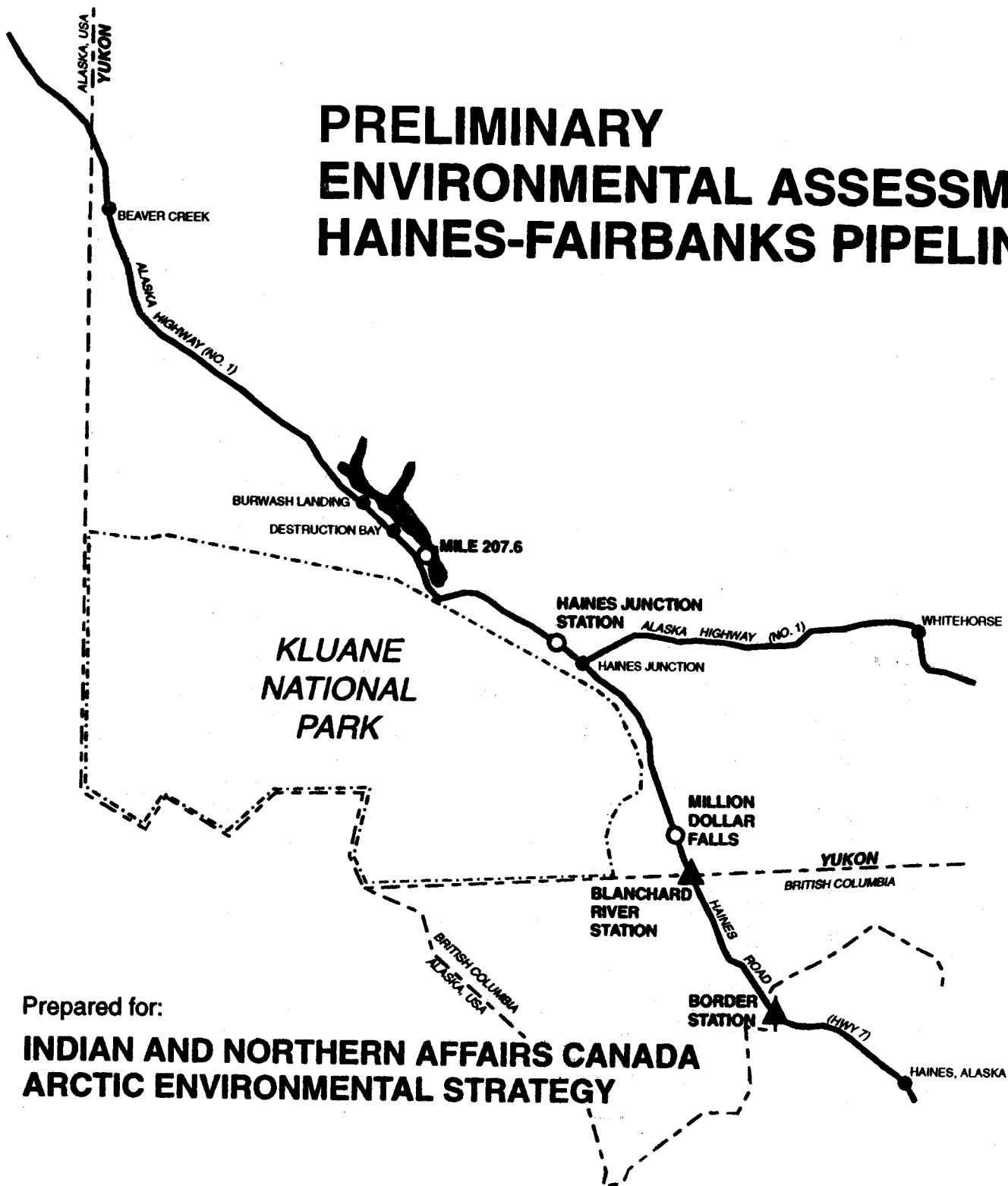


PRELIMINARY ENVIRONMENTAL ASSESSMENT HAINES-FAIRBANKS PIPELINE



Prepared for:

**INDIAN AND NORTHERN AFFAIRS CANADA
ARCTIC ENVIRONMENTAL STRATEGY**

Prepared by:

UMA Engineering Ltd.

In association with:

AMBIO Research Associates Inc.



AUGUST 1995

**PRELIMINARY ENVIRONMENTAL ASSESSMENT
HAINES-FAIRBANKS PIPELINE**

Mile 207.6 Spill Site
Haines Junction Pump Station
Million Dollar Falls
Blanchard River Pump Station
Border Pump Station

Prepared for:

Indian and Northern Affairs Canada
Arctic Environmental Strategy

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August 1995



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1995 08 29

File No.: 4440-033/34-42-3.6

Indian and Northern Affairs Canada
Arctic Environmental Strategy
345 - 300 Main Street
WHITEHORSE, Yukon Y1A 2B5

Attention: Mr. Brett W. Hartshorne
Manager, Action on Waste

Dear Sir:

RE: PRELIMINARY ENVIRONMENTAL ASSESSMENT
HAINES-FAIRBANKS PIPELINE
FINAL REPORT

Further to our discussions of August 24, 1995, please find enclosed ten copies of our final report for contracts 94-0038 and 95-0039.

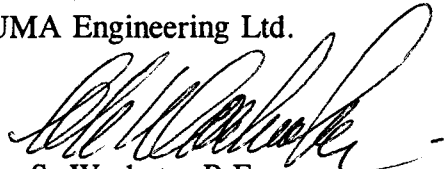
This report has been prepared by UMA in association with AMBIO Research Associates Inc. and addresses the following sites:

- Mile 207.6 Spill Site
- Haines Junction Pump Station
- Million Dollar Falls
- Blanchard River Pump Station
- Border Pump Station

We have also incorporated the comments received from Environment Canada on August 28, 1995. We trust that this report is consistent with your requirements and look forward to being of further assistance.

Yours very truly,

UMA Engineering Ltd.



A. S. Washuta, P.Eng.
Project Manager

Encl.

cc: T. Wingrove, UMA Winnipeg
Dr. S. Grundy, AMBIO

**PRELIMINARY ENVIRONMENTAL ASSESSMENT
HAINES-FAIRBANKS PIPELINE**

Mile 207.6 Spill Site
Haines Junction Pump Station
Million Dollar Falls
Blanchard River Pump Station
Border Pump Station

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LIMITATIONS

The information and data contained in this report, including without limitation the results of any sampling and analyses conducted by UMA Engineering Ltd. ("UMA") pursuant to its Agreement with Indian and Northern Affairs Canada, have been developed or obtained through the exercise of UMA's professional judgement and are set forth to the best of UMA's knowledge, information and belief. Although every effort has been made to confirm that all such information and data is factual, complete and accurate, UMA makes no guarantees or warranties whatsoever, whether expressed or implied, with respect to such information or data.

UMA shall not by the act of issuing this report be deemed to have represented thereby that any sampling and analyses conducted by it have been exhaustive or will identify all contamination of the sites, and persons relying on the results thereof do so at their own risk.

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GLOSSARY AND LIST OF ABBREVIATIONS

µg	=	10 ⁻⁶ grams
ABN	=	Acid/Base/Neutral Extractable
AES	=	Arctic Environmental Strategy
Ag	=	Silver
Al	=	Aluminum
anthropogenic	=	derived directly or indirectly from human activity
Aroclor	=	Commercial PCB mixture
As	=	Arsenic
asl	=	above sea level
authogenic	=	derived from natural sources
Ba	=	Barium
Be	=	Beryllium
Bo	=	Boron
BTEX	=	Benzene, toluene, ethylbenzene, xylenes
CCME	=	Canadian Council of Ministers of the Environment
Cd	=	Cadmium
Co	=	Cobalt
Cr	=	Chromium
Cu	=	Copper
DCC	=	DEW Line Cleanup Criteria
DDT	=	Dichlorodiphenyltrichloroethane
DEW	=	Distant Early Warning
DND	=	Department of National Defence
ECD	=	Electron Capture Detector
EM	=	Electromagnetometer
Fe	=	Iron
forb	=	Wildflower or flowering herb
GC	=	Gas Chromatography
HCB	=	Hexachlorobenzene
HCH	=	Hexachlorocyclohexane
Hg	=	Mercury
leachate	=	substances (usually in solution) migrating from a source
Mg	=	Magnesium
Mn	=	Manganese
Mo	=	Molybdenum
MS	=	Mass Spectroscopy
na	=	not analyzed
NBS	=	National Bureau of Standards (USA)
NDR	=	Not reliably detected
ng	=	10 ⁻⁹ grams
Ni	=	Nickel
NIST	=	National Institute of Standards and Technology
NRC	=	National Research Council
P	=	Phosphorus
PAH	=	Polycyclic Aromatic Hydrocarbons
Pb	=	Lead
PCB	=	Polychlorinated Biphenyl
PCDD	=	Polychlorinated Dibenzodioxin
PCDF	=	Polychlorinated Dibenzofuran
pg	=	10 ⁻¹² grams
POL	=	Petroleum, Oil, Lubricants
ppb	=	parts per billion, i.e., ng/g or µg/L
ppm	=	parts per million, i.e., µg/g

GLOSSARY AND LIST OF ABBREVIATIONS (cont.)

ppt	=	parts per trillion, i.e., pg/g or ng/L
QA	=	Quality Assurance
QC	=	Quality Control
Sb	=	Antimony
Se	=	Selenium
Si	=	Silicon
Sn	=	Tin
SSL	=	Soil Screening Level
TEF	=	toxic equivalent factor
TEH	=	total extractable hydrocarbons
TEQ	=	toxic equivalent
Ti	=	Titanium
TPH	=	Total Petroleum Hydrocarbons
USEPA	=	Environmental Protection Agency (USA)
V	=	Vanadium
YTG	=	Yukon Territorial Government
Zn	=	Zinc

EXECUTIVE SUMMARY

A preliminary environmental investigation was carried out at five sites along the decommissioned Haines-Fairbanks pipeline on behalf of Indian and Northern Affairs Canada, Arctic Environmental Strategy, Action On Waste. The program was designed to achieve the following major objectives:

- ascertain the impact of a 1956 fuel spill at Mile 207.6 of the pipeline;
- identify areas of waste disposal and contaminants at the Haines Junction Pump Station;
- evaluate drinking water quality and contaminant distribution at a historic dump site at Million Dollar Falls;
- identify areas of waste disposal and contaminants in surface and subsurface soil and water at the Blanchard River Pump Station and the Border Pump Station.

The overall objective was to assess the need for further action and to provide recommendations.

The methods employed included a historical review. Electromagnetic surveys were conducted to detect buried metallic debris. Intrusive soil and groundwater sampling using test pits and drill holes, as well as the installation of monitoring wells was conducted in order to detect subsurface contaminant sources and potential groundwater impacts. Surface soil and water samples were also collected and analyzed for a range of contaminants.

The analytical program consisted of two components. The field component utilized immunoassay test kits for PAHs, TPH, BTEX and PCBs; a photoionization detector was used to obtain gas-phase hydrocarbon concentrations. The laboratory component consisted of detailed analyses for a broad suite of inorganic and organic contaminants.

The five sites were visited in July 1995. Contaminant data from each site were interpreted relative to site-specific conditions and relevant soil and water assessment and remediation criteria (primarily CCME (1991) criteria). A preliminary risk assessment was carried out for each site.

Based on this methodology, the sites were ranked, in order of priority for remediation/action, as follows:

- 1) Blanchard River Pump Station
- 2) Million Dollar Falls
- 3) Border Pump Station
- 4) Haines Junction Pump Station
- 5) Mile 207.6 Spill Site

A summary of environmental problems and recommended actions is provided in Table 1.

**TABLE 1 PROJECT SUMMARY - PRELIMINARY ENVIRONMENTAL ASSESSMENT
HAINES-FAIRBANKS PIPELINE**

Site	Problems Detected	Risk	Recommended Action
Blanchard River Pump Station	- Hydrocarbon and inorganic element contaminated leachate from unknown source. - Hydrocarbon contaminated groundwater plume.	- Evidence for input to fish-bearing waters. - Direct input into Blanchard River.	- Full site assessment to delineate source(s), composition, extent, and migration of contaminants.
Million Dollar Falls	- Possible low level PCB contamination of campground water supply aquifer. - Elevated levels of zinc and DDT at the toe of the dump.	- Possible human and ecosystem health risk implications. - Potential migration to Takhanne River.	- Detailed confirmatory sampling and analysis. - Remediation of dump under the supervision of an experienced hazardous waste professional.
Border Pump Station	- Soil and groundwater contaminated with hydrocarbons.	- Potential for downgradient migration to Klehini River via Rainy Hollow site.	- Collate all available contaminant and geotechnical information, and provide recommendations. - Resample monitoring wells MW-8a and 8b in TH-8.
Haines Junction Pump Station	- Buried drums containing hydrocarbon products.	- Probable future release of liquid contents.	- Excavation and removal of non-empty drums under the supervision of an experienced hazardous waste professional.
Mile 207.6 Spill Site	- Extensive hydrocarbon contamination of soils.	- Past impact to vegetation has occurred; however, recovery is evident. Little, if any, potential for future risks.	- None at this site; caution is recommended in extrapolation to other spill sites.

Extensive hydrocarbon contamination was encountered at Mile 207.6 spill site, Blanchard River Pump Station, and Border Pump Station. This was confirmed by results obtained from the field analytical techniques. Laboratory analyses, however, did not confirm elevated levels of either PAHs or BTEX. Although not included in the laboratory analytical suite, the presence of alkylated aromatics is suspected.

Based on the substances analyzed, there was no evidence of direct risks to wildlife. The recommendations address situations where evidence suggests the potential for contaminants to migrate to fish-bearing waters. The investigation of impacts from this potential migration of contaminants was beyond the scope of this preliminary assessment. This investigation found no evidence for significant contamination by PCBs, chlorinated pesticides, PAHs, phenoxy acid herbicides, and volatile organohalogenes.

1.0 INTRODUCTION

1.1 Background

During the period 1950-1952, the United States government commissioned the Fluor Corporation, Los Angeles, California to construct an eight inch multi-fuel line to supply fuels from the deep water port at Haines to military sites in Alaska. The original Canol pipeline (three inch from Whitehorse to Fairbanks) was built during the threat of Japanese invasion during the Second World War, but was considered too small to supply northern military needs during the increased tension surrounding the Korean War. In response, the Haines-Fairbanks pipeline was constructed in 1954-1955. Six pump stations and associated facilities were constructed along the Canadian section of the line. This pipeline was decommissioned in 1972. The majority of the pipe was removed in 1990-91 and one pump station (Border) was buried on site.

In 1994, a preliminary environmental reconnaissance was undertaken at four of the pump stations in the Yukon as part of the Arctic Environmental Strategy (AES) - Action on Waste Program (Appendix H). Later that year, the British Columbia Ministry of the Environment, Lands and Parks, uncovered numerous DDT canisters during an investigation near the Border Pump Station in northern British Columbia (Golder Associates, 1995).

The AES Action on Waste program is researching possible environmental problems related to the construction and operation of the pipeline. This study was commissioned as part of the AES Action on Waste program to provide preliminary assessment information. This information will be used to identify additional resources required for future assessment and remediation. The relatively tight schedule for this contract necessitated a rapid analytical and interpretive program.

The program discussed in this report consisted of an initial investigation of five sites:

- **Mile 207.6 Spill Site:** This fuel spill is located 3 km south of the Destruction Bay Pump Station. The 60 m x 500 m spill was caused by the cutting of the pipe for maintenance purposes in 1956.
- **Haines Junction Pump Station:** This pump station is located approximately 15 km north of Haines Junction at Mile 158 of the pipeline. During the investigation, most of the buildings were intact and there were two suspected waste disposal areas.
- **Million Dollar Falls:** This site was originally used as a military camp and highway construction camp, and was later converted to a construction camp for the pipeline. There is one large disposal area and some evidence that materials were buried on site. The site is presently used as a recreational area and campsite.
- **Blanchard River Pump Station:** This site is located at Mile 87 of the pipeline and is just on the Yukon side of the border with British Columbia. The site is presently owned by the Yukon Territorial Government (YTG) Highways Department. The portions of the original pump station were either modified or removed, and there is evidence of old disposal areas at the site.

- **Border Pump Station:** This site, located at Mile 47 on the pipeline, was demolished and buried on site. This initial assessment program was focused solely on the Border Station Site and excluded the associated airstrip (Rainy Hollow) and dump areas.

A map showing the locations of these sites is presented in Chapter 2.1 (Figure 1). The work was carried out in four stages which included a review of existing knowledge and site reconnaissance; a field sampling and analytical program; an environmental assessment; and final interpretation report. The objectives and scope of work at each site were as follows:

a) **Mile 207.6 Spill Site:**

Objective - Ascertain the impact of the fuel spill recorded in 1956 by delineating hydrocarbon contamination and assessing vegetative recovery.

Program - Placement of approximately 13 power auger holes through the surface active layer and into the permafrost. Two samples per hole were to be field screened for contaminants and approximately two samples retained for laboratory analysis. An assessment of successional state of vegetation would also be conducted.

b) **Haines Junction Pump Station:**

Objective - Identify areas of waste disposal and potential contaminants.

Program - Geophysical survey of areas of suspected subsurface waste disposal. Based on the results of the geophysical survey, a series of shallow test pits would be excavated using a backhoe. Two soil samples would be obtained from each test pit for field screening, and two samples would be collected for laboratory analysis.

c) **Million Dollar Falls:**

Objective - Evaluate campsite water supply and dump site for potential contaminants.

Program - Water samples were to be obtained from the campsite, and several areas below the dump site. Soil samples would be obtained from above and below the dump site for field screening and laboratory analysis. Mini-piezometers would be installed where possible for the collection of groundwater samples.

d) **Blanchard River Pump Station:**

Objective - Identify areas of waste disposal and potential contaminants.

Program - A geophysical survey would be conducted of suspected subsurface waste disposal areas (or buried materials). Based on the results of the geophysical survey, a minimum of three shallow test pits would be excavated using a backhoe. Two soil samples would be obtained from each test pit for field screening; two samples would be collected for laboratory analysis. Approximately seven holes would be drilled by air-rotary drilling; soil would be sampled at 0.6 metre intervals, PVC piezometers installed and water samples obtained.

e) **Border Pump Station:**

Objective - Identify areas of waste disposal and potential contaminants in soil and groundwater.

Program - The program originally called for the excavation of test pits; this was cancelled after a preliminary EM survey revealed the large areal extent of debris buried at the site. Approximately six holes to a 10 m depth were drilled by an air rotary equipped rig. PVC piezometers were installed and water samples taken; soil samples were obtained at 0.6 m intervals during the drilling program.

The layout of this report reflects the program objectives and follows the chronological order in which the program was carried out.

- **Chapter 1:** Outlines the rationale and objectives of the study and discusses appropriate environmental criteria.
- **Chapter 2:** Section 2.1 reviews the history of the Haines-Fairbanks pipeline. Previous environmental studies are discussed and the geology/hydrology of the study area is presented. Section 2.2 presents a detailed description of the field program. The analytical program, including both field screening and laboratory analysis, is presented in Section 2.3.
- **Chapter 3:** The results of the field program and analytical program are presented in this chapter. The five sites are presented in separate sections.
- **Chapter 4:** The results of the field and analytical program, for each of the five sites, are discussed with respect to the remediation criteria presented in Chapter 1.
- **Chapter 5:** A simple risk assessment is presented for each site using human and ecosystem health risks in a qualitative manner.
- **Chapter 6:** Recommendations, based on the discussions in Chapters 3 to 5, are presented for each site.
- **Chapter 7:** The cited references are collected alphabetically in this chapter.
- **Appendix A:** Describes the sampling and analytical methods employed in the study.
- **Appendix B:** Provides information regarding the Quality Assurance/Quality Control Program.
- **Appendix C:** Summarizes sample descriptions for each site.
- **Appendix D:** Provides soil test pit logs.
- **Appendix E:** Provides soil drilling logs and results of sieve analyses.
- **Appendix F:** Summarizes the results of ground conductivity surveys carried out at three of the sites.
- **Appendix G:** Summarizes all analytical results.
- **Appendix H:** Includes a copy of a brief report prepared in 1994 by the Environmental Sciences Group at Royal Roads Military College regarding four abandoned pump stations.

1.2 Environmental Criteria

Within the last decade, considerable emphasis has been placed on ensuring that present and future human activities are 'environmentally friendly'. Comprehensive management strategies for potentially toxic substances from the time of production to the point of final destruction or storage (i.e., "cradle to grave" management) are one example of measures recently adopted by some regulatory agencies for ensuring the long-term co-existence of humans with

their environment. Many of the current environmental problems, however, are a direct result of historical practices, such as the inappropriate release and disposal of toxicants. This section documents the approach used during this study in order to determine the need for action based on contaminants found at the Haines-Fairbanks pipeline sites.

It is generally acknowledged that risk to the environment at historically - contaminated sites must be reduced to an acceptable level; however, clearly defining contaminant levels that increase risk to humans or other living organisms is not always a simple task. The presence of a chemical substance does not, in itself, indicate a deleterious environmental effect or impact. For this reason, scientists often distinguish between the terms *contaminant* and *pollutant*. A contaminant may be defined as a substance whose presence causes a deviation from the normal composition of the environment. A pollutant, on the other hand, is a substance that fits the above definition and also has a detrimental effect on the environment. This detrimental effect must be considered if one is to discuss the need for remediation of contaminated sites. Contaminated areas are not, therefore, always polluted. An *environmental impact* is defined in this report as a detrimental change to the environment, particularly living organisms, associated with either physical disturbance or pollution due to excessive contaminant concentrations.

In order to minimize or eliminate environmental impact, it is necessary to anticipate concentrations of contaminants which could lead to a decrease in environmental quality and respond accordingly. This requires a method for predicting levels of contaminant loading which could harm the environment. Methods for evaluating environmental quality can be divided into two main groups: absolute and relative. These are not mutually exclusive.

Absolute, or criterion-based, methods define numerical values or limits that can be compared with measured environmental levels. These methods establish baseline concentrations for various substances below which the impact on the environment is assumed to be negligible. Environmental samples which contain concentrations above this limit may require further investigation and/or remediation depending on the extent to which the level is exceeded. This approach benefits from the ease with which it can be administered. A contaminant concentration is simply measured in an environmental sample, and compared to tabulated criteria adopted by the appropriate regulators.

Absolute methods suffer, however, from the assumption that the concentration limits apply equally in all circumstances, and that there is a threshold concentration in an environmental medium beyond which there is a decline in environmental quality. In reality, however, the biological availability and subsequent impact of a contaminant occur at different threshold concentrations in different environments. Absolute criteria usually include a margin of safety in recognition of site-to-site differences in the relationship between contaminant input and impact.

Relative strategies of environmental monitoring (site-specific risk assessments) also begin with the identification of the concentration of substances in field samples. The focus, however, is primarily on identifying the potential for the direct or indirect movement of this substance from the substrate in which it is contained to humans or the living environment (the biosphere). It is necessary, therefore, to examine the major pathways for

this movement in a specific environment, and the impact that this will produce. Not surprisingly, the same concentration can display very different effects under different circumstances.

In most regulatory jurisdictions, the prescribed practice embraces site-specific investigations of environmental impact which draw on both relative strategies and numerical criteria. Numerical values such as remediation criteria are commonly used as a screening tool. Environmental samples with levels of substances that fall below the criteria do not catalyze either additional assessment of risk or corrective action unless site-specific conditions suggest an uncharacteristically large potential for impact. The presence of ecologically sensitive areas/species or aqueous contaminant migration are examples of site-specific conditions that require special consideration. Often, the onus is implicitly or explicitly placed on the party responsible for the site to either conduct a detailed risk assessment of the site or simply respond to the presence of contaminants in excess of the appropriate remediation criteria by taking action to clean up the contaminated material.

In Canada, federal remediation criteria (CCME, 1989) and contaminated site cleanup criteria adopted by several provinces (e.g., BCMOE, 1995) specify the guarded use of criteria in conjunction with site-specific investigations of risk. A similar approach has also been advocated recently by the USEPA [e.g., see USEPA (1994) Region IX Preliminary Remediation Goals]. This is the approach that has been used in this study. A brief description of federal contaminant criteria in Canada, some of the appropriate provincial criteria as well as relevant non-Canadian criteria/guidelines is provided below. The types of potentially contaminated environmental samples assessed at the sites include surface and subsurface water and soil, as well as liquid contents of discarded barrels. Other sets of criteria/objectives exist for freshwater or marine sediment, air quality, et cetera; however, these are not applicable to this study.

- a) Canadian Council of Ministers of the Environment (CCME): In September, 1991, the "Canadian Council of Ministers of the Environment (CCME) Interim Environmental Quality Criteria for Contaminated Sites" were published. The CCME criteria are largely based on values that have been used in other jurisdictions (especially British Columbia and Quebec), but are considered to be interim pending an increased amount of information about some contaminants, and future advances in the scientific understanding of contaminant dose - impact relationships.

Two classes of criteria are described for both soil and water - Assessment Criteria and Remediation Criteria. The CCME Interim Assessment Criteria (Table 1-1) indicate the background concentrations or analytical detection limit for contaminants. Soil and water with concentrations that do not exceed these limits are considered to be clean; i.e., free of any contamination. The Assessment Criteria may also be considered as a list of the minimum analytical detection limit that must be achieved in order to discount the contamination of a given sample by a specific analyte. The detection of substances at concentrations higher than the Assessment Criteria may or may not be indicative of contamination or pollution, but generally require further investigation. Results of such investigations are evaluated in terms of the CCME Interim Remediation Criteria that, for soils, are divided into three categories - agricultural (AG), residential/parkland (R/P), and

commercial/industrial (C/I). A list of the CCME R/P criteria are provided in Table 1-2. CCME remediation criteria, in turn, serve as benchmarks to evaluate the need for further investigation or remediation with respect to a specified land use.

CCME Remediation Criteria for Water (Table 1-3) are divided into four usage categories - freshwater aquatic life, irrigation, livestock watering, and drinking water. The criteria for freshwater aquatic life are adopted unmodified from the Canadian Water Quality Guidelines (CWQG; CCREM, 1987). Guidelines for drinking water are taken unamended from the Guidelines for Canadian Drinking Water (GCDWQ; Health and Welfare Canada, 1989), and are maximum acceptable concentrations for unfiltered samples at the point of consumption.

For the soils at pumping stations along the Haines-Fairbanks pipeline, the residential/parkland criteria are considered to be the most appropriate criteria for the purposes of this report. It might be argued that the CCME agricultural criteria are more appropriate in areas where food substances are collected; however, the agricultural criteria were developed for land use involving intensive and repeated sowing and harvesting of plants and intense livestock husbandry, and are based on scientific information such as the bioaccumulation of contaminants by livestock feeding exclusively on plants grown in contaminated soils. Whereas the agricultural criteria are generally lower than the residential/parkland criteria for most substances, they are higher for some substances including barium, chromium, copper, nickel and zinc.

For surface waters at the pumping stations, remediation criteria for freshwater aquatic life are relevant, as are drinking water standards where there is some reasonable expectation that the water might be used by humans for drinking. Aquatic life criteria would only be relevant if groundwater surfaced and organisms were exposed in a manner such that contaminant concentrations were not significantly reduced. The mobility of many organic and inorganic compounds can be attenuated by soils along the groundwater pathway.

TABLE 1-1
CCME INTERIM ENVIRONMENTAL QUALITY CRITERIA FOR CONTAMINATED SITES-
ASSESSMENT CRITERIA (NOTES ARE SHOWN AT THE END OF TABLE 1-3)

SUBSTANCE	SOIL ($\mu\text{g/g}$)	WATER ($\mu\text{g/L}$)	SUBSTANCE	SOIL ($\mu\text{g/g}$)	WATER ($\mu\text{g/L}$)
<i>Inorganics</i>			<i>Monocyclic Aromatic Hydrocarbons (cont)</i>		
aluminum	n.e.	n.e.			
ammonia	n.e.	n.e.	1,30dichlorobenzene	0.1	0.2
antimony	20 ¹	n.e.	1,4-dichlorobenzene	0.1	0.2
arsenic	5	5	ethylbenzene	0.1	0.5
barium	200	50	styrene	0.1	0.5
beryllium	4	n.e.	toluene	0.1	0.5
boron (hot water soluble)	1	n.e.	xylenes	0.1	0.5
boron (total)	n.e	n.e.			
cadmium	0.5	1	<i>Phenolic Compounds</i>		
chromium (+6)	2.5	n.e.	non-chlorinated ² (each)	0.1	0.1

TABLE 1-1
CCME INTERIM ENVIRONMENTAL QUALITY CRITERIA FOR CONTAMINATED SITES-
ASSESSMENT CRITERIA (NOTES ARE SHOWN AT THE END OF TABLE 1-3)

SUBSTANCE	SOIL (µg/g)	WATER (µg/L)	SUBSTANCE	SOIL (µg/g)	WATER (µg/L)
chromium (total)	20	15	chlorophenols ³ (each)	0.05	1
cobalt	10	10			
copper	30	25	<i>Polyaromatic Hydrocarbons</i> (PAHs)		
cyanide (free)	0.25	40	PAHs (Total)		
cyanide (total)	2.5	40	benzo(a)anthracene	0.1	0.01
fluoride (total)	200	n.e.	benzo(a)pyrene	0.1	0.01
iron	n.e.	n.e.	benzo(b)fluoranthene	0.1	0.01
lead	25	10	benzo(k)fluoranthene	0.1	0.01
manganese	n.e.	n.e.	dibenz(a,h,)anthracene	0.1	0.01
mercury	0.1	0.1	indeno(1,2,3-c,d)pyrene	0.1	0.1
molybdenum	2	5	naphthalene	0.1	0.2
nickel	20	10	phenanthrene	0.1	0.2
selenium	1	1	pyrene	0.1	0.2
silver	2	5			
sulphur (elemental)	250	n.e.	<i>Chlorinated Hydrocarbons</i>		
thallium	0.5	n.e.	chlorinated aliphatics ⁴ (each)	0.1	0.1
tin	5	10	chlorobenzenes ⁵ (each)	0.05	0.3
vanadium	25	n.e.	hexachlorobenzene	0.1	0.1
zinc	60	50	hexachlorocyclohexane	0.01	n.e.
			Chlorinated Pesticides	n.e.	n.e.
<i>Aliphatic Organics</i>			PCBs ⁶	0.1	0.1
non-chlorinated aliphatics (each)	0.3	n.e.	PCDDs and PCDFs ⁷	1E-05	n.e.
<i>Monocyclic Aromatic Hydrocarbons</i>			<i>Miscellaneous Organics</i>		
benzene	0.05	0.5	phthalic acid esters (each)	30	n.e.
chlorobenzene	0.1	0.1	quinoline	0.1	n.e.
1,2- dichlorobenzene	0.1	0.2	thiophene	0.1	n.e.
			2,4-D	n.e.	n.e.
			2,4,5-T	n.e.	n.e.

n.e.: not evaluated

TABLE 1-2
RELEVANT CANADIAN AND UNITED STATES SOIL REMEDIATION CRITERIA/VALUES (ALL
VALUES IN $\mu\text{g/g}$ DRY WEIGHT) (NOTES ARE SHOWN AT THE END OF TABLE 1-3)

Substance	CCME (1991) Residential/ Parkland	BCMOE (1989) Level B (Where different from CCME R/P ^{20,21})	USEPA (1994) Preliminary Remediation Goals (PRGs)	US Federal/ State Guidance
<i>Inorganics</i>				
aluminum	n.e.		78000	
ammonia	n.e.			
antimony	20		31	
arsenic	30		23	100 ²⁷
barium	500		5500	
beryllium	4		0.4	
boron (total)	n.e.		7000	
cadmium	5		39	20 ²⁷
chromium (+6)	8			
chromium (total)	250		940	100 ²⁷
cobalt	50			
copper	100		2900	
cyanide (free)	10		1600	
cyanide (total)	50			
fluoride (total)	400		2300	
iron	n.e.			
lead	500		500	100 ²⁷
manganese	n.e.		390	
mercury	2		23	
molybdenum	10		390	
nickel	100		1600	
selenium	3		390	
silver	20		390	
thallium	n.e.			
tin	50		47000	
vanadium	200		550	
zinc	500			
<i>Monocyclic Aromatic Hydrocarbons</i>				
benzene	0.5		2.7	0.5 ^{27,31}
chlorobenzene	1		300	
1,2-dichlorobenzene	1		230	0.66 ²⁶
1,3-dichlorobenzene	1		280	
1,4-dichlorobenzene	1		17	
ethylbenzene	5		68	10 ³¹
styrene	5		13000	

TABLE 1-2 (continued) RELEVANT CANADIAN AND UNITED STATES SOIL REMEDIATION CRITERIA/VALUES (ALL VALUES IN $\mu\text{g/g}$ DRY WEIGHT (NOTES ARE SHOWN AT THE END OF TABLE 1-3))				
Substance	CCME (1991) Residential/ Parkland	BCMOC (1989) Level B (Where different from CCME R/P ^{20,20})	USEPA (1994) Preliminary Remediation Goals (PRGs)	US Federal/ State Guidance
toluene	3		280	10 ³¹
xylene	5		99	10 ³¹
<i>Phenolic Compounds</i>				
non-chlorinated ² (each)	1			
chlorophenols ³ (each)	0.5		200	
<i>Polyaromatic Hydrocarbons (PAHs)</i>				
PAHs (Total)		20		
benzo(a)anthracene	1		1.2	NA ²⁸
benzo(a)pyrene	1		0.12	NA ²⁸
benzo(b)fluoranthene	1		1.2	NA ²⁸
benzo(k)fluoranthene	1		1.2	NA ²⁸
dibenz(a,h)anthracene	1		12	NA ²⁸
indeno(1,2,3-c,d)pyrene	1		1.2	NA ²⁸
naphthalene	5		80	NA ²⁸
phenanthrene	5			NA ²⁸
pyrene	10		1200	NA ²⁸
1,2-benzanthracene 7,2- dimethyl		1		
chrysene		1	120	NA ²⁸
3-methylcholanthrene		1		
benzo(g,h,i)perylene		1		NA ²⁸
dibenzo(a,h)pyrene		1		
dibenzo(a,i)pyrene		1		
dibenzo(a,l)pyrene		1		
acenaphthene		10	36	NA ²⁸
acenaphthylene		10		NA ²⁸
anthracene		10	1.9	NA ²⁸
fluoranthene		10	1600	NA ²⁸
fluorene		10	28	NA ²⁸
<i>Chlorinated Hydrocarbons</i>				
chlorinated aliphatics ⁴ (each)	5			
chlorobenzenes ⁵ (each)	2			
hexachlorobenzene	2		0.53	
hexachlorocyclohexane	n.e.		0.47	
chlorinated pesticides	n.e.	2 (total)		
PCBs ⁶	5		0.11	1 ³⁰
PCDDs and PCDFs ⁷	0.001		0.0000057	

n.e.: not evaluated; NA: not available

TABLE 1-2 (continued) RELEVANT CANADIAN AND UNITED STATES SOIL REMEDIATION CRITERIA/VALUES (ALL VALUES IN $\mu\text{g/g}$ DRY WEIGHT (NOTES ARE SHOWN AT THE END OF TABLE 1-3))				
Substance	CCME (1991) Residential/ Parkland	BCMOE (1989) Level B (Where different from CCME R/P ^{20,20})	USEPA (1994) Preliminary Remediation Goals (PRGs)	US Federal/ State Guidance
<i>Miscellaneous Organics</i>				
2,4-D			390	
2,4,5-T			390	
mineral oil and grease		1000		
light aliphatic hydrocarbons		150		
TPH -diesel/fuel oil #2				200 ³¹
TPH - gasoline				100 ³¹
TPH - kerosene				200 ³¹
TPH - miscellaneous				100 ³¹

TABLE 1-3
CCME (1989) AND BCMOE (1995) WATER CRITERIA (ALL VALUES IN µg/L) (NOTES ARE SHOWN AT THE END OF TABLE 1-3)

Substance	CCME (1991)		BCMOE (1995) (where different from CCME Criteria)	
	Freshwater Aquatic Life ⁸	Drinking Water ^{9,10}	Aquatic Life	Drinking Water
<i>General parameters</i>				
oxygen, dissolved	5 to 9.5 mg/L	n.e.		
pH	6.5 to 9	6.5 to 8.5		
conductivity	n.e.	n.e.		
sodium adsorption ratio	n.e.	n.e.		
total dissolved solids	n.e.	≤ 500 mg/L ^{11,12}		
<i>Inorganics</i>				
aluminum	5 to 100 ¹³	n.e.	5 to 50 ²²	200
ammonia	1.37 to 2.2 mg/L ¹⁴	n.e.	131 to 1840 ²²	n.e.
antimony	n.e.	n.e.		
arsenic	50	25 ¹⁵		
barium	n.e.	1000 ¹⁵	1000	
beryllium	n.e.	n.e.	5.3	n.e.
boron (hot water soluble)	n.e.	n.e.		
boron (total)	n.e.	5000 ⁹		
cadmium	0.2 to 1.8 ¹⁶	5		
chromium (+6)	n.e.	n.e.		
chromium (total)	2 to 20	50	2	
cobalt	n.e.	n.e.	50	n.e.
copper	2 to 4 ¹⁶	≤ 1000 ⁹	2 to 8 ¹⁶	1000
cyanide (free)	5	n.e.		
cyanide (total)	n.e.	200 ⁹		
fluoride (total)	n.e.	1500 ⁹	200 to 300 ¹⁶	
iron	300	≤ 300 ¹⁵		300
lead	1 to 7 ¹⁶	10 ¹⁵	3 to 11 ¹⁶	
manganese	n.e.	≤ 50 ¹⁵	100	50
mercury	0.1	1		
molybdenum	n.e.	n.e.	1000	n.e.
nickel	25 to 150 ¹⁶	n.e.		
selenium	1	10		
silver	0.1	n.e.		
sulphur (elemental)	n.e.	n.e.		
thallium	n.e.	n.e.		
tin	n.e.	n.e.		
vanadium	n.e.	n.e.		
zinc	30	≤ 5000 ¹⁵		5000
<i>Monocyclic Aromatic Hydrocarbons</i>				
benzene	300	5		
ethylbenzene	700	≤ 2.4		2.4
styrene	n.e.	n.e.		
toluene	300	≤ 24		
xylenes	n.e.	≤ 300		300

n.e.: not established

Table 1-3 (continued)

Substance	CCME (1991)		BCMOE (1995) (where different from CCME Criteria)	
	Freshwater Aquatic Life ⁸	Drinking Water ^{9,10}	Aquatic Life	Drinking Water
<i>Phenolic Compounds</i>				
non-chlorinated ² (each)	n.e.	n.e.		
chlorophenols ³ (each)	0.2 to 18 ¹⁸	<0.3 to 900 ^{18,19}	0.02 to 0.9 ²³	0.3 to 30 ²³
<i>Polyaromatic Hydrocarbons (PAHs)</i>				
PAHs (Total)				
benzo(a)anthracene	n.e.	n.e.	0.1	n.e.
benzo(a)pyrene	n.e.	0.01	0.01	
benzo(b)fluoranthene	n.e.	n.e.		
benzo(k)fluoranthene	n.e.	n.e.		
dibenz(a,h,)anthracene	n.e.	n.e.		
indeno(1,2,3-c,d)pyrene	n.e.	n.e.		
naphthalene	n.e.	n.e.	1	n.e.
phenanthrene	n.e.	n.e.	0.3	n.e.
pyrene	n.e.	n.e.	0.02	n.e.
acenaphthene			6	n.e.
anthracene			0.1	n.e.
fluoranthene			0.2	n.e.
fluorene			12	n.e.
<i>Chlorinated Hydrocarbons</i>				
chlorinated aliphatics ⁴ (each)	n.e.	n.e.		
dichloroethane, 1,2-	100	5 ^{15,17}		
dichloromethane	n.e.	50		
trichloroethylene	20	50 ¹⁵		
tetrachloroethylene	260 ¹⁷	n.e.		
chlorobenzenes ⁵ (each)	0.0065 to 15 ¹⁸	≤ 1 to 200 ^{15,18}		1 to 50 ²³
hexachlorobenzene				
hexachlorocyclohexane	0.01	n.e.		
chlorinated pesticides	0.001 to 4 ¹⁹	0.7 to 280 ¹⁹		
PCBs ⁶	1 ng/L	n.e.	0.0001	n.e.
PCDDs and PCDFs ⁷	n.e.	n.e.		
<i>Miscellaneous Organics</i>				
2,4-D	4	100 ¹⁰		
2,4,5-T	n.e.	280; < 20	n.e.	20

n.e.: not evaluated

Footnotes to Tables 1-1, 1-2 and 1-3:

n.a.: not applicable.

n.e.: not established.

