver, B.C.

Soil samples were collected at three depth intervals (0-0.01m, 0.01-0.05m and 0.05-0.1m) at each of the vegetation sampling stations. The thin sampling depth intervals were chosen to determine the presence of aerial deposition of metal containing particulates from the active mine site. The soil samples were collected using a stainless steel trowel and placed into plastic bags. Soil textures and temperatures at surface and at depth were recorded at each sampling station. The soil samples were shipped to the analytical laboratory accompanied by standard chain-of-custody forms.

2.3.1 Sample Site Locations and Surveying

Mine site survey personnel conducted a location and elevation survey for selected test pit locations. Aerial photographs and a hand-held GPS were used to locate test pit locations not surveyed, surficial soil sample locations and vegetation sampling stations. All survey data was transferred to the mine grid and plotted.

2.4 Analytical Program

The chemicals of concern at the Polaris Mine site include: metals, predominantly lead and zinc resulting from the mining, milling and concentration of ore; and, petroleum hydrocarbons associated with the storage, dispensing and disposal of fuels and oils. Other chemicals of potential concern include: ethylene and propylene glycol; quicklime and calcium chloride; ammonium nitrate; and process chemicals including: potassium amyl xanthate, methyl isobutyl carbinol, sodium cyanide, copper sulfate and zinc sulfate.

Soil Samples

In order to optimize use of the analytical budget for metal analyses, soil samples were initially analyzed to determine concentrations of lead and zinc only. The digested sample extracts were retained, and a selected number of soil samples were subsequently analyzed for a full metal scan by ICP.

Selected soil samples were subjected to a water leach procedure to determine the leachability of the lead and zinc components from the soil matrix. Total sulfur, sulfate, and sulfide components of the soil samples were also determined. The leachability data is expected to provide a measure of the mobility of the metals. The procedure consisted of a shake flask test conducted at a 2:1 ratio of water to solid matrix. The samples were gently agitated for 24 hours to ensure continuous exposure of all surfaces.

Soil samples tested to determine the concentration of diesel fuel residuals with a carbon range of C10-C19 were analyzed for light extractable petroleum hydrocarbons (LEPH). Lube and hydraulic oils were assessed by analysis of heavy extractable petroleum hydrocarbons (HEPH with a carbon range of C19-C32). Selected samples were also analyzed to determine concentrations of BTEX compounds (typical components of gasoline), volatile organic compounds (VOCs; components of solvents) and polycyclic aromatic hydrocarbons (PAHs; components of lube and hydraulic oils).

Water Samples

Surface water samples were collected from 6 locations at the mine site and groundwater samples were collected from 5 monitors, 3 test pits and the water level control sump at the barge. Conductivity, temperature and pH were measured for each sample in the field.

The samples were analyzed by Analytical Service Laboratories (ASL) to determine concentrations of total and dissolved metals, nutrients, PAHs, extractable petroleum hydrocarbons, halogenated and non-halogenated volatiles. The water samples were selected for analysis on the basis of proximity to source areas for the potential chemicals of concern.

Vegetation/Soil Samples

All of the samples of *Sal*ix *arctica* (Arctic willow), *Alopecurus alpinus* (grass) and *Thamnolia subuliformis* (white lichen) collected from the vegetation sampling stations were analyzed to determine total metal concentrations. Prior to submission to the analytical laboratory, soil adhering to the vegetation samples was removed and the samples were dried at room temperature.

Soil samples collected at the vegetation sampling stations were analyzed to determine concentrations of lead and zinc. Samples collected from the surface of the soil pit (0-0.01m) were also analyzed for a total metal scan to determine the presence of other metals of concern.

Analytical QA/QC

A quality assurance and quality control program (QA/QC) consisting of duplicate analyses, spike recovery, analyses of NRC reference materials, blind duplicates and blank analyses was undertaken concurrently with the analytical program. For the purpose of this study, QA/QC analytical protocols defined by the Canadian Council of Ministers of the Environment in CCME EPC - NCS 62E and CCME EPC - NCS 66E were used. The documents reflect the current state-of-the-art for analyses of samples collected during contaminated site assessments. The results of the QA/QC program are provided in the laboratory reports.

3. Site Characterization

3.1 Local Stratigraphy

The Polaris mine site is located in the high Arctic at latitude 75 degrees north, within the zone of continuous permafrost. Glacial processes have formed the subdued and rounded topography in the study area, while the surficial materials are dominated by marine sediments overlying carbonate bedrock (GLL, 1999).

Local stratigraphic information was obtained from shallow test pits excavated within the active mine site area and at the vegetation sampling stations located in the lands surrounding the mine. The Polaris mine site soils are classified as Cryolsolic. The stratigraphy is generally characterized by a stony surface consisting of angular to subangular pebble/cobble and gravels, underlain by fine to medium sand with subangular to subrounded pebbles or silty fine sand with gravel and pebbles. The depth to bedrock varies, but is typically less than 0.3m on the western sloping hillside above Crozier Strait.

Meadow areas are characterized by tan colored clayey-silty gravels, pebble sized angular, subangular fragments, typically coarsening downward to the base of the active layer.

Black shale bedrock occurs near the surface to the east of the Operational Landfill. Shale in the New Quarry is characterized as brown shale. Vegetation sample station "H" is located on the southeastern slope above the New Quarry . Soil development was very shallow, occurring in mossy areas only, and the subsurface consisted of flaggy shale underlain by bedrock.

The active layer, the upper portion of soil where annual freeze thaw cycling occurs, varies in thickness depending on the extent of seasonal thermal variations, the soil thermal properties and the nature of the soil and snow cover. In developed areas of the mine site, the thickness of the active layer is also locally influenced by the presence of external heat sources such as heated buildings and pipelines. The active layer at Polaris is relatively shallow, ranging from 0.1 to 1.4 metres in undeveloped areas. The thickness of the active layer immediately adjacent (within 1 metre) of the barge wall was found to be in excess of 3 metres, which is due to the heat emitted from the barge (Figure 4).

3.2 Groundwater Flow Patterns in the Vicinity of the Barge

The field program conducted in 1999 included the installation of 25 groundwater monitors in boreholes and test pits located in the vicinity of the process barge and the Operational and Construction Landfills. The monitors consisted of 5 cm diameter PVC pipes with machine slotted sections at the base for water intake. Water level measurements were taken in each of the monitor locations during the field program in 2000. A majority of the monitors contained frozen water. This suggests that the water accumulated within the monitor in the previous year did not thaw over the duration of the field program in late July and early August 2000, restricting the flow of fresh groundwater into the monitor.

The water level measurements within the monitors in the barge area are not representative of a true groundwater table, but consist of the accumulation of the seasonal melt water within the active layer above the permafrost. Large-scale movement of melt water is prevented by limited recharge, low temperature (which reduces water viscosity), and limited thickness of the saturated zone. The ground water flow system is, therefore, very localized and is significantly affected by local conditions such as differential melting due to the presence of heat sources, sump pumping, and soil permeability. Figure 4, shows a cross-section of the barge area and illustrates the occurrence of groundwater in relation to the measured thickness of the active layer.

A water level control sump is located at the northwest corner of the process barge (Photo 1). The sump is used to control the level of water accumulated beneath the barge during the melting season to prevent the barge from floating. The sump consists of a 1m diameter galvanized pipe, installed adjacent to the wall of the barge, to a depth of approximately 4m and fitted with a float switch pump.

The influence of intermittent pumping from the water level control sump on groundwater in the surrounding area was evaluated by measuring water levels in 5 nearby monitors that contained free water. The water level monitoring was initiated by Gartner Lee staff during the field program and continued by Polaris personnel for a period of 10 days.

Table 1 provides a summary of the water level measurements in the sump and the adjacent monitors. Graph 1 illustrates the effect of the intermittent pumping at the sump on the water levels in the adjacent monitors. The results indicate that water levels in monitor TP5 show the most immediate and strongest response to the water pumping in the sump. This result is expected given that both the sump and the TP5 monitor are installed adjacent to the west and east walls, respectively of the barge, and are terminated at approximately the same depth below ground surface within the deeper melted zone beneath the barge.

Water levels measured in the monitors installed in the shallow permafrost zone on the west side of the barge, do not appear to be strongly influenced by the intermittent pumping of the water level control sump. This suggests that the area west of the barge (ocean side) does not contribute a large portion of the water that accumulates beneath the barge. Based on the volume of water pumped from a pumping station installed within a truck box at the rear of the barge (east side), the primary source of water to the barge pumping sump is runoff and seasonal melt waters from the slope to the rear of the barge (accommodations side).

4. Mine Site Contaminant Occurrence and Distribution

4.1 Regulatory Framework

The Polaris Mine occupies land leased from the Government of Canada under the Territorial Lands Act and the Territorial Lands Regulations. Accordingly, environmental regulations developed for both Federal legislation and North West Territories/Nunavut Territory were used for the evaluation of contaminated site issues at the Polaris mine site. The NWT Remediation Guidelines provide a series of steps for the identification, assessment and remediation of contaminated sites. The NWT guidelines focus on hydrocarbons, although the principles outlined are intended for application to other types of site contamination. The required degree of remediation cited in the guidelines is determined by the CCME Criteria and Guidelines. Therefore, the Canadian Environmental Quality Guidelines, published by the CCME in 1999 were used as the primary numerical limits for the evaluation of environmental quality data at the Polaris mine site.

The Canadian Environmental Quality Guidelines (CCME, 1999) integrate national environmental quality guidelines to address the protection of atmospheric, aquatic, and terrestrial resources. The guidelines were developed by the Canadian Council of Ministers of the Environment (CCME) using risk-based procedures to provide equal protection to human health and ecological receptors. The guidelines represent generic recommendations that are based on the most current scientific information and are intended to provide a high level of protection for designated land uses.

Canada has adopted a three-tiered approach for the assessment and remediation of contaminated sites. The environmental quality guidelines represent the first tier, while a second tier allows limited modification of the guidelines to establish site-specific remedial objectives[6]. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis.

4.1.1 Petroleum Hydrocarbon Parameters

For parameters not addressed in the CCME Soil Quality Guidelines, specifically the light and heavy extractable petroleum hydrocarbons that indicate the presence of diesel fuel components, reference is made to the soil standards specified in the Yukon Territorial Contaminated Sites Regulation. The Northwest Territories Remediation Guidelines also prescribe a guideline for total petroleum hydrocarbons, a less specific chemical parameter that includes both the light and heavy extractable petroleum hydrocarbons.

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[6] CCME. 1996a. Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada. The National Contaminated Sites Remediation Program. En 108-4/9-1996e.

On June 6, 2000 the Canadian Council of Ministers of the Environment (CCME) introduced Canada-Wide Standards (CWS) for petroleum hydrocarbons (PHC) in soil. The standards were intended for endorsement in November 2000; however, discussion with the Pacific Regional office of Environment Canada (R. Glue, personal communication Nov.17, 2000) indicated that endorsement by the Ministers of the Environment has not yet occurred and is unlikely to occur in the short term. In addition, CCME have not yet established an implementation schedule and a guideline for use of the standards. For these reasons and technical considerations discussed below, the CWS PHC have been considered in the evaluation of petroleum hydrocarbon contamination at the Polaris Mine site, but have not directly been compared with the petroleum hydrocarbon concentrations in soil samples collected from the site.

The CWS PHC in soil is a remedial standard for contaminated soil and subsoil occurring in four land use categories – agricultural, residential/parkland, commercial and industrial. The standard is laid out in three tiers, which incorporate different levels of site-specific information. The standards are applied to four fractions of petroleum hydrocarbons which are based on boiling point ranges and are intended to represent grouping by physico-chemical and toxicological properties. Fraction 1(F1) is >C6-C10; F2 is >C10-C16; F3 is >C16-C34 and F4 is C35+. Different standards are applied to coarse grained (>75um) and fine grained soils (<75um) and to the surface soils from (0 to 1.5 m below grade) as well as subsoils at a depth of greater than 1.5 m.

A direct comparison of soil quality data to the PHC CWS cannot be made as the soil was analyzed and quantified according to established territorial standards for petroleum hydrocarbon parameters LEPH (C10-C19) and HEPH (C19-C32), the Yukon Contaminated Sites Regulation Standards. The closest comparison would be LEPH to Fraction F2 and HEPH to Fraction 3. However, the LEPH parameter includes a quantification of >C16-C19 which is excluded in the Fraction F2. Therefore, in order to make a suitable comparison, the total concentration of LEPH and HEPH was compared to the summation of Fraction F2 and F3.

Yukon CSR Soil Numerical Stnds	LEPH (C10-C19)	HEPH (C19-C32)	Total LEPH+HEPH (C10-C32)	CWS PHC	Fraction 2 (C10-C16)	Fraction 3 (C16-C34)	Frac 2 + 3 (C10-C34)
Park Land	1000	1000	2000	Tier 1 Coarse Surface Soils	450 16,000	400 29,000	850[a] > 30,000[b]
Park Land	1000	1000	2000	Tier 1 Fine Surface Soils	900 16,000	800 29,000	1,700[a] > 30,000[b]
Park Land (>3m)	1000	1000	2000	Tier 1 Coarse (>1.5m)	1,500 > 30,000	2,500 > 30,000	4,000[a] > 30,000[b]
Park Land (>3m)	1000	1000	2000	Tier 1 Fine (>1.5m)	2,200 > 30,000	3,500 > 30,000	3,700[a] > 30,000[b]

[a] Exposure Pathway = Eco-soil contact
[b] Exposure Pathway = Soil Ingestion

Comparison of the Yukon CSR soil numerical standards for extractable petroleum hydrocarbons with the proposed Canada Wide Standards for PHCs shows that the Yukon Standards represent a conservative approach for evaluation of the soil quality data.

4.1.2 Site Specific Soil Quality Remedial Objectives for Lead and Zinc

Cominco recognizes that the Polaris mine site is a unique environment and that site-specific conditions are an important component of environmental issues. In recognition of the unique nature of the local environment, Cominco commissioned Cantox Environmental Inc. (1999/2000) to develop site-specific soil quality remediation objectives (SQRO's) for lead and zinc that adequately protect the health of the environment and of the human users of the area. This work was done according to the permitted framework as governed by the Canadian Environmental Quality Guidelines (CCME, 1999). A stand-alone report has been prepared by Cantox that is available and under separate cover and a summary is appended here.

The CCME framework, outlined in the National Contaminated Sites soil protocol, provides the opportunity to move from generic soil guidelines to site-specific remediation objectives, which "allows the proponent to ensure that the assumptions used in the soil protocol apply to the site-specific conditions" (CCME, 1999).

The unique nature of the Polaris mine site suggests that the application of generic soil quality guidelines is not appropriate for remediative purposes. The historic lack of vegetation in the active mine area results in a limited number of wildlife. The "barren and rugged" terrain of Little Cornwallis Island (Graham, 1982) precludes the regular use of the area by both wildlife and human receptors. Further, the atypical characteristics and unusual exposure scenarios indicative of the high Arctic location of the Mine site necessitated the development of site-specific SQRO's.

SQRO's are based on the most sensitive receptor (ecological or human) to a chemical of potential concern. For example, a SQRO for chemical "X" of 100 mg/kg may be considered a safe soil concentration for herbivores, but may not be stringent enough for predatory mammals or the most sensitive human sub-groups. For this reason, the lowest SQRO's for either ecological or human receptors is chosen for the metals of concern.

Site characteristics relevant to the derivation of soil quality remediation objectives

Cominco's mining activities have largely remained isolated to the bare, coarse-textured areas of the southwest corner of Little Cornwallis Island. B.C. Research's (1975) evaluation of the mine's potential environmental impact identified the proposed active mining areas to be of moderate to low environmental sensitivity. The majority of the mine facilities are located within the barren, southwest land area, as shown in Figure 2. The exposure assumptions employed in the derivation of the soil quality remediation objectives for lead and zinc represent the active surface use areas only. This includes the barge (mill and concentrator), concentrate storage building, landfill site, backfill quarries, mine openings, road ways and airstrip. The soil quality remediation objectives have therefore been derived for the area identified as the active mine site and do not apply to the surrounding lands.

For the purposes of the risk assessment, two key features of the active mine area are:

- The soil is characterized as being well-drained coarse gravel with little organic matter (B.C. Research, 1975), and;
- That prior to the start of Cominco's mining efforts, the region now identified as the "actively mined area" exhibited "insignificant" proportions of vegetation typical of local herbivorous diets (B.C. Research, 1975). Figure 3 illustrates the vegetation units described by BC Research and outlines the area of the active mine site where vegetation loss has occurred due to mine activities.

This suggests that direct exposure to soils would likely be limited due to reduced chemical bioavailability and limited habitat suitability for wildlife. The actively mined area has historically (i.e., prior to mine start-up) supported little to no vegetation, and for this reason the soil quality remediation objectives excluded arctic plants as possible ecological receptors.

Derivation of Soil Quality Remediation Objective for Lead

As outlined in the Table A below, the CCME soil quality guideline of 140 ppm for lead (parkland land use) is based on long-term soil ingestion for a child receptor. Although the agricultural environmental soil quality guideline (70 ppm) is lower than the residential human soil quality guideline (140 ppm), it is generally recognized that human children are the primary receptor of concern when characterizing risk associated with lead exposure.

Table A. Relevant soil quality guidelines (ppm) for lead

	Residential/Parkland Land Use
Guideline	**140**
SQG_{HH}	140
Limiting pathway for SQG_{HH}	Soil ingestion
SQG_E	300
Limiting pathway for SQG_E	Soil contact

Notes: SQG_{HH} = soil quality guideline for human health; SQG_E = soil quality guideline for environmental health; NC = not calculated (CCME, 1999b)

Results from the risk assessment identified human children acutely exposed to lead-contaminated soils as being slightly more sensitive than chronically exposed arctic fox. Considering that the most sensitive receptors of exposure to lead are human fetuses, infants, and children up to six years of age (ATSDR, 1988), the site-specific SQRO for lead is intended to protect Inuit from measurable health effects associated with the future use of the site.

The “benchmark” probability that U.S. EPA uses to guide remediation decisions is a less than 5% probability that an individual’s blood lead level will exceed 10 μg/dL for long-term, chronic exposure periods (White et al., 1998). This target blood lead level is appropriate for long-term, chronic exposures and effects (e.g., effects on cognitive abilities). However, sensitive receptors such as Inuit children are assumed to visit the Mine site for perhaps one to three days per year (B.C. Research, 1975; LaVigne, 1980; results from community consultation, 2000). This type of short-term or acute exposure period suggests a different toxicological impact. Ingestion of soil while visiting the Mine site could result in larger, temporary increases in blood lead levels. For the purposes of this risk assessment, a more relevant short-term “benchmark” of 20 μg/dL was used as a target blood lead level (CDC, 1991; Health Canada, 1994).

The following relationship describes the uptake of lead into blood:

$[Pb]_{blood}$ = $\alpha + \beta$ (uptake)

where Pb = concentration of Pb in blood (μg/dL)
α = y intercept (baseline blood-Pb level = 4 μg/dL)
β = slope of the regression line (statistical regression technique was used to fit a curve to absorbed lead versus blood-Pb levels assume 0.04, US EPA 1989)

Assuming that a “safe” level or target level is 20 μg/dL …

$20\ \mu g/dL = 4 + 0.04\ (uptake_{Pb}),$

$uptake_{Pb} = 400\ \mu g/day$

So total exposure during an exposure episode should not exceed 400 μg or 0.4 mg. An Inuit child visiting the site can be exposed to lead through a number of pathways which include:

- Incidental ingestion of soil;
- Inhalation of soil and dusts;
- Dermal contact with soil.

The SQRO was estimated by back-calculating for soil concentrations that would result in an uptake of 400 μg/day.

The assessment incorporated the upper percentile of U.S. EPA recommended soil ingestion rates (400 mg/day; U.S. EPA, 1996), as well as a base-line blood lead level of 4 μg/dL (Wood, 2000) to calculate a site-specific SQRO for lead concentrations in soil of 2,000 ppm. Lead concentrations in surficial soil that are equal to or below this recommended objective are not expected to cause adverse health effects to children visiting the Mine site for brief, infrequent periods of time.

It should be noted that this SQRO is not protective of children exhibiting very high soil ingestion rates (e.g., pica behavior). This condition is typically not addressed in risk assessments, nor is it commonly considered when setting regulatory soil quality guidelines. Recent studies by Calabrese et al. (1997) suggest that certain children will ingest up to 50 g of soil per day during episodes of pica behaviour. At this ingestion rate, soil guidelines set by such regulatory agencies as CCME and U.S. EPA may not be stringent enough to protect the health of pica children.

Derivation of Soil Quality Remediation Objective for Zinc:

The generic soil quality guideline for zinc is based on soil contact data from toxicity studies on plants and invertebrates (Table B below).

Table B. Soil quality guidelines (ppm) for zinc

	Residential/Parkland Land Use
Guideline	**200**
SQG_{HH}	NC
Limiting pathway for SQG_{HH}	NC
SQG_E	200
Limiting pathway for SQG_E	Soil contact

Notes: SQG_{HH} = soil quality guideline for human health; SQG_E = soil quality guideline for environmental health; NC = not calculated (CCME, 1999c)

As stated earlier, the Mine site on Little Cornwallis Island is presently, and has historically been, barren with little vegetation. Further, toxicity to soil invertebrates was deemed largely irrelevant to the area of concern.

Instead, the risk assessment identified the receptor (wildlife or human) deemed most sensitive to zinc toxicity given their behavioural patterns and likelihood of exposure. In deriving a site-specific SQRO for zinc, the risk assessment:

- Determined a daily exposure to zinc that would result in either no measurable health effects on human individuals or wildlife populations; and in turn,
- Resolved a zinc soil concentration that, when ingested/inhaled/contacted, would not result in adverse effects.

Results from the risk assessment identified humans to likely be the most sensitive receptors under the assumed exposure scenarios. Zinc is a nutritionally essential metal and exhibits relatively low toxicity to terrestrial mammals and humans. Zinc does not accumulate with continued exposure, and body content is modulated by homeostatic mechanisms (Klaassen, 1996).

Zinc toxicity from excessive ingestion is uncommon, but gastrointestinal distress and diarrhea have been reported following ingestion of large doses. Due to the lack of overall human zinc toxicity data, the Health Canada provisional tolerable daily intake of 0.30 mg/kg$_{bw}$/day was used as an acute exposure limit for zinc (Health Canada, 1996). It is recognized that this likely overestimates the potency of zinc on an acute basis, however, at this time no further information was readily available.

When considering this acute exposure limit and the set of exposure assumptions, the results of the risk assessment indicate that the site-specific soil quality remediation objective for zinc at the Polaris Mine that would adequately protect both human and environmental health is approximately 10,000 mg/kg.

4.1.3 Water Quality Regulatory Parameters

The primary regulatory reference for the evaluation of water quality data for the Polaris Mine site is the CCME water quality guidelines for the protection of aquatic life. These guidelines are conservative and intended to represent ambient concentrations. The CCME guidelines are not, however, specific to the evaluation of groundwater quality. Modifying factors for chemical limits in groundwater due to factors such as natural attenuation and dilution are not considered in the CCME guidelines. Groundwater quality standards for the protection of freshwater aquatic life have been developed in the Yukon Contaminated Sites Regulation (CSR). The CSR standards generally apply a 10-fold dilution factor to regulated chemical parameters. These standards have also been presented with the analytical data to provide a more suitable comparison for the site-specific groundwater quality data.

4.2 Soil Quality

The overall objective of the soil sampling and analysis program conducted at the active mine site in 2000 was to delineate the extent of soil contamination with chemicals of concern in previously identified contaminant source areas. Soil sampling was also conducted at the vegetation sampling stations to determine the extent of dust dispersal. Soil quality at the vegetation sampling stations will be discussed in Section 5.

To delineate the extent of petroleum hydrocarbon contamination in the subsurface, additional soil sampling was conducted at the following areas:

- Former oil bladder storage area;
- Toe of the operational landfill;
- Former ASTs at the CRF Building;
- Diesel Tank at the Accommodations Building;
- Firehall fuelling area;

- Foldaway fuelling areas.

Based on the 1999 data for areas of environmental concern related to elevated lead and zinc concentrations in soil, focused soil sampling was conducted at the following areas of the mine site:

- Hillslope between the Accommodations Building and the Barge;
- Rock fill zone, west of the Concentrate Storage Building in the area used for outdoor chemical storage and seacontainer storage;
- Historic ore stockpiles, located near the Firehall and Training Buildings;
- South of the Concentrate Storage Building;
- Loon Lake area, east of the airstrip;
- Snow dumps at Loon Lake and Main (south of Foldaways)

The results of analysis for soil samples collected from each of the areas of investigation listed above are summarized in the following tables:

- Table 2. Extractable Petroleum Hydrocarbon Concentrations in Soil Samples
- Table 3. Water Leachable Hydrocarbon Concentrations in Shale
- Table 4. Total Lead and Zinc in Soil Samples
- Table 5. Total Metal Concentrations in Selected Soil Samples
- Table 6. Water Leachable Lead and Zinc Concentrations in Soil Samples

The applicable regulatory guidelines, objectives and standards for each chemical parameter are included with the analytical data in each table. The laboratory reports and results of QA/QC analysis are provided in Appendix A. Figures 5 through 8 illustrate the location of the sampling points and the concentrations of petroleum hydrocarbons and lead and zinc in soils at the Polaris Mine site.

4.2.1 Petroleum Hydrocarbons in Soils

Former Oil Bladder Storage Area

The former oil bladder storage area was located to the east of the south end of the airstrip, as determined from 1982 air photos of the Polaris Mine site and shown in Figure 5. The oil storage area was used during construction of the mine facility and was decommissioned in late 1981. Anectodal information indicated that a spill incident had occurred during operation of this facility. The field investigation conducted in 1999 identified the general location of hydrocarbon contamination associated with the oil spill incident; however, additional test pits were required to delineate the full extent of the oil contamination for remediation.

The field investigation program conducted in 2000 resulted in the excavation of an additional 35 shallow test pits in the vicinity of the former oil bladder storage area. Visual and olfactory observations were used during test pit excavation to indicate the possible presence or absence of petroleum hydrocarbon contamination. Based on field observations, the oil contamination was found to extend to the south side of the roadway. A further 11 test pits were excavated in this area to delineate the lateral extent of oil contamination in the subsurface.

The test pits were excavated to the top of the permafrost layer, at an average depth of 0.8m below ground surface. Contaminant observations indicated that the strongest odors and presence of a sheen were found within the saturated zone of the active layer, extending from depths in excess of 0.3 meters to the top of the permafrost zone. Photo 2 shows the presence of an oil layer at 0.5m depth on the wall of a test pit located within the oil contaminated zone of the former oil bladder storage area.

Thirty-eight soil samples were analyzed to determine concentrations of light and heavy extractable petroleum hydrocarbons. The results of analysis are shown in Table 2. Figure 5 illustrates the location of the sample points and highlights the areas where the extractable petroleum hydrocarbon concentrations exceed the Yukon CSR standard for park land use (1000 ug/g), as well as areas where field observations indicated strong petroleum hydrocarbon odors.

The results of the subsurface environmental investigation at the former oil bladder storage area indicate that the extent of the petroleum hydrocarbon contamination is greater than identified in 1999. The petroleum hydrocarbon contamination extends south of the bladder storage area and roadway down a south-facing slope toward the tailings line, terminating at the upper bench of the operational landfill. The areal extent of the oil contaminated zone is estimated to be 18,000 square meters.

Operational Landfill

The results of subsurface investigation conducted at the landfill in 1999 indicated the presence of a trace level of LEPH in TP 59, located at the toe of the landfill. The landfill represents a source of concern for petroleum hydrocarbons because waste oil is used for the open burning of garbage. The observations of petroleum hydrocarbon contamination downslope of the oil bladder spill area at the upper bench of the landfill also represents a concern with respect to contaminant migration.

Follow-up investigations conducted in 2000 consisted of the excavation of 5 additional test pits along the toe of the landfill, at locations downslope of the burn pit and the oil bladder spill area. The results of analysis of 5 soil samples collected from the test pits (Table 2) indicates that TP 140 contains LEPH and HEPH concentrations in soil at 0.5-0.8m depth that exceed the Yukon CSR standards for park land use. Detectible concentrations of extractable petroleum hydrocarbons were found in a soil sample collected from TP 138 located to the east of TP 140. Figure 5 shows the location of the test pits and the relative concentrations of extractable petroleum hydrocarbons.

The source of the petroleum hydrocarbon contamination at TP 140 is not clear. Based on its location, the contamination may have occurred via downslope migration from the burn pit or the bladder spill area. The results of soil samples collected at test pits in the vicinity of TP 140 indicate that the contamination is limited in extent. Given that this area will be buried with material moved from the Construction Landfill and will subsequently be frozen, remediation of contaminated soils is not required.

Former Above-ground Fuel Storage Tank Locations at the CRF Building

The subsurface environmental investigation conducted in 1999 identified petroleum hydrocarbon contamination in the vicinity of 2 former above ground fuel storage tanks (ASTs) located at the west and south wall of the CRF Building.

Three test pits were excavated in 2000 to provide step-out sampling locations from the areas of hydrocarbon contamination identified in 1999. The results of soil sample analysis are shown in Table 2 and illustrated in Figure 5. Additional areas of petroleum hydrocarbon contamination were not found. Therefore, the soil contamination appears to be restricted to the immediate area fronting the former ASTs.

Foldaway Fuel Tank Area

The 1999 subsurface investigation indicated that petroleum hydrocarbon contamination was present in soil samples collected from a test pit excavated directly adjacent to an aboveground diesel tank at the Foldaway buildings. One test pit was excavated on the west side of the building, but petroleum hydrocarbon contamination was not found at this location.

To delineate the extent of contamination in the vicinity of the diesel AST, and to determine the presence of petroleum hydrocarbon in the vicinity of former diesel tank locations at the Foldaway Buildings, 17 test pits were excavated in 2000 to allow observation of subsurface characteristics and to collect soil samples for analysis.

Twenty-one soil samples were analyzed to determine concentrations of extractable petroleum hydrocarbons. The results of analysis are shown in Table 2 and Figure 5. Concentrations of extractable petroleum hydrocarbons, predominantly LEPH, were found to exceed the Yukon CSR standards for park land use at 11 test pit locations. Curiously, petroleum hydrocarbon contamination was not present in TP 13, located near the 1999 test pit location TP 82. Discussions with Polaris staff indicated that the middle Foldaway Building is not heated, suggesting that in the absence of a heat source the migration of the petroleum hydrocarbons was restricted.

The results of sample analysis and contaminant observations during test pit excavation indicate that the petroleum hydrocarbon contamination occurs within the saturated portion of the active layer, generally at depths of 0.3 to 0.8 meters. The areal extent of the hydrocarbon contaminated soils in the vicinity of the Foldaway Buildings is 2800 square meters.

Diesel Tank at the Accommodations Building

Petroleum hydrocarbon contamination was observed in a test pit excavated adjacent to the above ground diesel tank (used for the emergency generator), located on the northeast side of the Accommodations

Building (Photo 3). Five additional test pits were excavated in the vicinity of the tank to delineate the extent of the hydrocarbon contamination. Six soil samples were analysed for extractable petroleum hydrocarbons and one sample collected from test pit ACC-3, located on the north side of the building, contained an LEPH concentration in excess of the Yukon CSR standard for park land use. The petroleum hydrocarbon contamination is therefore not extensive, and is estimated to cover an area of 400 square meters, directly adjacent to the north east corner of the Accommodations Building.

Firehall Fuel Tank Area

Petroleum hydrocarbon contamination was identified in a test pit excavated directly adjacent to the diesel tank located on the west wall of the Firehall Building during the 1999 field investigation. To determine the extent of the diesel contamination, 10 test pits were excavated during the field investigation conducted in 2000.

The results of soil analysis are summarized in Table 2 and Figure 5. Concentrations of light extractable petroleum hydrocarbons (LEPH) that exceed the Yukon CSR standards for park land use were found in soil samples collected from 5 of the test pits. Three of the test pits, FH2, FH3 and FH4 are located on the west side of the Firehall Building, adjacent to the diesel tank. Test pits FH6 and FH7 are located at the southwest corner of the Fire Rescue Training Building. The presence of petroleum hydrocarbon contamination at test pits FH6 and FH7 does not appear contiguous with the diesel contamination on the west side of the Firehall. The hydrocarbon contamination found in vicinity of the Fire Rescue Building may represent a different source and may be attributed to fuel storage and use at a 100-man camp that was formerly located in this general area.

The zone of petroleum hydrocarbon contamination in the vicinity of the Firehall diesel tank and the Fire Rescue Building appears to be restricted to the general area of investigation. The contamination is estimated to cover an area of 2800 square meters.

Leachate Testing of Shale Samples

Shale samples were collected from the New Quarry and the test pit TP137, located at the toe of the operational landfill. The New Quarry shale is described by Polaris Geologists as “Brown” shale, while that collected from TP137 is described as “Black” shale. These shale types are being evaluated for use as final cover material for the landfill. The shale samples were submitted for a water leachability test to provide data on the concentration of natural hydrocarbon components that could potentially be released from the crushed shale material.

The results of the water leach testing are shown in Table 3. The Black shale released slightly less light-end (C10-19) extractable hydrocarbons than the Brown shale, likely due to the lower concentration of natural organic material within the rock matrix. The data indicates that the shale material does not release significant quantities of natural hydrocarbon from leaching with water.

4.2.2 Total Lead and Zinc in Soils

Background Concentrations

In order to provide context for the lead and zinc concentrations found in soil samples at the active mine site, Cominco Ltd. provided Gartner Lee with geochemistry maps[7] prepared during the exploration phase of mine development as well as recent diamond drill core geochemical data. The geochemical data was plotted on drawings of the active mine site to outline areas containing naturally elevated background concentrations of lead and zinc in surficial soils. Figure 2 shows the location and concentrations of the geochemical anomalies mapped during the mine exploration phase at the Polaris property.

The most extensive areas of the mine site where naturally occurring concentrations of lead and zinc in surficial soils were found to exceed 2,000 ppm and 10,000 ppm, respectively, occur west and north of Loon Lake. These areas are also described as the Central and North showings and the Old Quarry area. Other areas of naturally occurring mineralization and associated elevated levels of lead and zinc occur southwest of the airstrip (South Showing), on the east side of the Accommodations Building and along the hillside sloping west of the airstrip, toward the Concentrate Storage Building and the Fuel Tank Farm.

Hillslope between the Accommodations Building and the Barge

Potential sources of metals may be contributed to the hillslope between the Accommodations Building and the Barge from particulate emissions emanating from the mine exhaust fan and the concentrate dryer. Thirteen test pits were excavated and 8 surficial grab samples were collected along the hillslope between the Accommodations Building and the Barge (Photo 4) to assess the levels of lead and zinc in soils.

Observations during test pit excavation showed that the stratigraphy of the hillslope to the north of the utilidor is characterized by colluvium cover and occasional thin layers of soil development, underlain by fractured frost heaved dolomitic limestone or badly fractured bedrock. The depth to permafrost ranged from 0.4 to 0.6 m. Although a narrow roadway had been excavated along the middle of the slope, the hillside appeared stable and relatively undisturbed by foot traffic or heavy equipment.

The hillside on the south side of the utilidor, in contrast, is heavily used as a footpath to the barge. Evidence of slumping and filling was noted in the area closest to the utilidor. A distinct roadway has been cut halfway up the slope to create a break in slope. Bedrock was not encountered within the excavation of the active layer. The stratigraphy consisted of angular frost heaved rocks with very little soil development. The depth to permafrost along the south portion of the hillslope varied from 0.5 to 0.8m.

Forty-two soil samples were analysed to determine concentrations of lead and zinc. The results of analysis are summarized in Table 4 and Figures 6 through 8. Total lead and zinc concentrations in the soil and

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[7] Cominco Ltd. 1966. Polaris Claims. Little Cornwallis Island, N.W.T. Data Composite (IP Survey, Geochem Assays, and Test Pit Assays) and 1974. Polaris Property Geology Map.

rock samples collected from the hillslope test pits generally contain lead and zinc concentrations that are less than the Tier 3 soil quality remediation objectives (SQRO's). Three sample locations to the north of the utilidor and one sample location south of the utilidor contained lead concentrations in excess of the risk-based SQRO of 2,000 ppm. Only one sample, collected at TP 205, contained a zinc concentration in excess of the SQRO of 10,000 ppm.

Surface soil samples (0-0.05 m) generally contained higher concentrations of total lead and zinc than samples collected at deeper depths. This result suggests that air-borne particulates may represent a source of metal concentrations to the ground surface.

To further evaluate the significance of the elevated metal concentrations in surface soils located on the hillslope, leachate testing was conducted to provide information on the relative mobility and bioavailability of lead and zinc concentrations in the soil and rock samples. The results of analysis are discussed in the section on leachable lead and zinc in soils below.

Rock Fill Zone – Sea Container and Concentrate Storage Building Area

The quality of rockfill that had been placed to extend the shoreline west of the concentrate storage building was assessed by excavating 9 test pits (TP143 to TP151) and collecting rockfill samples at depth. Four test pits (TP152 to TP155) were excavated on the southwest side and to the south of the concentrate storage building to provide data on the extent of contamination in the vicinity of the Concentrate Storage Building. The location of the test pits and a summary of the lead and zinc concentrations in soil samples at depth is shown in Figures 6, 7 and 8.

The analytical results (Table 4) indicate that concentrations of lead and zinc in soil samples collected at the surface (0-0.1m) from test pits TP145, TP148, TP149, TP150 and TP151 exceeded the risk-based SQRO's. With the exception of samples collected from TP149, the levels of lead and zinc were attenuated below 0.1m to concentrations less than the SQRO's. The source of the lead and zinc concentrations in the surface samples can likely be attributed to tracking of concentrates due to heavy vehicle traffic in the area. High concentrations of zinc were found in rockfill samples collected to a depth of 0.9m in TP149. This would represent a different source of zinc, possibly sulfide mineralization in the rockfill used to fill the shoreline.

Concentrations of lead and zinc in soil samples collected from test pits excavated to the southwest and south of the Concentrate Storage Building did not exceed the SQRO's. Selected samples from this area were submitted for leachate testing to determine if the form of the metal contamination in the samples could be evaluated on the basis of the leachability (eg., concentrate source vs sulfide mineralization).

Loon Lake Area

The Central showing and exploration geochemical anomalies are present over a large area the of the hillslope west of Loon Lake. Six test pits were excavated along the hillslope to the top of the permafrost zone. Soil samples were collected at depth to provide background lead and zinc concentrations for this area of the mine site. Selected soil samples were also submitted for leachate testing and the results are discussed in a subsequent section.

The results of total metal analysis for 16 soil samples are summarized in Table 4 and Figures 6 through 8. Lead and zinc concentrations in soil samples are less than the SQRO's with the exception of one zinc concentration in a sample collected from test pit LL-3 at 0.1-0.4m depth. This test pit is located in close proximity to the Central Showing and areas showing geochemical anomalies for zinc concentrations. Lead concentrations are generally low in this area as compared with zinc, a result that is consistent with the background metal concentration data.

Snow Dumps

Four main areas of the mine site are used to store snow from clearing activities. These are located: west of the firehall (Firehall snow dump), at the north end of the foldaway buildings (Foldaway snowdump), at the south end of Loon Lake (Loon Lake snow dump) and at the southern tip of the mine site peninsula (Main snowdump). The results of soil sampling and analysis conducted in the vicinity of the snow dumps in 1999 found evidence of contamination with lead and zinc and occasionally with cadmium. Step-out sampling to delineate the extent of the metal contamination in the vicinity of the Loon Lake snow dump, the Main snow dump and the Foldaway snow dump was conducted during the 2000 field program. Inspection of the Firehall snow dump area revealed that the historic ore stockpiles are located in close proximity to the snow dump, with sulfide mineralized rock evident along the toe of the snow dump. The Firehall snow dump area will therefore be addressed during the cleanup of the historic ore stockpiles, and further delineation of metal concentrations in soil was not considered necessary.

Loon Lake Snow Dump

Seven test pits were excavated around the Loon Lake snow dump. Two of the test pits were located upslope of the snow dump to obtain background metal concentration data and the remaining test pits were excavated on the downslope, melting front of the snow dump. Photo 5 shows the Loon Lake snow dump looking east toward the Tailings Thickener Building.

The results of soil sample analysis are summarized in Table 4 and illustrated in Figures 6 through 8. Lead and zinc concentrations were higher at the surface samples attenuating to low levels at depths below 0.1m. The elevated concentrations of lead and zinc in the surface samples did not extend beyond the immediate area of the melting front of the snow dump. Only one sample, collected from a test pit excavated at the downslope end of the snow dump, contained a lead concentration in excess of the SQRO.

Main Snow Dump

Five test pits were excavated at the Main snow dump. Test pits MSD-1 through –4 were excavated downslope of the snow dump, between the melting front and the ocean. Test pit MSD-5 was excavated upslope of the snow dump, to provide background metal concentrations in soils for the area. The results of sample analysis are summarized in Table 4 and illustrated in Figures 6 through 8. Photo 6 shows the Main snow dump face, looking north toward the Foldaway Buildings.

The stratigraphy in the vicinity of the Main snow dump consists of beach gravels, sand and stones underlain by bedrock at depths ranging from 0.2 to 0.55m below ground surface. The background concentrations of lead and zinc found in MSD-5 were less than 1,000 ppm. Lead and zinc concentrations in the beach gravels collected from test pits located at the snow dump face exceeded the SQRO's. Test pit MSD-4, located to the west of the snow dump did not contain elevated concentrations of lead and zinc, indicating that the contamination does not extend outside the immediate area of the snow dump face.

Total metal analysis of the samples collected in the vicinity of the snow dump (Table 5) showed that cadmium concentrations exceeded the CCME Tier 1park land guideline in samples collected from test pits MSD-1, -2 and –3, located at the snow dump face.

Foldaway Snow Dump

The foldaway snow dump was diminished to a small remnant at the beachfront as shown in Photo 7. Two test pits were excavated upland of the shoreline in the general area of the foldaway snow dump, F15 and F16 and two grab samples were taken of the remnant snow dump material (FSD-1 and FSD-2).

The results of analysis are shown in Table 4 (lead and zinc) and Table 5 (total metals). The surface samples collected from test pits F15 and F16 contained higher concentrations of lead and zinc than samples collected at depth, although the concentrations did not exceed the SQRO's. The metal concentrations found in the surface grab sample FSD-2 exceeded the SQRO's for both lead and zinc and the CCME Tier 1 soil quality guideline for cadmium. The analysis indicates that this sample contained 13.9% zinc, suggesting that the source of the metal contamination is either concentrate or sulfide mineralization.

Historic Ore Stockpiles

Sulfide mineralized rock was encountered at depth in test pits excavated to delineate the extent of petroleum hydrocarbon contamination in the vicinity of the Firehall diesel tank. The results of analysis (Table 4) for samples collected from test pits FH6, FH7, FH8 and FH10 found zinc concentrations ranging from 2.8% to 22.4% and lead concentrations in the range of 0.5% to 0.8%. Test pits FH6 and FH7 are located within an area designated as a historic ore stockpile, as shown in Figure 6. Test pit FH8 is also located in the vicinity of a historic ore stockpile.

4.2.3 Leachable Lead and Zinc in Soils

Twenty two soil samples were submitted for water leach testing. The results of the testing were intended to provide a measure of the relative mobility and bioavailability of the lead and zinc in the samples, as well as providing an indication of the possible source of the total metal concentrations, such as concentrate or mineralized rock.

Although site-specific regulatory objectives for leachable lead and zinc concentrations at the Polaris Mine site are not available, objectives and standards from other jurisdictions can be used to provide context for the results of leachate testing on samples collected from the mine site. The British Columbia Special Waste Regulation Leachate Quality Standards specify concentrations of 5 mg/L lead and 500 mg/L zinc in waste extracts. The Objectives for the Discharge of Final Effluents to Marine and Fresh Waters from the Pollution Control Objectives for the Mining, Smelting, and Related Industries of BC stipulates a range of 0.05 to 2 mg/L for lead and 0.2 to 1 mg/L for zinc.

Table 6 summarizes the results of water leach testing on soil samples collected from the Polaris Mine site. The relationship of total and leachable lead and zinc concentrations is shown in Graphs 2 and 3. A comparison of leachable sulfate concentrations with leachable concentrations of lead and zinc is depicted in Graph 4.

General Observations and Area Specific Results

- The analytical results generally show that leachable concentrations of zinc are higher than lead. This result is consist with the relative solubility of the two metals, with zinc being more soluble than lead. Zinc is therefore more mobile in the environment.

- Comparison of the leachability results with the BC Pollution Control Objectives indicates that only one sample contains a leachable lead concentration that exceeds the concentration range stipulated. This sample was collected from test pit FH7, excavated within an area designated as a historic ore stockpile. The sample contains visible evidence of sulfide mineralized ore. Leachable zinc in 4 samples exceed the range of zinc concentrations specified by the BC Pollution Control Objectives. Metal concentrations in samples collected from TP154 and TP34, located adjacent to the west side of the Concentrate Storage Building can be attributed to metal concentrates. The sample collected from the Main snow dump (MSD-2) also likely contains metal concentrates that have been scraped off the ground surface during snow removal operations. The fourth sample, collected from FH7, was discussed under the lead concentrations and is further discussed below.

- Leachability testing of mineralized samples collected from the historic ore stockpile area showed that a sample collected at 0.6-0.9m from test pit FH7 leached the highest concentrations of lead and zinc of the 22 samples tested. This sample also contained the highest concentration of zinc (19.6%) and the highest sulfide level (15.3%) of samples tested. Based on the evidence of mineralization in this sample, it is not considered representative of the majority of the samples tested.

- Soil/rock samples collected from the Accommodations hillslope contained low levels of leachable lead and zinc. Soil samples collected from slopes on the west side of Loon Lake also contained low levels of leachable lead and zinc. The leachable concentrations were significantly less than the BC Pollution

Control Objectives for Discharge of Final Effluents. The results of leachability testing indicate that the total metal concentrations reported for these areas do not pose a significant risk to the environment.

- Leachate testing of samples collected in the rockfill area to the west of the Concentrate Storage Building generally contained low levels of leachable lead and zinc. The surface sample collected from TP149 contained lower levels of total metals but higher levels of leachable lead and zinc than the deeper sample from the same test pit. This result suggests that the source of metals in the surface sample at TP149 was likely mineral concentrates that are readily leachable.

4.3 Water Quality

The primary chemicals of concern for water quality assessment are light extractable petroleum hydrocarbons and dissolved zinc. The focus is placed on these two parameters because they are generally indicative of the suite of parameters under consideration. The sample locations are illustrated on Figure 2 and the analytical data is summarized in Tables 7 and 8. The laboratory reports and results of QA/QC analysis are provided in Appendix A.

4.3.1 General Surface Water Samples

Surface water samples were collected at the outlet of Loon Lake (LL1), at the creek discharge into North Bay (NB1) and in Little Red Dog Quarry (LRD) as illustrated on Figure 2. The LRD sample was collected by Polaris mine personnel. A summary of selected parameters and the field data is provided in Table C.

The surface water samples that were collected at the outlet of Loon Lake (LL1) and at the creek discharge into North Bay (NB1) showed good water quality and reflected the effects of surface activities and natural run off along the creek path. The water quality data suggested no immediate concerns regarding the quality of water in the creek.

The data indicated that the water at the outlet of Loon Lake was warmer and softer than at the discharge into North Bay. The increase in flow and reduction in water temperature from LL1 to NB1 may suggest the influence of additional water sources from runoff the creek path. The increase in conductivity and hardness from LL1 to NB1 suggests the influence tidal activity in North Bay or surface runoff through the shale rocks in the area. The concentration of total zinc was less at the outlet of Loon Lake (0.08 mg/L) than at the discharge into North Bay (0.15 mg/L) which may be related to the influence of run off over the shale rocks in the old quarry or run off from the CRF plant and area.

Table C. Field Data and Selected Parameters for General Surface Water Samples

	LL1	NB1	LRD

Date Collected	Aug 1&2	Aug 1&2	July 7
Flow	~1 Lps	~3 Lps	-
Field pH	8.4	8.4	-
Field Temp	13.4 C	6.2 C	-
Field Conductivity	1127 uS	2061 uS	-
Field Salinity	0.7 ppt	1.7 ppt	-
Hardness – CaCO3	540 mg/L	929 mg/L	737 mg/L
Total Zinc	0.079 mg/L	0.147 mg/L	0.030 mg/L
Ammonia – N	-	-	6.63 mg/L

The water quality in Little Red Dog quarry (LRD) was good with moderate conductivity and low zinc for the area. The concentration of ammonia was slightly elevated which is as expected for a blasting area using nitrogen based explosives. The concentration of ammonia will decrease rapidly following the cessation of blasting activities in the quarry due to the elimination of the ammonia source and due to decommissioning contouring that will prevent the ponding of water in the pit bottom where residual blasting agents are currently accumulated. Additionally, filling, covering and contouring for decommissioning of the quarry will allow the pit bottom to freeze into permafrost.

4.3.2 Water Samples in the Vicinity of the Process Barge

Ground water samples in the vicinity of the process barge were collected from the boreholes installed in 1999, where boreholes were not dry or contained frozen water. Samples were collected from boreholes BH1, BH5, BH6, BH7, TP5 and two samples were collected from the barge pumping sump as illustrated on Figure 2. The barge sump samples were collected by Polaris mine personnel. A summary of selected parameters and the field data is provided in Table D.

Two surface water samples were also collected in the vicinity of the process barge as a means of further identifying the occurrence of contaminants in the area. The samples were collected from the run off collection sump (truck box) located at the east side of the barge area below the main entrance (ROSUMP) and from the large pool of standing water just east of the ship dock area (ROPOND). Field parameters were recorded for the ocean adjacent to the north end of the ship dock area (OCEAN). The locations are illustrated on Figure 2. A summary of selected parameters and the field data are listed in Table D.

The data generally indicate the presence of elevated concentrations of dissolved zinc and light extractable petroleum hydrocarbons (LEPH), in most of the sampled boreholes. A hydrocarbon odor was clearly evident at some locations. These results correspond reasonably well to previous (1999) data.

Field data for the ocean were collected (Table D) for comparison with location ROPOND. The water level the ROPOND was visually close to sea level and the field data verify that there is no discernible hydraulic connection between the two locations.

Table D. Field Data and Selected Parameters for Water Samples in the Vicinity of the Process Barge

	BH1	BH5	BH6	BH7	TP5	Barge Sump
Date Collected	Aug 1	Aug 1	Aug 1	Aug 1	Aug 2	July 7
Static Water Level	1.69 m	0.77 m	1.38 m	1.63	2.55 m	-
Appearance	-	-	sl turbid	v turbid	st hyd odour	-
Field Ph	7.4	7.7	6.9	6.6	7.6	-
Field Temp	1.2 C	2.3 C	1.9 C	1.5 C	5.5 C	-
Field Conductivity	1604 uS	3765 uS	1524 uS	3374 uS	1208 uS	-
Field Salinity	1.5 ppt	3.5 ppt	1.4 ppt	3.3 ppt	1.0 ppt	-
Hardness – CaCO3	1710 mg/L	2720 mg/L	1550 mg/L	452 mg/L	887 mg/L	928 mg/L
Dissolved Zinc	8.80 mg/L	1.64 mg/L	0.063 mg/L	90.6 mg/L	5.86 mg/L	0.658 mg/L
EPH10-19	-	1.2 mg/L	34.1 mg/L	49.5 mg/L	4.9 mg/L	-
EPH19-32	-	2 mg/L	4 mg/L	5 mg/L	<1 mg/L	-

Table D (cont'd). Field Data and Selected Parameters for Water Samples in the Vicinity of the Process Barge

	Barge Sump	ROSUMP	ROPOND	OCEAN
Date Collected	Aug 26	Aug 1&2	Aug 1&2	Aug 1
Static Water Level	-	50% full	Falling	-
Appearance	-	not pumping	not pumping	-
Field pH	-	8.0	7.7	-
Field Temp	-	2.8 C	7.4 C	1.8 C
Field Conductivity	-	678 uS	3260 uS	17.35 mS
Field Salinity	-	0.6 ppt	2.6 ppt	18.7 ppt
Hardness – CaCO3	834 mg/L	393 mg/L	1910 mg/L	-
Dissolved Zinc	3.35 mg/L	1.01 mg/L	1.55 mg/L	-
EPH10-19	2.7 mg/L	0.7 mg/L	0.8 mg/L	-
EPH19-32	2 mg/L	<1 mg/L	<1 mg/L	-

The greatest concentrations of LEPH in the vicinity of the process barge were observed in 2000 in boreholes BH7 near the geology core shack (49.5 mg/L), BH6 in the laydown area near the roadway (34.1 mg/L), the barge pumping sump (22.7 mg/L in July and 2.7 mg/L in August), and TP5 adjacent to the east side of the barge (4.9 mg/L). The lowest concentrations of LEPH were observed in 2000 in the run off sump located on the east side of the barge below the main entrance (ROSUMP, 0.7 mg/L), the standing pool at the bottom of the ramp to the dock (ROPOND, 0.8 mg/L) and in borehole BH5 at the bottom of the ramp to the dock (1.2 mg/L). Analysis for LEPH was not conducted for borehole BH1 near the northwest corner of the Benthorn building but would be expected to be in the higher range based on visual observations and 1999 data.

This distribution of LEPH corresponds reasonably with the general expectation that greater concentrations would be present in areas of high activity involving hydrocarbons such as in close proximity to the barge and heavily used roadways. The significant differences in concentrations of LEPH suggest that there is little mixing of the groundwater throughout the area. The difference in concentrations of LEPH in the barge pumping sump between the July and August samples suggests that this location is strongly influenced by activities in the immediate area or to periodic inflows from various sources.

The greatest concentrations of dissolved zinc in the vicinity of the process barge were observed in 2000 in boreholes BH7 near the geology core shack (90.6 mg/L), BH1 near the northwest corner of the Benthorn building (8.8 mg/L), TP5 adjacent to the east side of the barge (5.86 mg/L) and in the barge pumping sump (0.658 mg/L in July and 3.35 mg/L in August). The lowest concentrations of dissolved zinc were observed in 2000 borehole BH6 in the laydown area near the roadway (0.063 mg/L), in the run off sump located on the east side of the barge below the main entrance (ROSUMP, 1.01 mg/L), the standing pool at the bottom of the ramp to the dock (ROPOND, 1.55 mg/L) and in borehole BH5 at the bottom of the ramp to the dock (1.64 mg/L).

This distribution of dissolved zinc corresponds reasonably well with the general expectation that greater concentrations would be present in areas of high activity involving concentrates or ore such as near the geology core shack and in close proximity to the barge. The concentrations of dissolved zinc further from the barge (BH5, for example) are reduced but remain significant nonetheless and verify that the distribution of elevated concentrations includes the entire area. As above, the significant differences in concentrations of dissolved zinc suggest that there is little mixing of the groundwater throughout the area. Also, the difference in concentrations of dissolved zinc in the barge pumping sump between the July and August samples suggests that this location is strongly influenced by activities in the immediate area or to periodic inflows from various sources.

The presence of a slightly elevated concentration of dissolved zinc in the run off collection sump (truck box location ROSUMP) may be the result of any or a combination of natural mineralization on the upslope hillside, rusting of galvanized metal in the truck box, or airborne distribution of metal rich dust from general activities.

The very similar water quality for borehole BH5 and the adjacent standing pool of water (ROPOND) verifies that the standing water is hydraulically connected to the local area groundwater and not solely to precipitation and not to the ocean. Observed corresponding changes in the water levels in borehole BH5 and in the standing pool provided further verification.

The analytical data for samples in the vicinity of the process barge in 2000 were reasonably similar to corresponding sample data from 1999. This further confirms the general comments regarding the occurrence and distribution of contaminants. The most significant differences between 1999 and 2000 data are increases in the concentrations of dissolved zinc and nitrite nitrogen in the barge pumping sump, and an increase in the concentration of dissolved zinc in borehole BH6. The differences in the barge pumping sump may simply provide further verification that water quality at this location is strongly influenced by activities in the immediate area or by periodic inflows from various sources. The differences at borehole

BH6 are likely not suggestive of an increasing trend because there are no trends evident for other parameters.

4.3.3 Water Samples in the Vicinity of the Oil Bladder and Landfill Areas

One ground water sample was collected from a 1999 borehole in the landfill area (TP61), one water sample was collected from a small seep emerging to surface near the toe of the operational landfill area between TP138 and TP59 (LF1), and two water samples were collected from 2000 test pits located near the bottom of the oil bladder area (TP132 and TP140) as illustrated on Figure 2. A summary of selected parameters and the field data are listed in Table E.

All other 2000 test pits at the toe of the operational landfill were dry including TP141, TP139, TP138 and TP137. All other 1999 groundwater monitors were dry or frozen at the time of sampling in 2000 including TP57, TP55, TP52 and TP59.

Table E. Field Data and Selected Parameters for Water Samples in the Vicinity of the Oil Bladder and Landfill Areas

	TP61	LF1	TP132	TP140
Date Collected	Aug 1&2	Aug 2	Aug 1&2	Aug 2
Static Water Level / Flow	1.23 m	~1 Lps	test pit 50% full	test pit 50% full
Appearance	-	St hyd odour	sheen; st hyd odour	st hyd odour
Field pH	-	8.0	7.8	7.4
Field Temp	-	3.6 C	8.7 C	4.4 C
Field Conductivity	-	1618 uS	2650 uS	3051 uS
Field Salinity	-	1.4 ppt	2.1 pt	2.7 ppt
Hardness – CaCO3	1250 mg/L	1220 mg/L	2030 mg/L	2170 mg/L
Dissolved Zinc	0.017 mg/L	0.195 mg/L	0.020 mg/L	0.093 mg/L
EPH10-19	<0.3 mg/L	<0.3 mg/L	9.9 mg/L	2.4 mg/L
EPH19-32	<1 mg/L	<1 mg/L	<1 mg/L	1 mg/L

The water samples in the oil bladder and landfill areas confirm the general expectation of highly localized hydrocarbon contamination related to activities related to the oil bladder and landfill operations. The data suggest that the concentrations of hydrocarbons in ground water are generally less than in the vicinity of the process barge. Samples at locations TP61 and TP132 will reflect activities related primarily to the oil bladder area while samples at locations TP140 and seepage LF1 may include influences from the operational landfill area.

The concentrations of LEPH in TP61 (<0.3 mg/L) and TP132 (9.9 mg/L) reflect the highly localized nature of the contamination. A similar observation can be made regarding TP140 (2.4 mg/L) and seepage LF1 (<0.3 mg/L). The concentrations of dissolved zinc at all sampled locations are relatively low. The observation that concentrations of dissolved zinc are greater at locations TP140 and seepage LF1 (0.093

and 0.195 mg/L, respectively) than at locations TP61 and TP132 (0.017 and 0.02 mg/L, respectively) suggests that activities at the operational landfill area may be represent a small source of zinc.

The data for location TP61 in 2000 are reasonably similar to the data previously collected in 1999 and there is no apparent trend in parameter concentrations.

5. Vegetation / Soil Quality

Monitoring of metal concentrations in vegetation was conducted in 1975 (by B.C. Research Inc.) and in 1999 and 2000 (by Gartner Lee Limited). This has allowed a comparison of pre-mining and mining conditions to be developed. C.E. Jones & Associates Ltd. was retained, on behalf of Cominco Ltd., to review the 1999 and 2000 vegetation and soil quality data. The report prepared by C.E. Jones & Associates Ltd. is appended (Appendix C) and is summarized below.

The objectives of the data review were to:

1. Determine whether lead and zinc levels in vegetation are elevated in comparison to background levels from the Polaris site, and in comparison to other sites
2. Determine the source of metals additions, if elevated levels are detected
3. Determine the distribution of elevated metals levels in vegetation in relation to the mine

The data analysis focussed primarily on lead and zinc to evaluate the potential effects of deposition of wind borne particulates transported from the Polaris Mine lead-zinc facility to the surrounding lands. The analytical results for metal concentrations in vegetation and soil samples is summarized in Tables 9A and 9B, respectively. The laboratory reports and QA/QC data are provided in Appendix A.

The comparison of pre-mining to post mining concentrations of metals in vegetation revealed that concentrations of lead and zinc in all three species sampled were greater in 1999/2000 than in 1975 with the exception of zinc in one species, willow foliage, where a slight apparent average increase was shown to be statistically insignificant. The 1999/2000 concentrations of lead and zinc were shown to be elevated above “normal” concentrations for undisturbed sites across Canada.

The probable primary sources of contaminants in vegetation differed for lead and zinc. For lead, the analysis suggested that airborne distribution from the mine site is the primary source. For zinc, the analysis suggested that both airborne distribution and uptake from naturally mineralized soils are sources. These conclusions are based on the distribution of lead between roots and foliage of willow and between lichen and the other, rooted, species.

Lead and zinc were determined to be distributed equally throughout a radius around the mine site with no preference for a dominant wind direction. The concentrations of lead and zinc were observed to decrease with distance from the mine site. The radius to which the 1999/2000 concentrations of lead and zinc in vegetation were estimated to remain greater than the 1975 concentrations was estimated at approximately 4,400 to 4,700 metres.

Qualitative observations by GLL staff during the field programs conducted in 1999 and 2000 indicate that the plant communities do not appear to be negatively impacted by the mine site operations. The plant communities as described by the vegetation mapping units established by BC Research (1975) for the pre-mine baseline environmental assessment were found to contain a similar assemblage of species and were found to occur over comparable areas of the land.

Lead and zinc concentrations in soil samples were collected at each vegetation sampling location at three depths (0-1cm, 1-5cm, and 5-10cm).

