Cominco

POLARIS MINE

DECOMMISSIONING AND RECLAMATION PLAN

VOLUME 3 OF 4

1999 ENVIRONMENTAL SITE ASSESSMENT

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DECOMMISSIONING AND RECLAMATION PLAN

Volume 3 of 4
1999 Environmental Site Assessment

Prepared for
Cominco Ltd.

Prepared by:
Gartner Lee Limited

March 2001

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1999 Environmental Assessment Program

Prepared for
Cominco Ltd.

Prepared by:
Gartner Lee Limited

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Summary of Environmental Issues

This section provides an overall summary of the environmental issues identified in the phased environmental site assessment, and the marine environmental survey conducted in 1999 at the Polaris mine site located on Little Cornwallis Island, Nunavut Territory.

The objective of the environmental site assessment 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.

The Phase 1 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.

Following a preliminary review of the chemical concentration data for samples collected during the Phase 2 field investigation, a limited third phase of surface soil sampling was undertaken in September, 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 (APECs) 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 APECs and included the following tasks:

- a field investigation to collect soil, water and vegetation samples;
- laboratory analysis to determine the concentrations of chemicals of concern in soil, water and vegetation samples;
- an assessment of the environmental setting, including: a terrain analysis, physical descriptions of geologic media and measurement of groundwater levels;
- an evaluation of the chemical data in relation to the federal regulatory guidelines for environmental quality and territorial standards, as appropriate; and,
- delineation of the areas, depths and severity of contamination on the site, including an assessment of the potential for contaminant migration.

The field investigation program consisted of the drilling of 14 boreholes, excavation of 84 test pits, and 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; as well as the 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 Frustration Lake outlet 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.

Regulatory Framework

The Polaris mine occupies land leased from the Government of Canada under the Territorial Lands Act. Accordingly, the regulatory framework used to evaluate the chemical concentration data included guidelines and standards regulated by both federal and territorial environmental authorities.

Canada has adopted a three-tiered approach for the assessment and remediation of contaminated sites. The Canadian Environmental Quality Guidelines (CCME, 1999)[1] represent the first tier, while a second tier allows limited modification of the guidelines by setting site-specific remedial objectives (CCME, 1996)[2]. The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis.

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 (Cantox, 2000)[3]. The SQRO's for lead and zinc were determined within the permitted framework as governed by the Canadian Environmental Quality Guidelines (CCME, 1999), and described above.

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

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[1] CCME. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

[2] 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.

[3] Cantox, 2000. Using a Risk Based Approach to Derive Soil Quality Remediation Objectives for Cominco's Polaris Mine. Prepared for Cominco Ltd., Kimberley, B.C.

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. 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.

The site-specific SQRO’s for lead and zinc in soil were determined through the CCME recommended risk-based approach and are summarized below:

- Lead concentrations of 1,800 ppm in surficial soil are not expected to cause adverse health effects to children visiting the Mine site for brief, infrequent periods of time.
- The site-specific soil quality remediation objective for zinc at the Polaris Mine that would adequately protect both human and environmental health is a surficial concentration of 650 ppm.

Petroleum hydrocarbon contamination at the Polaris mine site was evaluated using the tier 1 CCME Environmental Quality Guidelines for the specific hydrocarbon specified (mono- and polycyclic aromatic hydrocarbons and volatile organic compounds). For parameters not specifically addressed in the CCME Environmental Quality Guidelines, such as the petroleum hydrocarbon parameters used to determine diesel contamination, the light and heavy extractable petroleum hydrocarbons, the Polaris mine soil quality data was compared to the soil standards specified in the Yukon Territorial Contaminated Sites Regulation[4] for these parameters.

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 industrial land use. These areas, and other areas of concern to be considered in remedial planning for the Polaris mine site are summarized below.

Rockfill around process barge

It is understood that the rockfill area surrounding the process barge will be excavated to allow the barge to be refloated for transport off-site. Evaluation of metal concentrations in the rockfill surrounding the barge has indicated the following:

- Lead and zinc concentrations in over 90% of the surface (to 0.1 m) and near surface (to 0.4 m) soil samples exceed the SQRO’s
- Analysis of lead and zinc concentrations in soil samples collected at depths in excess of 0.4 m showed that 75% of the samples contained metal concentrations that exceed the regulatory guidelines.
- Metal contamination of the rockfill generally attenuates at depths in excess of 1.5 meters.

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[4] Yukon Territorial Government. 1996. Environment Act. Contaminated Sites Regulation (Order-in-Council 1996/192).

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 have been identified: concentrates from dryer emissions, spillage, vehicle tracking, and conveyor transfer; and, mineralized rockfill materials which have resulted in the occurrence 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.

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 indicate 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 strongest within 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 pathway 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 and beneath the barge, migration of oil contaminated seasonal melt water would likely 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 the soil contaminant levels. Accordingly, dissolved zinc concentrations exceeded the CCME water quality guideline in all 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. In addition, a 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. The source of the elevated nutrients may be attributed to the sewage discharge line located in close proximity to the water level control sump.

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.

Concentrate storage building, concentrate conveyors and area to the south

Lead and zinc concentrations in soil samples were found to exceed the federal guidelines 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 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 line 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 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 concentration. 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 indicates 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 an zinc concentration in excess of the SQRO. Levels of lead measured in all the samples were less than the SQRO.

Petroleum hydrocarbon analysis was conducted on soil samples collected from the 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 indicate levels of ammonia and nitrite that exceeded the CCME water quality guidelines for protection of aquatic life 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. 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. 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 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 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.

The current field investigation has identified the general location of hydrocarbon contamination associated with the oil spill incident; however, additional test pits would be required to delineate the full extent of the oil contamination for remediation.

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 has 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 petroleum hydrocarbon contamination identified during the present study has not been delineated; however, based on the contaminant observations during test pit excavations, the contamination appears 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, and the occurrence of mineralized soils from the drilling of the raisebore holes, 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 along the foreshore, 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. Metals in the particulates may dissolve into melt waters during the summer season and be transported into sensitive receiving environments such as the foreshore.

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 will be collected to delineate the extent of potential metal contamination in the surrounding soils.

Acid Rock Drainage

Representative rock samples were tested to determine the static rock acid drainage characteristics. The results of analysis show that the four samples would not be classified as potentially acid generating, nor do heavy element concentrations indicate that significant leaching is likely.

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.
- Plant tissues collected from vegetation sampling stations that are progressively farther from the mill site contained concentrations of metals similar to the levels found at the background sampling location.
- Plant species tend to vary in their ability to accumulate contaminants from soil or airborne sources. For example, although zinc concentrations were generally higher than lead concentrations in similar plant species, the grass species was found to accumulate higher concentrations of zinc than other species while lead concentrations were found to be higher than zinc concentrations in lichens at each of the 8 sampling stations.
- 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.

Based on the results of the preliminary vegetation sampling program, it is not possible to determine the extent of the impacted area. Expansion of the sampling area will be conducted in the assessment program to be conducted this summer.

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 is difficult to attribute differences in marine life distribution and abundance among sampling sites to the activities of the Polaris Mine. Certainly, some of the sites near the dock appear 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 indicate that dissolved metals, cyanide and organic chemical parameters analyzed, 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 and Polaris Bays are generally less than the federal regulatory guidelines. Based on previous studies conducted by BC Research (1975)[5] prior to mine development, the concentrations of metals in Garrow Bay sediments are representative of background conditions. Sediment samples collected from sampling stations located adjacent to the landfill site contained levels of lead and zinc that slightly exceeded the CCME guidelines. The highest concentrations of cadmium, lead, and zinc were found in sediment samples collected from sampling stations located in Crozier Strait. The Crozier Strait sediment quality data also suggests that metal concentrations have increased in upcurrent areas from the levels reported prior to full-scale

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[5] 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.

development of the mine site. The highest levels of metal concentrations in sediments were found in the immediate vicinity of the dock area in Crozier Strait.

Given that the present data set indicates that metal concentrations in the sediments in the enriched zone fronting the dock are the same as those reported by Fallis (1984)[6] for data collected in 1981, prior to development of the mine; naturally occurring mineralization is the most likely source for the observed metal levels in the sediments.

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[7]) 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, it is apparent that the elevated concentrations of metals in Crozier Strait and the dock area, in particular, 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 may also be representative of naturally occurring concentrations.

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[6] 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.

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

1. Introduction

Gartner Lee Limited has completed an Environmental Site Assessment (ESA) of the Cominco Ltd. Polaris Mine Operation on Little Cornwallis Island in Nunavut Territory which is scheduled to close in 2001, when ore reserves are projected to be exhausted. In support of the abandonment and reclamation plan for the Polaris operations mine site, a three-part environmental assessment program of the mine site operations, lands and waters was completed by Gartner Lee Limited on behalf of Cominco Ltd.

The overall objective of the environmental site assessment was to identify and assess the significance of potential environmental issues at the Polaris mine site and receiving environment. This information will be used to provide direction for future remedial planning.

1.1 Overview of Polaris Mine

Cominco Ltd.'s Polaris Mine is located on Little Cornwallis Island in the Canadian High Arctic. Situated at about latitude 75°N and longitude 97°W, it is approximately 100 km northwest of Resolute, the closest settlement (Figure 1). Polaris is an underground zinc-lead mining operation and the world's most northerly metal mine (Photographs 1 and 2). The Polaris Mine occupies a total of about 952 hectares of land under surface leases from the Government of Canada. The legal description and lease areas are shown in Figure 2.

Mineralization was first discovered at Polaris in 1960 during surface mapping for oil exploration. Further exploration lead to the discovery of the orebody in the early 1970's. Following lengthy engineering and environmental studies and negotiations with the Canadian Government, construction was initiated in 1980. The first concentrate was produced in late 1981. The mine is due to close in 2001 when mining of the approximately 20 million tonne orebody will be complete.

The development and construction of the mine was highlighted by the construction of the process plant and related facilities on a barge in southern Canada and its subsequent transportation to the site, towed 4,800 km by tugs. The barge was then beached for use as the main plant building at the site.

The orebody is a Mississippi Valley type, situated completely in permafrost. The permafrost extends to more than 300 m below surface. Ore minerals are sphalerite and galena, waste rock (host rock) is predominantly dolomite with calcite. Hanging wall rocks are shales. The orebody is located as close as 60m to surface and extends to 300m below surface.

Except for a very small open pit on the north, the ore has been mined by innovative underground methods. Backfilling with waste rock to increase the recovery of ore has been an integral part of the mining operation. The underground fill has been obtained by quarrying surface shales above the orebody. In the last few years this has been supplemented by quarrying dolomite for cemented rock fill.

The mined ore is crushed underground and conveyed to the mill. The Polaris processing plant (mill) is a conventional, grinding and flotation plant processing just over 1,000,000 tonnes of ore per year and producing between 200,000 and 300,000 wet tonnes of zinc and lead concentrate each year. The concentrates are stored in a covered storage building through the winter and are shipped to market in the short summer season. The mill tailings are pumped via a 4 km tailings line to a tailings thickener located above Garrow Lake. The thickened tailings are deposited in the bottom of Garrow Lake. In 1991 construction of a frozen core dam was completed at the outlet of Garrow Lake. Summer runoff water is now controlled and when necessary the water is siphoned over the dam. Fresh water is obtained for the plant and domestic purposes by pipeline from Frustration Lake about 5 km from the mine.

The Polaris mine is one of the most compact mining operations in Canada. Most of the service facilities are located on the process barge, and include the power house, maintenance shops, warehouse and offices. The other two main buildings on site are the concentrate storage building and the accommodation building. Diesel fuel oil for power generation and mobile equipment is stored in a tank farm and in the barge bottom tanks. The mine is serviced by aircraft from Resolute using the 1200m airstrip located adjacent to the accommodation building. Bulk supplies are delivered by ship in the summer.

Water use and tailings disposal by the Polaris Operation has been regulated through Water Licences from the Northwest Territories Water Board. The current license expires on December 31, 2002.

In May 1996, a Preliminary Closure and Reclamation Plan was submitted to the Water Board as required by the Water License. The License requires that this Plan be reviewed annually and modified if necessary. The License further requires that the abandonment and restoration of the facility be implemented to the extent possible, prior to the closure of the facility.

The Water License now falls under the jurisdiction of the Nunavut Water Board.

1.2 Land Leases and Licenses

The Polaris Mine occupies land leased from the Government of Canada under the Territorial Lands Act and the Territorial Lands Regulations. There are five leases at the Polaris site (Figure 2). The leases all expire on April 30, 2011.

- Lease 3472; with an area of 328 hectares incorporates most of the mine facilities, including: the barge; concentrate storage building; accommodation building; landfill sites; backfill quarries; mine openings; the Frustration Lake pumphouse and the tailings thickener.
- Lease 68 H/8-1-3; with an area of 14.29 ha covers a portion of the bed of Crozier Strait and includes the docking infrastructure.
- Lease 68 H/8-3-3; with an area of 67.49 ha, covers the airstrip and some roads and pipelines.

- Lease 68 H/8-8-2; with an area of 403 ha covers the bed of Garrow Lake, which is designated as the tailings deposition area in the lease.
- Lease 68 H/8-9-2; with an area of 148.91 ha, provides a buffer zone around Garrow Lake, the Garrow Lake Dam and Garrow Creek to the ocean.

Cominco holds three mining leases under the Territorial Lands Act through the Canada Mining Regulations, Lease Numbers 2346, 3799, and 3800.

A Restoration Plan for the leases was submitted in 1984 and approved by the Department of Indian and Northern Affairs (DIAND) in 1985.

Water use, tailings disposal and effluent discharge at Polaris are governed by a Water License. The Water License was regulated under the Northern Inland Waters Act until 1993 when the Act was changed to the Northwest Territories Waters Act. Water Licenses were granted by the Northwest Territories Water Board under these Acts. The Nunavut Water Board has now assumed the responsibility for existing Water Licences in the new Territory; however, there is no new Water Act yet. There have been three Water Licences at Polaris.

- The first was effective for the period November 1981 to December 1991, with amendments to the Surveillance Network Program in 1983, 1985, and 1987.
- The second Water License was issued for the period January 1,1992 to December 31, 1993. The short term was requested by Cominco Ltd. to allow time to complete ongoing scientific and environmental studies being carried out to confirm that discharge from Garrow Lake had no effect on the ocean environment in Garrow Bay and to justify increasing the discharge effluent limits.
- The current Licence came into effect January 1, 1994 and will expire December 31, 2002.

The current Water License required the submission of an Interim Abandonment and Restoration Plan in 1996. This plan contains more detail than the plan submitted under the lease in 1984, but is based on the same concepts. A Final Plan will be required before closure.

Regular site inspections are carried out by DIAND to ensure the mine is operating according to the terms and conditions of the Leases and the Water License. Inspection reports are on file at the mine. A review of these reports did not indicate any major issues.

1.3 Scope of Work

Protocols established in published federal and territorial guidelines for decommissioning industrial properties prescribe a phased approach for the identification and management of contaminated sites. The Northwest Territories Water Board *Guidelines for Abandonment and Restoration Planning for Mines in* *the Northwest Territories*, adopts a similar phased approach for the identification of issues and development of an abandonment and restoration plan for a mine site. Accordingly, the environmental assessment for the Polaris mine site was conducted in three phases, including:

Phase 1 Environmental Site Assessment

The scope of work for this phase of the project followed the Canadian Standards Association (CSA) protocol Z768-94 for conducting Phase I Environmental Site Assessments (ESA). The first phase of the environmental site investigation process consists of a review of all available information relating to historic and current mine site operations to identify issues and areas of potential environmental concern.

The scope of work for the Phase 1 ESA included the following tasks:

Task 1: Desk-top review of site specific background information, historical information and regulatory information.

Task 2: Detailed site inspection, including inspection of operations, buildings, site conditions, adjacent property uses, and review of on-site files, records, and drawings, as well as interviews with on-site personnel.

Task 3: Documentation and reporting to provide a summary of potential environmental liabilities associated with land use activities at the Polaris Mine site.

Phase 2 Environmental Site Assessment

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. A description of the environmental setting, potential pathways for contaminant migration and major receptors is also provided.

Field work was conducted in July 1999 and included: surficial soil sampling, the excavation of test pits, and installation of monitoring wells to collect melt-water samples for chemical analysis; and, a location and elevation survey of the test hole locations. Laboratory analysis was conducted to determine the concentrations of chemicals of concern in soil and water samples. The chemical concentration data was evaluated to delineate the nature, distribution and approximate extent of contamination in soil and/or melt-water at the mine site.

Additional Soil Sampling

A second phase of surficial soil sampling was undertaken in early September 1999 in order to provide an expanded data base for metal concentrations in soils further define the environmental conditions at the mine site.

1.4 Objectives

The overall objective of the Phase I investigation was to identify the areas and issues of potential environmental concern on the basis of the types of mine site activities, their location and the potential environmental impacts. The results of the Phase 1 investigation were used to assess the data requirements and focus for the Phase 2 environmental assessment program. The specific objectives of the Phase 1 ESA were to:

- determine and document past activities and historical land uses which may have impacted site conditions;
- assess and summarize current site activities and adjacent mine related operations land uses which may be impacting, or have the potential to impact, site conditions;
- identify contaminant sources and discharge points;
- provide Cominco Ltd. with an assessment of the significance of potential environmental issues at the mine site;
- finalize a cost effective and environmentally sound work plan for a Phase 2 site assessment

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. The Phase 2 environmental quality data was used to evaluate if a third phase of environmental assessment was needed to define the extent of contamination in source areas, determine the potential migration pathways and identify sensitive receptors. The information provided in the Phase 2 ESA and additional soil sampling program would provide guidelines for future remedial actions during decommissioning of the mining operation. Specific objectives for the Phase 2 included:

a) To conduct a soil and seepage water sampling and analytical program to determine the nature and extent of potential chemicals of concern in the subsurface which exceed federal or other applicable regulatory standards, criteria or guidelines for industrial land use;
b) To conduct a marine environmental survey in the vicinity of the mine site and landfill operations to describe current ecological conditions and to determine the concentrations of potential chemicals of concern in biota tissue, seawater and sediments;
c) to establish the scope and nature of any environmental or human health concerns associated with past industrial activity at the site;
d) determine the requirements for remedial action to alleviate any present or future environmental issues related to subsurface contamination at the site; and
e) to generate a document suitable for review by government agencies.

1.5 Report Format

The report has been divided into the three major phases of environmental assessment conducted at the Polaris Mine site.

Sections 2 and 3 present the methods and findings of the Phase 1 Environmental Site Assessment; Section 4 through 6 present the results of the Phase 2 and additional soil sampling program; and, Section 7 and 8 describes the marine environmental sampling program.

2. Site Development and Facility Description

2.1 Environmental Setting

The Polaris Mine site is located at the southern tip of Little Cornwallis Island in the Canadian High Arctic. The site lies 600 miles north of the Arctic Circle in the Northern Arctic Ecozone, an area that incorporates the coldest and driest landscapes in Canada. The mean annual temperature is – 17 degrees Celsius, with an average frost-free period of 8 days. Summer temperatures are typically 4 to 6 degrees Celsius and winter temperatures may reach a minimum of –50 degrees Celsius in February.

Precipitation levels are low due to the extremely cold temperatures, which lowers the level of absolute humidity and hence the available moisture. Snowfall averages 73 cm a year and rainfall in the summer months is approximately 6 cm. Winds are predominantly from the northwest; however, the winds frequently shift to the north, east or southeast.

The mine site lies adjacent to Garrow and Polaris Bays to the east, Crozier Strait to the southwest and North Bay to the north. Topography is limited to gently sloping hills. Low lying terrestrial areas are generally wet or water filled during the summer months due to the presence of permafrost. Three major lakes are located within the mine site area: Frustration, Lois and Garrow Lakes. Frustration Lake is used as the potable and process water source for the mine site and Garrow Lake, a non-mixing, saline (meromictic) lake, is used for the disposal of tailings.

The surface drainage pattern follows the general topography at the mine site. The location of the air strip represents the high point of land from which slopes trend to the east – toward Loon Lake and the New Quarry; to the west toward the shipping dock and Crozier Strait; to the north toward North Bay; and to the south - toward the operational landfill and Polaris Bay.

2.1.1 Surface Geology (Sharp et al, 1996)

The Polaris Mine and other lead-zinc showings in the Cornwallis Islands area, District of Franklin, occur in lower Paleozoic carbonate rocks within the Cornwallis Fold Belt. The favored host strata for the lead-zinc mineralization is the Thumb Mountain Formation, an Ordovician limestone characterized by a lower member that accumulated in a shallow water tidal flat environment and an upper member that formed on a shallow water shelf environment. The Thumb Mountain Formation outcrops extensively on Cornwallis and Little Cornwallis Islands. Overlying the Thumb Mountain Formation are the Irene Bay Formation and the Cape Phillips Formation, both of which are exposed on surface. Erosion has removed any younger strata on Little Cornwallis Island.

Deposits of pebbles, mud and sand of variable thickness characterize the surface geology of the Polaris Mine area. The unconsolidated deposits have been extensively reworked into raised beaches formed during isostatic rebound following deglaciation. The Thumb Mountain and Irene Bay Formations weather into material characterized as well drained gravel. The Cape Phillips Formation weathers to form a much higher proportion of fines (sands and silts).

Outcrops of the lower member of the Thumb Mountain Formation are present near the Ocean on the west side of the peninsula by Crozier Strait. The hillside between the barge and the accommodations building is covered with micritic and fine-grained limestone, with fossil *Tetradium* corals becoming more abundant upward in the section. Surface showings of sphalerite, galena and marcasite stringers and disseminations associated with dolomitized rocks of the upper member of the Thumb Mountain Formation occur in three areas of the mine site as shown in Figure 5. The main sulfide deposit does not outcrop at the surface of the mine site. The outline of the orebody is shown projected to surface on Figure 5.

The Irene Bay formation is a poorly exposed, recessive weathering unit. It can be seen exposed in the southeast wall of the Old Quarry, where it lies in contact with the basal units of the Cape Phillips Formation. The Irene Bay formation consists of interbedded green mudstone (shale), argillaceous gray-green limestone and massive gray limestone. Large intact fossils of gastropods and corals are present, as well as crinoid, brachiopod and trilobite fragments. Marcasite nodules are common and often replace fossils in the lower green mudstone. Approximately 1-2% disseminated pyrite occurs throughout the green mudstone.

The Cape Phillips Formation is a black bituminous carbonate mudstone and is exposed in the New Quarry. Orange weathering patches extend along frost shattered fractures. A third quarry area, known as the Little Red Dog Quarry, is located to the southwest of the north showing of the upper member of the Thumb Mountain Formation. This quarry was developed to supply dolomite for use as cemented backfill material in the underground.

2.1.2 Terrain

Gartner Lee Limited, on behalf of Cominco Ltd., began a phased environmental site assessment process, including terrain analysis in 1999. The results of the terrain analysis to characterize the surficial materials and geomorphological processes for the vicinity of the Polaris Mine Site is summarized in this section. The terrain analysis report is provided in Appendix A.

The Polaris mine site area consists of very gently rolling low-relief hills and plains rising out of the ocean. Three large elliptical inland lakes (Garrow, Frustration and Lois Lakes) are found along the eastern edge of the study area. The bulk of the study area is comprised of two peninsulas, Riddle Point and the Polaris Mine site. The terminus of both peninsulas are characterized by large hills with relatively steeper slopes leading to the ocean.

The Polaris Mine site area is characterized by a steep west-facing hillside leading from the accommodation complex down to the mill site below. The slopes of Riddle Point are characterized by well developed marine terraces which have some bedrock exposure. The only other areas of steep topography are found along the Frustration Lake outlet creek which has incised a canyon into the bedrock.

The landscape and surficial materials of the Polaris Mine site study area are dominated by marine and glacial process. Hodgson (1989) suggests that the Little Cornwallis Island area was covered by the Queen Elizabeth Islands Glacial Complex until deglaciation between 8.5 and 10 thousand years ago. At this time, the study area was thought to be under approximately 100 metres of seawater. Since that time, the landscape uplifted, initially very quickly, to its current elevation above sea level. This probably occurred through isostatic rebound as the weight of the glaciers was removed from the landscape. This process of uplift is clearly shown by the prominent raised beach lines (strandlines) seen along the Frustration Lake access road and the Riddle Point area. This glaciation is probably responsible for the very subdued and rounded topography seen in the study area.

In spite of the presence of glaciers in study area, no obvious glacial or glaciomarine deposits are found in the study area. Rather, the study area is dominated by marine sediments overlying bedrock (Hodgson, 1989).

The study area has also been very heavily effected by permafrost and periglacial processes. Permafrost is found throughout the study area. Permafrost features commonly found are large frost wedge polygons which seem to penetrate the friable bedrock and perhaps are more common where bedrock is near surface.

The periglacial process consists of frost sorting and mechanical weathering of sediments. Furthermore, micro scale frost features such as frost mounding and stripping are common. On a larger scale, solifluction lobes are commonly found on the hillsides east of North Bay. Perhaps the most significant periglacial process is that of nivation. Nivation refers to “snow patch erosion” the development of shallow depressions at sites occupied by long lasting snow banks. The down slope areas from zones of nivation often have over-saturated soils due to the abundant water supply from the melting snow banks, as well as common surface rilling caused by surface runoff. A good example of nivation is found on the steeper slopes southwest of Loon Lake.

2.1.3 Soils

Soils in the Polaris Mine area are described as polar desert in character, with poorly developed horizons and are classified as Cryosols. In the vicinity of the mine site and elsewhere in the surrounding area, overburden forms a thin mantle over the calcareous bedrock. Barren, gravel type surface material predominates at the Polaris Mine site. Soil pH’s have been reported as alkaline (pH 8) confirming the calcareous nature of the parent materials. Finer textured materials are found in natural depressions, such as the Loon Lake area and others to the east, where vegetated meadow type zones have formed in poorly drained sand to clay materials.

The Polaris mine site is located within the zone of continuous permafrost. The zone overlying the permafrost that freezes and thaws in response to seasonal fluctuations in ambient temperature is referred to as the active layer. The thickness of the active layer is dependent, to varying degrees, upon several factors, including: mean surface temperature, topography, drainage, vegetative cover and soil type. The active layer in summer was found to vary across the mine site, with an average thickness of approximately 1 metre. The active layer is shallower (average of ~0.5m) in the lands surrounding the mine site, where ground disturbance has not occurred.

2.1.4 Vegetation

The vegetation of Little Cornwallis Island is classified as "Arctic Tundra". Due to the harsh climate, high winds and shallow soils, vegetation forms are typically dwarfed, low-lying and grow in clusters or as a dense mat. There is considerable variation in the moss and lichen flora, but few species of vascular plants. Vegetative cover tends to be greater on wetter sites in coastal lowlands, along streams and rivers and in sheltered valleys.

BC Research (1975, 1979) conducted a survey of vegetation types in the mine site area as part of their baseline environmental assessment prior to mine development. Six vegetation types were identified within the mine site area by BC Research: Bare (coarse textured), Bare (fine textured), willow, wet meadow, lichen-moss-algae, Bare–lichen-moss-algae. Vegetated areas, represented predominantly by the lichen-moss-algae type, were located no closer than 500 metres of the active mine site area. The active mine site area was located within the Bare (coarse textured) map unit, characterized by a coarse dolomitic stony surface, which is dry and well drained. This unit has relatively low biological sensitivity due to the scarcity of vegetation and the associated low potential for wildlife use. It also has a low susceptibility to mechanical disturbance. Figure 4 illustrates the location and extent of each of the six vegetation units identified by BC Research.

Field observations of vegetation recorded during the environmental assessment program conducted in 1999 found that, in general, the plant communities that were identified by B.C. Research were present throughout the study area. Some of the more common plants observed in 1999 included:

- Grasses (Alopecurus alpinus, Dupontia fisheri, Poa abbreviata etc.)
- Lichen (Thamnolia subuliformis)
- Algae (not identified)
- Mosses (Catascopium nigritum, Distichium capillaceum etc.)
- Willow (Salix arctica)
- Saxifrage (Saxifraga sp.)
- Arctic Poppies, (Papaver laponicum) and
- Dwarf Draba (Draba alpina)

Flowering plants were in bloom, at the time of the field survey in July 1999. Almost all the above vegetation types were found through out the study area. Saxifrage was found at all sites across the study area and was quite ubiquitous. Local Inuit occasionally consume saxifrage and sweet lettuce while on the land (personal communication, P.Amaroalik). Arctic poppies were also quite common, and were observed on the bare rocky and rubbley slopes between the process barge and concentrate storage building.

2.1.5 Wildlife

The environmental baseline studies conducted by BC Research (1975, 1979) included a survey of the population and distribution of mammals and birds on Little Cornwallis Island. The results of the survey indicated that individuals of the following animal and bird species were observed on the island:

- Herbivores: Peary caribou, Muskox, lemmings and Arctic hares;
- Carnivores: Arctic fox, Arctic wolf and Polar bear;
- Migratory birds: red-throated loons, rock ptarmigan, Eider duck, parasitic and long-tailed Jaegers, Glaucus gull, Arctic tern and Snowy owl.

A recent survey of mammal and bird populations on Little Cornwallis Island was completed in 1997 by Bryant Environmental Consultants Ltd. in support of a Preliminary Environmental Evaluation for the proposed Eclipse deposit located 30 km northeast of Polaris. The information provided on the habitat and behavior of the major mammals identified is summarized below.

Lemmings

The foraging, defecation and burrowing behavior of these small mammals plays an important role in the ecosystem of the High Arctic by influencing the productivity of vegetation, providing inputs of decomposed organic matter and dispersing soil nutrients. The lemming population numbers are subject to cycling, therefore influencing the abundance of wildlife at higher trophic levels.

Lemmings generally feed on willow, supplemented by grasses. The preferred vegetation units for lemming burrows includes the willow and lichen-moss-algae habitats, and to a lesser extent the bare-lichen-moss-algae and wet meadow habitats.

Arctic Hare

The Arctic hare is generally found in less abundance in the High Arctic than lemmings. The BC Research study (1975) did not observe any Arctic hares during the summer field work season. The preferred food source for these herbivores is willow, mountain avens and grasses.

Caribou

The caribou diet depends on seasonal availability, but consists largely of a combination of willow, herbs, mosses and lichens. They prefer mid-slope habitats where the vegetation is abundant, and the ground conditions are dry. Although the population sizes of caribou herds are known to fluctuate due to climatic conditions, the BC Research study in 1975 and subsequent studies have observed only a sparse population of Peary caribou on Little Cornwallis Island.

Musk Ox

Musk ox feed primarily on sedges and secondarily on willows. Their preferred habitat is the muddy wet meadow vegetation unit. Only 3 musk ox individuals were recorded near the Polaris mine site during the pre-mine environmental baseline study. Although the population fluctuates, significant populations of musk ox do not occur in this portion of LCI.

Arctic Fox

Arctic fox are scavengers, and as such include a variety of land-based and marine mammals and birds in their diet. They prey on the eggs and young of nesting birds. Anecdotal observations by mine site personnel indicate that the population of Arctic fox has increased since the mine opened, largely due to increased opportunities for shelter and year round food sources.

Arctic Wolf

Arctic wolves prey on caribou and muskox, therefore their productivity is related to the abundance of these ungulates. The environmental baseline studies did not observe wolf scats in the mine site area and recorded only one unconfirmed siting of a wolf. Therefore, the mine site area did not represent an important habitat for Arctic Wolves prior to mine development.

Polar Bear

Polar bears depend primarily on the marine life for food. Local movements of Polar bears across LCI are frequent, as established by the large number of sightings recorded by the mine site. The presence of bears at the mine site is related to their scavenging behavior and activity at the landfill area.

2.2 Site Development

2.2.1 Site Facilities and Construction Sequence

An exploration camp was constructed in the 1960s just east of Loon Lake. Two Nissan huts from this camp are still in use.

In 1973/4 a small camp was constructed adjacent to the original underground decline portal. This camp consisted of trailer style accommodations for 20 people, a steel equipment building and a temporary shop building. The accommodation building and steel building remain and are used as miscellaneous service buildings.

In 1980 a 100 man trailer camp was constructed just to the north of the original mine portal for accommodation of the construction crew. A small part of this camp survives and is used for mine rescue and fire fighter training. This was followed by underground mine development and construction of the accommodation building, concentrate storage building and the underground crusher and conveyor system.

In order to reduce construction costs and construction time, the process plant and related facilities were constructed on a barge that was towed to the site in 1981. The double-hulled barge was constructed in Quebec in 1980 and outfitted with a process plant and power generators. In July 1981 the barge was towed to Polaris by ice breaking tugs and floated into place in August 1981. A cofferdam was installed and the berthing lagoon was pumped out and backfilled.

The following major facilities were constructed later during the operational phase:

- One above ground fuel storage tank in the tank farm (1986)
- The "Bent Horn" fuel conditioning building (1987/8)
- The Cat generator building (1991)
- The CRF (Cemented Rock Fill) Plant (1995)

The waste rock produced from the original underground exploration decline (1973/4) was used to fill the area in front of the portal and along the shoreline. Mineralized (sulphide) material from the exploration excavations within the orebody was stockpiled on the waste rock fill for sampling and potential shipment for metallurgical testwork. One small shipment was made by sea in 1974.

In 1980/81, the waste rock from the pre-production mine development was used for fill around the site and in mine yard construction. All sulphide enriched material mined during this period was stockpiled for mill feed during the startup period.

As discussed above, prior to beaching the process barge a lagoon was excavated to provide access and a landing base for the barge. The excavated material was used for construction of the dock and infill once the barge was positioned and anchored. Minimum excavation was required for construction of the accommodation building, the oil tank farm, and the concentrate storage building. Much of the material excavated was used for fill around the dock area, while some was used for road building and for the airstrip.

After the mine was in operation, most new roads were constructed with material from the backfill quarries and surfaced with crushed material from old raised beaches.

2.3 Mine Process Overview

2.3.1 Mine

The mine began production in late 1981. Since 1988 production has been just over 1,000,000 tonnes each year. In 1998 production was about 1,040,000 tonnes of ore at an approximate grade of 4.0% Pb, 14.0% Zn, producing 48,000 tonnes of lead concentrate and 226,000 tonnes of zinc concentrate.

The orebody is a Mississippi Valley type with the main ore minerals being galena and sphalerite and the host rock dolomite with calcite.

Permafrost and freezing have been the key to success in mining the Polaris orebody. Permafrost extends below the orebody. The rock is normally competent in its frozen state. In order to maintain cold temperatures in the underground during the summer, a 450 tonne refrigeration plant was installed in the main ventilation intake decline at the portal in 1984 (Photograph 4).

Most of the orebody has been mined with sub-level longhole mining employing high productivity trackless equipment. All drilling at the mine is dry. Drill holes are blasted with an ammonium nitrate explosive mixed in the mine. A series of 1.8m diameter raisebore holes to be used for ventilation and backfill are drilled from surface into each mining block. Over 3,000m of raisebore holes are drilled each year.

Backfilling has been an integral part of the mining method to maintain stability and allow ore pillars to be mined. In the early days surface shales were quarried, mixed with water and placed in the underground openings to freeze. Since 1996 a cemented rock fill (CRF) has also been used. The CRF is produced from quarried dolomite (LRD), mixed with cement slurry in the CRF plant and dumped underground through the raisebore holes. Waste rock mined in development is also used as backfill, none is hauled to surface for disposal.

There is no water underground and none is pumped to surface. Occasionally water used with the shale fill leaks into the haulage drifts before it can freeze. Any water brine that leaks into the haulage drifts is pumped into a tank truck and then into a sump located at the bottom of the mine.

Underground mobile equipment is refueled in the workplaces by a mobile fuel tank truck each shift. The only permanent fuel tank underground is located adjacent to the explosive plant. This 15,000 litre tank is filled from the mobile tank truck as required (Photograph 28). Lubricants, grease and glycol are used underground and stored in 205 litre drums as required in the underground repair shop and the crusher stations.

As noted above the primary explosive is a mixture of ammonium nitrate and fuel oil, mixed underground daily as required. The mixing plant is located just below surface, close to the North Portal (Photograph 27). The ammonium nitrate is stored in a specially excavated chamber, close to the mixing plant. The ammonium nitrate is packaged in plastic lined 25kg bags and is delivered on shrink wrapped, metal strapped pallets.

There has been some surface subsidence above the orebody. The subsidence is being monitored by the use of survey monuments.

The mined ore is crushed underground to -15cm and conveyed to underground storage bins close to the surface.

2.3.2 Mill (Concentrator)

The mill was originally designed with a throughput capacity of 2,050 tonnes per day. Since 1986, it has been operating at about 2,850 tonnes per day. The mine ore is conveyed to the mill from two underground storage bins. The ore is crushed to -2cm with a cone crusher and conveyed to the grinding mills, two ball mills operating in parallel. The ball mill discharge is pumped to the coarse lead flotation cells from where the coarse lead concentrates are sent to the lead thickener. The remainder of the lead flotation circuit consists of rougher, scavenger and three stages of cleaning with the concentrates again flowing to the lead thickener. The zinc flotation circuit has four stages of cleaning. A tower mill is used to re-grind the zinc rougher concentrate to improve recovery. Zinc cleaner concentrates are pumped to the zinc thickener. The grades of flotation feed, lead and zinc concentrates and final tailings streams, along with other mill streams, are determined continuously by an " on-stream" XRF analyzer.

The concentrates are filtered on drum filters and dried in steel rotary dryers that are heated by the diesel generator exhaust gases. Wet scrubber dust collectors recover dust from the dryer exhausts. (Photograph 13). The concentrates are conveyed from the dryers to the storage building. The tailings are pumped to the tailings thickener (Photograph 29).

Chemicals used in the mill include sodium cyanide, zinc sulphate, potassium amyl xanthate, MIBC (Methyl Isobutyl Carbinol) and copper sulphate. Reagent usage depends upon the metal sulphide contents in the mill feed and the tonnage throughput. A brief description of the use of the chemicals in the milling process follows:

- Sodium Cyanide (NaCN) is used to depress the iron, and is usually added at the feed end of each ball mill.
- Zinc Sulphate ($ZnSO_4$) is used to depress the zinc in the lead circuit.
- Potassium Amyl Xanthate is used in both circuits as a collector for the activated metal sulphide particles.
- MIBC is used as a frother in the flotation circuits.
- Copper Sulphate ($CuSO_4$) is used to activate the zinc in the zinc circuit.
- Percol 351 is used as a flocculant in the tailings thickener.

Chemicals are shipped to the site by ocean freighter and transferred to land for outdoor storage on pallets. All pallets are heavy duty, shrink-wrapped and steel strapped. The mill chemicals are stored outside in a designated, labeled storage area located between the concentrate storage building and the sea container storage. (Photographs 11 and 12). Copper sulphate, lime, zinc sulphate, Percol and calcium chloride are packaged in 25 kg bags. Sodium cyanide is packaged in 100kg steel drums and MIBC in 165kg drums.

All chemicals used in the mill/concentrator process are moved into the process barge for mixing in designated areas in the southeast portion of the process barge. The chemical mixing and dispensing areas for working solutions are surrounded by containment berms and connected to the central collection sump at the base of the barge. Any spills during mixing are promptly swept up or contained within the sump system of the barge building and reused in the reclaim water. Calcium chloride is also mixed in the barge building for use at the surface diamond drilling sites.

The other chemicals used on site include,

- Pozzutec (205l drum) (CRF Plant)
- Ethylene glycol (235kg drum)
- Methanol (160kg drum)
- Cement (50kg bags) used for miscellaneous construction and a large quantity of 1.5 tonnes bags used at the CRF Plant. The large bags are stored adjacent to the CRF Plant.

2.3.3 Tailings

Mill tailings have been deposited in Garrow Lake since mill start up in late 1981. Garrow Lake is a meromictic lake which is both thermally and chemically stratified with no vertical circulation. The lake, with an area of about $4km^2$ has a maximum depth of 46 metres and has three distinct layers. The surface (or upper mixed layer) contains brackish water with limited populations of aquatic organisms, to a depth of about 20 metres. The halocline is a transition zone where the dissolved oxygen content diminishes and salinity increases with depth, to a depth of about 20 metres. The halocline supports no aquatic life. The bottom layer is also devoid of aquatic life, has no dissolved oxygen, contains soluble hydrogen sulphide and has a salinity more than twice that of seawater.

The mill tailings are deposited into the bottom layer of Garrow Lake. The density difference between the bottom layer and the surface layer is the most important factor which prevents the upward movement of the tailings through the halocline. As well, the anoxic conditions, which prevail in the bottom layer, preclude the dissolution of zinc and lead from the tailings solids.

The tailings are carried by a 4km insulated, heat traced, pipeline from the mill to a tailings thickener adjacent to Garrow Lake (Figure 2). The 33m diameter thickener tank, completely enclosed by insulated steel cladding, is constructed on an engineered permafrost fill base.

The thickener increases the solids content of the tailings to approximately sixty percent, recycling the overflow water back to the mill for re-use through a reclaim line twinned with the tailings line. The thickened tailings are carried by a double walled pipeline to the bottom of Garrow Lake and are deposited at least 26 metres below the surface in accordance with regulatory requirements established under the Water Licence.

Two pipelines into Garrow Lake are always available, one active and one for stand-by. Tailings are discharged from the active line until they approach the 26-metre horizon in Garrow Lake. The line is then cut to move the discharge point to a new location (closer to shore), to allow the tailings to discharge to the bottom of the lake once again. This process is repeated until the line cannot be moved any closer to shore. A new line is then installed, to direct the tailing to an unused area of the lake. Cutting of the line and installing new lines is carried out by divers working through the ice, usually in early spring. The standby line is used when the active line is being cut or replaced.

In 1985 and 1989 breaks in a single-walled pipeline within the lake resulted in tailings being accidentally discharged into the upper layer of the lake. In 1992 a double walled pipe system was installed. This system virtually eliminates any possibility of tailings from a pipeline break entering the lake between surface and 26 metres depth. Despite the discharge of almost all tailings below the 26-metre depth, dissolved zinc concentrations in the surface layer had increased from <0.05 mg/L in 1981 to almost 0.5mg/L by late 1989. The increase was attributed to the tailings line breaks in 1985 and 1989.

While the summer discharge from Garrow Lake to the ocean was always within the terms of the Water License, it became obvious that the increase in zinc concentration in the surface layer would make it difficult to meet these limits in the future. As a result, a containment dam was built across the lake outlet to the ocean in 1990/91. The dam was designed to provide sufficient capacity to store five full years of precipitation, runoff and tailings discharge. Construction using a frozen core technique provided a structure built on and keyed into the permafrost, which will maintain its structural integrity for an indefinite period following the conclusion of mining at Polaris.

Between 1990 and 1992 considerable site specific research was carried out on the effects of lead and zinc on the marine organisms in Garrow Bay and also on the chemical and physical characteristics of Garrow Lake. The results of these scientific studies were used to determine effluent discharge limits for lead and zinc in the next Water Licence.

The existing Water Licence came into effect in 1994, and discharge of Garrow Lake surface water has been resumed. The discharge method uses siphons to lift the water over the dam for discharge via Garrow Creek to the ocean. The mine has continued to meet the Water Licence Effluent Discharge Limits, without any incidents of exceedance of metal levels.

2.3.4 Concentrate Storage

The concentrate storage building is an A-frame structure 210m long and 53m wide, with a design storage capacity of about 40,000 tonnes of lead concentrate and 175,000 tonnes of zinc concentrate, separated by a partial wall. The building floor is engineered fill. The frame is a pre-fabricated steel structure. The footings are reinforced concrete. Front end loaders are used to reclaim the concentrates from storage to three feeders located within the building. The feeders can provide up to 1,500 tonnes per hour to the reclaim conveyor and the ship loader.

2.3.5 CRF Plant

The CRF plant was constructed in 1996 and consists of a "Sprung" style building with connection to the rock screening building by an enclosed conveyor gallery (Photographs 15 an 16).

The CRF plant adds a cement slurry to the dolomite fill. A large amount of cement (8,000 bags in 1999) is ocean freighted to the mine site in 1.5 tonne bags and stored adjacent to the CRF Plant.

2.3.6 Shiploading Dock

The dock is located on the shore of Crozier Strait and was built of engineered rock fill, frozen by a plant that circulated glycol coolant through pipes in the fill. Approximately 45 cooling cells were used on a 1m spacing. Temperature of the fill was monitored by thermistors, four at each end of the dock and two towards the centre. The depth of each thermistor was about 7m with 10 beads spaced at 0.7m. By the end of March 1983, temperatures had reached about –10°C at 2m below the surface and -2°C at 7m below surface. The freezing plant was removed in 1983 or 1984. The last recorded temperature readings for these thermistors was found to be September 3,1993, when temperatures on the south side of the dock ranged from –0.26°C to –2.5°C (surface to 7m), the north side of the dock ranged from –1.3°C to -3.85°C and in the centre ranged from –1.78°C to –5.25°C. These temperatures indicate that the dock material was frozen year round in 1993. There is no reason to believe that the situation has changed.

The dock has an interlocking steel piling docking face, 92m long with a minimum 14m draft below mean water level. The pier rises to a height of 4 to 5m above mean water level (Figure 5, Photographs 3 and 25). The dock was designed to accommodate bulk carriers up to 40,000WMT capacity. The shiploader, connected to the concentrate storage building by the reclaim conveyors is supported in the centre of the dock.

2.3.7 Accommodations

The accommodation building is located near the crest of the shoreline slope overlooking the other mine site facilities. The foundations lie on fractured limestone, overlain by about 1.5m of sand and gravel fill. The active soil zone is about 0.6m deep. The building is raised above the existing grade by 1.2 to 2.1 m, permitting preservation of the thermal regime under the building. The foundations consist of concrete pads and columns, and the footprint of the building covers an area of 5,120 $m^{2.}$ The building is a pre-engineered all steel construction, with exterior cladding of steel panels, insulation and a protective inner liner of steel.

There are about 240 rooms, in four residential modules, each module connected to the other by alternating service modules containing the kitchen and dining room, commissary and pool, nursing station and offices. Recreational facilities include a poolroom, library, swimming pool, sauna, gymnasium, mezzanine running track and weight room. At the north end of the building are the electrical/mechanical services module which includes three 450kw emergency generators, vacuum sewage system, fire pumps, boilers, laundry and glycol heat transfer system. Primary heat supply is from the glycol waste heat recovery system attached to the barge diesel generators At the south end of the building, beneath the gym, are food freezers, coolers and dry goods storage

2.3.8 Ancillary Services

- Miscellaneous buildings
  The following miscellaneous buildings are located around the site
  - Foldaway buildings(3)
  - Fuel conditioning building (1987/88)
  - Cat Generator building (1991)
  - Dock office (green shack)
  - Firehall
  - Carpenters shop/backfill lab
  - Steam bay/tire shop (connected to the barge)
  - Frustration Lake pumphouse
  - Explosives magazine
  - Surface gravel crusher
  - Nissan huts(2)

- ***Airstrip***
  The gravel airstrip is 1,200 m in length, capable of handling small commuter planes and cargo planes up to Hercules size (half load only).

2.3.9 Water and Sewage

1) Water Supply

The Polaris Mine is supplied with fresh water from a pump station at Frustration Lake approximately 5 km from the mine site. The pumphouse and intake are located on the end of a rockfill causeway reaching 100m into the lake. The water is pumped through a 200mm insulated, heat traced, fibreglass pipeline to a 760,000 litre storage tank above the plant site. Water flows by gravity to the accommodation building and the barge. Water used in the accommodation building is treated by an ultraviolet system.

2) Sewage System

The sewage from the accommodation building is collected by a vacuum system and flows by gravity through a 100mm pipeline to the 12,000 litre holding tank at the barge. The barge sewage and grey water as well as water from the oil/water separator at the steam bay is also collected in this holding tank. The holding tank contains three grinder pumps that discharge through a 180m long pipe to the submerged ocean outfall at about 11m below sea level close to the north dock cell.

3) Runoff Water

Spring runoff typically occurs over a short time period. Mine site melt waters are directed away from roadways and facilities by ditching, with most water eventually finding its way to the ocean due to the hilly terrain. Runoff water draining down the steep hill from the Accommodations building towards the barge area is intercepted in a sump (buried truck box) and is pumped into the mill or discharged in the sewer as greywater.

2.3.10 Fuel, Lubricating Oil, Grease, Solvents and Glycol - Storage, Use and Dispensing

Diesel Fuel

Diesel fuel has been the main fuel used at the mine. Two types are used, P20 and P60. Both are arctic diesel, but P60 has a lower viscosity and is designed for lower temperatures. The P20 is used for power generation and P60 for mobile equipment on surface and underground. Table 2.1 provides a list of diesel fuel storage tanks:

Table 2.1 Diesel Fuel Storage Tanks

Location	Capacity(Liters)	Date Installed
Accommodation	8,444	1980
Underground in the Mine	15,000	1981
Barge bottom (5 tanks)	10.6 million	1980
Oil Tank Farm	2 – 5.5 million L tanks	1980 and 1986
Oil Tank Farm	100,000	1980
CRF Plant	36,368	1995
Thickener	2,273	1981
Cat Building	34,095	1987
Fire Hall	8,444	1981
Foldaway Building	2273	1981
Service Tank	22,730	1981
Day Tank	22,730	1981

The tank farm consists of two 5.5 million litre tanks used for diesel storage and one 100,000 litre tank used for storage of “Bent Horn” crude. The storage area is lined with a geosynthetic material and surrounded by a soil/rock containment berm (Photographs 7 and 8).

Diesel fuel is delivered by ocean tanker each summer. The tanker delivers the fuel by pipeline from the dock to the two 5.5 million liter capacity surface storage tanks in the oil tank farm and the under-barge storage tanks. Annual consumption has ranged from 12 to 16 million litres.

After refueling of the storage tanks, the fuel in the under-barge tanks is used first and as these tanks are depleted they are replenished by transferring fuel by pipeline from the two surface tanks at the tank farm. Fuel for mobile equipment is dispensed from a fuelling station adjacent to the shops at the north-west end of the barge (Photographs 3,5 and 6). This tank is filled by underground pipeline from the barge as required. The fuel storage tank outside the north end of the accommodation building is also refilled by pipeline from the barge.

Other fuel storage tanks around the site are refilled by a mobile fuel truck. There are no fuel lines in the underground mine. Fuel is delivered each shift by a mobile fuel truck dedicated for underground use. One 15,000 liter capacity diesel storage tank is located within a vault adjacent to the underground explosive plant.

Gasoline

Gasoline was delivered to the mine site in bulk each summer and stored in the 100,000 liter storage tank in the oil tank farm until approximately 1987. Current gasoline usage is minimal and restricted to that used for skidoos and all-terrain vehicles (ATVs). Since 1987, gasoline stored in 45-gallon drums has been transported by air from Resolute, as required.

"Bent Horn" Crude Oil

In 1987 to 1989 arctic light crude oil was used on a trial basis to reduce power generation costs. Bent Horn crude was delivered by tanker from the Bent Horn well on Cameron Island in the High Arctic northwest of Polaris. A fuel conditioning building was constructed for heating the crude and removal of waxes by centrifuge. One generator (#1) was equipped with double walled fuel pipes and a ventilation system for the trial of this volatile crude. The crude was stored in one of the 5.5 million litre surface tanks at the oil tank farm. After completion of the trial, the remaining Bent Horn fuel was stored in the old gasoline tank within the bermed surface storage tank area. The fuel conditioning building is now used to supply the Cat generators with diesel fuel.

Jet B Fuel

A supply of jet fuel consisting of 20 drums is stored on pallets at the airstrip to refuel the medivac jet in case of emergency.

Lubricating Oil, Grease and Solvents

A large quantity and variety of hydraulic and lube oils are used for stationary, mobile and power generation equipment. Varsol is the main solvent used. The oils and solvents are delivered in 205 liter drums and the hydraulic and lube oils and grease are stored in kegs or tubes.

All of these items are stored on pallets in well marked locations on the pad below (to the west) of the oil tank farm (Photograph 10).

Glycol

Glycol is used in the heat exchanger system for the diesel generators and in the main heating system on the barge and in the accommodation building. Ethylene glycol is used in the barge systems and propylene glycol, a less toxic form of antifreeze/coolant, is used in the accommodations.

Glycol has also been used in the mine for expanding Swellex rock bolts; however, this use is rare at Polaris now. Glycol is delivered in 205L drums and stored on pallets in well marked locations on the pad below the diesel fuel tank farm. Forty-four drums of ethylene glycol were delivered to the mine site during the 1998 shipping season.

3. Facility Evaluation and Records Review

3.1 Site Inspection and Employee Interviews

A site visit was made by Gartner Lee personnel from May 11 to 15,1999. During the visit a complete site inspection was carried out, except for areas with no access in the winter conditions such as e.g. Frustration Lake.

The following Cominco/Contractor personnel assisted with the site inspection.

- Accommodation building: Doug Ryan (contract catering manager), Frank Murphy.
- Surface: Brad Sewell.
- Underground mine and CRF plant: Randy Reichert.
- Tailings thickener: Paul Simms.
- Barge: Paul Simms, Gerry Doyle, Jim Bonia, Dave Swain.

The following employees were interviewed to provide detailed history of the Polaris Operations.

- Dave Swain: Maintenance Supervisor.
- Mark Sampson: Supervisor, Maintenance Planning.
- Brad Sewell: Supervisor Surface Operations.
- Paul Simms: General Mill Foreman.
- Stu MacDonald: former General Foreman.
- George Casavant: former Mine General Foreman, (brief interview).

3.1.1 Landfill Site

No permits are required for solid waste disposal in landfill sites. The surface leases govern the establishment of landfill sites. The operational landfill, burn pit and an area currently used for open storage (former construction landfill) are located approximately 1 kilometre southeast of the mine process area, adjacent to the shoreline of Polaris Bay (Figure 7; Photographs 19-22). Information concerning the landfill construction, operation and maintenance was provided by Mr. Brad Sewell and Mr. Paul Simms of Cominco's Polaris Operations. A preliminary evaluation of the landfill area, conducted by UMA Engineering Ltd. in 1998, was also referenced.

The operational landfill has been used for disposal of domestic and non-hazardous waste since 1981. Waste disposal prior to 1981 apparently took place at the construction landfill; however, the type of waste disposed and the extent of the dumping and burial has not been confirmed. The surface of the former construction landfill is currently used for open storage of equipment.

The operational landfill is oriented in an east-west direction. Waste disposal was initiated at the west end of the landfill, with expansion occurring to the east. The landfill is elevated approximately 10 metres above the original grade. A soil berm has been constructed along the toe of the berm in order to contain any seepage.

Waste materials disposed to the landfill include:

- empty chemical and cement bags
- drained and rinsed chemical drums
- empty freon and propane gas cylinders
- empty explosive boxes
- empty waste oil containers
- food waste
- domestic waste
- metal waste (copper wire is recovered for sale by social club)
- rubber tires

Due to concerns such as attracting wildlife and in an effort to reduce the volume of waste buried at the site, waste oil is used to burn the combustible components of the disposed wastes to the greatest extent possible. Materials burned include: food and domestic waste, waste oils, fuels, and glycols. A burn pit has been used at the landfill site for open burning since it began operation. Concerns expressed by residents in Resolute regarding smoke from the burning operations, limited the burning to oil and food wastes from 1987 to the 1990's. However, observations of landfill gas buildup and rapid expansion of the landfill area prompted burning of all combustible material to be resumed in the early 1990's. A permanent burn pit structure was constructed in 1990, consisting of reinforced concrete for the walls and floor (Photograph 20).

Residue from the burn pit and the non-combustible wastes are dumped over the edge of the landfill and covered by granular material. The disposed material is not compacted, beyond that offered by the weight of the cover material.

Analytical data presented in the preliminary landfill investigation report prepared by UMA (1998) indicates that elevated levels of petroleum hydrocarbon components and metals were detected in soil samples and seepage at the toe of the landfill, particularly at the west end. Observations regarding the general condition of the landfill area were minimal due to the snow cover during the site visit in May.

Mine site personnel have installed a series of thermistors into the dump in March 1999 in order to monitor seasonal temperature conditions at depth. The information will be used to provide data for the development of reclamation options for mine decommissioning. A review of the data collected to date indicates that the dump remains frozen all year except for a surface layer of 1.05 m depth which warms to above zero in the summer (Figure 7). Thermistor measurements have been taken weekly since March 1999, the warmest readings to date were recorded on August 10,1999.

3.1.2 Reclamation Dump

A new landfill site was begun in 1997 and is known as the "Reclamation Dump" (Photographs 15, 17 and 18). This dump is located in the "sink hole" subsidence area above the orebody. The main purpose of this dump is to bury all unwanted equipment and non-hazardous materials (primarily steel) not destined for the landfill site. A written and photo record is being kept of all items buried in this dump (Brad Sewell, personal communication). Obsolete equipment to be buried is cleaned of all oils, fuels, and fluids and written approval given for each piece prior to burial. The Reclamation Dump has been used to clean up the old construction (Bechtel) laydown area. Items buried to date include dump truck boxes, sea-containers, tires, steel, wooden crates, conveyor pulleys, vehicles, rock bolts and others.

3.1.3 Particulate Air Emissions

No air emission permits are required under the regulatory framework for the mine operations. Following is a list of discharge sources that contribute particulate forms of lead and zinc to the environment at the mine site:

- Mine exhaust fans;
    - There are scrubbers on the dry exhaust to reduce the amount of contaminants discharged into the atmosphere; however, observations during the site visit indicate that significant quantities of particulates are discharged from these fans.
- Mill dryer exhaust fans. There are scrubbers on the dryer exhaust to reduce the amount of contaminants discharged into the atmosphere; however, observations during the site visit indicate that significant quantities of particulates are discharged from these fans.
- Cone crusher exhaust from the mill;
- Concentrate storage building, wind blown concentrate near the open access doors;
- Concentrate conveyor used to transfer concentrate to ship loading dock during the shipping season;
- Raise bore drill exhaust.

3.1.4 Rock Quarries

There are two types of quarries at the mine site, the Little Red Dog (LRD) quarry from which limestone aggregate material is extracted and the shale quarries (North Pit, Old Quarry and New Quarry), that have been used to fill the mined out areas of the underground.

Review of the available information on the geological properties of the ore, waste rock and overburden; as well as surface water runoff patterns and mine closure plans to minimize the infiltration of surface drainage to underground workings, indicates that potential for acid generation and acid rock drainage is very low. To confirm that metal leaching and acid rock drainage (ML/ARD) does not represent an issue of potential environmental concern at the mine site, four representative samples of the geologic units were collected for acid base accounting (ABA testing) and metal leaching tests. The rock samples were collected from the Little Red Dog Quarry, North Pit, Old Quarry and New Quarry and represent the Lower and Upper Thumb Mountain, Irene Bay, and Cape Phillips Formations, respectively. The results of the ARD testing indicate there is no potential for generation of ARD (Section 6.4).

3.1.5 Liquid Wastes

The only liquid wastes discharged to the environment are sewage and the summer discharge from Garrow Lake. No permits are required for sewage discharge. The sewage discharge includes: greywater from the accommodations building and process barge; water from the oil/water separator used to treat effluent from the steam bay; and, swimming pool water discharged for annual maintenance.

The design of the process barge incorporates a basement collection sump to contain all wash waters produced in the mill and concentrator. The wash waters are collected in the sump, coarse filtered and either recycled to the mill/concentrator process or combined with tailings for discharge to the thickener.

An indirect form of liquid waste results from the melting of snow containing particulate emissions of lead and zinc from air emissions such as the mill dryer exhaust. Because accumulations of snow in high traffic areas may require transport and stockpiling elsewhere, there is potential for metal contaminated melt waters to impact areas of the mine site where this snow is stored.

Garrow Lake effluent discharge limits are governed by the Water Licence discussed earlier. During the period up to and including 1989, the surface layer of Garrow Lake discharged through Garrow Creek into the ocean during the short open-water season, typically six to eight weeks. The maximum average concentrations of zinc and lead allowed in the discharge by the Water Licence were 0.15mg/L total zinc and 0.02mg/L total lead. All discharges during this period were within these concentrations.

As described above in Section 2.3.3 a dam was constructed in 1990 and there was no discharge from Garrow Lake for four years.

In 1994, the new Water License allowed maximum average concentrations for zinc and lead of 0.5mg/L and 0.07mg/L respectively. Each summer since 1994 a siphon discharge system has been discharging up to 3.2 million cubic metres of water while operating within the License limits. A summary of effluent discharge volumes and metal contents can be found in Table 3.1.

Table 3.1 Summary of Garrow Creek Effluent Discharge Quality

Year	Parameters mg/L (except pH) Pb	Zn	Cu	pH	Volume m3	Flow Dates	Remarks
1982	<0.02	<0.02-0.15	<0.02-0.016	-	n/a	July7-Sept8	One sample at end of flow season assayed 0.35mg/L Zn
1983				-	831,000	June30-Aug22	No sample results in report
1984	<0.005	<0.02-0.03	<0.002	-	1,594,334	June15-Sept2	
1985	<0.005	<0.02-0.04	<0.001-0.0038	-	1,704,067	June19-Aug21	
1986	<0.005	<0.04-0.12	<0.002-0.003	-	3,072,817	July1-Aug30	
1987	<0.001-0.006	0.02-0.14	<0.002-0.004	-	2,001,450	June29-Aug26	
1988	0.002-0.014	<0.02-0.12	<0.002-0.008	-	1,415,017	June27-Sept13	
1989	0.002-0.011	<0.02-0.13	<0.002-0.005	-	1,501,200	June 18-Sept18	
1990	-	-	-	-	-	-	No discharge from Garrow Lake, dam in place.
1991	-	-	-	-	-	-	No discharge from Garrow Lake.
1992	-	-	-	-	-	-	No discharge from Garrow Lake.
1993	-	-	-	-	-	-	No discharge from Garrow Lake.
1994	<0.001-0.004	0.1-0.3	-	7.8-8.3	1,034,023	July12-Sept13	New Water Licence Jan1/94.
1995	<0.001-0.004	0.12-0.35	-	7.0-8.9	2,906,783	July12-Sept9	
1996	0.001-0.006	0.09-0.18	-	8.0-8.8	2,665,934	July22-Oct7	
1997	0.003-0.026	0.1-0.24	-	7.62-8.3	3,283,773	July21-Oct7	All Pb assays below 0.02 except one sample at 0.026.
1998	<0.001-0.019	0.07-0.33	-	7.71-8.5	2,196,535	July2-Aug30	

3.1.6 Hazardous and Non-Hazardous Wastes

1) PCB's

There are 33 oil filled transformers on site, ranging from 4.5 to 21.5 gallon capacity. Twenty-six are in use on the tailings and fresh water line heat tracing and 7 are spares kept in a storage container. All other electrical transformers are the dry type.

All of these transformers were manufactured in 1980-1981. The manufacturers' nameplates do not indicate the oil type and it has been found impossible to contact the original manufacturer. Under the Canadian Environmental Protection Act, PCB containing equipment has not been manufactured since July 1980.

Samples were taken from four of the stored transformers by Cominco personnel following instructions from Gartner Lee. The samples were shipped to Gartner Lee and analyzed at an independent laboratory. No PCBs were detected in the oil (detection limit of 10 mg/L). It is likely the remaining transformers will show similar results, however this will be confirmed by sampling during Summer 2000.

2) Asbestos

The original insulation used for the diesel generator exhaust pipes contained asbestos bearing materials. In 1993 the asbestos material was removed by specialists and the exhausts were re-insulated with ceramic fibre and fibreglass tape. The asbestos material was sealed in steel drums and buried in backfill in the mine. The removal and disposal project received approval from the Environmental Engineer in the Mine Safety Division of the Government of the Northwest Territories.

3) Waste oils, lubricants, solvents and glycol

Waste oils, lubricants, solvents and glycol are collected in drums and burnt at the landfill site as fuel for burning the domestic garbage.

4) Batteries

Waste batteries handling consists of drumming for disposal off-site to an approved recycling facility.

3.1.7 Accidental Releases

1) Tailings

Between January 1982 and May 1999 there have been 11 minor tailings spills from the tailings line between the concentrator (barge) and the tailings thickener. The approximate locations of these spills are shown in Figure 8. In all cases the spills were reported to DIAND Water Resources.

Spill clean up was carried out as soon as possible. Spilled tailings and contaminated soils and gravels were disposed into the mine with the backfill. In cases where spills occurred in winter, final clean up was carried out when the surface active layer had thawed in the following summer (Photographs 32 and 39). Table 3.2 provides a list of accidental releases and estimated amounts of tailings spilled in each case.

Table 3.2 Tailing Spill Incidents

Date	Location	Description	Tonnes
1982 - March	Near Concentrator	Ruptured flange connection on tailings line	<10
1983 - April	Tailings Thickener	Valve coupling broke at tailings thickener. Tailings spilled into emergency berm and also across the road.	150-200
1986 - April	100m north of Thickener	Tailings line broken by D-8 Cat pushing snow	20
1988 - February	Between explosives magazine and landfill	Small hole in tailings line - no apparent cause	5
1989 - September	Near Concentrate storage building	Tailings line weld failure	10
1989 - September	Near Concentrate storage building	Tailings line weld failure	2
1989 - September	Between Concentrate storage and fuel tank farm	Tailings line weld failure	2
1991 - May	South of fuel storage tanks	Tailings line weld failure	5
1992 - May	South of Concentrate storage building	Tailings line weld failure	2
1992 - November	South of fuel storage tanks	Tailings line gasket failure	<20
1999 - February	Near Concentrate storage building	Small hole in tailings line.	2

2) Fuel

There are no documented fuel spills. However, there are verbal accounts of numerous small spills at the vehicle re-fuelling station adjacent to the steam bay at the north-west end of the barge. Employee interviews also determined there were a number of minor fuel spills in the area immediately north of the barge, during plant construction in 1980/81. There have been no fuel spills during unloading of fuel tankers at the dock and transfer of fuel to the above ground storage tanks. The employee interviews indicate minor amounts of fuel have been spilled from the external vents on barge storage tanks due to uneven flow when filling the tanks from tankers or when transferring fuel from the above ground tanks.

While no major spills have been documented, the type of fuel delivery (gravity feed) combined with the lack of volume and delivery controls at the vehicle re-fuelling station suggest that significant volumes of fuel may have been released to the ground during the years of mine operation. This possibility is further substantiated by observations of fuel odors in the meltwater control sump at the northwest corner of the process barge (personal communication Dave Swain, Paul Simms).

3) Chemicals

There are no documented chemical spills. There have been minor chemical spills in the storage areas caused by breakage of bags or boxes when handling with forklifts. These spills were always cleaned up with the materials disposed in the mill circuit.

3.2 Areas of Potential Environmental Concern

On the basis of the review of site information and a detailed inspection of current site conditions at the Cominco Ltd. Polaris Mine site, several areas and issues of potential environmental concern (APECs) have been identified. The APECs are listed below and the associated activity or use is summarized in Table 3.3 and illustrated in Figure 9.

1. Process Barge and Ship Loading Dock
2. Concentrate Storage Building
3. Outdoor Bulk Chemical Storage
4. Current and historic above-ground fuel storage tanks; barge storage tanks, diesel tank farm and pipelines
5. Outdoor lube/Hydraulic Oil and Glycol Drum Storage
6. Tailings Pipeline, Thickener Building and Emergency Discharge Basin
7. Former Oil Bladder Storage Area
8. Operational and Construction Landfill and Open Storage Areas
9. Fire Training Area
10. Old Anfo Mixing Plant, Explosives Storage and Old Crusher
11. Snow Dumps
12. Surface Above the Active Mining Area (Back-40)
13. Historic Surface Ore Stockpiles
14. Surface Lead Ore Stockpile

To address the issues and areas of potential environmental concern identified in the Phase 1 ESA, a Phase 2 reconnaissance testing program was undertaken at the Polaris mine site in July 1999. The work plan for the Phase 2 environmental site assessment was designed to provide environmental quality data for both known and suspected areas of contamination across the developed and adjacent undeveloped lands near the mine site. In addition, the Phase 2 testing program was designed to identify potential pathways for contaminant migration from source areas.

4. Phase 2 Environmental Site Assessment

The Phase 2 Environmental Site Assessment (ESA) constituted the initiation of field investigations to characterize the occurrence and extent of contamination in the areas of potential environmental concern identified in the Phase 1 ESA. An additional surficial soil sampling program was also conducted, and involved the collection of soil samples from far-field locations, in order to provide an expanded data base for metal concentrations in soils . The scope of work for the Phase 2 ESA included: a field investigation to collect soil, water and vegetation samples; laboratory analysis to determine the concentrations of chemicals of concern in soil, water and vegetation samples; an assessment of the environmental setting, including physical descriptions of geologic media and measurement of groundwater levels; an evaluation of the chemical data in relation to the federal regulatory guidelines for environmental quality and territorial standards, as appropriate; and delineation of the areas, depths and severity of contamination on the site, including an assessment of the potential for contaminant migration.

The overall objective of the Phase 2 ESA was to assess current environmental conditions to provide direction for future remedial planning. Specific objectives for the Phase 2 ESA conducted at the Polaris mine site were:

- To conduct a soil and groundwater sampling and analytical program to determine the nature, concentration and extent of any chemicals in the subsurface which exceed the federal or territorial regulatory guidelines for industrial land use or protection of aquatic life;
- To establish the scope and nature of any environmental or human health concerns relating to contaminant issues associated with the mining activity at the site; and
- To determine the requirements for remedial action to mitigate present or future environmental issues related to contamination of environmental media at the site, if any
- To generate a document suitable for review by government agencies.

4.1 Field Investigations

The majority of the Phase 2 field investigation program was conducted at the Polaris mine site from July 11 to July 16, 1999. A portion of the Phase 2 field investigations were conducted with the assistance of Polaris Operations geologists and engineers in May 1999, including: collection of country rock representative of the site geology for acid rock drainage (ARD) testing; and, a limited borehole drilling program and installation of water monitors in the vicinity of the process barge in May 1999, in order to utilize frozen ground conditions.

The field investigations conducted in July 1999 included: a test pit excavation and soil sampling program; surficial soil and vegetation sampling using judgmental and systematic grid sampling techniques; and, installation of monitoring wells to sample the meltwater or seepage that collects within the active layer. The field investigation program resulted in:

- the drilling of 14 boreholes and the installation of 10 monitors;
- the excavation of 84 test pits and the installation of monitors in 15 of the test pits;
- the collection of 145 surficial soil samples; and
- vegetation sampling at 8 locations, including locations near the mine operations, a background location and in downwind dispersion areas.
- Collection of 4 rock types for ARD testing

Table 3.3 provides the rationale for each borehole/test pit/vegetation sampling location in relation to the specific areas of potential environmental concern (APECs) identified in the Phase 1 ESA and illustrated in Figure 9. A summary of the seepage well monitoring information is provided in Table 4.1 and the locations of the sampling points are illustrated on Figure 10.

Sampling locations for the field investigation were chosen to address both the APECs identified in the Phase 1 and also to provide information on background concentrations of potential chemicals of concern (PCOCs) in soil and vegetation near the mine site. Background sampling was conducted at locations near the mine site, but outside the areas of operational impact (i.e.; up-wind, and reasonable distances from mine site operations)

4.1.1 Borehole Drilling

A limited borehole drilling program was conducted in May 1999 in the vicinity of the process barge. Historical site information collected during the Phase 1 ESA suggested that small scale spillage during refuelling at the vehicle fuelling facility, located at the northwest corner of the process barge had resulted in subsurface contamination with petroleum hydrocarbons, particularly diesel fuel, in this area. The purpose of the drilling program was to allow the collection of rockfill samples at depth, as well as to install monitors to sample groundwater. Drilling equipment at the mine site is limited to percussion type drills. Therefore frozen ground conditions are preferred to allow the collection of adequate soil samples at depth.

An electric hydraulic rotary percussion drill operated by Mr. Rory Clark of Cominco Ltd. - Polaris Operations was used to drill 14 boreholes. Monitoring wells were placed in 10 of them. The boreholes were drilled to an average depth of 3.7 meters, to coincide with the average thickness of the rockfill surrounding the process barge. Four of the boreholes were drilled to a maximum depth of 7.6 meters, to delineate the vertical extent of contamination in the rockfill.

Soil samples were generally collected over 0.6 meter intervals for the first 3 meters, and in 1.5 meter intervals at deeper depths. Due to the nature of the drilling and the high volume of air used to blow out the rockfill cuttings, the samples were highly disturbed. Detailed stratigraphic information was therefore not recorded. The soil samples were collected directly from the solids eject line into cleaned, laboratory certified 250 ml capacity glass jars. All soil samples were kept cool until transfer to the analytical laboratory. The samples were accompanied by completed, standard chain-of-custody forms.

Decontamination of the drilling apparatus between boreholes was not possible. Therefore, the least potentially contaminated locations were drilled first, with the last hole drilled in the location suspected to contain the highest level of petroleum hydrocarbon contamination.

4.1.2 Test Pit Excavation Program

Test pitting was conducted to allow observation of the subsurface soil conditions such as the presence of fill zones, soil horizons, permafrost, discoloration, oil sheens, hydrocarbon or other unusual odours, and seepage zones. Test pitting also permitted the collection of subsurface soil samples and the installation of seepage monitors. A total of 84 test pits were excavated in areas of potential environmental concern using a tracked excavator. Consideration was also given to obtaining adequate sampling coverage over the site.

Soil samples were taken during excavation of the test pits based on stratigraphy, visual and olfactory observations. Up to four soil samples were obtained from each test pit. Soil samples were collected directly from the walls of the test pit to a depth of 1.2 m and from the excavator bucket at deeper depths. Test pits were generally excavated until permafrost was encountered, at depths ranging from 0.8 to 1.2 meters.

Soil samples were collected into clean, laboratory certified 250 mL glass jars. Soil samples for possible volatile organic chemical (VOC) analyses were collected in a 125 mL jar with a Teflon lined lid. Duplicate soil samples were also collected. All soil was 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.

4.1.3 Surficial Soil Sampling

Surficial soil sampling was conducted within the active mine site, in areas previously identified as representing potential environmental concern, as well as potential downwind areas to the east and toward Riddle Point and background areas to the northeast near Frustration Lake. The rationale for the sampling of far-field locations was to assess the potential impact of airborne particulate sources of metal contamination (in particular lead and zinc) from areas such as the mill dryer exhausts and mine exhaust fans. Figure 10 shows the location of the surficial sampling locations.

Surficial soil sampling consisted of the collection of the upper 0.1 meters of the soil surface using a stainless steel trowel or mattock to break the compacted surface. The locations for the soil samples were identified using air photos. Soil samples were inspected, logged and collected directly into a cleaned, laboratory certified 250 mL capacity jar. A 1 cm diameter steel rod was used to determine the depth to permafrost at each location. This information, the physical description of the soil sample and the sample location were used to develop the terrain map for the Polaris mine site and adjacent lands. Duplicate soil samples were also collected. All soil was 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.

4.1.4 ARD Rock Sampling

In order to confirm that metal leaching and acid rock drainage (ML/ARD) does not represent an issue of potential environmental concern for the exposed rock at the surface quarries and surface waste dumps, representative samples of the four major geologic units were collected for static acid rock drainage potential tests, including: acid base accounting (ABA testing), total metals, and water leachable ions. The rock samples were collected from the Little Red Dog Quarry (LRD), North Pit, Old Quarry and New Quarry and represent the Lower and Upper Thumb Mountain, Irene Bay, and Cape Phillips Formations, respectively. The sample locations and rock types are listed below.

Location	Rock Type
LRD Pit	Limestone
North Pit	Dolomite
Old Quarry	Green Shale
New Quarry	Brown Shale

4.1.5 Installation of Seepage Monitors and Water Sampling

Following the drilling of the boreholes in May 1999 seepage monitors were installed. The monitors consist of 0.051m (2”) diameter, Schedule 40, threaded flush joint PVC pipe with a machine slotted screened section at the lower end. The screened section was isolated with a 0.5 meter thick plug of bentonite clay. A second plug of bentonite was placed just below ground surface to provide a seal and prevent downhole migration of surface water.

Monitor installation within the test pits was limited to those locations in which seepage waters accumulated to a minimum depth of 20 cm within 24 hours. The PVC pipe described above was used at each location; however, because of the disturbed nature of the excavation, a geotextile “sock” was placed over the slotted section of the pipe to act as a filter for suspended fine-grained sediment. The pit was backfilled around the vertical pipe and the surface was compacted.

Dedicated sampling equipment consisting of polyethylene tubing fitted with a Waterra inertial pump at the base was installed in each monitor for the purpose of purging and sampling the seepage water. This sampling system was also used to develop the monitor immediately after installation. Developing involved the agitation and evacuation of groundwater from the well to remove any drilling induced disturbances.

Seepage water level measurements were taken and sampling of each of the monitors was conducted approximately 2 days after the installation of the test pit monitors and well development activities in July 1999 to allow for the stabilization of subsurface conditions.

An electric oil/water interface probe was used to determine the presence of light (LNAPL) or dense (DNAPL) non-aqueous phase liquids. Non-aqueous phase liquids are immiscible in water. LNAPLs are lighter than water and tend to float on the water table. Diesel fuel and oils typically have a specific gravity less than 1 and therefore behave as LNAPLs. DNAPLs are denser than water and tend to sink to the base of a saturated layer.

A measurable thickness of LNAPL was encountered in one monitor, BH-1, located at the northwest corner of the Bent Horn building (Table 3.2 and Photograph 40). LNAPL was not measured at any of the other monitor locations. DNAPLs were not found in any of the monitor locations. Monitor construction details and water table elevations are provided in Table 3.2.

Prior to seepage water sampling, the monitoring wells were purged to remove a minimum of three well volumes using the dedicated sampling equipment. Seepage samples were collected from each well once the levels had recovered to near static values. If the volume of water accumulated in the monitor was less than 0.5 m of water, then a disposable bailer was used to collect the water sample. Water samples were placed into precleaned, laboratory certified containers, specific for each chemical parameter to be analyzed. A 1 litre capacity plastic bottle was used for conventional parameter analysis; samples collected for extractable petroleum hydrocarbons (EPH), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) were placed in 1 litre amber glass jars; samples obtained for analysis of volatile organic compounds (VOCs) were collected into purge and trap vials; nutrient samples were collected into 250 mL amber bottles and preserved with sulfuric acid; and, samples to be submitted for analysis of dissolved metal concentrations, were filtered in the field using an in-line filter apparatus, and preserved with nitric acid.

All water samples were collected as per established protocols specified in the *Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites* (CCME, 1993). Immediately after collection, each sample was placed in a cooler and stored at approximately 4^oC until delivered to the analytical laboratory. Standard chain-of-custody forms accompanied all samples submitted to the laboratory.

4.1.6 Vegetation Sampling

The vegetation sampling program was based on previous mapping of vegetation units, sampling and analysis conducted by BC Research (1975) prior to development of the Polaris Mine. The BC Research study described the baseline environmental conditions that may be affected by the mine development and outlined the major areas of ecological sensitivity.

Six vegetation types were identified and their extent was mapped. These areas have been overlain on a current map of the mine site and surrounding area (Figure 11). Figure 11 shows that the environmental study conducted by BC Research in 1975 prior to mine development classified the current mine site area, generally west of Loon Lake, as a Bare vegetation unit. This vegetation type has an average plant cover of less than 10% and is characterized by a coarse dolomitized surface that is dry and well drained. The wet meadow vegetation type was considered to be the most biologically sensitive and the willow and lichen-moss-algae units were categorized as moderately sensitive. The lichen-moss-algae unit was the most prevalent vegetation unit, extending over 63 percent of the study area.

Four vegetation sampling locations were established by BC Research in the 1975 study. These locations are shown as sampling points A, B, C and D on Figure 1. These sampling locations and four additional locations, labelled E, F, G and H (Figure 10) were sampled for vegetation during the Phase 2 field program. The vegetation sampling station located closest to the mine site development, Station A, is situated approximately 1 kilometre east of the concentrator.

Plants species sampled previously by BC Research (1975) include: *Thamnolia subuliformis* (an abundant lichen), *Alopecurus alpinus* (a grass species), and *Salix arctica* (the Arctic willow). BC Research selected these plant species on the basis of their widespread occurrence across the study area, ease of collection and importance as potential wildlife food. In order to provide a consistent data base, the present study also attempted to collect each of these three species at the sampling stations; however, not all species were found at all stations. The Arctic willow, in particular, was not found at 3 of the 8 vegetation sampling stations.

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. The plant species were collected into paper bags. Standard Chain-of Custody Forms accompanied all samples shipped to the analytical laboratory.

4.1.7 Sample Site Locations and Surveying

Mine site survey personnel conducted a location and elevation survey for the borehole and selected test pit locations. All test pit locations with a monitor installed were surveyed. Aerial photographs and a hand-held GPS were used to locate surface sampling stations. All survey data was transferred to the mine grid and plotted.

4.2 Analytical Program

On the basis of the information provided in the Phase 1 ESA concerning industrial activities and storage, use, and disposal of chemicals as well as contaminant observations during the field investigations, the potential chemicals of concern at the mine site would include: metals, predominantly lead and zinc, resulting from the mining, milling and concentration of ore; and, petroleum hydrocarbons from fuel storage, dispensing and disposal. 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. Analysis of soil, water and vegetation samples was conducted by Analytical Service Laboratories (ASL) of Vancouver, B.C.

Soil Samples

Soil samples were analyzed to determine concentrations of lead and zinc. The digested sample extracts were retained, and a selected number of soil samples were subsequently analyzed for a full metal scan by ICP.

The total number of soil samples collected by the three sampling methods, the analytical parameters and number of samples analyzed are summarized below in Table 4.2.

Table 4.2 Lead and Zinc Analysis Summary

Collection Method	Total # Samples	Number of Samples Analyzed	
		Pb & Zn	Extractable Petroleum Hydrocarbons
Borehole Drilling	65	28	32
Test Pit Excavation	239	114	75
Surficial Sampling	145	126	-

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).

Seepage Water Samples

Seepage water was collected from each of the monitors containing a sufficient volume of water (i.e. a minimum of 0.2 m of water) to be sampled. These included: 7 of the 10 monitors located in the vicinity of the process barge, and the 5 monitors located upgradient and downgradient of the operational and construction landfills. In addition, a water sample was collected from the sump located at the northwest corner of the barge. The water samples were collected using either a disposable bailer, or if a sufficient volume of water was available, a dedicated Waterra tubing apparatus. Samples collected for dissolved metals analysis were filtered in the field using a Waterra in-line filter apparatus.

Conductivity and pH measurements were obtained in the field for each seepage water sample. The seepage water samples were submitted to Analytical Service Laboratories Ltd. (ASL) in Vancouver, B.C. to determine concentrations of: dissolved metals, nutrients, cyanide, glycols, volatile organic compounds (VOCs), and petroleum hydrocarbon components, including: extractable petroleum hydrocarbons (LEPH/HEPH), BTEX compounds, and polycylic aromatic hydrocarbons (PAHs).

The seepage water samples were selected for analysis of the various chemical parameters on the basis of proximity to areas of potential environmental concern as well as to provide sufficient characterization of the water quality.

Vegetation Samples

All of the samples of *Salix arctica* (Arctic willow), *Alopecurus alpinus* grass and *Thamnolia subuliformis* (lichen) collected from the vegetation sampling stations were analyzed to determine pH and metal concentrations. Sample preparation included, physically removing soil adhering to the tissue, air drying and grinding. It should be noted that the leafy tissue had become dry and somewhat brittle prior to preparation for analysis. Therefore, thorough removal of the soil particles adhering to the plant was difficult.

Acid Rock Drainage Tests

Rock samples were submitted to BC Research for static acid rock drainage potential tests that included the following parameters:

- Acid-Base Account – Paste pH, total sulphur, sulphur as sulphate, sulphur as sulphide, inorganic carbon (carbonate). The method followed standard procedures described by Sobek et al (1978).
- Aqua regia digestible metals. Metals were determined by ICP.
- Water Leachable Ions. The samples were extracted for 24 hours using a 20:1 (w/w) deionized water leachate. The filtered leachate was analyzed using ICP.

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. 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 protocols 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. The results of the QA/QC program showed the following:

- analytical detection limits were generally consistent with currently achievable levels using accepted methodologies for each chemical parameter analyzed. However, detection limits for some of the metals and hydrocarbon parameters were increased in several samples due to analytical interferences caused by the high salt content of the samples.

- Concentrations for duplicate analyses were within acceptable ranges for soil and water samples; however, duplicate analyses for vegetation samples did not fall within acceptable ranges. Replicate analyses were subsequently undertaken by the analytical laboratory, with poor results. The laboratory concluded that the variability was not due to the analytical method, but likely reflected the heterogeneous nature of the samples.

5. Site Characterization

5.1 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 (Figure 4).

Local stratigraphic information was obtained from the 84 test pits excavated across the site and the field check data collected for the terrain analysis during the far-field soil sampling. 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 and on the soil thermal properties. In areas of development, 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 shallow, averaging 0.6m in undeveloped areas across the mine site and over 1 meter on south facing slopes and disturbed areas. Within the process barge rockfill area, observations during test pit excavation showed that the thickness of the active layer at a location directly adjacent to the barge wall is over 3 meters. The active layer thickness decreased to 1.5 meters within a 1 meter lateral distance from the barge wall, and averaged 1 meter at greater distances from the barge (Figure 5 and Photo 35).

The Polaris mine site soils are classified as Cryolsolic, having permafrost occurring within 1 to 2 meters of the ground surface and having a mean annual temperature below 0 degrees Celsius. 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. 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.

5.2 Groundwater– Physical Description

Water levels were measured July 10, 1999 in the 10 monitors installed in May 1999 (Table 4.1). Free water was measured in 4 of the 10 monitors (BH-1, -5, -6, -7). Two of the wells contained a thickness of frozen water (BH-2, -8) and the remaining wells were dry (BH-3, -4, -9, -10). The wells that were dry generally were screened at deeper depths (1.6-4.6 m) than the wells that accumulated meltwater (measured as either free or frozen and screened at a depth interval of 0.7-3.7 m). The test pit excavation program conducted in July 1999 showed that in the vicinity of the previously installed monitors screened at the deeper depths (BH-3, -4, -9 and -10) and in the vicinity of the process barge, the thickness of the active layer was approximately 1 to 1.2 m. These monitors had therefore been screened below the active layer, completely within the zone of permafrost.

The measured depth to groundwater in monitors installed in test pits excavated in the barge area varied from 0.4 m in BH-5 located closest to the dock, to 2.1 m in TP-5 located adjacent to the east side of the barge. The depth to water in the landfill area ranged from 0.24 m in the upgradient monitor (TP-61) where the active layer was measured to be 0.9 m thick, to 1.08 m in TP-55 located at the toe of the construction landfill where the active layer was 1.2 meters thick. The increase in the thickness of the active layer at the toe of the landfill is likely due to the accumulation of surface drainage in the area.

As discussed previously, the thickness of the active layer is also influenced by the presence of heat sources, such as the barge. Accordingly, the thickness of the active layer and the associated saturated layer is greater near the barge (i.e., TP-5) than distances away from the barge (i.e., TP-14). The cross-section of the barge area (Figure 5) illustrates the influence of this heat source on the thickness of the active layer.

The results of groundwater level monitoring show that a thin layer of melted water accumulates above the permafrost and within the active layer, during the summer season. However, there is little potential for large-scale movement of groundwater due to factors such as the restricted recharge, the low temperature of the groundwater which contributes to its viscosity, and the limited thickness of the saturated zone. The groundwater flow system is therefore very localized and would be significantly affected by local conditions such as differential melting due to the presence of heat sources, sump pumping, soil quality characteristics and soil permeability. Figure 5, showing the cross-section of the barge area, illustrates the occurrence of seepage water in relation to the measured thickness of the active layer.

6. Contaminant Occurrence And Distribution

Potential chemicals of concern (PCOCs) associated with industrial activities at the Polaris lead-zinc mine site are described below:

- **Heavy Metals, particularly lead and zinc**
  Potential sources include: stockpiling of ore above ground; storage, use and handling of metal containing mill process chemicals; concentrate storage, handling, vehicle tracking or spills; tailings spills; windborne air dispersion of particulates; snow dumps; mineralized rockfill.

- **Petroleum Hydrocarbons, including diesel fuel, lubricating and hydraulic oils**
  Potential contamination from the storage, transfer, use and disposal of petroleum hydrocarbon source areas at the mine site include: the barge bottom and side fuel storage tanks, the vehicle fuelling tank, a day tank located on the west side of the barge, fuel pipelines, the oil tank farm, outdoor lube and hydraulic oil storage, current and former aboveground fuel storage tank installations at the foldaway buildings, the CRF plant, the tailings thickener building, the firehall, and the fire training area, and a diesel tank located underground.

- **Mill and Mine Process Chemicals and Explosives**
  Potential sources of contamination from the storage, handling, use and disposal of bulk chemicals used in the mine and mill processes, include: the outdoor chemical storage area west of the concentrate storage building; the operational landfill, the explosives storage area and the underground.

In order to determine the occurrence, distribution and extent of the potential chemicals of concern, the Polaris mine site was divided into several geographically distinct areas on the basis of the industrial site activities. These areas correlate with the areas of potential environmental concern (APECs) identified in the Phase 1 ESA and illustrated in Figure 2. The results of sample analysis within each APEC are discussed in terms of: the occurrence in the potential source area, the potential migration pathways for PCOCs, and the lateral and vertical extent of soil and water containing chemical concentrations in excess of the regulatory guidelines or standards.

The units of measure generally used to quantify concentrations of contaminants in soil are generally µg/g or mg/kg , representing one part in one million (ppm). Units of measure generally used to quantify concentrations of contaminants in water are generally mg/l, parts per million or µg/l, parts per billion (ppb).

6.1 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[8] The third tier uses risk assessment procedures to establish remediation objectives at contaminated sites on a site-specific basis.

6.1.1 Soil Quality

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, 1999a).

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, 1999a).

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[8] 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.

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. 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.

The site-specific SQRO's for lead and zinc were determined through the CCME recommended risk-based approach. The guidance manual states that:

> When site conditions are outside what was considered in developing the guidelines using the soil protocol, or beyond the limited modifications outlined under *[the criteria-based approach of modifying guidelines within limits]*, the site-specific conditions may lead to a recommendation to perform risk assessment as the basis for developing site-specific remediation objectives (CCME, 1999a, p 19).

Given the unique high Arctic ecology, and the Inuit traditional land use pattern, the use of risk assessment for the development of the site-specific SQRO's was deemed appropriate.

The determination of the SQRO's for both lead and zinc are described below.

Site-specific soil quality remediation objective for lead:

As outlined in the Table 6.1 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 6.1 Soil quality guidelines (ppm) for lead

	LAND USE	
	Agricultural	**Residential/Parkland**
Guideline	**70**	**140**
SQG_{HH}	140	140
Limiting pathway for SQG_{HH}	Soil ingestion	Soil ingestion
SQG_E	70	300
Limiting pathway for SQG_E	Soil and food ingestion	Soil contact

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

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; A.J. Keen, personal communication, March 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 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 1,800 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.

Site-specific 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 6.2 below).

Table 6.2 Soil quality guidelines (ppm) for zinc

	LAND USE	
	Agricultural	**Residential/Parkland**
Guideline	**200**	**200**
SQG_{HH}	NC	NC
Limiting pathway for SQG_{HH}	NC	NC
SQG_{E}	200	200
Limiting pathway for SQG_{E}	Soil contact	Soil contact

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

B.C. Research (1975) described the Mine site on Little Cornwallis Island as barren with little vegetation. The three primary plant species were: *Salix arctica* (willow); *Alopecurus alpinus* (grass); and *Thamnolia subuliformis* (lichen). Historically, zinc concentrations have generally been the highest in willows. Willows are a long-lived species that tend to accumulate higher concentrations of metals than such short-lived species such as *Alopecurus*. Lichen derive metals from the air and therefore, unless relatively high ambient airborne metal concentrations were present, high lichen tissue concentrations would not occur.

Wildlife can be exposed to zinc by feeding on vegetation such as the aforementioned willow species. Herbivorous wildlife such as the site-identified lemmings (*Lemmus lemmus*) are an important component of the Arctic ecosystem and are considered key indicator (or sentinel) species which generally exhibit higher tissue concentrations than other wildlife species within the same environment. Factors contributing to this include: year-round residence; small home ranges; high consumption of food (vegetation) relative to body weight; direct contact with potentially contaminated media (i.e., soil); and high reproductive rates. Thus it is expected that impacts would occur in lemming populations before other wildlife populations in the area would be affected.

In deriving a site-specific SQRO for zinc, the risk assessment:

1. Determined a daily exposure to zinc that would result in no negative health effects in lemmings (i.e., no-observable-adverse-effect-level)
2. Calculated the site-specific soil to *Salix* biotransfer factor of zinc
3. Resolved a zinc soil concentration that would result in vegetation concentrations that, when fed upon by lemmings, would not result in adverse effect.

Following this procedure, 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 a concentration of 650 ppm.

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.

6.1.2 Groundwater Quality

Groundwater quality was initially evaluated using the CCME water quality guidelines for the protection of aquatic life. These guidelines are conservative and intended to represent ambient concentrations rather than remediation objectives for groundwater. The guidelines are also not 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.

6.2 Soil Quality Assessment

The results of analysis for the soil samples collected at the Polaris mine site during the Phase 2 and follow-up sampling are summarized in the following tables:

- Table 6.3. Lead and zinc concentrations in surface soil samples;
- Table 6.4. Lead and zinc concentrations in borehole and test pit soil samples;
- Table 6.5 Total metal concentrations in soil samples;
- Table 6.6 Extractable petroleum hydrocarbon (EPH) concentrations in borehole and test pit soil samples.

The applicable regulatory guidelines or standards for each analytical parameter are included with the analytical data in each table. The laboratory reports and results of the analytical QA/QC program are provided in Appendix B. Figures 12 A through D illustrate the location and general extent of the elevated metal and hydrocarbon concentrations in soil samples across the mine site.

6.2.1 Process Barge and Shiploading Dock Area

Metals

The results of lead and zinc analysis for surficial soil samples are shown in Table 6.3 and the results for test pit and borehole soil samples are shown in Table 6.4. Figure 12A illustrates the distribution and extent of the lead and zinc concentrations in the soil samples collected in the vicinity of the process barge and shiploading dock. Surficial sampling was conducted along the hillslope to the east and south of the process barge, where the overburden occurs as a thin veneer over bedrock. Borehole and test pit locations were largely confined to the rockfill area surrounding the barge.

Fourteen surface soil samples, 27 borehole soil samples, and 25 test pit samples were analyzed to determine lead and zinc concentrations. The results indicate that concentrations of lead in the soil samples range from 19 ug/g to 1.7% and the concentrations of zinc range from 40 ug/g to 11.1%. The majority of surface and near surface soil samples collected from the area surrounding the barge and shiploading dock contained lead zinc concentrations in excess of the risk-based remedial objectives (1,800 ug/g and 650 ug/g, respectively). Lead and zinc concentrations were also elevated at depths in excess of 0.4 meters in the rockfill area surrounding the barge.

Evaluation of the borehole drilling results indicates that, with some exceptions, metal contamination generally attenuates at depths in excess of 1.5 meters. Figure 12A indicates the sample locations where metal contamination occurs at depths in excess of 0.4 meters. The rockfill used to surround the process barge was derived from waste rock excavated during pre-production mine development. The source of the elevated lead and zinc can therefore likely be attributed to sulfide mineralization in the rockfill.

Samples collected from the area south of the barge where the concentrate dryers vent contained the highest levels of lead and zinc in surficial soil samples. Particulate emissions as well as concentrate transfer via the conveyor to the storage building represent the source of the metal contamination in this area (Photo 13).

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 have been identified:

- concentrates from dryer emissions, spillage, vehicle tracking, and conveyor transfer; and,
- mineralized rockfill materials which have resulted in the occurrence of elevated metal concentrations at depth.

Potential migration pathways 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.

Total Metal Concentrations

Analysis to determine total metal concentrations in soil samples (Table 6.5) confirms that lead and zinc are the primary metal contaminants in the samples, with some samples also containing concentrations of cadmium that exceed the regulatory guidelines. Zinc is the determining parameter in all samples contaminated with metals. For example, of the 36 soil samples collected from surface to 0.3 meters depth that exceeded the remedial objectives, all contained elevated zinc concentrations, while only 29 of the samples also exceeded the objective for lead concentrations. The occurrence of cadmium levels that exceed the CCME tier 1 soil quality guidelines is also closely correlated with zinc concentrations (i.e., Cd vs. Zn in linear regression fit results in an r-squared = 0.958).

Petroleum Hydrocarbons

Table 6.6 summarizes the results of extractable petroleum hydrocarbon concentrations in soil samples and Figure 12B illustrates the distribution and extent of hydrocarbon concentrations in the vicinity of the process barge and ship loading dock. Soil samples were selected for analysis on the basis of contaminant observations such as staining and detectable hydrocarbon odors, as well as to provide adequate data coverage. CCME does not regulate concentrations of extractable petroleum hydrocarbons. Therefore, the analytical results were compared with the Yukon Territorial Contaminated Sites Regulations standards for industrial land use and the NWT Remediation Guidelines for total petroleum hydrocarbons.

The results of analysis indicate that 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 indicate that the petroleum hydrocarbon source is diesel fuel. Elevated concentrations of heavy extractable petroleum hydrocarbons (HEPH) were found in soil samples collected from test pit TP8, located adjacent to the waste oil storage container at the entrance to the equipment maintenance shop.

Observations during test pit excavation indicated that evidence of petroleum hydrocarbon contamination such as odors and soil staining was strongest at the top of the water table and the permafrost contact. These observations correlate with the results of soil testing, where the highest concentrations of LEPH are found within the saturated portion of the active layer.