1: Set equal to CCME Agricultural Remediation Criterion

2: Including 2,4-dimethylphenol, 2,4.-dinotriphenol, 2-methyl 4,6-dinitrophenol, nitrophenol (2-,4-), pentachlorophenol.

3: Including chlorophenol isomers, di- to tetrachlorophenols, pentachlorophenol.

4: Including chloroform, dichloroethane(1,1- 1,2-), dichloroethene (1,1- 1,2-), dichloromethane, 1,2-dichloropropane, 1,2-dichloropropene, 1,1,2,2-tetrachlorethane, tetrachloroethene, carbon tetrachloride, trichloroethane (1,1,1- 1,1,2-), trichloroethene.

5: Including all tri- and tetrachlorobenzene isomers, pentachlorobenzene

6: Include Aroclor mixtures 1242, 1248, 1254, 1260.

7: PCDDs and PCDFs as expressed in 2,3,7,8-TCDD toxic equivalents (NATO I-TEFs).

8: Guidelines for heavy metals and trace ions are reported as total concentrations in an unfiltered sample.

9: Drinking water guidelines expressed as maximum acceptable concentrations in unfiltered samples at the point of consumption.

10: Several parameters also have aesthetic objectives; these are indicated by a "<" symbol.

11: Guideline under review for addition to the GCDWQ or possible changes in value.

12: Approximately equal to a conductivity of 1 dS/m.

13: Under review: number shown is a modification of previous guideline.

14: Tentative value due to insufficient evidence.

15: A modification of the previous Guidelines for Canadian Drinking Water Quality (Health and Welfare Canada, 1989) is proposed.

16: Guidelines vary with hardness.

17: Tentative Drinking Water Guideline due to insufficient evidence.

18: Criteria vary depending on number and positions of chlorides; see CCME(1991) for additional details.

19: Values vary across individual pesticides; see CCME(1989) for additional details.

20: Values reported include analytes not covered by CCME R/P Criteria.

21: BCMOE (1995) Criteria for Managing Contaminated Sites in British Columbia are identical to CCME (1989) Remediation Criteria for Soils.

22: Value varies depending on pH.

23: Criteria vary depending on number and positions of chlorides; see BCMOE(1989) for additional details.

24: PRGs - Tap Water 0.012 ug/L BaP

25: 55 FR 30798 - Proposed Rule RCRA Corrective Action for SWMUs 40 CFR [Section 264.521(a)(2)i-iv)] Health-based Criteria for Systemic Toxicant.

Footnotes to Tables 1-1, 1-2 and 1-3:

26: 55 FR 30798 - Proposed Rule RCRA Corrective Action for SWMUs 40 CFR [Section 264.521(a)(2)i-iv)] Health-based Criteria for Systemic Toxicant. Preliminary Risk Assessment Value based on RCRA Corrective Action Approach and EPA Verified Reference Dose.

27: Maximum Concentration of Contaminants for the Toxicity Characteristic 40 CFR Part 261. TC Rule Regulatory Levels were multiplied by 20 to simulate the dilution factor in TCLP Method for Solids.

28: Not Available. Regulatory Standards have not been established by State or Federal Agencies.

29: 55 FR 30798 - Proposed Rule RCRA Corrective Action for SWMUs 40 CFR [Section 264.521(a)(2)i-iv)] Health-based Criteria for Carcinogens.

30: A preliminary remediation goal of 1 ppm has been set for PCBs based on "Guidance on Remedial Actions for Superfund Sites with PCB Contamination," EPA/540G-90/007, Office of Emergency and Remedial Response, USEPA, 1990.

31: Alaska Department of Environment Conservation Interim Guidance for non-UST contaminated Soil Cleanup Levels, Guidance Number 001 - Revision Number 1, July 17, 1991, Table II. North Slope Cleanup Numeric Levels.

The cleanup level of benzene, toluene, ethylbenzene, and xylene is an accumulative cleanup level of 10 ppm and 0.5 ppm for benzene.

- b) **The DEW Line Cleanup Criteria (DCC):** The DEW Line was a radar system stretching across the Canadian Arctic and Alaska and Greenland at about 70° latitude. The DEW Line Cleanup Criteria (DCC) are very similar to the CCME criteria, and were developed in consultation with relevant government regulatory agencies (Environment Canada, Department of Indian Affairs and Northern Development, Government of the Northwest Territories Department of Health). The DCC are based, in part, on site specific investigations and ecosystem impact studies undertaken as part of environmental assessment associated with the down-sizing, modernization, and cleanup of DEW Line sites (Reimer et al., 1993).

The DCC were initially developed at the same time as the CCME criteria, using Quebec soil guidelines (MENVIQ, 1988) as a starting point. The DCC contain criteria equivalent to a small subset CCME residential/parkland (R/P) soil criteria, with two notable exceptions. Whereas the DCC "Level II Criteria" are identical to CCME R/P criteria for the subset of contaminants covered by the DCC (compare Table 1-2 to Table 1-4), the DCC specify an additional, more protective tier (Level I criteria) for two substances: lead and polychlorinated biphenyls (PCBs). Both lead and PCBs tend to migrate from a concentrated source to surrounding areas through the air. In addition, both substances are also known to exert chronic (long-term) - as opposed to acute (short term) - toxicological effects on animals in association with long-term bioaccumulation (in the case of lead) or food-chain related biomagnification (in the case of PCBs).

Aliphatic and aromatic hydrocarbons were not covered by the DCC.

TABLE 1-4
DEW LINE CLEANUP CRITERIA (DCC) FOR SOIL

Substance	DCC µg/g (ppm) dry weight	
	Tier I	Tier II
<i>Inorganic Elements</i>		
Arsenic (As)	---	30
Cadmium (Cd)	---	5
Chromium (Cr)	---	250
Cobalt (Co)	---	50
Copper (Cu)	---	100
Lead (Pb)	200	500
Mercury (Hg)	---	2
Nickel (Ni)	---	100
Zinc (Zn)	---	500
<i>Organic Contaminants</i>		
Polychlorinated Biphenyls (PCBs; dry wt. basis)	1	5

- c) **Other Canadian Criteria for Soils and Water:** The CCME criteria do not address levels in soils or water of some chemicals, particularly some of the polyaromatic hydrocarbons (PAHs) and organic contaminants that are often analyzed as part of the Volatile Organic Chemicals (VOC) or Acid/Base/Neutral (ABN) suite of contaminants. Appropriate criteria equivalent to CCME R/P can be found for some of these substances in the guidelines adopted by various provinces; for example Quebec guidelines (MENVIQ, 1986) and British Columbia (1989) guidelines.

Soil samples were also analyzed for total petroleum hydrocarbons (TPH) using immunoassay-based field test kits and Total Extractable Hydrocarbons (TEH) in the laboratory (see Chapter 2). There are no CCME criteria for TPH (or TEH). Other provinces (e.g., B.C., Alberta and Ontario) have guidelines, and a recent report from the Ontario Ministry of the Environment (Petroleum Contaminated Soils Working Group, 1993) summarizes the current state of knowledge regarding TPH contamination.

The level of TPH in an environmental sample is a meaningless measurement when taken on its own. TPH criteria have largely been developed in order to avoid contamination of groundwater resources. The toxic components of TPH are primarily benzene, toluene, ethyl benzene and xylenes (the BTEX suite of contaminants) and polyaromatic hydrocarbons (PAHs). The BTEX suite of chemicals are volatile and are rapidly depleted in surface soil and water samples through evaporation and sunlight-mediated photolysis. PAHs may be present, and may be more persistent than lighter aromatic and aliphatic fractions of hydrocarbons. Some of the PAHs are also known carcinogens; therefore, care must be taken to analyze a representative suite of samples for specific analytes in addition to TPH as a prelude to delineating risk. Accordingly, TPH results are used in this study only for the spatial delineation of hydrocarbon spills, and the analytical results for PAHs, BTEX and VOCs are used to assess the severity of contamination and risk.

Criteria for Managing Contaminated Sites in British Columbia (1989) specify concentrations of substances in soil and water which must not be exceeded in order to prevent specific detrimental effects under specific environmental conditions. The original B.C. Criteria include three tiers of concentration, like the Quebec guidelines: Levels A, B and C.

Level A is intended to represent either realistically achievable analytical detection limits for organic substances or natural background concentrations of inorganic elements (including metals and metalloids). Level B, approximately 5 to 10 times greater than level A on average, are remediation criteria where the intended land use is residential, recreational, and/or agricultural. For most substances, the B.C. level B values are identical to the CCME R/P values. According to the BC Ministry of Environment (BCMOE, 1989), action is required to reduce exposure to humans or other receptors if areas with these land uses contain substances in excess of the level B criteria. Similarly, soils with substances in exceedance of level C criteria are substantially contaminated, and level C are the remediation criteria for commercial/industrial sites. For substances not included amongst the CCME R/P criteria, B.C. Level B cleanup criteria have been included in Table 1-2.

More recently the B.C. Ministry of Environment, Lands and Parks amended their contaminated site cleanup criteria (BCMOE, August 1995). The revised soil cleanup criteria are identical in every way to the CCME remediation criteria. Substances with criterion values in the 1989 edition that were not found in the CCME (1989) criteria have been omitted in the most recent draft. The 1995 criteria listed for water as circulated by the B.C. Ministry of Environment, Lands and Parks contain some amendments to the earlier distributed values (BCMOE, 1989; CCME, 1991). These are shown in Table 1-3.

- d) **United States Soil and Water Criteria/Guidelines:** Soil criteria and guidelines provide screening levels that suggest an appropriate course of investigative and remedial action at potentially contaminated sites; however, they do not carry any legal weight or obligations in themselves. Environmental standards, on the other hand, are usually binding and legally-enforceable.

The United States does not have any federally-adopted, formally accepted soil remediation criteria, guidelines or standards at the present time. The primary U.S. statutes governing contaminants and waste in the environment are the Clean Air Act (CAA, 1970); Clean Water Act (CWA, 1972); Safe Drinking Water Act (SDWA, 1974); Resource Conservation and Recovery Act (RCRA, 1976) and subsequent amendments (Hazardous and Solid Waste Amendment Act, HWSA, 1984); as well as "Superfund" legislation (Comprehensive Environmental Response, Compensation, and Liability Act - CERCLA, 1980) with major amendments in 1986 (Superfund Amendment and Reauthorization Act, 1986). None of these statutes make direct reference to specific contaminant levels in soil, water or other media. Draft guidelines, however, have been proposed on several occasions, and draft sets of numbers exist. These have typically been used at contaminated sites to prioritize cleanup activities, and screen for problems pending a more complete risk assessment.

One example of draft screening criteria is the list of "Preliminary Remediation Goals" (PRGs) circulated by the USEPA (1994)(see Table 1-2). These are intended as estimates of "safe" contaminant levels in environmental media (soil, air, drinking water) based on EPA human toxicity data, major exposure pathways, and estimates of partitioning and assimilation. The PRGs attempt to provide lists of contaminant concentrations for both non-carcinogenic and carcinogenic chemicals below which the risk to humans is minimal.

Another set of numerical guidelines for contaminants in soils, "Draft Soil Screening Levels" (SSLs: Table 1-5) has also been circulated in draft form (revised in December 1994) by the USEPA, to be used for delineating soils at United States National Priorities List Sites under the Superfund program. These are assessment values applicable to screening areas of sites in order to determine the need for further action; they are not soil remediation criteria. Nor are they advocated by the USEPA for other than their intended use.

The USEPA will shortly introduce for debate and possible adoption another set of contaminant guidelines, under the EPA "Hazardous Waste Identification Rule" (HWIR)(pers. com., USEPA). Draft documents are due to be published in the Federal Register during August 1995 for contaminant levels in generated waste, and during September 1995 for

contaminant levels in contaminated media. These guidelines will probably be very similar to the SSLs, and are based on the same models of human assimilation and risk.

TABLE 1-5
SUBSET OF DRAFT "GENERIC SOIL SCREENING LEVELS FOR SUPERFUND"
($\mu\text{g/g}$) BASED ON HUMAN HEALTH CRITERIA ONLY

Substance	Pathway specific values for surface soils		¹ Migration to groundwater pathway levels ($\mu\text{g/g}$ in soil)
	² Ingestion	Inhalation	
Benzene	22	0.5	0.02
Benzo(a)anthracene	0.9	---	0.7
Benzo(a)pyrene	0.09	---	4
Chlorobenzene	1600	94	0.6
Ethylbenzene	7800	260	5
Fluoranthene	3100	---	980
Hexachlorobenzene	0.4	1	0.8
Naphthalene	3100	---	30
³ Polychlorinated Biphenyls	1	---	---
Toluene	16000	520	5
Xylenes (Total)	160000	320	74
Pentachlorophenol	3	---	0.01
Antimony	31	---	---
Arsenic	0.4	380	15
Barium	5500	350000	32
Beryllium	0.1	690	180
Cadmium	39	920	6
⁴ Lead	400	---	---
Mercury	23	7	3
Nickel	1600	6900	21
Selenium	390	---	3
Silver	390	---	---
Thallium	---	---	0.4
Zinc	23000	---	42000

Notes:

1. Assuming a tenfold dilution and attenuation factor.
2. Calculated values correspond to a cancer risk of 1 in 1,000,000 or noncancer hazard quotient of 1.
3. A preliminary remediation goal of 1 ppm has been set for PCBs based on "Guidance on Remedial Actions for Superfund Sites with PCB Contamination," EPA/540G-90/007, Office of Emergency and Remedial Response, USEPA, 1990.
4. A preliminary remediation goal of 400 ppm has been set for lead based on "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities," OSWER Directive #9355.4-12, Office of Solid Waste and Emergency Response, USEPA, July 14, 1994.

Perhaps the most important feature of federal draft guidelines under development in the United States, including PRGs and SSLs, is that they address risks to humans from contaminated media, but do not address "ecological risk"; i.e., risks to other, non-human receptors in the environment. The draft guidelines, therefore, are useful in discounting risks to human life at potentially contaminated sites provided the site-specific conditions encountered are similar to the range for which the underlying models apply, and the only major pathways of exposure by humans to the contaminant(s) of concern are likely to be by inhalation, soil ingestion, plant ingestion or dermal exposure. There are no simple numerical guidelines in the U.S. predicated on ecotoxicology, which are equivalent to the CCME Remediation Criteria.

Cleanup criteria for hydrocarbons in soil (BTEX and TPH) have been adopted by the State of Alaska (Alaska Department of Environment Conservation Interim Guidance for non-UST contaminated Soil Cleanup Levels, Guidance Number 001 - Revision Number 1, July 17, 1991, Table II. North Slope Cleanup Numeric Levels). These are provided in Table 1-2.

- e) **Contents of Discarded Barrels** There are provincial criteria available to decide whether the contents of a barrel can be incinerated. Some are shown in Table 1-5. The Government of the Northwest Territories is in the process of developing similar regulations.

TABLE 1-5
WASTE OIL INCINERATION CONTAMINANT LIMITS ($\mu\text{g/g}$)

	PCBs		Total Chlorine		Chromium		Cadmium		Lead	
	A	B	A	B	A	B	A	B	A	B
Alberta	3		1000		10		2		100	
British Columbia	3	500	1500	3000	10	10	2	3	50	1000
New Brunswick	5	500	1000	3000	10	10	2	3	100	1000
Nova Scotia	5		1000		10		2		100	
Newfoundland and Labrador	5	500	1000	3000	10	10	2	3	100	1000

Notes:

Level A is maximum allowable level for combustion in an incinerator.

Level B is maximum allowable level for combustion in a cement kiln.

2.0 METHODOLOGY

2.1 Information Review

a) History

The Haines-Fairbanks pipeline was built in the mid 1950s to replace the western portion of the Canol pipeline. Both projects were initiated as a result of perceived or real military threats to the US and Canadian northwest, and were essentially US military projects.

The Canol pipeline was built in the 1940s to carry oil from the new oil field at Norman Wells to a refinery in Whitehorse. It would then be distributed via a number of other pipelines, including Canol No. 2 from Whitehorse to Skagway, and Canol No. 4 from Whitehorse to Fairbanks. Canol No. 4 was a three inch diameter pipe and was not adequate for military needs during the Korean War.

Construction of the eight-inch Haines-Fairbanks pipeline was finished in October 1955 by independent contractors from Canada and the United States, at which time the US military took possession. Fuel was shipped in tankers and barges to the newly constructed POL terminal in Haines and transported 626 miles to Fairbanks via the pipeline. The final cost of the project was approximately \$43.7 million. The locations of these pipeline systems are shown on Figure 1.

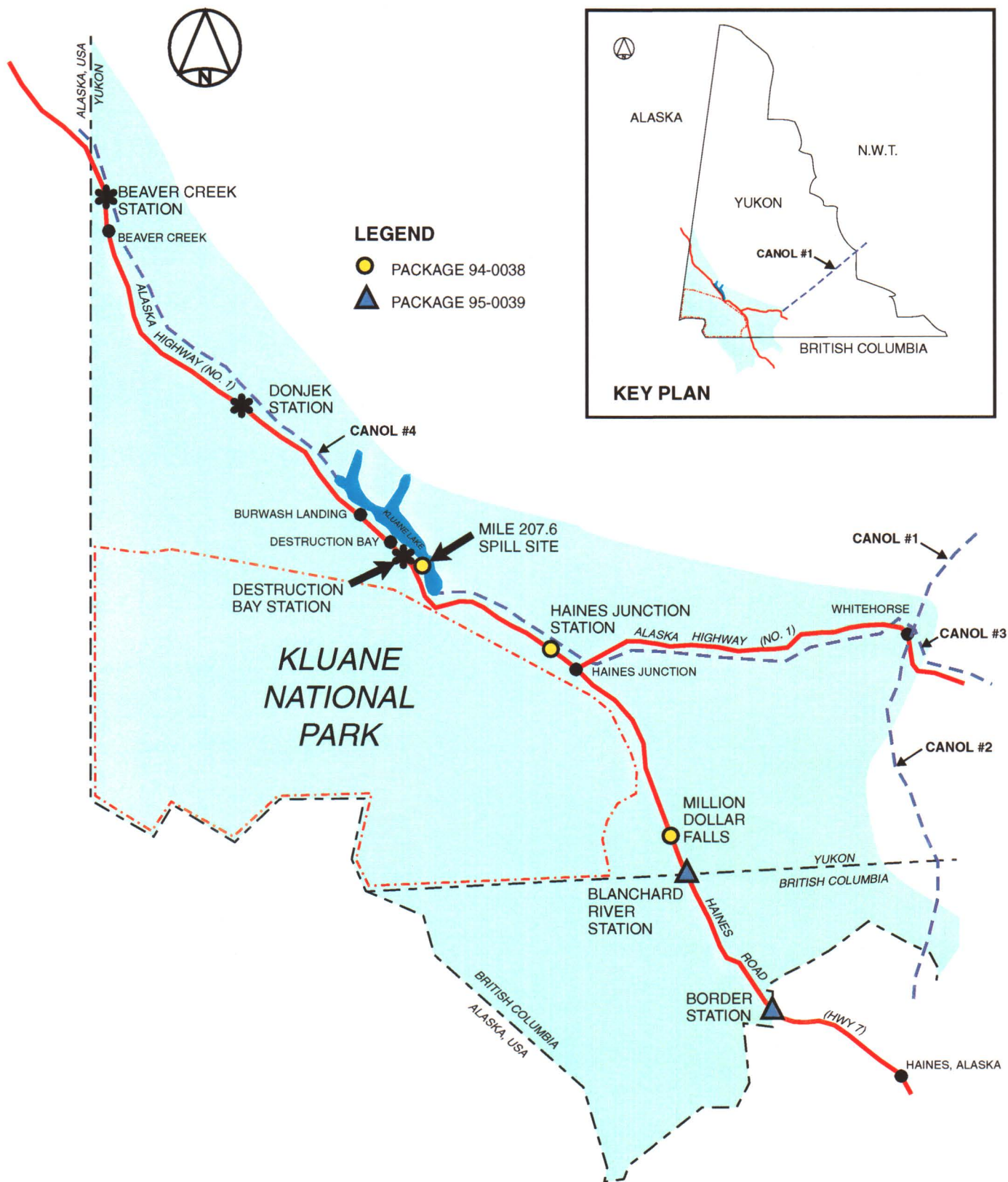
The pipeline operated for 17 years and operations ceased in 1971. Fuel needs in Alaska had been considerably reduced by the replacement of B-52 bombers and advent of surface launch missile capabilities. The pipeline was purged with water and dried with methanol and compressed air. In 1982, the Canadian Government took control of the pipeline and the Department of Indian Affairs and Northern Development (DIAND) became the custodians. It was not until 1991 that the majority of the pipe was removed from the right of way.

Pump stations were built at Haines (Alaska), Border (British Columbia), Junction (Yukon), Donjek (Yukon) and Tok (Alaska). In 1962, additional throughput was required and six more pump stations were built at Blanchard River, Destruction Bay and Beaver Creek in the Yukon, and Lakeview, Sear Creek and Timber in Alaska. Figure 1 also shows the relative locations of the Yukon sites. Each of the pump stations was constructed in a similar fashion. A summary of the three pump stations included in this study is presented in Table 2.1.1. A detailed description of the as-built structures is given below.

Table 2.1.1 - Pump Stations Studied in this Report

Station	Footprint	Legal Description	Pipeline Milepost
Border Station	32 acres	N/A	47
Blanchard River	12.2 acres	Lot 2 Gr 753	87
Haines Junction	5 acres	Lots 31, 33 Gr 803	158

The Border Pump Station was located on the old Haines Cut-Off Highway approximately 8 km north of the international boundary next to the Klehini River. The Pump Station (Photo 2.1.1) consisted of several facilities: a main pumping building, divided into an engine room, pump room and control room; a utility room, housing the generators, domestic water and heating systems; a warehouse - garage - shop; a cold locker building; and station housing consisting of one ten person dormitory and two (12 and 18 person) apartment buildings. All the structures were demolished in 1991 (Department of Public Works) and the buildings and debris were buried on site. The approximate locations of buried debris are shown on Figure 7 and in Appendix F.



PRELIMINARY
ENVIRONMENTAL ASSESSMENT
HAINES - FAIRBANKS PIPELINE

LOCATION PLAN

FIGURE 1



In 1993, a former resident of Haines reported that canisters of DDT had been buried next to the airstrip below the Border Pump Station. A subsequent investigation confirmed this and the canisters were removed. DDT contaminated soils were removed during the excavation of the buried canisters; this soil was placed at the Border station. The soil was encapsulated in a liner and placed in a fenced area (see Figure 7); it was still present at the site during the investigation for this study (July 1995), at which time the secure storage facility appeared to be in good condition.

The Blanchard River Pump Station is smaller than Border and consists of one main building and accommodation trailers. The main building housed the engine room, pumps, generators, maintenance shop and water supply. Family housing was provided by six trailers (see Photo 2.1.2). The trailers were removed in 1986 and the main building was converted to the Highways Maintenance Garage; the building was extended on the north end. An accommodation building was constructed on the original site of the trailers to house the highway workers. Demolition debris was buried to the north of the site.

The Haines Junction Pump Station is located approximately 15 km north of Haines Junction. The facilities consist of a main pumping building (engine room, pump room and office); utility building (generator room, garage-shop area, tool room and domestic water supply); and station housing (supervisor's house and 15 person apartment) (see Photo 2.1.3). All the buildings are intact (1995), although some vandalism has occurred at the site.

During the 17 years of operation there were numerous leaks along the pipeline (Rickard and Deneke, 1972). Most fuel spills were the result of errors occurring at the initial startup. The pipeline was pressure tested in 1955 using water; after it passed this test the US army assumed control of the line and the pumping of petroleum products commenced. Petroleum flow, however, was blocked in several locations by frozen water in the pipe from the hydrostatic testing. As a result, 28 cuts were required to clear the pipe and approximately 500 cubic yards of ice was removed. In addition to these earlier problems, there have been twelve recorded ruptures in the pipe. The locations of each cut and spill are provided in Table 2.1.2.

Table 2.1.2 Locations of Pipeline Cuts and Documented Spills								
Mile	Date	Loss (1)	Mile	Date	Loss	Mile	Date	Loss
1.9	6/56	100	207.6	2/56	*	264.8	2/56	*
3.0	11/64	-	208.2	2/56	*	266.0	3/56	*
6.5	7/68	50	208.6	2/56	*	268.0	2/56	*
17.7	12/68	800	217.1	2/56	*	268.9	3/56	*
19.5	9/70	1776	217.4	2/56	*	273.02	2/56	*
33.5	56	-	233.2	2/56	*	274.5	2/56	*
114.5	7/68	200	236.0	2/56	*	290.8	6/59	100
119.1	5/68	4000	242.0	2/56	*	303.5	3/56	*
195.8	1/56	*	247.9	2/56	*	382.5	3/56	*
196.4	1/56	*	251.4	2/56	*	420	12/67	-
197.1	1/56	*	252.4	2/56	*	511	5/69	-
203.6	1/56	*	253.0	2/56	*	585	67	-
205.0	1/56	*	253.4	2/56	*			
206.1	1/56	*	256.8	2/56	*			

Notes:

(1) Units: Bbl = 205 Litres

- Unknown

* The size of the any of the 1956 cut spills is not known; however, the rate of flow from the open end often exceeded 500 Bbl/h

In order to assess the impact of these oil spill sites, a clearly identifiable spill was chosen for this study. The spill that was chosen was at Mile 207.6; the pipe here was cut on the 2nd February, 1956, and purged on the 3rd February, 1956. In a June 1971 reconnaissance trip (Rickard and Deneke, 1972), the following observations were made: " This is a large area 200 feet wide near the pipe and forms an inverted V-shape 700-800 feet down a gentle slope. The area could be called a small watershed basin. Vegetation is completely lacking in the centre of the main spill area. Three soil pits were placed in the kill area and on the fringe. Odours of petroleum were present in all three with the soil frozen at 20 cm. "

In 1972, a more detailed study was undertaken at several spill sites including Mile 207.6 (Deneke et al., 1975). In this survey the spill was documented as a jet fuel spill. The jet fuel JP-4 is a low vapour pressure, wide-cut gasoline type fuel. Microbial inhibitors that were present in 1953 were 2,6-ditertiary butyl-4-methyl phenol, N,N' disec-butyl-p-phenylene diamine and 2,4-dimethyl-6-t-butyl phenol. Some of these substances may persist in soils. It is therefore possible that these inhibitors played an active part in the vegetative kill that occurred at this spill.

In the 1972 study, live ground cover averaged 36% compared to 75% in a control area outside the spill. Temperature and thaw measurements showed that permafrost had receded as a result of vegetative kill. However, the increased depth of the active layer was not considered significant enough to indicate a problem. Unfortunately, the archived soil samples from the area were lost which precludes a chemical comparison with this study.

One additional site is discussed in this study which was neither a spill nor a pump station. Million Dollar Falls was a communications relay station in the 1940s. It was also used as a highway construction camp for the Haines Road and later as a pipeline construction camp. The name Million Dollar Falls is purportedly the value of US military equipment that was buried on site.

Information Relating to Possible Contaminants of Concern

Clearly, concern at these sites is largely associated with the transfer of petroleum products. Petroleum product spills can lead to elevated levels of a variety of contaminants that may have an impact on ecosystem and human health. They are primarily, benzene, toluene, ethylbenzene and xylene (the BTEX suite of compounds), polycyclic aromatic hydrocarbons (PAHs) and chlorinated hydrocarbons used for their degreasing properties. Gasoline spills can also result in the concentration of high levels of lead in soils in the vicinity.

Transformer usage at these sites could have resulted in spills and leakages of fluids containing polychlorinated biphenyls (PCBs).

In addition to petroleum products, there is evidence that various pesticides were also used at the sites. The discovery of buried canisters of DDT at Rainy Hollow next to Border Station, for example, indicates that this pesticide was probably used in significant amounts.

There is also ample evidence that phenoxy-acid herbicides were routinely used at the stations and along the pipeline right of way. Permission to apply Esteron Brush Killer was granted in 1965. Esteron contained 2,4-dichlorophenoxy acetic acid (2,4-D) and 2,4,5-trichlorophenoxy acetic acid (2,4,5-T). In 1968, permission was granted for the use of Fenuron and Tordon 101. Fenuron contains 3-phenyl-1,1-dimethylurea and Tordon 101 contains 2,4-D and picloram. The main concern with the use of these phenoxy-acid herbicides is residual dioxins and furans that were present as a result of the manufacturing process. There has been a great deal of concern regarding the toxicity of dioxins and furans; the application of phenoxy acid herbicides along the pipeline right of way, therefore, may be cause for concern. The only available report of dioxin/furan analysis is in the vicinity of Klukshu Village on the Whitehorse-Haines Road (Fowler, 1993). Low levels of dioxins found were predominantly 2,3,7,8-tetrachlorodibenzodioxin, the most toxic of the dioxin group. This unusual dioxin fingerprint was not consistent with long range transport but indicated that a local source was possible. A follow-up report (Gray, 1994) greatly exaggerated the toxic effects of dioxins found at these low levels. This report will target phenoxy-herbicides for analysis; dioxin analysis is outside the scope of work for this report.

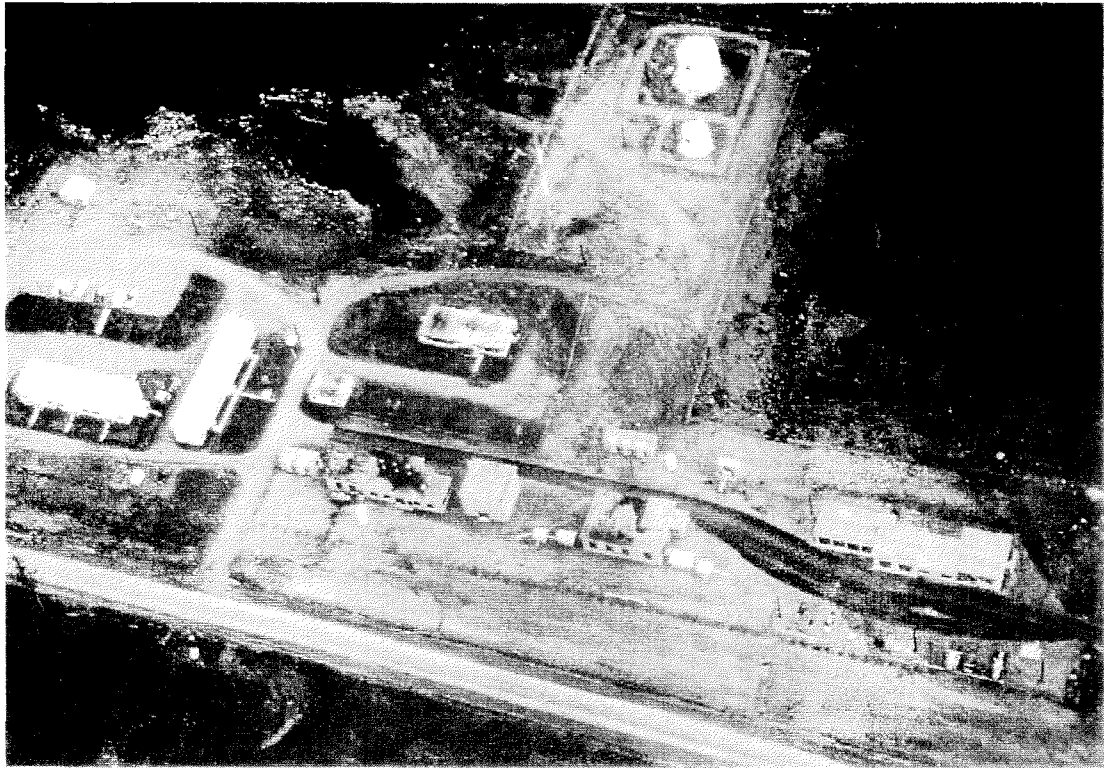


Photo 2.1.1: Border Pump Station (1960s).



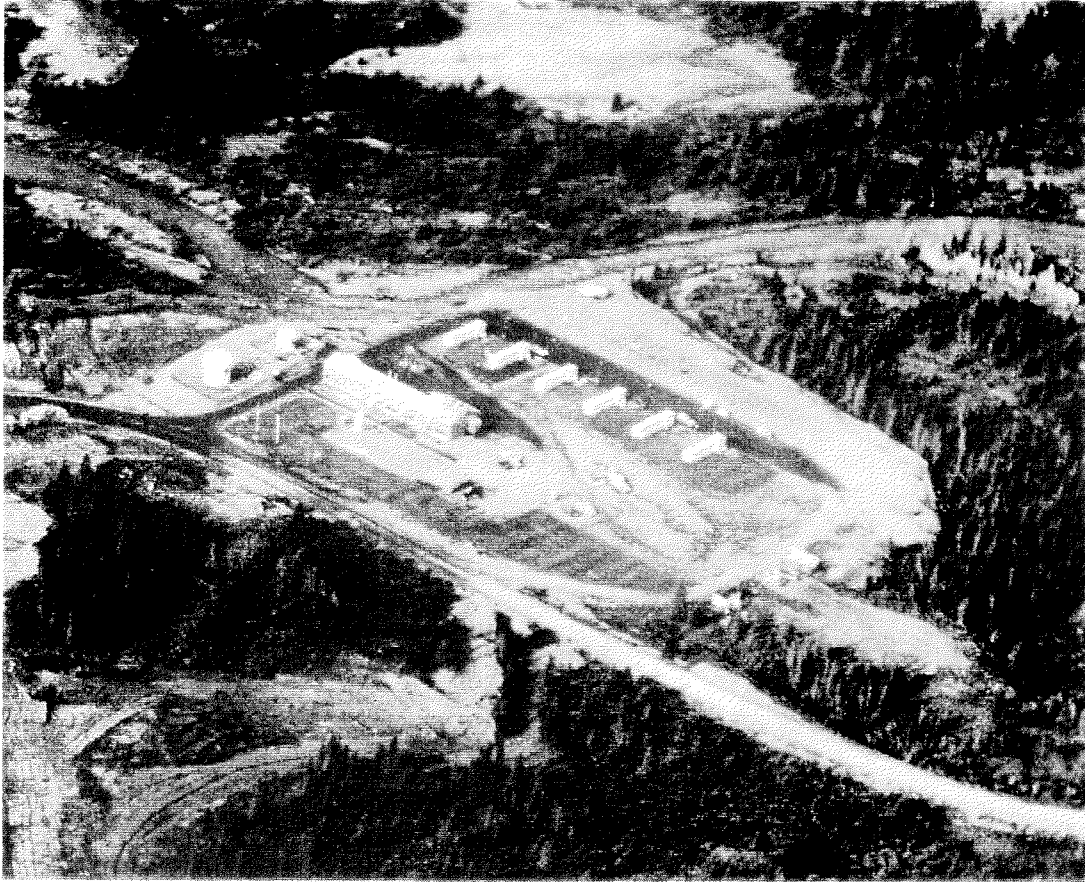


Photo 2.1.2: Blanchard River Pump Station (1960s).



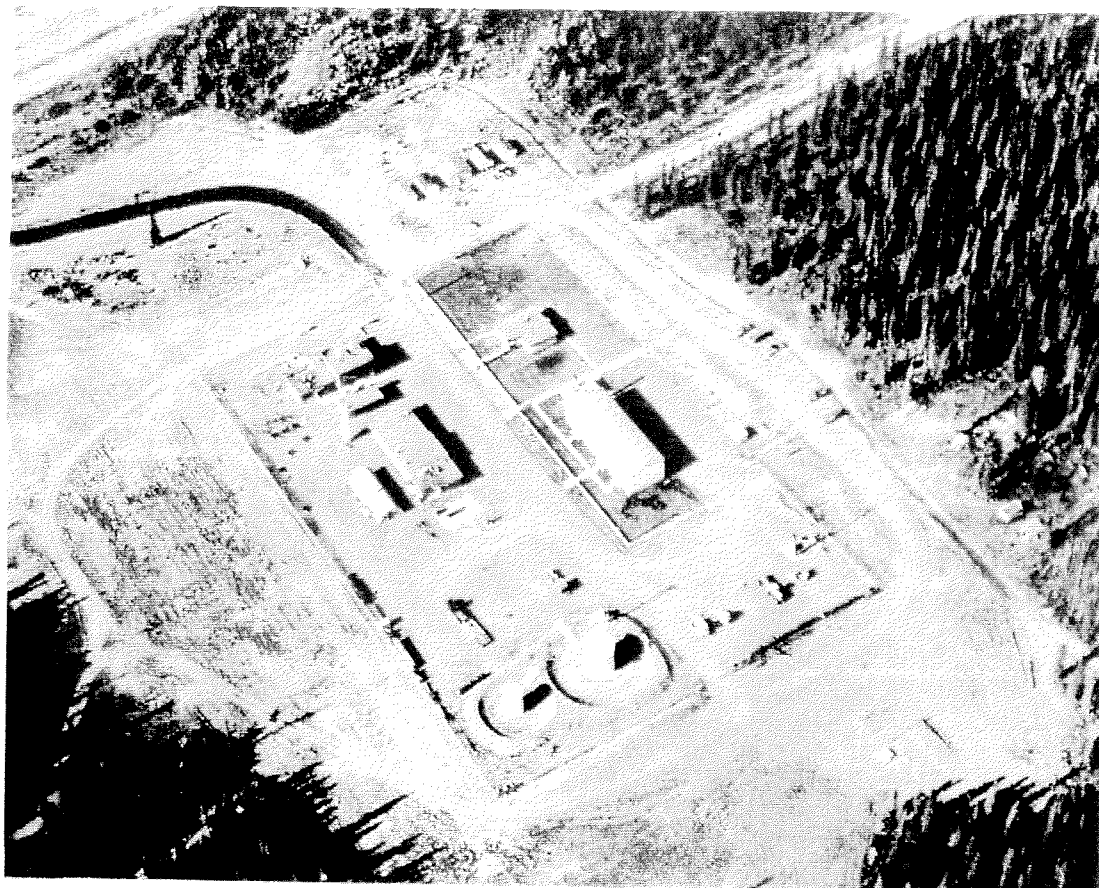


Photo 2.1.3: Junction Pump Station (1960s).



b) Site Geology

The geologic setting for the five sites is quite varied. Mile 207.6 Spill Site is situated on a flat to gently sloping till plain on the west shore of Kluane Lake. Soils consisted of organics overlying silty clay. Conditions could only be defined to about 50 cm. due to the presence of permafrost. Till associated with the parent moraine mapped for this area may likely underlie the lacustrine clay at shallow depth. Drainage is poor to imperfect.