The average concentrations of lead in soil for each depth were relatively uniform with depth. Only two sample concentrations of lead exceeded the Federal regulatory guideline for parkland use (140 ppm): the surface samples at location I within the active mining area and location E near to the active mining near sea level. This data supports the conclusion that the primary source of lead in vegetation is airborne dispersion.

The average concentrations of zinc in soil for each depth were elevated above the concentrations normally found in non-mineralized surface soils and the average concentration of zinc at surface was greater than at depth. Approximately 25% of the soil samples exceeded the Federal CCME Tier 1 soil quality guidelines for park land use (200 ppm) including samples at all depths at location K, located farthest from the mine site on the west hillslope above Frustration Lake. This data further confirms that naturally occurring mineralization is a significant source of zinc throughout the study area.

6. Other Work

6.1 Inspection of the Oil Tank Farm Liner and Perimeter Containment Dyke

The tank farm liner and perimeter containment dyke were visually inspected on August 1, 2000. Photo 11 shows the general arrangement of the tank farm.

The dyke crest and the liner were found to be in generally good condition although there were several areas where the liner had been exposed, torn or separated or where the crest of the perimeter containment dyke had been eroded, particularly along the east (back) limb of the perimeter containment dyke.

A physical sample of the liner was not recovered during the inspection. Given that the mine is scheduled for shut down within two years, it is recommended that physical testing for information purposes would be better conducted at that time.

Observations

On the internal face of the east limb of the perimeter containment dyke, the liner was exposed in several locations, a join of liner sections was opened in one location exposing the underlying soil and the liner was torn in one location. An open join was observed on the internal face near the north end that appeared to be related to uncontrolled surface flow that had also eroded a notch approximately 0.6 metres deep into the dyke crest (photo 12). An additional area of the liner was exposed in this location due to slumping of the protective soil cover. A tear was observed near the internal toe of the dyke near the south end of the east limb and water was flowing into the sump from beneath the liner via the tear at an estimated flow rate of 0.5 litres per second (photos 13 and 14). Green algae was visible along the flow path towards the centre of the sump. The crest of the perimeter dyke had also been eroded to a notch approximately 0.6 metres deep in this location. The reason that the east limb of the perimeter containment dyke and liner was in the poorest condition was likely due to uncontrolled run off water from the hillside above the tank farm.

The liner along the internal faces of the other limbs of the perimeter containment dyke was exposed in several locations but with no apparent effects on the integrity of the liner (photo 15). A partial tear was observed in the liner on the internal face of the north limb of the perimeter containment dyke where the surface layer of the liner was pulled back from the central core (photo 16). Minor longitudinal cracking was observed on the dyke crest in several locations and was most pronounced along the east and north limbs.

The fuel inflow pipe plus one smaller pipe were set into a cross trench on the north limb of the perimeter containment dyke. The pipes were partially wrapped in liner material. A small diameter vertical pipe was teed into the inflow pipe.

A sump dewatering arrangement was observed but not operating at the south end of the sump area wherein water that collected in the sump was apparently pumped intermittently from the south end (photo 17).

The external faces and toes of the perimeter containment dyke were found to be in good condition with the exceptions of the erosion along the east (back) limb as described above.

6.2 Electrical Transformer Oil Sampling and Analysis

The inspection of the mine facilities conducted in 1999 determined that the inventory of electrical transformers at the Polaris site included both dry-type and oil-filled units. There are 33 oil-filled transformers of which 26 are in use on the heat-traced tailings and freshwater lines and 7 are spares kept in a storage container.

Under the federal *Environmental Contaminants Act* and the *Chlorobiphenyls Regulation,* PCB-containing transformers have not been imported into Canada since July 1980, and use of such equipment has been restricted to units existing in Canada prior to that date.

Documentation reviewed at the mine indicated that all the transformers were manufactured in 1980 and 1981; however, information on the oil type was not available. Attempts to contact the original manufacturer to obtain information on the oil type were unsuccessful. Accordingly, oil samples were collected from 4 of the stored transformers in 1999 and 7 of the in-service transformers in 2000 and analyzed to determine the concentrations of chlorobiphenyls. The samples were collected to be representative of groups of sequential serial numbers.

The results of chlorobiphenyl analysis of the stored transformers was reported in the 1999 ESA. PCBs were not found in the oil samples collected from the stored transformers.

Table 10 shows the results of the laboratory analysis of oil samples collected from the in-service transformers. The results of analysis indicate that PCBs were not found in the oil samples collected from transformers in use and in storage at the Polaris mine site.

7. Recommendations for Remediation

The environmental site investigations completed in 1999 and 2000 have identified and delineated the extent of contamination in several areas of the active mine site where petroleum hydrocarbons from the storage, use and disposal of fuels and oil and lead and zinc from the mining operations are present at concentrations that exceed the Federal and Territorial guidelines, objectives and standards. Cominco Ltd. has targeted these areas of contamination for remediation to remove the source of the elevated chemical concentrations and to restore the soil quality to acceptable levels for human health and the environment.

Figure 9 illustrates the areas of the Polaris Mine site that have been targeted for remediation to remove petroleum hydrocarbon or lead and zinc contaminated soils. The nature and extent of soil contamination in these areas is summarized below:

Lead and Zinc Contaminated Areas

Areas of the Polaris Mine site targeted for remediation on the basis of lead and zinc concentrations are shown on Figure 9 and described below. The proposed remediation method for areas containing elevated concentrations of metals will involve excavation and disposal of the contaminated soil and rockfill to the underground mine. The disposal area will be deep within the zone of continuous permafrost in the mine.

Tailings Line Breaks and Tailings Spill Area Southwest of the Thickener Building:
Site investigations conducted in 1999 delineated the extent of lead and zinc contamination associated with documented areas of tailing line breaks and the location of a spill in the vicinity of the tailings thickener building. The estimated volume of lead and zinc contaminated material is 3,000 cubic meters.

Old Crusher Location:
The old crusher is located north of the detonator magazines. The crusher has most recently been used for hand sorted lead ore project described below. The volume of lead contamination has not been estimated. Lead ore contamination in the vicinity of the surface crusher will be excavated and disposed underground.

Lead Ore Stockpile Location at the North Portal:
A recent area used for surface stockpiling of mined ore is associated with the mining of lead ore. The surface waste dump at the North Portal has been used as a temporary storage for this material. The lead ore stockpiles were hand sorted, crushed in the surface crusher and shipped in bulk bags inside sea containers. The volume of lead ore contamination has not yet been estimated. These areas of lead ore contamination will be excavated and disposed underground.

Snow Dumps: Only surface samples appear to be contaminated with lead and zinc in the vicinity of the snow dumps. The metal contaminated zone does not extend beyond the melting front of the snow dumps. Cleanup is recommended over a minimum 0.1m interval beneath and immediately adjacent to the snow dumps. The shoreline area adjacent to the Foldaway snow dump will also require remediation. The volume of lead and zinc contaminated soil requiring cleanup from the Loon Lake, Main and Foldaway snow dumps is estimated to be 3,500 cubic meters.

Historic Ore Stockpiles:

The site investigations conducted in 1999 and 2000 found evidence of mineralized sulfide rock in test pits excavated near the Fire Rescue Training Building. Remediation of these areas will consist of either re-milling this ore or disposing to the underground.

Barge and Concentrate Storage Building Area:

The soil sampling and analysis programs conducted in 1999 and 2000 have identified lead and zinc contaminated areas in the vicinity of the Barge (mill and concentrator) and the Concentrate Storage Building. This area represents the largest source of contamination with metals from various sources, including: storage, handling, spilling and tracking of concentrates, as well as wind borne air dispersion of particulates from the concentrate drier emissions. The estimated volume of lead and zinc contaminated soil is 85,000 cubic meters.

Petroleum Hydrocarbon Contaminated Areas

The preferred remediation option for petroleum hydrocarbon contaminated soils is excavation and permanent disposal deep in the underground mine within the zone of continuous permafrost. Free-phase petroleum hydrocarbons have not been encountered during testing; however, if such contamination is found during the excavation of contaminated soils, provision will be made to segregate the oil and either place it into drums for shipment off-site or incinerate the oil on site according to appropriate procedures. Free phase petroleum hydrocarbons would not be disposed to the underground mine workings.

CRF Plant Historic Above Ground Fuel Tanks:

Contaminant observations and the results of EPH analysis of soil samples collected at the CRF plant area showed that petroleum hydrocarbon contamination in excess of the Yukon CSR standards is present in the vicinity of two former AST installations, located at the west and south sides of the building. The hydrocarbon contamination extends through the thickness of the active layer to the depth of continuous permafrost, at approximately 1.1m below ground level. Step-out soil sampling conducted in 2000 confirmed the localized nature of the hydrocarbon contamination.

The volume of petroleum contaminated soil requiring remediation to meet YTG residential/parkland standards in the vicinity of the former above ground fuel storage tanks at the CRF plant is estimated to be approximately 100 cubic metres.

Quonset Huts:

The site investigation conducted in 1999 identified hydrocarbon stained soil within the Quonset Hut where refueling facilities consist of hand pump attached to fuel drums. The extent of contamination is localized to the immediate area of refueling. This area of hydrocarbon contamination should be remediated by excavation and disposal following mine closure.

Former Oil Bladder Storage Area:

Bladders of oil were stored during the construction phase of the mine site in an area southeast of the airstrip. Anecdotal information indicated that a spill incident had occurred in this area in 1980 or 1981. Petroleum hydrocarbon contamination was found to occur within the saturated interval of the active layer, generally from 0.4 to 0.6 metres below ground level to the depth of continuous permafrost at 0.8 to 1m. Step-out soil sampling conducted in 2000 showed that the petroleum hydrocarbon contamination extended from the former oil bladder storage area, south across the roadway and down the slope, terminating at the upper bench of the landfill.

The volume of petroleum contaminated soil requiring remediation within the historic spill area and downgradient locations is estimated to be approximately 12,000 cubic metres.

Foldaway Diesel Tank Storage:

The subsurface investigation conducted in July 1999 identified an area of petroleum hydrocarbon contaminated soil adjacent to the above ground diesel tank at the Foldaway Buildings. Hydrocarbon odors and staining as well as elevated concentrations of petroleum hydrocarbon concentrations were present from the ground surface to the top of the permafrost layer. Step-out soil sampling conducted in 2000 identified other areas of contamination in the vicinity of the Foldaway Buildings and delineated the extent of petroleum hydrocarbon contamination.

The volume of petroleum contaminated soil requiring remediation in the vicinity of the Foldaway Buildings fuel storage tank is estimated to be 2000 cubic metres.

Accommodations Diesel Tank Storage:

Soil contamination was identified in the vicinity of the aboveground diesel tank located at the rear (northeast corner) of the Accommodation Building. Step-out test pit locations were excavated and the volume of soil contaminated with petroleum hydrocarbon at concentrations that exceed the Yukon CSR standards for parkland use is 500 cubic meters.

Firehall Diesel Tank Storage:

Diesel fuel contamination in soil at a location directly adjacent to the aboveground storage tank at the firehall was identified during the subsurface investigation conducted in July 1999. Step-out sampling locations investigated in 2000 found that the petroleum hydrocarbon contamination extended to the Fire Rescue Building to the northwest of the Firehall.

The volume of petroleum contaminated soil requiring remediation in the vicinity of the firehall fuel storage tank is estimated to be approximately 2000 cubic metres.

Barge Area Fuel Contamination:

Site investigations conducted in 1999 identified petroleum hydrocarbon contamination within the active layer surrounding the process barge. Due to differential heating of the permafrost adjacent to the barge walls, the thickness of the active zone and therefore the zone of petroleum hydrocarbon contamination in the rockfill and seepage water increased to over 3 meters at test hole locations directly adjacent to the barge walls. The process barge area contains multiple sources of petroleum hydrocarbons including: fuel stored in the hull of the barge, a day tank adjacent to the west side of the barge, the vehicle fuelling tank at the northwest corner of the barge, the Bent Horn conditioning building, and a waste oil collection tank outside the maintenance bay on the north side of the barge.

The volume of petroleum contaminated soil requiring remediation within the process barge area is estimated to be 20,000 cubic metres.

Tailings Thickener Fuel Storage Tank:

The soil immediately around the fuel storage tank located at the Tailings Thickener building is suspected of hydrocarbon contamination based on the nature of the activities carried out. Cominco will investigate and remediate soils at this location during mine decommissioning activities following mine closure.

8. References

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LEGEND

SOURCE OF DRAWING:
GSC MAP D1880A (1996) CD DIGITAL MAP
PROJECTION:
LAMBERT CONIC CONFORMAL
NAD 27
UNITS METRES

DRAWING INFORMATION:	
DESIGNED BY:	AJK
REVIEWED BY:	AJK/EHG
DRAWN BY:	CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20-930
FILE NAME:	20930-D2-01.DWG
REVISION:	0

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POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

LOCATION MAP

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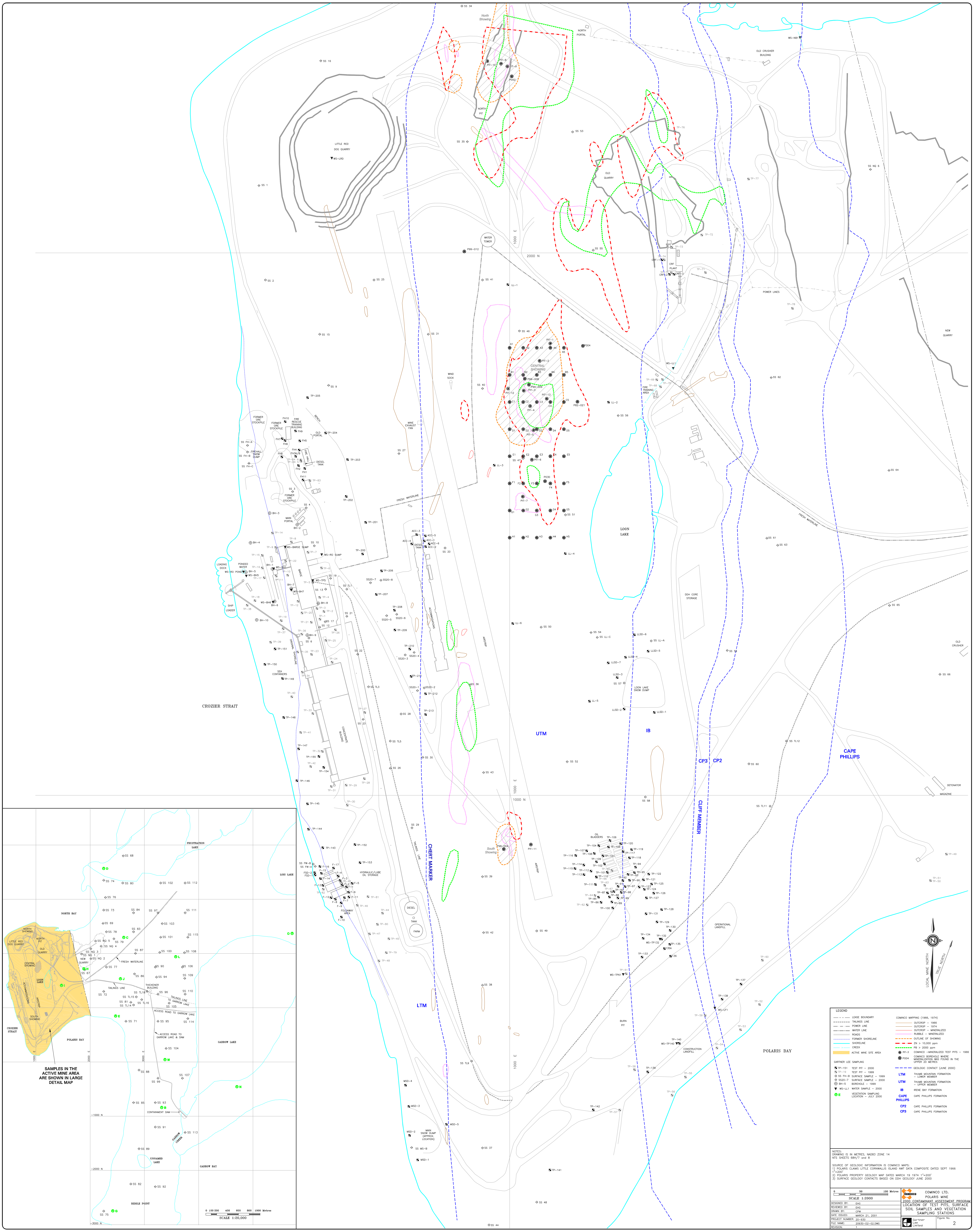
Lee
Limited

Figure No.
1



LEGEND

— — —	LEASE BOUNDARY
▬▬▬	TAILINGS LINE
— · —	POWER LINE
— ▪ —	WATER LINE
═══	ROADS
- - - -	FORMER SHORELINE
───	SHORELINE
— > —	CREEK
🟨	ACTIVE MINE SITE AREA

GARTNER LEE SAMPLING

▣ TP–151	TEST PIT – 2000
▣ TP–19	TEST PIT – 1999
◇ SS FH–B	SURFACE SAMPLE – 1999
◇ SS20–7	SURFACE SAMPLE – 2000
⊕ BH–5	BOREHOLE – 1999
▼ WS–LL1	WATER SAMPLE – 2000
Ⓥ E	VEGETATION SAMPLING LOCATION – JULY 2000

COMINCO MAPPING (1966, 1974)

───	OUTCROP – 1966
───	OUTCROP – 1974
───	OUTCROP – MINERALIZED
┊┊┊┊	RUBBLE – MINERALIZED
— · —	OUTLINE OF SHOWING
▬ · ▬	ZN > 10,000 ppm
▪▪▪▪	PB > 2000 ppm
◉ PIT–3	COMINCO –MINERALIZED TEST PITS – 1966
⊛ P004	COMINCO BOREHOLE WHERE MINERALIZATION WAS FOUND IN THE UPPER 20 METRES
— — —	GEOLOGIC CONTACT (JUNE 2000)
LTM	THUMB MOUNTAIN FORMATION – LOWER MEMBER
UTM	THUMB MOUNTAIN FORMATION – UPPER MEMBER
IB	IRENE BAY FORMATION
CAPE PHILLIPS	CAPE PHILLIPS FORMATION
CP2	CAPE PHILLIPS FORMATION
CP3	CAPE PHILLIPS FORMATION

NOTES:
DRAWING IS IN METRES, NAD83 ZONE 14
NTS SHEETS 68H/7 and 8

SOURCE OF GEOLOGIC INFORMATION IS COMINCO MAPS:
1) POLARIS CLAIMS LITTLE CORNWALLIS ISLAND NWT DATA COMPOSITE DATED SEPT 1966 1"=200'
2) POLARIS PROPERTY GEOLOGY MAP DATED MARCH 19 1974 1"=200'
3) SURFACE GEOLOGY CONTACTS BASED ON DDH GEOLOGY JUNE 2000

0 50 100 Metres
SCALE 1:2000

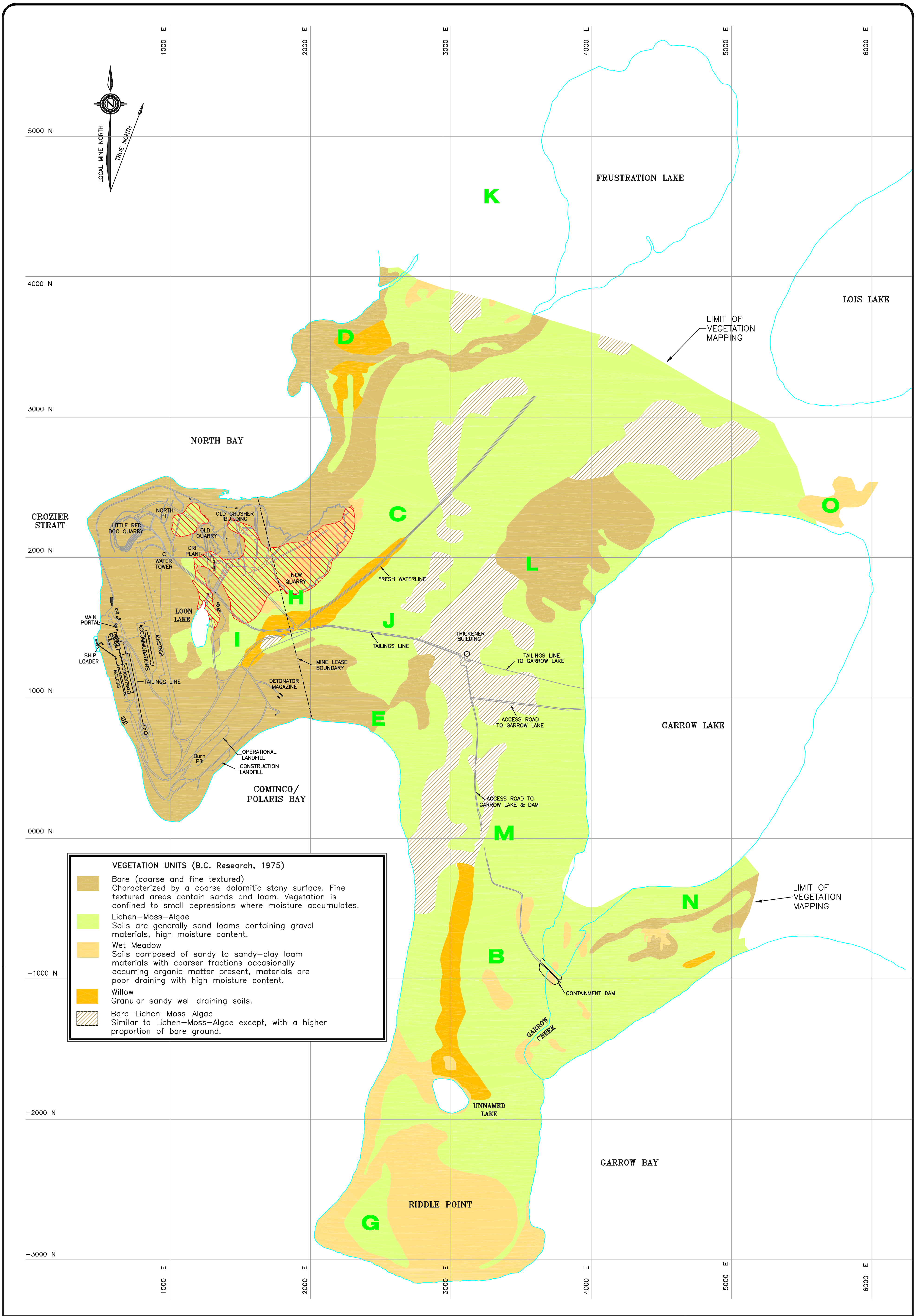
COMINCO LTD.
POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

LOCATION OF TEST PITS, SURFACE SOIL SAMPLES AND VEGETATION SAMPLING STATIONS

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	CPW
DATE ISSUED:	MARCH 21, 2001
PROJECT NUMBER:	20–930
FILE NAME:	20930–D2–02.DWG
REVISION:	1

Gartner Lee Limited

Figure No. 2



VEGETATION UNITS (B.C. Research, 1975)

🟫	Bare (coarse and fine textured) Characterized by a coarse dolomitic stony surface. Fine textured areas contain sands and loam. Vegetation is confined to small depressions where moisture accumulates.
🟩	Lichen–Moss–Algae Soils are generally sand loams containing gravel materials, high moisture content.
🟨	Wet Meadow Soils composed of sandy to sandy–clay loam materials with coarser fractions occasionally occurring organic matter present, materials are poor draining with high moisture content.
🟧	Willow Granular sandy well draining soils.
▨	Bare–Lichen–Moss–Algae Similar to Lichen–Moss–Algae except, with a higher proportion of bare ground.

LEGEND

A	VEGETATION SAMPLING LOCATION GLL JULY 2000
▨	AREA OF VEGETATION LOSS 445,322 sq.m.

ORIGINAL IN COLOUR

0 200 1000

metres

Scale 1:25,000

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	BB/CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20–930
FILE NAME:	20930–D2–03.DWG

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POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

SITE PLAN SHOWING MAJOR VEGETATION UNITS, 2000 SAMPLING AND AREA OF VEGETATION LOSS DUE TO MINE OPERATIONS

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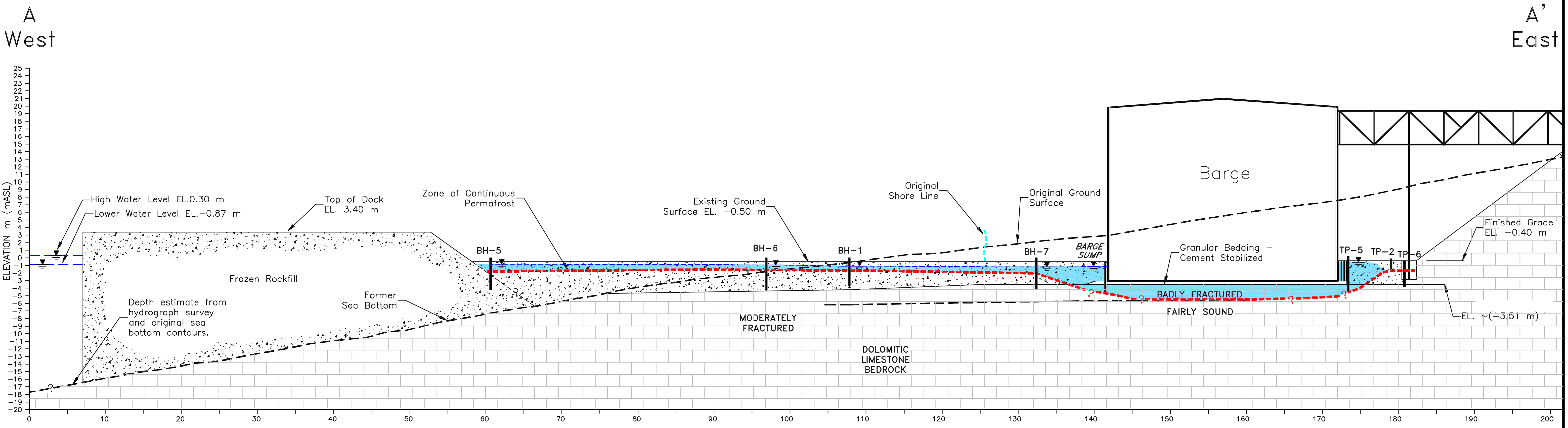
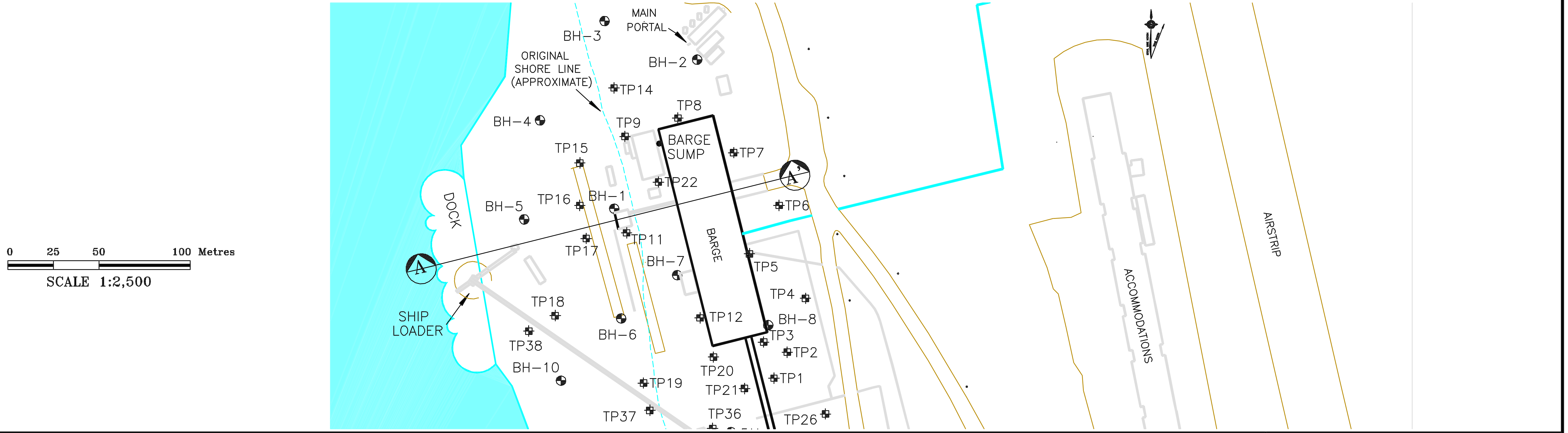
Limited

Figure No.
3



Scale 1:500 (approximate)



LEGEND:

▼ Water Level Measured August 9, 2000

- - - - Continuous Permafrost Boundary

🟦 Zone Where Groundwater is Liquid on August 9, 2000

NOTES:

1. Cross−section produced from drawing 110−C−116, Bechtel Canada Ltd., Cominco Ltd.
2. Water in test pits represents seasonal melt, measured August 9, 2000.
3. Boreholes and test pits are projected along cross section line.
4. Elevations are in metres, mean above sea level (mASL).
5. Stratigraphic information adapted from Figure 8 Concentrator−Section, Golder 1980.

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	BB/CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20−930
FILE NAME:	20930−D2−08.DWG

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2000 CONTAMINANT ASSESSMENT PROGRAM

CROSS SECTION OF THE
PROCESS BARGE AREA

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Figure No.
4

LEGEND

- LEASE BOUNDARY
- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS
- FORMER SHORELINE
- SHORELINE
- CREEK

TP-151	TEST PIT – 2000
TP-19	TEST PIT – 1999
◇ SS FH-B	SURFACE SAMPLE – 1999
◇ SS20-7	SURFACE SAMPLE – 2000
⊕ BH-5	BOREHOLE – 1999
▼ WS-LL1	WATER SAMPLE – 2000
○	PETROLEUM HYDROCARBON CONTAMINATION OBSERVED
○	HEPH OR LEPH > 1,000 (1999 & 2000 DATA)
○	HEPH OR LEPH 0–1,000 (1999 & 2000 DATA)

NOTES:
DRAWING IS IN METRES, NAD83 ZONE 14
NTS SHEETS 68H/7 and 8

0 50 100 Metres
SCALE 1:2000

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20-930
FILE NAME:	20930-D2-04.DWG
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2000 CONTAMINANT ASSESSMENT PROGRAM

CONCENTRATIONS OF PETROLEUM HYDROCARBONS IN SOIL SAMPLES

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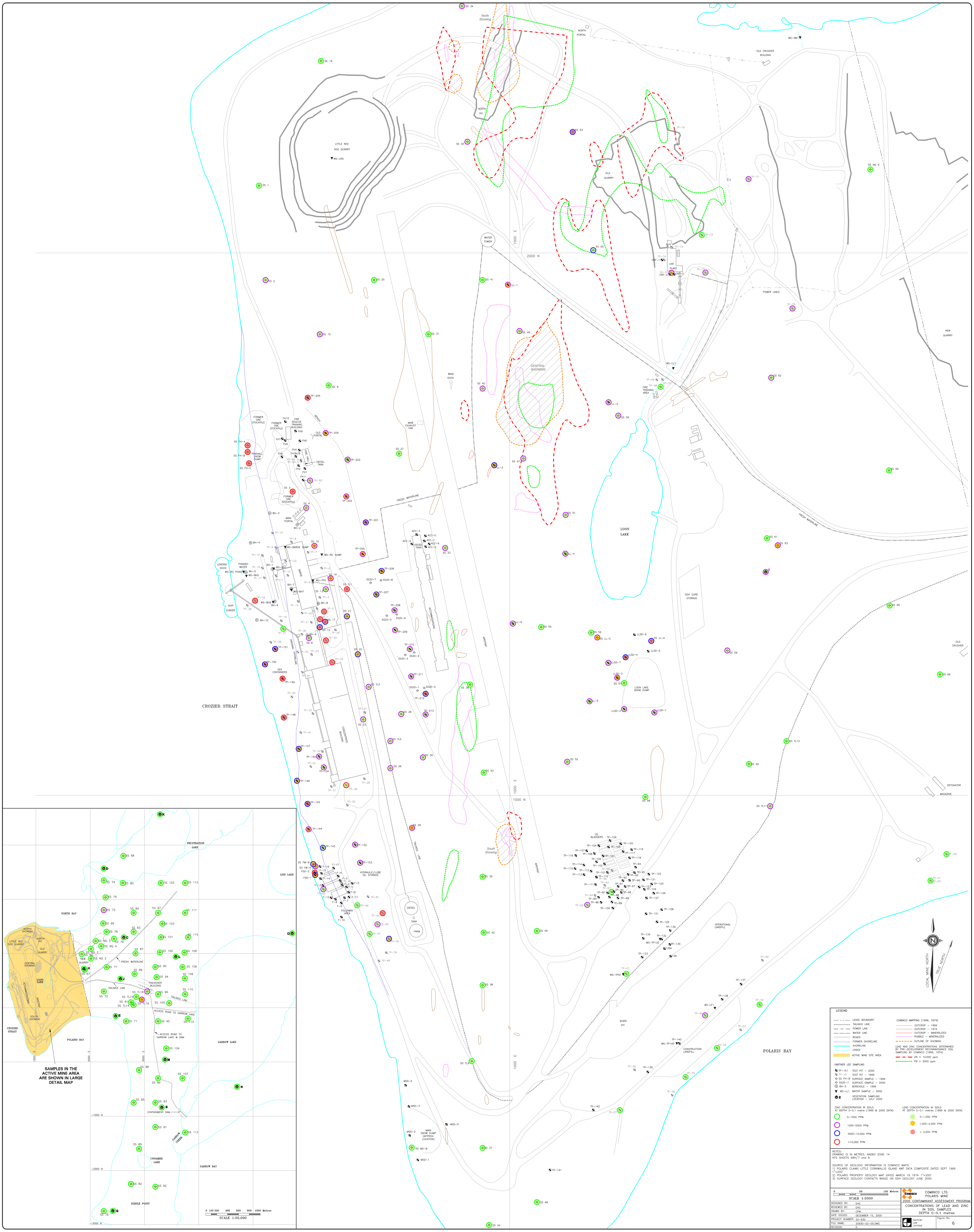
Figure No.
5



SAMPLES IN THE ACTIVE MINE AREA ARE SHOWN IN LARGE DETAIL MAP

LEGEND

- LEASE BOUNDARY
- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS
- FORMER SHORELINE
- SHORELINE
- CREEK
- ACTIVE MINE SITE AREA

COMINCO MAPPING (1966, 1974)

- OUTCROP – 1966
- OUTCROP – 1974
- OUTCROP – MINERALIZED
- RUBBLE – MINERALIZED
- OUTLINE OF SHOWING

LEAD AND ZINC CONCENTRATIONS DETERMINED BY PRE–DEVELOPMENT RECONNAISSANCE SOIL SAMPLING BY COMINCO (1966, 1974)

- ZN > 10,000 ppm
- PB > 2000 ppm

GARTNER LEE SAMPLING

TP–151	TEST PIT – 2000
TP–19	TEST PIT – 1999
SS FH–B	SURFACE SAMPLE – 1999
SS20–7	SURFACE SAMPLE – 2000
BH–5	BOREHOLE – 1999
WS–LL1	WATER SAMPLE – 2000
E	VEGETATION SAMPLING LOCATION – JULY 2000

ZINC CONCENTRATION IN SOILS
AT DEPTH 0–0.1 metre (1999 & 2000 DATA)

- 0–1000 PPM
- 1000–5000 PPM
- 5000–10,000 PPM
- >10,000 PPM

LEAD CONCENTRATION IN SOILS
AT DEPTH 0–0.1 metres (1999 & 2000 DATA)

- 0–1,000 PPM
- 1,000–2,000 PPM
- > 2,000 PPM

NOTES:
DRAWING IS IN METRES, NAD83 ZONE 14
NTS SHEETS 68H/7 and 8

SOURCE OF GEOLOGIC INFORMATION IS COMINCO MAPS:
1) POLARIS CLAIMS LITTLE CORNWALLIS ISLAND NWT DATA COMPOSITE DATED SEPT 1966 1"=200'
2) POLARIS PROPERTY GEOLOGY MAP DATED MARCH 19 1974 1"=200'
3) SURFACE GEOLOGY CONTACTS BASED ON DDH GEOLOGY JUNE 2000

0 50 100 Metres
SCALE 1:2000

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20–930
FILE NAME:	20930–D2–05.DWG
REVISION:	0

Cominco
COMINCO LTD.
POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

CONCENTRATIONS OF LEAD AND ZINC
IN SOIL SAMPLES
DEPTH 0–0.1 metres

Gartner Lee Limited

Figure No. 6

LEGEND

— — — —	LEASE BOUNDARY
- - - -	TAILINGS LINE
— · —	POWER LINE
—·—·—	WATER LINE
═	ROADS
----	FORMER SHORELINE
—	SHORELINE
— > —	CREEK

COMINCO MAPPING (1966, 1974)

—	OUTCROP – 1966
—	OUTCROP – 1974
—	OUTCROP – MINERALIZED
┆┆┆┆	RUBBLE – MINERALIZED
—·—·—	OUTLINE OF SHOWING

LEAD AND ZINC CONCENTRATIONS DETERMINED BY PRE-DEVELOPMENT RECONNAISSANCE SOIL SAMPLING BY COMINCO (1966, 1974)

—·—·—	ZN > 10,000 ppm
------	PB > 2000 ppm

GARTNER LEE SAMPLING

▚	TP-151	TEST PIT – 2000
▚	TP-19	TEST PIT – 1999
◇	SS FH-B	SURFACE SAMPLE – 1999
◇	SS20-7	SURFACE SAMPLE – 2000
⊕	BH-5	BOREHOLE – 1999
▼	WS-LL1	WATER SAMPLE – 2000
Ⓥ E		VEGETATION SAMPLING LOCATION – JULY 2000

ZINC CONCENTRATION IN SOILS AT DEPTH 0.1–0.3 metres (1999 & 2000 DATA)

○	0–1000 PPM
○	1000–5000 PPM
○	5000–10,000 PPM
○	>10,000 PPM

LEAD CONCENTRATION IN SOILS AT DEPTH 0.1–0.3 metres (1999 & 2000 DATA)

●	0–1,000 PPM
●	1,000–2,000 PPM
●	> 2,000 PPM

NOTES:
DRAWING IS IN METRES, NAD83 ZONE 14
NTS SHEETS 68H/7 and 8

SOURCE OF GEOLOGIC INFORMATION IS COMINCO MAPS:
1) POLARIS CLAIMS LITTLE CORNWALLIS ISLAND NWT DATA COMPOSITE DATED SEPT 1966 1"=200'
2) POLARIS PROPERTY GEOLOGY MAP DATED MARCH 19 1974 1"=200'
3) SURFACE GEOLOGY CONTACTS BASED ON DDH GEOLOGY JUNE 2000

0 50 100 Metres

SCALE 1:2000

DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20-930
FILE NAME:	20930-D2-06.DWG
REVISION:	0

COMINCO LTD.
POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

CONCENTRATIONS OF LEAD AND ZINC IN SOIL SAMPLES DEPTH 0.1–0.3 metres

Gartner
Lee
Limited

Figure No.
7

LEGEND

- LEASE BOUNDARY
- TAILINGS LINE
- POWER LINE
- WATER LINE
- ROADS
- FORMER SHORELINE
- SHORELINE
- CREEK

COMINCO MAPPING (1966, 1974)

- OUTCROP – 1966
- OUTCROP – 1974
- OUTCROP – MINERALIZED
- RUBBLE – MINERALIZED
- OUTLINE OF SHOWING

LEAD AND ZINC CONCENTRATIONS DETERMINED BY PRE–DEVELOPMENT RECONNAISSANCE SOIL SAMPLING BY COMINCO (1966, 1974)

- ZN > 10,000 ppm
- PB > 2000 ppm

GARTNER LEE SAMPLING

TP–151	TEST PIT – 2000
TP–19	TEST PIT – 1999
SS FH–B	SURFACE SAMPLE – 1999
SS20–7	SURFACE SAMPLE – 2000
BH–5	BOREHOLE – 1999
WS–LL1	WATER SAMPLE – 2000
E	VEGETATION SAMPLING LOCATION – JULY 2000

ZINC CONCENTRATION IN SOILS AT DEPTH GREATER THAN 0.3 metres (1999 & 2000 DATA)

- ○ 0–1000 PPM
- ○ 1000–5000 PPM
- ○ 5000–10,000 PPM
- ○ >10,000 PPM

LEAD CONCENTRATION IN SOILS AT DEPTH GREATER THAN 0.3 metres (1999 & 2000 DATA)

- ● 0–1,000 PPM
- ● 1,000–2,000 PPM
- ● > 2,000 PPM

NOTES:
DRAWING IS IN METRES, NAD83 ZONE 14
NTS SHEETS 68H/7 and 8

SOURCE OF GEOLOGIC INFORMATION IS COMINCO MAPS:
1) POLARIS CLAIMS LITTLE CORNWALLIS ISLAND NWT DATA COMPOSITE DATED SEPT 1966 1"=200'
2) POLARIS PROPERTY GEOLOGY MAP DATED MARCH 19 1974 1"=200'
3) SURFACE GEOLOGY CONTACTS BASED ON DDH GEOLOGY JUNE 2000

0 50 100 Metres
SCALE 1:2000

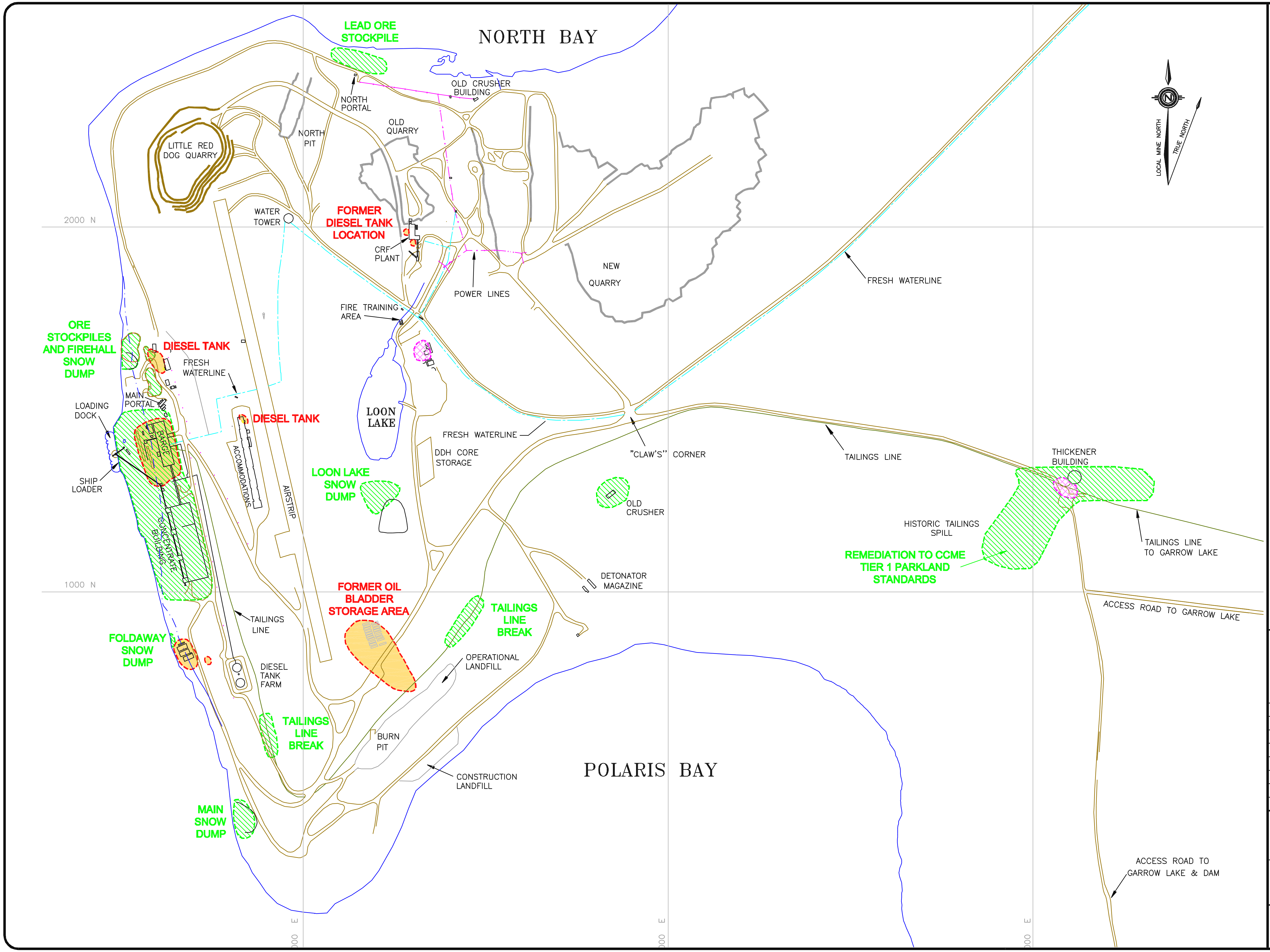
DESIGNED BY:	EHG
REVIEWED BY:	EHG
DRAWN BY:	CPW
DATE ISSUED:	DECEMBER 15, 2000
PROJECT NUMBER:	20–930
FILE NAME:	20930–D2–07.DWG
REVISION:	0

Cominco
COMINCO LTD.
POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

CONCENTRATIONS OF LEAD AND ZINC
IN SOIL SAMPLES
DEPTH GREATER THAN 0.3 metres

Gartner
Lee
Limited

Figure No.
8



LEGEND

▬	TAILINGS LINE
– · –	POWER LINE
– · –	WATER LINE
═	ROADS
▨	AREAS CONTAINING LEVELS OF LEAD AND ZINC THAT EXCEED THE CCME TIER 3 RISK BASED SOIL QUALITY REMEDIAL OBJECTIVES
🟧	AREAS CONTAINING PETROLEUM HYDROCARBON RESIDUALS THAT EXCEED THE YUKON CSR PARKLAND STANDARDS
▩	SUSPECT PETROLEUM HYDROCARBON CONTAMINATION

0 50 100 200 300 400 500 Metres

SCALE 1:10,000

NOTES:
DRAWING IS IN METRES, NAD 83, ZONE 14
NTS SHEETS 68H█ 7 & 8

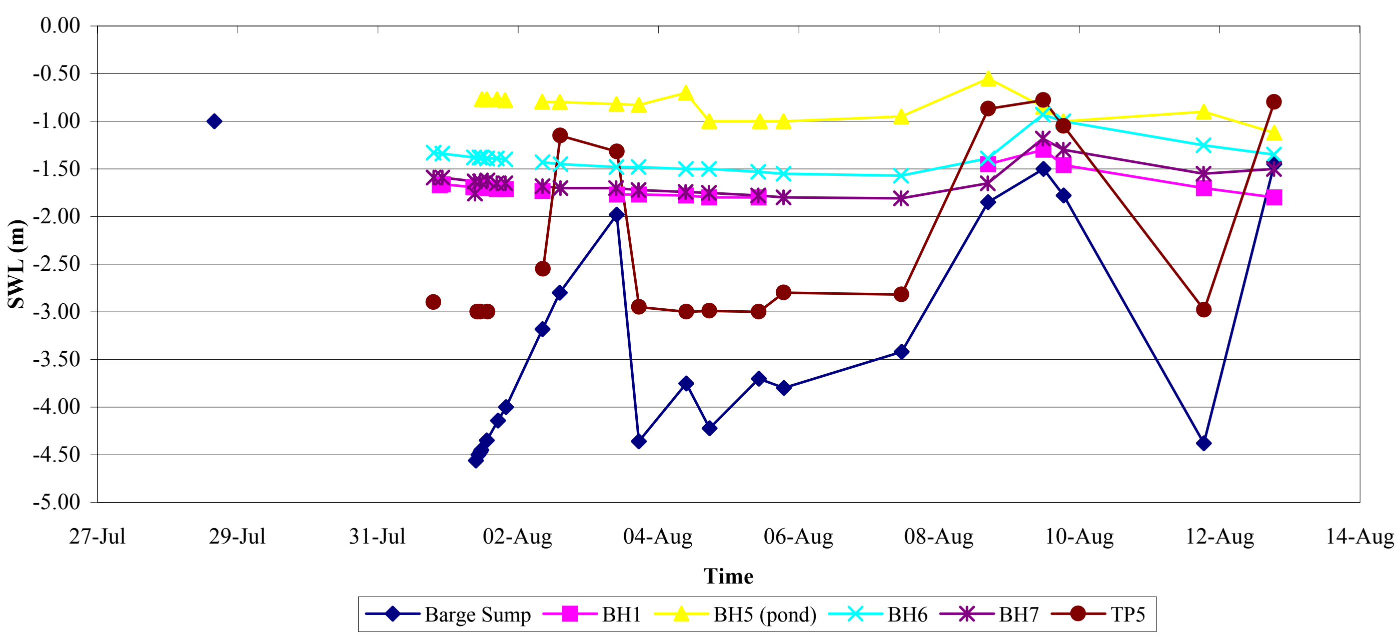
DRAWING INFORMATION:	
DESIGNED BY:	EHG
REVIEWED BY:	EHG, ED
DRAWN BY:	CPW
DATE ISSUED:	MARCH 21, 2001
PROJECT NUMBER:	20–930
FILE NAME:	20930–D2–09.DWG
REVISION:	1

Cominco
COMINCO LTD.
POLARIS MINE
2000 CONTAMINANT ASSESSMENT PROGRAM

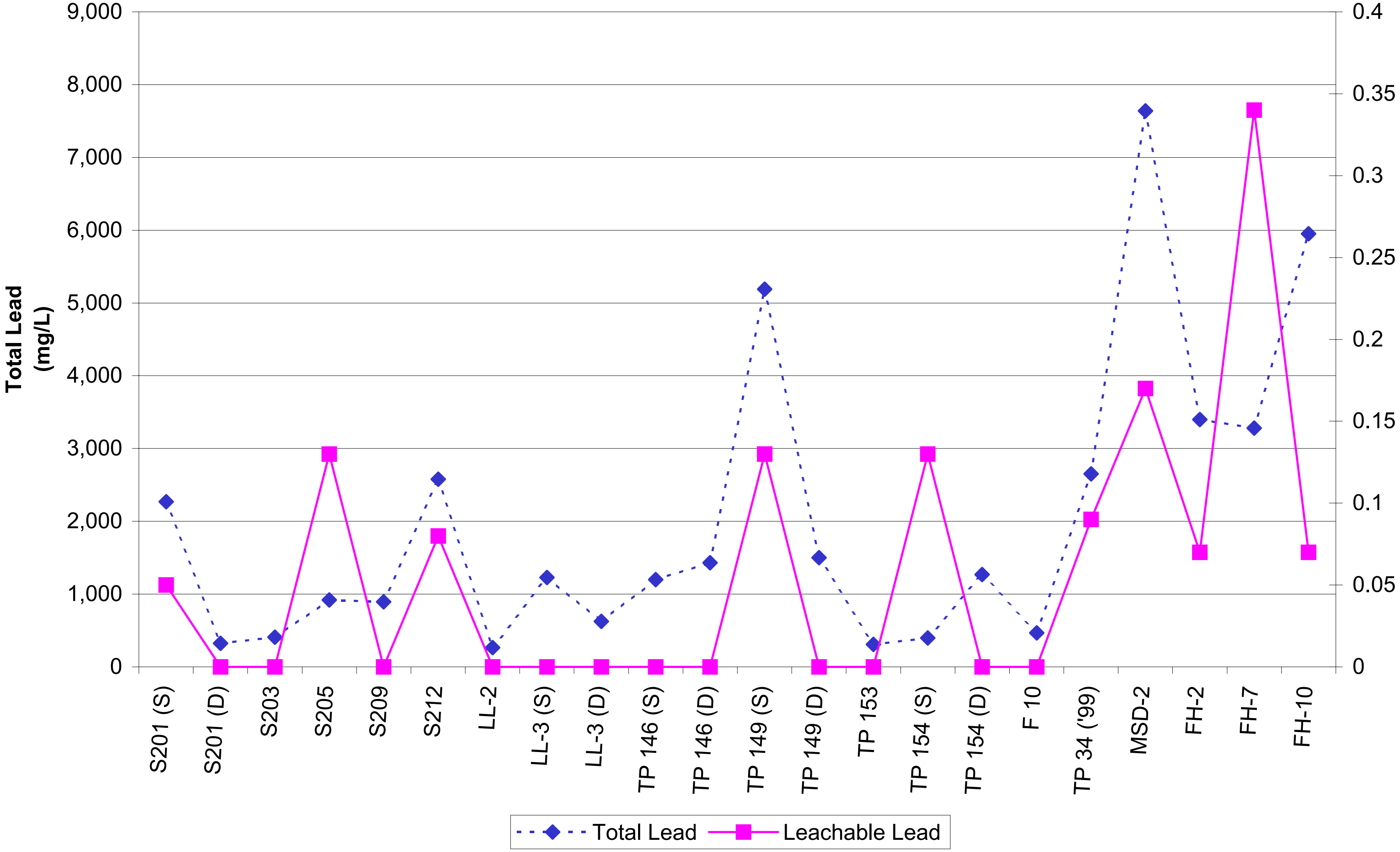
PETROLEUM HYDROCARBON AND
LEAD/ZINC CONTAMINATED AREAS

Gartner
Lee
Limited

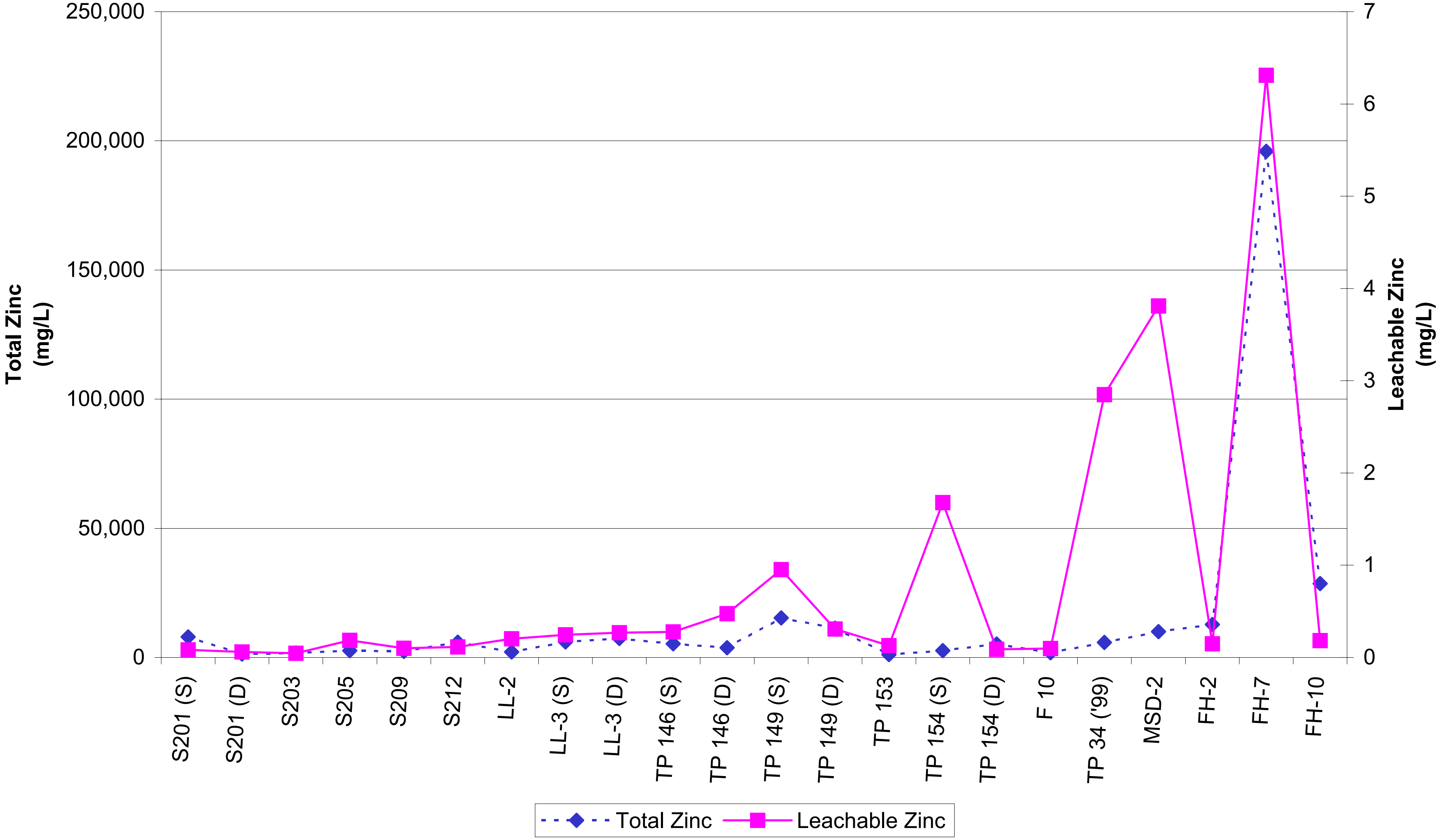
Figure No.
9


Graph 1. Polaris Barge Water Levels: August 1 to 12, 2000
SWL (m)
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
-5.00
27-Jul
29-Jul
31-Jul
02-Aug
04-Aug
06-Aug
08-Aug
10-Aug
12-Aug
14-Aug
Time
Barge Sump
BH1
BH5 (pond)
BH6
BH7
TP5

Graph 2
Total Lead vs. Leachable Lead



Graph 3
Total Zinc vs. Leachable Zinc



Graph 4
Leachable Sulphate vs. Leachable Lead and Zinc (mg/L)

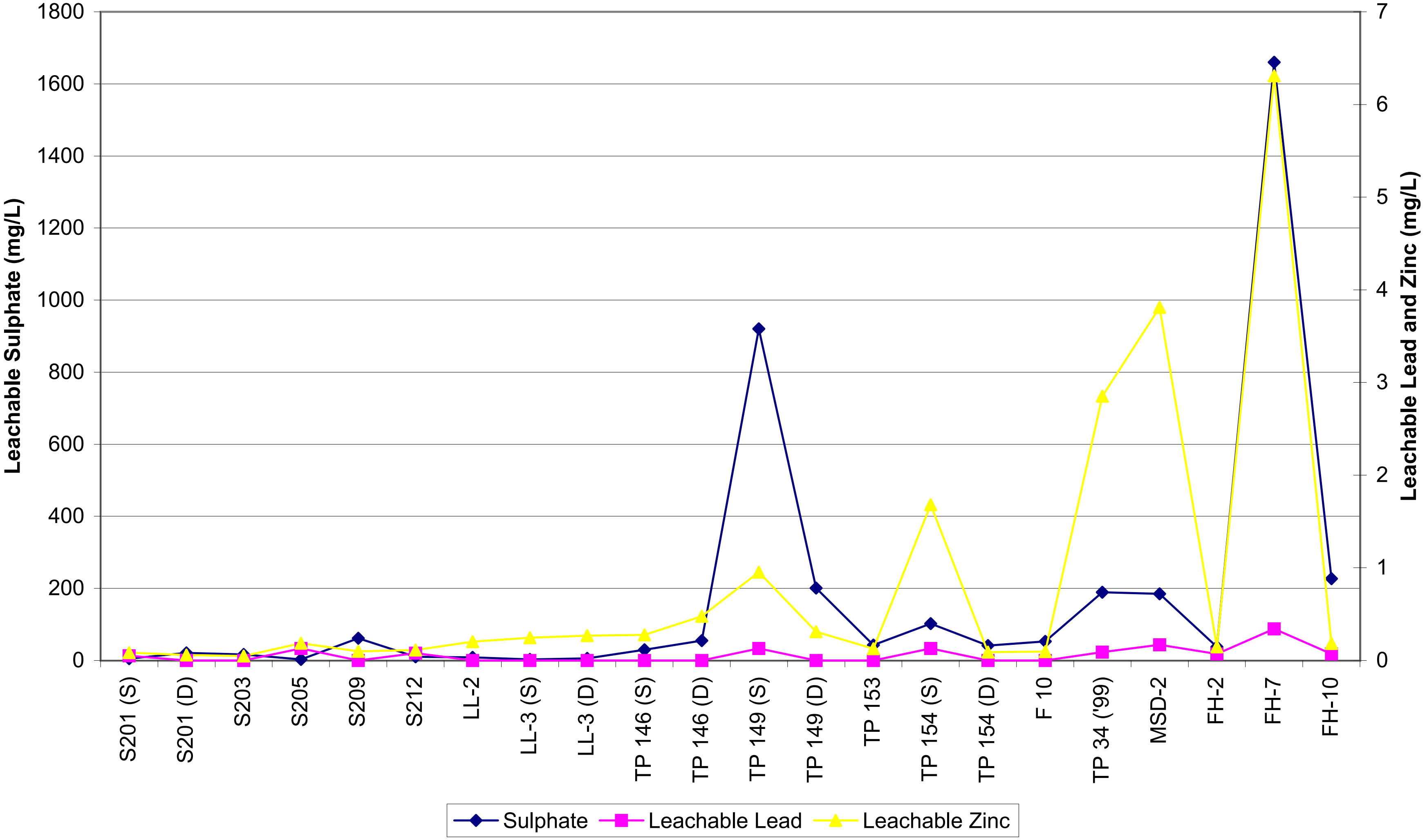


Table 1. Water Level Measurements Around Water Control Sump at Barge
Cominco Ltd. - Polaris Operations 2000 Contaminant Assessment