Soil samples collected within the layer of continuous permafrost during borehole drilling in May 1999, provided confirmation that the residual concentrations of hydrocarbons are confined to the active layer. Borehole 6 and 7 were drilled to a total depth of 3.7 meters. Test pit excavation in the vicinity of these boreholes in July 1999 as well as water level measurements within the boreholes in July 1999 showed the thickness of the active layer to be approximately 1.1 to 1.5 meters (Table 6.4) below ground level. The results of analysis shown in Table 6.6 indicate that elevated levels of hydrocarbon residuals in soils sampled from BH-6 and BH-7 are found at a depth interval of 0.6 to 1.5 meters. Samples collected at depths above and below this interval do not contain elevated concentrations of hydrocarbon residuals.

The distribution and extent of soils contaminated with petroleum hydrocarbons is illustrated in Figure 12B. Hydrocarbon contaminated soils are present within the rockfill area surrounding the process barge to the maximum depth of the active layer, as measured in July 1999. Therefore, the average depth of contamination at distances greater than 3 meters from the barge is approximately 1.2 meters, increasing to 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: the above ground vehicle fuelling tank, the day tank located on the west side of the barge, and the fuel tanks at the base of the barge. Infiltration of hydrocarbons from chronic spillage during vehicle fuelling and accidental releases from the vents during filling of the tanks in the base of the barge represents the major pathway for migration to the subsurface. Oil products are lighter than water and therefore tend to float on the water table. Differential heating has resulted in a thicker active layer adjacent to and beneath the barge.

The slope of the permafrost surface is in the direction of the barge and away from the ocean. Therefore it is suggested that the barge area serves as a sink for the migration of diesel fuel contaminated seasonal meltwater (groundwater) during the summer season. The presence of the frozen shiploading dock to the west of the barge would further limit migration of contaminated groundwater in the direction of the ocean.

6.2.2 Concentrate Storage Building / Conveyor and Outdoor Chemical Storage Area

The soil quality assessment in the vicinity of the concentrate storage building, conveyor and the outdoor chemical storage area was limited to potential metal contamination. Sources of petroleum hydrocarbon contamination are not present in this area of the mine site.

The results of lead and zinc analysis for test pit soil samples are shown in Table 6.4. Figure 12A illustrates the distribution and extent of the lead and zinc concentrations in the soil samples collected in the vicinity of the concentrate storage building and the outdoor chemical storage area. Surficial soil samples collected upslope of the concentrate storage building and along the tailings line are discussed in Section 6.2.8.

Twenty-seven soil samples collected from 15 test pits excavated in the vicinity of the concentrate storage building and conveyor, and 4 test pits located adjacent to the bulk chemical storage were analyzed to determine concentrations of lead and zinc. A total metal analysis (Table 6.5) was also conducted on 3 of the soil samples (TP-31, TP-34 and TP-40). The results of analysis show that lead and zinc concentrations are elevated in all test pit locations with the exception of the southwest side of the concentrate conveyor (Test pits TP-37 and TP-39) and the southern section of the outdoor bulk chemical storage (TP-42). 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 144 ug/g to 16.8% zinc. The source of the elevated metal concentrations in this area is attributed to wind-borne dispersion and vehicle tracking of metal concentrates.

On the basis of the analytical results and observations during soil sampling, the areas containing percentage levels of lead and zinc are located in the vicinity of the following source areas: the concentrate conveyor to the south 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); and the conveyor loading areas.

Total metal analysis of soil samples collected from test pit TP-40, located near the outdoor bulk chemical storage area for copper and zinc sulphates (Table 6.5) showed elevated concentrations of copper as well as cadmium, lead and zinc. The elevated concentrations of copper in this area is likely the result of accidental releases of $CuSO_4$ due to heavy equipment handling.

The concentrations of lead and zinc in surficial soil samples collected upslope and to the south of the concentrate storage building show that while the metal concentrations exceed the risk-based remedial objectives for protection of human health and the environment, the levels are generally less than those found in samples located near the barge and concentrate storage building.

6.2.3 Oil Tank Farm and Fuel Pipeline; Hydraulic/Lube Oil Storage Area and Foldaway Buildings

Soil samples collected from test pits excavated in the vicinity of sources of petroleum hydrocarbons, including: the diesel storage tanks, stored drums of hydraulic and lube oil, and a 500 gallon aboveground diesel fuel storage located on the east side of the foldways buildings. They were analyzed to determine concentrations of extractable petroleum hydrocarbons. Samples were not collected along the fuel pipeline area because both the Phase 1 record search and on-site observations failed to identify areas of potential concern with respect to accidental releases along the fuel pipeline in this area of the site.

Lead and zinc concentrations were also determined in several of the test pit soil samples and surficial sampling locations upslope and to the south of this area to determine the extent of potential metal contamination in areas down-wind of the milling and concentrate storage operations.

Metals

The analytical results for lead and zinc concentrations in soil samples is summarized in Tables 6.3 and 6.4. Figure 12C illustrates the location and distribution of metal concentrations in soil samples collected from the oil storage areas, foldaway buildings, and down-wind areas to the south and east.

Soil samples collected from test pits TP-80 and TP-81, located adjacent to the hydraulic and lube oil storage areas and test pits TP-44 and TP-45 located on the east side of the roadway contained percentage levels of lead and zinc to depths exceeding 0.4 metres. Soil samples collected from test pit locations downslope of the oil storage area (TP-46 and TP-47) did not contain concentrations of lead and zinc that exceeded the risk-based remedial objectives.

Stratigraphic observations during excavation at test pits TP-44 and TP-45 indicated that overburden formed a thin veneer over bedrock on the hillslope above the oil storage area. Based on the high levels of lead and zinc at depth, it is likely that construction of the bench on which the oil storage area is situated was constructed from rockfill material that contained mineralization. Although the thickness of the active layer in this area was measured to be approximately 1 meter, groundwater did not accumulate in sufficient volumes to allow sampling.

A surface soil sample collected from test pit TP-82, located on the west side of the foldaway buildings was also found to contain concentrations of lead and zinc in excess of risk-based remedial objectives. An old dock structure is located in this area, and inspection of the foreshore fronting this test pit location indicated the presence of sulfide-mineralization in waste rock surrounding the dock.

Metal concentrations in surface samples collected from down-wind dispersion areas, and upslope of the diesel and fuel storage areas contained concentrations of zinc that were slightly in excess of the risk-based remedial objectives. Lead concentrations were generally less than the remedial objectives. These results indicate that the down-wind dispersion pathway for particulate metal contamination originating at the mill and concentrate storage areas has not severely impacted surface soils near the mine site.

Petroleum Hydrocarbons

Table 6.6 and Figure 12D summarize the results of extractable petroleum hydrocarbon analysis in soil samples collected from test pits located downslope of the diesel storage tanks, at the oil storage area and adjacent to the above ground diesel tank at the foldaway buildings. The results indicate that, with the exception of the test pit location excavated directly adjacent to the aboveground diesel tank at the foldaway buildings (TP-43), petroleum hydrocarbon concentrations in soil samples do not exceed the NWT guidelines for TPH or Yukon industrial land use standards for LEPH. Observations during excavation of test pit TP-43 indicated that hydrocarbon odors and staining were present from the surface to the top of the permafrost layer. Test pit TP-82 was excavated downgradient of TP-43 in order to determine whether potential for contaminant migration to the ocean was possible. Observations during test pit excavation and the results of sample analysis showed that elevated concentrations of petroleum hydrocarbons were not present at this location.

6.2.4 Operational and Construction Landfill and Former Anfo Mixing Area

The construction landfill, located directly adjacent to the shoreline, was used during the construction phase of the mine, prior to 1981. The operational landfill, located directly upslope, became the primary disposal site following initiation of full-scale mine operation. The surface of the construction landfill is used as an open storage area for heavy equipment and used construction materials such as plywood sheets.

As discussed in Section 3.1.1, current disposal practices at the operational landfill involve the burning of any combustible wastes in the concrete burn pit, using waste oils as the fuel source. Operational practices have varied from burning only combustible materials to burning all waste materials to reduce the volume of wastes to be buried. The current burn pit is located at the west-end of the landfill. Historically, other areas of the landfill have also been used for burning, including areas near the base of the landfill. Residue from the burn pit and other waste materials are stockpiled at the east end of the landfill and subsequently pushed over the top of the slope. The waste materials are intermittently covered with rockfill material.

A rockfill berm has been constructed along the toe of the operational landfill. The berm is intended to restrict the downslope movement of wastes and surface runoff in the summer season. Deeply incised erosion channels have formed downslope of the operational landfill at the west-end (Photograph 31) likely in response to large volumes of melt water originating from snow dumps that were historically placed at the top of the landfill. The erosion channels were not observed to contain water during the week of the field investigation (July 11-16, 1999) or subsequent sampling in early September 1999. Test pit TP-56 was located downslope of a large erosion channel to determine potential for contaminant migration via surface water transport. No physical evidence of solid waste accumulation was found. The test pit was left open for 24 hours to allow water seepage to accumulate; however, it remained dry. A water monitor was therefore not installed at this location.

To identify potential migration pathways for contaminants originating in the landfill and to assess the potential impact of the landfills on the receiving environment, test pits were located: upgradient of the operational landfill (TP-61); along the toe of the operational landfill and downslope of the current burn pit area (TP-57, TP-58, TP-59 and TP-60); and, along the toe of the construction landfill, near the interface with the shoreline of Cominco Bay (TP-52, TP-53, TP-54, TP-55 and TP-56).

The location of the former Anfo mixing area was identified in historic aerial photographs. The facility has been decommissioned, with only a mound of disturbed rockfill remaining as evidence of its former location. Three test pits were excavated downslope of the former Anfo mixing area, TP-49, TP-50 and TP-51.

Soil samples collected from test pits located upgradient and downgradient of the landfills and in the vicinity of the former Anfo mixing area to the east were analyzed to determine concentrations of metals and petroleum hydrocarbons. The results of analysis are shown in Tables 6.3 through 6.6 and illustrated in Figures 12C and 12D.

Metals

The results of metal analysis indicate that lead and zinc concentrations in excess of the risk-based remedial objectives are not found in soil samples collected from the test pits located at the former Anfo mixing area. Two soil samples collected from the test pits located at the toe of the operational landfill (TP-57 and TP-59) contained concentrations of zinc that exceeded the risk-based remedial objective. Levels of lead measured in all the samples were less than the remedial objective.

Petroleum Hydrocarbons

The main source of petroleum hydrocarbon contamination at the operational landfill is attributed to the use of waste oil as a fuel for open burning of garbage. The source of potential petroleum hydrocarbon contamination at the former Anfo mixing area is related to historic diesel fuel storage and use in this area.

The analytical results for petroleum hydrocarbon testing of soil samples collected from test pits excavated at the former Anfo mixing area and the landfills did not reveal the presence of petroleum hydrocarbon contamination that exceeded the regulatory standards. The results of extractable petroleum hydrocarbon analysis of a soil sample collected from each of test pits TP-59 and TP-49 indicated the presence of a trace level of LEPH and HEPH, respectively; however, the concentrations were less than the NWT guideline or 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.

On the basis of the field observations and results of analytical testing, petroleum hydrocarbon contamination of soils downslope of the landfills and in the former Anfo mixing area does not represent a source of environmental concern.

6.2.5 Former Oil Bladder Storage Area

Figure 12D shows a general area southeast of the airstrip where bladders of oil were stored during the construction phase of the mine site. Anecdotal information indicated that a spill incident had occurred in this area in 1980 or 1981. Six test pits were excavated in this area to determine the presence, severity and approximate extent of petroleum hydrocarbon contamination in the subsurface. The test pits were excavated to the top of the permafrost layer, a depth measured to be approximately 0.8-1 metre in this area. Contaminant observations during the excavation of test pits indicated petroleum hydrocarbon odours and sheens to be present at all the sampling locations with the exception of TP-62. The strongest hydrocarbon odours were encountered within the saturated interval of the active layer, generally at 0.6 metres below ground level. Seven soil samples, collected from within the saturated layers of the test pits, were analyzed to determine the concentrations of extractable petroleum hydrocarbons.

The results of analysis (Table 6.6) 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. Potential for contaminant migration from this area was determined by testing soils from test pit TP-61 for EPH concentrations. TP-61 is located directly downslope of the former oil bladder storage area. Detectable concentrations of EPH were not found at TP-61 and contaminant observations did not indicate the presence of petroleum hydrocarbons in soils.

While the current field investigation has identified the general location of hydrocarbon contamination associated with the oil spill incident, step-out sampling locations are required to delineate the full extent of the oil contamination for remediation. Accordingly, additional investigation will be carried out in the summer of 2000 to fully delineate the extent of petroleum hydrocarbon contamination in this area of the mine-site.

6.2.6 Fire Training Area and CRF Plant Area

Three test pits were excavated at the Fire Training area (TP-68, TP-69 and TP-70), located northeast of Loon Lake and five test pits were excavated in the vicinity of the CRF building (TP-71, TP-71, TP-73, TP-74 and TP-75).

Contaminant sources at the Fire Training area include the storage and use of waste oils, fuels, mill chemicals and paints for the fire simulations. Contaminant sources at the CRF plant area include: two current aboveground fuel tanks (ASTs) used for storage and dispensing and two former locations of ASTs. One of the current ASTs is a green tank with full secondary containment. Accidental releases of cement from broken bags and metal contamination from underground vents and the use of the CRF plant for sorting operations associated with a specialized lead ore project represent other sources of contamination in the area.

Soil samples collected from the test pits were analyzed to determine concentrations of lead and zinc, total metals and extractable petroleum hydrocarbons. The results of analysis are summarized in Tables 6.3 through 6.6. Figures 12C and 12D illustrate the distribution and extent of metal and hydrocarbon contamination within the Fire Training area and CRF plant area.

Metals

The results of analysis indicated that zinc concentrations in samples collected at depths below 0.3 metres in test pits excavated at the Fire Training area exceeded the risk-based remedial objective. Lead concentrations did not exceed the remedial objectives in any of the soil samples tested. The Fire Training area is located near a mineralized surface showing (Central Showing in Figure 12). In addition, a stream sample collected in this area during the environmental baseline studies conducted by BC Research contained a zinc concentration that was higher than stream samples collected from other areas on the property (BC Research, 1975). These results suggest that the zinc concentrations detected in the soil samples from the Fire Training area may be representative of natural conditions.

Elevated metal concentrations in the vicinity of the CRF plant were found in surface samples collected from test pits TP-71, TP-72 and TP-75. Test pits TP-71 and TP-75 are located on the south side of the CRF building, in the area used to stockpile discarded fines. Test pit TP-72 is located near a vent for the underground mine operations. Sources of metal contamination can therefore be attributed to these sources.

Petroleum Hydrocarbons

Petroleum hydrocarbon contamination was determined in soil samples collected from the Fire Training area and in the vicinity of the former and current AST installations at the CRF plant. The results of analysis (Table 6.6) show that extractable hydrocarbon concentrations in soil samples obtained from the Fire training area are less than the analytical detection limit. Contaminant observations during test pit excavation confirm that evidence of potential hydrocarbon contamination was not found.

Contaminant observations and the results of EPH analysis of soil samples collected at the CRF plant area showed that levels of petroleum hydrocarbon contamination in excess of the NWT guidelines and Yukon CSR standards are present in test pits located in the vicinity of the former AST installations (TP-74 and TP-75). The hydrocarbon contamination extends through the thickness of the active layer. Observations during test pit excavation suggest that the petroleum hydrocarbon contamination is localized; however, additional test pit excavation is required to fully delineate the extent of contamination. Step-out soil samples will be collected during the field program in the summer of 2000.

Petroleum hydrocarbon contamination was not found in samples collected in the vicinity of the current AST installation (TP-73) at the north side of the CRF building. It should be noted that the slope beneath the north side footing is caving and the tank installation should be moved or provided with additional support on the north side. Soil samples were not collected in the vicinity of the green tank.

6.2.7 Surface Over Active Mining Area

Three test pits (TP-76, TP-77 and TP-78) were excavated in the raisebore area located over the active mining area (Figure 12). The test pits were excavated to the base of the active layer, an average depth of 0.9 meters in this area. Sources of metal contamination to the ground surface would include drilling, maintenance and decommissioning of the raisebore holes and associated rockfill materials; and operation of ventilation units for the underground mining facilities. While reclamation activities will result in recontouring of the surface above the active mining area, soil samples were analyzed to determine the range of metal concentrations in the soils at the present time.

The results of analysis are summarized in Table 6.4 and illustrated in Figure 12. Elevated levels of zinc were present in samples collected at 0.3 to 0.6 metres depth in TP-76 and TP-77. Lead concentrations in the soil samples ranged from 28 ug/g to 961 ug/g. Zinc concentrations ranged from 144 ug/g to 10,300 ug/g. One of the soil samples (TP-77 at 0.1-0.3 m.) was also analyzed to determine total metal concentrations (Table 6.5). Only lead and zinc concentrations were found to exceed the CCME tier 3 guidelines in the soil sample tested.

6.2.8 Tailings Pipeline, Thickener Building, and Emergency Discharge

The Phase 1 historical review of spill incidents revealed that 10 minor tailings spills have occurred along the pipeline between the concentrator and the tailings thickener building (Figure 8). A major tailings spill occurred in the vicinity of the thickener building in April 1983. A broken valve coupling resulted in the release of an estimated 150 to 200 tonnes of tailings into the emergency discharge basin and across the roadway to the southwest. Although the tailings spills were promptly cleaned up and disposed into the mine workings as backfill; observations during the field investigations indicated that tailing residuals were still evident along some areas of the pipeline and downslope of the thickener building toward

Polaris Bay. The approximate extent of the historic tailings spill area in the vicinity of the thickener building is illustrated in Figure 12.

Surface soil samples were collected along the tailings pipeline in previous spill areas and in the vicinity of the thickener building, at location identified as areas of potential environmental concern in the Phase 1 ESA. The results of lead and zinc analysis of the soil samples are summarized in Table 6.3 and shown in Figure 12. Concentrations of zinc that exceed the risk-based remedial objective were found in all the samples tested, with the exception of two soil samples downslope of the thickener building. Only one of the soil samples (TL-1) also contained an elevated concentration of lead.

Tailings residuals represent the source of the elevated metal concentrations in the soil samples tested. Potential pathways for contaminant migration would include wind dispersion, soil creep and surface runoff. Analysis of soil samples collected downslope of the tailings spill at the thickener building indicates 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.

6.2.9 Potential Downwind Dispersion Areas

Airborne particulates represent one of the major pathways for the introduction of contaminants into the surrounding environment from the sources of air emissions at the mine site (mill dryer exhausts, cone crusher exhaust, concentrate conveyor and loading areas, mine exhaust fans and raised borehole exhausts). The prevailing wind directions will therefore influence the distribution of contamination. Climate information from the Resolute Bay airport and Polaris Mine indicates that the winds are predominantly from the north and north-northeast, although the winds frequently shift to the south and northwest. The frequent high winds and typical lack of topography in the high Arctic suggest that wind dispersion is a potential pathway for wide area contamination of the surrounding lands.

Surface soil samples were collected in far-field locations from the mine site in the direction of the prevailing winds during the field investigation conducted in July 1999. Background samples were collected in locations considered upwind of the mine site activities. On the basis of the information on prevailing wind directions, samples collected from areas to the northeast of the mine site, near the Frustration Creek outlet to North Bay were determined to represent background locations. Thirty-seven additional surface soil samples were collected in early September 1999 (additional soil sampling) to confirm concentrations of lead and zinc in the vicinity of Loon Lake and the background sampling locations.

The surface samples were analyzed to determine concentrations of lead and zinc. Four soil samples were also submitted for total metal analysis. The results of analysis are summarized in Tables 6.3 and 6.5. Total metal analysis indicated that lead and zinc were the only metals in the soil samples that exceeded the regulatory guidelines and remedial objectives. The distribution and extent of lead and zinc concentrations in the surface soil samples is illustrated in Figure 12.

Concentrations of lead and zinc in soils that exceed the risk-based remedial objectives generally occur west of the air strip in the vicinity of the process barge, the concentrate storage building and the bench area on which the oil storage area is located; and, east of the air strip in the area surrounding Loon Lake and the surface over the active mining area.

Surficial soil samples generally did not contain lead concentrations in excess of the remedial objectives. Zinc concentrations that exceed the remedial objective of 650 ug/g are distributed along the peninsula to the south of the mine site and extend east, to approximately 2300 East on the mine grid.

With the exception of the tailings spill area in the vicinity of the thickener building, elevated levels of lead were not found in any of the soils collected in far-field sampling locations to the east toward Garrow Lake, to the southeast toward Riddle Point, and to the northeast toward Frustration Lake. Zinc concentrations were found to slightly exceed the risk-based remedial objectives in one surface soil sample collected northeast of the New Quarry. This area is considered upwind of the mine site operations and was chosen as a sampling location to provide information on background soil quality conditions. The zinc concentrations encountered may therefore be representative of natural soil levels in this area; although due to the lack of data for metal concentrations in soils prior to development of the mine, this can’t be verified.

Based on the results of the surface soil sampling program, air-borne particulate emissions originating at the mine site have not contributed to elevated levels of metals in surficial soils in the surrounding lands. Metal concentrations, particularly zinc, are elevated in surface soils located near mine site operations; however, metal concentrations were not found to exceed the risk-based remedial objectives for lead and zinc in the surrounding lands, from approximately 2300 East on the mine grid.

6.2.10 Snow Dumps

Four areas of the mine site are used to store snow. These are located along the foreshore, 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. Metals in the particulates may dissolve into melt waters during the summer season and be transported into sensitive receiving environments such as the marine foreshore.

Samples were collected from each of the snowdumps and submitted for lead and zinc analysis. One of the samples collected from the Firehall snowdump was also analyzed for total metal concentrations. The results of analysis are summarized in Tables 6.3 and 6.5 and illustrated in Figures 12A and 12C. Concentrations of lead and zinc exceeded the risk-based remedial objectives in samples collected from each of the snowdumps with the exception of the Main snowdump.

Samples collected from the Firehall snow dump contained the highest levels of lead and zinc, at percentage concentrations. In addition, total metal analysis of one of these snow dump samples indicated that the cadmium concentration also exceeded the CCME tier 1 soil quality guideline. The source of the high cadmium, lead and zinc concentration may be associated with mineralization from a historic low-grade stockpile located in the same area as the snowdump (Figure 12A). Geologists at the Polaris Mine will conduct an inspection during the summer of 2000 to confirm the presence and grade of the historic rock stockpiles located to the north of the process barge.

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 will be collected during the field program in 2000 to delineate the extent of potential metal contamination in the surrounding soils.

6.3 Groundwater Quality Assessment

The results of analysis of groundwater samples collected from the monitors installed in the vicinity of the process barge and landfill are summarized in Tables 6.7, 6.8, and 6.9. The tables also show the applicable CCME Tier 1 guidelines and the Yukon CSR standards for the protection of aquatic life. The Yukon standards generally apply a 10-fold dilution factor to account for the retardation factors inherent in groundwater flow through soil. The laboratory reports and QA/QC data are provided in Appendix B.

Water samples obtained from monitors installed at the process barge area (BH-5 and BH-6; TP-2, TP-5, TP-11, TP-14 and TP-15) were analyzed to determine concentrations of dissolved metals, volatile organic compounds and petroleum hydrocarbon parameters, including: light and heavy extractable petroleum hydrocarbons (LEPH and HEPH); benzene, toluene, ethylbenzene and xylene (BTEX compounds)); PAHs; and PCBs. A water sample collected from the water level control sump, located at the northwest corner of the barge, was also analyzed for nutrients and glycol. Water samples collected from monitors installed upgradient and downgradient of the operational and construction landfill (TP-52, TP-55, TP-57, TP-59 and TP-61) were analyzed to determine concentrations of nutrients, cyanide, dissolved metals and petroleum hydrocarbon parameters.

Conductivity and pH measurements were taken in the field at all sample locations. The pH of the groundwater varied from 6.6 to 7.6. Conductivities were high, ranging from 1920 to 17300 uS/cm. The high levels of conductivity are attributed to the high salt content of the shale rocks.

6.3.1 Process Barge Area

PCBs, Nutrients and glycol: Three water samples collected from BH-5, TP-11 and the water level control sump were analyzed to determine concentrations of PCBs (Table 6.8). The results showed that PCB concentrations were not detectable in the water samples.

One sample, collected from the water level control sump was analyzed to determine concentrations of nutrients and glycol. The results of analysis show that ammonia and nitrite concentrations in the sump water sample exceeded the CCME water quality guidelines for the protection of aquatic life. The water sample collected from the sump also exceeded the Yukon CSR standard for ammonia. Glycol was not present at detectable concentrations in the water sample.

Dissolved metals: Four water samples collected from monitors installed in the vicinity of the process barge were analyzed to determine concentrations of dissolved metals (BH-5, BH-6, TP-14 and sump). The results of analysis indicate that dissolved zinc concentrations exceeded the CCME water quality guideline in all the water samples. One sample (BH-5) contained an elevated concentration of dissolved selenium and one sample (TP-14) contained an elevated level of dissolved lead. Comparison of the dissolved metal concentrations found in the water samples with the Yukon CSR standards for protection of aquatic life shows that only the zinc concentrations were present in concentrations that exceeded the standards.

Petroleum hydrocarbons and VOCs: Extractable petroleum hydrocarbon parameters in water are not yet regulated by either the CCME or the Yukon Contaminated Sites Regulation (CSR). Although the Yukon Contaminated Sites Regulation stipulates that nonaqueous phase liquids are not to be present in the water column. In the absence of federal or territorial limits, the LEPH concentrations detected in the water samples can be compared with the recently introduced BC Contaminated Sites Regulation (CSR) generic numerical water standard for protection of aquatic life of 0.5 mg LEPH/L.

Concentrations of light extractable petroleum hydrocarbons that meet or exceed the BC CSR standard were found in 8 of the 9 seepage water samples analyzed (Table 6.8). In addition, as discussed in Section 3.1, a measurable thickness of light nonaqueous phase fluid was detected in BH-1, located at the northwest corner of the Bent Horn conditioning building.

BTEX analysis of 3 water samples (Table 6.8; BH-5, TP-11 and the sump) indicated that water sampled from TP-11 contained toluene at a concentration that exceeded the CCME water quality guideline for protection of aquatic life. Water samples from BH-5 and the sump did not contain elevated concentrations of BTEX compounds. Given that BTEX compounds are not commonly present in diesel fuel; the source of the BTEX concentrations is attributed to a light crude oil source, Bent Horn Crude that was used at the mine site from 1987 to 1989. Crude oils typically contain concentrations of BTEX.

PAH analysis of four water samples (BH-5, TP-5, TP-11 and the sump) showed that the water sample collected from the sump and seepage water obtained from TP-11 exceeded the CCME water quality guideline and the Yukon CSR standard for naphthalene. The seepage water sample collected from TP-11 also contained slightly elevated concentrations of 4 other specific PAH compounds. Fluoranthene and pyrene concentrations slightly exceeded the CCME guidelines for protection of aquatic life. A seepage water sample collected from BH-5 did not contain detectable concentrations of PAH compounds.

Volatile organic compounds (VOCs) are components of solvents. Detectable concentrations of VOCs were not found in the water samples tested (Table 6.9).

6.3.2 Operational and Construction Landfill Area

PCBs, Nutrients and Cyanide: Detectable concentrations of PCBs were not found in the two water samples tested from monitors installed at the toe of the operational landfill and the toe of the construction landfill.

Water samples collected from the upgradient monitor (TP-61) and 4 downgradient monitors were analyzed to determine concentrations of nutrients and cyanide. The results (Table 6.8) show that the upgradient monitor did not contain elevated nutrient concentrations or cyanide concentrations. Water samples collected from 2 monitors located at the toe of the operational landfill (TP-57 and TP-59) and two monitors located at the toe of the construction landfill (TP-52 and TP-55) contained levels of ammonia and nitrite that exceeded the CCME water quality guidelines for protection of aquatic life. Each of the downgradient monitor locations tested for cyanide, also exceeded the CCME guideline for this parameter. The nutrient and cyanide levels did not exceed the Yukon CSR standards.

Dissolved metals: Dissolved concentrations of zinc exceeded the CCME water quality guideline in water samples collected from all monitor locations installed at the landfills. Levels of dissolved aluminum, iron, lead and selenium also exceeded the CCME guidelines in one or more of the downgradient monitor locations in the landfill area. The water samples did not contain dissolved metal concentrations that exceeded the Yukon CSR standards for protection of aquatic life.

Petroleum hydrocarbons and VOCs: Analysis to determine concentrations of extractable petroleum hydrocarbons in seepage waters collected from the upgradient (TP-61) and downgradient monitors (TP-52, TP-55, TP-57, TP-59) installed at the landfills showed that LEPH concentrations were equivalent to or less than the BC CSR standard of 0.5 mg/L. Toluene was detected in groundwater collected from TP61 at a concentration that slightly exceeded the CCME water quality guidelines for protection of aquatic life. Given that extractable petroleum hydrocarbons were not detectable in the groundwater sample collected at this location, and contaminant observations did not indicate the presence of petroleum hydrocarbons, it is difficult to determine the source of the elevated toluene concentrations.

Detectable concentrations of PAH compounds were not found in groundwater sampled at the upgradient or downgradient locations within the landfills .

The results of groundwater analysis indicate that due to the limited thickness of the saturated zone, the concentrations of chemicals in the water tend to correlate closely with the soil contaminant levels. The seasonal restriction for the presence of subsurface 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. Erosion channels were noted downslope of the operational landfill; however, water flow was not observed during the field investigation conducted in July 1999. Surface runoff also represents a seasonally restricted pathway for contaminant migration.

6.4 Acid Rock Drainage (ARD)

The overall results of the ARD testing (Table 6.11) indicate that the four rock samples would not be classified as potentially acid generating, nor do heavy element concentrations indicate that significant leaching is likely. The laboratory report and QA/QC data is provided in Appendix B. Specific results of the testing indicate the following:

- The limestone and dolomite samples contain very low sulphur concentrations (<0.1%) and high neutralization potential. The limestone sample had carbonate and neutralization potential close to the theoretical maximum values of 1000 kg $CaCO_3$/t. The neutralization potential for the dolomite sample was close to the theoretical maximum for dolomite of 1090 kg $CaCO_3$/t. Total and leachable metal concentrations were very low. Both the limestone and dolomite samples therefore contain very few impurities and are nearly pure calcite and dolomite.

- The Green and Brown (Bitumen-rich) shale samples both contained high sulphur concentrations and the green shale contained some sulphate. These samples contained elevated neutralization potential, and carbonate content was nearly equivalent to neutralization potential, indicating that carbonate minerals are the main source of acid buffering capacity in the rock.

- The shale samples contained higher lead, zinc, cadmium and arsenic concentrations than the limestone and dolomite. These heavy elements are globally more concentrated in shales, hence the difference is not unusual. None of these elements appeared to be readily leachable. Elevated sulphate levels in the leachates were consistent with the higher total sulphur concentrations in the shale samples.

The majority of the underground mine workings are located in the Thumb Mountain limestone formations discussed above and are not a potential source of ML/ARD.

6.5 Vegetation Quality Assessment

Metal concentrations were determined in representative plant species collected near the mine site and up to 5 kilometers to the east, southeast and northeast in order to evaluate potential impacts from deposition of wind borne particulates transported from the mine operations to the surrounding lands.

Regulatory limits for metal levels in plant tissue have not been established by either the federal or territorial governments. Accordingly, the concentrations of metals in plant tissue determined in the present study have been compared with baseline vegetation quality data collected by BC Research (1975) prior to mine development.

The results of metal analysis in vegetation samples are shown in Table 6.10. Figures 13A and B provide a comparison of the 1999 study data with the BC Research data collected in 1975. The total lead and zinc concentrations measured in soil samples collected at the vegetation sampling stations have also been included in Figures 13A and B. The data from each sampling station have been plotted on a bar graph in relation to their proximity to the mill site (i.e. the closest station A to the farthest station G). The results indicate the following:

- Lead and zinc concentrations were highest in plant tissues collected from sampling stations located nearest the mine site (i.e. Station A, H and C). Sampling station D was established as a background location by BC Research (1975) because of its upwind location relative to the prevailing wind directions. Plant tissues collected from vegetation sampling stations that are progressively farther from the mill site i.e. E, B, F and G contained similar concentrations of metals to Station D.

- Total lead concentrations in soils at Polaris were positively correlated with lead concentrations found in the sampling of grass (r^2=0.890), willow (r^2=0.837) and lichen (r^2=0.885). These correlations were significant at the 95% confidence limit.

- Total zinc was also positively correlated with zinc concentrations found in the sampling of grass (r^2=0.896) at the 95% confidence limit. Correlations were not found to occur with the willow or lichen samples and soil zinc concentrations. Although a correlation with lichens is not expected since lichens absorb most elements from the atmosphere, the uptake of zinc by willows appears to be more complex. Comparison of the current metal concentration data in plant tissue with the 1975 BC Research data shows that zinc concentrations in willows sampled at Stations B and C, did not differ significantly from the 1975 BC Research data. This indicates that the foliar concentration of zinc at these sites had only slightly increased over the life of the mine. Therefore this increase in zinc, if not correlated with the total zinc in the soils may be the result of foliar uptake from atmospheric sources.

- The concentration of metals measured in the plants are generally higher than the soil because both are calculated on a dry weight basis, which does not take into account the typically high moisture content of most plant tissues. Considerably lower concentrations of metals would be expected in the plant tissues if calculated on a wet weight basis.

- Plant species tend to vary in their ability to accumulate contaminants from soil or airborne sources. For example, although zinc concentrations were generally higher than lead concentrations in similar plant species, the grass species was found to accumulate higher concentrations of zinc than other species while lead concentrations were found to be higher than zinc concentrations in lichens at each of the 8 sampling stations.

- The presence of detectable concentrations of lead in plant tissues, particularly lichens, suggests that aerial deposition of particulates may be a source of metals in far-field sampling locations. Lichens derive nutrients from photosynthesis, and because of an absence of roots and cuticle, exhibit a direct sensitivity to atmospheric pollutants. As biological monitors, lichens are recognized to have an ability to uptake metals far beyond their physiological needs and without apparent toxicity.

The 1999 data generally shows an increase in lead and zinc concentrations in plant tissues over the pre-mine baseline study. The pattern of decreasing concentrations with increasing distance from the source is typical of an atmospheric deposition. Since all sample locations indicate an increase in the metal concentrations over baseline data, the extent of the affected area can not be determined from the existing data set.

Field work to be undertaken in the summer of 2000 will include additional vegetation and soil sampling to determine the extent of the potential dust dispersal in the lands surrounding the mine site. Vegetation sampling will include analysis of both shoots and roots of vascular plants to determine the contribution of soil uptake vs. foliar uptake of metals.

7. Marine Environmental Survey

The marine environmental sampling program was undertaken May 11 through May 17, 1999, under the direction of GLL Senior Biologist David Osmond. A second round of seawater samples were collected by Polaris Mine in April 2000. Arctic Divers Ltd. of Yellowknife, NWT, conducted a SCUBA survey to document physical and biological conditions and to collect biota, sediment and seawater samples in the marine environment fronting the mine site (Crozier Strait), the landfill area (Polaris Bay), and the creek discharge from Garrow Lake (Garrow Bay). Video footage was obtained at all the dive site locations.

The overall objective of the marine environmental sampling program was to describe benthic marine conditions and provide current environmental quality information for sediments, seawater and biological tissue in the nearshore marine environment at the Cominco Ltd. Polaris mine site.

7.1 Sampling Methods

The marine environmental sampling program was conducted in three areas of the nearshore environment at the mine site: Garrow Bay, Polaris Bay and Crozier Strait. Eleven sampling stations were established at the three locations: Stations 1 and 2 in Garrow Bay; Stations 3A, 3B and 3C in Polaris Bay; and, Stations 4A, 4B, 4C, 4D, 4E, 4F and an outfall station in Crozier Strait. The sampling stations were also chosen to approximate nearshore locations sampled in previous studies by BC Research (1978), Fallis (1984) and Axys (1990).

Access to open water required the cutting of up to 2 metres of ice at each of the 11 sampling stations. The sampling stations were located within 9 to 14 meters of water. The location of the sampling stations and the types of samples collected at each station are illustrated in Figure 15 and discussed below:

Garrow Bay Sampling Stations 1 and 2.

Station 1 was located upcurrent of the Garrow Creek discharge point. This sampling location was chosen to represent background environmental quality conditions. Samples of seawater, sediment and biota were collected at this location.

Station 2 was located at the Garrow Lake discharge point to Garrow Bay. This sampling location was chosen to assess potential ecosystem impacts resulting from the discharge of waters from the Garrow Lake tailings deposit. Samples of seawater, sediment and biota were collected at this location.

Polaris Bay Sampling Stations 3A, 3B and 3C

Station 3A was located upcurrent of the operational and construction landfills, and Stations 3B and 3C were located in the nearshore marine environment fronting the landfill. The three sampling stations were established to assess potential impacts from the landfill operation. Samples of sediments were collected at all three dive hole locations; biota samples were collected at stations 3A and 3C, and a seawater sample was collected at station 3C.

Crozier Strait

Stations 4A through 4F were located in the nearshore marine environment fronting the mine site. The sampling stations were established to assess the potential impacts of the mine site development on the marine environment. Sources of contamination to the marine environment fronting the mine site include: spillage of concentrates, discharge of melt waters from snowdumps contaminated with Pb/Zn particulates; and, sewage/greywater discharge.

Station 4A was located in the nearshore environment fronting an area used to dump cleared snow (the Main snowdump); station 4B was located in front of the concentrate storage building; stations 4C and 4D was located adjacent to the dock area; the outfall station was located at the end of pipe discharge for sewage/greywater from the mine site; stations 4E and 4F were located north of the shiploading dock. Biota, seawater and sediment samples were collected at stations 4B and 4E. Sediment samples were collected at the remaining stations.

7.1.1 Seawater Sampling

Seawater samples were taken just below the water surface and approximately 0.5 meters above the seabed using a Sutex sampler. The seawater samples were collected prior to the divers entering the water. Care was taken to clear the water surface of debris and ice before the water samples were collected in order to obtain a representative water sample. pH, temperature, conductivity and dissolved oxygen were measured in the field. These measurements and the depth of water at the sampling stations are provided in Table 6.13.

The seawater samples were preserved, as required, following collection and kept cool until transfer to the analytical laboratory. Standard chain-of-custody forms were completed and accompanied the samples to the laboratory.

7.1.2 Sediment and Biota Collections

Sediment and biota samples were collected by the divers. Care was taken to sample only the surficial layer of sediment, as this layer represents the most recent accumulations. Surficial sediment samples were collected directly into the sample jar and capped underwater. Specimens of biota were collected opportunistically by the divers. *Mya truncata* clams were collected at each of the designated sampling stations, with the exception of Station 4B, where Mya clams were not found. An abundant population of sea urchins (*Strongylocentrotus* sp.) was present at this sample location, therefore this species was sampled at Station 4B instead. Each of the clam samples and the sea urchin sample consisted of at least 10 individuals. Other species collected included amphipods and selected individuals of sculpins, and blennie fish. The biota samples were collected into labelled, zip-lock bags. Depuration of the clam and urchin samples was not undertaken. Given that these species are not harvested as a human food source in this area, it was intended that the tissue quality reflect marine food chain conditions.

The sediment and biota samples were frozen immediately following collection. The samples were shipped to the analytical laboratory accompanied by completed standard chain-of-custody forms.

7.2 Analytical Program

On the basis of the mine site activities and potential sources of contamination to the marine nearshore environment at the Polaris mine site, the potential chemicals of concern included: metals, cyanide, petroleum hydrocarbons, and PCBs.

All samples were received in good condition by Analytical Service Laboratories Ltd. (ASL) in Vancouver, B.C. Freezer packs were included in each of the coolers, and the biota and sediments were reported by ASL to have been frozen on receipt, and the seawater samples had been kept cool.

Seawater samples were submitted for analysis to determine concentrations of anions, metals, cyanide, extractable petroleum hydrocarbons (EPHs), polycyclic aromatic hydrocarbons (PAHs), and PCBs. Sediment samples were analyzed to determine concentrations of metals, EPHs, PAHs, and PCBs. Mya clams and one set of sea urchins collected at station 4B were analyzed to determine concentrations of total metals.

Sediment samples not analyzed have been archived by ASL, in a frozen state, for a period of one year.

8. Results of Dive Survey and Sampling Program

8.1 Ecological Quality

Divers were equipped with a helmet-mounted video camera which transmitted an instantaneous and continuous record of conditions seen at the sea bottom during sample collection. This along with audio communication between the diver and the dive operations team on the ice above allowed guidance on sediment and marine organism collection. The resulting video tapes provide a permanent record of ecological quality at each marine sampling location. In addition there was a scuba diver taking video with a second camera some of the time. Both sets of tapes were combined into one summary video. These are available upon request. Table 8.1 summarizes field observations as underwater sampling was taking place.

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, various crustaceans such as shrimp and amphipods) was evident at all sites although abundance appeared to vary among sites. Crustaceans including isopods, amphipods and shrimp or "krill" were found in abundance immediately under the ice at all stations and generally throughout the water column near the sewage outfall at Site 4, where they were most abundant. *Mya* clams were observed at all sites with the exception of stations 4A through D. This necessitated the collection of sea urchins at site 4B to provide bottom organism tissue for comparison with previous work.

Owing to natural differences in water depths, current velocities, substrate composition and slope, it is difficult to attribute differences in marine life distribution and abundance among sampling sites to the activities of the Polaris Mine. Certainly, some of the sites near the dock appear 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 organisms due to the nutrient rich food source.

8.2 SeaWater Quality Assessment

The results of analysis to determine concentrations of potential chemicals of concern in seawater are summarized in Tables 8.2 and 8.3. The laboratory reports and QA/QC data are provided in Appendix B. The relevant regulatory guidelines for each of the chemical parameters, as well as comparative data reported in the BC Research (1978) aquatic environmental study conducted prior to mine site development and data from Axys (1990) have been included in the tables. The CCME water quality guidelines for the protection of aquatic life in marine environments were used to evaluate the data.

Where the CCME guidelines for protection of marine aquatic life have not been developed, the guidelines for the protection of freshwater aquatic life were applied.

Table 8.2 shows that, in general, all inorganic chemical parameters analyzed, including cyanide, were either not present in detectable concentrations or the concentrations were below the CCME guidelines for protection of aquatic life. However, lead concentrations in seawater samples collected from the near surface layer in Garrow Bay, Polaris Bay and Crozier Strait during the May 1999 sampling event exceeded the CCME freshwater guideline of 7 ug/L. The lead concentration in seawater collected from the surface layer at the Garrow Bay reference station was 7 ug/L. Lead concentrations in the seawater samples collected near the ocean bed were less than the detection limit of 1 ug/L at all the sampling stations.

Due to the variability in the results of metal analysis of surface seawater samples as compared with the near bottom samples, as well as the relatively high analytical detection limit for the samples collected in May 1999, a second set of seawater samples was collected from selected marine sampling stations in April 2000.

Seawater samples were collected in April 2000 from near the ocean surface in Garrow Bay at stations 1 and 2, in Polaris Bay at station 3C, and in Crozier Strait at station 4E. Following the cutting of approximately 2 meters of ice, the seawater samples were collected using a device consisting of a solid polyethylene tube fitted with a polyethylene foot valve at the base. Each station was sampled with a dedicated sampling apparatus to minimize any cross contamination.

The results of the sampling and analysis program conducted in April 2000 showed that the metal concentrations in near surface water sampling stations were less than the CCME water guidelines for the protection of aquatic life at all the locations sampled. The analytical detection limits were improved by one to two orders of magnitude, depending on the metal. One possible explanation for the discrepancy between the May 1999 results and the April 2000 metal concentrations may involve the formation of ice crystals in the large ice hole drilled for the previous set of water samples. The ice holes were cut in advance of the sampling. Due to longer time required to cut the large diameter holes in the ice, they were prepared approximately half a day in advance of the sampling event. Although care was taken to scoop any solids such as ice or debris out of the hole prior to the collection of water samples, it is likely that particulates associated with ice crystals became entrained in the water samples. The April 2000 seawater sampling results are consistent with the May 1999 results for seawater samples collected from near the ocean bed. These samples did not contain detectable concentrations of lead or levels that exceeded the regulatory guidelines.

The results of extractable petroleum hydrocarbon, PAH and PCB analysis in seawater samples (Table 8.3) indicated that detectable concentrations of these parameters are not present in the seawater samples collected.

8.3 Sediment Quality Assessment

The results of analysis to determine concentrations of potential chemicals of concern in sediments are summarized in Table 8.4. The laboratory reports and QA/QC data are provided in Appendix B. The CCME interim sediment quality guidelines (ISQG) as well as the limits established for probable effect levels (PEL) are included in Table 8.4. The ISQG is typically used as an assessment tool, while the PEL limits have been used to evaluate the requirements for remediation. Previous analytical data for metal concentrations in sediments reported by Fallis (1984) is summarized in Table 8.5. The location of the sampling stations used in the Fallis (1984) study are shown in Figure 15. Data reported in Fallis (1984) was collected in 1981, prior to the Polaris mine starting production.

Metals

Lead, zinc and cadmium concentrations in sediments collected from Garrow and Polaris Bays are generally less than the federal regulatory guidelines. Sediment samples collected from sampling stations located adjacent to the landfill site contained levels of lead and zinc that slightly exceeded the CCME guidelines. The highest concentrations of cadmium, lead, and zinc were found in sediment samples collected from sampling stations located in Crozier Strait.

Table 8.5 provides a summary of the cadmium, lead and zinc concentrations in marine sediments reported in the Fallis (1984) and Axys (1991) studies and the present study. The following comparisons between the Fallis (1984) and Axys (1991) data and the present study were found:

- Metal concentrations in sediments sampled in Garrow Bay in 1999 fall within the range reported by Fallis (1984) and Axys (1991) for the sample stations located in this area. Therefore, it is concluded that Garrow Bay has not been impacted by potential sources of metal contamination such as the Garrow Lake surface water discharge.

- Cadmium and lead concentrations in sediments taken at the upcurrent sampling station in Polaris Bay 3A, compare closely with the Station 4 data reported by Fallis (1984). Although the current zinc concentration is approximately twice as high as the level reported by Fallis (1984), it is within the CCME regulatory guideline for sediment quality.

- Sediment samples from GLL station 3C, located in the nearshore environment of Polaris Bay fronting the landfill, contained a similar concentration of cadmium, but approximately four times the levels of lead and zinc found at the upcurrent sample location. While this finding suggests the potential for impact, the concentrations are not significantly higher than the CCME regulatory guidelines for sediment quality.

- Sediment samples collected from stations located in Crozier Strait contained significantly higher concentrations of cadmium, lead and zinc than sampling locations in Garrow or Polaris Bays.

- Comparison of the sediment quality data for Crozier Strait with the Fallis (1984) data indicates that concentrations of metals in sediment samples collected near the shipping dock are equivalent to or lower than the levels reported by Fallis (1984). Metal concentrations in sediment samples collected at the upcurrent station 4A are lower than those found in sediments collected from the dock area. The upcurrent metal concentrations found in the present study are approximately four times higher than the levels reported by Fallis (1984) for Station 3.

The Crozier Strait sediment quality data suggests that metal concentrations have increased in upcurrent areas from the levels reported prior to full-scale development of the mine site. Fallis (1984) found the metal concentrations in sediments fronting the dock area to be significantly enriched with cadmium, lead and zinc. The results of the present study have confirmed this finding. The source of the higher metal concentrations in Crozier Strait have not been determined. Fallis (1984) suggested three possible reasons for the high metal levels, including:

- Spillage from a shipment of ore, prior to production of the mine;
- Mineralized waste rock used in the construction of a jetty used for loading ore; and,
- A naturally occurring dyke of mineralization associated with the Polaris ore body that extends off-shore into Crozier Strait.

Based on the stage of mine development and the off-shore location of the sediment samples collected by Fallis (1984) it is unlikely that the first two suggestions are indicative of the source of the elevated metal concentration fronting the shiploading dock. The Fallis (1984) and GLL (1999) data indicate that the most likely source for the observed metal levels is a naturally occurring zone of metal enriched sediments.

Organic Chemical Parameters

Concentrations of heavy extractable petroleum hydrocarbons (HEPH), slightly above the detection limit of 200 ug/g , were found in sediment samples collected from three sites in Crozier Strait (Table 8.4). These sample sites are located adjacent to the shiploading dock and process barge area. The presence of extractable petroleum hydrocarbons may be related to the storage, use and release of diesel fuel residuals and possibly light crude oil to the rock fill surrounding the process barge.

PAH concentrations were generally not detectable in the sediment samples analyzed. Sediments collected at sampling locations fronting the landfill site in Polaris Bay contained PAH compounds at concentrations slightly above the detection limit, but less than the CCME guidelines. The leaching of burned materials may have contributed to the presence of detectable PAH concentrations in this area. PCB concentrations were not detectable in the sediment samples analyzed.

8.4 Tissue Quality Assessment

Federal or Territorial regulatory limits have not been developed for chemical parameters in biological tissue. Accordingly, the tissue sample results were compared with both background concentrations in biota collected at the upcurrent station in Garrow Bay, Station 1; as well as, tissue quality results reported by BC Research (1974) and Fallis (1984) for biota collections at marine sampling stations in Garrow Bay, Polaris Bay and Crozier Strait. The biota were analyzed for the following chemical parameters: metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs).

An important difference in the present data set and the previously conducted tests for tissue quality is the aspect of depuration of the organism following collection. Depuration involves re-immersing the organism in seawater to allow them to purge ingested material (including solid material such as sediment) for a period of time. The biota is then frozen for shipment to the analytical laboratory.

Depuration is typically conducted if the evaluation of the tissue quality data is to determine the suitability for human consumption. A more conservative, ecosystem approach is to provide contaminant concentration data for the whole organism, without allowing purging of solids in the gut. The previous studies depurated the organisms following collection. Clams and sea urchins were not depurated in the present study in order to provide a more conservative data set.

Tables 8.6 and 8.7 summarize the tissue quality data for samples of *Mya truncata* and *Strongylocentrotus* sp. collected from sampling stations located in Garrow Bay, Polaris Bay and Crozier Strait. The chemical concentration data is presented as both dry weight and wet weight to facilitate comparison with data collected in previous studies. The location of sampling stations established by Fallis (1984) is shown in Figure 15. The results of analysis indicate the following:

- Metal concentrations in clam tissue sampled from the background sampling station in Garrow Bay were similar to the values reported by B.C. Research (1975, 1978) and Fallis (1984).
- Biota samples collected at the upcurrent sampling station in Polaris Bay (Station 3A) contained metal concentrations that were comparable to values reported by B.C. Research (1975, 1978) and Fallis (1984). The lead and zinc levels increased in biota tissue collected from Station 3C, located adjacent to the landfill site, where lead was present at approximately 5 times the concentration reported by BC Research (1978) and zinc concentrations were approximately 2.5 times higher.
- Clams were not abundant at sampling stations located in Crozier Strait, with the exception of Station 4E, situated approximately 20 meters downcurrent of the greywater/sewage discharge line. Sea urchins were found in abundance at the Crozier Strait sampling stations. Sea urchin tissue collected at Station 4B, adjacent to the concentrate storage building, contained the highest concentrations of lead and zinc measured at the Polaris mine site. Fallis (1984) also determined

metal concentrations in sea urchin tissue at Crozier Strait. The metal concentrations in sea urchins collected at Station 2 (Fallis, 1984) are comparable to the levels found at Station 4B in the present study. Metal concentration data collected by Fallis (1984) shows that metal levels in clam and sea urchin tissue were similar at the same sampling station.

- Clam tissue, collected at Station 4E also contained lower levels of cadmium, lead and zinc than the sea urchin tissue at Station 4B. The cadmium, lead and zinc concentrations were within the range found at Polaris Bay, and were comparable to levels reported by Fallis (1984) at Station 3 in Crozier Strait (Figure 15.)

- The elevated concentrations of metals in Crozier Strait and the dock area, in particular, are reflected in the tissue quality data for Mya clams and sea urchins. The results of biota tissue analysis are generally consistent with the Fallis (1984) results. Based on the sediment quality information, it appears that the elevated levels of cadmium, lead and zinc in the tissue samples also represent naturally occurring concentrations.

- The results of PAH and PCB analysis in biota collected from Garrow Bay, Polaris Bay and Crozier Strait show that the Mya clam tissue does not contain detectable concentrations of these organic compounds.

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Figures

LEGEND

🟩 NUNAVUT TERRITORY

SOURCE OF DRAWING:

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

DRAWING INFORMATION:

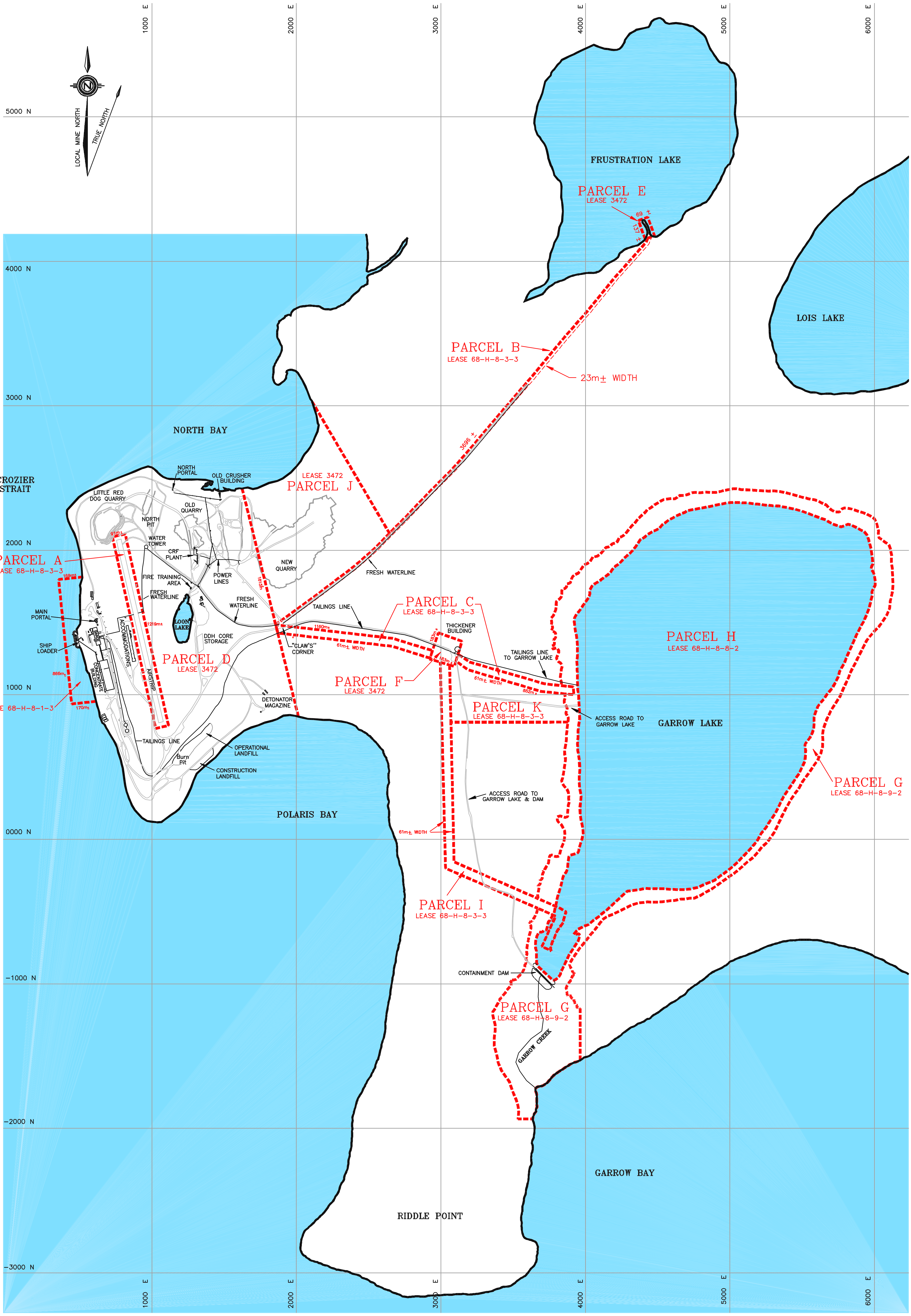
DESIGNED BY:	AJK
REVIEWED BY:	AJK
DRAWN BY:	CPW
DATE ISSUED:	MARCH 21, 2001
PROJECT NUMBER:	99-902
FILE NAME:	99902-D1-08.DWG
REVISION:	0

Cominco Ltd.
Polaris Mine

SITE LOCATION

Gartner Lee Limited

Figure No. 1



LEGEND

Base map provided by Cominco Resources

Scale 1:25,000
metres
0 200 1000

Date Issued: June 22 2000
Drawn by: BB/CPW
GLL Project Number: 99−902
File Name: 99902−D1−01.dwg

Cominco
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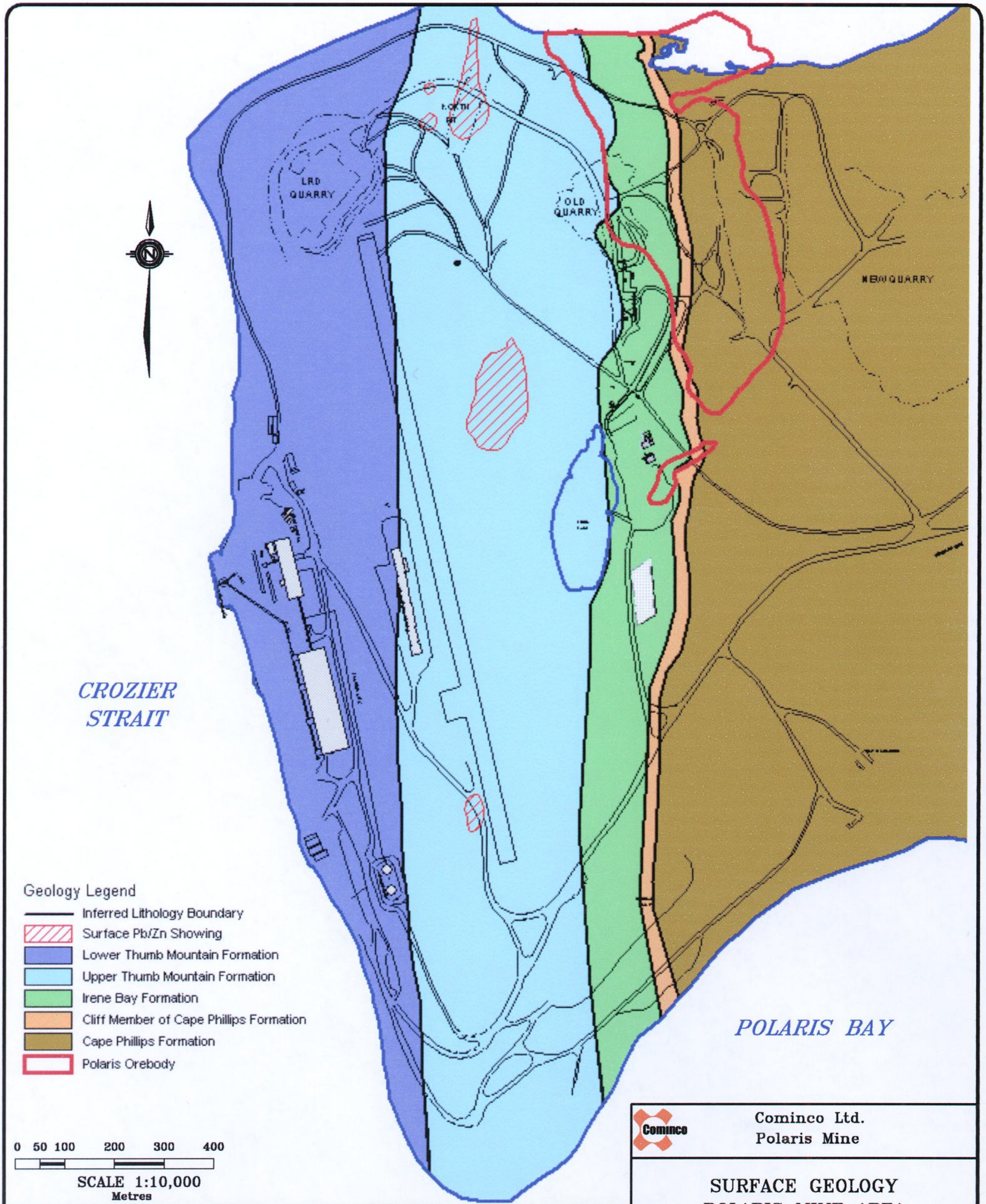
Polaris Mine

Site Plan Showing Lease Areas and Legal Description

Gartner
Lee
Limited

Figure No.
2



Cominco Ltd.
Polaris Mine

SURFACE GEOLOGY
POLARIS MINE AREA

SOURCE OF DRAWING:
DRAWING PROVIDED BY VICTORIA YEHL OF COMINCO LTD. FEBRUARY, 2001

REVIEWED BY: COMINCO

DRAWN BY: CPW

DATE ISSUED:	MARCH 21, 2001
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REVISION:	0

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Figure No. 3

FIGURE 4: TERRAIN MAP

POLARIS MINE
COMINCO LTD.

Scale
Approx. 1 : 10,000

80 0 80 240 400 560 metres

N

TOPOGRAPHIC LEGEND

INFRASTRUCTURE
- Roads
- Buildings
- Water Line
- Tailings Line
- Headwall Scarps

DRAINAGE FEATURES
- Creek
- Lake/Ocean

TERRAIN LEGEND

Surficial Material

⬜	A - Anthropogenic
🟫	C - Colluvium
🟨	F - Fluvial
🟨	FA - Fluvial, Active
🟪	O - Organic
🟥	R - Bedrock
🟦	W - Marine
🟦	WA - Marine, Active

Simple Map Unit

gsWb-S: terrain texture; surficial material; surface expression; geomorphic process

Composite Map Unit

eOv/gWb: primary terrain texture; primary surficial material; primary surface expression; composite symbol; secondary surficial material

Terrain Texture
- c - clay
- d - mixed fragments
- e - fibric
- g - gravel
- r - rubble
- s - sand
- u - mesic
- x - angular fragments
- z - silt

Surface Expression
- a - moderate slope
- b - blanket
- f - fan(s)
- h - hummock(s)
- j - gentle slope
- k - moderate steep slope
- p - plain
- s- steep slope
- t - terrace(s)
- v - veneer

Geomorphic Process
- F - fill material
- M - mass movement
- N - nivation
- S - solifluction
- V - gully erosion
- W - washing
- Xp - permafrost, palsas
- Xw - permafrost, ice wedges

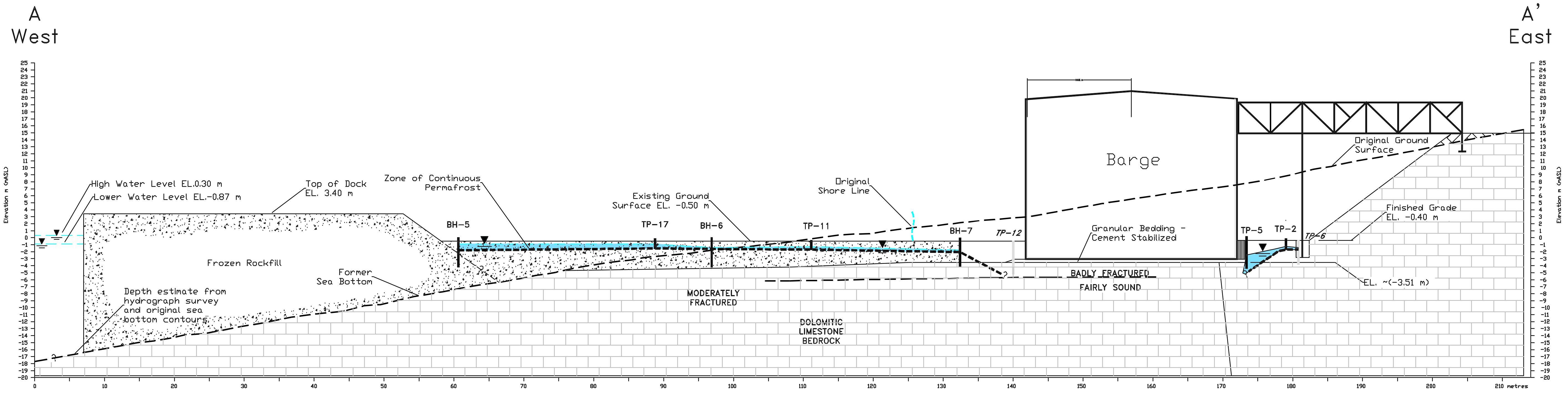
On-Site Symbols
- gully
- escarpment/terrace
- strandline

Composite Symbols

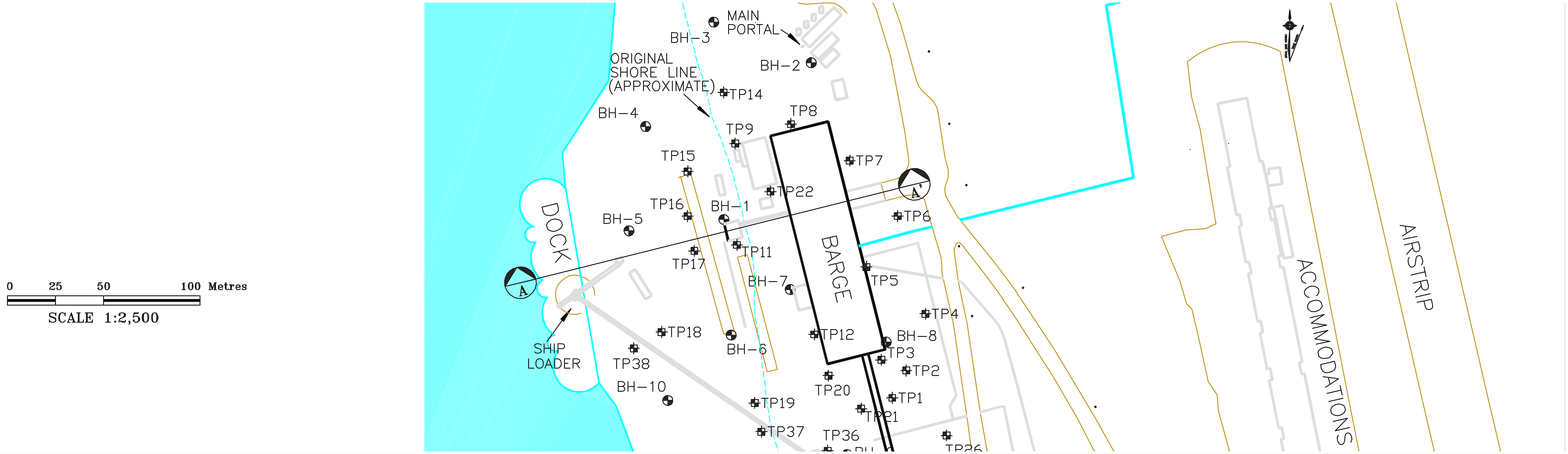
. materials on either side are of equal proportion
- material infront of symbol is more extensive than the one following
/ material infront of symbol overlies (stratigraphic) the following material

Compiled By: F. Pearson
Gartner Lee Ltd.
Compiled On: 26.10.99
Revised On.: 21.06.00
Ver. No.: 1C File: Terrain1C-r1.wor
GLL Project: 99-902

Gartner Lee Limited



Scale 1:600 (approximate)



NOTES:
1. Cross-section produced from drawing 110-C-116, Bechtel Canada Ltd., Cominco Ltd.
2. Water in test pits represents seasonal melt, measured July 11-16 1999.
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.

Cominco

Cominco Ltd.
Polaris Mine

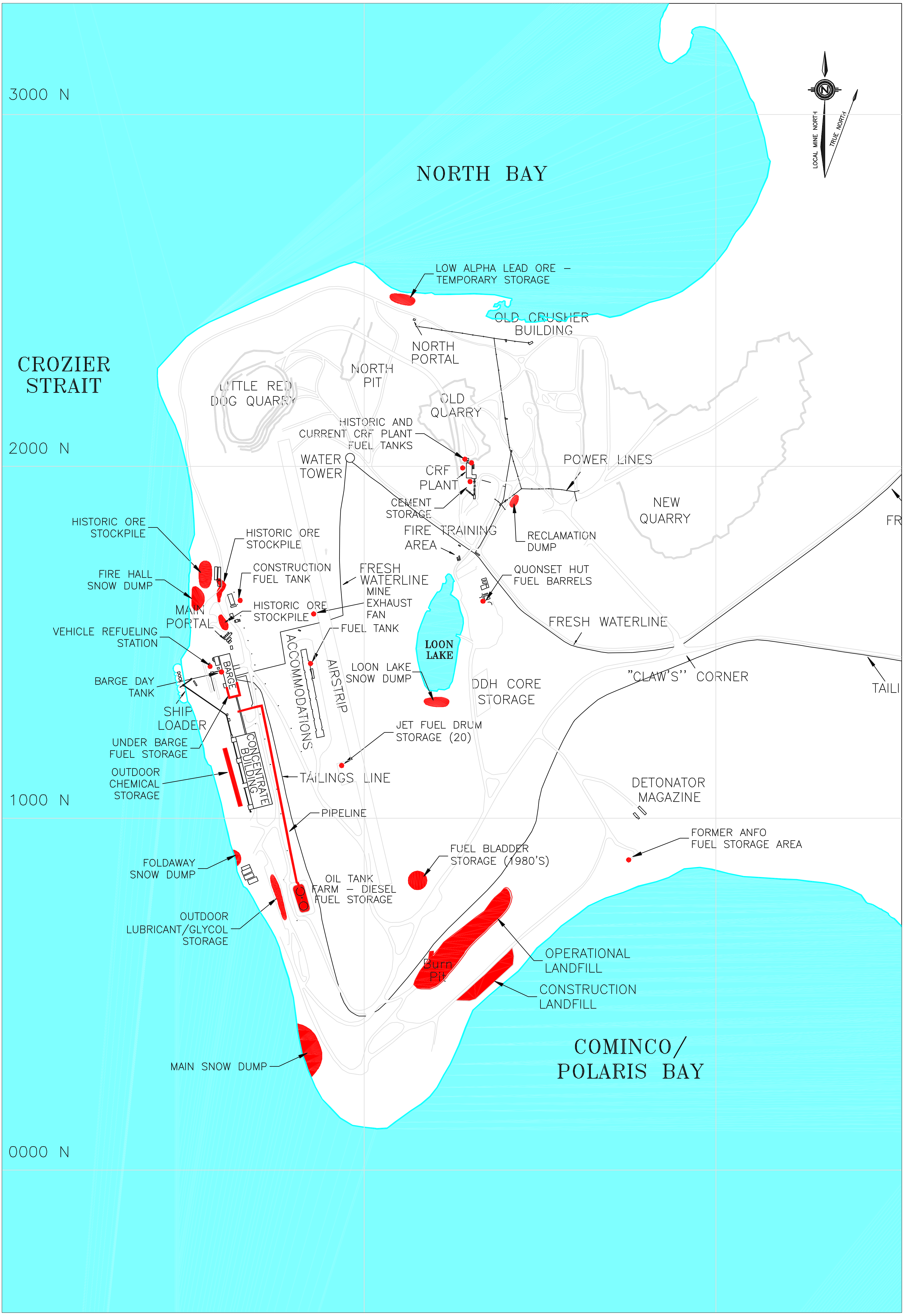
Cross Section A–A'

Scales

Designed By:	D.L./AJK	Drawn By:	D.L./CPW
Checked By:	A.J.K./EG	Approved By:	A.J.K./EG
Date Issued:	22 June 2000	Project No.	99-902
Site Name:	POLARIS MINE	File Name:	99902-D1-02.dwg

Gartner
Lee
Limited

Drawing No.
5



LEGEND

Base map provided by Cominco Resources

Scale 1:10,000
metres
0 100 500

Date Issued: 22 June 2000

Drawn by: BB/CPW

GLL Project Number: 99–902

File Name: 99902–D1–03.dwg

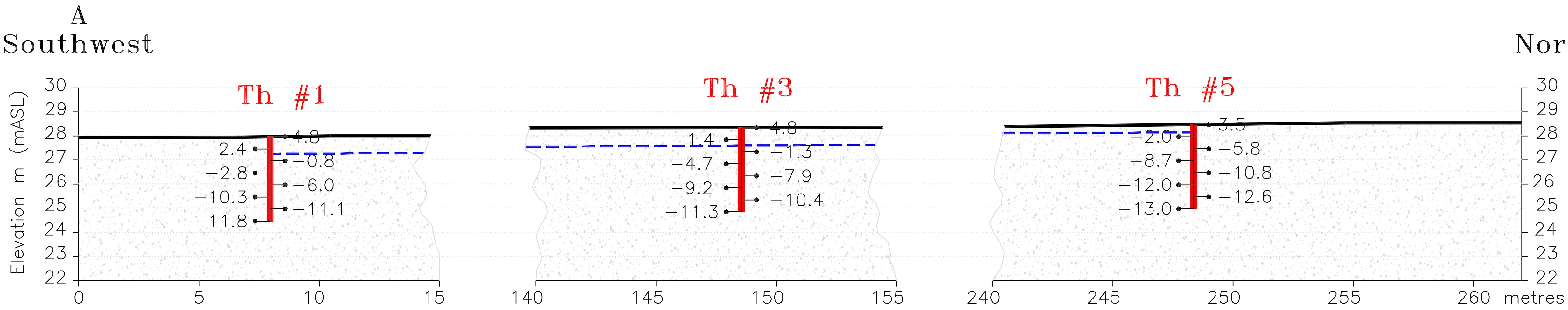
Cominco

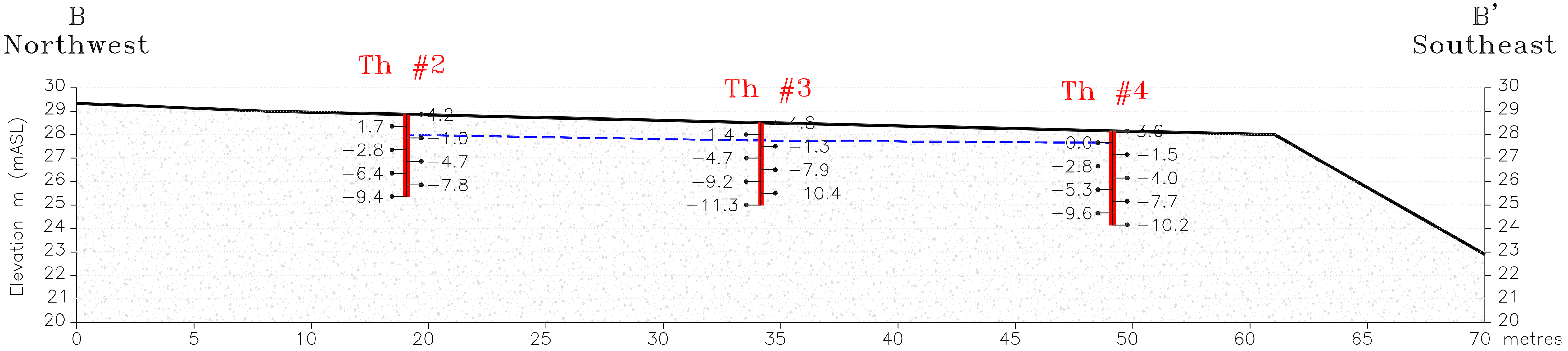
Cominco Ltd.
Polaris Mine

Site Plan Showing
Fuel/Chemical Storage Areas
Landfills and other Areas
of Potential Environmental Concern

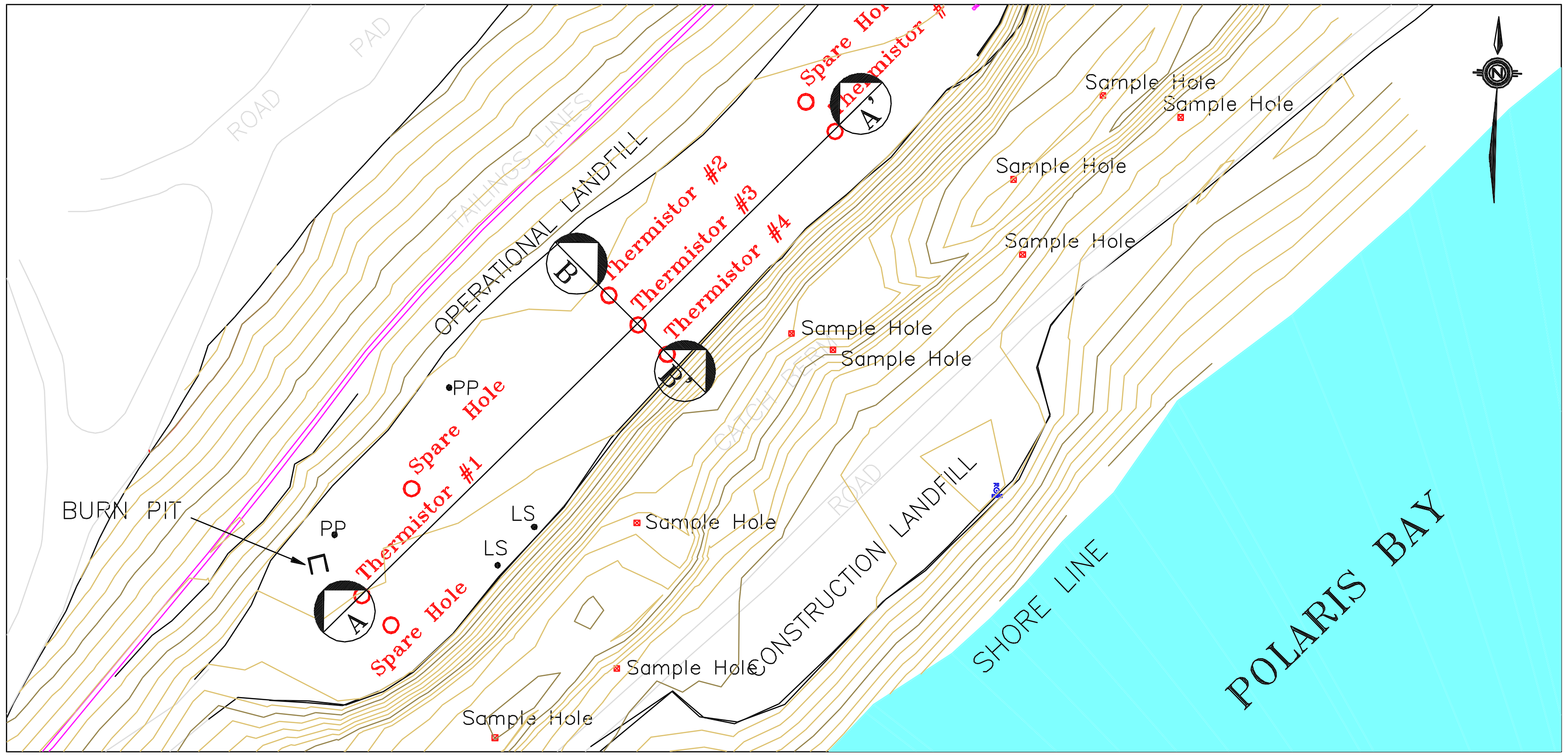
Gartner
Lee
Limited

Figure No.
6



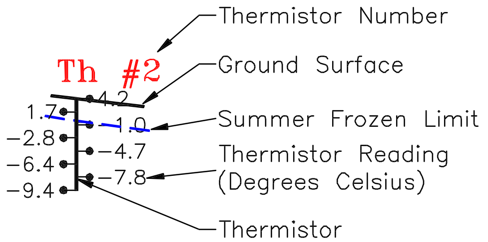


Scale
Horizontal 1:200
Vertical 1:200
Vertical Exaggeration: none



Polaris Mine Landfill
Scale 1:2,500

Legend



○	Thermistor
▪	Sample Hole
PP●	Power Poles
—	Contour, Intermediate
—	Contour, Index
Ⓑ	Cross Section

NOTES:
1. Original drawing provided by Cominco Ltd.
2. Elevations are in metres, mean above sea level (mASL).
3. Contour interval one metre.
4. Thermistor readings measured 10 Aug 1999.

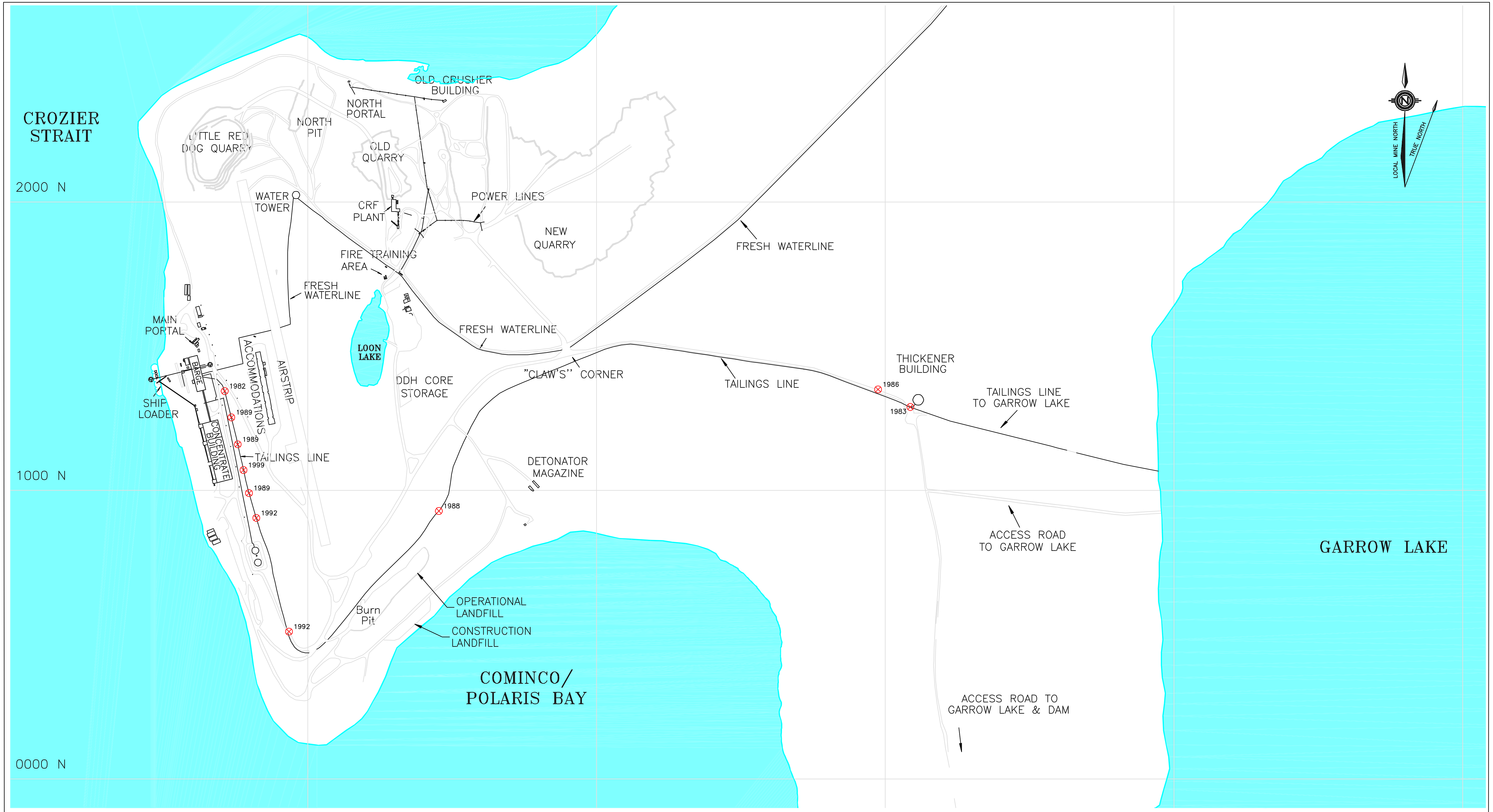
Date Issued: 22 June 2000
Drawn by: BB/CPW
GLL Project Number: 99–902
File Name: 99902–D1–04.dwg

Cominco Ltd.
Polaris Mine

Polaris Mine Landfill
Warmest Thermistor Readings
August 10, 1999

Gartner Lee Limited

Figure No.
7



LEGEND

⊗1986 Tailings Spills (1982 – 1999)
Locations are approximate.

Scale 1:12,500
metres
0 100 500

Date Issued: 22 June 2000
Drawn by: BB/CPW
GLL Project Number: 99–902
File Name: 99902–D1–05.dwg

Cominco
Cominco Ltd.
Polaris Mine

Site Plan Showing Historical
Spill Locations along Tailings Line

Gartner
Lee
Limited

Figure No.
8

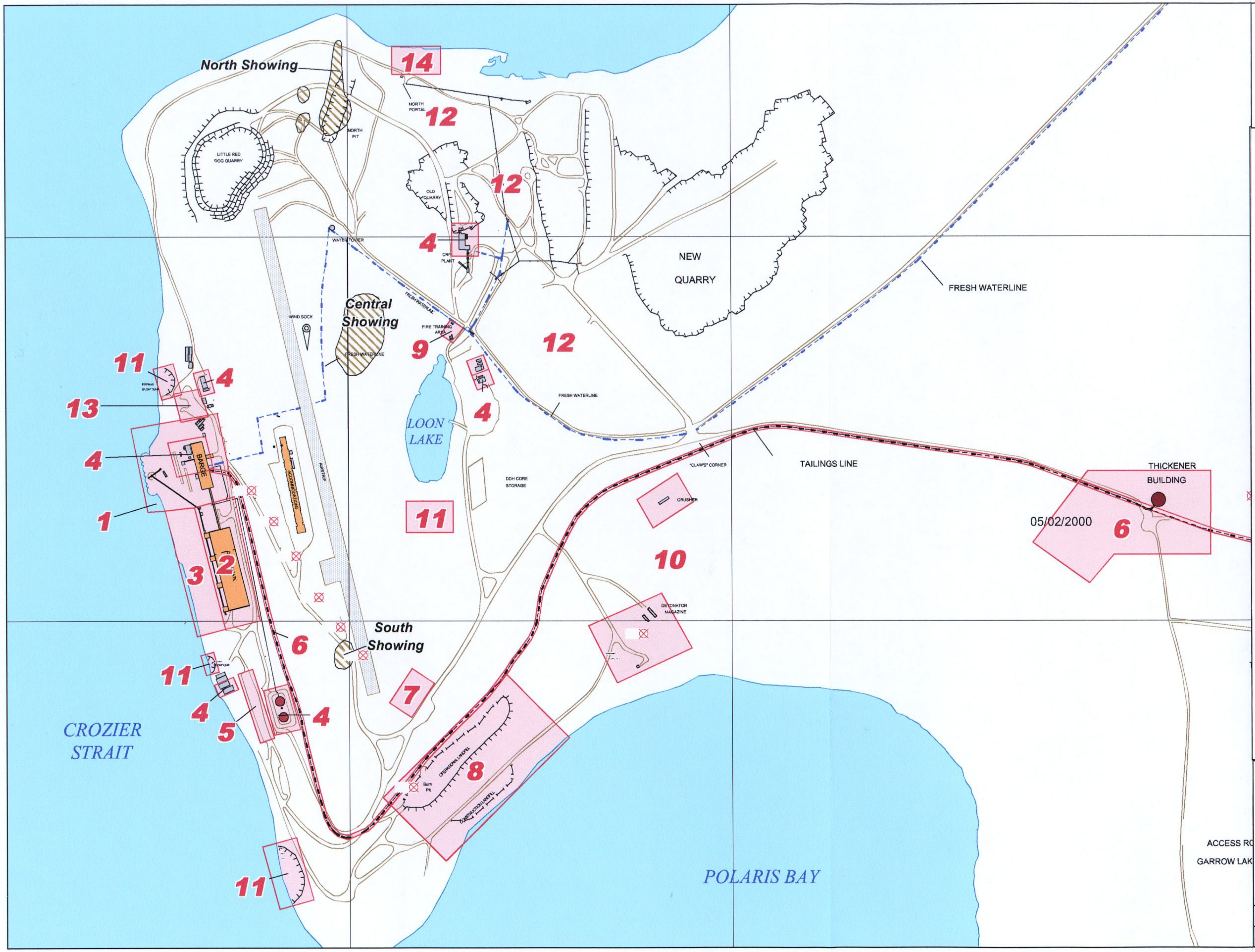


FIGURE 9: AREAS OF POTENTIAL ENVIRONMENTAL CONCERN

Cominco

POLARIS MINE
COMINCO LTD.

11 **Areas of Potential Environmental Concern**

1 - Process barge and ship loading dock
2 - Concentrate storage building
3 - Outdoor bulk chemical storage
4 - Current and historic above ground fuel storage tanks; barge storage tanks; diesel tank farm and pipelines
5 - Outdoor lube/hydraulic oil and glycol drum storage
6 - Tailings pipeline, thickener building and emergency discharge basin
7 - Former fuel bladder storage area
8 - Operational and construction landfills and open storage area
9 - Fire training area
10 - Old ANFO mixing plant; Explosives storage and crusher
11 - Snow dumps
12 - Surface above active mining area
13 - Historic surface stockpiles
14 - Surface lead ore stockpile area

☒ Documented tailings line breaks

Gartner Lee Limited

Scale
1 : 10,000

100 0 100 300 500 metres

N

Drawn On: June 21 2000	Project No.: 99-902
Drawn By: F. Pearson / CPW	Ver. No.: 1a File:Fig9.pdf

FIGURE 10: SAMPLE LOCATION MAP

POLARIS MINE

COMINCO LTD.

Cominco

Scale
Approx. 1 : 8,000

80 0 80 240 400 560 metres

TOPOGRAPHIC LEGEND

INFRASTRUCTURE
- Roads
- Buildings
- Water Line
- Tailings Line
- Headwall Scarps
- Mineralized Showings

DRAINAGE FEATURES
- Creek
- Lake/Ocean

SAMPLE LOCATIONS

○ Sample Location

BH Borehole
TP Test Pit
SS Surface Sample

Drawn On: 11.24.99	Project No.: 99-902
Drawn By: F. Pearson	Ver. No.: 2b File: Fig10_2C.wor

Gartner Lee Limited

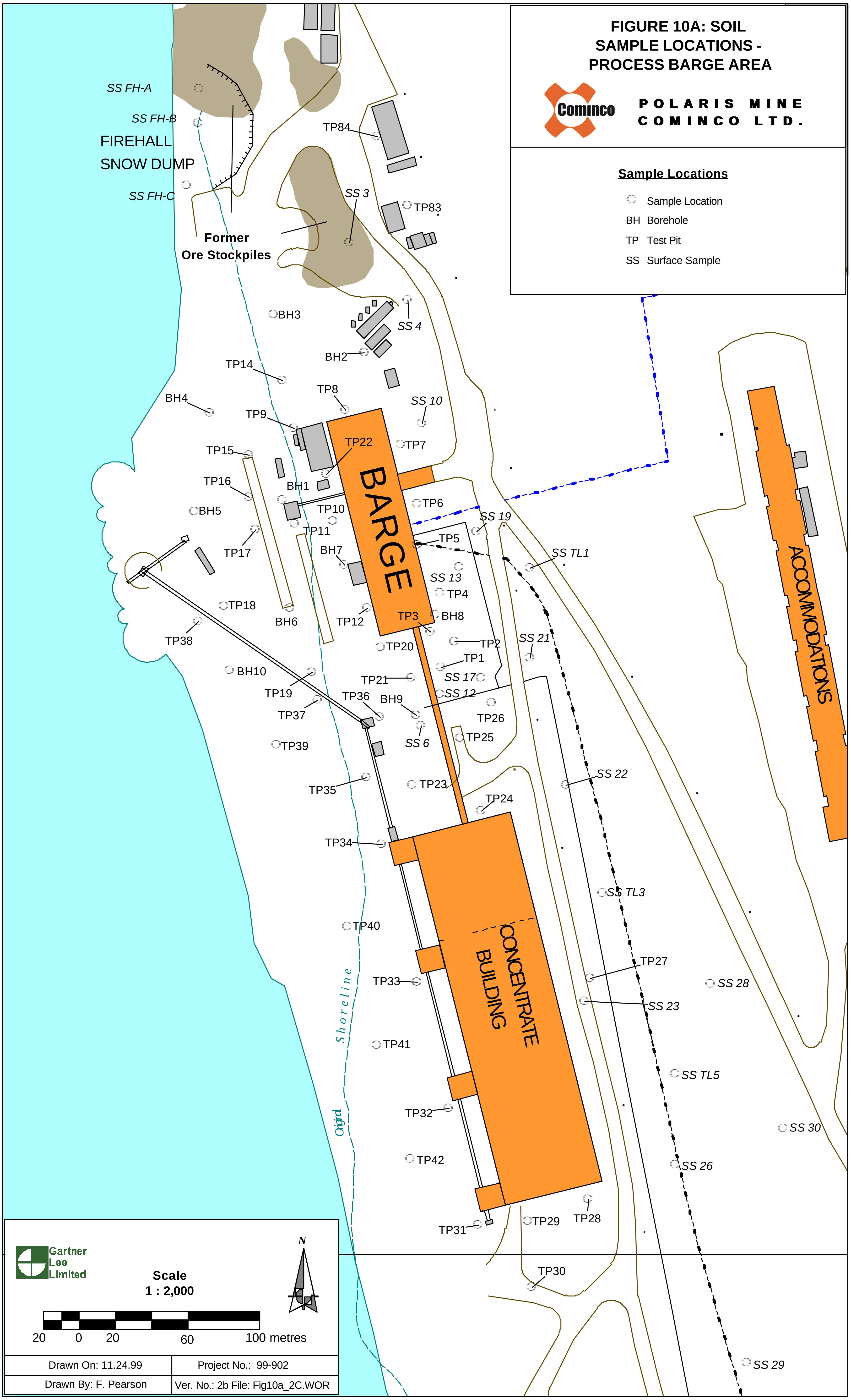


FIGURE 10A: SOIL SAMPLE LOCATIONS - PROCESS BARGE AREA

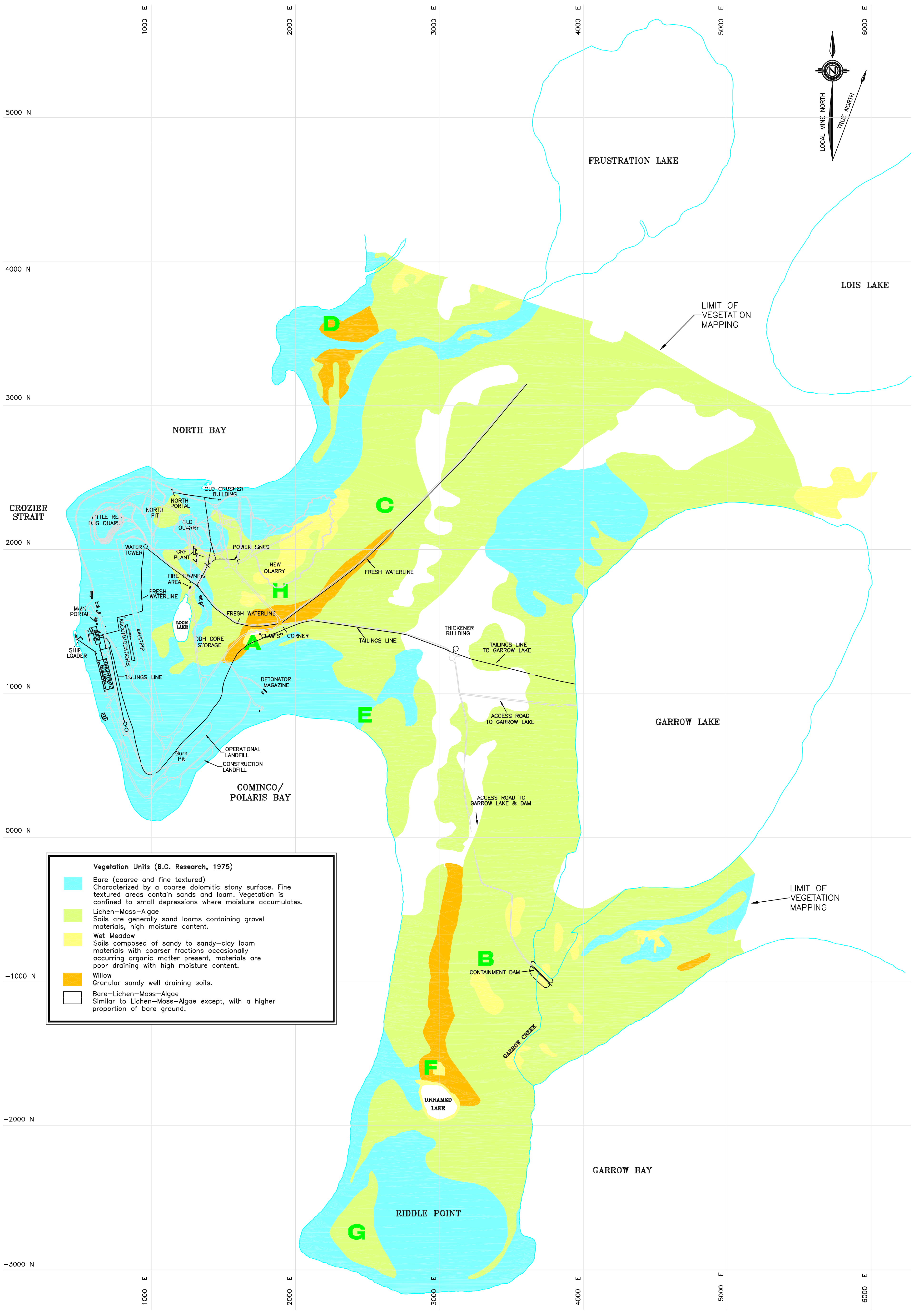
Cominco

POLARIS MINE
COMINCO LTD.