Haines Junction Pump Station is situated on a flat to gently sloping till plain. Test pits identified a clay rich till with silt, sand and gravel. The site has good to imperfect drainage.

Million Dollar Falls is within a glaciofluvial deposit adjacent to the Takhanne River. Soils are sand and gravel and the site is well drained. Bedrock is exposed in the Takhanne gorge. Topography is gently sloping to rolling with a steep drop down to the Takhanne River on the north side and to the stream on the south and west side of the old camp site. Postglacial and recent sediments occupy the valley that borders the site to the south and west.

Blanchard River Pump Station is in the valley between the St. Elias and Boundary Mountains on the east shore of the Blanchard River. Mapping identifies this to be an area of rolling glaciofluvial sand and gravel deposits. Drilling confirmed the upper granular deposits but also identified a grey clay under these materials at a depth of 4 to 9 m. The clays are likely glaciolacustrine deposits from Glacial Lake Champagne. The surface granular deposits are glaciofluvial deposits laid down after the glacial lake receded. Local topography is flat to moderately sloping and drainage is good. Recent fluvial deposits occupy the modern river channel.

Border Pump Station is in the St. Elias Mountains on the east side of the Klehini River. The former pump station is underlain by a thick layer of glaciofluvial sand and gravel. The old Haines Highway marks the west border of the site and the start of a steep slope down to the river. The station site and the slope above it are flat to moderately sloped. Site drainage is good.

2.2 Field Program

a) Diary

July 4, 1995 - Day 1

Crew travelled to Whitehorse.
Recovered all gear from Canadian air freight.
Met briefly with DIAND.
Travelled to Haines Junction.

July 5, 1995 - Day 2

Completed field investigations at Mile 207.6 Spill Site.

This consisted of shallow soil sampling along and across the path of the old oil spill plus vegetation assessments. Soil samples were collected for both field vapour screening (HNU) and submission to the lab for organic and inorganic analysis. Twelve test holes were completed. Holes were to be advanced with the power auger however the adapter to couple the augers to the drive shaft on the power head was not shipped. Holes were advanced with a hand auger. Frozen soil at shallow depths (35 to 45 cm) limited the hole depths. Typically, holes did not penetrate more than 15 cm into the frozen layer.

EM31 and EM61 surveys were completed at Haines Junction Station. Several anomalies in the waste disposal area were identified, mainly on the west side.

July 6, 1995 - Day 3

Test pitting at Haines Junction Station uncovered several drums with product that were recovered to surface and will have to be disposed of properly. Soil samples were collected as well as a sample of the contents of one of the drums. Test pits in the area east of the station and along the trail did not reveal any problems in these areas. The concern appeared to be confined to the old dump site.

EM31 and EM61 surveys of the area inside the compound at Blanchard River Pump Station started. This area seemed quiet with the exception of one lineal anomaly that may be a pipe. The rest of the geophysics were to be done on Friday.

July 7, 1995 - Day 4

Geophysics were completed at Blanchard River Pump Station. EM31 and EM61 were used to delineate and estimate depths of anomalous features. Anomalies included indications of surface debris, buried lines and possibly a tank. The highest zones of conductivity around the main station were outlined for investigation by the back hoe. There were also signs of metallic anomalies at the lower side of the small clearing near the rafting tent sites.

Hydrocarbon staining was visible on the bank of the Blanchard River on the west side of the station. A mini-piezometer was set to 0.6 m near the water's edge and a water sample recovered with a peristaltic pump. Field test kits identified BTEX in the water sample. A complete set of water samples was taken for analysis. Water samples were also taken from the camp water supply well, the pipe that discharges near the rafting operation and from the leachate discharge.

Field test kit work was completed on samples collected from Mile 207.6 Spill Site and Haines Junction Station.

Back hoe test pits were selected for July 8 program at Blanchard River Pump Station.

July 8, 1995 - Day 5

EM31 survey was completed over the west edge of the Border Pump Station property to assist with selection of drill sites. There was one pipe anomaly but otherwise the area on the property west of the former buildings was quiet. Drill sites will have to be selected based on the old facility layout and the results from the Rainy Hollow work.

Test pitting was completed at Blanchard River Pump Station. The pits excavated in the old waste area were innocuous; however the pits in the large anomaly that spans the camp access road proved to be relatively contaminated. When the hoe reached the water table at about 2 m there was an strong odour of hydrocarbons.

Two test pits were excavated on the terrace feature above the Blanchard River as this location was not accessible to the drill rig. This location was of interest based on the staining in the soil near the river and the high BTEX recorded in the water sample from the mini piezometer. Both test pits hit hydrocarbons at a depth of 2.5 to 3 m.

July 9, 1995 - Day 6

At Million Dollar Falls, the camp well was sampled. Three stream water samples were collected above, across from and below the waste debris pile at the toe of the slope. Shallow soil samples and stream sediment were collected. Vapour screening on three soil samples proved to be negative. Two mini piezometers were set to 0.6 and 1.5 m. There was not adequate production to collect a groundwater sample. They may be re-visited at a later date to see if they are more productive after the formation collapses around the tip.

July 10, 1995 - Day 7

Drillers were to arrive at Blanchard River Pump Station by noon. While waiting for the drill crew, time was spent on the collection of shallow soil samples, surface water samples and vegetation samples. Field test kit work continued. Drillers arrived at 7:30 P.M.

July 11, 1995 - Day 8

Started at 6:00 A.M. on Test Hole 12. Progress was slow at first but improved during the day. The upper soils were a granular fill followed by sands and gravels and then clay at a depth of about 4 m. Piezometer set from 2.4 to 4 m. to span the most contaminated soils. During subsequent development, it was impossible to completely clear the water, however it did clear significantly. The soils in Test Hole 2 (MW2) were slightly more coarse, but the scenario was similar to TH1. Piezometer was set to 4 m. TH3 (MW3) drilled east of the orange stained ravine. Soils were clean. Hole was extended to 9 m. Clay was hit at 5 m.

Returned to Mile 207.6 Spill Site to attempt to drill further into the permafrost with the power auger. This met with limited success. Drilled a hole west of Station 8 to better define the lateral bound in this area.

July 12, 1995 - Day 9

Finished drilling TH4 on the north side of the ravine. This hole was clean. A piezometer was set to 4 m. below ground. Drilled TH5 on the west side of the site near the Blanchard River, above the terrace where we saw the hydrocarbon staining. This hole encountered hydrocarbons at an elevation coincident with the test pits. MH5 was completed in this hole.

Moved to Border Pump Station and drilled TH6. This hole was clean and ended in a dry dense silt till at a depth of 23 m.

July 13, 1995 - Day 10

Drilled second hole at Border (TH7). This hole had significant contamination. The hole was stopped at about 21 m. Soils were quite dry and no piezometer was installed.

Moved to TH8 and drilled to 21 m. The hole was similar to (TH7) in terms of soil contamination. This hole was below the POL tanks. The stratigraphy and moisture contents were slightly different than the previous hole and it was decided to set two piezometers in this hole to measure vertical gradient and to examine any differences in groundwater quality between the two zones. The deep piezometer was set to 17 m. and the shallow well was set to 9 m. This activity took the rest of the day. Moved to TH 9 (last hole for this site).

There were two outfall pipes across from Sta. 193 that daylight on the downslope side of the old Haines Highway. One was 20 cm and the other 8 cm in diameter. These pipes did not create an EM anomaly on the station side and may have been removed. They could offer an explanation for all or part of the hydrocarbon contamination seen in WP3 installed by Golder in 1994.

July 14, 1995 - Day 11

Drilled Test Hole 9 at the Border Pump Station. This hole was contaminated in two intervals but not to the extent observed in holes 7 and 8. Soil samples were collected for VOC screening and lab analysis. No piezometer was installed. Water samples were collected from the two piezometers in TH8.

Additional water sampling completed at Blanchard River Pump Station.

Packed up all the gear and travelled to Whitehorse. Met briefly with DIAND before catching the flight to Vancouver.

b) **Sampling Program**

Field investigations were completed at five locations - a former spill site at Mile 207.6, Haines Junction Pump Station, a former construction camp site known as Million Dollar Falls, the Blanchard River Pump Station and the Border Pump Station. The nature of site work varied for each location based on the site history. At Mile 207.6, field work consisted of a series of hand auger holes and a vegetation assessment. Twelve hand auger holes were advanced to depths of up to 58 cm. The depth of augering was limited by the presence of permafrost. Samples were collected for field VOC screening and submission to the laboratory for organic and inorganic analysis. Sampling included the organic layer, the unfrozen silty clay and the upper few centimetres of the frozen clay layer. The site was re-visited with a power auger to see if test holes could be further advanced into the frozen layer but with no success.

The former Haines Junction Pump Station was investigated by electromagnetic geophysical survey and back-hoe. All samples from this site were collected from the nine test pits excavated. Seven of the test pits were dug in the former landfill site. Soil samples were recovered for field VOC screening and lab analysis for organic and inorganic parameters. One barrel sample was collected from a drum exposed during the test pitting. The maximum depth of sampling was 2.5 m. Additional soil samples were collected from test pits excavated near a former loading ramp east of the pump station and from a suspected dump site in a small clearing south east of the station.

The Million Dollar Falls site was a camp site during the pipeline construction. It has been converted to a recreational camping site by the Yukon Territorial Government. The main concern at this site was the debris pile at the toe of the slope on the west side. It appeared that camp refuse was dumped in this location. A small stream flows at the toe of this slope and empties into the Takhanne River. Surface water samples were collected at three locations upstream, across from and downstream of the debris. Shallow soil and stream sediment samples were also recovered. Field VOC screening was completed and samples were retained for lab analysis of organic and inorganic parameters. Two small diameter piezometers were set into the shallow soils adjacent to the stream in an attempt to recover porewater samples. Unfortunately, the soils were of low permeability and water could not be suctioned for a sample. The water supply well that serves the campground was also sampled.

The Blanchard River site was a pumping station for the pipeline that has been converted to a permanent maintenance camp for the highway's department of the YTG. Initial assessments of this site noted a leachate plume from one of the former dump sites as well as a stained soil area on the bank of the Blanchard River. Investigations at this site included geophysical surveys, back-hoe test pitting and test drilling/piezometer installations. Soil samples were collected from six test pits from depths up to 3 m. for field VOC screening and inorganic and organic lab analysis. Soil samples were also recovered from five test holes drilled to depths up to 12 m. for similar analyses. Water samples were recovered from the camp water supply well, the water source used by the rafting outfitters, shallow groundwater near the stained area on the Blanchard River west of the station, the spring originating from the orange leachate plume east of the station and from the five monitoring wells set in the test holes. Head space VOC screening was completed and samples were selected for lab analysis of organic and inorganic parameters. Shallow soil samples were also collected from the area of the leachate plume. Vegetation samples were collected from the area below the leachate staining east of the station and from an area 200 m. from the station to serve as background.

Border Pump Station was investigated with a limited geophysical survey and by drilling four test holes. Test holes extended to depths up to 24 m. Soil samples were collected for VOC screening and for organic and inorganic lab analysis. Two piezometers were set at staggered intervals in test hole 8. Groundwater samples were collected for organic and inorganic analysis. Shallow soil samples were collected from a surface stain on the north end of the site.

Field chemistry was completed on several samples from these five sites as a preliminary indication of contaminants present in the soils and to assist in selecting the samples and analytical package for lab analysis. This component of the field program proved to be very useful in providing an early indication of the chemistry at the various sites. Sample descriptions and identifiers are shown on the various site plans and in the appendices.

2.3 Analytical Program

The analytical program consisted of two components: the field component utilized portable analytical equipment that supplied results while the sampling program was still in progress; the laboratory component involved more detailed analyses that could only be carried out in an analytical laboratory after the program was complete.

- a) **Field Component:** The advantage of incorporating field analytical work into this program was the ability to direct both the continuing field work and the selection of analytes for further laboratory analysis. Six field methods were employed, four of which are based on immunosorbent assays.

Immunoassay Test Kits

These test kits are designed for screening a variety of contaminants. In this program, kits were used for the detection of total petroleum hydrocarbons (TPH), BTEX, PCBs and PAHs. Fifty-one soil samples were screened for PCBs, 50 soil samples for TPH, 43 for PAHs and 38 for BTEX; eight water samples were screened for BTEX. The immunoassay test relies on the interaction between an antibody and the target analyte (Van Emon and Gerlach, 1995). The analyte-selective antibody is coated on the inside surface of a test tube. The analyte from the sample (methanol extract from soil) and a known amount of enzyme tagged analyte compete for the limited number of antibody sites. Quantization is achieved by comparing the colorimetric signal generated by a unknown sample with a set of standards using a spectrophotometer.

Photoionization Detector (PID)

One hundred and ten soil samples, and one water sample were routinely screened using a Hnu™ photoionization detector. These detectors measure air concentrations of volatile organic compounds (VOCs) in the 1-2000 ppm range. The detector was placed in the head (air) space of the soil sample container after a 10 minute equilibration time.

Conductivity

The conductivity ($\mu\text{mhos/cm}$) was measured in seven selected water samples using a portable conductivity meter.

The field analytical program is summarized by site in Table 2.3.1 below.

Table 2.3.1 Field Analytical Program							
Site	Number of Samples						
	Type	PCBs	TPH	PAH	BTEX	PID	Cond.
Mile 207.6 Spill Site	Soil	13	22	15	22	25	-
Haines Junction Station	Soil	7	11	6	11	10	-
Million Dollar Falls	Soil	3	3	3	3	3	-
	Water	-	-	-	-	-	3
Blanchard River	Soil	20	14	19	2	37	
	Water	-	-	-	8	1	4
Border Station	Soil	8	-	-	-	35	

Full details of above techniques can be found in the Methods section of the Appendices (Appendix A).

- b) **Laboratory Component:** The analytical program was guided, as much as possible, by the results from the field screening program. Laboratory analyses were conducted by Axys Analytical Services in Sidney, British Columbia. Metal analyses were subcontracted out to CanTest, Vancouver, B.C.

All of the analytical methods are outlined in the appendices; a brief review of the program is given below.

Volatile Organic Compounds

This suite of compounds includes benzene, toluene, ethylbenzene and xylenes (BTEX) and also a number of compounds that are used as industrial solvents. Under normal circumstances approximately 20 halogenated compounds can be quantified, they are: chloroform, bromoform, dichloromethane, carbon tetrachloride, chloroethane, bromodichloromethane, chlorobenzene, dibromochloromethane, bromodichloromethane, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloropropane, trichloroethene, trans-1,2-dichloropropene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1,2,2-tetrachloro-ethane.

Thirteen soil samples and 14 water samples were analyzed for the halogenated VOCs. Nineteen soil samples, one oil sample and 15 water samples were analyzed for the BTEX suite of contaminants.

Total Extractable Hydrocarbons (TEH)

Nineteen soil samples and 12 water samples were analyzed for TEH. By using this method, it is sometimes possible to classify the type of hydrocarbon e.g., diesel. TEH concentrations correspond to hydrocarbon compounds with 1 - 30 carbon atoms.

Polycyclic Aromatic Hydrocarbons (PAHs)

The following chemicals are included in the PAH suite: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(a)fluoranthene, benzo(e)pyrene, benzo(a)pyrene, perylene, dibenz(ah)anthracene, indeno(1,2,3-cd)pyrene, benzo(ghi)perylene. Two soil samples and one water sample were analyzed for PAHs.

Inorganic Elements by Inductively Coupled Plasma (ICP) Atomic Absorption Spectrometry

Thirty three soil samples, one oil sample and 14 water samples were analyzed for inorganic elements. The inorganic element suite consisted of: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silicon, silver, sodium, strontium, titanium, vanadium, zinc, zirconium.

Polychlorinated Biphenyls (PCBs)

PCBs consist of a class of 209 compounds which were commonly used in transformer fluids until the late 1970s. The method used here is an analysis that is reported in terms of Aroclor equivalence. Aroclors were the commercially available PCB formulations in North America. Although a congener specific analysis would give more indication of toxicity and possible sources, it was not considered necessary at this stage of the investigation. Ten soil samples, one oil sample and nine water samples were analyzed for PCBs. In addition, one water sample and one soil sample were also screened for chlorobenzenes, a class of compounds used as industrial solvents.

Chlorinated Pesticides

Seven soil samples, one oil sample and seven water samples were analyzed for pesticides. This suite included the following pesticides: HCB (hexachlorobenzene), alpha HCH, beta HCH, gamma HCH (hexachlorocyclohexane), heptachlor, aldrin, oxychlordane, trans-chlordane, cis-chlordane, o,p'-DDE, p,p'-DDE (dichlorodiphenyldichloroethane), trans-nonachlor, cis-nonachlor, o,p'-DDD, p,p'-DDD, p,p'-DDT (dichlorodiphenyltrichloroethane), mirex, heptachlor epoxide, alpha-endosulphan, dieldrin, endrin, methoxychlor.

Herbicides

Five soil samples and six water samples were analyzed for phenoxy acid herbicides, that were reported to be in routine use along the pipeline. The analytical suite included: 2,4,5-T (trichlorophenoxy acetic acid), 2,4-D (dichlorophenoxy acetic acid), 2,4-DB (2,4-dichlorophenoxy butyric acid), Dicamba (2-methyl-3,6-dichloro-benzoic acid), MCPA and MCPP (2-methyl-4-chlorophenoxy aliphatic acids and esters), 2,4,5-TP (trichlorophenoxy propionic acid) and Picloram (). One water sample was also analyzed for the herbicide Fenuron.

The analytical program is summarized by site in Table 2.3.2. All of the results are collated in the Appendices and discussed in Chapter 3.

Table 2.3.2 Laboratory Analytical Program									
Site	Type	Number of Samples							
		VOCs	BTEX	TEH	PAH	ICP	PCBs	Pest	Herb
Mile 207.6 Haines Junction	Soil	-	3	3	1	1	1	1	1
	Soil	-	2	1	1	7	1	1	1
	Oil	-	1	-	-	1	1	1	
Million Dollar Falls	Soil	2	2	2	-	4	2	2	2
	Water	4	4	3	-	3	3	3	2*
Blanchard River	Soil	4	5	5	-	12	4	1	-
	Water	8	9	7	1	9	5	3	3
Border	Soil	7	7	8	-	9	2**	2	1
	Water	2	2	2	-	2	1**	1	1

Notes: * one sample also analyzed for Fenuron.
 ** one sample also analyzed for chlorobenzenes.

3.0 RESULTS OF THE STUDY

3.1 Mile 207.6 Spill Site

a) Site Description

This spill site originated from an intentional pipeline cut at mile post 207.6 along the Haines-Fairbanks pipeline to remove ice blockage in February of 1956. An undetermined amount of jet fuel JP-4 was purged at that time and released into the environment. The resulting spill way currently comprises an area of approximately 3 hectares and forms an inverted V-shape leading from the pipeline right-of-way into a small watershed basin. This path curves and follows a gentle slope averaging 6% (with an aspect of N 35° E) for a distance of approximately 500 m through spruce-dominated forest (Figure 2). The site is situated 500 m southwest of the Alaska highway at an elevation of 790 m asl and is reached by highway mile access road 1082.5. This old road, which is becoming overgrown, diverges before the spill area to form two arms; both of these cross the spill way area and eventually intersect the pipeline right of way (Figure 2). These roads were probably developed for the original pipeline servicing cut in 1956, and subsequently reclaimed for field studies conducted in the early 1970's (Deneke et al., 1975).

The soil parent material in the area consists of lacustrine clays underlain by till. Top soils at the site are highly organic to humic (peaty) in composition ranging in depth from 7 to 35 cm; this overlays clay with an occasional thin middle layer of sand. Permafrost was detected in the clay layer at depths ranging from 33 to 58 cm during this investigation.

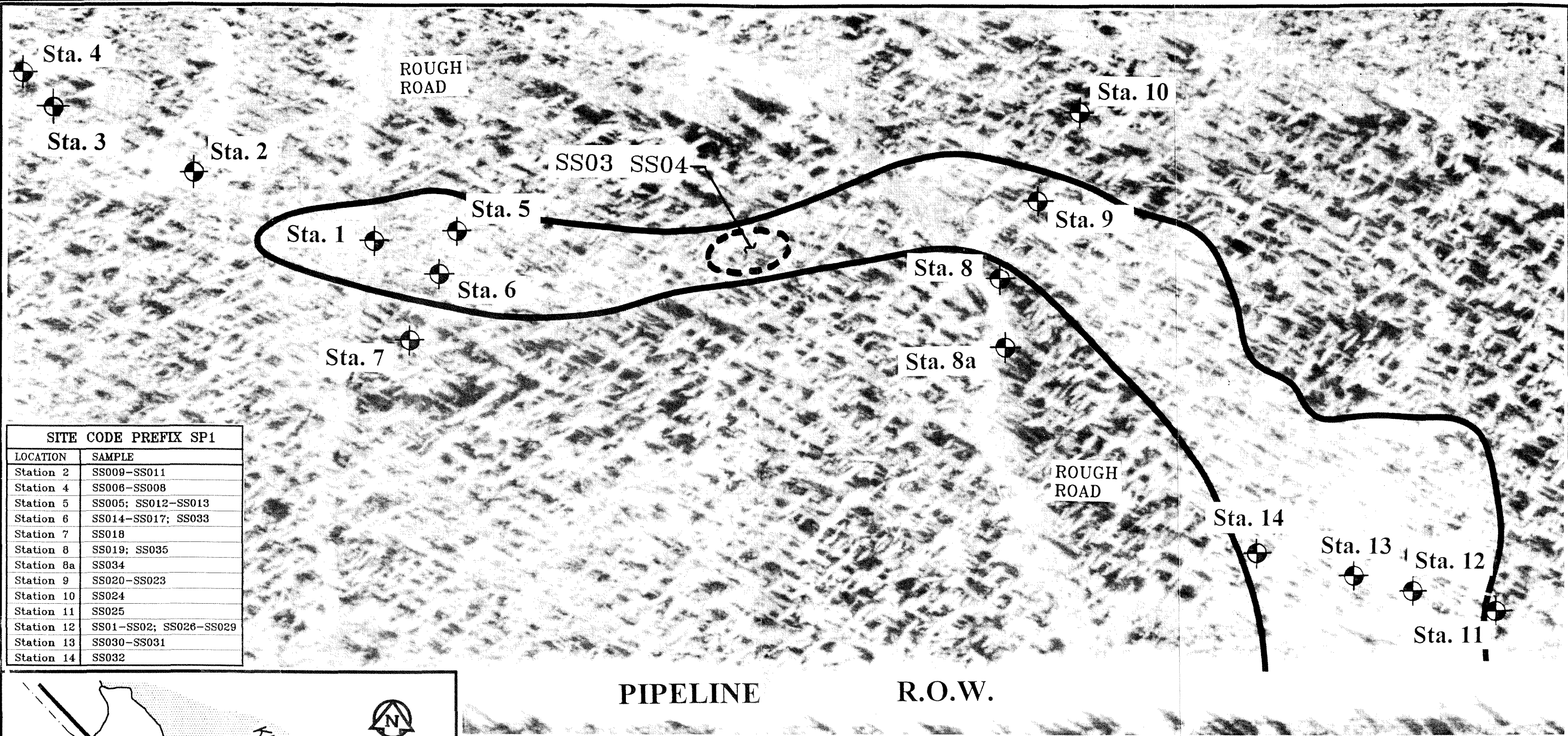
Vegetation around the affected area is dominated by a mature white spruce (*Picea glauca*) forest with many of the understorey species noted by Deneke et al. (1975): bear berrys (*Arctostaphylos* spp.), crow berry (*Empetrum* sp.), twin flower (*Linnaea* sp.), Labrador tea (*Ledum* sp.), liquorice-root (*Hedysarum* sp.), horsetail (*Equisetum* sp.), sedge (*Carex* sp.), lichen and moss. The only wildlife observed at the time of the visit were least chipmunks (*Eutamias minimus*) living in the spill area. Droppings and tracks along the access road, however, indicated that the area is also frequented by larger animals such as bears and (possibly) moose.

b) Site Condition

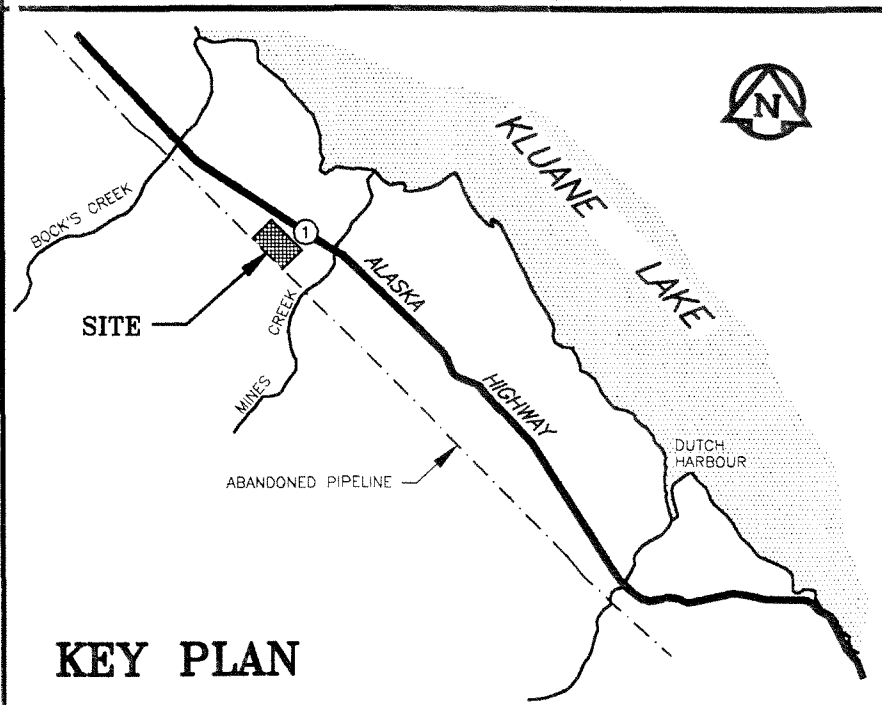
This site was previously investigated as part of studies of terrestrial oil spills conducted in the early 1970's by Deneke et al. (1975). The area at that time could be clearly delineated by the lack of vegetation, even 15 years after the spill incident (Photo 3.1.1). Hydrocarbon odours were present in three soil test pits dug at various locations in the spill, and the soil permafrost¹ had receded due to the loss of vegetative ground cover. It was suggested, however, that the permafrost differences were not sufficient to suggest a potential problem with degradation. Vegetation kill was believed to be due to either soil toxicity from fuel additives, changes to the soil moisture regime by

¹ Frozen soil was detected at a depth of 20 cm in 1972.

petroleum, or a combination of the two. Plant life was completely absent in the middle of the main spill area near the pipeline right of way. Live ground coverage by vegetation was found to be 50 % lower in the spill area, and sharp boundaries were noted between the locations influenced and those unaffected by the fuel spill. Within the spill area, live ground cover was greater in channels and low-lying areas where spruce seedlings, willow-herb, and grasses were found. Other species, such as crowberry, mountain cranberry and twinflower were absent, whereas bear berry and Labrador tea were depauperate in the spill area (Deneke et al., 1975).



SITE CODE PREFIX SP1	
LOCATION	SAMPLE
Station 2	SS009-SS011
Station 4	SS006-SS008
Station 5	SS005; SS012-SS013
Station 6	SS014-SS017; SS033
Station 7	SS018
Station 8	SS019; SS035
Station 8a	SS034
Station 9	SS020-SS023
Station 10	SS024
Station 11	SS025
Station 12	SS01-SS02; SS026-SS029
Station 13	SS030-SS031
Station 14	SS032

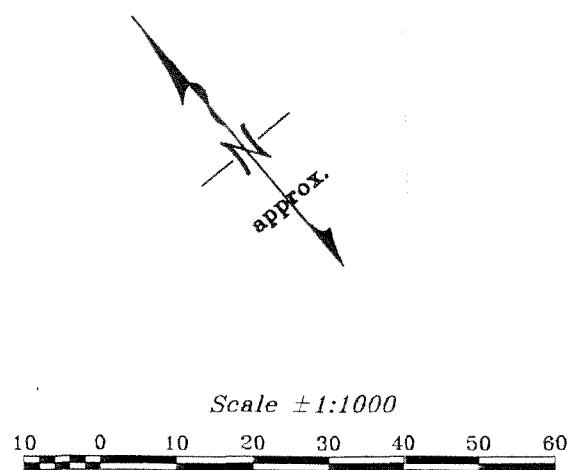


PIPELINE R.O.W.

LEGEND

Sta. 5 - LOCATION OF SURVEY STATIONS

- APPROXIMATE LIMIT OF FUEL SPILL



UMA Engineering Ltd. Engineers, Planners and Surveyors		MILE 207.6	
in association with AMBIO Research Associates Inc.		TITLE: LOCATION PLAN	DATE: AUGUST 1995
		JOB No. 4440 033 00 02	FIGURE 2
		DRAWN: RN	
		CHECKED: TRW	

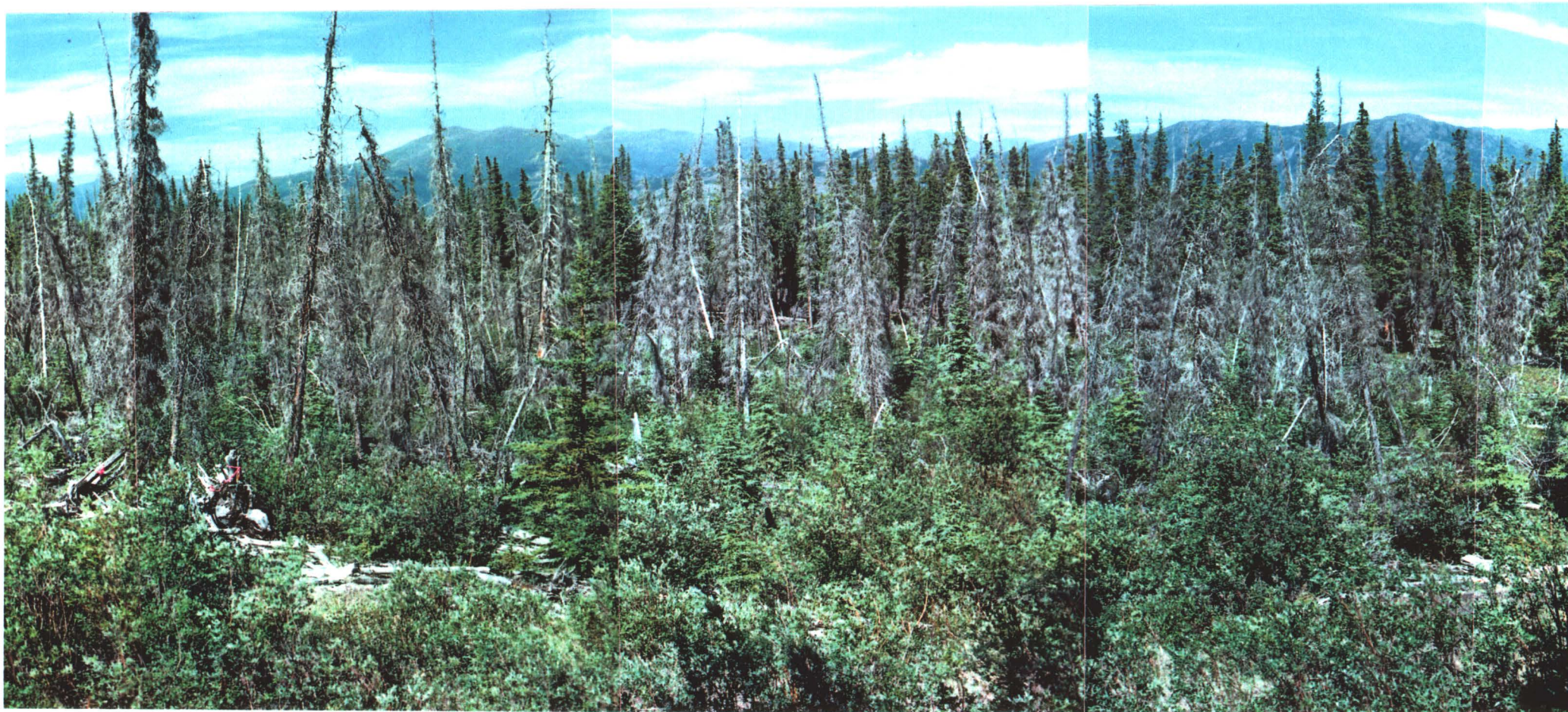


Photo 3.1.1: Mile 207.6 Spill Site - looking down along the spill site from the pipeline ROW
- dead trees show the spill site



Photo 3.1.2: Ground cover re-establishment and recolonization
in the Mile 207.6 spill over the past 20 years.

A notable recovery in vegetation has occurred at this site since the above study was conducted over the past 20 years. Although the original area of damage is still demarcated by the presence of dead, sometimes burnt spruce (standing and fallen), the abundance and diversity of ground cover has increased significantly and includes many successional species which were previously absent or severely reduced (Photo 3.1.2): willow (*Salix* sp.) cingefoil (*Potentilla* sp.), soap berry (*Shepherdia* sp.), bear berrys, twin flower, crow berry, willow-herb (*Epilobium* sp.), lupine (*Lupinus* sp.), fernweed (*Pedicularis* sp.), sweet coltsfoot (*Petasites* sp.), mountain cranberry (*Vaccinium* sp.), bluegrass (*Poa* sp.) and other grasses, sedges (*Carex* spp.), and moss (*Spaghnum* sp.). A number of young white spruce (up to 1.5 m in height) are also colonizing the spill area suggesting this site is beginning to revert back to its "natural" or original state.

c) **Subsurface Soil Conditions**

The site is mapped as a till plain on the available surficial mapping. The shallow hand augering encountered recent organic deposits overlying a lacustrine silty clay. The parent till soils may be present at shallow depth below the clay; however this could not be confirmed with this field program. The clay was frozen at a depth of 35 to 50 cm at the time of the investigation. The thaw front would continue to advance for another two months following this site visit, however it appeared that permafrost underlies this site. The combination of the low permeability of the clay and the presence of the frozen layer serve as natural controls on the lateral or vertical migration of the hydrocarbons present from the pipeline spill.

Soils in the spill location contain a large amount of detrital material, resulting from earlier petroleum spills, over a highly organic to peaty topsoil which is underlain by a silty clay. The strong hydrocarbon odour previously reported in the soils of the spill was also detected during this site investigation. A soil vapour probe survey through three zones at the top (five stations), middle (three stations) and lower (four stations) portions of the spill area was conducted to detect the presence of volatile organic compounds (VOCs), such as hydrocarbons; these are expressed in units of ppm (parts per million). The locations of these areas are indicated in Figure 2. Concentrations of VOCs in the soils ranged from 0, at the lowest portion of the spill, up to 290 ppm in low-lying areas and locations at the top edge of the spill. These results indicate that some hydrocarbon product from the original spill remains in the soil after nearly 40 years. No consistent pattern was found across the soil profiles; the VOC values, however, were generally higher in the active layer compared with the permafrost, indicating that this lower frozen layer probably serves as a barrier to further vertical migration through the soil.

The active (freeze-thaw) soil layer depth range found in this study (33 to 58 cm) is considerably lower than previously reported by Deneke et al. (1975). This discrepancy may exist for one of two possible reasons:

- the time of year the permafrost measurements were taken in the two studies may have differed, resulting in differing thaw levels in the soil; or
- further permafrost degradation may have, in fact, occurred since the 1975 study.

d) **Groundwater Conditions**

The presence of underlying permafrost throughout the area precluded studies of groundwater at this site.

Due to the relatively small area of the spill site, the underlying low permeability clay and the fact that the clays are frozen at shallow depth, evaluation of groundwater conditions was not necessary.

e) **Contaminant Considerations**

Soil samples collected from test pit profiles at Station 12, at the upper end of the (original) spillway; Station 9, in the mid-section; and Stations 5/6, at the lower end; were analyzed for various contaminants including inorganic elements, total extractable hydrocarbons (TEHs), volatile organic compounds (VOCs, including BTEX), pesticides, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCs). These results are tabulated in Appendix G. The relative locations of these samples are indicated in Figure 2.

Inorganic elements were analyzed in soil samples from Station 12 (SP1SS028 - profile sample taken at 20-30 cm in organic clay), and a similar sample obtained from Station 9 (SP1SS022 - taken at an 8-20 cm depth). Concentrations of all substances were comparable to, or slightly higher than the applicable CCME Assessment Criteria, but well below the corresponding R/P Remediation Criteria.

One sample from Station 12 (SP1SS027 - a profile at 20-30 cm in organic clay) near the pipeline right of way was analyzed for organochlorine pesticides, phenoxy herbicides, PCBs and PAHs. Concentrations for all organochlorine pesticides and phenoxy herbicides in the sample were below the analytical detection limits. Most analytes from the PAH suite, by contrast, were detectable but at concentrations well below the available CCME assessment criteria; many of these values were affected by interferences. The highest reliable PAH values were found for fluorene, phenanthrene and acenaphthene with concentrations ranging from 400 to 820 ng/g (0.40 to 0.76 µg/g). These higher PAH values, however, were still below applicable soil remediation criteria (i.e., CCME R/P and BC MOE Level B). Low levels of PCBs (Aroclor 1254 at 1.5 ng/g) were also detected at Station 12. Detectable concentrations of Aroclor 1260 (0.82 ng/g) were also detected; this second value, however, was unreliable due to comparable levels of this mixture found in the method blank. Total PCB Aroclor concentrations in the sample were well below the CCME Assessment Criterion (0.1 µg/g or 100 ng/g).

Soil samples from profiles of test pits at Station 12 (SP1SS027), Station 9 (SP1SS021) and Station 5 (SP1SS017) were analyzed for TEHs. Concentrations in samples along this sequence of stations were 6000, 2500, and 1300 µg/g, respectively, indicating a declining gradient of TEH levels along the length of the original spillway. These levels all exceeded the US Federal/State Guidelines adopted by Alaska (200 µg/g).

Volatile organic compounds (VOCs) were also analyzed in soil profile samples at the mid-point and lower end of the spill at Station 9 (SP1SS021) and Station 6 (SP1SS017: at 30-51 cm in clay permafrost). Total concentrations of xylene were detected at both stations with the level being four orders of magnitude higher at Station 6 further down the spill (2500 ng/g), than at Station 9 (0.51 ng/g). Only the higher level at Station 6 exceeded the CCME assessment criteria for soils (0.1 µg/g or 100 ng/g), but was still less than the CCME R/P soil remediation criteria (5 µg/g or 5000 ng/g). The only other BTEX analyte detected was ethyl benzene which was found in soil from Station 6 (12 ng/g) at a value less than the CCME assessment criterion (0.1 µg/g, or 100 ng/g).