	Barge Sump		BH1		BH5 (pond)		BH6		BH7		TP5	
Date	Depth	Time	Depth	Time	Depth	Time	Depth	Time	Depth	Time	Depth	Time
28-Jul	-1.00	28-07-00 16:00										
31-Jul			-1.67	31-07-00 21:10	frozen		-1.33	31-07-00 19:00	-1.59	31-07-00 19:00	-2.90	31-07-00 19:00
31-Jul			-1.66	31-07-00 22:05			-1.34	31-07-00 22:00	-1.59	31-07-00 22:00		
01-Aug	-4.56	01-08-00 9:30	-1.69	01-08-00 8:35	-0.77	01-08-00 11:35	-1.38	01-08-00 8:50	-1.63	01-08-00 9:05	-3.00	01-08-00 10:00
01-Aug	-4.50	01-08-00 10:20	-1.69	01-08-00 9:20	-0.77	01-08-00 13:15	-1.38	01-08-00 10:45	-1.76	01-08-00 9:10	-3.00	01-08-00 11:05
01-Aug	-4.47	01-08-00 11:00	-1.67	01-08-00 10:40	-0.77	01-08-00 16:45	-1.38	01-08-00 11:30	-1.63	01-08-00 10:55	-3.00	01-08-00 13:35
01-Aug	-4.45	01-08-00 11:25	-1.70	01-08-00 13:30	-0.78	01-08-00 19:30	-1.39	01-08-00 13:20	-1.62	01-08-00 13:25		
01-Aug	-4.35	01-08-00 13:15	-1.71	01-08-00 16:40			-1.39	01-08-00 16:35	-1.65	01-08-00 16:40		
01-Aug	-4.14	01-08-00 17:05	-1.71	01-08-00 19:40			-1.40	01-08-00 19:35	-1.65	01-08-00 19:35		
01-Aug	-4.00	01-08-00 19:45										
02-Aug	-3.18	02-08-00 8:20	-1.73	02-08-00 8:20	-0.80	02-08-00 8:10	-1.43	02-08-00 8:15	-1.68	02-08-00 8:15	-2.55	02-08-00 8:30
02-Aug	-2.80	02-08-00 14:10			-0.80	02-08-00 14:15	-1.45	02-08-00 14:25	-1.70	02-08-00 14:25	-1.15	02-08-00 14:25
03-Aug	-1.98	03-08-00 9:45	-1.77	03-08-00 9:42	-0.82	03-08-00 9:39	-1.48	03-08-00 9:35	-1.70	03-08-00 9:32	-1.32	03-08-00 9:50
03-Aug	-4.36	03-08-00 17:19	-1.77	03-08-00 17:15	-0.83	03-08-00 17:13	-1.48	03-08-00 17:10	-1.72	03-08-00 17:07	-2.95	03-08-00 17:22
04-Aug	-3.75	04-08-00 9:29	-1.78	04-08-00 9:26	-0.70	04-08-00 9:24	-1.50	04-08-00 9:21	-1.74	04-08-00 9:18	-3.00	04-08-00 9:33
04-Aug	-4.22	04-08-00 17:28	-1.80	04-08-00 17:24	-1.00	04-08-00 17:20	-1.50	04-08-00 17:17	-1.75	04-08-00 17:16	-2.99	04-08-00 17:31
05-Aug	-3.70	05-08-00 10:19	-1.80	05-08-00 10:16	-1.00	05-08-00 10:40	-1.53	05-08-00 10:11	-1.78	05-08-00 10:08	-3.00	05-08-00 10:23
05-Aug	-3.80	05-08-00 18:52			-1.00	05-08-00 18:50	-1.55	05-08-00 18:48	-1.80	05-08-00 18:45	-2.80	05-08-00 18:55
07-Aug	-3.42	07-08-00 11:11			-0.95	07-08-00 11:05	-1.57	07-08-00 11:03	-1.81	07-08-00 11:00	-2.82	07-08-00 11:13
08-Aug	-1.85	08-08-00 16:50	-1.45	08-08-00 16:48	-0.55	08-08-00 16:52	-1.39	08-08-00 16:40	-1.65	08-08-00 16:44	-0.87	08-08-00 16:54
09-Aug	-1.50	09-08-00 11:42	-1.30	09-08-00 11:45	-0.85	09-08-00 11:38	-0.93	09-08-00 11:35	-1.18	09-08-00 11:34	-0.78	09-08-00 11:47
09-Aug	-1.78	09-08-00 18:40	-1.46	09-08-00 18:37	-1.00	09-08-00 18:35	-1.00	09-08-00 18:32	-1.30	09-08-00 18:30	-1.05	09-08-00 18:40
11-Aug	-4.38	11-08-00 18:41	-1.70	11-08-00 18:39	-0.90	11-08-00 18:37	-1.25	11-08-00 18:32	-1.55	11-08-00 18:30	-2.98	11-08-00 18:45
12-Aug	-1.45	12-08-00 18:48	-1.80	12-08-00 18:46	-1.12	12-08-00 18:43	-1.35	12-08-00 18:40	-1.50	12-08-00 18:38	-0.80	12-08-00 18:44

1. Barge Sump was pumped intermittently

TABLE 2. RESULTS OF ANALYSIS - SOIL SAMPLES
Extractable Petroleum Hydrocarbons (EPH) (ug/g)
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Sample ID	Depth (m)	Light EPH (C10-C19)	Heavy EPH (C19-C32)
Former Oil Bladder Storage Area			
TP 85	0.4-0.5	< 200	< 200
TP 88	0.4-0.6	3500	< 200
TP 89	0.5-0.7	< 200	< 200
TP 91	0.1-0.3	901	< 200
TP 91	0.6-0.8	7600	301
TP 94	0.5-0.7	< 200	< 200
TP 95	0.7-0.8	< 200	< 200
TP 96	0.7-0.9	1150	< 200
TP 98	0.7-0.9	< 200	< 200
TP 100	0.5-0.7	1840	< 200
TP 103	0.3-0.5	5480	< 200
TP 104	0.5-0.7	< 200	< 200
TP 105	0.5-0.7	353	< 200
TP 106	0.4-0.6	360	620
TP 107	0.4-0.6	< 200	< 200
TP 108	0.4-0.6	< 200	< 200
TP 109	0.4-0.6	2210	< 200
TP 110	0.4-0.6	894	< 200
TP 112	0.4-0.6	< 200	< 200
TP 114	0.4-0.6	2010	< 200
TP 115	0.4-0.6	907	< 200
TP 116	0.4-0.6	1270	< 200
TP 117	0.2-0.4	2430	< 200
TP118	0.3-0.5	6050	< 200
TP 119	0.5-0.7	< 200	< 200
TP 121	0.6-0.7	1870	< 200
TP 122	0.6-0.7	< 200	< 200
TP 124	0.6-0.8	< 200	< 200
TP 126	0.4-0.6	< 200	< 200
TP 128	0.6-0.8	< 200	212
TP 129	0.5-0.7	< 200	263
TP 130	0.4-0.6	< 200	< 200
TP 130	0.8-1	1160	< 200
TP 131	0.2-0.4	9090	206
TP 132	0.4-0.6	2100	< 200
TP 133	0.7-0.9	< 200	< 200
TP 134	0.7-0.9	< 200	< 200
TP 135b	0.7-0.9	< 200	< 200
CRF Plant Former Fuel Tank Storage			
CRF-1	0.3-0.5	< 200	< 200
CRF-1	0.8-1	< 200	< 200
CRF-2	0.7-0.8	< 200	< 200
CRF-3	0.6-0.8	< 200	< 200
Accommodations Diesel Storage Tank Area			
ACC-2	0.1-0.3	960	< 200
ACC-3	0.3-0.5	2580	< 200
ACC-4	0.3-0.6	< 200	< 200
ACC-4	0.6-0.9	< 200	< 200
ACC-5	0.6-0.9	< 200	< 200
ACC-6	0.2-0.4	< 200	< 200

Sample ID	Depth (m)	Light EPH (C10-C19)	Heavy EPH (C19-C32)
Operational Landfill			
TP 137	0.6-0.8	< 200	423
TP 138	0.5-0.7	989	283
TP 139	0.5-0.8	< 200	< 200
TP 140	0.5-0.8	4310	2420
Bechtel Laydown			
TP 141	0.4-0.7	< 200	478
Firehall Fuelling Area			
FH 1	0.1-0.3	< 200	< 200
FH 1	0.6-0.9	< 200	< 200
FH 2	0.9-1.2	3800	1360
FH 3A	0.3-0.6	1230	< 200
FH3B	0.3-0.6	827	< 200
FH3B	0.6-0.9	610	< 200
FH 4	0.7-1	2350	232
FH 6	0.3-0.6	3200	454
FH 6	0.6-0.9	2410	< 200
FH 7	0.3-0.6	1210	450
FH 7	0.6-0.9	3380	< 200
FH 8	0.3-0.6	< 200	618
FH 8	0.6-0.9	< 200	< 200
FH 9	0.5-0.7	< 200	< 200
FH 10	0.6-0.9	< 200	< 200
FH 11	0.4-0.6	< 200	< 200
Foldaway Fuelling Areas			
F Tank 1	0.5-0.7	12000	671
F Tank 3	0.4-0.6	14600	539
F Tank 4	0.6-0.8	13400	581
F Tank 5	0.5-0.8	< 200	< 200
F Tank 6	0.1-0.3	7030	2600
F Tank 6	0.5-0.7W	2100	372
F Tank 6	0.5-0.7E	1230	< 200
F Tank 7	0.6-0.8	2810	1130
F Tank 8	0.6-0.8	1910	1620
F Tank 9	0.6-0.8	1300	< 200
F Tank 10	0.2-0.5	< 200	< 200
F Tank 10	0.6-0.9	< 200	< 200
F Tank 11	0.3-0.6	2000	1220
F Tank 11	0.7-1	833	< 200
F Tank 12	0.6-0.9	6590	372
F Tank 13	0.6-0.8	< 200	< 200
F Tank 14	0.6-0.9	5220	314
F Tank 15	0.3-0.6	981	< 200
F Tank 16	0.6-0.9	948	234
F Tank 17	0.1-0.3	1610	630
F Tank 17	0.6-0.9	3340	250
Yukon CSR Standards			
Parkland Land Use		1000	1000

"-" = no analysis
"< " = less than the analytical detection limit
🟨 Exceeds the Yukon CSR for Park Land Use

TABLE 3. RESULTS OF ANALYSIS - ROCK SAMPLES
Water Leachable Hydrocarbon Concentrations in Shale (mg/L)
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Sample Identification	Extractable Hydrocarbons	
	C10-19	C19-32
TP 137: Black Shale	0.4	< 1
New Quarry: Brown Shale	< 0.3	< 1

TABLE 4. RESULTS OF ANALYSIS - SOIL SAMPLES
Total Lead and Zinc (ug/g)
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Sample ID	Depth (m)	Pb	Zn
Accommodations Hillslope			
TP 200	0-0.05	1200	4590
TP 200	0.1-0.3	3000	9750
TP 201	0-0.1	2270	7950
TP 201	0.2-0.3	322	1280
TP 201	0.3-0.6	91	544
TP 202	0-0.1	1190	4310
TP 202	0.4	149	483
TP 203	0-0.05	737	2870
TP 203	0.05-0.1	407	1750
TP 203	0.1-0.3	630	2630
TP 204	0-0.05	1040	2760
TP 204	0.1-0.3	150	524
TP 205	0-0.05	5540	16300
TP 205	0.05-0.1	919	2640
TP 205	0.1-0.3	302	834
TP 206	0-0.05	1750	8150
TP 206	0.05-0.1	771	3380
TP 206	0.3-0.6	505	4080
TP 207	0-0.05	1390	5390
TP 207	0.1-0.3	128	781
TP 207	0.3-0.6	285	832
TP 208	0-0.05	585	2330
TP 208	0.1-0.3	137	1140
TP 208	0.3-0.5	173	812
TP 209	0-0.05	894	2380
TP 209	0.1-0.3	348	1010
TP 210	0-0.05	369	1330
TP 210	0.05-0.1	243	706
TP 210	0.3-0.5	348	668
TP 211	0-0.05	745	2160
TP 211	0.05-0.1	267	858
TP 211	0.1-0.3	189	710
TP 212	0-0.05	2580	5940
TP 212	0.05-0.1	900	4080
TP 212	0.1-0.3	808	1950
TP 212	0.3-0.6	4420	725
TP 213	0-0.1	706	1590
TP 213	0.3-0.5	36	104
S 1	sfc. grab	1240	1130
S 3	sfc. grab	363	1250
S 5	sfc. grab	194	738
S 7	sfc. grab	1960	6570
Accommodations Diesel Tank Area			
ACC-2	0.1-0.3	123	305
ACC-4	0.3-0.6	161	582
ACC-4	0.6-0.9	262	128
ACC-5	0.6-0.9	126	180
Seacontainer Area			
TP 143	0-0.1	984	7270
TP 143	0.3-0.6	48	426
TP 144	0-0.1	1120	3200
TP 144	0.1-0.3	79	188
TP 144	0.3-0.6	31	146
TP 145	0-0.1	2050	5940
TP 145	0.3-0.6	10	65.1
TP 146	0-0.1	1200	5300
TP 146	0.1-0.3	422	1670
TP 146	0.3-0.6	1430	3790
TP 147	0-0.1	1500	5860
TP 147	0.3-0.6	31	173

Sample ID	Depth (m)	Pb	Zn
TP 148	0-0.1	5470	24400
TP 148	0.1-0.3	1720	1700
TP 148	0.3-0.6	199	1940
TP 149	0-0.1	5190	15300
TP 149	0.1-0.3	2180	7510
TP 149	0.3-0.6	2320	13200
TP 149	0.6-0.9	1500	11300
TP 150	0-0.1	3180	9000
TP 150	0.1-0.3	846	3080
TP 150	0.3-0.6	80	319
TP 151	0-0.1	3580	8370
TP 151	0.1-0.3	248	702
TP 151	0.3-0.6	117	414
South of Concentrate Storage			
TP 152	0-0.05	906	3700
TP 152	0.05-0.1	447	872
TP 152	0.1-0.4	364	939
TP 153	0.-0.05	708	3250
TP 153	0.05-0.1	308	1160
West of Concentrate Storage			
TP 154	0-0.1	399	2610
TP 154	0.3-0.6	1270	5200
TP 155	0-0.1	366	2080
TP 155	0.3-0.6	63	247
Firehall Fuelling Area			
FH 1	0.1-0.3	728	3100
FH 2	0.9-1.2	3400	12800
FH 3A	0.3-0.6	17	42
FH3B	0.3-0.6	226	1780
FH 4	0.7-1	448	3750
FH 6	0.3-0.6	6630	172,000
FH 6	0.6-0.9	1420	224,000
FH 7	0.1-0.3	4450	155,000
FH 7	0.3-0.6	877	196000
FH 7	0.6-0.9	3280	196000
FH 8	0.3-0.6	5860	53,600
FH 8	0.6-0.9	8610	49400
FH 9	0.2-0.4	63	165
FH 9	0.5-0.7	14	150
FH 10	0.1-0.3	228	101
FH 10	0.6-0.9	5950	28600
FH 11	0.1-0.3	554	1670
FH 11	0.4-0.6	158	382
CRF Plant Former Fuel Tank Storage			
CRF-3	0.2-0.4	< 200	174
Foldaway Fuelling Areas			
F Tank 2	0.1-0.3	479	1450
F Tank 5	0.1-0.3	481	1670
F Tank 5	0.5-0.8	244	1700
F Tank 10	0.2-0.5	467	1820
F Tank 12	0.3-0.6	95	47.7
F Tank 12	0.6-0.9	168	152
F Tank 15	0.1-0.3	1530	3500
F Tank 15	0.3-0.6	837	309
F Tank 16	0.1-0.3	1220	4330
F Tank 16	0.6-0.9	160	409
CCME Tier 3 Soil Quality Objective			
Soil Quality Remedial Objective		2000	10,000

"-" = no analysis
"< " = less than the analytical detection limit
🟨 Exceeds the Tier 3 Soil Quality Remedial Objectives

TABLE 4. RESULTS OF ANALYSIS - SOIL SAMPLES
Total Lead and Zinc (ug/g)
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Sample ID	Depth (m)	Pb	Zn
Foldaway Snow Dump			
FSD-1	sfc	1820	8700
FSD-2	sfc	4950	139000
Operational Landfill			
TP 140	0.5-0.8	83	304
Bechtel Laydown			
TP 141	0.4-0.7	< 100	127
Loon Lake Area			
LL-1	0-0.03	1070	3970
LL-1	0.03-0.1	53	435
LL-2	0-0.05	708	4050
LL-2	0.05-0.1	265	2170
LL-2	0.4-0.7	125	1180
LL-3	0-0.05	1230	5990
LL-3	0.05-0.1	625	7330
LL-3	0.1-0.4	961	20,300
LL-4	0-0.05	293	1530
LL-4	0.05-0.1	223	867
LL-4	0.1-0.4	227	905
LL-5	0-0.05	506	1900
LL-5	0.05-0.1	36	185
LL-6	0-0.05	544	2100
LL-6	0.05-0.2	96	351
LL-6	0.4-0.7	28	85.6
Loon Lake Snow Dump			
LLSD-1	0-0.05	526	1600
LLSD-1	0.05-0.1	103	280
LLSD-1	0.1-0.4	16	98.5
LLSD-2	0.05-0.1	922	2440
LLSD-2	0.1-0.4	23	85.7
LLSD-3	0-0.1	1350	4320
LLSD-3	0.2-0.5	59	252
LLSD-4	0-0.1	3490	6270
LLSD-4	0.1-0.4	22	139
LLSD-5	0.1-0.4	959	6780
LLSD-5	0.4-0.7	17	104
LLSD-6	0-0.3	30	250
LLSD-7	0-0.1	297	1230
LLSD-7	0.4-0.7	285	1230
Main Snow Dump			
MSD-1	0.1-0.3	7060	15100
MSD-1	0.3-0.5	11400	10100
MSD-2	0.1-0.3	7640	9970
MSD-3	0.1-0.3	8180	17400
MSD-4	0.1-0.3	599	2170
MSD-5	01-0.2	652	788
CCME Tier 3 Soil Quality Objective			
Soil Quality Remedial Objective		2000	10,000

"-" = no analysis

"< " = less than the analytical detection limit

🟨 Exceeds the Tier 3 Soil Quality Remedial Objectives

TABLE 5. RESULTS OF ANALYSIS - SOIL SAMPLES
Total Metal Concentrations in Soil (ug/g)
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Location	CCME Tier 1 Soil Quality Guidelines[1.] and Tier 3 Risk Based Remedial Objectives[2.]		Main Snow Dump						Foldaway Snow Dump				
Sample ID			MSD-1	MSD-1	MSD-2	MSD-3	MSD-4	MSD-5	FSD-1	FSD-2	TP 140	TP 141	CRF-3
Depth (m)			0.1-0.3	0.3-0.6	0.1-0.3	0.1-0.3	0.1-0.3	0.1-0.2	sfc grab	sfc grab	0.5-0.8	0.4-0.7	0.2-0.4
Soil pH	PL	Tier 3	8.39	8.51	8.08	8.91	9.15	9.13	-	-	8.14	9.04	9.02
Total Metals[1.] (ug/g)													
Antimony	20	-	< 60	< 40	< 40	< 60	< 40	< 60	< 40	< 200	< 20	< 40	< 60
Arsenic	12	-	< 20	< 10	< 5	< 20	< 10	< 20	< 5	< 5	< 5	< 10	< 20
Barium	500	-	79	103	91	80	134	334	250	50	142	257	281
Beryllium	4	-	< 2	< 1	< 1	< 2	< 1	< 2	< 1	< 3	1.2	< 1	< 2
Cadmium	10	-	37	26	20.4	44	6	7	20.4	318	0.6	< 1	< 2
Chromium	64	-	< 6	5	5	7	< 4	< 6	< 4	< 20	48	< 4	< 6
Cobalt	50	-	< 6	< 4	< 4	< 6	< 4	< 6	< 4	< 20	20	< 4	< 6
Copper	63	-	36	24	113	8	3	< 3	< 2	85	19	< 2	< 3
Lead[2.]	-	2,000	7060	11400	7640	8180	599	652	1820	4950	83	< 100	< 200
Mercury	6.6	-	0.03	0.026	0.031	0.033	0.022	0.019	0.012	0.053	0.013	0.012	0.018
Molybdenum	10	-	< 20	< 8	< 8	< 20	< 8	< 20	< 8	< 30	< 8	< 8	< 20
Nickel	50	-	< 20	< 10	< 10	< 20	< 10	< 20	< 10	< 30	43	< 10	< 20
Selenium	3	-	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Silver	20	-	< 6	< 4	< 4	< 6	< 4	< 6	<4	< 20	< 4	< 4	< 6
Tin	50	-	< 30	< 20	< 20	< 30	< 20	< 30	< 20	< 60	< 20	< 20	< 30
Vanadium	130	-	33	31	14	47	26	24	< 4	< 20	64	9	20
Zinc[2.]	-	10,000	15100	10100	9970	17400	2170	788	8700	139000	304	127	174

"<" = less than analytical detection limit

"-" = no measurement or remedial objective not developed

[1] CCME. 1999. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, Tier 1.

[2.] CCME. Tier 3 Risk Based Soil Quality Remedial Objectives

☐	Exceeds the CCME Tier 1 Recommended Soil Quality Guidelines for Park Land Use
🟨	Exceeds the CCME Tier 3 Risk- Based Soil Quality Remedial Objectives

TABLE 6. RESULTS OF ANALYSIS - SOIL SAMPLES
Water Leachable Metal and Sulfur Concentrations in Soil
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment

Sample ID	Depth (m)	Total S %	$S(SO_4)$ %	Total Metals		Leachable Metals		pH	SO_4 (mg/L)
				Pb	Zn	Pb	Zn		
Accommodations Hillslope									
TP 201	0-0.1	0.06	< 0.01	2,270	7,950	0.05	0.084	8.05	5
TP 201	0.2-0.3	0.11	0.02	322	1,280	< 0.05	0.06	7.98	21
TP 203	0.05-0.1	-	-	407	1,750	< 0.05	0.047	8.10	17
TP 205	0.05-0.1	-	-	919	2,640	0.13	0.185	7.94	3
TP 209	0-0.05	-	-	894	2,380	< 0.05	0.099	7.94	62
TP 212	0-0.05	0.29	0.02	2,580	5,940	0.08	0.113	8.08	10
Loon Lake Western Slope									
LL-2	0.05-0.1	-	-	265	2,170	< 0.05	0.202	7.97	9
LL-3	0-0.05	0.66	< 0.01	1,230	5,990	< 0.05	0.246	8.03	3
LL-3	0.05-0.1	0.60	0.01	625	7,330	< 0.05	0.268	8.05	6
Seacontainer and Concentrate Storage Building Area									
TP 146	0-0.1	-	-	1,200	5,300	< 0.05	0.277	8.06	30
TP 146	0.3-0.6	-	-	1,430	3,790	< 0.05	0.476	7.99	55
TP 149	0-0.1	0.69	0.13	5,190	15,300	0.13	0.954	7.83	920
TP 149	0.6-0.9	0.54	< 0.01	1,500	11,300	< 0.05	0.309	7.84	201
TP 153	0.05-0.1	-	-	308	1,160	< 0.05	0.128	8.10	43
TP 154	0-0.1	-	-	399	2,610	0.13	1.68	7.88	102
TP 154	0.3-0.6	0.37	< 0.01	1,270	5,200	< 0.05	0.089	8.03	41
F 10	0.2-0.5	-	-	467	1,820	< 0.05	0.096	8.01	53
TP 34 ('99)	0.6-0.9	-	-	2,650	5,830	0.09	2.85	7.78	189
Main Snow Dump									
MSD-2	0.1-0.3	-	-	7,640	9,970	0.17	3.81	7.73	185
Firehall Area - Historic Ore Stockpiles									
FH-2	0.9-1.2	1.5	0.03	3,400	12,800	0.07	0.148	8.05	38
FH-7	0.6-0.9	15.6	0.26	3,280	196,000	0.34	6.31	7.23	1,660
FH-10	0.6-0.9	2.92	0.03	5,950	28,600	0.07	0.183	7.95	227

TABLE 7. RESULTS OF ANALYSIS - SURFACE WATER AND GROUNDWATER SAMPLES
Metals, Nutrients and Conventional Parameters
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment Program

Sample[6] **Date Collected** **Lab Ref. No.**	**CCME**[2] **Fresh Water**	**Yukon CSR**[7] **Fresh Water**	Barge Sump 07-Jul-00 L8751	Barge Sump 26-Aug-00 M1428	LRD 07-Jul-00 L8751	BH1 01-Aug-00 L9693	BH5 01-Aug-00 L9693	BH6 01-Aug-00 L9693	BH7 01-Aug-00 L9693	TP61[1] 01-Aug-00 L9693	TP132[1] 01-Aug-00 L9693	ROSUMP[1] 01-Aug-00 L9693	ROPOND[1] 01-Aug-00 L9693	LL1[1] 01-Aug-00 L9693	NB1[1] 01-Aug-00 L9693	TP140 02-Aug-00 L9693	LF1 02-Aug-00 L9693	TP5 02-Aug-00 L9693
Physical Tests																		
Conductivity (umhos/cm)	-	-	2350	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hardness CaCO3	-	-	928	834	737	1710	2720	1550	452	1250	2030	393	1910	540	929	2170	1220	887
pH	6.5-9.0	-	7.02	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nutrients																		
Ammonia Nitrogen	1.37-2.20[3]	1.3-8.5	11.9	14.8	6.63	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrate Nitrogen	0.025-0.150	400	2.7	9	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite Nitrogen	0.06	0.2-2	4.5	3.4	0.223	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Phosphate	-	-	0.052	0.116	0.038	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Phosphate	-	-	0.01	-	0.003	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Metals																		
Aluminum	0.005-0.100[4]	0.05-0.5	0.72	0.06	0.97	-	-	-	-	-	-	-	-	<0.05	<0.05	-	<0.05	-
Arsenic	0.005	0.5	0.003	0.0029	0.004	-	-	-	-	-	-	-	-	<0.001	0.006	-	0.001	-
Barium	-	10	0.35	0.05	0.03	-	-	-	-	-	-	-	-	0.07	0.01	-	0.02	-
Cadmium	0.000017[4]	0.002-0.018	0.013	0.0007	<0.0005	-	-	-	-	-	-	-	-	<0.0005	0.0179	-	<0.0005	-
Chromium	0.0010-0.0089[5]	0.02	<0.005	<0.002	<0.005	-	-	-	-	-	-	-	-	<0.001	<0.001	-	<0.001	-
Cobalt	-	0.5	0.004	0.0055	0.003	-	-	-	-	-	-	-	-	<0.001	0.013	-	0.003	-
Copper	0.002-0.004[4]	0.02-0.09	0.022	0.008	0.006	-	-	-	-	-	-	-	-	0.002	0.008	-	0.007	-
Iron	0.3	3	5.65	3.46	0.42	-	-	-	-	-	-	-	-	0.07	<0.03	-	<0.03	-
Lead	0.001-0.007[4]	0.04-0.16	2.93	0.192	0.0105	-	-	-	-	-	-	-	-	0.015	0.0015	-	0.0182	-
Manganese	-	-	0.229	0.196	0.022	-	-	-	-	-	-	-	-	0.007	0.041	-	0.08	-
Mercury	0.0001	0.001	<0.00002	<0.00002	<0.00002	-	-	-	-	-	-	-	-	<0.00002	<0.00002	-	<0.00002	-
Molybdenum	0.073	10	<0.03	<0.03	0.04	-	-	-	-	-	-	-	-	<0.03	<0.03	-	<0.03	-
Nickel	0.025-0.150[4]	0.25-1.5	0.02	0.036	0.02	-	-	-	-	-	-	-	-	<0.01	0.17	-	0.02	-
Selenium	0.001	0.01	<0.01	<0.004	<0.02	-	-	-	-	-	-	-	-	<0.0005	0.09	-	0.0023	-
Silver	0.0001	0.001	0.0002	<0.00004	<0.0001	-	-	-	-	-	-	-	-	<0.0001	<0.0001	-	<0.0001	-
Thallium	0.0008	0.003	0.0005	0.0004	0.0008	-	-	-	-	-	-	-	-	0.0026	0.0029	-	0.0022	-
Zinc	0.03	0.3	4.02	3.18	0.03	-	-	-	-	-	-	-	-	0.079	0.147	-	0.199	-
Dissolved Metals																		
Aluminum	0.005-0.100[4]	0.05-0.5	0.08	0.06	-	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	<0.05	<0.05	<0.05
Arsenic	0.005	0.5	0.001	0.0025	-	0.003	0.007	0.002	0.004	<0.001	0.002	<0.001	0.005	-	-	0.004	0.002	0.002
Barium	-	10	0.1	0.06	-	0.11	0.19	0.03	0.13	0.01	0.02	0.05	0.04	-	-	0.02	0.02	0.13
Cadmium	0.000017[4]	0.002-0.018	0.0024	0.0006	-	0.0022	0.0006	<0.0005	0.0118	<0.0005	<0.0005	0.0005	0.0042	-	-	<0.0005	<0.0005	0.0013
Chromium	0.0010-0.0089[5]	0.02	<0.005	<0.002	-	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	-	-	<0.001	<0.001	<0.001
Cobalt	-	0.5	0.003	0.0056	-	0.018	0.015	0.005	0.098	<0.001	0.003	0.002	0.006	-	-	0.006	0.003	0.01
Copper	0.002-0.004[4]	0.02-0.09	0.009	0.0054	-	0.006	0.007	0.004	0.016	0.003	0.004	0.006	0.036	-	-	0.009	0.006	0.002
Iron	0.3	3	3.73	3.65	-	0.12	<0.03	0.09	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	<0.03
Lead	0.001-0.007[4]	0.04-0.16	1.02	0.203	-	0.047	0.017	0.001	0.05	0.001	0.004	0.035	0.126	-	-	0.019	0.012	0.018
Manganese	-	-	0.204	0.208	-	0.413	0.437	0.188	1.19	<0.005	0.106	0.066	0.156	-	-	0.096	0.068	0.234
Mercury	0.0001	0.001	<0.00002	<0.00002	-	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	-	-	<0.00002	<0.00002	<0.00002
Molybdenum	0.073	10	<0.03	<0.03	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	-	-	<0.03	<0.03	<0.03
Nickel	0.025-0.150[4]	0.25-1.5	0.02	0.036	-	0.06	0.05	0.01	0.42	<0.01	<0.01	0.01	0.03	-	-	0.01	0.02	0.03
Selenium	0.001	0.01	<0.01	<0.004	-	0.0052	0.003	0.0005	0.0042	0.0021	0.0012	0.0013	0.025	-	-	0.002	0.0022	0.0022
Silver	0.0001	0.001	<0.0001	<0.00004	-	0.0003	0.0002	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	0.0004	-	-	<0.0001	<0.0001	<0.0001
Thallium	0.0008	0.003	<0.0005	0.0004	-	<0.003	<0.003	<0.004	<0.004	<0.003	<0.003	<0.003	<0.003	-	-	<0.003	<0.002	<0.002
Zinc	0.03	0.3	0.658	3.35	-	8.8	1.64	0.063	90.6	0.017	0.02	1.01	1.55	-	-	0.093	0.195	5.86

Notes:
1. Sample collected in stages on August 1 and August 2.
2. CCME, Canadian Council of Ministers of the Environment, 1999, Guidelines for the Protection of Fresh Water Aquatic Life
3. CCME guideline for ammonia: 1.370 mg/L at ph8.0 and 10degC; 2.200 mg/L at pH 6.5 and 10degC
4. CCME guideline dependent on pH, DOC or CaCO3 (hardness)
5. CCME guideline for chromium depends on valent state
6. Sample Names: LRD=Little Red Dog Quarry; ROSUMP=run off sump at east side of barge below main entrance; ROPOND=pond adjacent to BH5; LL1-outlet of Loon Lake; NB1=creek flow to North Bay; LF1=seep emerging at toe of operational landfill between TP138 and TP59
7. Yukon Contaminated Sites Regulation Generic Numerical Water Standard for the Protection of Aquatic Life

All parameter concentrations in mg/L unless stated otherwise

Sample Locations are described in the body of the repor

xx	Data exceed the CCME Guideline
xx	Data exceed the Yukon CSR Guideline

TABLE 8. RESULTS OF ANALYSIS - SURFACE WATER AND GROUNDWATER SAMPLES
PAH's, Extractable Hydrocarbons and Volatiles
Cominco Ltd. - Polaris Operations: 2000 Contaminant Assessment Program

Sample^{3} **Date Collected** **Lab Ref. No.**	**CCME**^{1} **Fresh Water**	**Yukon CSR**^{4} **Fresh Water**	Barge Sump 07-Jul-00 L8751	Barge Sump 26-Aug-00 M1428	BH5 01-Aug-00 L9693	BH6 01-Aug-00 L9693	BH7 01-Aug-00 L9693	TP61 01-Aug-00 L9693	TP132 01-Aug-00 L9693	ROSUMP 01-Aug-00 L9693	ROPOND 01-Aug-00 L9693	TP140 02-Aug-00 L9693	LF1 02-Aug-00 L9693	TP5 02-Aug-00 L9693
Polycyclic Aromatic Hydrocarbons														
Acenaphthene	0.0058	0.06	<0.0007	<0.0005	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	-	-	<0.0002	<0.0005	-	-	-	-	-	-	-	-	-	-
Acridine	0.0044	0.0005	<0.0003	<0.00005	-	-	-	-	-	-	-	-	-	-
Anthracene	0.000012	0.001	<0.0001	<0.00005	-	-	-	-	-	-	-	-	-	-
Benz(a)anthracene	0.000018	0.001	0.00014	<0.00005	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	0.000015	-	0.00013	<0.00001	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	0.00019	<0.00005	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	0.00013	<0.00005	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	0.00023	<0.00005	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	0.00022	<0.00005	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	0.00014	<0.00005	-	-	-	-	-	-	-	-	-	-
Fluoranthene	0.00004	0.002	0.00011	<0.00005	-	-	-	-	-	-	-	-	-	-
Fluorene	0.003	0.12	0.00048	<0.00008	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	0.00014	<0.00005	-	-	-	-	-	-	-	-	-	-
Naphthalene	0.0011	0.01	<0.002	<0.0005	-	-	-	-	-	-	-	-	-	-
Phenanthrene	0.0004	0.003	<0.0001	<0.00005	-	-	-	-	-	-	-	-	-	-
Pyrene	0.000025	0.0002	0.00013	<0.00005	-	-	-	-	-	-	-	-	-	-
Extractable Hydrocarbons														
EPH10-19	0.5^{2}	-	22.7	2.7	1.2	34.1	49.5	<0.3	9.9	0.7	0.8	2.4	<0.3	4.9
EPH19-32	-	-	10	2	2	4	5	<1	<1	<1	<1	1	<1	<1
LEPH	0.5^{2}	-	22.7	2.7	-	-	-	-	-	-	-	-	-	-
HEPH	-	-	10	2	-	-	-	-	-	-	-	-	-	-
Non-halogenated Volatiles														
Benzene	0.37	3	0.0027	-	-	-	-	-	-	-	-	-	-	-
Ethylbenzene	0.09	7	0.0154	-	-	-	-	-	-	-	-	-	-	-
Styrene	0.072	-	<0.0005	-	-	-	-	-	-	-	-	-	-	-
Toluene	0.002	3	0.0071	-	-	-	-	-	-	-	-	-	-	-
meta- & para-Xylene	-	-	0.0398	-	-	-	-	-	-	-	-	-	-	-
ortho-Xylene	-	-	0.0176	-	-	-	-	-	-	-	-	-	-	-
Halogenated Volatiles														
Bromodichloromethane	-		<0.001	-	-	-	-	-	-	-	-	-	-	-
Bromoform	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Carbon Tetrachloride	0.013	-	<0.005	-	-	-	-	-	-	-	-	-	-	-
Chlorobenzene	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Chloroethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Chloroform	0.0018	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Chloromethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Dibromochloromethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	0.0007	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,3-Dichlorobenzene	0.15	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	0.026	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloroethane	0.1	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
cis-1,2-Dichloroethylene	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
trans-1,2-Dichloroethylene	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,1-Dichloroethylene	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Dichloromethane	0.0981	-	<0.03	-	-	-	-	-	-	-	-	-	-	-
1,2-Dichloropropane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
cis-1,3-Dichloropropylene	-	-	<0.02	-	-	-	-	-	-	-	-	-	-	-
trans-1,3-Dichloropropylene	-	-	<0.005	-	-	-	-	-	-	-	-	-	-	-
1,1,1,2-Tetrachloroethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,1,2,2-Tetrachloroethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Tetrachloroethylene	0.111	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
1,1,1-Trichloroethane	-	-	<0.02	-	-	-	-	-	-	-	-	-	-	-
1,1,2-Trichloroethane	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Trichloroethylene	0.021	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Trichlorofluoromethane	-	-	0.002	-	-	-	-	-	-	-	-	-	-	-
Vinyl Chloride	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-
Water Soluble Volatiles														
Diethylene Glycol	-	-	<10	-	-	-	-	-	-	-	-	-	-	-
Ethylene Glycol	192	-	63	-	-	-	-	-	-	-	-	-	-	-
Propylene Glycol	500	-	<10	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. CCME, Canadian Council of Ministers of the Environment, 1999, Guidelines for the Protection of Fresh Water Aquatic Life
2. There is no CCME Guideline for LEPH; Yukon Contaminated Sites Regulation (1997) is shown
3. Sample Names: ROSUMP=run off sump at east side of barge below main entrance;ROPOND=pond adjacent to BH5
LF1=seep emerging at toe of operational landfill between TP138 and TP59
4. Yukon Contaminated Sites Regulation Generic Numerical Water Standard for the Protection of Aquatic Life
All parameter concentrations in mg/L unless stated otherwise
Sample Locations are described in the body of the repor

xx	Data exceed the CCME Guideline
🟨 xx	Data exceed the Yukon CSR Guideline

TABLE 9A RESULTS OF ANALYSIS - VEGETATION SAMPLES
Cominco Ltd. - Polaris Mine Operations
Total Metal Concentrations in Vegetation Samples (ug/g)
July and August 2000

	SITE B				SITE C				SITE D				SITE E			
Sample ID	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top
Total Metals (µg/g)																
Arsenic	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 10	< 10	< 10
Cadmium	< 0.5	< 1	1.2	1.1	1.9	2	5.1	4.2	0.9	1	2.2	2.6	< 0.5	1.1	8.2	6.2
Chromium	1.1	1	1.2	0.9	7.5	11	8.7	0.8	2.2	12	4.0	0.7	2.1	0.7	2.1	0.8
Copper	4.1	< 1	5.0	4.5	6.8	6	5.0	4.1	5.6	< 1	4.8	3.6	3.9	< 0.5	8.6	3.1
Lead	8	113	< 5	< 5	232	337	28	16	84	528	10	32	50	798	62	44
Molybdenum	1	< 2	< 1	< 1	2	< 2	< 1	< 1	2	< 2	< 1	< 1	1	< 1	< 1	< 1
Nickel	2	< 4	7	5	6	8	6	< 2	2	6	7	< 2	2	< 2	8	4
Zinc	52.0	69.0	264	236	778	188	325	325	249	193	303	443	223	403	503	483

	SITE G				SITE H				SITE I				SITE J			
Sample ID	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top
Total Metals (µg/g)																
Arsenic	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10
Cadmium	1.3	2	10.1	7.6	< 0.5	1	4.4	4.5	2.2	3	2.3	2.5	< 0.5	1	5.2	4.1
Chromium	0.7	2	2.9	< 0.5	2.7	18	5.3	1.0	11.9	4	15.9	7.4	3.2	3	2.7	0.7
Copper	4.2	< 1	5.5	3.4	2.6	3	5.6	6.2	8.2	< 1	9.4	7.4	4.8	2	4.5	2.8
Lead	24	157	< 5	6	20	299	61	12	363	1590	188	117	19	459	20	7
Molybdenum	2	< 2	1	< 1	< 1	< 2	1	< 1	1	< 2	2	1	1	< 2	< 1	< 1
Nickel	< 2	< 4	5	2	< 2	10	4	< 2	8	< 4	17	8	< 2	< 4	6	2
Zinc	120	107	360	398	142	259	455	493	1050	690	620	610	116	217	429	316

BC Research Data (1974) µg/g

	SITE A			SITE B			SITE C			SITE D		
Sample ID	Grasses	Lichen	Willow	Grasses	Lichen	Willow	Grasses	Lichen	Willow	Grasses	Lichen	Willow
Cadmium	< 0.4	< 0.4	1	< 0.4	0.8	3	< 0.4	< 0.4	0.7	< 0.4	< 0.4	5.9
Copper	6.35	0.78	6.68	3.38	1	7.07	4.32	1.39	8.22	4.74	0.59	8.26
Iron	87.7	81.2	55.6	73.3	59.2	53	74.1	117.9	228	98.7	72.6	73.4
Lead	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Zinc	49.5	16.8	267	47.4	19.7	259	33.4	11.3	215	41.5	17.7	41.5

TABLE 9A RESULTS OF ANALYSIS - VEGETATION SAMPLES
Cominco Ltd. - Polaris Mine Operations
Total Metal Concentrations in Vegetation Samples (ug/g)
July and August 2000

	SITE K				SITE L				SITE M				SITE N			
Sample ID	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top	Grasses	Lichen	Willow Root	Willow Top
Total Metals (µg/g)																
Arsenic	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10	< 10	< 20	< 10	< 10
Cadmium	2.3	1	12.5	12.4	< 0.5	< 1	6.2	7.9	< 0.5	< 1	0.8	0.8	< 0.5	<1	0.6	< 0.5
Chromium	1.0	6	1.1	1.0	0.7	9	16.8	3.6	1.0	3	17.7	18.7	16.2	10	21.8	1.9
Copper	4.4	1	4.2	4.5	3.3	5	6.4	4.7	5.8	< 1	8.4	5.6	4.1	< 1	6.6	4.9
Lead	24	117	6	6	< 5	141	6	8	5	220	< 5	7	19	94	< 5	< 5
Molybdenum	1	< 2	< 1	< 1	1	< 2	1	< 1	< 1	< 2	4	1	1	< 2	2	< 1
Nickel	< 2	< 4	2	< 2	4	6	12	3	3	< 4	21	15	10	5	19	3
Zinc	239	95.5	358	441	84.5	86.0	256	323	57.0	114	237	254	88.0	55.5	307	283

	SITE O			
Sample ID	Grasses	Lichen	Willow Root	Willow Top
Total Metals (µg/g)				
Arsenic	< 10	< 20	< 10	< 10
Cadmium	< 0.5	< 1	1.8	1.9
Chromium	1.4	< 1	0.8	2.4
Copper	4.2	< 1	4.4	4.9
Lead	< 5	109	< 5	< 5
Molybdenum	< 1	< 2	< 1	< 1
Nickel	< 2	< 4	3	3
Zinc	37.0	57.5	331	483

TABLE 9B. RESULTS OF ANALYSIS - SOIL SAMPLES
Cominco Ltd. - Polaris Mine Operations
Total Metals in Soil Samples (ug/g)
July and August 2000

Sample ID	SITE B			SITE C			SITE D			SITE E		
	Soil Depth (m)			Soil Depth (m)			Soil Depth (m)			Soil Depth (m)		
	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10
Total Metals (µg/g)												
Arsenic	< 100	-	-	-	-	-	< 100	-	-	< 100	-	-
Cadmium	< 2	-	-	-	-	-	< 2	-	-	< 2	-	-
Chromium	22	-	-	-	-	-	10	-	-	9	-	-
Copper	19	-	-	-	-	-	7	-	-	13	-	-
Lead	9	11	10	60	12	-	23	10	7	259	12	-
Molybdenum	< 4	-	-	-	-	-	< 4	-	-	< 4	-	-
Nickel	30	-	-	-	-	-	10	-	-	11	-	-
Zinc	66.0	75.2	74.3	445	236	-	105	66.1	54.9	794	111	-

Sample ID	SITE G			SITE H			SITE I			SITE J		
	Soil Depth (m)			Soil Depth (m)			Soil Depth (m)			Soil Depth (m)		
	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10
Total Metals (µg/g)												
Arsenic	-	-	-	-	-	-	< 200	< 200	-	< 100	-	-
Cadmium	-	-	-	-	-	-	< 4	< 4	-	< 2	-	-
Chromium	-	-	-	-	-	-	20	20	-	35	-	-
Copper	-	-	-	-	-	-	17	18	-	36	-	-
Lead	16	16	16	15	11	-	404	32	16	16	16	8
Molybdenum	-	-	-	-	-	-	< 8	< 8	-	< 4	-	-
Nickel	-	-	-	-	-	-	22	24	-	30	-	-
Zinc	303	316	307	154	86.1	-	1350	162	106	161	173	164

TABLE 9B. RESULTS OF ANALYSIS - SOIL SAMPLES
Cominco Ltd. - Polaris Mine Operations
Total Metals in Soil Samples (ug/g)
July and August 2000

	SITE K			**SITE L**			**SITE M**			**SITE N**		
	Soil Depth (m)			Soil Depth (m)			Soil Depth (m)			Soil Depth (m)		
Sample ID	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10	0-0.01	0.01-0.05	0.05-0.10
Total Metals (µg/g)												
Arsenic	< 100	-	-	< 200	-	-	-	-	-	< 200	-	-
Cadmium	< 2	-	-	< 4	-	-	-	-	-	< 4	-	-
Chromium	16	-	-	22	-	-	-	-	-	26	-	-
Copper	14	-	-	19	-	-	-	-	-	13	-	-
Lead	28	13	14	13	13	10	14	12	12	9	6	7
Molybdenum	< 4	-	-	< 8	-	-	-	-	-	< 8	-	-
Nickel	14	-	-	24	-	-	-	-	-	22	-	-
Zinc	355	372	447	109	124	125	99.5	100	108	55.7	39.9	63.8

	SITE O			CCME
	Soil Depth (m)			Soil Quality
Sample ID	0-0.01	0.01-0.05	0.05-0.10	Guidelines
Total Metals (µg/g)				Parkland Use
Arsenic	-	-	-	12
Cadmium	-	-	-	10
Chromium	-	-	-	64
Copper	-	-	-	63
Lead	10	9	7	140
Molybdenum	-	-	-	10
Nickel	-	-	-	50
Zinc	54.2	46.7	46.3	200

"<" = less than detection limit

"-" = not analyzed

CCME. 1999. Canadian Soil Quality Guidelines for the Protection of Human Health and the Environment.

🟨 Exceeds CCME Soil Quality Guidelines for Park Land Use

TABLE 10. RESULTS OF ANALYSIS - PCB's in in-service transformers

Serial Number	PCB (ppm)
112-LC-02	<10
112-LC-05	<10
112-LC-09	<10
112-LC-13	<10
118-LC-01	<10
118-LC-08	<10
118-LC-10	<10
118-LC-08	<10

- PHOTOGRAPHS -

PHOTOGRAPH 1

North end of barge. Barge sump located between barge and wash bay.

PHOTOGRAPH 2

Oil stained layer evident at depth. (TP 91 at 0.5m, oil bladder spill area).

- PHOTOGRAPHS -

PHOTOGRAPH 3

Accommodations diesel tank.

PHOTOGRAPH 4

Hillside between accommodations and barge.

- PHOTOGRAPHS -

PHOTOGRAPH 5

Loon Lake snow dump.

PHOTOGRAPH 6

Main snow dump.

PHOTOGRAPH 7

Remnants of Foldaway Snowdump.

PHOTOGRAPH 8

Site H, willow in foreground.

- PHOTOGRAPHS -

PHOTOGRAPH 9

Site L grasses.

PHOTOGRAPH 10

Site K lichen/willow.

PHOTOGRAPH 11

General arrangement of tank farm, looking approximately southwest, August 1, 2000.

PHOTOGRAPH 12

Erosion of crest perimeter containment dyke on east limb showing separated liner sections and exposed soil, August 1, 2000.

- PHOTOGRAPHS -

PHOTOGRAPH 13

Exposed section of tank farm on internal face of east limb of perimeter containment dyke showing location of tear near internal toe, looking approximately northeast, August 1, 2000.

PHOTOGRAPH 14

Water inflow through tear in tank farm liner near internal toe of east limb of perimeter containment dyke, August 1, 2000.

- PHOTOGRAPHS -

PHOTOGRAPH 15

North limb of tank farm perimeter containment dyke, looking approximately west, August 1 , 2000.

PHOTOGRAPH 16

Partial surficial tear in tank farm liner on internal face of north limb of perimeter containment dyke, August 1, 2000.

- PHOTOGRAPHS -

PHOTOGRAPH 17

Tank farm sump dewatering arrangement, south end, looking approximately southeast, August 1, 2000.

- PHOTOGRAPHS -

PHOTOGRAPH A

Hillside below accommodations, snow dump (fire hall), fire hall test pits area, ore stockpile.

PHOTOGRAPH B

Barge showing concentrator emissions.

- PHOTOGRAPHS -

PHOTOGRAPH C

Concentrate loading.

PHOTOGRAPH D

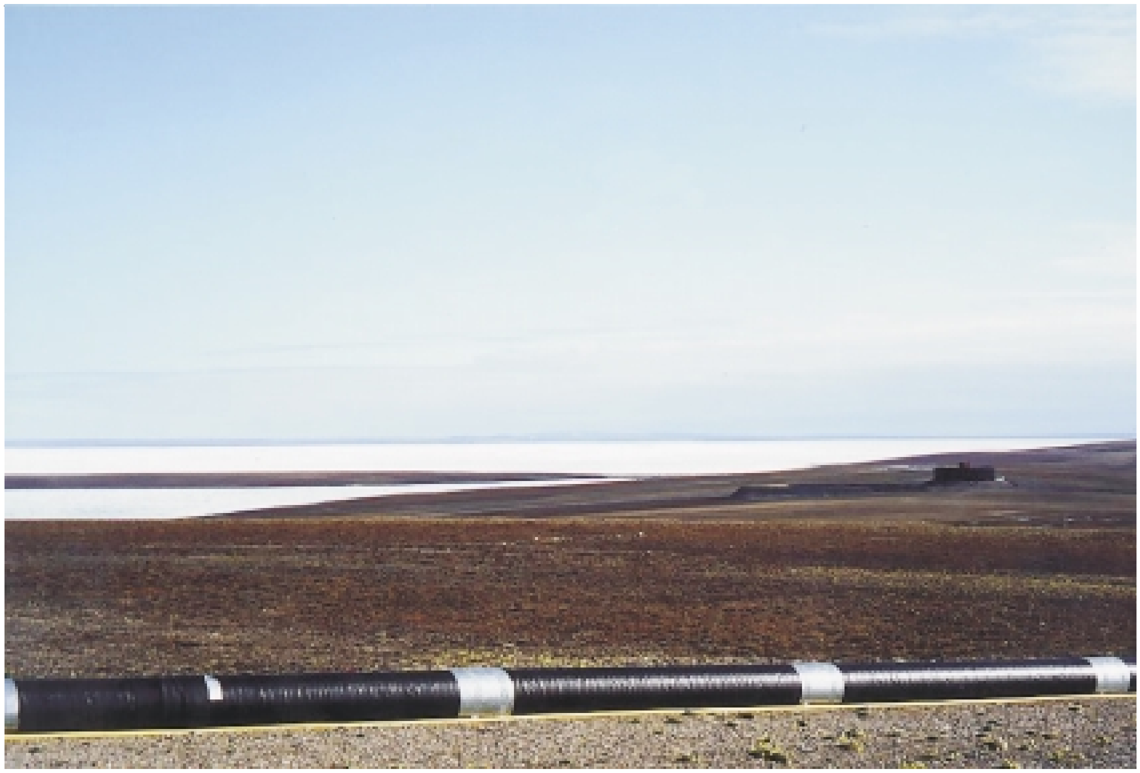
Concentrate loading.

- PHOTOGRAPHS -

PHOTOGRAPH E

Operational and construction landfills, looking northwest.

PHOTOGRAPH F



Tailings thickener and emergency discharge pond.

PHOTOGRAPH G

Freshwater Line Road looking west. View over the active mining area.

Appendix A

Laboratory Reports

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date:	December 15, 2000
ASL File No.	M3704
Report On:	Polaris Project Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	October 26, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

RESULTS OF ANALYSIS - Sediment/Soil

File No. M3704

Sample ID		TP130 0.8-1m	TP152 0.1-0.4m	LL3 0.1-0.4m	LL4 0.1-0.4m	FH4 0.7-1m
Sample Date *ASL ID*		00 07 30 *1*	00 08 01 *2*	00 07 30 *3*	00 07 30 *4*	00 08 01 *5*
Physical Tests						
Moisture	%	8.9	5.2	1.8	8.5	13.2
Total Metals						
Lead	T-Pb	-	364	961	227	448
Zinc	T-Zn	-	939	20300	905	3750
Extractable Hydrocarbons						
EPH10-19		1160	-	-	-	-
EPH19-32		<200	-	-	-	-

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M3704

Sample ID		FH6 0.6-0.9m	FH8 0.3-0.6m	FH9 0.~~3~~-0.7m 5	FH11 0.4-0.6m	FH11 0.1-0.3m
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	8.6	6.7	4.0	4.7	5.2
Total Metals						
Lead	T-Pb	1420	5860	14	158	554
Zinc	T-Zn	224000	53600	150	382	1670

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M3704

Sample ID		LLSD-1 0-0.05m	FTank-16 0.3-0.6m	S207 0.1-0.3m	S212 0.1-0.3m	TP111 0.4-0.6m
Sample Date		00 07 31	00 08 01	00 08 02	00 08 02	00 07 29
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	7.4	4.9	6.8	4.3	11.2
Total Metals						
Lead	T-Pb	526	160	128	808	-
Zinc	T-Zn	1600	409	781	1950	-
Extractable Hydrocarbons						
EPH10-19		-	-	-	-	<200
EPH19-32		-	-	-	-	<200

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M3704

		TP115 0.4-0.6m	TP116 0.4-0.6m	TP128 0.6-0.8m
Sample Date		00 07 29	00 07 29	00 07 30
ASL ID		*16*	*17*	*18*
Physical Tests				
Moisture	%	10.4	15.3	7.5
Extractable Hydrocarbons				
EPH10-19		907	1270	<200
EPH19-32		<200	<200	212

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M3704

Sediment/Soil		LL4 0.1-0.4m 00 07 30	LL4 0.1-0.4m QC # 218097
Physical Tests			
Moisture	%	8.5	6.7
Total Metals			
Lead	T-Pb	227	234
Zinc	T-Zn	905	994

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M3704

Sediment/Soil		**S207 0.1-0.3m**	**S207 0.1-0.3m**
		00 08 02	QC # 218099
Physical Tests			
Moisture	%	6.8	6.9
Total Metals			
Lead	T-Pb	128	140
Zinc	T-Zn	781	613

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure uses an automated system (Accelerated Solvent Extractor - ASE) to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone at high temperature and pressure. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:
Sample: 14 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

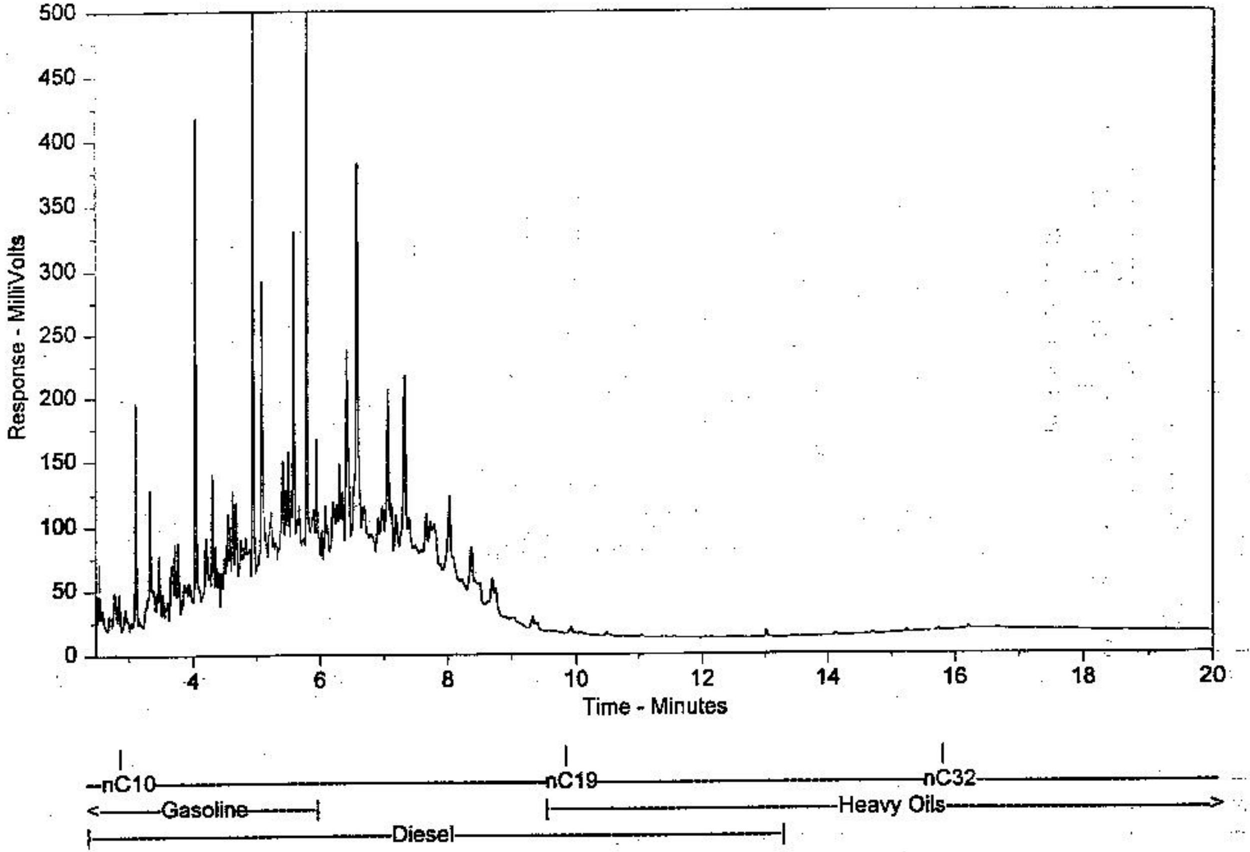
End of Report

Appendix

HYDROCARBON DISTRIBUTION REPORTS

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **M3704-T--1**
File Name: m:\chrom\gc12\data\gc12_01novB.0007.RAW
Run Information: Acquired on GC12, 11/1/00 11:39:09 AM



Sample Amount = 8.9 (g or mL)

Dilution Factor = 10.0

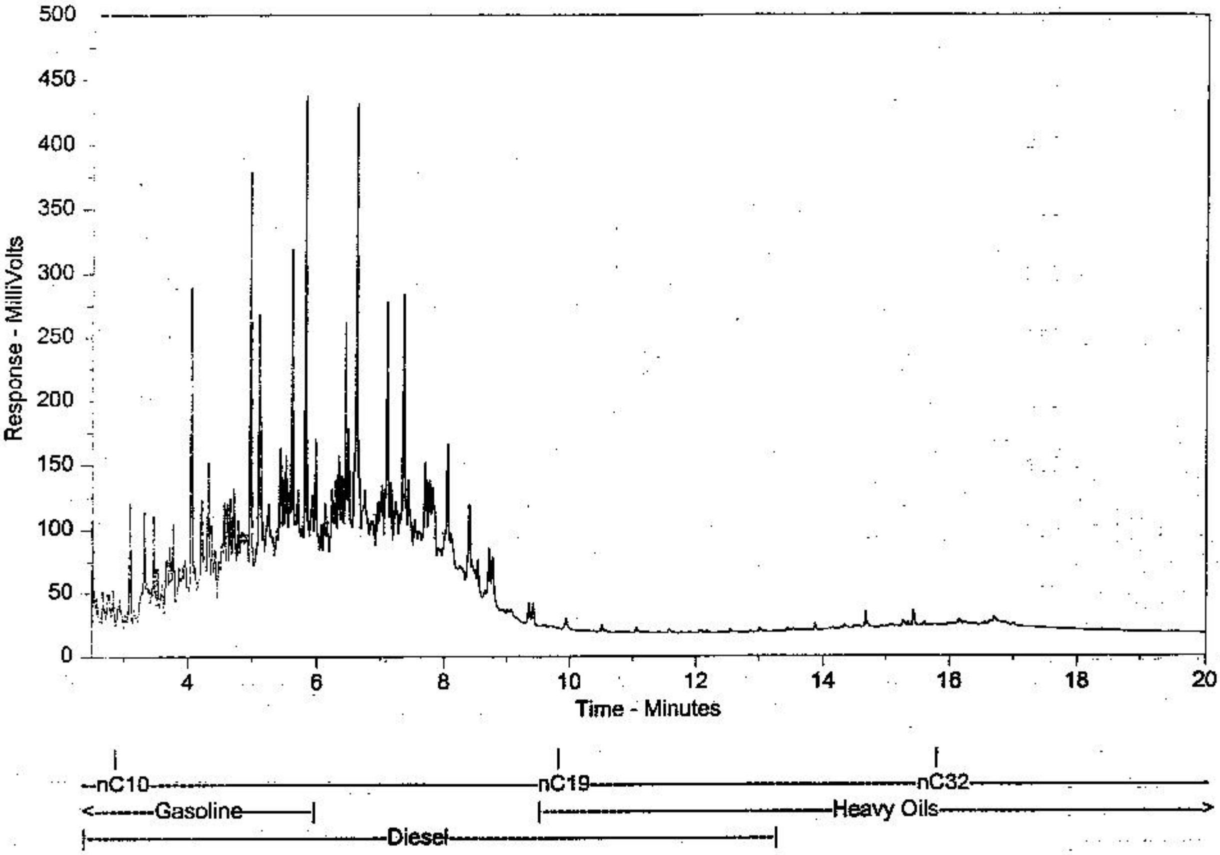
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: M3704 - 16
File Name: m:\chrom\gc04\data\gc04_28augB.0033.RAW
Run Information: Acquired on GC04, 8/29/00 10:26:12 AM