Sample Locations

○	Sample Location
BH	Borehole
TP	Test Pit
SS	Surface Sample

Drawn On: 11.24.99	Project No.: 99-902
Drawn By: F. Pearson	Ver. No.: 2b File: Fig10a_2C.WOR



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 1999

Base map provided by Cominco Resources

Scale 1:25,000
metres
0 200 1000

Date Issued: 22 June 2000
Drawn by: BB/CPW
GLL Project Number: 99–902
File Name: 99902–D1–06.dwg

Cominco
Cominco Ltd.
Polaris Mine

Site Plan Showing Major Vegetation Units and Sampling Locations

Gartner
Lee
Limited

Figure No.
11

FIGURE 12: SOIL SAMPLING RESULTS FOR METALS (PB & ZN)

POLARIS MINE
COMINCO LTD.

Scale
Approx. 1 : 8,000

TOPOGRAPHIC LEGEND

INFRASTRUCTURE

- Roads
- Buildings
- Water Line
- Tailings Line
- Headwall Scarps

- Mineralized Showings

DRAINAGE FEATURES

- Creek
- Lake/Ocean

SAMPLE LOCATIONS & RESULTS

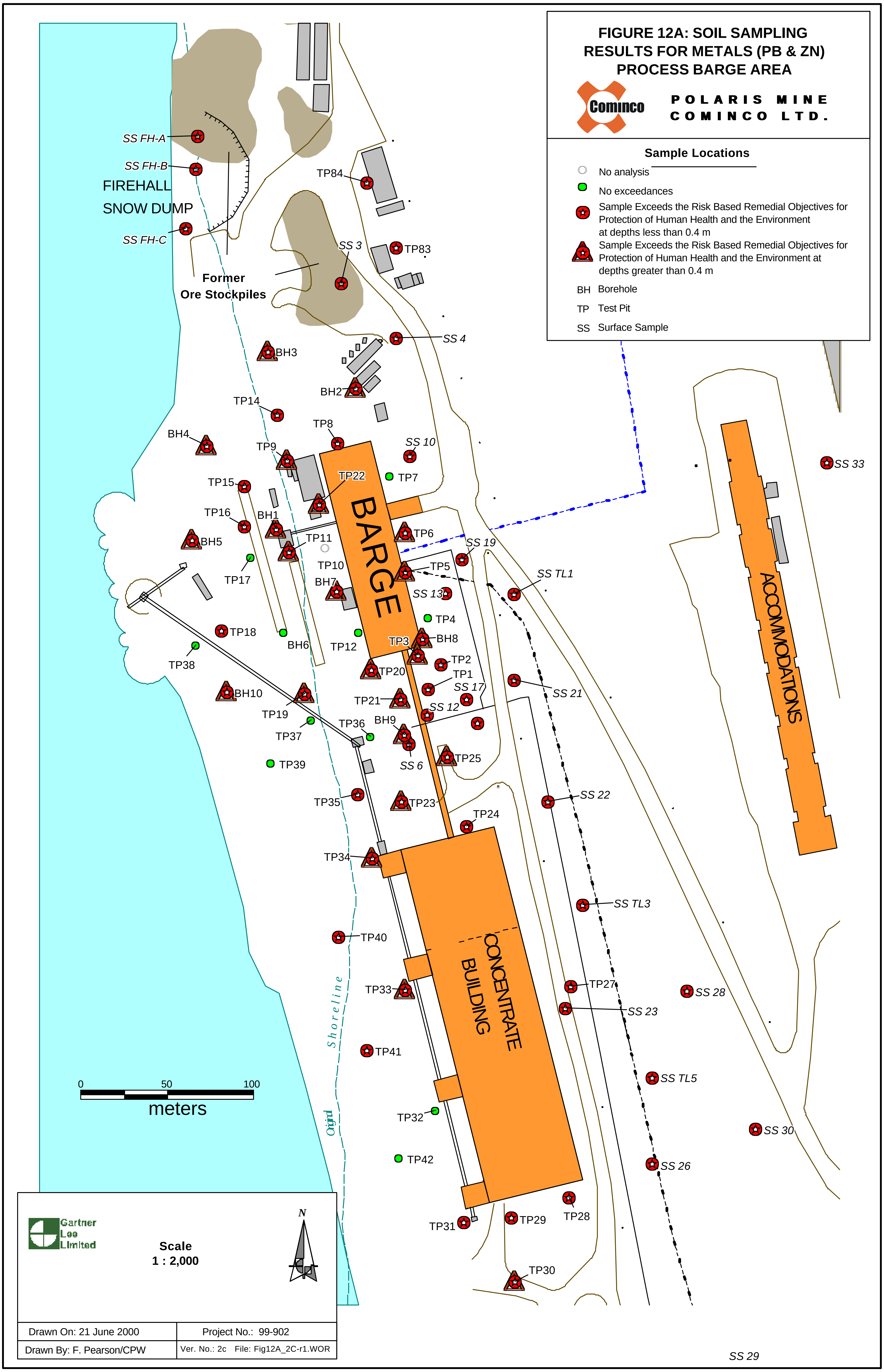
- ○ No analysis
- ● No exceedences
- ● Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment
- ▲ Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths greater than 0.4 m

BH Borehole
TP Test Pit
SS Surface Sample

Drawn On: 06 June 2000	Project No.: 99-902	Gartner Lee Limited
Drawn By: F. Pearson/ CPW	Ver. No.: 2c File: Fig12_2C_r1.wor	

FIGURE 12A: SOIL SAMPLING RESULTS FOR METALS (PB & ZN) PROCESS BARGE AREA

POLARIS MINE
COMINCO LTD.



Sample Locations

- ○ No analysis
- 🟢 No exceedances
- 🔴 Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths less than 0.4 m
- 🔺 Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths greater than 0.4 m

BH	Borehole
TP	Test Pit
SS	Surface Sample

Gartner Lee Limited

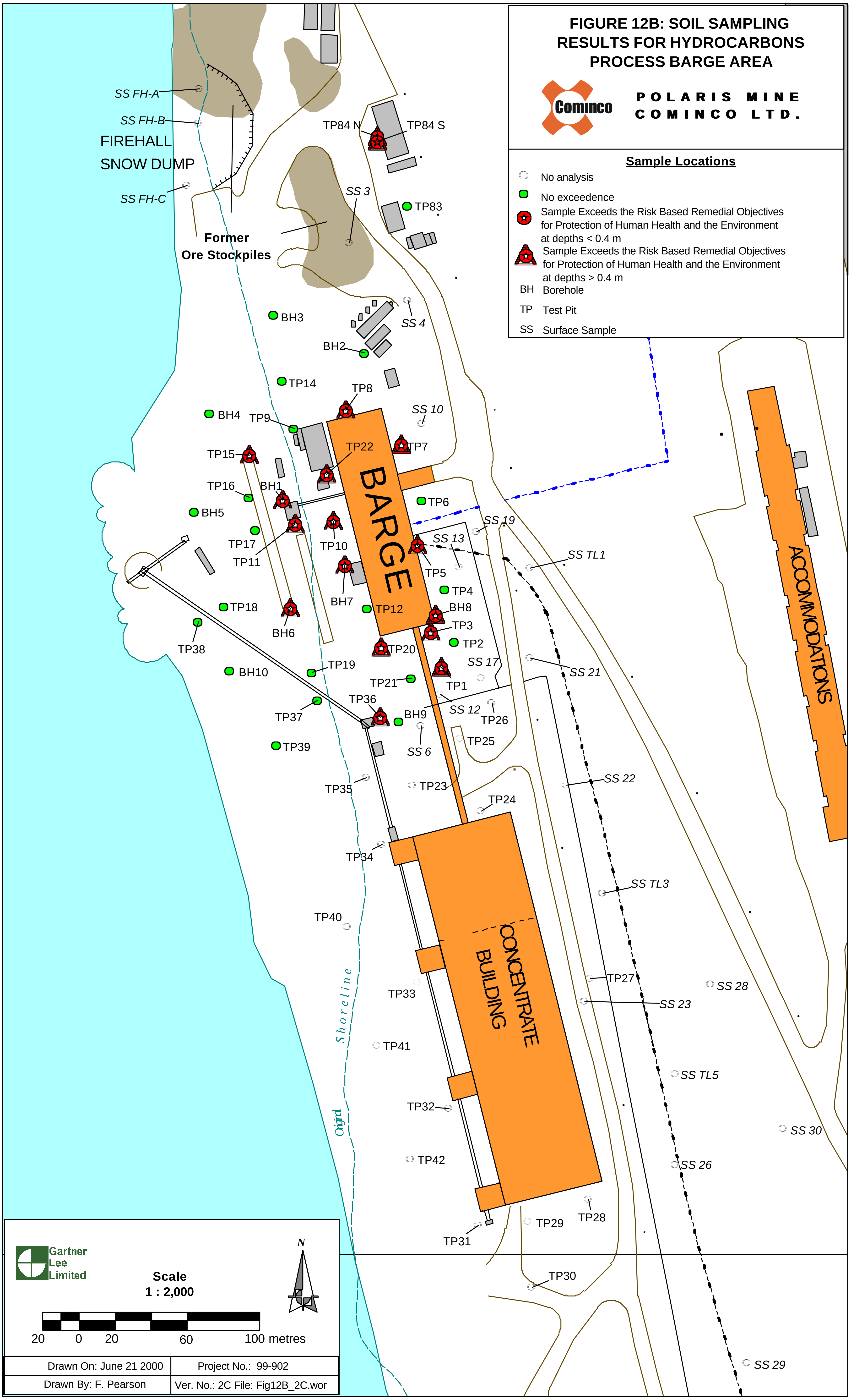
Scale
1 : 2,000

Drawn On: 21 June 2000	Project No.: 99-902
Drawn By: F. Pearson/CPW	Ver. No.: 2c File: Fig12A_2C-r1.WOR

FIGURE 12B: SOIL SAMPLING RESULTS FOR HYDROCARBONS PROCESS BARGE AREA

Cominco

POLARIS MINE
COMINCO LTD.



Sample Locations

○ No analysis

🟢 No exceedence

🔴 Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths < 0.4 m

🔺 Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths > 0.4 m

BH	Borehole
TP	Test Pit
SS	Surface Sample

Gartner Lee Limited

Scale
1 : 2,000

20 0 20 60 100 metres

Drawn On: June 21 2000	Project No.: 99-902
Drawn By: F. Pearson	Ver. No.: 2C File: Fig12B_2C.wor

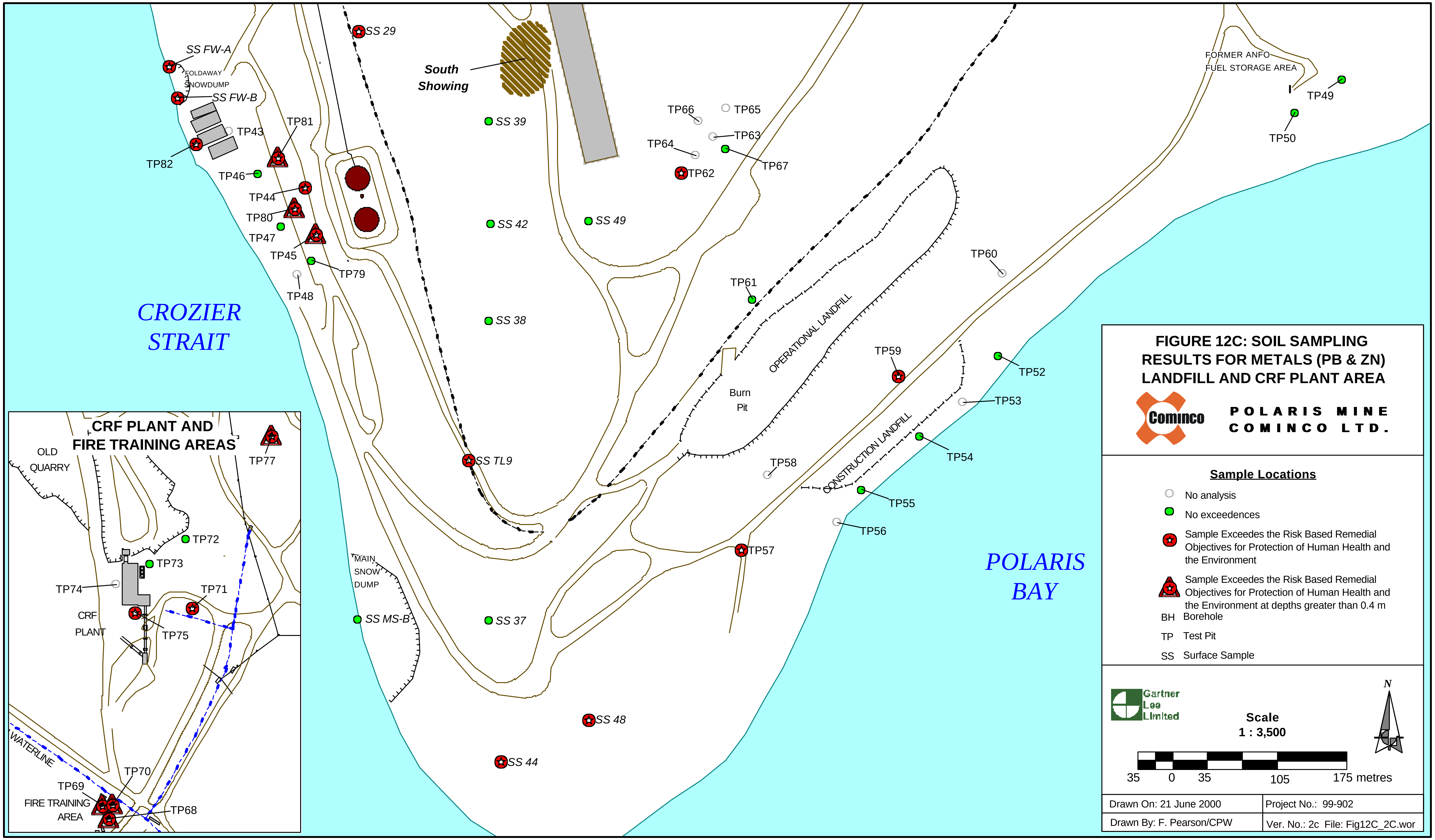


FIGURE 12C: SOIL SAMPLING RESULTS FOR METALS (PB & ZN) LANDFILL AND CRF PLANT AREA

Cominco

POLARIS MINE
COMINCO LTD.

Sample Locations

○ No analysis

● No exceedences

● Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment

▲ Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths greater than 0.4 m

BH	Borehole
TP	Test Pit
SS	Surface Sample

Gartner Lee Limited

Scale
1 : 3,500

35 0 35 105 175 metres

Drawn On: 21 June 2000	Project No.: 99-902
Drawn By: F. Pearson/CPW	Ver. No.: 2c File: Fig12C_2C.wor

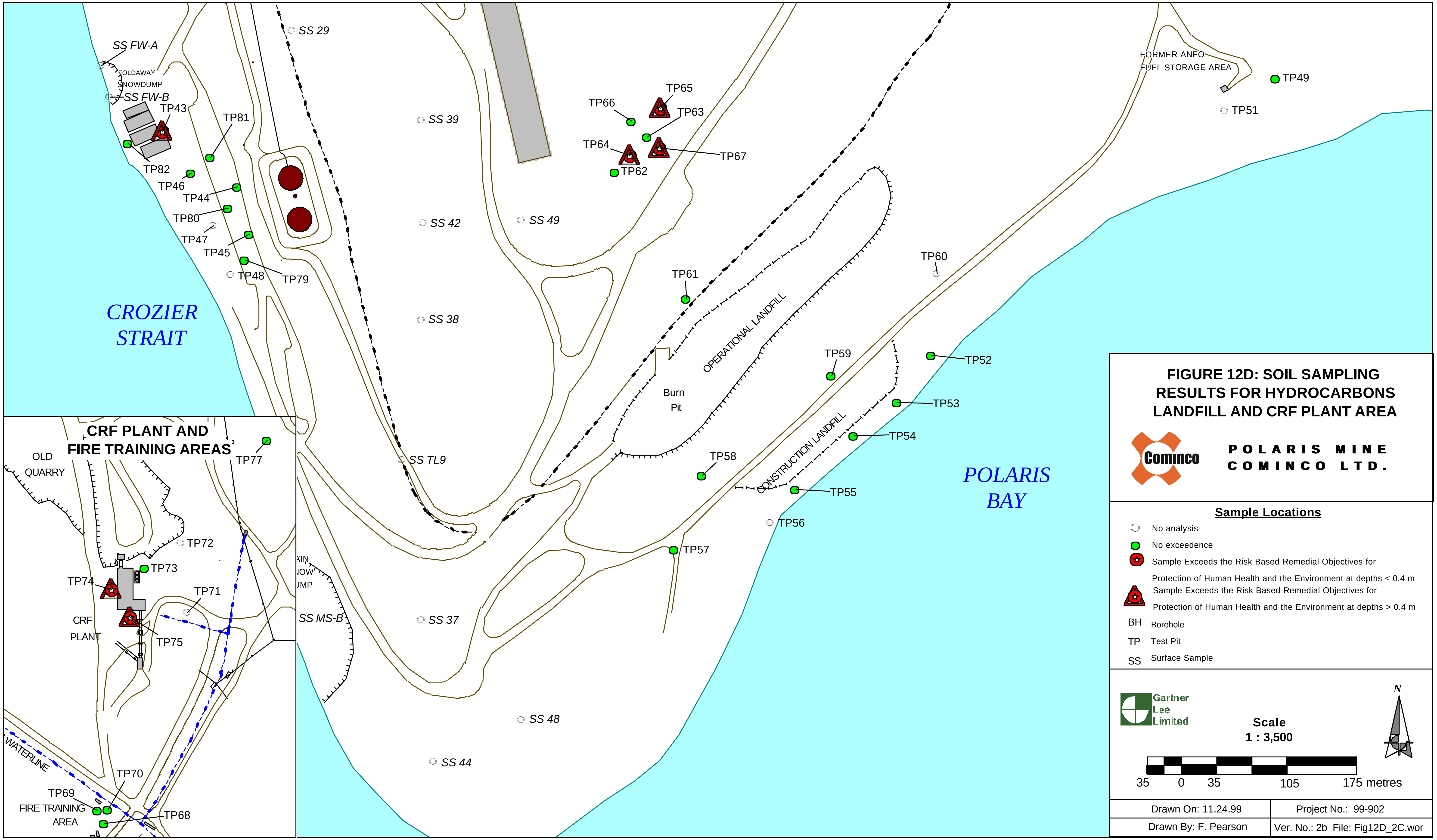


FIGURE 12D: SOIL SAMPLING RESULTS FOR HYDROCARBONS LANDFILL AND CRF PLANT AREA

Cominco

POLARIS MINE
COMINCO LTD.

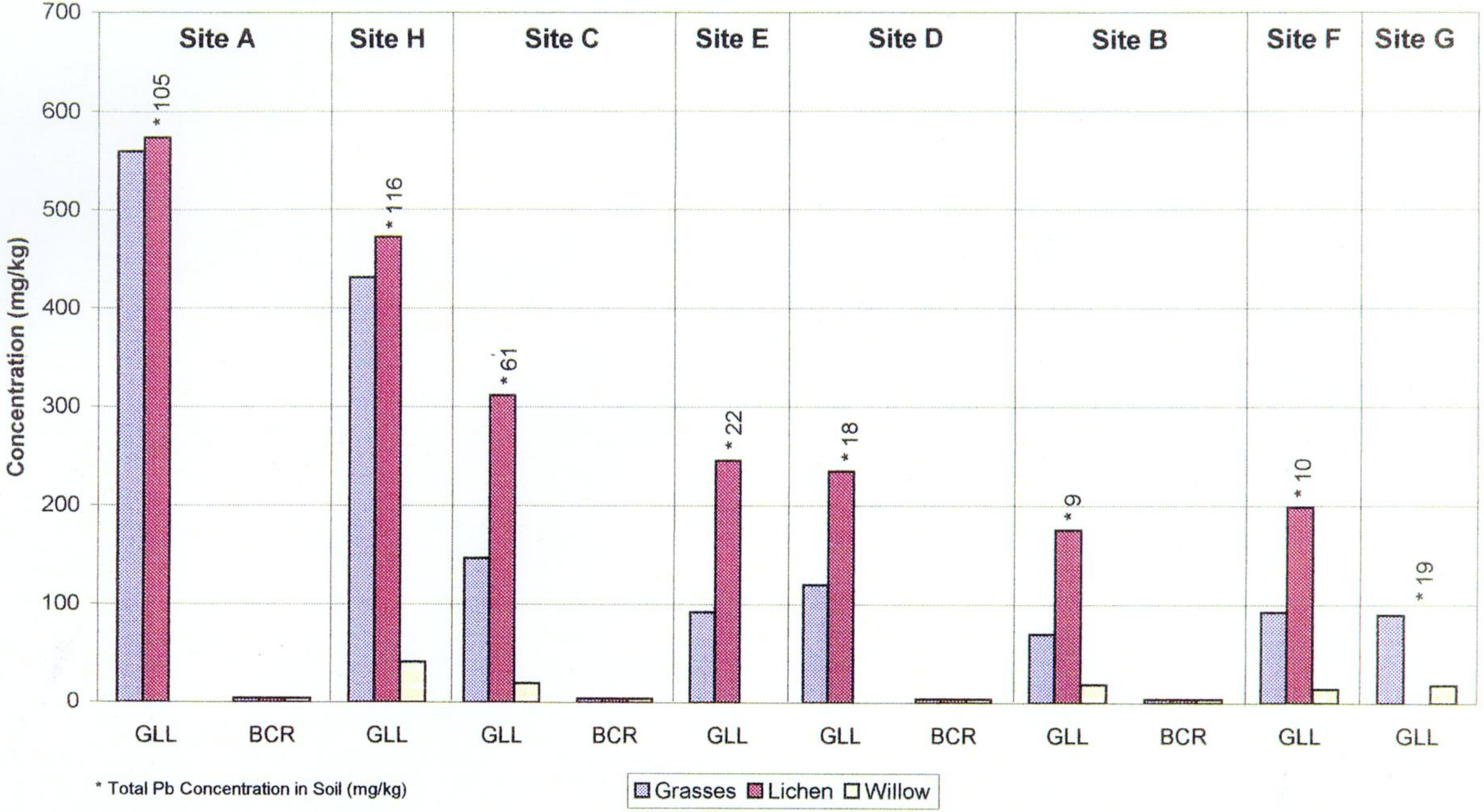
Sample Locations

- ○ No analysis
- 🟩 No exceedence
- ● Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths < 0.4 m
- ▲ Sample Exceeds the Risk Based Remedial Objectives for Protection of Human Health and the Environment at depths > 0.4 m

BH	Borehole
TP	Test Pit
SS	Surface Sample

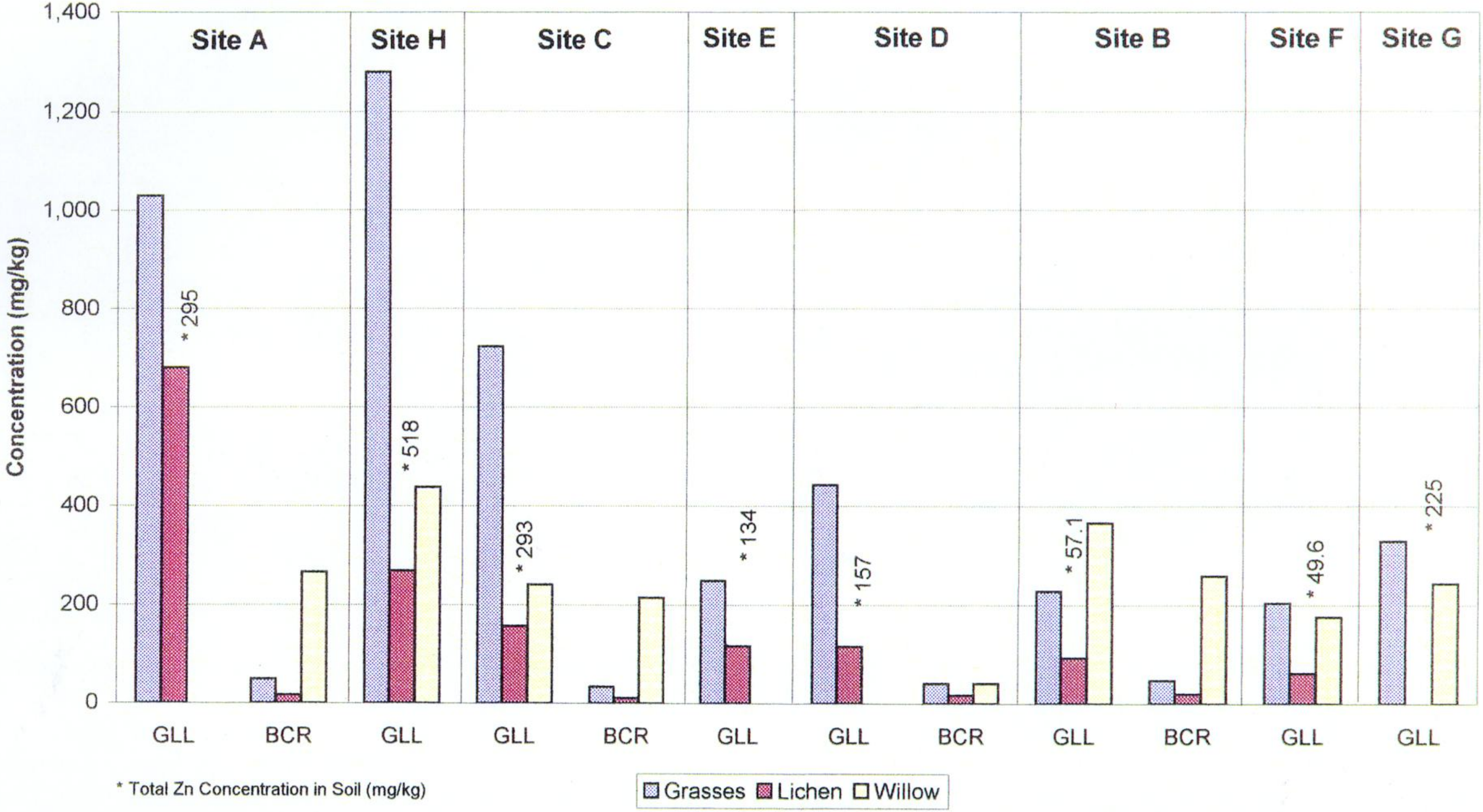
Drawn On: 11.24.99	Project No.: 99-902
Drawn By: F. Pearson	Ver. No.: 2b File: Fig12D_2C.wor

Figure 13A
Cominco Limited - Polaris Mine Operation
Lead Concentration in Vegetation Samples
BC Research (BCR 1974) and Gartner Lee Limited (GLL 1999)



* Total Pb Concentration in Soil (mg/kg)

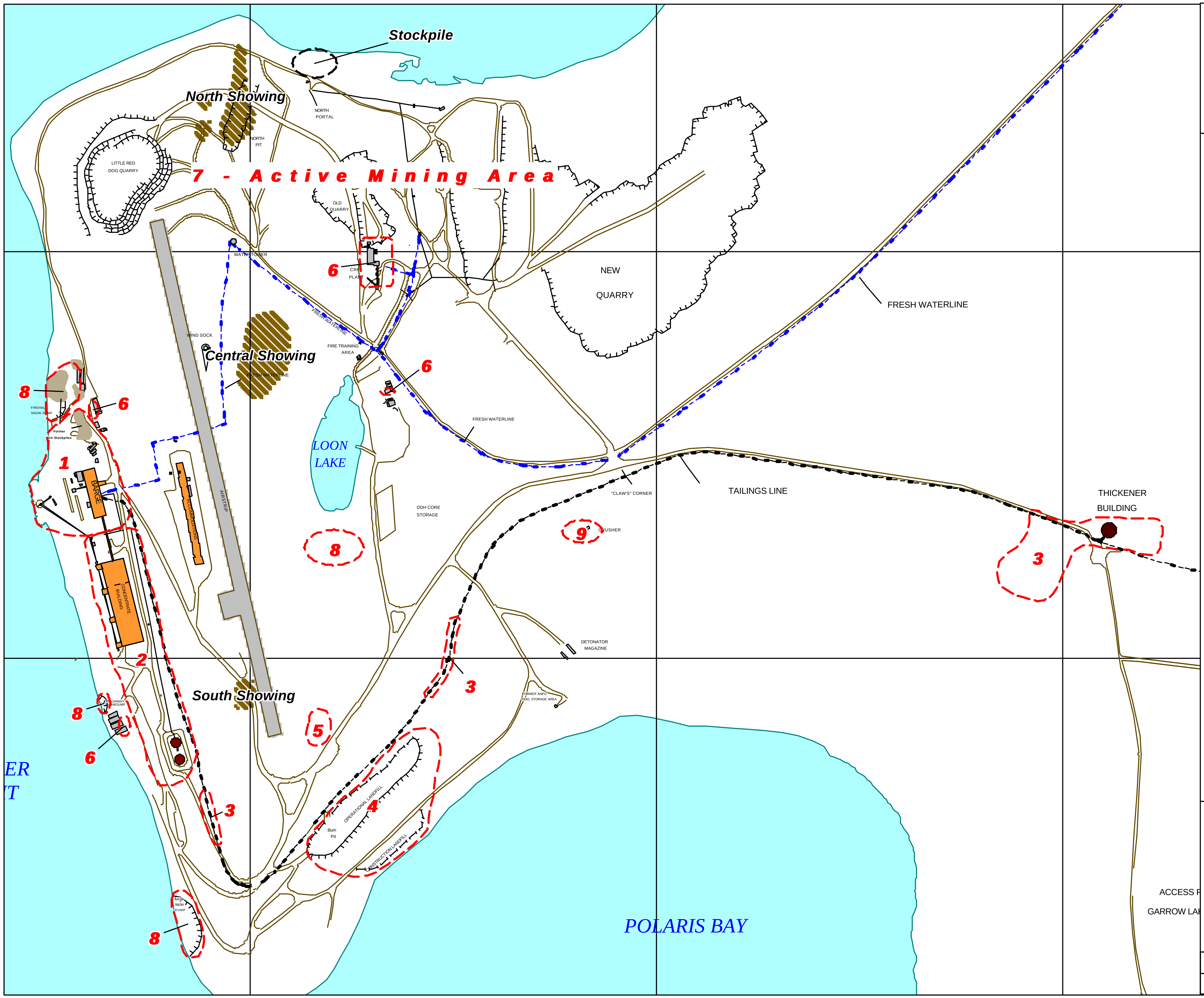
Figure 13B
Cominco Limited - Polaris Mine Operation
Zinc Concentration in Vegetation Samples
BC Research (BCR 1974) and Gartner Lee Limited (GLL 1999)



* Total Zn Concentration in Soil (mg/kg)

FIGURE 14: TARGETED AREAS FOR REMEDIATION

POLARIS MINE
COMINCO LTD.



Areas Targeted for Remediation

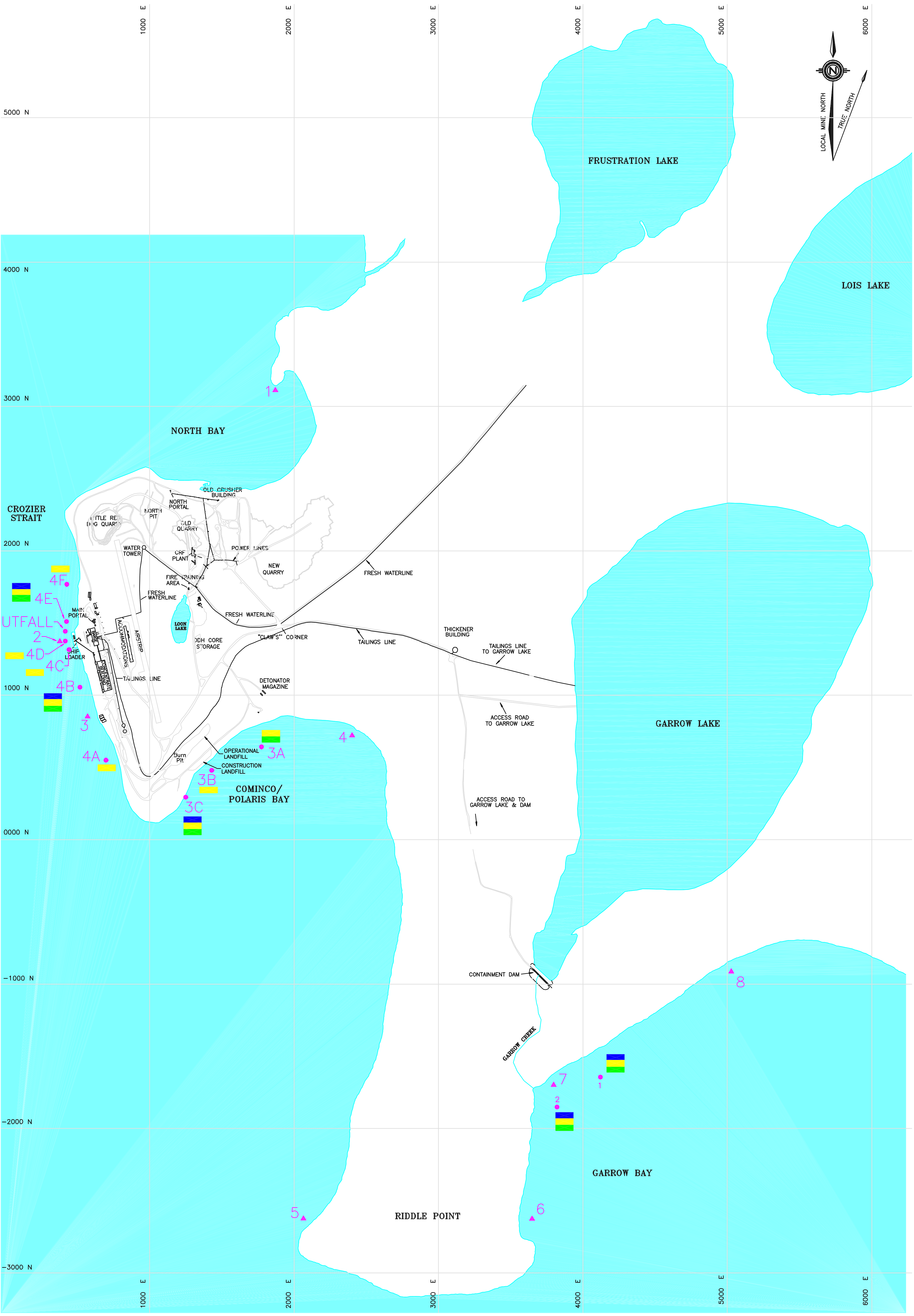
1 - Rockfill around process barge
2 - Concentrate storage building, concentrate conveyors, south to diesel tank farm
3 - Tailings line and tailings spill areas
4 - Landfills
5 - Former oil bladder storage area spills
6 - Fuel tanks at firehall, foldaways, quonset huts, and CRF plant
7 - Surface over active mining area
8 - Snowdumps
9 - Old crusher

Gartner Lee Limited

Scale
1 : 10,000

100 0 100 300 500 metres

Drawn On: 06 June 2000	Project No.: 99-902
Drawn By: F. Pearson / CPW	Ver. No.:1C File: Fig14_1C.wor



LEGEND

Base map provided by Cominco Resources

4F ● Marine Sampling Station, GLL (1999)

🟦 Water
🟨 Sediments
🟩 Biota

4 ▲ Marine Sampling Station, Sediment Fallis (1984)

Scale 1:25,000
metres
0 200 1000

Date Issued: 23 June 2000
Drawn by: BB/CPW
GLL Project Number: 99–902
File Name: 99902–D1–07.dwg

Cominco
Cominco Ltd.
Polaris Mine

Site Plan Showing Marine Sampling Locations

Gartner Lee Limited

Figure No.
15


Cominco

Photographs

- PHOTOGRAPHS -

PHOTOGRAPH 1

Mine site in winter, looking east.

PHOTOGRAPH 2

Barge and ship loading dock, looking west.

PHOTOGRAPH 3

Mine yard and dock, showing Steam Bay on left, vehicle fuelling station in centre, in front of Benthorn Fuel Building and Cat Generator Building.

PHOTOGRAPH 4

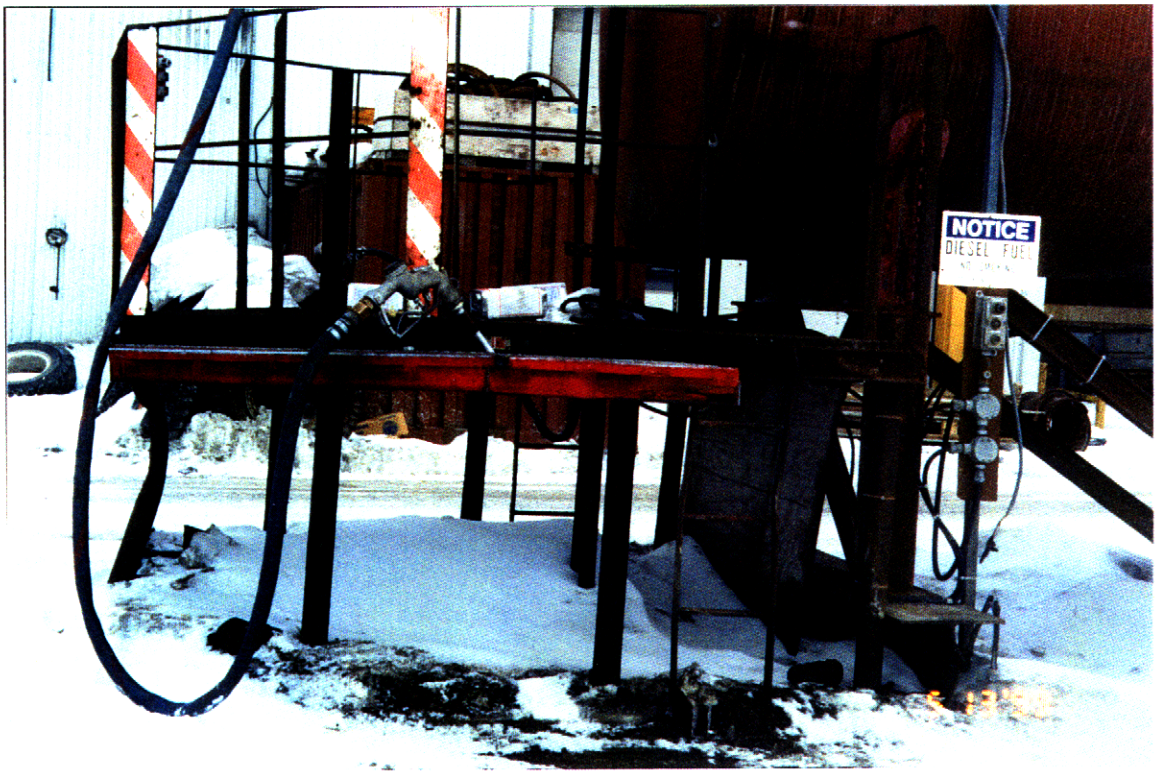
Mine yard and Portal - Refrigeration plant to right of portal.

- PHOTOGRAPHS -

PHOTOGRAPH 5

Diesel equipment fuelling station.

PHOTOGRAPH 6



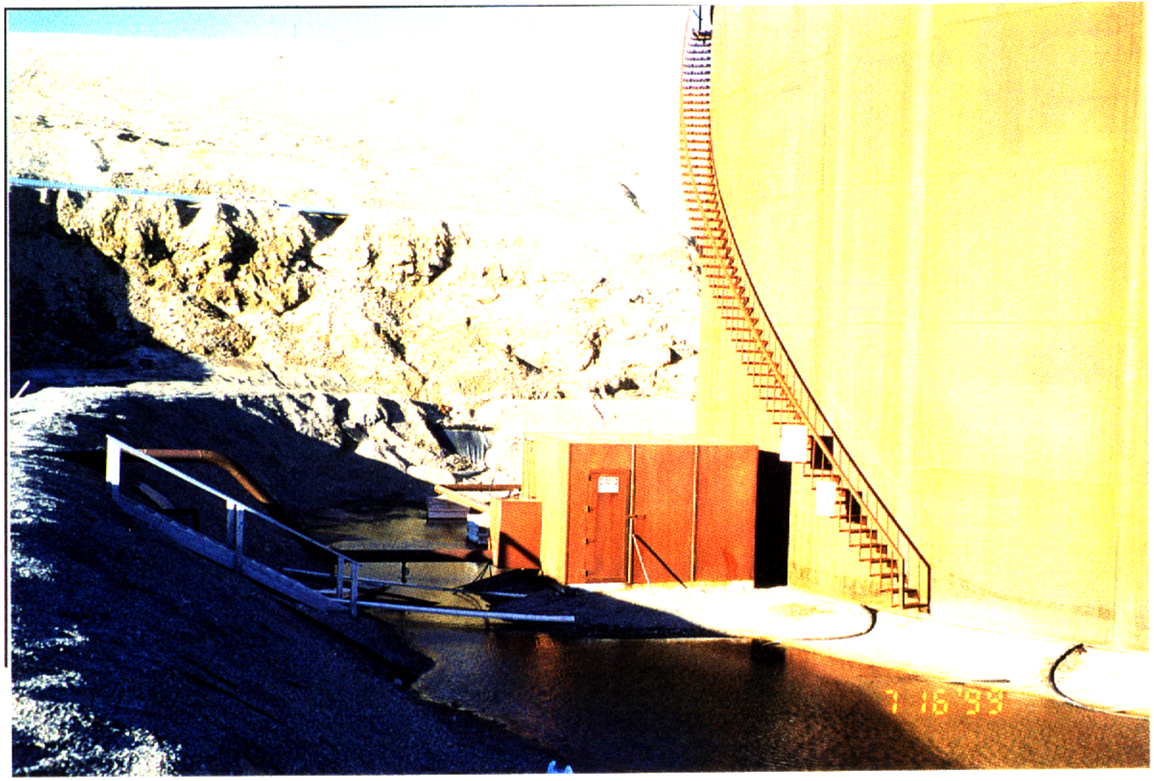
Diesel equipment fuelling station.

- PHOTOGRAPHS -

PHOTOGRAPH 7

Fuel Tank Farm.

PHOTOGRAPH 8



Fuel Tank Farm Showing Berm.

PHOTOGRAPH 9

Chemical Storage Area.

PHOTOGRAPH 10

Lube Oil/Grease Storage Area.

- PHOTOGRAPHS -

PHOTOGRAPH 11

Zinc Sulphate Storage.

PHOTOGRAPH 12

Sodium Cyanide Storage.

- PHOTOGRAPHS -

PHOTOGRAPH 13

Dryer Exhaust At Rear Of Mill (lead/zinc concentrate dust on snow).

PHOTOGRAPH 14

5 14 '99

Drilling Test Hole #1 near Benthorn Building.

- PHOTOGRAPHS -

PHOTOGRAPH 15

CRF Plant behind Reclamation Dump.

PHOTOGRAPH 16

CRF Plant, Cement Mixing and Diesel Fuel Tank (Envirotank).

- PHOTOGRAPHS -

PHOTOGRAPH 17

Reclamation Dump - Looking North.

PHOTOGRAPH 18

Reclamation Dump - Looking Southwest.

PHOTOGRAPHS -

PHOTOGRAPH 19

Operational Landfill - Elevated Food Garbage Container Barn Pit is in the Background.

- PHOTOGRAPHS -

PHOTOGRAPH 20

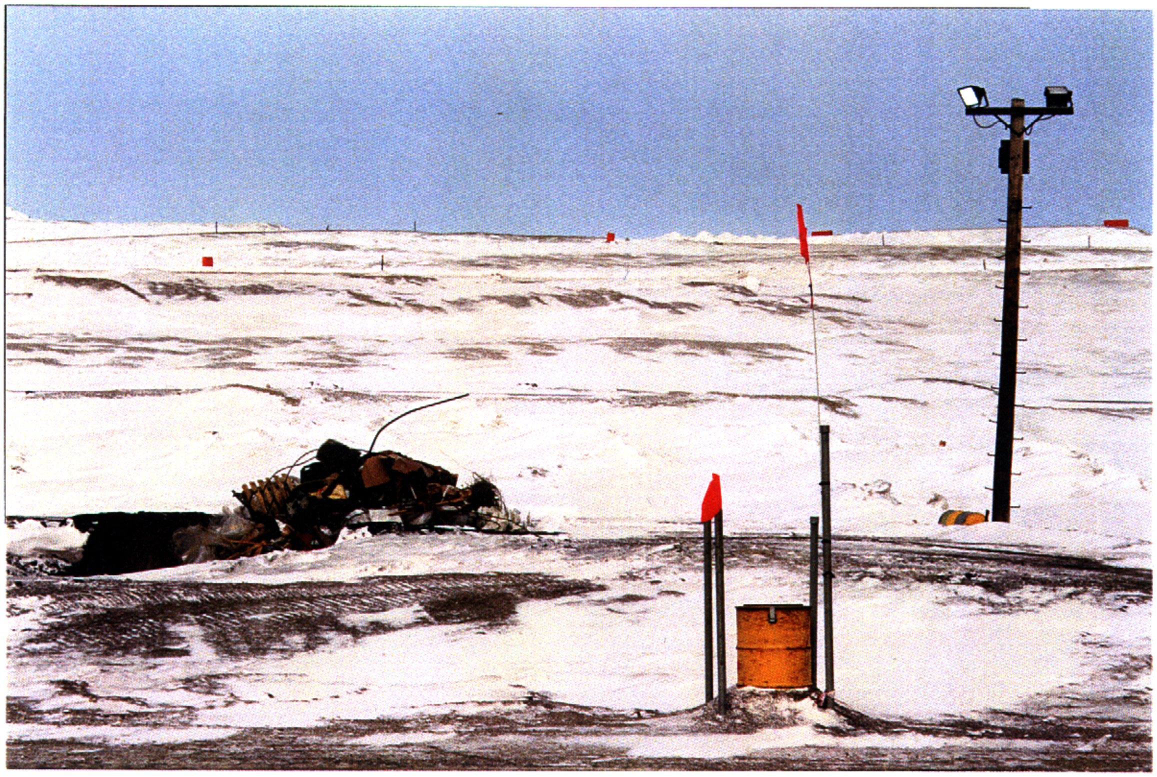
Burn Pit.

- PHOTOGRAPHS -

PHOTOGRAPH 21

Toe of Operational Landfill.

PHOTOGRAPH 22



Operational Landfill.

- PHOTOGRAPHS -

PHOTOGRAPH 23

Cutting Hole in Ocean Ice for Marine Sampling by Divers.

PHOTOGRAPH 24

Water Sampling in Cominco/Polaris Bay.

- PHOTOGRAPHS -

PHOTOGRAPH 25

Marine sampling in front of Dock.

PHOTOGRAPH 26

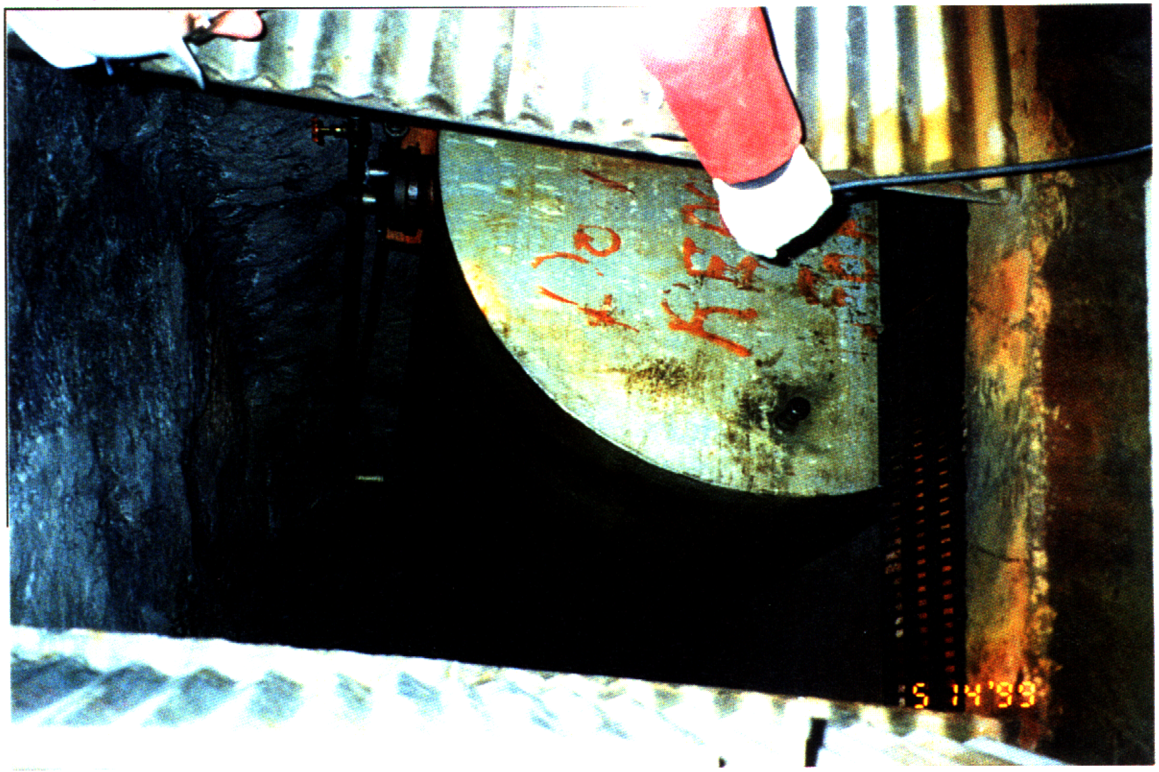
Clams from Marine Sampling Station at Station #2 in Gorrow Bay.

- PHOTOGRAPHS -

PHOTOGRAPH 27

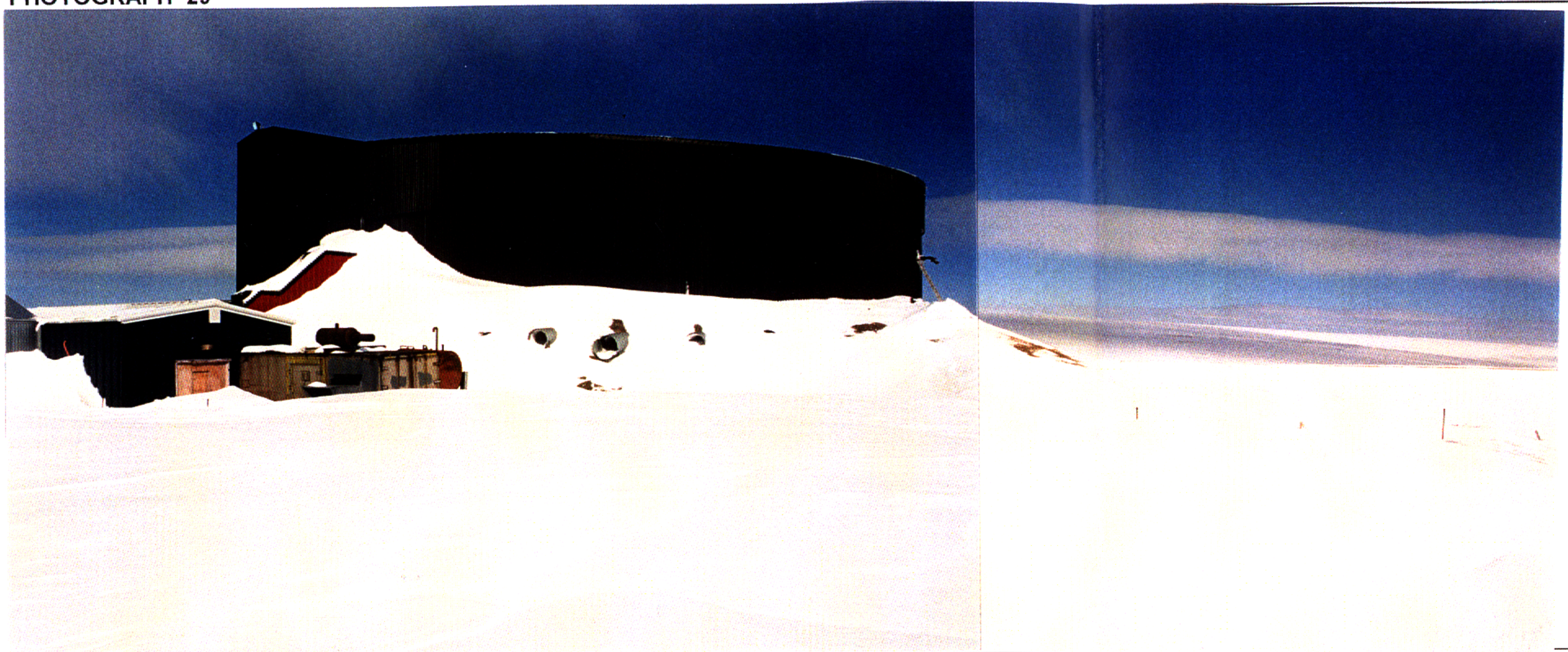
Underground Explosives Plant Loading Dock.

PHOTOGRAPH 28



Explosives Plant Diesel Fuel Storage Tank.

PHOTOGRAPH 29



Tailings Thickener and Garrow Lake.

- PHOTOGRAPHS -

PHOTOGRAPH 30


7 14 '99

Little Red Dog Quarry

PHOTOGRAPH 31


7 14 '99

Erosion Gully to West of Construction Landfill.

- PHOTOGRAPHS -

PHOTOGRAPH 32

Typical Tailings Spill from Tailings Line Break.

PHOTOGRAPH 33

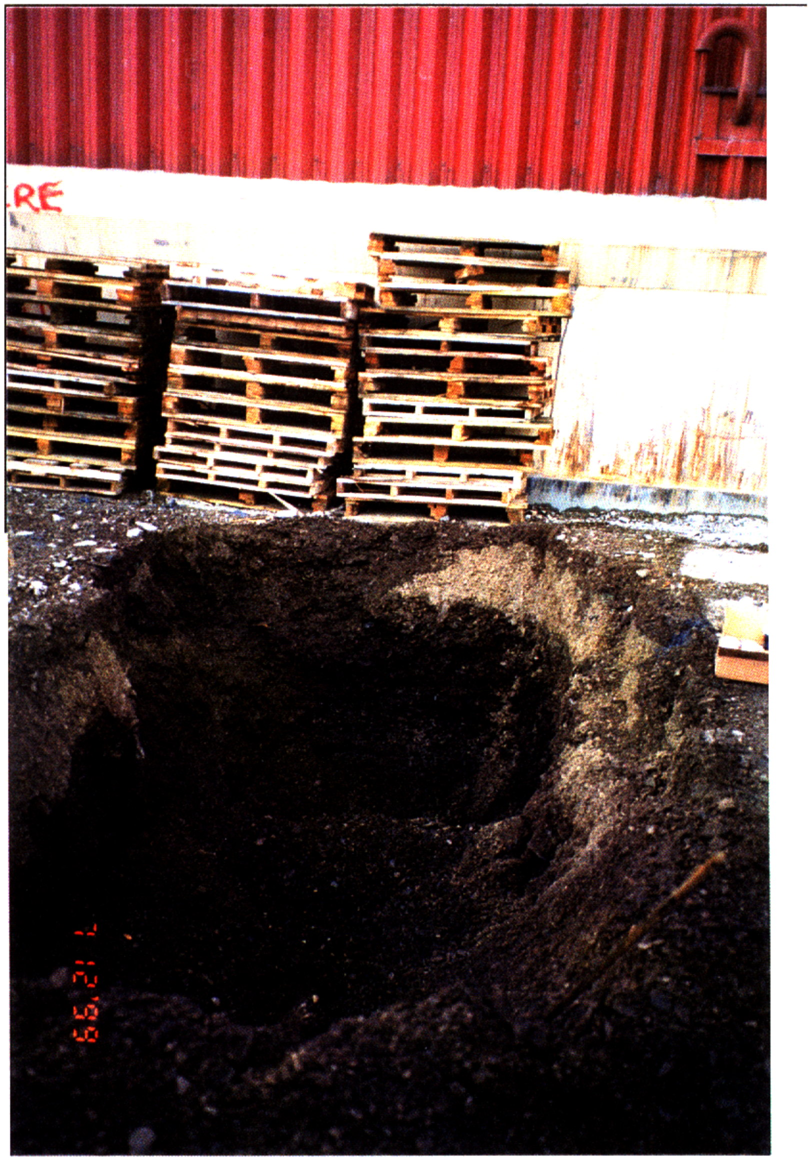
Main Snow Dump Looking North.

- PHOTOGRAPHS -

PHOTOGRAPH 34

Test Pit #3 - Below dryer exhaust. Accumulation of concentrate can be seen on the surface. Sample taken at 0.6 - 0.9 m depth.

PHOTOGRAPH 35



Test Pit #12 Near door at SW Corner of Barge. Showing increased depth of active layer adjacent to barge.

- PHOTOGRAPHS -

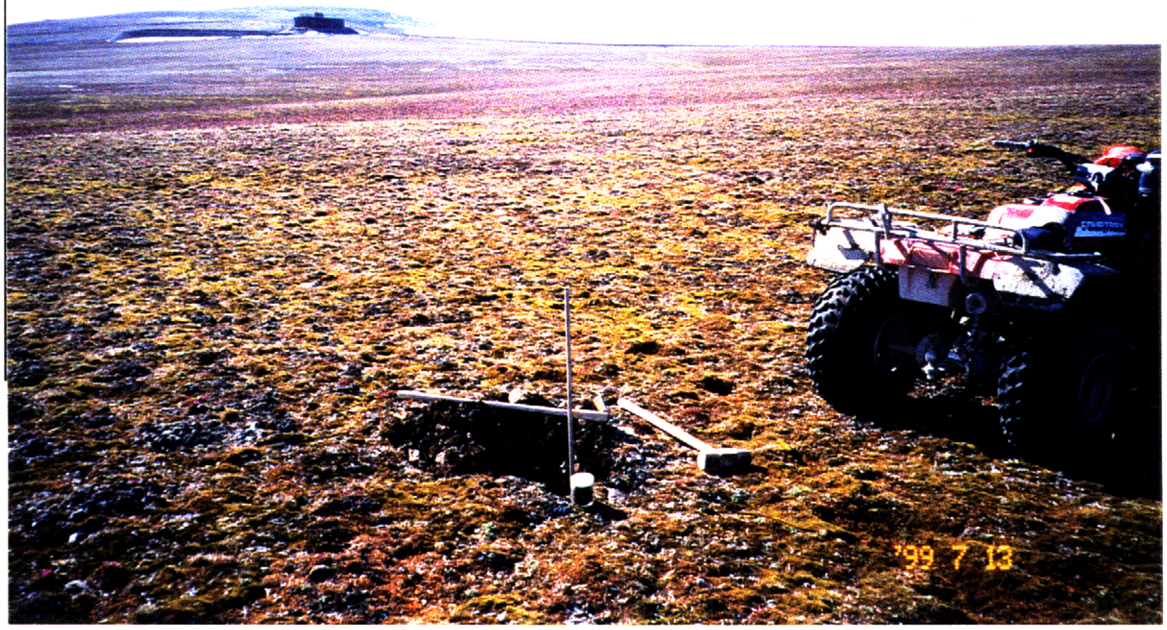
PHOTOGRAPH 36

Soil Sample Location #81 (2750E, 1100N)

PHOTOGRAPH 37

Willows at Location "H" Looking South.

PHOTOGRAPH 38



Soil Sample Location #101, Looking South to the Tailings Thickener.

PHOTOGRAPH 39

Looking down slope from the 1983 Tailings Spill Location.

PHOTOGRAPHS -

PHOTOGRAPH 40

Diesel Fuel from BH#1.

Appendix A

Terrain Analysis

1. Introduction

This study provides Cominco Ltd. with a 1:8,000 scale terrain map showing the surficial materials and geomorphological processes for the vicinity of the Polaris Mine Site on Little Cornwallis Island, Nunavut Territory. The study area consists of the Polaris Mine site peninsula to Garrow Lake to the east, Riddle Point to the south and Frustration Lake to the north.

This report supports the terrain map (located in the map pocket of this report) by providing a description of the methods (section 2), regional physiography (Section 3), surficial materials and landforms (Section 4) and geomorphological processes (Section 5).

This mapping will be useful to Cominco Ltd. as part of their reclamation planning of the Polaris mine since it accurately maps out the distribution and thickness of -unconsolidated deposits (e.g. Quaternary deposits) and associated geomorphic processes. In short this type of mapping sets out the natural conditions and environmental setting of the mine area. Furthermore, the geomorphic processes highlight potential terrain hazards that could be encountered. Field information was collected as part of the far-field soil and vegetation sampling conducted by Gartner Lee Limited in July, 1999.

2. Methods

A complete terrain mapping project includes preliminary mapping from aerial photographs (pretyping), field-checks, corrections to the mapping in light of the field findings, digitizing and the production of finalized maps and reports. This work was completed based a standard procedure for terrain classification produced for British Columbia (Hoews and Kenk, 1997), but modified to be appropriate for the Little Cornwallis study area.

2.1 Pretyping Airphotos

The study area was pretyped using approximately 1:5,000-scale black and white aerial photographs. Specifically, the coverage used was Line A26054 photos numbers 1-113 flown September 1982. During pretyping, polygonsof relatively uniform slope and surficial materials were assigned a terrain symbol and geomorphic process where applicable.

A legend outlining all of the terrain symbol components is included on the terrain map.

2.2 Field Checking and Corrections

Field work for terrain mapping was conducted in conjunction with far-field soil and vegetation sampling over the study area as part of the Phase II environmental site assessment. Field-check sites were accessed by use of 4-wheel ATV's provided by Cominco Ltd. Field-checks were conducted from July 12 to 14, 1999. A total of 42 detailed ground sites were completed over the study area. An average of 3.2 sites were visited per 100 ha. Corrections where made to the interpreted air photos in light of the field observations.

2.3 Map Production

The linework from the interpreted and corrected air photos were manually transferred to a mylar basemap of equivalent scale to the air photos. This linework was then scanned into the Geographical Information System (GIS), registered to the mine grid, and vectorized using ARC/INFO. Polygon label information was then entered into the terrain map database in the GIS. Cartographic design was then completed, and the final map product produced at 1:8,000 scale.

2.4 Terrain Labels

A complete map legend is provided on the terrain map. Each polygon has a label with up to two surficial material types, up to two surficial textures, and up to two geomorphic processes. Examples of terrain polygons symbols are as such:

Simple Terrain Units: e.g., textures → gsWb-V ← process
surficial material ____/ ____ surface expression

Note: two letters may be used to describe any characteristic other than surficial material, or letters may be omitted if information is lacking. For textures, the symbols are placed in reverse order of importance so that the symbology may be easily verbalized. The above example would read as a "gravelly sand marine blanket with gullying".

Composite Units: Two groups of letters are used to indicate that two kinds of terrain are present within a map unit.

e.g.,	xCv.Rj	indicates that "xCv" (angular colluvium veneer) and "Rj" (gentle bedrock slope) are of roughly equal extent
	gWb-gFt	indicates "gWb" (gravelly marine blanket) is more extensive than "gFt" (gravelly fluvial terrace) (about 2/1 or 3/2)

Stratigraphic Units: Groups of letters are arranged one before the other separated by the "/" symbol where one kind of surficial material overlies a different material or bedrock.

e.g., gsWv/Rj-Xw indicates that "gsWv" (gravelly sandy marine veneer) overlies "Rj" (gentle bedrock slope). This unit also has frost wedges ,"Xw".

The terrain map polygons are colour coded based on the *primary* surficial material, and therefore the user of the maps are cautioned to read the entire terrain polygon label to determine if the polygon contains more than one surficial material.

3. Physiography

3.1 Topography

The study area consists of very gently rolling low-relief hills and plains rising out of the ocean. Several large elliptical inland lakes (Garrow, Frustration and Lois Lakes) are found along the eastern edge of the study area. The bulk of the study area is comprised of two peninsulas, Riddle Point and the Polaris Mine site. The ends of both peninsulas are characterized by large hills with relatively steeper slopes leading to the ocean.

The Polaris Mine site area is characterized by a steep, west-facing hillside leading from the accommodation complex down to the mill site below. This slope is probably a function of the more resistive limestones of the Upper Member of the Thumb Mountain Formation.- resisting marine and/or glacial erosion. The slopes of Riddle Point are characterized by well developed marine terraces which have some bedrock exposure. The only other areas of steep topography are found along the Frustration Lake outlet creek which has incised a canyon into the bedrock.

3.2 Bedrock geology

Bedrock geology of the study area has been well studied and is quite accessible through such publications as Sharp et. al. (1993) "A Field guide to the Geology of the Polaris Mine". This information will not be repeated here other than to note that effect of the major geological units' impact on surface expression and topography.

As noted earlier, the restive nature of the Upper Thumb Mountain Formation limestones has lead to steeper topography and exposed bedrock in the mine site area. This is in contrast to the Irene Bay Formation found in the Loon Lake area. This mudstone interbedded with limestones is more susceptible to weathering, and therefore has recessive topography. Much of the rest of the study area to the east of the mine site is underlain by the bituminous carbonate mudstone of the Cape Phillips Formation. This material is also —a —— friable unit and therefore expresses very rounded and subdued topography.

It is important to note that throughout much of the study area, bedrock is found very near surface and that significant thicknesses of surficial material are not anticipated. Technically, much of the surficial materials could be classified as veneers over bedrock, but for the purposed of this study, the term veneer was reserved for surficial materials less than 0.5 m thick. –

3.3 Landscape Evolution and Deposition of Surficial Materials

The landscape and surficial materials of the Polaris Mine Site study area are dominated by marine and glacial process. Hodgson (1989) suggests that the Little Cornwallis Island area was covered by the Queen Elizabth Islands Glacier Complex until deglaciation between 8.5 and 10 thousand years ago. At this time, the study area was thought to be under approximately 100 metres of sea water. Since that time, the landscape uplifted, initially very quickly, to its current elevation above sea level. This probably occurred through isostatic rebound as the weight of the glaciers was removed from the landscape. This process of uplift is clearly shown by the prominent raised beach lines (strandlines) seen along the Frustration Lake access road and the Riddle Point area. This glaciation- is probably responsible for the very subdued and rounded topography seen in the study area.

In spite of the presence of glaciers in study area, no obvious glacial-or glaciomarine- deposits are found in the study area. Rather, the study area is dominated by marine sediments overlying bedrock (Hodgson, 1989).- This sediments vary from fine grained (clayey, silty and fine sand) deposits to course, clean, gravelly beach deposits. The fine grained materials appear to become more extensive towards the eastern half of the study area. –

The study area also have been very heavily effected by permafrost and periglacial processes. Permafrost is found throughout the study area, with the active layer approximately 0.5 m thick. Permafrost features commonly found are large frost wedge polygons which seem to penetrate the friable bedrock and perhaps are more common where bedrock is near surface. These frost wedge polygons are clearly seen on aerial photographs and often form polygons 10 to 30 metres in diametre.

Periglacial process consist of common frost sorting and mechanical weathering of sediments. Furthermore, micro scale frost features such as frost mounding and stripping are common. On a larger scale, soilfluction lobes commonly found on the hillsides east of North Bay. Perhaps the most significant periglacial process is that of nivation. Nivation refers to "snow patch erosion"—the development of shallow depressions at sites occupied by long-lasting snow banks. The down slope areas from zones of nivation often have over-saturated soils due to the abundant water supply from the melting snow banks,; as well as common surface rilling caused by surface runoff. A good example of nivation is found on the steeper slopes southwest of Loon Lake.

4. Surficial Materials and Associated Landforms

Surficial materials are defined as non-lithified, unconsolidated sediments. They are produced by weathering, sediment deposition, biological accumulation, human and volcanic activity. They include residual materials weathered from rock in situ; transported materials composed of mineral, rock and organic fragments deposited by water, wind, ice, gravity, or any combination of these agents. (Hoews and Kenk, 1997)

4.1 Anthropogenic Materials(A)

This category includes areas of unconsolidated materials that are sufficiently disturbed by human activity that the original properties of the undisturbed materials have been altered substantially. The mined and heavily reworked areas of the "back-40" area are good examples of anthropogenic materials. Almost all the landscape east of "Claw's Corner" around the mine site has been extensively re-worked and stripped of surficial materials which have been used for construction aggregate and backfill material. For example, much of the area around the former ANFO storage area has been stripped of its marine gravels.

4.2 Colluvium (C)

Colluvial deposits are formed as a result of slope processes and most commonly in the Polaris area, the result of rock creep caused by seasonal frost action. Most of the colluvium in the study area is found west of the airstrip on the steep west facing slopes. This material consists primarily of broken angular bedrock derived fragments and sub-angular gravel veneers and blankets over bedrock. These area also have been extensively re-worked by earthmoving equipment during the mine's construction, and therefore could be considered somewhat anthropogenic in nature.

Colluvium tends to be mixed, poorly sorted and is derived from both local bedrock sources and marine related sediments.

4.3 Fluvial Materials (F, FA)

Fluvial deposits are those have been transported and deposited by flowing stream water. Fluvial deposits can be gravelly, sandy or silty and underlie floodplains (FAp, Fp) creek terraces (Ft) and alluvial fans (FAf, Ff).

Fluvial deposits are commonly found in the study area associated with creek outlets to Garrow and Frustration Lakes. These creeks have relatively wide floodplains with braided channels and consist of well-sorted gravels with subangular to subrounded clasts (due to the platy nature of local -bedrock material).

4.4 Organic Materials (O)

Organic materials included peat and other organic soil horizons thicker than 0.3 m.– Organic soils are generally frozen, and are composed of peaty material at varying stages of decomposition. Organic soils are highly susceptible to degradation due to the repeated passage of equipment and even foot traffic. Organic deposits are found sporadically across the study area and are associated with localized depressions hosting small wetlands and standing water. These deposits are found almost exclusively as veneers over marine deposits and are quite thin in nature.

4.5 Bedrock (R)

Bedrock is shown on the terrain map where it outcrops or lies very close (within a few centimetres) to the surface. As well, it is mapped as an underlying material where the overlying material is mapped as a veneer. Bedrock is found near surface everywhere on the slope between the accommodation complex and the shoreline to the west. Bedrock is also found very near surface in the Claw's Corner area between the New Quarry and Polaris Bay. Bedrock in this area is very friable and may not be immediately recognized as such.

4.6 Marine (W, WA)

Marine deposits form the majority of the surficial materials found in the Polaris Mine study area. These materials are deposited in the marine environment either from fine-grained suspension settling (e.g. fine grained deposits such as clay/silt) or through the erosion and accumlation of coarser gravelly sediments in shoreline setting.. Some of the materials may have been deposited directly from ice into a marine environment, but the material has been so extensively re-worked during uplift that they can be no longer classified as glaciomarine.

The fine grained materials seen in the Garrow Lake area probably represented some the submarine deposition, where the extensive gravel deposits and strandlines seen around North Bay and Riddle Point will have formed as shoreline processes.- These shoreline materials are often very clean, well sorted subrounded gravels which often form terraces as well as prominent strandlines. Modern beach surfaces around the shoreline are denoted by the "WA" symbol for active beaches.

5. Geomorphological Processes

Geomorphological processes are largely post depositional mechanisms which includes weathering, washing, solifluction and others that results in the modification of the surficial materials and landforms at the earth's surface (Hoews and Kenk, 1997).

5.1 Fill Material (F)-

This symbol is used to represent areas, primarily anthropogenic in nature, that have had substantial volumes of material deposits during mine development. Common examples of this are the built up areas around the mill barge and other areas of ocean filled to create operation space.

5.2 Mass Movement (M)

Mass movement process involve the downslope movement, due to gravity, of surficial materials or bedrock fragments. In the study area, there appears to be only one occurrence of mass movements. This movement is located along the Frustration Creek canyon and is probably the result of undercutting by the creek as well as saturation of the surficial materials through seasonal frost (the active layer) or permafrost degradation.

5.3 Nivation (N)

Nivation is the erosion of surficial materials beneath and along the margin of snow patches by freeze-thaw processes, meltwater action and snow creep. French (1976) describes nivation as:

> "...a term given to the combined action of frost shattering, gelifluction and slopewash processes which operate in the vicinity of snowbanks. It is an erosive process involving intense physical weathering, the result of an abundant moisture supply percolating into the [soil] beneath and around the snowbank...In its simplest form, nivation processes erode shallow hollows or cirque-like basins which form on slopes and upland surfaces (Cook and Raiche, 1962b)...Debris is removed from the hollow by sheetwash, rillwash and gelifluction."

In the Polaris area, these areas are common and important geomorphological process, often occupied by semi-permanent snowbanks. The soils downslope of these areas are often oversaturated and easily liquefied if disturbed.

5.4 Solifluction (S)

Solifluction is a periglacial process that results in the slow gravitation downslope movement of saturated non-frozen surficial materials across a frozen (permafrost) substrate. On surface, these areas are characterized by lobes of material that are creeping downslope. Abundant solifluction lobes are found on the hillsides east of North Bay.

5.5 Gully Erosion (V)

Gullies are small ravines with a V-shaped cross section formed in the surficial materials. The symbol is usually applied to polygons where more than one gully is present. The symbol is also used to represent areas with well developed surface rilling caused by spring and summer runoff. Gullies are formed by the erosive effects of small streams and surface runoff. Larger gullies are commonly found in area where roadways have affected the surface water flow regime, for example downslope of the road leading to the freshwater intake on Frustration Lake.

5.6 Washing (W)

Washing is causes the modification of surficial materials through wave action, or occasionally, by running water. This results in lag deposits formed by the removal of fines from a mixture of course and fine particles. This term has been applied to the active shorelines where the beach material consists of very well sorted, clean pebble to cobble gravels.

5.7 Permafrost (X)-

Since permafrost is found everywhere in the study area, typically at a depth of less than 0.5 m, the geomoprhic process of permafrost ("X") has not been applied to each polygon since it is implied. Where specific, unique permafrost related features have been observed, these have been noted. These include the following:

5.7.1 Palsas (Xp)

The term palsa has been used in this study to identify small rounded frozen mounds of organic material or peaty material formed by differential frost heaving. –These often contain a core of permafrost or perennial ice lenses. Small palsas are found in areas with abundant or standing water.

5.7.2 Ice Wedges (Xw)

Ice wedges consist of intersection narrow cracks (up to 0.4 m wide) or subsidence (up to 5 cm deep) that contain ice-wedges. These create polygonal patterns on the ground and often penetrate several metres into the friable bedrock in the study area.

6. References

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A field Guide to the Geology of the Polaris Mine, Little Cornwallis Island, Nortwest Territories, Canada. Cominco Ltd. Unpublished.

Appendix B

Laboratory Reports and QA/QC Data

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

CHEMICAL ANALYSIS REPORT

Date: August 13, 1999

ASL File No. K5830r

Report On: 99-902 Polaris
Soil And Water Analysis

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

Attention: **Ms. Eva Gerencher**

Received: May 17, 1999

AUG 18 1999
GARTNER LEE

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K5830r

This report, ASL file number K5830r, supersedes the previous ASL file number K5830. The client requested that some of the Lead results be reported to a lower detection limit. The following data tables reflect this change.

The detection limits for some of the metals for some of the soil samples reported in the following data tables have been increased due to the high concentrations of certain other metals in the samples.

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

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

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 2 Top	Stn 1A Bottom
Sample Date		99 05 14	99 05 14	99 05 12	99 05 13	99 05 12
Physical Tests						
Hardness	CaCO3	5680	6090	5960	5550	5760
pH		7.44	7.52	7.58	7.35	7.60
Dissolved Anions						
Alkalinity-Total	CaCO3	127	129	128	-	130
Chloride	Cl	20900	19400	20300	-	19600
Fluoride	F	0.80	0.84	0.84	-	0.84
Sulphate	SO4	2610	2750	2750	-	2680
Cyanides						
Total Cyanide	CN	<0.005	<0.005	<0.005	-	<0.005

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1] File No. K5830r

Sample ID		Stn 2 Bottom
Sample Date		99 05 13
Physical Tests		
Hardness	$CaCO_3$	5920
pH		7

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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 2 Top	Stn 1A Bottom
Sample Date		99 05 14	99 05 14	99 05 12	99 05 13	99 05 12
Dissolved Metals						
Aluminum	D-Al	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony	D-Sb	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	D-As	0.001	0.001	0.001	0.001	0.001
Barium	D-Ba	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium	D-Cd	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Calcium	D-Ca	369	399	389	362	376
Chromium	D-Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	D-Cu	0.002	<0.001	<0.001	0.002	<0.001
Iron	D-Fe	<0.6	<0.6	<0.6	<0.6	<0.6
Lead	D-Pb	0.029	<0.001	0.007	0.013	<0.001
Magnesium	D-Mg	1160	1240	1210	1130	1170
Manganese	D-Mn	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.6	<0.6	<0.6	<0.6	<0.6
Nickel	D-Ni	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	D-Se	0.0006	<0.0005	<0.0005	0.0006	<0.0005
Silver	D-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	9900	10400	10200	9610	9910
Uranium	D-U	0.003	0.003	0.003	0.003	0.003
Zinc	D-Zn	<0.01	<0.01	<0.01	<0.01	<0.005

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1] File No. K5830r

Sample ID		Stn 2 Bottom
Sample Date		99 05 13
Dissolved Metals		
Aluminum	D-Al	<0.005
Antimony	D-Sb	<0.001
Arsenic	D-As	0.001
Barium	D-Ba	<0.2
Cadmium	D-Cd	<0.0001
Calcium	D-Ca	388
Chromium	D-Cr	<0.001
Cobalt	D-Co	<0.001
Copper	D-Cu	<0.001
Iron	D-Fe	<0.6
Lead	D-Pb	<0.001
Magnesium	D-Mg	1200
Manganese	D-Mn	<0.1
Mercury	D-Hg	<0.00005
Molybdenum	D-Mo	<0.6
Nickel	D-Ni	<0.001
Selenium	D-Se	<0.0005
Silver	D-Ag	<0.0001
Sodium	D-Na	10100
Uranium	D-U	0.003
Zinc	D-Zn	<0.01

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LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID	Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 1A Bottom
Sample Date	99 05 14	99 05 14	99 05 12	99 05 12
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.00005	-	<0.00005	<0.00005
Acenaphthylene	<0.00005	-	<0.00005	<0.00005
Acridine	<0.00005	-	<0.00005	<0.00005
Anthracene	<0.00005	-	<0.00005	<0.00005
Benz(a)anthracene	<0.00005	-	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	-	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	-	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	-	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	-	<0.00005	<0.00005
Chrysene	<0.00005	-	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	-	<0.00005	<0.00005
Fluoranthene	<0.00005	-	<0.00005	<0.00005
Fluorene	<0.00005	-	<0.00005	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	-	<0.00005	<0.00005
Naphthalene	<0.00005	-	<0.00005	<0.00005
Phenanthrene	<0.00005	-	<0.00005	<0.00005
Pyrene	<0.00005	-	<0.00005	<0.00005
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	<0.001	<0.001	<0.001	<0.001
Extractables				
EPH (C10-18)	<0.3	<0.3	<0.3	<0.3
EPH (C19-31)	<1	<1	<1	<1
LEPH	<0.3	-	<0.3	<0.3
HEPH	<1	-	<1	<1

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

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[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID		Stn 3C Sed.	Stn 3B Sed.	Stn 3A Sed.	Stn 1A Sed.	Stn 2 Sed.
Sample Date		99 05 14	99 05 14	99 05 15	99 05 12	99 05 13
Physical Tests						
Moisture	%	39.7	65.9	29.7	48.0	68.7
pH		8.24	8.03	8.30	8.29	8.44
Total Metals						
Antimony	T-Sb	<60	<40	<20	<40	<40
Arsenic	T-As	6	7.1	16	3.5	4.7
Barium	T-Ba	717	1040	226	556	470
Beryllium	T-Be	<2	<1	0.7	<1	<1
Cadmium	T-Cd	1.0	1.8	0.6	0.2	0.1
Chromium	T-Cr	16	30	24	18	20
Cobalt	T-Co	<6	<4	3	<4	<4
Copper	T-Cu	11	17	20	9	9
Lead	T-Pb	99	128	23	7	8
Mercury	T-Hg	0.085	0.080	0.094	0.040	0.045
Molybdenum	T-Mo	<20	<8	6	<8	<8
Nickel	T-Ni	<20	16	20	11	15
Selenium	T-Se	0.7	1.0	1.4	0.5	0.5
Silver	T-Ag	<6	<4	<2	<4	<4
Tin	T-Sn	<30	<20	<10	<20	<20
Vanadium	T-V	59	127	116	56	72
Zinc	T-Zn	298	520	155	35	40

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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID		Bent Horn 0-3'	Bent Horn 6-9'	Bent Horn 12-15'
Sample Date		99 05 14	99 05 14	99 05 14
Physical Tests				
Moisture	%	4.3	10.3	11.0
pH		8.64	8.99	-
Total Metals				
Antimony	T-Sb	<100	<200	-
Arsenic	T-As	2.1	0.6	-
Barium	T-Ba	393	214	-
Beryllium	T-Be	<3	<3	-
Cadmium	T-Cd	2.8	3.4	-
Chromium	T-Cr	<10	<20	-
Cobalt	T-Co	<10	<20	-
Copper	T-Cu	<5	<6	-
Lead	T-Pb	571	350	-
Mercury	T-Hg	0.018	0.006	-
Molybdenum	T-Mo	<20	<30	-
Nickel	T-Ni	<30	<30	-
Selenium	T-Se	<0.1	<0.1	-
Silver	T-Ag	<10	<20	-
Tin	T-Sn	<50	<60	-
Vanadium	T-V	11	<20	-
Zinc	T-Zn	1550	2070	-

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VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID	Stn 3C Sed.	Stn 3B Sed.	Stn 3A Sed.	Stn 1A Sed.	Bent Horn 0-3'
Sample Date	99 05 14	99 05 14	99 05 15	99 05 12	99 05 14
Non-halogenated Volatiles					
Benzene	-	-	-	-	<0.04
Ethylbenzene	-	-	-	-	<0.05
Styrene	-	-	-	-	<0.05
Toluene	-	-	-	-	0.06
meta- & para-Xylene	-	-	-	-	2.07
ortho-Xylene	-	-	-	-	1.72
Volatile Hydrocarbons (VH) C6-10	-	-	-	-	274
VPH C6-10 (calculated)	-	-	-	-	270
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.01	<0.01	<0.01	<0.2
Acenaphthylene	<0.01	<0.01	<0.01	<0.01	<0.2
Anthracene	0.01	<0.01	<0.01	<0.01	0.06
Benz(a)anthracene	<0.02	<0.01	0.02	<0.01	<0.01
Benzo(a)pyrene	<0.02	<0.01	0.01	<0.01	<0.01
Benzo(b)fluoranthene	<0.02	<0.01	0.02	<0.01	<0.05
Benzo(g,h,i)perylene	<0.02	0.03	0.03	<0.02	<0.01
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01	<0.05
Chrysene	0.03	<0.02	0.03	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.03	<0.03	0.02	<0.01	0.01
Fluorene	<0.01	<0.01	<0.01	<0.01	0.28
Indeno(1,2,3-c,d)pyrene	0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	<0.01	0.01	0.08	<0.01	2.12
Phenanthrene	0.04	<0.03	0.02	<0.01	0.27
Pyrene	0.03	<0.03	0.02	<0.01	0.03
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<0.05	-	-	-	-
Extractables					
EPH (C10-18)	<200	<200	<200	<200	4130
EPH (C19-31)	<200	<200	<200	<200	1220
LEPH	<200	<200	<200	<200	-
HEPH	<200	<200	<200	<200	-

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

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

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID Sample Date	Bent Horn 6-9' 99 05 14	Bent Horn 12-15' 99 05 14
Non-halogenated Volatiles		
Benzene	<0.04	-
Ethylbenzene	<0.05	-
Styrene	<0.05	-
Toluene	0.08	-
meta- & para-Xylene	0.38	-
ortho-Xylene	0.30	-
Volatile Hydrocarbons (VH) C6-10	<100	-
VPH C6-10 (calculated)	<100	-
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.05	-
Acenaphthylene	<0.05	-
Anthracene	<0.01	-
Benz(a)anthracene	<0.01	-
Benzo(a)pyrene	<0.01	-
Benzo(b)fluoranthene	<0.02	-
Benzo(g,h,i)perylene	<0.01	-
Benzo(k)fluoranthene	<0.02	-
Chrysene	<0.01	-
Dibenz(a,h)anthracene	<0.01	-
Fluoranthene	<0.01	-
Fluorene	0.05	-
Indeno(1,2,3-c,d)pyrene	<0.01	-
Naphthalene	0.31	-
Phenanthrene	0.06	-
Pyrene	<0.01	-
Extractables		
EPH (C10-18)	917	<200
EPH (C19-31)	998	221

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K5830r

Sediment/Soil[1]		**Bent Horn 6-9'** 99 05 14	**Bent Horn 6-9'** QC # 157214
Physical Tests			
Moisture	%	10.3	10.2
pH		8.99	9.07
Total Metals			
Antimony	T-Sb	<200	<200
Arsenic	T-As	0.6	0.7
Barium	T-Ba	214	214
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	3.4	4.5
Chromium	T-Cr	<20	<20
Cobalt	T-Co	<20	<20
Copper	T-Cu	<6	<6
Lead	T-Pb	350	407
Mercury	T-Hg	0.006	0.006
Molybdenum	T-Mo	<30	<30
Nickel	T-Ni	<30	<30
Selenium	T-Se	<0.1	<0.1
Silver	T-Ag	<20	<20
Tin	T-Sn	<60	<60
Vanadium	T-V	<20	<20
Zinc	T-Zn	2070	2520
Non-halogenated Volatiles			
Benzene		<0.04	<0.04
Ethylbenzene		<0.05	0.09
Styrene		<0.05	<0.05
Toluene		0.08	0.10
meta- & para-Xylene		0.38	0.41
ortho-Xylene		0.30	0.26
Volatile Hydrocarbons (VH) C6-10		<100	<100
VPH C6-10 (calculated)		<100	<100

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K5830r

Sediment/Soil[1]	**Bent Horn 6-9'** 99 05 14	**Bent Horn 6-9'** QC # 157214
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.05	<0.05
Acenaphthylene	<0.05	<0.05
Anthracene	<0.01	0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.02	<0.02
Benzo(g,h,i)perylene	<0.01	0.01
Benzo(k)fluoranthene	<0.02	<0.02
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	0.05	0.05
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	0.31	0.35
Phenanthrene	0.06	0.07
Pyrene	<0.01	0.01
Extractables		
EPH (C10-18)	917	841
EPH (C19-31)	998	1010

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

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.

Trace Metals in Seawater by SPR-IDA Chelation

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 Cetac Technologies Incorporated. A suspended particulate resin (SPR), consisting of immobilized iminodiacetate (IDA) on a divinylbenzene polymer, is used to chelate and preconcentrate metals in seawater. Instrumental analysis is by inductively coupled plasma mass spectrometry (ICPMS) and/or routine atomic absorption spectrophotometry techniques (EPA 7000 series).

Recommended Holding Time:
Sample/Extract: 6 months
Reference: EPA
For more detail see: ASL "Collection & Sampling Guide"

Metals in Seawater

Revised and Replaced: 1998 03 16

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 or filtration (EPA Method 3005A). Instrumental analysis of the seawater 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 Seawater

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 seawater 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 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.

Polychlorinated Biphenyls in Water

This analysis is carried out using a procedure adapted from U.S. EPA Methods 3510, 8080 and 8082. (Publ. #SW-846, 3rd Ed., Washington, DC 20460). The procedure involves liquid-liquid extraction of the sample with dichloromethane. The extract is cleaned and analyzed by capillary column gas chromatography with electron capture detection.

Extractable Hydrocarbons in Water

This analysis is carried out using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and

British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Water

These results 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(C10-18). To calculate HEPH, the individual results for benz(a)anthracene, benzo(a)pyrene, fluoranthene, and pyrene are subtracted from EPH(C19-31).

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"

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"

Volatile Organic Compounds in Sediment/Soil

This analysis is based on United States Environmental Protection Agency Methods 5035, 8260/8021 and British Columbia Ministry of Environment, Lands and Parks Method *"Volatile Hydrocarbons in Solids by GC/FID "*. The procedure involves a 1:2 extraction of the sediment/soil sample with methanol. Aliquots of the methanol extract are then analyzed by capillary column gas chromatography with mass spectrometric, and/or photo-ionization/flame-ionization detection.

Volatile Petroleum Hydrocarbons (VPH) in Sediment/Soil

Volatile Petroleum Hydrocarbons (VPH) is a calculation defined by British Columbia Ministry of Environment, Lands and Parks (BCMELP) Draft Method "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water", June 1998. The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). Analysis of Volatile Hydrocarbons adheres to all prescribed elements of BCMELP method "Volatile Hydrocarbons in Solid", June 1998.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. A portion of the extract is exchanged to toluene, cleaned, and analysed by capillary column gas chromatography with mass spectrometric detection.

Polychlorinated Biphenyls in Sediment

This analysis is carried out using a procedure adapted from EPA Method 8082 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a solid-liquid extraction of the sample with hexane/acetone and back extraction with water. The hexane extract is cleaned and analysed by capillary column gas chromatography with electron capture detection.

Extractable Petroleum Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. The extract is exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection.

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Soil

Method Revised and Replaced: 1999 07 02

End of Report

APPENDIX

HYDROCARBON DISTRIBUTION REPORTS

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K5830-T--12** ent Horn 0-3'

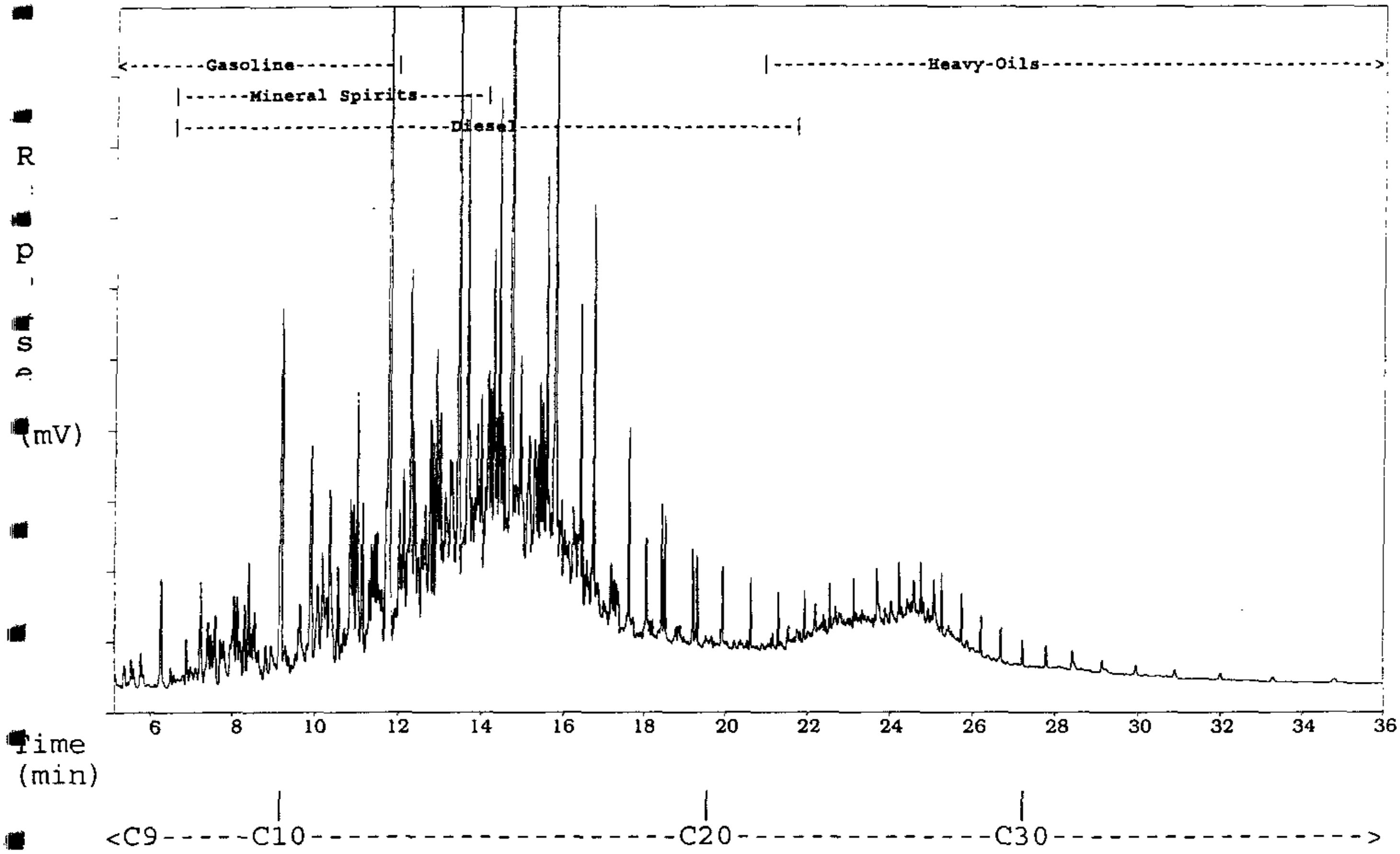
Sample acquired: MAY 19, 1999 04:32:28

99 05 14

Sequence File: EH3MAY18

File Name: C:\TEH2\MAY18\EH3MAY18.46R , Sample Name: K5830-T--12

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K5830-T--12* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K5830-T--14** ent Horn 6-9'

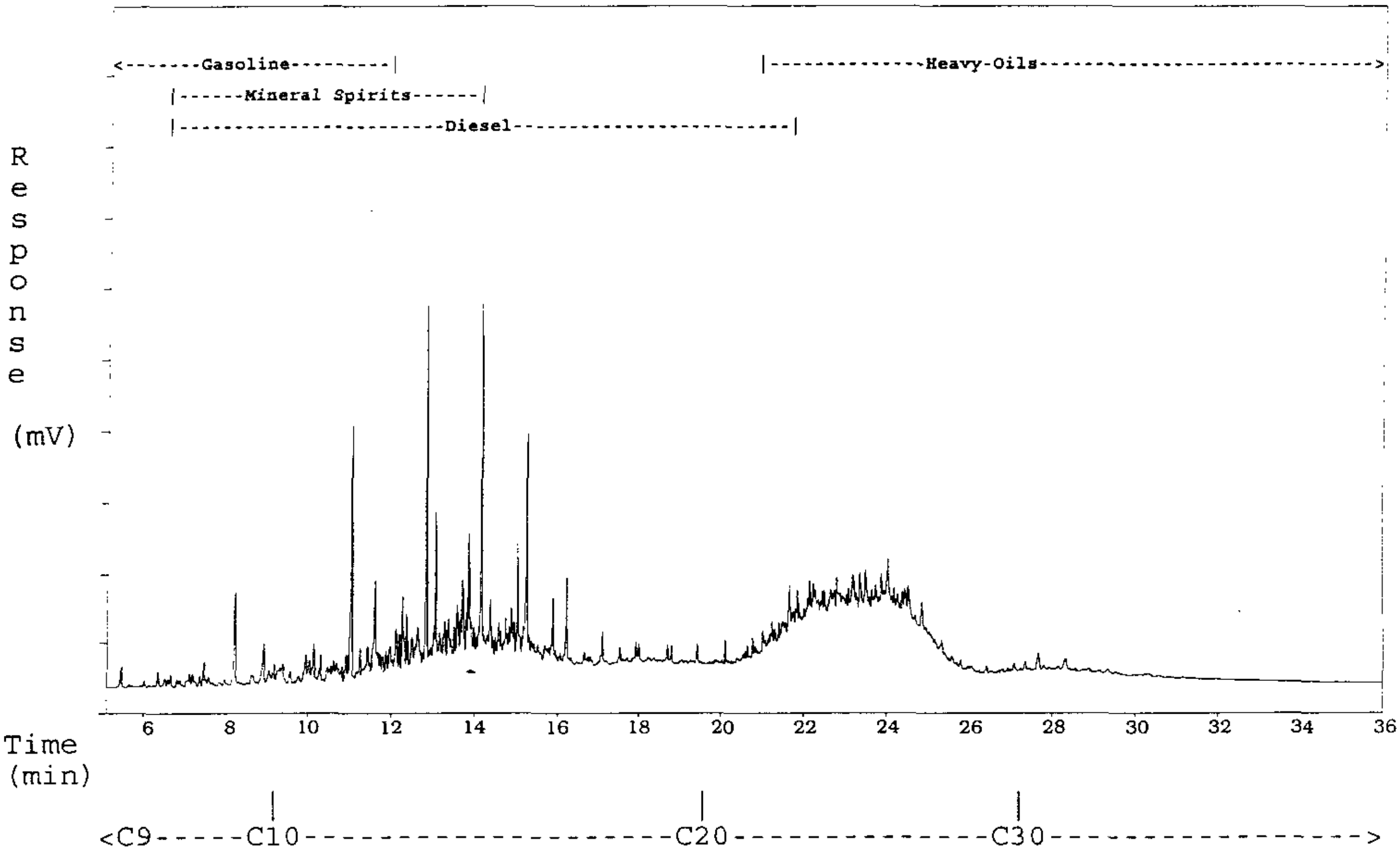
Sample acquired: MAY 19, 1999 05:25:43

File Name: C:\TEH2\MAY18\EH3MAY18.47R , Sample Name: K5830-T--14

Chromatogram Scale: 50.0 millivolts

99 05 14

Sequence File: EH3MAY18



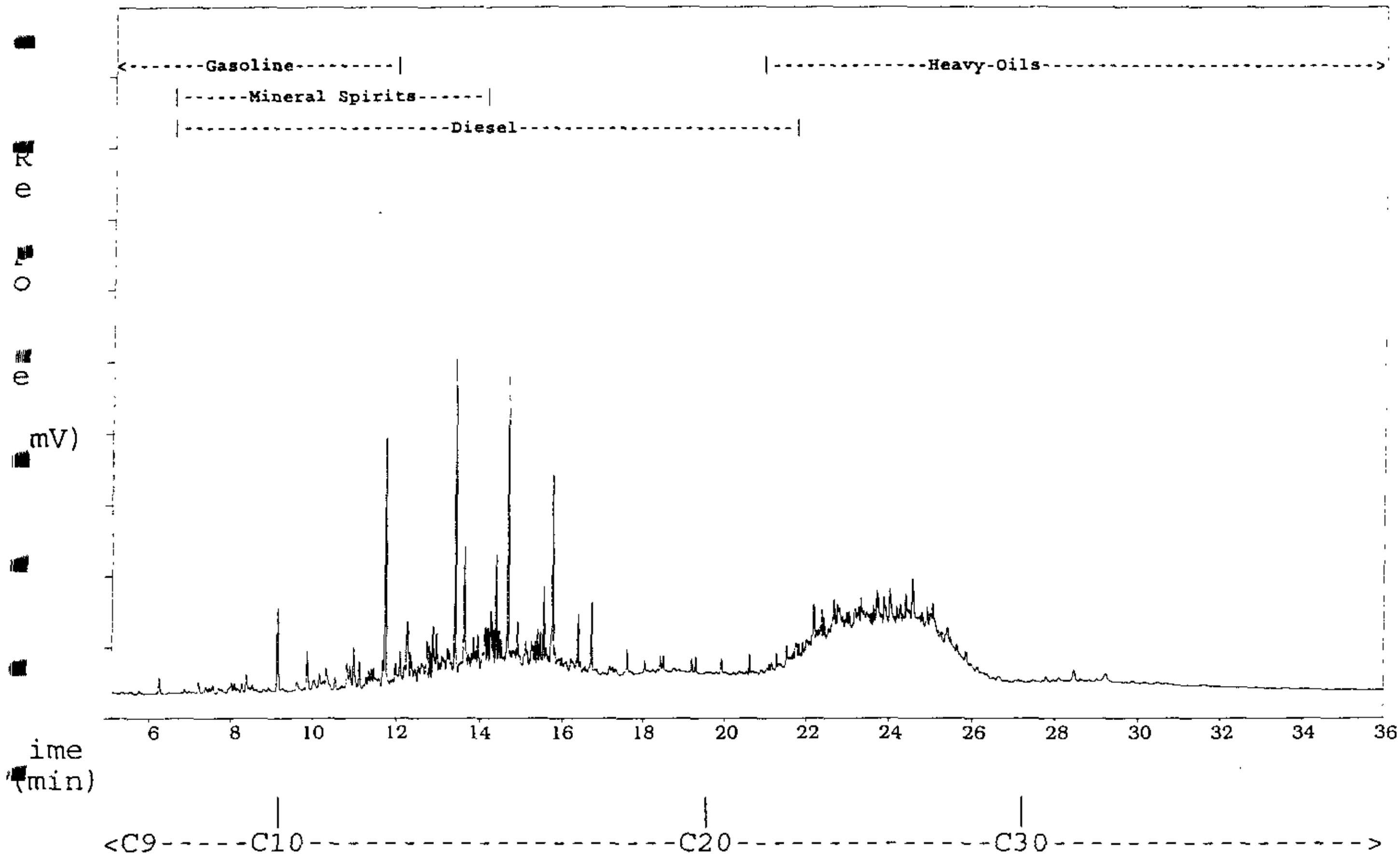
ASL Sample ID: K5830-T--14* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K5830 - 14 Bent Horn 6-9' LRep

Sample acquired: MAY 19, 1999 05:25:43 99 05 14 Sequence File: EH3MAY18
File Name: C:\TEH2\MAY18\EH3MAY18.48R , Sample Name: QC-T--157214#K5830 14DP
Chromatogram Scale: 50.0 millivolts



ASL Sample ID: QC-T--157214#K5830 14DP* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

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

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JUN 29 1999

CHEMICAL ANALYSIS REPORT

Date:	June 22, 1999
ASL File No.	K5918
Report On:	99-902 Water and Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	May 19, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K5918

The detection limits for some of the metals have been increased for some of the soil samples reported in the following data tables due to high concentrations of metals in the samples.