3.2 Haines Junction Pump Station

a) Site Description

This site was one of the five original pump stations built along the pipeline in the mid 1950's. The station, which occupies an area of approximately 2 ha, is located at Mile 158 of the pipeline (milepost 1026.5 of the Alaska Highway), 15 km north of Haines Junction (60° 50' N., 137° 45' W) at an elevation of 830 m asl. The original site facilities were situated along the northeast side of the pipeline right-of-way (Figure 3). These included a mainline pumping building (engine room, pump room and office); a multi-purpose utility building (generator room, garage-shop area, tool room and domestic water supply); and station accommodation (supervisor's house and 15 person apartment) (Photo 3.2.1). Other facilities included two POL storage tanks at the northeast end of the site and a Quonset hut.

Two sites, suspected to be old dumps, are situated to the west of the site on the opposite side of the pipeline right-of-way. The first consists of a large clearing roughly 1 ha in area, located 50 m northwest of the pipeline right-of-way, while the second is much smaller (approximately 0.25 ha) and situated further to the northwest. Drainage from these areas follows a slope into the forest to the south and west. The remains of two old shacks and a small disturbed area are located in the woods to the east of the site. General features are shown on Figure 3.

Surface soils at the site are variable and consist of mixtures of clay with silt, sand and gravel (till) in disturbed and worked areas, and organic-detrital soil over reddish sandy clays in wooded regions. Where test pits were dug, the soils overlay a gray clay base layer occurring at depths ranging from 50 cm in wooded, undisturbed locations to 3 m in worked (fill) areas. Permafrost was not detected in the test pits.

The areas surrounding the site consisted of mid-successional forest with a mix of white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), and grey/hoary alder (*Ulnus incana*) trees. Understory shrubs included willow (*Salix* sp.), soapberry (*Shepherdia* sp.) and mountain cranberry (*Vaccinium* sp.). A variety of forbs were also found on the forest floor such as willow-herb (*Epilobium* sp.), maguire (*Arnica* sp.), fernweed (*Pedicularis* sp.), and lupine (*Lupinus* sp.).

b) Site Condition

Most of the original buildings at the station were intact at the time of the 1995 visit, although some vandalism has occurred at the site. Doors and windows, for example, were missing from virtually all of the buildings and some debris has been left strewn around the station site. This included piping, lead batteries, culvert casing, barrels and building materials. Stains in the soil around the pumphouse also indicate that some hydrocarbon spillage has occurred.

A number of areas around the station have been extensively worked, in addition to the two suspected dumpsites mentioned above (see Figure 3). These include large areas at the northeast and southeast sides of the site, and a large double-fenced area along the northwest side which may have served as some type of storage area (see Photos 3.2.1 and 3.2.3). A ramp structure made from gravel and old pipeline has also been constructed near the northwest end of the site.

Much of the existing vegetation at the site was originally damaged or removed during the initial construction and/or operations of the site. Any past effects of released hydrocarbon contaminants at the sites on vegetation has probably been less severe by comparison. The greatest physical effects have been at the main operations site where station activities have been the most intense (see Photo 3.2.1). Vegetation was very sparse here, and was dominated by a few early successional or colonizing species of flowers and grasses such as prairie sagewort (*Artemesia* sp.), yarrow (*Achillea* sp.), brome-grass (*Bromus* sp.), and bluegrass (*Poa* sp.).

A much wider range of plants occurred at the smaller suspected dumpsite further to the northwest than the main station; plants seen at the dump included forbs [e.g., lupine, aster (*Aster* sp.), dandelion (*Taraxacum* sp.), rock-cress (*Arabis* sp.), yarrow, milk-vetch (*Astragalus* sp.), Indian paintbrush (*Castilleja* sp.)], grasses (e.g., bluegrass), sedges (*Carex* sp.), shrubs (e.g., willows, soapberry), and young trees characteristic of the surrounding forest (e.g., white spruce, alder, balsam poplar). This area was at a much more advanced successional state relative to the main site, suggesting that the degree of activity has not been as severe and was less recent (Photo 3.2.2).

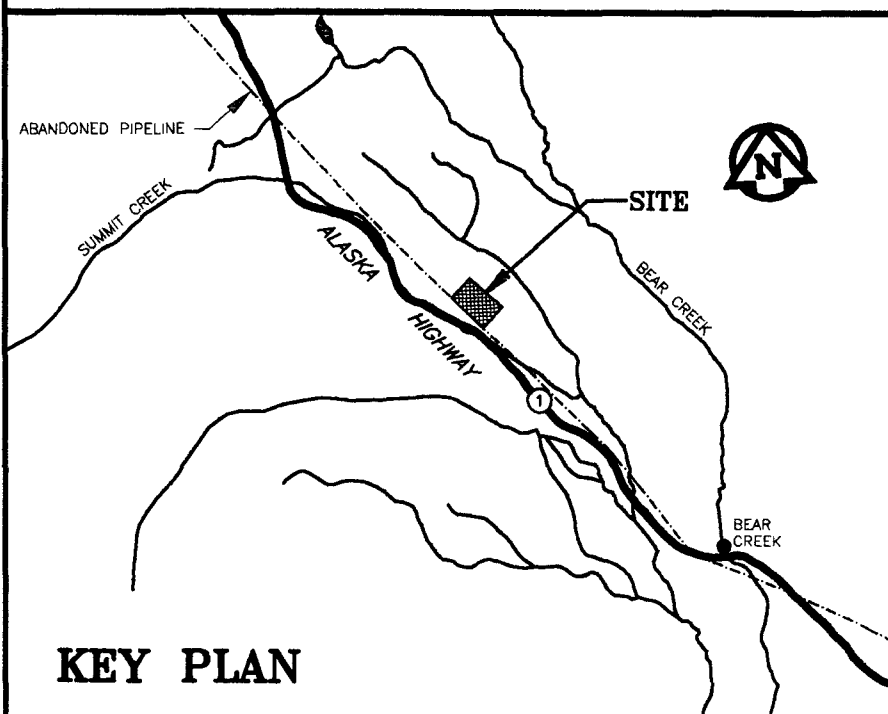
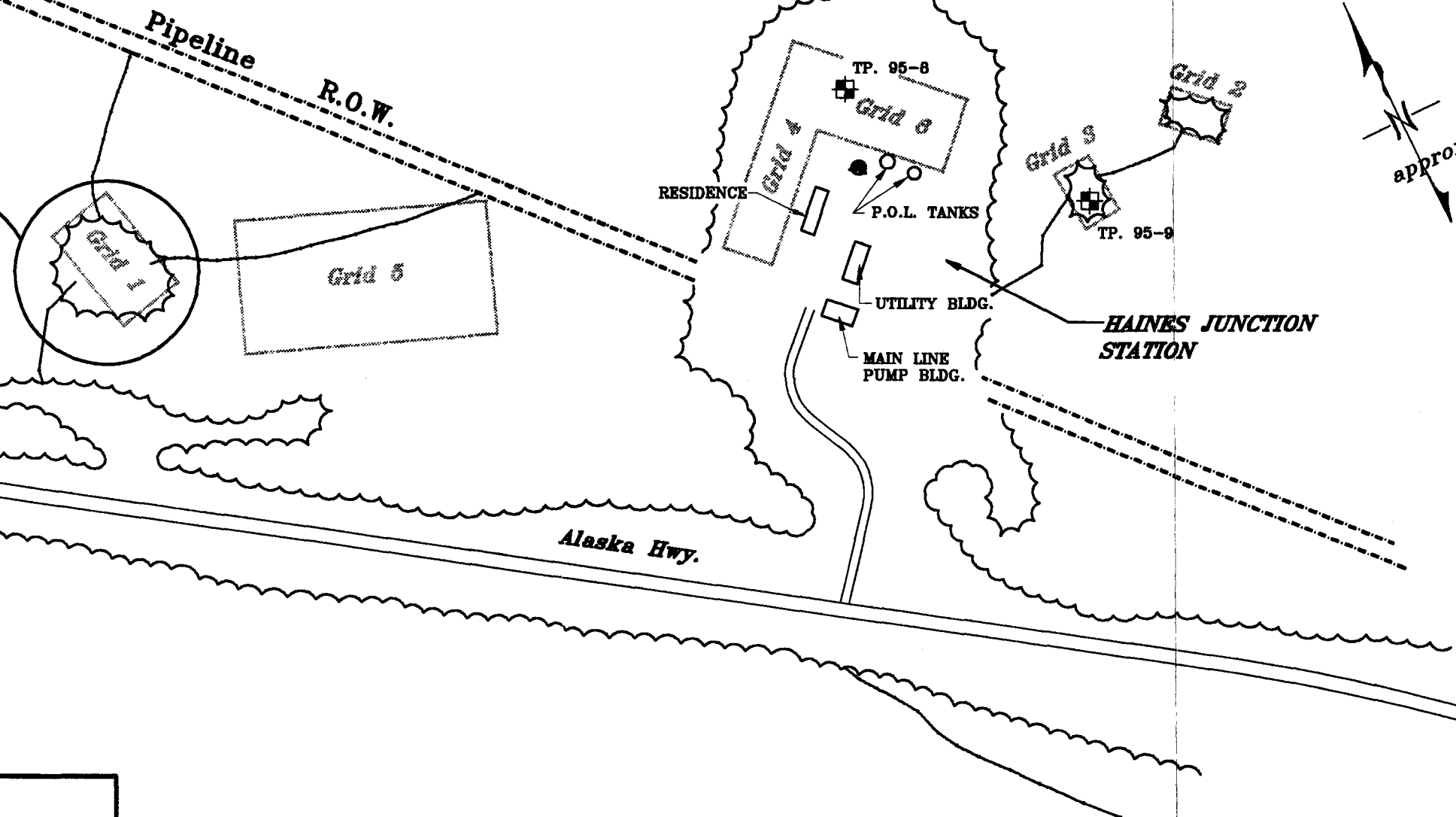
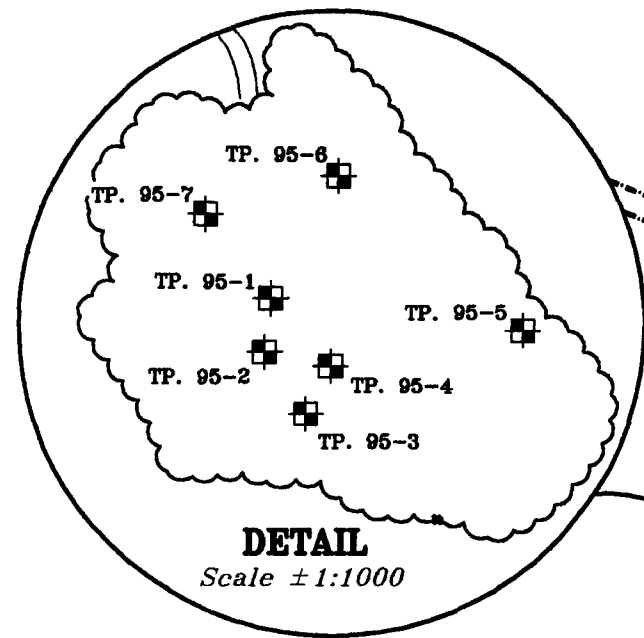
c) Subsurface Soil Conditions

The first investigations at this site were electromagnetic geophysical surveys. Six areas surrounding the former pump station were selected for surveys based either on the available site history or the observations from the initial reconnaissance. Grid 1 is the former landfill area and the area of greatest interest. Grids 2 and 3 are small clearings south and east of the station that were suspected dump sites. Grid 4 is a clearing north of the station bounded by two fence lines. Grid 6 appears to be a former loading area. Grid 5 is a large clearing north of the station that was believed to be only a potential borrow source cleared by the Highway's Department. The locations of the survey grids are shown on the station site plan (Figure 3) and in more detail in the appended geophysical report (Appendix F). All grids were surveyed with both the EM 31 and the EM 61 with the exception of grid 5 which was surveyed with only the EM 31. The EM 31 identifies changes in the apparent conductivity of the ground within about 6 metres of the surface. The presence of buried metal objects or changes in conductivity produced by the presence of contaminants or lateral changes in conductivity that might represent a contact such as the limit of a landfill are the responses looked for in the survey data. The EM 61 is an instrument designed specifically to respond to the presence of buried metal. The complete report on the geophysical survey including the interpretation can be found in Appendix F. A brief summary of the results is presented in this section.

Grid 1 was the area of greatest interest at Junction Station. There were several anomalous conductivity responses from the EM 31 and metal anomalies from the EM 61. Generally, metal anomalies occurred within the broad zone of ground conductivity anomalies in the central and west central portion of the landfill. There were also several smaller discrete anomalies from the EM 61 and the EM 31 scattered across the site that were suspected metallic objects of varying size and shape. Grids 2 and 3 are small clearings south and east of the station suspected to be former dump sites. The survey showed that the areas may contain a number of buried metal objects. Grid 4 was immediately north of the former station. The area bounded by two fence lines appeared to have been reworked. Only one anomaly was identified in this area interpreted as a shallow buried metallic object. Grid 6 was surveyed over an area east of the station that appeared to be a former loading/unloading area. One broad conductivity anomaly was identified and interpreted as either conductive fill or scattered metal. Grid 5 was surveyed over the large clearing north of the station. This area was suspected to be a clearing by Highway's during a borrow source investigation. No anomalies were identified in this area. The survey data were interpreted in the evening so that test pit locations could be selected for the next day's work.

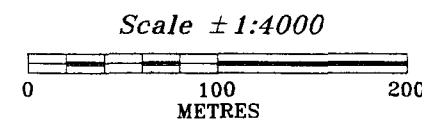
A rubber tired back-hoe was mobilized to the site the next day. The focus of the test pitting investigation was the former landfill site (grid 1). Seven test pits were excavated in this area. Locations were selected to correspond with the geophysical anomalies. Various metal debris including drums, tires and batteries were uncovered. The drums were recovered to surface for later disposal by DIAND. Organic vapour readings were taken on several soil samples but were generally low with the exception of one reading of 42 from a sample in test pit 95-1. Typical depth of waste was 2 m. The soil underlying the waste was a silty clay with a small gravel fraction. Soils were damp to moist with no evidence of seepage. The maximum depth of test pitting was 2.5 m. Soil samples were collected for organic and inorganic lab analysis and one barrel sample was collected. One test pit was excavated in the area of the former loading ramp (grid 6). The test pit encountered clay with sand and gravel to the depth of 1.8 m. There was no sign of debris and no seepage into the test pit. Samples were collected for lab analysis. One test pit was also excavated in one of the clearings south of the station (grid 3). This shallow test pit identified a shallow clay fill overlying a sandy silt. A car or truck hood was found at 150 mm. One soil sample was collected.

Locations of test pits and sample references are indicated on Figure 3. The fine grained soils that underlie the site and the dry conditions at the base of the test pits limits the potential for contaminant migration from the dump sites.



SITE CODE PREFIX JU1	
LOCATION	SAMPLE
TP 95-1	SS001-SS002; SS004-SS005; SS013-SS014
TP 95-2	SS003
TP 95-3	SS006-SS008
TP 95-4	SS009-SS012
TP 95-8	SS016-SS019
TP 95-9	SS020