Sample Amount = 11.1 (g or mL) Dilution Factor = 10.0

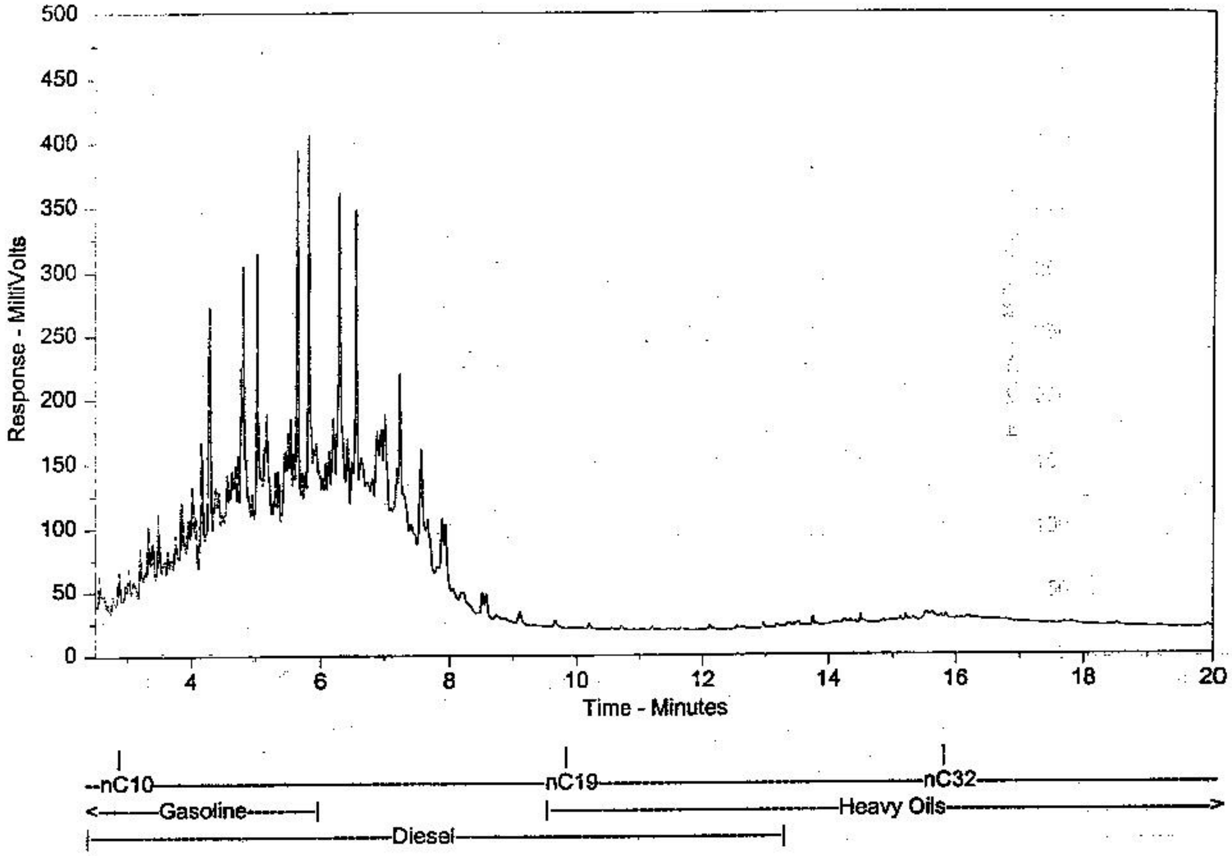
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: M3704 - 17
File Name: m:\chrom\gc04\data\gc04_28augA.0034.RAW
Run Information: Acquired on GC04, 8/29/00 10:57:25 AM



Sample Amount = 8.9 (g or mL)

Dilution Factor = 10.0

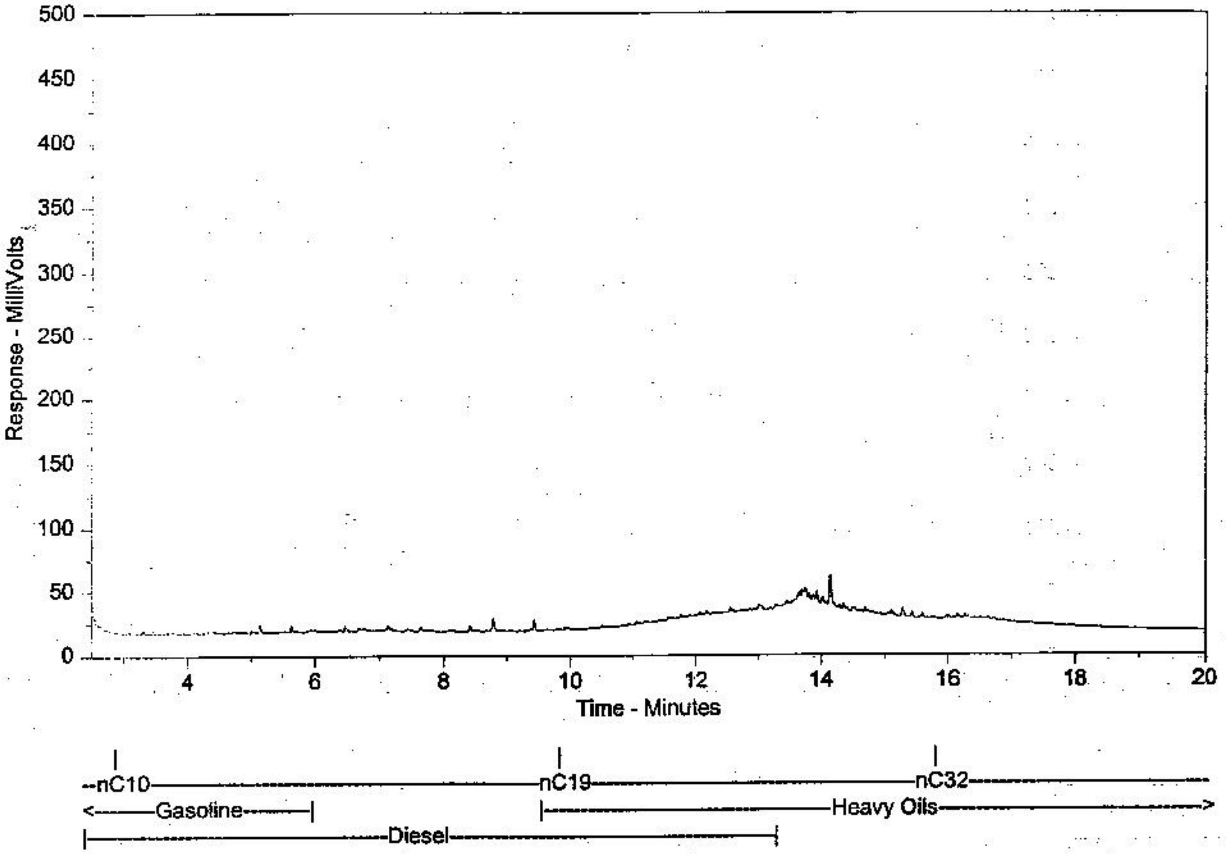
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: M3704 - 18
File Name: m:\chrom\gc04\data\gc04_28augB.0039.RAW
Run Information: Acquired on GC04, 8/29/00 1:33:48 PM



Sample Amount = 9.9 (g or mL)

Dilution Factor = 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

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988 Triumph Street, Vancouver, BC Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date:	September 25, 2000
ASL File No.	L9951
Report On:	20-930 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	August 4, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

REMARKS

File No. L9951

Please note that the detection limits for certain Total Metals for some of the samples in the following data tables due to sample matrix interferences.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID	TP 96 0.4-0.6	TP 96 0.7-0.9	TP98 0.7-0.9	TP99 0.5-0.7	TP100 0.5-0.7
Sample Date	00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID	*1*	*2*	*3*	*4*	*5*
Physical Tests					
Moisture %	1.6	3.9	8.6	7.1	5.7
Extractable Hydrocarbons					
EPH10-19	-	1150	<200	-	1840
EPH19-32	-	<200	<200	-	<200

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
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EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP103 0.3-0.5	TP104 0.5-0.7	TP105 0.5-0.7	TP109 0.4-0.6	TP110 0.4-0.6
Sample Date *ASL ID*		00 07 29 *6*	00 07 29 *7*	00 07 29 *8*	00 07 29 *9*	00 07 29 *10*
Physical Tests						
Moisture	%	9.2	14.5	11.2	14.4	9.7
Extractable Hydrocarbons						
EPH10-19		5480	<200	353	2210	894
EPH19-32		<200	<200	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID	TP111 0.4-0.6	TP112 0.4-0.6	TP112 0.6-0.8	TP113 0.4-0.6	TP114 0.4-0.6
Sample Date	00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID	*11*	*12*	*13*	*14*	*15*
Physical Tests					
Moisture %	11.2	10.3	10.5	9.9	12.3
Extractable Hydrocarbons					
EPH10-19	-	<200	-	-	2010
EPH19-32	-	<200	-	-	<200

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID	TP115 0.4-0.6	TP116 0.4-0.6	TP117 0.2-0.4	TP118 0.3-0.5	TP119 0.5-0.7
Sample Date	00 07 29	00 07 29	00 07 30	00 07 30	00 07 30
ASL ID	*16*	*17*	*18*	*19*	*20*
Physical Tests					
Moisture %	10.4	15.3	19.1	15.8	18.3
Extractable Hydrocarbons					
EPH10-19	-	-	2430	6050	<200
EPH19-32	-	-	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP121 0.6-0.7	TP122 0.6-0.7	TP123 0.6-0.7	TP124 0.6-0.8	TP125 0.6-0.8
Sample Date *ASL ID*		00 07 30 *21*	00 07 30 *22*	00 07 30 *23*	00 07 30 *24*	00 07 30 *25*
Physical Tests						
Moisture	%	14.8	13.4	7.7	12.1	12.8
Extractable Hydrocarbons						
EPH10-19		1870	<200	-	<200	-
EPH19-32		<200	<200	-	<200	-

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Sample ID		TP126 0.4-0.6	TP127 0.5-0.7	TP128 0.6-0.8	TP129 0.5-0.7	TP130 0.4-0.6
Sample Date *ASL ID*		00 07 30 *26*	00 07 30 *27*	00 07 30 *28*	00 07 30 *29*	00 07 30 *30*
Physical Tests						
Moisture	%	12.3	13.2	7.5	6.8	13.2
Extractable Hydrocarbons						
EPH10-19		<200	-	-	<200	<200
EPH19-32		<200	-	-	263	<200

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No: L9951

Sample ID	TP132 0.4-0.6	TP133 0.7-0.9	TP134 0.7-0.9	TP135B 0.7-0.9	TP137 0.6-0.8
Sample Date *ASL ID*	00 07 30 *31*	00 07 30 *32*	00 07 30 *33*	00 07 30 *34*	00 07 31 *35*
Physical Tests					
Moisture %	16.1	12.6	9.7	10.8	2.0
Extractable Hydrocarbons					
EPH10-19	2100	<200	<200	<200	<200
EPH19-32	<200	<200	<200	<200	423

Remarks regarding the analyses appear at the beginning of this report.
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Sample ID		TP138 0.5-0.7	TP139 0.5-0.8	TP140 0.5-0.8	TP141 0.4-0.7	TP142 0.4-0.7
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*36*	*37*	*38*	*39*	*40*
Physical Tests						
Moisture	%	7.8	9.8	9.9	4.5	10.3
pH		-	-	8.14	9.04	-
Total Metals						
Antimony	T-Sb	-	-	<20	<40	-
Arsenic	T-As	-	-	<5	<10	-
Barium	T-Ba	-	-	142	257	-
Beryllium	T-Be	-	-	1.2	<1	-
Cadmium	T-Cd	-	-	0.6	<1	-
Chromium	T-Cr	-	-	48	<4	-
Cobalt	T-Co	-	-	20	<4	-
Copper	T-Cu	-	-	19	<2	-
Lead	T-Pb	-	-	83	<100	-
Mercury	T-Hg	-	-	0.013	0.012	-
Molybdenum	T-Mo	-	-	<4	<8	-
Nickel	T-Ni	-	-	43	<10	-
Selenium	T-Se	-	-	<2	<2	-
Silver	T-Ag	-	-	<2	<4	-
Tin	T-Sn	-	-	<10	<20	-
Vanadium	T-V	-	-	64	9	-
Zinc	T-Zn	-	-	304	127	-
Extractable Hydrocarbons						
EPH10-19		989	<200	4310	<200	<200
EPH19-32		283	<200	2420	478	<200

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP143 0-0.1	TP143 0.3-0.6	TP144 0.1-0.3	TP144 0.3-0.6	TP145 0-0.1
Sample Date *ASL ID*		00 08 01 *41*	00 08 01 *42*	00 08 01 *43*	00 08 01 *44*	00 08 01 *45*
Physical Tests						
Moisture	%	4.4	12.8	9.9	10.0	5.7
Total Metals						
Lead	T-Pb	984	48	79	31	2050
Zinc	T-Zn	7270	426	188	146	5940

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP145 0.3-0.6	TP146 0.3-0.6	TP147 0-0.1	TP147 0.3-0.6	TP148 0.1-0.3
Sample Date *ASL ID*		00 08 01 *46*	00 08 01 *47*	00 08 01 *48*	00 08 01 *49*	00 08 01 *50*
Physical Tests						
Moisture	%	3.3	6.1	8.0	6.5	5.1
Total Metals						
Lead	T-Pb	10	1430	1500	31	1720
Zinc	T-Zn	65.1	3790	5860	173	1700

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

		TP148 0.3-0.6	TP149 0-0.1	TP149 0.3-0.6	TP150 0.1-0.3	TP150 0.3-0.6
Sample ID		TP148 0.3-0.6	TP149 0-0.1	TP149 0.3-0.6	TP150 0.1-0.3	TP150 0.3-0.6
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*51*	*52*	*53*	*54*	*55*
Physical Tests						
Moisture	%	5.0	4.7	3.6	4.1	5.1
Total Metals						
Lead	T-Pb	199	5190	2320	846	80
Zinc	T-Zn	1940	15300	13200	3080	319

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

		TP151 0-0.1	TP151 0.3-0.6	TP152 0-0.05	TP152 0.05-0.1	TP153 0-0.05
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*56*	*57*	*58*	*59*	*60*
Physical Tests						
Moisture	%	8.2	5.8	10.5	8.8	3.2
Total Metals						
Lead	T-Pb	3580	117	906	447	708
Zinc	T-Zn	8370	414	3700	872	3250

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP153 0.05-0.1	TP154 0.3-0.6	TP155 0.3-0.6	CRF-1 0.3-0.5	CRF-1 0.8-1
Sample Date		00 08 01	00 08 01	00 08 01	00 07 30	00 07 30
ASL ID		*61*	*62*	*63*	*64*	*65*
Physical Tests						
Moisture	%	10.7	5.3	7.6	2.8	5.8
Total Metals						
Lead	T-Pb	308	1270	63	-	-
Zinc	T-Zn	1160	5200	247	-	-
Extractable Hydrocarbons						
EPH10-19		-	-	-	<200	<200
EPH19-32		-	-	-	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil

Sample ID		CRF-2 0.7-0.8	CRF-3 0.2-0.4	CRF-3 0.6-0.8	LL-1 0-0.03	LL-1 0.03-0.1
Sample Date		00 07 30	00 07 30	00 07 30	00 07 30	00 07 30
ASL ID		*66*	*67*	*68*	*69*	*70*
Physical Tests						
Moisture	%	5.7	3.4	3.2	19.0	5.6
pH		-	9.02	-	-	-
Total Metals						
Antimony	T-Sb	-	<60	-	-	-
Arsenic	T-As	-	<20	-	-	-
Barium	T-Ba	-	281	-	-	-
Beryllium	T-Be	-	<2	-	-	-
Cadmium	T-Cd	-	<2	-	-	-
Chromium	T-Cr	-	<6	-	-	-
Cobalt	T-Co	-	<6	-	-	-
Copper	T-Cu	-	<3	-	-	-
Lead	T-Pb	-	<200	-	1070	53
Mercury	T-Hg	-	0.018	-	-	-
Molybdenum	T-Mo	-	<20	-	-	-
Nickel	T-Ni	-	<20	-	-	-
Selenium	T-Se	-	<2	-	-	-
Silver	T-Ag	-	<6	-	-	-
Tin	T-Sn	-	<30	-	-	-
Vanadium	T-V	-	20	-	-	-
Zinc	T-Zn	-	174	-	3970	435
Extractable Hydrocarbons						
EPH10-19		<200	-	<200	-	-
EPH19-32		<200	-	<200	-	-

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		LL-2 0-0.05	LL-2 0.05-0.1	LL-2 0.4-0.7	LL-5 0-0.05	LL-5 0.05-0.1
Sample Date		00 07 30	00 07 30	00 07 30	00 07 31	00 07 31
ASL ID		*71*	*72*	*73*	*74*	*75*
Physical Tests						
Moisture	%	11.1	7.6	9.3	26.7	12.6
Total Metals						
Lead	T-Pb	708	265	125	506	36
Zinc	T-Zn	4050	2170	1180	1900	185

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		LL-6 0-0.05	LL-6 0.05-0.2	LL-6 0.4-0.7	LLSD-1 0.1-0.4	LLSD-2 0.1-0.4
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*76*	*77*	*78*	*79*	*80*
Physical Tests						
Moisture	%	4.7	12.1	7.2	7.6	10.7
Total Metals						
Lead	T-Pb	544	96	28	16	23
Zinc	T-Zn	2100	351	85.6	98.5	85.7

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		LLSD-3 0.2-0.5	LLSD-4 0.1-0.4	LLSD-5 0.4-0.7	LLSD-6 0-0.3	LLSD-7 0.4-0.7
Sample Date *ASL ID*		00 07 31 *81*	00 07 31 *82*	00 07 31 *83*	00 07 31 *84*	00 07 31 *85*
Physical Tests						
Moisture	%	10.3	9.5	14.3	18.5	9.1
Total Metals						
Lead	T-Pb	59	22	17	30	285
Zinc	T-Zn	252	139	104	250	1230

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		MSD-1 0.1-0.3	MSD-1 0.3-0.5	MSD-3 0.1-0.3	MSD-4 0.1-0.3	MSD-5 0.1-0.2
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*86*	*87*	*88*	*89*	*90*
Physical Tests						
Moisture	%	6.9	4.8	4.0	3.4	8.4
pH		8.39	8.51	8.91	9.15	9.13
Total Metals						
Antimony	T-Sb	<60	<40	<60	<40	<60
Arsenic	T-As	<20	<10	<20	<10	<20
Barium	T-Ba	79	103	80	134	334
Beryllium	T-Be	<2	<1	<2	<1	<2
Cadmium	T-Cd	37	26	44	6	7
Chromium	T-Cr	<6	5	7	<4	<6
Cobalt	T-Co	<6	<4	<6	<4	<6
Copper	T-Cu	36	24	8	3	<3
Lead	T-Pb	7060	11400	8180	599	652
Mercury	T-Hg	0.030	0.026	0.033	0.022	0.019
Molybdenum	T-Mo	<20	<8	<20	<8	<20
Nickel	T-Ni	<20	<10	<20	<10	<20
Selenium	T-Se	<2	<2	<2	<2	<2
Silver	T-Ag	<6	<4	<6	<4	<6
Tin	T-Sn	<30	<20	<30	<20	<30
Vanadium	T-V	33	31	47	26	24
Zinc	T-Zn	15100	10100	17400	2170	788

check
Sample
ID.

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FTank2 0.1-0.3	FTank3 0.4-0.6	FTank5 0.1-0.3	FTank5 0.5-0.8	FTank6 0.5-0.7W
Sample Date *ASL ID*		00 07 31 *91*	00 07 31 *92*	00 07 31 *93*	00 07 31 *94*	00 08 01 *95*
Physical Tests						
Moisture	%	13.9	8.8	6.0	7.6	8.4
Total Metals						
Lead	T-Pb	479	-	481	244	-
Zinc	T-Zn	1450	-	1670	1700	-
Extractable Hydrocarbons						
EPH10-19		-	14600	-	<200	2100
EPH19-32		-	539	-	<200	372

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FTank6 0.5-0.7E	FTank7 0.6-0.8	FTank9 0.6-0.8	FTank10 0.2-0.5	FTank10 0.6-0.9
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*96*	*97*	*98*	*99*	*100*
Physical Tests						
Moisture	%	4.5	25.9	15.8	6.7	7.3
Total Metals						
Lead	T-Pb	-	-	-	467	-
Zinc	T-Zn	-	-	-	1820	-
Extractable Hydrocarbons						
EPH10-19		1230	2810	1300	<200	<200
EPH19-32		<200	1130	<200	<200	<200

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID	FTank11 0.3-0.6	FTank11 0.7-1	FTank12 0.6-0.9	FTank13 0.6-0.8	FTank14 0.6-0.9
Sample Date	00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID	*101*	*102*	*103*	*104*	*105*
Physical Tests					
Moisture %	8.9	9.2	8.2	6.6	8.2
Extractable Hydrocarbons					
EPH10-19	2000	833	6590	<200	5220
EPH19-32	1220	<200	372	<200	314

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FTank15 0.6-0.8	FTank16 0.1-0.3	FTank16 0.6-0.9	FTank17 0.1-0.3	FTank17 0.6-0.9
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*106*	*107*	*108*	*109*	*110*
Physical Tests						
Moisture	%	8.4	5.6	10.2	8.4	8.3
Total Metals						
Lead	T-Pb	-	1220	-	-	-
Zinc	T-Zn	-	4330	-	-	-
Extractable Hydrocarbons						
EPH10-19		981	-	948	1610	3340
EPH19-32		<200	-	234	630	250

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RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FH-1 0.1-0.3	FH-1 0.6-0.9	FH-3A 0.3-0.6	FH-3B 0.3-0.6	FH-3 0.6-0.9
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*111*	*112*	*113*	*114*	*115*
Physical Tests						
Moisture	%	4.3	5.3	4.5	2.9	5.3
Total Metals						
Lead	T-Pb	728	-	17	226	-
Zinc	T-Zn	3100	-	42.0	1780	-
Extractable Hydrocarbons						
EPH10-19		<200	<200	1230	827	610
EPH19-32		<200	<200	<200	<200	<200

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EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID			FH-4 0.7-1	FH-6 0.6-0.9	FH-7 0.3-0.6	FH-7 0.6-0.9	FH-8 0.3-0.6
Sample Date			00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID			*116*	*117*	*118*	*119*	*120*
Physical Tests							
Moisture	%		12.7	8.0	5.5	5.3	7.2
Total Metals							
Lead	T-Pb		-	-	877	3280	-
Zinc	T-Zn		-	-	196000	196000	-
Leachable Anions & Cations							
Bromide	Br		-	-	<5	-	-
Chloride	Cl		-	-	793	-	-
Fluoride	F		-	-	0.3	-	-
Nitrate Nitrogen		N	-	-	0.28	-	-
Nitrite Nitrogen		N	-	-	<1	-	-
Sulphate	SO4		-	-	11900	-	-
Extractable Hydrocarbons							
EPH10-19			2350	2410	1210	3380	<200
EPH19-32			232	<200	450	<200	618

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FH-8 0.6-0.9	FH-9 0.2-0.4	FH-9 0.5-0.7	FH-10 0.1-0.3	FH-10 0.6-0.9
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*121*	*122*	*123*	*124*	*125*
Physical Tests						
Moisture	%	7.2	6.0	4.9	2.6	7.4
Total Metals						
Lead	T-Pb	8610	63	-	228	5950
Zinc	T-Zn	49400	165	-	101	28600
Extractable Hydrocarbons						
EPH10-19		<200	-	<200	-	<200
EPH19-32		<200	-	<200	-	<200

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		FH-11 0.4-0.6	FH-11 0.9	S200 0-0.05	S200 0.1-0.3	S201 0-0.1
Sample Date *ASL ID*		00 08 01 *126*	00 08 01 *127*	00 08 01 *128*	00 08 01 *129*	00 08 01 *130*
Physical Tests						
Moisture	%	5.6	5.2	5.7	9.2	1.1
Total Metals						
Lead	T-Pb	-	-	1200	3000	2270
Zinc	T-Zn	-	-	4590	9750	7950
Extractable Hydrocarbons						
EPH10-19		<200	-	-	-	-
EPH19-32		<200	-	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		S201 0.3-0.6	S202 0-0.1	S202 0.4	S203 0-0.05	S203 0.1-0.3
Sample Date *ASL ID*		00 08 01 *131*	00 08 01 *132*	00 08 01 *133*	00 08 01 *134*	00 08 01 *135*
Physical Tests						
Moisture	%	14.2	1.1	4.2	7.0	11.1
Total Metals						
Lead	T-Pb	91	1190	149	737	630
Zinc	T-Zn	544	4310	483	2870	2630

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		S204 0-0.05	S204 0.1-0.3	S205 0-0.05	S205 0.1-0.3	S206 0-0.05
Sample Date		00 08 02	00 08 02	00 08 02	00 08 02	00 08 02
ASL ID		*136*	*137*	*138*	*139*	*140*
Physical Tests						
Moisture	%	5.9	9.0	0.1	4.2	3.8
Total Metals						
Lead	T-Pb	1040	150	5540	302	1750
Zinc	T-Zn	2760	524	16300	834	8150

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		S206 0.3-0.6	S207 0-0.05	S207 0.3-0.6	S208 0-0.05	S208 0.1-0.3
Sample Date		00 08 02	00 08 02	00 08 02	00 08 02	00 08 02
ASL ID		*141*	*142*	*143*	*144*	*145*
Physical Tests						
Moisture	%	7.0	2.3	7.7	6.0	6.5
Total Metals						
Lead	T-Pb	505	1390	285	585	137
Zinc	T-Zn	4080	5390	832	2330	1140

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		S208 0.3-0.5	S209 0-0.05	S209 0.1-0.3	S210 0-0.05	S210 0.3-0.5
Sample Date		00 08 02	00 08 02	00 08 02	00 08 02	00 08 02
ASL ID		*146*	*147*	*148*	*149*	*150*
Physical Tests						
Moisture	%	9.3	4.2	6.2	3.5	6.2
Total Metals						
Lead	T-Pb	173	894	348	369	348
Zinc	T-Zn	812	2380	1010	1330	668

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

		S211 0-0.05	S211 0.1-0.3	S212 0-0.05	S212 0.3-0.6	S213 0-0.1
Sample Date *ASL ID*		00 08 02 *151*	00 08 02 *152*	00 08 02 *153*	00 08 02 *154*	00 08 02 *155*
Physical Tests						
Moisture	%	6.6	10.7	2.3	8.4	4.7
Total Metals						
Lead	T-Pb	745	189	2580	4420	706
Zinc	T-Zn	2160	710	5940	725	1590

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		S213 0.3-0.5	ACC-2 0.1-0.3	ACC-3 0.1-0.3	ACC-3 0.3-0.5	ACC-4 0.3-0.6
Sample Date		00 08 02	00 08 02	00 08 02	00 08 02	00 08 02
ASL ID		*156*	*157*	*158*	*159*	*160*
Physical Tests						
Moisture	%	16.0	7.5	5.8	7.7	6.3
Total Metals						
Lead	T-Pb	36	123	-	-	161
Zinc	T-Zn	104	305	-	-	582
Extractable Hydrocarbons						
EPH10-19		-	960	-	2580	<200
EPH19-32		-	<200	-	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		ACC-4 0.6-0.9	ACC-5 0.6-0.9	ACC-6 0.2-0.4	TP85 0.4-0.5	TP89 0.5-0.7
Sample Date		00 08 02	00 08 02	00 08 02	00 07 29	00 07 29
ASL ID		*161*	*162*	*163*	*164*	*165*
Physical Tests						
Moisture	%	7.2	7.7	6.3	3.4	5.8
Total Metals						
Lead	T-Pb	262	126	-	-	-
Zinc	T-Zn	128	180	-	-	-
Extractable Hydrocarbons						
EPH10-19		<200	<200	<200	<200	<200
EPH19-32		<200	<200	<200	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9951

Sample ID		TP91 0.1-0.3	TP91 0.6-0.8	TP94 0.5-0.7	TP95 0.7-0.8	T146 0.1-0.3
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 08 01
ASL ID		*166*	*167*	*168*	*169*	*170*
Physical Tests						
Moisture	%	9.6	7.4	11.7	9.0	5.2
Total Metals						
Lead	T-Pb	-	-	-	-	422
Zinc	T-Zn	-	-	-	-	1670
Extractable Hydrocarbons						
EPH10-19		901	7600	<200	<200	-
EPH19-32		<200	301	<200	<200	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure uses an automated system (Accelerated Solvent Extractor - ASE) to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone at high temperature and pressure. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:
Sample: 14 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

pH in Soil

This analysis is carried out in accordance with procedures described in "Soil Sampling and Methods of Analysis" (CSSS). The procedure involves mixing the air-dried sample with deionized/distilled water. The pH of the solution is then measured using a standard pH probe. A one to two ratio of sediment to water is used for mineral soils and a one to ten ratio is used for highly organic soils.

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Conventional Parameters in Sediment/Soil

These analyses are carried out on a leachable basis. The procedure involves mixing the sample with reagent grade water in a one to ten ratio and leaching for several hours. The leachate is filtered and analyzed in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Nitrate and Nitrite in Water by Colourimetry

This analysis is carried out using procedures adapted from APHA Method 4500-NO2 "Nitrogen (Nitrite)" and Method 4500-NO3 "Nitrogen (Nitrate)". Nitrite is determined using the azo dye colourimetric method. Nitrate is determined using the cadmium reduction colourimetric method. Nitrate/nitrite is the sum of the concentrations of nitrate and nitrite present in the sample.

Recommended Holding Time:
Sample: 2 days
Reference: APHA and EPA
For more detail see ASL "Collection & Sampling Guide"

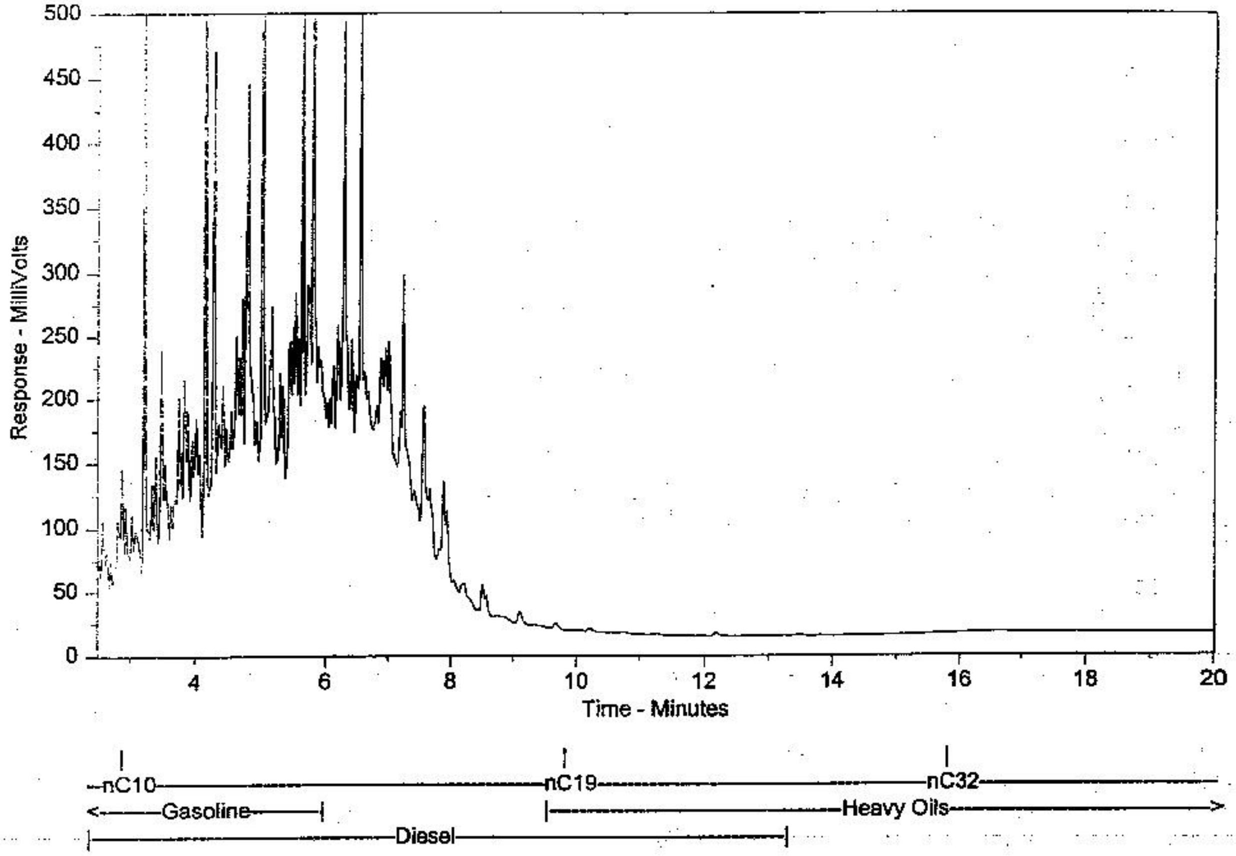
End of Report

Appendix

HYDROCARBON
DISTRIBUTION
REPORTS

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--21**
File Name: m:\chrom\gc04\data\gc04_28augA.0036.RAW
Run Information: Acquired on GC04, 8/29/00 12:00:02 PM



Sample Amount = 9.5 (g or mL)

Dilution Factor = 10.0

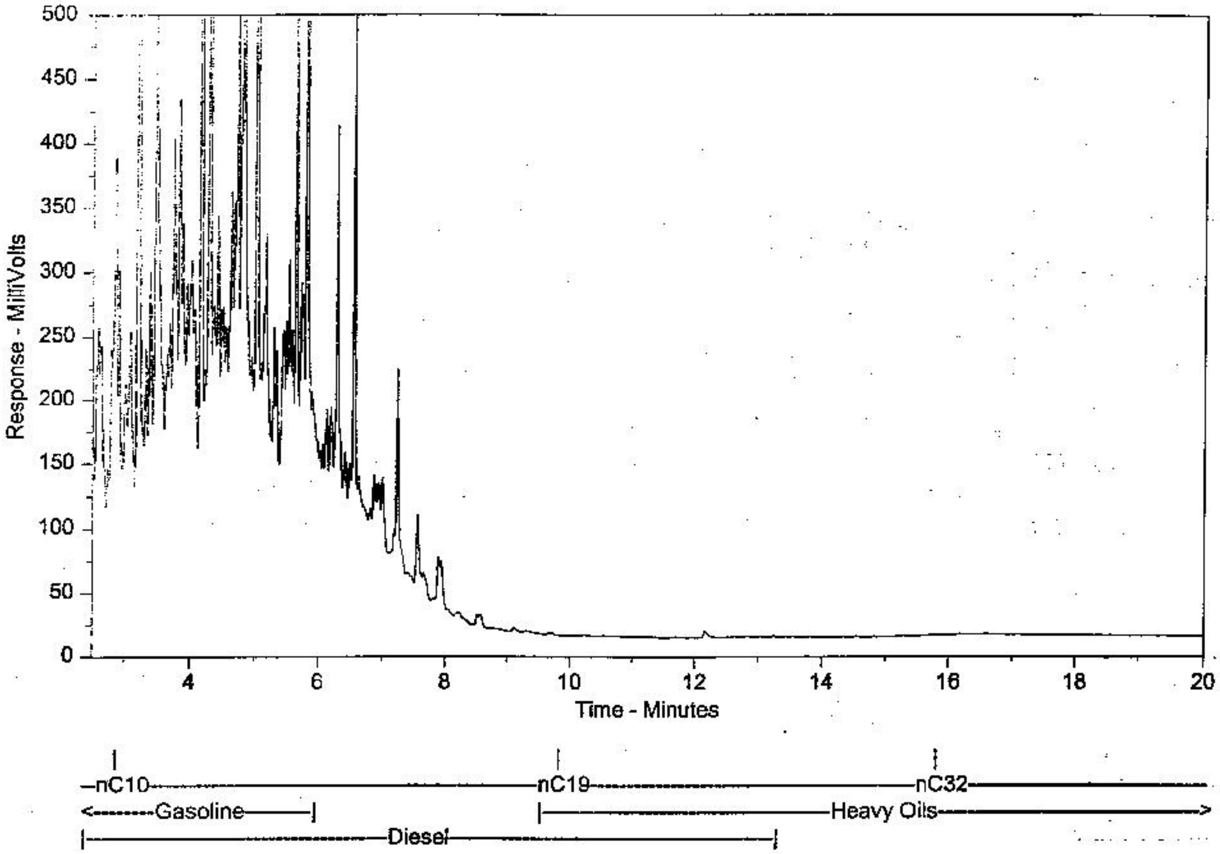
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--31**
File Name: m:\chrom\gc04\data\gc04_28augA.0041.RAW
Run Information: Acquired on GC04, 8/29/00 2:36:33 PM



Sample Amount = 10.7 (g or mL)

Dilution Factor = 10.0

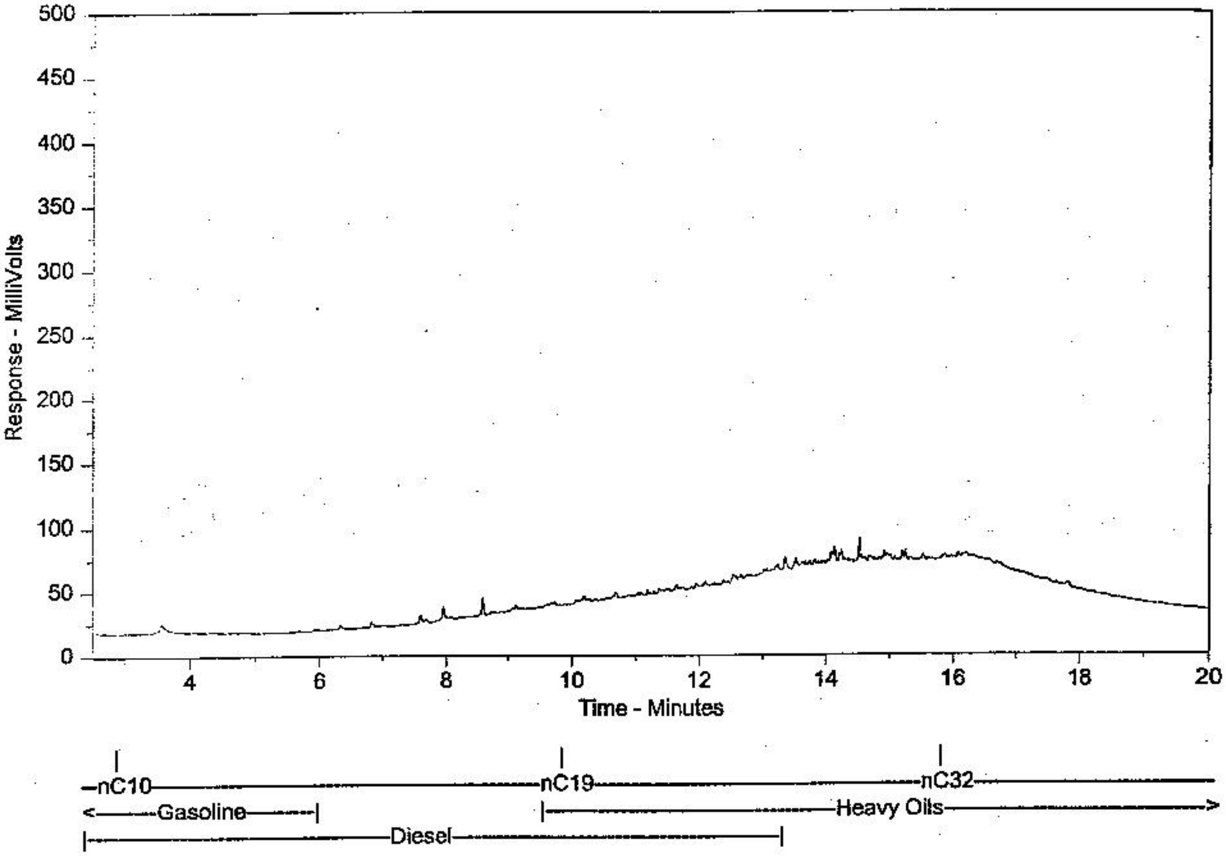
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T-35**
File Name: m:\chrom\gc04\data\gc04_28augA.0043.RAW
Run Information: Acquired on GC04, 8/29/00 3:39:11 PM



Sample Amount = 10.0 (g or mL)

Dilution Factor = 10.0

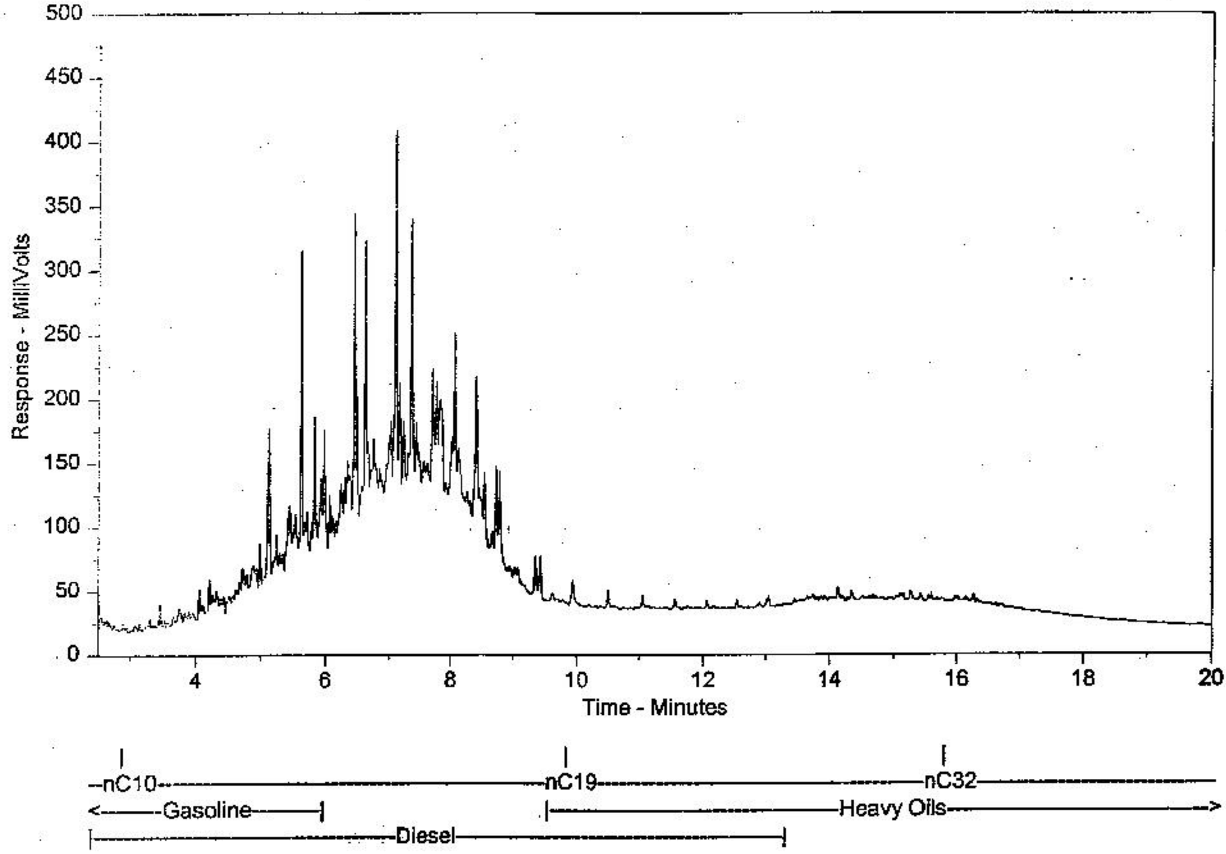
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T-36**
File Name: m:\chrom\gc04\data\gc04_28augB.0043.RAW
Run Information: Acquired on GC04, 8/29/00 3:39:11 PM



Sample Amount = 11.0 (g or mL)

Dilution Factor = 10.0

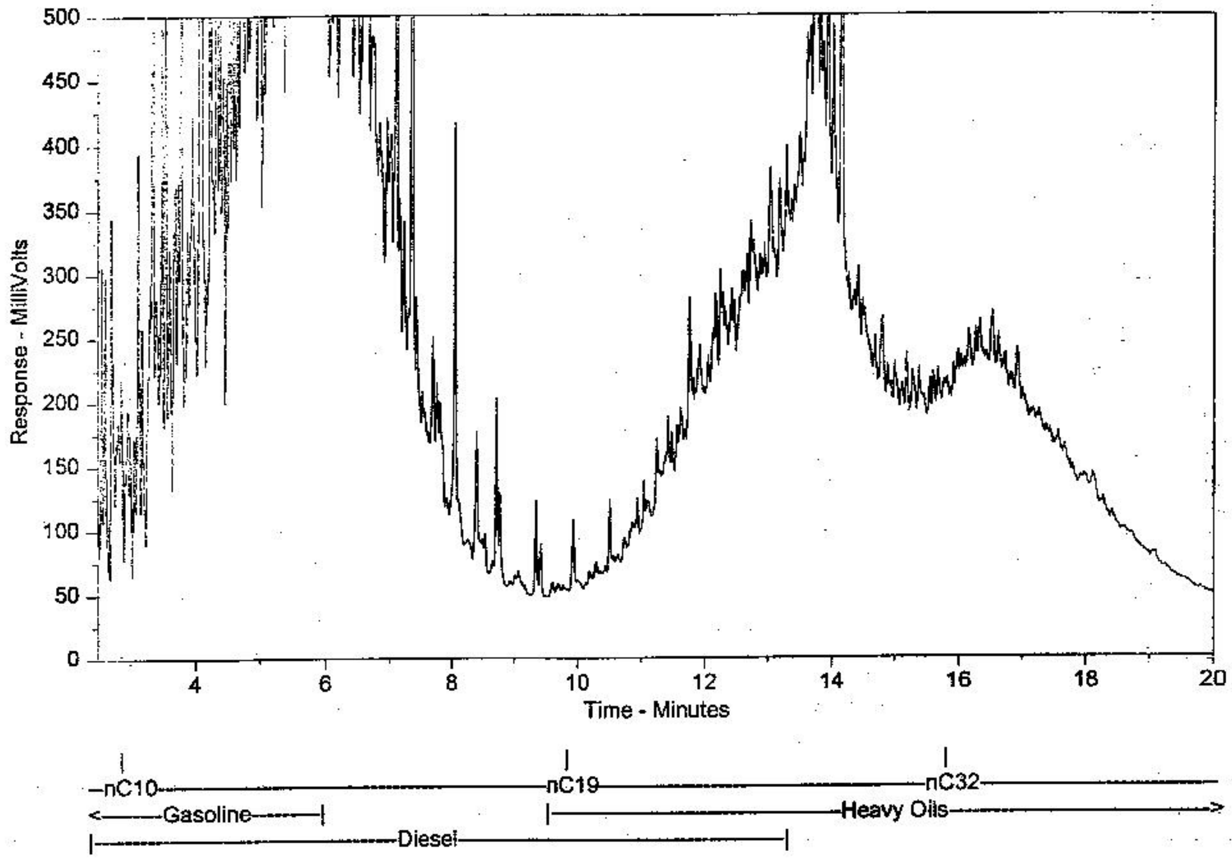
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--38**
File Name: m:\chrom\gc04\data\gc04_28augB.0044.RAW
Run Information: Acquired on GC04, 8/29/00 4:10:32 PM



Sample Amount = 10.5 (g or mL) Dilution Factor = 10.0

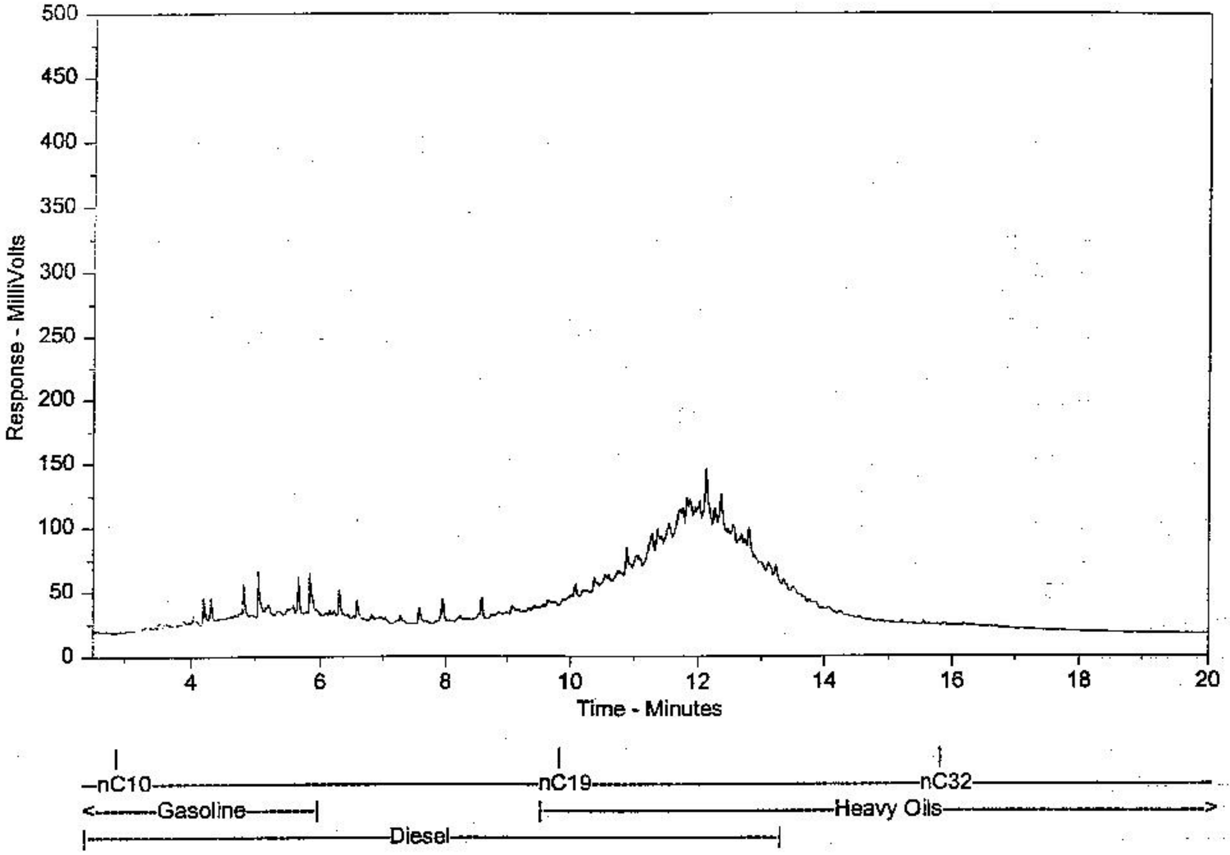
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--39**
File Name: m:\chrom\gc04\data\gc04_29augA.0006.RAW
Run Information: Acquired on GC04, 8/29/00 7:28:07 PM



Sample Amount = 11.3 (g or mL)

Dilution Factor = 10.0

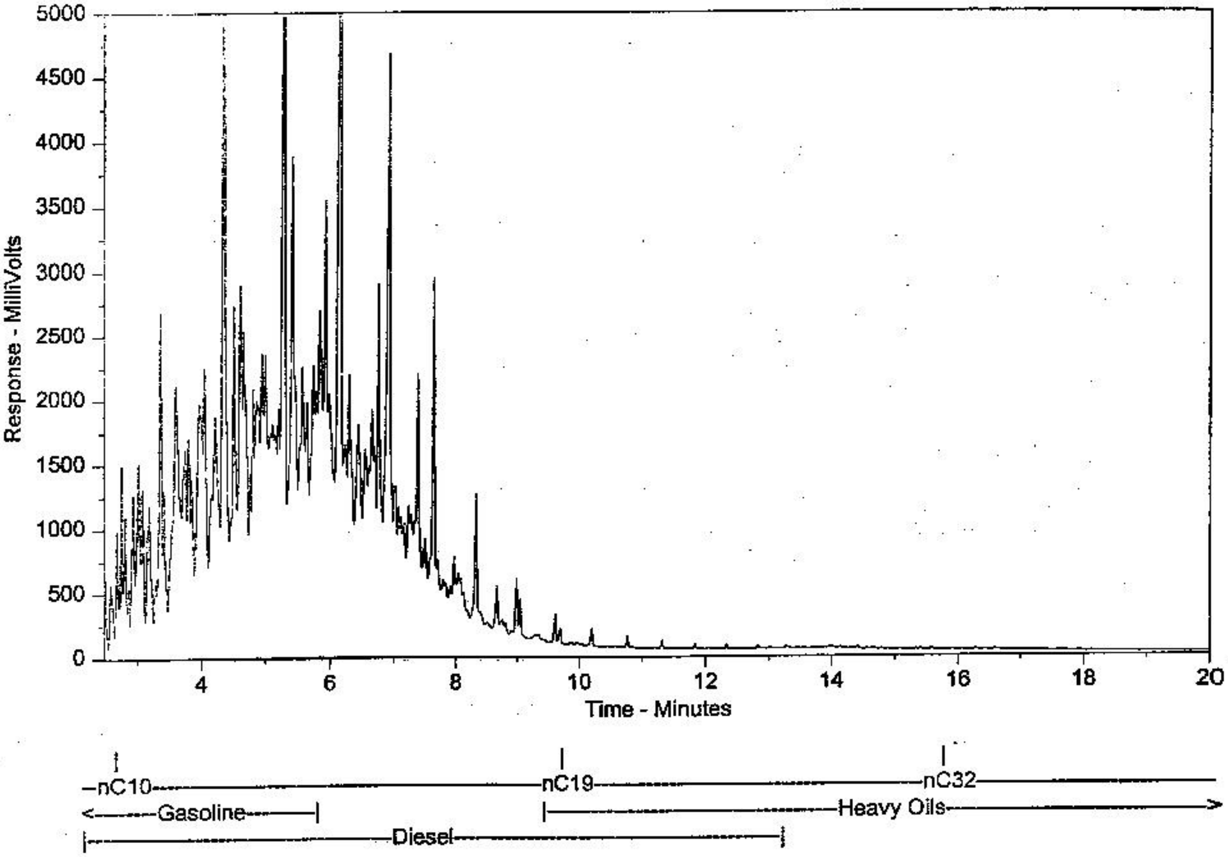
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--92**
File Name: m:\chrom\gc12\data\gc12_29augA.0031.RAW
Run Information: Acquired on GC12, 8/30/00 9:19:51 AM



Sample Amount = 11.7 (g or mL)

Dilution Factor = 10.0

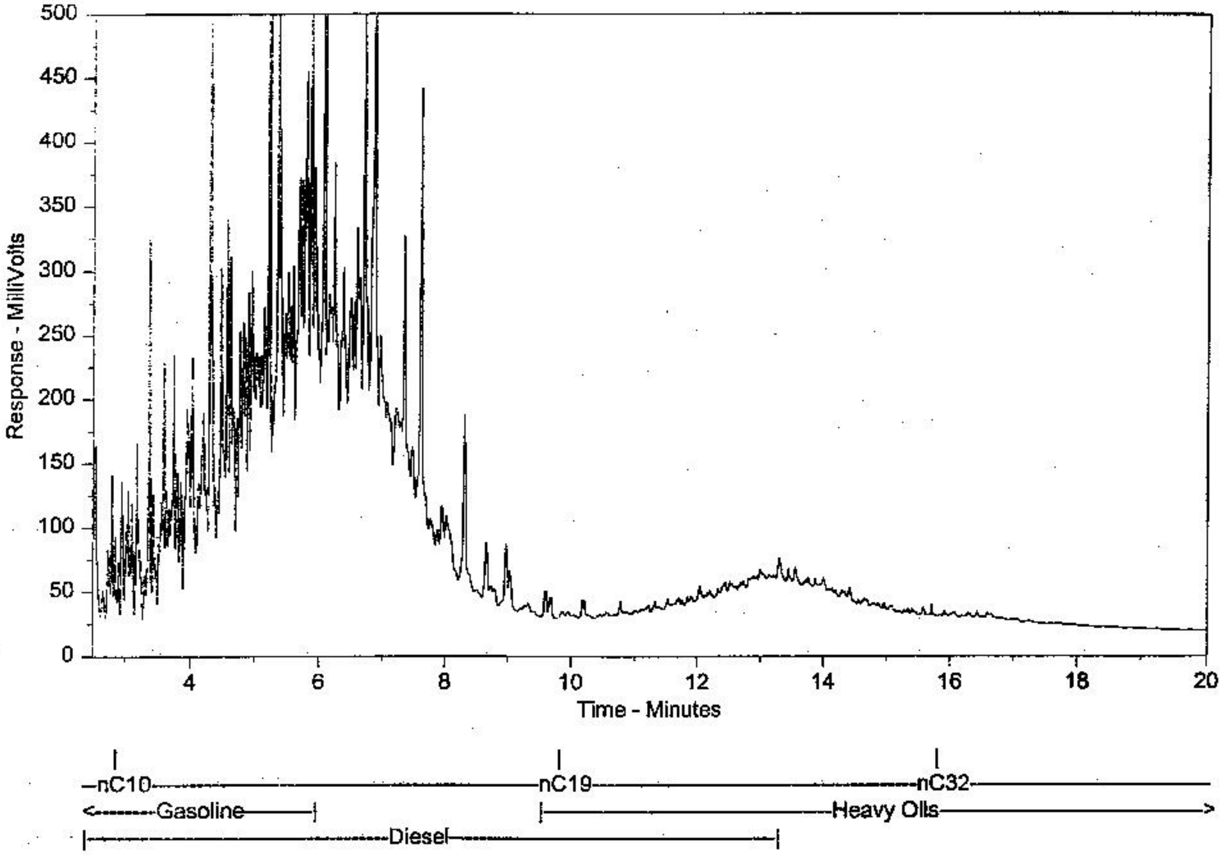
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	
ASL Sample ID:	**L9951-T--95**
File Name:	m:\chrom\gc12\data\gc12_29augA.0032.RAW
Run Information:	Acquired on GC12, 8/30/00 9:51:00 AM



Sample Amount = 10.6 (g or mL)

Dilution Factor = 10.0

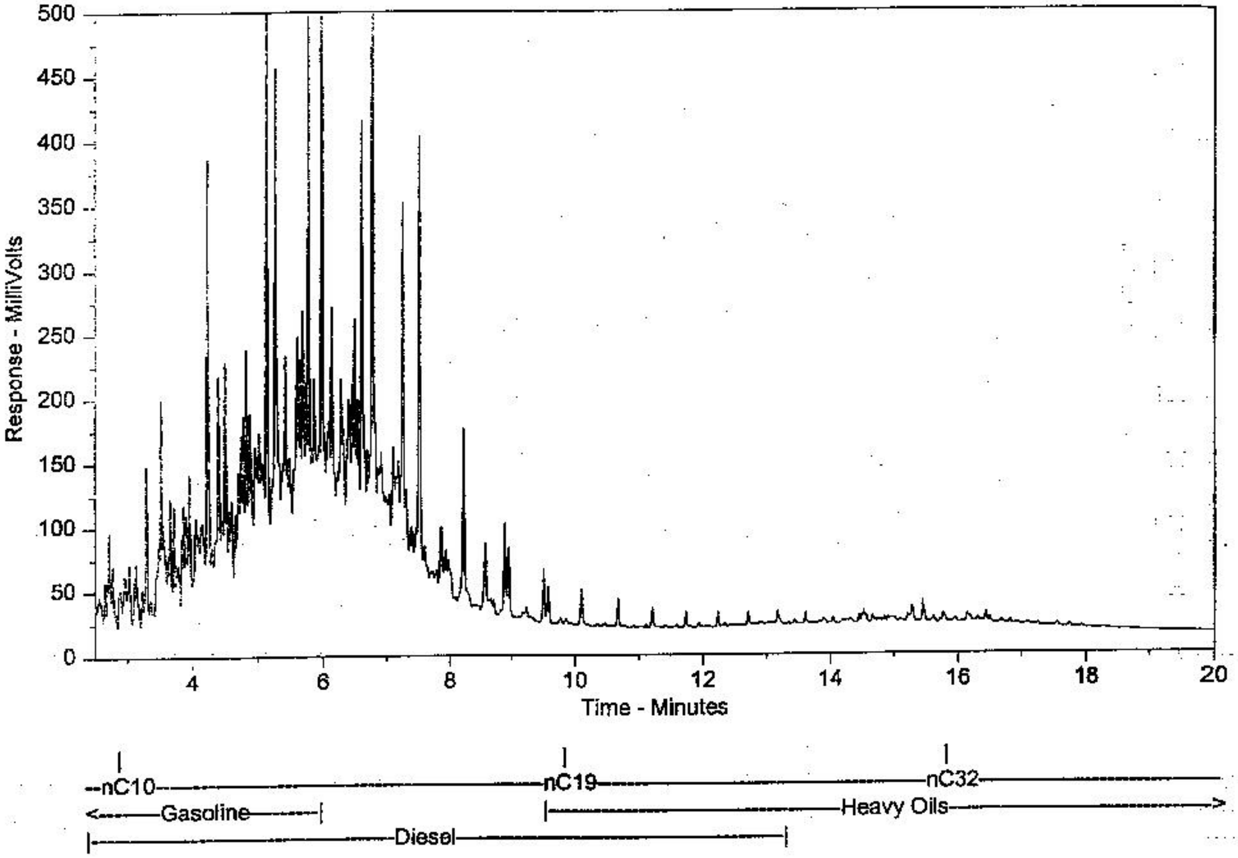
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--96**
File Name: m:\chrom\gc12\data\gc12_29augB.0032.RAW
Run Information: Acquired on GC12, 8/30/00 9:51:00 AM