The detection limits for some of the Polycyclic Aromatic Hydrocarbons have been increased for samples "Stn 4 Outfall" and "Stn 4C" due to analytical interferences.

RESULTS OF ANALYSIS - Water[1]

File No. K5918

			Stn 4E Top 99 05 16	Stn 4E Bottom 99 05 16	Stn 4B Bottom 99 05 15
Physical Tests					
Hardness	CaCO3		6100	6310	6430
pH			7.45	7.53	7.59
Dissolved Anions					
Alkalinity-Total		CaCO3	129	130	132
Chloride	Cl		17700	18600	18900
Fluoride	F		0.82	0.84	0.84
Sulphate	SO4		2630	2740	2620

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Water[1]

File No. K5918

		Stn 4E Top 99 05 16	Stn 4E Bottom 99 05 16	Stn 4B Bottom 99 05 15
Dissolved Metals				
Aluminum	D-Al	<0.005	<0.005	<0.005
Antimony	D-Sb	<0.001	<0.001	<0.001
Arsenic	D-As	<0.001	0.001	0.001
Barium	D-Ba	<0.2	<0.2	<0.2
Cadmium	D-Cd	<0.0001	<0.0001	<0.0001
Calcium	D-Ca	386	400	409
Chromium	D-Cr	<0.001	<0.001	<0.001
Cobalt	D-Co	<0.001	<0.001	<0.001
Copper	D-Cu	0.004	<0.001	<0.001
Iron	D-Fe	<0.6	<0.6	<0.6
Lead	D-Pb	0.014	0.002	<0.001
Magnesium	D-Mg	1250	1290	1310
Manganese	D-Mn	<0.1	<0.1	<0.1
Mercury	D-Hg	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.6	<0.6	<0.6
Nickel	D-Ni	<0.001	<0.001	<0.001
Selenium	D-Se	<0.0005	<0.0005	<0.0005
Silver	D-Ag	<0.0001	<0.0001	<0.0001
Sodium	D-Na	10000	10300	10500
Uranium	D-U	0.001	<0.001	<0.001
Zinc	D-Zn	<0.01	<0.01	<0.01

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Water[1]

File No. K5918

	Stn 4E Top 99 05 16	Stn 4E Bottom 99 05 16	Stn 4B Bottom 99 05 15
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	<0.00005	<0.00005	<0.00005
Acenaphthylene	<0.00005	<0.00005	<0.00005
Acridine	<0.00005	<0.00005	<0.00005
Anthracene	<0.00005	<0.00005	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	<0.00005
Chrysene	<0.00005	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	<0.00005
Fluoranthene	<0.00005	<0.00005	<0.00005
Fluorene	<0.00005	<0.00005	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	<0.00005
Naphthalene	<0.00005	<0.00005	<0.00005
Phenanthrene	<0.00005	<0.00005	<0.00005
Pyrene	<0.00005	<0.00005	<0.00005
Extractables			
EPH (C10-18)	<0.3	<0.3	<0.3
EPH (C19-31)	<1	<1	<1
LEPH	<0.3	<0.3	<0.3
HEPH	<1	<1	<1

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.

[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5918

		Stn 4A	Stn 4B	Stn 4E	Stn 4F	Stn 4 Outfall
		99 05 15	99 05 15	99 05 16	99 05 16	99 05 17
Physical Tests						
Moisture	%	40.7	23.6	21.4	23.6	36.6
pH		8.42	8.50	8.52	8.27	8.44
Total Metals						
Antimony	T-Sb	<40	<100	<200	<40	<60
Arsenic	T-As	5	5	4.3	5	3.8
Barium	T-Ba	392	107	390	184	443
Beryllium	T-Be	<1	<3	<3	<1	<2
Cadmium	T-Cd	4.9	27	64	81	35
Chromium	T-Cr	12	13	<20	8	11
Cobalt	T-Co	<4	<10	<20	<4	<6
Copper	T-Cu	9	18	29	14	26
Lead	T-Pb	639	2510	7520	9360	5430
Mercury	T-Hg	0.044	0.061	0.049	0.047	0.048
Molybdenum	T-Mo	<8	<20	<30	<8	<20
Nickel	T-Ni	<10	<30	<30	<10	<20
Selenium	T-Se	0.5	0.7	0.4	0.3	0.5
Silver	T-Ag	<4	<10	<20	<4	<6
Tin	T-Sn	<20	<50	<60	<20	<30
Vanadium	T-V	55	65	38	39	43
Zinc	T-Zn	1670	11200	25000	29900	14200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5918

	Stn 4A	Stn 4B	Stn 4E	Stn 4 Outfall
	99 05 15	99 05 15	99 05 16	99 05 17
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	-	-	-	<0.01
Acenaphthylene	-	-	-	<0.01
Anthracene	-	-	-	<0.01
Benz(a)anthracene	-	-	-	<0.01
Benzo(a)pyrene	-	-	-	<0.01
Benzo(b)fluoranthene	-	-	-	<0.01
Benzo(g,h,i)perylene	-	-	-	<0.02
Benzo(k)fluoranthene	-	-	-	<0.01
Chrysene	-	-	-	<0.01
Dibenz(a,h)anthracene	-	-	-	<0.01
Fluoranthene	-	-	-	<0.01
Fluorene	-	-	-	<0.01
Indeno(1,2,3-c,d)pyrene	-	-	-	<0.01
Naphthalene	-	-	-	<0.02
Phenanthrene	-	-	-	<0.02
Pyrene	-	-	-	<0.01
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	-	-	-	<0.05
Extractables				
EPH (C10-18)	<200	<200	<200	<200
EPH (C19-31)	<200	<200	258	247
LEPH	-	-	-	<200
HEPH	-	-	-	247

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1]Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1] File No. K5918

		Stn 4D	Stn 4C
		99 05 17	99 05 17
Physical Tests			
Moisture	%	17.8	20.0
pH		8.73	8.67
Total Metals			
Antimony	T-Sb	<100	<200
Arsenic	T-As	4.2	2.6
Barium	T-Ba	291	588
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	52	14.3
Chromium	T-Cr	<10	<20
Cobalt	T-Co	<10	<20
Copper	T-Cu	29	9
Lead	T-Pb	6290	1600
Mercury	T-Hg	0.044	0.031
Molybdenum	T-Mo	<20	<30
Nickel	T-Ni	<30	<30
Selenium	T-Se	0.4	0.6
Silver	T-Ag	<10	<20
Tin	T-Sn	<50	<60
Vanadium	T-V	42	22
Zinc	T-Zn	20600	5600

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5918

	Stn 4D	Stn 4C
	99 05 17	99 05 17
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	-	<0.01
Acenaphthylene	-	<0.01
Anthracene	-	<0.01
Benz(a)anthracene	-	<0.01
Benzo(a)pyrene	-	<0.01
Benzo(b)fluoranthene	-	<0.01
Benzo(g,h,i)perylene	-	<0.02
Benzo(k)fluoranthene	-	<0.01
Chrysene	-	<0.01
Dibenz(a,h)anthracene	-	<0.01
Fluoranthene	-	<0.01
Fluorene	-	<0.01
Indeno(1,2,3-c,d)pyrene	-	<0.01
Naphthalene	-	<0.01
Phenanthrene	-	<0.02
Pyrene	-	<0.01
Extractables		
EPH (C10-18)	<200	<200
EPH (C19-31)	205	<200
LEPH	-	<200
HEPH	-	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K5918

Sediment/Soil[1]		Stn 4E 99 05 16	Stn 4E QC # 158480
Physical Tests			
Moisture	%	21.4	21.7
pH		8.52	8.56
Total Metals			
Antimony	T-Sb	<200	<200
Arsenic	T-As	4.3	4.2
Barium	T-Ba	390	207
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	64	69
Chromium	T-Cr	<20	<20
Cobalt	T-Co	<20	<20
Copper	T-Cu	29	50
Lead	T-Pb	7520	7780
Mercury	T-Hg	0.049	0.048
Molybdenum	T-Mo	<30	<30
Nickel	T-Ni	<30	<30
Selenium	T-Se	0.4	0.4
Silver	T-Ag	<20	<20
Tin	T-Sn	<60	<60
Vanadium	T-V	38	34
Zinc	T-Zn	25000	26700

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
EPH = Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 2 - METHODOLOGY

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.

Trace Metals in Seawater by SPR-IDA Chelation

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 Cetac Technologies Incorporated. A suspended particulate resin (SPR), consisting of immobilized iminodiacetate (IDA) on a divinylbenzene polymer, is used to chelate and preconcentrate metals in seawater. *Instrumental analysis is by inductively coupled plasma mass* spectrometry (ICPMS) and/or routine atomic absorption spectrophotometry techniques (EPA 7000 series).

Recommended Holding Time:
Sample/Extract: 6 months
Reference: EPA
For more detail see: ASL "Collection & Sampling Guide"

Metals in Seawater

Revised and Replaced: 1998 03 16

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 or filtration (EPA Method 3005A). Instrumental analysis of the seawater 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 Seawater

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 seawater 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 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 using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Water

These results 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(C10-18). To calculate HEPH, the individual results for benz(a)anthracene, benzo(a)pyrene, fluoranthene, and pyrene are subtracted from EPH(C19-31).

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"

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"

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. A portion of the extract is exchanged to toluene, cleaned, and analysed by capillary column gas chromatography with mass spectrometric detection.

Polychlorinated Biphenyls in Sediment

This analysis is carried out using a procedure adapted from EPA Method 8082 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a solid-liquid extraction of the sample with hexane/acetone and back extraction with water. The hexane extract is cleaned and analysed by capillary column gas chromatography with electron capture detection.

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Extractable Petroleum Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. The extract is exchanged to toluene and analysed by capillary *column gas chromatography with flame ionization detection.*

Light and Heavy Extractable Petroleum Hydrocarbons in Soil

These results are calculated by subtracting selected Polynuclear Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for naphthalene and phenanthrene are subtracted from EPH(C10-18). To calculate HEPH, the individual results for benz(a)anthracene, benzo(b)]fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and pyrene are subtracted from EPH(C19-31).

End of Report

APPENDIX

HYDROCARBON DISTRIBUTION REPORTS

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K5918-T--6 Stn 4E

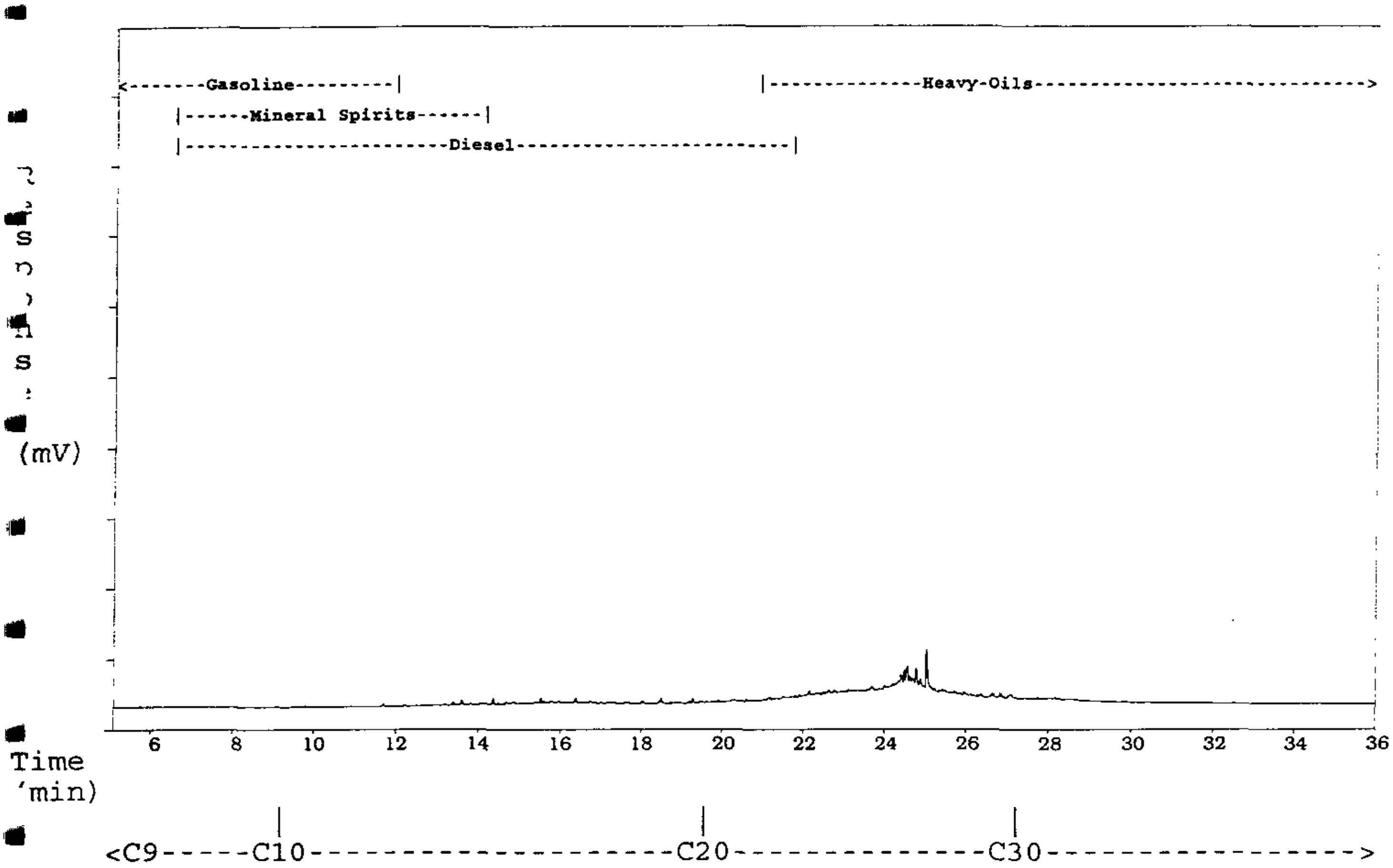
99 05 16

Sample acquired: MAY 30, 1999 11:12:21

Sequence File: EH3MAY28

File Name: C:\TEH2\MA281\EH3MA281.06R , Sample Name: K5918-T--6

Chromatogram Scale: 50.0 millivolts



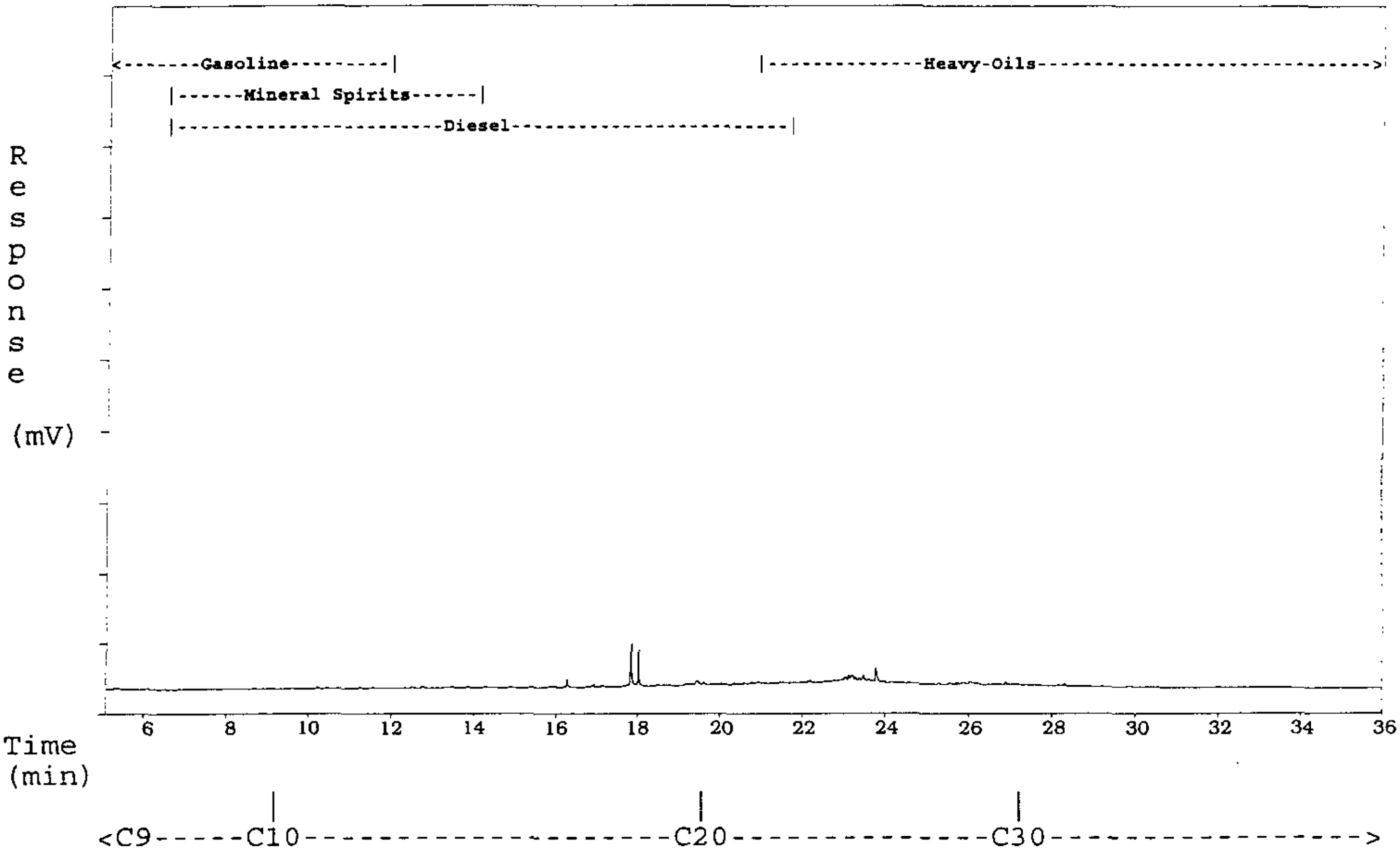
ASL Sample ID: K5918-T--6* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K5918-T--8** tn 4 Outfall 99 05 17

Sample acquired: JUN 1, 1999 03:21:22 Sequence File: EH1MAY31
File Name: C:\TEH\MAY31\EH1MAY31.34R , Sample Name: K5918-T--8
Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K5918-T--8* 10.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

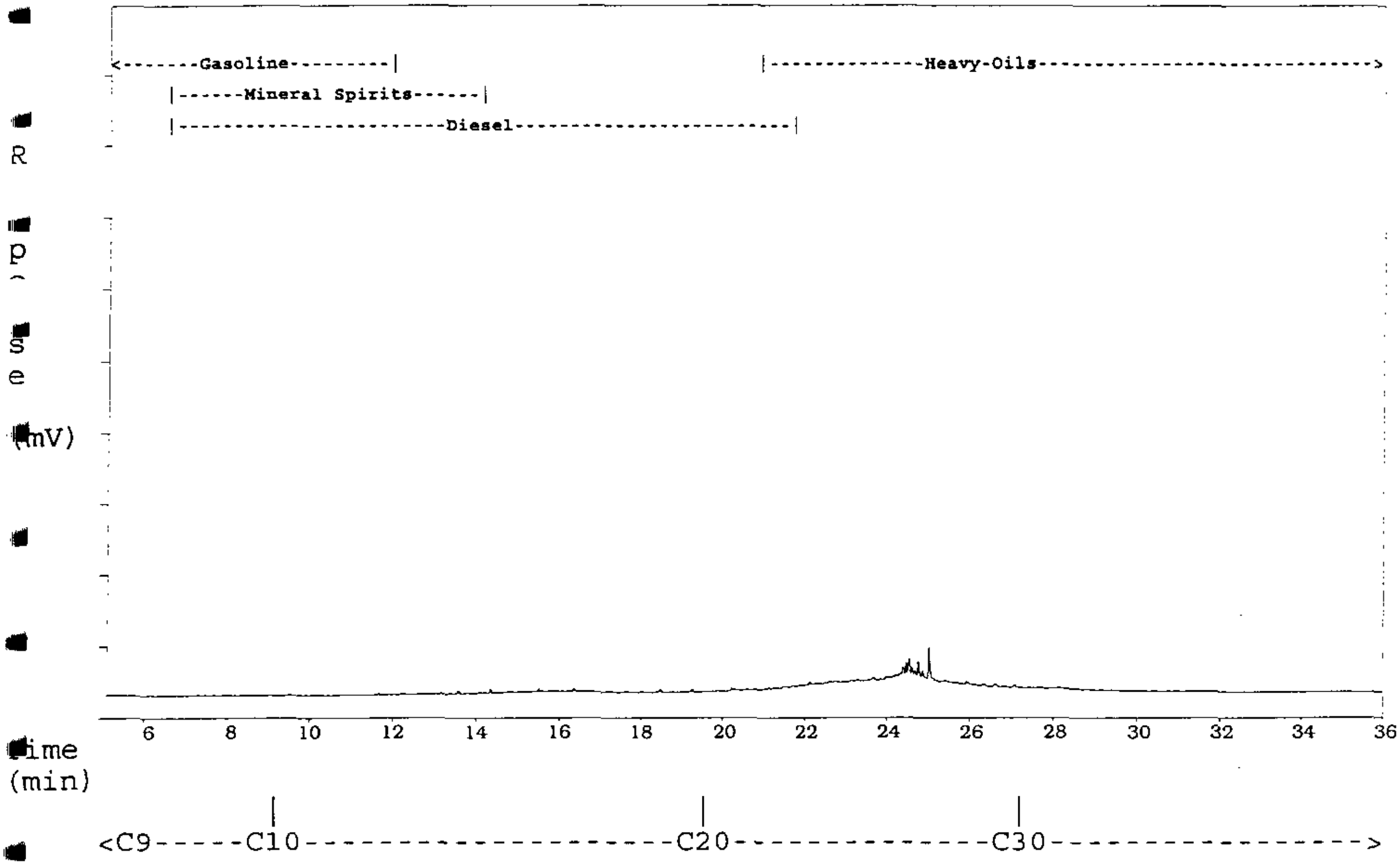
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K5918-T--9** n 4D 99 05 17

Sample acquired: MAY 30, 1999 12:59:39 Sequence File: EH3MAY28

File Name: C:\TEH2\MA281\EH3MA281.10R , Sample Name: K5918-T--9

Chromatogram Scale: 50.0 **millivolts**



ASL Sample ID: K5918-T--9* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

CHEMICAL ANALYSIS REPORT

Date:	August 13, 1999
ASL File No.	K5830r
Report On:	99-902 Polaris Soil And Water Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	May 17, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K5830r

This report, ASL file number K5830r, supersedes the previous ASL file number K5830. The client requested that some of the Lead results be reported to a lower detection limit. The following data tables reflect this change.

The detection limits for some of the metals for some of the soil samples reported in the following data tables have been increased due to the high concentrations of certain other metals in the samples.

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

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

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 2 Top	Stn 1A Bottom
Sample Date		99 05 14	99 05 14	99 05 12	99 05 13	99 05 12
Physical Tests						
Hardness	CaCO3	5680	6090	5960	5550	5760
pH		7.44	7.52	7.58	7.35	7.60
Dissolved Anions						
Alkalinity-Total	CaCO3	127	129	128	-	130
Chloride	Cl	20900	19400	20300	-	19600
Fluoride	F	0.80	0.84	0.84	-	0.84
Sulphate	SO4	2610	2750	2750	-	2680
Cyanides						
Total Cyanide	CN	<0.005	<0.005	<0.005	-	<0.005

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 2 Top	Stn 1A Bottom
Sample Date		99 05 14	99 05 14	99 05 12	99 05 13	99 05 12
Dissolved Metals						
Aluminum	D-Al	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony	D-Sb	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	D-As	0.001	0.001	0.001	0.001	0.001
Barium	D-Ba	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium	D-Cd	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Calcium	D-Ca	369	399	389	362	376
Chromium	D-Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	D-Cu	0.002	<0.001	<0.001	0.002	<0.001
Iron	D-Fe	<0.6	<0.6	<0.6	<0.6	<0.6
Lead	D-Pb	0.029	<0.001	0.007	0.013	<0.001
Magnesium	D-Mg	1160	1240	1210	1130	1170
Manganese	D-Mn	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	D-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.6	<0.6	<0.6	<0.6	<0.6
Nickel	D-Ni	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	D-Se	0.0006	<0.0005	<0.0005	0.0006	<0.0005
Silver	D-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium	D-Na	9900	10400	10200	9610	9910
Uranium	D-U	0.003	0.003	0.003	0.003	0.003
Zinc	D-Zn	<0.01	<0.01	<0.01	<0.01	<0.005

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID	Stn 3C Top	Stn 3C Bottom	Stn 1A Top	Stn 1A Bottom
Sample Date	99 05 14	99 05 14	99 05 12	99 05 12
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.00005	-	<0.00005	<0.00005
Acenaphthylene	<0.00005	-	<0.00005	<0.00005
Acridine	<0.00005	-	<0.00005	<0.00005
Anthracene	<0.00005	-	<0.00005	<0.00005
Benz(a)anthracene	<0.00005	-	<0.00005	<0.00005
Benzo(a)pyrene	<0.00001	-	<0.00001	<0.00001
Benzo(b)fluoranthene	<0.00005	-	<0.00005	<0.00005
Benzo(g,h,i)perylene	<0.00005	-	<0.00005	<0.00005
Benzo(k)fluoranthene	<0.00005	-	<0.00005	<0.00005
Chrysene	<0.00005	-	<0.00005	<0.00005
Dibenz(a,h)anthracene	<0.00005	-	<0.00005	<0.00005
Fluoranthene	<0.00005	-	<0.00005	<0.00005
Fluorene	<0.00005	-	<0.00005	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	-	<0.00005	<0.00005
Naphthalene	<0.00005	-	<0.00005	<0.00005
Phenanthrene	<0.00005	-	<0.00005	<0.00005
Pyrene	<0.00005	-	<0.00005	<0.00005
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	<0.001	<0.001	<0.001	<0.001
Extractables				
EPH (C10-19)	<0.3	<0.3	<0.3	<0.3
EPH (C19-32)	<1	<1	<1	<1
LEPH	<0.3	-	<0.3	<0.3
HEPH	<1	-	<1	<1

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 2 Bottom
Sample Date		99 05 13
Physical Tests		
Hardness	CaCO3	5920
pH		7

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Seawater[1]

File No. K5830r

Sample ID		Stn 2 Bottom
Sample Date		99 05 13
Dissolved Metals		
Aluminum	D-Al	<0.005
Antimony	D-Sb	<0.001
Arsenic	D-As	0.001
Barium	D-Ba	<0.2
Cadmium	D-Cd	<0.0001
Calcium	D-Ca	388
Chromium	D-Cr	<0.001
Cobalt	D-Co	<0.001
Copper	D-Cu	<0.001
Iron	D-Fe	<0.6
Lead	D-Pb	<0.001
Magnesium	D-Mg	1200
Manganese	D-Mn	<0.1
Mercury	D-Hg	<0.00005
Molybdenum	D-Mo	<0.6
Nickel	D-Ni	<0.001
Selenium	D-Se	<0.0005
Silver	D-Ag	<0.0001
Sodium	D-Na	10100
Uranium	D-U	0.003
Zinc	D-Zn	<0.01

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per litre except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID		Stn 3C Sed.	Stn 3B Sed.	Stn 3A Sed.	Stn 1A Sed.	Stn 2 Sed.
Sample Date		99 05 14	99 05 14	99 05 15	99 05 12	99 05 13
Physical Tests						
Moisture	%	39.7	65.9	29.7	48.0	68.7
pH		8.24	8.03	8.30	8.29	8.44
Total Metals						
Antimony	T-Sb	<60	<40	<20	<40	<40
Arsenic	T-As	6	7.1	16	3.5	4.7
Barium	T-Ba	717	1040	226	556	470
Beryllium	T-Be	<2	<1	0.7	<1	<1
Cadmium	T-Cd	1.0	1.8	0.6	0.2	0.1
Chromium	T-Cr	16	30	24	18	20
Cobalt	T-Co	<6	<4	3	<4	<4
Copper	T-Cu	11	17	20	9	9
Lead	T-Pb	99	128	23	7	8
Mercury	T-Hg	0.085	0.080	0.094	0.040	0.045
Molybdenum	T-Mo	<20	<8	6	<8	<8
Nickel	T-Ni	<20	16	20	11	15
Selenium	T-Se	0.7	1.0	1.4	0.5	0.5
Silver	T-Ag	<6	<4	<2	<4	<4
Tin	T-Sn	<30	<20	<10	<20	<20
Vanadium	T-V	59	127	116	56	72
Zinc	T-Zn	298	520	155	35	40

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1]Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID	Stn 3C Sed.	Stn 3B Sed.	Stn 3A Sed.	Stn 1A Sed.
Sample Date	99 05 14	99 05 14	99 05 15	99 05 12
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	<0.01	<0.01	<0.01	<0.01
Anthracene	0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	<0.02	<0.01	0.02	<0.01
Benzo(a)pyrene	<0.02	<0.01	0.01	<0.01
Benzo(b)fluoranthene	<0.02	<0.01	0.02	<0.01
Benzo(g,h,i)perylene	<0.02	0.03	0.03	<0.02
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	<0.01
Chrysene	0.03	<0.02	0.03	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.03	<0.03	0.02	<0.01
Fluorene	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-c,d)pyrene	0.01	<0.01	<0.01	<0.01
Naphthalene	<0.01	0.01	0.08	<0.01
Phenanthrene	0.04	<0.03	0.02	<0.01
Pyrene	0.03	<0.03	0.02	<0.01
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	<0.05	-	-	-
Extractables				
EPH (C10-19)	<200	<200	<200	<200
EPH (C19-32)	<200	<200	<200	<200
LEPH	<200	<200	<200	<200
HEPH	<200	<200	<200	<200

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID		Bent Horn 0-3'	Bent Horn 6-9'	Bent Horn 12-15'
Sample Date		99 05 14	99 05 14	99 05 14
Physical Tests				
Moisture	%	4.3	10.3	11.0
pH		8.64	8.99	-
Total Metals				
Antimony	T-Sb	<100	<200	-
Arsenic	T-As	2.1	0.6	-
Barium	T-Ba	393	214	-
Beryllium	T-Be	<3	<3	-
Cadmium	T-Cd	2.8	3.4	-
Chromium	T-Cr	<10	<20	-
Cobalt	T-Co	<10	<20	-
Copper	T-Cu	<5	<6	-
Lead	T-Pb	571	350	-
Mercury	T-Hg	0.018	0.006	-
Molybdenum	T-Mo	<20	<30	-
Nickel	T-Ni	<30	<30	-
Selenium	T-Se	<0.1	<0.1	-
Silver	T-Ag	<10	<20	-
Tin	T-Sn	<50	<60	-
Vanadium	T-V	11	<20	-
Zinc	T-Zn	1550	2070	-

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

RESULTS OF ANALYSIS - Sediment/Soil[1]

File No. K5830r

Sample ID	Bent Horn 0-3'	Bent Horn 6-9'	Bent Horn 12-15'
Sample Date	99 05 14	99 05 14	99 05 14
Non-halogenated Volatiles			
Benzene	<0.04	<0.04	-
Ethylbenzene	<0.05	<0.05	-
Styrene	<0.05	<0.05	-
Toluene	0.06	0.08	-
meta- & para-Xylene	2.07	0.38	-
ortho-Xylene	1.72	0.30	-
Volatile Hydrocarbons (VH) C6-10	274	<100	-
VPH C6-10 (calculated)	270	<100	-
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	<0.2	<0.05	-
Acenaphthylene	<0.2	<0.05	-
Anthracene	0.06	<0.01	-
Benz(a)anthracene	<0.01	<0.01	-
Benzo(a)pyrene	<0.01	<0.01	-
Benzo(b)fluoranthene	<0.05	<0.02	-
Benzo(g,h,i)perylene	<0.01	<0.01	-
Benzo(k)fluoranthene	<0.05	<0.02	-
Chrysene	<0.01	<0.01	-
Dibenz(a,h)anthracene	<0.01	<0.01	-
Fluoranthene	0.01	<0.01	-
Fluorene	0.28	0.05	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	-
Naphthalene	2.12	0.31	-
Phenanthrene	0.27	0.06	-
Pyrene	0.03	<0.01	-
Extractables			
EPH (C10-19)	4130	917	<200
EPH (C19-32)	1220	998	221
LEPH	-	-	-
HEPH	-	-	-

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[1] Results are expressed as milligrams per dry kilogram except where noted.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K5830r

Sediment/Soil[1]		**Bent Horn 6-9'** 99 05 14	**Bent Horn 6-9'** QC # 157214
Physical Tests			
Moisture	%	10.3	10.2
pH		8.99	9.07
Total Metals			
Antimony	T-Sb	<200	<200
Arsenic	T-As	0.6	0.7
Barium	T-Ba	214	214
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	3.4	4.5
Chromium	T-Cr	<20	<20
Cobalt	T-Co	<20	<20
Copper	T-Cu	<6	<6
Lead	T-Pb	350	407
Mercury	T-Hg	0.006	0.006
Molybdenum	T-Mo	<30	<30
Nickel	T-Ni	<30	<30
Selenium	T-Se	<0.1	<0.1
Silver	T-Ag	<20	<20
Tin	T-Sn	<60	<60
Vanadium	T-V	<20	<20
Zinc	T-Zn	2070	2520
Non-halogenated Volatiles			
Benzene		<0.04	<0.04
Ethylbenzene		<0.05	0.09
Styrene		<0.05	<0.05
Toluene		0.08	0.10
meta- & para-Xylene		0.38	0.41
ortho-Xylene		0.30	0.26
Volatile Hydrocarbons (VH) C6-10		<100	<100
VPH C6-10 (calculated)		<100	<100

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K5830r

Sediment/Soil[1]	**Bent Horn 6-9'** 99 05 14	**Bent Horn 6-9'** QC # 157214
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.05	<0.05
Acenaphthylene	<0.05	<0.05
Anthracene	<0.01	0.01
Benz(a)anthracene	<0.01	<0.01
Benzo(a)pyrene	<0.01	<0.01
Benzo(b)fluoranthene	<0.02	<0.02
Benzo(g,h,i)perylene	<0.01	0.01
Benzo(k)fluoranthene	<0.02	<0.02
Chrysene	<0.01	<0.01
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	<0.01	<0.01
Fluorene	0.05	0.05
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01
Naphthalene	0.31	0.35
Phenanthrene	0.06	0.07
Pyrene	<0.01	0.01
Extractables		
EPH (C10-19)	917	841
EPH (C19-32)	998	1010

Remarks regarding the analyses appear at the beginning of this report.
< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

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

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.

Trace Metals in Seawater by SPR-IDA Chelation

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 Cetac Technologies Incorporated. A suspended particulate resin (SPR), consisting of immobilized iminodiacetate (IDA) on a divinylbenzene polymer, is used to chelate and preconcentrate metals in seawater. Instrumental analysis is by inductively coupled plasma mass spectrometry (ICPMS) and/or routine atomic absorption spectrophotometry techniques (EPA 7000 series).

Recommended Holding Time:

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

Metals in Seawater

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 or filtration (EPA Method 3005A). Instrumental analysis of the seawater 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 Seawater

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 seawater 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 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.

Polychlorinated Biphenyls in Water

This analysis is carried out using a procedure adapted from U.S. EPA Methods 3510, 8080 and 8082. (Publ. #SW-846, 3rd Ed., Washington, DC 20460). The procedure involves liquid-liquid extraction of the sample with dichloromethane. The extract is cleaned and analyzed by capillary column gas chromatography with electron capture detection.

Extractable Hydrocarbons in Water

This analysis is carried out using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Water

These results 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(C10-18). To calculate HEPH, the individual results for benz(a)anthracene, benzo(a)pyrene, fluoranthene, and pyrene are subtracted from EPH(C19-31).

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"

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"

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. A portion of the extract is exchanged to toluene, cleaned, and analysed by capillary column gas chromatography with mass spectrometric detection.

Polychlorinated Biphenyls in Sediment

This analysis is carried out using a procedure adapted from EPA Method 8082 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a solid-liquid extraction of the sample with hexane/acetone and back extraction with water. The hexane extract is cleaned and analysed by capillary column gas chromatography with electron capture detection.

Extractable Petroleum Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. The extract is exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection.

Light and Heavy Extractable Petroleum Hydrocarbons in Soil

Method Revised and Replaced: 1999 07 02

Volatile Organic Compounds in Sediment/Soil

This analysis is based on United States Environmental Protection Agency Methods 5035, 8260/8021 and British Columbia Ministry of Environment, Lands and Parks Method "Volatile Hydrocarbons in Solids by GC/FID ". The procedure involves a 1:2 extraction of the sediment/soil sample with methanol. Aliquots of the methanol extract are then analyzed by capillary column gas chromatography with mass spectrometric, and/or photo-ionization/flame-ionization detection.

Volatile Petroleum Hydrocarbons (VPH) in Sediment/Soil

Volatile Petroleum Hydrocarbons (VPH) is a calculation defined by British Columbia Ministry of Environment, Lands and Parks (BCMELP) Draft Method "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water", June 1998. The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). Analysis of Volatile Hydrocarbons adheres to all prescribed elements of BCMELP method "Volatile Hydrocarbons in Solid", June 1998.

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

End of Report

Soil

1988 Triumph Street, Vancouver, BC Canada V5L 1K5
analytical service laboratories ltd.
FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: November 23, 1999

ASL File No. L2620

Report On: 99-902 Soil Analysis

NOV 29 1999
GARTNER LEE

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

Attention: **Ms. Eva Gerencher**

Received: November 18, 1999

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. L2620

Sample ID		NQ-1	NQ-2	NQ-3	NQ-4	NQ-5
Sample Date *ASL ID*		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	7.7	10.2	9.7	8.3	4.7
Total Metals						
Lead	T-Pb	92	27	22	86	86
Zinc	T-Zn	349	123	300	292	369

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

RESULTS OF ANALYSIS - Sediment/Soil File No. L2620

		NQ-6	SS 3250E 1750N	TP81 0.1-0.3	NQ-1 Dup
Sample Date			99 07 13		
ASL ID		*6*	*7*	*8*	*9*
Physical Tests					
Moisture	%	9.0	17.8	4.3	9.0
Total Metals					
Lead	T-Pb	17	13	13500	99
Zinc	T-Zn	38.6	77.5	40000	465

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L2620

Sediment/Soil		NQ-5	NQ-5 QC # 180738
Total Metals			
Lead	T-Pb	86	87
Zinc	T-Zn	369	338

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

Appendix 2 - METHODOLOGY File No. L2620

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

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CHEMICAL ANALYSIS REPORT

Date: November 4, 1999

ASL File No. L2113

Report On: 99-902 Soil Analysis

NOV 10 1999
GARTNER LEE

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

Attention: **Ms. Eva Gerencher**

Received: October 25, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. L2113

The detection limits for certain Total Metals for some of the samples in the following data tables have been increased due to sample matrix interferences, specifically the high concentration of other Total Metals in the samples.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L2113

GLL Sample ID		3	17	29	73	
Sample ID		SS600E 1560N	SS660E 1320N	SS820E 940N	SS2250E 2800N	Firehall Snowdump A
Sample Date		99 07 11	99 07 11	99 07 11	99 07 14	99 07 14
Total Metals						
Aluminum	T-Al	2150	3220	6900	12700	3610
Antimony	T-Sb	<100	<100	<200	<20	<80
Arsenic	T-As	<500	<500	<600	<100	<400
Barium	T-Ba	21	22	27	277	26
Beryllium	T-Be	<3	<3	<3	0.6	<2
Bismuth	T-Bi	<50	<50	<60	<10	48
Cadmium	T-Cd	70	16	<20	9	105
Calcium	T-Ca	267000	272000	244000	30200	129000
Chromium	T-Cr	<10	<10	<20	20	<8
Cobalt	T-Co	<10	<10	<20	4	<8
Copper	T-Cu	8	11	13	34	7
Iron	T-Fe	8130	5740	10000	10500	24000
Lead	T-Pb	6440	3560	999	988	11200
Lithium	T-Li	<10	<10	<20	11	<8
Magnesium	T-Mg	26300	39600	24800	7430	82300
Manganese	T-Mn	97	160	199	178	368
Molybdenum	T-Mo	<20	<20	<30	<4	<20
Nickel	T-Ni	<30	<30	<30	39	<20
Phosphorus	T-P	<300	<300	370	997	<200
Potassium	T-K	1100	1580	2740	4380	1910
Selenium	T-Se	<300	<300	<300	<50	<200
Silver	T-Ag	<10	<10	<20	<2	<8
Strontium	T-Sr	145	205	249	115	91
Thallium	T-Tl	<300	<300	<300	<50	<200
Tin	T-Sn	<50	<50	<60	<10	<40
Titanium	T-Ti	14	21	54	204	12
Vanadium	T-V	<10	24	50	116	12
Zinc	T-Zn	39200	6660	4680	2970	46900

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. L2113

	GLL ID	47	59			
Sample ID		Soil #12 1025E 1621N	Soil #24 1401E 1267N	TP5 0.5-0.8m	TP19 0.3-0.6m	TP31 0.1-0.3m
Sample Date		99 09 17	99 09 17	99 07 12	99 07 13	99 07 13
Total Metals						
Aluminum	T-Al	5060	10500	1650	5910	3890
Antimony	T-Sb	<40	<60	<100	<200	<100
Arsenic	T-As	<200	<300	<500	<600	<500
Barium	T-Ba	62	120	16	28	42
Beryllium	T-Be	<1	<2	<3	<3	<3
Bismuth	T-Bi	<20	<30	<50	<60	<50
Cadmium	T-Cd	10	<6	14	<20	<10
Calcium	T-Ca	166000	127000	211000	293000	272000
Chromium	T-Cr	13	24	<10	<20	<10
Cobalt	T-Co	<4	<6	<10	<20	<10
Copper	T-Cu	5	23	<5	21	<5
Iron	T-Fe	15500	12100	5990	8960	5200
Lead	T-Pb	779	398	4120	5240	<300
Lithium	T-Li	6	10	<10	<20	<10
Magnesium	T-Mg	95400	42600	92200	18700	35600
Manganese	T-Mn	499	150	365	198	248
Molybdenum	T-Mo	<8	<20	<20	<30	<20
Nickel	T-Ni	10	43	<30	<30	<30
Phosphorus	T-P	309	459	<300	<300	<300
Potassium	T-K	1890	4340	<1000	2190	1230
Selenium	T-Se	<100	<200	<300	<300	<300
Silver	T-Ag	<4	<6	<10	<20	<10
Strontium	T-Sr	167	261	116	236	212
Thallium	T-Tl	<100	<200	<300	<300	<300
Tin	T-Sn	<20	<30	<50	<60	<50
Titanium	T-Ti	12	134	<5	36	22
Vanadium	T-V	21	170	<10	<20	17
Zinc	T-Zn	5720	1220	4350	4040	5210

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. L2113

Sample ID		TP34 0.2-0.4m	TP40 0.1-0.3m	TP68 0.4-0.6m	TP77 0.1-0.3m
Sample Date		99 07 13	99 07 14	99 07 16	99 07 16
Total Metals					
Aluminum	T-Al	2550	2430	7320	26200
Antimony	T-Sb	<100	<40	<40	<40
Arsenic	T-As	<500	<200	<200	<200
Barium	T-Ba	83	17	22	12
Beryllium	T-Be	<3	<1	<1	<1
Bismuth	T-Bi	<50	<20	<20	26
Cadmium	T-Cd	30	42	6	5
Calcium	T-Ca	219000	179000	161000	102000
Chromium	T-Cr	<10	5	22	44
Cobalt	T-Co	<10	<4	<4	14
Copper	T-Cu	15	196	15	15
Iron	T-Fe	4490	5930	11800	23000
Lead	T-Pb	13700	2060	533	834
Lithium	T-Li	<10	4	6	27
Magnesium	T-Mg	58100	105000	36900	50400
Manganese	T-Mn	235	485	270	182
Molybdenum	T-Mo	<20	<8	<8	<8
Nickel	T-Ni	<30	<10	16	37
Phosphorus	T-P	<300	<100	1270	319
Potassium	T-K	1100	1200	2770	13900
Selenium	T-Se	<300	<100	<100	<100
Silver	T-Ag	<10	<4	<4	<4
Strontium	T-Sr	115	63	258	60
Thallium	T-Tl	<300	<100	<100	<100
Tin	T-Sn	<50	<20	<20	<20
Titanium	T-Ti	20	8	70	44
Vanadium	T-V	18	7	103	52
Zinc	T-Zn	11300	17000	2570	2750

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 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

analytical
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ltd.

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

CHEMICAL ANALYSIS REPORT

Date: November 4, 1999

ASL File No. L2023

Report On: 99-902 Soil Analysis

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

Attention: **Ms. Eva Gerencher**

Received: October 28, 1999

NOV 10 1999
GARTNER LEE

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. L2023

	GCL ID	17	47	73	80	101
Sample ID		SS 660E 1320N	SS 1025E 1621N	SS 2250E 2800N	SS 2600E 3300N	SS 3300E 2300N
Sample Date						
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
1st Preliminary TCLP pH		8.75	8.71	8.45	8.15	8.17
2nd Preliminary TCLP pH		4.11	1.99	1.43	1.50	1.52
TCLP Extraction Fluid pH		4.94	4.94	4.94	4.94	4.94
Final TCLP pH		5.84	5.73	5.48	5.14	5.14
Extractable Metals[1]						
Antimony	Sb	<1	<1	<1	<1	<1
Arsenic	As	<1	<1	<1	<1	<1
Barium	Ba	<3	<3	<3	<3	<3
Beryllium	Be	<0.03	<0.03	<0.03	<0.03	<0.03
Boron	B	<0.5	<0.5	<0.5	<0.5	<0.5
Cadmium	Cd	<0.05	0.20	<0.05	<0.05	<0.05
Calcium	Ca	642	577	473	240	240
Chromium	Cr	<0.3	<0.3	<0.3	<0.3	<0.3
Cobalt	Co	<0.05	<0.05	<0.05	<0.05	<0.05
Copper	Cu	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	Fe	<0.2	0.9	<0.2	0.5	0.7
Lead	Pb	24.5	4.0	<0.3	<0.3	<0.3
Magnesium	Mg	6.7	25.5	26.3	47.1	53.1
Mercury	Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	Ni	<0.3	<0.3	<0.3	<0.3	<0.3
Selenium	Se	<1	<1	<1	<1	<1
Silver	Ag	<0.3	<0.3	<0.3	<0.3	<0.3
Thallium	Tl	<1	<1	<1	<1	<1
Vanadium	V	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc	Zn	10.7	31.1	0.4	<0.3	<0.3

< = Less than the detection limit indicated.

[1] Results are expressed as milligrams per litre in the TCLP extract.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L2023

Sample ID		TP5 0.5-0.8m	TP16 0.2-0.4m	TP19 0.3-0.6m	TP27 0.1-0.3m	TP81 0.3-0.6m
Sample Date						
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	-	-	-	-	4.8
1st Preliminary TCLP pH		8.52	9.15	8.76	9.27	-
2nd Preliminary TCLP pH		3.28	4.24	4.95	3.82	-
TCLP Extraction Fluid pH		4.94	4.94	4.94	4.94	-
Final TCLP pH		5.90	5.92	6.03	5.96	-
Total Metals[1]						
Lead	T-Pb	-	-	-	-	4570
Zinc	T-Zn	-	-	-	-	13600
Extractable Metals[2]						
Antimony	Sb	<1	<1	<1	<1	-
Arsenic	As	<1	<1	<1	<1	-
Barium	Ba	<3	<3	<3	<3	-
Beryllium	Be	<0.03	<0.03	<0.03	<0.03	-
Boron	B	<0.5	<0.5	<0.5	<0.5	-
Cadmium	Cd	<0.05	<0.05	<0.05	<0.05	-
Calcium	Ca	724	677	701	705	-
Chromium	Cr	<0.3	<0.3	<0.3	<0.3	-
Cobalt	Co	<0.05	<0.05	<0.05	<0.05	-
Copper	Cu	<0.05	<0.05	<0.05	<0.05	-
Iron	Fe	<0.2	<0.2	<0.2	<0.2	-
Lead	Pb	9.6	2.1	6.0	9.5	-
Magnesium	Mg	8.7	28.9	8.4	11.0	-
Mercury	Hg	<0.00005	<0.00005	<0.00005	<0.00005	-
Nickel	Ni	<0.3	<0.3	<0.3	<0.3	-
Selenium	Se	<1	<1	<1	<1	-
Silver	Ag	<0.3	<0.3	<0.3	<0.3	-
Thallium	Tl	<1	<1	<1	<1	-
Vanadium	V	<0.2	<0.2	<0.2	<0.2	-
Zinc	Zn	3.6	0.7	12.8	5.2	-

< = Less than the detection limit indicated.

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

[2] Results are expressed as milligrams per litre in the TCLP extract.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L2023

Sample ID		TL 2950E 1150N	TP70 0.3-0.6m
Sample Date		99 07 15	99 07 16
ASL ID		*11*	*12*
Physical Tests			
1st Preliminary TCLP pH		7.75	8.82
2nd Preliminary TCLP pH		4.65	1.63
TCLP Extraction Fluid pH		4.94	4.94
Final TCLP pH		5.96	5.92
Extractable Metals[1]			
Antimony	Sb	<1	<1
Arsenic	As	<1	<1
Barium	Ba	<3	<3
Beryllium	Be	<0.03	<0.03
Boron	B	<0.5	<0.5
Cadmium	Cd	0.05	0.06
Calcium	Ca	704	677
Chromium	Cr	<0.3	<0.3
Cobalt	Co	<0.05	<0.05
Copper	Cu	<0.05	<0.05
Iron	Fe	<0.2	0.4
Lead	Pb	2.1	<0.3
Magnesium	Mg	12.4	8.0
Mercury	Hg	<0.00005	<0.00005
Nickel	Ni	<0.3	<0.3
Selenium	Se	<1	<1
Silver	Ag	<0.3	<0.3
Thallium	Tl	<1	<1
Vanadium	V	<0.2	<0.2
Zinc	Zn	11.9	21.3

< = Less than the detection limit indicated.

[1] Results are expressed as milligrams per litre in the TCLP extract.

Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil		**SS 660E 1320N**	**SS 660E 1320N** QC # 178321
Extractable Metals			
Antimony	Sb	<1	<1
Arsenic	As	<1	<1
Barium	Ba	<3	<3
Beryllium	Be	<0.03	<0.03
Boron	B	<0.5	<0.5
Cadmium	Cd	<0.05	<0.05
Calcium	Ca	642	638
Chromium	Cr	<0.3	<0.3
Cobalt	Co	<0.05	<0.05
Copper	Cu	<0.05	<0.05
Iron	Fe	<0.2	<0.2
Lead	Pb	24.5	21.9
Magnesium	Mg	6.7	6.6
Mercury	Hg	<0.00005	<0.00005
Nickel	Ni	<0.3	<0.3
Selenium	Se	<1	<1
Silver	Ag	<0.3	<0.3
Thallium	Tl	<1	<1
Vanadium	V	<0.2	<0.2
Zinc	Zn	10.7	10.5

< = Less than the detection limit indicated.

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

Toxicity Characteristic Leaching Procedure (TCLP) for Metals

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1311, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using either extraction fluid #1 (glacial acetic acid, water and sodium hydroxide) or extraction fluid #2 (glacial acetic acid), depending on the pH of the original sample. The extract is then filtered through a 0.6 to 0.8 micron glass fibre filter and analysed using atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Recommended Holding Time:

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

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

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CHEMICAL ANALYSIS REPORT

NOV 10 1999
GARTNER LEE

Date:	November 4, 1999
ASL File No.	L1796
Report On:	99-902 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	May 31, 1999

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. L1796

		BH4		BH7		BH9
Sample ID		TH#2 10-15ft	TH#2 15-20ft	TH#3 10-15ft	TH#3 15-20ft	TH#4 15-20ft
Sample Date		99 05 27	99 05 27	99 05 27	99 05 27	99 05 27
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	5.0	5.6	4.3	8.9	0.5
Total Metals						
Lead	T-Pb	1150	223	1150	1430	52
Zinc	T-Zn	3690	1210	4630	6660	37.9

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1796

		BH9		
Sample ID		TH#4 20-25ft	BH8 10-12ft	BH10 10-15ft
Sample Date		99 05 27	99 05 26	99 05 26
ASL ID		*6*	*7*	*8*
Physical Tests				
Moisture	%	1.1	3.8	9.0
Total Metals				
Lead	T-Pb	77	70	39
Zinc	T-Zn	57.3	180	191

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1796

Sediment/Soil		**TH#2 10-15ft** 99 05 27	**TH#2 10-15** QC # 177323
Physical Tests			
Moisture	%	5.0	4.6
Total Metals			
Lead	T-Pb	1150	904
Zinc	T-Zn	3690	3730

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

Appendix 2 - METHODOLOGY

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
analytical service laboratories ltd.
FAX: (604) 253-6700 TEL: (604) 253-4188

CHEMICAL ANALYSIS REPORT

Date: November 3, 1999

ASL File No. L1790

Report On: 99-902 Soil Analysis

NOV -8 1999
GARTNER LEE

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

Attention: **Ms. Eva Gerencher**

Received: July 28, 1999

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. L1790

Sample ID		TP23 0.6-0.9	TP25 0.1-0.3	TP25 0.3-0.6	TP30 0.7-0.9	TP33 0.6-1.0
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	6.2	0.7	2.3	10.2	4.0
1st Preliminary TCLP pH		-	-	9.34	-	9.06
2nd Preliminary TCLP pH		-	-	1.47	-	1.37
TCLP Extraction Fluid pH		-	-	4.91	-	4.91
Final TCLP pH		-	-	5.84	-	6.09
Total Metals						
Lead	T-Pb	2900	157	7400	185	59
Zinc	T-Zn	6500	1280	46100	1330	1070
Extractable Metals[1,2]						
Antimony	Sb	-	-	<1	-	<1
Arsenic	As	-	-	<1	-	<1
Barium	Ba	-	-	1.0	-	1.1
Beryllium	Be	-	-	<0.03	-	<0.03
Boron	B	-	-	<0.5	-	<0.5
Cadmium	Cd	-	-	<0.05	-	<0.05
Calcium	Ca	-	-	580	-	820
Chromium	Cr	-	-	<0.05	-	<0.05
Cobalt	Co	-	-	<0.05	-	<0.05
Copper	Cu	-	-	<0.05	-	<0.05
Iron	Fe	-	-	<0.2	-	<0.2
Lead	Pb	-	-	15.3	-	<0.3
Magnesium	Mg	-	-	55.8	-	7.4
Mercury	Hg	-	-	<0.00005	-	<0.00005
Nickel	Ni	-	-	<0.3	-	<0.3
Selenium	Se	-	-	<1	-	<1
Silver	Ag	-	-	<0.05	-	<0.05
Thallium	Tl	-	-	<1	-	<1
Vanadium	V	-	-	<0.2	-	<0.2
Zinc	Zn	-	-	3.0	-	20.3

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

[1] Results are expressed as milligrams per litre in the TCLP extract.

[2] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1790

Sample ID		TP34 0.6-0.9	TP41 0.3-0.6	TP45 0.3-0.6	TP51 0.3-0.6	TP67 0.4-0.6
Sample Date		99 07 13	99 07 14	99 07 14	99 07 14	99 07 15
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	4.7	3.4	4.5	4.1	4.3
1st Preliminary TCLP pH		-	-	9.38	-	-
2nd Preliminary TCLP pH		-	-	1.41	-	-
TCLP Extraction Fluid pH		-	-	4.91	-	-
Final TCLP pH		-	-	6.07	-	-
Total Metals						
Lead	T-Pb	2650	51	371	53	6
Zinc	T-Zn	5830	347	2150	142	22.4
Extractable Metals[1,2]						
Antimony	Sb	-	-	<1	-	-
Arsenic	As	-	-	<1	-	-
Barium	Ba	-	-	1.5	-	-
Beryllium	Be	-	-	<0.03	-	-
Boron	B	-	-	<0.5	-	-
Cadmium	Cd	-	-	<0.05	-	-
Calcium	Ca	-	-	763	-	-
Chromium	Cr	-	-	<0.05	-	-
Cobalt	Co	-	-	<0.05	-	-
Copper	Cu	-	-	<0.05	-	-
Iron	Fe	-	-	<0.2	-	-
Lead	Pb	-	-	0.5	-	-
Magnesium	Mg	-	-	8.6	-	-
Mercury	Hg	-	-	<0.00005	-	-
Nickel	Ni	-	-	<0.3	-	-
Selenium	Se	-	-	<1	-	-
Silver	Ag	-	-	<0.05	-	-
Thallium	Tl	-	-	<1	-	-
Vanadium	V	-	-	<0.2	-	-
Zinc	Zn	-	-	1.4	-	-

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

[1] Results are expressed as milligrams per litre in the TCLP extract.

[2] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1790

Sample ID		TP75 0.1-0.3	TP76 0.1-0.3	TP77 0.3-0.6	TP80 0.3-0.6	TP78 0.1-0.3
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	1.9	5.5	6.9	4.9	5.6
1st Preliminary TCLP pH		-	-	-	8.97	-
2nd Preliminary TCLP pH		-	-	-	1.37	-
TCLP Extraction Fluid pH		-	-	-	4.91	-
Final TCLP pH		-	-	-	5.84	-
Total Metals						
Lead	T-Pb	55	196	961	14200	49
Zinc	T-Zn	215	1380	10300	34900	236
Extractable Metals[1,2]						
Antimony	Sb	-	-	-	<1	-
Arsenic	As	-	-	-	<1	-
Barium	Ba	-	-	-	<0.3	-
Beryllium	Be	-	-	-	<0.03	-
Boron	B	-	-	-	<0.5	-
Cadmium	Cd	-	-	-	<0.05	-
Calcium	Ca	-	-	-	734	-
Chromium	Cr	-	-	-	<0.05	-
Cobalt	Co	-	-	-	0.06	-
Copper	Cu	-	-	-	<0.05	-
Iron	Fe	-	-	-	<0.2	-
Lead	Pb	-	-	-	4.9	-
Magnesium	Mg	-	-	-	37.6	-
Mercury	Hg	-	-	-	<0.00005	-
Nickel	Ni	-	-	-	<0.3	-
Selenium	Se	-	-	-	<1	-
Silver	Ag	-	-	-	<0.05	-
Thallium	Tl	-	-	-	<1	-
Vanadium	V	-	-	-	<0.2	-
Zinc	Zn	-	-	-	2.0	-

Results are expressed as milligrams per dry kilogram except where noted.
[1] Results are expressed as milligrams per litre in the TCLP extract.
[2] < = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Sediment/Soil File No. L1790

Sample ID		TP78 0.3-0.6
Sample Date		99 07 16
ASL ID		*16*
Physical Tests		
Moisture	%	8.3
Total Metals		
Lead	T-Pb	28
Zinc	T-Zn	144

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1790

Sediment/Soil		**TP23 0.6-0.9**	**TP23 0.6-0.9**
		99 07 13	QC # 177297
Physical Tests			
Moisture	%	6.2	6.7
Total Metals			
Lead	T-Pb	2900	2070
Zinc	T-Zn	6500	4690

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

Sediment/Soil		**TP75 0.1-0.3** 99 07 16	**TP75 0.1-0.3** QC # 177298
Physical Tests			
Moisture	%	1.9	1.7
Total Metals			
Lead	T-Pb	55	38
Zinc	T-Zn	215	143

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

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"

Toxicity Characteristic Leaching Procedure (TCLP) for Metals

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1311, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using either extraction fluid #1 (glacial acetic acid, water and sodium hydroxide) or extraction fluid #2 (glacial acetic acid), depending on the pH of the original sample. The extract is then filtered through a 0.6 to 0.8 micron glass fibre filter and analysed using atomic absorption spectrophotometry (EPA Method 7000 series) and/or inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Recommended Holding Time:

Sample:	6 months (Mercury = 28 days)
Extract:	6 months (Mercury = 28 days)
Reference:	EPA
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

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CHEMICAL ANALYSIS REPORT

Date:	October 14, 1999
ASL File No.	L1102
Report On:	99-902 Cominco Polaris Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	September 29, 1999

OCT 21 1999
GA[illegible] 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. L1102

		# Data Table	44	42	43	36	33
Sample ID			Soil 1	Soil 2	Soil 3	Soil 4	Soil 5
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*1*	*2*	*3*	*4*	*5*
Physical Tests							
Moisture	%		5.3	4.4	4.3	3.8	6.9
pH			8.71	8.69	8.85	8.92	8.35
Total Metals							
Lead	T-Pb		228	30	386	107	995
Zinc	T-Zn		749	30.8	557	896	2820
		East	952	952	952	927	881
		North	709	747	1042	1208	1456

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

			27	1	16	34	35
Sample ID		[illegible] Data Table	Soil 6	Soil 7	Soil 8	Soil 9	Soil 10
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*6*	*7*	*8*	*9*	*10*
Physical Tests							
Moisture	%		8.8	8.0	3.1	3.9	10.1
pH			8.54	8.53	9.26	8.97	8.29
Total Metals							
Lead	T-Pb		152	151	32	285	253
Zinc	T-Zn		681	560	54.8	1130	1110
		East	796	538	652	912	922
		North	1630	2124	2354	2455	2205

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

		GLL [illegible] Tbl	46	47	51	50	52
Sample ID			Soil 11	Soil 12	Soil 13	Soil 14	Soil 15
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*11*	*12*	*13*	*14*	*15*
Physical Tests							
Moisture	%		8.0	10.3	8.3	7.7	10.7
pH			8.49	8.21	8.25	8.10	8.09
Total Metals							
Lead	T-Pb		299	820	653	74	323
Zinc	T-Zn		2270	2250	4310	229	1480
		East	1018	1025	1103	1056	1106
		North	1856	1621	1517	1310	1062

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

		GLG Data	54	61	60	57	55
Sample ID		761	Soil 16	Soil 17	Soil 18	Soil 19	Soil 20
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*16*	*17*	*18*	*19*	*20*
Physical Tests							
Moisture	%		15.6	4.0	8.6	24.1	10.9
pH			8.10	8.65	8.27	7.38	8.16
Total Metals							
Lead	T-Pb		114	50	22	154	477
Zinc	T-Zn		477	210	118	606	8480
		East	1250	1474	1441	1211	1154
		North	997	859	1058	1207	2005

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

		GLL Data T61.	53	62	63	57	64
Sample ID			Soil 21	Soil 22	Soil 23	Soil 24	Soil 25
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*21*	*22*	*23*	*24*	*25*
Physical Tests							
Moisture	%		5.2	4.5	27.6	27.4	14.2
pH			8.50	8.84	7.81	8.12	8.39
Total Metals							
Lead	T-Pb		2340	169	1220	387	161
Zinc	T-Zn		6780	1130	3540	1270	557
		East	1116	1482	1494	1401	1699
		North	2223	1770	1461	1267	1597

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

		GLL Data Tbl	66	76	69	79	87
Sample ID			Soil 26	Soil 27	Soil 28	Soil 29	Soil 30
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*26*	*27*	*28*	*29*	*30*
Physical Tests							
Moisture	%		5.3	22.4	23.9	15.4	12.8
pH			8.90	7.92	8.56	8.03	8.51
Total Metals							
Lead	T-Pb		375	21	127	61	14
Zinc	T-Zn		537	144	466	293	122
		East	1793	2283	2237	2438	2835
		North	1223	3034	2555	2271	2002

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

GLL Data 761		86	105	94	100	103
Sample ID		Soil 31	Soil 32	Soil 33	Soil 34	Soil 35
Sample Date		99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID		*31*	*32*	*33*	*34*	*35*
Physical Tests						
Moisture	%	32.6	14.2	14.7	17.2	16.4
pH		7.91	8.36	8.38	8.32	8.60
Total Metals						
Lead	T-Pb	21	12	12	15	10
Zinc	T-Zn	223	76.3	94.4	23.4	126

East	2817	3456	3223	3282	3326
North	1623	1084	1564	2020	2550

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. L1102

		GCC Data T61.	108	109			
Sample ID			Soil 36	Soil 37	Soil 15B	Soil 25B	Soil 35B
Sample Date			99 09 17	99 09 17	99 09 17	99 09 17	99 09 17
ASL ID			*36*	*37*	*38*	*39*	*40*
Physical Tests							
Moisture	%		16.0	19.1	8.7	12.2	14.1
pH			8.53	8.34	8.55	8.37	8.17
Total Metals							
Lead	T-Pb		11	8	104	249	15
Zinc	T-Zn		106	52.9	325	798	133

East	3738	3743
North	2016	1541

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

Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil		**Soil 7**	**Soil 7**
		99 09 17	QC # 174583
Physical Tests			
Moisture	%	8.0	7.7
pH		8.53	8.48
Total Metals			
Lead	T-Pb	151	157
Zinc	T-Zn	560	587

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1102

Sediment/Soil		**Soil 20**	**Soil 20**
		99 09 17	QC # 174584
Physical Tests			
Moisture	%	10.9	11.2
pH		8.16	8.26
Total Metals			
Lead	T-Pb	477	402
Zinc	T-Zn	8480	7820

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1102

Sediment/Soil		**Soil 32**	**Soil 32**
		99 09 17	QC # 174586
Physical Tests			
Moisture	%	14.2	12.7
pH		8.36	8.37
Total Metals			
Lead	T-Pb	12	13
Zinc	T-Zn	76.3	82.6

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1102

Sediment/Soil		**Soil 37**	**Soil 37**
		99 09 17	QC # 174587
Physical Tests			
Moisture	%	19.1	18.4
pH		8.34	8.19
Total Metals			
Lead	T-Pb	8	9
Zinc	T-Zn	52.9	60.2

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

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"

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"

End of Report

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CHEMICAL ANALYSIS REPORT

OCT - 4 1999
GARTNER LEE

Date:	September 24, 1999
ASL File No.	K9413
Report On:	99-902 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	July 28, 1999

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. K9413

		15	2-	31	2	27
Sample ID		SS650E 1850N	SS720E 1260N	SS850E 1850N	SS950E 350N	SS950E 850N
Sample Date		99 07 15	99 07 11	99 07 15	99 07 15	99 07 15
Physical Tests						
Moisture	%	14.5	7.8	8.3	6.4	7.4
Total Metals						
Lead	T-Pb	789	1900	89	135	301
Zinc	T-Zn	2010	5100	563	466	323

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9413

		40	49	72	24	102
Sample ID		SS950E 1750N	SS1050E 750N	SS2250E 1300N	SS2250E 3350N	SS3300E 3300N
Sample Date		99 07 15	99 07 15	99 07 12	99 07 14	99 07 14
Physical Tests						
Moisture	%	11.1	5.8	23.4	18.7	20.6
Total Metals						
Lead	T-Pb	179	105	60	116	24
Zinc	T-Zn	1250	452	459	469	294

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9413

		120	111
Sample ID		SS3700E 1750N	SS3750E 2750N
Sample Date		99 07 13	99 07 14
Physical Tests			
Moisture	%	15.8	12.6
Total Metals			
Lead	T-Pb	15	10
Zinc	T-Zn	107	113

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K9413

Sediment/Soil		**SS950E 850N** 99 07 15	**SS950E 850N** QC # 171900
Physical Tests			
Moisture	%	7.4	7.2
Total Metals			
Lead	T-Pb	301	718
Zinc	T-Zn	323	414

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

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

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CHEMICAL ANALYSIS REPORT

OCT 18 1999
GARTNER LEE

Date: October 12, 1999

ASL File No. K9702

Report On: 99-902 Soil Analysis

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

Attention: **Ms. Eva Gerencher**

Received: July 28, 1999

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. K9702

Sample ID		TP4 0.9-1.2m	TP5 0.5-0.8m	TP6 0.6-0.9m	TP9 0.6-0.9m	TP11 0.9-1.2m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
ASL ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Moisture	%	11.6	5.5	5.0	7.2	5.6
Total Metals						
Lead	T-Pb	90	4620	447	3540	345
Zinc	T-Zn	112	4380	1640	13100	1880

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP14 0.1-0.3m	TP15 0.1-0.3m	TP18 0-0.1m	TP19 0.3-0.6m	TP21 0.6-0.9m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Moisture	%	4.1	6.1	8.4	5.4	5.1
Total Metals						
Lead	T-Pb	9550	4340	9350	5580	1480
Zinc	T-Zn	2230	11500	18900	4040	2890

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

		TP22 0.3-0.6m	TP23 0.1-0.3m	TP24 0-0.1m	TP25 0-0.1m	TP26 0.1-0.3m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	4.9	4.0	5.6	5.4	5.4
Total Metals						
Lead	T-Pb	3940	632	13900	15800	183
Zinc	T-Zn	5420	1410	10800	168000	883

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP27 0.1-0.3m	TP28 0.1-0.3m	TP29 0.1-0.3m	TP30 0.1-0.3m	TP31 0.1-0.3m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*16*	*17*	*18*	*19*	*20*
Physical Tests						
Moisture	%	5.2	6.5	6.3	4.3	3.5
Total Metals						
Lead	T-Pb	980	187	981	270	63
Zinc	T-Zn	1950	3140	40100	4670	5160

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP39 0.1-0.3m	TP40 0.1-0.3m	TP41 0.1-0.3m	TP42 0.1-0.3m	TP44 0-0.2m
Sample Date		99 07 13	99 07 14	99 07 14	99 07 14	99 07 14
ASL ID		*21*	*22*	*23*	*24*	*25*
Physical Tests						
Moisture	%	3.6	5.4	3.6	6.9	5.9
Total Metals						
Lead	T-Pb	104	2470	101	55	3550
Zinc	*T-Zn*	422	17700	711	301	11100

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP45 0-0.1m	TP49 0-0.1m	TP51 0-0.1m	TP52 0-0.1m	TP67 0-0.1m
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 15
ASL ID		*26*	*27*	*28*	*29*	*30*
Physical Tests						
Moisture	%	11.0	4.1	2.8	5.4	6.5
Total Metals						
Lead	T-Pb	2000	14	234	62	682
Zinc	T-Zn	7830	38.6	575	231	126

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP75 0-0.05m	TP80 0.1-0.3m	TP82 0-0.1m	TP83 0.1-0.3m	TP46 0.1-0.2m
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 14
ASL ID		*31*	*32*	*33*	*34*	*35*
Physical Tests						
Moisture	%	12.5	6.7	3.0	3.6	11.6
Total Metals						
Lead	T-Pb	1300	9710	970	655	31
Zinc	T-Zn	4660	38700	4030	1340	237

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP55 0.6-0.8m	TP62 0.5-0.8m	TP70 0.6-0.9m	TP77 0.1-0.3m	TP77 0-0.1m
Sample Date		99 07 14	99 07 15	99 07 16	99 07 16	99 07 16
ASL ID		*36*	*37*	*38*	*39*	*40*
Physical Tests						
Moisture	%	4.0	9.1	4.5	6.4	2.4
Total Metals						
Lead	T-Pb	26	9	161	911	869
Zinc	T-Zn	69.5	63.5	2180	2850	3330

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

Sample ID		TP32 0.2-0.4m	TP33 0.2-0.4m	TP34 0.2-0.4m	TP35 0.1-0.3m	TP54 0-0.1m
Sample Date						
ASL ID		*41*	*42*	*43*	*44*	*45*
Physical Tests						
Moisture	%	4.4	4.4	4.7	3.6	4.2
Total Metals						
Lead	T-Pb	93	636	14600	606	159
Zinc	T-Zn	545	2820	11000	1990	644

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9702

Sample ID		TP55 0-0.1m	TP57 0-0.1m	TP59 0-0.1m	TP61 0-0.1m	TP68 0-0.1m
Sample Date						
ASL ID		*46*	*47*	*48*	*49*	*50*
Physical Tests						
Moisture	%	4.8	5.0	7.6	11.2	9.7
Total Metals						
Lead	T-Pb	71	163	61	16	59
Zinc	T-Zn	224	722	1180	115	275

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K9702

Sediment/Soil		**TP11** **0.9-1.2m**	**TP11** **0.9-1.2m**
		99 07 12	QC # 172962
Physical Tests			
Moisture	%	5.6	6.8
Total Metals			
Lead	T-Pb	345	800
Zinc	T-Zn	1880	1920

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K9702

Sediment/Soil		**TP26** **0.1-0.3m**	**TP26** **0.1-0.3m**
		99 07 13	QC # 172963
Physical Tests			
Moisture	%	5.4	5.9
Total Metals			
Lead	T-Pb	183	369
Zinc	T-Zn	883	878

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K9702

Sediment/Soil		**TP45 0-0.1m** 99 07 14	**TP45 0-0.1m** QC # 172964
Physical Tests			
Moisture	%	11.0	7.9
Total Metals			
Lead	T-Pb	2000	3250
Zinc	T-Zn	7830	10400

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K9702

Sediment/Soil		**TP55 0.6-0.8m**	**TP55 0.6-0.8m**
		99 07 14	QC # 172965
Physical Tests			
Moisture	%	4.0	3.8
Total Metals			
Lead	T-Pb	26	26
Zinc	T-Zn	69.5	52.7

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

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

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ASL

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CHEMICAL ANALYSIS REPORT

Date: September 8, 1999

ASL File No. K9066

Report On: 99-902 Soil Analysis

SEP 13 1999
GARTNER LEE

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

Attention: **Ms. Eva Gerencher**

Received: August 13, 1999

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. K9066

Sample ID		TP 71 0-0.05m	TP 71 0.1-0.3m	TP 72 0-0.1m	TP 72 0.1-0.3m	TP 76 Comp
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Moisture	%	7.3	4.3	6.5	3.0	8.0
pH		8.50	8.35	8.54	8.75	7.98
Total Metals						
Lead	T-Pb	330	137	339	22	350
Zinc	T-Zn	1160	582	633	66.1	1590

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K9066

Sample ID		TP 78 Comp
Sample Date		99 07 16
Physical Tests		
Moisture	%	6.4
pH		8.52
Total Metals		
Lead	T-Pb	324
Zinc	T-Zn	2080

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

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"

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"

End of Report

1988 Triumph Street, Vancouver, BC Canada V5L 1K5
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FAX: (604) 253-6700 TEL: (604) 253-4188

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CHEMICAL ANALYSIS REPORT

Date: September 3, 1999

ASL File No. K8868

Report On: 99-902 Soil Analysis

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

Attention: **Ms. Eva Gerencher**

Received: July 28, 1999

SEP 10 1999
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. K8868

		3	4	10	19	13
Sample ID		SS 600E 1560N	SS 620E 1510N	SS 640E 1460N	SS 670E 1400N	SS 650E 1380N
Sample Date		99 07 11	99 07 11	99 07 11	99 07 11	99 07 11
Physical Tests						
Moisture	%	0.5	9.5	3.3	4.0	1.7
pH		8.15	8.16	8.16	8.30	8.39
Total Metals						
Lead	T-Pb	6670	586	1750	1180	984
Zinc	T-Zn	40100	1680	4810	2690	2730

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		17	12	6	21	23
Sample ID		SS 660E 1320N	SS 650E 1310N	SS 630E 1290N	SS 700E 1330N	SS 730E 1140N
Sample Date		99 07 11	99 07 11	99 07 11	99 07 11	99 07 11
Physical Tests						
Moisture	%	8.8	3.3	5.3	3.2	5.0
pH		8.24	8.22	8.30	8.24	8.60
Total Metals						
Lead	T-Pb	3960	2320	465	1270	612
Zinc	T-Zn	6940	6180	2490	5740	1390

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		26	29	30	28	7
Sample ID		SS 780E 1050N	SS 820E 940N	SS 840E 1070N	SS 800E 1150N	SS 630E 1730N
Sample Date		99 07 11	99 07 11	99 07 11	99 07 11	99 07 11
Physical Tests						
Moisture	%	5.0	6.1	4.9	5.4	1.8
pH		8.44	8.50	8.35	8.34	8.50
Total Metals						
Lead	T-Pb	304	1090	898	898	129
Zinc	T-Zn	1300	4900	2170	2910	471

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		56	54	65	67	31
Sample ID		SS 1200E 1700N	SS 1150E 1300N	SS 1700E 1350N	SS 1900E 1700N	SS 2750E 1100N
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	13.2	14.9	24.3	14.9	16.2
pH		8.24	8.34	8.19	7.88	8.51
Total Metals						
Lead	T-Pb	257	58	105	116	14
Zinc	T-Zn	2680	300	295	518	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. K8868

		71	52	35	90	15
Sample ID		SS 2250E 750N	SS 2900E -150N	SS 2800E -750N	SS 3200E 1750N	SS 3800E 2300N
Sample Date		99 07 12	99 07 12	99 07 12	99 07 13	99 07 13
Physical Tests						
Moisture	%	17.2	24.4	21.2	14.2	16.9
pH		8.34	8.15	8.43	8.48	8.33
Total Metals						
Lead	T-Pb	22	26	10	17	12
Zinc	T-Zn	134	155	77.8	414	121

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		101	[illegible]	19	[illegible]	[illegible]
Sample ID		SS 3300E 2300N	SS 2800E 2400N	SS 2300E 2400N	SS 3250E 1250N	SS 3750E 1250N
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	63.5	19.0	17.6	15.6	13.9
pH		8.04	8.08	8.14	8.25	8.17
Total Metals						
Lead	T-Pb	113	16	24	20	11
Zinc	T-Zn	646	353	310	133	76.9

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		95	104	99	93	91
Sample ID		SS 3250E 750N	SS 3400E 250N	SS 3250E -300N	SS 3200E -750N	SS 3200E -1200N
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	16.9	20.6	17.1	16.2	35.1
pH		8.40	8.16	8.32	8.57	7.95
Total Metals						
Lead	T-Pb	14	16	22	9	69
Zinc	T-Zn	107	84.9	135	57.1	249

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		87	82	75	92	113
Sample ID		SS 2900E -1600N	SS 2750E -2250N	SS 2250E -2750N	SS 3200E -2300N	SS 3750E -1300N
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	10.7	9.3	26.5	13.8	13.1
pH		8.19	8.80	8.05	8.57	8.66
Total Metals						
Lead	T-Pb	10	8	19	10	9
Zinc	T-Zn	49.6	61.3	225	95.6	50.2

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		102	114	73	84	17
Sample ID		SS 3700E -300N	SS 3800E 800N	SS 2250E 2800N	SS 2800E 2750N	SS 3250E 2750N
Sample Date		99 07 13	99 07 13	99 07 14	99 07 14	99 07 14
Physical Tests						
Moisture	%	12.9	25.1	68.5	15.9	13.9
pH		8.22	8.06	7.80	8.39	7.90
Total Metals						
Lead	T-Pb	13	14	1010	23	13
Zinc	T-Zn	120	83.1	2920	329	159

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		112	80	68		
Sample ID		*SS 3750E* 3300N	*SS 2600E* 3300N	*SS 2100E* 3800N	*Firehall* Snowdump A	*Firehall* Snowdump B
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
Physical Tests						
Moisture	%	14.8	75.1	21.3	9.0	9.4
pH		8.54	7.83	7.79	8.31	8.75
Total Metals						
Lead	T-Pb	9	103	18	15600	16500
Zinc	T-Zn	61.0	456	157	59300	56700

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

Sample ID		Firehall Snowdump C	Foldaway Snowdump A	Foldaway Snowdump B	Main Snowdump B	Loon Lk. Snowdump A
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
Physical Tests						
Moisture	%	10.9	9.4	9.3	9.5	7.8
pH		8.13	8.63	8.58	9.06	8.37
Total Metals						
Lead	T-Pb	13500	1980	1670	173	2040
Zinc	T-Zn	30800	4690	5030	479	7260

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

Sample ID		Loon Lk. Snowdump C	TL 700E 1380N	TL 740E 1200N	TL 780E 1100N	TL 930E 510N
Sample Date		99 07 14	99 07 15	99 07 15	99 07 15	99 07 15
Physical Tests						
Moisture	%	11.4	9.9	8.0	6.5	7.5
pH		8.42	8.13	8.54	8.51	8.51
Total Metals						
Lead	T-Pb	1220	9470	449	273	233
Zinc	T-Zn	3050	45200	1930	1420	960

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

Sample ID		TL 1510E 1100N	TL 1480E 980N	TL 2800E 1050N	TL 2850E 1200N	TL 2950E 1150N
Sample Date		99 07 15	99 07 15	99 07 15	99 07 15	99 07 15
Physical Tests						
Moisture	%	7.9	7.6	18.4	15.1	27.3
pH		8.26	8.48	8.31	8.34	7.98
Total Metals						
Lead	T-Pb	213	365	60	43	1310
Zinc	T-Zn	760	1060	219	243	2970

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

			25	41	2	41
Sample ID		TL 3050E 1300N	SS 750E 1950N	SS 950E 1950N	SS 550E 1950N	SS 1050E 250N
Sample Date		99 07 15	99 07 15	99 07 15	99 07 15	99 07 15
Physical Tests						
Moisture	%	12.6	4.5	12.7	8.1	5.7
pH		8.11	8.85	8.47	8.45	8.83
Total Metals						
Lead	T-Pb	591	76	98	360	332
Zinc	T-Zn	4520	323	751	1320	896

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

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8868

		75	77
Sample ID		SS 950E 650N	SS 2300E 1750N
Sample Date		99 07 15	99 07 12
Physical Tests			
Moisture	%	2.8	40.8
pH		8.91	7.54
Total Metals			
Lead	T-Pb	138	65
Zinc	T-Zn	416	367

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8868

Sediment/Soil		**SS 780E 1050N**	**SS 780E 1050N**
		99 07 11	QC # 169805
Physical Tests			
Moisture	%	5.0	5.5
pH		8.44	8.36
Total Metals			
Lead	T-Pb	304	292
Zinc	T-Zn	1300	1240

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8868

Sediment/Soil		**SS 3800E 2300N** 99 07 13	**SS 3800E 2300N** QC # 169807
Physical Tests			
Moisture	%	16.9	14.7
pH		8.33	8.40
Total Metals			
Lead	T-Pb	12	48
Zinc	T-Zn	121	234

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8868

Sediment/Soil		**SS 2750E -2250N**	**SS 2750E -2250N**
		99 07 13	QC # 169810
Physical Tests			
Moisture	%	9.3	10.1
pH		8.80	8.54
Total Metals			
Lead	T-Pb	8	7
Zinc	T-Zn	61.3	62.8

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8868

Sediment/Soil		**Firehall Snowdump B** 99 07 14	**Firehall Snowdump B** QC # 169811
Physical Tests			
Moisture	%	9.4	9.6
pH		8.75	8.72
Total Metals			
Lead	T-Pb	16500	15000
Zinc	T-Zn	56700	51800

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8868

Sediment/Soil		**TL 930E 510N**	**TL 930E 510N**
		99 07 15	QC # 169812
Physical Tests			
Moisture	%	7.5	7.6
pH		8.51	8.52
Total Metals			
Lead	T-Pb	233	290
Zinc	T-Zn	960	1170

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

Sediment/Soil		**SS 1050E 250N** 99 07 15	**SS 1050E 250N** QC # 169813
Physical Tests			
Moisture	%	5.7	6.4
pH		8.83	8.80
Total Metals			
Lead	T-Pb	332	411
Zinc	T-Zn	896	1380

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"

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"

End of Report

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

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CHEMICAL ANALYSIS REPORT

OCT - 4 1999
GARTNER LEE

Date: September 28, 1999

ASL File No. K8052b

Report On: 99-902 Soil Analysis

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

Attention: **Ms. Eva Gerencher**

Received: July 28, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

Specialists in Environmental Chemistry

REMARKS File No. K8052b

The Extractable Petroleum Hydrocarbon analysis was performed on extracts that were prepared shortly after the samples were received in July. The holding time for organic extracts is 40 days after extraction. The analysis for these samples was performed within this holding time.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052b

Sample ID		TP1 0-0.05m	TP1 0.3-0.5m	TP2 0-0.05m	TP5 0.1-0.3m	TP8 0.1-0.3m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
ASL ID		*1*	*2*	*4*	*11*	*17*
Physical Tests						
Moisture	%	11.2	5.4	9.5	8.6	4.9
pH		7.48	-	7.53	7.53	7.96
Total Metals						
Lead	T-Pb	10800	-	13500	1870	2010
Zinc	T-Zn	44500	-	44500	6420	6640
Extractable Hydrocarbons						
EPH (C10-19)		<200	3950	226	<200	2160
EPH (C19-32)		1940	<200	500	231	5910

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. K8052b

Sample ID		TP10 0.3-0.6m	TP14 0.5-0.8m	TP15 0.4-0.7m	TP20 0.3-0.6m	TP36 0.2-0.4m
Sample Date		99 07 12	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*22*	*28*	*29*	*34*	*38*
Physical Tests						
Moisture	%	5.8	6.4	6.8	5.8	4.7
pH		-	-	-	8.34	8.28
Total Metals						
Lead	T-Pb	-	-	-	378	182
Zinc	T-Zn	-	-	-	1860	278
Extractable Hydrocarbons						
EPH (C10-19)		9430	<200	6610	5750	408
EPH (C19-32)		240	<200	490	330	<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. K8052b

		TP70	TP84
Sample ID		TP70 0.3-0.6m	TP84 0.3-0.6m
Sample Date		99 07 16	99 07 16
ASL ID		*73*	*94*
Physical Tests			
Moisture	%	4.2	6.4
pH		8.43	8.39
Total Metals			
Lead	T-Pb	399	24
Zinc	T-Zn	2320	275
Extractable Hydrocarbons			
EPH (C10-19)		-	11200
EPH (C19-32)		-	355

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"

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"

Extractable Hydrocarbons in Sediment/Soil

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 Solids by GC/FID, Version 2.1 July 1999". The procedure involves the extraction of the sample with a 1:1 mixture of Hexane and Acetone. The extract is then back extracted with water 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).