NOTE: LOCATIONS OF EXISTING FEATURES ARE APPROXIMATE



LEGEND

- ⊕ - TEST PITS
- ▭ - EXISTING BUILDINGS
- - TRAILS
- ~~~~ - TREELINE
- - GEOPHYSICAL SURVEY GRID

uma

UMA Engineering Ltd.
Engineers, Planners and Surveyors

in association with



AMBIO
Research
Associates
Inc.

HAINES JUNCTION STATION

TITLE: LOCATION PLAN	
JOB No. 4440 033 00 02	DATE: AUGUST 1995
DRAWN: RN	FIGURE 3
CHECKED: TRW	

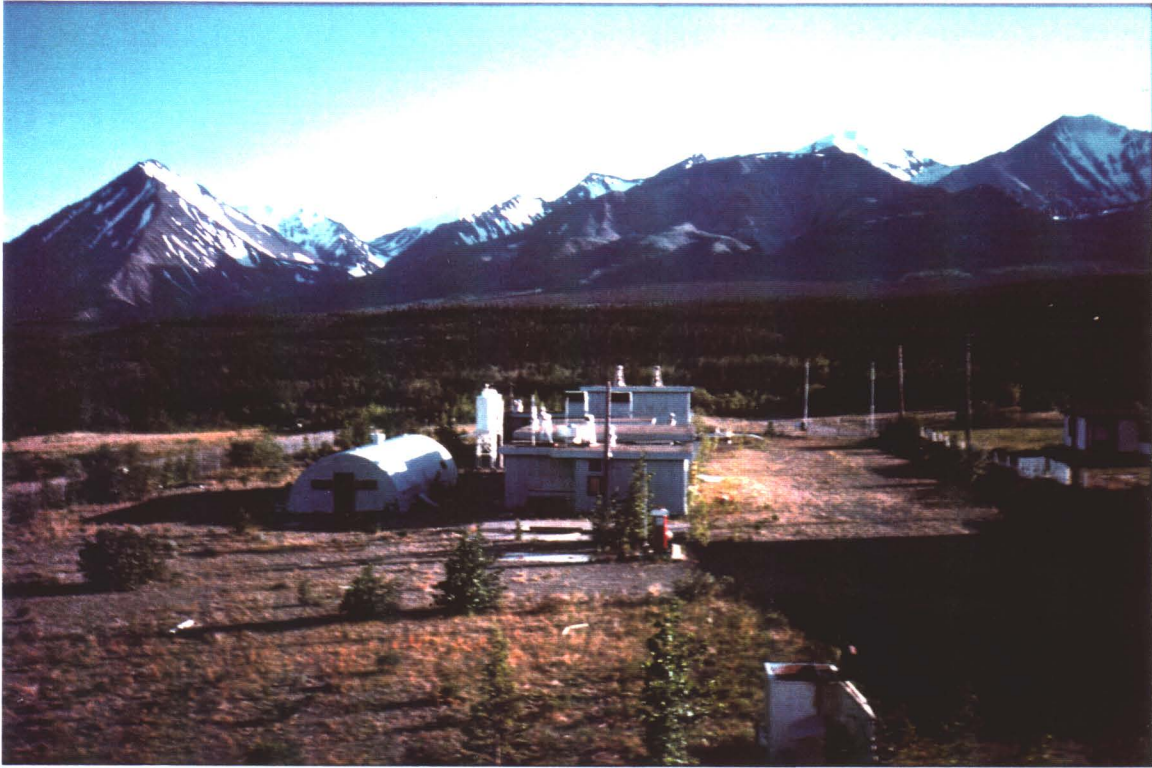


Photo 3.2.1: Haines Junction Pump Station showing existing facilities.



Photo 3.2.2: Re-establishment of vegetation including trees, shrubs (willow) and grasses in larger, suspected dumpsite area west of Junction Station site. Excavation of test pit.



Photo 3.2.3: Haines Junction Pump Station - looking west from the POL tank

d) **Groundwater Conditions**

Studies of groundwater at the site were not included in the scope of work. There is a well present at this site, but no information could be obtained with respect to the depth to the water table. The nearest surface drainage is approximately 1 km away.

e) **Contaminant Considerations**

Soil samples collected from test pit profiles in the landfill (i.e., TP 95-1, 3 and 4), where significant amounts of debris were excavated and by the gravel ramp at the northeast end of the station (TP 95-8) were analyzed for various potential contaminants including inorganic elements, total extractable hydrocarbons (TEHs), volatile organic compounds (BTEX), organochlorine pesticides (OCs), phenoxyacid herbicides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These results are tabulated in Appendix G. The relative locations of these samples are indicated on Figure 3.

Samples from TP 95-4 (JULSS010/011) collected in soil surrounding some excavated barrels were analyzed for a number of analytes associated with petroleum products, including inorganic elements, TEHs, PAHs, PCBs, OCs and phenoxyacid herbicides. Concentrations of most inorganic elements were comparable to, or slightly higher than the CCME Assessment Criteria; none of these levels exceeded the CCME R/P Remediation Criteria. The concentration for TEH for this soil sample, however, was 13,000 $\mu\text{g/g}$ which is considerably higher than US Federal/State Guidelines adopted by Alaska (200 $\mu\text{g/g}$). A number of analytes from the PAH suite were detected. Concentrations for reliable values ranged from 1.5 ng/g for acenaphthene to 35 ng/g for phenanthrene; these PAH values were still below the CCME Assessment Criteria available for individual analytes (0.1 $\mu\text{g/g}$ or 100 ng/g). Concentrations of BTEX analytes ranged from 1.3 to 9.6 ng/g for individual compounds which were all well below CCME Assessment Criteria for soils. Levels of OCs, phenoxyacid herbicides and individual PCB Aroclors were all below the detection limits. Analytical results for the one oil sample collected indicate that chlorinated pesticides and PCBs were below the detection limit. Ethylbenzene and xylenes were detected at concentrations of 170-780 ng/g. These BTEX components are normal constituents of hydrocarbon based oils.

Soil samples from profiles at the base of TP 95-1 (JUSSF002/005), TP 95-3 (JULSS007) in the landfill, and from various depths at TP 95-8 (JULSS016/017/018) were analyzed for inorganic elements. Concentrations of most substances were comparable to or slightly higher than the CCME Assessment Criteria, only one sample from the base of TP 95-1 (JULSS002) contained concentrations of copper (97 $\mu\text{g/g}$) and tin (46 $\mu\text{g/g}$) which were comparable to the CCME R/P Soil Remediation Criterion. The zinc concentration (259 $\mu\text{g/g}$) in this sample was also significantly higher than the CCME Assessment Criterion, but was lower than the R/P Soil Remediation Criteria. One sample obtained from the base of TP 95-1 (JULSS014 at a 3 m depth in clay) was also analyzed for BTEX; all concentrations for these analytes were below detection.

3.3 Million Dollar Falls

a) Site Description

Million Dollar Falls is located at milepost 103 (formerly milepost 99 along the old Haines Road prior to highway improvement) above the Takhanne River. This site was a communications relay station in the early 1940s. It was also used as a highway construction camp in 1943 for the Haines Road and later as a pipeline construction camp from 1954 to 1955. The name "Million Dollar Falls" is purportedly derived from the value of US military equipment and buildings that was buried on site. The site is presently used as a recreational area and campsite (Figure 4). The falls themselves are located to the northwest of the site (Photo 3.3.1)

The original construction camp was quite large and consisted of a number of barracks, mess halls, garage/gas station facilities, and radio station buildings. In addition to the burial of equipment mentioned above, it is reported that a large amount of dumping occurred in the ravine on the west side of the site during the 1943-44 abandonment of the camp (Figure 4). All that remains from the original buildings are cement pads presently found among the sites at the Million Dollar Falls campground. A large day-use shelter and a groundwater supply well situated near the centre of the site are also located at the campground.

Surface soils at the campsite consist principally of sand and gravel; organic clay in the ravine to the west; and fine sandy silt sediments in nearby creek beds.

Vegetation in the ravine surrounding the site consisted of late successional forest dominated by white spruce (*Picea* sp.) and the occasional balsam poplar (*Populus* sp.). Understory plants consisted of willow (*Salix* sp.), a few forbs [e.g., willow-herb (*Epilobium* sp.)], grasses, and horsetail (*Equisetum* sp.) in wetter areas.

b) Site Condition

The campsite area, where the original construction site was located, had no visible evidence of debris or surface staining aside from the remaining cement pads. Much of the original vegetation at the camp was undoubtedly destroyed during previous operations. Outside of the campsite areas vegetation is beginning to re-establish in less travelled areas as indicated by the small groupings (or woodlots) of balsam poplar and willow. Other early successional plants also abound, such as willow-herb and grasses.

There were two dump areas at the base of the ravine cliff on the west side of the site, along the edge of the surrounding forest. The largest of these, roughly 30 m by 20 m, consisted of wood scraps (some burned), metal straps and cans, rubber, barrels and car parts (Photo 3.3.2). A second smaller dump is situated further to the south near the Takhanne River and contained mostly domestic refuse such as cans. Both areas drain into a small creek approximately 3 m away, which subsequently flows north for 50 m to intersect with the Takhanne River just below the falls. The remains of a small homemade salmon hatchery constructed from coolers and piping were also found along this creek, 114 m upstream (south) of the larger dump (Photo 3.3.3). A few barrels were also strewn

in the forest along the creek; one barrel was found partially buried in the creek bed, 16 m upstream (south) of its confluence with the Takhanne River (Photo 3.3.4).

c) **Subsurface Soil Conditions**

The sand-clay soils at the base of the ravine dump on the west side of the site contained charred pieces of wood; no unusual odours such as hydrocarbons, however, were detected. Surface sediments in the creek near the toe of the dump appeared to be clean and also free of any unusual discolouration or odour. A field soil vapour probe survey was conducted of soils at the surface and depth (65 cm) at the toe of the dump and in sediments of the nearby creek. No volatile organic compounds (VOCs) were detected at any of these locations.

d) **Groundwater Conditions**

Mini-piezometers were set in the soft sediments adjacent to the stream as part of the investigations in the creek valley at the toe of the debris pile. The objective was to collect porewater samples at the base of the debris pile to see if leaching from the waste was impacting the groundwater. It was possible to drive the piezometers to a depth of 1.5 m; however the soils were too fine-grained to allow the collection by suctioning of a water sample. Groundwater impacts were inferred from the surface water chemistry. Any groundwater impacted by the waste pile will discharge into the creek as this is a local flow system and the severe topography creates strong upward gradients.

e) **Contaminant Considerations**

Selected soil and water samples from the campsite well and three stations along the creek of an old river bed to the west of the site were analyzed for various contaminants. The creek stations consisted of the Upper Station, near a homemade fish hatchery; Middle Station, at the base of a dump; and Lower Station, near the Takhanne River. Contaminants analyzed included inorganic elements, total extractable hydrocarbons (TEHs), volatile organic compounds (VOCs), organochlorine pesticides (OCs), phenoxyacid herbicides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These results are tabulated in Appendix G. The relative positions of these sample locations are indicated in Figure 4.

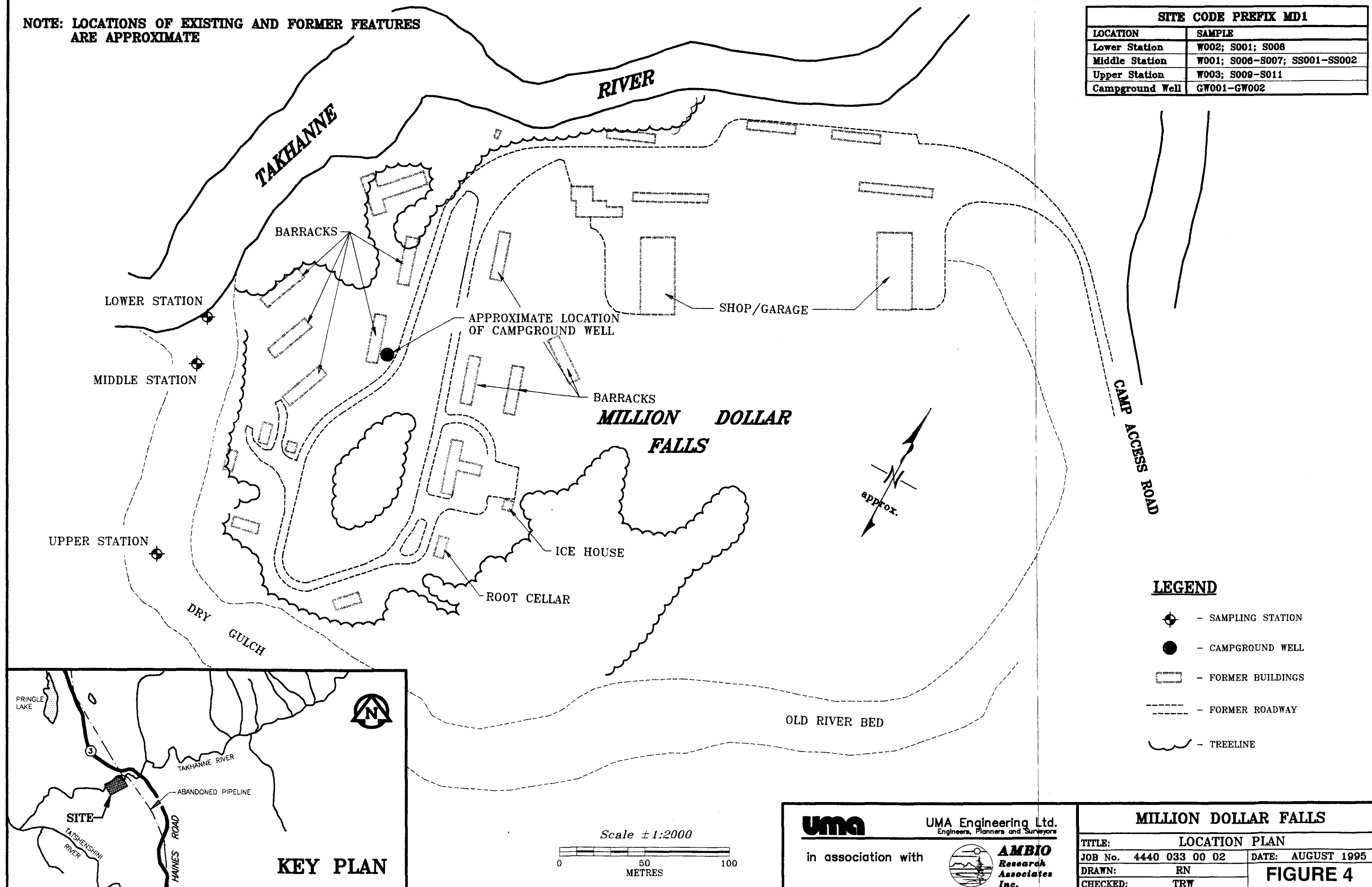
Inorganic elements were analyzed in sediment/soil samples from the Upper (MD1S010), Middle (MD1S004/5) and Lower Stations (MD1S008). Concentrations of most inorganic substances were comparable to or slightly higher than the CCME Assessment Criteria, and well below the CCME R/P Soil Remediation Criteria. The only exception were concentrations of zinc at MD1S004 (269 µg/g) and MD1S005 (497 µg/g) along the toe of the dump which exceeded the CCME Assessment Criteria; the larger value of these was also comparable to the R/P Soil Remediation Criterion.

Field duplicate soil samples at toe of landfill at the Middle Station (MD1S006/007 and MD1S004/005) were analyzed for phenoxyacid herbicides, VOCs (excluding BTEX), TEHs and OCs. Concentrations of most of these analytes were below detection with exception of TEHs which ranged from <20 to 180 µg/g between the field duplicates. These values were below US Federal/State Guidelines adopted by Alaska (200 µg/g). Concentrations of most OCs analyzed in field duplicate samples MD1S006/007 were below detection with the exception of DDT and its derivative compounds (50 and 62 ng/g, respectively). The total concentrations of these compounds however were below the BC MOE Level B Criterion. Low levels of PCB Aroclor 1254 were also detected in these samples (1.7 to 2.0 ng/g) which were well below the CCME Assessment Criterion.

Water samples from the campsite well (MD1GW001/2) and surface water sampled at the Middle Station (MD1W001) were tested for PCBs, OCs, TEHs and inorganic elements. Concentrations of most analytes, including OCs and TEHs were below detection in both sample locations. A number of analytes in the suite of inorganic elements were detectable, but these concentrations were well below CCME Assessment Criteria for water. A low level of PCB Aroclor 1254 (5.6 ng/L) was detected in the water sample duplicates obtained from the campsite well, but this value was well below the CCME Assessment Criteria for water (0.1 µg/L or 100 ng/L).

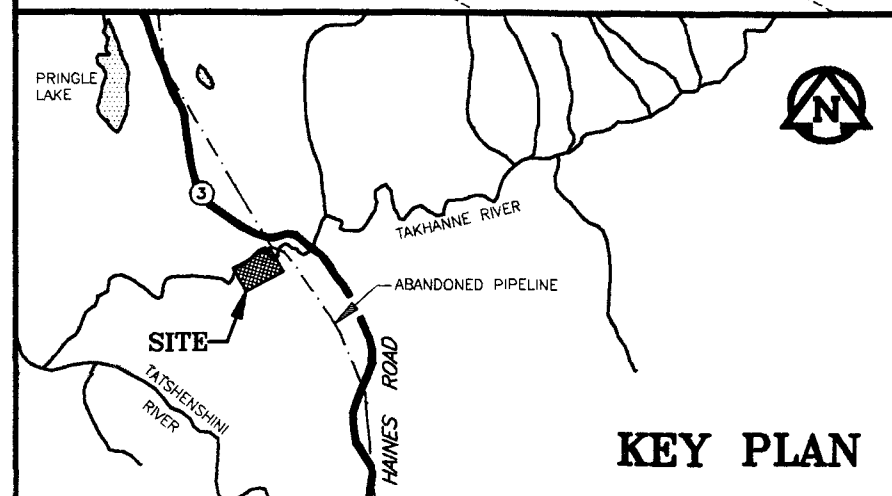
NOTE: LOCATIONS OF EXISTING AND FORMER FEATURES ARE APPROXIMATE

SITE CODE PREFIX MD1	
LOCATION	SAMPLE
Lower Station	W002; S001; S008
Middle Station	W001; S006-S007; SS001-SS002
Upper Station	W003; S009-S011
Campground Well	GW001-GW002



LEGEND

- SAMPLING STATION
- CAMPGROUND WELL
- FORMER BUILDINGS
- FORMER ROADWAY
- TREELINE



KEY PLAN

Scale $\pm 1:2000$



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MILLION DOLLAR FALLS

TITLE: LOCATION PLAN	
JOB No. 4440 033 00 02	DATE: AUGUST 1995
DRAWN: RN	FIGURE 4
CHECKED: TRW	

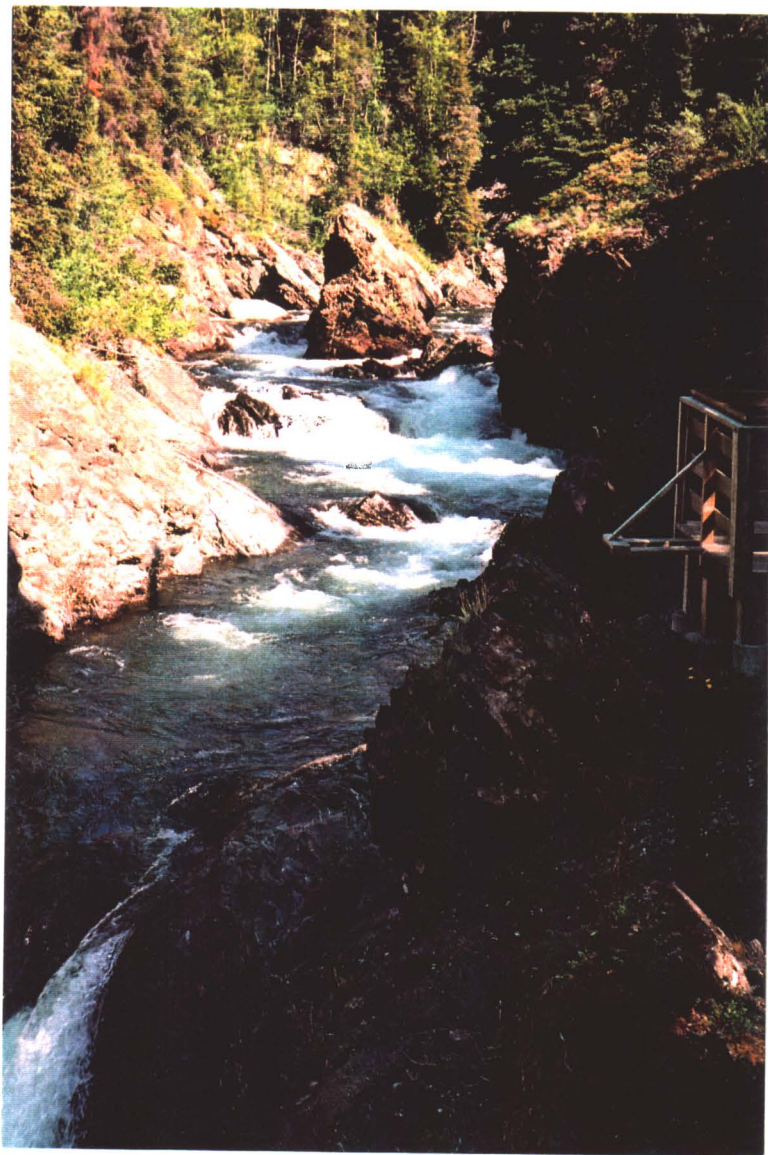


Photo 3.3.1: Million Dollar Falls as viewed from the campsite access.



Photo 3.3.2: Dump along ravine at west side of Million Dollar Falls site.



Photo 3.3.3: Small salmon hatchery in creek along ravine west of site.



Photo 3.3.4: Partially buried barrel in creek bed upstream from the Takhanne River.

3.4 Blanchard River Pump Station

a) Site Description

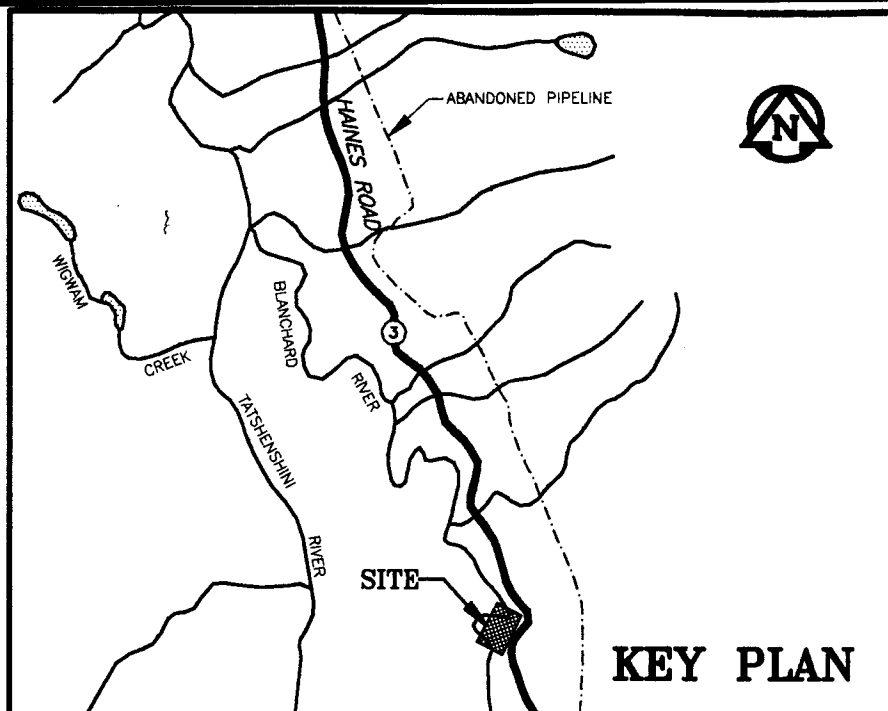
This former pump station site is located at Mile 87 of the pipeline (highway milepost 95.8), situated above its namesake at an elevation of 829 m asl; the site is situated in the Yukon near the British Columbia border (60° 31' N., 136° 28' W.). The original station, occupying an area of 5 ha, was constructed in 1962 along with five other stations in the Yukon and Alaska in response to the need for increased pipeline throughput. The Blanchard River ravine flanks the site on the north, west and south sides. The site itself is situated on a foothill terrace or bench. A number of springs are also found in ravine slope at the north end of the site. The site is presently owned by the Yukon Territorial Government (YTG) Highways Department.

Blanchard River Station originally consisted of one main multi-purpose building which housed the engine room, pumps, generators, maintenance shop and water supply; and six accommodation trailers used as family housing. Two POL storage tanks were also located at the south end of the site (Figure 5).

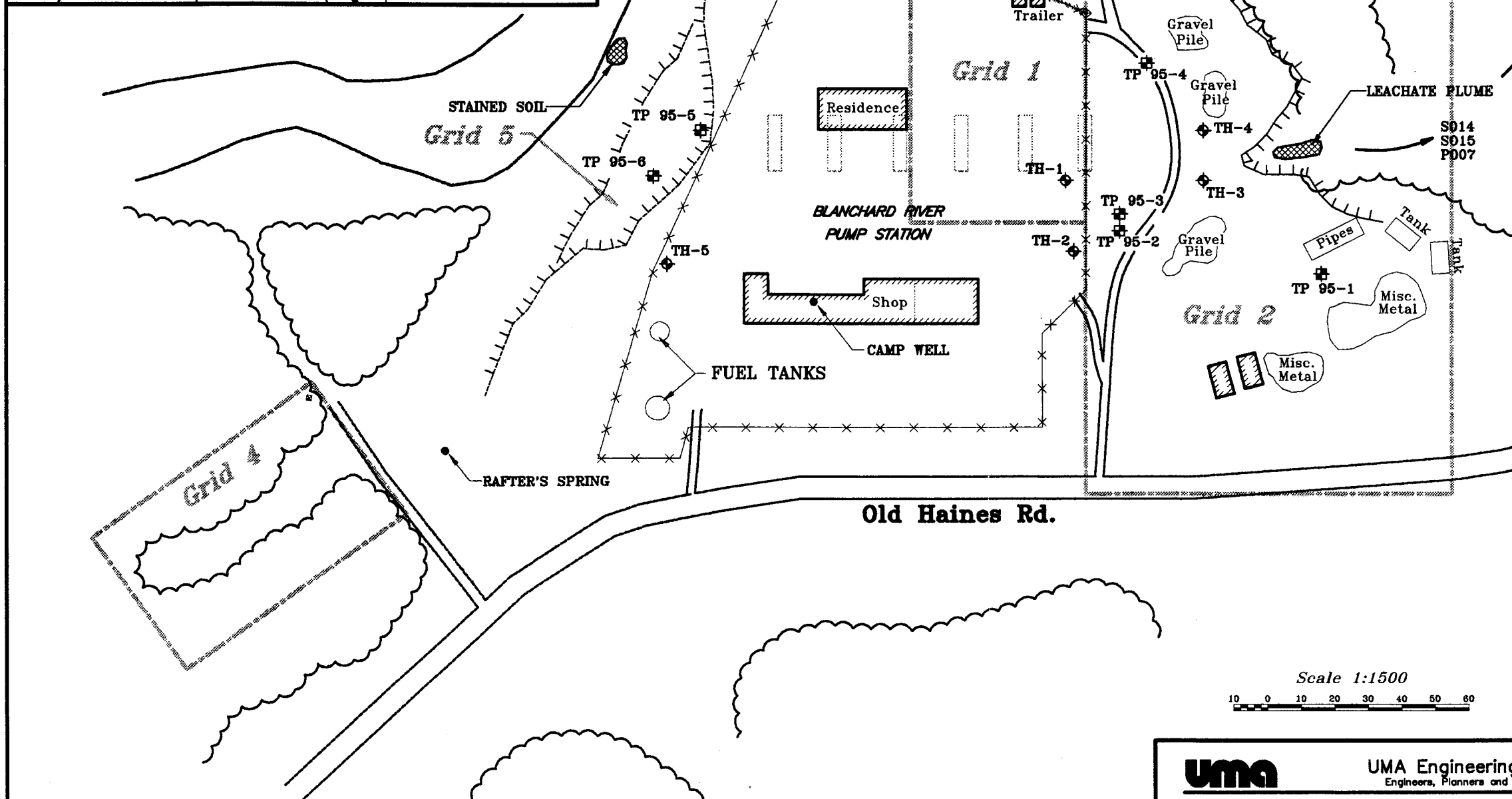
Portions of the original pump station were either modified or removed when the site was taken over by Yukon Highways in the mid 1980's. The trailers were removed in 1986 along with one of the two POL storage tanks, and the multi-purpose building was extended at the north end and converted to the Highways Maintenance Garage (see Figure 5). An accommodation building was also constructed on the original site of the trailers to house the highway workers; these areas have been entirely fenced in (Photo 3.4.1). Demolition debris was buried to the north of the site and old transformers were apparently buried to the west of the existing buildings. Photo 3.4.3 shows the overall site.

Additional private and public facilities also exist just outside the current boundaries of the maintenance camp. A series of old worked areas to the south of the station border fence are presently occupied by a whitewater rafting company. These areas serve as storage and camping space for the company's operations. A spring-fed pipe in this area also provides a water supply for the camp. An old service road curves from the west end of the site in a northern direction to the river shore and an old log cabin below. From this point, the road follows the river bank to the north side of the site. Camping areas and an outhouse have been set up for anglers at the end of this road.

Surface soils at the station are variable and consist of mixtures of silt, sand and gravel (mainly fill) in disturbed and worked areas at the station. Organic-sandy soils occur in wooded regions, and sand with varying amounts of silt occurs along drainage and waterways. Based on test pits, soils in the station area consist of sands and gravels underlain by clay at a depth of 4 to 9 m. Permafrost was not detected in the test pits.



SITE CODE PREFIX BL1	
LOCATION	SAMPLE
TP 95-1	SS001-SS004
TP 95-3	SS005-SS010
TP 95-4	SS011
TP 95-5	SS013
TP 95-6	SS014
TH-1	GW005; SS015-SS025
TH-2	GW006; SS026-SS032
TH-3	GW007; SS033-SS035
TH-4	GW008; SS036
TH-5	GW009-GW010; SS037-SS045; P001-P006
Leachate Plume	GW004; S001; S007-S013; W001
Stained Soil	GW003; S002-S008
Camp Well	GW001
Rafter's Spring	GW002



LEGEND

- TH-5 - LOCATION OF TESTHOLES/MONITORING WELLS
- TP 95-3 - LOCATION OF TEST PITS
- FORMER BUILDINGS
- FENCELINE
- TREELINE
- EXISTING BUILDING/STRUCTURE
- LOCATION OF VISIBLE STAINING AND/OR LEACHATE AT GROUND SURFACE
- GEOPHYSICAL SURVEY GRID

NOTE: LOCATIONS OF EXISTING FEATURES ARE APPROXIMATE

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BLANCHARD RIVER PUMP STATION

TITLE: LOCATION PLAN

JOB No. 4440 034 00 02

DATE: AUGUST 1995

DRAWN: RN

CHECKED: TRW

FIGURE 5



Photo 3.4.1: View of the present maintenance camp from the north showing the fence perimeter and workers' accommodation building.



Photo 3.4.2: Rusty leachate from a spring near the top of a slope at the north end of the site.

Vegetation in the region, outside of disturbed areas is primarily late successional to mature spruce (*Picea* sp.) forest with the occasional balsam poplar (*Populus* sp.), and understory plants such as willow (*Salix* sp.) and horsetail (*Equisetum* sp.). Natural river bank areas are dominated by willow, balsam poplar, horsetail, and grasses [eg. squirrel-tail grass (*Hordeum* sp.)]. Forbs such as willow-herb (*Epilobium* sp.) are common. The only wildlife observed at the time of the visit were a pair of least chipmunks (*Eutamias minimus*) living under a pallet, west of the maintenance garage. A grizzly bear is also reported to frequent the region, and the waters are well-known for salmon sport fishing.

b) **Site Condition**

The main operations site is relatively clean with no evidence of spillage or debris; the only exceptions are gravel piles and highway equipment stored by the highway maintenance camp at the north and south ends of the site. As mentioned above, a number of worked areas have been noted around the site which may be suspected areas of buried debris. Vegetation in the vicinity of the station was removed during the original station construction and is extremely sparse at present due to the physical disturbance by continued station activities. Plants here consist mostly of grasses [e.g., bluegrass (*Poa* sp.), squirrel-tail grass, brome-grass (*Bromus* sp.)]; and forbs such as dandelion (*Taraxacum* sp.), milk-vetch (*Astragalus* sp.), aster (*Aster* sp.), maguire (*Arnica* sp.), cinquefoil (*Potentilla* sp.), willow-herb (*Epilobium* sp.) and sedge (*Carex* sp.). Understory shrubs (e.g., willow) and young trees of balsam poplar are beginning to establish in less-travelled locations around the site.

Rust-coloured leachate has also been observed in a spring emanating from the ground near the top of the slope at the north end of the site; an oily sheen was also noted on the water surface (Photo 3.4.2). This discolouration suggested the presence of buried materials somewhere in the north portion of the site. This stream is one of a few along this slope which follows a drainage pathway through a low wooded area dominated by willow and horsetail to a wet marshy area along the shore of the Blanchard River, 100 m to the north.

c) **Subsurface Soil Conditions**

Electromagnetic geophysical surveys, back-hoe test pitting and drilling were employed to evaluate sub-surface conditions at Blanchard. Five geophysical grids were surveyed. Their locations are shown on Figure 5. Grid 1 was north of the residence and inside the fence line. Grid 2 was outside the fenced area on the north side of the station and encompassed the former waste site. Grid 3 was west of the residence and outside the fence line in a suspected waste disposal area. Grid 4 was south of the station in a suspected dump site. Grid 5 represents an informal survey near a hydrocarbon contaminated area on the west side of the station. EM 31 surveys were completed in all grid areas. EM 61 surveys were completed only in areas 1 and 2.

Surveys in grid 1 identified several large anomalies interpreted as buried metal objects of varying size, shape and depth of burial. There were also several smaller discrete anomalies believed to be produced by metal objects at shallow depth. Three linear anomalies were also

identified, which may be associated with buried pipe features. Grid 3 had no distinguishing anomalies. The results from Grid 2 included strong lineal anomalies, several areas of buried metal and a zone of elevated conductivities in the vicinity of the gravel stockpile. This zone is believed to be partly the result of the high salt content in the pile but may also be associated with other metal and lineal pipe anomalies. The surveys over grid 4 are near the rafting staging area. Several metal anomalies were identified on the edge of the grid area along with one zone of elevated conductivity. Surveys at grid 5 were aimed at trying to identify any geophysical correlation with identified hydrocarbon contamination in the soils in this area. Conductivity contrasts were very small and there were cultural (fences, buildings, etc.) interference effects that made any interpretation impossible. The results from the geophysics were used to target test pit and test hole locations. The complete report and illustrations for this work are included in Appendix F.

During the initial site reconnaissance, it was decided to include test pitting in the investigation program in advance of the test drilling. A total of six test pits were excavated. Test pits 95-1 to 95-3 were excavated in geophysical grid 2 to investigate the metal anomalies. Test pits 95-1 and 95-2 were dug in the northeast area of grid 2. The observation at these pits gave no indication of significant debris or contamination. Test pit 95-3 was dug on the south side of the camp access road. Debris including pipe components and concrete blocks were encountered in test pit 95-3, to a depth of 2.7 m. A gravelly sand was encountered at this depth, as was the water table. The groundwater had a very strong hydrocarbon odour. Samples were collected for VOC screening and lab analysis. The maximum HNu reading was 220 ppm. Test pit 95-4 was excavated in grid 4 near the rafters camp site. This test pit was only advanced to 1.2 m. Barrels, cable and various steel pieces were buried in a gravel fill. Soil samples from below one of the drums were collected. The last two test pits were excavated on a gravel terrace above the stained soil area on the edge of the river. Strong hydrocarbon odours were noticed in the sand and gravel at 2.5 to 3 m depth, roughly coincident with the elevation of the stained area near the water's edge. HNu readings of 88 and 190 were observed in field screening samples. Lab samples were also collected for organic and inorganic analysis.

Five test holes were drilled at Blanchard. Four of these holes were drilled in the area north of the station to investigate the geophysical anomalies and the hydrocarbon odours in test pit 95-3. A casing hammer was used to advance a continuous casing string down the hole. A drill bit advances with the casing and air is used to return cuttings to the surface. Cuttings are directed to a cyclone and are then collected in pails with a sample liner for identification and sampling. This system provides a more or less continuous sample of the entire soil profile. Test holes 1 and 2 were drilled inside the fence line.

The soil profile consisted of sand fill over sand, silt and gravel to a depth of 3.5 to 4.5 m. Clay and silt underlay the granular soils. At about 2 m. there was a strong hydrocarbon odour that continued below the water table. Maximum VOC readings were recorded at about 2.5 m below surface. Saturated conditions were encountered at 2.5 to 3 m. Soil samples were recovered for organic and inorganic analysis and

piezometers were installed to the base of the granular section in each of the holes. Test holes 3 and 4 were drilled outside the fence line on either side of the drainage course with the leachate plume. The stratigraphy was similar to holes 1 and 2 however there was no hydrocarbon odour to the soils. Test hole 3 was drilled to 9 m to verify that the clay layer was reasonably thick. Five metres of clay was identified in this hole. Field vapour readings were zero. A monitoring well was set in each of holes 3 and 4.

Test hole 5 was drilled on the west side of the station to further investigate the hydrocarbons identified at the water's edge and beneath the terrace above the river. The soil profile was sand with gravel to a depth of almost 10 m. Two metres of clay were drilled below the sand before terminating the test hole. Strong hydrocarbon odours were observed at about 7.5 m, just above the water table. This depth roughly corresponds with the elevation of the lower stained soil near the river. VOC readings of 100 were recorded from soil samples below the water table. Samples were selected for lab analysis and a piezometer was set to 9 m.

d) Groundwater Conditions

Figure 6 illustrates the typical construction of the monitoring wells. Specific details are shown on the individual well logs (appended). Dedicated inertial lift sampling systems (Waterra) were set in each well and water samples were collected for analysis. Level surveys were run to establish the relative difference in water level elevation between the 5 monitoring wells. Gradation analyses for soil samples corresponding to the depth of the well intakes are also appended.

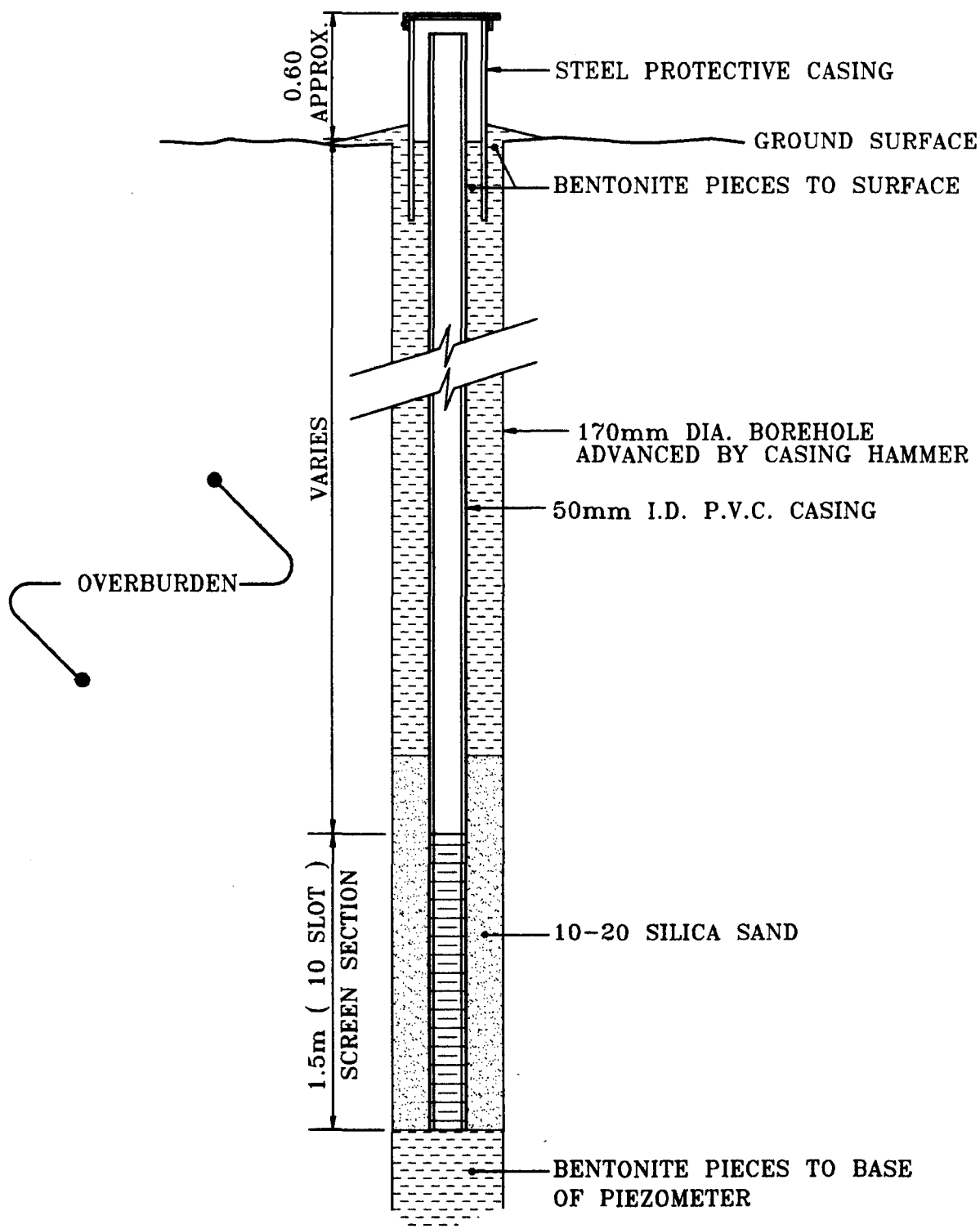
The water level in well 5 is about 3.75 m above the level of the Blanchard River. Groundwater flow in this area is likely to the west with discharge to the Blanchard River. The water levels recorded in the four wells on the north side of the site are all very similar. The water table is quite flat in this area with a slight slope towards the north and east in the direction of the surface drainage features. The groundwater flow system in the upper few metres of the sand overlying the clay, is a shallow flow system perched on the low permeability clay soils.

e) Contaminant Considerations

Selected soil and water samples from test pits (TP 95-1 and 95-3), test holes (TH-1, TH-2, TH-4 and TH-5), and stained locations at the west and north edges of the station were analyzed for various contaminants. These included total extractable hydrocarbons (TEHs), volatile organic compounds (VOCs), organochlorine pesticides (OCs), phenoxyacid herbicides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These results are tabulated in Appendix G. The relative positions of these sample locations are indicated in Figure 5.

One water sample (BL1GW004) obtained from the top of a rust-coloured leachate plume along the slope at the north side of the site was analyzed for PAHs, OCs, PCBs, inorganic elements, herbicides and VOCs.

NOTE : VERTICAL DIMENSIONS ARE
SHOWN ON INDIVIDUAL WELL LOGS



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DIAND
HAINES-FAIRBANKS PIPELINE ESA

TITLE: TYPICAL MONITORING WELL DETAIL

JOB No. 4440-034-00-02

DATE: AUG. 1995

DRAWN: RN

CHECKED: TRW

FIGURE 6

The majority of PAH analytes had concentrations below the detection limits with the exception of five compounds with levels ranging from 1.1 ng/L for benzo(ghi)perylene to 290 ng/L for naphthalene. This maximum value for naphthalene was slightly higher than its corresponding CCME Assessment Criterion for water (0.2 µg/L or 200 ng/L), but well below the BC MOE Criteria for aquatic life. Concentrations of all inorganic elements in this groundwater sample were well below the CCME Assessment Criteria for water and levels of all OC and herbicide analytes were below detection. A trace level of PCBs as Aroclor 1254 was detected in this sample (7.7 ng/L); this value, however, was well below CCME Assessment Criterion for water (0.1 µg/L or 100 ng/L). Most of the BTEX analytes were also detected in this sample including benzene (0.45 µg/L), ethylbenzene (1.7 µg/L) and xylenes (total: 1.15 µg/L). Concentrations of both ethylbenzene and xylenes exceeded the CCME Assessment Criteria for water, but were still well below available CCME and BC MOE remediation criteria.

A surface water sample (BL1W001) obtained from a small horsetail (*Equisetum* sp.) dominated marsh (by the Blanchard River) which received drainage from the leachate plume was also analyzed for TEHs, inorganic elements and VOCs. The TEH concentration was found to be below detection (< 100 µg/L), and all inorganic analytes were well below the CCME Assessment Criteria for water. Only xylenes were detected out of the suite of VOCs (including BTEX) analyzed for; their total concentration (0.05 µg/L), however, was well below the CCME Assessment Criteria for water.

Surface soil samples from this same leachate plume were also analyzed for TEHs, VOCs (excluding BTEX), and inorganic elements. One sample (BL1S012) from near the top of the plume contained a TEH concentration of 6800 µg/g, which was considerably higher than found for a background sample BL1S014 (< 20 µg/g) collected in the foothills east of the site. The leachate plume soil value also exceeded the US Federal/State Guidelines adopted by Alaska (200 µg/g). Concentrations for most VOCs (excluding BTEX) in this soil sample were below detection with the exception of 1,1,2,2-Tetrachloroethane which was detected at 12 ng/g; this value, however, may not be reliable due to analytical interferences associated with the result. Analytical considerations notwithstanding, this result is well below the CCME Assessment Criteria of 100 ng/g. Two samples from the rusted leachate plume located at the top (BL1S013) and at mid-slope (BL1S010) were also analyzed for inorganic elements. A number of analytes exceeded the CCME R/P Remediation Criteria at these locations including arsenic (138 and 85 µg/g), barium (2360 and 4770), cobalt (55 and 90 µg/g), selenium (3.1 µg/g at the top of the plume), and zinc (1490 µg/g and 3570 µg/g); all other analytes were comparable to, or slightly lower than the CCME Assessment Criteria for soils.

A groundwater sample (BL1GW003) taken by mini-piezometer from a stained soil area along the west side of the site by the river was analyzed for TEHs, inorganic elements, OCs, herbicides, VOCs (including BTEX) and PCBs. The TEH concentration in this sample was 4700 µg/g which exceeded the guidelines adopted by Alaska. Concentrations for all inorganic analytes were well below the CCME Assessment Criterion for water; all OCs, herbicides with the exception of 2,4,5 TP (0.5 µg/L) which was below the CCME Freshwater and Drinking Water Criteria, and PCB Aroclor levels were below detection limits. Only ethylbenzene (1.9 µg/L) and

xylenes (total: 3.2 µg/L) were detected out of the (BTEX) VOC compounds analyzed for in this sample. Concentrations of both ethylbenzene and toluenes exceeded the CCME Assessment Criteria for water, but were still well below CCME and BC MOE remediation criteria. Concentrations of inorganic elements analyzed in surface soil at this location (BL1S004) were all comparable to, or less than CCME Assessment Criteria for soils.

Other groundwater samples from a number of test holes and water supply locations at the station were also examined for various contaminants including TEHs, inorganic elements, OCs, VOCs, PCBs and pesticides. TEHs were analyzed for in groundwater samples from TH-1 (BL1GW005), TH-4 (BL1GW008) and TH-5 (BL1GW009/10); detectable concentrations were found at TH-5, where the highest level was found (3700 µg/L), and TH-1 (690 µg/L). Water samples from the camp water supply (BL1GW001), spring water supply for the rafting company (BLGW002), TH-1 (BL1GW005), TH-2 (BL1GW006), and TH-5 (BL1GW009/10) were all analyzed for inorganic elements. Concentrations for nearly all analytes were well below the CCME Assessment Criterion for water, with the exception of mercury in groundwater at TH-1, which contained a concentration comparable to the CCME Assessment Criterion for water. The water sample from TH-5 was also analyzed for OCs and herbicides which were found to be at concentrations below detection. An analysis of PCBs in groundwater at TH-2 and TH-5 indicated trace Aroclor 1260 in TH-5 at a concentration close to the detection limits (3.8 ng/L). A field duplicate sample from this same location, however, contained Aroclor 1254 (4.8 ng/L) near the detection limits. This discrepancy brings to question the reliability of the two results; both values, nevertheless were well below CCME Assessment Criterion for water (0.1 µg/L or 100 ng/L). All PCB Aroclor concentrations at TH-2 were below detection (<2 to < 5.4 ng/L for individual Aroclors). Detectable levels of BTEX were found in water samples analyzed from TH-2 (BL1GW006) and field duplicates at TH-5 (BL1GW009/10). Most of these concentrations were below the applicable remediation criteria with the exception of ethylbenzene and benzene. Concentrations of ethylbenzene at all three locations exceeded the CCME Criteria for Drinking Water (< 2.4 µg/L based on aesthetic objectives). The level of benzene at TH-2 (11 µg/L) also exceeded the CCME Drinking Water Criterion (5 µg/L).

Soil samples from profiles in selected test pits and holes were analyzed for TEHs, VOCs and/or inorganic elements. Tests for TEHs in soils from TH-1 (BL1SS024), TH-2 (BL1SS029) and TH-5 (BL1SS043) indicated the highest values to be at TH-1 and 5 with concentrations of 360-370 µg/g. These levels exceeded guidelines adopted by Alaska (200 µg/g); the value for TH-1, by contrast, (43 µg/g) was considerably lower. Concentrations of all VOC analytes (excluding BTEX) were below detection in the soil profile sample obtained from TH-5 (BL1SS005). Inorganic element concentrations in profile samples at TH-5 (BL1S042), TP (95-)1 (BL1SS002/004), TP-3 (BL1SS006/009), and TP-4 (BL1SS012) were comparable to, or less than CCME Assessment Criteria for soils.

3.5 Border Pump Station

a) Site Description

This site was one of the five stations originally constructed in the mid 1950's. The station is located at Mile 47 on the pipeline on the old Haines Cut-Off Highway, at an elevation of 396 m asl just inside the British Columbia border. Border Pump Station is also located approximately 8 km north of the international boundary next to the Klehini River (59° 31' N., 136° 28' W). Following its closure, the 13 ha of land used by the station was reclaimed by the B.C. Land Management Branch in 1977; the facilities were used as a base camp for the Haines Road re-alignment in 1978 and 1979, and for mineral exploration from 1983 to 1987. The station was finally closed in 1987 at which time a cleanup was conducted by B.C. Ministry of Forests.

Border was one of the largest pump stations and is situated on a bench approximately 25 m above the Klehini River. The station consisted of several facilities: a main pumping building divided into an engine room, pump room and control room; an utility room housing the generators, domestic water and heating systems; a warehouse/garage/shop; a cold locker building; and station housing consisting of one ten person dormitory and two (12 and 18 person) apartment buildings (Figure 7; see also Photo 3.5.1). An airstrip and water pumping station were situated along a lower bench (old river bed) approximately 125 m to the south in Rainy Hollow by the shore of the Klehini River. All of the buildings and facilities at the site were subsequently demolished by the Department of Public Works (now Government Services, Canada) under contract in 1992-3, and buried on site.

Top soils at the station consist of well graded sand with varying amounts of gravel and silt; these extend quite deeply into the profile based on soil test pits. Surface soils are comprised of detritus (up to 10 cm) over sandy silt in forested areas to the south towards the Klehini River.

Mature white spruce (*Picea* sp.) forest dominates the region outside of the station and includes understory shrubs such as willow (*Salix* sp.), and a number of forbs. Numerous animal droppings were also observed along old Haines Road leading into the station from the highway and indicate that the area is frequented by bears and large game; char (*Salvelinus* sp.) also occur in the nearby river.

b) Site Condition

The station was relatively free of debris; a number of recently worked areas occurred throughout the site. A few stains were also discovered toward the west end of the site, including a large hydrocarbon stain measuring approximately 20 m², just north of where the accommodation facilities were once located (Photo 3.5.1).

Much of the plant life in the vicinity of the station was removed during the original station construction, as for other sites. Isolated areas with hydrocarbon staining were also observed to be devoid of plants (see Photo 3.5.1). Vegetation is beginning to re-establish, following the site's recent use. Some of the more common colonizing plants in these worked areas include grasses [e.g., wild rye (*Elymus* sp.), timothy

(*Phleum* sp.), brome-grass (*Bromus* sp.)], sedge (*Carex* sp.); forbs such as dandelion (*Taraxacum* sp.), willow-herb (*Epilobium* sp.), lupine (*Lupinus* sp.), cinquefoil (*Potentilla* sp.), clover (*Trifolium* sp.), mountain sorrel (*Oxyria* sp.); and horsetail (*Equisetum* sp.). Young trees (e.g., balsam poplar) and shrubs, such as willow, are also beginning to establish in less travelled areas and along the periphery of the site.

DDT contaminated soils, removed during the excavation of the buried canisters at Rainy Hollow in 1994, were temporarily encapsulated with a liner and placed in a fenced area at Border Station (see Figure 7). This storage facility, located in roughly the centre of the site (see Photo 3.5.1), was still present during this investigation. The storage facility appeared to be in satisfactory condition.

Two open ended drainage pipes (75 and 200 mm, respectively) protrude from under the south side of the old Haines Road, at the top of the slope above Rainy Hollow (Photo 3.5.2). The drainage path, which passed through an open area in the forest canopy, was directly above a monitoring well (WP 3) at Rainy Hollow which was installed by contractors to Environment Canada in 1994.

c) Subsurface Soil Conditions

This site was investigated with a limited geophysical survey and test holes. The former station buildings have been demolished and it was a concern that a blanket geophysical survey would generate numerous anomalies indicative of the former buildings. Instead, it was decided to conduct an EM 31 survey over the west edge of the property to assist with selecting test hole locations. The survey identified numerous metal anomalies and anomalies believed to be associated with former building foundations. Three zones of elevated conductivity are present on the eastern portion of the property that could either be reflecting underlying soil conductivities or be a result of surrounding features. Eleven lineal trends are present scattered across the site. All or some of these may be associated with buried pipes or utilities. In the final analysis, the geophysical data offered little direction to preferred drill sites.