Sample Amount = 11.4 (g or mL)

Dilution Factor = 10.0

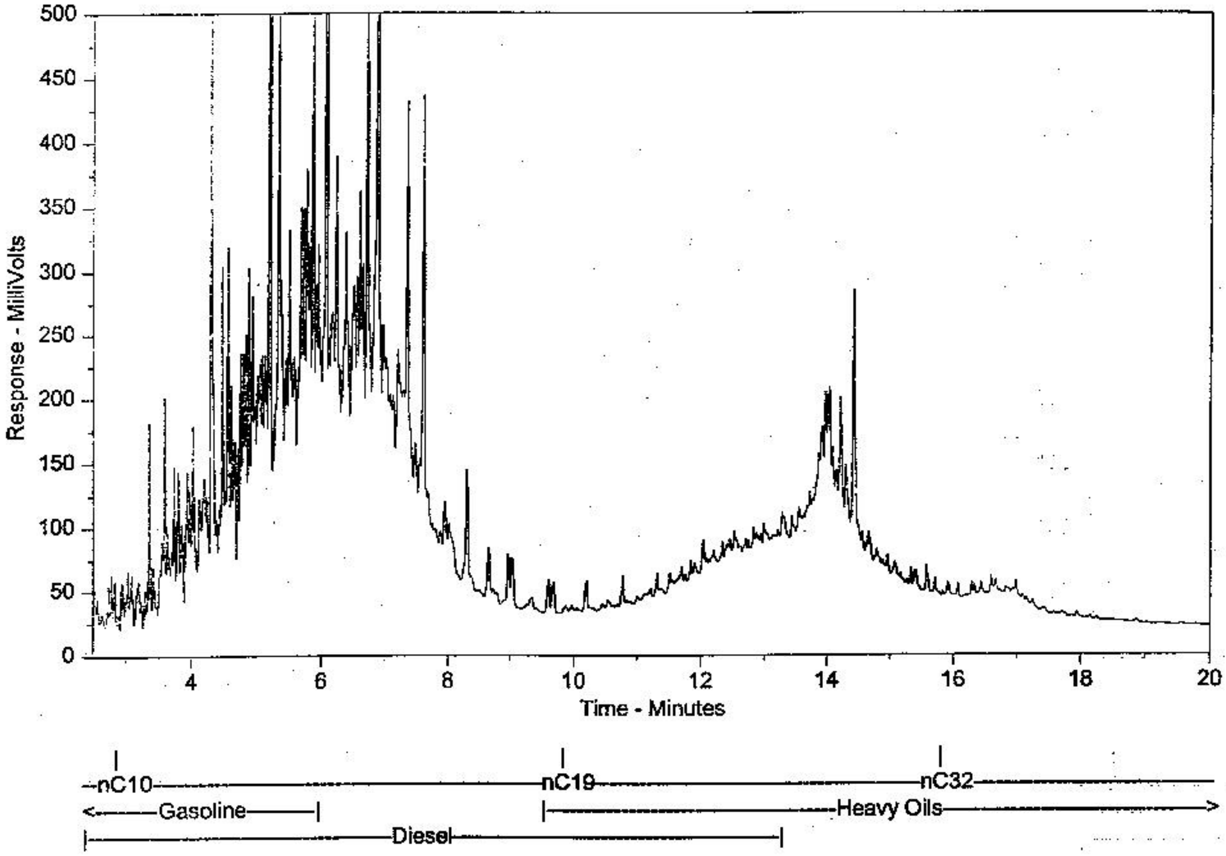
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--97**
File Name: m:\chrom\gc12\data\gc12_29augA.0033.RAW
Run Information: Acquired on GC12, 8/30/00 10:21:56 AM



Sample Amount = 7.7 (g or mL) Dilution Factor = 10.0

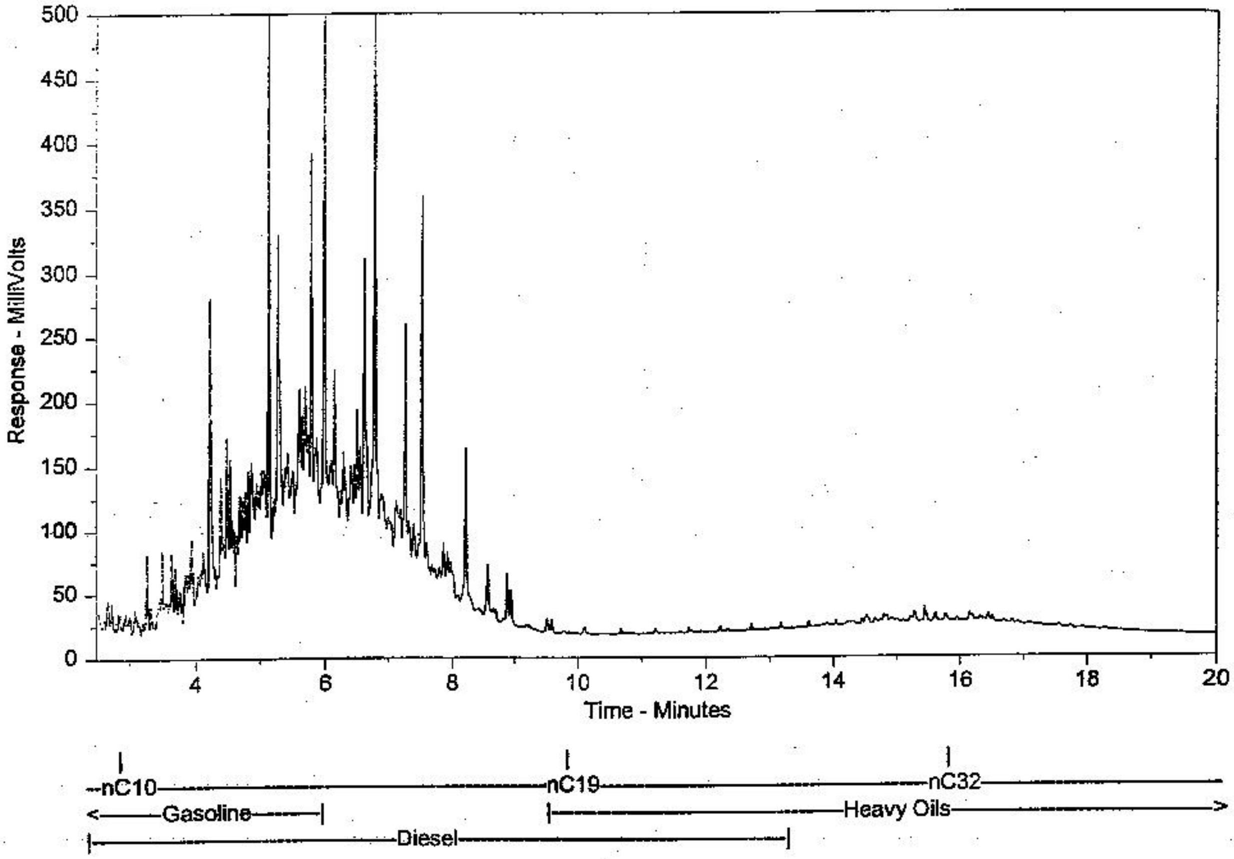
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--98**
File Name: m:\chrom\gc12\data\gc12_29augB.0033.RAW
Run Information: Acquired on GC12, 8/30/00 10:21:57 AM



Sample Amount = 8.8 (g or mL) Dilution Factor = 10.0

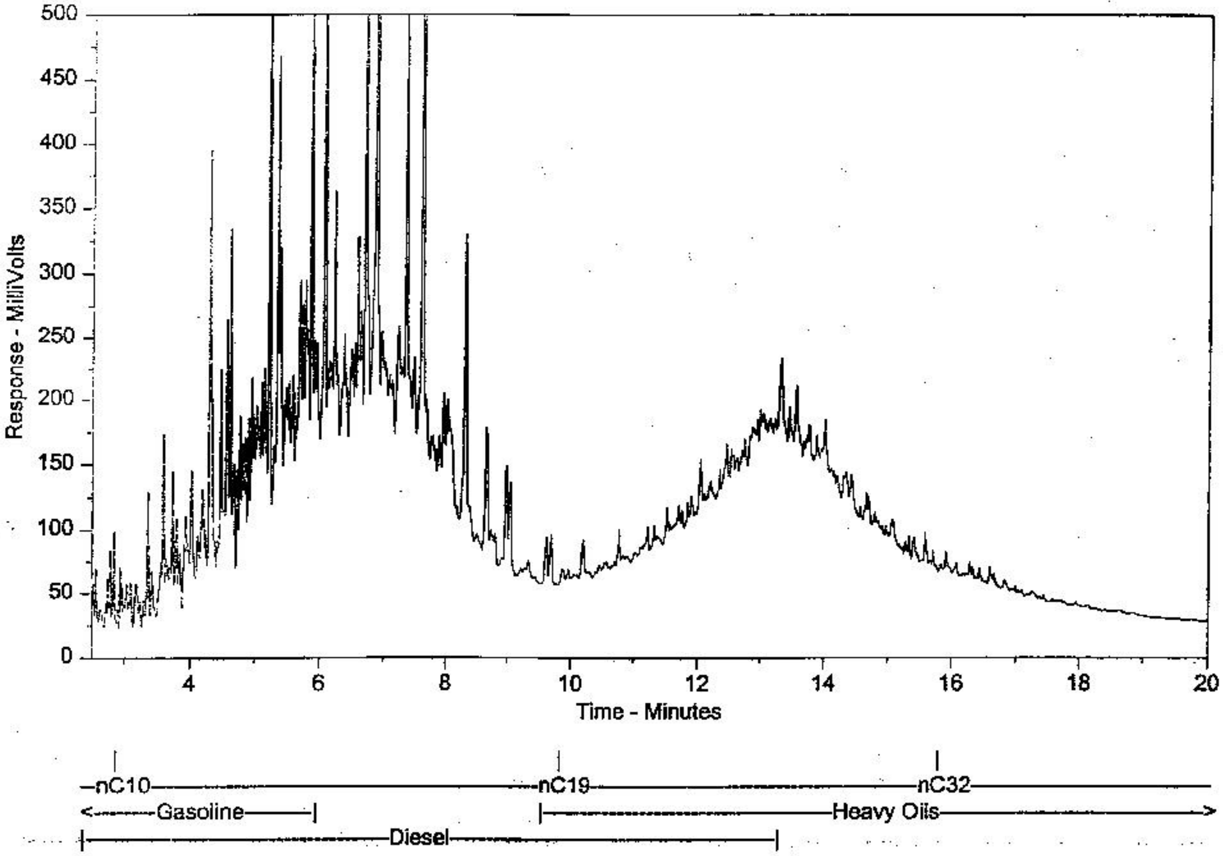
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	
ASL Sample ID:	**L9951-T--101**
File Name:	m:\chrom\gc12\data\gc12_29augA.0035.RAW
Run Information:	Acquired on GC12, 8/30/00 11:23:56 AM



Sample Amount = 11.3 (g or mL)

Dilution Factor = 10.0

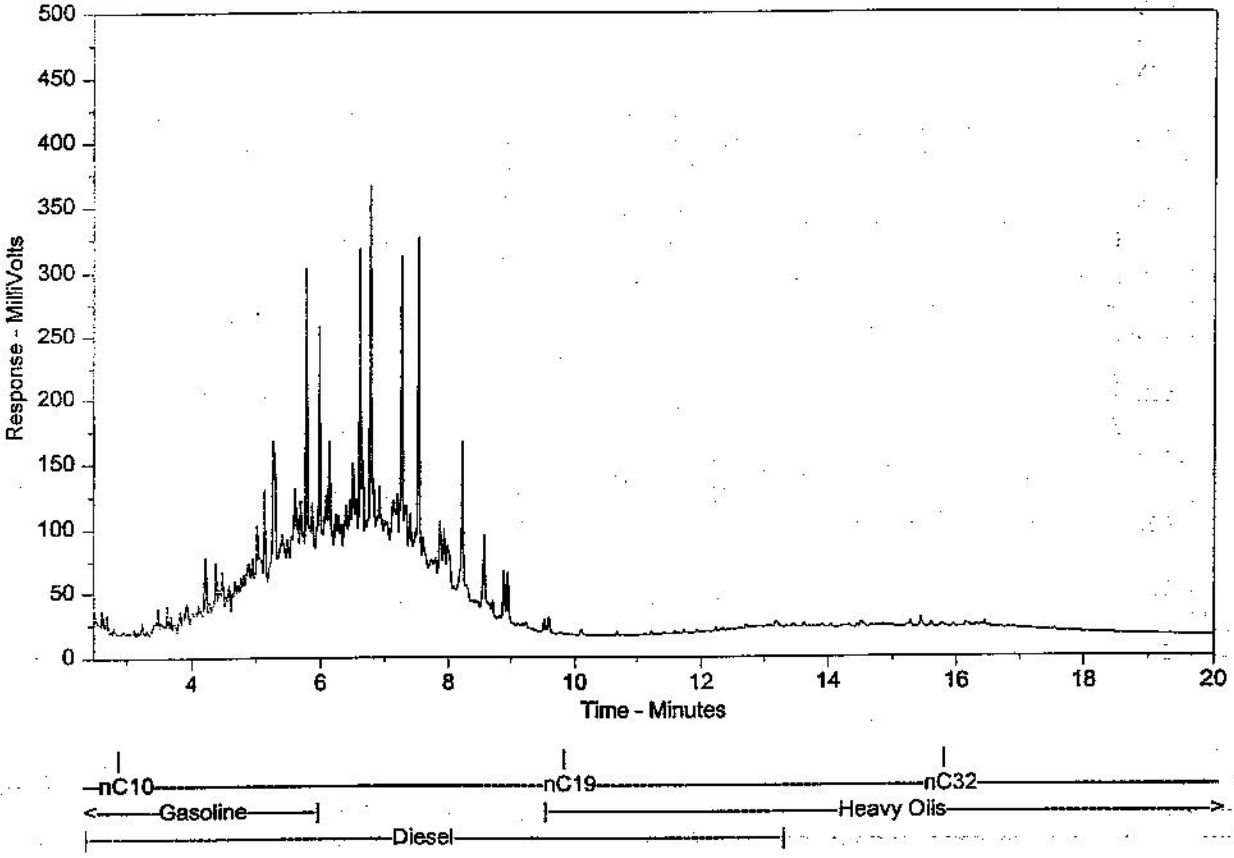
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--102**
File Name: m:\chrom\gc12\data\gc12_29augB.0035.RAW
Run Information: Acquired on GC12, 8/30/00 11:23:57 AM



Sample Amount = 10.0 (g or mL) **Dilution Factor = 10.0**

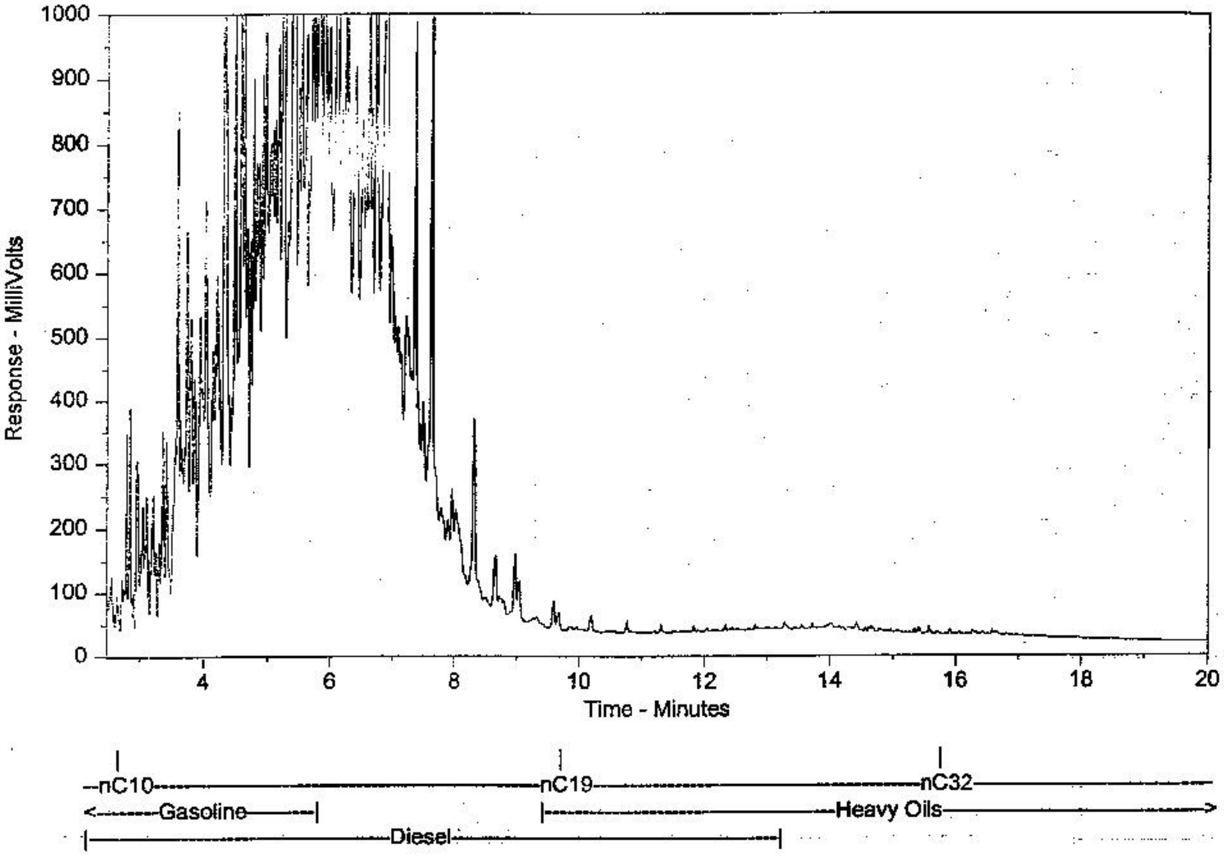
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--103**
File Name: m:\chrom\gc12\data\gc12_29augA.0036.RAW
Run Information: Acquired on GC12, 8/30/00 11:55:28 AM



Sample Amount = 10.5 (g or mL) Dilution Factor = 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

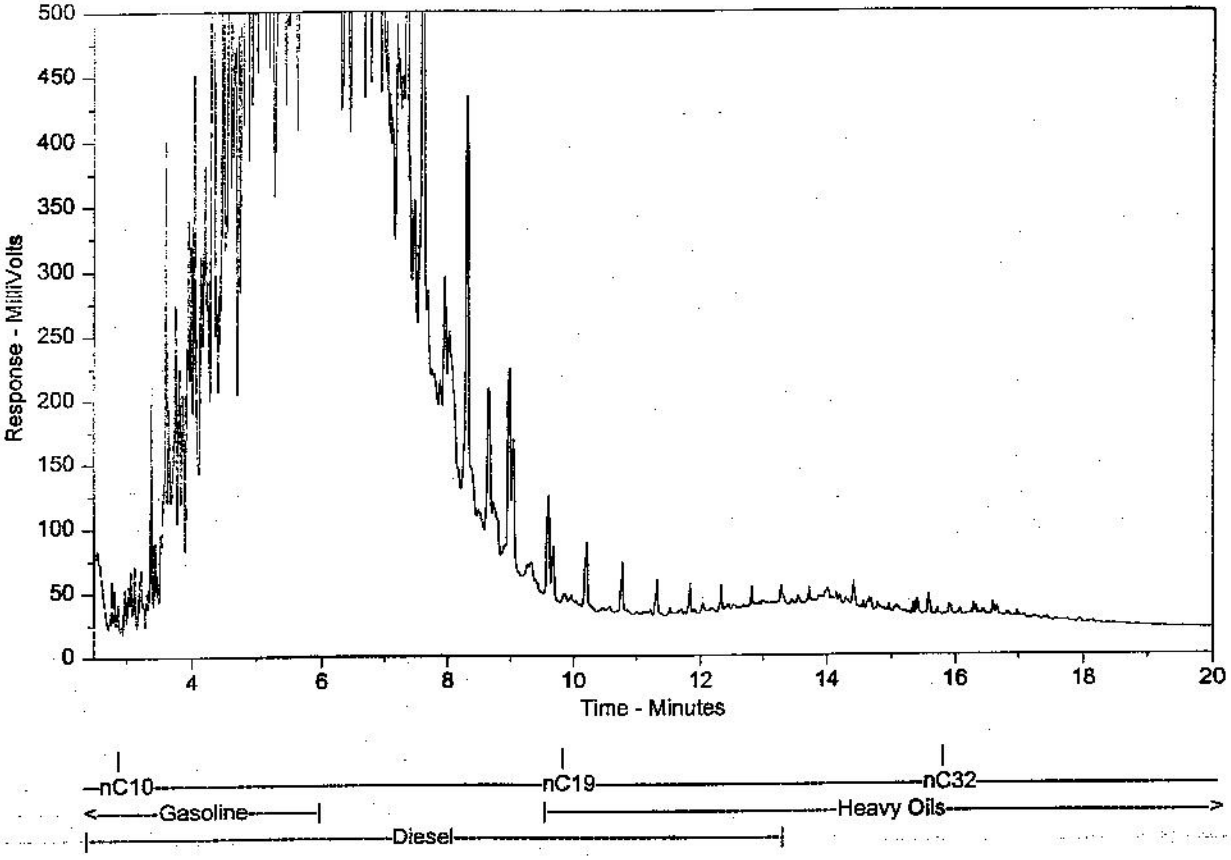
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

Printed on 8/30/00 6:03:44 PM

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--105**
File Name: m:\chrom\gc12\data\gc12_29augA.0037.RAW
Run Information: Acquired on GC12, 8/30/00 12:26:29 PM



Sample Amount = 10.1 (g or mL)

Dilution Factor = 10.0

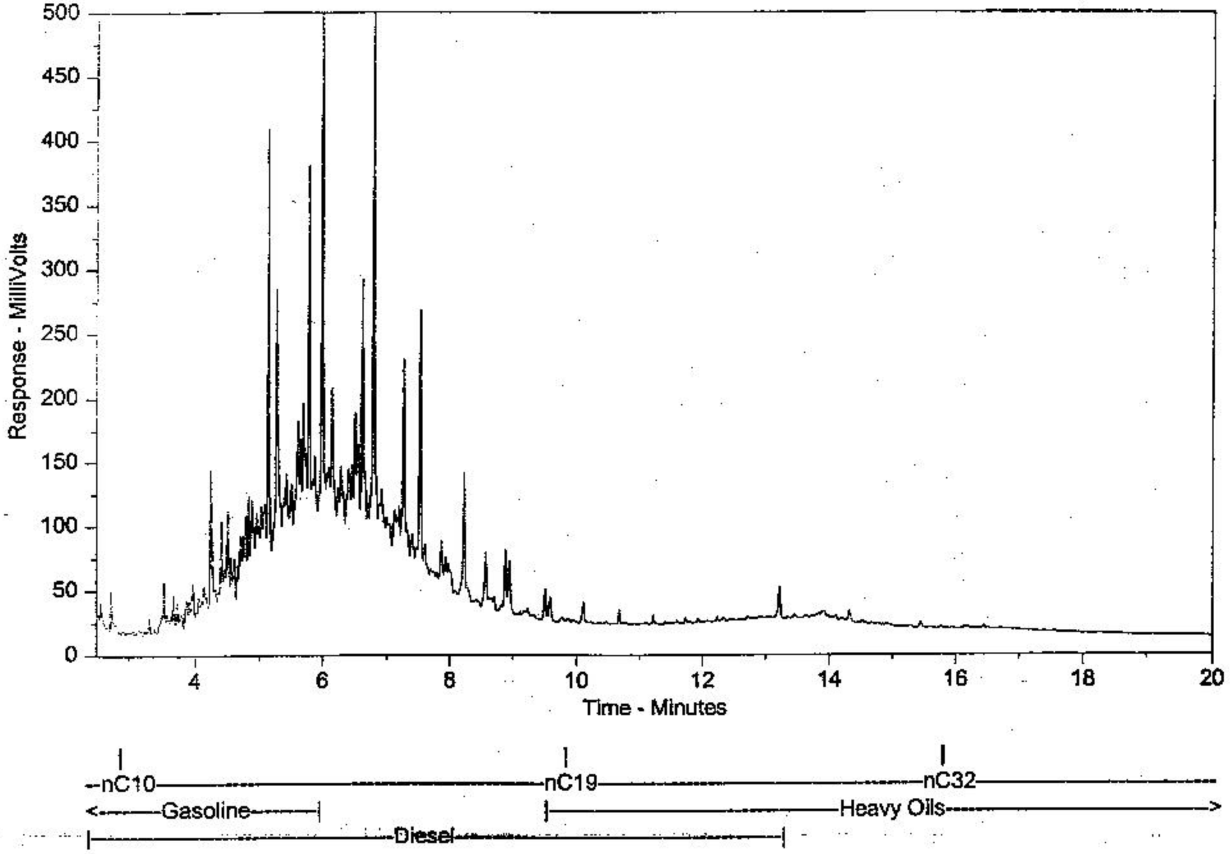
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--106**
File Name: m:\chrom\gc12\data\gc12_29augB.0037.RAW
Run Information: Acquired on GC12, 8/30/00 12:26:30 PM



Sample Amount = 10.2 (g or mL)

Dilution Factor = 10.0

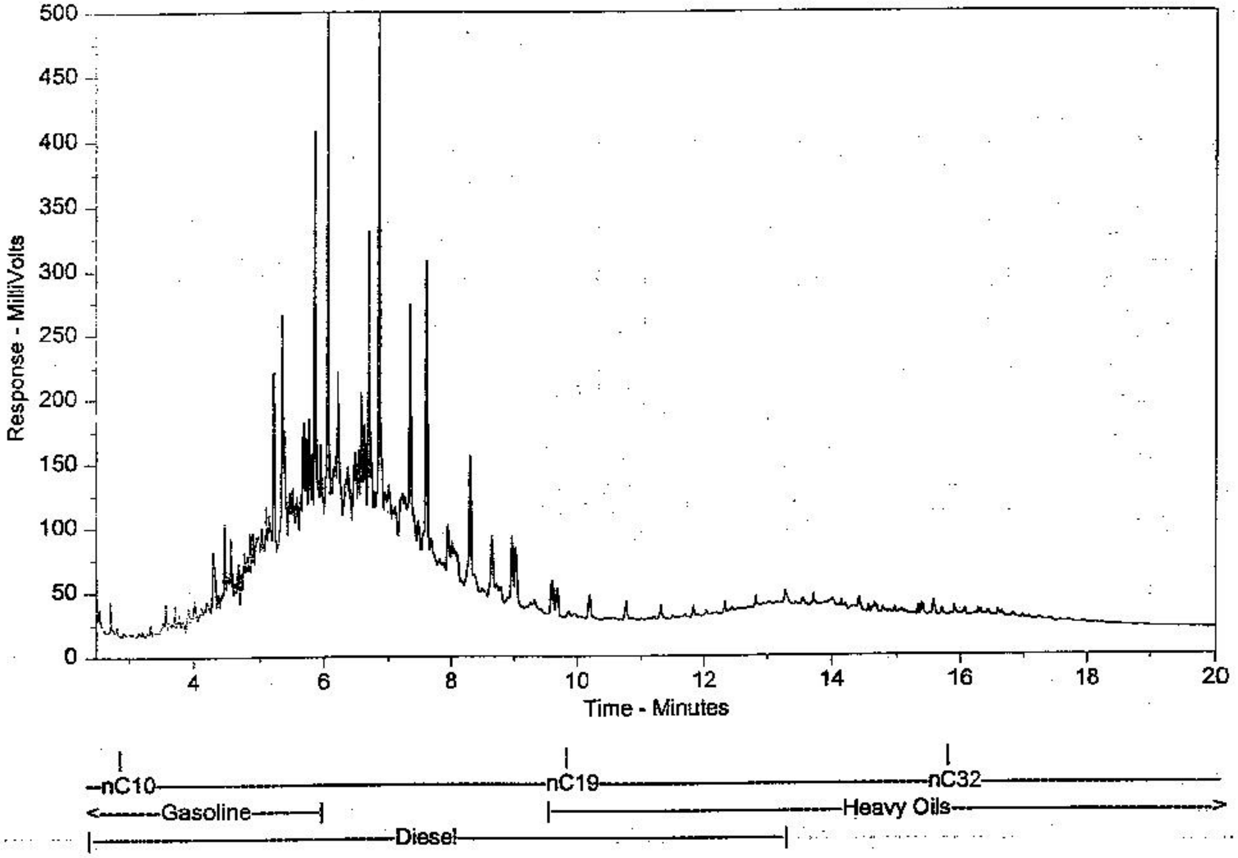
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--108**
File Name: m:\chrom\gc12\data\gc12_29augA.0038.RAW
Run Information: Acquired on GC12, 8/30/00 12:57:29 PM



Sample Amount = 11.5 (g or mL) **Dilution Factor = 10.0**

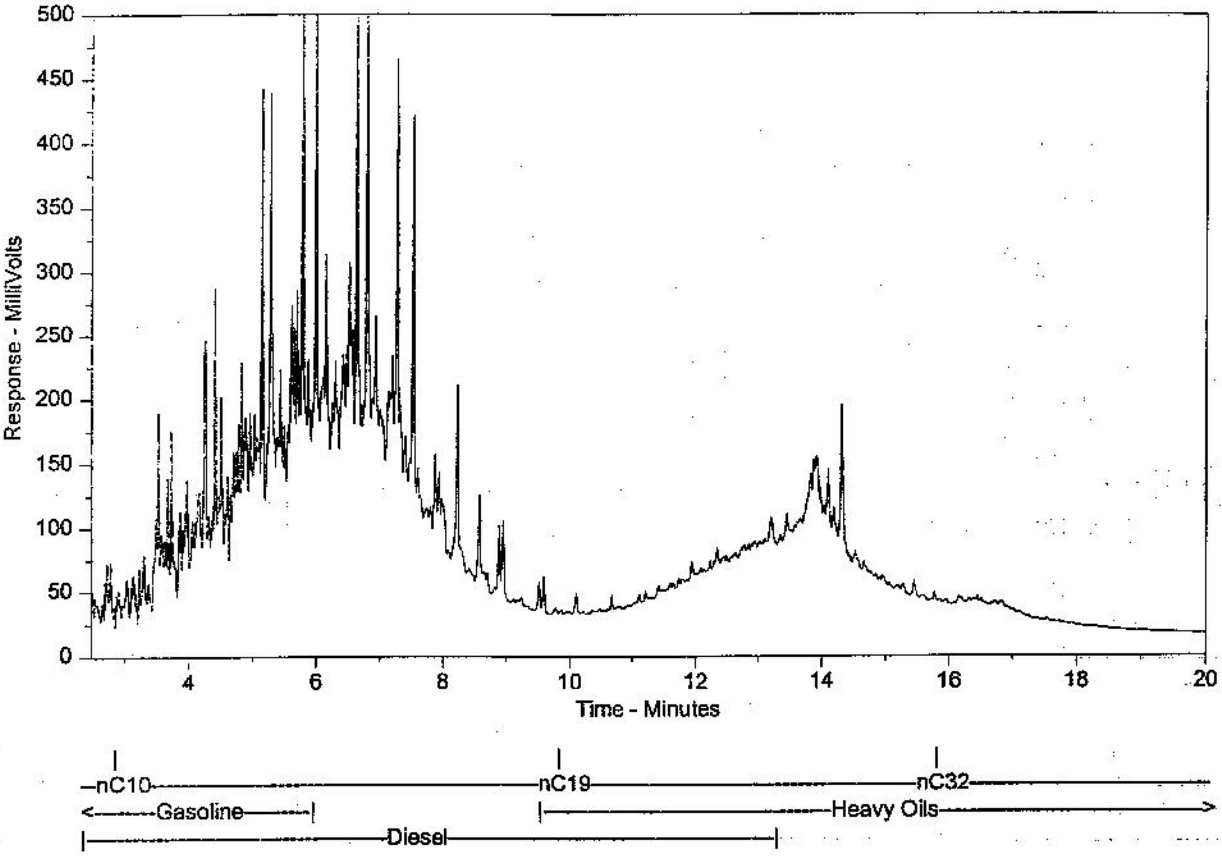
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--109**
File Name: m:\chrom\gc12\data\gc12_29augB.0038.RAW
Run Information: Acquired on GC12, 8/30/00 12:57:29 PM



Sample Amount = 10.6 (g or mL) Dilution Factor = 10.0

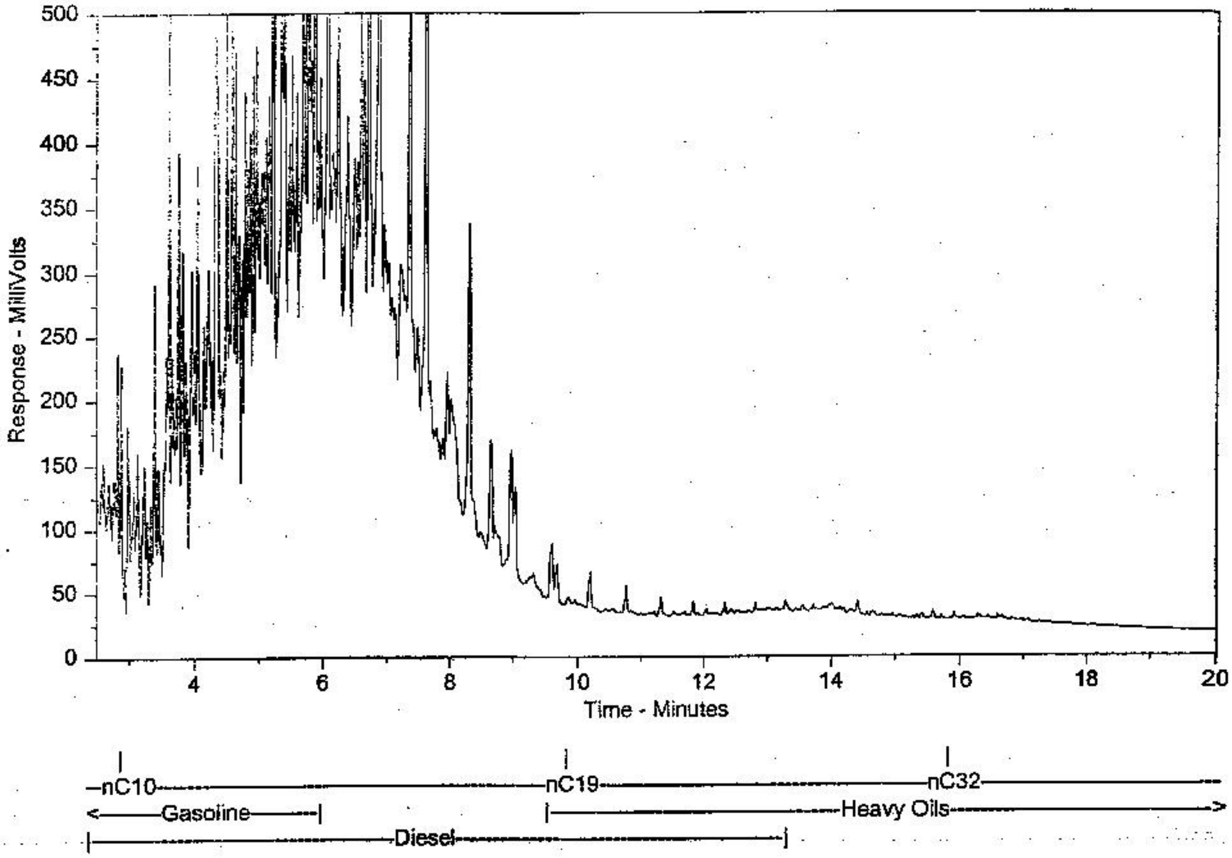
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--110**
File Name: m:\chrom\gc12\data\gc12_29augA.0039.RAW
Run Information: Acquired on GC12, 8/30/00 1:28:30 PM



Sample Amount = 10.7 (g or mL)

Dilution Factor = 10.0

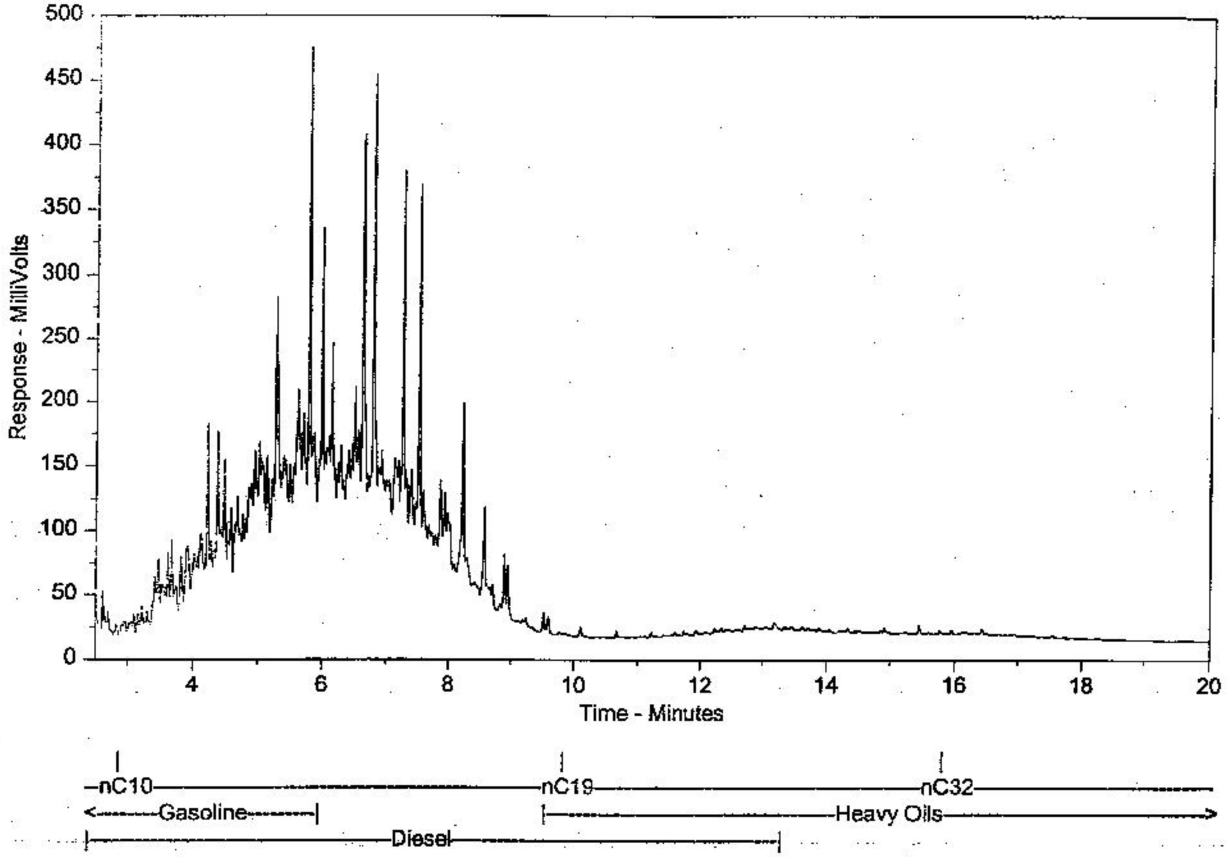
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--113**
File Name: m:\chrom\gc12\data\gc12_29augB.0040.RAW
Run Information: Acquired on GC12, 8/30/00 1:59:34 PM



Sample Amount = 10.3 (g or mL)

Dilution Factor = 10.0

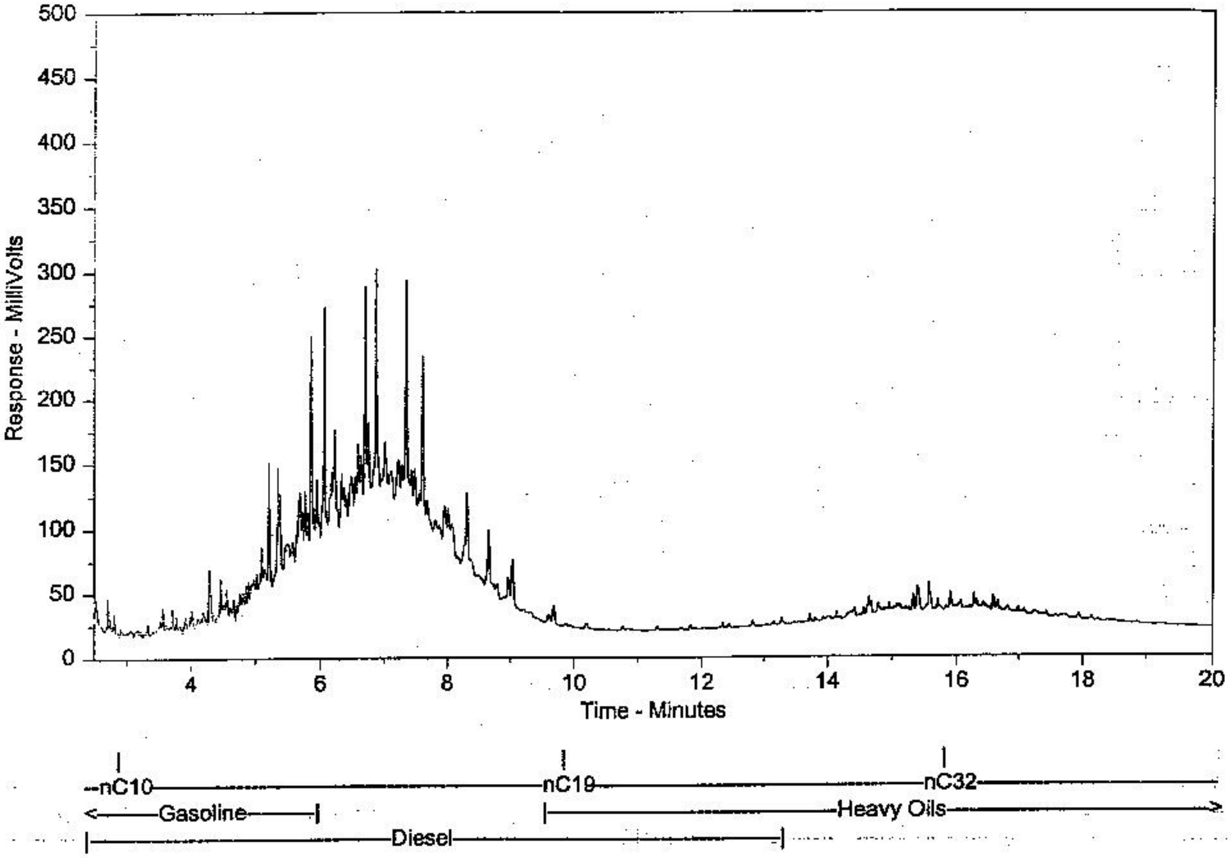
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--114**
File Name: m:\chrom\gc12\data\gc12_29augA.0041.RAW
Run Information: Acquired on GC12, 8/30/00 2:30:42 PM



Sample Amount = 11.8 (g or mL)

Dilution Factor = 10.0

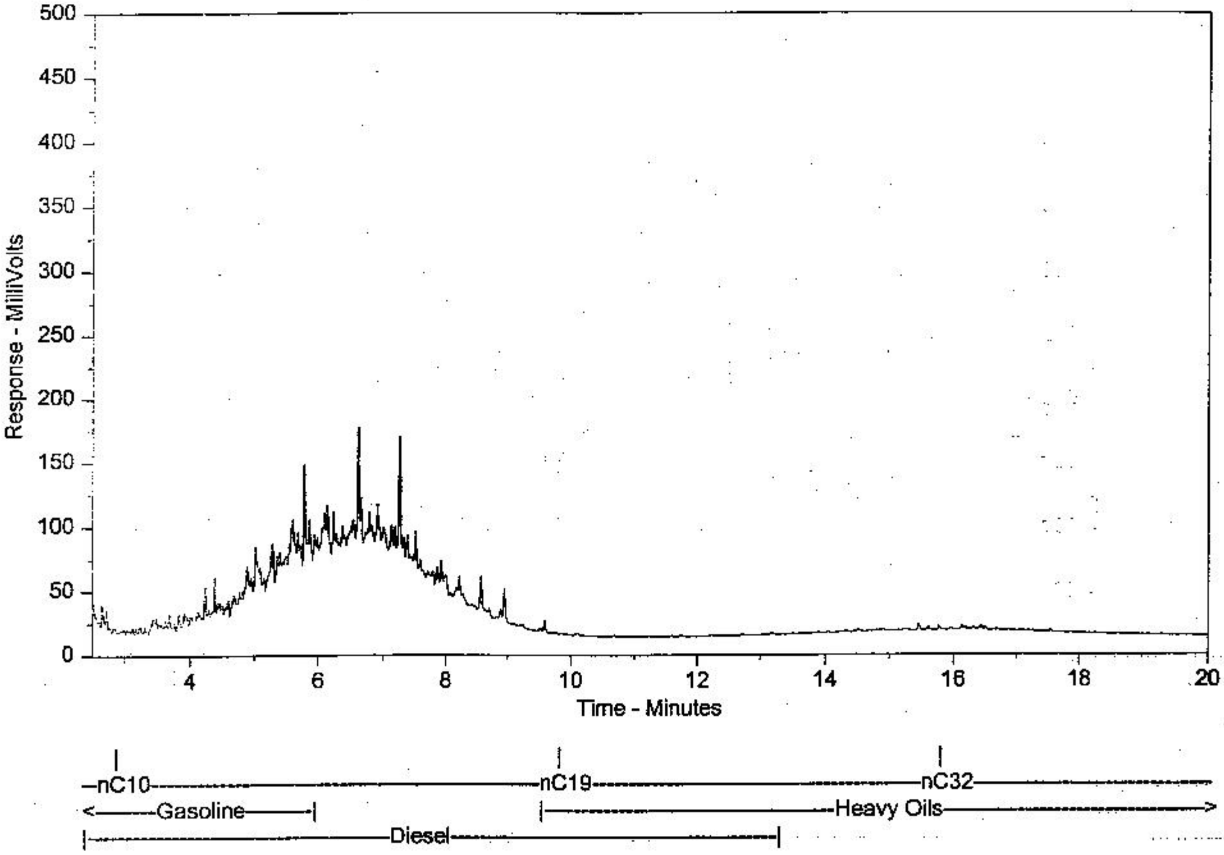
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--115**
File Name: m:\chrom\gc12\data\gc12_29augB.0041.RAW
Run Information: Acquired on GC12, 8/30/00 2:30:43 PM



Sample Amount = 10.1 (g or mL)

Dilution Factor = 10.0

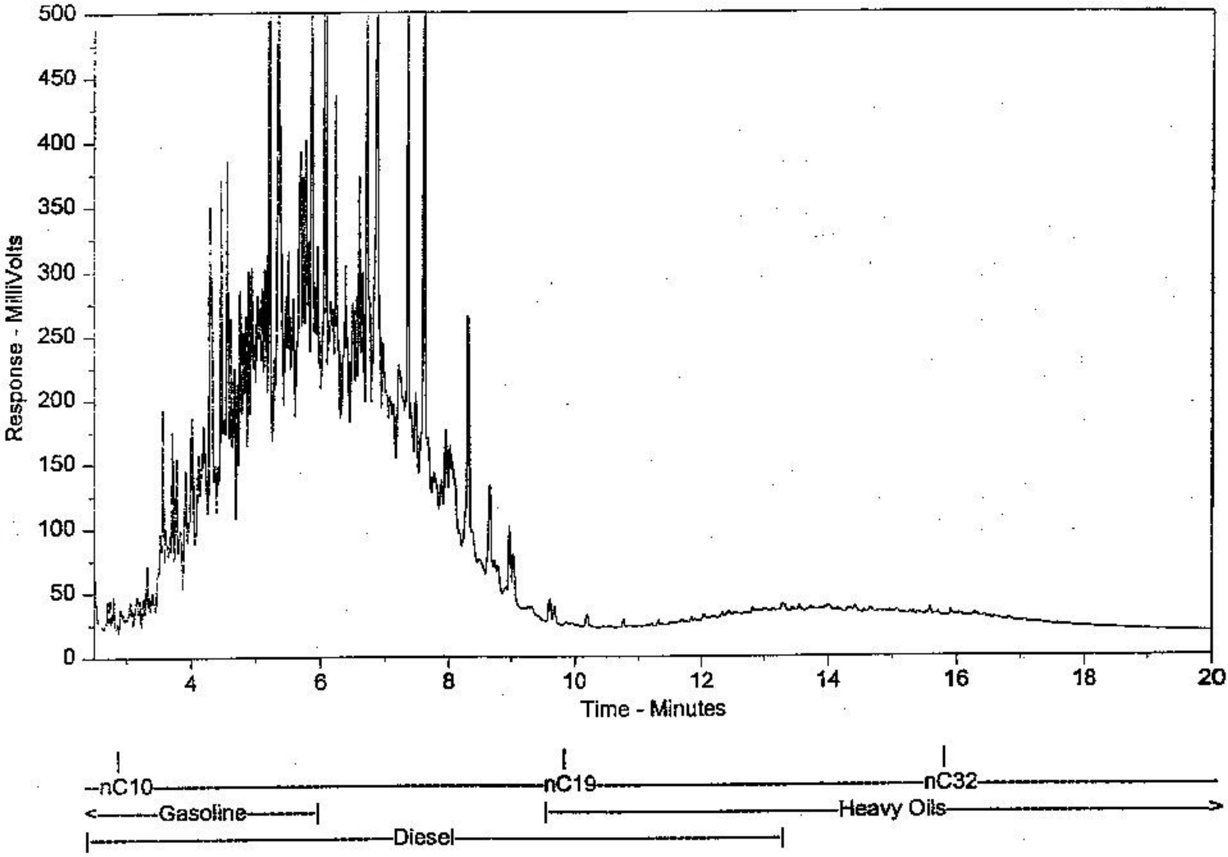
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--116**
File Name: m:\chrom\gc12\data\gc12_29augA.0042.RAW
Run Information: Acquired on GC12, 8/30/00 3:01:46 PM



Sample Amount = 10.1 (g or mL)

Dilution Factor = 10.0

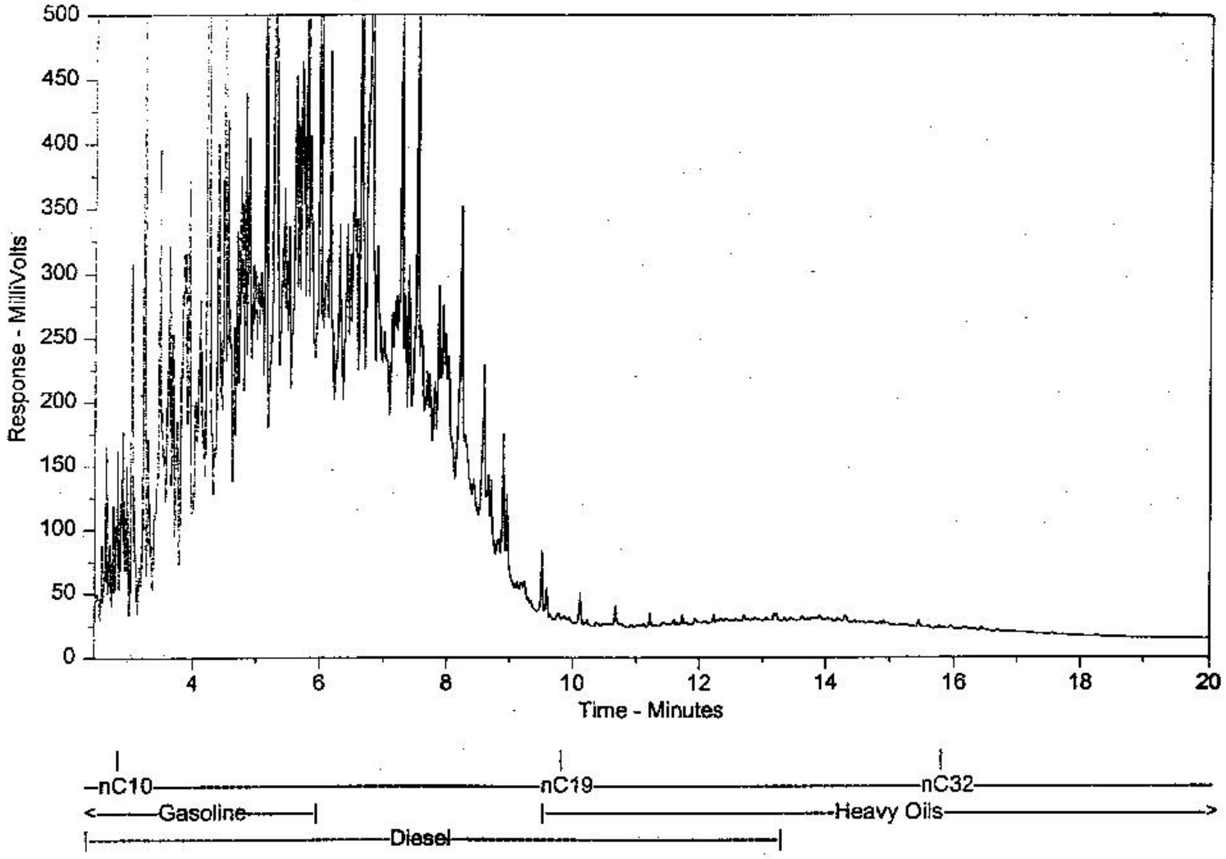
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	
ASL Sample ID:	**L9951-T--117**
File Name:	m:\chrom\gc12\data\gc12_29augB.0042.RAW
Run Information:	Acquired on GC12, 8/30/00 3:01:46 PM



Sample Amount = 12.4 (g or mL)

Dilution Factor = 10.0

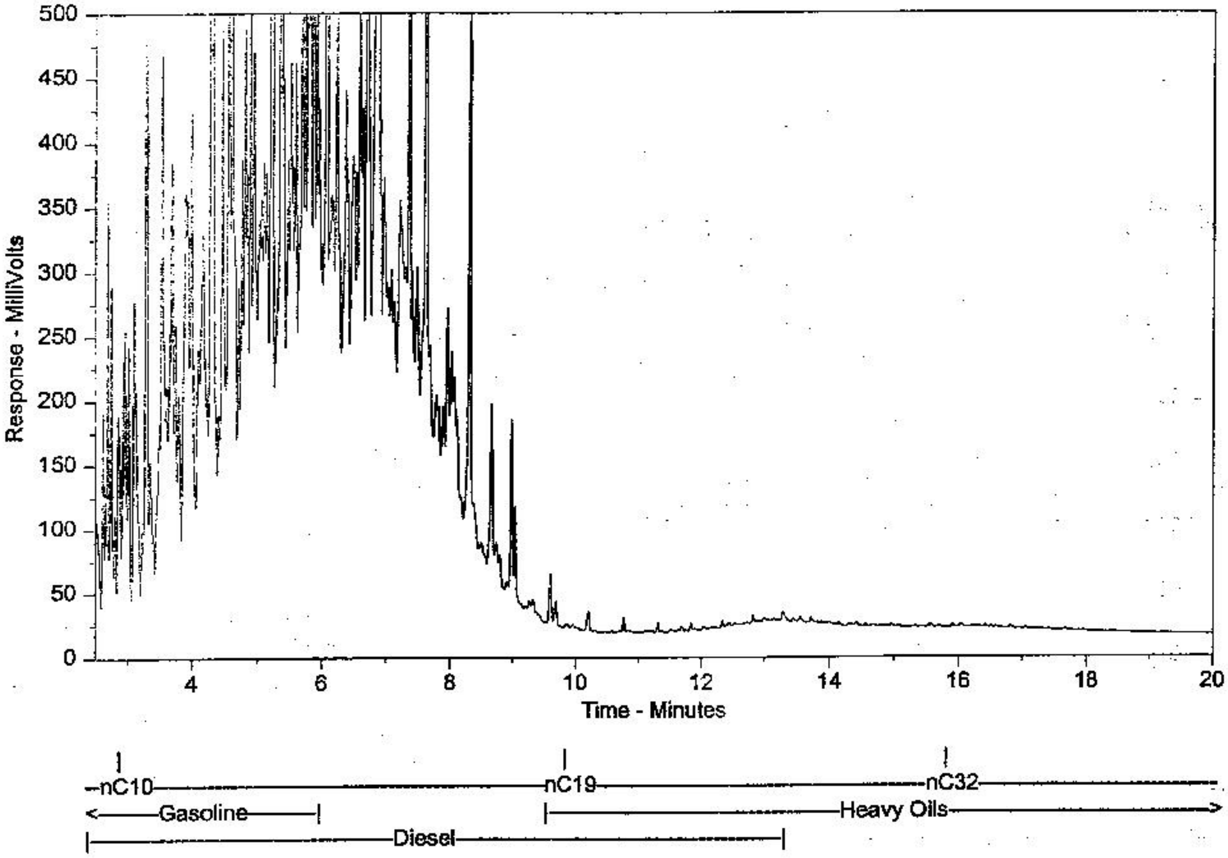
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--119**
File Name: m:\chrom\gc12\data\gc12_29augA.0043.RAW
Run Information: Acquired on GC12, 8/30/00 3:32:50 PM



Sample Amount = 11.6 (g or mL)

Dilution Factor = 10.0

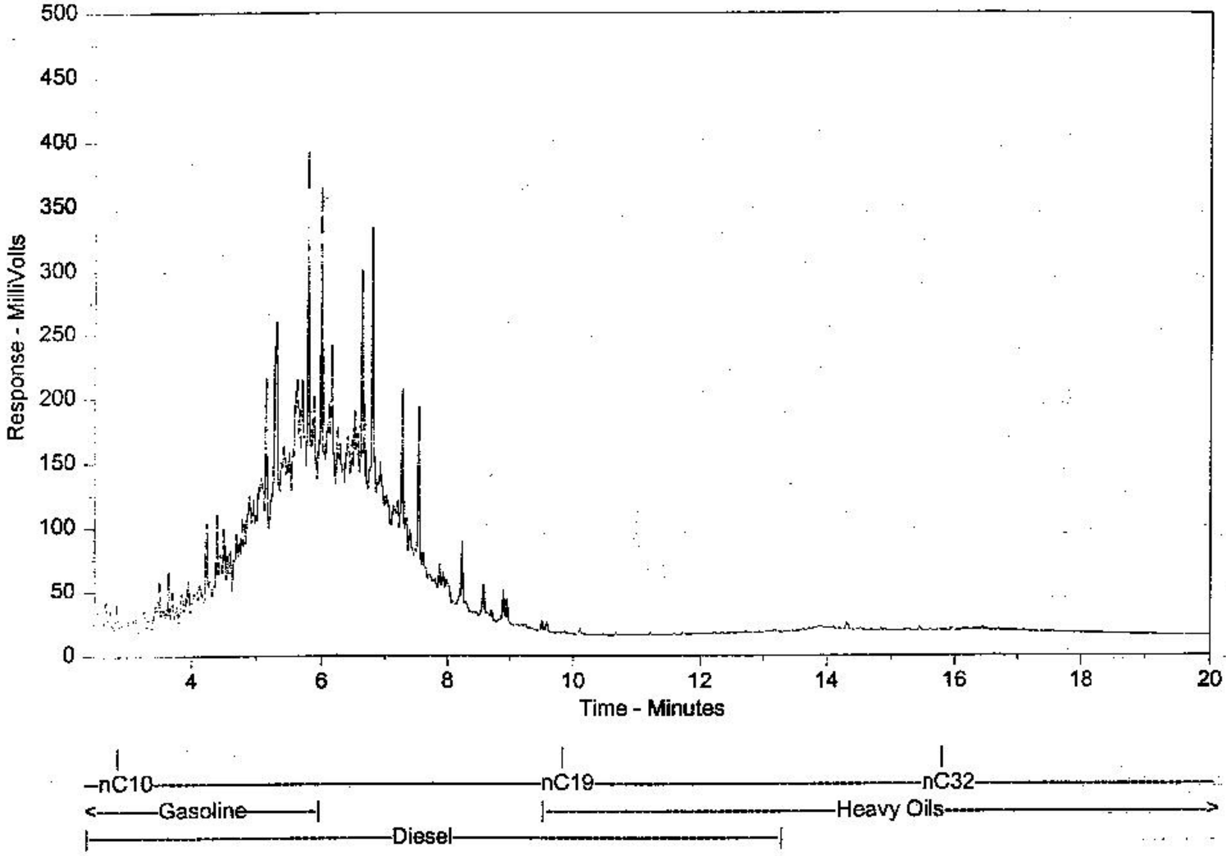
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--157**
File Name: m:\chrom\gc12\data\gc12_30augB.0007.RAW
Run Information: Acquired on GC12, 8/30/00 10:15:09 PM



Sample Amount = 10.9 (g or mL)