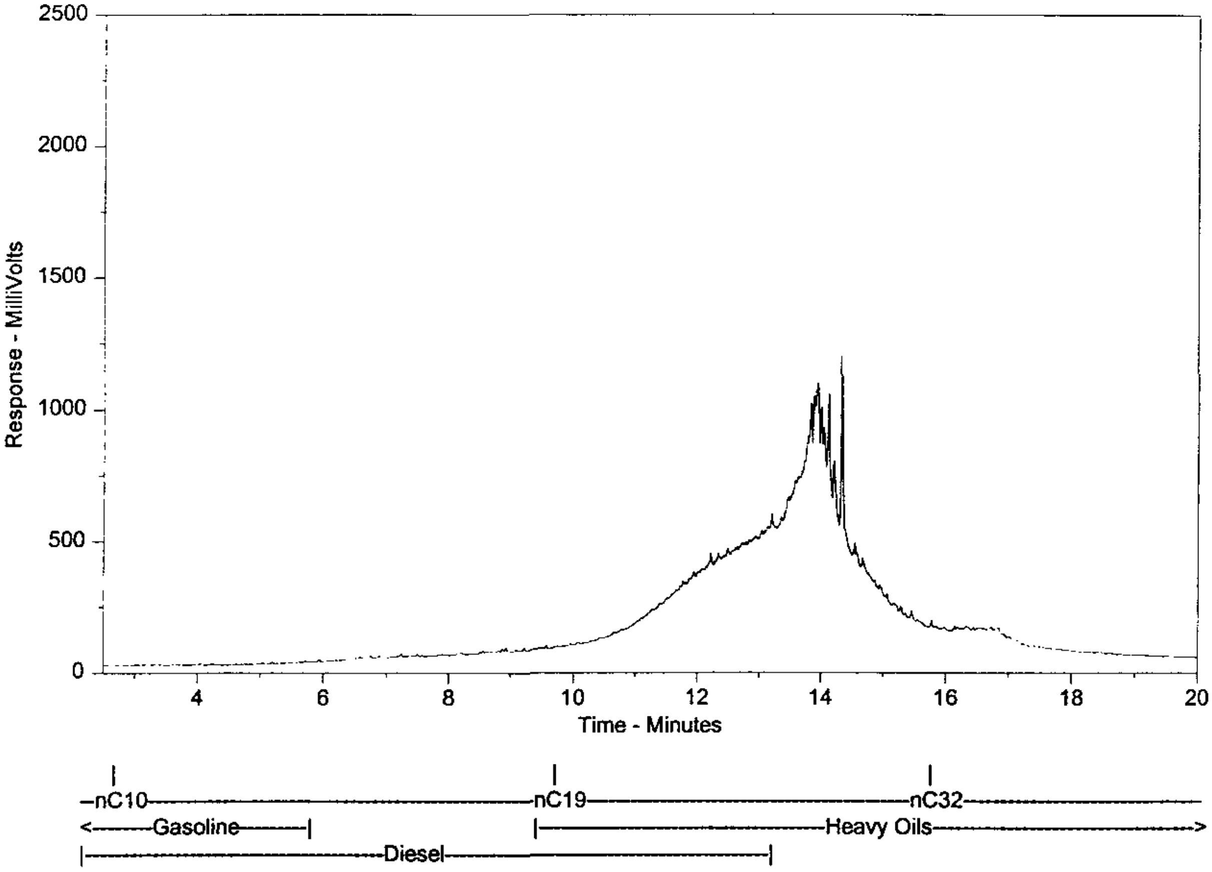
Please note that in August of 1999, BCMELP replaced the EPH(C10-18) and EPH(C19-31) parameters with EPH(C10-19) and EPH(C19-32). These parameters were redefined so that they more accurately describe how the analysis is carried out. Results reported by ASL for the old and new parameters are equivalent. 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"

End of Report

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **K8052-T--1**
File Name: c:\chrom\gc12\data\10sep\gc12_10sepA.0024.RAW
Run Information: Acquired on GC12, 9/11/99 6:05:27 AM



Sample Amount = 12.1 (g or mL) Dilution Factor = 8.0

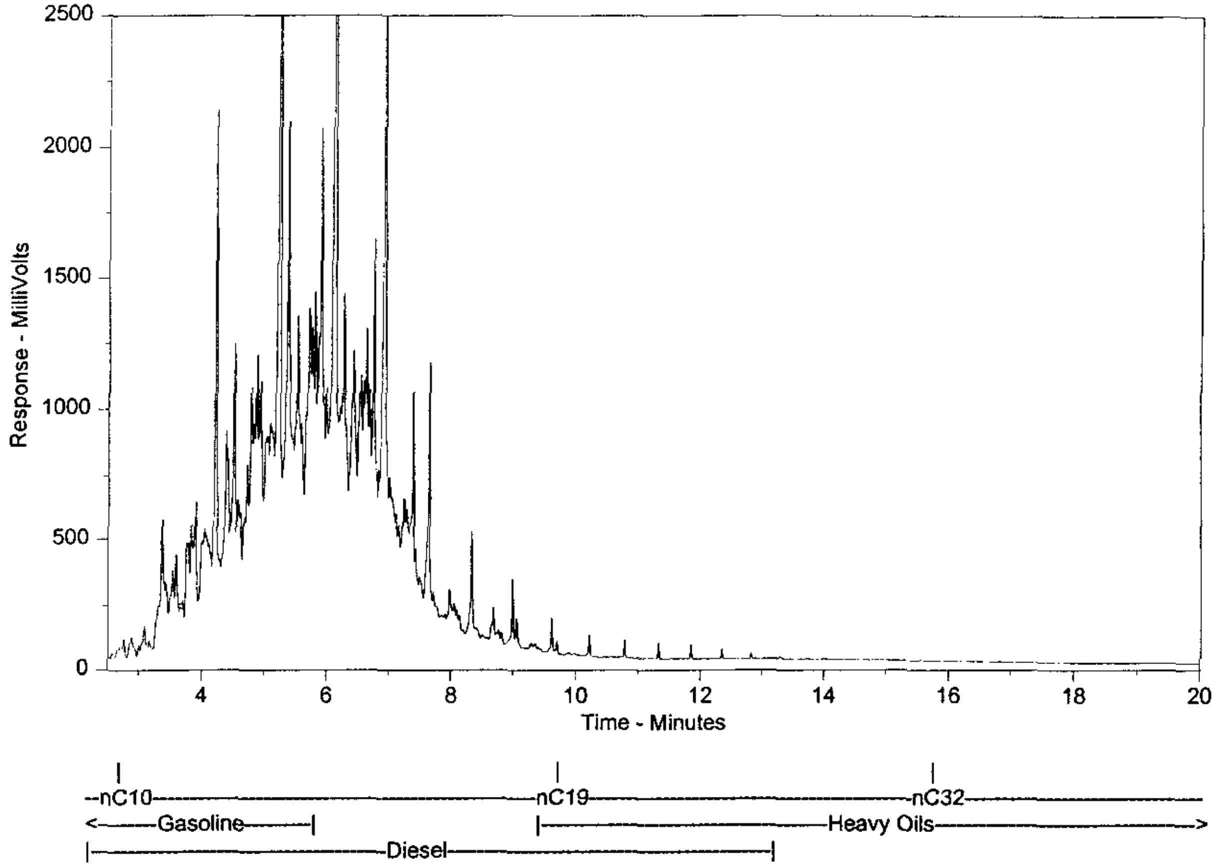
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--2**
File Name: C:\Chrom\gc12\data\10sep\gc12_10sepB.0024.RAW
Run Information: Acquired on GC12, 9/11/99 6:05:27 AM



Sample Amount = 12.1 (g or mL) Dilution Factor = 8.0

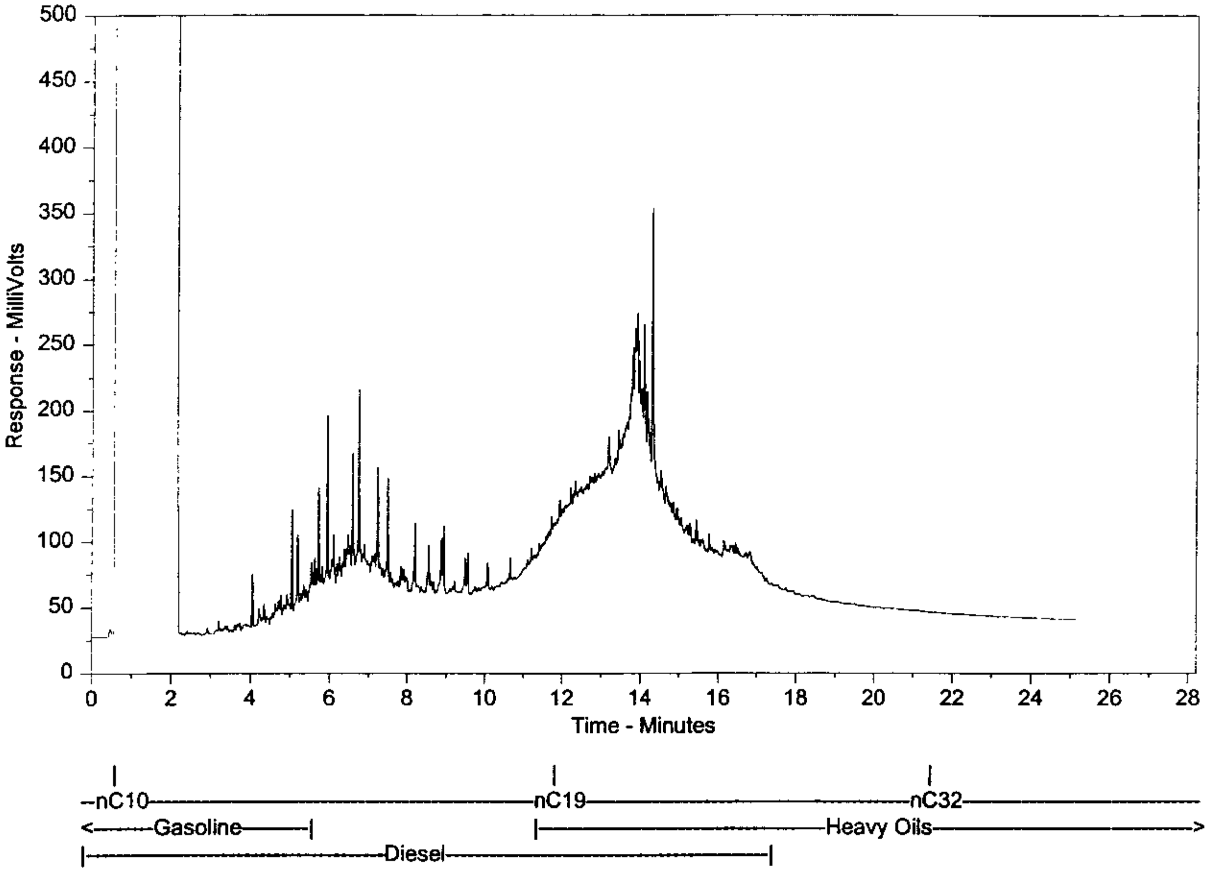
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--4**
File Name: c:\chrom\gc12\data\10sep\gc12_10sepA.0025.RAW
Run Information: Acquired on GC12, 9/11/99 6:37:15 AM



Sample Amount = 12.6 (g or mL) Dilution Factor = 8.0

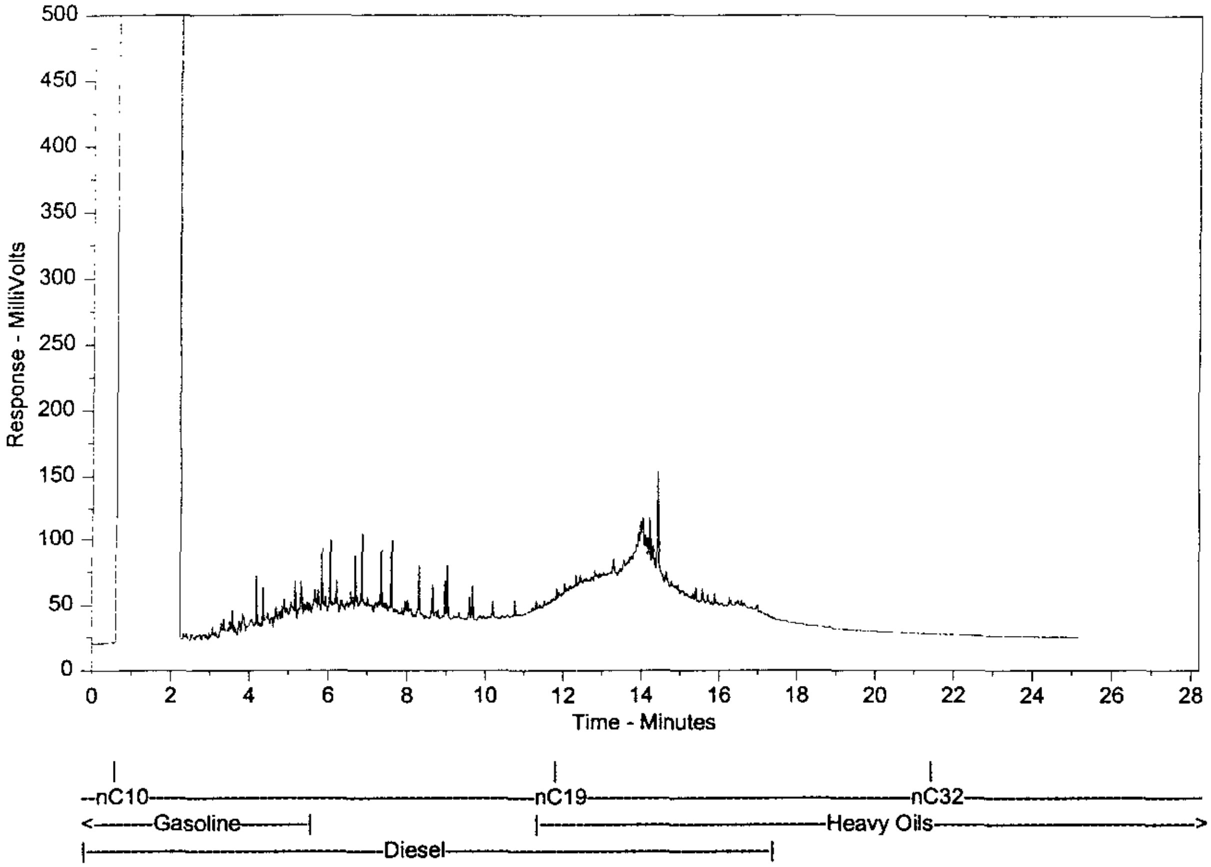
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--11**
File Name: C:\Chrom\gc12\data\10sep\gc12_10sepB.0025.RAW
Run Information: Acquired on GC12, 9/11/99 6:37:15 AM



Sample Amount = 12.9 (g or mL) Dilution Factor = 8.0

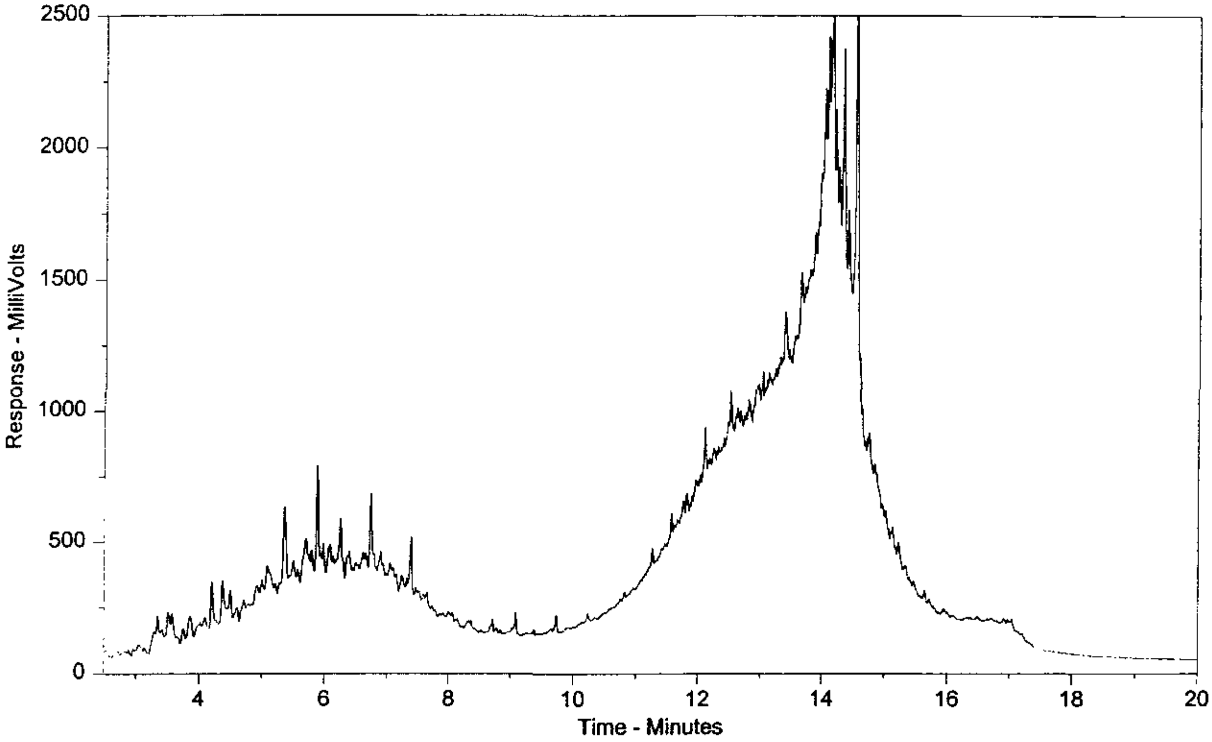
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052B-T--17**
File Name: M:\Chrom\gc05\data\16sep\gc5_sep16.0018.RAW
Run Information: Acquired on GC05, 9/17/99 4:26:13 AM



–nC10–––––––––nC19–––––––––nC32–––––
<–––Gasoline–––| |––––––––Heavy Oils––––––––>
|––––––––Diesel––––––––|

Sample Amount = 13.6 (g or mL) Dilution Factor = 8.0

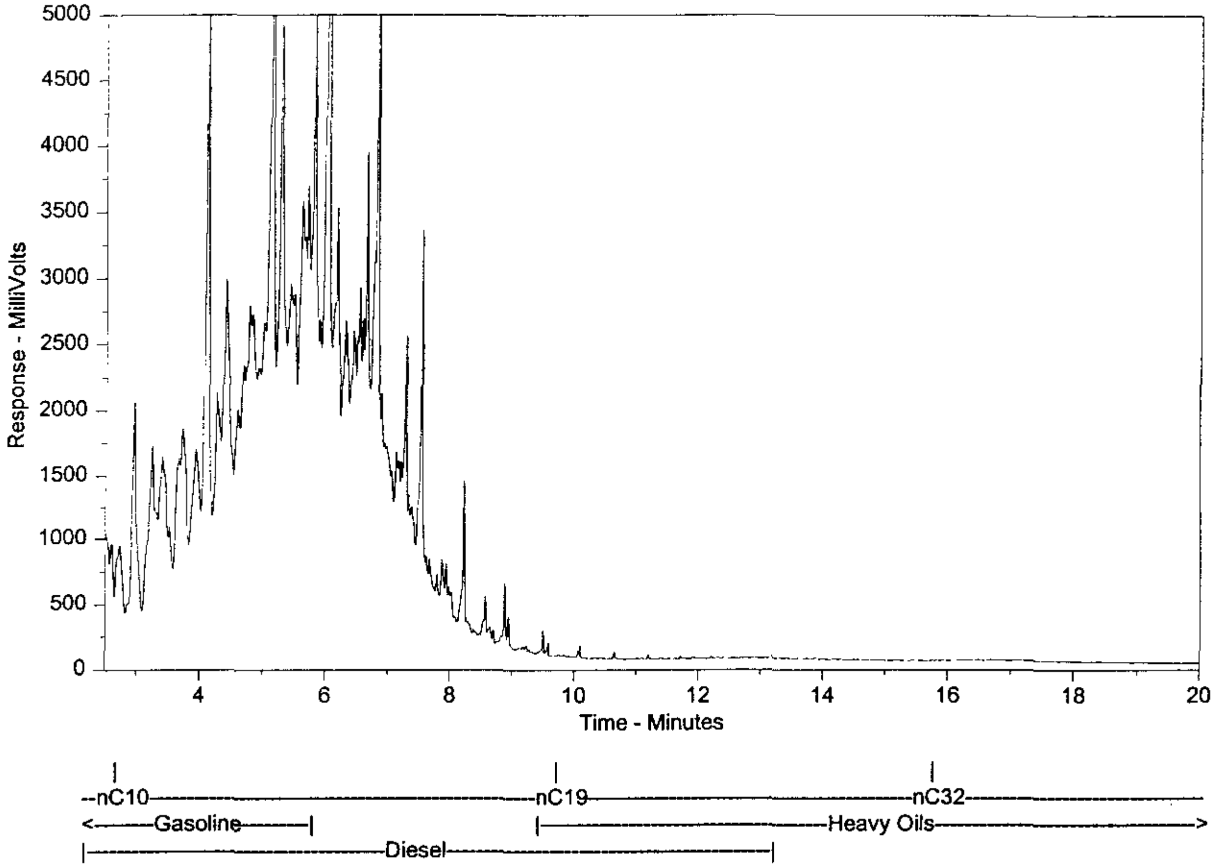
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--22**
File Name: c:\chrom\gc12\data\10sep\gc12_10sepA.0026.RAW
Run Information: Acquired on GC12, 9/11/99 7:09:06 AM



Sample Amount = 12.9 (g or mL)

Dilution Factor = 8.0

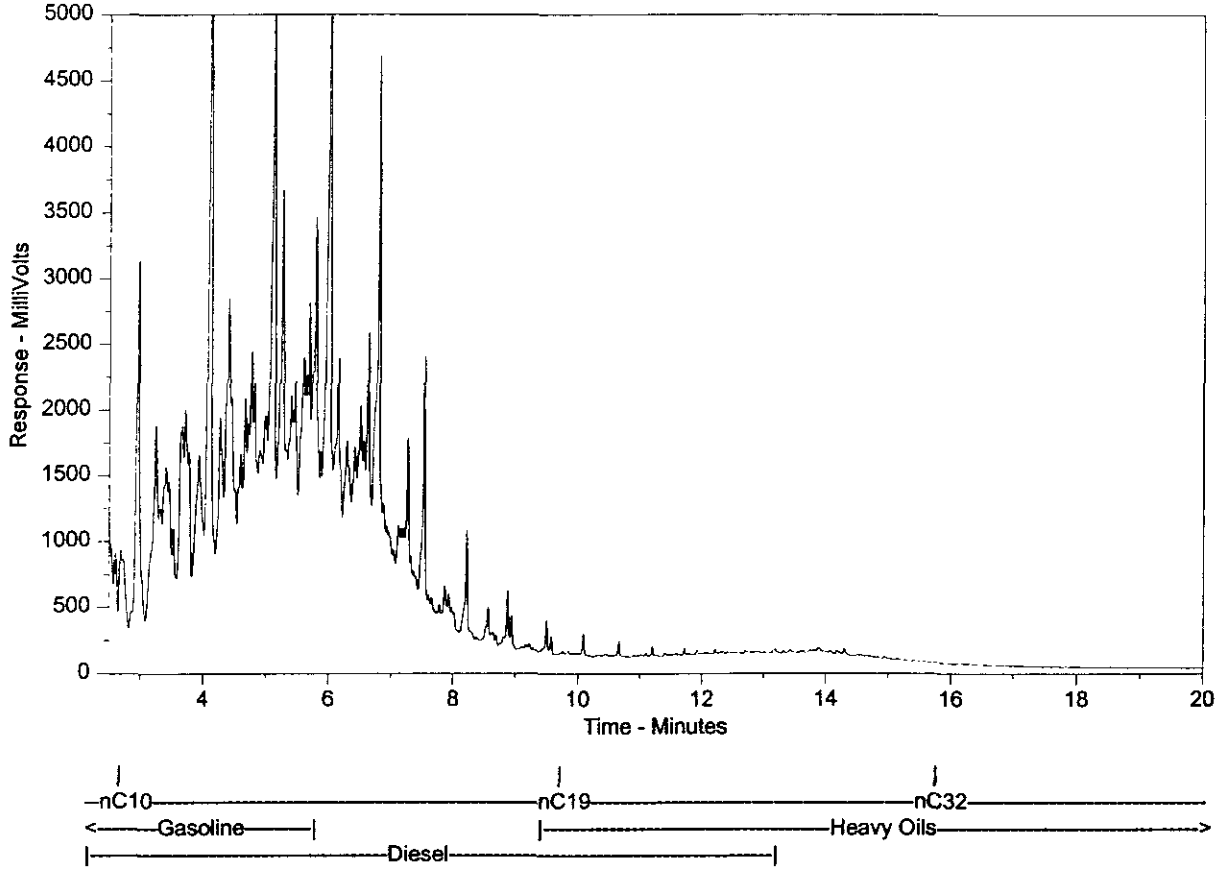
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--29**
File Name: c:\chrom\gc12\data\10sep\gc12_10sepA.0027.RAW
Run Information: Acquired on GC12, 9/11/99 7:40:55 AM



Sample Amount = 14.1 (g or mL) Dilution Factor = 8.0

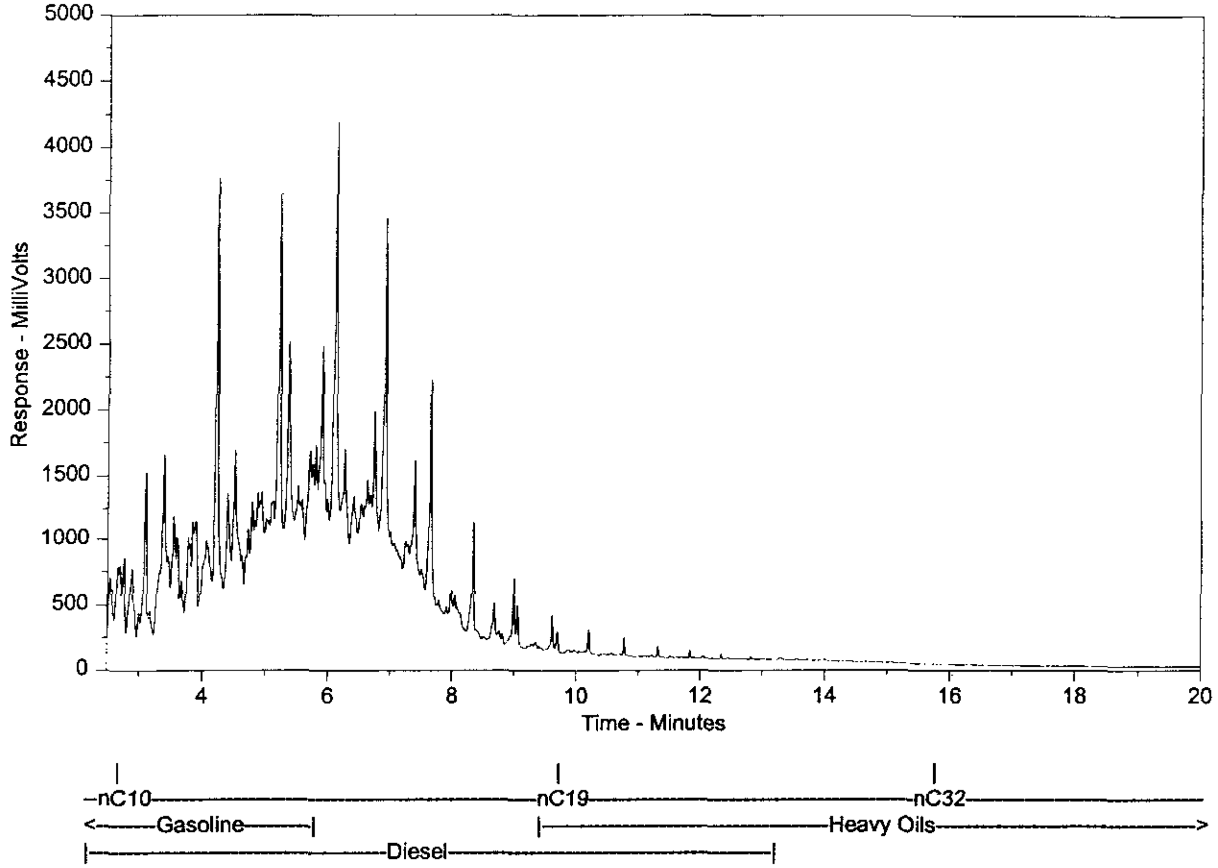
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--34**
File Name: C:\Chrom\gc12\data\10sep\gc12_10sepB.0027.RAW
Run Information: Acquired on GC12, 9/11/99 7:40:56 AM



Sample Amount = 13.0 (g or mL) Dilution Factor = 8.0

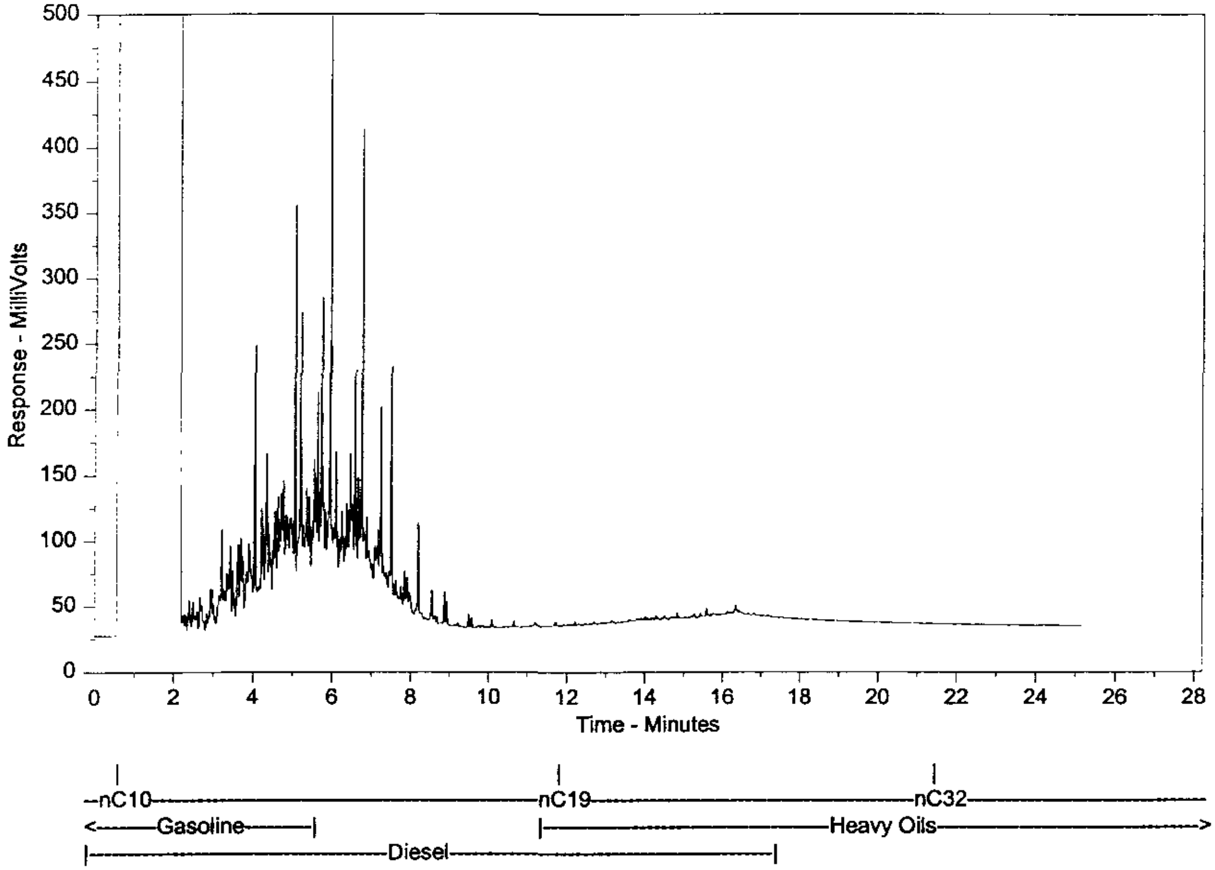
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--38**
File Name: c:\chrom\gc12\data\10sep\gc12_10sepA.0028.RAW
Run Information: Acquired on GC12, 9/11/99 8:12:38 AM



Sample Amount = 10.1 (g or mL) Dilution Factor = 8.0

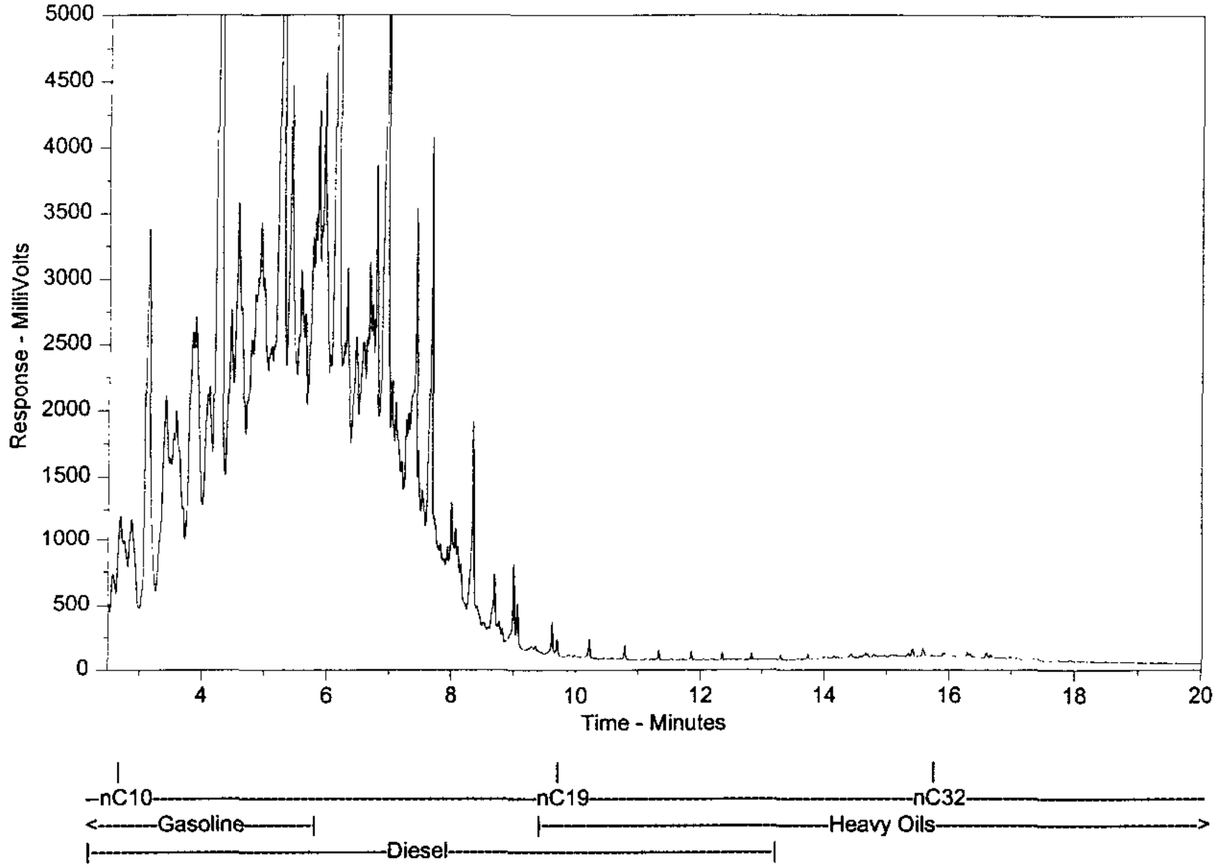
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds. 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: **K8052-T--94**
File Name: C:\Chrom\gc12\data\10sep\gc12_10sepB.0028.RAW
Run Information: Acquired on GC12, 9/11/99 8:12:39 AM



Sample Amount = 14.0 (g or mL)

Dilution Factor = 8.0

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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laboratories
ltd.

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

CHEMICAL ANALYSIS REPORT

Date:	August 27, 1999
ASL File No.	K8052
Report On:	99-902 Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	July 28, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K8052

The samples identified as "TP9 1.3-1.5m" and "TP44 0.3-0.7m" were replicated as part of ASL's routine quality control protecols. The initial replicate was outside our Data Quality Objectives, and was replicated an additional two times. All of these replicates are tabulated in the Quality Control Appendix at the end of this report.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP1 0-0.05m	TP1 0.3-0.5m	TP1 0.8-1.0m	TP2 0-0.05m	TP2 0.9-1.2m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	11.2	5.4	9.4	9.5	7.3
Extractables						
EPH (C10-19)		-	-	7210	-	<200
EPH (C19-32)		-	-	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP3 0.2-0.5m	TP3 0.6-0.9m	TP3 1.2-1.5m	TP4 0.1-0.3m	TP4 0.9-1.2m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	4.9	4.5	11.3	7.4	15.2
pH		-	8.23	-	8.33	-
Total Metals						
Lead	T-Pb	-	267	-	87	-
Zinc	T-Zn	-	983	-	428	-
Non-halogenated Volatiles						
Benzene		-	-	<0.04	-	-
Ethylbenzene		-	-	<0.05	-	-
Styrene		-	-	<0.05	-	-
Toluene		-	-	<0.05	-	-
meta- & para-Xylene		-	-	0.27	-	-
ortho-Xylene		-	-	0.70	-	-
Volatile Hydrocarbons (VH) C6-10		-	-	625	-	-
VPH C6-10 (calculated)		-	-	624	-	-
Extractables						
EPH (C10-19)		-	-	3770	-	<200
EPH (C19-32)		-	-	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP5 0.1-0.3m	TP5 0.5-0.8m	TP5 1.8-2.4m	TP6 0.1-0.3m	TP7 0.5-0.8m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	8.6	6.1	13.3	4.6	4.0
pH		-	-	-	8.23	8.66
Total Metals						
Lead	T-Pb	-	-	-	564	22
Zinc	T-Zn	-	-	-	1260	58.7
Extractables						
EPH (C10-19)		-	889	17000	<200	-
EPH (C19-32)		-	225	848	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP7 2.5-2.7m	TP8 0.1-0.3m	TP8 1.2-1.5m	TP9 0.1-0.3m	TP9 0.6-0.9m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	17.0	4.9	7.1	5.5	7.0
pH		-	-	-	8.14	-
Total Metals						
Lead	T-Pb	-	-	-	2570	-
Zinc	T-Zn	-	-	-	9670	-
Extractables						
EPH (C10-19)		6130	-	2910	-	1470
EPH (C19-32)		583	-	6380	-	475

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP9 1.3-1.5m	TP10 0.3-0.6m	TP10 0.9-1.2m	TP11 0.3-0.6m	TP11 0.9-1.2m
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
Physical Tests						
Moisture	%	8.4	5.2	6.9	5.8	7.2
pH		-	-	-	7.95	-
Total Metals						
Lead	T-Pb	-	-	-	565	-
Zinc	T-Zn	-	-	-	3410	-
Non-halogenated Volatiles						
Benzene		-	-	<0.04	-	-
Ethylbenzene		-	-	<0.05	-	-
Styrene		-	-	<0.05	-	-
Toluene		-	-	0.07	-	-
meta- & para-Xylene		-	-	10.3	-	-
ortho-Xylene		-	-	8.30	-	-
Volatile Hydrocarbons (VH) C6-10		-	-	1800	-	-
VPH C6-10 (calculated)		-	-	1780	-	-
Extractables						
EPH (C10-19)		380	-	12300	-	4270
EPH (C19-32)		549	-	356	-	248

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

		TP12 0.6-0.9m	TP13 0.7-1.0m	TP14 0.5-0.8m	TP15 0.4-0.7m	TP16 0.2-0.4m
Sample Date		99 07 12	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	9.6	15.6	6.4	6.8	4.9
pH		7.89	-	-	-	8.33
Total Metals						
Lead	T-Pb	70	-	-	-	1110
Zinc	T-Zn	256	-	-	-	5740
Extractables						
EPH (C10-19)		-	<200	-	-	<200
EPH (C19-32)		-	354	-	-	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil File No. K8052

Sample ID		TP17 0.2-0.4m	TP18 0.3-0.6m	TP19 0.3-0.6m	TP20 0.3-0.6m	TP20 1.5-1.6m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	4.0	6.8	5.8	5.8	11.1
pH		8.38	8.03	-	-	-
Total Metals						
Lead	T-Pb	270	233	-	-	-
Zinc	T-Zn	488	324	-	-	-
Extractables						
EPH (C10-19)		<200	276	<200	-	7340
EPH (C19-32)		486	887	270	-	847

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP21 0.6-0.9m	TP22 0.9-1.2m	TP36 0.2-0.4m	TP36 0.6-0.9m	TP37 0-0.05m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 13
Physical Tests						
Moisture	%	6.1	5.6	4.7	4.2	8.5
Extractables						
EPH (C10-19)		<200	7020	-	3860	<200
EPH (C19-32)		<200	571	-	<200	2550

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP37 0.1-0.2m	TP38 0-0.05m	TP38 0.1-0.3m	TP39 0.6-0.9m	TP43 0.3-0.6m
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 14
Physical Tests						
Moisture	%	7.0	3.9	7.7	6.8	9.5
pH		8.27	-	8.24	-	-
Total Metals						
Lead	T-Pb	105	-	67	-	-
Zinc	T-Zn	313	-	144	-	-
Extractables						
EPH (C10-19)		-	<200	-	<200	17900
EPH (C19-32)		-	<200	-	<200	389

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID			TP44 0.3-0.7m	TP45 0.3-0.6m	TP46 0.1-0.2m	TP47 0-0.1m	TP48 0.1-0.2m
Sample Date			99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
Physical Tests							
Moisture	%		7.8	7.0	11.2	6.7	12.7
pH			-	-	-	8.58	-
Total Metals							
Lead	T-Pb		-	-	-	147	-
Zinc	T-Zn		-	-	-	465	-
Leachable Anions & Cations							
Bromide	Br		-	-	-	-	<5
Chloride	Cl		-	-	-	-	6
Fluoride	F		-	-	-	-	1.3
Nitrate Nitrogen		N	-	-	-	-	<1
Nitrite Nitrogen		N	-	-	-	-	<1
Sulphate	SO4		-	-	-	-	36
Extractables							
EPH (C10-19)			<200	<200	<200	-	-
EPH (C19-32)			<200	873	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

Sample ID			TP49 0.6-0.9m	TP51 0.3-0.6m	TP52 0.3-0.6m	TP53 0.6-0.9m	TP54 0.8-1.0m
Sample Date			99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
Physical Tests							
Moisture	%		7.4	4.5	8.1	9.1	5.4
pH			-	-	8.40	-	-
Total Metals							
Lead	T-Pb		-	-	8	-	-
Zinc	T-Zn		-	-	16.3	-	-
Leachable Anions & Cations							
Bromide	Br		<5	<5	-	<5	<5
Chloride	Cl		17	8	-	43	14
Fluoride	F		1.1	0.6	-	1.5	0.4
Nitrate Nitrogen		N	10	<1	-	1	<1
Nitrite Nitrogen		N	<1	<1	-	<1	<1
Sulphate	SO4		718	29	-	65	31
Extractables							
EPH (C10-19)			<200	-	<200	<200	<200
EPH (C19-32)			207	-	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP55 0.6-0.8m	TP57 0.3-0.6m	TP58 0.6-0.9m	TP59 0.2-0.4m	TP59 0.6-0.9m
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
Physical Tests						
Moisture	%	4.6	6.7	9.5	9.2	9.1
pH		-	8.05	-	7.87	-
Total Metals						
Lead	T-Pb	-	27	-	15	-
Zinc	T-Zn	-	103	-	90	-
Non-halogenated Volatiles						
Benzene		-	-	-	-	<0.04
Ethylbenzene		-	-	-	-	<0.05
Styrene		-	-	-	-	<0.05
Toluene		-	-	-	-	<0.05
meta- & para-Xylene		-	-	-	-	<0.05
ortho-Xylene		-	-	-	-	<0.05
Volatile Hydrocarbons (VH) C6-10		-	-	-	-	<100
VPH C6-10 (calculated)		-	-	-	-	<100
Extractables						
EPH (C10-19)		<200	<200	<200	-	730
EPH (C19-32)		<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP61 0.2-0.4m	TP61 0.6-0.9m	TP62 0-0.1m	TP62 0.5-0.8m	TP63 0.4-0.6m
Sample Date		99 07 15	99 07 15	99 07 15	99 07 15	99 07 15
Physical Tests						
Moisture	%	10.2	11.2	6.9	7.9	9.1
pH		7.99	-	7.74	-	-
Total Metals						
Lead	T-Pb	9	-	277	-	-
Zinc	T-Zn	60.7	-	1020	-	-
Extractables						
EPH (C10-19)		-	<200	-	<200	-
EPH (C19-32)		-	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID	TP63 0.6-0.8m	TP64 0.4-0.6m	TP65 0.4-0.6m	TP66 0.4-0.6m	TP67 0.4-0.6m
Sample Date	99 07 15	99 07 15	99 07 15	99 07 15	99 07 15
Physical Tests					
Moisture %	12.5	10.7	7.7	9.9	4.8
Non-halogenated Volatiles					
Benzene	-	<0.04	-	-	-
Ethylbenzene	-	<0.05	-	-	-
Styrene	-	<0.05	-	-	-
Toluene	-	<0.05	-	-	-
meta- & para-Xylene	-	0.12	-	-	-
ortho-Xylene	-	0.36	-	-	-
Volatile Hydrocarbons (VH) C6-10	-	455	-	-	-
VPH C6-10 (calculated)	-	455	-	-	-
Extractables					
EPH (C10-19)	<200	5120	4760	<200	7140
EPH (C19-32)	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP68 0.4-0.6m	TP69 0.4-0.6m	TP70 0.3-0.6m	TP70 0.6-0.9m	TP73 0-0.1m
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Moisture	%	10.0	5.4	4.2	4.4	16.2
pH		7.85	8.28	-	-	-
Total Metals						
Lead	T-Pb	622	208	-	-	-
Zinc	T-Zn	2630	1690	-	-	-
Extractables						
EPH (C10-19)		<200	<200	-	<200	346
EPH (C19-32)		<200	<200	-	<200	481

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP73 0.1-0.3m	TP73 0.3-0.6m	TP74 0.3-0.6m	TP75 0.5-0.8m	TP77 Comp
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Moisture	%	3.4	6.3	3.3	9.0	7.1
pH		8.39	-	-	-	8.40
Total Metals						
Lead	T-Pb	143	-	-	-	947
Zinc	T-Zn	142	-	-	-	3080
Extractables						
EPH (C10-19)		<200	<200	3500	3280	-
EPH (C19-32)		<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP77 0.2-0.3m	TP79 0.1-0.3m	TP79 0.3-0.6m	TP80 0-0.1m	TP81 0-0.1m
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Moisture	%	9.2	4.0	7.8	6.7	4.5
pH		-	9.02	-	8.52	-
Total Metals						
Lead	T-Pb	-	51	-	782	-
Zinc	T-Zn	-	191	-	3110	-
Extractables						
EPH (C10-19)		332	-	<200	<200	250
EPH (C19-32)		270	-	<200	<200	1040

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID		TP81 0.3-0.6m	TP82 0.3-0.6m	TP83 0-0.1m	TP84 0-0.1m North	TP84 0.3-0.6m North
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Moisture	%	6.4	6.1	3.5	4.4	6.5
pH		-	-	8.61	-	-
Total Metals						
Lead	T-Pb	-	-	821	-	-
Zinc	T-Zn	-	-	2010	-	-
Extractables						
EPH (C10-19)		<200	<200	<200	1970	-
EPH (C19-32)		230	530	<200	336	-

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K8052

Sample ID Sample Date		TP84 0.6-0.9m North 99 07 16	TP84 0-0.1m South 99 07 16	TP84 0.1-0.3m South 99 07 16	TP84 0.3-0.6m South 99 07 16	TP84 0.6-0.9m South 99 07 16
Physical Tests						
Moisture	%	19.8	7.5	7.6	6.3	16.4
pH		-	-	8.22	-	-
Total Metals						
Lead	T-Pb	-	-	490	-	-
Zinc	T-Zn	-	-	2050	-	-
Extractables						
EPH (C10-19)		7100	<200	-	-	10500
EPH (C19-32)		210	<200	-	-	227

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP9 1.3-1.5m**	**TP9 1.3-1.5m**	**TP9 1.3-1.5m**	**TP9 1.3-1.5m**
		99 07 12	QC # 166300	QC # 170251	QC # 170252
Physical Tests					
Moisture	%	8.4	8.2	-	-
Extractables					
EPH (C10-19)		380	<200	283	703
EPH (C19-32)		549	230	279	1110

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP12 0.6-0.9m**	**TP12 0.6-0.9m**
		99 07 12	QC # 166304
Physical Tests			
Moisture	%	9.6	10.5
pH		7.89	7.84
Total Metals			
Lead	T-Pb	70	133
Zinc	T-Zn	256	490

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP16** **0.2-0.4m** 99 07 13	**TP16** **0.2-0.4m** QC # 166305
Physical Tests			
Moisture	%	4.9	5.7
pH		8.33	8.19
Total Metals			
Lead	T-Pb	1110	903
Zinc	T-Zn	5740	3520
Extractables			
EPH (C10-19)		<200	<200
EPH (C19-32)		<200	259

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil	**TP44** **0.3-0.7m**	**TP44** **0.3-0.7m**	**TP44** **0.3-0.7m**	**TP44** **0.3-0.7m**
	99 07 14	QC # 166308	QC # 169101	QC # 169102
Physical Tests				
Moisture %	7.8	8.4	-	-
Extractables				
EPH (C10-19)	<200	280	805	<200
EPH (C19-32)	<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.
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EPH = Extractable Petroleum Hydrocarbons.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil			**TP49 0.6-0.9m**	**TP49 0.6-0.7m**
			99 07 14	QC # 166310
Physical Tests				
Moisture	%		7.4	7.3
Leachable Anions & Cations				
Bromide	Br		<5	<5
Chloride	Cl		17	16
Fluoride	F		1.1	1.1
Nitrate Nitrogen		N	10	10
Nitrite Nitrogen		N	<1	<1
Sulphate	SO4		718	585
Extractables				
EPH (C10-19)			<200	<200
EPH (C19-32)			207	<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP63 0.4-0.6m**	**TP63 0.4-0.6m**
		99 07 15	QC # 166311
Physical Tests			
Moisture	%	9.1	6.1

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		TP69 0.4-0.6m 99 07 16	TP69 0.4-0.6m QC # 166312
Physical Tests			
Moisture	%	5.4	5.5
pH		8.28	8.21
Total Metals			
Lead	T-Pb	208	185
Zinc	T-Zn	1690	1620
Extractables			
EPH (C10-19)		<200	<200
EPH (C19-32)		<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP80 0-0.1m**	**TP80 0-0.1m**
		99 07 16	QC # 166313
Physical Tests			
Moisture	%	6.7	6.8
pH		8.52	8.49
Total Metals			
Lead	T-Pb	782	753
Zinc	T-Zn	3110	2420
Extractables			
EPH (C10-19)		<200	<200
EPH (C19-32)		<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8052

Sediment/Soil		**TP84** **0.6-0.9m** **South** 99 07 16	**TP84** **0.6-0.9m** QC # 166314
Physical Tests			
Moisture	%	16.4	12.0
Extractables			
EPH (C10-19)		10500	11100
EPH (C19-32)		227	285

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.
VPH = Volatile 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 using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

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"

Volatile Organic Compounds in Sediment/Soil

This analysis is based on United States Environmental Protection Agency Methods 5035, 8260/8021 and British Columbia Ministry of Environment, Lands and Parks Method "Volatile Hydrocarbons in Solids by GC/FID ". The procedure involves a 1:2 extraction of the sediment/soil sample with methanol. Aliquots of the methanol extract are then analyzed by capillary column gas chromatography with mass spectrometric, and/or photo-ionization/flame-ionization detection.

Volatile Petroleum Hydrocarbons (VPH) in Sediment/Soil

Volatile Petroleum Hydrocarbons (VPH) is a calculation defined by British Columbia Ministry of Environment, Lands and Parks (BCMELP) Draft Method "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water", June 1998. The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). Analysis of Volatile Hydrocarbons adheres to all prescribed elements of BCMELP method "Volatile Hydrocarbons in Solid", June 1998.

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.

End of Report

APPENDIX

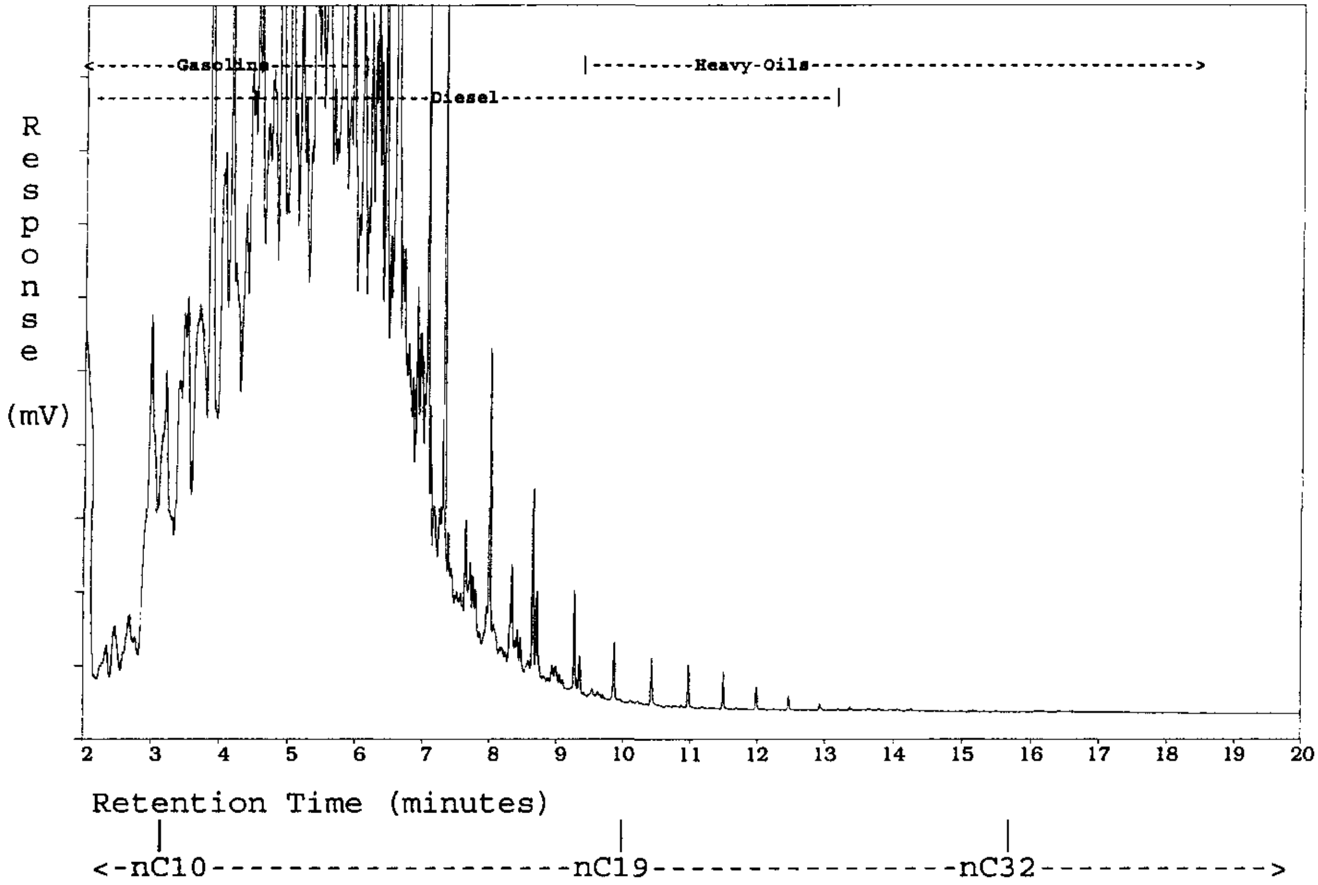
HYDROCARBON DISTRIBUTION REPORTS

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--3 TP1 0.8-1.0m

File Name: C:\TEH\JL30\EH1JL30.73R ASL Sample ID: K8052-T--3 Sample acquired: AUG 4, 1999 06:48:35

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.3 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

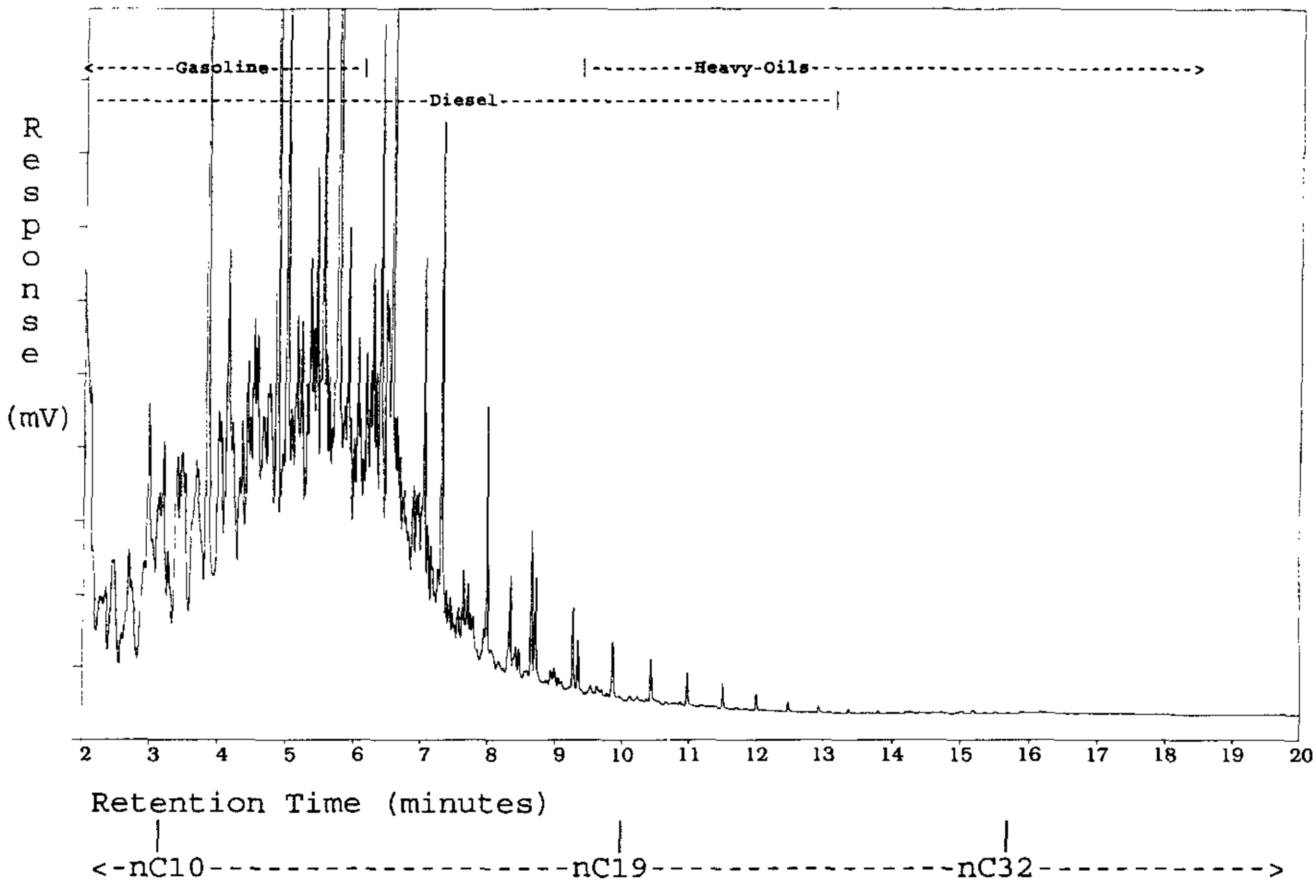
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--8 TP3 1.2-1.5m

File Name: C:\TEH\JL30\EH1JL30.75R ASL Sample ID: K8052-T--8 Sample acquired: AUG 4, 1999 07:51:19

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.2 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

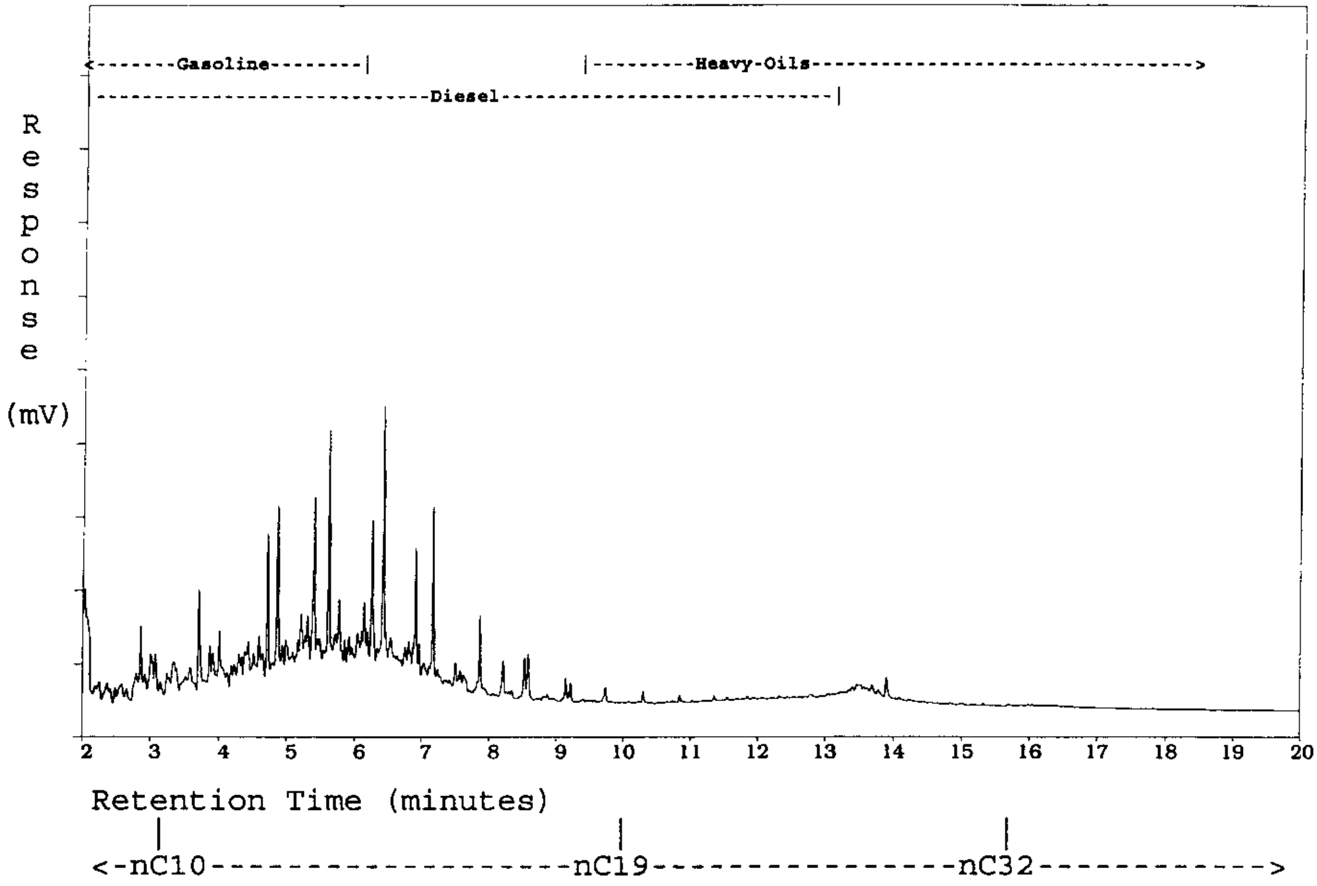
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--12 TP5 0.5-0.8m

File Name: C:\TEH\JL30\EH1JL30.76R ASL Sample ID: K8052-T--12 Sample acquired: AUG 4, 1999 07:51:19

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.9 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

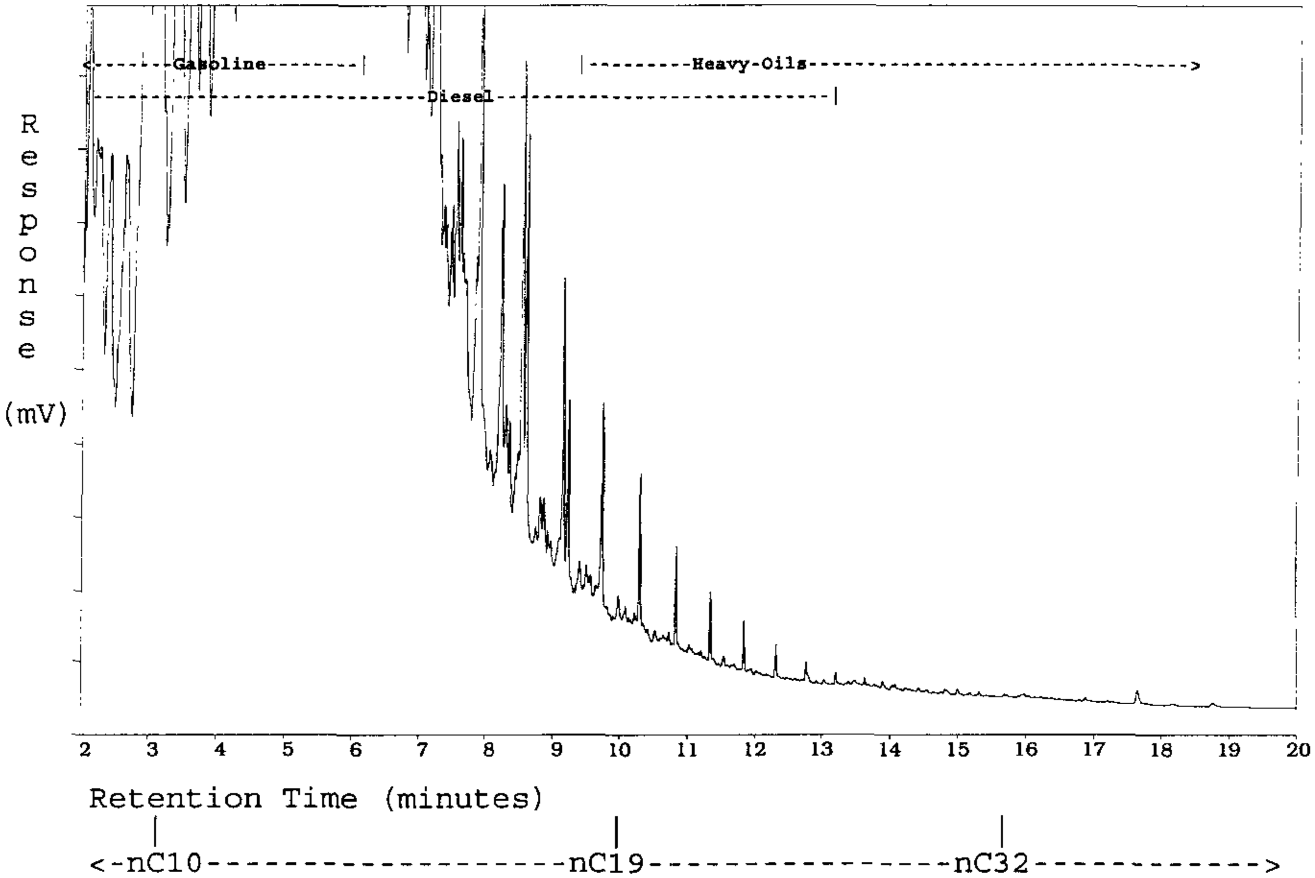
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--13 TP5 1.8-2.4m

File Name: C:\TEH\JL30\EH1JL30.72R ASL Sample ID: K8052-T--13 Sample acquired: AUG 4, 1999 00:03:36

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.2 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

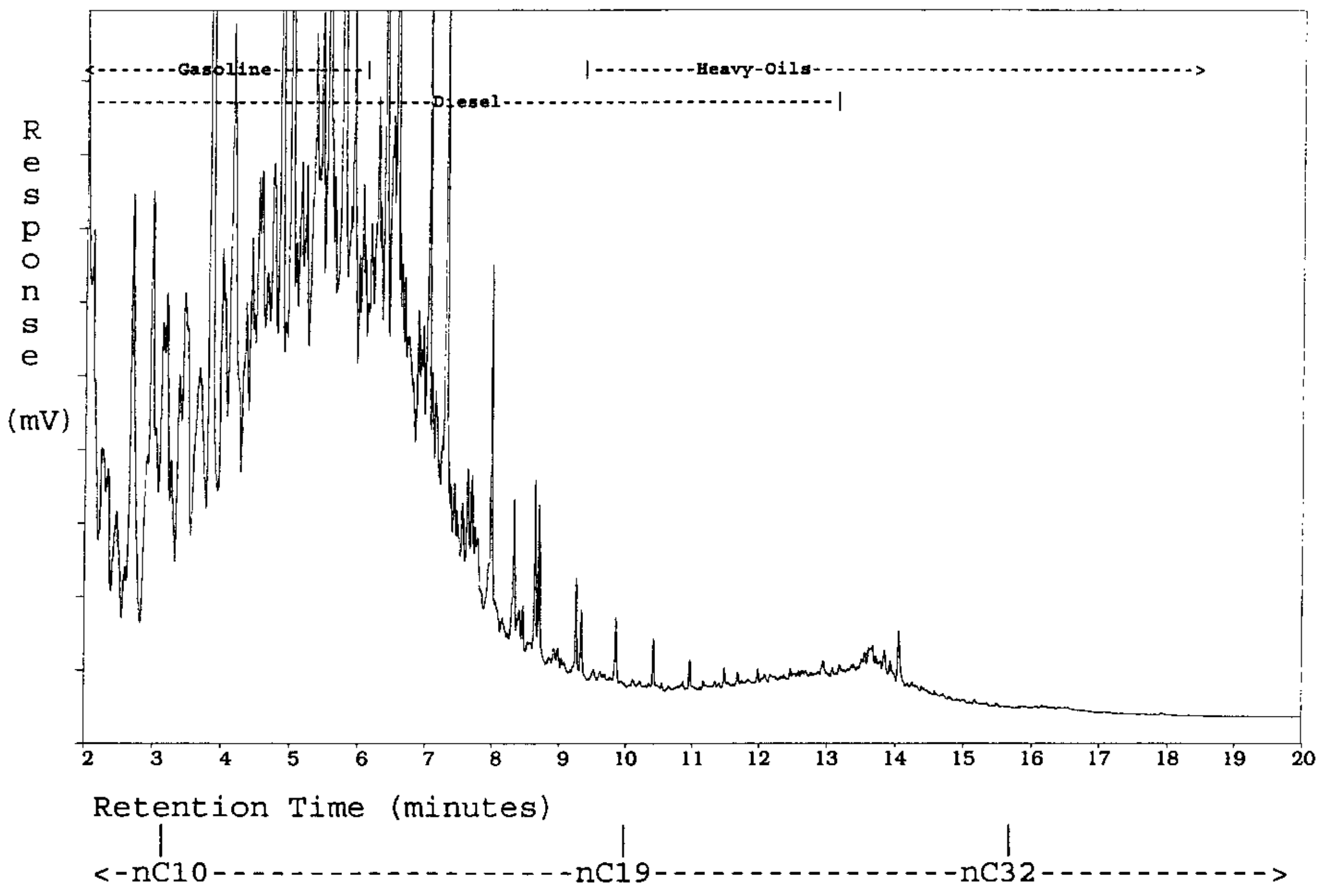
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--16 TP7 2.5-2.7m

File Name: C:\TEH\JL30\EH1JL30.77R ASL Sample ID: K8052-T--16 Sample acquired: AUG 4, 1999 08:26:58

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.1 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

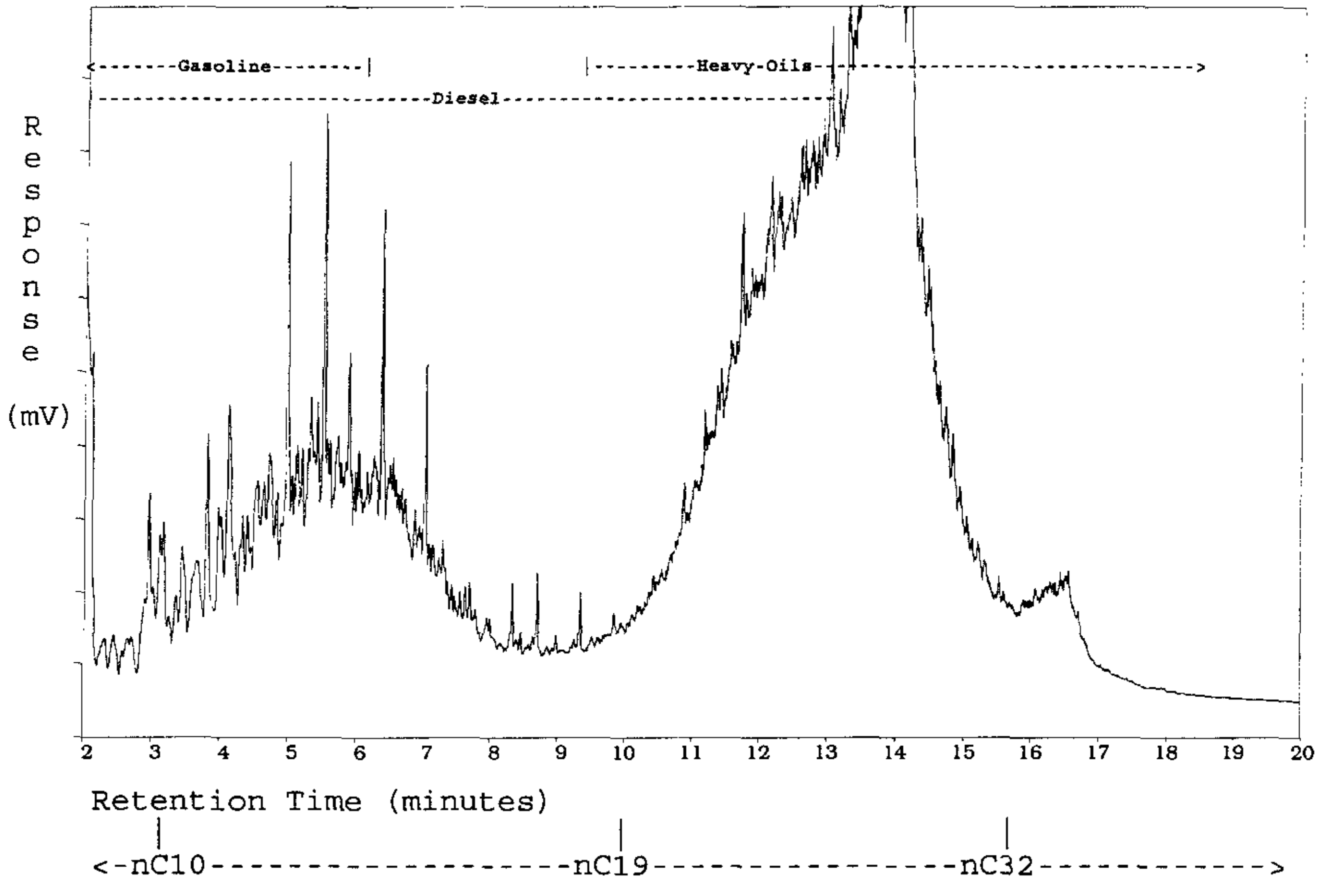
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--18 TP8 1.2-1.5m

File Name: C:\TEH\JL30\EH1JL30.79R ASL Sample ID: K8052-T--18 Sample acquired: AUG 4, 1999 09:02:39

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.1 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

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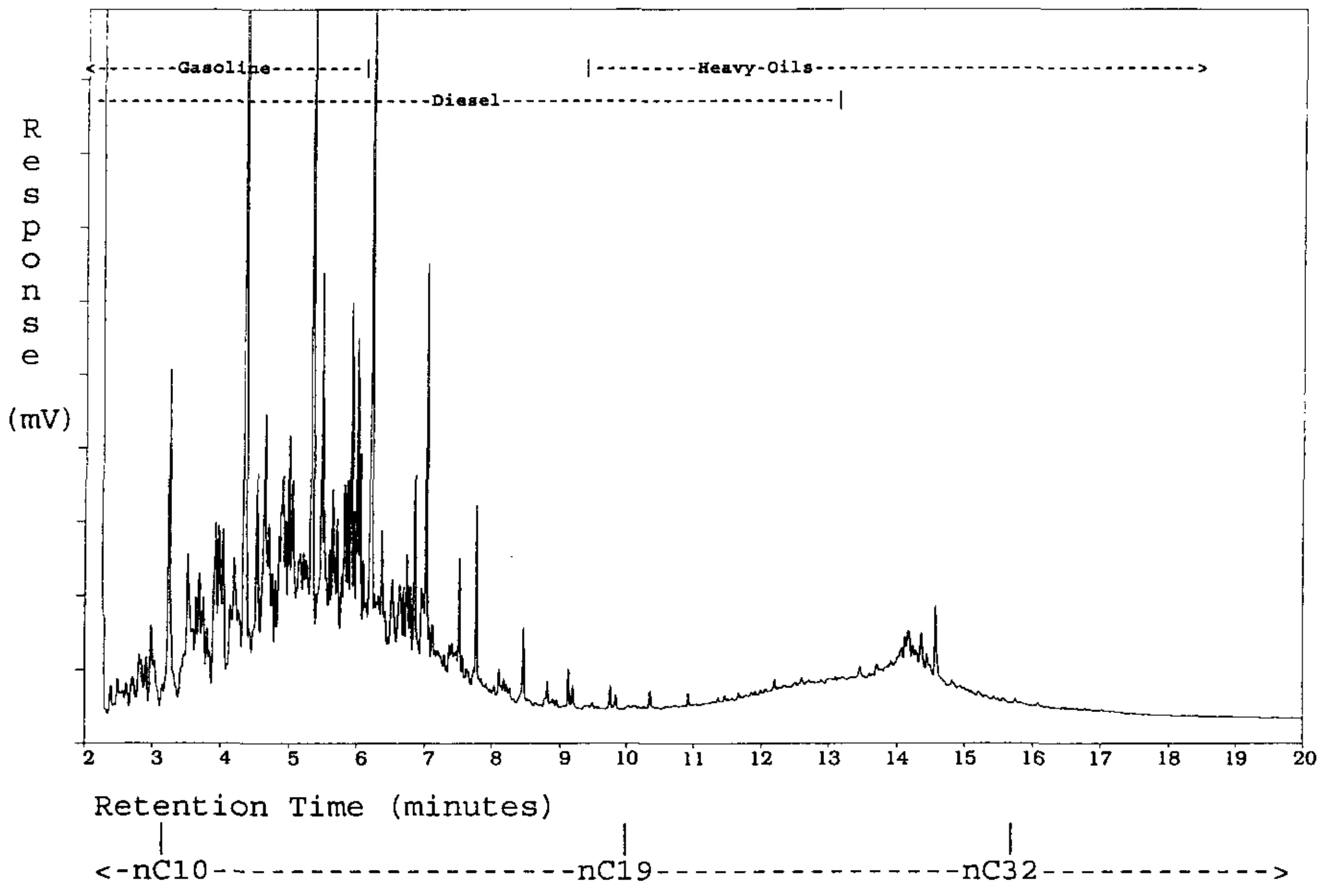
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--20 TP9 0.6-0.9m 99 07 12

File Name: C:\TEH2\AU12\EH3AU12.88R ASL Sample ID: K8052-T--20 Sample acquired: AUG 13, 1999 11:50:17

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.8 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which 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 with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

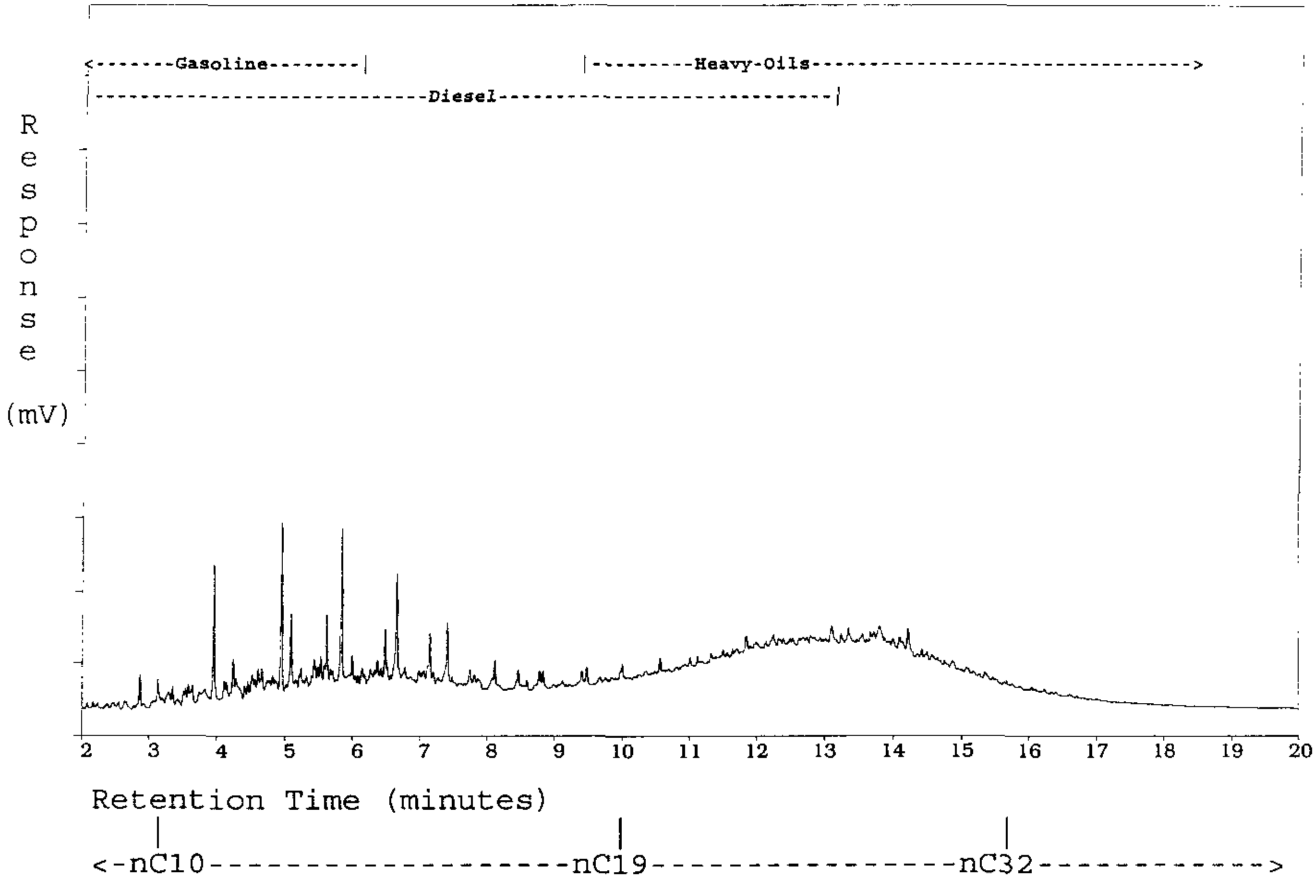
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--21#RE

_.3-1.5m

File Name: C:\TEH2\AU05\EH3AU05.81R   ASL Sample ID: K8052-T--21#RE   Sample acquired: AUG 6, 1999 12:13:54

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 18.3 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which 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 with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

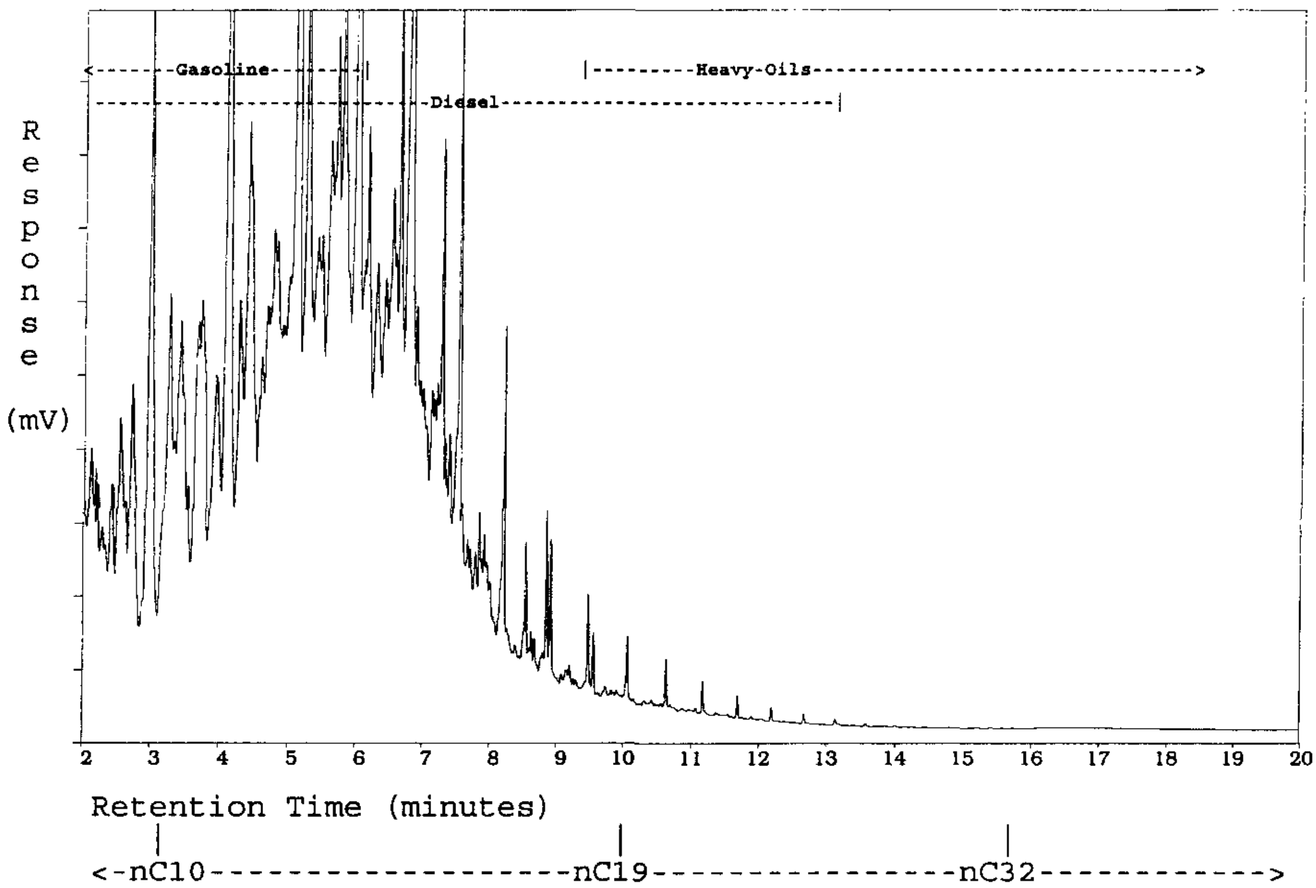
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--23

TP10 0.9-1.2m

File Name: C:\TEH2\AU03\EH3AU03.24R ASL Sample ID: K8052-T--23 Sample acquired: AUG 3, 1999 14:06:59

Chromatogram Scale: 100.0 millivolts



Sample Amt. (g or mL): 12.6 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

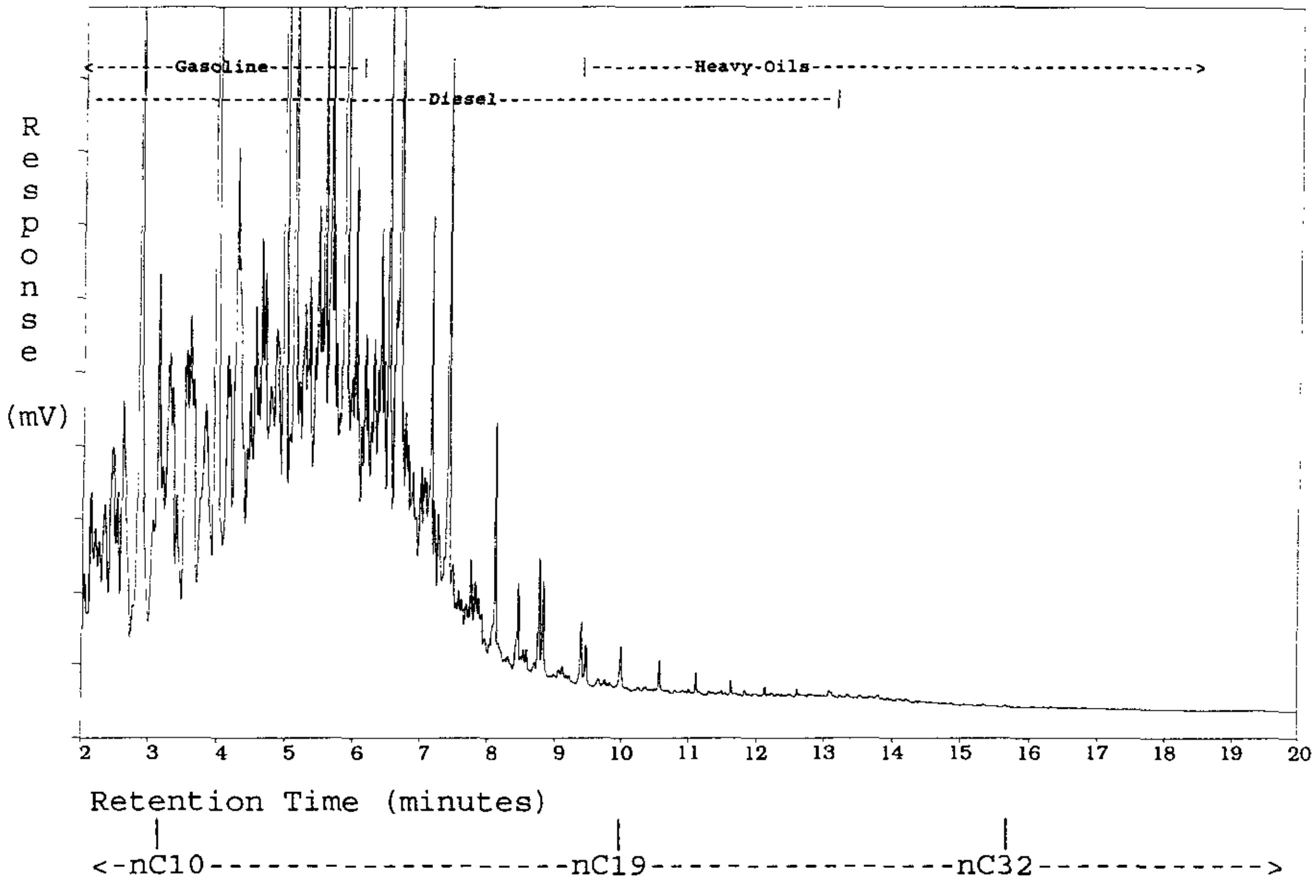
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--25 TP11 0.9-1.2m

File Name: C:\TEH2\AU03\EH3AU03.25R ASL Sample ID: K8052-T--25 Sample acquired: AUG 3, 1999 14:46:34

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.3 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

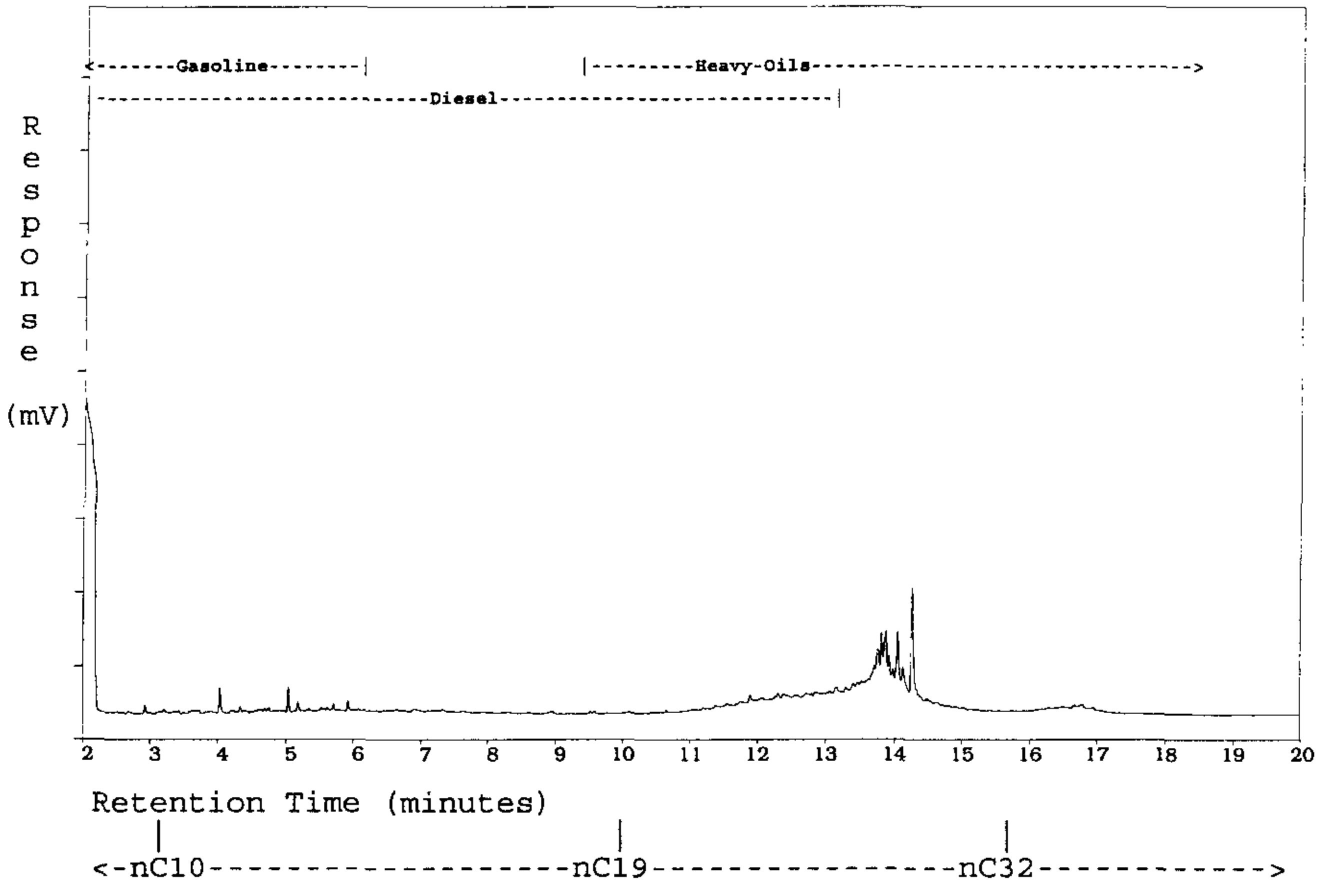
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--27 TP13 0.7-1.0m

File Name: C:\TEH2\AU03\EH3AU03.32R ASL Sample ID: K8052-T--27 Sample acquired: AUG 3, 1999 16:59:30

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.6 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

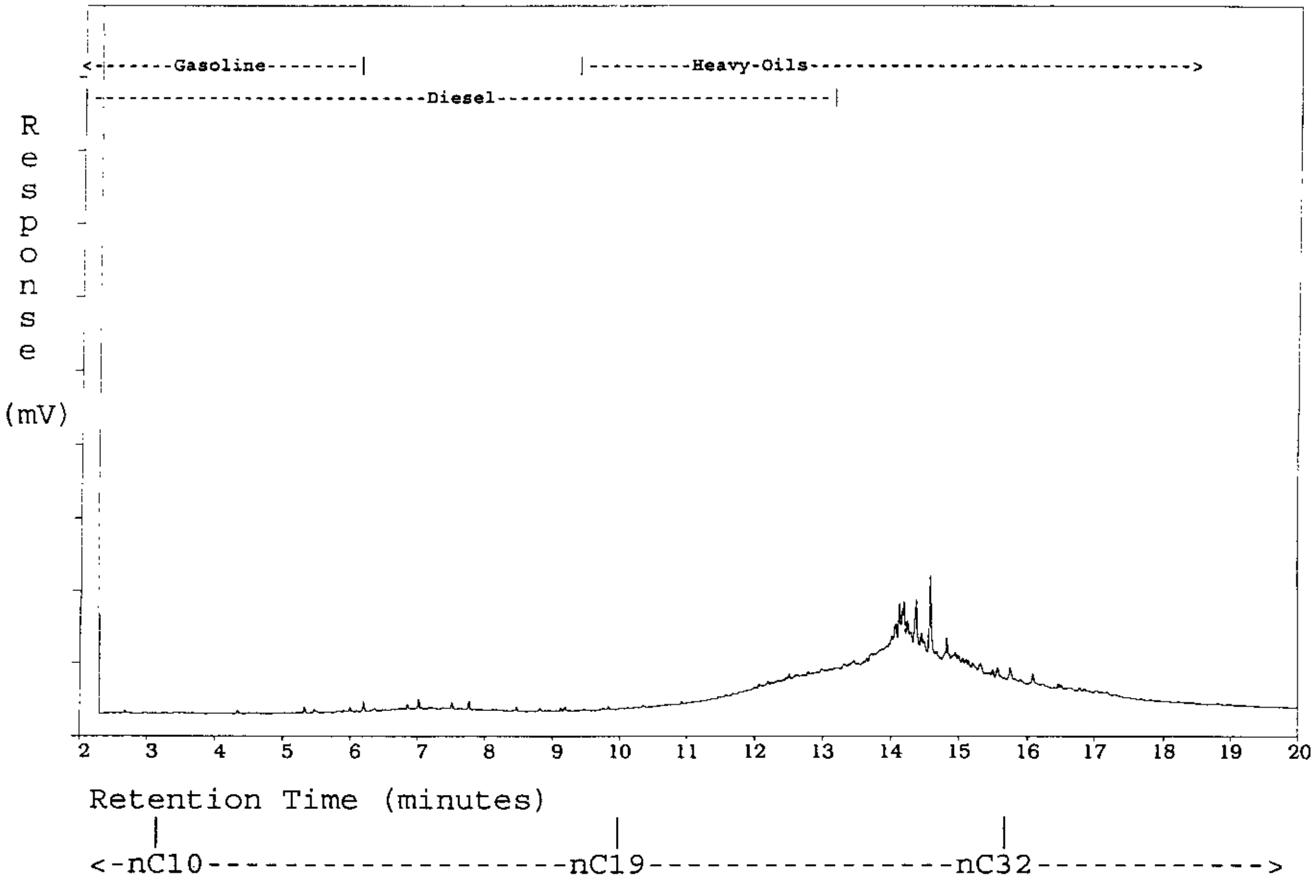
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--31 TP17 0.2-0.4m

File Name: C:\TEH2\AU12\EH3AU12.86R ASL Sample ID: K8052-T--31 Sample acquired: AUG 13, 1999 11:14:59

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.2 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

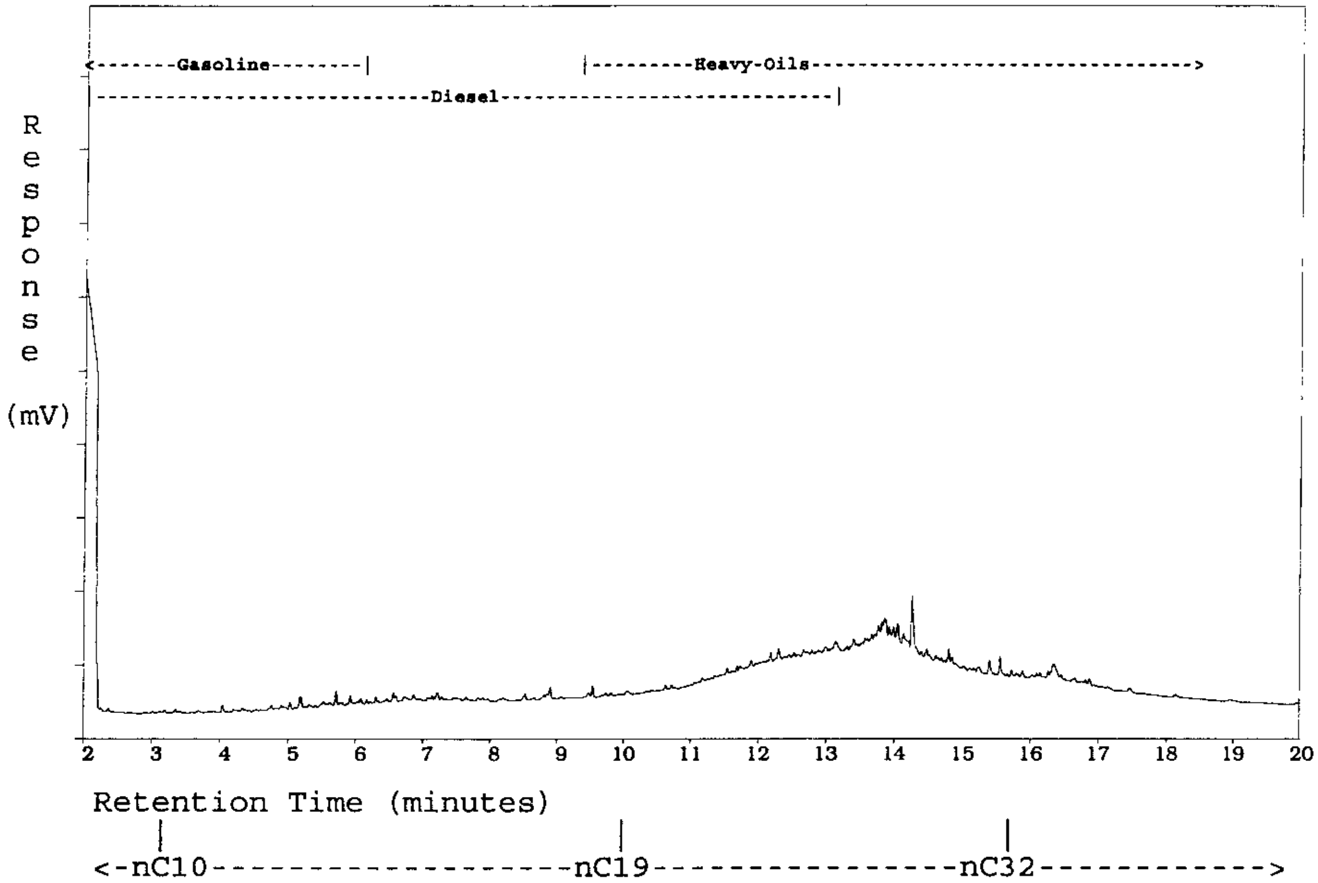
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--32 TP18 0.3-0.6m

File Name: C:\TEH2\AU03\EH3AU03.38R ASL Sample ID: K8052-T--32 Sample acquired: AUG 3, 1999 18:46:50

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.5 Dilution: 8.0

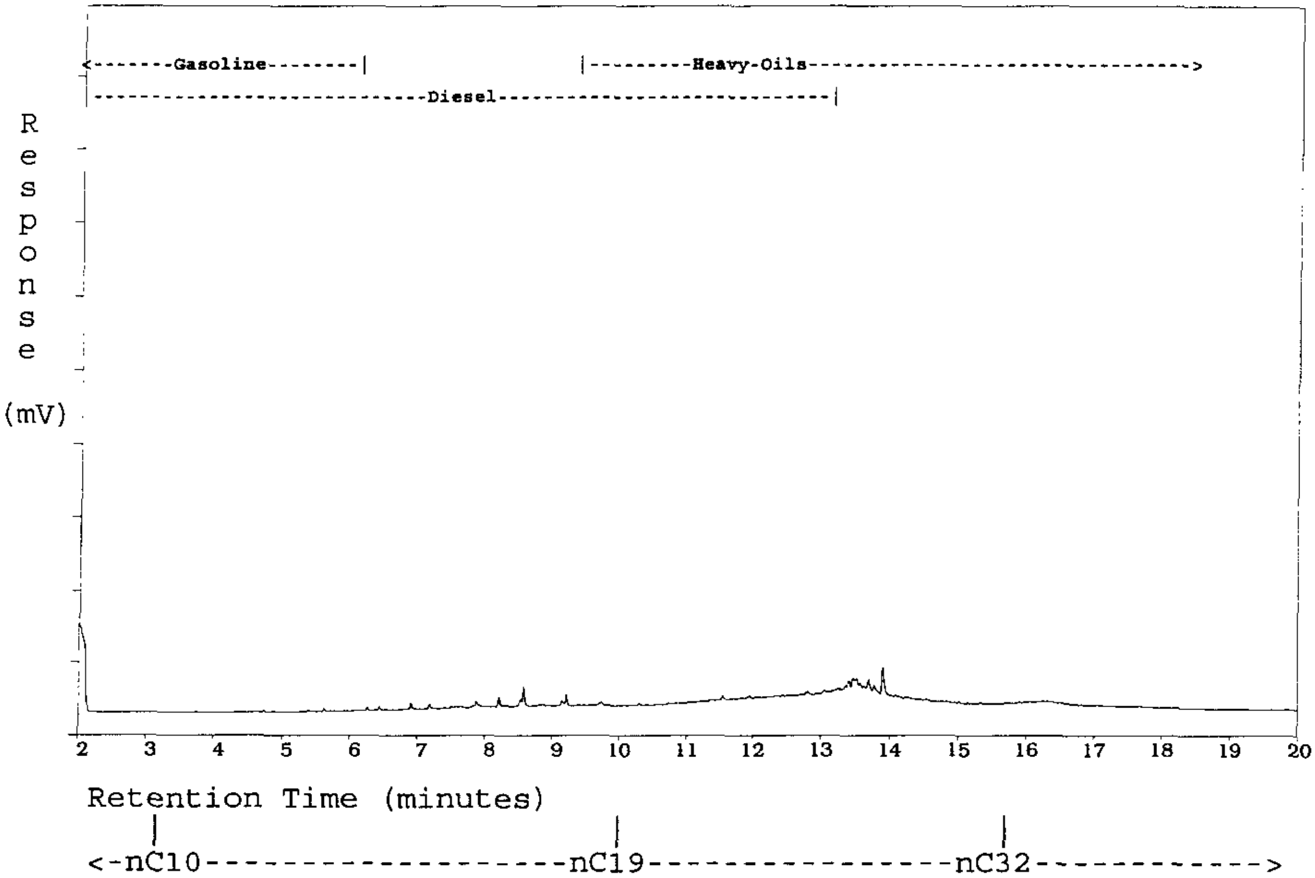
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which 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 with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--33 TP19 0.3-0.6m

File Name: C:\TEH\JL30\EH1JL30.80R ASL Sample ID: K8052-T--33 Sample acquired: AUG 4, 1999 09:02:39
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.7 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

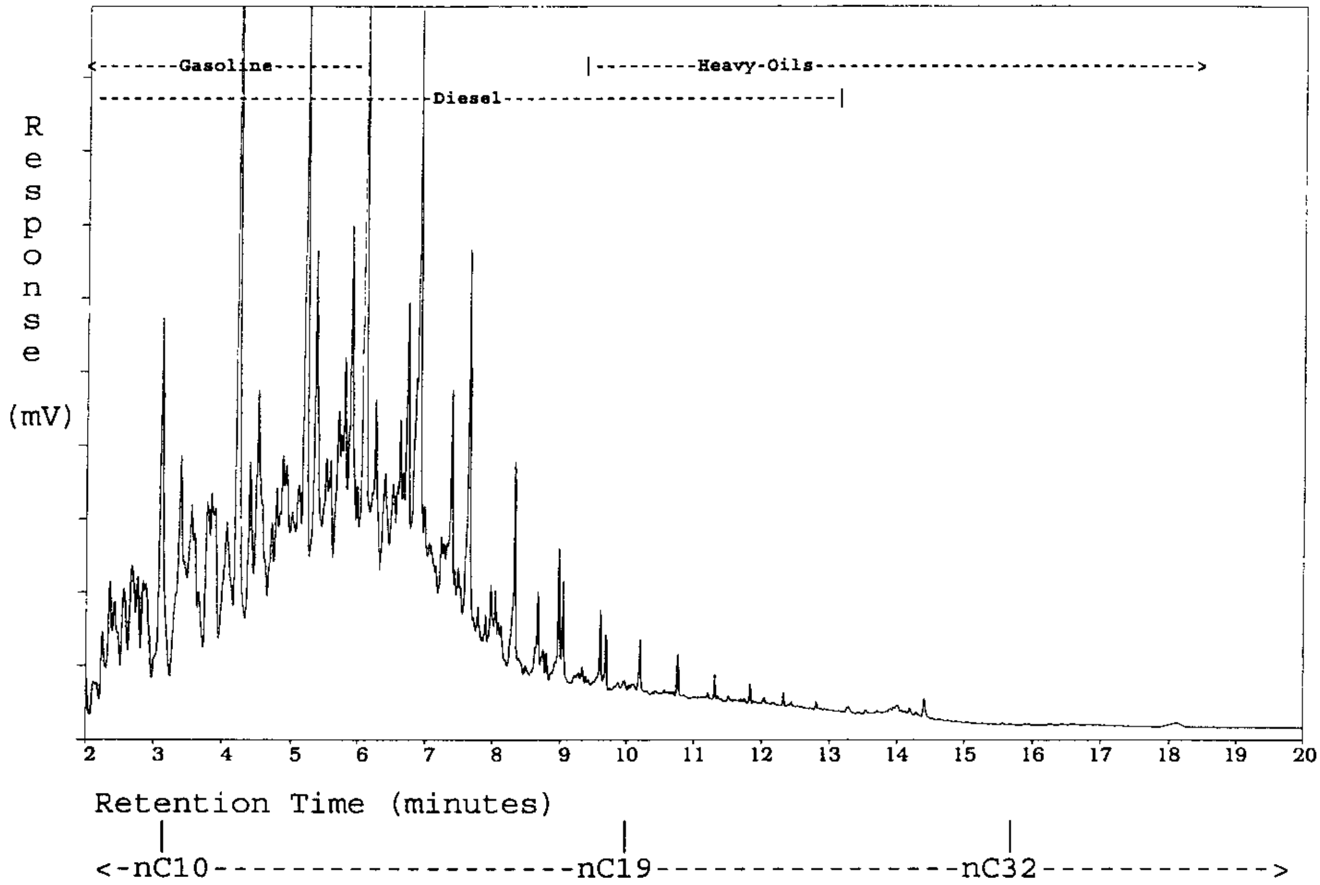
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--35 TP20 1.5-1.6m

File Name: C:\TEH2\AU12\EH3AU12.85R ASL Sample ID: K8052-T--35 Sample acquired: AUG 13, 1999 11:14:59

Chromatogram Scale: 150.0 millivolts



Sample Amt. (g or mL): 12.5 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

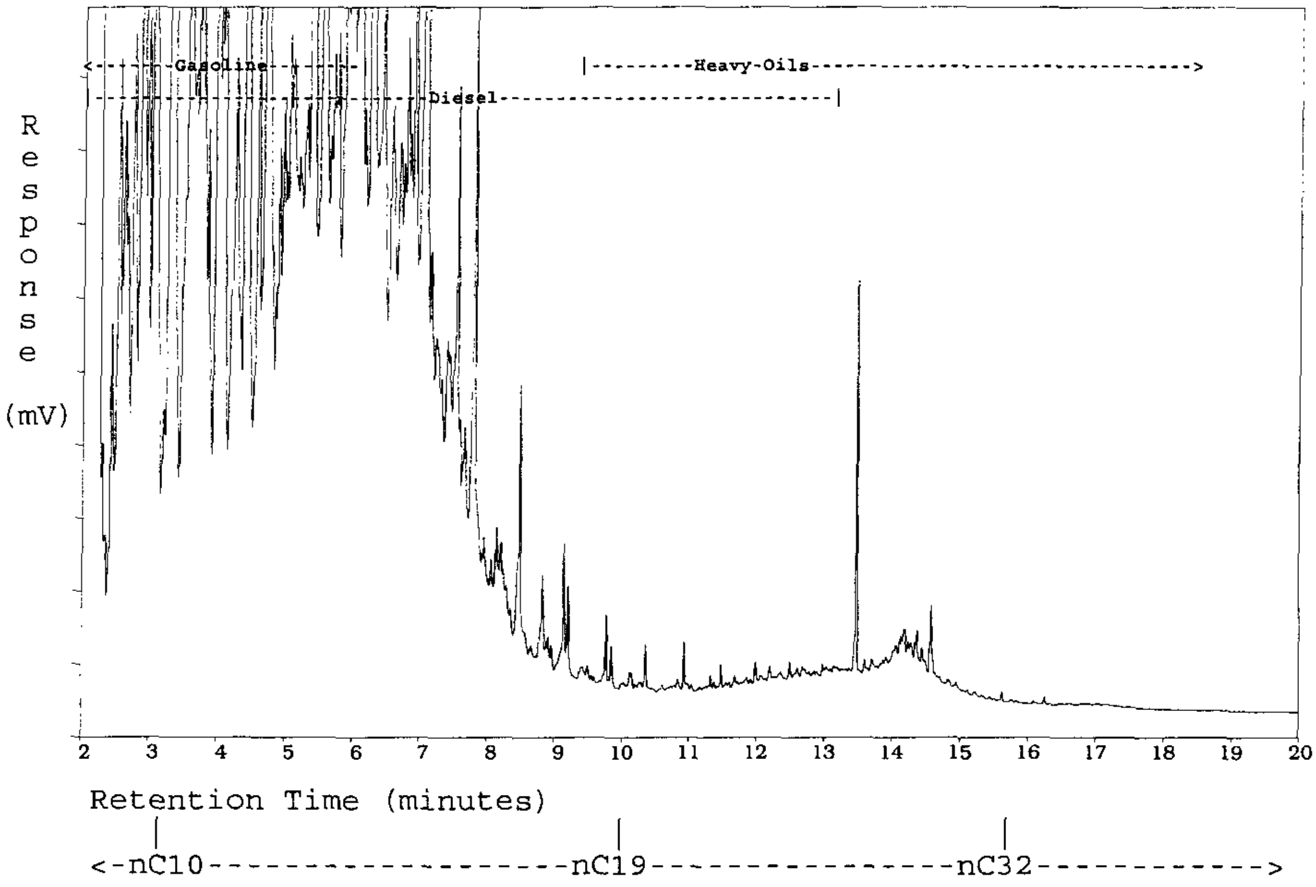
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--37 TP22 0.9-1.2m.