Four test holes were drilled using the same method as described for Blanchard River. Locations were selected along the west side of the site based largely on the former layout of the facilities. Drilling started at the south end of the site. Test hole 6 was drilled to 23 m. Soils were predominantly sand to a depth of 15 m. Below that depth, soils were principally a silt till. The hole was dry and no piezometer was set. Field VOC samples were collected in the upper portion of the test hole along with samples of laboratory organics and inorganics analyses. Field HNu readings were zero. Test hole seven was drilled about 90 m north of test hole 6. The conditions in this hole were remarkably different from the other holes. Soils were primarily sand and gravel with no till layer. The soils had a distinct hydrocarbon odour at and below 3 m depth. Several field screening samples were collected and readings as high as 100 ppm were recorded to a depth of 22 m. VOC readings declined substantially below this to the final depth of 24 m. Three samples were collected for organic and inorganic lab analysis. Soils were relatively dry and no piezometer was installed. Test hole 8 was drilled about 70 m to the north of test hole 7. Positive VOC readings did not occur above 8 m. VOCs were detected from

the final depth of 22 m. Odours were noticeably lower below 17 m. Maximum HNU readings were 100 ppm. Four samples were selected for lab analysis for organic and inorganic parameters. The soils were primarily sand and gravel, as seen in test hole 7, and there was the indication that sections of the soil column was saturated. For this reason, it was decided to install a pair of piezometers at staggered depths in this hole. One piezometer was set to 9 m and the second was set to 18 m. The last test hole at this site, test hole 9, was drilled 60 m north of test hole 8. The stratigraphy in this hole was still primarily sand and gravel but silt and clay zones were noted below 16 m. Hydrocarbon odours were not very noticeable above a depth of 14 m and diminished greatly by about 18 m. Field screening was completed on several samples from the lower depths and three samples were selected for lab analysis. No piezometer was installed. Logs for the test holes are appended (Appendix D) along with gradation analyses for soil samples corresponding to the piezometer intake depths in test hole 8. Figure 7 shows the hole locations.

d) **Groundwater Conditions**

Few comments can be provided on groundwater flow systems since only one pair of piezometers was set in test hole 8. There was a substantial difference in the water level in the two piezometers. The shallow well had the higher water level inferring a downward vertical flow gradient. As this site is well above the river valley, it is quite possible that this is a recharge area and groundwater flow is primarily downward at this site. Neither piezometer had much water in it. They did, however, have sufficient permeability to produce the water volumes required for sampling. The difference in water level between the two wells is about 8 m with the level in the deeper well about 5 m above the Klehini River. An inertial lift sampling system was set in each piezometer and water samples were collected from each of the wells. Construction details for the wells are shown on the logs in Appendix D.

e) **Contaminant Considerations**

Selected soil and water samples from the four test holes (TH-6 to -9) and a stained location at the northwest end of the station were analyzed for various contaminants including total extractable hydrocarbons (TEHs), volatile organic compounds (VOCs, some including the BTEX suite), organochlorine pesticides (OCs), (phenoxy acid) herbicides, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). These results are tabulated in Appendix G. The relative positions of these sample locations are indicated in Figure 7.

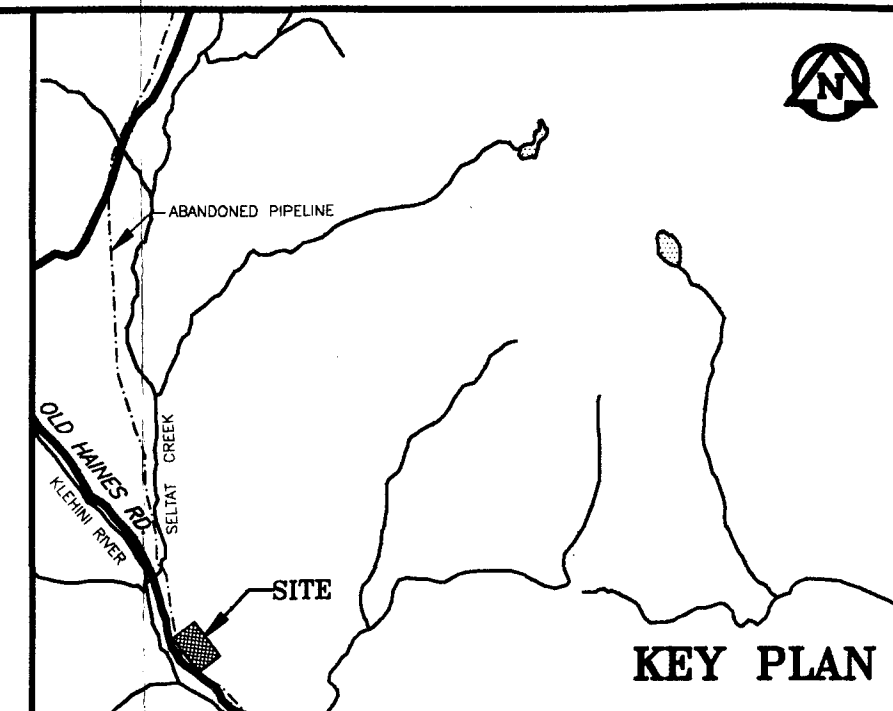
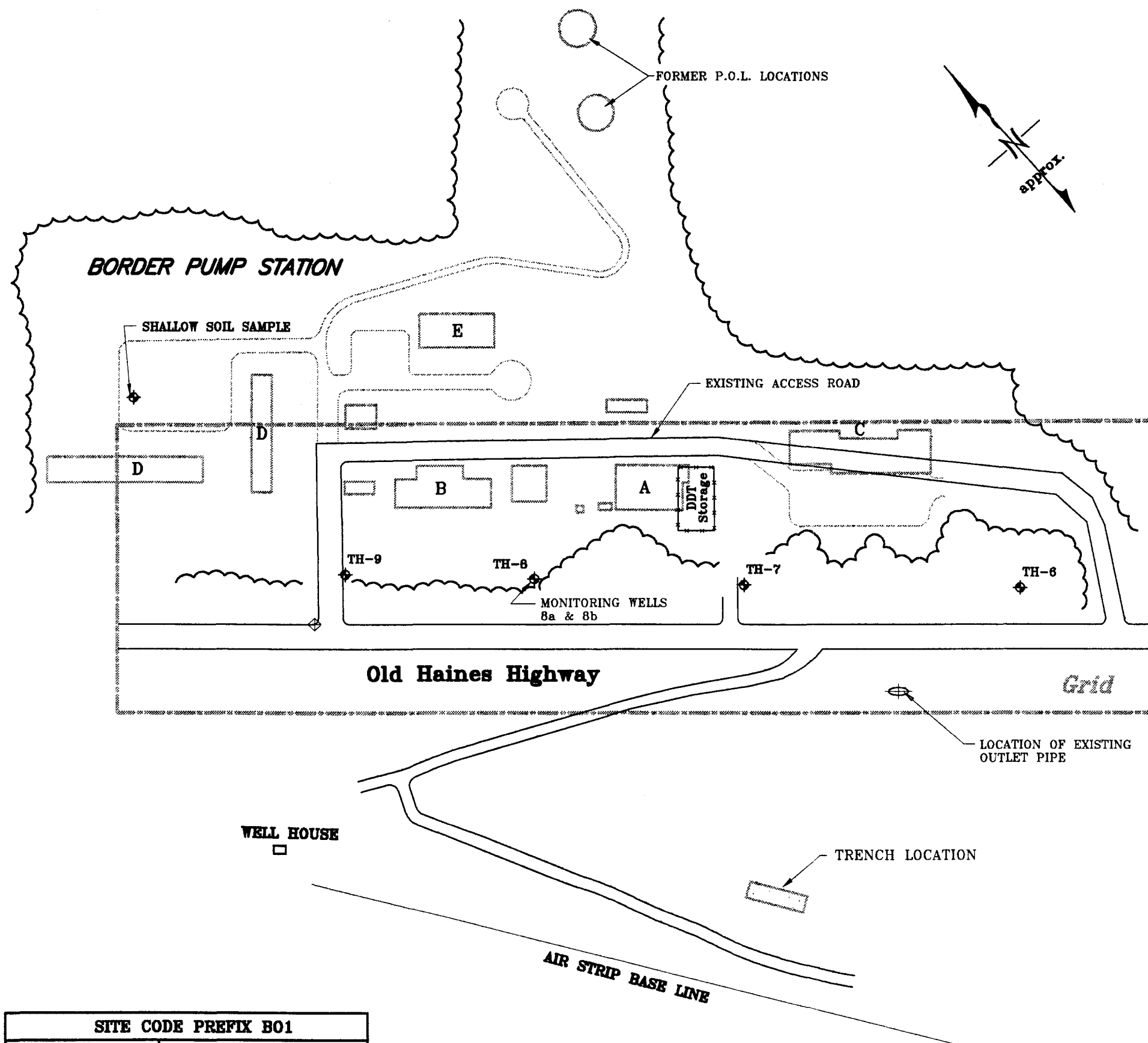
Soil samples from the large stained area near the northwest end of the site (BOLS001/002) were analyzed for TEHs, inorganic elements, OCs, PCBs. The concentration of TEH in this stain was quite high (3200 µg/g) and far exceeded guidelines adopted by Alaska (200 µg/g). Levels of all inorganic elements were comparable to, or lower than CCME Assessment Criteria. A total concentration of 209 ng/g was obtained for OCs, which was composed almost entirely of DDT and its derivatives (DDD and DDE). This total level, however, was below BC MOE Level B Criterion for total pesticides (2 µg/g or 2000 ng/g). The value for HCH (0.06 ng/g - HCH) exceeded the CCME Assessment Criterion but was also well below the USEPA

Preliminary Remediation Goals (Chapter 1.2) ($0.47 \mu\text{g/g}$ or 470 ng/g). A detectable level of PCB Aroclor 1254 (1.3 ng/g) was also found at this location, but this, again, was well below the CCME Assessment Criteria ($0.1 \mu\text{g/g}$ or 100 ng/g).

Groundwater samples from two nested wells at TH-8 (BO1GW001/002 at 17.5 and 9.5 m depths, respectively), near the centre edge of the site, were tested for TEHs, VOCs (excluding BTEX), herbicides, inorganic elements, OCs and PCBs. The concentration of TEH in the shallower of the two wells (BO1GW002) was $150,000 \mu\text{g/L}$, while the deeper well (BO1GW001) contained a much lower concentration of $1200 \mu\text{g/L}$. Concentrations for VOCs tested in the deeper well (BO1GW001) were below detection, as were levels of herbicides in the shallower well (BO1GW002). Inorganic element concentrations in both wells were well below CCME Assessment Criteria for water with slightly higher concentrations occurring in the shallower well. The only exceptions were mercury concentrations (0.12 and $0.33 \mu\text{g/L}$ in the deeper and shallower wells, respectively) which were present at a level greater than CCME assessment criterion for water and remediation criterion for Freshwater Aquatic Life, but were well below the CCME Drinking Water Criterion ($1 \mu\text{g/L}$). It should be noted however that these groundwater samples contained a significant amount of sediment which was not filtered prior to analysis. Out of the suite of OC compounds analyzed in the shallower well sample (BO1GW002 - 9.5 m well) only p,p'-DDD (8.9 ng/L) was detected. This concentration was below the range for CCME Drinking Water Criteria (700 to $280,000 \text{ ng/g}$) but within range for CCME Freshwater Aquatic Life Criteria (1 to 4000 ng/g). Other DDT compounds such as p,p'-DDE and o,p'-DDD were also detected, but at or near the limits of detection and they were not reliably quantified. PCB Aroclor levels in this shallower well sample were below the detection limit.

Selected subsurface soil samples were analyzed for TEH, VOCs (including BTEX for one sample), inorganic elements, herbicides, OCs and PCBs. Samples were obtained from various depths at TH-7 (BO1SS018 - 3.7 m; BO1SS020 - 12.2 m; and BO1SS025 - 24.4 m) and TH-9 (BO1SS041 - 15.2 m; BO1SS045 - 17.7 m; and BO1SS046 - 22.9 m). Concentrations of TEH in TH-7 decreased with depth from 1300 at 3.7 m to $< 50 \mu\text{g/g}$ at 22.4 m; concentrations at the two shallower depths (1300 and $260 \mu\text{g/g}$, respectively) exceeded the US Federal/State Guidelines adopted by Alaska ($200 \mu\text{g/g}$). A similar vertical gradient in TEH concentration was also evident in TH-9 (77 to $< 20 \mu\text{g/g}$). These concentrations, however, were considerably lower than the Alaska guidelines. Analysis for VOCs in soils was conducted at TH-6 (BO1SS005, including BTEX), and at depths described above for TEH analysis at TH-7 and TH-9. Concentrations of nearly all VOC analytes were below detection with the exception of 1,1,2,2-tetrachloroethane in the two shallower depths at TH-7. Levels of this compound, however, could not be reliably determined due to analytical interferences.

Inorganic elements were analyzed in samples from all four test holes including TH-6 (BO1SS004), TH-7 (BO1SS019/021/026, described above), field duplicates at TH-8 (BO1SS036/37 at 23 m), and TH-9 (BO1SS049/50 at 15.2 and 17.7 m, respectively). Concentrations of all inorganic analytes were comparable to, or lower than the CCME Assessment Criteria for soils. Herbicides analyzed for in the soil profile at TH-7 (BO1SS020-12.2 m depth) were found to be below detection. One soil sample from TH-6 (BO1SS020 - 12.2 m depth) was analyzed for OCs and PCBs. Levels of most OCs were below detection with the exception of dichlorobenzene (0.68 ng/g), trichlorobenzene (0.14 ng/g) and pentachlorobenzene (0.03 ng/g). Only the dichlorobenzene value exceeded the CCME Assessment Criteria for soil, but all levels were well below CCME R/P Soil Remediation Criteria (2 μ g/g or 2000 ng/g). PCBs (as Aroclors) were not found at detectable concentrations in this sample.

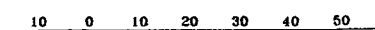


LEGEND

- TH-5 - LOCATION OF TESTHOLES
- FORMER LOCATION OF ROADWAY
- TREELINE
- FORMER LOCATION OF BUILDINGS
- GEOPHYSICAL SURVEY GRID

- A - MAIN LINE PUMP BLDG.
- B - UTILITY BLDG.
- C - WAREHOUSE/SHOP/GARAGE
- D - APARTMENT COMPLEX
- E - DORMITORY

Scale 1:1500



SITE CODE PREFIX B01	
LOCATION	SAMPLE
TH-6	SS001-SS005
TH-7	SS006-SS026
TH-8	GW001-GW002; SS027-SS037
TH-9	SS038-SS050
Shallow Soil Sample	S001-S002

NOTE: LOCATIONS OF EXISTING FEATURES ARE APPROXIMATE

uma

UMA Engineering Ltd.
Engineers, Planners and Surveyors

in association with



AMBIO
Research
Associates
Inc.

BORDER PUMP STATION

TITLE: LOCATION PLAN

JOB No. 4440 034 00 02 DATE: AUGUST 1995

DRAWN: RN

CHECKED: TRW

FIGURE 7



Photo 3.5.1: Large hydrocarbon stain/spill (B01S-001/002) at the west end of the site. The DDT soil storage facility and drill rig can be seen in the background to the left and right, respectively.



Photo 3.5.2: Two drainage pipes extending from the south side of the old Haines Road above Rainy Hollow.

4.0 INTERPRETATION

Background Conditions

Background conditions were estimated from the analysis of a soil sample (BL1S014/015) taken in the foothills above the Blanchard River Station and results are summarized in the table below. The limited scope of the analytical program did not allow for a more rigorous assessment of background conditions. Levels of organic compounds were below the detection limit, with the exception of DDT which was not reliably quantified but was present at very low levels. Levels of all inorganic elements were below the CCME Assessment Criteria.

Compound/Element	Conc	Units	Compound/Element	Conc	Units
Arsenic	1.3	µg/g	Hexachlorobenzene	<0.05	ng/g
Barium	86	µg/g	alpha HCH	<0.04	ng/g
Cadmium	< 0.25	µg/g	beta HCH	<0.05	ng/g
Chromium	17	µg/g	gamma HCH	<0.05	ng/g
Cobalt	6	µg/g	Heptachlor	<0.04	ng/g
Copper	12	µg/g	Aldrin	<0.01	ng/g
Lead	< 1	µg/g	Oxychlordane	<0.06	ng/g
Mercury	0.013	µg/g	trans-Chlordane	<0.02	ng/g
Molybdenum	< 4	µg/g	cis-Chlordane	<0.02	ng/g
Nickel	13	µg/g	o,p'-DDE	<0.09	ng/g
Selenium	< 0.5	µg/g	p,p'-DDE	<0.14	ng/g
Silver	< 2	µg/g	trans-Nonachlor	<0.03	ng/g
Tin	< 5	µg/g	cis-Nonachlor	<0.03	ng/g
Zinc	30	µg/g	o,p'-DDD	<0.12	ng/g
Aluminum	7410	µg/g	p,p'-DDD	<0.13	ng/g
Antimony	< 10	µg/g	o,p'-DDT	<0.5	ng/g
Beryllium	< 1	µg/g	p,p'-DDT	NDR(3.8)	ng/g
Boron	9.5	µg/g	Mirex	<0.02	ng/g
Calcium	3700	µg/g	Heptachlor Epoxide	<0.01	ng/g
Iron	14300	µg/g	alpha-Endosulphan (I)	<0.01	ng/g
Magnesium	4640	µg/g	Dieldrin	<0.01	ng/g
Manganese	391	µg/g	Endrin	<0.02	ng/g
Phosphorus	1060	µg/g	Methoxychlor	<0.05	ng/g
Sodium	142	µg/g			
Strontium	14	µg/g	1,1-Dichloroethane	<0.8	ng/g
Titanium	277	µg/g	t-1,3-Dichloropropene	<0.96	ng/g
Vanadium	19	µg/g	1,1-Dichloroethane	<0.7	ng/g
			c-1,2-Dichloroethene	<0.73	ng/g
TEH	<20	µg/g	Chloroform	<0.64	ng/g
			1,1,1-Trichloroethane	<0.32	ng/g
Aroclor 1242	<1.1	ng/g	1,2-Dichloroethane	<0.77	ng/g
Aroclor 1254	<0.21	ng/g	1,2-Dichloropropane	<0.49	ng/g
Aroclor 1260	<0.14	ng/g	Bromodichloromethane	<0.44	ng/g
			Trichloroethylene	<0.52	ng/g
			1,1,2-Trichloroethane	<0.18	ng/g
			1,1,2,2-Tetrachloroethane	<0.24	ng/g
			Bromoform	<0.29	ng/g

General Comments

Of the five sites discussed in this report, there are minor outstanding questions at two of the sites (Haines Junction and Million Dollar Falls), major outstanding questions at two other sites (Blanchard and Border) and no real concern at Mile 207.6.

The analytical program, which was specified in the RFP for this project, has left some major questions unanswered. Specifically, the field test kits frequently reported, with excellent reproducibility, very high levels of TPH, BTEX and PAHs. These high levels were not corroborated by laboratory analyses of the standard BTEX, PAH analytical suite. It is most likely that the field results showed positive results due to the presence of substances that are not part of the normal laboratory analysis. These might include alkylatic aromatics and/or chlorobenzenes. The gas chromatograms for these samples are presently being scrutinized in order to assess the possible presence of these or other contaminants. The delineation of contamination at Border and Blanchard will require a targeted analytical program that should be quite different from this one. The occasional positive PCB results that showed up in the test kit results were not confirmed by laboratory analysis, and may be due to cross-reactivity of the antibody with other natural or non-natural substances. The PCB antibody, however, is not known to exhibit much cross-reactivity with non-PCB molecules (R.O. Harrison, Manager, Assay Development, Millipore; pers. com.).

4.1 Mile 207.6 Spill Site

The spill at Mile 207.6 occurred in 1956, and an area of approximately 3 hectares was affected. Vegetation was completely killed after the spill, but had recovered to some extent by 1975. Our visit confirmed that vegetation recovery was progressing and late successional species were common.

Levels of contaminants were low with no analytes exceeding the CCME assessment criteria. Clearly hydrocarbons (mainly aliphatics) are the only substances of those analyzed that are a problem at this site. High total extractable hydrocarbon results were not mirrored by correspondingly high PAH or VOC levels. The presence of elevated concentrations of o-xylenes in the absence of other aromatics is unusual and may be an artifact of microbial degradation.

4.2 Haines Junction Pump Station

The Junction Pump Station was visited in 1994 by the Environmental Sciences Group (formerly of Royal Roads Military College, now resident at The Royal Military College of Canada in Kingston). A brief letter report was submitted to DIAND, Whitehorse which is attached as Appendix H. In this study, building swabs were obtained from the living quarters and the generator building and analyzed for PCBs. PCBs were not detected in any of the samples. Soil samples were also obtained around the buildings and POL tanks. Levels of inorganic elements, PCBs, pesticides and PAHs were all well below the CCME R/P criteria.

This present study did not investigate the area immediately surrounding the buildings but concentrated on areas that may have been used as waste disposal sites. An EM survey targeted three areas for test-pitting and samples were obtained from these areas (Section 3.2).

None of the samples analyzed contained analyte concentrations in excess of the remediation criteria (see Section 3.2(e) and Appendix G).

A series of partially filled drums containing hydrocarbon products were removed from two of the test pits. It is likely that the area contains many more buried drums, some of which will contain product.

4.3 Million Dollar Falls

The Million Dollar Falls site is now used as a campground. There is anecdotal evidence that material was buried in the vicinity of the campground; however, it was decided to concentrate in the gully below the campground to minimize disturbance of campers. Surface and subsurface contaminant transport from the campsite would be at least partly reflected by contaminant levels in gully samples. There is also a small dump on the campground side of the gully.

Three sample sites were selected in the gully; one upstream of the dump, one adjacent to the dump and one below the dump just before the confluence with the Takhanne River.

Water samples from the Campground Well were also obtained and analyzed. Detectable levels of Aroclor 1254 were found in these samples, although the concentrations are well below the CCME Assessment Criteria.

The only other elevated analytes were zinc and DDT. Zinc was found at levels of 269 and 497 ppm in samples obtained near the toe of the dump in the gully. This level approaches the CCME R/P Criteria (500 ppm) and indicates that some leaching of metal contaminants has occurred into soils directly below the dump. Elevated levels of DDT (50-62 ng/g) were also found in this area, indicating that a source of DDT may exist within the dump.

4.4 Blanchard River Pump Station

The former pump station at Blanchard River is now a highways maintenance camp for the Yukon Highways Department. There are two separate contaminated groundwater and soil problems at this site.

A rust coloured leachate plume is present on the north side of the site. This surfacing groundwater drains directly to the Blanchard River. A soil/sediment sample taken at the spring (BL1S013) contained high levels of a number of inorganic elements and high TEH concentrations. A sample taken further downslope (BL1S010) in the same drainage contained even higher levels of some inorganic elements. These results are summarized in Table 4.3.1

TABLE 4.3.1
SOIL SAMPLES AT THE RUST COLOURED LEACHATE SPRING
THAT EXCEED THE CCME R/P CRITERIA

Element	BL1S013	BL1S010	CCME R/P
	ppm	ppm	ppm
Arsenic	138	85	30
Barium	2360	4770	500
Cobalt	55	90	50
Nickel	-	138	100
Selenium	3.1	-	3
Zinc	1490	3570	500

TEH levels in the Sample BL1S010 were also high (6800 µg/g). This leachate plume must originate at the site. Hydrocarbon contaminated groundwater was obtained from TH-1 and TH-2 but not from TH-3 and TH-4. This would indicate that the hydrocarbon contamination originates in the vicinity of the garage/shop. Test pits that were excavated between TH-2 and TH-3 indicated that a very large amount of metallic debris was buried in this area. A buried pipe was located between the residence and the shop by the EM survey; this pipe terminated at the leachate plume. The pipe may serve to focus the contaminants from a source somewhere in the vicinity of the garage to the leachate plume. Old site drawings indicated a gravel/rock soak-away drainage system was used from the garage. This was located just to the northwest of the garage and may be the source of this contamination. A groundwater sample obtained from the piezometer installed at TH-2 contained elevated levels of BTEX. The concentrations of benzene and ethyl benzene exceeded the Canadian drinking water standard.

There is an area within the maintenance yard that appears to be acting as a source of hydrocarbon and inorganic element contamination. There is evidence from these results that this contamination may be spreading downstream towards the river. The extent of the source and contamination is not known. The concentrations of inorganic elements in two samples are far greater than the concentrations of any other samples at this site and suggest anthropogenic rather than natural elevation.

The other contaminated groundwater plume is situated on the southwest side of the camp. The groundwater surfaces immediately above the Blanchard River below a small bench. In this case, inorganic elements do not appear to be significantly elevated but hydrocarbon levels are high. During sampling, next to the Blanchard River, a small amount of free product could be seen floating on top of the water. BTEX levels were low at this site, but it was clear that there were hydrocarbons present. Similarly, in two test pits (TP 95-5 and TP 95-6) excavated on the bench above the river, a strong hydrocarbon odour was detected. A test hole was drilled (TH 5) at the level of the site and between the test pits and the POL tanks and garage. The water table was located at approximately 7.5 m. A very strong hydrocarbon odour was noted. TEH levels in the soils were elevated (370 µg/g) and were also high in the groundwater (3700 -4100 µg/L). The extent, actual content and source of this plume could not be ascertained from this study, but the direct input of contaminated groundwater into the Blanchard River is cause for concern.

It should be noted that despite the high hydrocarbon concerns found at this site, there were no significant detectable results for PCBs, volatile halogenated hydrocarbons, phenoxy herbicides, pesticides or PAHs.

4.5 Border Pump Station

The results for the Border Station indicate that there is a very large area of contaminated soil and groundwater. The exact nature of the contamination is not clear from the suite of analytes chosen for this study. The area of contamination is enclosed by TH-6 on the southeast side of the site; the extent of contamination to the northwest is unclear. A pair of nested wells were installed on the final day of sampling in TH 8. It should be noted that these wells did not have adequate time to stabilize before they were sampled. However, the TEH levels were very high (up to 150000 µg/L) indicating the possible existence of free product. Even if these levels were elevated by particulate matter they still provide evidence for substantial aquifer contamination by hydrocarbons. This discovery of hydrocarbon contamination at

this site fits well with the observations of hydrocarbon contamination in test pits above the Rainy Hollow site (Golder, 1995). The depth of contaminated soil was also of concern. Hydrocarbon contaminated soils were first encountered at a depth of approximately 2 m at TH-7, 7 m at TH-8 and 9 m at TH-9. In all cases the contaminated soil extended to approximately 20 m depth.

DDT concentrations were elevated in a surface soil sample. It is possible that the excavation and trucking of material from the DDT contaminated site at Rainy Hollow has caused a high background DDT level around this site.

No significantly elevated levels were found for any other contaminants (PCBs, other pesticides, herbicides or VOCs).

5.0 PRELIMINARY ENVIRONMENTAL RISK ASSESSMENT

The assessment of environmental risk can be measured or modelled using a wide variety of methods. A necessary condition for there to be an environmental risk due to a contaminant is the immediate or future presence of bioavailable forms. If a contaminant is present and bioavailable, then the associated risk varies as a function of the exposure concentration, size of the contaminated area, sensitivity/ characteristics of the local ecosystem (microbes, flora, fauna), and longevity of the impact. Risk assessments often involve the delineation of (i) direct human health risks, and (ii) ecosystem health risks - i.e.; risks to living organisms other than humans.

The assessment of human health risk is simplified by the fact that there is a large body of knowledge on the likely mechanisms of human exposure to contaminants and associated health risks. For most inorganic elements and organic contaminants, the major pathways of human exposure include:

- ingestion of soil;
- inhalation of volatiles and fine particulates;
- consumption of contaminated drinking water (groundwater or surface water); and
- ingestion of bioaccumulative, persistent organic contaminants in food substances.

For a small subset of substances, a handful of other exposure pathways need to be considered; for example, dermal exposure. The USEPA has developed mathematical models for estimating human health risk from toxicants in soils, based on the partitioning of specific substances between soil, air, and water; estimates of maximum soil ingestion rates for people of various age groups; estimates of expected drinking water and food consumption rates; and dose-response relationships. Chapter 1 (criteria) provides limited discussion of USEPA draft soil screening Levels (SSLs) - assessment levels for residential sites below which human health effects can be discounted without further investigation. SSLs are generally based on concentrations of potential toxicants in soil at residential sites only that constitute a risk of increased cancer of $\leq 10^{-6}$ for carcinogens (1 in 1,000,000 people), or hazard quotient of 1 for non-carcinogens.

Use of the SSLs, although not advocated by the USEPA for applications outside of their intended use, provides a simple, scientifically-defensible gauge of soil contaminant levels beyond which further investigation/risk-assessment may be required. It is important to note that soils with substances in excess of the SSLs may or may not constitute a human health risk, depending on site-specific conditions, and SSLs should not be considered as remediation criteria.

Use of USEPA models for human health risk assessment is not formally advocated in Canada; nor is it recommended here as the primary means of estimating risk. The interpretation of soil contaminant concentrations using USEPA SSLs should be treated as a subordinate indicator of risk relative to other, site-specific considerations.

Contaminant concentrations in drinking water, furthermore, probably provide a more meaningful indication of possible human health risks than soil contaminant concentrations. Concentrations of analytes in water have been compared to Canadian Drinking Water Standards.

For each site of the Haines-Alaska pipeline included in this study, the major pathways of exposure by humans are examined. This provides a second, more direct method of assessing human health risk. The data on concentrations of substances in water relative to drinking water standards, and potential for use by humans of potable water at each site are particularly relevant. Health Canada provides guidance on levels of contaminants in food substances that may cause human health problems; however, assessment of contaminants in food substances was beyond the scope of this preliminary investigation. A study of contaminants in food would only be warranted if there is a reasonable suspicion that contaminants in soil or water are sufficiently high relative to background locations and bioavailable, such that they are entering the food chain at significant rates.

Ecosystem health risk relates to the possible deleterious change in any number of components at or around specific sites; for example, contaminant-induced effects on microbes, plants, animals, species interactions, productivity, or the resilience (or ability to recover) of whole ecosystems against other natural or non-natural perturbations. The assessment of ecosystem health risk, therefore, is considerably more complicated than human health risk. Assessment and remediation criteria established by the Canadian Council of Ministers of the Environment (CCME, 1991), however, are designed to minimize ecosystem health risk, subject to site-specific conditions. As discussed in Chapter 1, the use of CCME Residential/Parkland soil remediation criteria is a reasonable approach to providing a preliminary ecosystem risk assessment at these sites.

For this study, the assessment of ecosystem health risk was based first of all on whether contaminated soil and water were found: If all contaminants were found only at levels below CCME Residential/Parkland Criteria or equivalent guidelines, then the associated risk was assumed to be trivial, unless some local condition (e.g., presence of a highly sensitive biotic element) suggested otherwise. Evidence of the migration of contaminants - regardless of the concentrations - along water courses and into fish-bearing waters is taken as a sign of possible direct risk, and has implications under the Fisheries Act. Evidence of risk also included visual evidence of the use of a contaminated area by wild-life and humans, as well as direct signs of impact such as the presence of dead or stunted vegetation.

The assessment of either ecosystem or human health risk during this study was limited by the small number of samples collected at each site; however, the sampling effort focused on detecting and assessing the most contaminated areas at each site, which minimizes the probability of under-estimating the risk.

5.1 Mile 207.6 Spill Site

5.1.1 General

The historical spill at Mile 207.6 occurs in a wooded area that is isolated from any area of human habitation or extended and chronic use. The boundaries of the spill are limited in distribution to a distance of approximately 0.5 km or greater from any fish-bearing body of water (approximately 0.5 km from unnamed stream draining into Kluane Lake, and 2 km from Kluane Lake itself). Given the presence of permafrost in subsurface soils, the subsurface migration of contaminants associated with the spill has been limited to the surface active layer.

5.1.2 Human Health Risk

a) Contaminant Exposure Via Major Ingestion Pathways

This site is not used for any extended human activity; therefore, contaminant uptake via soil ingestion, drinking water consumption, inhalation or dermal exposure is very unlikely. The aforementioned USEPA Soil Screening Levels (SSLs) would not be applicable since they have been developed for residential sites where chronic exposures occur. Modeled SSLs for occasional transient exposures at Mile 207.6 would be much higher than tabulated in Chapter 1, since rates of soil and water ingestion as well as inhalation of air at the site would be virtually insignificant relative to total ingestion and inhalation on an annual basis. These considerations aside, there was little evidence of contaminants in surface soils that would be bioavailable through ingestion, inhalation, or dermal exposure. The one exception was elevated TEH; however, TEH levels are not measures of toxicants per se, and the more toxic component of refined fossil fuels - BTEX and PAH - were not found at levels that would constitute a direct human health risk. The data do not provide any evidence for the presence of persistent organic substances such as organochlorines that tend to biomagnify in the food chain. Therefore, human health risks associated with consumption of wildlife feeding in the vicinity of the site are probably negligible.

b) Relationship to Drinking Water Guidelines

Surface or subsurface water samples were not collected at the Mile 207.6 spill site. There was no source of surface standing water available for either sampling or possible consumption as drinking water. In addition, there was no available groundwater, due to the presence of permafrost.

The results of this preliminary investigation did not provide any evidence for human health risks at the Mile 207.6 spill site.

5.1.3 Ecosystem Health Risk

a) Relationship to CCME R/P Soil Criteria

Elevated levels of total extractable hydrocarbons (TEH) were noted in all three subsurface soil samples from the site that were sent for laboratory analysis; the TEH levels ranged from 1,300 to 6,000 $\mu\text{g/g}$ (ppm) which exceed Alaska State guidelines (see Chapter 1). In two samples analyzed for BTEX, the levels were low (benzene and toluene were below the limits of detection, ethylbenzene ≤ 12 ng/g (ppb), Σ xylenes ≤ 1900 ng/g). The levels of PAHs in the third sample, which also had a high TEH concentration, were also very low (≤ 820 ng/g for individual PAHs). One possibility is that the contaminants are aliphatic or alkylated aromatic compounds. The laboratory analyses indicated only low levels of BTEX and PAH in virtually all samples from all five sites in spite of the presence of strong hydrocarbon odours in many of the samples, as well as elevated TEH concentrations. The TEH numbers in soil are not, in themselves, cause for concern.

- b) **Relationship to CCME and BCMOE Water Guidelines for the Protection of Aquatic Life**

No water samples were collected or analyzed from this site, since neither groundwater nor surface water were present during the site visit.

- c) **Surface and Subsurface Aqueous Migration of Contaminants**

The extent of migration of the original spill is clearly delineated by the presence of dead vegetation and early colonizing plant species. There was evidence that the migration of contaminants beyond the immediate spill area has occurred at the soil surface or within the surface active layer; however, there was little indication that the affected area has increased substantially since the 1975 study (Deneke, 1975).

- d) **Sensitivity of the Local Ecosystem and Other Considerations**

The plant and animal communities in the immediate vicinity of the spill have obviously been profoundly altered by the original spill. There is evidence, however, that the plants in the spill area are recovering. There are no known major concerns for wildlife, food substances, or other potentially sensitive components of the ecosystem in the area around the spill.

5.2 Haines Junction Pump Station

5.2.1 General

The preliminary site investigation at Junction Pump Station included the analysis of contaminants only in surface soils and subsurface soils obtained from test pits; no water samples were collected. Human use of the site is very limited. The site is located approximately 1 km from any fish-bearing body of water.

5.2.2 Human Health Risk

- a) **Contaminant Exposure Via Major Ingestion Pathways**

None of the surface or subsurface soil samples collected at Junction Pumping Station contained contaminants at elevated concentrations (except TEH: see section 5.2.3a)). Human health risks associated with the ingestion of soil, dermal uptake, or inhalation of particulate or vapour-phase contaminants can, therefore, be discounted provided that the collected samples accurately reflect the worst-case contamination at this site. Results for TPH, BTEX, PAHs, and PCBs obtained using immunoassay-based field test kits or volatile organics using a Photoionization Detector provided little, if any, evidence of contamination in the larger number of samples screened.

- b) **Relationship to Drinking Water Guidelines**

Subsurface investigations at Junction Station were limited to the excavation of test pits and sampling of subsurface soils. The study of surface and groundwater was not included in the scope of the study. Drinking water would rarely, if ever, be collected from the site.

The results of this preliminary investigation did not provide any evidence for human health risks at Junction Pump Station.

5.2.3 Ecosystem Health Risk

a) Relationship to CCME R/P Soil Criteria

Elevated levels of total extractable hydrocarbons (TEH) were noted in the single soil sample from the site that was sent for laboratory analysis; i.e., 13,000 µg/g (ppm) in sample JU1SS010 (mineral soil around drums in test pit 4), which exceeds Alaska State guidelines (see Chapter 1). Concentrations of BTEX compounds in this sample, however, were very low (≤ 10 ng/g), as were PAHs (≤ 35 ng/g for individual PAHs).

Sample JUSS002 contained levels of copper (97 µg/g) and tin (46 µg/g) that approach the CCME R/P soil criteria, as well as zinc (259 µg/g) at level that is elevated over expected background concentrations, but still lower than the R/P criterion.

None of the other substances were detected at concentrations that approached or exceeded any relevant remediation criteria.

b) Relationship to CCME and BCMOE Water Guidelines for the Protection of Aquatic Life

No water samples were collected or analyzed at this site.

c) Surface and Subsurface Aqueous Migration of Contaminants

Investigation of groundwater conditions at Junction Pump Station was beyond the scope of this study. The presence of buried drums with unknown contents in the landfill to the northwest of the site cannot be discounted as a possible future source of contaminants without further study; however, the data provide no evidence of subsurface contaminant migration from this dump, except for TEHs. Levels of chlorinated pesticides, PCBs, and phenoxy acid herbicides were all below the analytical detection limit in sample JU1SS010, collected in test pit 4, and levels of BTEX and PAHs were extremely low. The concentrations of inorganic elements in all soil samples collected at Junction Pump Station were similar to background levels, and there was no evidence of contaminant migration from sites of buried debris or other areas.

d) Sensitivity of the Local Ecosystem and Other Considerations

There were no special considerations noted at this site.

5.3 Million Dollar Falls

5.3.1 General

This site has had a long and varied history of human occupation and use. The presence of a campsite at Million Dollar Falls provides the potential for extended human exposure to any contaminants in surface soil or groundwater. Any contaminant problem might be exacerbated by the proximity of the site to the Takhanne River and a small tributary along the old river bed.

5.3.2 Human Health Risk

a) Contaminant Exposure Via Major Ingestion Pathways

All substances analyzed in surface or subsurface soil samples were sufficiently low to preclude human health risks based on soil ingestion, dermal exposure, and inhalation. Comparison of the surface soil data (for samples MD1S004 to MD1S011) to USEPA Soil Screening Levels (SSLs) may be justifiable for this site given the use of the campsite as an area of temporary residence. The inorganic element levels in all samples were far lower than the SSLs, except for the Ingestion SSL for arsenic, set at 0.4 $\mu\text{g/g}$. This value is below the CCME Assessment Value for arsenic and much lower than median or maximum natural arsenic soil concentrations. The SSL, therefore, is clearly unreasonably low and should be discounted. VOCs, phenoxy acid herbicides, and most chlorinated organic compounds were below the analytical detection limit in surface soil samples from the site. The limited soil data did not provide any evidence of a human health risk at Million Dollar Falls.

b) Relationship to Drinking Water Guidelines

The water from the campsite well was sampled in duplicate (MD1GW001, MD1GW002) and analyzed for inorganic elements, VOCs, TEH, chlorinated pesticides, PCBs and phenoxy acid herbicides. None of these were found at concentrations that exceed the CCME remediation criteria for drinking water. The vast majority of these analytes were not detected in laboratory analyses. The one exception was PCBs (Aroclor 1254), with a concentration in the range of 3.5 to 7.7 ng/L. There is no CCME or BCMOE drinking water standard for PCBs.

5.3.3 Ecosystem Health Risk

a) Relationship to CCME R/P Soil Criteria

One surface soil sample at Million Dollar Falls (MD1S005) contained zinc at 497 $\mu\text{g/g}$ (ppm) which approaches the CCME R/P criterion value of 500 ppm. All other inorganic element levels in this sample, however, were similar to background levels. The implications of the elevated zinc are discussed further in section 5.3.3c), below. None of the other soil analytical results exceeded the CCME R/P criteria.

b) Relationship to CCME and BCMOE Water Guidelines for the Protection of Aquatic Life