Dilution Factor = 10.0

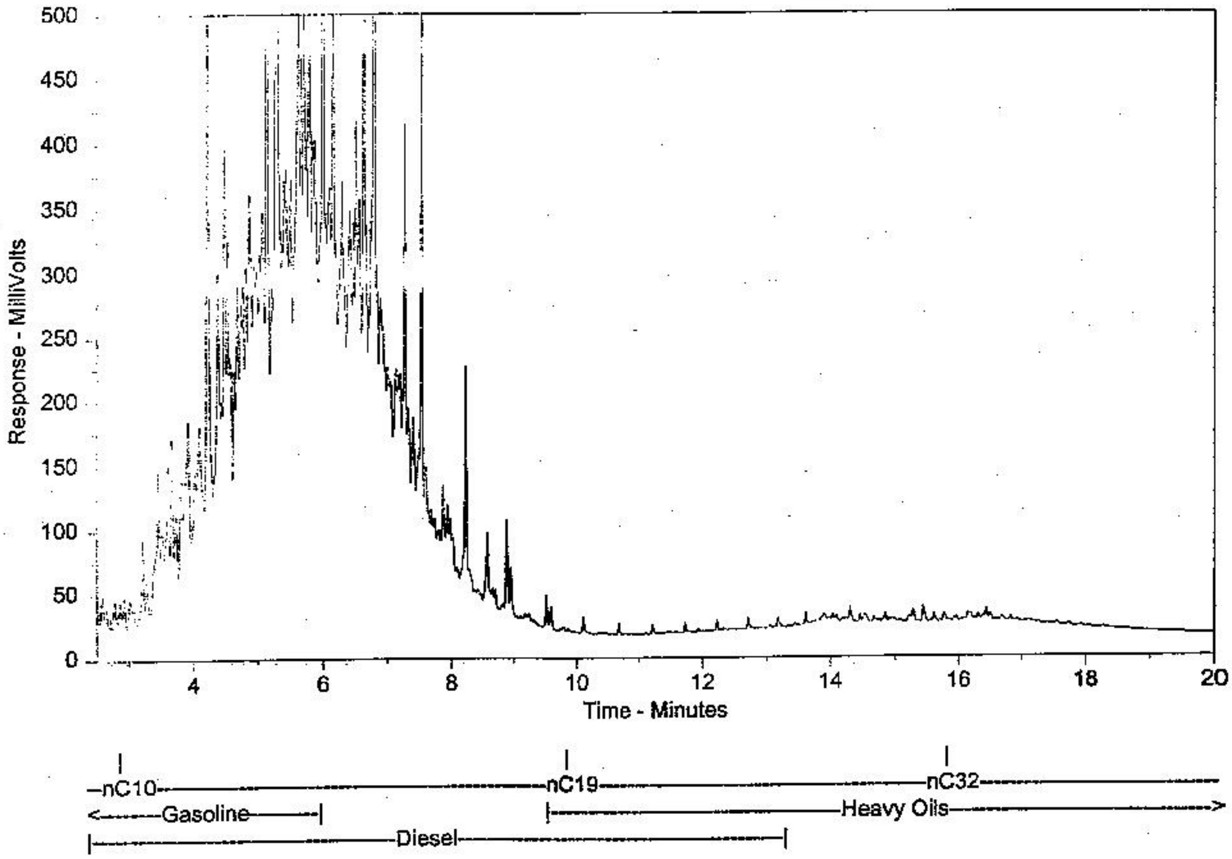
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--159**
File Name: m:\chrom\gc12\data\gc12_30augB.0008.RAW
Run Information: Acquired on GC12, 8/30/00 10:46:06 PM



Sample Amount = 9.9 (g or mL) Dilution Factor = 10.0

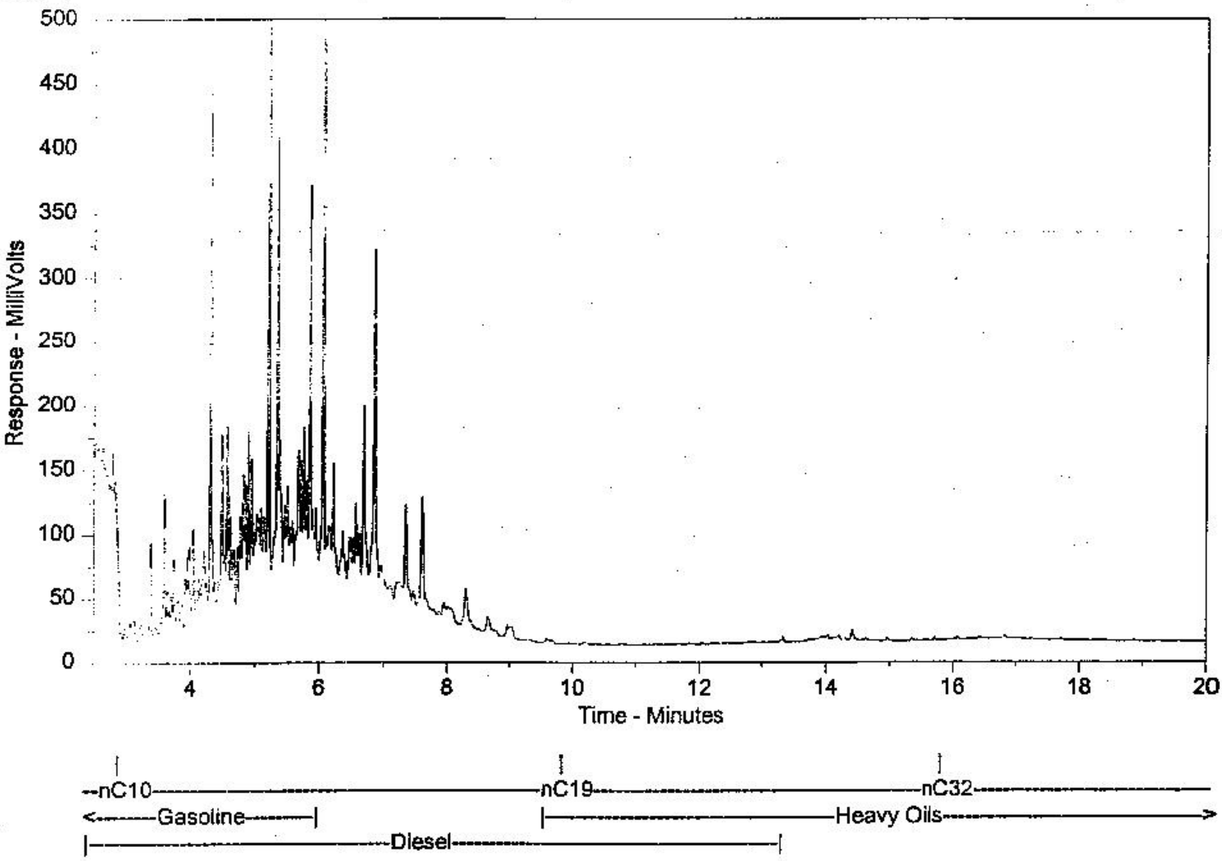
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--166**
File Name: m:\chrom\gc12\data\gc12_30augA.0012.RAW
Run Information: Acquired on GC12, 8/31/00 12:50:05 AM



Sample Amount = 9.3 (g or mL)

Dilution Factor = 10.0

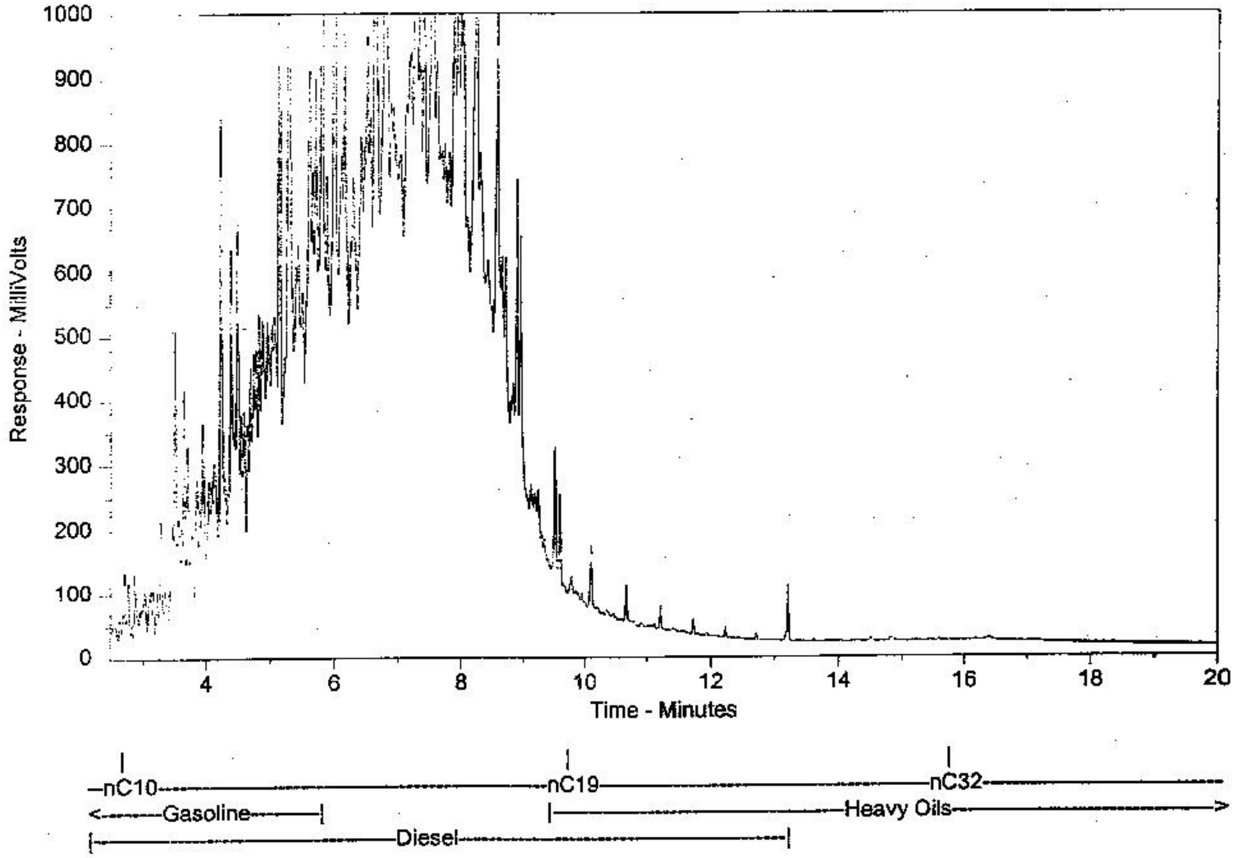
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9951-T--167**
File Name: m:\chrom\gc12\data\gc12_30augB.0012.RAW
Run Information: Acquired on GC12, 8/31/00 12:50:05 AM



Sample Amount = 10.1 (g or mL) Dilution Factor = 10.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

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FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date:	November 14, 2000
ASL File No.	M1842r
Report On:	20930 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	September 8, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

REMARKS File No. M1842r

This report, ASL file number M1842r, supersedes the previous ASL file number M1842. The client requested some additional metals results for some of the samples reported in the following data tables.

Please note that the detection limits for certain Total Metals have been increased for some of the samples in the following data tables due to sample matrix interferences, specifically the presence of high levels of Calcium.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		S1	S3	S5	S7	LL3 0-0.05m
Sample Date *ASL ID*		00 07 30 *1*	00 07 30 *2*	00 07 30 *3*	00 07 30 *4*	00 07 30 *5*
Physical Tests						
Moisture	%	5.5	9.4	8.6	6.0	3.6
Total Metals						
Lead	T-Pb	1240	363	194	1960	1230
Zinc	T-Zn	1130	1250	738	6570	5990

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		LL3 0.05 -0.1m	LL4 0-0.05m	Site D 0-0.01m	Site D .01-.05m	Site D .05-.10m
Sample Date		00 07 30	00 07 30	00 07 30	00 07 30	00 07 30
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	4.3	26.1	27.4	15.9	10.3
Total Metals						
Aluminum	T-Al	-	-	5260	-	-
Antimony	T-Sb	-	-	<20	-	-
Arsenic	T-As	-	-	<100	-	-
Barium	T-Ba	-	-	93	-	-
Beryllium	T-Be	-	-	<0.5	-	-
Bismuth	T-Bi	-	-	<10	-	-
Cadmium	T-Cd	-	-	<2	-	-
Calcium	T-Ca	-	-	59100	-	-
Chromium	T-Cr	-	-	10	-	-
Cobalt	T-Co	-	-	2	-	-
Copper	T-Cu	-	-	7	-	-
Iron	T-Fe	-	-	5960	-	-
Lead	T-Pb	625	293	23	10	7
Lithium	T-Li	-	-	6	-	-
Magnesium	T-Mg	-	-	25900	-	-
Manganese	T-Mn	-	-	84	-	-
Molybdenum	T-Mo	-	-	<4	-	-
Nickel	T-Ni	-	-	10	-	-
Phosphorus	T-P	-	-	266	-	-
Potassium	T-K	-	-	2120	-	-
Selenium	T-Se	-	-	<50	-	-
Silver	T-Ag	-	-	<2	-	-
Strontium	T-Sr	-	-	120	-	-
Thallium	T-Tl	-	-	<50	-	-
Tin	T-Sn	-	-	<10	-	-
Titanium	T-Ti	-	-	74	-	-
Vanadium	T-V	-	-	55	-	-
Zinc	T-Zn	7330	1530	105	66.1	54.9

Remarks regarding the analyses appear at the beginning of this report.
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EPH = Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		Site G 0-0.01m	Site G .01-.05m	Site G .05-.10m	Site K 0-0.01m	Site K .01-.05m
Sample Date		00 07 31	00 07 31	00 07 31	00 07 30	00 07 30
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	26.7	20.5	18.3	20.4	19.6
Total Metals						
Aluminum	T-Al	-	-	-	6760	-
Antimony	T-Sb	-	-	-	<20	-
Arsenic	T-As	-	-	-	<100	-
Barium	T-Ba	-	-	-	46	-
Beryllium	T-Be	-	-	-	<0.5	-
Bismuth	T-Bi	-	-	-	<10	-
Cadmium	T-Cd	-	-	-	<2	-
Calcium	T-Ca	-	-	-	20400	-
Chromium	T-Cr	-	-	-	16	-
Cobalt	T-Co	-	-	-	2	-
Copper	T-Cu	-	-	-	14	-
Iron	T-Fe	-	-	-	6350	-
Lead	T-Pb	16	16	16	28	13
Lithium	T-Li	-	-	-	4	-
Magnesium	T-Mg	-	-	-	6380	-
Manganese	T-Mn	-	-	-	60	-
Molybdenum	T-Mo	-	-	-	<4	-
Nickel	T-Ni	-	-	-	14	-
Phosphorus	T-P	-	-	-	572	-
Potassium	T-K	-	-	-	2750	-
Selenium	T-Se	-	-	-	<50	-
Silver	T-Ag	-	-	-	<2	-
Strontium	T-Sr	-	-	-	85.2	-
Thallium	T-Tl	-	-	-	<50	-
Tin	T-Sn	-	-	-	<10	-
Titanium	T-Ti	-	-	-	108	-
Vanadium	T-V	-	-	-	136	-
Zinc	T-Zn	303	316	307	355	372

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		Site K .05-.10m	Site L 0-0.01m	Site L .01-.05m	Site L .05-.10m	Site M 0-0.01m
Sample Date *ASL ID*		00 07 30 *16*	00 07 30 *17*	00 07 30 *18*	00 07 30 *19*	00 07 31 *20*
Physical Tests						
Moisture	%	19.6	11.5	12.4	12.6	21.1
Total Metals						
Aluminum	T-Al	-	12500	-	-	-
Antimony	T-Sb	-	<40	-	-	-
Arsenic	T-As	-	<200	-	-	-
Barium	T-Ba	-	444	-	-	-
Beryllium	T-Be	-	<1	-	-	-
Bismuth	T-Bi	-	<20	-	-	-
Cadmium	T-Cd	-	<4	-	-	-
Calcium	T-Ca	-	163000	-	-	-
Chromium	T-Cr	-	22	-	-	-
Cobalt	T-Co	-	5	-	-	-
Copper	T-Cu	-	19	-	-	-
Iron	T-Fe	-	13600	-	-	-
Lead	T-Pb	14	13	10	10	14
Lithium	T-Li	-	12	-	-	-
Magnesium	T-Mg	-	52600	-	-	-
Manganese	T-Mn	-	180	-	-	-
Molybdenum	T-Mo	-	<8	-	-	-
Nickel	T-Ni	-	24	-	-	-
Phosphorus	T-P	-	524	-	-	-
Potassium	T-K	-	4720	-	-	-
Selenium	T-Se	-	<100	-	-	-
Silver	T-Ag	-	<4	-	-	-
Strontium	T-Sr	-	421	-	-	-
Thallium	T-Tl	-	<100	-	-	-
Tin	T-Sn	-	<20	-	-	-
Titanium	T-Ti	-	188	-	-	-
Vanadium	T-V	-	167	-	-	-
Zinc	T-Zn	447	109	124	125	99.5

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		Site M .01-.05m	Site M .05-.10m	Site N 0-0.01m	Site N .01-.05m	Site N .05-.10m
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*21*	*22*	*23*	*24*	*25*
Physical Tests						
Moisture	%	20.6	19.2	27.0	15.0	15.7
Total Metals						
Aluminum	T-Al	-	-	14500	-	-
Antimony	T-Sb	-	-	<40	-	-
Arsenic	T-As	-	-	<200	-	-
Barium	T-Ba	-	-	126	-	-
Beryllium	T-Be	-	-	<1	-	-
Bismuth	T-Bi	-	-	<20	-	-
Cadmium	T-Cd	-	-	<4	-	-
Calcium	T-Ca	-	-	172000	-	-
Chromium	T-Cr	-	-	26	-	-
Cobalt	T-Co	-	-	4	-	-
Copper	T-Cu	-	-	13	-	-
Iron	T-Fe	-	-	16200	-	-
Lead	T-Pb	12	12	9	6	7
Lithium	T-Li	-	-	18	-	-
Magnesium	T-Mg	-	-	27100	-	-
Manganese	T-Mn	-	-	210	-	-
Molybdenum	T-Mo	-	-	<8	-	-
Nickel	T-Ni	-	-	22	-	-
Phosphorus	T-P	-	-	581	-	-
Potassium	T-K	-	-	5690	-	-
Selenium	T-Se	-	-	<100	-	-
Silver	T-Ag	-	-	<4	-	-
Strontium	T-Sr	-	-	449	-	-
Thallium	T-Tl	-	-	<100	-	-
Tin	T-Sn	-	-	<20	-	-
Titanium	T-Ti	-	-	193	-	-
Vanadium	T-V	-	-	60	-	-
Zinc	T-Zn	100	108	55.7	39.9	63.8

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		Site O 0-0.01m	Site O .01-.05m	Site O .05-.10m	TP106 0.4-0.6	TP107 0.4-0.6
Sample Date		00 07 31	00 07 31	00 07 31		
ASL ID		*26*	*27*	*28*	*29*	*30*
Physical Tests						
Moisture	%	26.3	18.2	18.4	57.8	11.8
Total Metals						
Lead	T-Pb	10	9	7	-	-
Zinc	T-Zn	54.2	46.7	46.3	-	-

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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

		TP108 0.4-0.6	TP88 0.4-0.6m	TP131 0.2-0.4	TP144 0-0.1	TP146 0-0.1
Sample Date			00 07 29	00 07 30	00 08 01	00 08 01
ASL ID		*31*	*32*	*33*	*34*	*35*
Physical Tests						
Moisture	%	9.2	2.9	10.4	4.6	5.2
Total Metals						
Lead	T-Pb	-	-	-	1120	1200
Zinc	T-Zn	-	-	-	3200	5300
Extractable Hydrocarbons						
EPH10-19		-	3500	9090	-	-
EPH19-32		-	<200	206	-	-

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		TP147 0.1-0.3	TP148 0-0.1	TP149 0.1-0.3	TP149 0.6-0.9	TP150 0-0.1
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*36*	*37*	*38*	*39*	*40*
Physical Tests						
Moisture	%	3.3	8.7	3.6	3.8	3.0
Total Metals						
Lead	T-Pb	64	5470	2180	1500	3180
Zinc	T-Zn	514	24400	7510	11300	9000

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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		TP151 0.1-0.3	TP154 0-0.1	TP155 0-0.1	LLSD-1 0.05-0.1	LLSD-2 0.05-0.1
Sample Date		00 08 01	00 08 01	00 08 01	00 07 31	00 07 31
ASL ID		*41*	*42*	*43*	*44*	*45*
Physical Tests						
Moisture	%	5.7	11.0	8.2	11.4	27.2
Total Metals						
Lead	T-Pb	248	399	366	103	922
Zinc	T-Zn	702	2610	2080	280	2440

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		LLSD-3 0-0.1	LLSD-4 0-0.1	LLSD-5 0-0.1	LLSD-5 0.1-0.4	LLSD-7 0-0.1
Sample Date *ASL ID*		00 07 31 *46*	00 07 31 *47*	00 07 31 *48*	00 07 31 *49*	00 07 31 *50*
Physical Tests						
Moisture	%	5.8	8.9	5.7	10.0	14.7
Total Metals						
Lead	T-Pb	1350	3490	959	140	297
Zinc	T-Zn	4320	6270	6780	492	1230

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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		FTank-1 0.5-0.7	FTank-4 0.6-0.8	FTank-6 0.1-0.3	FTank-8 0.6-0.8	FTank-15 0.1-0.3
Sample Date		00 07 31	00 07 31	00 08 01	00 08 01	00 08 01
ASL ID		*51*	*52*	*53*	*54*	*55*
Physical Tests						
Moisture	%	7.5	8.6	16.5	9.8	7.0
Total Metals						
Lead	T-Pb	-	-	-	-	1530
Zinc	T-Zn	-	-	-	-	3300
Extractable Hydrocarbons						
EPH10-19		12000	13400	7030	1910	-
EPH19-32		671	581	2600	1620	-

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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		FTank-15 0.3-0.6	FH-2 0.1-0.6	FH-2 0.9-1.2	FH-6 0.3-0.6	FH-7 0.1-0.3
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*56*	*57*	*58*	*59*	*60*
Physical Tests						
Moisture	%	5.2	4.4	6.8	6.2	5.6
Total Metals						
Lead	T-Pb	837	2300	3400	6630	4450
Zinc	T-Zn	309	8960	12800	172000	155000
Extractable Hydrocarbons						
EPH10-19		-	-	3800	3200	-
EPH19-32		-	-	1360	454	-

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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		S201 0.2-0.3	S203 0.05-0.1	S205 0.05-0.1	S206 0.05-0.1	S209 0.05-0.1
Sample Date		00 08 01	00 08 01	00 08 02	00 08 02	00 08 02
ASL ID		*61*	*62*	*63*	*64*	*66*
Physical Tests						
Moisture	%	8.7	10.5	1.8	6.0	6.6
Total Metals						
Lead	T-Pb	322	407	919	771	381
Zinc	T-Zn	1280	1750	2640	3380	1050

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

Sample ID		S210 0.05-0.1	S211 0.05-0.1	S212 0.05-0.1	MSD-2 0.1-0.3	FSD-1 Foldaway Snow Dump-1
Sample Date		00 08 02	00 08 02	00 08 02	00 07 31	00 07 31
ASL ID		*67*	*68*	*69*	*70*	*71*
Physical Tests						
Moisture	%	5.2	11.1	4.4	7.4	5.6
pH		-	-	-	8.08	8.31
Total Metals						
Antimony	T-Sb	-	-	-	<40	<40
Arsenic	T-As	-	-	-	<5	<5
Barium	T-Ba	-	-	-	91	250
Beryllium	T-Be	-	-	-	<1	<1
Cadmium	T-Cd	-	-	-	20.4	20.4
Chromium	T-Cr	-	-	-	5	<4
Cobalt	T-Co	-	-	-	<4	<4
Copper	T-Cu	-	-	-	113	<2
Lead	T-Pb	243	267	900	7640	1820
Mercury	T-Hg	-	-	-	0.031	0.012
Molybdenum	T-Mo	-	-	-	<8	<8
Nickel	T-Ni	-	-	-	<10	<10
Selenium	T-Se	-	-	-	<2	<2
Silver	T-Ag	-	-	-	<4	<4
Tin	T-Sn	-	-	-	<20	<20
Vanadium	T-V	-	-	-	14	<4
Zinc	T-Zn	706	858	4080	9970	8700

Remarks regarding the analyses appear at the beginning of this report.
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RESULTS OF ANALYSIS - Sediment/Soil

File No. M1842r

		FSD-2 Foldaway Snow Dump	LL4 0.05-0.1
Sample ID		Foldaway Snow Dump	LL4 0.05-0.1
Sample Date		00 07 31	00 07 31
ASL ID		*72*	*73*
Physical Tests			
Moisture	%	10.7	11.8
pH		8.34	-
Total Metals			
Antimony	T-Sb	<200	-
Arsenic	T-As	<5	-
Barium	T-Ba	50	-
Beryllium	T-Be	<3	-
Cadmium	T-Cd	318	-
Chromium	T-Cr	<20	-
Cobalt	T-Co	<20	-
Copper	T-Cu	85	-
Lead	T-Pb	4950	223
Mercury	T-Hg	0.053	-
Molybdenum	T-Mo	<30	-
Nickel	T-Ni	<30	-
Selenium	T-Se	<2	-
Silver	T-Ag	<20	-
Tin	T-Sn	<60	-
Vanadium	T-V	<20	-
Zinc	T-Zn	139000	867

Remarks regarding the analyses appear at the beginning of this report.
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Sediment/Soil		**LL3** **0-0.05m**	**LL3** **0-0.05m**
		00 07 30	QC # 211234
Physical Tests			
Moisture	%	3.6	2.6
Total Metals			
Lead	T-Pb	1230	471
Zinc	T-Zn	5990	3250

Remarks regarding the analyses appear at the beginning of this report.
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Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil		Site K .01-.05m 00 07 30	Site K .01-.05m QC # 211235
Physical Tests			
Moisture	%	19.6	20.1
Total Metals			
Lead	T-Pb	13	14
Zinc	T-Zn	372	376

Remarks regarding the analyses appear at the beginning of this report.
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Appendix 1 - QUALITY CONTROL - Replicates

File No. M1842r

Sediment/Soil		**Site O 0-0.01m**	**Site O 0-0.01m**
		00 07 31	QC # 211236
Physical Tests			
Moisture	%	26.3	26.9
Total Metals			
Lead	T-Pb	10	8
Zinc	T-Zn	54.2	56.9

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
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Appendix 1 - QUALITY CONTROL - Replicates

File No. M1842r

Sediment/Soil		**TP146 0-0.1**	**TP146 0-0.1**
		00 08 01	QC # 211237
Physical Tests			
Moisture	%	5.2	4.9
Total Metals			
Lead	T-Pb	1200	1220
Zinc	T-Zn	5300	5460

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
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Appendix 1 - QUALITY CONTROL - Replicates

File No. M1842r

Sediment/Soil		LLSD-4 0-0.1	LLSD-4 0-0.1
		00 07 31	QC # 211238
Physical Tests			
Moisture	%	8.9	8.8
Total Metals			
Lead	T-Pb	3490	1650
Zinc	T-Zn	6270	5570

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
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EPH = Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M1842r

Sediment/Soil		**FTank-15 0.3-0.6**	**FTank-15 0.3-0.6**
		00 08 01	QC # 211239
Physical Tests			
Moisture	%	5.2	4.8
Total Metals			
Lead	T-Pb	837	100
Zinc	T-Zn	309	149

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
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Appendix 1 - QUALITY CONTROL - Replicates

File No. M1842r

Sediment/Soil		**S211** **0.05-0.1**	**S211** **0.05-0.1**
		00 08 02	QC # 211241
Physical Tests			
Moisture	%	11.1	11.6
Total Metals			
Lead	T-Pb	267	357
Zinc	T-Zn	858	1080

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
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EPH = Extractable Petroleum Hydrocarbons.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:
Sample: 14 days
Reference: Puget
For more detail see: ASL "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:
Sample/Extract: 6 months (Mercury = 28 days)
Reference: EPA
For more detail see: ASL "Collection & Sampling Guide"

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure uses an automated system (Accelerated Solvent Extractor - ASE) to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone at high temperature and pressure. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:
Sample: 14 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

pH in Soil

This analysis is carried out in accordance with procedures described in "Soil Sampling and Methods of Analysis" (CSSS). The procedure involves mixing the air-dried sample with deionized/distilled water. The pH of the solution is then measured using a standard pH probe. A one to two ratio of sediment to water is used for mineral soils and a one to ten ratio is used for highly organic soils.

End of Report

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

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CHEMICAL ANALYSIS REPORT

Date:	December 5, 2000
ASL File No.	M4449
Report On:	20-930 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	November 17, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

RESULTS OF ANALYSIS - Sediment/Soil

File No. M4449

Sample ID		FTank12- 0.3-0.6m	FTank12- 0.6-0.9m
ASL ID		*1*	*2*
Physical Tests			
Moisture	%	7.3	6.8
Total Metals			
Lead	T-Pb	95	168
Zinc	T-Zn	47.7	152

Results are expressed as milligrams per dry kilogram except where noted.

METHODOLOGY File No. M4449

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

End of Report

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

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FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: September 18, 2000

ASL File No. M1428

Report On: Polaris Water Analysis

Report To: **Gartner Lee Ltd.**
Sperling Plaza
Suite 490, 6400 Roberts Street
Burnaby, BC
V5G 4C9

Attention: **Ms. Eva Gerencher**

Received: August 28, 2000

SEP 22 2000
GARTNER LEE

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

REMARKS File No. M1428

The detection limits for some of the metals have been increased for the sample reported in the following data tables due to analytical interferences.

The detection limits for some of the Polycyclic Aromatic Hydrocarbons have been increased for the sample reported in the following data tables due to sample matrix interferences.

For the submitted water sample identified as "Polaris Barge Sump", the measured concentration of specific dissolved metals is greater than the corresponding total metals concentration. The explanation for these findings is one or a combination of the following:

- laboratory method variability;
- field sampling method variability;
- bias introduced during field sample filtration;
- bias introduced during general handling, storage and/or transportation of the sample;
- field sample grab bias - where separate grab samples are processed to produce total and dissolved samples;
- field sample split bias - where total and dissolved metals samples are produced from the same grab sample.

For further clarification on any of the above information, please contact your ASL representative.

RESULTS OF ANALYSIS - Water

File No. M1428

Sample ID			Polaris Barge Sump
ASL ID			*1*
Physical Tests			
Hardness	CaCO3		834
Nutrients			
Ammonia Nitrogen		N	14.8
Nitrate Nitrogen		N	9.0
Nitrite Nitrogen		N	3.4
Total Phosphate		P	0.116
Total Metals			
Aluminum	T-Al		0.06
Antimony	T-Sb		0.0020
Arsenic	T-As		0.0029
Barium	T-Ba		0.05
Beryllium	T-Be		<0.004
Boron	T-B		0.4
Cadmium	T-Cd		0.0007
Calcium	T-Ca		262
Chromium	T-Cr		<0.002
Cobalt	T-Co		0.0055
Copper	T-Cu		0.0080
Iron	T-Fe		3.46
Lead	T-Pb		0.192
Magnesium	T-Mg		31.3
Manganese	T-Mn		0.196
Mercury	T-Hg		<0.00002
Molybdenum	T-Mo		<0.03
Nickel	T-Ni		0.036
Potassium	T-K		11
Selenium	T-Se		<0.004
Silver	T-Ag		<0.00004
Sodium	T-Na		64
Thallium	T-Tl		0.0004
Titanium	T-Ti		<0.01
Uranium	T-U		0.0026
Vanadium	T-V		<0.03
Zinc	T-Zn		3.18

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. M1428

Sample ID		Polaris Barge Sump
ASL ID		*1*
Dissolved Metals		
Aluminum	D-Al	0.06
Antimony	D-Sb	0.0019
Arsenic	D-As	0.0025
Barium	D-Ba	0.06
Beryllium	D-Be	<0.004
Boron	D-B	0.4
Cadmium	D-Cd	0.0006
Calcium	D-Ca	279
Chromium	D-Cr	<0.002
Cobalt	D-Co	0.0056
Copper	D-Cu	0.0054
Iron	D-Fe	3.65
Lead	D-Pb	0.203
Magnesium	D-Mg	33.1
Manganese	D-Mn	0.208
Mercury	D-Hg	<0.00002
Molybdenum	D-Mo	<0.03
Nickel	D-Ni	0.036
Potassium	D-K	11
Selenium	D-Se	<0.004
Silver	D-Ag	<0.00004
Sodium	D-Na	68
Thallium	D-Tl	0.0004
Titanium	D-Ti	<0.01
Uranium	D-U	0.0025
Vanadium	D-V	<0.03
Zinc	D-Zn	3.35

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. M1428

Sample ID	Polaris Barge Sump
ASL ID	*1*
Polycyclic Aromatic Hydrocarbons	
Acenaphthene	<0.0005
Acenaphthylene	<0.0005
Acridine	<0.00005
Anthracene	<0.00005
Benz(a)anthracene	<0.00005
Benzo(a)pyrene	<0.00001
Benzo(b)fluoranthene	<0.00005
Benzo(g,h,i)perylene	<0.00005
Benzo(k)fluoranthene	<0.00005
Chrysene	<0.00005
Dibenz(a,h)anthracene	<0.00005
Fluoranthene	<0.00005
Fluorene	<0.00008
Indeno(1,2,3-c,d)pyrene	<0.00005
Naphthalene	<0.0005
Phenanthrene	<0.00005
Pyrene	<0.00005
Extractable Hydrocarbons	
EPH10-19	2.7
EPH19-32	2
LEPH	2.7
HEPH	2

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Ammonia in Water by Selective Ion Electrode

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ASL "Collection & Sampling Guide"

Nitrate and Nitrite in Water by Colourimetry

This analysis is carried out using procedures adapted from APHA Method 4500-NO2 "Nitrogen (Nitrite)" and Method 4500-NO3 "Nitrogen (Nitrate)". Nitrite is determined using the azo dye colourimetric method. Nitrate is determined using the cadmium reduction colourimetric method. Nitrate/nitrite is the sum of the concentrations of nitrate and nitrite present in the sample.

Recommended Holding Time:
Sample: 2 days
Reference: APHA and EPA
For more detail see ASL "Collection & Sampling Guide"

Phosphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". All forms of phosphate are determined by the ascorbic acid colourimetric method. Dissolved ortho-phosphate (dissolved reactive phosphorous) is determined by direct measurement. Total phosphate (total phosphorous) is determined after persulphate digestion of a sample. Total dissolved phosphate (total dissolved phosphorous) is determined by filtering a sample through a 0.45 micron membrane filter followed by persulfate digestion of the filtrate.

Recommended Holding Time:
Sample: 2 days
Reference: EPA
For more detail see ASL "Collection & Sampling Guide"

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption spectrophotometry (EPA Method 7470A/7471A).

Recommended Holding Time:

Sample:	28 days
Reference:	EPA

For more detail see: ASL "Collection & Sampling Guide"

Polycyclic Aromatic Hydrocarbons in Water

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3510, 3630 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene prior to analysis by capillary column gas chromatography with mass spectrometric detection (GC/MS).

Recommended Holding Time:
Sample: 7 days Extract: 40 days
Reference: EPA
For more detail see ASL "Collection & Sampling Guide"

Extractable Hydrocarbons in Water

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 1999). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:
Sample: 7 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

Light and Heavy Extractable Petroleum Hydrocarbons in Water

These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated by subtracting selected Polynuclear Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Acenaphthene, Acridine, Anthracene, Fluorene, Naphthalene, and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(a)pyrene, Fluoranthene, and Pyrene are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 20, 1999).

Recommended Holding Time: Not Applicable

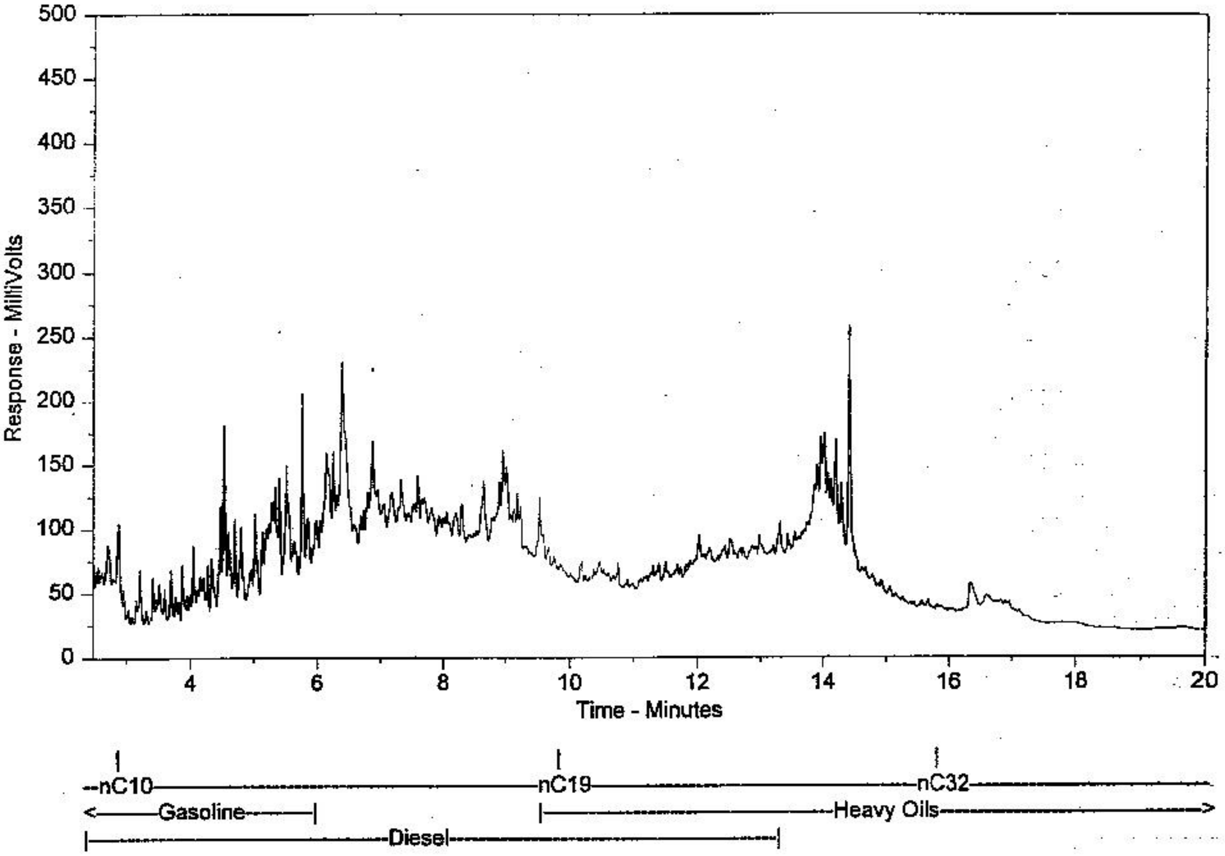
End of Report

Appendix

HYDROCARBON DISTRIBUTION REPORTS

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **M1428-T--1**
File Name: m:\chrom\gc12\data\gc12_06sepA.0018.RAW
Run Information: Acquired on GC12, 9/7/00 3:08:00 AM



Sample Amount = 460.0 (g or mL) Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

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CHEMICAL ANALYSIS REPORT

Date:	August 25, 2000
ASL File No.	L9693
Report On:	20-930 Water Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	August 5, 2000

AUG 31 2000
GARTNER LEE

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

REMARKS

File No. L9693

Please note that the detection limits for certain Total and Dissolved Metals for some of the samples in the following data tables were increased due to sample matrix interferences. The detection limits reported for these metals are the lowest possible.

RESULTS OF ANALYSIS - Water

File No. L9693

Sample ID		BH1	BH5	BH6	BH7	TP61
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Hardness	CaCO3	1710	2720	1550	452	1250

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

RESULTS OF ANALYSIS - Water

File No. L9693

Sample ID			TP132	Truck Box ROSUMP	[illegible] Sump ROPOND	Loon Lake LL1 Outlet	[illegible] Discharge NB1
Sample Date			00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID			*6*	*7*	*8*	*9*	*10*
Physical Tests							
Hardness		CaCO3	2030	393	1910	540	929
Total Metals							
Aluminum	T-Al		-	-	-	<0.05	<0.05
Antimony	T-Sb		-	-	-	<0.001	0.004
Arsenic	T-As		-	-	-	<0.001	0.006
Barium	T-Ba		-	-	-	0.07	0.01
Beryllium	T-Be		-	-	-	<0.01	<0.01
Boron	T-B		-	-	-	0.1	0.9
Cadmium	T-Cd		-	-	-	<0.0005	0.0179
Calcium	T-Ca		-	-	-	173	225
Chromium	T-Cr		-	-	-	<0.001	<0.001
Cobalt	T-Co		-	-	-	<0.001	0.013
Copper	T-Cu		-	-	-	0.002	0.008
Iron	T-Fe		-	-	-	0.07	<0.03
Lead	T-Pb		-	-	-	0.0150	0.0015
Magnesium	T-Mg		-	-	-	26.3	89.4
Manganese	T-Mn		-	-	-	0.007	0.041
Mercury	T-Hg		-	-	-	<0.00002	<0.00002
Molybdenum	T-Mo		-	-	-	<0.03	<0.03
Nickel	T-Ni		-	-	-	<0.01	0.17
Potassium	T-K		-	-	-	7	47
Selenium	T-Se		-	-	-	<0.0005	0.09
Silver	T-Ag		-	-	-	<0.0001	<0.0001
Sodium	T-Na		-	-	-	59	537
Thallium	T-Tl		-	-	-	0.0026	0.0029
Titanium	T-Ti		-	-	-	<0.01	<0.01
Uranium	T-U		-	-	-	<0.001	0.026
Vanadium	T-V		-	-	-	<0.03	<0.03
Zinc	T-Zn		-	-	-	0.079	0.147

↗
BC Research
W7
= 0.14 mg/L

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

RESULTS OF ANALYSIS - Water

File No. L9693

Sample ID		TP140	Seep LF1	TP5
Sample Date		00 08 02	00 08 02	
ASL ID		*11*	*12*	*13*
Physical Tests				
Hardness	CaCO3	2170	1220	887
Total Metals				
Aluminum	T-Al	-	<0.05	-
Antimony	T-Sb	-	0.001	-
Arsenic	T-As	-	0.001	-
Barium	T-Ba	-	0.02	-
Beryllium	T-Be	-	<0.01	-
Boron	T-B	-	0.8	-
Cadmium	T-Cd	-	<0.0005	-
Calcium	T-Ca	-	357	-
Chromium	T-Cr	-	<0.001	-
Cobalt	T-Co	-	0.003	-
Copper	T-Cu	-	0.007	-
Iron	T-Fe	-	<0.03	-
Lead	T-Pb	-	0.0182	-
Magnesium	T-Mg	-	86.9	-
Manganese	T-Mn	-	0.080	-
Mercury	T-Hg	-	<0.00002	-
Molybdenum	T-Mo	-	<0.03	-
Nickel	T-Ni	-	0.02	-
Potassium	T-K	-	30	-
Selenium	T-Se	-	0.0023	-
Silver	T-Ag	-	<0.0001	-
Sodium	T-Na	-	207	-
Thallium	T-Tl	-	0.0022	-
Titanium	T-Ti	-	<0.01	-
Uranium	T-U	-	0.006	-
Vanadium	T-V	-	<0.03	-
Zinc	T-Zn	-	0.199	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

RESULTS OF ANALYSIS - Water

File No. L9693

Sample ID		BH1	BH5	BH6	BH7	TP61
Sample Date		00 08 01	00 08 01	00 08 01	00 08 01	00 08 01
ASL ID		*1*	*2*	*3*	*4*	*5*
Dissolved Metals						
Aluminum	D-Al	<0.05	<0.05	<0.05	<0.05	<0.05
Antimony	D-Sb	0.002	0.002	<0.001	0.002	<0.001
Arsenic	D-As	0.003	0.007	0.002	0.004	<0.001
Barium	D-Ba	0.11	0.19	0.03	0.13	0.01
Beryllium	D-Be	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	D-B	1.9	1.0	0.9	1.3	0.9
Cadmium	D-Cd	0.0022	0.0006	<0.0005	0.0118	<0.0005
Calcium	D-Ca	564	756	486	11.8	331
Chromium	D-Cr	0.001	<0.001	<0.001	0.001	<0.001
Cobalt	D-Co	0.018	0.015	0.005	0.098	<0.001
Copper	D-Cu	0.006	0.007	0.004	0.016	0.003
Iron	D-Fe	0.12	<0.03	0.09	<0.03	<0.03
Lead	D-Pb	0.047	0.017	0.001	0.050	0.001
Magnesium	D-Mg	72.1	202	81.5	103	104
Manganese	D-Mn	0.413	0.437	0.188	1.19	<0.005
Mercury	D-Hg	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	0.06	0.05	0.01	0.42	<0.01
Potassium	D-K	41	98	26	59	28
Selenium	D-Se	0.0052	0.0030	0.0005	0.0042	0.0021
Silver	D-Ag	0.0003	0.0002	<0.0001	0.0002	<0.0001
Sodium	D-Na	142	1180	156	201	159
Thallium	D-Tl	<0.003	<0.003	<0.004	<0.004	<0.003
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	0.004	0.005	0.005	0.006	0.003
Vanadium	D-V	0.04	0.07	<0.03	<0.03	<0.03
Zinc	D-Zn	8.80	1.64	0.063	90.6	0.017
Extractable Hydrocarbons						
EPH10-19		-	1.2	34.1	49.5	<0.3
EPH19-32		-	2	4	5	<1

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

RESULTS OF ANALYSIS - Water

File No. L9693

Sample ID		TP132	ROSUMP	ROPOND	TP140	LF1
Sample Date		00 08 01	00 08 01	00 08 01	00 08 02	00 08 02
ASL ID		*6*	*7*	*8*	*11*	*12*
Dissolved Metals						
Aluminum	D-Al	<0.05	<0.05	<0.05	<0.05	<0.05
Antimony	D-Sb	<0.001	<0.001	0.002	<0.001	0.001
Arsenic	D-As	0.002	<0.001	0.005	0.004	0.002
Barium	D-Ba	0.02	0.05	0.04	0.02	0.02
Beryllium	D-Be	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	D-B	1.1	0.3	0.7	3.1	0.8
Cadmium	D-Cd	<0.0005	0.0005	0.0042	<0.0005	<0.0005
Calcium	D-Ca	480	117	595	501	349
Chromium	D-Cr	<0.001	<0.001	0.001	<0.001	<0.001
Cobalt	D-Co	0.003	0.002	0.006	0.006	0.003
Copper	D-Cu	0.004	0.006	0.036	0.009	0.006
Iron	D-Fe	<0.03	<0.03	<0.03	<0.03	<0.03
Lead	D-Pb	0.004	0.035	0.126	0.019	0.012
Magnesium	D-Mg	203	24.5	104	223	84.4
Manganese	D-Mn	0.106	0.066	0.156	0.096	0.068
Mercury	D-Hg	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.01	0.01	0.03	0.01	0.02
Potassium	D-K	34	12	73	120	30
Selenium	D-Se	0.0012	0.0013	0.025	0.0020	0.0022
Silver	D-Ag	<0.0001	<0.0001	0.0004	<0.0001	<0.0001
Sodium	D-Na	335	57	675	666	201
Thallium	D-Tl	<0.003	<0.003	<0.003	<0.003	<0.002
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	0.005	0.001	0.002	0.021	0.006
Vanadium	D-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	D-Zn	0.020	1.01	1.55	0.093	0.195
Extractable Hydrocarbons						
EPH10-19		9.9	0.7	0.8	2.4	<0.3
EPH19-32		<1	<1	<1	1	<1

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

RESULTS OF ANALYSIS - Water File No. L9693

Sample ID		TP5
Sample Date *ASL ID*		*13*
Dissolved Metals		
Aluminum	D-Al	<0.05
Antimony	D-Sb	0.002
Arsenic	D-As	0.002
Barium	D-Ba	0.13
Beryllium	D-Be	<0.01
Boron	D-B	0.7
Cadmium	D-Cd	0.0013
Calcium	D-Ca	282
Chromium	D-Cr	<0.001
Cobalt	D-Co	0.010
Copper	D-Cu	0.002
Iron	D-Fe	<0.03
Lead	D-Pb	0.018
Magnesium	D-Mg	44.3
Manganese	D-Mn	0.234
Mercury	D-Hg	<0.00002
Molybdenum	D-Mo	<0.03
Nickel	D-Ni	0.03
Potassium	D-K	18
Selenium	D-Se	0.0022
Silver	D-Ag	<0.0001
Sodium	D-Na	98
Thallium	D-Tl	<0.002
Titanium	D-Ti	<0.01
Uranium	D-U	0.002
Vanadium	D-V	<0.03
Zinc	D-Zn	5.86
Extractable Hydrocarbons		
EPH10-19		4.9
EPH19-32		<1

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L9693

Water		BH5	BH5
		00 08 01	QC # 207199
Physical Tests			
Hardness	CaCO3	2720	2710
Dissolved Metals			
Aluminum	D-Al	<0.05	<0.05
Antimony	D-Sb	0.002	0.002
Arsenic	D-As	0.007	0.008
Barium	D-Ba	0.19	0.19
Beryllium	D-Be	<0.01	<0.01
Boron	D-B	1.0	1.0
Cadmium	D-Cd	0.0006	0.0007
Calcium	D-Ca	756	755
Chromium	D-Cr	<0.001	<0.001
Cobalt	D-Co	0.015	0.015
Copper	D-Cu	0.007	0.008
Iron	D-Fe	<0.03	<0.03
Lead	D-Pb	0.017	0.017
Magnesium	D-Mg	202	201
Manganese	D-Mn	0.437	0.436
Mercury	D-Hg	<0.00002	<0.00002
Molybdenum	D-Mo	<0.03	<0.03
Nickel	D-Ni	0.05	0.05
Potassium	D-K	98	100
Selenium	D-Se	0.0030	0.0030
Silver	D-Ag	0.0002	0.0002
Sodium	D-Na	1180	1170
Thallium	D-Tl	<0.003	<0.003
Titanium	D-Ti	<0.01	<0.01
Uranium	D-U	0.005	0.004
Vanadium	D-V	0.07	0.07
Zinc	D-Zn	1.64	1.62

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption spectrophotometry (EPA Method 7470A/7471A).

Recommended Holding Time:

Sample:	28 days
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Extractable Hydrocarbons in Water

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for

Contaminated Sites "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 1999). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Recommended Holding Time:
Sample: 7 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

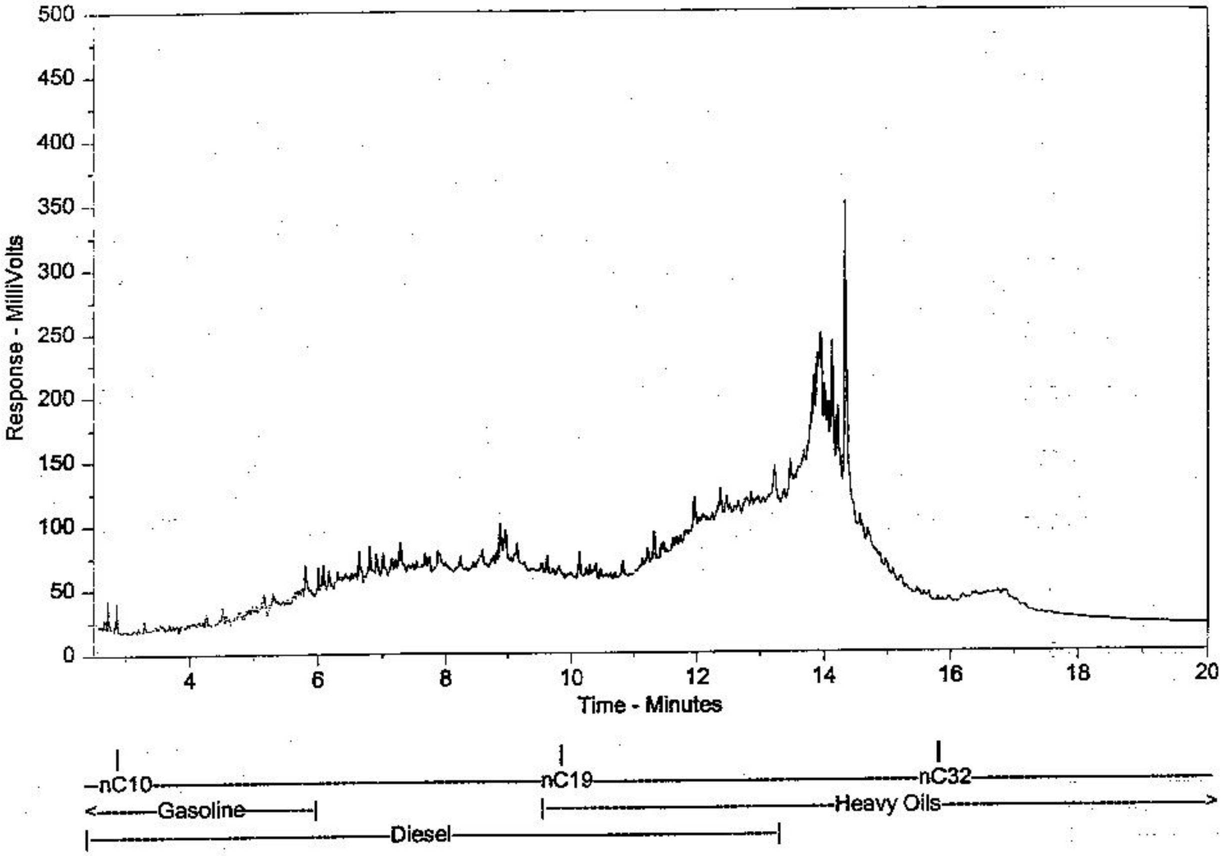
End of Report

Appendix

HYDROCARBON DISTRIBUTION REPORTS

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--2**
File Name: m:\chrom\gc12\data\gc12_17augB.0023.RAW
Run Information: Acquired on GC12, 8/18/00 4:18:39 AM



Sample Amount = 530.0 (g or mL)

Dilution Factor = 1.0

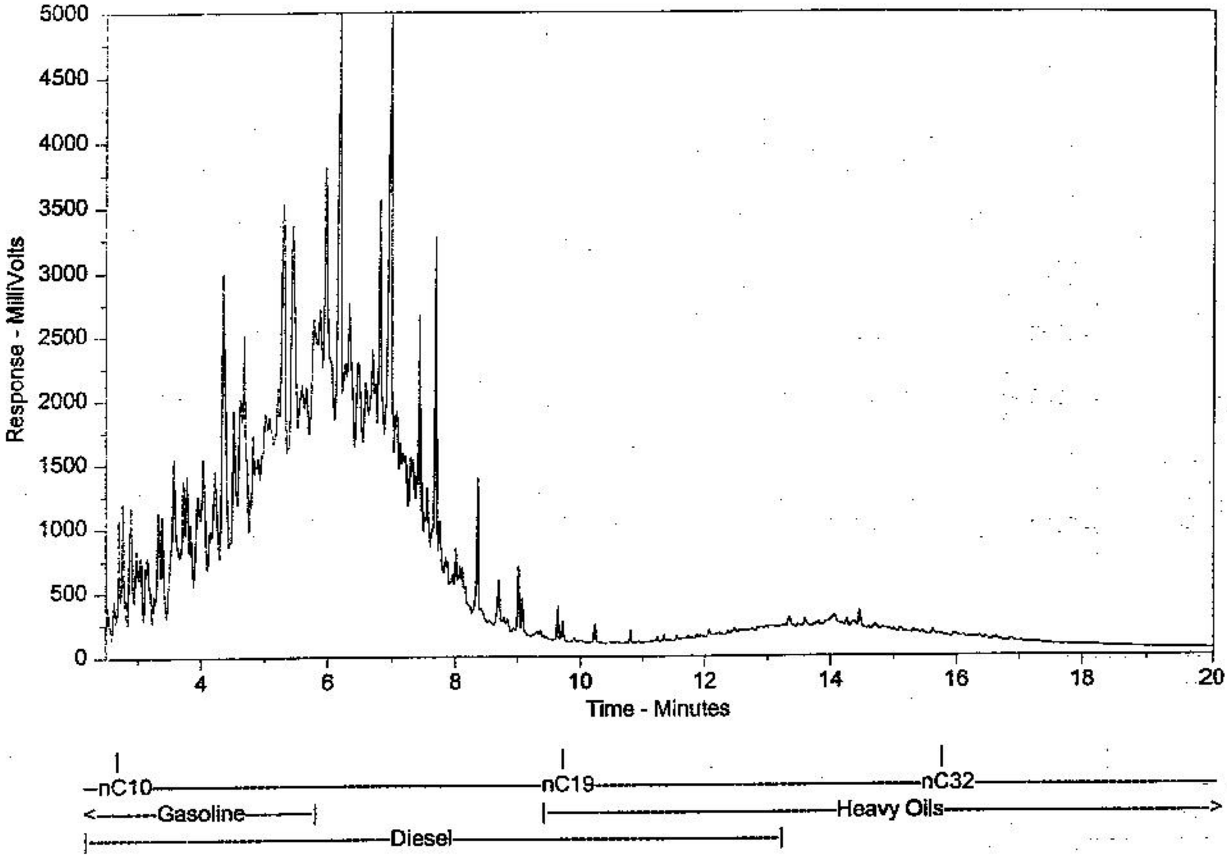
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--3**
File Name: m:\chrom\gc12\data\gc12_17augA.0025.RAW
Run Information: Acquired on GC12, 8/18/00 5:20:28 AM



Sample Amount = 530.0 (g or mL)

Dilution Factor = 1.0

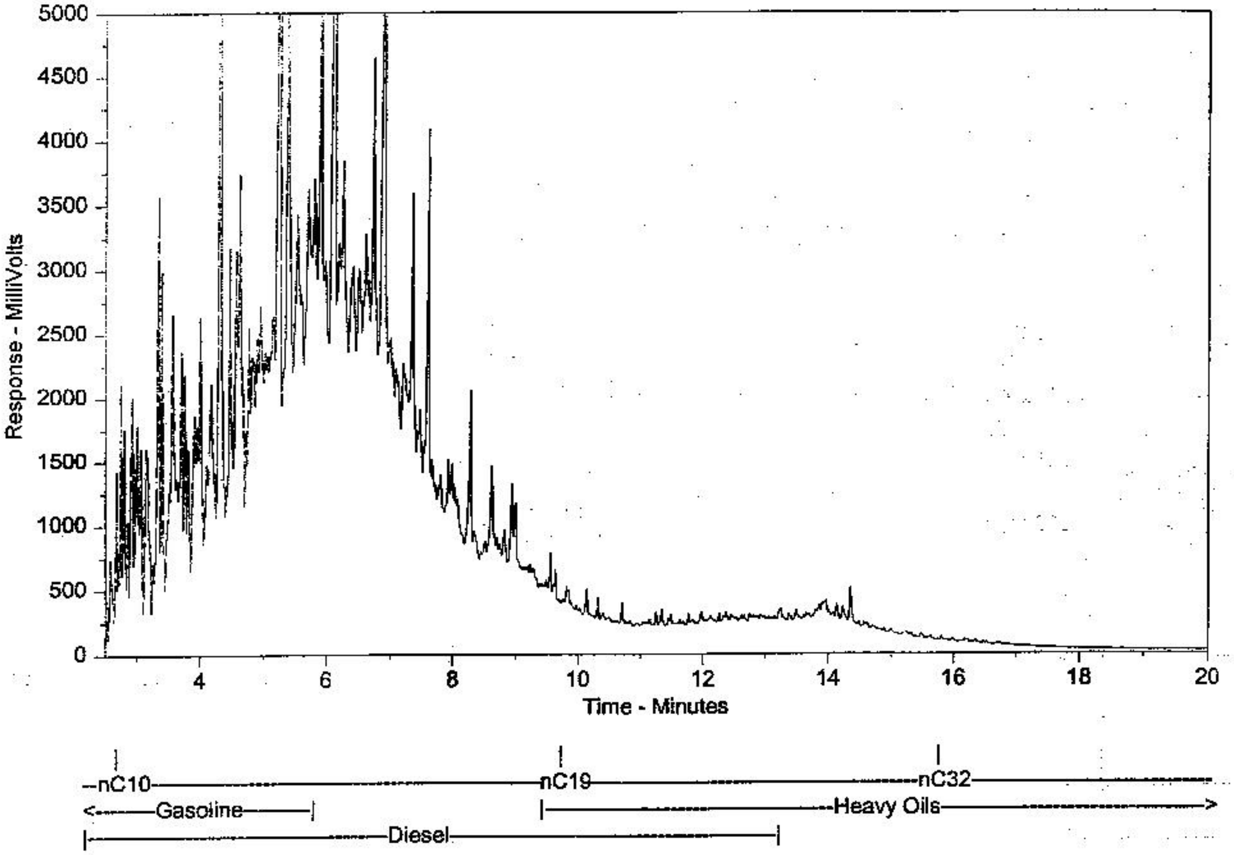
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--4**
File Name: m:\chrom\gc12\data\gc12_17augB.0024.RAW
Run Information: Acquired on GC12, 8/18/00 4:49:35 AM



Sample Amount = 530.0 (g or mL)