File Name: C:\TEH2\AU12\EH3AU12.76R ASL Sample ID: K8052-T--37 Sample acquired: AUG 13, 1999 08:16:48

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.1 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

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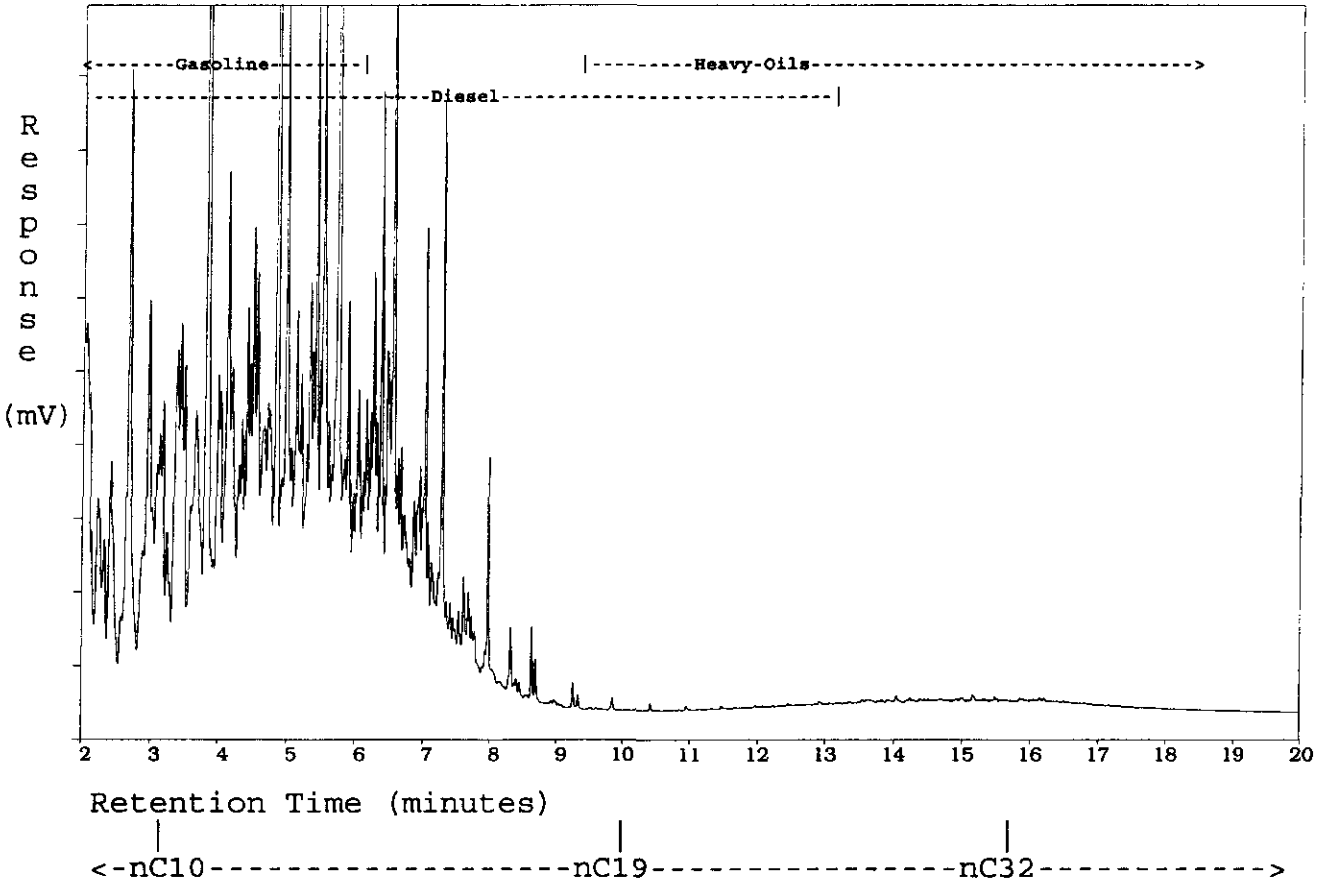
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--39 TP36 0.6-0.9m

File Name: C:\TEH\JL30\EH1JL30.83R ASL Sample ID: K8052-T--39 Sample acquired: AUG 4, 1999 10:14:11

Chromatogram Scale: 50.0 **millivolts**



Sample Amt. (g or mL): 11.5 Dilution: 8.0

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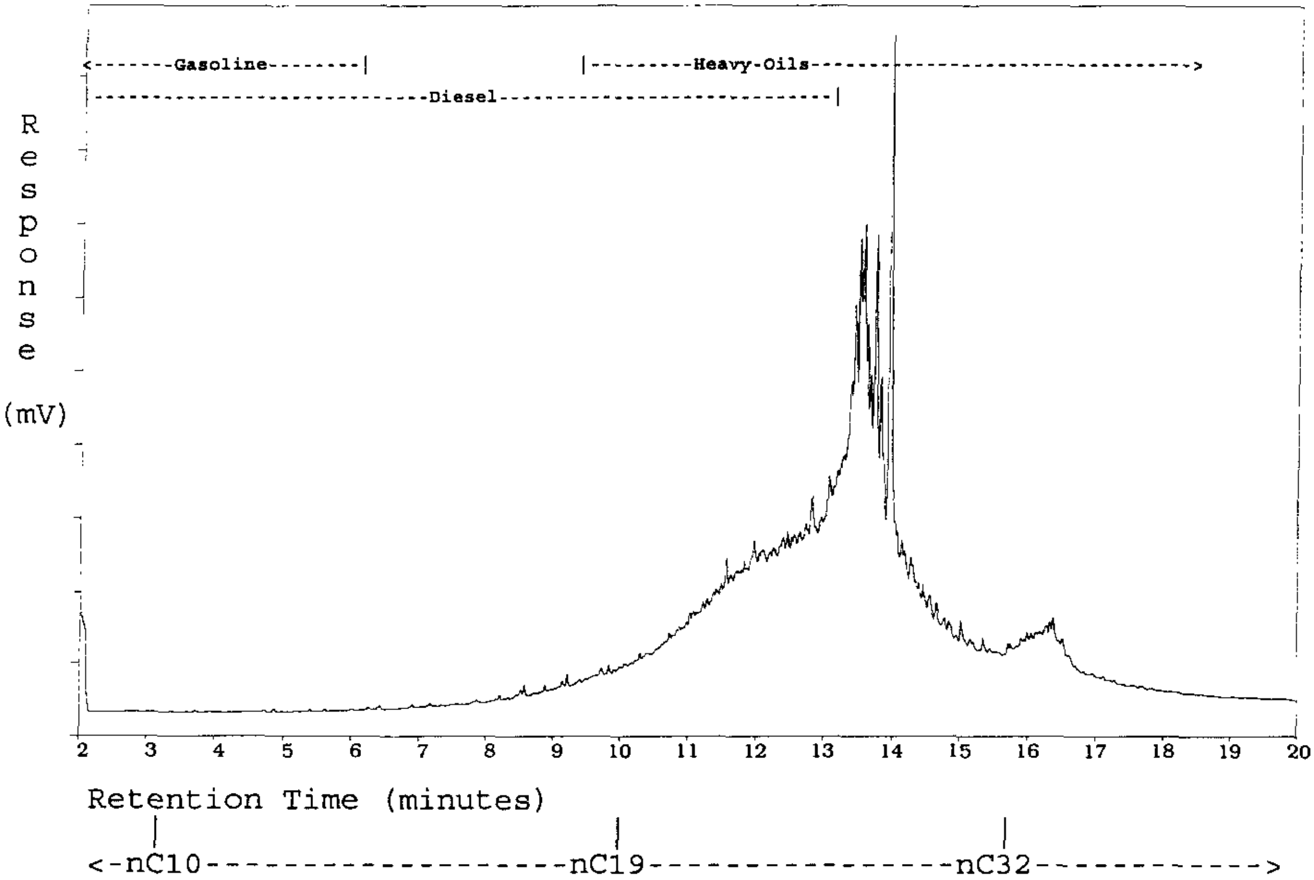
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--40 TP37 0-0.05m

File Name: C:\TEH\JL30\EH1JL30.82R ASL Sample ID: K8052-T--40 Sample acquired: AUG 4, 1999 09:38:33

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.8 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

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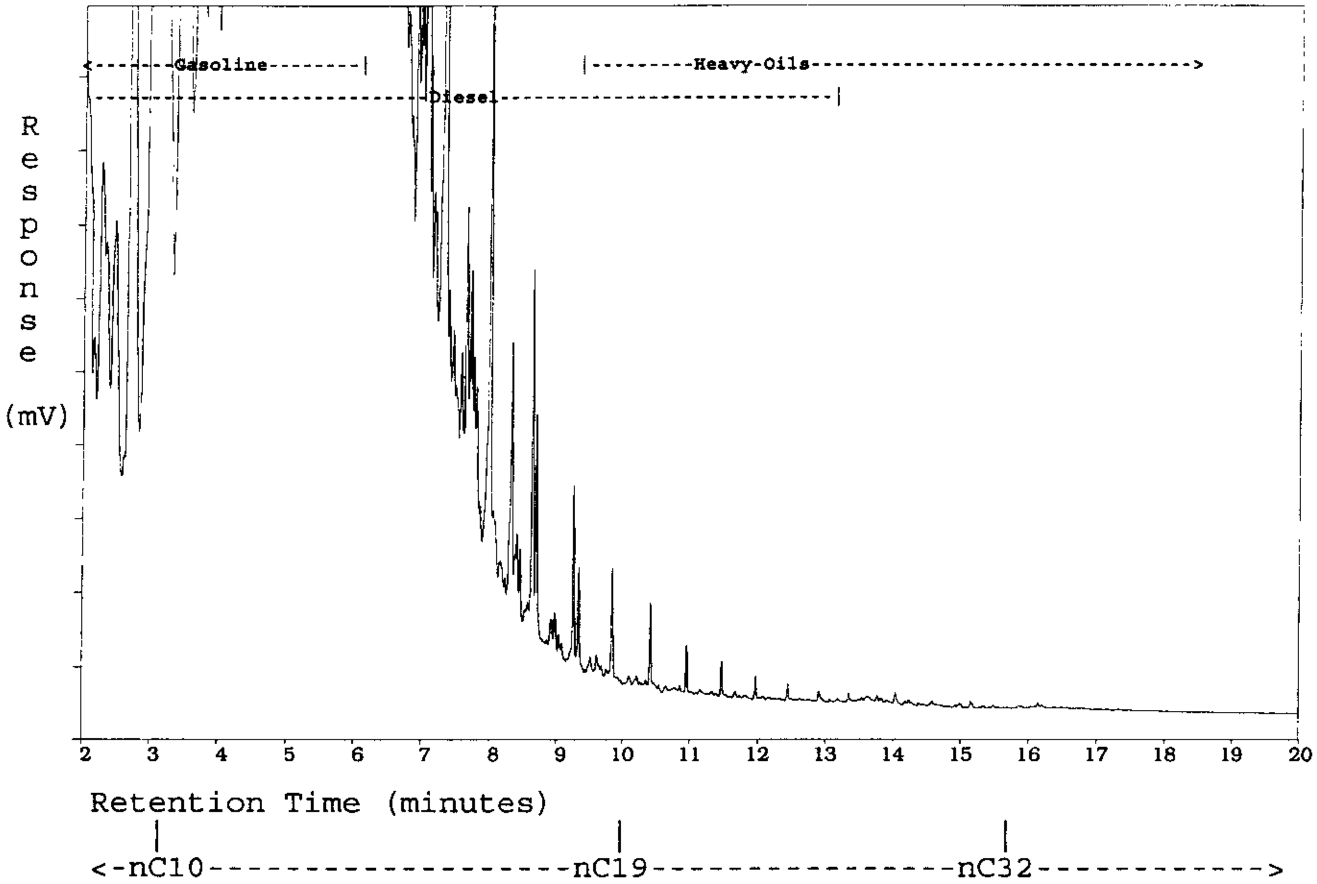
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--45 TP43 0.3-0.6m

File Name: C:\TEH\JL30\EH1JL30.87R ASL Sample ID: K8052-T--45 Sample acquired: AUG 4, 1999 11:24:44

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 9.5 Dilution: 8.0

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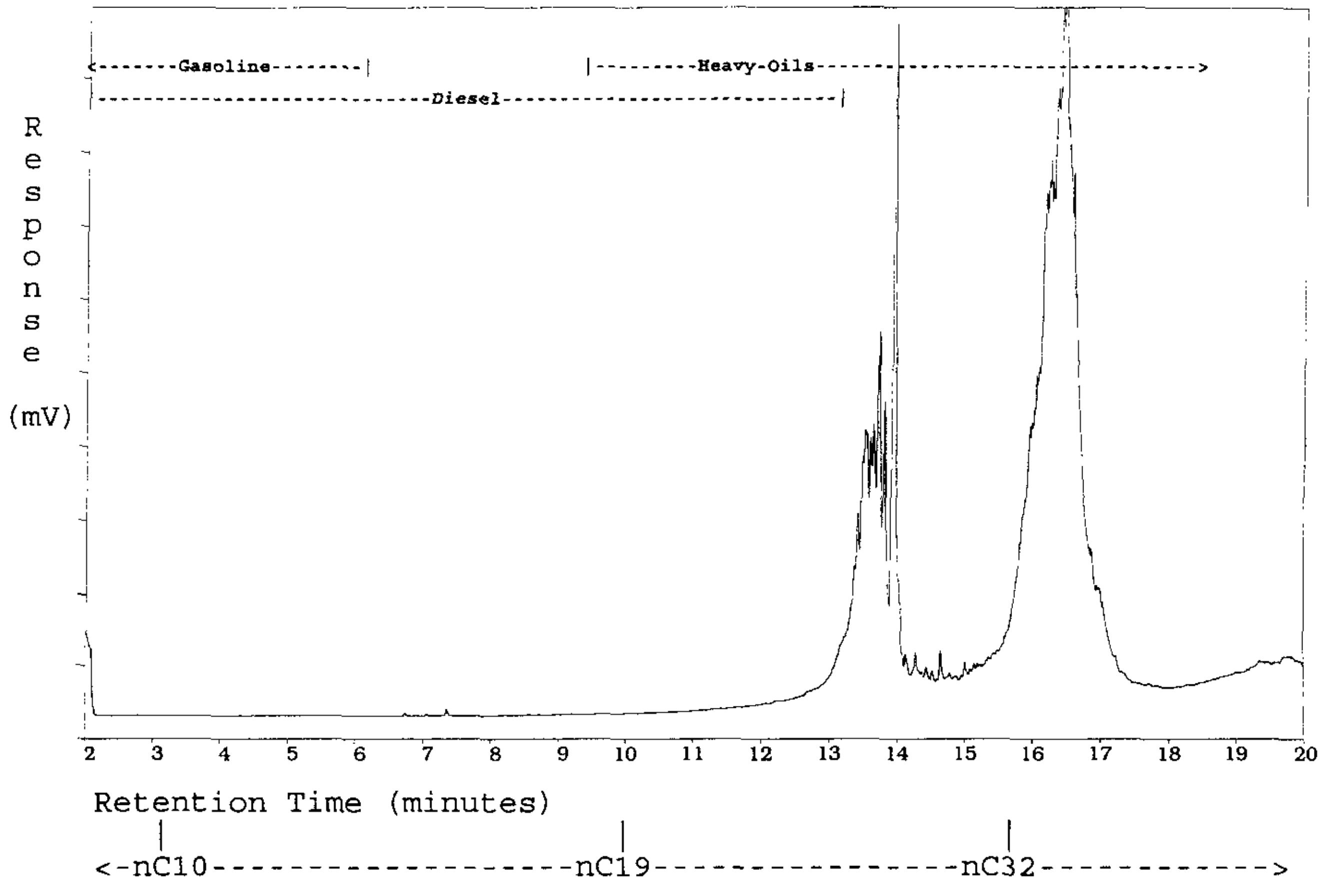
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--47 TP45 0.3-0.6m

File Name: C:\TEH\JL30\EH1JL30.88R ASL Sample ID: K8052-T--47 Sample acquired: AUG 4, 1999 11:24:44

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.0 Dilution: 8.0

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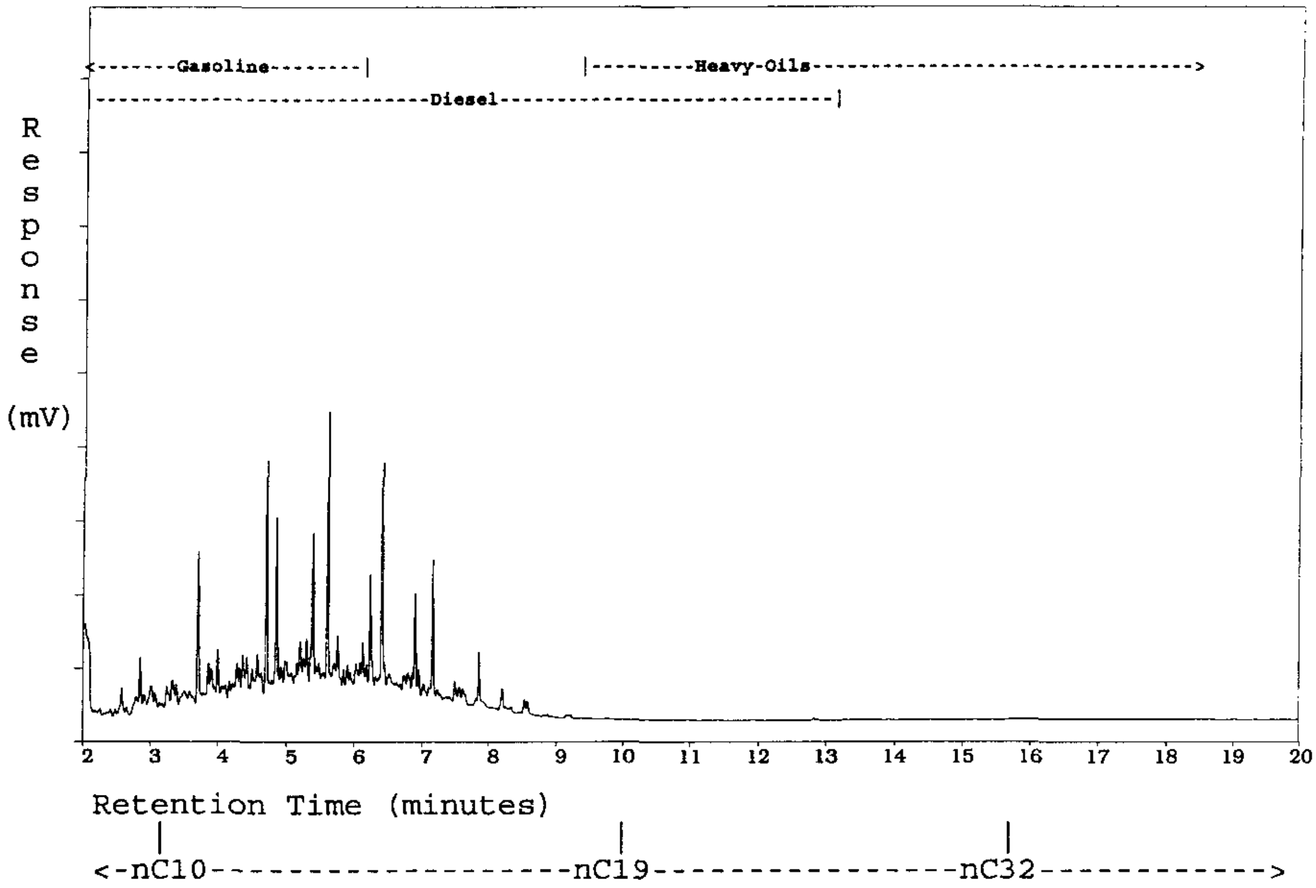
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--60 TP59 0.6-0.9m

File Name: C:\TEH\AU04\EH1AU04.22R ASL Sample ID: K8052-T--60 Sample acquired: AUG 4, 1999 22:04:48

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.2 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

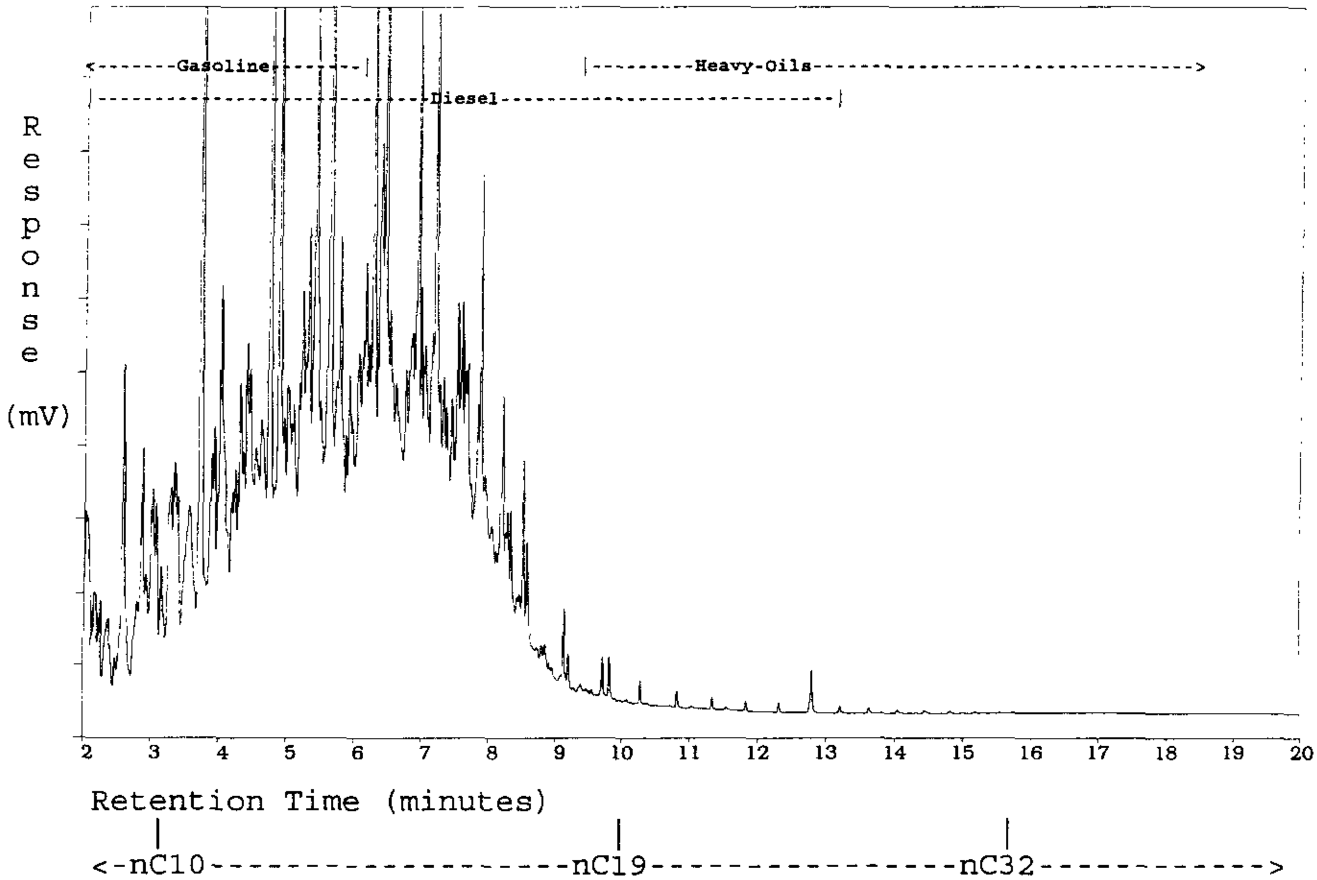
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--67 TP64 0.4-0.6m

File Name: C:\TEH\JL30\EH1JL30.50R ASL Sample ID: K8052-T--67 Sample acquired: AUG 3, 1999 17:30:32

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.7 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

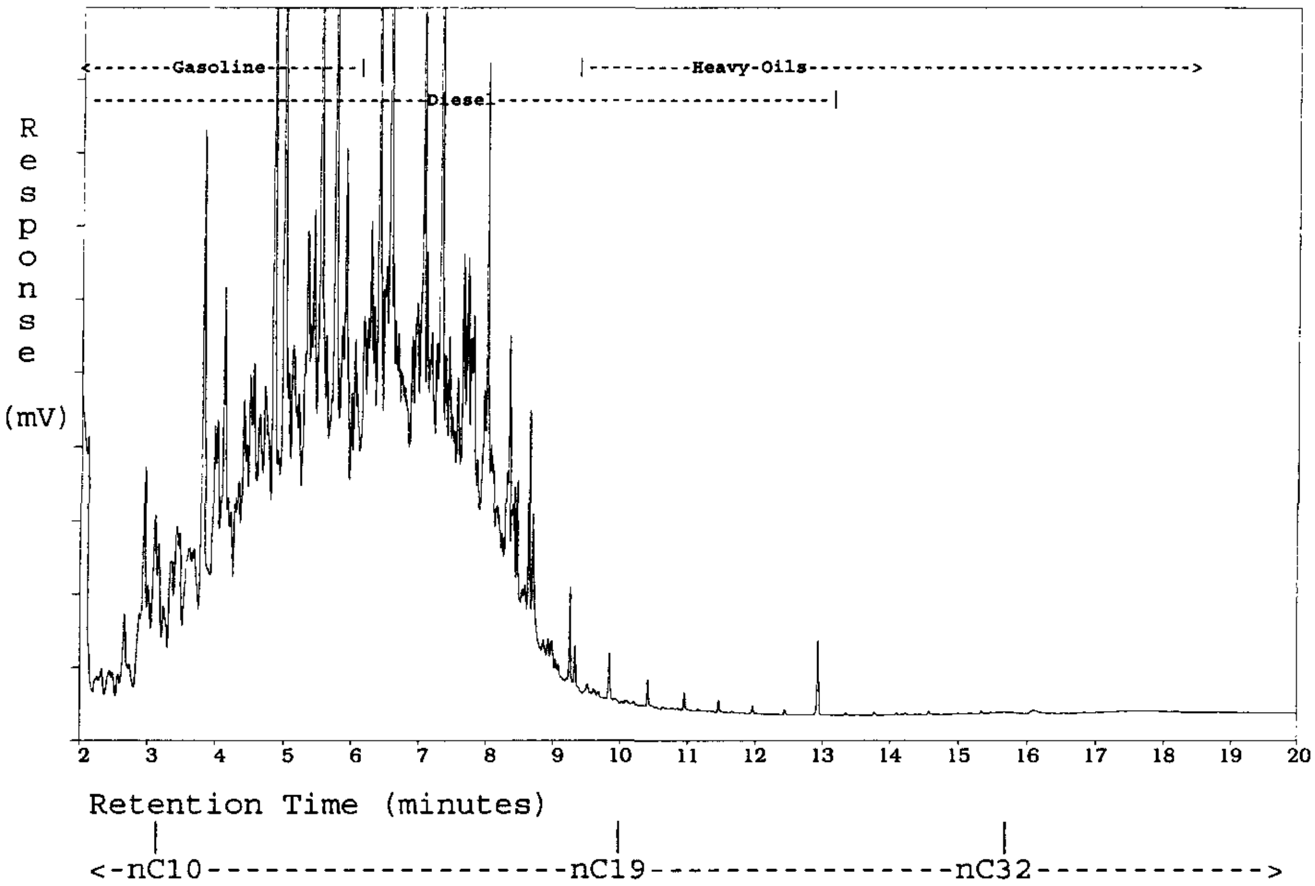
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--68 TP65 0.4-0.6m

File Name: C:\TEH\JL30\EH1JL30.47R ASL Sample ID: K8052-T--68 Sample acquired: AUG 3, 1999 16:55:06

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.4 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

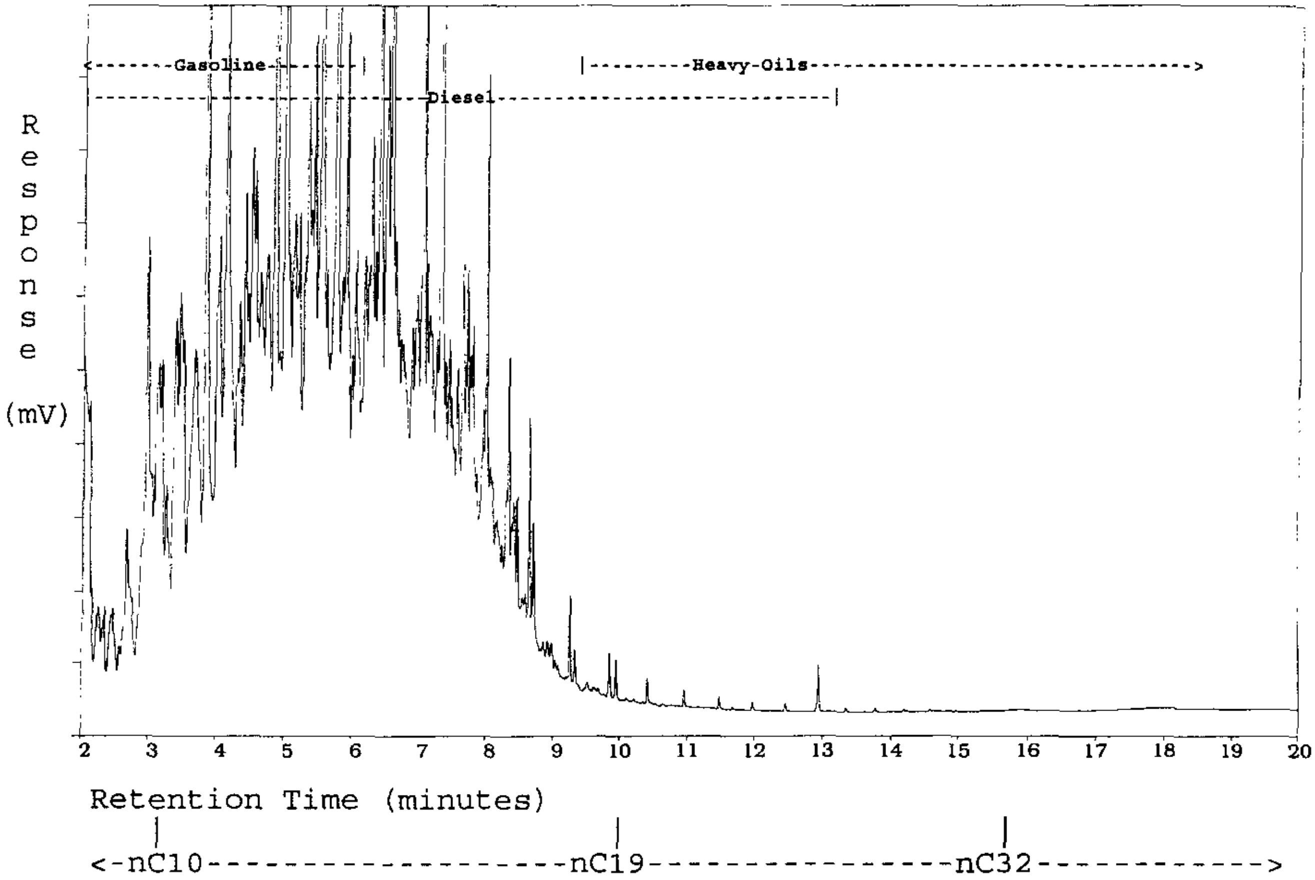
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--70 TP67 0.4-0.6m

File Name: C:\TEH\JL30\EH1JL30.49R ASL Sample ID: K8C52-T--70 Sample acquired: AUG 3, 1999 17:30:32

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.4 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

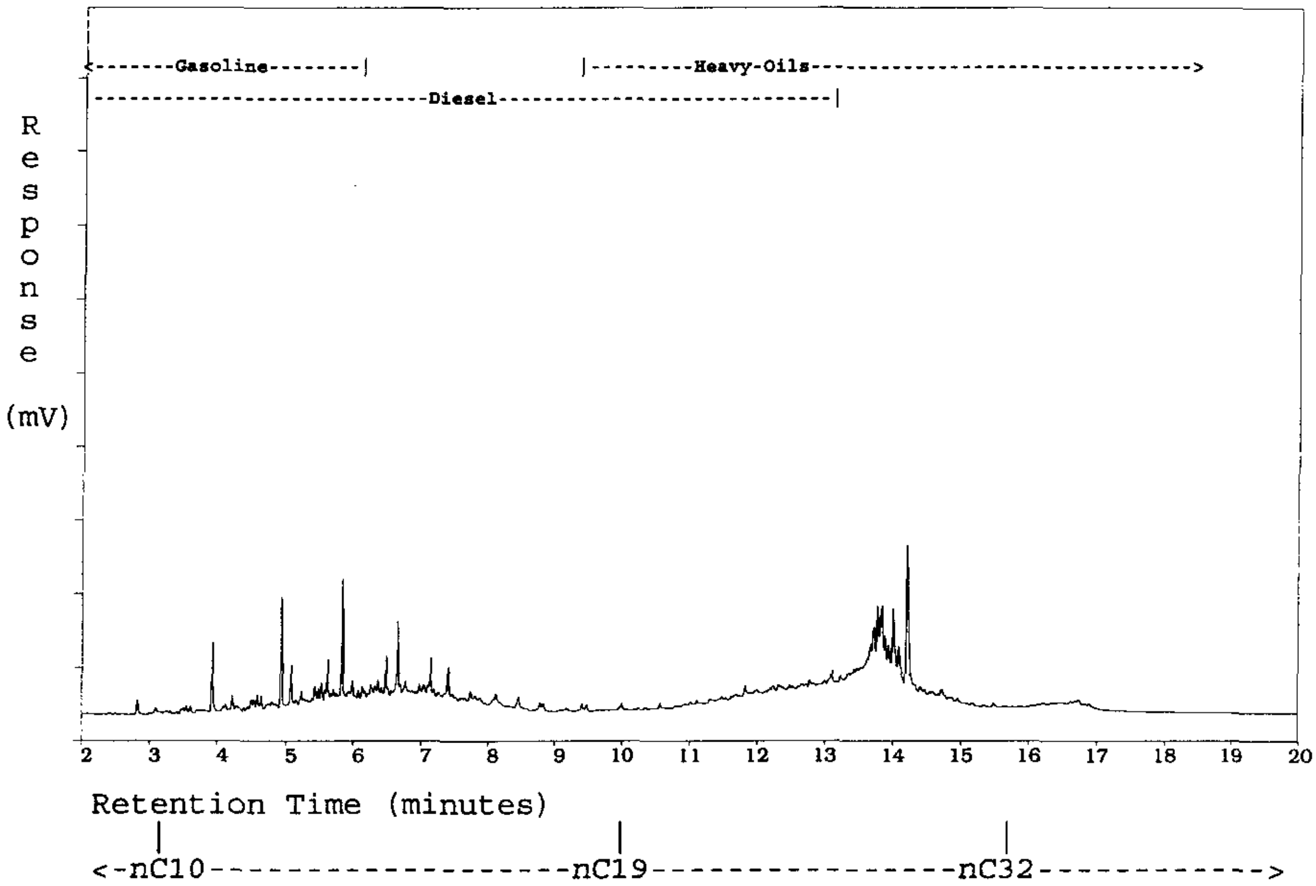
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--75 TP73 0-0.1m

File Name: C:\TEH2\JL30\EH3JL30.39R ASL Sample ID: K8052-T--75 Sample acquired: JUL 30, 1999 23:24:42

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 9.5 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

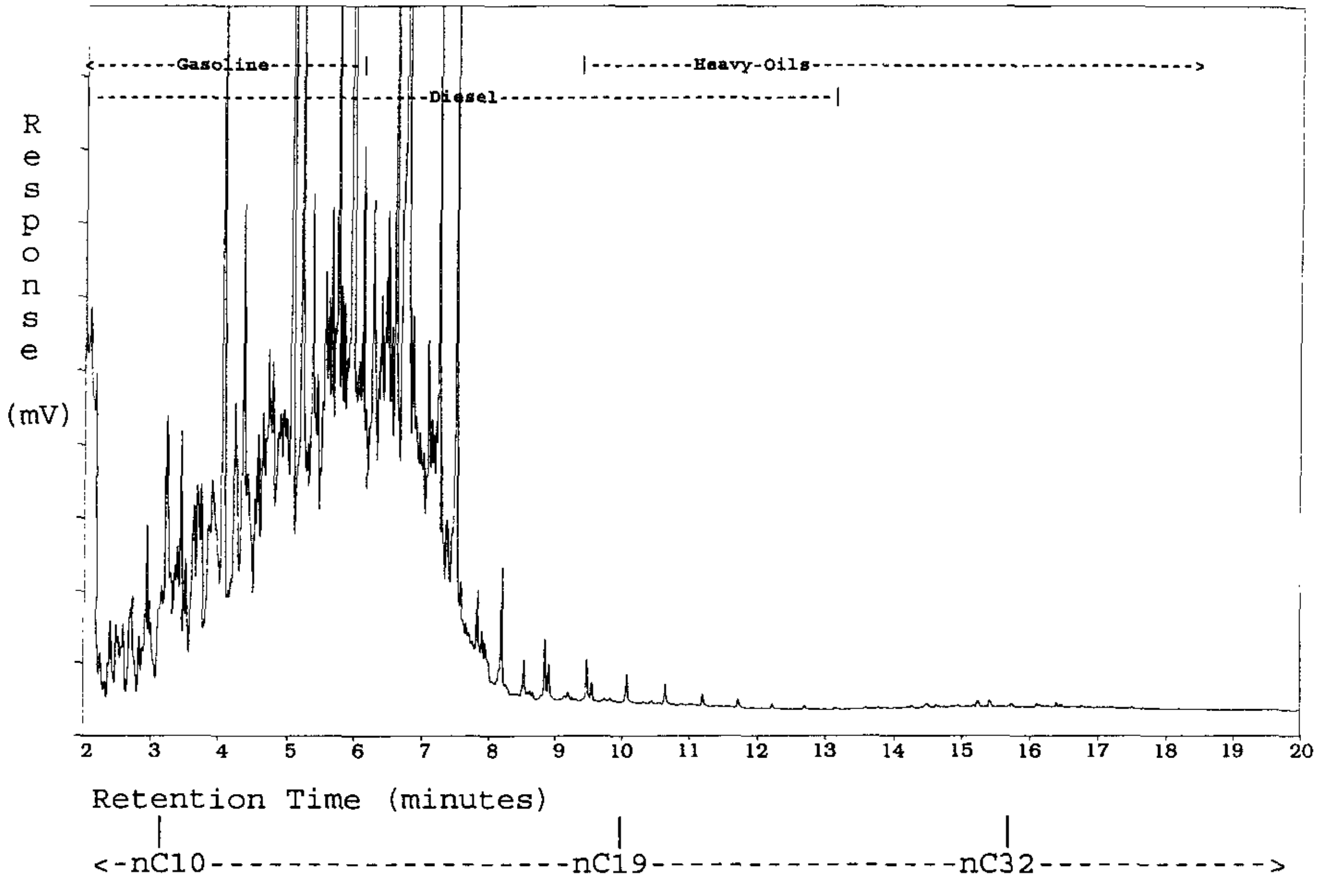
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--78 TP74 0.3-0.6m

File Name: C:\TEH2\JL30\EH3JL30.42R ASL Sample ID: K8052-T--78 Sample acquired: JUL 30, 1999 23:59:56

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.4 Dilution: 8.0

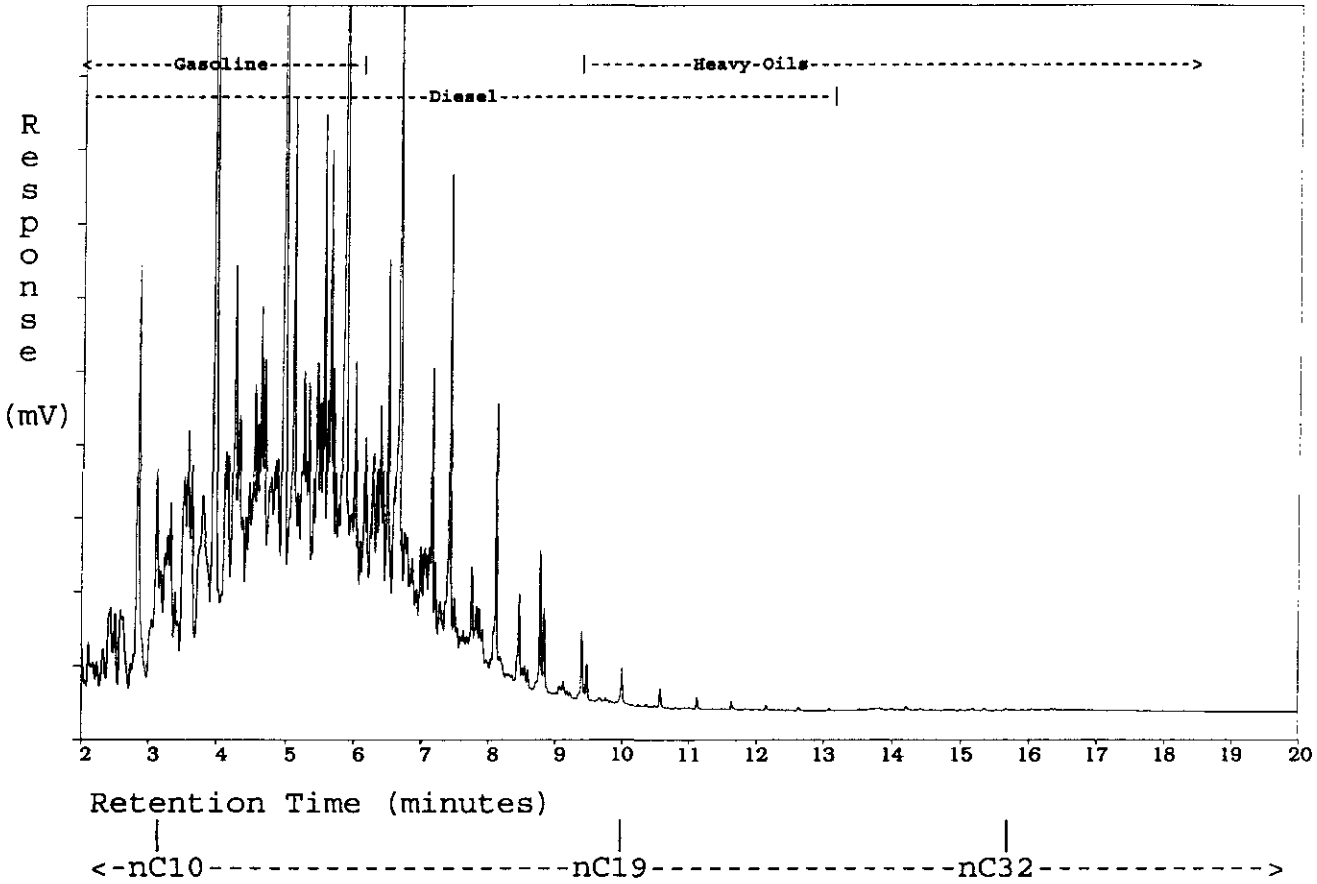
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which 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 with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--79 TP75 0.5-0.8m

File Name: C:\TEH2\JL30\EH3JL30.43R ASL Sample ID: K8052-T--79 Sample acquired: JUL 31, 1999 00:35:09
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.2 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

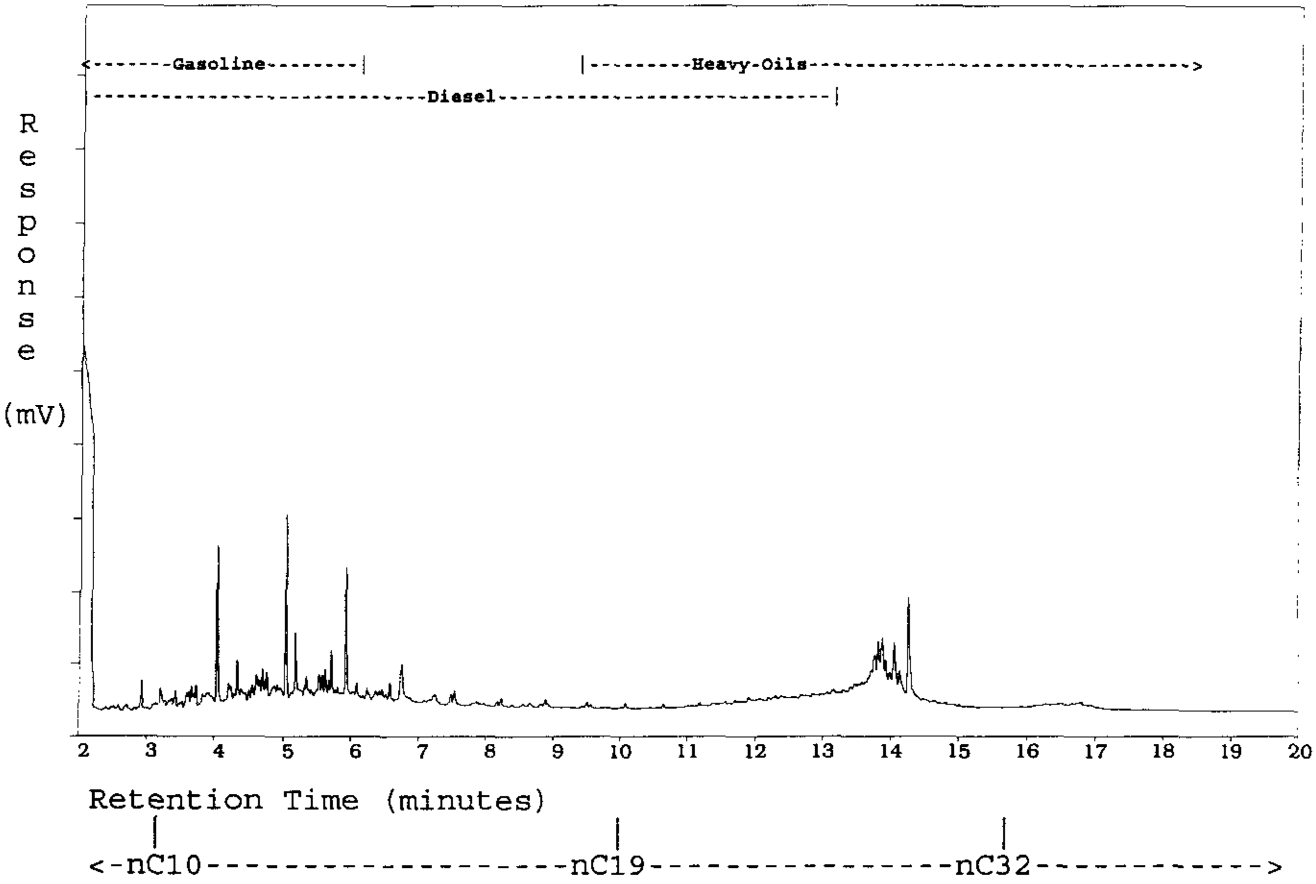
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--81 TP77 0.2-0.3m

File Name: C:\TEH2\JL30\EH3JL30.44R ASL Sample ID: K8052-T--81 Sample acquired: JUL 31, 1999 00:35:09

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.0 *Dilution:* 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

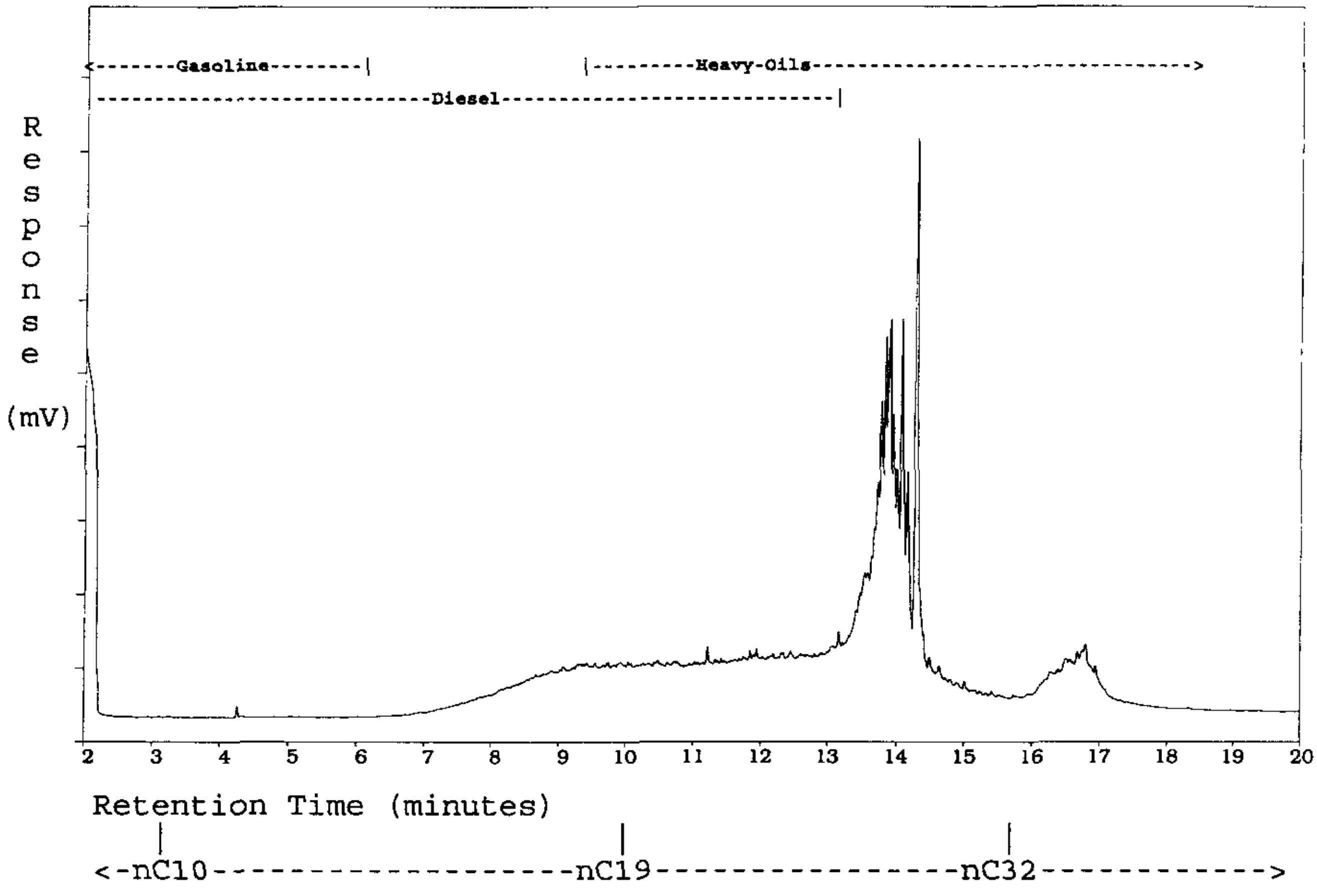
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--85 TP81 0-0.1m

File Name: C:\TEH2\JL30\EH3JL30.48R ASL Sample ID: K8052-T--85 Sample acquired: JUL 31, 1999 01:45:18

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 15.1 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

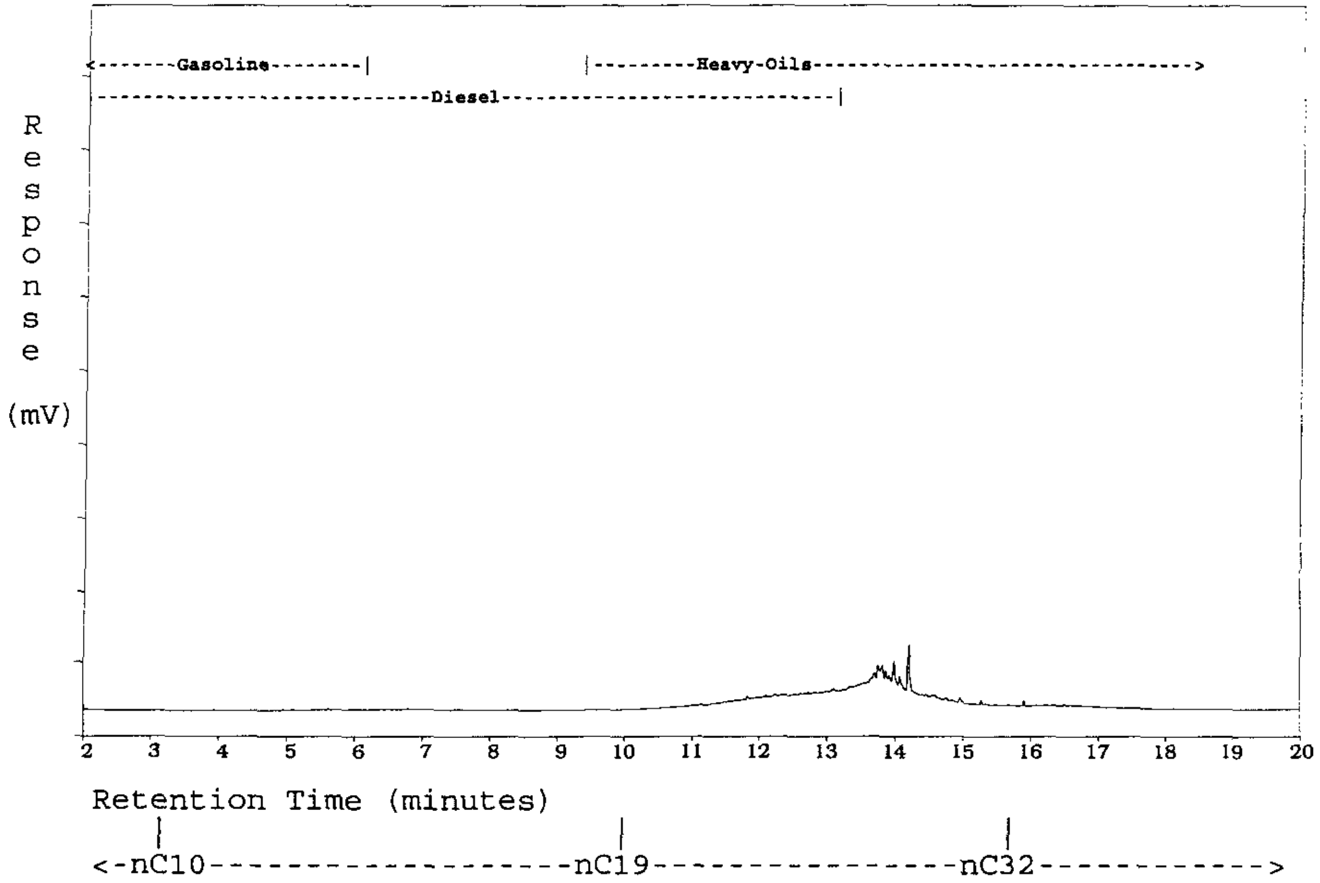
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--86 TP81 0.3-0.6m

File Name: C:\TEH2\JL30\EH3JL30.49R ASL Sample ID: K8052-T--86 Sample acquired: JUL 31, 1999 02:20:24

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 10.8 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

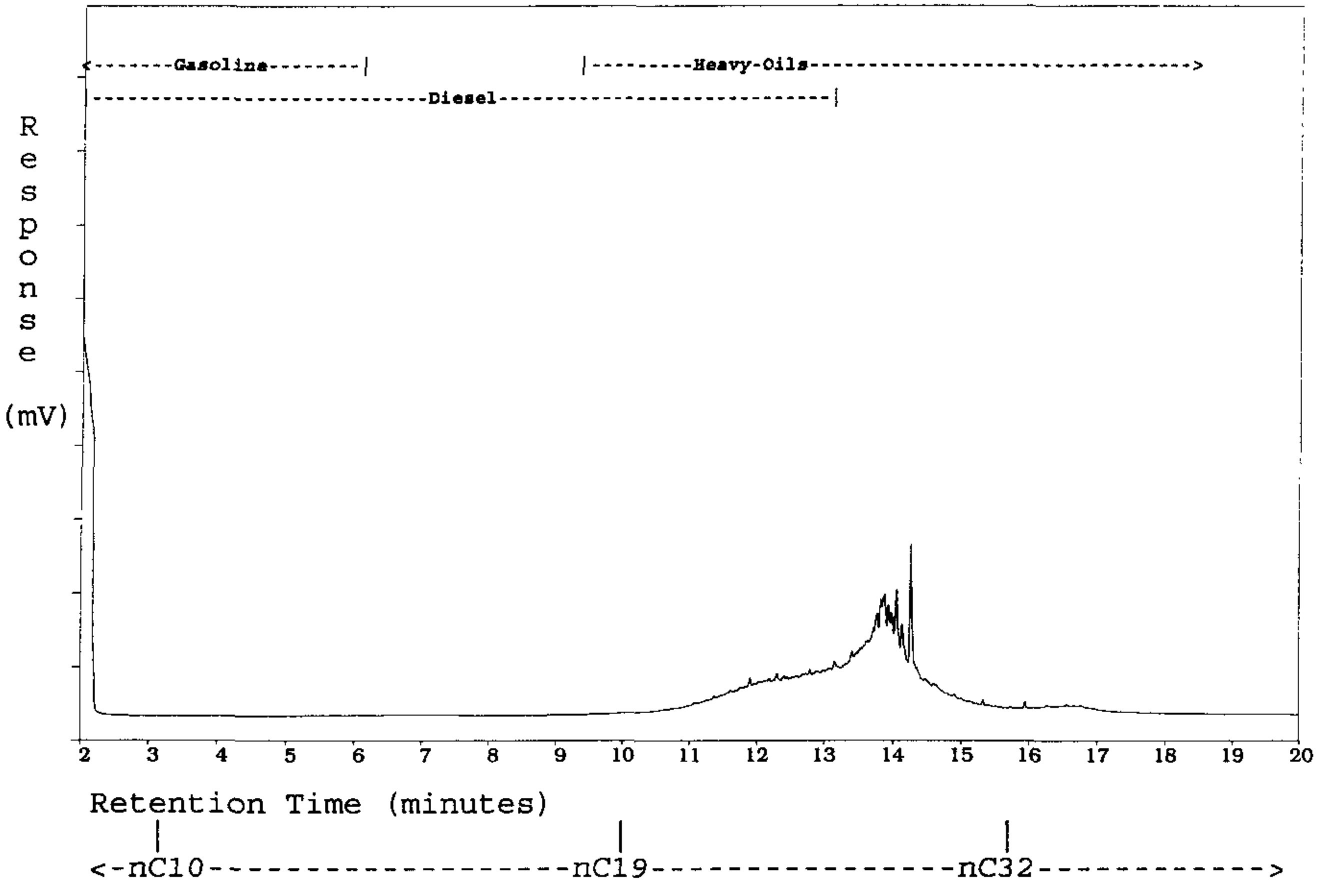
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--87 TP82 0.3-0.6m

File Name: C:\TEH2\JL30\EH3JL30.52R ASL Sample ID: K8052-T--87 Sample acquired: JUL 31, 1999 02:55:34

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 12.7 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

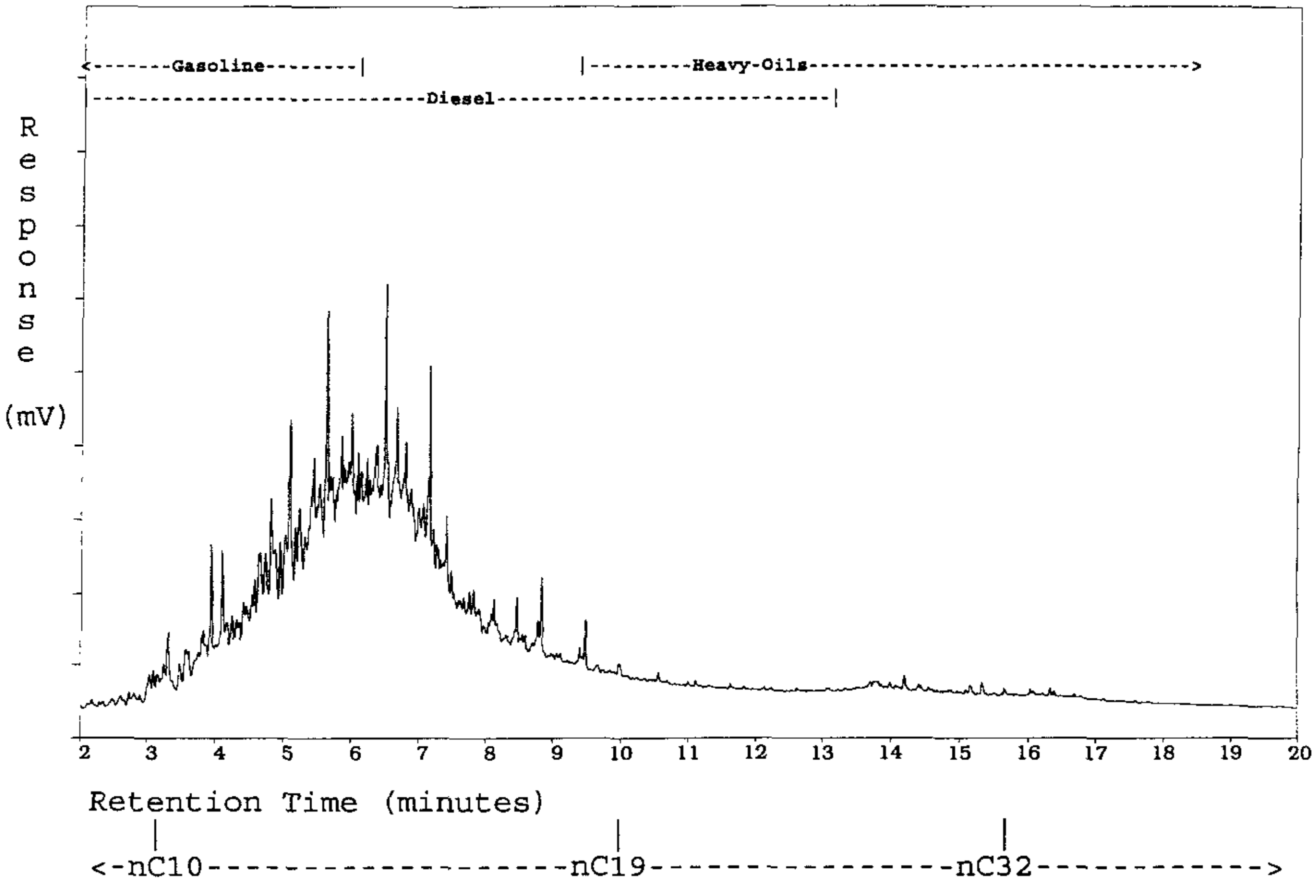
Note: This Hydrocarbon Distribution Report was produced using a temperature profile which was implemented on June 21st, 1999. Under these new conditions hydrocarbon compounds elute sooner than before, although characteristic patterns will appear similar. Please exercise caution when comparing this report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

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--89 TP84 0-0.1m North

File Name: C:\TEH2\JL30\EH3JL30.53R ASL Sample ID: K8052-T--89 Sample acquired: JUL 31, 1999 03:30:44

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 13.7 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

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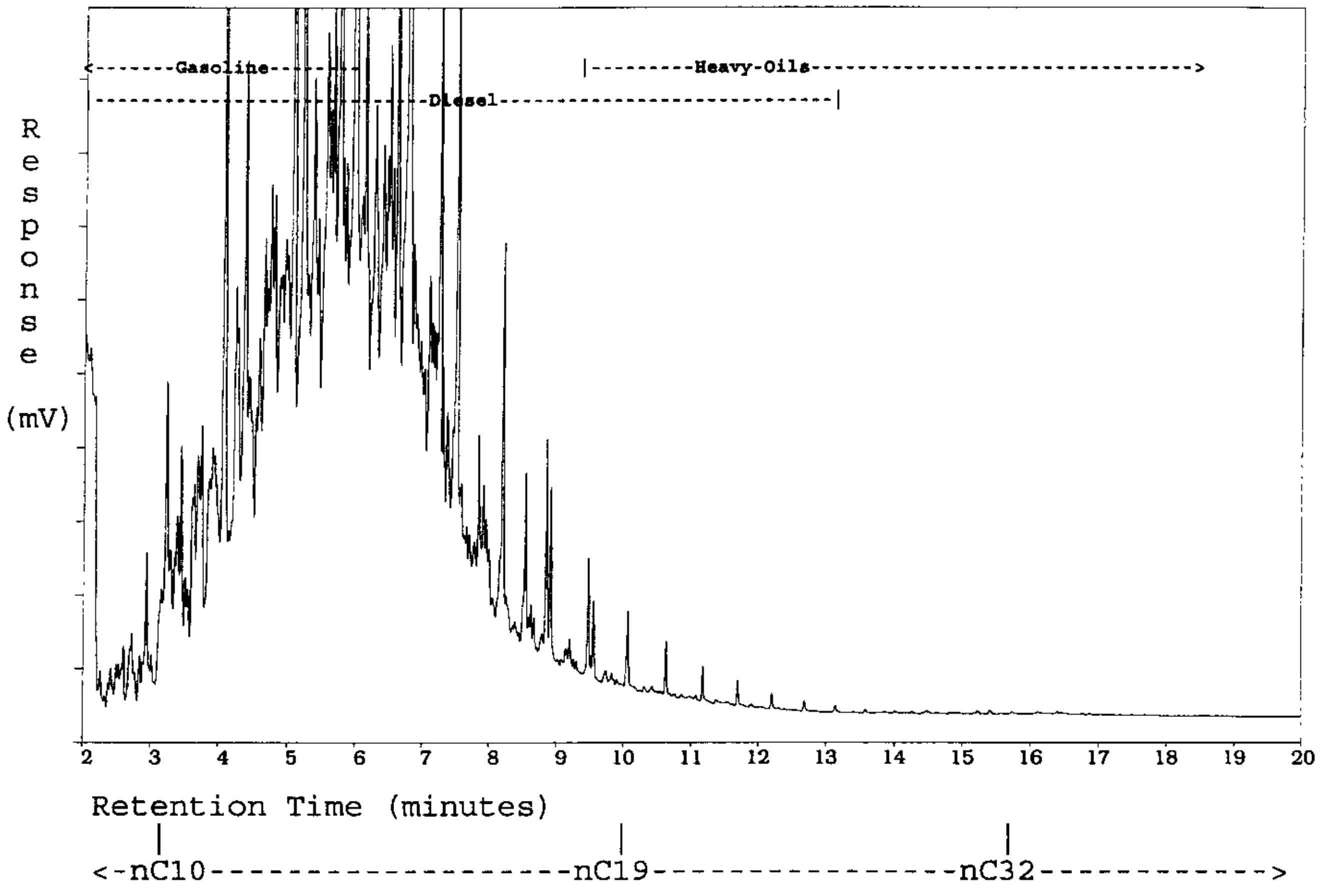
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--91 TP84 0.6-0.9m North

File Name: C:\TEH2\JL30\EH3JL30.54R ASL Sample ID: K8052-T--91 Sample acquired: JUL 31, 1999 03:30:44

Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 9.8 Dilution: 8.0

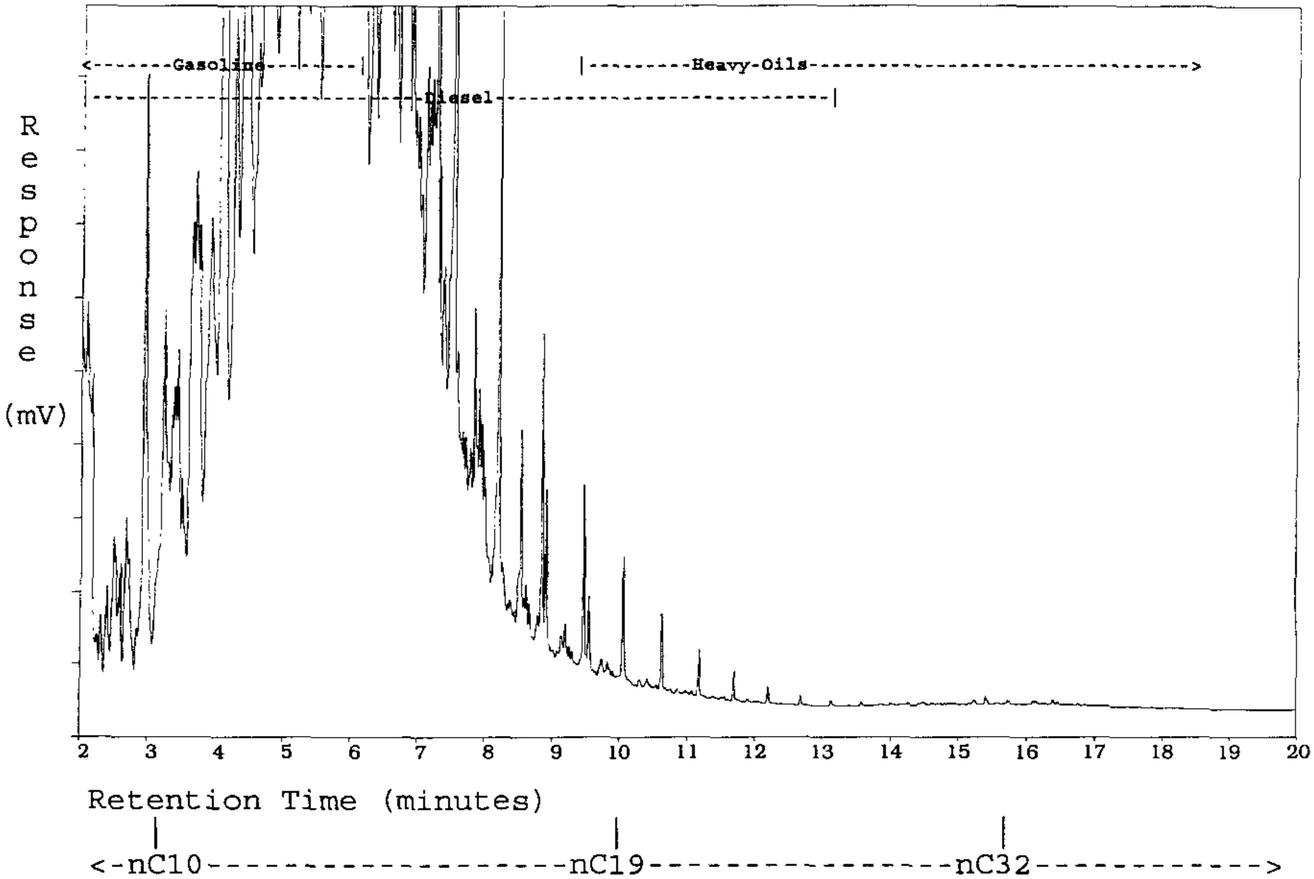
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

Note: This Hydrocarbon Distribution Report was produced using a temperature profile which 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 with reports produced prior to June 21st, 1999. A current library of reference products is available upon request.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K8052-T--95 TP84 0.6-0.9m South

File Name: C:\TEH2\JL30\EH3JL30.56R ASL Sample ID: K8052-T--95 Sample acquired: JUL 31, 1999 04:05:53
Chromatogram Scale: 50.0 millivolts



Sample Amt. (g or mL): 11.3 Dilution: 8.0

The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the top of this report represents the approximate hydrocarbon range of common petroleum products. The scale at the bottom of the report shows retention times with the approximate positions of key marker compounds indicated. Comparison of this report with those of reference standards may also assist in characterizing the hydrocarbons present.

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

JUN 29 1999
GARTNER LEE

CHEMICAL ANALYSIS REPORT

Date:	June 22, 1999
ASL File No.	K6215
Report On:	Soil Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	May 31, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K6215

The detection limits for some of the metals have been increased for several of the samples reported in the following data tables due to high concentrations of metals in the samples.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		TH#1 0-2ft. 99 05 27	TH#1 2-5ft. 99 05 27	TH#2 0-2ft. 99 05 27	TH#2 2-5ft. 99 05 27	TH#3 0-2ft. 99 05 27
Physical Tests						
Moisture	%	2.1	1.4	4.1	6.3	4.5
pH		8.28	-	8.55	-	7.87
Total Metals						
Antimony	T-Sb	<100	-	<100	-	<100
Arsenic	T-As	1.3	-	1.4	-	1.4
Barium	T-Ba	337	-	222	-	262
Beryllium	T-Be	<3	-	<3	-	<3
Cadmium	T-Cd	20.0	-	14.0	-	29
Chromium	T-Cr	<10	-	<10	-	<10
Cobalt	T-Co	<10	-	<10	-	<10
Copper	T-Cu	<5	-	<5	-	17
Lead	T-Pb	1100	-	3210	14900	3730
Mercury	T-Hg	0.014	-	0.020	-	0.013
Molybdenum	T-Mo	<20	-	<20	-	<20
Nickel	T-Ni	<30	-	<30	-	<30
Selenium	T-Se	0.1	-	0.1	-	0.3
Silver	T-Ag	<10	-	<10	-	<10
Tin	T-Sn	<50	-	<50	-	<50
Vanadium	T-V	<10	-	<10	-	<10
Zinc	T-Zn	6980	-	11500	111000	12000
Non-halogenated Volatiles						
Benzene		<0.04	-	-	-	<0.04
Ethylbenzene		<0.05	-	-	-	<0.05
Styrene		<0.05	-	-	-	<0.05
Toluene		<0.05	-	-	-	<0.05
meta- & para-Xylene		<0.05	-	-	-	0.08
ortho-Xylene		<0.05	-	-	-	0.05
Volatile Hydrocarbons (VH) C6-10		<100	-	-	-	<100
VPH C6-10 (calculated)		<100	-	-	-	<100

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		TH#3 2-5ft. 99 05 27	TH#3 5-10ft. 99 05 27	TH#3 10-15ft. 99 05 27	TH#3 20-25ft. 99 05 27	TH#4 0-2ft. 99 05 27
Physical Tests						
Moisture	%	2.6	7.0	6.8	6.2	5.5
pH		-	-	-	-	8.13
Total Metals						
Antimony	T-Sb	-	-	-	-	<100
Arsenic	T-As	-	-	-	-	3.4
Barium	T-Ba	-	-	-	-	255
Beryllium	T-Be	-	-	-	-	<3
Cadmium	T-Cd	-	-	-	-	34
Chromium	T-Cr	-	-	-	-	<10
Cobalt	T-Co	-	-	-	-	<10
Copper	T-Cu	-	-	-	-	24
Lead	T-Pb	2210	-	-	-	17100
Mercury	T-Hg	-	-	-	-	0.038
Molybdenum	T-Mo	-	-	-	-	<20
Nickel	T-Ni	-	-	-	-	<30
Selenium	T-Se	-	-	-	-	0.5
Silver	T-Ag	-	-	-	-	<10
Tin	T-Sn	-	-	-	-	<50
Vanadium	T-V	-	-	-	-	35
Zinc	T-Zn	8860	-	-	-	12500
Non-halogenated Volatiles						
Benzene		<0.04	-	-	-	-
Ethylbenzene		0.12	-	-	-	-
Styrene		<0.05	-	-	-	-
Toluene		<0.05	-	-	-	-
meta- & para-Xylene		1.47	-	-	-	-
ortho-Xylene		1.03	-	-	-	-
Volatile Hydrocarbons (VH) C6-10		251	-	-	-	-
VPH C6-10 (calculated)		248	-	-	-	-

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VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		TH#4 2-5ft. 99 05 27	TH#4 10-15ft. 99 05 27	BH#2 0-2ft. 99 05 26	BH#2 2-5ft. 99 05 26	BH#2 5-10ft. 99 05 26
Physical Tests						
Moisture	%	6.6	1.9	3.5	1.3	0.5
pH		-	-	8.91	-	-
Total Metals						
Antimony	T-Sb	-	-	<100	-	-
Arsenic	T-As	-	-	1.9	-	-
Barium	T-Ba	-	-	373	-	-
Beryllium	T-Be	-	-	<3	-	-
Cadmium	T-Cd	-	-	8.9	-	-
Chromium	T-Cr	-	-	<10	-	-
Cobalt	T-Co	-	-	<10	-	-
Copper	T-Cu	-	-	5	-	-
Lead	T-Pb	11100	-	876	39	-
Mercury	T-Hg	-	-	0.016	-	-
Molybdenum	T-Mo	-	-	<20	-	-
Nickel	T-Ni	-	-	<30	-	-
Selenium	T-Se	-	-	0.2	-	-
Silver	T-Ag	-	-	<10	-	-
Tin	T-Sn	-	-	<50	-	-
Vanadium	T-V	-	-	12	-	-
Zinc	T-Zn	5140	-	4020	130	-

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VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil File No. K6215

		BH#3 0-2ft.	BH#3 2-5ft.	BH#3 10-15ft.	BH#5 0-2ft.	BH#5 2-5ft.
		99 05 26	99 05 26	99 05 26	99 05 26	99 05 26
Physical Tests						
Moisture	%	4.3	2.9	2.9	5.1	6.9
pH		8.48	-	-	8.81	-
Total Metals						
Antimony	T-Sb	<100	-	-	<80	-
Arsenic	T-As	2.8	-	-	1.8	-
Barium	T-Ba	168	-	-	259	-
Beryllium	T-Be	<3	-	-	<2	-
Cadmium	T-Cd	9.3	-	-	4.9	-
Chromium	T-Cr	<10	-	-	<8	-
Cobalt	T-Co	<10	-	-	<8	-
Copper	T-Cu	8	-	-	<4	-
Lead	T-Pb	1060	158	-	659	412
Mercury	T-Hg	0.032	-	-	0.016	-
Molybdenum	T-Mo	<20	-	-	<20	-
Nickel	T-Ni	<30	-	-	<20	-
Selenium	T-Se	0.5	-	-	0.1	-
Silver	T-Ag	<10	-	-	<8	-
Tin	T-Sn	<50	-	-	<40	-
Vanadium	T-V	33	-	-	8	-
Zinc	T-Zn	3920	189	-	1850	1200

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		BH#5 10-12ft. 99 05 26	BH#6 0-2ft. 99 05 26	BH#6 2-5ft. 99 05 26	BH#6 5-10ft. 99 05 26	BH#6 10-12ft. 99 05 26
Physical Tests						
Moisture	%	12.8	2.9	8.1	7.3	9.3
pH		-	8.72	-	-	-
Total Metals						
Antimony	T-Sb	-	<200	-	-	-
Arsenic	T-As	-	2.7	-	-	-
Barium	T-Ba	-	401	-	-	-
Beryllium	T-Be	-	<4	-	-	-
Cadmium	T-Cd	-	0.7	-	-	-
Chromium	T-Cr	-	<20	-	-	-
Cobalt	T-Co	-	<20	-	-	-
Copper	T-Cu	-	<7	-	-	-
Lead	T-Pb	-	<400	19	-	-
Mercury	T-Hg	-	0.020	-	-	-
Molybdenum	T-Mo	-	<30	-	-	-
Nickel	T-Ni	-	<40	-	-	-
Selenium	T-Se	-	0.2	-	-	-
Silver	T-Ag	-	<20	-	-	-
Tin	T-Sn	-	<70	-	-	-
Vanadium	T-V	-	<20	-	-	-
Zinc	T-Zn	-	278	43	-	-
Non-halogenated Volatiles						
Benzene		-	-	<0.04	-	-
Ethylbenzene		-	-	<0.05	-	-
Styrene		-	-	<0.05	-	-
Toluene		-	-	<0.05	-	-
meta- & para-Xylene		-	-	0.33	-	-
ortho-Xylene		-	-	0.32	-	-
Volatile Hydrocarbons (VH) C6-10		-	-	190	-	-
VPH C6-10 (calculated)		-	-	189	-	-

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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VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		BH#8 0-2ft.	BH#8 2-5ft.	BH#8 5-10ft.	BH#8 10-12ft.	BH#10 0-2ft.
		99 05 26	99 05 26	99 05 26	99 05 26	99 05 26
Physical Tests						
Moisture	%	7.2	7.9	6.7	6.6	4.5
pH		8.48	-	-	-	8.54
Total Metals						
Antimony	T-Sb	<100	-	-	-	<100
Arsenic	T-As	4.6	-	-	-	<0.4
Barium	T-Ba	159	-	-	-	295
Beryllium	T-Be	<3	-	-	-	<3
Cadmium	T-Cd	23.6	-	-	-	3.6
Chromium	T-Cr	<10	-	-	-	<10
Cobalt	T-Co	<10	-	-	-	<10
Copper	T-Cu	16	-	-	-	6
Lead	T-Pb	2870	1750	-	-	1120
Mercury	T-Hg	0.058	-	-	-	0.026
Molybdenum	T-Mo	<20	-	-	-	<20
Nickel	T-Ni	<30	-	-	-	<30
Selenium	T-Se	0.8	-	-	-	0.3
Silver	T-Ag	<10	-	-	-	<10
Tin	T-Sn	<50	-	-	-	<50
Vanadium	T-V	54	-	-	-	20
Zinc	T-Zn	9270	6120	-	-	1930
Non-halogenated Volatiles						
Benzene		<0.04	<0.04	-	-	-
Ethylbenzene		<0.05	<0.05	-	-	-
Styrene		<0.05	<0.05	-	-	-
Toluene		<0.05	<0.05	-	-	-
meta- & para-Xylene		0.07	<0.05	-	-	-
ortho-Xylene		<0.05	<0.05	-	-	-
Volatile Hydrocarbons (VH) C6-10		117	157	-	-	-
VPH C6-10 (calculated)		117	157	-	-	-

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

		BH#10 2-5ft. 99 05 26	BH#10 10-15ft. 99 05 26
Physical Tests			
Moisture	%	3.6	6.9
Total Metals			
Lead	T-Pb	488	-
Zinc	T-Zn	24800	-

Remarks regarding the analyses appear at the beginning of this report.
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VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

	TH#1 0-2ft. 99 05 27	TH#1 2-5ft. 99 05 27	TH#2 0-2ft. 99 05 27	TH#2 2-5ft. 99 05 27	TH#3 0-2ft. 99 05 27
Extractables					
EPH (C10-18)	666	470	<200	<200	599
EPH (C19-31)	1560	206	<200	284	522

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RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

	TH#3 2-5ft. 99 05 27	TH#3 5-10ft. 99 05 27	TH#3 10-15ft. 99 05 27	TH#3 20-25ft. 99 05 27	TH#4 0-2ft. 99 05 27
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.3	-	-	-	-
Acenaphthylene	0.07	-	-	-	-
Anthracene	0.03	-	-	-	-
Benz(a)anthracene	<0.01	-	-	-	-
Benzo(a)pyrene	<0.01	-	-	-	-
Benzo(b)fluoranthene	<0.01	-	-	-	-
Benzo(g,h,i)perylene	<0.01	-	-	-	-
Benzo(k)fluoranthene	<0.01	-	-	-	-
Chrysene	<0.01	-	-	-	-
Dibenz(a,h)anthracene	<0.01	-	-	-	-
Fluoranthene	<0.01	-	-	-	-
Fluorene	0.19	-	-	-	-
Indeno(1,2,3-c,d)pyrene	<0.01	-	-	-	-
Naphthalene	1.11	-	-	-	-
Phenanthrene	0.24	-	-	-	-
Pyrene	0.02	-	-	-	-
Extractables					
EPH (C10-18)	2530	1520	<200	<200	<200
EPH (C19-31)	<200	<200	<200	<200	320

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

	TH#4 2-5ft. 99 05 27	TH#4 10-15ft. 99 05 27	BH#2 5-10ft. 99 05 26	BH#3 0-2ft. 99 05 26	BH#3 2-5ft. 99 05 26
Extractables					
EPH (C10-18)	<200	<200	<200	<200	<200
EPH (C19-31)	<200	<200	<200	545	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

	BH#3 10-15ft.	BH#5 0-2ft.	BH#5 2-5ft.	BH#5 10-12ft.	BH#6 0-2ft.
	99 05 26	99 05 26	99 05 26	99 05 26	99 05 26
Extractables					
EPH (C10-18)	<200	<200	<200	<200	<200
EPH (C19-31)	<200	633	331	<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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil

File No. K6215

	BH#6 2-5ft. 99 05 26	BH#6 5-10ft. 99 05 26	BH#6 10-12ft. 99 05 26	BH#8 0-2ft. 99 05 26	BH#8 2-5ft. 99 05 26
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.3	-	-	<0.2	-
Acenaphthylene	<0.2	-	-	0.05	-
Anthracene	0.08	-	-	0.10	-
Benz(a)anthracene	0.02	-	-	0.03	-
Benzo(a)pyrene	<0.01	-	-	0.02	-
Benzo(b)fluoranthene	0.01	-	-	0.05	-
Benzo(g,h,i)perylene	<0.01	-	-	0.03	-
Benzo(k)fluoranthene	<0.01	-	-	0.01	-
Chrysene	0.02	-	-	0.04	-
Dibenz(a,h)anthracene	<0.01	-	-	<0.01	-
Fluoranthene	0.07	-	-	0.10	-
Fluorene	0.23	-	-	0.41	-
Indeno(1,2,3-c,d)pyrene	<0.01	-	-	0.02	-
Naphthalene	1.19	-	-	0.65	-
Phenanthrene	0.26	-	-	0.43	-
Pyrene	0.06	-	-	0.12	-
Extractables					
EPH (C10-18)	3250	<200	<200	4170	3830
EPH (C19-31)	431	292	<200	451	431

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.
VPH = Volatile Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil File No. K6215

	BH#8 5-10ft. 99 05 26	BH#8 10-12ft. 99 05 26	BH#10 0-2ft. 99 05 26	BH#10 2-5ft. 99 05 26	BH#10 10-15ft. 99 05 26
Extractables					
EPH (C10-18)	3980	1960	<200	<200	<200
EPH (C19-31)	457	243	<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K6215

Sediment/Soil		**TH#2 0-2ft.** 99 05 27	**TH#2 0-2ft.** QC # 159263
Physical Tests			
Moisture	%	4.1	4.3
pH		8.55	8.48
Total Metals			
Antimony	T-Sb	<100	<100
Arsenic	T-As	1.4	1.2
Barium	T-Ba	222	240
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	14.0	15.4
Chromium	T-Cr	<10	<10
Cobalt	T-Co	<10	<10
Copper	T-Cu	<5	<5
Lead	T-Pb	3210	8400
Mercury	T-Hg	0.020	0.015
Molybdenum	T-Mo	<20	<20
Nickel	T-Ni	<30	<30
Selenium	T-Se	0.1	<0.1
Silver	T-Ag	<10	<10
Tin	T-Sn	<50	<50
Vanadium	T-V	<10	<10
Zinc	T-Zn	11500	14000
Extractables			
EPH (C10-18)		<200	<200
EPH (C19-31)		<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K6215

Sediment/Soil	**TH#4 10-15ft.**	**TH#4 10-15ft.**
	99 05 27	QC # 159265
Physical Tests		
Moisture %	1.9	2.1
Extractables		
EPH (C10-18)	<200	<200
EPH (C19-31)	<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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K6215

Sediment/Soil		BH#8 0-2ft. 99 05 26	BH#8 0-2ft. QC # 159266
Physical Tests			
Moisture	%	7.2	6.3
pH		8.48	8.40
Total Metals			
Antimony	T-Sb	<100	<100
Arsenic	T-As	4.6	4.7
Barium	T-Ba	159	183
Beryllium	T-Be	<3	<3
Cadmium	T-Cd	23.6	21.7
Chromium	T-Cr	<10	<10
Cobalt	T-Co	<10	<10
Copper	T-Cu	16	15
Lead	T-Pb	2870	2500
Mercury	T-Hg	0.058	0.055
Molybdenum	T-Mo	<20	<20
Nickel	T-Ni	<30	<30
Selenium	T-Se	0.8	0.7
Silver	T-Ag	<10	<10
Tin	T-Sn	<50	<50
Vanadium	T-V	54	65
Zinc	T-Zn	9270	8430

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.
VPH = Volatile Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

Sediment/Soil	**BH#8** **0-2ft.** 99 05 26	**BH#8** **0-2ft.** QC # 159266
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	<0.2	<0.2
Acenaphthylene	0.05	0.05
Anthracene	0.10	0.07
Benz(a)anthracene	0.03	0.02
Benzo(a)pyrene	0.02	0.01
Benzo(b)fluoranthene	0.05	0.03
Benzo(g,h,i)perylene	0.03	0.02
Benzo(k)fluoranthene	0.01	<0.01
Chrysene	0.04	0.03
Dibenz(a,h)anthracene	<0.01	<0.01
Fluoranthene	0.10	0.06
Fluorene	0.41	0.37
Indeno(1,2,3-c,d)pyrene	0.02	0.01
Naphthalene	0.65	0.67
Phenanthrene	0.43	0.35
Pyrene	0.12	0.09
Extractables		
EPH (C10-18)	4170	3900
EPH (C19-31)	451	446

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.
VPH = Volatile 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"

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"

Volatile Organic Compounds in Sediment/Soil

This analysis is based on United States Environmental Protection Agency Methods 5035, 8260/8021 and British Columbia Ministry of Environment, Lands and Parks Method "Volatile Hydrocarbons in Solids by GC/FID ". The procedure involves a 1:2 extraction of the sediment/soil sample with methanol. Aliquots of the methanol extract are then analyzed by capillary column gas chromatography with mass spectrometric, and/or photo-ionization/flame-ionization detection.