Groundwater samples collected from the campsite drinking well contained PCBs in the range of 3.5 to 7.7 ng/L as Aroclor 1254. This exceeds the CCME remediation criterion for Freshwater Aquatic Life of 1.0 ng/L. The PCB concentration in the analytical blank analyzed along with the groundwater samples was 2.7 ng/L, suggesting that at least a portion of the apparent PCB concentration was due to laboratory contamination. Nonetheless, the PCB concentration in the campsite potable water probably exceeds the Freshwater Aquatic Life criterion. Given the low-level PCB contamination of the groundwater at the site, some detailed confirmatory testing is required. If the PCB concentration in the water well is indicative of the PCB levels in the aquifer surrounding the well, then the emergence of the groundwater at the surface, and/or introduction into the Takhanne River or its tributaries could constitute

an environmental risk. Two obvious questions arise: What is the primary source of the PCB contamination? What is the expected fate of contaminants?

c) **Surface and Subsurface Aqueous Migration of Contaminants**

An elevated zinc level (497 µg/g) was found in sample MD1S005, collected down slope from the dump and in close proximity to the small stream that drains into the Takhanne River. Although the data are limited to a single sample, the zinc contamination may be due to leachate emanating from the toe of the dump. The proximity of the sample to the creek, and to a fish-bearing water body, suggests a potential ecosystem risk. Zinc does not usually constitute a risk to terrestrial organisms; however, aquatic organisms are generally more sensitive to elevated concentrations.

Two surface soil samples also collected near the toe of the dump, MD1S006 and MD1S007, contained detectable concentrations of DDT (50 ng/g and 62 ng/g respectively) as well as breakdown products of DDT. These low but nonetheless elevated concentrations would not constitute a direct health risk to humans or other organisms/ biological communities. These samples were field duplicates, both collected near the toe of the dump and within 3 m of the stream that drains into the Takhanne River. In addition, the soil samples contained primarily the parent DDT compound, rather than breakdown products (DDD's, DDE's), suggesting that the dump contains a primary source of DDT. A water sample taken in the creek at a point adjacent to the dump (MD1W001) did not contain detectable levels of DDT, other organochlorine pesticides, PCBs, or VOCs.

d) **Sensitivity of the Local Ecosystem and Other Considerations**

The primary consideration at this site is the proximity to the Takhanne River and its small tributary.

5.4 **Blanchard River Pump Station**

5.4.1 **General**

The close proximity of the Blanchard River Pump Station to the Blanchard River, and active groundwater flow as evidenced by the number of springs that emerge on the slope below the site, underscore the potential for aqueous migration of substances. The information review of the site revealed several possible contaminant concerns. These include the possible burial of old transformers to the west of the existing buildings. The site is regularly occupied by employees of the Yukon Territorial Government.

5.4.2 **Human Health Risk**

a) **Contaminant Exposure Via Major Ingestion Pathways**

Surface sediment samples collected in a spring that emerges downslope from the site (BL1S010, BL1S013) contained very high levels of several inorganic elements. The concentrations in these samples exceed USEPA Soil Screening Levels (SSLs) for a "Migration to groundwater" exposure pathway for arsenic, barium, and nickel.

The actual human exposure to these contaminants, however, is probably insignificant given the extremely limited spatial distribution of contaminated versus non-contaminated soils. We did not find any other evidence of human health risks at Blanchard River, within the limits of the scope of the study.

b) Relationship to Drinking Water Guidelines

Three groundwater samples at Blanchard River contained ethylbenzene at levels exceeding the CCME criterion for Drinking Water, which is an aesthetic rather than health-based objective. These were samples BL1GW006 (42 µg/L), BL1GW009 (20 µg/L and BL1GW010 (20 µg/L). Sample BL1GW006 also contained benzene (11 µg/L) at a concentration exceeding the CCME (health-based) Drinking Water criterion of 5 µg/L. This might constitute a human health risk only if there is a reasonable possibility that groundwater of a similar contaminant composition will be ingested by humans.

The quality of the drinking water was assessed directly through the collection and analysis of samples from the well used to obtain drinking water (BL1GW001) and rafting operator's water supply (BL1GW002). All substances were much lower than the CCME remediation criteria for Drinking Water. In fact, VOCs and most inorganic elements were below the analytical detection limits.

The results of this preliminary investigation did not provide any evidence for human health risks at Blanchard River Pump Station.

5.4.3 Ecosystem Health Risk

a) Relationship to CCME R/P Soil Criteria

Two surface soil/sediment samples, BL1S10 and BL1S013, greatly exceeded CCME R/P criteria for some inorganic elements, including arsenic, barium, cobalt, nickel, selenium and zinc. One sample was collected from fine, silt sediment in a red rusty spring on the north slope of the site, near the top where effluent appeared. The second sample, BL1S010 was also sediment, collected from the same rust coloured drainage, half way down the north slope of the site. The analytical results for inorganic analyses indicate a problem both in terms of the *in situ* levels of contaminants and in terms of aqueous migration away from the source. This area will require additional attention.

Elevated levels of total extractable hydrocarbons (TEH) were noted in three of five soil samples from the site that were sent for laboratory analysis; TEH levels that exceeded Alaska State guidelines occurred in samples BL1S012, BL1SS024 and BL1SS043 [6,800, 360 and 370 µg/g (ppm) respectively]. VOC concentrations in these three samples, however, were all less than the analytical detection limit, as were chlorinated pesticides. PCB concentrations were near or below the detection limit.

b) **Relationship to CCME and BCMOE Water Guidelines for the Protection of Aquatic Life**

Groundwater samples BL1GW005 (drill hole 1; 2 m depth increment) and BL1GW009 (drill hole 2; 3 m depth increment) contained detectable mercury concentrations which approached or slightly exceeded the CCME criterion for Freshwater Aquatic Life ($0.1 \mu\text{g/L}$). The source or significance of the mercury concentrations is not clear, since the concentrations of all other inorganic elements were in the range found in uncontaminated groundwater.

PCB levels in groundwater samples BL1GW004 (4.8 ng/L) and BL1GW010 (7.5 ng/L) also exceeded the CCME criterion for Freshwater Aquatic Life.

The risk to aquatic life from contaminants in groundwater is actually zero while the water remains underground since there is no possible exposure pathway. Some elevated ecosystem risk might occur if water containing low but elevated levels of PCBs or mercury emerged at the surface and flowed into the Blanchard River.

c) **Surface and Subsurface Aqueous Migration of Contaminants**

The presence of inorganic element contaminants in sediments from a spring fed by groundwater from the site (BL1S010 and BL1S013) suggests that an active subsurface source might be present up gradient from the spring. Neither of these samples were analyzed for other substances such as chlorinated pesticides, PCBs, or BTEX; however, sample BL1S012, collected from the same spring was analyzed for TEH, PCBs and VOCs. 1,1,2,2-tetrachloroethane was detected in sample BL1S012 ($\leq 12 \mu\text{g/L}$) along with 6800 mg/L TEH. The presence of a subsurface source and aqueous migration of a broader suite of contaminants cannot be discounted within the scope of this study.

Benzene, toluene, ethylbenzene, *p/m*-xylene and *o*-xylene occurred at detectable concentrations in three (BL1GW006, BL1GW009, BL1GW010) of five water samples, although none of the BTEX suite compounds exceeded the CCME Freshwater Aquatic Life remediation criteria. Similarly, TEH concentrations were high in groundwater samples BL1GW003 ($4700 \mu\text{g/L}$), BL1GW005 ($690 \mu\text{g/L}$), BL1GW009 ($3700 \mu\text{g/L}$), and BL1GW010 ($4100 \mu\text{g/L}$).

2,4-D was detected in only one water or soil sample collected from any of the sites; water sample BL1GW003, collected from a ledge above the river, contained $0.58 \mu\text{g/L}$ 2,4-D. The CCME remediation criterion for 2,4-D is $4 \mu\text{g/L}$ for Freshwater Aquatic Life and $100 \mu\text{g/L}$ for Drinking Water.

d) **Sensitivity of the Local Ecosystem and Other Considerations**

The Blanchard River hosts an active salmon sports fishery. The site is actively used for foraging by at least one Grizzly Bear. Least squirrels were quite abundant in the immediate station area. Aqueous migration from the two contaminated areas could affect plants and animals in the marsh area next to the Blanchard River as well as aquatic life in the river.

5.5 Border Pump Station

5.5.1 General

Runoff from the Border Pump Station enters the Klehini River. The site is no longer in use, and all buildings were demolished as of 1992-93.

5.5.2 Human Health Risk

a) Contaminant Exposure Via Major Ingestion Pathways

Use of the USEPA Soil Screening Levels (Chapter 1) is inappropriate for this site since they are designed based on the estimated exposure at residential sites, and Border Pump Station is unoccupied. The presence of slightly elevated DDT-group levels in surface sample B01S001 (up to 90 ng/g DDE) probably would not lead to a significantly increased risk of cancer even if the site were permanently occupied; the soil ingestion pathway SSL for DDE is calculated to be 2,000 ng/g. The limited data do not provide any other evidence of a human health risk.

b) Relationship to Drinking Water Guidelines

Only two subsurface water samples were collected and sent for laboratory analysis; no surface samples were collected. VOCs, 2,4-D, 2,4,5-T, PCBs and inorganic element levels in water samples B01GW001 and B01GW002 were all below the CCME criteria for Drinking Water. The TEH levels in these samples, however, were extremely high (1200 and 150000 µg/L respectively).

The results of this preliminary investigation did not provide any evidence for human health risks at Border Pump Station.

5.5.3 Ecosystem Health Risk

a) Relationship to CCME R/P Soil Criteria

None of the surface or subsurface soil samples exceeded CCME R/P criteria for any substance. Sample B01SS01, a subsurface sample taken in drill hole 7 in the 5.5 to 6.5 m profile, contained elevated levels - albeit at concentrations less than the appropriate soil remediation criteria - of DDT and its breakdown products (45 ng/g p,p'-DDT, 64 ng/g o,p'-DDE, 82 ng/g o,p'-DDD). Surface soil sample B01S001 also contained levels of DDT compounds that were elevated over background concentrations. These levels demonstrate migration from the source, but are not high enough to constitute a risk in and of themselves.

TEH levels that exceeded Alaska State guidelines occurred in samples B01SS018, B01SS020, and B01S001 [1300, 260 and 3200 µg/g (ppm) respectively].

b) **Relationship to CCME and BCMOE Water Guidelines for the Protection of Aquatic Life**

Groundwater samples from drill hole 8, B01GW001 (17.5 m depth) and B01GW002 9.45 m depth) exceeded CCME and BCMOE guidelines for the protection of aquatic life for the elements aluminum (166 and 571 $\mu\text{g/L}$) and mercury (0.12 and 0.33 $\mu\text{g/L}$) [CCME Remediation Criteria for Freshwater Life: mercury, 0.1 $\mu\text{g/L}$; aluminum, 5 to 100 $\mu\text{g/L}$ (depending on pH and hardness)].

A DDT breakdown product, o,p'-DDD, was also detected in groundwater sample B01GW002 at a concentration of 8.9 ng/L, which exceeds the CCME Criterion for Freshwater Aquatic Life for DDT (1 ng/L). No criterion exists for DDD. All other analytes, except TEH were sufficiently low to preclude any concern for aquatic life.

Since these are subsurface water samples, risks to aquatic life would not be of concern unless the aquifer surfaced or directly entered a surface water body with little dilution.

c) **Surface and Subsurface Aqueous Migration of Contaminants**

The presence of DDT-type compounds and elevated TEH levels in groundwater from drill hole 8 demonstrates the subsurface aqueous migration of DDT from the original source.

TEH concentrations were high in groundwater samples B01GW001 (1200 $\mu\text{g/L}$), and extremely high in B01GW002 (150,000 $\mu\text{g/L}$).

d) **Sensitivity of the Local Ecosystem and Other Considerations**

The primary concern at this site is the possibility of subsurface migration of contaminants to the adjacent river ecosystem. The contaminated groundwater plume from the upper Border Station flows past the Rainy Hollow site (subsurface) and emerges along the edge of the Klehini River.

6.0 RECOMMENDATIONS

The site conditions, interpretation of analytical results and the risk assessments outlined in the previous chapters were used to rank the sites in the order of priority for remediation/action as follows:

1. Blanchard River Pump Station
2. Million Dollar Falls Campground
3. Border Station
4. Junction Station
5. Mile 207.6

The reasons for these rankings and proposed actions at each site are given below, the sites are presented in the order that they have been discussed throughout the text. Rough order-of-magnitude cost estimates are given as a range for the proposed action at each site.

6.1 Mile 207.6 Spill Site

The spill at Mile 207.6 was rated as the lowest priority. There seems to be little risk of the spill spreading beyond the current boundaries. Since the human health risk and ecosystem risk associated with this spill are minor, it is proposed that no action be taken at this site.

It is understood that the limited assessment of this spill may be used as a model for the treatment of all the spills that have occurred along the pipeline. Migration of hydrocarbons has been limited by the relative isolation of the site from surface water bodies as well as the low permeability of the clay soils at the site. The presence of permafrost may make Mile 207.6 a special case. It is possible that Mile 207.6 may represent a best case scenario rather than the worst. It is recommended, before such an assumption is made, that a basic inspection of all the spills be made. It is envisioned that this could simply consist of a site visit and a brief consideration of site specific risk (e.g., hydrology, soil conditions, wildlife use, etc.). This could be done over a period of time by DIAND field personnel. Alternatively, an appropriate inspection of the approximately 40 spill sites could be conducted over a three to five day period.

6.2 Haines Junction Pump Station

Haines Junction Station was rated second lowest in priority. There is little evidence of any environmental indicators that would be cause for concern. Some of the buried drums that were found did contain hydrocarbon products. The EM survey delineated the area of buried material and it is quite small. It is recognized that these buried drums are present in a location where there would not be much risk even if the drums were to puncture. However, the contents of the drums are not known and they may contain toxic materials. It is recommended that carefully planned excavation of this landfill be undertaken and that drums containing product be removed and placed in a secure processing area. They should be tested and subsequently disposed of in an appropriate manner. This whole operation should be carried out under the supervision of an experienced hazardous waste professional and by a competent contractor to minimize the risks of environmental damage during construction. The cost, if no hazardous materials are uncovered, could be in the range of \$20,000 - \$50,000. The sampling and analysis of unknown barrel contents, and subsequent disposal could lead to additional costs. The costs would depend on the number of barrels recovered with unknown contents.

6.3 Million Dollar Falls

The site at Million Dollar Falls was rated second in priority. The discovery of low level PCB contamination in the Campground water supply raises some concerns and the presence of elevated levels of zinc and DDT at the foot of the dump in the gully represents an ecosystem risk.

It is recommended that the Campground water supply be carefully sampled and analyzed. The current pumping system should be temporarily removed and replaced with an environmental sampling system. The well should be sounded, thoroughly purged and large volume water samples obtained. These samples should be very carefully screened for hydrocarbons and PCBs using GC/MS techniques and congener fingerprinting. The fingerprint should give some information about potential sources. The cost of this should not exceed approximately \$10,000 to \$20,000. It would also be appropriate, given the historical information on buried debris in this area, to monitor the water quality of the well on an ongoing basis.

It is also recommended that the dump in the gully be removed. There is evidence that it may be acting as a source of zinc and DDT that could migrate into waters frequented by fish and thus constitute a violation of the Fisheries Act. The remediation of the dump could probably be best accomplished by a crane/platform or winch system from the top of the gully. The clean-up should be supervised by an experienced hazardous waste professional. The cost could be in the range of \$100,000 to \$150,000.

6.4 Blanchard River Pump Station

This site was rated as the highest priority. There is ample evidence that the rust coloured leachate on the north side of the site is carrying high levels of inorganic elements and hydrocarbons directly to the Blanchard River. On the other side of the site, a hydrocarbon contaminated groundwater plume surfaces right at the bank of the Blanchard River.

There is, unfortunately, insufficient information from this preliminary assessment to provide credible clean up recommendations. The contaminant plumes need to be fully characterized, in terms of extent, composition and source. The ecosystem impact, especially in the marsh area below the leachate spring, should be assessed. Following this, remedial options, if necessary, can be proposed. The current operation of the site, and its contribution, if any, to contaminants loading would also need to be assessed.

It is recommended that a full site assessment be carried out at the Blanchard River Station. A network of monitoring wells should be installed and sampled and additional test pitting should be carried out in the maintenance yard. The cost of this work including recommendations could be in the range of \$100,000 - \$200,000.

6.5 Border Pump Station

The Border Site was rated third in order of priority. There is evidence that a large volume of soil and groundwater is contaminated with hydrocarbons and that the contaminated groundwater may be moving towards the Klehini River under the Rainy Hollow site. It is unclear whether hydrocarbon contaminated groundwater is in fact reaching the Klehini River or whether hydrocarbons potentially reaching the river are at levels that could have an environmental impact.

Monitoring Wells MW-8a and MW-8b in TH-8 should be resampled since the well may not have stabilized prior to sampling.

The Border Station cannot be treated in isolation from the Rainy Hollow site. They are hydrologically linked and contaminants from the Border site could travel through the Rainy Hollow site with the potential of mobilizing contaminants at Rainy Hollow.

It is recommended that before any action is taken a thorough review of all information pertaining to these sites be undertaken. New data, for example, collected by Environment Canada in 1995 are directly applicable to a proper assessment of contamination at Border Station. This would involve the cooperation of DIAND, Environment Canada, B.C. Ministry of Environment and consultants retained for work at these sites. This review should incorporate all the analytical results obtained and critically evaluate the clean-up efforts to date. The review should also provide recommendations regarding further investigative or remedial actions required. The cost of this review could be in the range of \$10,000 - \$50,000.

7.0 REFERENCES

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APPENDICES

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APPENDIX A
SAMPLING AND ANALYTICAL METHODS

A. SAMPLING AND ANALYTICAL METHODS

a) Sampling Program:

Approach

Given the past activities that occurred at these sites, there are a limited number of potential pathways for the introduction of contaminants to the local environment. These include:

- direct spillage or discharge of the contaminants onto the soil or into a body of water;
- burial of contaminated or hazardous materials; and,
- surface or subsurface migration of contaminants from a primary source.

Identification of major sources of contamination was the focus of this study, since this will form the basis for recommendations. Consequently the delineation of subsurface waste materials was considered a high priority. The extent of migration of contaminants away from the primary sources is a key determinant in the assessment of environmental risk. As related to these requirements, the primary components of the field investigation were:

- geophysical surveys;
- test pitting program, and;
- drilling program.

A soil and water sampling program was coordinated with the above activities. A field screening program was also implemented to guide the sampling and analytical activities.

Geophysical Survey

Geophysical surveys using ground conductivity measurements (EM31 and EM61) were carried out at Haines Junction Station, Blanchard River Station and Border Station. Full details and results can be found in Appendix F.

Soil/Sediment/Plant and Water Sampling

Sampling locations were selected on the basis of historical records, interviews, visual inspection and the geophysical survey. Field screening samples were collected in 150 mL glass jars capped with foil lined screw-on lids. The jars were half filled with soil. Soil samples for laboratory analysis were collected in Whirl Pak bags (inorganic analysis) or 500 mL amber wide mouthed glass jars (organic analysis). The glass jars were filled to the brim and sealed with an aluminum foil lined lid. Samples for organic analysis were collected using a stainless steel scoop (pre-washed and baked); samples for inorganic analysis were collected using a plastic scoop.

Water samples were collected in 500 mL acid-washed polyethylene bottle for inorganic analysis. Water samples for TEH analysis were collected in 1 L clear glass jars equipped with foil lined lids. Water samples for PCB, PAH, pesticide and herbicide analyses were collected in pre-baked 4 L glass jars with foil lined lids. The water samples collected for VOC and BTEX analysis were collected in 60 mL amber purgeable bottles obtained from Supelco.

Sub-surface water samples were collected from wells using the Waterra™ foot valve system. Mini-piezometer installations were sampled using a Masterflex peristaltic pumping system. The wells were purged by pumping and discarding approximately four times the sampling volume.

All soil and water samples were kept in coolers at 4°C and shipped (air cargo) to the analytical lab at the end of each sampling period (2-3 days).

Plant samples were obtained from some of the soil/sediment sampling locations. These were packed in baked aluminum foil for organic analysis or plastic zip-lock bags for inorganic analysis. The samples were archived (frozen) by the Analytical laboratory.

Duplicate field notes were independently recorded at each sample site. In addition, a minimum of two photographs were taken and video footage was recorded.

b) Field Screening Program:

A soil vapour probe survey was carried using an Hnu™ photoionization detector. Soil samples were collected in 250 mL jars as outlined above. The half-filled jars were shaken thoroughly for 30 seconds, the lid was carefully removed and the foil was pierced using the vapour probe. Care was taken to sample only the headspace. The maximum reading was recorded. These samples were retained and sent to the analytical lab to be used as backups for the analysis for organic compounds if needed.

Selected soil and water samples were also screened for the presence of BTEX, TPH, PAHs and PCBs using immunoassay field test kits. The instructions accompanying the field test kits were used throughout. Variation in detection limit levels were caused by differing dilution factors e.g., 5 mL of methanol is normally used to extract 5 g of the soil sample; however, clay samples often require 10 mL of methanol thereby doubling the detection limits. The Millipore immunoassay test kits were obtained from Bioman Products, Ontario.

c) Laboratory Program:

Laboratory analyses were conducted by Axys Analytical Services Ltd., Sidney, B.C. or under subcontract by Cantest Ltd, Vancouver, B.C. (for inorganic elements and TEH). The analytical screen for soil and water samples included metals and other inorganic elements by I.C.P., polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorobenzenes (CBs), chlorinated pesticides, chlorophenols, phenoxy herbicides, Fenuran, volatile organic contaminants (including the BTEX suite), and total extractable hydrocarbons (TEHs). The analytical program is summarized in Table 2.3.2.

Inorganic Elements in Soil and Water (ICP-AES)

General: Metal and inorganics analysis was carried out using inductively coupled argon plasma - atomic emission spectrometry (ICP-AES), based on USEPA Method 6010A and British Columbia Laboratory Manual Method Section 2.5.3. ICP-AES is a rapid multi-element scanning technique. Arsenic and cadmium were separately determined using graphite furnace - atomic absorption spectrometry (see below) due to the high detection limits achievable using ICP-AES.

Extraction: Soil samples were thoroughly homogenized and approximately 5 to 15 grams of sample were accurately sub-sampled and subjected to a strong acid (aqua regia: nitric/hydrochloric acid) digest. The soil sample was placed in a clean, acid-washed 250 mL beaker along with 10 mL nitric acid and 20 mL hydrochloric acid. The mixture was placed on a hot plate and reduced to a volume of 10 mL. The extract was diluted with ultra-pure water to a volume of 100 mL. A soil subsample was weighed, dried and reweighed in order to determine wet:dry conversion factors.

Analysis: The extract was analyzed by ICP-AES. Method detection limits for soil, derived by multiplying (weight/volume) factors by the estimated instrument detection limit, were as follows (in g/g, or ppm, dry weight):

Element	D.L.	Element	D.L.	Element	D.L.
Aluminum	10	Chromium	2	Nickel	2
Antimony	10	Cobalt	1	Phosphorus	20
Arsenic	30	Copper	1	Silver	5
Barium	0.1	Iron	2	Sodium	0.1
Beryllium	1	Lead	10	Strontium	5
Boron	0.5	Magnesium	0.1	Tin	0.3
Cadmium	5	Manganese	0.2	Zanadium	0.5
Calcium	1	Molybdenum	4	Zinc	1

Arsenic, Cadmium, and Selenium in Soil (GF-AAS)

General: Arsenic and cadmium levels in soil samples were analyzed by graphite furnace - atomic absorption spectrometry (GF-AAS) of aqua regia acid digests. GF-AAS was performed using Zeeman background correction, and with palladium and nickel as matrix modifiers in the graphite tube.

Extraction: as for ICP-AES (above).

Zinc in Water (AAS)

Zinc in water samples was analyzed by Atomic Absorption Spectrometry.

Mercury in Soil and Water

Mercury was analyzed in soil samples using Cold Vapour Atomic Absorption Spectrometry (CV-AAS). Mercury in water samples was also analyzed by CV-AAS following prior digestion with acid permanganate.

Volatile Organic Contaminants (VOCs)

General: Soil, water and oil samples were prepared for the analysis of volatile organic contaminants (VOCs) according to USEPA method 5021. VOCs were subsequently analyzed using headspace method followed by GC/MS analysis, based on USEPA Method 8260A.

Sample Extraction (Headspace Analysis): Aliquots of soil (2.0 g) or water (5.0 g) were placed in tared headspace vials and spiked with a suite of surrogate and internal standard compounds. Oil was prepared in methanol using a dilution series, and added to headspace vials along with surrogate and internal standards along with 10 mL of a matrix modifying solution. The vials were then sealed with teflon faced septa and crimp caps.

The vials were shaken to allow for diffusion of the standards through out the matrix. The vials were then placed in a Teckmar 7050 headspace autosampler carousel. Approximately 10 min prior to analysis, the vials were moved to a heated zone (85° C) and allowed to equilibrate. The samples were then mixed by mechanical agitation at elevated temperature, and subsequently pressurized with helium to force the VOCs into the sample loop and transfer line to the GC column.

Instrumental Analysis: Analysis of trapped VOCs was performed using a Varian 3400 GC with a 30 m DB-5 column (0.32 mm i.d. x 1.0 m film thickness) coupled to a Finnigan Incos Model 50B MS and at DG 10 Data system. The MS was operated in the EI mode (40 eV) and selected ions acquired using multiple ion detection. The system was calibrated twice-daily by injection of a response calibration standard. Compounds were identified on the basis of relative retention times in the appropriate ion mass chromatogram. At least two characteristic ions were monitored for each analyte.

BTEX (Benzene, Toluene, Ethylbenzenes, Xylenes)

General: BTEX compounds were analyzed using the same methods as for VOCs (above), except that fewer analytes/ions were monitored overall (only those ions corresponding to benzene, toluene, ethylbenzenes and xylenes), which reduced the time required for interpretation and quantification of chromatograms.

Total Extractable Hydrocarbons (TEH)

General: Total extractable hydrocarbons were determined in water samples using methods based on USEPA Method 8015 and British Columbia Ministry of Environment (1994) Laboratory Manual Method X366. Water samples were extracted in dichloromethane and analyzed by gas chromatography (GC), Photoionization Detection (PID). The concentration reported includes dichloromethane extractable hydrocarbon material in the n-C₁₀ to n-C₃₀ range.

Polycyclic Aromatic Hydrocarbons (PAHs)

General: All soil and water samples were spiked with an aliquot of perdeuterated PAH surrogate standards (acenaphthene, chrysene, naphthalene, perylene, phenanthrene, pyrene, dibenz(a,h)anthracene, benzo(a)pyrene, and benzo(g,h,i)perylene) prior to analysis. Soil

samples were extracted using a base digestion procedure followed by dissolution in pentane. The resultant extracts were cleaned on a silica gel column and the polar fraction was analyzed for PAHs by GC/MS.

Sample Extraction - Soils: The sample was thoroughly homogenized and a subsample dried overnight at 105° C for moisture determination. A portion of the soil sample (10 - 15 g wet g), along with an aliquot of surrogate standard, methanol, and potassium hydroxide solution were refluxed by heating for 1 h. Solvent extracted water was added the mixture was heated for an additional 1 h. The resulting digest and aqueous phase were cooled and extracted three times with pentane. The pentane phases were combined, backwashed with solvent extracted water, dried over anhydrous sodium sulphate, concentrated in a Kuderna-Danish flask to a small volume and cleaned on a silica gel column.

Column Cleanup: The sample extract was loaded onto a silica gel column and eluted with pentane (discarded) followed by dichloromethane (retained). The dichloromethane fraction was concentrated in a Kuderna-Danish flask and an aliquot of recovery standard (containing benzo(b)fluoranthene d-12, fluoranthene d-10, and acenaphthylene d-8) was added. The extract was then transferred to a microvial, concentrated under a stream of nitrogen and, analyzed by GC/MS.

Instrumental Analysis: The concentrated extracts were analyzed for PAHs by gas chromatography with detection by quadropole mass spectrometer (GC/MS). The GC/MS system consisted of a Finnigan INCOS 50 mass spectrometer and a Varian 3400 gas chromatograph, with a CTC autosampler and a DG 10 Data system. Chromatographic separation was carried out using a DB-5 column (30 m, 0.25 mm i.d. x 0.25 m film thickness). The mass spectrometer was operated in the electron impact (EI) mode (70 EV) using Multiple Ion Detection (MID) to enhance sensitivity, acquiring two characteristic ions for each target analyte and surrogate standard. A split/splitless injection sequence was used.

Persistent chlorinated organics (PCBs, CBs, chlorinated pesticides)

General: Samples were analyzed for chlorinated organic contaminants by gas chromatography (GC) with either mass spectrometry (MS) or electron capture detection (ECD). In general, the laboratory procedures involved sample homogenization, addition of recovery and surrogate standards, solvent extraction, preliminary chromatographic separation/cleanup, and instrumental analysis. Soil samples were extracted with a solvent on a shaker table. Water was liquid/liquid extracted with dichloromethane. The sample extracts were separated into three separate fractions on a Florisil column. The first fraction was analyzed for PCBs (as Aroclors 1242, 1254, 1260), chlorobenzenes, and chlorinated pesticides by GC/ECD or GC/MS. The second and third fractions were analyzed for chlorinated pesticides by GC/ECD.

Sample Extraction - Soils: Details of the soil extraction method were as follows. Each analytical sample consisted of approximately 5 to 15 g (wet weight) of thoroughly homogenized soil. A subsample was taken for the determination of wet weight/dry weight ratio. For GC-ECD, the sample was spiked with an aliquot of surrogate standard (2,4,5,6-tetrachloro-m-xylene, PCB 209 and d₄-alpha endosulphan). For gas chromatography with mass spectrometry (GC/MS), the sample was spiked with an aliquot of ¹³C labelled surrogate standard (PCB 101, PCB 180, PCB 209, gamma-BHC, Mirex, p,p'-DDE, p,p'-DDT and d₄-alpha endosulphan).

Each soil sample was extracted once with 80 mL of 1:1 dichloromethane/methanol by agitation on a shaker table for 30 minutes. The extraction procedure was repeated using 80 mL of dichloromethane. The extracts were combined, washed with solvent-extracted water, dried over anhydrous sodium sulphate and concentrated using the Kuderna Danish technique. After the addition of activated copper to remove sulphur, the combined extract was separated on a Florisil column.

Sample Extraction - Water: For groundwater and surface water samples, a 1 litre sample was placed in a separatory funnel and spiked with aliquots of surrogate standard solution and methanol. The sample was extracted with three 100 mL aliquots of dichloromethane. The solvent was collected, dried over anhydrous sodium sulphate, spiked with hexane and reduced in volume by rotary evaporation prior to cleanup and fractionation on a Florisil column.

Sample Cleanup and Separation: For GC/ECD analysis, sample extracts were transferred to a Florisil column and eluted consecutively with three solvent systems: (i) hexane (Fraction-1); (ii) 85:15 dichloromethane:hexane (Fraction-2); and (iii) 50:50 dichloromethane:hexane (Fraction-3). An aliquot of surrogate standard was added to each of the Fraction-2 extracts in order to facilitate quantification since the surrogate standard added at the beginning of the procedure eluted into Fraction-1 and Fraction-3. Each fraction was concentrated, transferred to a microvial, and an aliquot of recovery standard added (4,4'-dibromooctafluorobiphenyl and PCB 204 to Fraction-1 and Fraction-2; ¹³C-PCB 153 to Fraction-3) prior to instrumental analysis. Fraction-1 was analyzed by for PCBs as Aroclors, chlorobenzenes and mildly polar chlorinated pesticides. Fraction-2 was analyzed for moderately polar chlorinated pesticides. Fraction-3 was analyzed for the most polar chlorinated pesticides. Samples which exhibited large peaks in the chromatographs that interfered with quantification of the target analytes were recolumned on basic alumina and reanalysed.

For GC/MS analysis, sample extracts were transferred to a Florisil column, and the column was eluted with hexane followed by 85:15 dichloromethane/hexane. The eluates were combined (combined Fraction-1 and -2). The column was then eluted with 50/50 dichloromethane/hexane (Fraction-3). Each fraction was concentrated, transferred to a microvial and spiked with an aliquot of recovery standard (¹³C-PCB 153) prior to instrumental analysis. The combined Fraction-1 and 2 was analyzed by GC/MS for PCBs as Aroclors, non-polar and moderately polar chlorinated pesticides. Fraction-2 was analyzed by GC/ECD for the most polar chlorinated pesticides.

Instrumental Analysis by GC/ECD: Each fraction was analyzed for chlorinated organic contaminants using an HP 5830A gas chromatogram equipped with a ^{63}Ni electron capture detector (GC/ECD), a 60 m DB-5 column (0.25 mm i.d x 0.10 μm film thickness) and HP 3392 integrator. The chromatographic conditions were as follows. Initial Temp.: 100°C; Injection: splitless, 1 min; Initial time: 2 min; Ramp: 10°C/min to 150°C, 3°C/min to 300°C; Final time: 5 min. The carrier gas used was helium (pressure: 21 psi; flow rate: 60 mL/min; split ratio, 15:1).

The instrument was calibrated daily using a solvent blank and standards of Aroclor 1242, Aroclor 1254 and Aroclor 1260. For each Aroclor, the sum of the areas of three characteristic peaks was used to calculate its response factor against the internal standard. The area of the same three peaks was used to determine the concentration of each Aroclor in the sample.

Instrumental Analysis by GC/MS: The combined Fraction-1 and 2 was analyzed for PCB Aroclors,, chlorobenzenes, and non-polar and moderately polar chlorinated pesticides using either a Varian 3400 GC and INCOS 50 mass spectrometer (GC-low resolution mass spectrometry) or a VG 70SE mass spectrometer (GC-high resolution mass spectrometry) equipped with a Hewlett Packard 5890 GC, and a CTC autosampler. Chromatographic separation of pesticides was achieved with a 60 m DB-5 column (0.25 mm i.d. and 0.10 μm film thickness). The mass spectrometer was operated in the electron impact (EI) mode at unit mass resolution in the multiple ion detection (MID) mode acquiring two characteristic ions for each target analyte and surrogate standard.