Dilution Factor = 1.0

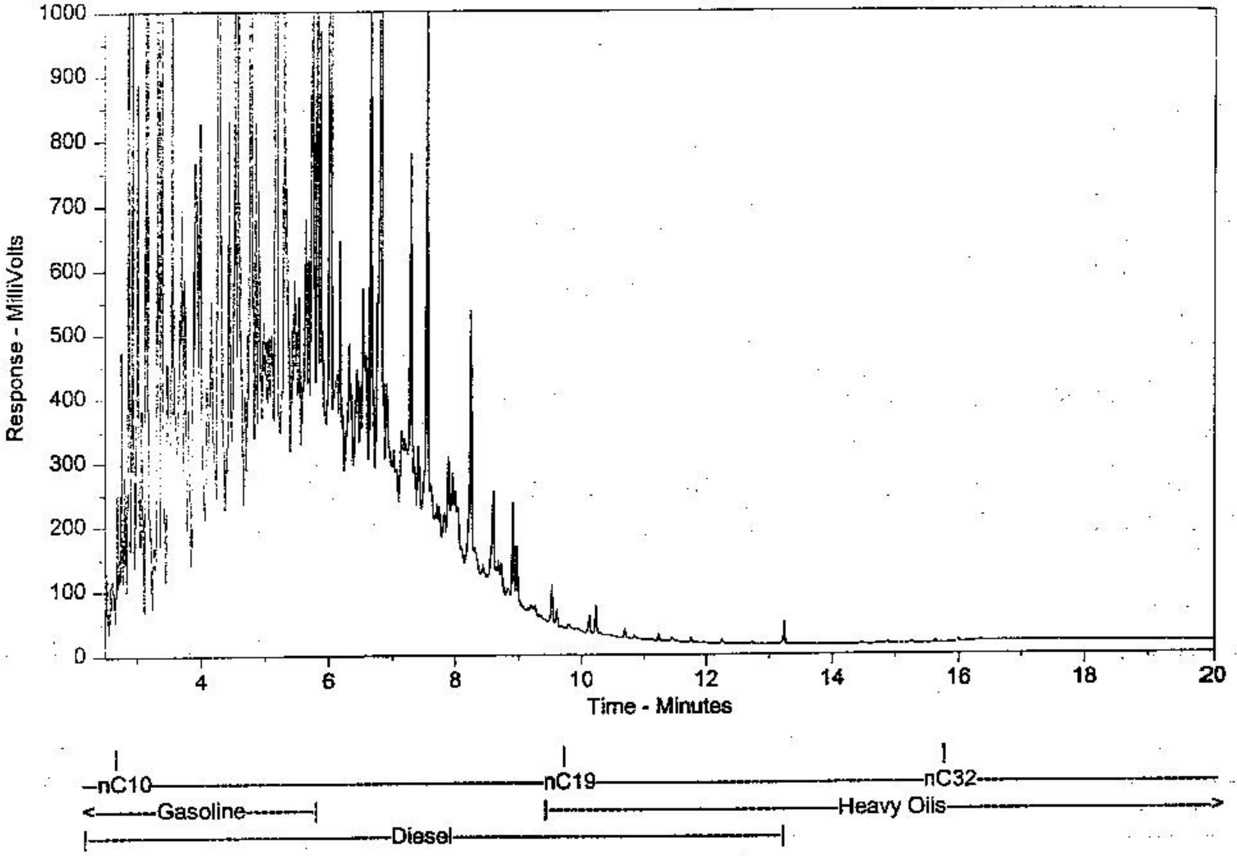
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--6**
File Name: m:\chrom\gc12\data\gc12_17augB.0025.RAW
Run Information: Acquired on GC12, 8/18/00 5:20:28 AM



Sample Amount = 535.0 (g or mL)

Dilution Factor = 1.0

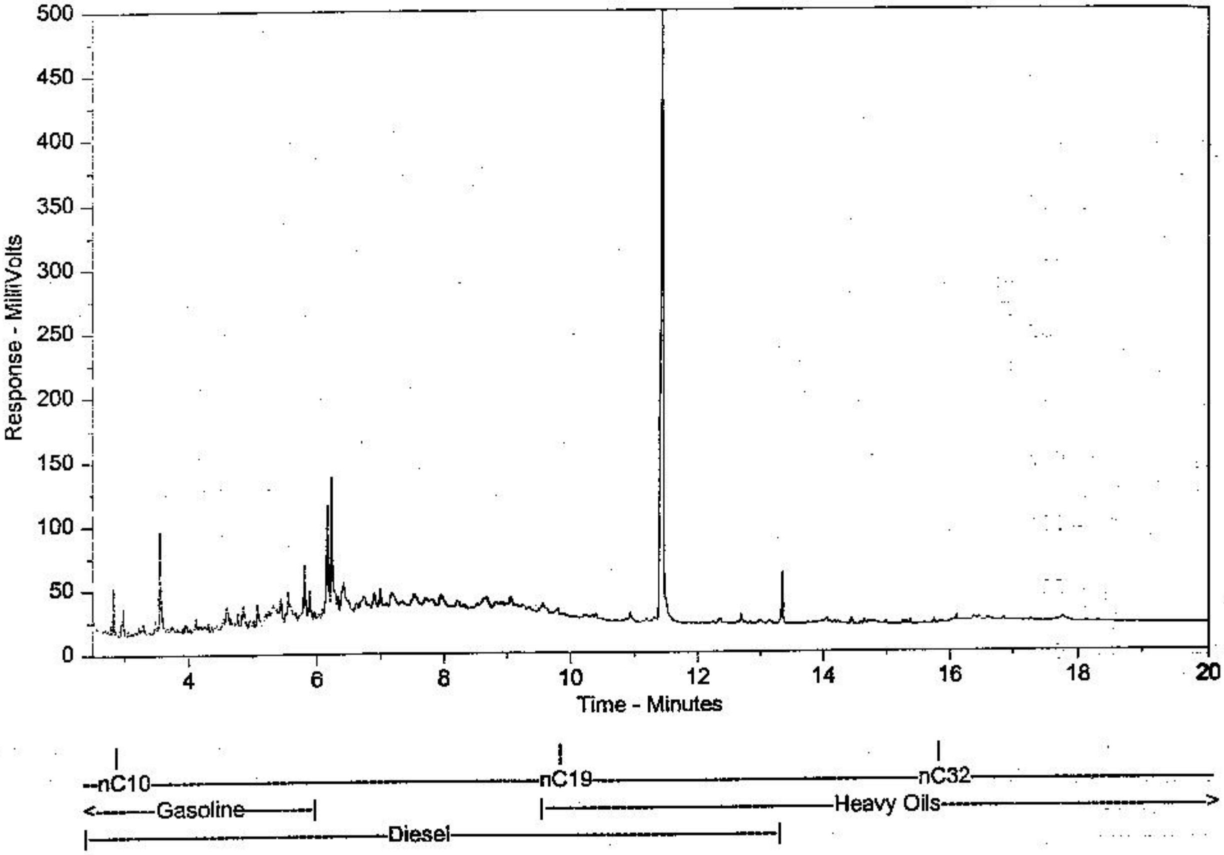
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:	
ASL Sample ID:	**L9693-T--7**
File Name:	m:\chrom\gc12\data\gc12_17augA.0027.RAW
Run Information:	Acquired on GC12, 8/18/00 9:06:19 AM



Sample Amount = 535.0 (g or mL)

Dilution Factor = 1.0

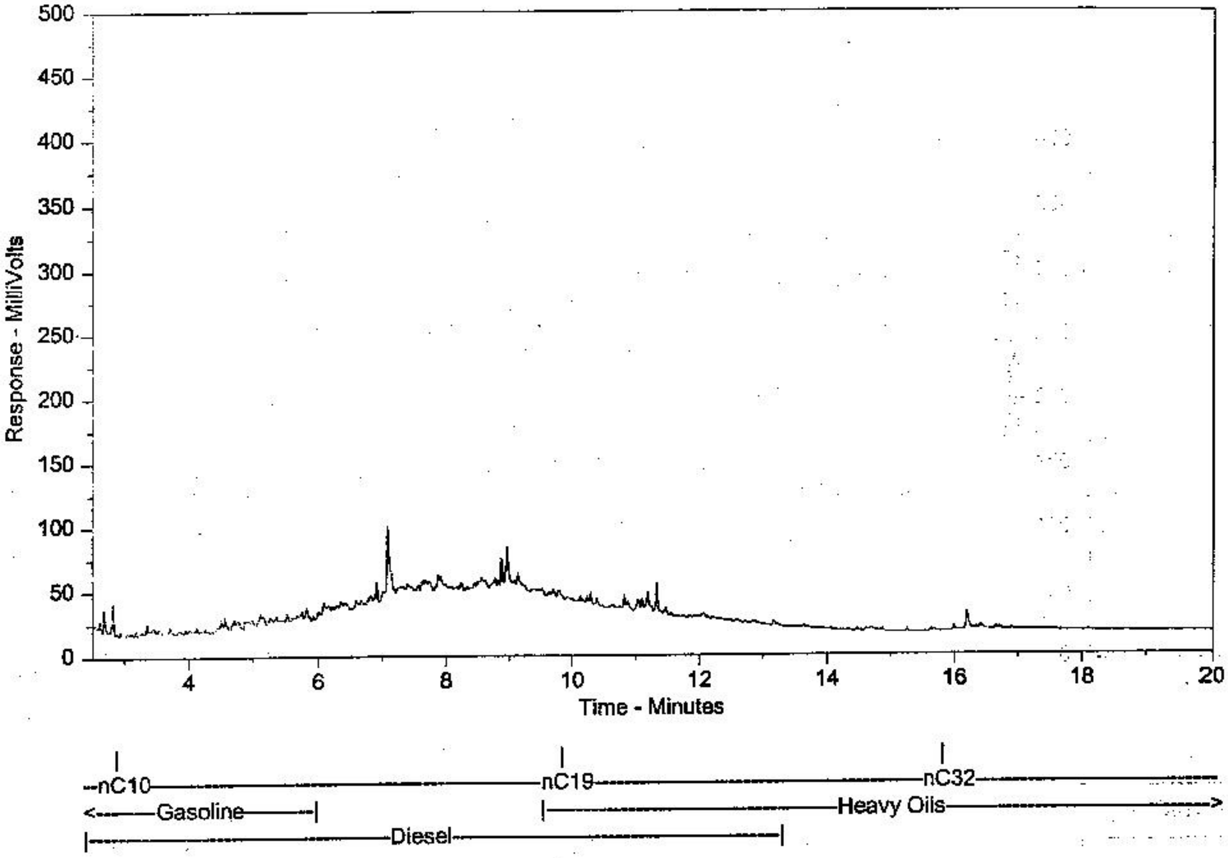
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--8**
File Name: m:\chrom\gc12\data\gc12_17augB.0035.RAW
Run Information: Acquired on GC12, 8/18/00 1:15:02 PM



Sample Amount = 530.0 (g or mL)

Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

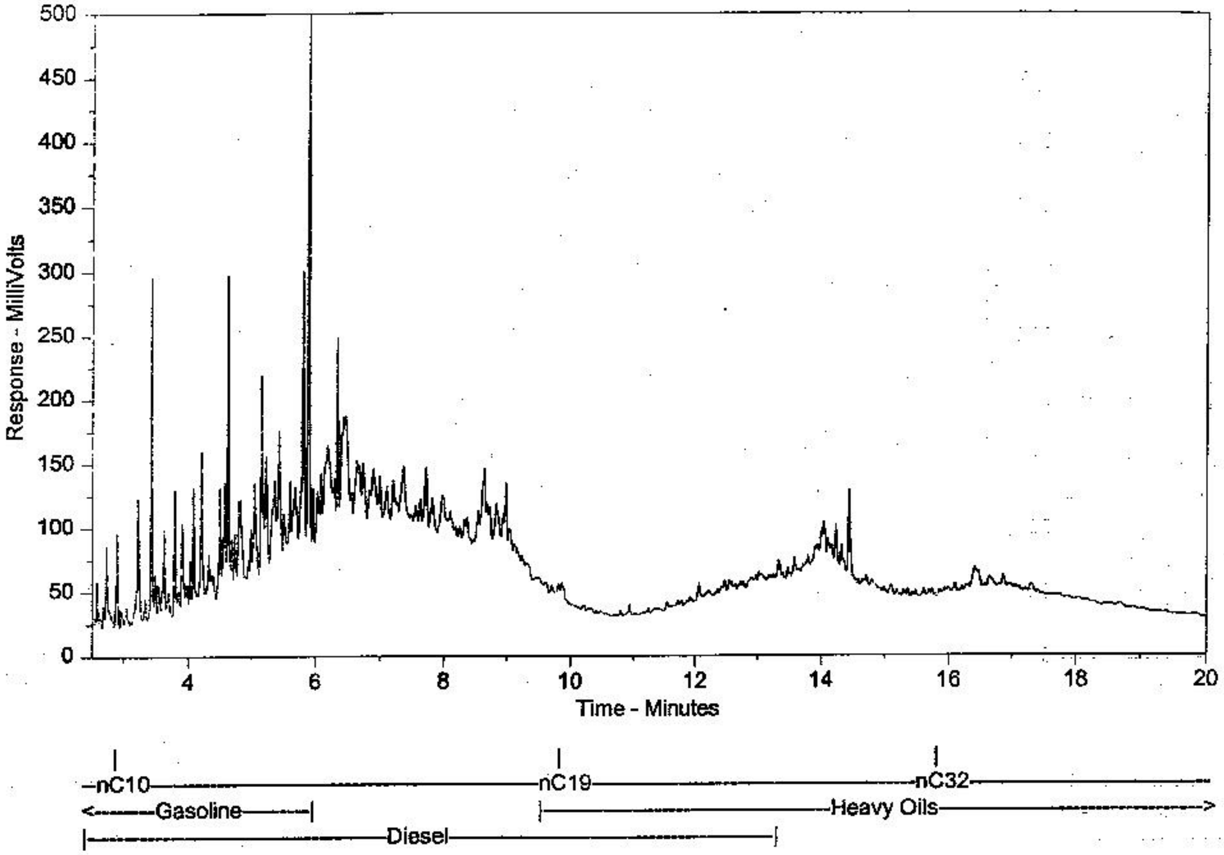
Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

Printed on 8/19/00 7:56:36 AM

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--11**
File Name: m:\chrom\gc12\data\gc12_17augA.0036.RAW
Run Information: Acquired on GC12, 8/18/00 1:46:09 PM



Sample Amount = 530.0 (g or mL)

Dilution Factor = 1.0

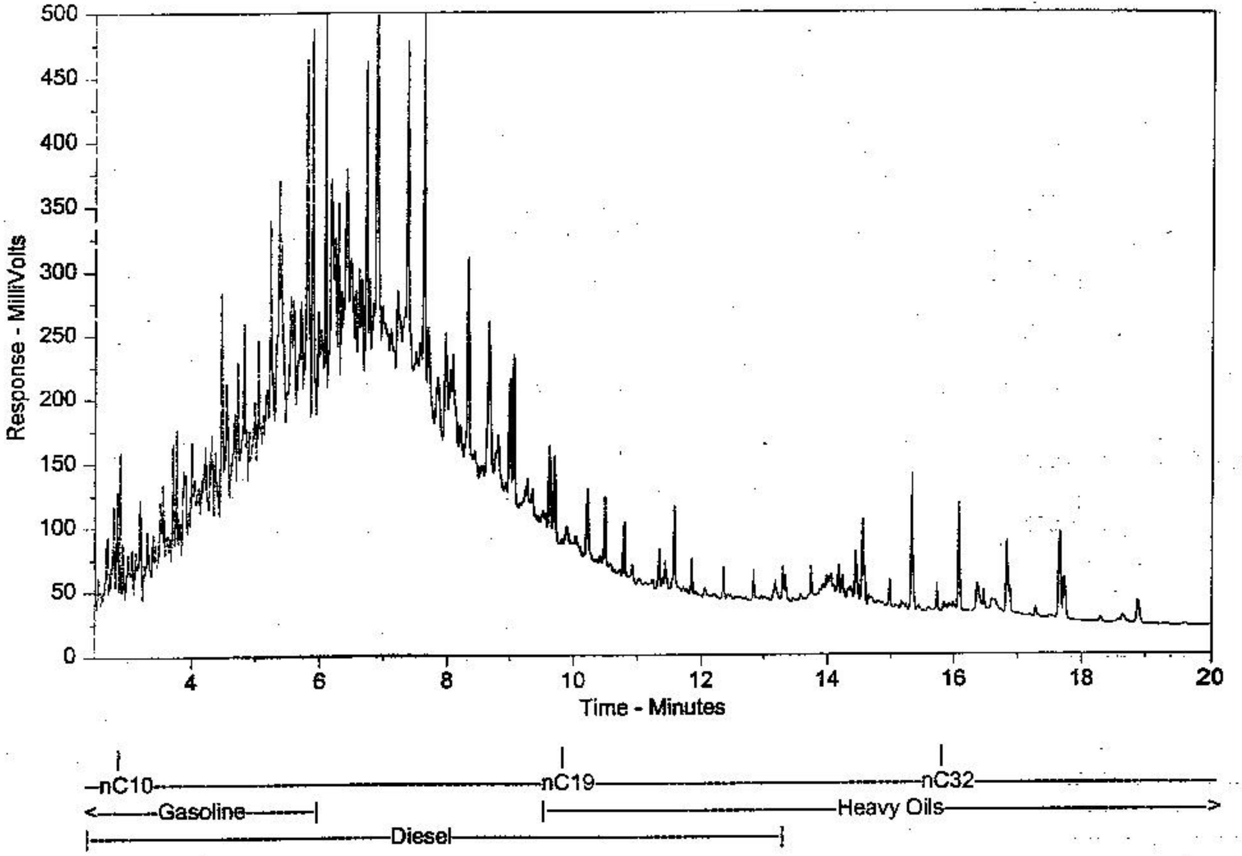
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L9693-T--13**
File Name: m:\chrom\gc12\data\gc12_17augA.0037.RAW
Run Information: Acquired on GC12, 8/18/00 2:17:12 PM



Sample Amount = 540.0 (g or mL)

Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st,1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

1988 Triumph Street, Vancouver, B.C., Canada V5L 1K5

analytical
service
laboratories
ltd.

FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

JUL 31 2000
GARTNER LEE

Date:	July 25, 2000
ASL File No.	L8751
Report On:	99-902 Cominco Polaris Water Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	July 11, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

REMARKS File No. L8751

The detection limits for some of the Polycyclic Aromatic Hydrocarbons (PAHs) have been increased for the sample "Barge Sump July 7" due to matrix interferences.

The detection limits for some of the metals and Halogenated Volatiles have been increased for the sample "Barge Sump July 7" due to analytical interferences.

RESULTS OF ANALYSIS - Water

File No. L8751

		Barge Sump July 7	LRD July 7
Sample ID		Barge Sump July 7	LRD July 7
Sample Date		00 07 07	00 07 07
ASL ID		*1*	2
Physical Tests			
Conductivity	(umhos/cm)	2350	-
Hardness	CaCO3	928	737
pH		7.02	-
Nutrients			
Ammonia Nitrogen	N	11.9	6.63
Nitrate Nitrogen	N	2.7	6.0
Nitrite Nitrogen	N	4.5	0.223
Total Dissolved Phosphate	P	0.010	0.003
Total Phosphate	P	0.052	0.038
Total Metals			
Aluminum	T-Al	0.72	0.97
Antimony	T-Sb	0.001	0.003
Arsenic	T-As	0.003	0.004
Barium	T-Ba	0.35	0.03
Beryllium	T-Be	<0.01	<0.01
Boron	T-B	1.1	1.2
Cadmium	T-Cd	0.0130	<0.0005
Calcium	T-Ca	318	128
Chromium	T-Cr	<0.005	<0.005
Cobalt	T-Co	0.004	0.003
Copper	T-Cu	0.022	0.006
Iron	T-Fe	5.65	0.42
Lead	T-Pb	2.93	0.0105
Magnesium	T-Mg	41.6	101
Manganese	T-Mn	0.229	0.022
Mercury	T-Hg	<0.00002	<0.00002
Molybdenum	T-Mo	<0.03	0.04
Nickel	T-Ni	0.02	0.02
Potassium	T-K	13	75
Selenium	T-Se	<0.01	<0.02
Silver	T-Ag	0.0002	<0.0001
Sodium	T-Na	92	746
Thallium	T-Tl	0.0005	0.0008
Titanium	T-Ti	0.03	0.05
Uranium	T-U	0.002	0.008
Vanadium	T-V	<0.03	0.05
Zinc	T-Zn	4.02	0.030

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. L8751

Sample ID		Barge Sump July 7
Sample Date		00 07 07
ASL ID		*1*
Dissolved Metals		
Aluminum	D-Al	0.08
Antimony	D-Sb	<0.001
Arsenic	D-As	0.001
Barium	D-Ba	0.10
Beryllium	D-Be	<0.01
Boron	D-B	1.3
Cadmium	D-Cd	0.0024
Calcium	D-Ca	310
Chromium	D-Cr	<0.005
Cobalt	D-Co	0.003
Copper	D-Cu	0.009
Iron	D-Fe	3.73
Lead	D-Pb	1.02
Magnesium	D-Mg	37.6
Manganese	D-Mn	0.204
Mercury	D-Hg	<0.00002
Molybdenum	D-Mo	<0.03
Nickel	D-Ni	0.02
Potassium	D-K	13
Selenium	D-Se	<0.01
Silver	D-Ag	<0.0001
Sodium	D-Na	102
Thallium	D-Tl	<0.0005
Titanium	D-Ti	<0.01
Uranium	D-U	0.002
Vanadium	D-V	<0.03
Zinc	D-Zn	0.658

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Sample ID	Barge Sump July 7
Sample Date	00 07 07
ASL ID	*1*
Halogenated Volatiles	
Bromodichloromethane	<0.001
Bromoform	<0.001
Carbon Tetrachloride	<0.005
Chlorobenzene	<0.001
Chloroethane	<0.001
Chloroform	<0.001
Chloromethane	<0.001
Dibromochloromethane	<0.001
1,2-Dichlorobenzene	<0.001
1,3-Dichlorobenzene	<0.001
1,4-Dichlorobenzene	<0.001
1,1-Dichloroethane	<0.001
1,2-Dichloroethane	<0.001
cis-1,2-Dichloroethylene	<0.001
trans-1,2-Dichloroethylene	<0.001
1,1-Dichloroethylene	<0.001
Dichloromethane	<0.03
1,2-Dichloropropane	<0.001
cis-1,3-Dichloropropylene	<0.02
trans-1,3-Dichloropropylene	<0.005
1,1,1,2-Tetrachloroethane	<0.001
1,1,2,2-Tetrachloroethane	<0.001
Tetrachloroethylene	<0.001
1,1,1-Trichloroethane	<0.02
1,1,2-Trichloroethane	<0.001
Trichloroethylene	<0.001
Trichlorofluoromethane	0.002
Vinyl Chloride	<0.001
Non-halogenated Volatiles	
Benzene	0.0027
Ethylbenzene	0.0154
Styrene	<0.0005
Toluene	0.0071
meta- & para-Xylene	0.0398
ortho-Xylene	0.0176

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. L8751

Sample ID	Barge Sump July 7
Sample Date	00 07 07
ASL ID	*1*
Water Soluble Volatiles	
Diethylene Glycol	<10
Ethylene Glycol	63
Propylene Glycol	<10
Polycyclic Aromatic Hydrocarbons	
Acenaphthene	<0.0007
Acenaphthylene	<0.0002
Acridine	<0.0003
Anthracene	<0.0001
Benz(a)anthracene	0.00014
Benzo(a)pyrene	0.00013
Benzo(b)fluoranthene	0.00019
Benzo(g,h,i)perylene	0.00013
Benzo(k)fluoranthene	0.00023
Chrysene	0.00022
Dibenz(a,h)anthracene	0.00014
Fluoranthene	0.00011
Fluorene	0.00048
Indeno(1,2,3-c,d)pyrene	0.00014
Naphthalene	<0.002
Phenanthrene	<0.0001
Pyrene	0.00013
Extractables	
EPH10-19	22.7
EPH19-32	10
LEPH	22.7
HEPH	10

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
EPH10-19 is equivalent to EHw10-19.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Conductivity in Water

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Recommended Holding Time:
 Sample: 28 days
 Reference: APHA
 For more detail see ASL "Collection & Sampling Guide"

pH in Water

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Recommended Holding Time:
 Sample: 2 hours
 Reference: APHA
 For more detail see ASL "Collection & Sampling Guide"

Ammonia in Water by Selective Ion Electrode

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

Recommended Holding Time:
 Sample: 28 days
 Reference: APHA
 For more detail see ASL "Collection & Sampling Guide"

Nitrate and Nitrite in Water by Colourimetry

This analysis is carried out using procedures adapted from APHA Method 4500-NO2 "Nitrogen (Nitrite)" and Method 4500-NO3 "Nitrogen (Nitrate)". Nitrite is determined using the azo dye colourimetric method. Nitrate is determined using the cadmium reduction colourimetric method. Nitrate/nitrite is the sum of the concentrations of nitrate and nitrite present in the sample.

Recommended Holding Time:
Sample: 2 days
Reference: APHA and EPA
For more detail see ASL "Collection & Sampling Guide"

Phosphate in Water

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". All forms of phosphate are determined by the ascorbic acid colourimetric method. Dissolved ortho-phosphate (dissolved reactive phosphorous) is determined by direct measurement. Total phosphate (total phosphorous) is determined after persulphate digestion of a sample. Total dissolved phosphate (total dissolved phosphorous) is determined by filtering a sample through a 0.45 micron membrane filter followed by persulfate digestion of the filtrate.

Recommended Holding Time:
Sample: 2 days
Reference: EPA
For more detail see ASL "Collection & Sampling Guide"

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption spectrophotometry (EPA Method 7470A/7471A).

Recommended Holding Time:

Sample:	28 days
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Volatile Organic Compounds and Volatile Hydrocarbons in Water

This analysis involves a Purge and Trap extraction of the sample with subsequent analysis for Volatile Hydrocarbons (VH) by capillary column gas chromatography with flame-ionization detection and for specific Volatile Organic Compounds (VOC) by capillary column gas chromatography with mass spectrometric detection. The VH analysis is carried out according to British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Volatile Hydrocarbons in Water by GC/FID" (Version 2.1 July 1999). Analysis of VOC is carried out using procedures adapted from the United States Environmental Protection Agency Methods 624, 5030 and 8260 (Publ. # SW-846 3rd ed., Washington, DC 20460).

Recommended Holding Time:
Sample: 7 days Extract: n/a
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

Water Soluble Organic Compounds

These analyses are carried out in accordance with EPA Method 8000 (Publ. #SW-846, 3rd Ed., Washington, DC 20460). Water samples are analysed as received, or diluted, by direct injection into a gas chromatograph with Flame Ionization Detector. Quantification is by external calibration with due consideration of the response of an internal standard.

Polycyclic Aromatic Hydrocarbons in Water

This analysis is carried out using a procedure adapted by ASL from U.S. EPA Methods 3510, 3630 and 8270 (publ. #SW-846, 3rd Ed., Washington, DC 20460). The procedure involves the extraction of the sample with methylene chloride followed by silica column chromatography cleanup. This cleanup procedure has been found to effectively remove aliphatic and heterocyclic hydrocarbons which could potentially interfere with the analysis. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection.

Extractable Hydrocarbons in Water

This analysis is carried out according to British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Water by GC/FID, Version 2.1 July 1999". The procedure involves extraction of the entire water sample with Dichloromethane. The extract is exchanged to Toluene and analysed by capillary column gas chromatography with flame ionization detection. Reported results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbon (LEPH/HEPH).

Please note that in August of 1999, BCMELP replaced the EPH(C10-18) and EPH(C19-31) parameters with EPH(C10-19) and EPH(C19-32). These parameters were redefined so that they more accurately describe how the analysis is carried out. Results reported by ASL for the old and new parameters are equivalent. ASL implemented the new parameters on August 23, 1999.

Recommended Holding Time:
Sample: 7 days Extract: 40 days
Reference: BCMELP
For more detail see ASL "Collection & Sampling Guide"

Light and Heavy Extractable Petroleum Hydrocarbons in Water

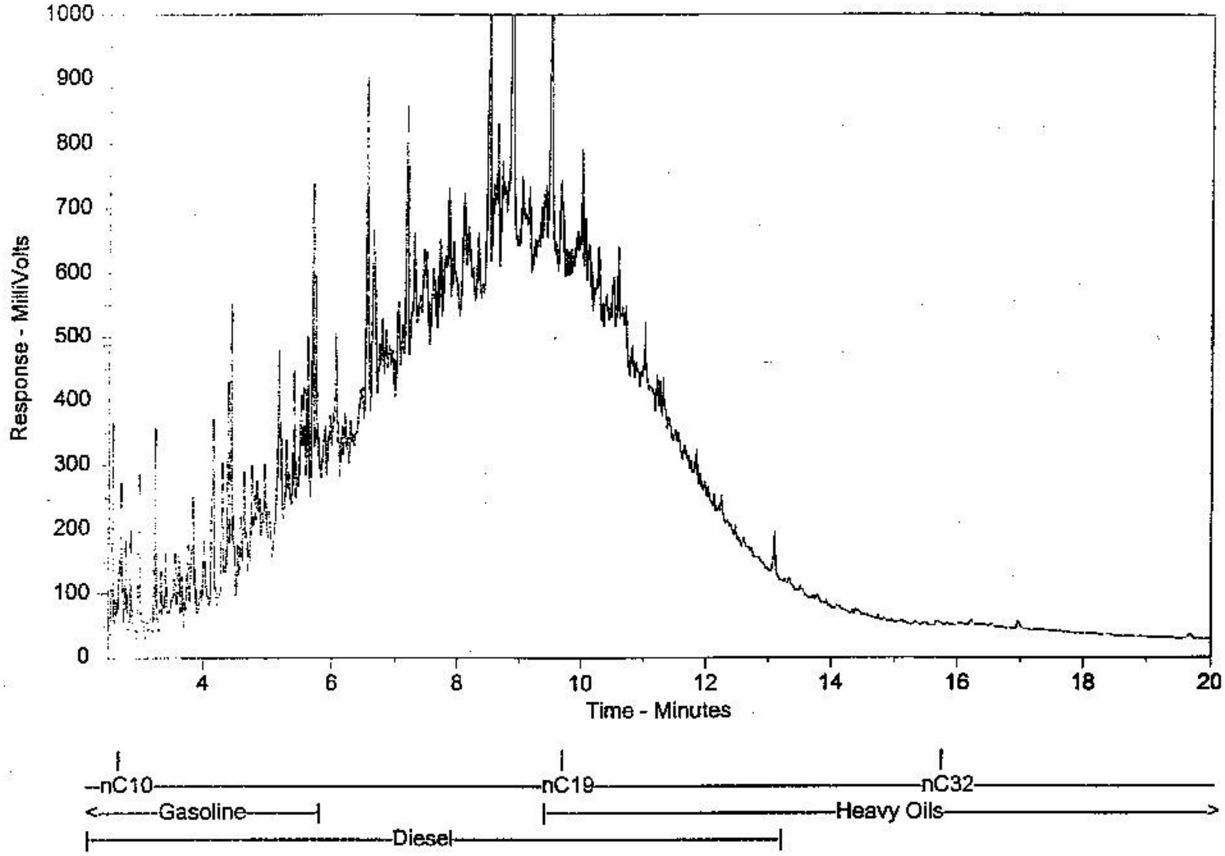
These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated by subtracting selected Polynuclear Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for acenaphthene, acridine, anthracene, fluorene, naphthalene, and phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for benz(a)anthracene, benzo(a)pyrene, fluoranthene, and pyrene are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Water by GC/FID"(Version 2.1, July 20, 1999).

Recommended Holding Time: Not Applicable

End of Report

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L8751-T--1**
File Name: m:\chrom\gc04\data\gc04_14julB.0037.RAW
Run Information: Acquired on GC04, 7/15/00 7:56:22 AM



Sample Amount = 235.0 (g or mL) Dilution Factor = 1.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. Comparison of this report with those of reference standards may also assist in characterizing hydrocarbons present in the sample.

Peak heights in this report are a function of the sample concentration, the sample amount extracted, the sample dilution factor, and the scale at left.

Note: This report was produced using a temperature profile that was implemented on June 21st, 1999. Under these new conditions, hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report to other reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

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ASL

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CHEMICAL ANALYSIS REPORT

Date:	November 24, 2000
ASL File No.	M1257r
Report On:	20-930 Plant Tissue Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	August 4, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.

per:

Heather A. Ross, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

CHARGEABLE

REMARKS

This report, ASL file number M1257r, supersedes the previous ASL file number M1257. The client requested additional metals on all of the samples reported in the following data tables.

The detection limits for some of the metals have been increased for several of the samples reported in the following data tables due to the high concentration of Calcium in these samples.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site B Lichen	Site B Grass	Site B Willow Root	Site B Willow Top	Site C Lichen
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*1*	*2*	*3*	*4*	*5*
Total Metals						
Aluminum	T-Al	249	168	101	69	2140
Antimony	T-Sb	<20	<10	<10	<10	<20
Arsenic	T-As	<20	<10	<10	<10	<20
Barium	T-Ba	28	61.7	28.0	22.8	131
Beryllium	T-Be	<0.4	<0.2	<0.2	<0.2	<0.4
Bismuth	T-Bi	<10	<5	<5	<5	<10
Cadmium	T-Cd	<1	<0.5	1.2	1.1	2
Calcium	T-Ca	86300	4100	6090	5690	56000
Chromium	T-Cr	1	1.1	1.2	0.9	11
Cobalt	T-Co	<1	<0.5	0.5	<0.5	<1
Copper	T-Cu	<1	4.1	5.0	4.5	6
Iron	T-Fe	256	210	109	87	2650
Lead	T-Pb	113	8	<5	<5	337
Lithium	T-Li	1	<0.5	<0.5	<0.5	2
Magnesium	T-Mg	368	1170	1180	1200	1830
Manganese	T-Mn	4.7	106	29.0	24.2	15.8
Molybdenum	T-Mo	<2	1	<1	<1	<2
Nickel	T-Ni	<4	2	7	5	8
Phosphorus	T-P	309	3630	1310	1330	524
Potassium	T-K	1560	18900	5920	6210	2400
Selenium	T-Se	<20	<10	<10	<10	<20
Sodium	T-Na	<200	261	<100	<100	<200
Strontium	T-Sr	120	14.4	33.8	28.8	66.9
Thallium	T-Tl	<20	<10	<20	<20	<20
Tin	T-Sn	<4	<2	<2	<2	<4
Titanium	T-Ti	7	4.8	2.8	2.0	38
Vanadium	T-V	<4	<2	<2	<2	32
Zinc	T-Zn	69.0	52.0	264	236	188

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue File No. M1257r

Sample ID		Site C Grass	Site C Willow Root	Site C Willow Top	Site D Lichen	Site D Grass
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*6*	*7*	*8*	*9*	*10*
Total Metals						
Aluminum	T-Al	1220	273	71	297	283
Antimony	T-Sb	<10	<10	<10	<20	<10
Arsenic	T-As	<10	<10	<10	<20	<10
Barium	T-Ba	204	88.5	39.8	36	200
Beryllium	T-Be	<0.2	<0.2	<0.2	<0.4	<0.2
Bismuth	T-Bi	<5	<5	<5	<10	<5
Cadmium	T-Cd	1.9	5.1	4.2	1	0.9
Calcium	T-Ca	20500	8440	6420	80500	13600
Chromium	T-Cr	7.5	8.7	0.8	12	2.2
Cobalt	T-Co	0.7	<0.5	<0.5	<1	<0.5
Copper	T-Cu	6.8	5.0	4.1	<1	5.6
Iron	T-Fe	1640	347	92	456	399
Lead	T-Pb	232	28	16	528	84
Lithium	T-Li	1.0	<0.5	<0.5	1	<0.5
Magnesium	T-Mg	3110	1100	1250	5630	1800
Manganese	T-Mn	27.8	20.4	17.7	8.2	41.7
Molybdenum	T-Mo	2	<1	<1	<2	2
Nickel	T-Ni	6	6	<2	6	2
Phosphorus	T-P	1070	1530	1920	327	1380
Potassium	T-K	5190	4940	8630	1550	9200
Selenium	T-Se	<10	<10	<10	<20	<10
Sodium	T-Na	<100	<100	<100	<200	750
Strontium	T-Sr	51.2	33.8	22.0	110	48.5
Thallium	T-Tl	<20	<20	<20	<20	<10
Tin	T-Sn	<2	<2	<2	<4	<2
Titanium	T-Ti	25.6	8.0	2.6	10	9.1
Vanadium	T-V	17	5	<2	5	3
Zinc	T-Zn	778	325	325	193	249

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Sample ID		Site D Willow Roots	Site D Willow Top	Site E Lichen	Site E Grass	Site E Willow Root
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*11*	*12*	*13*	*14*	*15*
Total Metals						
Aluminum	T-Al	295	41	144	287	157
Antimony	T-Sb	<10	<10	<10	<10	<10
Arsenic	T-As	<10	<10	<10	<10	<10
Barium	T-Ba	98.2	28.0	20.8	55.6	66.8
Beryllium	T-Be	<0.2	<0.2	<0.2	<0.2	<0.2
Bismuth	T-Bi	<5	<5	<5	<5	<5
Cadmium	T-Cd	2.2	2.6	1.1	<0.5	8.2
Calcium	T-Ca	4280	4220	35700	5220	7790
Chromium	T-Cr	4.0	0.7	0.7	2.1	2.1
Cobalt	T-Co	<0.5	<0.5	<0.5	<0.5	<0.5
Copper	T-Cu	4.8	3.6	<0.5	3.9	8.6
Iron	T-Fe	331	46	198	379	196
Lead	T-Pb	10	32	798	50	62
Lithium	T-Li	<0.5	<0.5	0.6	<0.5	<0.5
Magnesium	T-Mg	887	791	242	1060	922
Manganese	T-Mn	12.3	11.8	3.4	39.6	14.7
Molybdenum	T-Mo	<1	<1	<1	1	<1
Nickel	T-Ni	7	<2	<2	2	8
Phosphorus	T-P	619	739	176	1890	744
Potassium	T-K	1840	2980	896	15300	3100
Selenium	T-Se	<10	<10	<10	<10	<10
Sodium	T-Na	<100	<100	<100	110	<100
Strontium	T-Sr	29.3	25.0	33.3	12.3	29.7
Thallium	T-Tl	<10	<10	<10	<20	<20
Tin	T-Sn	<2	<2	<2	<2	<2
Titanium	T-Ti	7.1	1.0	5.5	7.5	4.8
Vanadium	T-V	5	<2	<2	4	2
Zinc	T-Zn	303	443	403	223	503

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site E Willow Top	Site G Lichen White	Site G Grass	Site G Willow Root	Site G Willow Top
Sample Date		00 07 29	00 07 30	00 07 30	00 07 30	00 07 30
ASL ID		*16*	*17*	*18*	*19*	*20*
Total Metals						
Aluminum	T-Al	46	393	109	359	87
Antimony	T-Sb	<10	<20	<10	<10	<10
Arsenic	T-As	<10	<20	<10	<10	<10
Barium	T-Ba	27.8	87	35.6	179	32.2
Beryllium	T-Be	<0.2	<0.4	<0.2	<0.2	<0.2
Bismuth	T-Bi	<5	<10	<5	<5	<5
Cadmium	T-Cd	6.2	2	1.3	10.1	7.6
Calcium	T-Ca	5690	101000	8210	7690	6960
Chromium	T-Cr	0.8	2	0.7	2.9	<0.5
Cobalt	T-Co	<0.5	<1	<0.5	<0.5	<0.5
Copper	T-Cu	3.1	<1	4.2	5.5	3.4
Iron	T-Fe	88	395	146	274	92
Lead	T-Pb	44	157	24	<5	6
Lithium	T-Li	<0.5	1	<0.5	<0.5	<0.5
Magnesium	T-Mg	1070	382	832	825	964
Manganese	T-Mn	14.5	5.8	55.5	15.4	12.3
Molybdenum	T-Mo	<1	<2	2	1	<1
Nickel	T-Ni	4	<4	<2	5	2
Phosphorus	T-P	967	376	803	402	988
Potassium	T-K	5150	1580	5190	1950	4390
Selenium	T-Se	<10	<20	<10	<10	<10
Sodium	T-Na	<100	<200	151	123	111
Strontium	T-Sr	17.0	169	34.8	73.2	37.0
Thallium	T-Tl	<20	<20	<20	<10	<20
Tin	T-Sn	<2	<4	<2	<2	<2
Titanium	T-Ti	1.6	10	3.3	7.3	2.7
Vanadium	T-V	<2	7	<2	8	<2
Zinc	T-Zn	483	107	120	360	398

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site H Lichen	Site H Grass	Site H Willow Root	Site H Willow Top	Site I Lichen
Sample Date		00 07 28	00 07 28	00 07 28	00 07 28	00 07 28
ASL ID		*22*	*23*	*24*	*25*	*26*
Total Metals						
Aluminum	T-Al	1430	277	429	105	497
Antimony	T-Sb	<20	<10	<10	<10	<20
Arsenic	T-As	<20	<10	<10	<10	<20
Barium	T-Ba	221	59.2	100	36.3	76
Beryllium	T-Be	<0.4	<0.2	<0.2	<0.2	<0.4
Bismuth	T-Bi	<10	<5	<5	<5	<10
Cadmium	T-Cd	1	<0.5	4.4	4.5	3
Calcium	T-Ca	80900	3490	10900	9300	102000
Chromium	T-Cr	18	2.7	5.3	1.0	4
Cobalt	T-Co	<1	<0.5	<0.5	<0.5	<1
Copper	T-Cu	3	2.6	5.6	6.2	<1
Iron	T-Fe	1750	301	481	126	671
Lead	T-Pb	299	20	61	12	1590
Lithium	T-Li	2	<0.5	<0.5	<0.5	2
Magnesium	T-Mg	2300	597	1450	2240	660
Manganese	T-Mn	19.7	37.8	30.0	23.0	10.5
Molybdenum	T-Mo	<2	<1	1	<1	<2
Nickel	T-Ni	10	<2	4	<2	<4
Phosphorus	T-P	436	1160	1740	2790	318
Potassium	T-K	2130	9510	4470	12100	1690
Selenium	T-Se	<20	<10	<10	<10	<20
Sodium	T-Na	<200	110	141	<100	209
Strontium	T-Sr	107	12.6	39.5	31.2	92.7
Thallium	T-Tl	<20	<10	<10	<20	<20
Tin	T-Sn	<4	<2	<2	<2	<4
Titanium	T-Ti	28	3.5	10.2	3.3	23
Vanadium	T-V	27	<2	10	<2	4
Zinc	T-Zn	259	142	455	493	690

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site I Grass	Site I Willow Root	Site I Willow Top	Site J Lichen	Site J Grass
Sample Date		00 07 28	00 07 28	00 07 28	00 07 29	00 07 29
ASL ID		*27*	*28*	*29*	*30*	*31*
Total Metals						
Aluminum	T-Al	1950	1390	412	562	239
Antimony	T-Sb	<10	<10	<10	<20	<10
Arsenic	T-As	<10	<10	<10	<20	<10
Barium	T-Ba	502	311	126	59	62.9
Beryllium	T-Be	<0.2	<0.2	<0.2	<0.4	<0.2
Bismuth	T-Bi	<5	<5	<5	<10	<5
Cadmium	T-Cd	2.2	2.3	2.5	1	<0.5
Calcium	T-Ca	24600	14200	10400	67500	6790
Chromium	T-Cr	11.9	15.9	7.4	3	3.2
Cobalt	T-Co	0.7	1.0	0.9	<1	<0.5
Copper	T-Cu	8.2	9.4	7.4	2	4.8
Iron	T-Fe	2070	1360	503	579	317
Lead	T-Pb	363	188	117	459	19
Lithium	T-Li	1.9	1.1	<0.5	1	<0.5
Magnesium	T-Mg	4940	3210	2220	484	1580
Manganese	T-Mn	120	31.1	36.1	8.0	123
Molybdenum	T-Mo	1	2	1	<2	1
Nickel	T-Ni	8	17	8	<4	<2
Phosphorus	T-P	1750	1360	1880	456	2630
Potassium	T-K	12700	5440	8270	1880	16200
Selenium	T-Se	<10	<10	<10	<20	<10
Sodium	T-Na	1340	262	175	<200	217
Strontium	T-Sr	56.3	53.2	29.1	72.5	14.9
Thallium	T-Tl	<10	<10	<10	<20	<10
Tin	T-Sn	<2	<2	<2	<4	<2
Titanium	T-Ti	39.6	22.9	9.9	17	3.9
Vanadium	T-V	18	14	4	14	3
Zinc	T-Zn	1050	620	610	217	116

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site J Willow Root	Site J Willow Top	Site K Lichen	Site K Grass	Site K Willow Root
Sample Date		00 07 29	00 07 29	00 07 30	00 07 30	00 07 30
ASL ID		*32*	*33*	*34*	*35*	*36*
Total Metals						
Aluminum	T-Al	161	36	1190	168	82
Antimony	T-Sb	<10	<10	<20	<10	<10
Arsenic	T-As	<10	<10	<20	<10	<10
Barium	T-Ba	101	38.3	146	82.3	43.9
Beryllium	T-Be	<0.2	<0.2	<0.4	<0.2	<0.2
Bismuth	T-Bi	<5	<5	<10	<5	<5
Cadmium	T-Cd	5.2	4.1	1	2.3	12.5
Calcium	T-Ca	5960	5260	67400	9560	6350
Chromium	T-Cr	2.7	0.7	6	1.0	1.1
Cobalt	T-Co	<0.5	<0.5	<1	<0.5	<0.5
Copper	T-Cu	4.5	2.8	1	4.4	4.2
Iron	T-Fe	195	52	1100	211	104
Lead	T-Pb	20	7	117	24	6
Lithium	T-Li	<0.5	<0.5	1	<0.5	<0.5
Magnesium	T-Mg	1090	1380	1770	1330	1250
Manganese	T-Mn	11.4	12.2	14.4	30.5	20.4
Molybdenum	T-Mo	<1	<1	<2	1	<1
Nickel	T-Ni	6	2	<4	<2	2
Phosphorus	T-P	1400	2000	392	1540	2180
Potassium	T-K	4340	7980	1900	11100	9280
Selenium	T-Se	<10	<10	<20	<10	<10
Sodium	T-Na	<100	<100	<200	125	<100
Strontium	T-Sr	27.4	16.9	98.8	27.5	23.0
Thallium	T-Tl	<10	<10	<20	<10	<20
Tin	T-Sn	<2	<2	<4	<2	<2
Titanium	T-Ti	4.6	0.6	26	3.4	1.6
Vanadium	T-V	2	<2	12	4	<2
Zinc	T-Zn	429	316	95.5	239	358

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

Sample ID		Site K Willow Top	Site L Lichen	Site L Grass	Site L Willow Root	Site L Willow Top
Sample Date		00 07 30	00 07 30	00 07 30	00 07 30	00 07 30
ASL ID		*37*	*38*	*39*	*40*	*41*
Total Metals						
Aluminum	T-Al	83	1660	61	1590	229
Antimony	T-Sb	<10	<20	<10	<10	<10
Arsenic	T-As	<10	<20	<10	<10	<10
Barium	T-Ba	43.9	405	54.0	460	105
Beryllium	T-Be	<0.2	<0.4	<0.2	<0.2	<0.2
Bismuth	T-Bi	<5	<10	<5	<5	<5
Cadmium	T-Cd	12.4	<1	<0.5	6.2	7.9
Calcium	T-Ca	6280	84200	5050	12200	8690
Chromium	T-Cr	1.0	9	0.7	16.8	3.6
Cobalt	T-Co	<0.5	<1	<0.5	0.7	<0.5
Copper	T-Cu	4.5	5	3.3	6.4	4.7
Iron	T-Fe	103	5300	101	1460	224
Lead	T-Pb	6	141	<5	6	8
Lithium	T-Li	<0.5	2	<0.5	1.1	<0.5
Magnesium	T-Mg	1250	2800	1080	2240	1370
Manganese	T-Mn	20.1	19.5	32.1	28.3	20.7
Molybdenum	T-Mo	<1	<2	1	1	<1
Nickel	T-Ni	<2	6	4	12	3
Phosphorus	T-P	2120	333	3060	1480	1690
Potassium	T-K	9260	1790	17600	4450	6900
Selenium	T-Se	<10	<20	<10	<10	<10
Sodium	T-Na	<100	<200	<100	<100	<100
Strontium	T-Sr	23.0	201	21.4	67.9	44.1
Thallium	T-Tl	<20	<20	<10	<10	<10
Tin	T-Sn	<2	<4	<2	<2	<2
Titanium	T-Ti	1.9	34	1.1	30.0	4.7
Vanadium	T-V	<2	42	<2	21	2
Zinc	T-Zn	441	86.0	84.5	256	323

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site M Lichen	Site M Grass	Site M Willow Root	Site M Willow Top	Site N Lichen
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*42*	*43*	*44*	*45*	*46*
Total Metals						
Aluminum	T-Al	828	80	1360	502	995
Antimony	T-Sb	<20	<10	<10	<10	<20
Arsenic	T-As	<20	<10	<10	<10	<20
Barium	T-Ba	101	26.4	171	95.7	82
Beryllium	T-Be	<0.4	<0.2	<0.2	<0.2	<0.4
Bismuth	T-Bi	<10	<5	<5	<5	<10
Cadmium	T-Cd	<1	<0.5	0.8	0.8	<1
Calcium	T-Ca	105000	2530	13600	10500	91500
Chromium	T-Cr	3	1.0	17.7	18.7	10
Cobalt	T-Co	<1	<0.5	0.8	0.7	<1
Copper	T-Cu	<1	5.8	8.4	5.6	<1
Iron	T-Fe	702	128	1300	558	1200
Lead	T-Pb	220	5	<5	7	94
Lithium	T-Li	2	<0.5	1.1	<0.5	2
Magnesium	T-Mg	679	730	2160	1530	1050
Manganese	T-Mn	11.0	64.9	24.5	24.7	61.8
Molybdenum	T-Mo	<2	<1	4	1	<2
Nickel	T-Ni	<4	3	21	15	5
Phosphorus	T-P	336	2410	1320	1470	331
Potassium	T-K	1700	19500	4500	5920	1750
Selenium	T-Se	<20	<10	<10	<10	<20
Sodium	T-Na	<200	<100	<100	<100	<200
Strontium	T-Sr	149	8.1	68.0	50.8	148
Thallium	T-Tl	<20	<10	<10	<10	<20
Tin	T-Sn	<4	<2	<2	<2	<4
Titanium	T-Ti	36	2.4	23.2	8.8	21
Vanadium	T-V	5	<2	14	5	4
Zinc	T-Zn	114	57.0	237	254	55.5

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Sample ID		Site N Grass	Site N Willow Root	Site N Willow Top	Site O Lichen	Site O Grass
Sample Date		00 07 31	00 07 31	00 07 31	00 07 31	00 07 31
ASL ID		*47*	*48*	*49*	*50*	*51*
Total Metals						
Aluminum	T-Al	1920	1930	111	124	47
Antimony	T-Sb	<10	<10	<10	<20	<10
Arsenic	T-As	<10	<10	<10	<20	<10
Barium	T-Ba	225	110	22.6	38	25.6
Beryllium	T-Be	<0.2	<0.2	<0.2	<0.4	<0.2
Bismuth	T-Bi	<5	<5	<5	<10	<5
Cadmium	T-Cd	<0.5	0.6	<0.5	<1	<0.5
Calcium	T-Ca	16600	11000	6230	99200	2340
Chromium	T-Cr	16.2	21.8	1.9	<1	1.4
Cobalt	T-Co	0.7	0.7	<0.5	<1	<0.5
Copper	T-Cu	4.1	6.6	4.9	<1	4.2
Iron	T-Fe	1680	1620	135	119	93
Lead	T-Pb	19	<5	<5	109	<5
Lithium	T-Li	1.6	1.4	<0.5	1	<0.5
Magnesium	T-Mg	3230	2710	1400	354	794
Manganese	T-Mn	55.7	27.3	18.9	4.8	74.7
Molybdenum	T-Mo	1	2	<1	<2	<1
Nickel	T-Ni	10	19	3	<4	<2
Phosphorus	T-P	2030	2700	2190	241	2160
Potassium	T-K	13600	6920	8950	1280	16800
Selenium	T-Se	<10	<10	<10	<20	<10
Sodium	T-Na	191	211	113	<200	<100
Strontium	T-Sr	51.5	57.0	27.5	111	7.3
Thallium	T-Tl	<10	<10	<20	<20	<10
Tin	T-Sn	<2	<2	<2	<4	<2
Titanium	T-Ti	34.3	32.5	2.9	4	1.5
Vanadium	T-V	7	8	<2	<4	<2
Zinc	T-Zn	88.0	307	283	57.5	37.0

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. M1257r

Sample ID		Site O Willow Root	Site O Willow Top
Sample Date		00 07 31	00 07 31
ASL ID		*52*	*53*
Total Metals			
Aluminum	T-Al	76	240
Antimony	T-Sb	<10	<10
Arsenic	T-As	<10	<10
Barium	T-Ba	79.7	57.0
Beryllium	T-Be	<0.2	<0.2
Bismuth	T-Bi	<5	<5
Cadmium	T-Cd	1.8	1.9
Calcium	T-Ca	5170	6420
Chromium	T-Cr	0.8	2.4
Cobalt	T-Co	<0.5	<0.5
Copper	T-Cu	4.4	4.9
Iron	T-Fe	76	208
Lead	T-Pb	<5	<5
Lithium	T-Li	<0.5	<0.5
Magnesium	T-Mg	688	1140
Manganese	T-Mn	16.3	22.8
Molybdenum	T-Mo	<1	<1
Nickel	T-Ni	3	3
Phosphorus	T-P	756	1500
Potassium	T-K	2980	8100
Selenium	T-Se	<10	<10
Sodium	T-Na	<100	<100
Strontium	T-Sr	23.9	22.3
Thallium	T-Tl	<10	<10
Tin	T-Sn	<2	<2
Titanium	T-Ti	2.0	5.2
Vanadium	T-V	<2	<2
Zinc	T-Zn	331	483

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Quality Control[1]

File No. M1257r

Sample ID Sample Date *ASL ID*		Method Blank *MBlk*	RM Found Value *RMF*	RM Target Value *RMT*
Total Metals				
Aluminum	T-Al	<10	254	286
Antimony	T-Sb	<10	<10	<10
Arsenic	T-As	<10	<10	<10
Barium	T-Ba	<0.5	46.7	49.0
Beryllium	T-Be	<0.2	<0.2	-
Bismuth	T-Bi	<5	<5	-
Cadmium	T-Cd	<0.5	<0.5	<0.5
Calcium	T-Ca	<10	15600	15300
Chromium	T-Cr	<0.5	<0.5	<0.5
Cobalt	T-Co	<0.5	<0.5	<0.5
Copper	T-Cu	<0.5	5.1	5.6
Iron	T-Fe	<1	72	83
Lead	T-Pb	<5	<5	<5
Lithium	T-Li	<0.5	<0.5	-
Magnesium	T-Mg	<5	2450	2710
Manganese	T-Mn	<0.2	51.3	54.0
Molybdenum	T-Mo	<1	<1	<1
Nickel	T-Ni	<2	<2	<2
Phosphorus	T-P	<20	1510	1590
Potassium	T-K	<100	15900	16100
Selenium	T-Se	<10	<10	<10
Sodium	T-Na	<100	<100	<100
Strontium	T-Sr	<0.3	25.7	25.0
Thallium	T-Tl	<10	<10	-
Tin	T-Sn	<2	<2	-
Titanium	T-Ti	<0.5	5.1	-
Vanadium	T-V	<2	<2	<2
Zinc	T-Zn	<0.5	18.0	17.9

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.
[1] RM = Reference Material.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M1257r

Tissue		Site D Grass	Site D Grass
		00 07 29	QC # 212563
Total Metals			
Aluminum	T-Al	283	249
Antimony	T-Sb	<10	<10
Arsenic	T-As	<10	<10
Barium	T-Ba	200	180
Beryllium	T-Be	<0.2	<0.2
Bismuth	T-Bi	<5	<5
Cadmium	T-Cd	0.9	0.9
Calcium	T-Ca	13600	13400
Chromium	T-Cr	2.2	1.9
Cobalt	T-Co	<0.5	<0.5
Copper	T-Cu	5.6	3.5
Iron	T-Fe	399	368
Lead	T-Pb	84	82
Lithium	T-Li	<0.5	<0.5
Magnesium	T-Mg	1800	1770
Manganese	T-Mn	41.7	41.7
Molybdenum	T-Mo	2	1
Nickel	T-Ni	2	2
Phosphorus	T-P	1380	1390
Potassium	T-K	9200	9210
Selenium	T-Se	<10	<10
Sodium	T-Na	750	740
Strontium	T-Sr	48.5	46.7
Thallium	T-Tl	<10	12
Tin	T-Sn	<2	<2
Titanium	T-Ti	9.1	7.1
Vanadium	T-V	3	3
Zinc	T-Zn	249	253

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Tissue		Site G Willow Top 00 07 30	Site G Willow Top QC # 212564
Total Metals			
Aluminum	T-Al	87	77
Antimony	T-Sb	<10	<10
Arsenic	T-As	<10	<10
Barium	T-Ba	32.2	29.8
Beryllium	T-Be	<0.2	<0.2
Bismuth	T-Bi	<5	<5
Cadmium	T-Cd	7.6	7.2
Calcium	T-Ca	6960	6530
Chromium	T-Cr	<0.5	<0.5
Cobalt	T-Co	<0.5	<0.5
Copper	T-Cu	3.4	3.0
Iron	T-Fe	92	82
Lead	T-Pb	6	6
Lithium	T-Li	<0.5	<0.5
Magnesium	T-Mg	964	905
Manganese	T-Mn	12.3	11.4
Molybdenum	T-Mo	<1	<1
Nickel	T-Ni	2	<2
Phosphorus	T-P	988	932
Potassium	T-K	4390	4160
Selenium	T-Se	<10	<10
Sodium	T-Na	111	101
Strontium	T-Sr	37.0	35.4
Thallium	T-Tl	<20	<20
Tin	T-Sn	<2	<2
Titanium	T-Ti	2.7	2.1
Vanadium	T-V	<2	<2
Zinc	T-Zn	398	385

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

Tissue		Site J Lichen 00 07 29	Site J Lichen QC # 212565
Total Metals			
Aluminum	T-Al	562	613
Antimony	T-Sb	<20	<20
Arsenic	T-As	<20	<20
Barium	T-Ba	59	60
Beryllium	T-Be	<0.4	<0.4
Bismuth	T-Bi	<10	<10
Cadmium	T-Cd	1	1
Calcium	T-Ca	67500	68200
Chromium	T-Cr	3	3
Cobalt	T-Co	<1	<1
Copper	T-Cu	2	2
Iron	T-Fe	579	609
Lead	T-Pb	459	459
Lithium	T-Li	1	1
Magnesium	T-Mg	484	496
Manganese	T-Mn	8.0	8.2
Molybdenum	T-Mo	<2	<2
Nickel	T-Ni	<4	<4
Phosphorus	T-P	456	456
Potassium	T-K	1880	1850
Selenium	T-Se	<20	<20
Sodium	T-Na	<200	<200
Strontium	T-Sr	72.5	71.4
Thallium	T-Tl	<20	<20
Tin	T-Sn	<4	<4
Titanium	T-Ti	17	18
Vanadium	T-V	14	15
Zinc	T-Zn	217	224

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

Tissue		Site L Willow Top 00 07 30	Site L Willow Top QC # 209242
Total Metals			
Aluminum	T-Al	229	231
Antimony	T-Sb	<10	<10
Arsenic	T-As	<10	<10
Barium	T-Ba	105	99.4
Beryllium	T-Be	<0.2	<0.2
Bismuth	T-Bi	<5	<5
Cadmium	T-Cd	7.9	7.5
Calcium	T-Ca	8690	8230
Chromium	T-Cr	3.6	3.2
Cobalt	T-Co	<0.5	<0.5
Copper	T-Cu	4.7	4.2
Iron	T-Fe	224	217
Lead	T-Pb	8	7
Lithium	T-Li	<0.5	<0.5
Magnesium	T-Mg	1370	1290
Manganese	T-Mn	20.7	19.9
Molybdenum	T-Mo	<1	<1
Nickel	T-Ni	3	3
Phosphorus	T-P	1690	1630
Potassium	T-K	6900	6550
Selenium	T-Se	<10	<10
Sodium	T-Na	<100	<100
Strontium	T-Sr	44.1	41.7
Thallium	T-Tl	<10	<10
Tin	T-Sn	<2	<2
Titanium	T-Ti	4.7	4.5
Vanadium	T-V	2	3
Zinc	T-Zn	323	308

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M1257r

Tissue		Site O Lichen 00 07 31	Site O Lichen QC # 212566
Total Metals			
Aluminum	T-Al	124	112
Antimony	T-Sb	<20	<20
Arsenic	T-As	<20	<20
Barium	T-Ba	38	38
Beryllium	T-Be	<0.4	<0.4
Bismuth	T-Bi	<10	<10
Cadmium	T-Cd	<1	<1
Calcium	T-Ca	99200	99100
Chromium	T-Cr	<1	<1
Cobalt	T-Co	<1	<1
Copper	T-Cu	<1	<1
Iron	T-Fe	119	117
Lead	T-Pb	109	109
Lithium	T-Li	1	1
Magnesium	T-Mg	354	354
Manganese	T-Mn	4.8	4.5
Molybdenum	T-Mo	<2	<2
Nickel	T-Ni	<4	<4
Phosphorus	T-P	241	241
Potassium	T-K	1280	1290
Selenium	T-Se	<20	<20
Sodium	T-Na	<200	<200
Strontium	T-Sr	111	110
Thallium	T-Tl	<20	<20
Tin	T-Sn	<4	<4
Titanium	T-Ti	4	5
Vanadium	T-V	<4	<4
Zinc	T-Zn	57.5	54.5

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Metals in Vegetation and Animal Tissue

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. Tissue samples are homogenized either mechanically or manually prior to digestion. The hotplate digestion involves the use of nitric acid followed by repeated additions of hydrogen peroxide. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series), inductively coupled plasma - mass spectrometry (EPA Method 6020), and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Recommended Holding Time:

Sample/Extract:	2 years (Mercury = 28 days)
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

End of Report

1988 Triumph Street, Vancouver, BC Canada V5L 1K5
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CHEMICAL ANALYSIS REPORT

Date: November 14, 2000

ASL File No. L9694r

Report On: 20-930 Soil Analysis

Report To:
Gartner Lee Ltd.
Sperling Plaza
Suite 490, 6400 Roberts Street
Burnaby, BC
V5G 4C9

Attention: **Ms. Eva Gerencher**

Received: August 4, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

REMARKS File No. L9694r

The detection limits for some of the metals have been increased for the samples reported in the following data tables due to the high concentration of certain metals in the samples.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694r

Sample ID			Site B 0-0.01m	Site B 0.01- 0.05m	Site B 0.05- 0.1m	Site I 0-0.01m	Site I 0.01- 0.05m
Sample Date			00 07 28	00 07 28	00 07 28	00 07 29	00 07 29
ASL ID			*1*	*2*	*3*	*4*	*5*
Physical Tests							
Moisture	%	soil std.	14.2	22.3	14.7	16.3	13.7
Total Metals							
Aluminum	T-Al		11600	-	-	9760	9370
Antimony	T-Sb		<20	-	-	<40	<40
Arsenic	T-As	(12)	<100	-	-	<200	<200
Barium	T-Ba		19	-	-	33	101
Beryllium	T-Be		0.7	-	-	<1	<1
Bismuth	T-Bi		<10	-	-	<20	<20
Cadmium	T-Cd	(1.4)	<2	-	-	<4	<4
Calcium	T-Ca		144000	-	-	165000	152000
Chromium	T-Cr		22	-	-	20	20
Cobalt	T-Co		6	-	-	4	5
Copper	T-Cu	(63)	19	-	-	17	18
Iron	T-Fe		17800	-	-	14000	15600
Lead	T-Pb	(70)	9	11	10	404	32
Lithium	T-Li		15	-	-	11	11
Magnesium	T-Mg		38800	-	-	52500	48300
Manganese	T-Mn		214	-	-	160	176
Molybdenum	T-Mo		<4	-	-	<8	<8
Nickel	T-Ni		30	-	-	22	24
Phosphorus	T-P		555	-	-	525	619
Potassium	T-K		4360	-	-	3850	3510
Selenium	T-Se		<50	-	-	<100	<100
Silver	T-Ag		<2	-	-	<4	<4
Strontium	T-Sr		370	-	-	274	293
Thallium	T-Tl		<50	-	-	<100	<100
Tin	T-Sn		<10	-	-	<20	<20
Titanium	T-Ti		74	-	-	109	77
Vanadium	T-V		61	-	-	124	118
Zinc	T-Zn	(200)	66.0	75.2	74.3	1350	162

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694r

Sample ID		Site I 0.05-0.1m	Site H 0-0.01m	Site H 0.01-0.05m	Site E 0-0.01m	Site E 0.01-0.05m
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	12.3	14.5	59.2	59.0	15.2
Total Metals						
Aluminum	T-Al	-	-	-	4870	-
Antimony	T-Sb	-	-	-	<20	-
Arsenic	T-As	-	-	-	<100	-
Barium	T-Ba	-	-	-	27	-
Beryllium	T-Be	-	-	-	<0.5	-
Bismuth	T-Bi	-	-	-	<10	-
Cadmium	T-Cd	-	-	-	<2	-
Calcium	T-Ca	-	-	-	8870	-
Chromium	T-Cr	-	-	-	9	-
Cobalt	T-Co	-	-	-	<2	-
Copper	T-Cu	-	-	-	13	-
Iron	T-Fe	-	-	-	4590	-
Lead	T-Pb (70)	16	15	11	259	12
Lithium	T-Li	-	-	-	3	-
Magnesium	T-Mg	-	-	-	1750	-
Manganese	T-Mn	-	-	-	71	-
Molybdenum	T-Mo	-	-	-	<4	-
Nickel	T-Ni	-	-	-	11	-
Phosphorus	T-P	-	-	-	346	-
Potassium	T-K	-	-	-	1660	-
Selenium	T-Se	-	-	-	<50	-
Silver	T-Ag	-	-	-	<2	-
Strontium	T-Sr	-	-	-	32.3	-
Thallium	T-Tl	-	-	-	<50	-
Tin	T-Sn	-	-	-	<10	-
Titanium	T-Ti	-	-	-	63	-
Vanadium	T-V	-	-	-	50	-
Zinc	T-Zn 200	106	154	86.1	794	111

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694r

Sample ID		Site C 0-0.01m	Site C 0.01-0.05m	Site J 0-0.01m	Site J 0.01-0.05m	Site J 0.05-0.10m
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	62.9	33.8	38.2	40.6	47.0
Total Metals						
Aluminum	T-Al	-	-	12100	-	-
Antimony	T-Sb	-	-	<20	-	-
Arsenic	T-As (17)	-	-	<100	-	-
Barium	T-Ba	-	-	388	-	-
Beryllium	T-Be	-	-	0.8	-	-
Bismuth	T-Bi	-	-	<10	-	-
Cadmium	T-Cd	-	-	<2	-	-
Calcium	T-Ca	-	-	10700	-	-
Chromium	T-Cr	-	-	35	-	-
Cobalt	T-Co	-	-	5	-	-
Copper	T-Cu	-	-	36	-	-
Iron	T-Fe	-	-	17000	-	-
Lead ✓	T-Pb (70)	60	12	16	16	8
Lithium	T-Li	-	-	6	-	-
Magnesium	T-Mg	-	-	3130	-	-
Manganese	T-Mn	-	-	166	-	-
Molybdenum	T-Mo	-	-	<4	-	-
Nickel	T-Ni	-	-	30	-	-
Phosphorus	T-P	-	-	2100	-	-
Potassium	T-K	-	-	4060	-	-
Selenium	T-Se	-	-	<50	-	-
Silver	T-Ag	-	-	<2	-	-
Strontium	T-Sr	-	-	52.2	-	-
Thallium	T-Tl	-	-	<50	-	-
Tin	T-Sn	-	-	<10	-	-
Titanium	T-Ti	-	-	101	-	-
Vanadium	T-V	-	-	104	-	-
Zinc	T-Zn (200)	445	236	161	173	164

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Sample ID			TP10	Bent Horn 0.5-1
Sample Date			00 08 01	00 08 01
ASL ID			*16*	*17*
Particle Size				
Gravel	(>2.00mm)	(%)	78.1	81.6
Sand	(2.00mm - 0.063mm)	(%)	16.0	13.4
Silt	(0.063mm - 4um)	(%)	3.6	3.8
Clay	(<4um)	(%)	2.3	1.2

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L9694r

Sediment/Soil		**Site E 0.01-0.05m** 00 07 29	**Site E 0.01-0.05m** QC # 207226
Physical Tests			
Moisture	%	15.2	14.7
Total Metals			
Lead	T-Pb	12	14
Zinc	T-Zn	111	113

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Particle Size Distribution in Sediment/Soil

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton, 1978. The procedure involves oven-drying and sample pre-treatment to remove organics, prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

Note: Particle Size analysis is subcontracted.