Volatile Petroleum Hydrocarbons (VPH) in Sediment/Soil

Volatile Petroleum Hydrocarbons (VPH) is a calculation defined by British Columbia Ministry of Environment, Lands and Parks (BCMELP) Draft Method "Calculation of Volatile Petroleum Hydrocarbons in Solids or Water", June 1998. The concentrations of specific Monocyclic Aromatic Hydrocarbons (Benzene, Toluene, Ethylbenzene, Xylenes and Styrene) are subtracted from the collective concentration of Volatile Hydrocarbons (VH) that elute between n-hexane (nC6) and n-decane (nC10). Analysis of Volatile Hydrocarbons adheres to all prescribed elements of BCMELP method "Volatile Hydrocarbons in Solid", June 1998.

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from U.S. EPA Methods 3500/8015 (Publ. # SW-846 3rd ed., Washington, DC 20460) and British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Soil by GC/FID" (January 1996) The procedure involves a hexane/acetone solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Method 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. A portion of the extract is exchanged to toluene, cleaned, and analysed by capillary column gas chromatography with mass spectrometric detection.

End of Report

APPENDIX

HYDROCARBON DISTRIBUTION REPORTS

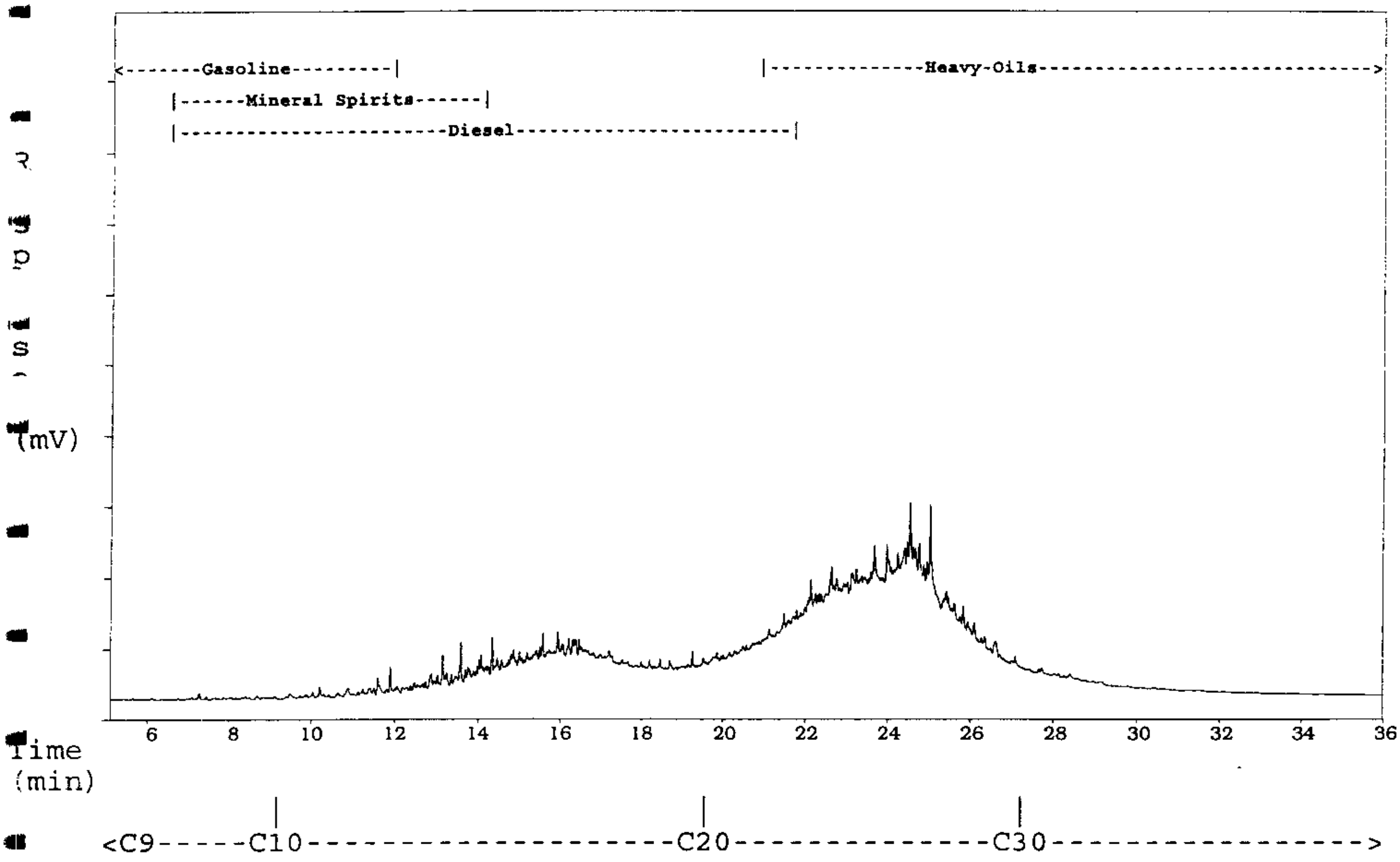
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--1** TH#1 0-2ft.

Sample acquired: JUN 8, 1999 02:40:44 Sequence File: EH3JUN07

File Name: C:\TEH2\JUN07\EH3JUN07.44R , Sample Name: K6215-T--1 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--1* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

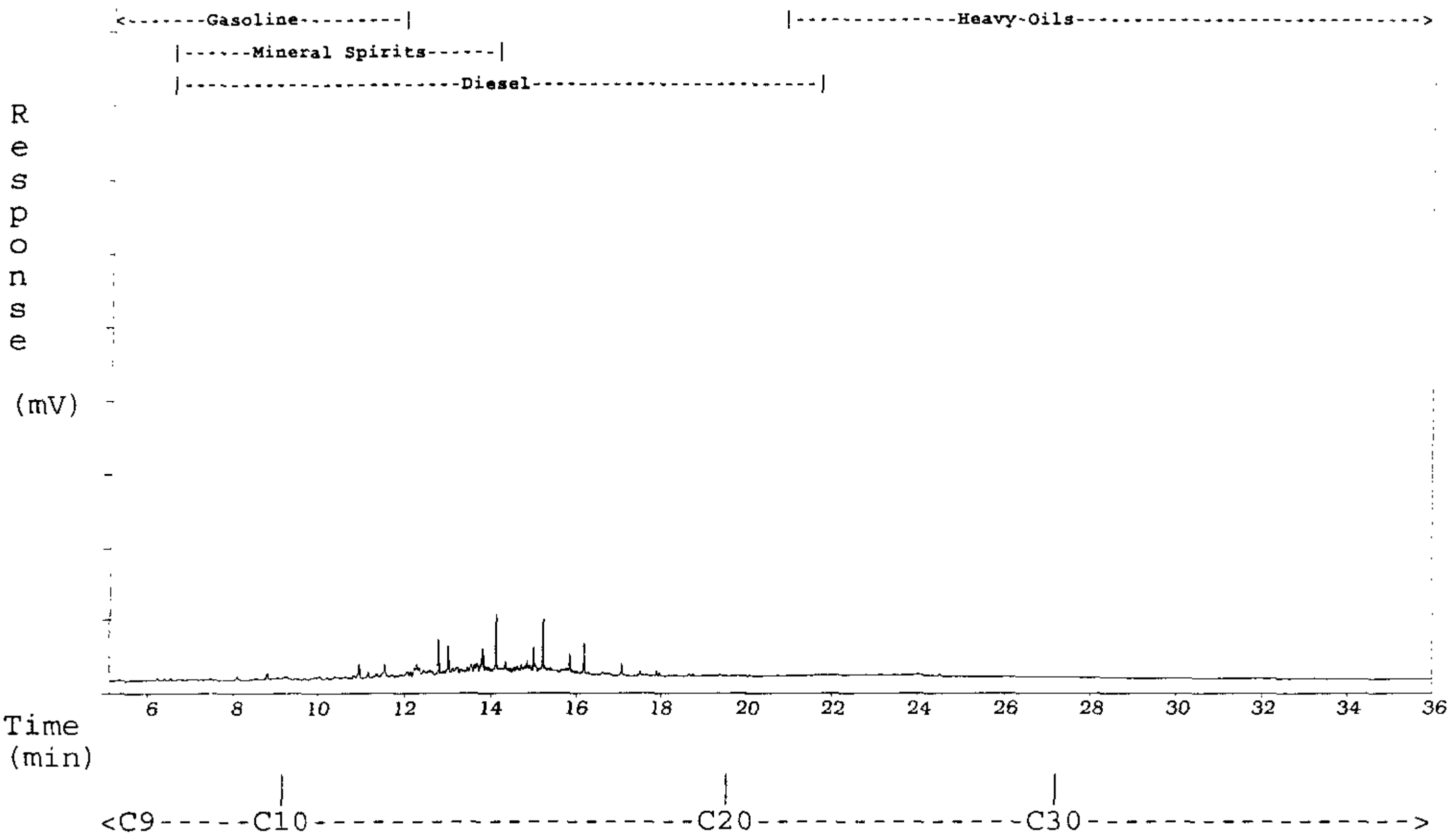
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K6215-T--2 TH#1 2-5ft.

Sample acquired: JUN 6, 1999 05:18:38 Sequence File: EH3JUN04

File Name: C:\TEH2\JUN04\EH3JUN04.99R , Sample Name: K6215-T--2 99 05 27

Chromatogram Scale: 100.0 millivolts



ASL Sample ID: K6215-T--2* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

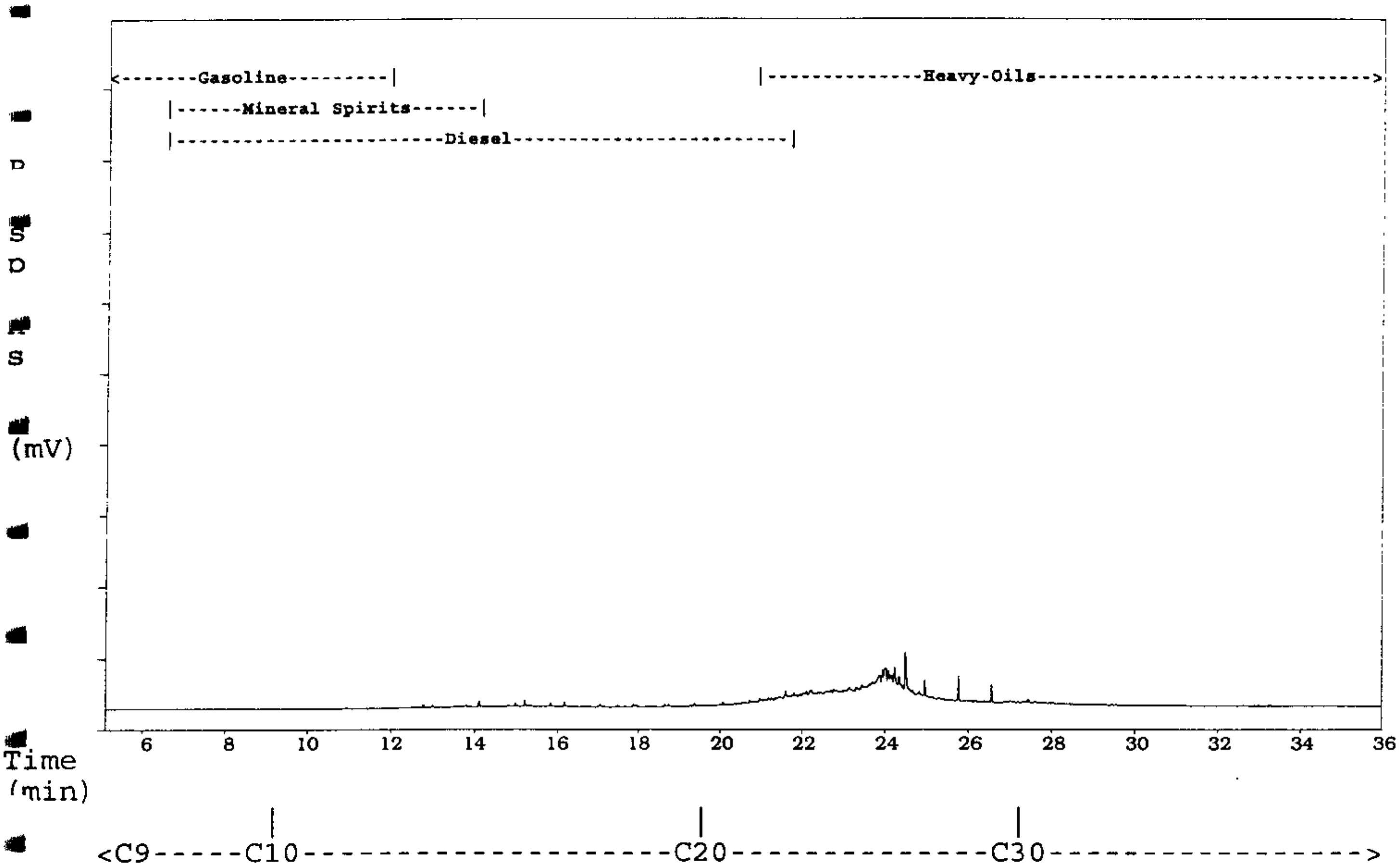
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--8** TH#2 2-5ft.

Sample acquired: JUN 8, 1999 05:21:34 Sequence File: EH3JUN07

File Name: C:\TEH2\JUN07\EH3JUN07.49R , Sample Name: K6215-T--8 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--8* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

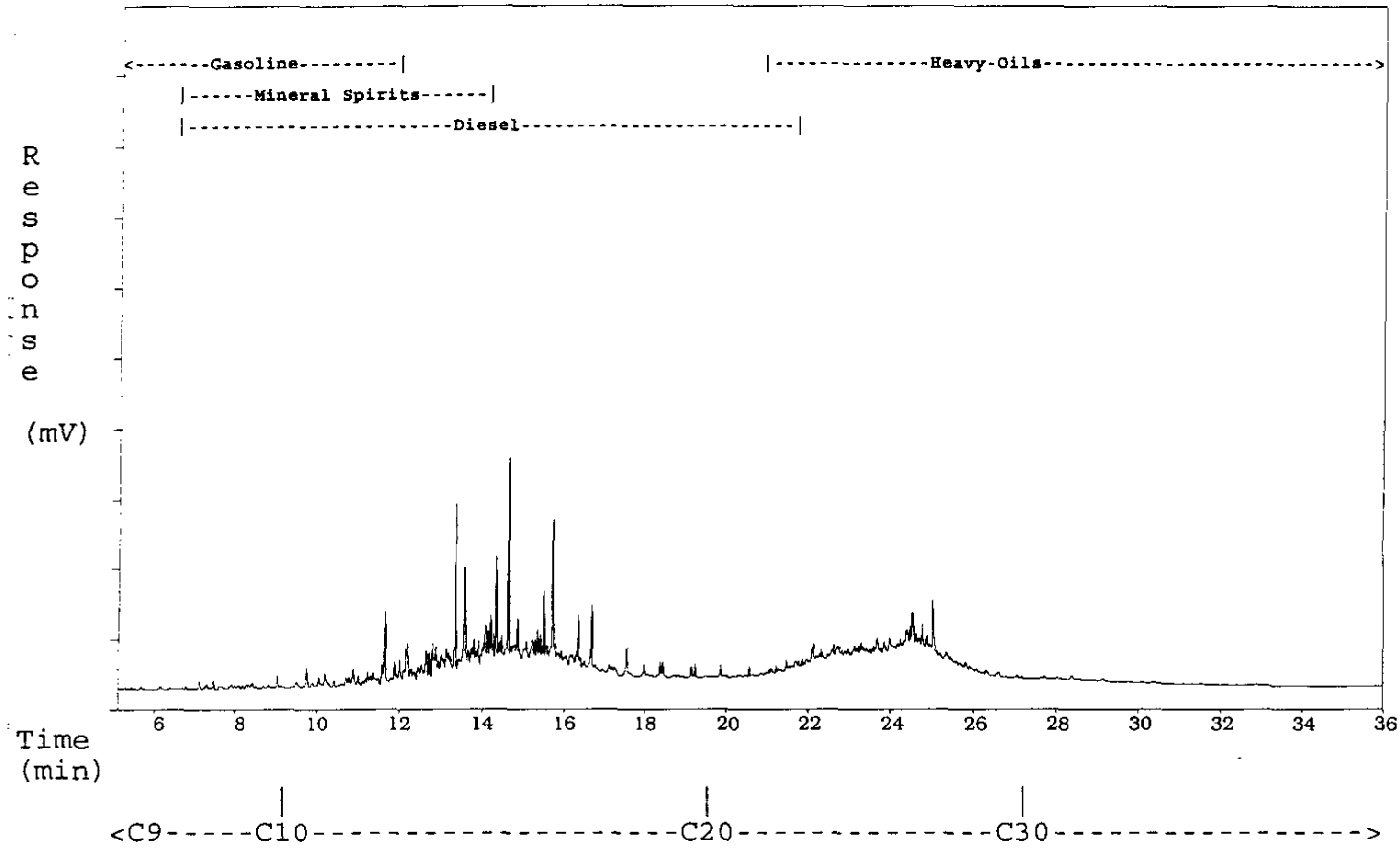
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K6215-T--13 TH#3 0-2ft.

Sample acquired: JUN 8, 1999 05:21:34 Sequence File: EH3JUN07

File Name: C:\TEH2\JUN07\EH3JUN07.50R , Sample Name: K6215-T--13 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--13* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

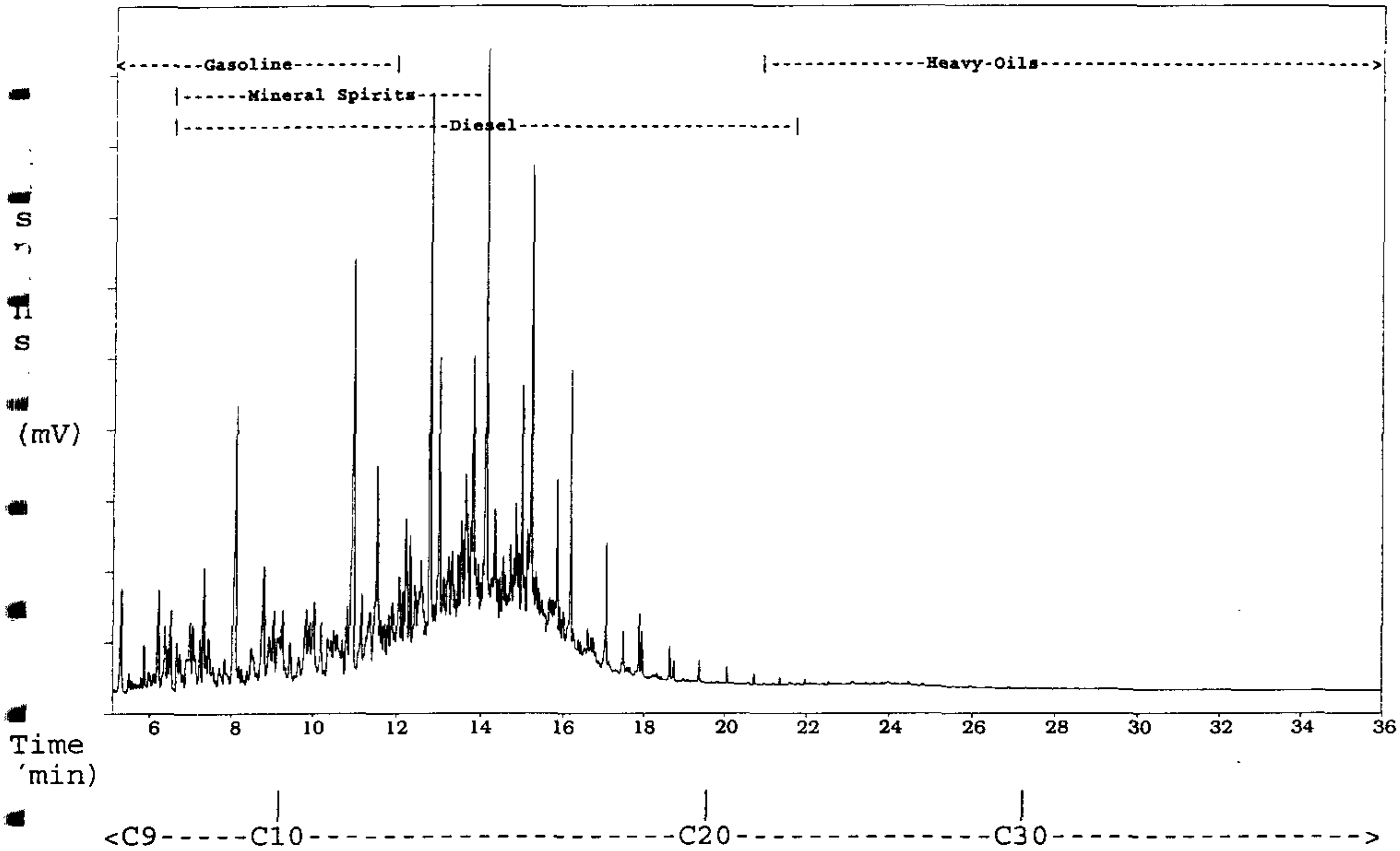
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--14** TH#3 2-5ft.

Sample acquired: JUN 8, 1999 06:15:20 Sequence File: EH3JUN07

File Name: C:\TEH2\JUN07\EH3JUN07.51R , Sample Name: K6215-T--14 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--14* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

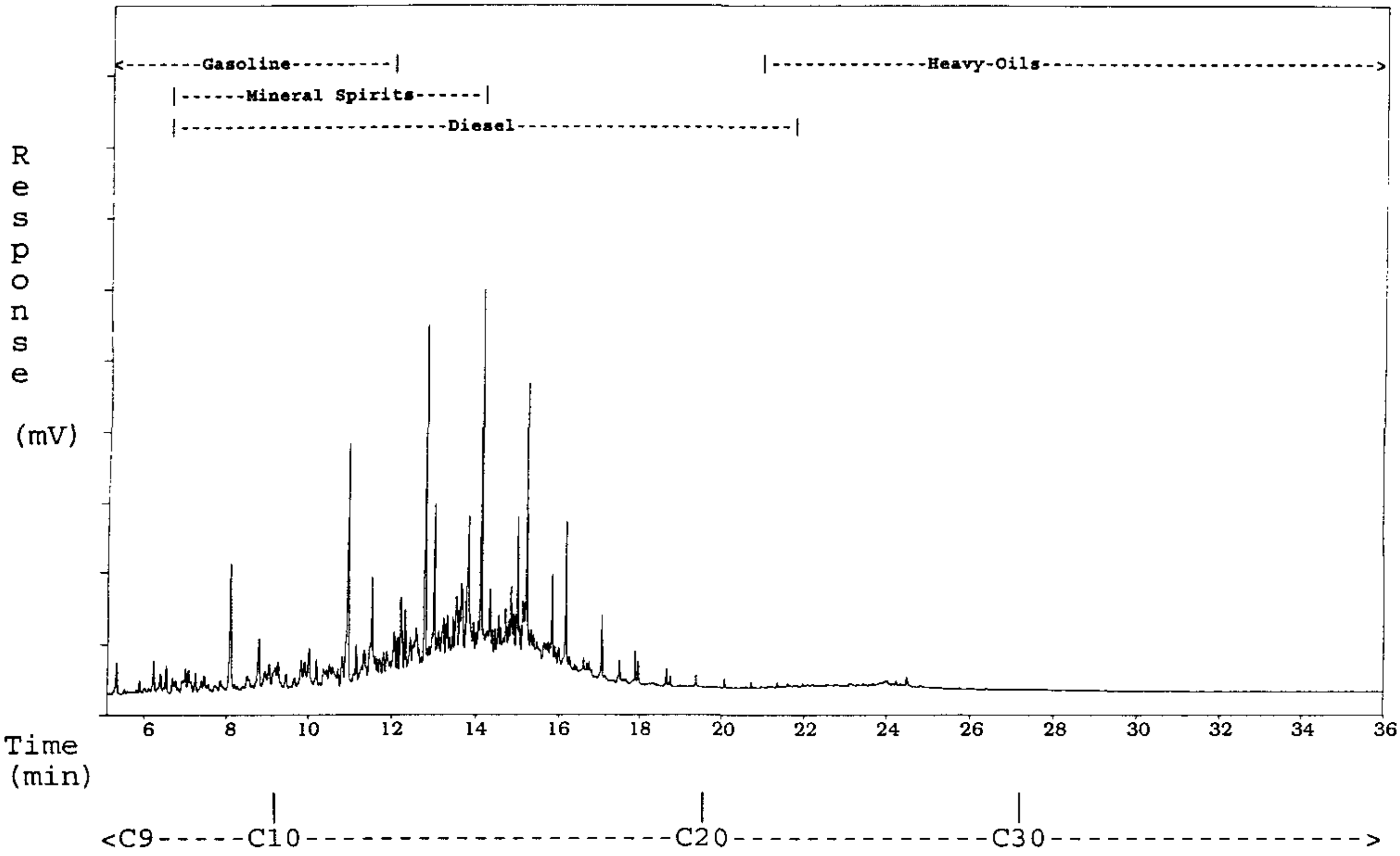
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--15** TH#3 5-10ft.

Sample acquired: JUN 16, 1999 12:48:51 Sequence File: EH3JN16

File Name: C:\TEH2\JN16\EH3JN16.07R , Sample Name: K6215-T--15 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--15* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

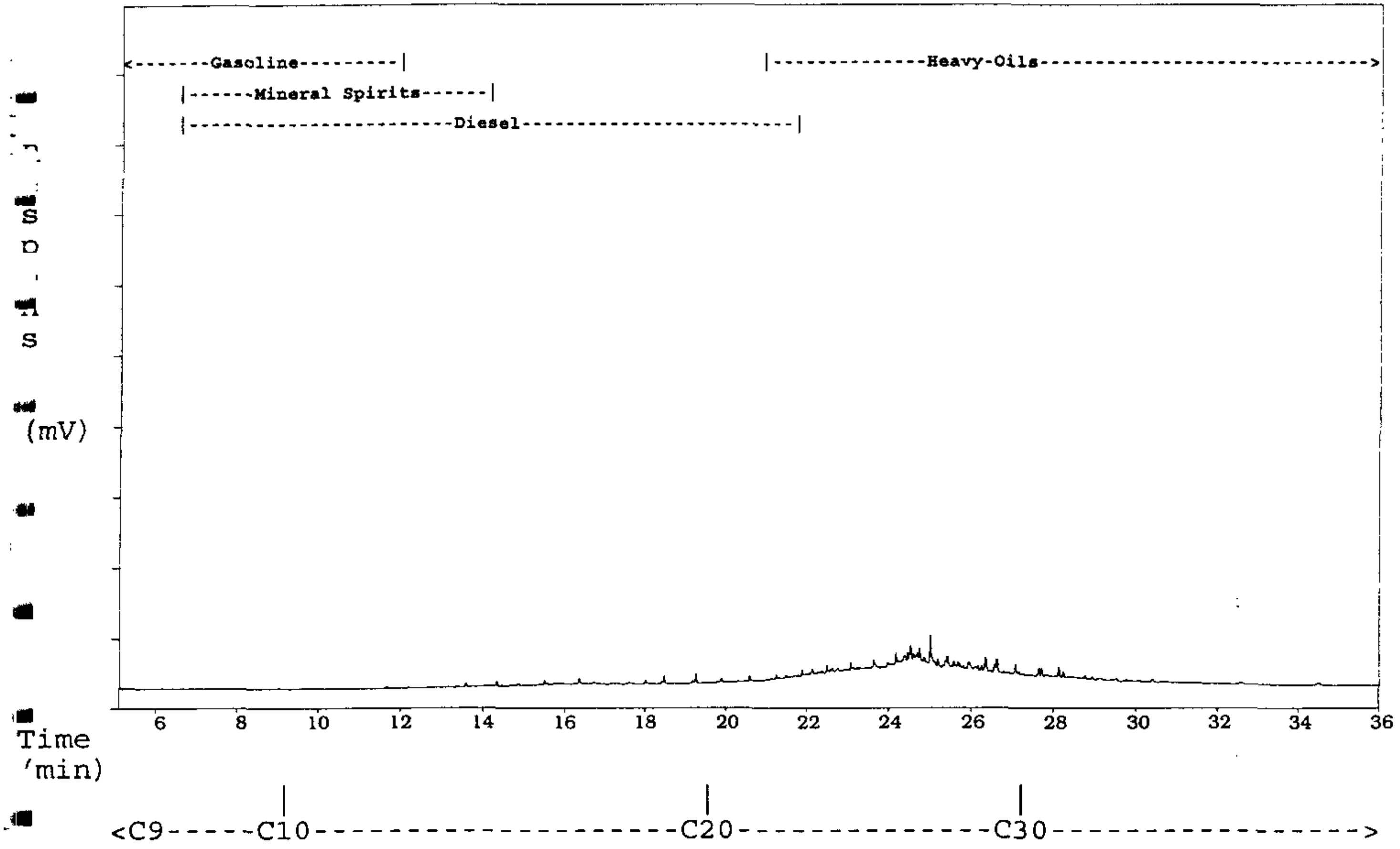
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--19** TH#4 0-2ft.

Sample acquired: JUN 8, 1999 07:09:06 Sequence File: EH3JUN07

File Name: C:\TEH2\JUN07\EH3JUN07.54R , Sample Name: K6215-T--19 99 05 27

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--19* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

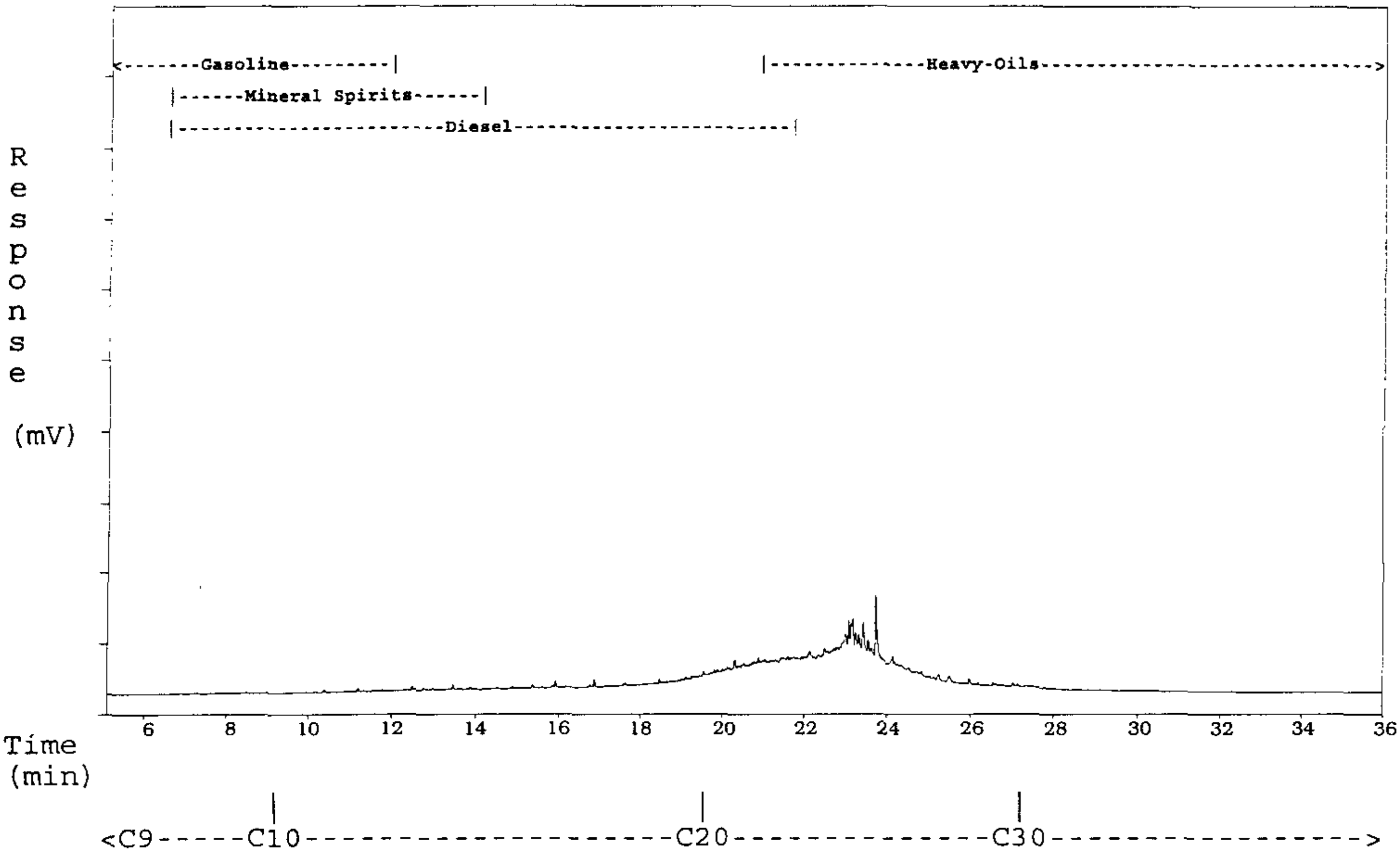
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--29** BH#3 0-2ft.

Sample acquired: JUN 8, 1999 02:43:25 Sequence File: EH1JUN07

File Name: C:\TEH\JUN07\EH1JUN07.36R , Sample Name: K6215-T--29 99 05 26

Chromatogram Scale: 50.0 **millivolts**



ASL Sample ID: K6215-T--29* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

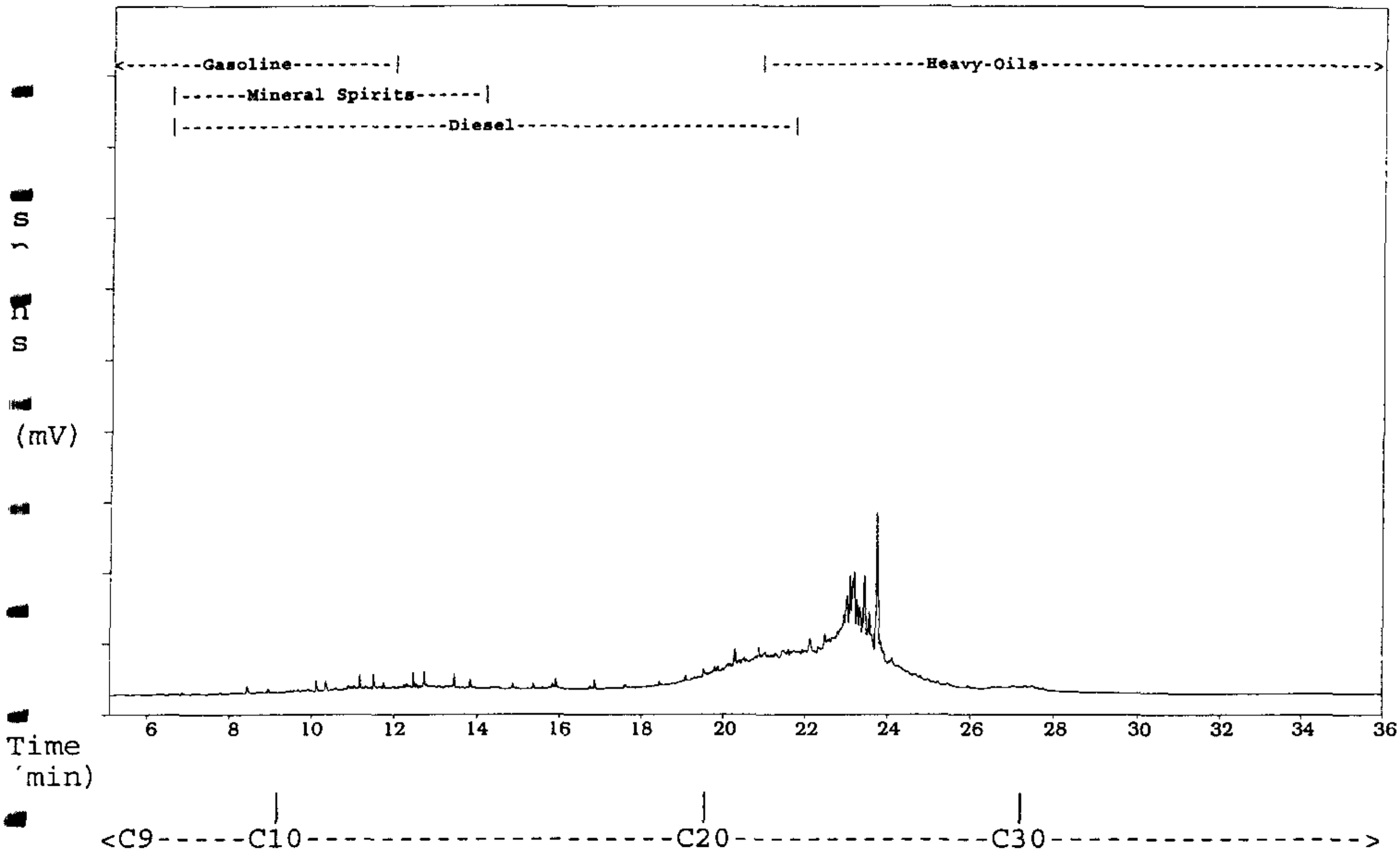
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--37** BH#5 0-2ft.

Sample acquired: JUN 8, 1999 05:24:05 Sequence File: EH1JUN07

File Name: C:\TEH\JUN07\EH1JUN07.42R , Sample Name: K6215-T--37 99 05 26

Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--37* 8.0Dilution

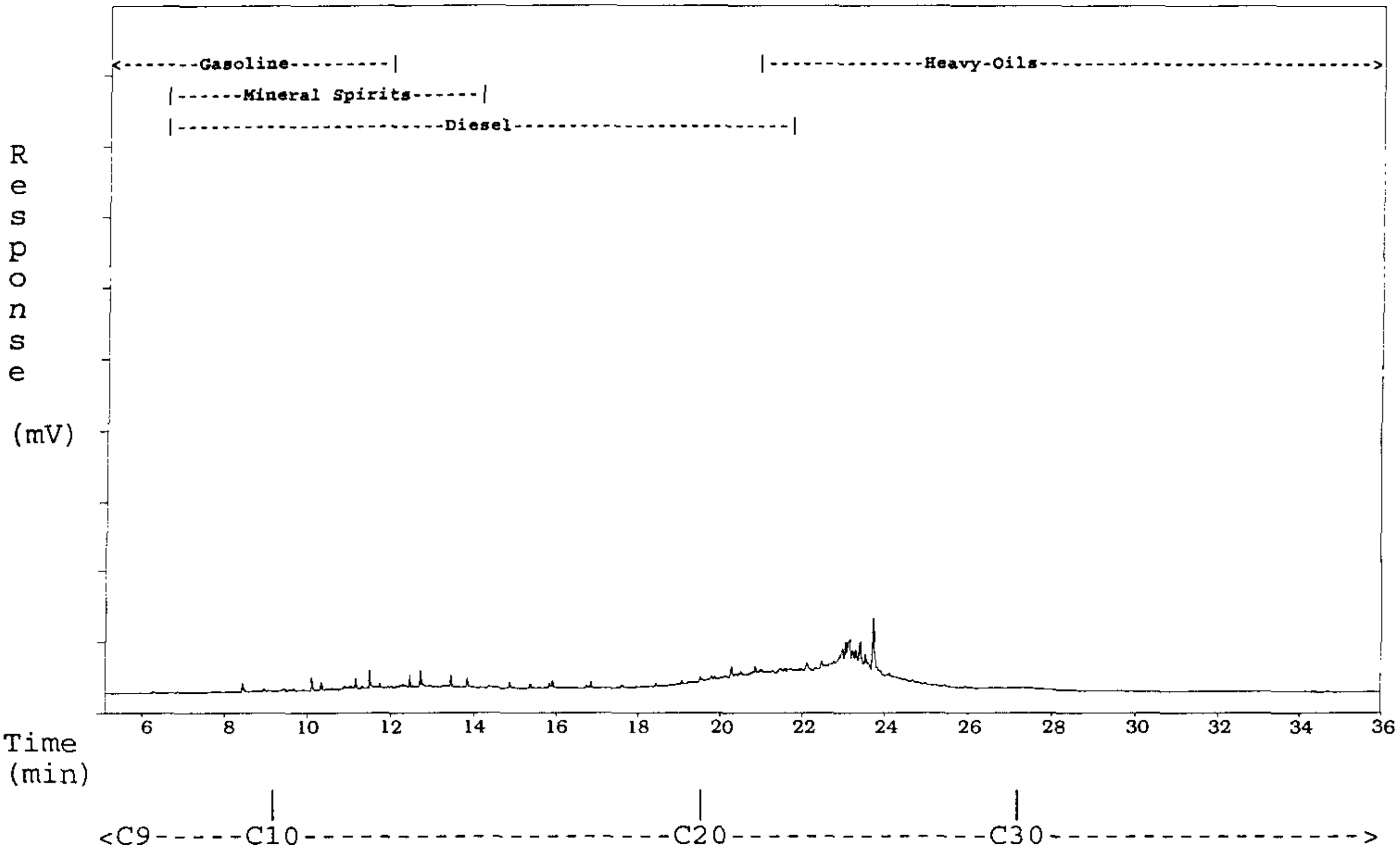
The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--38** BH#5 2-5ft.

Sample acquired: JUN 8, 1999 06:17:52
File Name: C:\TEH\JUN07\EH1JUN07.44R , Sample Name: K6215-T--38 99 05 26
Chromatogram Scale: 50.0 millivolts

Sequence File: EH1JUN07



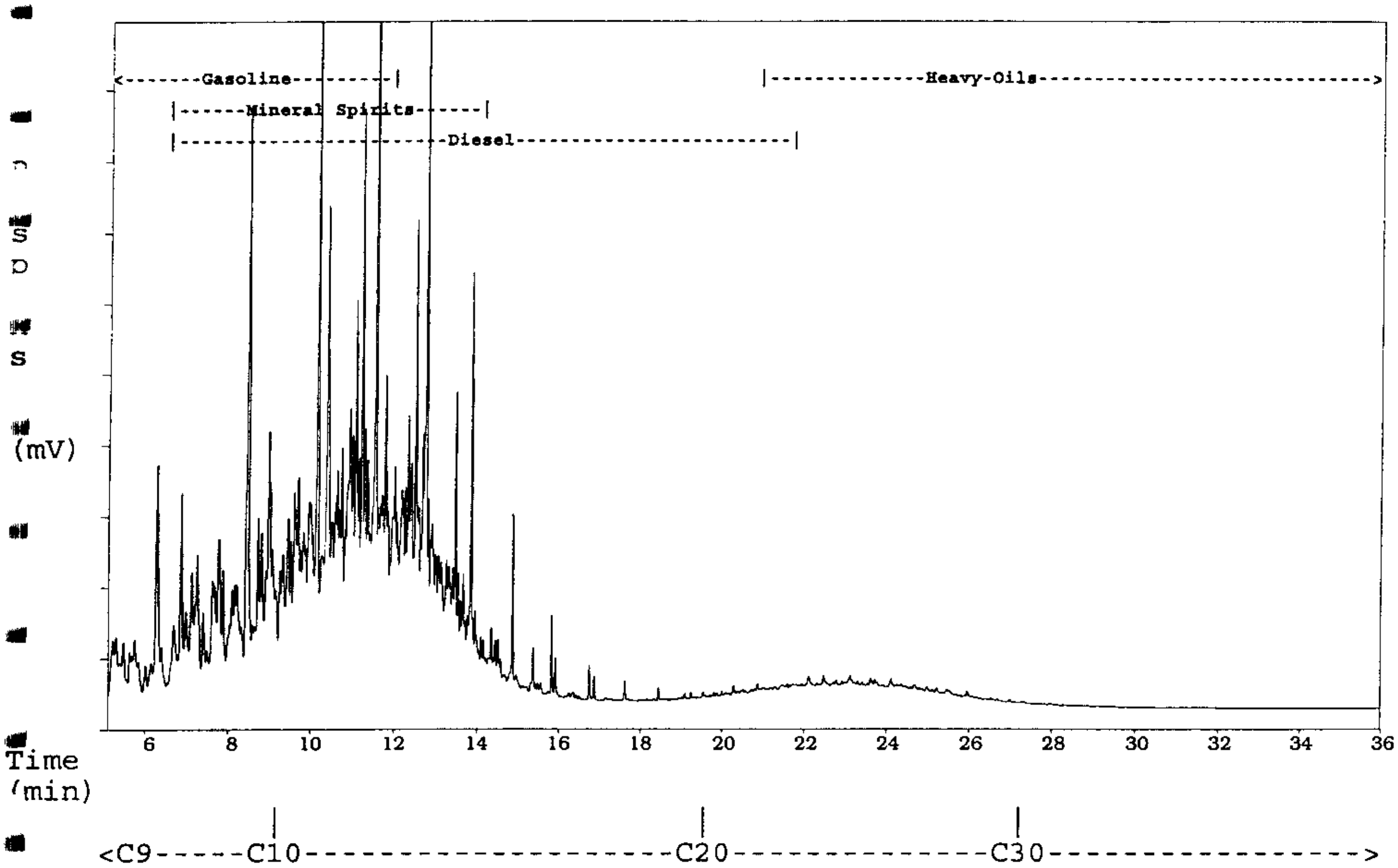
ASL Sample ID: K6215-T--38* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--42** BH#6 2-5ft.

Sample acquired: JUN 8, 1999 09:12:17 99 05 26 Sequence File: EH1JUN07
File Name: C:\TEH\JUN07\EH1JUN07.50R , Sample Name: K6215-T--42
Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--42* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

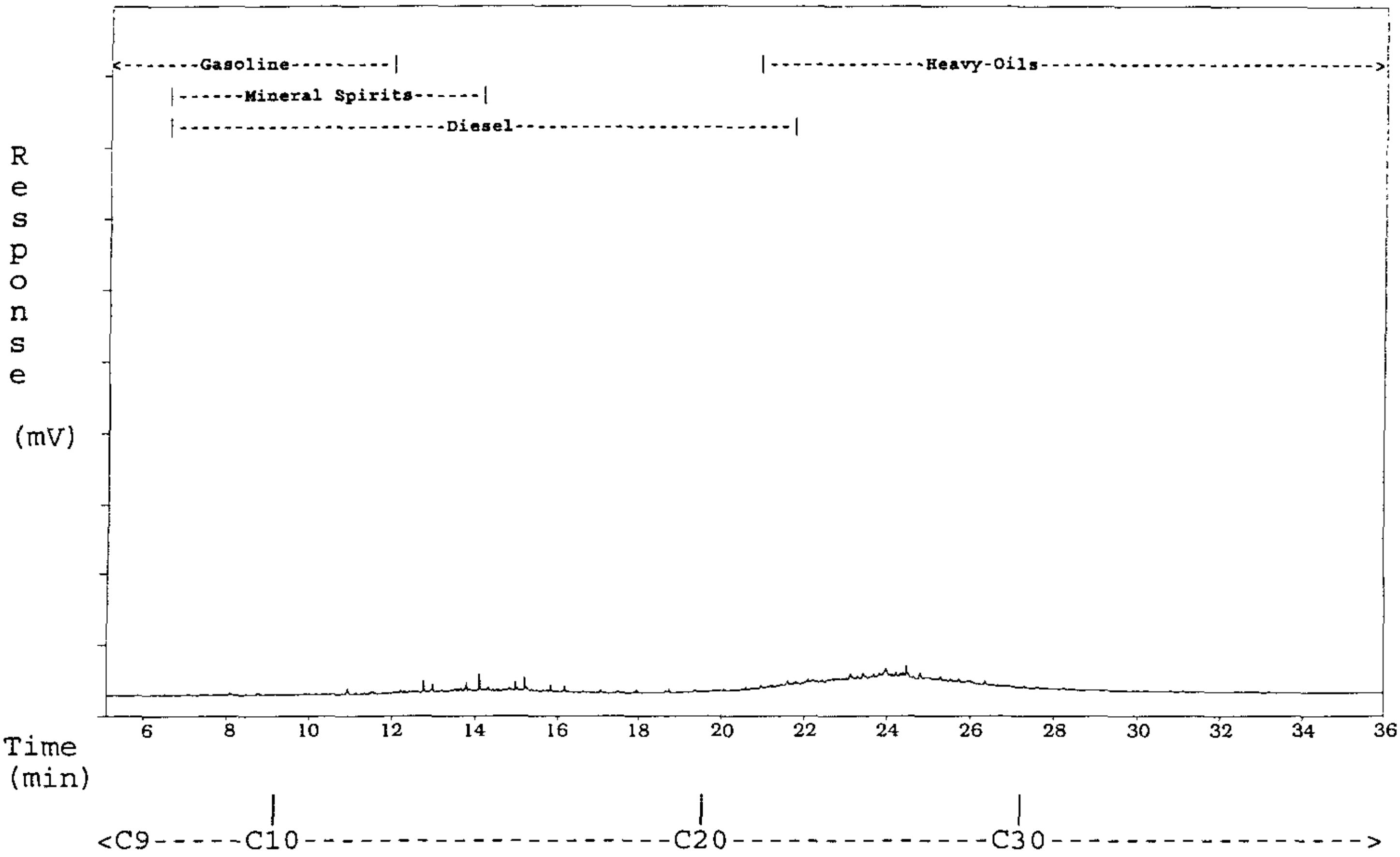
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--43** BH#6 5-10ft.

Sample acquired: JUN 16, 1999 13:42:40
File Name: C:\TEH2\JN16\EH3JN16.09R , Sample Name: K6215-T--43
Chromatogram Scale: 50.0 millivolts

99 05 26

Sequence File: EH3JN16



ASL Sample ID: K6215-T--43* 8.0Dilution

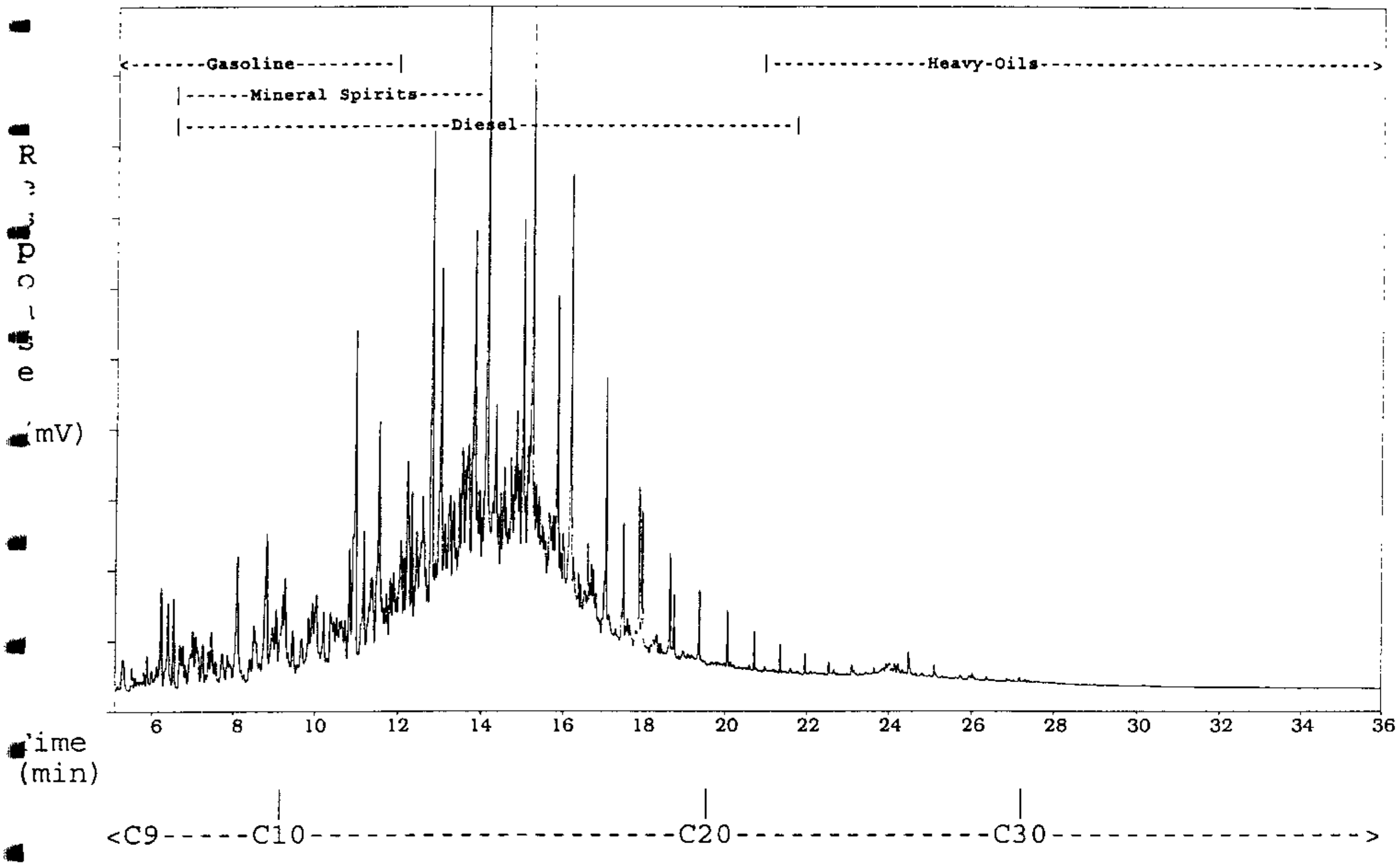
The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--49** H#8 0-2ft.

Sample acquired: JUN 8, 1999 12:07:31 Sequence File: EH3JUN08
File Name: C:\TEH2\JUN08\EH3JUN08.07R , Sample Name: K6215-T--49
Chromatogram Scale: 50.0 millivolts

99 05 26



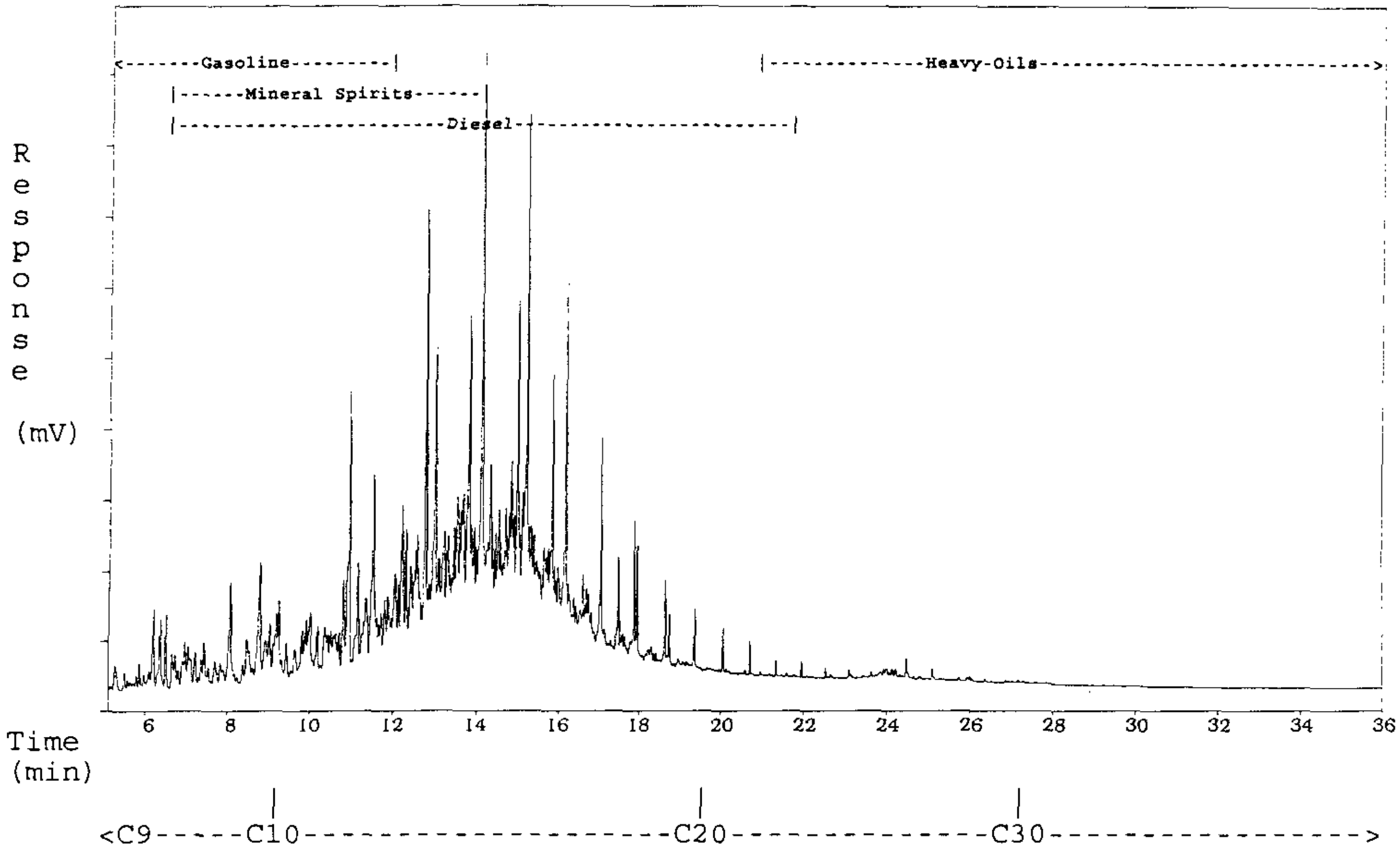
ASL Sample ID: K6215-T--49* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K6215 - 49 BH#8 0-2ft.

Sample acquired: JUN 8, 1999 13:01:06 Sequence File: EH3JUN08
File Name: C:\TEH2\JUN08\EH3JUN08.09R , Sample Name: QC-T--1592 99 05 26 LRep
Chromatogram Scale: 50.0 millivolts



ASL Sample ID: QC-T--159266#K6215 49DP* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

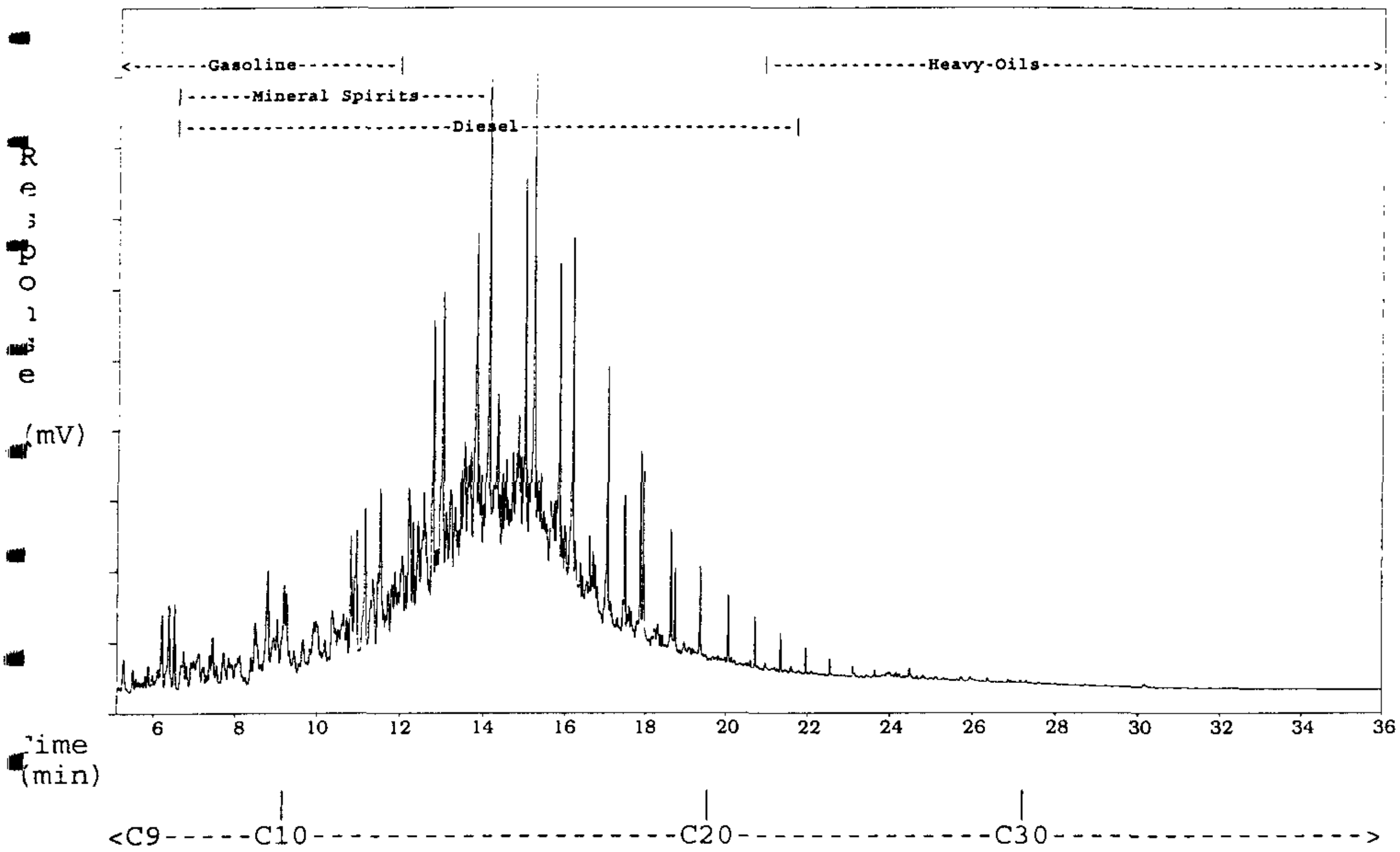
HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--50** BH#8 2-5ft.

Sample acquired: JUN 8, 1999 13:54:42 Sequence File: EH3JUN08

File Name: C:\TEH2\JUN08\EH3JUN08.11R , Sample Name: K6215-T--50 99 05 26

Chromatogram Scale: 50.0 millivolts



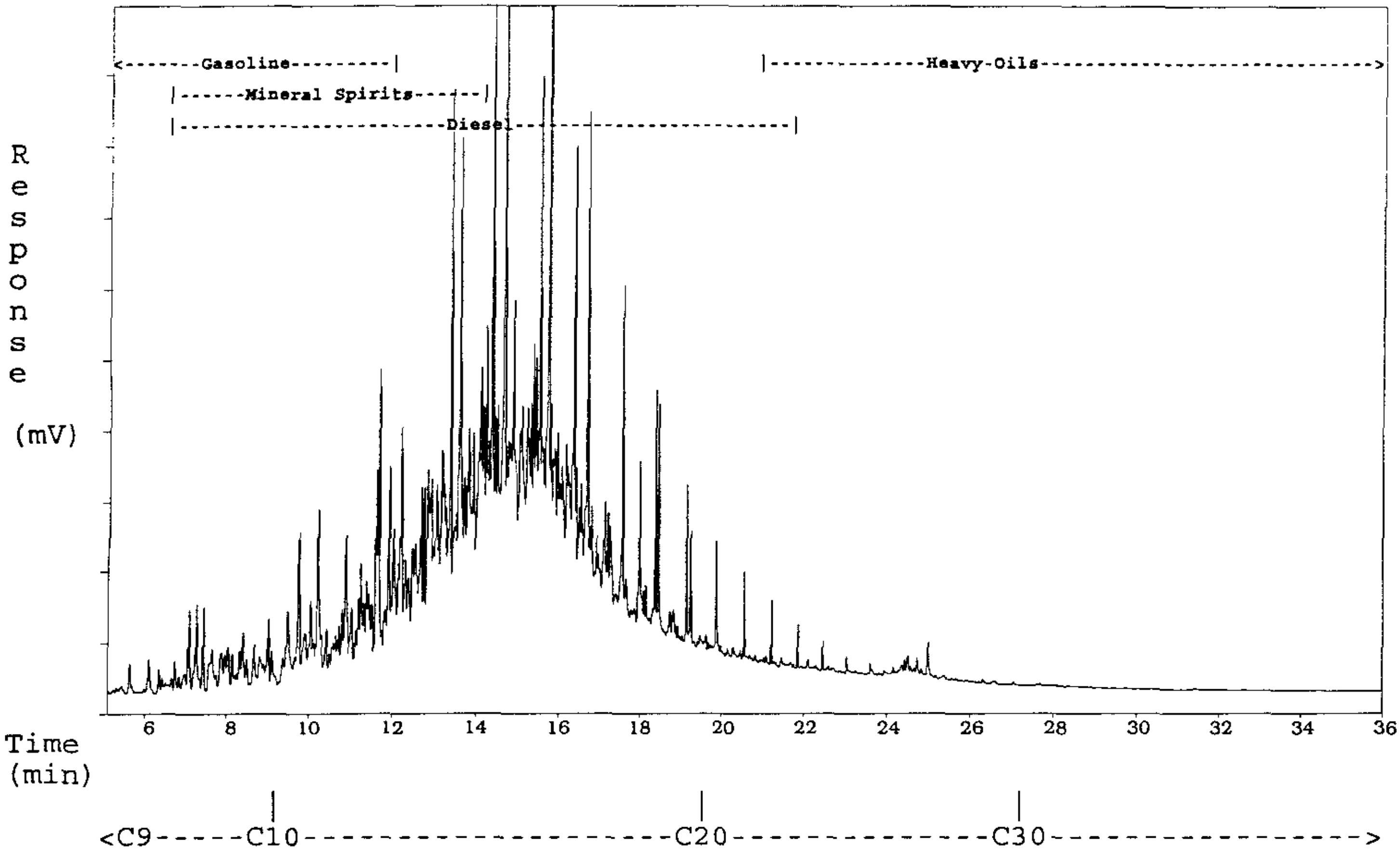
ASL Sample ID: K6215-T--50* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: **K6215-T--51** BH#8 5-10ft.

Sample acquired: JUN 16, 1999 13:42:40 Sequence File: EH3JN16
File Name: C:\TEH2\JN16\EH3JN16.10R , Sample Name: K6215-T--51 99 05 26
Chromatogram Scale: 50.0 millivolts



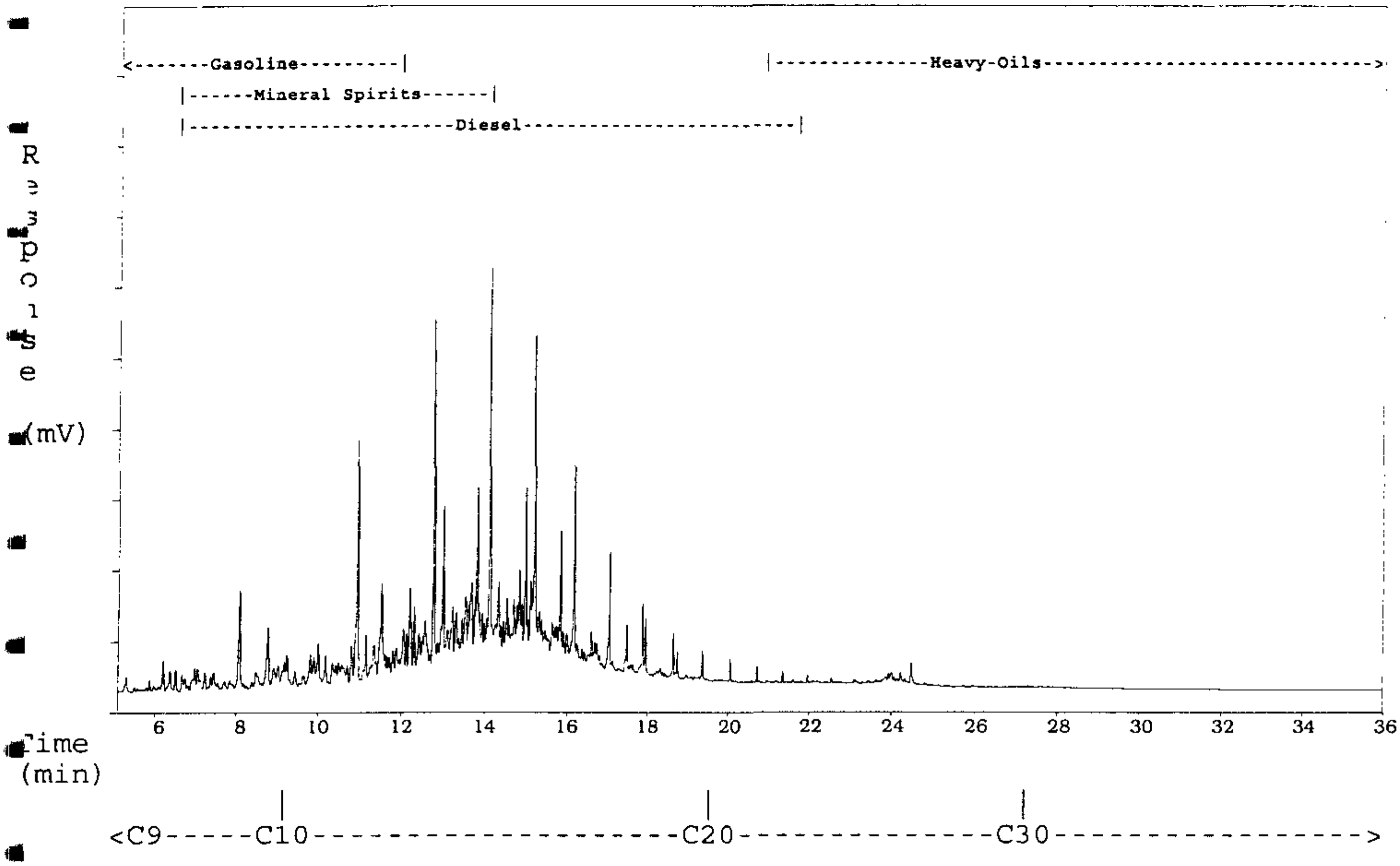
ASL Sample ID: K6215-T--51* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

HYDROCARBON DISTRIBUTION REPORT

SAMPLE NAME: K6215-T--52 BH#8 10-12ft.

Sample acquired: JUN 8, 1999 14:47:57 Sequence File: EH3JUN08
File Name: C:\TEH2\JUN08\EH3JUN08.13R , Sample Name: K6215-T--52 99 05 26
Chromatogram Scale: 50.0 millivolts



ASL Sample ID: K6215-T--52* 8.0Dilution

The Hydrocarbon Distribution Report is intended to assist you in characterizing the hydrocarbon product present in a given sample. The scale at the top of the chromatographic trace represents the hydrocarbon range of common petroleum products. Comparison of this report with those of reference standards may also assist you in the identification of the hydrocarbon product detected in your sample.

Groundwater

Marine

- Seawater

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

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laboratories
ltd.

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

CHEMICAL ANALYSIS REPORT

MAY 17 2000
GARTNER LEE

Date:	May 12, 2000
ASL File No.	L6143
Report On:	20-910 Water Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	April 10, 2000

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

The sample identified as "Travel Blank" was not prepared using the seawater method. This sample is prepared and sent to clients as a control sample to determine if there is any contamination occurring during the transport and storage of the sample containers and subsequently the samples. As such this sample was analysed as received.

RESULTS OF ANALYSIS - Seawater

File No. L6143

Sample ID		Stn.#1 Garrow Bay	Stn.#1 Garrow Bay F.	Stn.#2 Garrow Bay	Stn.#2 Garrow Bay F.	Stn.3C Cominco Bay
Sample Date		00 04 03	00 04 03	00 04 03	00 04 03	00 04 03
ASL ID		*1*	*1a*	*2*	*2a*	*3*
Dissolved Metals						
Arsenic	D-As	0.0014	0.0014	0.0014	0.0014	0.0015
Cadmium	D-Cd	0.00006	0.00007	0.00004	0.00005	0.00005
Chromium	D-Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Copper	D-Cu	0.00033	0.00045	0.00027	0.00040	0.00028
Iron	D-Fe	<0.01	<0.01	<0.01	<0.01	<0.01
Lead	D-Pb	0.00051	0.00184	0.00054	0.00099	0.00024
Manganese	D-Mn	0.00021	0.00030	0.00020	0.00030	0.00019
Mercury	D-Hg	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	D-Mo	0.008	0.005	0.007	0.006	0.007
Nickel	D-Ni	0.00049	0.00051	0.00051	0.00055	0.00053
Selenium	D-Se	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Uranium	D-U	0.00175	0.00218	0.00110	0.00225	0.00071
Zinc	D-Zn	<0.001	0.013	<0.001	0.010	<0.001

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.
The samples identified with an "F." are the samples that were filtered in the field.

RESULTS OF ANALYSIS - Seawater

File No. L6143

Sample ID		Stn.3C Cominco Bay F.	Stn.4E Shipload Dock	Stn.#4E Shipload Dock F.	Travel Blank
Sample Date		00 04 03	00 04 03	00 04 03	00 04 03
ASL ID		*3a*	*4*	*4a*	*5*
Dissolved Metals					
Arsenic	D-As	0.0015	0.0014	0.0016	<0.0002
Cadmium	D-Cd	*0.00005*	*0.00007*	*0.00007*	*<0.00002*
Chromium	D-Cr	<0.001	<0.001	<0.001	<0.001
Cobalt	D-Co	<0.00005	<0.00005	<0.00005	<0.0001
Copper	D-Cu	0.00029	0.00026	0.00049	<0.0001
Iron	D-Fe	<0.01	<0.01	<0.01	<0.01
Lead	D-Pb	0.00134	0.00083	0.00165	<0.00005
Manganese	D-Mn	0.00023	0.00018	0.00028	<0.00005
Mercury	D-Hg	0.00002	<0.00001	0.00002	<0.00001
Molybdenum	D-Mo	0.006	0.007	0.006	<0.002
Nickel	D-Ni	0.00050	0.00050	0.00059	<0.0001
Selenium	D-Se	<0.0005	<0.0005	0.0005	<0.0005
Uranium	D-U	0.00147	0.00207	0.00188	<0.00005
Zinc	D-Zn	0.001	0.006	0.018	<0.001

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.
The samples identified with an "F." are the samples that were filtered in the field.

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

Metals in Seawater

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 or filtration (EPA Method 3005A). Instrumental analysis of the seawater 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"

Trace Metals in Seawater by SPR-IDA Chelation

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 Cetac Technologies Incorporated. A suspended particulate resin (SPR), consisting of immobilized iminodiacetate (IDA) on a divinylbenzene polymer, is used to chelate and preconcentrate metals in seawater. Instrumental analysis is by inductively coupled plasma mass spectrometry (ICPMS) and/or routine atomic absorption spectrophotometry techniques (EPA 7000 series).

Recommended Holding Time:

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

Mercury in Seawater

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 seawater 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"

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"

End of Report

CHEMICAL ANALYSIS REPORT

Date: August 23, 1999

ASL File No. K8047

Report On: 99-902 Water Analysis

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

Attention: **Ms. Eva Gerencher**

Received: July 28, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

REMARKS File No. K8047

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 Sodium in the samples.** + also Ca levels elevated

The detection limit for Dichloromethane has been increased for the sample "TP11" due to analytical interferences.

The detection limit for some of the Polycyclic Aromatic Hydrocarbons have been increased for several of the samples in the following data tables due to hydrocarbon interferences.

RESULTS OF ANALYSIS - Water

File No. K8047

Sample ID		BH5	BH6	Sump	TP2	TP5
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Conductivity	(umhos/cm)	17300	2640	2930	2040	2670
Hardness	CaCO3	2780	1260	-	-	-
pH		7.20	7.12	7.08	7.41	6.59
Nutrients						
Ammonia Nitrogen	N	-	-	9.18	-	-
Nitrate Nitrogen	N	-	-	5.24	-	-
Nitrite Nitrogen	N	-	-	0.286	-	-
Total Dissolved Phosphate	P	-	-	0.009	-	-
Total Phosphate	P	-	-	0.073	-	-
Dissolved Metals						
Aluminum	D-Al	<0.3	<0.05	-	-	-
Antimony	D-Sb	<1	<0.2	-	-	-
Arsenic	D-As	<1	<0.2	-	-	-
Barium	D-Ba	<0.05	0.03	- *	-	-
Beryllium	D-Be	<0.03	<0.005	-	-	-
Boron	D-B	1.0	0.5	-	-	-
Cadmium	D-Cd	<0.01	<0.002	-	*	-
Calcium	D-Ca	659	395	-	-	-
Chromium	D-Cr	<0.05	<0.01	-	-	-
Cobalt	D-Co	<0.05	<0.01	-	-	-
Copper	D-Cu	<0.05	<0.01	-	-	-
Iron	D-Fe	<0.2	0.28	-	-	-
Lead	D-Pb	<0.05	<0.01	-	-	-
Magnesium	D-Mg	276	66.7	-	-	-
Manganese	D-Mn	0.39	0.100	-	-	-
Mercury	D-Hg	<0.00005	<0.00005	-	-	-
Molybdenum	D-Mo	<0.2	<0.03	-	-	-
Nickel	D-Ni	<0.3	<0.05	-	-	-
Selenium	D-Se	0.0013	<0.01	-	-	-
Silver	D-Ag	<0.005	<0.001	-	-	-
Sodium	D-Na	2330	169	-	-	-
Thallium	D-Tl	<0.005	<0.001	-	-	-
Uranium	D-U	0.0053	0.0038	-	-	-
Zinc	D-Zn	1.19	0.019	-	-	-

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. K8047

Sample ID		TP11	TP14	TP15	TP52	TP55
Sample Date		99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Physical Tests						
Conductivity	(umhos/cm)	3430	4950	3740	1920	3620
Hardness	CaCO3	-	-	-	771	1320
pH		7.12	6.83	6.71	7.61	7.36
Nutrients						
Ammonia Nitrogen	N	-	-	-	1.88	2.59
Nitrate Nitrogen	N	-	-	-	9.23	99.2
Nitrite Nitrogen	N	-	-	-	0.121	0.380
Total Dissolved Phosphate	P	-	-	-	<0.006	0.02
Total Phosphate	P	-	-	-	0.29	0.14
Cyanides						
Total Cyanide	CN	-	-	-	-	0.006
Dissolved Metals						
Aluminum	D-Al	-	-	-	<0.03	0.14
Antimony	D-Sb	-	-	-	<0.2	<0.2
Arsenic	D-As	-	-	-	<0.2	<0.2
Barium	D-Ba	-	-	-	0.08	0.05
Beryllium	D-Be	-	-	-	<0.005	<0.005
Boron	D-B	-	*	-	0.4	1.5
Cadmium	D-Cd	-	-	-	<0.001	<0.002
Calcium	D-Ca	-	-	-	234	343
Chromium	D-Cr	-	-	-	<0.01	<0.01
Cobalt	D-Co	-	-	-	0.01	<0.01
Copper	D-Cu	-	-	-	<0.01	<0.01
Iron	D-Fe	-	-	-	<0.03	0.11
Lead	D-Pb	-	-	-	<0.005	0.01
Magnesium	D-Mg	-	-	-	45.4	112
Manganese	D-Mn	-	-	-	0.056	0.037
Mercury	D-Hg	-	-	-	<0.00005	<0.00005
Molybdenum	D-Mo	-	-	-	<0.03	<0.03
Nickel	D-Ni	-	-	-	<0.05	<0.05
Selenium	D-Se	-	-	-	0.007	<0.01
Silver	D-Ag	-	-	-	<0.0005	<0.001
Sodium	D-Na	-	-	-	118	369
Thallium	D-Tl	-	-	-	<0.0005	<0.001
Uranium	D-U	-	-	-	0.00751	0.0078
Zinc	D-Zn	-	-	-	0.080	0.213

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. K8047

Sample ID		TP57	TP59	TP61
Sample Date		99 07 16	99 07 16	99 07 16
Physical Tests				
Conductivity	(umhos/cm)	3930	3580	2550
Hardness	CaCO3	1400	1260	1080
pH		7.63	7.50	7.44
Nutrients				
Ammonia Nitrogen	N	3.48	2.07	0.25
Nitrate Nitrogen	N	1.66	27.4	0.993
Nitrite Nitrogen	N	0.031	0.148	0.020
Total Dissolved Phosphate	P	0.042	0.02	<0.006
Total Phosphate	P	0.26	0.33	0.17
Cyanides				
Total Cyanide	CN	-	0.007	<0.005
Dissolved Metals				
Aluminum	D-Al	<0.05	0.20	<0.03
Antimony	D-Sb	<0.2	<0.2	<0.2
Arsenic	D-As	<0.2	<0.2	<0.2
Barium	D-Ba	0.03	0.02	0.03
Beryllium	D-Be	<0.005	<0.005	<0.005
Boron	D-B	2.0	1.1	0.9
Cadmium	D-Cd	<0.002	<0.002	<0.001
Calcium	D-Ca	354	359	287
Chromium	D-Cr	<0.01	<0.01	<0.01
Cobalt	D-Co	<0.01	<0.01	<0.01
Copper	D-Cu	<0.01	<0.01	<0.01
Iron	D-Fe	<0.03	0.17	<0.03
Lead	D-Pb	<0.01	<0.01	<0.005
Magnesium	D-Mg	125	88.1	87.6
Manganese	D-Mn	0.083	0.040	0.008
Mercury	D-Hg	<0.00005	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.05	<0.05	<0.05
Selenium	D-Se	<0.01	<0.01	<0.005
Silver	D-Ag	<0.001	<0.001	<0.0005
Sodium	D-Na	407	345	135
Thallium	D-Tl	<0.001	<0.001	<0.0005
Uranium	D-U	0.0040	0.0085	0.00263
Zinc	D-Zn	0.062	0.128	0.032

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Sample ID	BH5	Sump	TP11	TP59	TP61
Sample Date	99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Halogenated Volatiles					
Bromodichloromethane	<0.001	<0.001	<0.001	<0.001	<0.001
Bromoform	<0.001	<0.001	<0.001	<0.001	<0.001
Carbon Tetrachloride	<0.001	<0.001	<0.001	<0.001	<0.001
Chlorobenzene	<0.001	<0.001	<0.001	<0.001	<0.001
Chloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
Chloroform	<0.001	<0.001	<0.001	<0.001	<0.001
Chloromethane	<0.001	<0.001	<0.001	<0.001	<0.001
Dibromochloromethane	<0.001	<0.001	<0.001	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001	<0.001
1,3-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001	<0.001
1,4-Dichlorobenzene	<0.001	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
1,2-Dichloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
cis-1,2-Dichloroethylene	<0.001	<0.001	<0.001	<0.001	<0.001
trans-1,2-Dichloroethylene	<0.001	<0.001	<0.001	<0.001	<0.001
1,1-Dichloroethylene	<0.001	<0.001	<0.001	<0.001	<0.001
Dichloromethane	<0.005	<0.005	<0.01	<0.005	<0.005
1,2-Dichloropropane	<0.001	<0.001	<0.001	<0.001	<0.001
cis-1,3-Dichloropropylene	<0.001	<0.001	<0.001	<0.001	<0.001
trans-1,3-Dichloropropylene	<0.001	<0.001	<0.001	<0.001	<0.001
1,1,1,2-Tetrachloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
1,1,2,2-Tetrachloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
Tetrachloroethylene	<0.001	<0.001	<0.001	<0.001	<0.001
1,1,1-Trichloroethane	<0.001	0.001	<0.001	<0.001	<0.001
1,1,2-Trichloroethane	<0.001	<0.001	<0.001	<0.001	<0.001
Trichloroethylene	<0.001	<0.001	<0.001	<0.001	<0.001
Trichlorofluoromethane	<0.001	0.001	<0.001	<0.001	<0.001
Vinyl Chloride	<0.001	<0.001	<0.001	<0.001	<0.001
Non-halogenated Volatiles					
Benzene	<0.0005	<0.0005	0.0095	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005	0.0084	<0.0005	<0.0005
Styrene	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Toluene	<0.0005	<0.0005	0.0905	<0.0005	0.0027
meta- & para-Xylene	0.0009	<0.0005	0.166	<0.0005	<0.0005
ortho-Xylene	0.0006	<0.0005	0.116	<0.0005	<0.0005

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. K8047

Sample ID	BH5	BH6	Sump	TP2	TP5
Sample Date	99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Water Soluble Volatiles					
Diethylene Glycol	-	-	<10	-	-
Ethylene Glycol	-	-	<10	-	-
Propylene Glycol	-	-	<10	-	-
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.00005	-	0.00060	-	0.00033
Acenaphthylene	<0.00005	-	0.00018	-	0.00006
Acridine	<0.00005	-	<0.00005	-	<0.00005
Anthracene	<0.00005	-	<0.00005	-	<0.00005
Benz(a)anthracene	<0.00005	-	<0.00005	-	<0.00005
Benzo(a)pyrene	<0.00001	-	<0.00001	-	<0.00001
Benzo(b)fluoranthene	<0.00005	-	<0.00005	-	<0.00005
Benzo(g,h,i)perylene	<0.00005	-	<0.00005	-	<0.00005
Benzo(k)fluoranthene	<0.00005	-	<0.00005	-	<0.00005
Chrysene	<0.00005	-	<0.00005	-	<0.00005
Dibenz(a,h)anthracene	<0.00005	-	<0.00005	-	<0.00005
Fluoranthene	<0.00005	-	<0.00005	-	0.00005
Fluorene	<0.00005	-	0.00065	-	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	-	<0.00005	-	<0.00005
Naphthalene	<0.0001	-	0.0302	-	<0.002
Phenanthrene	<0.00005	-	0.00024	-	<0.00005
Pyrene	<0.00005	-	<0.00005	-	0.00007
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<0.001	-	<0.001	-	-
Extractables					
EPH (C10-19)	0.8	7.0	4.4	<0.3	5.6
EPH (C19-32)	<1	<1	<1	<1	<1
LEPH	0.8	-	4.4	-	5.6
HEPH	<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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water File No. K8047

Sample ID	TP11	TP14	TP15	TP17	TP52
Sample Date	99 07 16	99 07 16	99 07 16	99 07 16	99 07 16
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	0.00142	-	-	-	-
Acenaphthylene	0.00039	-	-	-	-
Acridine	<0.0001	-	-	-	-
Anthracene	0.00008	-	-	-	-
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	0.00127	-	-	-	-
Indeno(1,2,3-c,d)pyrene	<0.00005	-	-	-	-
Naphthalene	0.0283	-	-	-	-
Phenanthrene	0.00080	-	-	-	-
Pyrene	0.00006	-	-	-	-
Polychlorinated Biphenyls					
Total Polychlorinated Biphenyls	<0.001	-	-	-	-
Extractables					
EPH (C10-19)	14.8	7.1	31.1	0.7	0.5
EPH (C19-32)	1	3	6	1	<1
LEPH	14.7	-	-	-	-
HEPH	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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Water

File No. K8047

Sample ID	TP55	TP57	TP59	TP61
Sample Date	99 07 16	99 07 16	99 07 16	99 07 16
Polycyclic Aromatic Hydrocarbons				
Acenaphthene	<0.00005	<0.00005	-	<0.00005
Acenaphthylene	<0.00005	<0.00005	-	<0.00005
Acridine	<0.00005	<0.00005	-	<0.00005
Anthracene	<0.00005	<0.00005	-	<0.00005
Benz(a)anthracene	<0.00005	<0.00005	-	<0.00005
Benzo(a)pyrene	<0.00001	<0.00001	-	<0.00001
Benzo(b)fluoranthene	<0.00005	<0.00005	-	<0.00005
Benzo(g,h,i)perylene	<0.00005	<0.00005	-	<0.00005
Benzo(k)fluoranthene	<0.00005	<0.00005	-	<0.00005
Chrysene	<0.00005	<0.00005	-	<0.00005
Dibenz(a,h)anthracene	<0.00005	<0.00005	-	<0.00005
Fluoranthene	<0.00005	<0.00005	-	<0.00005
Fluorene	<0.00005	<0.00005	-	<0.00005
Indeno(1,2,3-c,d)pyrene	<0.00005	<0.00005	-	<0.00005
Naphthalene	<0.00005	<0.00005	-	<0.00005
Phenanthrene	<0.00005	<0.00005	-	<0.00005
Pyrene	<0.00005	<0.00005	-	<0.00005
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls	<0.001	-	<0.001	-
Extractables				
EPH (C10-19)	<0.3	0.5	0.3	<0.3
EPH (C19-32)	<1	<1	<1	<1
LEPH	<0.3	0.5	-	<0.3
HEPH	<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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates File No. K8047

Water		BH5 99 07 16	BH5 QC # 166269
Physical Tests			
Conductivity	(umhos/cm)	17300	17400
Hardness	CaCO3	2780	2810
pH		7.20	7.24
Dissolved Metals			
Aluminum	D-Al	<0.3	<0.3
Antimony	D-Sb	<1	<1
Arsenic	D-As	<1	<1
Barium	D-Ba	<0.05	<0.05
Beryllium	D-Be	<0.03	<0.03
Boron	D-B	1.0	0.8
Cadmium	D-Cd	<0.01	<0.01
Calcium	D-Ca	659	665
Chromium	D-Cr	<0.05	<0.05
Cobalt	D-Co	<0.05	<0.05
Copper	D-Cu	<0.05	<0.05
Iron	D-Fe	<0.2	<0.2
Lead	D-Pb	<0.05	<0.05
Magnesium	*D-Mg*	276	279
Manganese	D-Mn	0.39	0.40
Mercury	D-Hg	<0.00005	<0.00005
Molybdenum	D-Mo	<0.2	<0.2
Nickel	D-Ni	<0.3	<0.3
Selenium	D-Se	0.0013	0.0013
Silver	D-Ag	<0.005	<0.005
Sodium	D-Na	2330	2360
Thallium	D-Tl	<0.005	<0.005
Uranium	D-U	0.0053	0.0054
Zinc	D-Zn	1.19	1.19

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8047

Water	BH5 99 07 16	BH5 QC # 166269
Halogenated Volatiles		
Bromodichloromethane	<0.001	<0.001
Bromoform	<0.001	<0.001
Carbon Tetrachloride	<0.001	<0.001
Chlorobenzene	<0.001	<0.001
Chloroethane	<0.001	<0.001
Chloroform	<0.001	<0.001
Chloromethane	<0.001	<0.001
Dibromochloromethane	<0.001	<0.001
1,2-Dichlorobenzene	<0.001	<0.001
1,3-Dichlorobenzene	<0.001	<0.001
1,4-Dichlorobenzene	<0.001	<0.001
1,1-Dichloroethane	<0.001	<0.001
1,2-Dichloroethane	<0.001	<0.001
cis-1,2-Dichloroethylene	<0.001	<0.001
trans-1,2-Dichloroethylene	<0.001	<0.001
1,1-Dichloroethylene	<0.001	<0.001
Dichloromethane	<0.005	<0.005
1,2-Dichloropropane	<0.001	<0.001
cis-1,3-Dichloropropylene	<0.001	<0.001
trans-1,3-Dichloropropylene	<0.001	<0.001
1,1,1,2-Tetrachloroethane	<0.001	<0.001
1,1,2,2-Tetrachloroethane	<0.001	<0.001
Tetrachloroethylene	<0.001	<0.001
1,1,1-Trichloroethane	<0.001	<0.001
1,1,2-Trichloroethane	<0.001	<0.001
Trichloroethylene	<0.001	<0.001
Trichlorofluoromethane	<0.001	<0.001
Vinyl Chloride	<0.001	<0.001
Non-halogenated Volatiles		
Benzene	<0.0005	<0.0005
Ethylbenzene	<0.0005	<0.0005
Styrene	<0.0005	<0.0005
Toluene	<0.0005	<0.0005
meta- & para-Xylene	0.0009	0.0009
ortho-Xylene	0.0006	0.0005

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Appendix 1 - QUALITY CONTROL - Replicates

File No. K8047

Water			TP55	TP55
			99 07 16	QC # 166288
Physical Tests				
Conductivity	(umhos/cm)		3620	3870
Hardness	CaCO3		1320	1340
pH			7.36	7.38
Nutrients				
Ammonia Nitrogen		N	2.59	2.53
Nitrate Nitrogen		N	99.2	98.9
Nitrite Nitrogen		N	0.380	0.381
Dissolved Metals				
Aluminum	D-Al		0.14	0.15
Antimony	D-Sb		<0.2	<0.2
Arsenic	D-As		<0.2	<0.2
Barium	D-Ba		0.05	0.05
Beryllium	D-Be		<0.005	<0.005
Boron	D-B		1.5	1.5
Cadmium	D-Cd		<0.002	<0.002
Calcium	D-Ca		343	349
Chromium	D-Cr		<0.01	<0.01
Cobalt	D-Co		<0.01	<0.01
Copper	D-Cu		<0.01	<0.01
Iron	D-Fe		0.11	0.11
Lead	D-Pb		0.01	0.01
Magnesium	D-Mg		112	114
Manganese	D-Mn		0.037	0.039
Mercury	D-Hg		<0.00005	<0.00005
Molybdenum	D-Mo		<0.03	<0.03
Nickel	D-Ni		<0.05	<0.05
Selenium	D-Se		<0.01	<0.01
Silver	D-Ag		<0.001	<0.001
Sodium	D-Na		369	372
Thallium	D-Tl		<0.001	<0.001
Uranium	D-U		0.0078	0.0084
Zinc	D-Zn		0.213	0.215

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.
LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

Appendix 2 - METHODOLOGY

File No. K8047

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.

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 in Water

This analysis is based on United States Environmental Protection Agency Methods 624/524 and 5030/8260. These procedures involve purge and trap extraction of the sample and subsequent analysis of the volatile components by capillary column gas chromatography with mass spectrometric detection.

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.

Polychlorinated Biphenyls in Water

This analysis is carried out using a procedure adapted from U.S. EPA Methods 3510, 8080 and 8082. (Publ. #SW-846, 3rd Ed., Washington, DC 20460). The procedure involves liquid-liquid extraction of the sample with dichloromethane. The extract is cleaned and analyzed by capillary column gas chromatography with electron capture detection.

Extractable Hydrocarbons in Water

This analysis is carried out using procedures adapted from U.S. EPA Methods 3510/8015 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and

British Columbia Ministry of Environment, Lands and Parks Method for "Extractable Petroleum Hydrocarbons in Water by GC/FID" (January 1996). The procedure involves a methylene chloride solvent extraction followed by analysis of the extract by capillary column gas chromatography with flame ionization detection. Results are not corrected for Polycyclic Aromatic Hydrocarbons (PAHs) for Extractable Petroleum Hydrocarbon (LEPH/HEPH) purposes.

Light and Heavy Extractable Petroleum Hydrocarbons in Water

These results 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(C10-18). To calculate HEPH, the individual results for benz(a)anthracene, benzo(a)pyrene, fluoranthene, and pyrene are subtracted from EPH(C19-31).

End of Report

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CHEMICAL ANALYSIS REPORT

NOV 1[illegible] 1999
[illegible] EE

Date:	November 9, 1999
ASL File No.	L2103
Report On:	99-902 Water Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	July 29, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

Specialists in Environmental Chemistry

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

RESULTS OF ANALYSIS - Water

File No. L2103

		Sump	TP14
Sample ID		Sump	TP14
Sample Date		99 07 16	99 07 16
ASL ID		*1*	*2*
Physical Tests			
Hardness	CaCO3	1100	2490
Dissolved Metals			
Aluminum	D-Al	<0.03	<0.05
Antimony	D-Sb	<0.2	<0.2
Arsenic	D-As	0.0005	<0.0001
Barium	D-Ba	0.13	0.03
Beryllium	D-Be	<0.005	<0.005
Boron	D-B	0.7	0.3
Cadmium	D-Cd	<0.001	<0.002
Calcium	D-Ca	363	919
Chromium	D-Cr	<0.01	<0.01
Cobalt	D-Co	<0.01	0.01
Copper	D-Cu	<0.01	<0.01
Iron	D-Fe	1.68	<0.03
Lead	D-Pb	<0.005	0.04
Magnesium	D-Mg	47.7	48.4
Manganese	D-Mn	0.207	0.311
Mercury	D-Hg	<0.00005	<0.00005
Molybdenum	D-Mo	<0.03	<0.03
Nickel	D-Ni	<0.05	0.07
Selenium	D-Se	0.009	0.0023
Silver	D-Ag	<0.0005	<0.001
Sodium	D-Na	163	142
Thallium	D-Tl	<0.0005	<0.001
Uranium	D-U	0.00138	0.0061
Zinc	D-Zn	0.052	2.28

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.

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.

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"

End of Report

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CHEMICAL ANALYSIS REPORT

Date: November 4, 1999

ASL File No. K8797b

Report On: 99-902 Tissue Analysis

NOV - 8 1999
GARTNER LEE

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

Attention: **Ms. Eva Gerencher**

Received: August 20, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

RESULTS OF ANALYSIS - Tissue

File No. K8797b

Sample ID		Site A Grasses	Site A Grasses LRep	Site A Lichen	Site A Lichen LRep	Site B Grasses
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 14
ASL ID		*1*	*1 a*	*2*	*2 a*	*3*
Total Metals						
Aluminum	T-Al	957	1480	692	1060	861
Antimony	T-Sb	0.16	0.22	0.10	0.13	0.07
Arsenic	T-As	0.57	0.97	0.61	0.77	0.27
Barium	T-Ba	213	365	188	316	133
Beryllium	T-Be	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	1.41	2.73	1.85	2.74	0.87
Calcium	T-Ca	21700	37900	88600	95900	14000
Chromium	T-Cr	6.2	9.4	2.0	3.3	5.2
Cobalt	T-Co	0.5	0.8	0.2	0.3	0.3
Copper	T-Cu	11.8	14.5	1.92	2.58	3.08
Lead	T-Pb	331	560	463	574	70.5
Lithium	T-Li	1.0	1.7	0.5	0.9	0.7
Magnesium	T-Mg	3690	6670	1010	1650	1960
Manganese	T-Mn	77.5	96.0	20.8	24.1	51.4
Molybdenum	T-Mo	1.24	1.42	0.71	0.89	0.86
Nickel	T-Ni	5.3	7.9	0.9	2.1	3.8
Selenium	T-Se	<1	<1	<1	<1	<1
Strontium	T-Sr	51.4	70.4	143	154	41.0
Thallium	T-Tl	0.03	0.05	<0.03	0.04	0.04
Tin	T-Sn	<0.2	<0.2	0.2	<0.2	<0.2
Uranium	T-U	0.65	0.95	0.50	0.60	0.30
Vanadium	T-V	8.6	14.9	5.7	9.1	4.1
Zinc	T-Zn	549	1030	353	680	228

Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797b

Sample ID		Site B Lichen	Site B Willow	Site C Willow	Site C Grasses	Site C Lichen
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 14
ASL ID		*4*	*5*	*6*	*7*	*8*
Total Metals						
Aluminum	T-Al	263	102	310	562	869
Antimony	T-Sb	<0.03	<0.03	0.03	0.07	0.10
Arsenic	T-As	0.20	<0.05	0.12	0.26	0.48
Barium	T-Ba	34.9	36.3	42.1	185	69.8
Beryllium	T-Be	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.63	1.47	2.28	2.85	1.51
Calcium	T-Ca	71100	11600	8920	14300	48600
Chromium	T-Cr	1.5	<0.5	1.7	2.5	3.4
Cobalt	T-Co	<0.1	1.0	0.3	0.3	0.3
Copper	T-Cu	0.75	9.35	9.93	5.84	3.22
Lead	T-Pb	176	19.1	19.6	147	312
Lithium	T-Li	<0.2	<0.2	<0.2	0.4	0.4
Magnesium	T-Mg	397	3290	2950	2820	614
Manganese	T-Mn	5.08	39.1	24.4	30.1	12.2
Molybdenum	T-Mo	0.16	0.92	0.28	0.66	0.20
Nickel	T-Ni	0.6	4.2	2.6	3.3	1.7
Selenium	T-Se	<1	<1	<1	<1	<1
Strontium	T-Sr	112	44.6	21.4	34.1	58.3
Thallium	T-Tl	<0.03	<0.03	<0.03	<0.03	<0.03
Tin	T-Sn	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	T-U	0.37	0.06	0.04	0.19	0.19
Vanadium	T-V	1.3	0.5	2.0	4.4	11.6
Zinc	T-Zn	93.0	366	241	723	157

Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797b

Sample ID		Site D Lichen	Site D Grasses	Site E Grasses	Site E Lichen	Site F Willow
Sample Date		99 07 14	99 07 14	99 07 12	99 07 12	99 07 13
ASL ID		*9*	*10*	*11*	*12*	*13*
Total Metals						
Aluminum	T-Al	103	212	782	549	188
Antimony	T-Sb	<0.03	0.04	0.06	0.04	<0.03
Arsenic	T-As	0.13	0.13	0.29	0.30	0.07
Barium	T-Ba	26.3	101	137	77.9	177
Beryllium	T-Be	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	1.71	2.05	1.02	0.89	0.86
Calcium	T-Ca	70600	12600	14300	84900	11000
Chromium	T-Cr	<0.5	1.4	4.1	1.3	0.9
Cobalt	T-Co	<0.1	0.1	0.3	0.1	0.5
Copper	T-Cu	0.80	3.13	18.3	1.24	9.98
Lead	T-Pb	235	120	92.2	246	14.4
Lithium	T-Li	<0.2	<0.2	0.6	0.3	<0.2
Magnesium	T-Mg	341	1800	1800	656	3340
Manganese	T-Mn	2.65	42.9	138	8.80	28.2
Molybdenum	T-Mo	0.09	0.84	0.93	0.21	0.38
Nickel	T-Ni	<0.1	1.5	3.9	0.8	3.9
Selenium	T-Se	<1	<1	<1	<1	<1
Strontium	T-Sr	68.2	32.1	46.1	131	69.9
Thallium	T-Tl	<0.03	<0.03	0.04	<0.03	<0.03
Tin	T-Sn	<0.2	<0.2	<0.2	<0.2	<0.2
Uranium	T-U	0.15	0.08	0.36	0.77	0.07
Vanadium	T-V	0.8	2.1	5.8	3.9	1.1
Zinc	T-Zn	116	443	249	117	176

Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797b

Sample ID		Site F Grasses	Site F Lichen	Site G Grasses	Site G Willow	Site H Grasses
Sample Date		99 07 13	99 07 13	99 07 13	99 07 13	99 07 12
ASL ID		*14*	*15*	*16*	*17*	*18*
Total Metals						
Aluminum	T-Al	1580	381	495	90	1720
Antimony	T-Sb	0.10	<0.03	0.17	0.03	0.18
Arsenic	T-As	0.60	0.27	0.27	<0.05	2.05
Barium	T-Ba	2020	288	99.3	28.3	400
Beryllium	T-Be	<0.1	<0.1	<0.1	<0.1	0.1
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.63	0.63	1.90	5.22	3.61
Calcium	T-Ca	21500	79500	11600	7280	19700
Chromium	T-Cr	8.7	1.0	2.5	<0.5	4.2
Cobalt	T-Co	0.7	<0.1	0.2	0.3	0.7
Copper	T-Cu	69.1	1.00	8.48	8.89	6.99
Lead	T-Pb	92.9	199	89.9	18.8	431
Lithium	T-Li	1.8	0.2	0.2	<0.2	1.4
Magnesium	T-Mg	5140	737	1360	1940	3710
Manganese	T-Mn	44.5	9.23	76.9	12.0	32.4
Molybdenum	T-Mo	1.92	0.17	1.67	0.49	1.75
Nickel	T-Ni	6.8	0.4	3.0	3.8	5.6
Selenium	T-Se	<1	<1	<1	<1	<1
Strontium	T-Sr	80.3	142	57.8	36.1	54.9
Thallium	T-Tl	0.06	<0.03	0.06	<0.03	0.08
Tin	T-Sn	<0.2	<0.2	<0.2	<0.2	0.2
Uranium	T-U	1.13	0.66	0.42	0.18	0.91
Vanadium	T-V	9.8	1.8	5.5	1.1	26.5
Zinc	T-Zn	205	62.4	330	244	1280

Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797b

Sample ID		Site H Lichen	Site H Willow
Sample Date		99 07 12	99 07 12
ASL ID		*19*	*20*
Total Metals			
Aluminum	T-Al	529	163
Antimony	T-Sb	0.08	<0.03
Arsenic	T-As	0.48	0.08
Barium	T-Ba	87.1	68.3
Beryllium	T-Be	<0.1	<0.1
Bismuth	T-Bi	<0.1	<0.1
Cadmium	T-Cd	1.85	4.62
Calcium	T-Ca	90400	11500
Chromium	T-Cr	1.5	0.7
Cobalt	T-Co	0.1	0.3
Copper	T-Cu	1.68	7.75
Lead	T-Pb	472	41.5
Lithium	T-Li	0.2	<0.2
Magnesium	T-Mg	705	3410
Manganese	T-Mn	10.6	30.5
Molybdenum	T-Mo	0.26	0.41
Nickel	T-Ni	0.8	1.2
Selenium	T-Se	<1	<1
Strontium	T-Sr	100	32.9
Thallium	T-Tl	<0.03	<0.03
Tin	T-Sn	<0.2	<0.2
Uranium	T-U	1.04	0.07
Vanadium	T-V	5.5	1.6
Zinc	T-Zn	269	438

Results are expressed as milligrams per kilogram, dry weight basis.

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

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CHEMICAL ANALYSIS REPORT

Date:	September 21, 1999
ASL File No.	K8797
Report On:	Polaris 99-90~~9~~2 Tissue Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	August 20, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

The samples "Site A Grasses" and "Site A Lichen" were replicated and the replicate results are reported as "LRep." in the following data tables.
Due to the poor replication these samples were re-digested and re-analysed and the results for this analysis are reported as "... Recheck" in the following data tables. This variability is not typical of the method of analysis. The variability may be explained by the heterogeneous nature of the samples.

RESULTS OF ANALYSIS - Tissue

File No. K8797

Sample ID		Site A Grasses	Site A Grasses LRep.	Site A Grasses Recheck	Site A Lichen	Site A Lichen LRep.
Sample Date		99 07 12	99 07 12	99 07 12	99 07 12	99 07 12
ASL ID		*1*	*1 '*	*1 Re*	*2*	*2 '*
Physical Tests						
pH		7.23	-	-	5.92	-
Total Metals						
Lead	T-Pb	311	531	653	458	607
Zinc	T-Zn	523	988	1200	377	700

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue File No. K8797

Sample ID		Site A Lichen Recheck	Site B Grasses	Site B Lichen	Site B Willow	Site C Willow
Sample Date		99 07 12	99 07 14	99 07 14	99 07 14	99 07 14
ASL ID		*2 Re*	*3*	*4*	*5*	*6*
Physical Tests						
pH		-	6.71	5.36	6.28	6.16
Total Metals						
Lead	T-Pb	633	70.0	187	21.2	21.7
Zinc	T-Zn	738	244	105	410	267

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797

Sample ID		Site C Grasses	Site C Lichen	Site D Lichen	Site D Grasses	Site E Grasses
Sample Date		99 07 14	99 07 14	99 07 14	99 07 14	99 07 12
ASL ID		*7*	*8*	*9*	*10*	*11*
Physical Tests						
pH		6.88	5.73	5.29	6.54	6.75
Total Metals						
Lead	T-Pb	147	312	234	116	91.4
Zinc	T-Zn	719	170	126	464	263

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797

7

Sample ID		Site E Lichen	Site F Willow	Site F Grasses	Site F Lichen	Site E Grasses
Sample Date		99 07 12	99 07 13	99 07 13	99 07 13	99 07 13
ASL ID		*12*	*13*	*14*	*15*	*16*
Physical Tests						
pH		5.93	6.82	6.75	5.53	6.86
Total Metals						
Lead	T-Pb	248	14.9	92.7	202	90.6
Zinc	T-Zn	128	194	264	74.4	338

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per kilogram, dry weight basis.

RESULTS OF ANALYSIS - Tissue

File No. K8797

Sample ID		Site E Willow	Site H Grasses	Site H Lichen	Site H Willow
Sample Date		99 07 13	99 07 12	99 07 12	99 07 12
ASL ID		*17*	*18*	*19*	*20*
Physical Tests					
pH		6.18	7.09	6.26	7.19
Total Metals					
Lead	T-Pb	19.3	421	459	43.2
Zinc	T-Zn	252	1220	268	446

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per kilogram, dry weight basis.

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

pH in Soil

This analysis is carried out in accordance with U.S. EPA Method 9045 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves mixing the soil in a one to one ratio with deionized/distilled water or calcium chloride solution, depending on whether the soil is considered calcareous or noncalcareous. The pH of the resulting solution is then measured with a standard pH probe.

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

Marine

Biota

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SEP -7 1999
GARTNER LEE

CHEMICAL ANALYSIS REPORT

Date:	September 2, 1999
ASL File No.	K8242r
Report On:	99-902 Tissue Analysis
Report To:	**Gartner Lee Ltd.** Sperling Plaza Suite 490, 6400 Roberts Street Burnaby, BC V5G 4C9
Attention:	**Ms. Eva Gerencher**
Received:	May 19, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

This report, ASL file number K8242r, supersedes the previous ASL file number K8242. The client requested that the data be reported using both wet weight and dry weight factors. The data that was calculated using the dry weight factors is identified in the following data tables with "Dry" after the sample identifier.

It should be noted that the sample identified as "Stn 4B Clams" is comprised of 25 Urchins. The remaining samples are Clams only.

RESULTS OF ANALYSIS - Tissue

File No. K8242r

Sample ID		Stn 1A Clams	Stn. 1A Clams Dry	Stn 2 Clams	Stn. 2 Clams Dry	Stn 3C Clams
Sample Date		99 05 12	99 05 16	99 05 12	99 05 16	99 05 14
Total Metals						
Aluminum	T-Al	<10	<80	11	85	<10
Antimony	T-Sb	<0.03	<0.3	<0.03	<0.3	<0.03
Arsenic	T-As	1.15	8.7	1.31	10.0	1.50
Barium	T-Ba	2.46	18.6	14.0	106	25.7
Beryllium	T-Be	<0.1	<0.8	<0.1	<0.8	<0.1
Bismuth	T-Bi	<0.1	<0.8	<0.1	<0.8	<0.1
Cadmium	T-Cd	0.83	6.3	0.67	5.0	0.55
~~Calc~~ium	T-Ca	463	3510	517	4010	650
Chromium	T-Cr	<0.5	<4	1.0	8	<0.5
Cobalt	T-Co	<0.1	<0.8	<0.1	<0.8	<0.1
Copper	T-Cu	0.91	7.0	0.94	7.0	2.27
Lead	T-Pb	<0.1	<0.8	<0.1	<0.8	2.2
Lithium	T-Li	<0.2	<2	<0.2	<2	<0.2
~~Magn~~esium	T-Mg	867	6570	922	7150	652
Manganese	T-Mn	0.88	7.0	0.78	6.0	1.71
Molybdenum	T-Mo	0.07	0.5	0.10	0.8	0.06
Nickel	T-Ni	0.3	2.3	0.6	5.0	0.1
Selenium	T-Se	<1	<8	<1	<8	<1
~~Stro~~ntium	T-Sr	6.53	49.5	6.63	51.0	6.45
~~Thal~~lium	T-Tl	<0.03	<0.3	<0.03	<0.3	<0.03
Tin	T-Sn	<0.2	<2	<0.2	<1	<0.2
~~U~~ranium	T-U	0.02	0.15	0.03	0.23	0.02
~~Vana~~dium	T-V	<0.5	<4	<0.5	<4	<0.5
Zinc	T-Zn	23.5	178	18.6	144	54.9

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per wet kilogram except where noted.
The samples identified as "... Dry" have results that are expressed as milligrams per dry kilogram. The dry weight factors are based on an average sample moisture of 86%.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. K8242r

Sample ID		Stn. 3C Clams Dry	Stn 3A Clams	Stn.3A Clams Dry	Stn 4B "~~Clams~~" SeaUrchins	Stn. 4B ~~"Clams"~~ Sea urchins Dry
Sample Date		99 05 16	99 05 14	99 05 16	99 05 15	99 05 16
Total Metals						
Aluminum	T-Al	80	<10	<80	168	1290
Antimony	T-Sb	<0.3	<0.03	<0.3	<0.03	<0.3
Arsenic	T-As	12.0	1.50	12.0	0.81	6.2
Barium	T-Ba	198	3.13	25.7	46.4	357
Beryllium	T-Be	<0.8	<0.1	<0.8	<0.1	<0.8
Bismuth	T-Bi	<0.8	<0.1	<0.8	<0.1	<0.8
Cadmium	T-Cd	4.2	0.73	6.0	1.37	10.0
Calcium	T-Ca	5000	714	5850	4660	35800
Chromium	T-Cr	<4	<0.5	<4	0.9	7
Cobalt	T-Co	<0.8	<0.1	<0.8	<0.1	<0.8
Copper	T-Cu	17.5	0.90	7.4	1.49	11.0
Lead	T-Pb	17.0	0.7	5.7	136	1050
Lithium	T-Li	<2	<0.2	<2	0.3	2
Magnesium	T-Mg	5020	876	7180	1660	12800
Manganese	T-Mn	13.0	0.67	5.5	3.46	27.0
Molybdenum	T-Mo	0.5	0.11	0.9	0.10	0.8
Nickel	T-Ni	0.8	0.3	2.5	0.5	3.8
Selenium	T-Se	<8	<1	<8	<1	<8
Strontium	T-Sr	50.0	8.56	70.0	16.3	125
Thallium	T-Tl	<0.3	<0.03	<0.3	<0.03	<0.3
Tin	T-Sn	<2	<0.2	<2	<0.2	<2
Uranium	T-U	0.15	0.05	0.41	0.09	0.70
Vanadium	T-V	<4	<0.5	<4	1.8	14
Zinc	T-Zn	422	21.1	173	348	2680

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per wet kilogram except where noted.
The samples identified as "... Dry" have results that are expressed as milligrams per dry kilogram. The dry weight factors are based on an average sample moisture of 86%.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. K8242r

Sample ID		Stn 4E Clams	Stn. 4E Clams Dry
Sample Date		99 05 16	99 05 16
Total Metals			
Aluminum	T-Al	<10	<80
Antimony	T-Sb	<0.03	<0.3
Arsenic	T-As	1.11	8.4
Barium	T-Ba	0.33	2.5
Beryllium	T-Be	<0.1	<0.8
Bismuth	T-Bi	<0.1	<0.8
Cadmium	T-Cd	0.82	6.2
Calcium	T-Ca	345	2620
Chromium	T-Cr	<0.5	<4
Cobalt	T-Co	<0.1	<0.8
Copper	T-Cu	2.25	17.0
Lead	T-Pb	19.2	146
Lithium	T-Li	<0.2	<2
Magnesium	T-Mg	834	6320
Manganese	T-Mn	0.91	6.9
Molybdenum	T-Mo	0.06	0.5
Nickel	T-Ni	0.1	0.8
Selenium	T-Se	<1	<8
Strontium	T-Sr	5.85	44.0
Thallium	T-Tl	<0.03	<0.3
Tin	T-Sn	<0.2	<2
Uranium	T-U	0.02	0.20
Vanadium	T-V	<0.5	<4
Zinc	T-Zn	34.4	261

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per wet kilogram except where noted.
The samples identified as "... Dry" have results that are expressed as milligrams per dry kilogram. The dry weight factors are based on an average sample moisture of 86%.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Tissue

File No. K8242r

Sample ID		Stn 1A Clams	Stn. 1A Clams Dry	Stn 3C Clams	Stn. 3C Clams Dry	Stn 3A Clams
Sample Date		99 05 12	99 05 16	99 05 14	99 05 16	99 05 14
Polycyclic Aromatic Hydrocarbons						
Acenaphthene		<0.01	<0.08	<0.01	<0.08	<0.01
Acenaphthylene		<0.01	<0.08	<0.01	<0.08	<0.01
Anthracene		<0.01	<0.08	<0.01	<0.08	<0.01
Benz(a)anthracene		<0.01	<0.08	<0.01	<0.08	<0.01
Benzo(a)pyrene		<0.01	<0.08	<0.01	<0.08	<0.01
Benzo(b)fluoranthene		<0.01	<0.08	<0.01	<0.08	<0.01
Benzo(g,h,i)perylene		<0.01	<0.08	<0.01	<0.08	<0.01
Benzo(k)fluoranthene		<0.01	<0.08	<0.01	<0.08	<0.01
Chrysene		<0.01	<0.08	<0.01	<0.08	<0.01
Dibenz(a,h)anthracene		<0.01	<0.08	<0.01	<0.08	<0.01
Fluoranthene		<0.01	<0.08	<0.01	<0.08	<0.01
Fluorene		<0.01	<0.08	<0.01	<0.08	<0.01
Indeno(1,2,3-c,d)pyrene		<0.01	<0.08	<0.01	<0.08	<0.01
Naphthalene		<0.01	<0.08	<0.01	<0.08	<0.01
Phenanthrene		<0.01	<0.08	<0.01	<0.08	<0.01
Pyrene		<0.01	<0.08	<0.01	<0.08	<0.01
Polychlorinated Biphenyls						
Total Polychlorinated Biphenyls		<0.05	<0.4	-	<0.4	-
Surrogate Standards						
d10-Acenaphthene (SS)	%	93	-	101	-	91
d12-Chrysene (SS)	%	68	-	70	-	66
d8-Naphthalene (SS)	%	71	-	80	-	68
d12-Perylene (SS)	%	87	-	89	-	86
d10-Phenanthrene (SS)	%	84	-	88	-	83

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per wet kilogram except where noted.
The samples identified as "... Dry" have results that are expressed as milligrams per dry kilogram. The dry weight factors are based on an average sample moisture of 86%.
< = *Less than the detection limit indicated.*

RESULTS OF ANALYSIS - Tissue

File No. K8242r

Sample ID Sample Date		Stn.3A Clams Dry 99 05 16	Stn 4E Clams 99 05 16	Stn. 4E Clams Dry 99 05 16
Polycyclic Aromatic Hydrocarbons				
Acenaphthene		<0.08	<0.01	<0.08
Acenaphthylene		<0.08	<0.01	<0.08
Anthracene		<0.08	<0.01	<0.08
Benz(a)anthracene		<0.08	<0.01	<0.08
Benzo(a)pyrene		<0.08	<0.01	<0.08
Benzo(b)fluoranthene		<0.08	<0.01	<0.08
Benzo(g,h,i)perylene		<0.08	<0.01	<0.08
Benzo(k)fluoranthene		<0.08	<0.01	<0.08
Chrysene		<0.08	<0.01	<0.08
Dibenz(a,h)anthracene		<0.08	<0.01	<0.08
Fluoranthene		<0.08	<0.01	<0.08
Fluorene		<0.08	<0.01	<0.08
Indeno(1,2,3-c,d)pyrene		<0.08	<0.01	<0.08
Naphthalene		<0.08	<0.01	<0.08
Phenanthrene		<0.08	<0.01	<0.08
Pyrene		<0.08	<0.01	<0.08
Polychlorinated Biphenyls				
Total Polychlorinated Biphenyls		<0.4	<0.05	<0.4
Surrogate Standards				
d10-Acenaphthene (SS)	%	-	101	-
d12-Chrysene (SS)	%	-	71	-
d8-Naphthalene (SS)	%	-	82	-
d12-Perylene (SS)	%	-	90	-
d10-Phenanthrene (SS)	%	-	87	-

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per wet kilogram except where noted.
The samples identified as "... Dry" have results that are expressed as milligrams per dry kilogram. The dry weight factors are based on an average sample moisture of 86%.
< = 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"

Polycyclic Aromatic Hydrocarbons in Tissue

This analysis is carried out using a modification of the AOAC method "Determination of Monocyclic and Polycyclic Aromatic Hydrocarbons in Fish Tissue" (1990). The procedure involves saponification, subsequent extraction into hexane and clean-up with silica-gel. These clean-up procedures have 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.

Organochloride Pesticides and Polychlorinated Biphenyls in Tissue

This analysis is carried out in accordance with U.S. EPA Method 8080 (Publ. # SW-846 3rd ed., Washington, DC 20460). The procedure involves a soxhlet extraction using methylene chloride. The extract is then solvent exchanged to hexane followed by an alumina column clean-up. The final extract is analysed by dual capillary column gas chromatography with electron capture detection.

End of Report

TABLE 3.3
Cominco Ltd. - Polaris Operations, Nunavut Territory
Phase 2 Environmental Site Assessment
Rationale for Sampling Plan

Area	Area of Potential Environmental Concern	Description	Potential Chemicals of Concern	Sampling Locations
1	Process Barge and Ship Loading Dock	Spills and leaks of diesel fuel at the vehicle fuelling tank and from filling barge tanks: concentrate dispersion by wind during ship loading; vehicle tracking; air emissions from concentrate dryers	Petroleum hydrocarbons, metals, glycol, PCB's	24 Test Pits
2	Concentrate Storage Building	Concentrate dispersion by wind at open doorways, vehicle tracking and conveyor spills.	Metals	13 Test Pits
3	Outdoor Bulk Chemical Storage	Spills or leaks, chemicals remaining when mine closes.	Mill chemicals including: lime, sodium cyanide, xanthate, MIBC, CuSO4, ZnSO4	4 Test Pits
4	Outdoor Lube/Hydraulic Oil and Glycol Storage; Diesel Tank Farm and Pipelines	Spills and leaks from drums, pipelines, especially at valves and transfers	Petroleum hydrocarbons, glycols	8 Test Pits
5	Miscellaneous Above Ground Fuel Storage Tanks (AST's).	Spills and leaks	Petroleum hydrocarbons	4 Test Pits
6	Tailings Pipeline, Thickener Building and Emergency Discharge Basin	Tailings spills from tailings line breaks, tailigs contamination in discharge basin.	Metals	18 Surface Soil Samples
7	Former Oil Bladder Storage Area	Spills and leaks	Petroleum hydrocarbons	6 Test Pits
8	Operational and Construction Landfills and Open Storage Area	Waste handling, incomplete combustion of waste oil, leaching and downhill soil contamination, ash disposal.	Metals, petroleum hydrocarbons mill chemicals, nitrates, PCBs	9 Test Pits
9	Fire Training Area	Incomplete combustion of petroleum hydrocarbons, burning of paints and possibly other chemicals.	Petroleum hydrocarbons and metals	3 Test Pits
10	Old Anfo Mixing Plant; Explosives Storage and Low Alpha Lead Crusher	Soil contamination, explosives disposal and safety issues	Ammonium nitrate; petroleum hydrocarbons, metals	3 Test Pits
11	CRF Plant	Cement and chemical spillage; 2 former fuel tank locations 2 current fuel tanks; low alpha Pb sorting	Caustic pH's; petroleum hydrocarbons and metals	5 Test Pits
12	Surface Above the Active Mining Area	Air emissions from ventilation raises, soil contamination from drilling raisebore holes, contamination from temporary stockpiling of low alpha lead etc.	Metals.	4 Test Pits
13	Snow Dumps	Melting of particulate contaminated snow	Metals.	12 Surface Soil Samples
14	Adjacent Lands (Far-Field Areas)	Wind dispersion of particulate air emissions from vent raises, concentrate dryers and other mining activity.		101 Surface Soil Samples
15	Open Pits, Rock Quarries and Historic Surface Stockpiles	ARD potential, residual mineralised waste rock or ore from former stockpiles	Metals.	4 Typical Waste Rock Samples
16	Background	Natural levels of metals	Metals	6 Surface Soil Samples

TABLE 4.1 SUMMARY OF SEEPAGE MONITOR INFORMATION

Cominco Ltd. - Polaris Mine

Seep Monitor ID	Total Installed Depth (m)	Screen Interval (m)	Elevation (mASL) Ground	Stickup (m)	Elevation (mASL) Top of Pipe	Depth to Frozen Layer[B.]	16-Jul-99				
							Depth to Water[A.] (m)	Depth to Water[B.] (m)	Elev. of WaterTable (mASL)	pH	Conductivity (uS/cm)
BH-1	3.7	0.7-3.7	999.8	0.710	1,000.5	0.9	1.4[C.]	0.69	999.11	-	-
BH-2	3.7	0.7-3.7	999.8	0.640	1,000.4	-	dry	-	-	-	-
BH-3	4.7	1.6-4.6	999.8	0.610	1,000.4	-	dry	-	-	-	-
BH-4	4.5	1.6-4.6	999.8	-	-	-	dry	-	-	-	-
BH-5	3.7	0.7-3.7	999.5	0.500	1,000.0	1.3	0.9	0.40	999.10	7.2	17300
BH-6	3.7	0.7-3.7	999.5	0.510	1,000.0	1.1	1.4	0.89	998.61	7.1	2640
BH-7	3.7	0.7-3.7	999.5	0.480	1,000.0	1.5	1.7	1.22	998.28	-	-
BH-8	3.7	0.7-3.7	999.6	0.160	999.8	-	-	-	-	-	-
BH-9	4.7	1.6-4.6	-	0.650	-	-	dry	-	-	-	-
BH-10	5.5	1.6-4.6	-	-	-	-	dry	-	-	-	-
TP-1	1.36	0.5-1.5	999.9	0.200	1,000.1	-	1.5	1.30	998.60	-	-
TP-2	1.3	0.5-1.5	999.8	0.270	1,000.1	-	1.4	1.13	998.67	7.4	2040
TP-5	4	1-4	999.6	0.580	1,000.2	-	2.7	2.12	997.48	6.6	2670
TP-8	1.33	0.5-1.3	999.8	destroyed		-	1.6	-	-	-	-
TP-11	1.2	0.2-1.2	999.5	0.120	999.6	-	0.9	0.78	998.72	7.1	3430
TP-13	1.2	0.2-1.2	1,001.1	destroyed		-	1.1	-	-	-	-
TP-14	1.28	0.3-1.3	1,000.2	0.280	1,000.5	-	1.2	0.92	999.28	6.8	4950
TP-15	1.22	0.2-1.2	999.4	0.360	999.8	-	1	0.64	998.76	6.7	3740
TP-17	1.03	0.2-1	999.5	0.350	999.9	-	0.8	0.45	999.05	-	-
TP-20	1.9	0.5-1.8	999.6	0.230	999.8	-	2	1.77	997.83	-	-
TP-52	1.17	0.2-1.2	1,001.9	0.170	1,002.1	-	1	0.83	1001.07	7.6	1920
TP-55	1.26	0.2-1.2	1,000.9	0.500	1,001.4	-	1.6	1.10	999.80	7.4	3620
TP-57	1.3	0.2-1.2	1,012.0	0.250	1,012.3	-	1.3	1.05	1010.95	7.6	3930
TP-59	1.39	0.2-1.2	1,009.8	0.160	1,010.0	-	1	0.84	1008.96	7.5	3580
TP-61	1	0.2-1	1,032.9	0.560	1,033.5	-	0.8	0.24	1032.66	7.4	2550

'-' no measurement

: the total measured depth coincides with the depth to permafrost or in the case of the boreholes where it is close to the total drilled depth, it means that little or no water accumulated during the seasonal melt

A. Depth measured from top of casing

B. Depth measured from ground level

C. measured 4 cm of free product floating on water table

Notes:

1. See Figure 2 for location of borehole and monitoring wells.

2. Top of Pipe elevation is a reference point used for water level measurements in boreholes with a monitoring well installed.

3. Elevations were surveyed relative to mine elevations

TABLE 6.3 RESULTS OF ANALYSIS - SURFACE SOIL SAMPLES

Lead and Zinc Concentrations in Soil (ug/g)

Cominco Ltd. - Polaris Operations

Sample ID	Coordinates East	Coordinates North	pH	Lead	Zinc
1	538	2124	8.53	151	560
2	550	1950	8.45	360	1320
3[1]	600	1560	-	6,440	39,200
3 dup.	600	1560	8.15	6,670	40,100
4	620	1510	8.16	586	1,680
6	630	1290	8.3	465	2,490
9	630	1730	8.5	129	471
10	640	1460	8.16	1,750	4,810
12	650	1310	8.22	2,320	6,180
13	650	1380	8.39	984	2,730
15	650	1850	-	789	2,010
16	652	2354	9.26	32	55
17[1]	660	1320	-	3,560	6,660
17 dup.	660	1320	8.24	3,960	6,940
19	670	1400	8.3	1,180	2,690
21	700	1330	8.24	1,270	5,740
22	720	1260	-	1,900	5,100
23	730	1140	8.6	612	1,390
25	750	1950	8.85	76	323
26	780	1050	8.44	304	1,300
27	796	1630	8.54	152	681
28	800	1150	8.34	898	2,910
29[1]	820	940	-	999	4,680
29 dup.	820	940	8.5	1,090	4,900
30	840	1070	8.35	898	2,170
31	850	1850	-	89	563
33	881	1456	8.35	995	2,820
34	912	2455	8.97	285	1,130
35	922	2205	8.29	253	1,110
36	927	1204	8.92	107	896
37	950	350	-	135	466
38	950	650	8.91	138	416
39	950	850	-	301	323
40	950	1750	-	179	1,250
41	950	1950	8.47	98	751
42	952	747	8.69	30	31
43	952	1042	8.85	386	557
44	962	208	8.71	228	749
46	1018	1856	8.49	299	2,270
47[1]	1025	1621	-	779	5,720
47 dup.	1025	1621	8.21	820	2,250
48	1050	250	8.83	332	896
49	1050	750	-	105	452
50	1058	1310	8.1	74	229
51	1103	1517	8.25	653	4,310
52	1106	1062	8.09	323	1,480
53	1116	2223	8.5	2,340	6,780
54	1150	1300	8.34	58	300
55	1154	2005	8.16	477	8,480
56	1200	1700	8.24	257	2,680

1. Sample analyzed for full metal scan

🟦 Exceeds the Risk-Based Remedial Objectives

Sample ID	Coordinates East	Coordinates North	pH	Lead	Zinc
57	1211	1207	7.38	154	606
58	1250	997	8.1	114	477
59[1]	1401	1267	-	398	1,220
59 dup.	1401	1267	8.12	387	1,270
60	1441	1058	8.27	22	118
61	1474	1474	8.65	50	210
62	1482	1770	8.84	169	1,130
63	1494	1461	7.81	1,220	3,540
64	1699	1599	8.39	161	557
65	1700	1350	8.19	105	295
66	1793	1223	8.9	375	537
67	1900	1700	7.88	116	518
68	2100	3800	7.79	18	157
69	2237	2555	8.56	127	466
71	2250	750	8.34	22	134
72	2250	1300	-	60	459
73	2250	2800	-	988	2,970
73[1]	2250	2800	7.8	1,010	2,920
74	2250	3350	-	116	469
75	2250	-2750	8.05	19	225
76	2283	3034	7.92	21	144
77	2300	1750	7.54	65	367
78	2300	2400	8.14	21	310
79	2438	2271	8.03	61	293
80	2600	3300	7.83	103	456
81	2750	1100	8.51	14	111
82	2750	-2250	8.8	8	61.3
83	2800	2400	8.08	16	353
84	2800	2750	8.39	23	329
85	2800	-750	8.43	10	77.8
86	2817	1623	7.941	21	223
87	2835	2002	8.51	14	122
88	2900	-150	8.15	26	155
89	2900	-1600	8.19	10	49.6
90	3200	1750	8.48	17	414
91	3200	-1200	7.95	69	249
92	3200	-2300	8.57	10	95.6
93	3200	-750	8.57	9	57.1
94	3223	1564	8.38	12	94.4
95	3250	750	8.4	14	107
96	3250	1250	8.25	20	133
97	3250	2750	7.9	13	159
98	3250	-1750	-	13	77.5
99	3250	-300	8.32	22	135
100	3282	2020	8.32	15	23.4
101	3300	2300	8.04	113	646
102	3300	3300	-	24	294
103	3328	2550	8.3	10	126
104	3400	250	8.16	16	84.9
105	3456	1084	8.36	12	76.3
107	3700	-300	8.22	13	120
106	3700	1750	-	15	107

Risk Based Remedial Objectives		
Objective for Protection of Human Health and the Environment	1,800	650

Sample ID	Coordinates East	Coordinates North	pH	Lead	Zinc
108	3738	2016	8.53	11	106
109	3743	1541	8.34	8	53
113	3750	-1300	8.66	9	50.2
110	3750	1250	8.17	11	77
111	3750	2750	-	10	113
112	3750	3300	8.54	9	61
114	3800	800	8.06	14	83.1
115	3800	2300	8.33	12	121
Tailings Line					
TL1	700	1380	8.13	9470	45200
TL3	740	1200	8.54	449	1,930
TL5	780	1100	8.51	273	1,420
TL9	930	510	8.51	233	960
TL11	1480	980	8.48	365	1,060
TL12	1510	1100	8.26	213	760
TL14	2800	1050	8.31	60	219
TL15	2850	1200	8.34	43	243
TL16	2950	1150	7.98	1,310	2,970
TL18	3050	1300	8.11	591	4,520
Firehall Snowdump					
FH-A	A		8.31	15,600	59,300
FH-A[1]	A		-	11,200	46,900
FH-B	B		8.75	16,500	56,700
FH-C	C		8.13	13,500	30,800
Foldaway Snowdump					
FW-A	A		8.63	1,980	4,690
FW-B	B		8.58	1,670	5,030
MAIN	Main Snowdump		9.06	173	479
Loon Lake Snowdump					
LL-A	A		8.37	2,040	7,260
LL-C	C		8.42	1,220	3,050
New Quarry					
NQ-1			-	92	349
NQ-1	duplicate		-	99	465
NQ-2				27	123
NQ-3			-	22	300
NQ-4			-	86	292
NQ-5			-	86	369
NQ-6			-	17	38.6

Risk Based Remedial Objectives		
Objective for Protection of Human Health and the Environment	1,800	650

1. Duplicate sample, also analyzed for full metal scan

🟦 Exceeds the Risk-Based Remedial Objectives

TABLE 6.4 RESULTS OF ANALYSIS - TEST PIT SOIL SAMPLES

Lead and Zinc Concentrations in Soil (ug/g)

Cominco Ltd. - Polaris Operations

Sample ID	Depth (m)	pH	Lead	Zinc
Process Barge and Concentrate Storage Area				
BH1	0-0.9	8.64	571	1,550
BH1	1.8-2.7	8.99	< 300	2,070
BH2	0-0.61	8.91	876	4,020
BH2 (dup)	0-0.61	8.28	1,100	6,980
BH2	0.61-1.5	-	39	130
BH3	0-0.61	-	1,060	3,920
BH3	0.61-1.5	-	158	189
BH4	0-0.61	8.55	3,210	11,500
BH4	0.61-1.5	-	14,900	111,000
BH4	3.1-4.6	-	1,150	3,690
BH4	4.6-6.1	-	223	1,210
BH5	0-0.61	8.81	659	1,850
BH5	0.61-1.5	-	412	1,200
BH6	0-0.61	8.72	< 400	278
BH6	0.61-1.5	-	19	43
BH7	0-0.61	7.87	3,730	12,000
BH7	3.1-4.6	-	1,150	4,630
BH7	4.6-6.1	-	1,430	6,660
BH8	0-0.61	8.48	2,870	9,270
BH8	0.61-1.5	-	1,750	6,120
BH8	3.1-3.6	-	70	180
BH9	0-0.61	8.13	17,100	12,500
BH9	0.61-1.5	-	11,100	5,140
BH9	4.6-6.1	-	52	37.9
BH9	6.1-7.6	-	77	57.3
BH10	0-0.61	8.54	1,120	1,930
BH10	0.61-1.5	-	488	24,800
BH10	3.1-4.6	-	39	191
TP1	0-0.05	7.48	10,800	44,500
TP2	0-0.05	7.53	13,500	44,500
TP3	0.6-0.9	8.23	267	983
TP4	0.1-0.3	8.33	87	428
TP4	0.9-1.2	-	90	112
TP5	0.1-0.3	7.53	1,870	6,420
TP5 dup.	0.5-0.8	-	4,620	4,380
TP5[1.]	0.5-0.8	-	4,120	4,350
TP6	0.1-0.3	8.23	564	1,260
TP6	0.6-0.9	-	447	1,640
TP7	0.5-0.8	8.66	22	58.7
TP8	0.1-0.3	7.96	2,010	6,640
TP9	0.1-0.3	8.14	2,570	9,670
TP9	0.6-0.9	-	3,540	13,100
Risk Based Remedial Objectives				
Objective for Protection of Human Health & the Environment			1800	650

Sample ID	Depth (m)	pH	Lead	Zinc
TP11	0.3-0.6	7.95	565	3,410
TP11	0.9-1.2	-	345	1,880
TP12	0.6-0.9	7.89	70	256
TP14	0.1-0.3	-	9,550	2,230
TP15	0.1-0.3	-	4,340	11,500
TP16	0.2-0.4	8.33	1,110	5,740
TP17	0.2-0.4	8.38	270	488
TP18	0-0.1	-	9,350	18,900
TP18	0.3-0.6	8.03	233	324
TP19[1.]	0.3-0.6	-	5,240	4,040
TP20	0.3-0.6	8.34	378	1,860
TP21	0.6-0.9	-	1,480	2,890
TP22	0.3-0.6	-	3,940	5,420
TP23	0.1-0.3	-	632	1,410
TP23	0.6-0.9	-	2,900	6,500
TP24	0-0.1	-	13,900	10,800
TP25	0-0.1	-	15,800	168,000
TP25	0.1-0.3	-	157	1,280
TP25	0.3-0.6	-	7,400	46,100
TP26	0.1-0.3	-	183	883
TP27	0.1-0.3	-	980	1,950
TP28	0.1-0.3	-	187	3,140
TP29	0-0.1	-	981	40,100
TP30	0.1-0.3	-	270	4,670
TP30	0.7-0.9	-	185	1,330
TP31[1.]	0.1-0.3	-	< 300	5,210
TP31dup.	0.1-0.3	-	63	5,160
TP32	0.2-0.4	-	93	545
TP33	0.2-0.4	-	636	2,820
TP33	0.6-1	-	59	1,070
TP34[1.]	0.2-0.4	-	13,700	11,300
TP34dup.	0.2-0.4	-	14,600	11,000
TP34	0.6-0.9	-	2,650	5,830
TP35	0.1-0.3	-	606	1,990
TP36	0.2-0.4	8.28	182	278
TP37	0.1-0.2	8.27	105	313
TP38	0.1-0.3	8.24	67	144
TP39	0.1-0.3	8.24	104	422
TP40[1.]	0.1-0.3	-	2,060	17,000
TP40dup.	0.1-0.3	-	2,470	17,700
TP41	0.1-0.3	-	101	711
TP41	0.3-0.6	-	51	347
TP42	0.1-0.3	-	55	301

🟦 Exceeds the Risk-Based Remedial Objectives

[1.] Full metal scan

"-" no measurement

TABLE 6.4 RESULTS OF ANALYSIS - TEST PIT SOIL SAMPLES
Lead and Zinc Concentrations in Soil (ug/g)
Cominco Ltd. - Polaris Operations

Sample ID	Depth (m)	pH	Lead	Zinc
Outdoor Oil Storage Area				
TP44	0-0.2	-	3,550	11,100
TP45	0-0.1	-	2,000	7,830
TP45	0.3-0.6	-	371	2,150
TP79	0.3-0.6	9.02	51	191
TP80	0-0.1	8.52	782	3,110
TP80	0.1-0.3	-	9,710	38,700
TP80	0.3-0.6	-	14,200	34,900
TP81	0.1-0.3	-	13,500	40,000
TP81	0.3-0.6	-	4,570	13,600
Downslope of Outdoor Oil Storage Area				
TP46	0.1-0.2	-	31	237
TP47	0-0.1	8.58	147	465
Foldaway Buildings				
TP82	0-0.1	-	970	4,030
Downslope of the Construction Landfill				
TP52	0-0.1	-	62	231
TP52	0.3-0.6	8.4	8	16
TP54	0-0.1	-	159	644
TP55	0-0.1	-	71	224
TP55	0.6-0.8	-	26	69.5
Downslope of the Operational Landfill				
TP57	0-0.1	-	163	722
TP57	0.3-0.6	8.05	27	103
TP59	0-0.1	-	61	1,180
TP59	0.2-0.4	7.87	15	90
Upslope of the Operational Landfill				
TP61	0-0.1	-	16	115
TP61	0.2-0.4	7.99	9	60.7
Former Oil Bladder Storage Area				
TP62	0-0.1	7.74	277	1,020
TP62	0.5-0.8	-	9	64
TP67	0-0.1	-	682	126
TP67	0.4-0.6	-	6	22

Sample ID	Depth (m)	pH	Lead	Zinc
Former Anfo Mixing Plant Area				
TP49	0-0.1	-	14	39
TP51	0-0.1	-	234	575
TP51	0.3-0.6	-	53	142
Fire Training Area				
TP68	0-0.1	-	59	275
TP68[1.]	0.4-0.6	-	533	2,570
TP68dup.	0.4-0.6	7.85	622	2,630
TP69	0.4-0.6	8.28	208	1,690
TP70	0.3-0.6	8.43	399	2,320
TP70	0.6-0.9	-	161	2,180
CRF Plant Area				
TP71	0-0.05	8.5	330	1,160
TP71	0.1-0.3	8.35	137	582
TP72	0-0.1	8.54	339	633
TP72	0.1-0.3	8.75	22	66
TP73	0.1-0.3	8.39	143	142
TP75	0-0.05	-	1,300	4,660
TP75	0.1-0.3	-	55	215
Raised Bore Area				
TP76	comp	7.98	350	1,590
TP76	0.1-0.3	-	196	1,380
TP77	0-0.1	-	869	3,330
TP77[1.]	0.1-0.3	-	834	2,750
TP77dup.	0.1-0.3	-	911	2,850
TP77	0.3-0.6	-	961	10,300
TP77	comp	8.4	947	3,080
TP78	0.1-0.3	-	49	236
TP78	0.3-0.6	-	28	144
TP78	comp	8.52	324	2,080
Firehall Area				
TP83	0-0.1	8.61	821	2,010
TP83	0.1-0.3		655	1,340
TP84	0.1-0.3	8.22	490	2,050
TP84	0.3-0.6	8.39	24	275

Risk Based Remedial Objectives		
Objective for Protection of Human Health & the Environment	1800	650

🟦 Exceeds the Risk-Based Remedial Objectives

[1.] Full metal scan

"-" no measurement

TABLE 6.5 RESULTS OF ANALYSIS - SOIL SAMPLES

Total Metal Concentrations in Soil (ug/g)

Cominco Ltd. - Polaris Operations

Sample ID	CCME Soil Quality Guidelines[1.] and Risk Based Remedial Objectives[2.]		3	17	29	47	59	73	Firehall	Barge Area		Concentrate Building			FTA[3]	Raised Bore
Coordinates			600E	660E	820E	1025E	1401E	2250E	Snowdump	TP5	TP19	TP31	TP34	TP40	TP68	TP77
or Depth (m)			1560N	1320N	940N	1621N	1267N	2800N	surface	0.5-0.8	0.3-0.6	0.1-0.3	0.2-0.4	0.1-0.3	0.4-0.6	0.1-0.3
Soil pH	RL/PL	IL/CL	-	-	-	-	-	-	-							
Total Metals[1.] (ug/g)																
Antimony	20	40	< 100	< 100	< 200	< 40	< 60	< 20	< 80	< 100	< 200	< 100	< 100	< 40	< 40	< 40
Arsenic	12	12	< 500	< 500	< 600	< 200	< 300	< 100	< 400	< 500	< 600	< 500	< 500	< 200	< 200	< 200
Barium	500	2,000	21	22	27	62	120	277	26	16	28	42	83	17	22	12
Beryllium	4	8	< 3	< 3	< 3	< 1	< 2	0.6	< 2	< 3	< 3	< 3	< 3	< 1	< 1	< 1
Cadmium	10	22	70	16	< 20	10	<6	9	105	14	< 20	< 10	30	42	6	5
Chromium	64	87	< 10	< 10	< 20	13	24	20	< 8	< 10	< 20	< 10	< 10	5	22	44
Cobalt	50	300	< 10	< 10	< 20	< 4	< 6	4	< 8	< 10	< 20	< 10	< 10	< 4	< 4	14
Copper	63	91	8	11	13	5	23	34	7	< 5	21	< 5	15	196	15	15
Lead[2.]	1800	1,800	6,440	3,560	999	779	398	988	11,200	4,120	5,240	< 300	13,700	2,060	533	834
Molybdenum	10	40	< 20	< 20	< 30	< 8	< 20	< 4	< 20	< 20	< 30	< 20	< 20	< 8	< 8	< 8
Nickel	50	50	< 30	< 30	< 30	10	43	39	< 20	< 30	< 30	< 30	< 30	< 10	16	37
Selenium	3	10	< 300	< 300	< 300	< 100	< 200	< 50	< 200	< 300	< 300	< 300	< 300	< 100	< 100	< 100
Silver	20	40	< 10	< 10	< 20	< 4	< 6	< 2	< 8	< 10	< 20	< 10	< 10	< 4	< 4	< 4
Tin	50	300	< 50	< 50	< 60	< 20	< 30	< 10	< 40	< 50	< 60	< 50	< 50	< 20	< 20	< 20
Zinc[2.]	650	650	39,200	6,660	4,680	5,720	1,220	2,970	46,900	4,350	4,040	5,210	11,300	17,000	2,570	2,750

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

[2.] Risk Based Remedial Objectives

▨ Exceeds the CCME Recommended Soil Quality Guidelines for Industrial Land Use or the Risk Based Remedial Objectives

[3.] FTA = Fire Training Area

TABLE 6.6 RESULTS OF ANALYSIS - SOIL SAMPLES

Total and TCLP Extractable Metal Concentrations in Soil (ug/g)

Cominco Ltd. - Polaris Operations

Location and Sample ID	CCME Soil Quality Guidelines or Risk Based Remedial Objectives	17	47	73	80	101	TL	Process Barge Area			Concentrate Storage Building and Outdoor Chemical Storage Area				Training Area	Oil Storage
Coordinates		660E	1025E	2250E	2600E	3300E	2950E	TP5	TP16	TP19	TP25	TP27	TP33	TP45	TP70	TP80
or Depth (m)		1320N	1621N	2800N	3300N	2300N	1150N	0.5-0.8	0.2-0.4	0.3-0.6	0.3-0.6	0.1-0.3	0.6-1	0.3-0.6	0.3-0.6	0.3-0.6
Soil pH	**Industrial**	8.75	8.71	8.45	7.83	8.04	7.98	8.52	8.33	8.76	9.34	9.27	9.06	9.38	8.43	8.97
Total Metals (ug/g)																
Antimony	40	< 100	< 40	< 20	-	-	-	< 100	-	< 200	-	-	-	-	-	-
Arsenic	12	< 500	< 200	< 100	-	-	-	< 500	-	< 600	-	-	-	-	-	-
Barium	2,000	22	62	277	-	-	-	16	-	28	-	-	-	-	-	-
Beryllium	8	< 3	< 1	0.6	-	-	-	< 3	-	< 3	-	-	-	-	-	-
Cadmium	22	16	10	9	-	-	-	14	-	< 20	-	-	-	-	-	-
Chromium	87	< 10	13	20	-	-	-	< 10	-	< 20	-	-	-	-	-	-
Cobalt	300	< 10	< 4	4	-	-	-	< 10	-	< 20	-	-	-	-	-	-
Copper	91	11	5	34	-	-	-	< 5	-	21	-	-	-	-	-	-
Lead	600	3,560	779	988	103	113	1,310	4,120	1,100	5,240	7,400	980	59	371	399	14,200
Molybdenum	40	< 20	< 8	< 4	-	-	-	< 20	-	< 30	-	-	-	-	-	-
Nickel	50	< 30	10	39	-	-	-	< 30	-	< 30	-	-	-	-	-	-
Selenium	10	< 300	< 100	< 50	-	-	-	< 300	-	< 300	-	-	-	-	-	-
Silver	40	< 10	< 4	< 2	-	-	-	< 10	-	< 20	-	-	-	-	-	-
Tin	300	< 50	< 20	< 10	-	-	-	< 50	-	< 60	-	-	-	-	-	-
Zinc	360	6,660	5,720	2,970	456	646	2,970	4,350	5,740	4,040	46,100	1,950	1,070	2,150	2,320	34,900
TCLP Extractable Metals (mg/L)																
Arsenic	5 [2]	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Barium	100	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	1	< 3	1.1	1.5	< 3	< 0.3
Cadmium	1	< 0.05	0.2	< 0.05	< 0.05	< 0.05	0.05	0.05	0.05	< 0.05	< 0.05	0.05	< 0.05	< 0.05	0.06	< 0.05
Chromium	5	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.05	< 0.3	< 0.05	< 0.05	< 0.3	< 0.05
Copper	100	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Lead	5	24.5	4	< 0.3	< 0.3	< 0.3	2.1	9.6	2.1	6	15.3	9.5	< 0.3	0.5	< 0.3	4.9
Selenium	1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Silver	5	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.05	< 0.3	< 0.05	< 0.05	< 0.3	< 0.05
Zinc	500	10.7	31.1	0.4	< 0.3	< 0.3	11.9	3.6	0.7	12.8	3	5.2	20.3	1.4	21.3	2

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

[2] BC Special Waste Regulation. Leachate Quality Standards.

▭ Exceeds CCME Recommended Soil Quality Guidelines for Industrial Land Use or Risk Based Remedial Objectives

🟦 Exceeds the BC Leachate Quality Standard

[3] FTA = Fire Training Area

TABLE 6.6 RESULTS OF ANALYSIS - BOREHOLE AND TEST PIT SOIL SAMPLES
Extractable Petroleum Hydrocarbons (EPH) ug/g
Cominco Ltd. - Polaris Operations

Sample ID	Depth (m)	Light EPH (C10-C19)	Heavy EPH (C19-C32)
Process Barge Area			
BH 1	0-0.91	4130	1220
BH 1	1.8-2.7	917	998
BH 1	3.7-4.6	< 200	221
BH 2	0-0.61	< 200	< 200
BH 2 (dupl)	0-0.61	< 200	545
BH 2	0.6-1.5	470	206
BH 3	0-0.61	< 200	< 200
BH 3	0.6-1.5	< 200	< 200
BH 3	3.1-4.6	< 200	< 200
BH 4	0-0.61	< 200	< 200
BH 4	0.6-1.5	< 200	284
BH 5	0-0.61	< 200	633
BH 5	0.6-1.5	< 200	331
BH 5	3.1-3.7	< 200	< 200
BH 6	0-0.61	< 200	< 200
BH 6	0.6-1.5	3250	431
BH 6	3.1-3.7	< 200	< 200
BH 7	0-0.61	599	522
BH 7	0.6-1.5	2530	< 200
BH 7	1.5-3.1	1520	< 200
BH 7	3.1-4.6	< 200	< 200
BH 7	6.1-7.6	< 200	< 200
BH 8	0-0.61	4170	451
BH 8	0.6-1.5	3830	431
BH 8	1.5-3.1	3980	457
BH 8	3.1-3.7	1960	243
BH 9	0-0.61	< 200	< 200
BH 9	0.6-1.5	320	< 200
BH 9	3.1-4.6	< 200	< 200
BH 10	0-0.61	< 200	< 200
BH 10	0.6-1.5	< 200	< 200
BH 10	3.1-4.6	< 200	< 200
TP1	0-0.05	< 200	1940
TP1	0.3-0.5	3950	< 200
TP1	0.8-1	7210	< 200
TP2	0-0.05	226	500
TP2	0.9-1.2	< 200	< 200
TP3	1.2-1.5	3770	< 200
TP4	0.9-1.2	< 200	< 200
TP5	0.1-0.3	< 200	231
TP5	0.5-0.8	889	225
TP5	1.8-2.4	17000	848
TP6	0.1-0.3	< 200	< 200
TP7	2.5-2.7	6130	583
TP8	0.1-0.3	2160	5910
TP8	1.2-1.5	2910	6380

Sample ID	Depth (m)	Light EPH (C10-C19)	Heavy EPH (C19-C32)
TP9	0.6-0.9	1470	475
TP9	1.3-1.5	380	549
TP10	0.3-0.6	9430	240
TP10	0.9-1.2	12300	356
TP11	0.9-1.2	4270	248
TP12	0.7-1	< 200	354
TP14	0.5-0.8	< 200	< 200
TP15	0.4-0.7	6610	490
TP16	0.2-0.4	< 200	< 200
TP17	0.2-0.4	< 200	486
TP18	0.3-0.6	276	887
TP19	0.3-0.6	< 200	270
TP20	0.3-0.6	5750	330
TP20	1.5-1.6	7340	847
TP21	0.6-0.9	< 200	< 200
TP22	0.9-1.2	7020	571
Shiploading Area			
TP36	0.2-0.4	408	< 200
TP36	0.6-0.9	3860	< 200
TP37	0-0.05	< 200	2550
TP38	0.1-0.2	105	313
TP38	0-0.05	< 200	< 200
TP38	0.6-0.9	< 200	< 200
TP39	0.6-0.9	< 200	< 200
Foldaway AST			
TP43	0.3-0.6	17900	389
TP82	0.3-0.6	< 200	530
Downslope of Diesel ASTs and Oil Storage			
TP44	0.3-0.7	< 200	< 200
TP45	0.3-0.6	< 200	873
TP46	0.1-0.2	< 200	< 200
Former Anfo Mixing Area			
TP49	0.6-0.9	< 200	207
Downslope of Construction Landfill			
TP52	0.3-0.6	< 200	< 200
TP53	0.3-0.6	< 200	< 200
TP54	0.8-1	< 200	< 200
TP55	0.6-0.8	< 200	< 200
Downslope of Operational Landfill			
TP57	0.3-0.6	< 200	< 200
TP58	0.6-0.9	< 200	< 200
TP59	0.2-0.4	730	< 200
Upslope of Operational Landfill			
TP61	0.6-0.9	< 200	< 200
NWT Remediation Guidelines for TPH			
Industrial Land Use		2500	
Yukon CSR Standards			
Industrial Land Use		2000	5000

Sample ID	Depth (m)	Light EPH (C10-C19)	Heavy EPH (C19-C32)
Former Oil Bladder Storage Area			
TP62	0.5-0.8	< 200	< 200
TP63	0.6-0.8	< 200	< 200
TP64	0.4-0.6	5120	< 200
TP65	0.4-0.6	4760	< 200
TP66	0.4-0.6	< 200	< 200
TP67	0.4-0.6	7140	< 200
TP68	0.4-0.6	< 200	< 200
Fire Training Area			
TP69	0.4-0.6	< 200	< 200
TP70	0.6-0.9	< 200	< 200
CRF Building Area			
TP73	0-0.1	346	481
TP73	0.1-0.3	< 200	< 200
TP73	0.3-0.6	< 200	< 200
TP74	0.3-0.6	3500	< 200
TP75	0.5-0.8	3280	< 200
Raised Bore Area			
TP77	0.2-0.3	332	270
Outdoor Oil Storage Area			
TP79	0.3-0.6	< 200	< 200
TP80	0-0.1	< 200	< 200
TP81	0-0.1	250	1040
TP81	0.3-0.6	< 200	230
Firehall			
TP83	0-0.1	< 200	< 200
TP84 N	0-0.1	1970	336
TP84 N	0.3-0.6	11200	355
TP84 N	0.6-0.9	7100	210
TP84 S	0-0.1	< 200	< 200
TP84 S	0.6-0.9	10500	227
NWT Remediation Guidelines for TPH			
Industrial Land Use		2500	
Yukon CSR Standards			
Industrial Land Use		2000	5000

"-" no measurement

"<" less than the analytical detection limit

▨ Exceeds the NWT Remediation Guidelines for Total Petroleum Hydrocarbon (TPH) or Yukon CSR Numerical Soil Standards for Industrial Land Use

TABLE 6.7 RESULTS OF GROUNDWATER ANALYSIS

Cominco Ltd. - Polaris Mine Operations

Conventional Parameters, Nutrients, Cyanide and Dissolved Metals

Monitor ID	Canadian Water Quality Guidelines Aquatic Life	Yukon CSR Standards Aquatic Life	BH-5	BH-6	Sump	TP-2	TP-5	TP-11	TP-14	TP-15	TP-52	TP-55	TP-57	TP-59	TP-61
Physical Tests															
Hardness $CaCO_3$	-	-	2780	1260	1100	-	-	-	2490	-	771	1320	1400	1260	1080
pH	6.5 - 9.0	-	7.2	7.12	7.08	7.41	6.59	7.12	6.83	6.71	7.61	7.36	7.63	7.5	7.44
Conductivity (uS/cm)	-	-	17300	2640	2930	2040	2670	3430	4950	3740	1920	3620	3930	3580	2550
Nutrients (mg/L)															
Ammonia	1.37 - 2.20 [1]	1.3-8.5	-	-	9.18	-	-	-	-	-	1.88	2.59	3.48	2.07	0.25
Nitrite	0.06	0.2-2	-	-	0.286	-	-	-	-	-	0.121	0.38	0.031	0.148	0.02
Nitrate	-	400	-	-	5.24	-	-	-	-	-	9.23	99.2	1.66	27.4	0.993
Total Dissolved Phosphate	-	-	-	-	0.009	-	-	-	-	-	< 0.006	0.02	0.042	0.02	< 0.006
Total Phosphate	-	-	-	-	0.073	-	-	-	-	-	0.29	0.14	0.26	0.33	0.17
Total Cyanide (CN)	0.005	0.05	-	-	-	-	-	-	-	-	-	0.006	-	0.007	< 0.005
Dissolved Metals (ug/L)															
Aluminum	5 -100 [1]	50-500	< 300	< 50	< 30	-	-	-	< 50	-	< 30	140	< 50	200	< 30
Arsenic	5	500	< 1000	< 200	0.5	-	-	-	< 0.1	-	< 200	< 200	< 200	< 200	< 200
Barium	-	10000	< 50	30	130	-	-	-	30	-	80	50	30	20	30
Cadmium	0.017 [1]	2-18	< 10	< 2	< 1	-	-	-	< 2	-	< 1	< 2	< 2	< 2	< 1
Chromium	1	20	< 50	< 10	< 10	-	-	-	< 10	-	< 10	< 10	< 10	< 10	< 10
Cobalt	-	500	< 50	< 10	< 10	-	-	-	10	-	10	< 10	< 10	< 10	< 10
Copper	2 - 4 [1]	20-90	< 50	< 10	< 10	-	-	-	< 10	-	< 10	< 10	< 10	< 10	< 10
Iron	0.3	3000	< 200	280	1680	-	-	-	< 30	-	< 30	110	< 30	170	< 30
Lead	1 - 7 [1]	40-160	< 50	< 10	< 5	-	-	-	40	-	< 5	10	< 10	< 10	< 5
Mercury	0.1	1	< 0.05	< 0.05	< 0.05	-	-	-	< 0.05	-	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Molybdenum	73	10000	< 200	< 30	< 30	-	-	-	< 30	-	< 30	< 30	< 30	< 30	< 30
Nickel	25 - 150 [1]	250-1500	< 30	< 50	< 50	-	-	-	70	-	< 50	< 50	< 50	< 50	< 50
Selenium	1	10	1.3	< 10	9	-	-	-	-	-	7	< 10	< 10	< 10	< 5
Silver	0.1	1	< 5	< 1	< 0.5	-	-	-	< 1	-	< 0.5	< 1	< 1	< 1	< 0.05
Thallium	0.8	3	< 5	< 1	< 0.5	-	-	-	< 1	-	< 0.5	< 1	< 1	< 1	< 0.5
Zinc	30	300	1190	19	52	-	-	-	2280	-	80	213	62	128	32

"-" = not analyzed.

< 0.05 = less than detection limit.

[1] Standard varies with water sample pH or hardness.

◻ Exceeds Canadian Water Quality Guidelines for the Protection of Aquatic Life.

■ Exceeds the Yukon CSR Generic Numerical Water Standard for the Protection of Aquatic Life

TABLE 6.8 RESULTS OF GROUNDWATER ANALYSIS
Cominco Ltd. - Polaris Mine Operations
PCBs, EPH, BETX, PAH in Groundwater

Monitor ID	Canadian Water Quality Guidelines Aquatic Life	Yukon CSR Standards Aquatic Life	BH-5	BH-6	Sump	TP-2	TP-5	TP-11	TP-14	TP-15	TP-17	TP-52	TP-55	TP-57	TP-59	TP-61
Total Polychlorinated Biphenyls (ug/L)	-	-	< 1	-	< 1	-	-	< 1	-	-	-	-	< 1	-	< 1	-
Extractable Petroleum Hydrocarbons (EPH) mg/L																
LEPH	0.5[3]	-	0.8	7	4.4	< 0.3	5.6	14.8	7.1	31.1	0.7	0.5	< 0.3	0.5	0.3	< 0.3
HEPH	-	-	< 1	< 1	< 1	< 1	< 1	1	3	6	1	< 1	< 1	< 1	< 1	< 1
BETX Compounds (ug/L)																
Benzene	370	3000	< 0.5	-	< 0.5	-	-	9.5	-	-	-	-	-	-	< 0.5	< 0.5
Ethylbenzene	90	7000	< 0.5	-	< 0.5	-	-	8.4	-	-	-	-	-	-	< 0.5	< 0.5
Toluene	2	3000	< 0.5	-	< 0.5	-	-	90.5	-	-	-	-	-	-	< 0.5	2.7
Xylenes	-	-	1.5	-	< 0.5	-	-	282	-	-	-	-	-	-	< 0.5	< 0.5
Polycyclic Aromatic Hydrocarbons (PAHs) ug/L																
Naphthalene	1.1	10	< 0.1	-	30.2	-	< 2	28.3	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Acenaphthylene	-	-	< 0.05	-	0.18	-	0.06	0.39	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Acenaphthene	5.8	60	< 0.05	-	0.6	-	0.33	1.42	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Fluorene	3	120	< 0.05	-	0.65	-	< 0.05	1.27	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Phenanthrene	0.4	3	< 0.05	-	0.24	-	< 0.05	0.8	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Anthracene	0.012	1	< 0.05	-	< 0.05	-	< 0.05	0.08	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Acridine	4.4	0.5	< 0.05	-	< 0.05	-	< 0.05	0.1	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Fluoranthene	0.04	2	< 0.05	-	< 0.05	-	0.05	0.05	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Pyrene	0.025	0.2	< 0.05	-	< 0.05	-	0.07	0.06	-	-	-	-	< 0.05	< 0.05	-	< 0.05
Benzo(a)anthracene	0.018	1	< 0.05	-	< 0.05	-	< 0.05	< 0.05	-	-	-	-	< 0.05	< 0.05	-	< 0.05

< 0.05 = less than detection limit.

▨ Exceeds Canadian Water Quality Guidelines for the Protection of Aquatic Life.
or the [3] BC Contaminated Sites Regulation (1997) Generic Numerical Water Standard for Aquatic Life Water Use

🟦 Exceeds the Yukon CSR Generic Numerical Water Standard for Protection of Aquatic Life

TABLE 6.9 RESULTS OF GROUNDWATER ANALYSIS

Cominco Ltd. - Polaris Mine Operations

Glycols and Volatile Organic Compounds

Monitor ID	Canadian Water Quality Guidelines Aquatic Life	BH-5	Sump	TP-11	TP-59	TP-61
Water Soluble Volatiles (mg/L)						
Diethylene Glycol	-	-	< 10	-	-	-
Ethylene Glycol	192	-	< 10	-	-	-
Propylene Glycol	500	-	< 10	-	-	-
Volatile Organic Compounds (ug/L)						
Carbon Tetrachloride	-	< 1	< 1	< 1	< 1	< 1
Chlorobenzene	-	< 1	< 1	< 1	< 1	< 1
1,2-Dichlorobenzene	0.7	< 1	< 1	< 1	< 1	< 1
1,3-Dichlorobenzene	150	< 1	< 1	< 1	< 1	< 1
1,4-Dichlorobenzene	26	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethane	-	< 1	< 1	< 1	< 1	< 1
1,2-Dichloroethane	100	< 1	< 1	< 1	< 1	< 1
Tetrachloroethene	-	< 1	< 1	< 1	< 1	< 1
Trichloroethene	-	< 1	< 1	< 1	< 1	< 1
Vinyl Chloride	-	< 1	< 1	< 1	< 1	< 1
Bromodichloromethane	-	< 1	< 1	< 1	< 1	< 1
Bromoform	-	< 1	< 1	< 1	< 1	< 1
Chloroethane	-	< 1	< 1	< 1	< 1	< 1
Chloroform	-	< 1	< 1	< 1	< 1	< 1
Chloromethane	-	< 1	< 1	< 1	< 1	< 1
Dibromochloromethane	-	< 1	< 1	< 1	< 1	< 1
cis-1,2-Dichloroethylene	-	< 1	< 1	< 1	< 1	< 1
trans-1,2-Dichloroethylene	-	< 1	< 1	< 1	< 1	< 1
1,1-Dichloroethylene	-	< 1	< 1	< 1	< 1	< 1
Dichloromethane	-	< 5	< 5	< 5	< 5	< 5
1,2-Dichloropropane	-	< 1	< 1	< 1	< 1	< 1
cis-1,3-Dichloropropylene	-	< 1	< 1	< 1	< 1	< 1
trans-1,3-Dichloropropylene	-	< 1	< 1	< 1	< 1	< 1
1,1,1,2-Tetrachloroethane	-	< 1	< 1	< 1	< 1	< 1
1,1,2,2-Tetrachloroethane	-	< 1	< 1	< 1	< 1	< 1
1,1,1-Trichloroethane	-	< 1	< 1	< 1	< 1	< 1
1,1,2-Trichloroethane	-	< 1	< 1	< 1	< 1	< 1
Trichlorofluoromethane	-	< 1	< 1	< 1	< 1	< 1

"-" = not analyzed.

< 0.05 = less than detection limit.

🟦 Exceeds Canadian Water Quality Guidelines for the Protection of Aquatic Life.

TABLE 6.10 RESULTS OF ANALYSIS - VEGETATION SAMPLES
Cominco Ltd. - Polaris Mine Operations
Total Metal Concentrations in Vegetation Samples (ug/g)
July 1999

	SITE A					SITE B			SITE C			SITE D		SITE E		SITE F			SITE G		SITE H		
Sample ID	Grasses	Grasses LRep.	Grasses Recheck	Lichen LRep.	Lichen Recheck	Grasses	Lichen	Willow	Grasses	Lichen	Willow	Grasses	Lichen	Grasses	Lichen	Grasses	Lichen	Willow	Grasses	Willow	Grasses	Lichen	Willow
pH	7.23	-	-	-	-	6.71	5.36	6.28	6.88	5.73	6.16	6.54	5.29	6.75	5.93	6.75	5.53	6.82	6.86	6.18	7.09	6.26	7.19
Total Metals (mg/L)																							
Aluminum	957	1480	-	1060	-	861	263	102	562	869	310	212	103	782	549	1580	381	188	495	90	1720	5.29	163
Antimony	0.156	0.22	-	0.13	-	0.07	< 0.03	< 0.03	0.07	0.1	0.03	0.04	< 0.03	0.06	0.04	0.1	< 0.03	< 0.03	0.17	0.03	0.18	0.08	< 0.03
Arsenic	0.57	0.97	-	0.77	-	0.27	0.2	< 0.05	0.26	0.48	0.12	0.13	0.13	0.29	0.3	0.6	0.27	0.07	0.27	< 0.05	2.05	0.48	0.08
Barium	213	365	-	316	-	133	34.9	36.3	185	69.8	42.1	101	26.3	137	77.9	2020	288	177	99.3	28.3	400	87.1	68.3
Beryllium	< 0.1	< 0.1		< 0.1		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium	1.41	2.73	-	2.74	-	0.87	0.63	1.47	2.85	1.51	2.28	2.05	1.71	1.02	0.89	0.63	0.63	0.86	1.9	5.22	3.61	1.85	4.62
Chromium	6.2	9.4	-	3.3	-	5.2	1.5	< 0.5	2.5	3.4	1.7	1.4	< 0.5	4.1	1.3	8.7	1	0.9	2.5	< 0.5	4.2	1.5	0.7
Cobalt	0.5	0.8	-	0.3	-	0.3	< 0.1	1	0.3	0.3	0.3	0.1	< 0.1	0.3	0.1	0.7	< 0.1	0.5	0.2	0.3	0.7	0.1	0.3
Copper	11.8	14.5	-	2.58	-	3.08	0.75	9.35	5.84	3.22	9.93	3.13	0.8	18.3	1.24	69.1	1	9.98	8.48	8.89	6.99	1.68	7.75
Lead	331	560	653	574	633	70.5	176	19.1	147	312	19.6	120	235	92.2	246	92.9	199	14.4	89.9	18.8	431	472	41.5
Manganese	77.5	96	-	24.1	-	513.4	5.08	39.1	30.1	12.2	24.4	42.9	2.65	138	8.8	44.5	9.23	28.2	76.9	12	32.4	10.6	30.5
Molybdenum	1.24	1.42	-	0.89	-	0.86	0.16	0.92	0.66	0.2	0.28	0.84	0.09	0.93	0.21	1.92	0.17	0.38	1.67	0.49	1.75	0.26	0.41
Nickel	5.3	7.9	-	2.1	-	3.8	0.6	4.2	3.3	1.7	2.6	1.5	< 0.1	0.39	0.8	6.8	0.4	3.9	3	3.8	5.6	0.8	1.2
Selenium	< 1	< 1		< 1		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Tin	< 0.2	< 0.2		< 0.2		< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Vanadium	8.6	14.9	-	9.1	-	4.1	1.3	0.5	4.4	11.6	2	2.1	0.8	5.8	3.9	9.8	1.8	1.1	5.5	1.1	26.5	5.5	1.6
Zinc	549	1030	1200	680	738	228	93	366	723	157	241	443	116	249	117	205	62.4	176	330	244	1280	269	438

BC Research Data (1974) mg/L

	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 6.11 SUMMARY OF ARD TESTING
Chemical Analysis of Rock Samples
Cominco Ltd. - Polaris Mine

Location	Rock Type	Paste pH	CO_2	CO_2	Total S	S-SO_4	S-Sulfide	AP	NP	NP/AP	NNP
			%	kg $CaCO_3$/t	%	%	%	kg $CaCO_3$/t	kg $CaCO_3$/t		kg $CaCO_3$/t
LRD Pit	Limestone	8.2	42.3	962	0.06	0.02	0.04	1	992	793	990
North Pit	Dolomite	8.7	47.9	1090	0.05	<0.01	0.05	2	1034	662	1032
Old Quarry	Green shale	8.1	9.7	220	0.85	0.07	0.78	24	206	8	182
New Quarry	Brown shale	8.5	26.4	601	0.63	<0.01	0.63	20	553	28	533

AP - Acid Potential
NP - Neutralization Potential
NNP - Net Neutralization Potential

Location	Rock Type	Aqua Regia Digestible Metals									
		Pb	Zn	Ag	Ni	Co	Mn	Fe	As	Sr	Cd
		ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
LRD Pit	Limestone	20	6	< .3	2	1	45	0.13	< 2	165	< .2
North Pit	Dolomite	28	36	< .3	2	1	305	0.23	< 2	33	< .2
Old Quarry	Green shale	54	139	< .3	61	17	303	3.11	9	103	0.9
New Quarry	Brown shale	72	79	0.4	16	4	510	2.65	5	330	0.9

Location	Rock Type	Aqua Regia Digestible Metals									
		Ca	P	Cr	Mg	Ba	Ti	B	Al	Na	K
		%	%	ppm	%	ppm	%	ppm	%	%	%
LRD Pit	Limestone	31.4	0.002	5	1.6	123	< .01	9	0.03	0.03	0.02
North Pit	Dolomite	17.4	0.003	5	8.6	12	< .01	6	0.05	0.02	0.02
Old Quarry	Green shale	4.5	0.036	45	2.3	251	< .01	20	1.16	0.09	0.34
New Quarry	Brown shale	12.5	0.046	24	3.7	478	0.01	16	0.31	0.06	0.14

Location	Rock Type	Water Leach									
		Final	SO4	Zn	Ag	Al	As	B	Ba	Be	Bi
		pH	mg/L	ppb	ppb	ppm	ppb	ppb	ppb	ppb	ppb
LRD Pit	Limestone	9.7	6	< 5	< 5	< .1	< 30	< 20	331	< 2	< 20
North Pit	Dolomite	9.9	10	< 5	< 5	< .1	< 30	< 20	23	< 2	< 20
Old Quarry	Green shale	9.0	88	< 5	< 5	< .1	< 30	263	34	< 2	< 20
New Quarry	Brown shale	9.5	19	< 5	< 5	0.1	< 30	75	130	< 2	< 20

Table 6.12 Results of field measurements taken at sampling sites in the marine environment adjacent to Cominco's Polaris operation (May, 1999)

Station	Conductivity (mS)		Salinity pp thousand		pH		Dissolved Oxygen (mg/L)		Temperature (°C)		Depth to Sediment
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	m of water
1A	29	27	34.8	34.3	7.2	7.3	11.7	11.9	-0.4	-2.0	13.7
2	28.53	25.5	33.2	32.5	7.4	7.4	11.2	11.7	0.8	-2.1	9.5
3C	27.9	26.5	34.0	33.6	7.7	7.8	10.3	10.9	-0.5	-1.8	9
4B	28.8	27.6	35.6	34.8	7.8	7.8	10.7	11.0	-1.1	-1.6	10
4E	28.36	28.25	35.8	34.9	7.4	7.6	12.6	11.5	-1.2	-1.0	13.1

Table 8.1 Observations of sea life and bottom conditions during sample collection May 12-16, 1999

Stations	Marine Life Presence	General Appearance	Comments
1A	abundant (clams (*Mya*), starfish anemones, shrimp, crustaceans, urchins, snails, *Fucus*)	clean silt/sand bottom	• few fish seen • empty clam shells common
2	abundant (clams, sea stars, fewer anemones, comb jelly fish, urchins, small fish common, shrimp and other crustaceans common, *Fucus*)	clean sand/silt bottom	• more kelp here • empty clam shells common
3A	common (fish, clams, snails, smaller anemones "fan worms", occasional urchins)	clean sand/silt bottom with some stones	• less slope than 3B & C
3C	abundant urchins plus anemones, snails, starfish, clams (occasional), amphipods common, fish (blennies and a sculpin)	clean-sand/silt with more stones	• fewer clams owing to stonier bottom
4A	abundant urchins; anemones in deeper water; starfish, amphipods far less common	clean sand, fewer stones	• hard hat
4B	urchins, starfish, anemones, comb jellyfish; pseudobranch, sculpin and small blennies, shrimp, mostly common; clams rare	clean sand	• single strand of hose on bottom
4C	anemones, kelp, barnacles, abundant on dock face; spider crab; shrimp common	clean sand/silt and more rocky this year from rip-rap added after storm damage in 1998	• no clams but empty shells • no sign of sculpins
4D	abundant shrimp; barnacles, mussels, anemones, fish on dock face	clean silt/sand	• single tire • ladder near dock • "less life than in previous years"
4	shrimp very abundant; clams, starfish further offshore; kelp	sand and silt with some sewage-related solids; rock	• scaling bar • "less life and diversity than previous winter dives" • no fish seen
4E	kelp, anemones; tiny blennies; clams common and empty shells; shrimp present but scarcer	clean sand with silt	• old cement bag and single cable strand • larger sand beds with less rock
4F	urchins, starfish, kelp; few clams and anemones; a few small fish	clean sand with some silt; some rocks	• small section of conveyor belt; marker post; cable • looked less productive

TABLE 8.2: RESULTS OF SEAWATER ANALYSIS - INORGANIC PARAMETERS
Cominco Ltd. - Polaris Operations
May 1999 and April 2000

Chemical Parameter	CCME Aquatic Life Guidelines		Garrow Bay						Polaris Bay			Crozier Strait					BC Research (1978)		Axys	
			Station 1			Station 2			Station 3C			Station 4B		Station 4E						
	Freshwater	Marine	top	bottom	top	top	bottom	top	top	bottom	top	top	bottom	top	bottom	top	Garrow Bay	Cominco Bay	Garrow Bay	
Sample Date			May-99	May-99	Apr-00	May-99	May-99	Apr-00	May-99	May-99	Apr-00	May-99	May-99	May-99	May-99	Apr-00	1978	1978	May-90	Sep-90
Hardness CaCO3	-	-	5960	5760	-		5920	-	5680	6090	-					-	5500-5810	5760-5660	-	-
pH	6.5-9	7-8.7	7.58	7.6	-	7.35	7	-	7.44	7.52	-	7.8	7.8	7.4	7.6	-	8.1-8.2	7.8-8.2	-	-
Conductivity (mS/cm)	-	-	29	27	-	28.5	25.5	-	27.9	26.5	-	28.8	27.6	28.36	28.25	-	40-41.2	40.2-41	-	-
Salinity (ppt)	-	-	34.8	34.3	-	33.2	32.5	-	34	33.6	-	35.6	34.8	35.8	34.9	-	-	-	-	-
Dissolved O_2 (mg/L)	5.5-9.5	> 8	11.7	11.9	-	11.2	11.7	-	10.3	10.9	-	10.7	11	12.6	11.5	-	-	-	-	-
Temperature (^{o}C)	-	-	-0.4	-2	-	0.8	-2.1	-	-0.5	-1.8	-	-1.1	-1.6	-1.2	-1	-	-	-	-	-
Total Cyanide (mg/L)	-	-	< 0.005	< 0.005	-	-	-	-	< 0.005	< 0.005	-	-	-	-	-	-	-	-	-	-
Fluoride (mg/L)	-	-	-	0.84	-	-	-	-	0.8	0.84	-	-	-	-	-	-	-	-	-	-
Chloride (mg/L)	-	-	-	19600	-	-	-	-	20900	19400	-	-	-	-	-	-	-	-	-	-
Sulphate (mg/L)	-	-	-	2680	-	-	-	-	2610	2750	-	-	-	-	-	-	-	-	-	-
Dissolved Metals (ug/L)																				
Aluminum	5-100^2	-	< 5	< 5	-	< 5	< 5	-	< 5	< 5	-	-	< 5	< 5	< 5	-	-	-	-	-
Arsenic	5	12.5	< 1	< 1	1.4	< 1	< 1	1.4	1	1	1.5	-	1	< 1	1	1.4	1.2-1.5	1.4-1.6	-	-
Cadmium	0.017	0.12	< 0.1	< 0.1	0.06	< 0.1	< 0.1	0.04	< 0.1	< 0.1	0.05	-	< 0.1	< 0.1	< 0.1	0.07	< 0.2	< 0.2-0.9	0.043	0.013
Chromium	8.9	56	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	-	< 1	< 1	< 1	< 1	-	-	-	-
Copper	2-4^2	-	< 1	< 1	0.33	2	< 1	0.27	2	< 1	0.28	-	< 1	4	< 1	0.26	2-20	2-4.8	0.307	0.184
Iron	300	-	< 600	< 600	< 10	< 600	< 600	< 10	< 600	< 600	< 10	-	< 600	< 600	< 600	< 10	10-30	10-16	-	-
Lead	1-7	-	7	< 1	0.51	13	< 1	0.54	29	< 1	0.24	-	< 1	14	2	0.83	< 2	< 2-16	< 0.015	< 0.02
Mercury	0.1	-	< 0.05	< 0.05	0.01	< 0.05	< 0.05	0.01	< 0.05	< 0.05	0.01	-	< 0.05	< 0.05	< 0.05	< 0.01	-	-	-	-
Molybdenum	73	-	< 600	< 600	8	< 600	< 600	7	< 600	< 600	7	-	< 600	< 600	< 600	7	-	-	-	-
Nickel	25-150^2	-	< 1	< 1	0.49	< 1	< 1	0.51	< 1	< 1	0.53	-	< 1	< 1	< 1	0.5	-	-	-	-
Selenium	1	1	< 0.5	< 0.5	< 0.5	0.6	< 0.5	< 0.5	0.6	< 0.5	< 0.5	-	< 0.5	< 0.5	< 0.5	< 0.5	-	-	-	-
Silver	0.1	-	< 0.1	< 0.1	-	< 0.1	< 0.1	-	< 0.1	< 0.1	-	-	< 0.1	< 0.1	< 0.1	-	-	-	-	-
Zinc	30	-	< 10	< 5	< 1	< 10	< 10	< 1	< 10	< 10	< 1	-	< 10	< 10	< 10	6	2.6-39	3.5-5.6	0.172	0.06

"-" = not analyzed
< 0.05 = less than detection limit
[1] CCME. 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life.
[2] Standard varies with water sample pH or hardness
🟦 Exceeds the CCME guideline for protection of aquatic life

TABLE 8.3: RESULTS OF SEAWATER ANALYSIS - ORGANIC PARAMETERS

Cominco Ltd. - Polaris Operations

May 1999

Chemical Parameter	CCME Aquatic Life Guidelines		Garrow Bay		Polaris Bay		Crozier Strait		
			Stn. 1		Stn. 3C		Stn. 4B	Stn. 4E	
	Freshwater	Marine	top	bottom	top	bottom	bottom	top	bottom
Extractable Petroleum Hydrocarbons (ug/L)									
LEPH (C10-C18)	-	-	-	-	-	-	< 300	< 300	< 300
HEPH	-	-	-	-	-	-	< 1000	< 1000	< 1000
Polycyclic Aromatic Hydrocarbons (PAHs) ug/L									
Acenaphthene	5.8	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Acenaphthylene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Acridine	4.4	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Anthracene	0.012	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Benz(a)anthracene	0.018	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Benzo(a)pyrene	0.015	-	< 0.01	< 0.01	< 0.01	-	< 0.01	< 0.01	< 0.01
Benzo(b+k)fluoranthene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Benzo(g,h,i)perylene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Chrysene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Dibenzo(a,h)anthracene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Fluoranthene	0.04	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Fluorene	3	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Indeno(1,2,3-c,d)pyrene	-	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Naphthalene	1.1	1.4	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Phenanthrene	0.4	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Pyrene	0.025	-	< 0.05	< 0.05	< 0.05	-	< 0.05	< 0.05	< 0.05
Total PCBs	-	-	< 1	< 1	< 1	< 1	< 1	< 1	< 1

"-" = not analyzed

< 0.05 = less than detection limit

[1] CCME. 1999. Canadian Water Quality Guidelines for the Protection of Aquatic Life.

[2] Standard varies with water sample pH or hardness

🟦 Exceeds the CCME guideline for protection of aquatic life

TABLE 8.4: RESULTS OF SEDIMENT ANALYSIS
Cominco Ltd. - Polaris Operations
May 1999

Chemical Parameter	CCME Sediment Quality Guidelines[1.]		Garrow Bay		Polaris Bay			Crozier Strait						
	ISQG	**PEL**	**1**	**2**	**3A**	**3B**	**3C**	**4A**	**4B**	**4C**	**4D**	**4E**	**Outfall**	**4F**
pH	-	-						8.42	8.5			8.52	8.44	8.27
Metals (mg/kg)														
Arsenic	7.24	41.6	3.5	4.7	16	7.1	6	5	5	2.6	4.2	4.3	3.8	5
Cadmium	0.7	4.2	0.2	0.1	0.6	1.8	1	4.9	27	14.3	52	64	35	81
Chromium	52.3	160	18	20	24	30	16	12	13	< 20	< 10	< 20	11	8
Copper	18.7	108	9	9	20	17	11	9	18	9	29	29	26	14
Lead	30.2	112	7	8	23	128	99	639	2,510	1,600	6,290	7,520	5,430	9,360
Mercury	0.13	0.7	0.04	0.045	0.094	0.08	0.085	0.044	0.061	0.031	0.044	0.049	0.048	0.047
Zinc	124	271	35	40	155	520	298	1,670	11,200	5,600	20,600	25,000	14,200	29,900
Extractable Petroleum Hydrocarbons (EPH)														
EPH (C10-18)	-	-	< 200	-	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	
EPH (C19-31)	-	-	< 200	-	< 200	< 200	< 200	< 200	< 200	< 200	205	258	247	
Polycyclic Aromatic Hydrocarbons (PAHs)														
Acenaphthene	0.00671	0.0889	< 0.01	-	< 0.01	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Acenaphthylene	0.00587	0.128	< 0.01	-	< 0.01	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Anthracene	0.0469	0.245	< 0.01	-	< 0.01	< 0.01	0.01	-	-	< 0.01	-	-	< 0.01	-
Benzo(a)anthracene	0.0748	0.693	< 0.01	-	0.02	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Benzo(a)pyrene	0.0888	0.763	< 0.01	-	0.01	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Chrysene	0.108	0.846	< 0.01	-	0.03	< 0.01	0.03	-	-	< 0.01	-	-	< 0.01	-
Dibenz(a,h)anthracene	0.00622	0.135	< 0.01	-	< 0.01	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Fluoranthene	0.113	1.49	< 0.01	-	0.02	< 0.01	0.03	-	-	< 0.01	-	-	< 0.01	-
Fluorene	0.0212	0.144	< 0.01	-	< 0.01	< 0.01	< 0.01	-	-	< 0.01	-	-	< 0.01	-
Naphthalene	0.0346	0.391	< 0.01	-	0.08	0.01	< 0.01	-	-	< 0.01	-	-	< 0.02	-
Phenanthrene	0.0867	0.544	< 0.01	-	0.02	< 0.02	0.04	-	-	< 0.02	-	-	< 0.02	-
Pyrene	0.153	1.398	< 0.01	-	0.02	< 0.01	0.03	-	-	< 0.01	-	-	< 0.01	-
Polychlorinated Biphenyls (PCBs)														
Total PCBs	0.0215	0.189	-	-	-	-	< 0.05	-	-	-	-	-	< 0.05	-

"-" denotes no analysis or no standards

"<" denotes less than the analytical detection limit

[1.] CCME. 1999. Canadian Sediment Quality Guidelines. Interim Marine Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs)

🟦 Exceeds CCME PEL

Table 8.5 Comparison of concentrations of selected metals in sediments collected in May 1999 (GLL) with those collected by Fallis in 1981 and Axys 1991 (mg/kg)

Location	Cadmium	Lead	Zinc
Garrow Bay			
Fallis Station 8 (1984)	0.1-0.2	7-9	27-29
Axys Station 4 (1991)	0.3	4.0	29.8
GLL Station 1 (1999)	0.2	7	35
Fallis Station 7 (1984)	0.2-0.25	8.2-11.6	28.4-41.2
Axys Station 1 (1991)	0.19-0.25	3.4-3.8	31-36.9
GLL Station 2 (1999)	0.1	8	40
Cominco Bay			
Fallis Station 4 (1984)	0.4-0.6	11.9-21.9	48-79.9
GLL Station 3A (1999)	0.6	23	155
GLL Station 3C (1999)	1.0	99	298
Crozier Strait			
Fallis Station 3 (1984)	1.35-1.6	110-150	265-420
GLL Station 4A (1999)	4.9	639	1,670
Fallis Station 2 (1984)	52-74	800-9,795	24,450-35,700
GLL Station 4D (1999)	52	6,290	20,600

Axys Environmental Consulting Ltd. 1991. Concentrations of Zinc, Lead, Cadmium and Copper in Garrow Bay, 1990. Report Prepared for Cominco Ltd. – Polaris Operations.

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.

TABLE 8.6 RESULTS OF ANALYSIS - MARINE BIOTA TISSUE

Cominco Ltd. - Polaris Mine Operations

Metal Concentrations in Clam and Sea Urchin Soft Tissue (ug/g)

Location	Garrow Bay				Polaris Bay				Garrow and Polaris Bays	Polaris Bay	Garrow Bay	Polaris Bay
Sampling Station	Station 1A [1]		Station 2 [1]		Station 3A [1]		Station 3C [1]		BCR (1978)	BCR (1975)	Fallis (1984)	
ug/g wet or dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	dry wt.	dry wt.	dry wt.	dry wt.
Aluminum	< 10	< 80	11	85	< 10	< 80	< 10	80	-	-	-	-
Antimony	< 0.03	< 0.3	< 0.03	< 0.3	< 0.03	< 0.3	< 0.03	< 0.3	-	-	-	-
Arsenic	1.15	8.7	1.31	10	1.5	12	1.5	12	3.1-8.3	-	-	-
Barium	2.46	18.6	14	106	3.13	25.7	25.7	198	-	-	-	-
Beryllium	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	-	-	-	-
Bismuth	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	-	-	-	-
Cadmium	0.83	6.3	0.67	5	0.73	6	0.55	4.2	1.1-5.2	4.54	3.9-4.28	3.15
Calcium	463	3510	517	4010	714	5850	650	5000	-	-	-	-
Chromium	< 0.5	< 4	1	8	< 0.5	< 4	< 0.5	< 4	-	-	-	-
Cobalt	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	< 0.1	< 0.8	-	-	-	-
Copper	0.91	7	0.94	7	0.9	7.4	2.27	17.5	11.1-65.6	10.9	-	-
Lead	< 0.1	< 0.8	< 0.1	< 0.8	0.7	5.7	2.2	17	0.3-2.9	< 4.5	0.92-1.25	0.92
Lithium	< 0.2	< 2	< 0.2	< 2	< 0.2	< 2	< 0.2	< 2	-	-	-	-
Magnesium	867	6570	922	7150	876	7180	652	5020	-	-	-	-
Manganese	0.88	7	0.78	6	0.67	5.5	1.71	13	-	-	-	-
Molybdenum	0.07	0.5	0.1	0.8	0.11	0.9	0.06	0.5	-	-	-	-
Nickel	0.3	2.3	0.6	5	0.3	2.5	0.1	0.8	-	-	-	-
Selenium	< 1	< 8	< 1	< 8	< 1	< 8	< 1	< 8	-	-	-	-
Strontium	6.53	49.5	6.63	51	8.56	70	6.45	50	-	-	-	-
Thallium	< 0.03	< 0.3	< 0.03	< 0.3	< 0.03	< 0.3	< 0.03	< 0.3	-	-	-	-
Tin	< 0.2	< 2	< 0.2	< 1	< 0.2	< 2	< 0.2	< 2	-	-	-	-
Uranium	0.02	0.15	0.03	0.23	0.05	0.41	0.02	0.15	-	-	-	-
Vanadium	< 0.5	< 4	< 0.5	< 4	< 0.5	< 4	< 0.5	< 4	-	-	-	-
Zinc	23.5	178	18.6	144	21.1	173	54.9	422	61.6-170	168	107-117	116

Location	Crozier Strait				Fallis (1984)	
Sampling Station	Station 4B [2]		Station 4E [1]		Station 2	Station 3
ug/g wet or dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	dry wt.	dry wt.
Aluminum	168	1290	< 10	< 80	-	-
Antimony	< 0.03	< 0.3	< 0.03	< 0.3	-	-
Arsenic	0.81	6.2	1.11	8.4	-	-
Barium	46.4	357	0.33	2.5	-	-
Beryllium	< 0.1	< 0.8	< 0.1	< 0.8	-	-
Bismuth	< 0.1	< 0.8	< 0.1	< 0.8	-	-
Cadmium	1.37	10	0.82	6.2	9.62	5.03
Calcium	4660	35800	345	2620	-	-
Chromium	0.9	7	< 0.5	< 4	-	-
Cobalt	< 0.1	< 0.8	< 0.1	< 0.8	-	-
Copper	1.49	11	2.25	17	-	-
Lead	136	1050	19.2	146	556	31.6
Lithium	0.3	2	< 0.2	< 2	-	-
Magnesium	1660	12800	834	6320	-	-
Manganese	3.46	27	0.91	6.9	-	-
Molybdenum	0.1	0.8	0.06	0.5	-	-
Nickel	0.5	3.8	0.1	0.8	-	-
Selenium	< 1	< 8	< 1	< 8	-	-
Strontium	16.3	125	5.85	44	-	-
Thallium	< 0.03	< 0.3	< 0.03	< 0.3	-	-
Tin	< 0.2	< 2	< 0.2	< 2	-	-
Uranium	0.09	0.7	0.02	0.2	-	-
Vanadium	1.8	14	< 0.5	< 4	-	-
Zinc	348	2680	34.4	261	2117	208

"-" = not analyzed.

< 0.05 = less than detection limit.

[1] *Mya truncata* - soft tissue

[2] *Strongylocentrotus sp.* (sea urchin) - soft tissue

TABLE 8.7 RESULTS OF ANALYSIS - MARINE BIOTA TISSUE

Cominco Ltd. - Polaris Mine Operations

PCBs and PAHs (ug/g)

Sampling Station Biota	Stn 1A Clams		Stn 3C Clams		Stn 3A Clams		Stn 4E Clams	
ug/g wet or dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	wet wt.	dry wt.	wet wt.	dry wt.
Total Polychlorinated Biphenyls (PCBs)	< 0.05	< 0.4	-	< 0.4	-	< 0.4	< 0.05	< 0.4
Polycyclic Aromatic Hydrocarbons (PAHs)								
Acenaphthene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Acenaphthylene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Anthracene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Benz(a)anthracene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Benzo(a)pyrene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Benzo(b)fluoranthene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Benzo(g,h,i)perylene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Benzo(k)fluoranthene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Chrysene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Dibenz(a,h)anthracene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Fluoranthene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Fluorene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Indeno(1,2,3-c,d)pyrene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Naphthalene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Phenanthrene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08
Pyrene	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08	< 0.01	< 0.08

"-" = not analyzed.
< 0.05 = less than detection limit.