End of Report

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CHEMICAL ANALYSIS REPORT

Date:	August 28, 2000
ASL File No.	L9694
Report On:	20-930 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	August 4, 2000

AUG 31 2000
GARTNER LEE

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Brent C. Mack, B.Sc. - Project Chemist
Heather A. Ross, B.Sc. - Project Chemist

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694

Sample ID		Site B 0-0.01m	Site B 0.01-0.05m	Site B 0.05-0.1m	Site I 0-0.01m	Site I 0.01-0.05m
Sample Date		00 07 28	00 07 28	00 07 28	00 07 29	00 07 29
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	14.2	22.3	14.7	16.3	13.7
Total Metals						
Lead	T-Pb	9	11	10	404	32
Zinc	T-Zn	66.0	75.2	74.3	1350	162

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694

Sample ID		Site I 0.05-0.1m	Site H 0-0.01m	Site H 0.01-0.05m	Site E 0-0.01m	Site E 0.01-0.05m
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	12.3	14.5	59.2	59.0	15.2
Total Metals						
Lead	T-Pb	16	15	11	259	12
Zinc	T-Zn	106	154	86.1	794	111

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil File No. L9694

Sample ID		Site C 0-0.01m	Site C 0.01-0.05m	Site J 0-0.01m	Site J 0.01-0.05m	Site J 0.05-0.10m
Sample Date		00 07 29	00 07 29	00 07 29	00 07 29	00 07 29
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	62.9	33.8	38.2	40.6	47.0
Total Metals						
Lead	T-Pb	60	12	16	16	8
Zinc	T-Zn	445	236	161	173	164

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L9694

		TP10	Bent Horn 0.5-1
Sample Date		00 08 01	00 08 01
ASL ID		*16*	*17*
Particle Size			
Gravel (>2.00mm)	(%)	78.1	81.6
Sand (2.00mm - 0.063mm)	(%)	16.0	13.4
Silt (0.063mm - 4um)	(%)	3.6	3.8
Clay (<4um)	(%)	2.3	1.2

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L9694

Sediment/Soil		**Site E 0.01-0.05m** 00 07 29	**Site E 0.01-0.05m** QC # 207226
Physical Tests			
Moisture	%	15.2	14.7
Total Metals			
Lead	T-Pb	12	14
Zinc	T-Zn	111	113

Results are expressed as milligrams per dry kilogram except where noted.
< = Less than the detection limit indicated.

Appendix 2 - METHODOLOGY File No. L9694

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Moisture in Sediment/Soil

This analysis is carried out gravimetrically by drying the sample at 103 C for a minimum of six hours.

Recommended Holding Time:

Sample:	14 days
Reference:	Puget
For more detail see:	ASL "Collection & Sampling Guide"

Metals in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 Method 3050B or Method 3051, published by the United States Environmental Protection Agency (EPA). The sample is manually homogenized and a representative subsample of the wet material is weighed. The sample is then digested by either hotplate or microwave oven using a 1:1 ratio of nitric acid and hydrochloric acid. Instrumental analysis is by atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

Recommended Holding Time:

Sample/Extract:	6 months (Mercury = 28 days)
Reference:	EPA
For more detail see:	ASL "Collection & Sampling Guide"

Particle Size Distribution in Sediment/Soil

This analysis is carried out using a method adapted for Fisheries and Environment Canada, Ottawa, described in Walton, 1978. The procedure involves oven-drying and sample pre-treatment to remove organics, prior to using standard sieves for the sand and silt fractions and the pipette method for the clay fraction.

Note: Particle Size analysis is subcontracted.

End of Report

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CHEMICAL ANALYSIS REPORT

OCT 27 2000
GARTNER LEE

Date: October 18, 2000

ASL File No. M2473

Report On: 20-935 Oil Analysis

Report To: **Gartner Lee Ltd.**
Sperling Plaza
Suite 490, 6400 Roberts Street
Burnaby, BC
V5G 4C9

Attention: **Ms. Eva Gerencher**

Received: September 22, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc. - Project Chemist
Brent C. Mack, B.Sc. - Project Chemist

RESULTS OF ANALYSIS - Oil

File No. M2473

Sample ID	112-LC-02	112-LC-05	112-LC-09	112-LC-13	118-LC-01
Sample Date	00 08 14	00 08 14	00 08 14	00 08 14	00 08 14
ASL ID	*1*	*2*	*3*	*4*	*5*
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<10	<10	<10	<10	<10

Results are expressed as milligrams per kilogram oil.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Oil

File No. M2473

Sample ID	118-LC- 08	118-LC- 10
Sample Date *ASL ID*	00 08 14 *6*	00 08 14 7
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	<10	<10

Results are expressed as milligrams per kilogram oil.
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

File No. M2473

Oil	**118-LC-08** 00 08 14	**118-LC-08** QC # 213465
Polychlorinated Biphenyls		
Total Polychlorinated Biphenyls	<10	<10

Results are expressed as milligrams per kilogram oil.
< = Less than the detection limit indicated.

Appendix 2 - METHODOLOGY File No. M2473

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Polychlorinated Biphenyls in Oil

This analysis is carried out using procedures adapted from the American Society for Testing Materials (ASTM), Method D4059-86, and from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves extraction of a subsample of the oil with hexane followed by a florisil clean-up of the extract. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

Recommended Holding Time:
Sample: 14 days Extract: 40 days
Reference: EPA
For more detail see ASL "Collection & Sampling Guide"

End of Report

Appendix B

Derivation of Site Specific Soil Quality Remedial Objectives for Lead and Zinc, Cominco Ltd.-Polaris Operations, Nunavut, Cantox Environmental Inc.

CANTOX ENVIRONMENTAL INC.

DERIVATION OF SITE SPECIFIC SOIL QUALITY REMEDIAL OBJECTIVES FOR LEAD AND ZINC
COMINCO LTD. – POLARIS OPERATIONS, NUNAVUT

As Cominco prepares for the future decommissioning of its Polaris Mine, careful consideration was given to the remediation of all areas of potential environmental concern. Evaluation of remediation strategies resulted in the derivation of site-specific soil quality remediation objectives (SQRO's) for lead and zinc that adequately protect the area's environmental health. SQRO's for lead and zinc were determined within the permitted framework as governed by the Canadian Environmental Quality Guidelines (CCME, 1999).

This, framework outlined in the National Contaminated Sites soil protocol, provides the opportunity to move from generic soil guidelines to site-specific remediation objectives, which in turn "allows the proponent to ensure that the assumptions used in the soil protocol apply to the site-specific conditions" (CCME, 1999).

The unique nature of the Polaris Mine site suggests that the application of generic soil quality guidelines is not appropriate for remediative purposes. The scarcity of vegetation in the area results in a limited number of wildlife. The "barren and rugged" terrain of Little Cornwallis Island (Graham, 1982) precludes the regular use of the area by both wildlife and human receptors. Further, the atypical characteristics and unusual exposure scenarios indicative of the high Arctic location of the Mine site necessitated the development of site-specific SQRO's.

SQRO's are based on the most sensitive receptor (ecological or human) to a chemical of potential concern. For example, a SQRO for chemical "X" of 100 mg/kg may be considered a safe soil concentration for herbivores, but may not be stringent enough for predatory mammals or the most sensitive human sub-groups. For this reason, the lowest SQRO's for either ecological or human receptors were chosen for the metals of concern.

Site characteristics relevant to the derivation of soil quality remediation objectives

Cominco's mining activities have largely remained isolated to the bare, coarse-textured areas of the southwest corner of Little Cornwallis Island. B.C. Research's (1975) evaluation of the mine's potential environmental impact identified the proposed active mining areas to be of moderate to low environmental sensitivity. The majority of the mine facilities are located within the barren, southwest land area, as shown in Figure 2. The exposure assumptions employed in the derivation of the soil quality remediation objectives for lead and zinc represent the active surface use areas only. This includes the barge (mill and concentrator), concentrate storage building, landfill site, backfill quarries, mine openings, road ways and airstrip. The soil quality remediation objectives have therefore been derived for the area identified as the active mine site and do not apply to the surrounding lands.

For the purposes of the risk assessment, two key features of the active mine area are:

- The soil is characterized as being well-drained coarse gravel with little organic matter (B.C. Research, 1975), and;

- That prior to the start of Cominco's mining efforts, the region now identified as the "actively mined area" exhibited "insignificant" proportions of vegetation typical of local herbivorous diets (B.C. Research, 1975). Figure 3 illustrates the vegetation units described by BC Research and outlines the area of the active mine site where vegetation loss has occurred due to mine activities.

This suggests that direct exposure to soils would likely be limited due to reduced chemical bioavailability and limited habitat suitability for wildlife. The actively mined area has historically (i.e., prior to mine start-up) supported little to no vegetation, and for this reason the soil quality remediation objectives excluded arctic plants as possible ecological receptors.

Methodology of the risk assessment

Human health risk assessment

To the extent applicable, the human health risk assessment was completed in accordance with the methods consistent with those recommended by the Canadian Council of Ministers of the Environment (CCME), Environment Canada, Health Canada and the US EPA. It is noted, however, that wherever possible, special consideration was given to the uniqueness of the High Arctic conditions.

The four basic steps of the risk assessment procedure were:

- Problem formulation: identification of the land use scenario, human receptors, exposure pathways and chemicals of concern;
- Exposure assessment: quantification of the estimated rate of exposure to chemicals, exposure pathways, and human receptors of concern;
- Toxicity assessment: the identification and potential hazards and recommendation of upper limits of exposure (i.e., maximum exposure without measurable risks to health) for lead and zinc; and,
- Risk characterization: assessment of potential human health risks based on the comparison between the estimated exposures through lifestyle characteristics and recommended toxicity endpoints for both lead and zinc.

The historical and anticipated land use of Little Cornwallis Island was determined through a series of discussions with residents both Resolute Bay and Grise Fiord. Some of the details vital to the risk assessment are outlined below:

- People visiting the site do so irregularly and typically stay for no longer than 3 days;
- Residents of Resolute Bay and Grise Fiord rarely eat wild game or fish harvested on Little Cornwallis Island;
- Little Cornwallis Island is considered to be a transition camp for other areas where the hunting is considered better;
- Children accompany adults on visits to the Island;
- Following closure of the mine, respondents expected to camp away from the mining area (i.e., further north).

The historical and anticipated land use represent acute or short-term exposure scenarios. Estimated short-term exposures were therefore compared to short-term exposure limits.

A complete description of the human health risk assessment methodology, results and conclusions will be presented separately in a CANTOX ENVIRONMENTAL INC. report entitled, "*Human health and ecological risk assessment of Cominco's mined area on Little Cornwallis Island: Derivation of soil quality remediation objectives*".

Ecological risk assessment

The ecological risk assessment was based on frameworks described by the CCME. The assessment served to determine soil concentrations of lead and zinc on the actively mined area that would pose negligible risks to the Valued Ecosystem Components (i.e., ecological receptors) identified in the immediate area.

Due to the nature of the site ("insignificant" plant coverage, extreme latititude etc.), toxicity to terrestrial plants and invertebrates were not incorporated into the calculation of the soil quality remediation objectives. However, the soil quality remediation objective for zinc incorporated arctic plants as a sensitive ecological receptor for those areas that had suffered vegetation loss as a direct result of mining activity. In an attempt to recover these vegetative areas, soils are to be cleaned up to levels at which local plants are known to survive. A study by CE Jones (2000) on the study area's vegetation identified root uptake as the principle route of exposure to zinc. Therefore, in order to eliminate the source of exposure to zinc, soils in areas that had experienced plant loss need to be remediated. When considering lead contamination, CE Jones (2000) concluded that plant tissue concentrations resulted from airborne dust deposition. The cessation of Cominco's operation of its concentrate dryer and ventilation underground mine stacks will effectively remove the source of lead contamination and should thereby reduce lead concentrations in plants over time.

Potential impact on microbial processes was eliminated from the risk assessment due to its uncertain ecological relevance.

It is difficult to identify endpoints in microbial toxicity tests which are environmentally meaningful (Efroymson and Suter, 1999; Kapustka, 1999). Chemicals may change the microbial community structure without changing the functional ability of the community (Efroymson et al., 1997).

As outlined in the CCME protocol (1996):

> *Ideally, the selection of receptors should be compatible with, and reflect important characteristics of the ecosystem (i.e., ecologically relevant) ... however, the selection of ecological receptors ... must focus on key receptors that maintain land use activities.*

The four representative wildlife species selected as Valued Ecosystem Components included: collared lemmings (*D. lentus*); arctic hare (*L. arcticus*); Peary caribou (*R. tarandus*), and; arctic fox (*A. lagopus*).

The lemming was selected because these small mammals are relatively abundant in Canada's Arctic, replacing field mice and meadow voles as the dominant rodent. Several behavioural factors influence the extent of chemical exposure of the lemming which makes it a relatively sensitive receptor. This species has a high potential for exposure to chemicals within surface soils, due to its burrowing and preening behaviour patterns. Lemmings are also quite territorial and migrate only out of necessity (e.g., overcrowding). They are therefore quite sedentary with a limited home range, and as such, lemmings residing “on-site” would likely experience continual metal exposure throughout their lives. Lemmings form the base of the terrestrial arctic food chain, being prey for higher terrestrial wildlife species, and are therefore important for the assessment of the effects of metal exposures on higher trophic level organisms (i.e., arctic fox).

The arctic hare was selected for assessment for several reasons. Arctic hare, like the collared lemming, does not migrate, has a relatively small home range and has a high potential for expsoure via direct contact with soil.

Unlike the lemming and hare, caribou are migratory in nature. Migratory patterns of movement significantly decrease the exposure of caribou to any on-site contamination. However, during calving, the herd may remain at a specific location for an extended period of time. Although the area surrounding the Mine site is not expected to be a suitable location for this type of activity, caribou were included in the assessment due to their inherent value to the surrounding Arctic communities.

The arctic fox is one of the smaller predatory animals found in Canada’s arctic. Arctic foxes are considered to be top predators, feeding on regionally-important species of small mammals such as lemmings. By virtue of its position in the food chain, the fox is susceptible to contaminants which my accumulate in the tissue of its prey. Despite significant food shortages during the harsh winter months, the arctic fox does not migrate. Food caught during the summer is preserved in the permafrost and retrieved later. As a result, exposure to on-site contamination will occur on a continuous basis. Although the home range of the arctic fox likely exceeds the Mine site’s area, foxes may spend a substantial amount of time at the site.

Terrestrial wildlife exposure pathways:

Exposure pathways were selected based on the behavioural characteristics of the terrestrial receptors, site characteristics, the source of contamination, the types of receptors present, and chemical fate.

The possible soil (direct and indirect) pathways which lemmings and hare could be exposed to include:

- Ingestion of soils or dusts;
- Ingestion of vegetation; and,
- Dermal contact with soils or dusts;
- Inhalation of dusts or soils.

Caribou exposure could come from the three of the above pathways. Caribou were not expected to be exposed to on-site metals through dermal contact.

Due to the nature of the actively mined area (see site characteristics relevant to the risk assessment) and the historic and present lack of vegetation cover, the plant consumption pathway was removed from the analysis. Further, the apparent absence of suitable drinking water areas on the Mine site precluded the evaluation of the drinking water pathway.

To ensure that risks were not underestimated for the herbivores, an acceptable hazard quotient of 0.2 was used. This implies that the receptors are receiving up to 80% of their total exposure from other sources (e.g., drinking water, food consumption). Exposure from the Mine site would be responsible for 20% of the total metal exposure. Therefore, chemical risks to herbivorous wildlife exposed to Mine-contaminated soils are overestimated when compared to CCME's apportionment of the total exposure contributed by various media (CCME, 1996).

The exposure pathways used in the assessment of the arctic fox included:

- Ingestion of soils or dusts;
- Ingestion of prey (e.g., lemming);
- Dermal contact with soil or dusts;
- Inhalation of dusts.

Since the derivation of soil quality remediation objectives excluded the drinking water pathway, the acceptable level of exposure was assumed to be 80% of the lowest-observable-adverse-effect level for the arctic fox. CCME (1996) protocol suggests that up to 20% of total exposure may come from drinking contaminated water.

Selection of assessment and measurement endpoints:

In order to narrow the focus of the risk assessment, it was necessary to select assessment endpoints, which may include estimating risks at the individual, population, community or ecosystem level. The assessment endpoints for the ERA should be relevant to the site-specific contamination and should be capable of being assessed based on the available data (CCME, 1996). For the purposes of the proposed ERA, assessment endpoints were selected to evaluate the potential for site-specific toxic effects that could result in reduction of populations of valued ecological receptors, relative to comparable non-contaminated sites or background areas.

Assessment endpoints must be translated into measurement endpoints in order to practically conduct an ERA. Measurement endpoints are measurable environmental endpoint characteristics that are related to the assessment endpoint (CCME, 1996). For the Cominco ERA, population level measurement endpoints (i.e., effects on survival, reproduction, growth etc.) were selected for the chemicals whenever possible.

A complete description of the ecological risk assessment methodology, results and conclusions will be presented separately in a CANTOX ENVIRONMENTAL INC. report entitled, "Human health and ecological risk assessment of Cominco's mined area on Little Cornwallis Island: Derivation of soil quality remediation objectives".

The determination of the SQRO's for both lead and zinc are described below.

Soil quality remediation objectives

Lead:

As outlined in the Table 1.1 below, the CCME soil quality guideline of 140 ppm for lead (residential land use) is based on long-term soil ingestion for a child receptor. Although the agricultural environmental soil quality guideline (70 ppm) is lower than the residential human soil quality guideline (140 ppm), it is generally recognized that human children are the primary receptor of concern when characterizing risk associated with lead exposure.

Table 1.1 Relevant soil quality guidelines (ppm) for lead

	Residential/Parkland Land Use
Guideline	**140**
SQG_{HH}	140
Limiting pathway for SQG_{HH}	Soil ingestion
SQG_{E}	300
Limiting pathway for SQG_{E}	Soil contact

Notes: SQG_{HH} = soil quality guideline for human health; SQG_{E} = soil quality guideline for environmental health; NC = not calculated (CCME, 1999b)

Results from the risk assessment identified human children acutely exposed to lead-contaminated soils as being slightly more sensitive than chronically exposed arctic fox. Considering that the most sensitive receptors of exposure to lead are human fetuses, infants, and children up to six years of age (ATSDR, 1988), the site-specific SQRO for lead is intended to protect Inuit from measurable health effects associated with the future use of the site.

The "benchmark" probability that U.S. EPA uses to guide remediation decisions is a less than 5% probability that an individual's blood lead level will exceed 10 µg/dL for long-term, chronic exposure periods (White et al., 1998). This target blood lead level is appropriate for long-term, chronic exposures and effects (e.g., effects on cognitive abilities). However, sensitive receptors such as Inuit children are only expected to visit the Mine site for perhaps one to three days per year (B.C. Research, 1975; LaVigne, 1980; results from community consultation, 2000). This type of short-term or acute exposure period suggests a different toxicological impact. Ingestion of soil while visiting the Mine site could result in larger, temporary increases in blood lead levels, possibly giving rise to such clinical effects as gastrointestinal distress, weight loss, tremors, irritability, and lethargy. For the purposes of this risk assessment, a more relevant short-term "benchmark" of 20 µg/dL was used as a target blood lead level (CDC, 1991; Health Canada, 1994).

The following relationship describes the uptake of lead into blood:

$$[Pb]_{blood} = \alpha + \beta\,(\text{uptake})$$

where Pb = concentration of Pb in blood (µg/dL)

α = y intercept (baseline blood-Pb level = 4 µg/dL)

β = slope of the regression line (statistical regression technique was used to fit a curve to absorbed lead versus blood-Pb levels assume 0.04, US EPA 1989)

Assuming that a "safe" level or target level is 20 µg/dL …

$$20\ \mu g/dL = 4 + 0.04\,(\text{uptake}_{Pb}),$$

$$\text{uptake}_{Pb} = 400\ \mu g/day$$

So total exposure during an exposure episode should not exceed 400 µg or 0.4 mg. An Inuit child visiting the site can be exposed to lead through a number of pathways which include:

- Incidental ingestion of soil;

- Inhalation of soil and dusts;
- Dermal contact with soil.

The SQRO was estimated by back-calculating for soil concentrations that would result in an uptake of 400 µg/day.

The assessment incorporated the upper percentile of U.S. EPA recommended soil ingestion rates (400 mg/day; U.S. EPA, 1996), as well as a base-line blood lead level of 4 µg/dL (Wood, 2000) to calculate a site-specific SQRO for lead concentrations in soil of 2,000 ppm. Lead concentrations in surficial soil that are equal to or below this recommended objective are not expected to cause adverse health effects to children visiting the Mine site for brief, infrequent periods of time.

It should be noted that this SQRO is not protective of children exhibiting very high soil ingestion rates (e.g., pica). This condition is typically not addressed in risk assessments, nor is it commonly considered when setting regulatory soil quality guidelines. Recent studies by Calabrese et al. (1997) suggest that certain children will ingest up to 50 g of soil per day during episodes of pica behaviour. At this ingestion rate, soil guidelines set by such regulatory agencies as CCME and U.S. EPA may not be stringent enough to protect the health of pica children.

Zinc:

The generic soil quality guideline for zinc is based on soil contact data from toxicity studies on plants and invertebrates (Table 1.2 below).

Table 1.2 Soil quality guidelines (ppm) for zinc

	Residential/Parkland Land Use
Guideline	**200**
SQG_{HH}	NC
Limiting pathway for SQG_{HH}	NC
SQG_E	200
Limiting pathway for SQG_E	Soil contact

Notes: SQG_{HH} = soil quality guideline for human health; SQG_E = soil quality guideline for environmental health; NC = not calculated (CCME, 1999c)

As stated earlier, the Mine site on Little Cornwallis Island is presently, and has historically been, barren with little vegetation. Further, toxicity to soil invertebrates was deemed largely irrelevant to the area of concern.

Instead, the risk assessment identified the receptor (wildlife or human) deemed most sensitive to zinc toxicity given their behavioural patterns and likelihood of exposure. In deriving a site-specific SQRO for zinc, the risk assessment:

- Determined a daily exposure to zinc that would result in either no measurable health effects on human individuals or wildlife populations; and in turn,
- Resolved a zinc soil concentration that, when ingested/inhaled/contacted, would not result in adverse effect.

Results from the risk assessment identified humans to likely be the most sensitive receptors under the assumed exposure scenarios. Zinc is a nutritionally essential metal and exhibits relatively low toxicity to terrestrial mammals and humans. Zinc does not accumulate with continued exposure, and body content is modulated by homeostatic mechanisms (Klaassen, 1996).

Zinc toxicity from excessive ingestion is uncommon, but gastrointestinal distress and diarrhea have been reported following ingestion of large doses. Due to the lack of overall human zinc toxicity data, the Health Canada provisional tolerable daily intake of 0.30 $mg/kg_{bw}/day$ was used as an acute exposure limit for zinc (Health Canada, 1996). It is recognized that this likely overestimates the potency of zinc on an acute basis, however, at this time no further information was readily available.

When considering this acute exposure limit and the set of exposure assumptions, the results of the risk assessment indicate that the site-specific soil quality remediation objective for zinc at the Polaris Mine that would adequately protect both human and environmental health is approximately 10,000 mg/kg.

References

B.C. Research 1975. Environmental Study of Polaris Mine, Little Cornwallis Island. Submitted to Cominco Ltd., Project No. 1642. Prepared by Division of Applied Biology, B.C. Research.

Bryant Environmental Consultants Ltd. 1997. Environmental Evaluation Report: The Eclipse Report (Draft). Vol I and II. Yellowknife, Northwest Territories.

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Appendix C

A Review of Lead and Zinc Levels in Vegetation of the Polaris Mine Site, C.E. Jones & Associates Ltd., November 2000.

GARTNER LEE LTD.

A REVIEW OF LEAD AND ZINC LEVELS IN VEGETATION OF THE POLARIS MINE SITE

NOVEMBER 2000

GARTNER LEE LTD.

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A REVIEW OF LEAD AND ZINC LEVELS IN VEGETATION OF THE POLARIS MINE SITE

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NOVEMBER 2000

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1.0 INTRODUCTION

Gartner Lee Limited, on behalf of Cominco Ltd., requested C.E. Jones & Associates Ltd. to review the results of vegetation and soil sampling conducted at the Polaris mine in 1999 and 2000. The objectives of this review were to:

- Determine whether lead and zinc levels in vegetation are elevated in comparison to background levels from the Polaris site, and in comparison to other sites
- Determine the source of metals additions, if elevated levels are detected
- Determine the distribution of elevated metals levels in vegetation in relation to the mine
- Evaluate the effects of elevated metals levels on vegetation health

2.0 METHODS

The discussion in this report is based on vegetation data collected by B.C. Research in 1975, prior to mine development, and on vegetation and soils data collected by Gartner Lee in 1999 and 2000. The 1975 data consists of vegetation sampling at four locations (A-D on Gartner Lee mapping). At each sample location foliar samples were collected from the following species: *Thamnolia subuliformis* (an abundant lichen), *Alopecurus alpinus* (a grass species), and *Salix arctica* (arctic willow) (hereafter lichen, grass, and willow, respectively). These foliar samples were analyzed for lead and zinc concentrations, as well as other metals.

In order to provide a consistent data base, foliar sampling conducted by Gartner Lee in 1999 consisted of sampling the above species at the original sample points established by B.C. research, plus an additional four locations (E-H – note that not all species were found at all stations). Foliar sampling conducted by Gartner Lee in 2000 included sampling of 6 of the 8 1999 stations (B, C, D, E, G, and H), plus an additional seven locations (I-H). Vegetation sampling in 2000 also included sampling of willow root tissue, to allow determination of air vs. soil metals sources.

Sampling conducted by Gartner Lee in 1999 and 2000 included soil sampling at all vegetation sampling locations. In 1999, soil was sampled from the surface 10 cm; in 2000, three discrete samples were taken at each location from the following soil depths: 0-1 cm, 1-5 cm, and 5-10 cm. This stratification was done to allow detection of elevated soil metals concentrations resulting from airborne deposition. The soil data used in this report are the 2000 data, as the separation of samples by depth is useful in interpretation of metals sources.

The discussions of this review's objectives contained in the following sections are based on statistical analysis and interpretation of the above vegetation and soils data. It should be noted that the use of the term "significant" in these discussions with respect to identified trends or differences indicates statistical significance, not subjective determination of difference.

3.0 COMPARISON OF METALS CONCENTRATIONS IN VEGETATION WITH BACKGROUND LEVELS

Lead and zinc concentrations in foliar samples collected by Gartner Lee in 1999 and 2000 were compared to levels measured in the 1975 B.C. Research samples – results are summarized in Table 3.1. Testing for differences in metals levels between the 1999 and 2000 foliar samples indicated no significant differences by year of sampling (t-test, $\alpha = 0.05$), so these data were treated as one post-mining set, to compare with the pre-mining 1975 data. Analysis of the foliar data indicated elevated post-mining vegetation concentrations for the following parameters: lead in grass, lichen, and willow; and zinc in grass and lichen. Willow showed no significant differences in zinc concentrations between the pre-mining and post-mining samples, which can be attributed to elevated zinc levels measured in willow leaves collected prior to mine development.

TABLE 3.1
Lead and Zinc Concentrations by Vegetation Species in Pre-mine and Post-mine Samples

		Pre-mine Concentrations (mg/kg)	Post-mine Concentrations (mg/kg)
Lead	Grass	<4	114.8*
	Lichen	<4	360.3*
	Willow	<4	20.9*
Zinc	Grass	43	362.8*
	Lichen	16.4	202.9*
	Willow	195.6	347.4

* indicates statistical difference between pre- and post-mining means at a significance level of 0.95

Lead

Plants growing in unmineralized locations typically range from 0.05 to 3.0 mg Pb/kg. Average lead concentrations in grasses were reported to be 2.1 mg Pb/kg (Kabata-Pendias and Pendias, 1992). In British Columbia, ranges of <1.2 to 3.0 mg Pb/kg for pinegrass (*Calamagrostis rubescens*), <1.2 to 3.6 mg Pb/kg for Kentucky bluegrass (*Poa pratensis*), and 1.8 to 3.6 mg Pb/kg for bluebunch wheatgrass (*Agropyron spicatum*) are considered normal background concentrations (Fletcher and Brink, 1969). The Ontario Ministry of the Environment (1989) uses 60 mg Pb/kg for urban and 30 mg Pb/kg for rural locations as the upper limit of the normal range for southern Ontario tree/shrub leaves. They consider concentrations in grass of 20 mg Pb/kg to be the upper limit of the normal range.

In a review of trace element uptake by vegetation on mined soils in B.C. (Jones *et al.*, unpublished), the concentrations of lead from lead mining operations ranged from a mean of 12 mg Pb/kg in grasses and legumes growing on tailings at the HB mine, Cominco Ltd. to a mean of 65 mg Pb/kg from herbaceous vegetation growing on limed tailings at Kimberley Operations, Cominco Ltd. The report also documents mean concentrations up to 202 mg Pb/kg in herbaceous vegetation growing on tailings at Pine Point mine, Cominco Ltd. Mean concentrations measured at Polaris in 1999 and 2000 were 114.8, 360.3 and 20.9 mg Pb/kg for grass, lichen, and willow respectively.

Zinc

In a review based on the work of several authors, Kabata-Pendias and Pendias (1992) report that zinc normally occurs in leaf tissues in concentrations ranging from 27 to 150 mg/kg. This is supported by another review that states that the normal range for most forest species is 15 to 125 mg Zn/kg (Boardman and McGuire, 1990). On average, terrestrial plants contain 100 mg Zn/kg (Eisler, 1993). In a British Columbia survey, zinc concentrations were 22.7 mg Zn/kg for pinegrass, 16.6 mg Zn/kg for Kentucky bluegrass, and 19.8 mg Zn/kg for wheatgrass (Fletcher and Brink, 1969).

A review of trace element uptake on mined sites in B.C. indicates that zinc concentrations in vegetation on zinc mines varies widely, from a mean of 57 mg Zn/kg in herbaceous vegetation growing on limed tailings at Kimberley Operations, Cominco Ltd., to 330 mg

Zn/kg in herbaceous vegetation growing on waste rock at the Bluebell mine, Cominco Ltd. The highest mean concentration of zinc noted was 1368 mg/kg from herbaceous vegetation growing on tailings at the Pine Point mine in NWT, Cominco Ltd. Mean zinc concentrations measured at Polaris in 1999 and 2000 were 362.8, 202.9 and 347.4 mg/kg for grass, lichen and willow respectively.

Other Elements

Laboratory analysis of vegetation samples collected in 2000 included a 29-element ICP scan. For cadmium, copper, and iron, pre-mining vegetation concentrations are available for the Polaris mine site, due to inclusion of these parameters in the 1975 B.C. Research work. Comparison of the 2000 sampling program results to the pre-mine 1975 data for these elements indicates that the following parameters are significantly elevated in post-mine samples: cadmium in grass and lichen, and iron in grass and lichen. However, concentrations reported for these elements in the post-mine vegetation samples remain within a range cited as normal in published literature (Kabata-Pendias and Pendias, 1992). Other analytes reported in the 2000 vegetation data were reviewed and compared to published research on normal vegetation concentrations at non-contaminated sites. This review indicates that only chromium is reported in concentrations at Polaris that exceed normal levels (range: <0.5-21.8 ppm). Phytotoxicity of chromium has been documented at concentrations ranging from 4-100 ppm. However, due to the lack of pre-mine data for this element, it cannot be concluded that chromium levels at Polaris are elevated in the local context, or that there has been any effect on chromium concentrations in vegetation as a result of mine development.

Conclusions

Statistical analyses of the vegetation data collected at the Polaris mine prior to mine development and subsequent to development indicate that post-mine lead and zinc concentrations are significantly elevated in comparison to the pre-mining levels for most species. A review of published data from other sources shows that the lead and zinc concentrations in vegetation measured subsequent to mine development at Polaris are also elevated in comparison to background levels in unmineralized locations. Comparison to

other mined sites indicates that mean lead concentrations in vegetation at Polaris generally exceed those measured at other sites, while mean zinc concentrations in vegetation at Polaris are in the upper end of the range measured at other sites.

Statistical analyses also indicate elevated cadmium and iron concentrations in vegetation samples, in comparison to pre-mine values. However, the concentrations reported in post-mine sampling remain within globally normal levels. Chromium concentrations in post-mine vegetation samples are elevated in comparison to published normal levels, but cannot be attributed to mine development and operations, due to a lack of pre-mine data for this element.

4.0 SOURCE OF ELEVATED METALS CONCENTRATIONS IN VEGETATION

The second objective of this review was to determine whether elevated levels of lead and zinc in vegetation (if elevated levels were detected) were the result of plant root uptake from mineralized soil, or resulted from atmospheric deposition and foliar uptake from the mining and milling process. The answer to this question appears to be partially element-specific – thus, the sources of elevated lead and zinc levels are discussed separately below.

Lead

Plant uptake of lead from soil is passive; however, translocation within the plant is limited and lead taken up from soil tends to accumulate in roots rather than foliage (Kabata-Pendias and Pendias, 1992). Airborne lead is a major source of elevated lead in the environment, and lead is readily taken up by plants through foliage.

The results of laboratory analyses for lead and zinc in the stratified soil samples taken from the Polaris site in 2000 are summarized in Table 4.1. (Note that although the reported mean value for lead from the surface samples appears to be substantially higher than those from the subsurface samples, statistical testing indicates no significant differences for concentrations by depth. The appearance of higher values at surface is due to skewing by extremely high surface concentrations at sample points E and I). Although lead concentrations in vegetation at Polaris are significantly elevated in comparison to baseline data and in comparison to unmineralized sites, the soil lead concentrations reported in Table 4.1 are within a range reported in published literature as normal for surface soils (Kabata-Pendias and Pendias, 1992). This evidence points to post mine-development atmospheric deposition, as opposed to soil mineralization, as the source of elevated lead levels in vegetation. This conclusion is supported by a comparison of lead concentrations in willow leaves (mean = 20.2 mg/kg) vs. willow roots (mean = 30.3 mg/kg). Statistical testing indicates no significant differences in these means. As stated above, translocation of lead from roots to shoots is greatly limited, with an average of 3 percent of lead taken up by roots being translocated to shoots (Kabata-Pendias and Pendias, 1992). Thus, if uptake from soils were the primary source of elevated lead levels in vegetation, an expected foliar lead concentration for a root concentration of 30.3 mg/kg would be approximately 1 mg/kg. The higher levels measured at Polaris indicate the presence of atmospheric lead deposition.

A final interpretation that is useful in determining the source of lead at Polaris is a comparison of lead levels between species (Table 3.1). Because lichens uptake elements solely from the atmosphere, one would expect that in an environment where airborne metals sources are predominant, lichens would have high metals concentrations relative to vascular plant species. In an environment in which soils metal sources are predominant, one would expect vascular plants to have higher metals concentrations. The post-mine Polaris vegetation data shows a significantly higher mean lead concentration in lichens, in comparison to grass and willow. This reinforces the conclusion of atmospheric deposition being the primary source of lead.

TABLE 4.1
Lead and Zinc Concentrations by Soil Depth in Post-mine Samples

Soil Depth	Lead (mg/kg)	Zinc (mg/kg)
0-1 cm	67.4	311.6
1-5 cm	13.1	146.8
5-10 cm	10.7	149.6

Zinc

In environments where zinc-enriched soils are present, roots tend to accumulate more zinc than do shoots. However, in contrast to lead, zinc is intermediately to highly mobile within plant tissue, and at luxury levels, zinc may be translocated to foliage. In environments where zinc is an airborne pollutant, foliage is likely to accumulate more zinc than roots.

The pre-mining vegetation data collected by B.C. Research at Polaris in 1975 indicates elevated foliar zinc concentrations in willow. Statistical testing of Gartner Lee's post mine-development vegetation data against the pre-mine data shows a significant increase in post-mine mean zinc concentrations in grass and lichen, but not in willow. These data indicate that while there has been some increase in vegetation zinc concentrations as a result of mining, it is likely that soil at the Polaris site contains elevated zinc levels unrelated to the mining process. This conclusion is supported by a comparison of the soil zinc concentrations measured at Polaris (Table 4.1) with published data, which indicates that even the subsurface samples (which may be taken as analogous to pre-mine soils, in the absence of direct information) from Polaris have elevated zinc levels in comparison to non-mineralized surface soils.

Statistical testing of zinc concentrations in willow roots (mean = 365.2 mg Zn/kg) versus willow shoots (mean = 368.3 mg Zn/kg) in the post-mine Polaris vegetation samples shows no significant difference. If the primary source of zinc were atmospheric deposition, one would expect higher shoot concentrations than root concentrations. This comparison again suggests that at least a portion of the elevated zinc levels documented in vegetation at Polaris is attributable to zinc-mineralized soil.

As noted in the above discussion on lead sources, a comparison of metals concentrations between species can be useful in inferring metals sources. In environments with airborne pollutants, one would expect higher metals accumulations in lichens relative to vascular plants, whereas in environments with metals-enriched soils, one would expect vascular plants to have higher concentrations. In contrast to lead, which was suggested to have an atmospheric source at Polaris, there are no significant differences in zinc concentrations between vegetation species. This information, taken together with the significant increase in zinc concentrations over pre-mine levels documented for both grass and lichen, indicates that elevated zinc levels in vegetation at Polaris have originated both from the presence of zinc-enriched soil unrelated to mining, and from atmospheric deposition of zinc attributable to the mining process.

Conclusions

The data collected at Polaris suggest that the elevated zinc levels found in vegetation in the vicinity of the mine site are due both to zinc-mineralized soil which likely existed prior to mine development and to atmospheric deposition resulting from the mining process, whereas elevated lead levels are attributable solely to atmospheric deposition resulting from mining. It is important to note that these inferences of metals sources are not absolute, as atmospheric deposition results not only in foliar metals uptake, but also in surface soil enrichment and subsequent metals uptake by plant roots. (Although this effect was not statistically identified in a comparison of soil depths from all samples, at some individual points there is a substantial increase in surface versus subsurface metals concentrations.) This point is important to interpretation of the duration of these effects following mine closure. Elevated zinc levels in plant species are likely to be persistent following mine closure, due to the inferred presence of zinc-mineralized soil prior to mine development. The duration of lead concentrations in plant species will be shorter than that of zinc, due to atmospheric deposition from mining being the primary source of lead, but will have some persistence following mine closure as a result of increased surface soil lead concentrations at isolated points. It is assumed that lead and zinc levels in lichens will not persist beyond the lifespan of the organisms inhabiting the site at closure, provided that the source of atmospheric deposition is removed.

5.0 DISTRIBUTION OF ELEVATED METALS CONCENTRATIONS IN VEGETATION

Statistical testing indicated five vegetation parameters for which post mine-development values exceeded those measured prior to mine development: lead in grass, lichen, and willow, and zinc in grass and lichen. These parameters were examined to determine the distributions of elevated metals levels, and to identify the effects of distance from the mine and prevailing wind patterns on these distributions. Wind data was provided by Gartner Lee; distance of sample points from the mine was determined using Gartner Lee mapping, with the process barge (approx. 1400 N, 600 E, mine grid) taken as the point from which distance from the mine was calculated.

Graphical representation of the spatial distribution of vegetation metals concentrations was conducted in order to evaluate the effects of wind direction on measured metals levels. Figure 5.1, which shows zinc concentrations in lichen by sample position, is presented to provide an example of this representation – plots of the other four parameters are similar in appearance. (This plot uses a Kriging process to interpolate values between sample points. It should be noted that the x-axis is terminated at 1500 m E, as this is the location of the closest sample point to the process barge. The barge itself is approximately 900 m further west.) These representations do not indicate any identifiable effects of wind direction, and suggest that metals concentrations in vegetation may be described as a simple distance function from the mine site. Figure 5.2, which shows zinc concentrations in willow by sample location, is presented as a comparison to illustrate spatial distribution of a parameter for which elevated levels were not detected by post mine-development sampling.

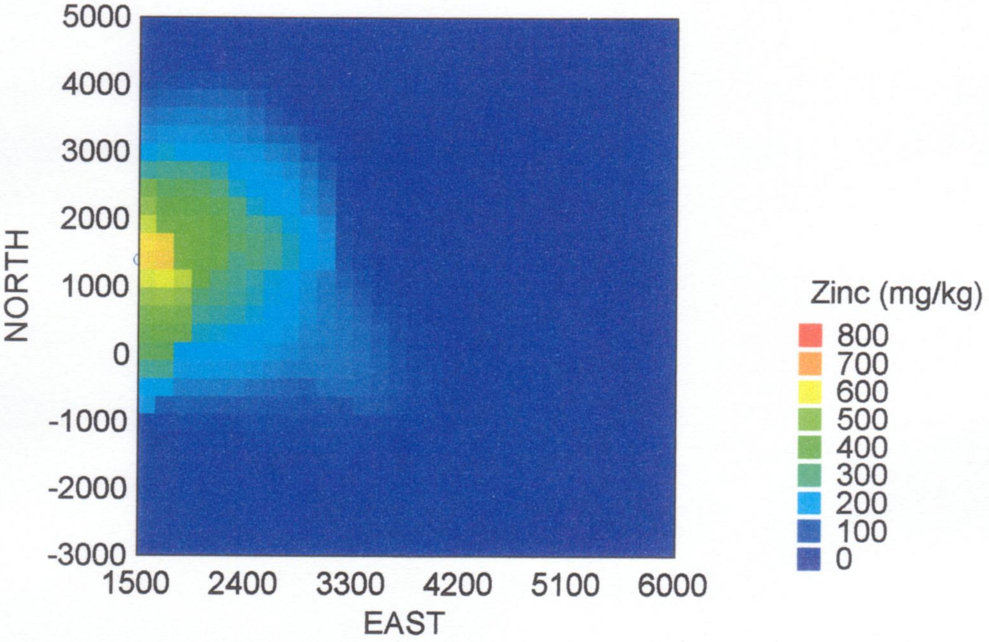

FIGURE 5.1 Spatial Distribution of Zinc Concentrations in Lichen in Post Mine-development Sampling at Polaris

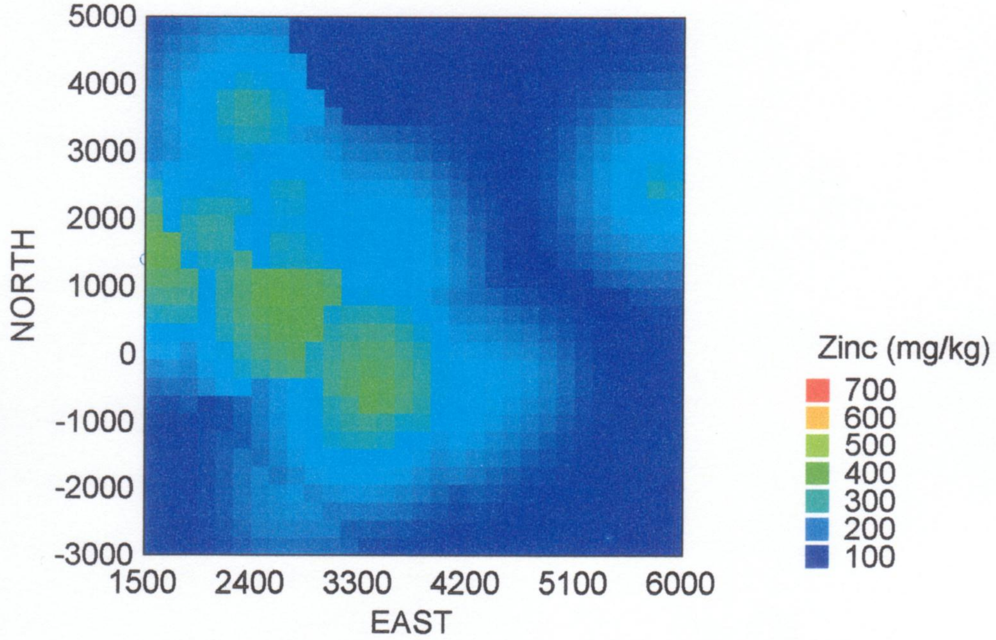

FIGURE 5.2 Spatial Distribution of Zinc Concentrations in Willow in Post Mine-Development Sampling at Polaris

Plotting of metals concentration data versus distance from the process barge indicates that it is reasonable to interpret concentration as having an inverse linear correlation with distance. There is no evident abrupt delineation between a mine-affected and a far-field zone. It should be noted that at sample points within the mine operating area (A and I) vehicle movement and snow dumping also contribute to the levels of metals in surface soils.

Based on this information, and the finding of a lack of apparent correlation with prevailing wind direction, simple linear regression expressions were constructed for the parameters reporting elevated post-mining levels, e.g.:

$$Pb_{GRASS} = \text{constant} + m \cdot \text{distance}$$

The resulting equations for the five examined parameters are included as an appendix to this report. All equations were statistically significant, with r^2 values from 0.37 to 0.54.

The developed regression equations were utilized to estimate the distance from the mine centre at which vegetation metals concentrations return to values measured prior to mine operation. To accomplish this, the mean values from the 1975 B.C. Research sampling for the five relevant species/element combinations were entered into the appropriate equations, to yield a background concentration distance for each combination. These distances describe the radii of areas affected by mining activities at Polaris. (Note that although pre-mine concentrations were used in these equations for the purposes of this report, other critical values, such as those determined by risk assessment, may also be utilized.) Despite differences in absolute values in both pre and post-mine concentrations for different parameters, all regressions indicated affected areas with radii between 4417 and 4713 m from the process barge, with a mean radius of 4535 m.

Conclusions

The distribution of elevated lead and zinc concentrations at the Polaris mine site can be described with statistical validity as an inverse linear correlation with distance from the mine centre. There is no apparent identifiable effect of prevailing wind direction on this distribution. The data used in this study indicate that the average zone of elevated metals levels resulting from mining activities at the Polaris site is the area within approximately 4500 m of the mine centre.

6.0 EFFECTS OF ELEVATED METALS CONCENTRATIONS ON VEGETATION HEALTH

Lead

Lead has been reported to be non-injurious to plants (NRC, 1973), but other studies have reported lead toxicity in plants. Rolfe and Bazzaz (1975) demonstrated reduction in photosynthesis of 11 to 17 percent with foliar concentrations of 60 and 72 mg Pb/kg. Legume shoot concentrations of >133 mg Pb/kg significantly reduced above ground biomass (Sudhakar et al., 1992). A lethal concentration of lead in shoots of Sitka spruce (Picea sitchensis) was 43 mg Pb/kg (Parker and Parker, 1986). Necrotic parts of needles of Scotch pine (Pinus sylvestris) exposed to emissions from a smelter contained 434 mg Pb/kg (Czuchajowska, 1987).

Mean lead concentrations in vegetation growing in the mine-affected area (as determined by the regression equations developed in section 5.0) were 134 mg/kg for grass, 397 mg/kg for lichen, and 25 mg/kg for willow. No toxicity symptoms were noted for the species collected at Polaris mine, but lead poisoning of plants has seldom been observed in field conditions (Kabata-Pendias and Pendias, 1992). Reductions in biomass would be difficult to determine, since no pre-mine productivity data exists. However, the post-mine levels in lead in vegetation at Polaris are of the magnitude that it would be reasonable to accept the possibility of detrimental effects on vegetation health. Of grass samples taken from the mine-affected zone, 65 percent exceeded the lowest reported toxicity value of 43 mg Pb/kg, and 29 percent of samples exceeded the 133 mg Pb/kg value (at points A, C, H, and I). Twenty-one percent of willow samples collected exceeded the 43 mg Pb/kg value (at points E, H and I). The above information can be utilized in combination with the developed regression equations to define a smaller mine-affected zone in which there may be an increased probability of risk to vegetation health. For example, using the 133 mg Pb/kg toxicity value in the grass/lead regression equation indicates a >133 mg Pb/kg zone with a radius of 2623 m – this corresponds closely to the observation of levels in excess of 133 mg/kg at sample points A, C, H and I.

Zinc

Plant species sensitive to zinc may experience toxicity symptoms at tissue levels of 150 to 200 mg Zn/kg while the upper limit for most plants is considered to be in the range of 100 to 500 mg Zn/kg (Eisler, 1993; Kabata-Pendias and Pendias, 1992).

Mean zinc concentrations for species showing elevated levels growing in the mine-affected area at Polaris were 400 mg/kg for grass and 236 mg/kg for lichen. As stated above, no sampled vegetation was described as having severe toxicity symptoms (chlorotic and necrotic leaf tips, interveinal chlorosis in new leaves, retardation of growth and leaf desiccation). However, as with lead, there is a possibility of detrimental effects to vegetation health resulting from elevated zinc concentrations in the mine-affected zone at Polaris. On the other hand, this study's investigation of sources of zinc in vegetation indicates the probability of zinc-mineralized soils at this site prior to mine development. Several plant species and genotypes are known to have a great tolerance of zinc and a great selectivity in absorbing zinc from soils. It is possible that the vegetation growing in the mineralized area where the mine was developed have evolved a tolerance to elevated soil zinc concentrations. Of grass samples collected from the mine-affected zone, 68 percent exceeded the 200 mg/kg value, and 26 percent exceeded the 500 mg/kg value (at sample points A,C,H and I). This data can again be used to define a mine-affected area with an increased probability of risk to vegetation health. Utilization of a critical value of 500 mg Zn/kg in the grass/zinc regression equation indicates a >500 mg Zn/kg zone with a radius of 2118 m – this corresponds closely to both the observation of high levels at sample points A, C, H and I, and to the higher-probability risk zone defined for lead.

Duration of Elevated Lead and Zinc Levels

Although it is impossible to predict with certainty the expected duration of elevated metals concentrations in vegetation at the Polaris mine site, it is possible to speculate on the relative longevity of these levels for the different elements and different species reviewed in this report. Lead, as stated above, is likely to be the least persistent of the two metals in above-ground plant material, due to its primary source being atmospheric deposition, and to the limited translocation of this element in plants from roots to shoots. Among the species studied at Polaris, grass is likely to show the most rapid recovery from elevated lead levels, due to annual renewal of above-ground tissue. Willow is likely to have a less rapid reduction in foliar lead concentrations, due to the longer lifespan of willow stem material, and the possibility of translocation between above-ground tissues. It is anticipated that elevated lead concentrations will not persist in lichen beyond the lifespan of these organisms once the source of aerial deposition is removed, as their uptake is determined solely by atmospheric sources. However, due to long lifespan and slow rate of tissue renewal in lichen, persistence of lead is likely to be greater than in the vascular plant species.

For zinc, it is more difficult to speculate on the duration of elevated levels in plant tissue, due to the presence of elevated zinc levels in soils at the mine site, and to the relatively high mobility of this element within plants. Thus, it is not possible to predict the duration of elevated zinc levels in grass. As with lead, elevated zinc levels are not expected to persist in lichen beyond the lifespan of these organisms. However, as noted above, reduction of zinc levels in lichen is likely to be a relatively slow process.

It should be noted that the above discussion of duration of elevated metals concentrations is confined solely to duration in above-ground plant tissue. Both lead and zinc are likely to be more persistent in root tissue, due to the presence of elevated soils zinc levels and to aerial deposition of lead onto surface soils. It should also be noted that the above speculation on metals duration does not take into account effects of element cycling resulting from decomposition of both above and below-ground plant tissues, which may extend the persistence of elevated levels beyond that expected.

7.0 SUMMARY

A review of the vegetation data collected from the Polaris mine site in 1975 and 1999/2000 indicates that the following parameters are significantly elevated in post mine-development samples, in comparison to pre-mine samples: lead in grass, lichen, and willow; and zinc in grass and lichen. In addition, these parameters are elevated in comparison to background levels at other undisturbed sites, and are in the upper range of values documented at other lead/zinc mines.

The sources of these elevated lead and zinc levels appear to be element-specific. The primary source identified for elevated lead levels is atmospheric deposition resulting from the mining/milling process, with no evidence of lead mineralization of surface soils existing prior to mine development. For zinc, there is evidence of both soil zinc mineralization existing prior to mine development, and of zinc additions through atmospheric deposition.

Graphical representation of the spatial distribution of elevated lead and zinc levels indicates an inverse correlation to distance from the mine process barge. There is no apparent effect of prevailing wind direction, nor is there an evident abrupt delineation between a mine-affected and far-field zone. Based on this information linear regression equations that describe metals concentrations as distance functions were developed for each elevated species/metal combination. Application of these equations using the background vegetation metals concentrations measured prior to mine development indicates an elevated-metals zone of between approximately 4400 and 4700 m radius from the mine process barge.

The effects of elevated lead and zinc concentrations on vegetation health at the Polaris mine site are difficult to determine, as no toxicity symptoms have been observed during sampling, and no pre-mine/post-mine productivity assessments are available for comparison. For both lead and zinc, concentrations measured in vegetation samples collected in the mine-affected zone at Polaris are within ranges reported as causing toxicities in other studies. Thus, there is a possibility of detrimental effects on vegetation health as a result of these elevated levels. However, for zinc, surface soil mineralization in this area that is unrelated to mine development may have lead to the evolution of zinc-tolerant populations, which may be resistant to toxicity effects from mine-related atmospheric zinc additions. The published vegetation health data cited in this report was used in conjunction with the developed concentration/distance regression equations to define zones with higher potential of risk to vegetation health resulting from elevated metals levels. Utilization of the higher toxicity values (133 mg/kg for lead and 500 mg/kg for zinc) indicates a possible at-risk zone with a radius of between approximately 2100 and 2600 m from the mine process barge. This exercise is provided as an illustration of the potential to utilize vegetation metals concentrations determined by risk assessment in the regression expressions developed in this report in order to identify possible at-risk zones, not as a risk assessment itself.

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APPENDIX I

Lead in Grass

$Pb_{GRASS} = -0.073 \cdot DISTANCE + 324.476$; $p = 0.002$, $r^2 = 0.392$

Lead in Lichen

$Pb_{LICHEN} = -0.186 \cdot DISTANCE + 878.663$; $p = 0.001$, $r^2 = 0.445$

Lead in Willow

$Pb_{WILLOW} = -0.013 \cdot DISTANCE + 60.005$; $p = 0.007$, $r^2 = 0.370$

Zinc in Grass

$Zn_{GRASS} = -0.181 \cdot DISTANCE + 883.387$; $p = 0.002$, $r^2 = 0.397$

Zinc in Lichen

$Zn_{LICHEN} = -0.113 \cdot DISTANCE + 518.201$; $p = 0.000$, $r^2 = 0.540$