Chlorophenolic Compounds

General: Chlorophenolic compounds were analyzed in soil and water samples by GC/MS after derivatization of sample extracts (acetylation) with acetic anhydride. All samples were spiked with an aliquot of chemically labelled surrogate standards (4-monochlorophenol, 4-monochloroguaiacol, 2,4-dichlorophenol, 4,5-dichloro- catechol, 2,4,6-trichlorophenol, 2,4,5-trichlorophenol, 4,5,6-trichloroguaiacol, 2,3,4,5-tetrachlorophenol, 3,4,5,6-tetrachloroguaiacol, 3,4,5,6-tetrachlorocatechol and pentachlorophenol) prior to analysis. Soil samples were extracted with a solution of potassium hydroxide in methanol:water. Water samples were extracted with dichloromethane.

Sample Extraction: A mixture of wet soil (10 g), ascorbic acid and an aliquot of surrogate standard solution was sonicated. Potassium hydroxide solution was added to the mixture, which was again sonicated. The mixture was filtered through a Millipore apparatus. Ascorbic acid was added to the filtrate and the pH of the filtrate was then adjusted to pH 8 with boric acid solution in preparation for the derivatization procedure. Water samples (1 L each) were placed in separatory funnels and spiked with aliquots of surrogate standard solution. Each sample was extracted with three 100 mL aliquots of dichloromethane. The extract was adjusted to pH 8 prior to derivatization.

Derivatization/Cleanup: Acetic anhydride and hexane were added to the sample extract and the solution was allowed to react for 30 minutes to convert the chlorophenolics to their acetate derivatives. The acetylated compounds were extracted with hexane. The extract was dried over anhydrous sodium sulphate and concentrated by rotary evaporation prior to cleanup on a silica gel column.

The derivatized sample extract was loaded onto a silica gel column and eluted with hexane (discarded), followed by toluene:hexane (discarded), and then by isopropanol:toluene. This last fraction was collected and concentrated, and activated copper was added to remove traces of sulphur. An aliquot of recovery standard solution (fluoranthene-d10) was added and the extract transferred to a microvial prior to analysis by GC/MS.

Instrumental Analysis: Sample extracts were analyzed using a Finnigan INCOS 50 mass spectrometer equipped with a Varian 3400 gas chromatograph, a CTC autosampler and a DG 10 Data system. The chromatographic separation was carried out using a Restekx-5 column (30 m, 0.25 mm i.d. x 0.25 um film thickness). The mass spectrometer was operated at unit mass resolution in the EI mode (70 eV) using Multiple Ion Detection (MID) to enhance sensitivity, acquiring two characteristic ions for each target analyte and surrogate standard. A split/splitless injection sequence was used.

Phenoxy Herbicides and Fenuron

Phenoxy acid herbicides were determined in soil in accordance with USEPA Method 8150A, and in water samples based on USEPA Method 515.1. The procedures involved extraction with dichloromethane, clean up on a Florosil column, and analysis by gas chromatography with electron capture detection (GC/ECD).

Fenuron was determined in water in accordance with USEPA Method 507/8140. The procedure involved extraction with dichloromethane, solvent exchange to acetonitrile, and analysis by HPLC with spectrophotometric detection.

APPENDIX B
QA/QC

B. QUALITY ASSURANCE/QUALITY CONTROL QA/QC PROGRAM

A quality assurance/quality control program was set up to monitor data quality and reliability on an ongoing basis. As discussed in previous sections, all samples were given sequential numerical codings before submitting them to the analytical contractor. This masked all information on the nature, location and possible concentration of each sample, and negated the potential for bias in the analysis. All samples were run in batches of varying sizes with QA/QC samples which accompanied the set through the entire analytical procedure. These samples included the following:

- internal spikes (using a known concentration of an analyte), surrogate standards and/or reference material (depending on the type of analysis) to monitor analytical accuracy;
- internal blanks to monitor interferences from potential lab contamination and other analytes; and
- analytical or procedural duplicates of samples to monitor internally the precision or repeatability of the results.

Precision was also monitored externally by the prime contractors (AMBIO Research and UMA Engineering) through the blind submission of field duplicates obtained during sampling. Travel blanks (opened briefly in the field) were also submitted by the prime contractors to monitor interferences externally for certain analysis (i.e., volatile organic compounds). The results of the QA/QC program are summarized below and the QA/QC data is presented in the Tables (8.2.1 to 8.2.13) at the end of this section.

a) Inorganic Element (Metal) Analysis

Analytical precision for inorganic elements analysis was performed internally by CANTEST using NRC (National Research Council) Standard Reference Material PACS-1 for soils and a spiked matrix sample for water (Tables 8.2.1 and 8.2.2, respectively). Generally, determined values which fall within 30% of the expected value (for spikes), and/or within the range indicated by the certified value (for reference material) are considered to indicate reasonable to good analytical accuracy. Good agreement was found for a majority of the inorganic analytes in the reference material suggesting good analytical precision for the soil analysis (Table 8.2.1). A few elements, however, exhibited determined values outside of the certified range such as selenium (which was overestimated) and molybdenum, antimony, strontium and titanium (which were underestimated) suggesting fair to poor precision for these particular analytes. This discrepancy may have been due to differences in the analytical methods employed. Recovery values for the spiked water sample (Table 8.1.2) were well within the acceptable limits ($\pm 30\%$) indicating good precision. The only exception was silicon which was overestimated relative to the expected value (145%).

Three soil and two water blanks were used internally to monitor interferences (Table 8.2.1 and 8.2.2, respectively). Levels of most elements were below the detection limits with the exception of boron in the soil blank and the more common ubiquitous elements such as calcium, silicon, and sodium in the water blanks.

One pair of submitted field duplicates for soil and water were each analyzed as external monitors of analytical precision. Agreement between duplicates can be measured either by direct comparison or by calculating

the relative standard deviation (RSD), which is simply the standard deviation of the duplicates divided by the mean (expressed as a percentage). Values of RSD less than 30% indicate reasonable to good precision, while those exceeding this value are fair to poor. In the case of the field duplicates for soil, a majority of these values occurred within this limit indicating reasonable precision for most analytes (Table 8.2.1). Values for chromium (41%), aluminum (42%) and manganese (42%) suggested fair precision, while duplicates for calcium (98%) and titanium (73%) indicated relatively poor repeatability. Good precision for water analysis was indicated for a majority of the analytes based on RSD values for the pair of water sample duplicates (Table 8.2.2). The only exception was the RSD for copper (85%) which suggested poor precision for this particular analyte.

Three pairs of analytical duplicates for soils and one pair for water were analyzed to monitor precision internally by CANTEST (Tables 8.2.1 and 8.2.2). Good analytical precision was indicated for all of the analytes based on the majority of low RSD values found in both types of samples.

b) Total Extractable Hydrocarbon (TEH) Analysis

Two spiked samples each of water and soil were used internally by CANTEST to monitor analytical precision (Table 8.2.3). Reasonable accuracy for water and soil analysis was indicated by the % recovery results for these spiked samples. The values for the soil spikes were slightly high indicating that the soil results for TEH may be slightly over-estimated.

One water and two soil blank samples were used to monitor interferences internally (Table 8.2.3). The TEH values for all of these samples were below detection.

One pair of field duplicates each for soil and water were analyzed to monitor precision in TEH analysis externally by the prime contractors (Table 8.2.3). Good agreement was found between samples for both pairs of duplicates.

A pair of analytical duplicates for both soil and water were also analyzed to monitor precision internally by CANTEST. Good analytical precision was again found for both soil and water (Table 8.2.3).

c) Volatile Organic Compound (VOC) Analysis

Two spiked soil samples and one water sample were analyzed as an internal monitor of accuracy by CANTEST (Table 8.2.4 and 8.2.5, respectively). Determined values for all analytes occurred within 30% of the expected values (based on % recovery results) indicating good accuracy for both soil and water analyses. A surrogate standard of bromofluorobenzene was also analyzed with every soil and water sample. Average recovery values of this standard for 37 soil samples ($87 \pm 19\%$) and 30 water samples ($94 \pm 12\%$) were well within acceptable limits, indicating good analytical accuracy.

Three soil and water blanks, as well as two travel blanks (analyzed twice and three times, respectively) were used to monitor analytical interferences. Concentrations of all analytes were below detection in

the soil blanks and nearly all of the water blanks. The only minor exception was a detectable trace concentration of chloroform found in one of the travel blank replicates (Table 8.2.5).

Analytical precision for VOCs was monitored both externally and internally using two pair of soil analytical duplicates and six pair of water analytical duplicates, among which included a complimentary pair of field duplicates (MDGW001 and MDGW002). Although all of the values were below detection, the similarity of the detection limits of corresponding analytes for pairs of duplicates suggested good analytical precision (Table 8.2.4 and 8.2.5).

d) Volatile Organic Compounds - BTEX Analysis

Accuracy was monitored internally by Axys for the BTEX suite of volatile organic compounds using two spiked soil and an additional soil matrix spiked for oil analysis (Table 8.2.6 and 8.2.7, respectively). Percent recovery based on the determined concentrations were well within acceptable limits (< 30% of the expected value) indicating good analytical precision for this type of analysis.

Three soil and water blanks, as well as two travel blanks (analyzed twice and three times, respectively) were used to monitor analytical interferences (Tables 8.2.6 and 8.2.7, respectively). Values for most analytes were below detection in all samples with the exception of toluene which was found at detectable concentrations in the soil and two of the three analytical blanks. The lack of detectable concentrations of this compound in the travel banks suggests the possibility of a small amount of lab contamination.

Analytical precision for VOCs was monitored both externally and internally using three pair of soil analytical duplicates; six pair of water analytical duplicates among which included a complimentary pair of field duplicates (MDGW001 and MDGW002); and one pair of oil sample analytical duplicates. Good agreement was found for analytes in duplicate samples where they were found at detectable levels. The detection limits for non-detected analytes between duplicates pairs were also similar. These above results collectively indicate good analytical precision for the BTEX suite of volatiles.

e) Polycyclic Aromatic Hydrocarbon (PAH) Analysis

One sample of National Research Council (NRC) Certified Reference Material HS-6 for soils was used to monitor accuracy internally by Axys (Table 8.2.8). Reasonable agreement was found between determined and available certified values for all of the analytes indicating good analytical precision. Surrogate recovery results for specific PAHs were also used as an internal monitor for accuracy. Results for percent recoveries for most analytes (averages ranging from 53 to 79%) suggest fair to good analytical accuracy.

Analytical interferences were monitored internally using one soil and one water blank (Table 8.2.8). A number of interferences were indicated by the presence of non-reliably detected (NDR) values, particularly for the water blank. The high value of naphthalene in these blanks suggests some degree of lab contamination. Many of these NDR values are relatively close to the detection limits of other analytes. Any trace values found in samples for these particular PAHs should therefore be interpreted with caution.

f) Chlorinated Pesticide (Organochlorine) Analysis

Analytical accuracy was monitored internally by Axys using one spiked matrix each for soil (Table 8.2.9) and water (Table 8.2.10). Recovery values for various analytes ranged from 81 to 120% for soil and 66 to 100% for water suggesting reasonable to good accuracy for chlorinated pesticide analysis. A combination of 13 surrogate standards were also analyzed with soil and water samples to monitor analytical accuracy (Table 8.2.9 and 8.2.10). Average recovery values of standards in the samples were quite variable ranging from 48 to 87% for standards occurring in more than one sample. These results suggest a fair to reasonable degree of accuracy.

One analytical blank each of soil, water and oil were analyzed to monitor internally for interferences. Concentrations of analytes in nearly all samples were below detection with the exception of trace levels of dichlorobenzene in the soil and water blanks, and trichlorobenzene in the soil blank.

Two pairs of field duplicate soil samples and one pair of water samples were analyzed as an external monitor of analytical precision. Good agreement was found between both detectable and non-detectable analytes (based on similar detection limit values) indicating an acceptable degree of precision (Table 8.2.9 and 8.2.10).

Precision was also monitored internally by Axys using one pair each of soil, water and oil analytical duplicates. Good agreement between pairs, again, indicated reasonable analytical precision for pesticide analysis.

g) Polychlorinated Biphenyls (PCBs) Analysis

One spiked matrix each for soil (Table 8.2.11) and water (Table 8.2.12) were used to monitor analytical accuracy internally by Axys. Recovery values for individual Aroclors ranged from 85 to 98% indicating good accuracy; recovery values for water were slightly lower than those for soils. Accuracy was also monitored internally using PCB surrogate standards analyzed with the soil and water samples. High recovery values obtained for these standards again suggested a high degree of accuracy.

Interferences were monitored using one sample blank each for soil, water and oil (Tables 8.2.11 and 8.2.12). Trace concentrations of some Aroclors were detected in the soil and water samples and indicated that trace levels found in other samples of these types should be interpreted with caution.

Precision was monitored externally by the prime contractors using one pair each of soil and water field duplicates (Tables 8.2.11 and 8.2.12). Fair to good agreement was found for field duplicate pairs, with better analytical precision being obtained for water (Table 8.2.12).

One pair each of soil, water and oil analytical duplicate samples were used to monitor precision internally by Axys. Analytical precision was variable for these samples ranging from fair (for water samples) to good (for oil samples).

h) Phenoxyacid Herbicide Analysis

One spiked soil and one spike water sample were used to monitor accuracy internally by Axys (Table 8.2.13). Recovery values for various analytes ranged from 72 to 95% indicating good accuracy for both soil and water analysis.

One blank each for soil and water were used to monitor internally for interferences. Concentrations of all analytes were below detection.

Precision was monitored externally by the prime contractors using one pair each of water and soil field duplicates (Table 8.2.13). Although all of the values were below detection in both pairs, the similarity of the detection limits of corresponding analytes for pairs of duplicates suggested good analytical precision.

Table 8.2.1
Inorganic Element (Metal) Soil Analysis QA/QC Report

QA/QC Parameter:		Reference Material		Blanks:		
		PACS-1 (NRC) Ref#1				
Sample: Units (µg/g)	Determined	Certified	Recovery %	Blank#1	Blank#2	Blank#3
Arsenic	165	171 ±14		<0.01	<0.01	<0.01
Barium	385	-	-	<0.001	<0.001	<0.001
Cadmium	2.6	2.38 ±0.20	109	<0.005	<0.005	<0.005
Chromium	67.0	113 ±8	59	<0.03	<0.03	<0.03
Cobalt	15.5	17.5 ±1.1	89	<0.02	<0.02	<0.02
Copper	443	452 ±16	98	<0.015	<0.015	<0.015
Lead	419	404 ±20	104	<0.08	<0.08	<0.08
Mercury	4.70	4.57 ±0.16	103	<0.0002	<0.0002	<0.0002
Molybdenum	6.0	12.9 ±0.9	47	<0.04	<0.04	<0.04
Nickel	38.5	44.1 ±2.0	87	<0.025	<0.025	<0.025
Selenium	1.55	1.09 ±0.11	142	<0.05	<0.05	<0.05
Silver	<15	-	-	<0.03	<0.03	<0.03
Tin	27.0	41.1 ±3.1	66	<0.03	<0.03	<0.03
Zinc	780	824 ±22	95	<0.015	<0.015	<0.015
Aluminum	6.38	6.96 ±0.12	92	<0.15	<0.15	<0.15
Antimony	65	171 ±14	38	<0.16	<0.16	<0.16
Beryllium	<3.0	-	-	<0.006	<0.006	<0.006
Boron	85	-	-	0.07	0.06	0.07
Calcium	1.56	2.92 ±0.09	53	0.03	0.03	0.03
Iron	6.38	6.96 ±0.12	92	0.06	<0.030	<0.030
Magnesium	1.78	2.41 ±0.09	74	0.01	<0.001	<0.001
Manganese	315	470 ±12	67	<0.003	<0.003	<0.003
Phosphorus	2650	3110 ±240	85	<0.4	<0.4	<0.4
Sodium	2.40	4.40 ±0.11	55	0.1	<0.1	<0.1
Strontium	95.0	277 ±11	34	<0.001	<0.001	<0.001
Titanium	1650	4210 ±66	39	0.041	0.39	<0.006
Vanadium	93	127 ±5	73	<0.010	<0.010	<0.010

RSD = Relative Standard Deviation

Table 8.2.1
Inorganic Element (Metal) Soil Analysis QA/QC Report (cont.)

QA/QC Parameter:	Field Duplicates:			Analytical Duplicates:		
Sample: Units (µg/g)	MD1S004	MD1S005	RSD(%)	BL1S013	BL1S013	RSD(%)
Arsenic	8.7	6.3	22.6	135	140	2.6
Barium	290	270	5.1	2370	2350	0.6
Cadmium	0.26	0.27	2.7	<0.25	<0.26	-
Chromium	64	35	41.4	58	59	1.2
Cobalt	12	9	20.2	56	55	1.3
Copper	39	47	13.2	41	39	3.5
Lead	139	57	59.2	<1	<1	-
Mercury	0.31	0.054	99.5	0.26	0.27	2.7
Molybdenum	<4	<4	-	<4	<4	-
Nickel	30	22	21.8	42	41	1.7
Selenium	1.2	0.9	20.2	3.2	3.1	2.2
Silver	<2	<2	-	<2	<2	-
Tin	<5	6	-	<5	<5	-
Zinc	269	497	42.1	1490	1490	0.0
Aluminum	18400	16900	6.0	1110	1800	33.5
Antimony	<10	<10	-	<10	<10	-
Beryllium	<1	<1	-	<1	<1	-
Boron	31	26	12.4	269	282	3.3
Calcium	15200	84700	98.4	16800	17100	1.3
Iron	37500	33600	7.8	429000	437000	1.3
Magnesium	9770	7270	20.7	870	1490	37.2
Manganese	1010	1870	42.2	50000	48100	2.7
Phosphorus	2690	3870	25.4	1190	1330	7.9
Sodium	476	545	9.6	71	70	1.0
Strontium	68	120	39.1	111	115	2.5
Titanium	1220	391	72.8	55	39	24.1
Vanadium	64	46	23.1	111	116	3.1

RSD = Relative Standard Deviation

Table 8.2.1
Inorganic Element (Metal) Soil Analysis QA/QC Report (Cont.)

QA/QC Parameter:		Analytical Duplicates				
Sample:						
Units (µg/g)	JU1SS005	JU1SS005	RSD(%)	BL1SS012	BL1SS012	RSD(%)
Arsenic	2.5	2.8	8.0	3.6	3.4	4.0
Barium	52	55	4.0	117	113	2.5
Cadmium	<0.25	<0.25	-	<0.25	<0.25	-
Chromium	48	49	1.5	36	31	10.6
Cobalt	11	12	6.1	9	10	7.4
Copper	50	53	4.1	28	26	5.2
Lead	3	3	0.0	4	4	0.0
Mercury	0.026	0.032	14.6	0.016	0.016	0.0
Molybdenum	<4	<4	-	<4	<4	-
Nickel	33	35	4.2	27	24	8.3
Selenium	<0.5	<0.5	-	<0.5	<0.5	-
Silver	<2	<2	-	<2	<2	-
Tin	<5	<5	-	<5	<5	-
Zinc	82	80	1.7	60	80	20.2
Aluminum	17800	19300	5.7	13800	13700	0.5
Antimony	<10	<10	-	<10	<10	-
Beryllium	<1	<1	-	<1	<1	-
Boron	18	20	7.4	15	16	4.6
Calcium	16500	19700	12.5	5210	4300	13.5
Iron	31400	35100	7.9	25700	26400	1.9
Magnesium	11300	12300	6.0	8380	8850	3.9
Manganese	517	585	8.7	474	505	4.5
Phosphorus	1830	1890	2.3	2510	1820	22.5
Sodium	190	206	5.7	160	125	17.4
Strontium	52	64	14.6	22	18	14.1
Titanium	578	572	0.7	394	424	5.2
Vanadium	52	59	8.9	40	42	3.4

RSD = Relative Standard Deviation

Table 8.2.2
Inorganic Element (Metal) Water Analysis QA/QC Report

QA/QC Parameter:	Spike:		Blanks		
Sample: Units (mg/L)	Determined	Expected	Recovery %	Blank#1	Blank#2
Aluminum	-	-	-	<0.15	<0.15
Antimony	-	-	-	<0.15	<0.15
Arsenic	0.025	0.025	100	<0.001	<0.001
Barium	1.12	1.00	102	<0.001	<0.001
Beryllium	0.47	0.50	94	<0.003	<0.003
Boron	-	-	-	<0.01	<0.01
Cadmium	0.49	0.50	98	<0.0002	<0.0002
Calcium	-	-	-	0.07	0.05
Chromium	1.01	1.00	101	<0.001	<0.001
Cobalt	0.95	1.00	95	<0.001	<0.001
Copper	0.98	1.00	98	0.001	<0.001
Iron	2.02	1.00	120	<0.03	<0.03
Lead	0.95	1.00	95	<0.001	<0.001
Magnesium	-	-	-	<0.01	<0.01
Manganese	1.00	1.00	100	<0.003	<0.003
Mercury	0.0003	0.0003	100	<0.00005	<0.00005
Molybdenum	0.026	0.025	104	<0.001	<0.001
Nickel	0.95	1.00	95	<0.001	<0.001
Phosphorus	-	-	-	<0.4	<0.4
Potassium	-	-	-	<0.01	<0.01
Selenium	0.021	0.025	100		
Silicon	24.5	16.9	145	0.2	0.1
Silver	-	-	-	<0.001	<0.001
Sodium	-	-	-	0.7	0.7
Strontium	-	-	-	<0.001	<0.001
Tin	-	-	-	<0.001	<0.001
Titanium	-	-	-	<0.006	<0.006
Vanadium	-	-	-	<0.01	<0.01
Zinc	0.49	0.5	98	<0.01	<0.01
Zirconium	-	-	-	<0.015	<0.015

Table 8.2.2
Inorganic Element (Metal) Water Analysis QA/QC Report (cont.)

QA/QC Parameter: Field Duplicates: Analytical Duplicates:

Sample: Units (mg/L)	MD1GW001	MD1GW002	RSD(%)	BL1GW001	BL1GW001	RSD(%)
Aluminum	0.2	0.2	0.0	<0.15	<0.15	-
Antimony	<0.15	<0.15	-	<0.15	<0.15	-
Arsenic	<0.001	<0.001	-	<0.001	<0.001	-
Barium	0.031	0.037	12.5	0.067	0.065	2.1
Beryllium	<0.003	<0.003	-	<0.003	<0.003	-
Boron	13.3	12.9	2.2	0.03	0.03	0.0
Cadmium	<0.0002	<0.0002	-	<0.0002	<0.0002	-
Calcium	6.90	7.74	8.1	29.5	29.1	1.0
Chromium	0.001	<0.001	-	<0.001	<0.001	-
Cobalt	<0.001	<0.001	-	<0.001	<0.001	-
Copper	0.004	0.001	84.9	0.010	0.011	6.7
Iron	0.82	1.04	16.7	<0.03	<0.03	-
Lead	0.001	0.001	0.0	0.002	0.001	47.1
Magnesium	1.92	2.09	6.0	5.61	5.52	1.1
Manganese	0.19	0.22	10.3	<0.003	<0.003	-
Mercury	<0.00005	<0.00005	-	<0.00005	<0.00005	-
Molybdenum	<0.001	<0.001	-	0.003	0.003	0.0
Nickel	<0.001	<0.001	-	0.003	0.003	0.0
Phosphorus	<0.4	<0.4	-	<0.4	<0.4	-
Potassium	2.23	2.32	2.8	2.37	2.37	0.0
Selenium	<0.001	<0.001	-	-	-	-
Silicon	12.6	11.4	7.1	8.1	7.4	6.4
Silver	<0.001	<0.001	-	0.003	0.002	28.3
Sodium	439	380	10.2	2.5	2.4	2.9
Strontium	0.29	0.31	4.7	0.076	0.075	0.9
Tin	<0.001	<0.001	-	<0.001	<0.001	-
Titanium	<0.006	<0.006	-	<0.006	<0.006	-
Vanadium	<0.01	<0.01	-	<0.01	<0.01	-
Zinc	0.052	0.067	17.8	0.035	0.039	7.6
Zirconium	<0.015	<0.015	-	<0.015	<0.015	-

RSD = Relative Standard Deviation

Table 8.2.3
Total Extractable Hydrocarbon (TEH) Analysis QA/QC Report

QA/QC Parameter	Spikes:				Blank:		
	Water		Soil		Water	Soil	
	W-Spike1	W-Spike2	Spike 1	Spike 2	W-Blank	S-Blank1	S-Blank2
Sample Units	% Recovery		% Recovery		µg/L	µg/g	µg/g
TEH	112	115	134	126	<100	<20	<20

QA/QC Parameter	Field Duplicates:					
	Water		Water		Soil	
	MD1GW001	MD1GW002	BL1GW009	BL1GW010	MD1S006	MD1S007
Sample Units	µg/L	µg/L	µg/L	µg/L	µg/g	µg/g
TEH	<100	<100	3700	4100	<20	180

QA/QC Parameter	Analytical Duplicates:			
	Soil		Water	
	Dup#1	Dup#2	BL1GW009	BL1GW009
Sample Units	µg/g	µg/g	µg/L	µg/L
TEH	1400	1600	3700	4100

Table 8.2.4
Volatile Organic Compounds (VOCs) Soil Analysis QA/QC Report

QA/QC Parameter Sample Units (ng/g)	SSPM003			Spike:		
	Determined	Expected	Recovery %	Determined	Expected	Recovery %
1,1-Dichlorethane	12	10	120	4.0	4.3	93
t-1,3-Dichloropropene	12	10	120	2.6	4.3	60
1,1-Dichloroethane	14	10	140	2.5	4.3	58
c-1,2-Dichloroethene	11	10	110	3.3	4.3	77
Chloroform	11	10	110	6.6	4.3	153
1,1,1-Trichloroethane	13	10	130	4.7	4.3	109
1,2-Dichloroethane	10	10	100	4.6	4.3	107
1,2-Dichloropropane	13	10	130	4.5	4.3	105
Bromodichloromethane	13	10	130	4.6	4.3	107
Trichloroethylene	12	10	120	7	4.3	163
1,1,2-Trichloroethane	11	10	110	4	4.3	93
1,1,2,2-Tetrachloroethane	15	10	150	5	4.3	116
Bromoform	11	10	110	4	4.3	93

QA/QC Parameter Sample Units (ng/g)	Blanks:		
	SBLK001	SBLK002	SBLK11
1,1-Dichlorethane	<3.0	<1.9	<0.31
t-1,3-Dichloropropene	<1.8	<2.4	<0.22
1,1-Dichloroethane	<1.4	<1.6	<0.21
c-1,2-Dichloroethene	<1.9	<1.4	<0.18
Chloroform	<0.86	<1.5	<0.37
1,1,1-Trichloroethane	<0.97	<1.1	<0.16
1,2-Dichloroethane	<1.1	<1.7	<0.61
1,2-Dichloropropane	<0.8	<0.86	<0.21
Bromodichloromethane	<0.8	<0.56	<0.25
Trichloroethylene	<0.75	<1.1	<0.22
1,1,2-Trichloroethane	<0.42	<0.45	<0.24
1,1,2,2-Tetrachloroethane	<0.4	<0.44	<0.37
Bromoform	<0.43	<0.48	<0.08

Table 8.2.4
Volatile Organic Compounds (VOCs) Soil Analysis QA/QC Report (Cont.)

QA/QC Parameter		Analytical Duplicates:			
Sample Units (ng/g)					
		BO1SS005	BO1SS005	BL1SS043	BL1SS043
Compounds					
1,1-Dichlorethane		<0.17	<0.34	<0.24	<0.17
t-1,3-Dichloropropene		<0.19	<0.51	<0.27	<0.17
1,1-Dichloroethane		<0.11	<0.44	<0.18	<0.16
c-1,2-Dichloroethene		<0.19	<0.54	<0.28	<0.2
Chloroform		<0.18	<0.38	<0.24	<0.19
1,1,1-Trichloroethane		<0.13	<0.3	<0.13	<0.13
1,2-Dichloroethane		<0.17	<0.54	<0.19	<0.17
1,2-Dichloropropane		<0.11	<0.24	<0.18	<0.12
Bromodichloromethane		<0.14	<0.22	<0.17	<0.15
Trichloroethylene		<0.13	<0.32	<0.16	<0.18
1,1,2-Trichloroethane		<0.17	<0.21	<0.3	<0.11
1,1,2,2-Tetrachloroethane		<0.25	<0.25	<0.05	<0.04
Bromoform		<0.28	<0.14	<0.1	<0.13

Table 8.2.5
Volatile Organic Compounds (VOCs) Water Analysis QA/QC Report

QA/QC Parameter	Spike:			Blanks:		
	WSPM60C					
Sample Units (µg/L)	Determined	Expected	Recovery %	WBLK 1	WBLK 2	WBLK 9
1,1-Dichlorethane	2.5	2.0	120	<0.59	<2.2	<0.54
t-1,3-Dichloropropene	1.6	2.0	80	<0.64	<1.0	<0.54
1,1-Dichloroethane	1.5	2.0	75	<0.6	<0.74	<0.60
c-1,2-Dichloroethene	1.7	2.0	85	<0.71	<1.0	<0.45
Chloroform	2.0	2.0	100	<0.48	<0.51	<0.33
1,1,1-Trichloroethane	2.0	2.0	100	<0.36	<0.30	<0.25
1,2-Dichloroethane	1.5	2.0	75	<0.85	<0.93	<0.62
1,2-Dichloropropane	2.0	2.0	100	<0.39	<0.32	<0.51
Bromodichloromethane	1.9	2.0	95	<0.3	<0.31	<0.40
Trichloroethylene	2.4	2.0	120	<0.33	<0.31	<0.34
1,1,2-Trichloroethane	1.4	2.0	70	<0.22	<0.22	<0.2
1,1,2,2-Tetrachloroethane	2.0	2.0	100	<0.27	<0.25	<0.32
Bromoform	1.7	2.0	85	<0.3	<0.26	<0.13

QA/QC Parameter	Travel Blanks:				
Sample Units (µg/L)	Blank#1	Blank#4	Blank #4	Blank#4B	Blank#1
1,1-Dichlorethane	<0.48	<1.0	<0.69	<0.89	<0.69
t-1,3-Dichloropropene	<0.48	<0.49	<0.78	<0.57	<0.78
1,1-Dichloroethane	<0.4	<0.48	<0.59	<0.4	<0.59
c-1,2-Dichloroethene	<0.37	<0.41	<0.56	<0.5	<0.56
Chloroform	0.51	<0.26	<0.50	<0.45	<0.5
1,1,1-Trichloroethane	<0.28	<0.1	<0.27	<0.16	<0.27
1,2-Dichloroethane	<0.62	<0.38	<0.77	<0.42	<0.77
1,2-Dichloropropane	<0.06	<0.19	<0.68	<0.18	<0.68
Bromodichloromethane	<0.25	<0.15	<0.41	<0.13	<0.41
Trichloroethylene	<0.23	<0.15	<0.38	<0.16	<0.38
1,1,2-Trichloroethane	<0.18	<0.14	<0.24	<0.15	<0.24
1,1,2,2-Tetrachloroethane	<0.27	<0.23	<0.4	<0.12	<0.4
Bromoform	<0.05	<0.24	<0.24	<0.18	<0.24

Table 8.2.5
Volatile Organic Compounds (VOCs) Water Analysis QA/QC Report

QA/QC Parameter	Field/Analytical Duplicates				Field Duplicates:	
Sample						
Units (µg/L)	MD1GW002	MD1GW002	MD1GW001	MD1GW001	BL1GW009	BL1GW010
1,1-Dichlorethane	<0.44	<0.41	<0.75	<0.41	<0.31	<0.48
t-1,3-Dichloropropene	<0.21	<0.17	<0.43	<0.12	<0.21	<0.24
1,1-Dichloroethane	<0.13	<0.17	<0.39	<0.18	<0.11	<0.16
c-1,2-Dichloroethene	<0.17	<0.11	<0.42	<0.18	<0.15	<0.17
Chloroform	<0.09	<0.09	<0.22	<0.19	<0.10	<0.16
1,1,1-Trichloroethane	<0.07	<0.09	<0.11	<0.08	<0.08	<0.07
1,2-Dichloroethane	<0.12	<0.13	<0.42	<0.16	<0.13	<0.22
1,2-Dichloropropane	<0.06	<0.07	<0.15	<0.10	<0.08	<0.09
Bromodichloromethane	<0.07	<0.08	<0.15	<0.08	<0.06	<0.07
Trichloroethylene	<0.07	<0.06	<0.16	<0.07	<0.06	<0.08
1,1,2-Trichloroethane	<0.07	<0.05	<0.13	<0.09	<0.05	<0.07
1,1,2,2-Tetrachloroethane	<0.05	<0.06	<0.13	<0.08	<0.05	<0.06
Bromoform	<0.07	<0.06	<0.25	<0.12	<0.07	<0.08

QA/QC Parameter	Analytical Duplicates:			
Sample				
Units (µg/L)	BL1GW003	BL1GW003	BL1GW004	BL1GW004
1,1-Dichlorethane	<0.39	<0.31	<0.89	<1.0
t-1,3-Dichloropropene	<0.30	<0.24	<0.64	<0.57
1,1-Dichloroethane	<0.35	<0.28	<0.45	<0.48
c-1,2-Dichloroethene	<0.32	<0.29	<0.45	<0.52
Chloroform	<0.28	<0.18	<0.19	<0.34
1,1,1-Trichloroethane	<0.14	<0.14	<0.2	<0.14
1,2-Dichloroethane	<0.35	<0.33	<0.43	<0.43
1,2-Dichloropropane	<0.15	<0.18	<0.2	<0.16
Bromodichloromethane	<0.18	<0.15	<0.21	<0.22
Trichloroethylene	<0.15	<0.16	<0.16	<0.16
1,1,2-Trichloroethane	<0.17	<0.15	<0.19	<0.21
1,1,2,2-Tetrachloroethane	<0.16	<0.13	<0.27	<0.22
Bromoform	<0.17	<0.17	<0.22	<0.25

Table 8.2.5
Volatile Organic Compounds (VOCs) Water Analysis QA/QC Report (cont.)

QA/QC Parameter				
Sample Units (µg/L)	BL1GW001	BL1GW001	BL1GW002	BL1GW002
1,1-Dichlorethane	<0.62	<1.1	<0.33	<0.46
t-1,3-Dichloropropene	<0.87	<0.98	<0.42	<0.54
1,1-Dichloroethane	<0.67	<0.75	<0.26	<0.40
c-1,2-Dichloroethene	<0.73	<0.69	<0.31	<0.51
Chloroform	<0.51	<0.61	<0.24	<0.36
1,1,1-Trichloroethane	<0.35	<0.21	<0.2	<0.26
1,2-Dichloroethane	<0.71	<0.76	<0.39	<0.63
1,2-Dichloropropane	<0.27	<0.5	<0.24	<0.23
Bromodichloromethane	<0.36	<0.42	<0.19	<0.23
Trichloroethylene	<0.33	<0.35	<0.17	<0.20
1,1,2-Trichloroethane	<0.25	<0.21	<0.15	<0.22
1,1,2,2-Tetrachloroethane	<0.35	<0.38	<0.16	<0.17
Bromoform	<0.26	<0.29	<0.3	<0.22

Table 8.2.6
BTEX Soil Analysis QA/QC Report

QA/QC Parameter		Spikes:				
Sample Units (ng/g)	SSPM-003			SSPM041		
	Determined	Expected	Recovery %	Determined	Expected	Recovery %
Benzene	11	10	110	2.1	4.3	49
Toluene	10	10	100	4.4	4.3	102
Ethylbenzene	11	10	110	5.0	4.3	116
p/m -Xylene	22	20	110	10	8.7	115
o-Xylene	11	10	110	5	4.3	116

QA/QC Parameter		Method Blanks:		
Sample Units (ng/g)				
	SBLK-002	SBLK-001	SBLK11	
Benzene	<0.19	<0.16	0.95	
Toluene	0.72	1.6	1.4	
Ethylbenzene	<0.04	<0.05	<0.02	
p/m -Xylene	<0.05	<0.06	<0.03	
o-Xylene	<0.04	<0.06	<0.03	

QA/QC Parameter	Analytical Duplicates:					
Sample Units (ng/g)	BO1SS005	BO1SS005	SP1SS021	SP1SS022	SP1SS017	SP1SS017
Benzene	<0.06	<0.10	<0.30	<0.30	<0.25	<0.80
Toluene	<0.70	<0.70	<2.0	<2.1	<2.7	<2.1
Ethylbenzene	<0.05	<0.05	<0.07	<0.16	NDR 7.4	NDR 12
p/m -Xylene	0.07	<0.02	0.34	0.21	130	120
o-Xylene	<0.02	<0.03	0.17	<0.18	2300	2600

Table 8.2.7
BTEX Water and Oil Analysis QA/QC Report

QA/QC Parameter: Sample Units ($\mu\text{g/L}$)	Spike Determined	SPM60C		Travel Blanks:			
		Expected	Recovery	Blank #1	Blank #1B	Blank #4A	Blank #4B
Benzene	2.5	2.0	120	<0.07	<0.03	<0.03	<0.04
Toluene	3.6	3.2	100	<0.3	<0.4	<1.0	<1.0
Ethylbenzene	3.9	3.8	100	<0.02	<0.02	<0.01	<0.01
p/m -Xylene	5.3	5.3	100	<0.02	<0.02	<0.02	<0.03
o-Xylene	3.8	3.8	100	<0.02	<0.02	<0.01	<0.01

QA/QC Parameter: Sample Units ($\mu\text{g/L}$)	Analytical Blanks:				Field/Analytical Duplicates		
	WBLK1	WBLK2	WBLK9	MD1GW001	MD1GW001	MD1GW002	MD1GW002
Benzene	<0.07	<0.08	<0.06	<0.03	<0.02	<0.01	<0.02
Toluene	<0.02	1.2	<0.007	<1.0	<1.0	<0.62	<0.64
Ethylbenzene	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
p/m -Xylene	<0.03	<0.05	<0.02	<0.03	<0.03	<0.01	<0.01
o-Xylene	<0.02	<0.01	<0.02	<0.01	<0.01	<0.01	<0.01

QA/QC Parameter: Sample Units ($\mu\text{g/L}$)	Analytical Duplicates:					
	BO1GW001	BO1GW001	BL1GW001	BL1GW001	BL1GW002	BL1GW002
Benzene	<0.09	<0.15	<0.07	<0.08	<0.04	<0.05
Toluene	<0.8	<0.8	<1.0	<0.88	<0.88	<0.78
Ethylbenzene	<0.25	<0.24	<0.01	<0.02	<0.01	<0.01
p/m -Xylene	<0.39	<0.45	<0.02	<0.02	<0.05	<0.05
o-Xylene	<0.13	<0.12	<0.02	<0.02	<0.02	<0.01

QA/QC Parameter: Sample Units ($\mu\text{g/L}$)	Analytical Duplicates:				JU1SS021 Oil ($\mu\text{g/g}$)	JU1SS021 Oil ($\mu\text{g/g}$)
	BL1GW003	BL1GW003	BL1GW009	BL1GW010		
Benzene	0.4	0.41	2.4	2.3	<340	<350
Toluene	<1.2	<1.6	18	19	<800	<5000
Ethylbenzene	1.8	2.0	20	20	140	170
p/m -Xylene	1.3	1.4	68	69	610	780
o-Xylene	1.6	1.8	49	50	330	380

Table 8.2.8
Polycyclic Aromatic Hydrocarbon (PAH) Analysis QA/QC Report

QA/QC Parameter	Certified Reference		Blanks:	
	Material HS-6 (NRC): S-CRM 264i		Soil SBLK 776 i	Water WBLK 775
Sample Units	Determined ng/g	Expected	ng/g	ng/L
Naphthalene	4800	4100 +/- 1100	18	12
Acenaphthylene	140	190 +/- 50	<1.8	0.6
Acenaphthene	150	230 +/- 70	4.8	<0.54
Fluorene	360	470 +/- 120	NDR(5.7)	NDR 1.6
Phenanthrene	3600	3000 +/- 600	11	NDR 3.9
Anthracene	910	1100 +/- 400	NDR 3.9	NDR 1.3
Fluoranthene	3800	3540 +/- 650	2.8	NDR 1.4
Pyrene	3100	3000 +/- 600	2.9	NDR 1.0
Benz(a)anthracene	1800	1800 +/- 300	<0.8	0.38
Chrysene	2200	2000 +/- 300	<0.78	NDR 1.8
Benzofluoranthenes	5000	4230 +/- 750	<3.8	<1.8
Benzo(e)pyrene	1900		<3.6	<1.8
Benzo(a)pyrene	1700	2200 +/- 400	<4.6	<2.2
Perylene	520		<4.8	<2
Dibenz(ah)anthracene	470	490 +/- 160	<3.5	<3.2
Indeno(1,2,3-cd)pyrene	2100	1950 +/- 580	NDR 2.6	<2.1
Benzo(ghi)perylene	1800	1780 +/- 720	NDR 1.3	<1.8

Surrogate Recovery Results (%)		
Surrogate Standards	Average (n=6)	SD.
Naphthalene d-8	53	±9
Acenaphthene d-10	63	±19
Phenanthrene d-10	66	±14
Pyrene d-10	75	±10
Chrysene d-12	79	±26
Benzo(a)pyrene d-12	72	±10
Perylene d-12	74	±7
Dibenz(ah)anthracene d-14	53	±10
Benzo(ghi)perylene d-12	64	±6

Table 8.2.9
Chlorinated Pesticide Soil Analysis QA/QC Report

QA/QC Parameter:	Spike			Blank:
Sample Units (ng/g)	SPM 441			SBLK599 i2
	Determined	Expected	Recovery %	
Dichlorobenzene	9.7	12	81	0.29
Trichlorobenzene	9.9	12	83	0.04
Tetrachlorobenzene	10	11	91	<0.002
Pentachlorobenzene	3.3	3.9	85	<0.005
Hexachlorobenzene	5.8	5.6	104	<0.02
alpha HCH	5.6	5.6	100	<0.02
beta HCH	7.2	8.2	88	<0.04
gamma HCH	5.1	5.4	94	<0.03
Heptachlor	6.3	5.3	119	<0.04
Aldrin	3.5	3.1	113	<0.01
Oxychlordane	4.7	5.0	94	<0.05
trans-Chlordane	3.2	3.2	100	<0.01
cis-Chlordane	4.5	4.8	94	<0.01
o,p'-DDE	4.9	5.7	86	<0.07
p,p'-DDE	6.0	5.4	111	<0.1
trans-Nonachlor	4.2	4.1	102	<0.01
cis-Nonachlor	4.2	4.2	100	<0.02
o,p'-DDD	5.1	5.6	91	<0.09
p,p'-DDD	5.7	6.2	92	<0.1
o,p'-DDT	6.9	7.6	91	<0.39
p,p'-DDT	7.0	6.2	113	<0.49
Mirex	5.4	5.4	100	<0.01
Heptachlor Epoxide	4.0	4.0	100	<0.02
alpha-Endosulphan (I)	3.4	4.0	85	<0.02
Dieldrin	5.0	5.2	96	<0.02
Endrin	11	11	100	<0.04
Methoxychlor	30	25	120	<0.09

Table 8.2.9
Chlorinated Pesticide Soil Analysis QA/QC Report (Cont.)

Surrogate Recovery Results for Soils (%)			
Surrogate Standards	Average (n=10)		SD.
13C-1,4-Dichlorobenzene	9		-
13C-1,2,4-Trichlorobenzene	24		-
13C-1,2,4,5-Tetrachlorobenzene	30		-
13C-Pentachlorobenzene	35		-
13C-Hexachlorobenzene	48	±	20
13C-gamma HCH	51	±	21
13C-p,p'-DDE	65	±	20
13C-p,p'-DDT	58	±	29
13C-Mirex	58	±	25
13C-PCB 101	65	±	20
13C-PCB 180	75	±	19
13C-PCB 209	77	±	20
d4-alpha-Endosulphan	79	±	18

Table 8.2.9
Chlorinated Pesticide Soil Analysis QA/QC Report (cont.)

QA/QC Parameter:	Field Duplicates:		Analytical Duplicates:	
Sample Units (ng/g)	MD1SS006	MD1SS007	B01S001	B01S001
Dichlorobenzene	-	-	-	-
Trichlorobenzene	-	-	-	-
Tetrachlorobenzene	-	-	-	-
Pentachlorobenzene	-	-	-	-
Hexachlorobenzene	2.6	1.6	<0.06	<0.1
alpha HCH	2.4	2.5	0.06	0.06
beta HCH	<0.26	0.1	<0.04	<0.04
gamma HCH	0.31	0.3	<0.03	<0.03
Heptachlor	<0.16	<0.07	<0.07	<0.12
Aldrin	<0.01	<0.02	<0.004	<0.006
Oxychlordan	<0.05	<0.06	<0.06	<0.04
trans-Chlordan	<0.05	<0.06	<0.07	<0.01
cis-Chlordan	0.07	<0.04	<0.03	<0.02
o,p'-DDE	<0.11	<0.09	1.10	1.10
p,p'-DDE	1.3	1.1	60	64
trans-Nonachlor	<0.04	NDR 0.05	<0.04	<0.02
cis-Nonachlor	<0.04	<0.03	<0.05	<0.06
o,p'-DDD	1.2	NDR 0.42	12	13
p,p'-DDD	4.6	0.81	80	82
o,p'-DDT	<3.8	<0.86	6.4	6.9
p,p'-DDT	NDR 62	50	47	45
Mirex	<0.05	<0.03	<0.05	<0.03
Heptachlor Epoxide	<0.05	<0.1	<0.5	<0.4
alpha-Endosulphan (I)	<0.05	<0.03	<0.26	<0.27
Dieldrin	<0.05	<0.15	<0.26	<0.27
Endrin	<0.08	<0.05	<0.45	<0.46
Methoxychlor	<0.25	<0.16	<1.4	<1.5

Table 8.2.10
Chlorinated Pesticide Water and Oil Analysis QA/QC Report

QA/QC Parameter: Sample Units (ng/L)	Spikes: Water			Blanks: Water Oil WBLK600 OBLK608 ng/g	
	Determined	Expected	Recovery %		
Dichlorobenzene	120	120	100	1.2	-
Trichlorobenzene	100	120	83	<0.26	-
Tetrachlorobenzene	110	110	100	<0.06	-
Pentachlorobenzene	37	39	95	<0.25	-
Hexachlorobenzene	50	56	89	0.16	<2.8
alpha HCH	46	56	82	<1.3	<1.3
beta HCH	70	82	85	<2.2	<5.2
gamma HCH	46	54	85	<1.7	<2.6
Heptachlor	60	58	100	<0.87	<5.2
Aldrin	31	36	86	<0.3	<3.0
Oxychlordane	41	50	82	<1.6	<3.4
trans-Chlordane	29	32	91	<0.12	<3.0
cis-Chlordane	40	48	83	<0.13	<3.2
o,p'-DDE	45	57	79	<0.09	<4.2
p,p'-DDE	52	54	96	NDR 0.36	<4.0
trans-Nonachlor	36	41	88	<0.12	<3.4
cis-Nonachlor	35	42	83	<0.12	<3.0
o,p'-DDD	46	56	82	<0.15	<5.0
p,p'-DDD	50	62	81	<0.16	<4.8
o,p'-DDT	60	76	79	<0.28	-
p,p'-DDT	57	62	92	<0.33	<10
Mirex	51	54	94	NDR 3.4	<6.6
Heptachlor Epoxide	27	40	68	<0.12	<14
alpha-Endosulphan (I)	28	40	70	<0.14	<15
Dieldrin	36	52	69	<0.14	<14
Endrin	73	110	66	<0.22	<120
Methoxychlor	170	250	68	<0.63	<84

Table 8.2.10
Chlorinated Pesticide Water and Oil Analysis QA/QC Report (Cont.)

Surrogate Recovery Results for Water (%)		
Surrogate Standards	Average (n=8)	SD.
13C-1,4-Dichlorobenzene	14	-
13C-1,2,4-Trichlorobenzene	32	-
13C-1,2,4,5-Tetrachlorobenzene	42	-
13C-Pentachlorobenzene	52	-
13C-Hexachlorobenzene	63	±27
13C-gamma HCH	65	±27
13C-p,p'-DDE	79	±26
13C-p,p'-DDT	64	±29
13C-Mirex	65	±25
13C-PCB 101	78	±25
13C-PCB 180	76	±22
13C-PCB 209	80	±24
d4-alpha-Endosulphan	87	±15

Table 8.2.10
Chlorinated Pesticide Water and Oil Analysis QA/QC Report

QA/QC Parameter: Sample Units (ng/L)	Field/Analytical Duplicates:				
	MD1GW002	MD1GW001	MD1GW001	JU1SS021	JU1SS021
	Water	Water	Water	Oil ng/g	Oil ng/g
Dichlorobenzene	-	-	-	-	-
Trichlorobenzene	-	-	-	-	-
Tetrachlorobenzene	-	-	-	-	-
Pentachlorobenzene	-	-	-	-	-
Hexachlorobenzene	<0.14	<0.12	<0.16	<1.0	<2.2
alpha HCH	<0.81	<0.81	<0.84	<1.3	<1.2
beta HCH	<1.3	<1.3	<1.4	<5.2	<4.6
gamma HCH	<1	<1.5	<1.1	<2.6	<2.4
Heptachlor	<0.53	<0.83	<0.68	<11	<7.2
Aldrin	<0.32	<0.45	<0.25	<6.2	<6.2
Oxychlordane	<1.4	<2.2	<1.5	<4.6	<3.8
trans-Chlordane	<0.13	<0.11	<0.11	<3.8	<3.2
cis-Chlordane	<0.14	<0.11	<0.12	<4.2	<3.6
o,p'-DDE	<0.1	<0.17	<0.12	<8.8	<6.0
p,p'-DDE	<0.55	<0.4	<0.40	<8.2	<5.6
trans-Nonachlor	<0.19	<0.11	<0.1	<7.0	<4.6
cis-Nonachlor	<0.2	<0.12	<0.11	<4.0	<3.4
o,p'-DDD	<0.17	<0.2	<0.13	<6.6	<5.6
p,p'-DDD	<0.18	<0.2	<0.14	<6.2	<5.2
o,p'-DDT	<0.33	<0.37	<0.26	-	-
p,p'-DDT	<0.4	<0.45	<0.32	<22	<14
Mirex	<3.5	<3.5	<3.6	<14	<10
Heptachlor Epoxide	<0.18	<0.14	<0.24	<14	<18
alpha-Endosulphan (I)	<0.2	<0.25	<0.27	NDR 42	NDR 75
Dieldrin	<0.2	<0.16	<0.27	<14	<18
Endrin	<0.32	<0.25	<0.43	<130	<150
Methoxychlor	<1	<0.82	<1.4	<54	<66

Surrogate Recovery Results for Oil (%)

Surrogate Standards	JU1SS021	JU1SS021	OBLK608	Average	SD
Tetrachloro-M-xylene	90	81	95	89	±7
d4-alpha endosulphan	93	92	90	92	±2

QA/QC Parameter	Spike:			Blank:
Sample Units (ng/L)	SSPM441 Determined	Expected	Recovery %	SBLK599
Aroclor 1242	40	45	89	<1.1
Aroclor 1254	45	46	98	0.22
Aroclor 1260	42	46	91	0.31

QA/QC Parameter Sample Units (ng/L)	Field Duplicates:		Analytical Duplicates:	
	MD1S006	MD1S007	BO1S001	BO1S001
Aroclor 1242	2.4	<0.2	<0.31	<0.2
Aroclor 1254	2	1.7	1.1	1.4
Aroclor 1260	1.3	<0.8	<0.6	<0.5

Surrogate Recovery Results for Soil (%)					
Surrogate Standards	BL1SS043	BL1SS024	BL1S012	Average	SD.
13C-PCB 101	70	85	68	74	±9
13C-PCB 180	81	89	80	83	±5

Table 8.2.12 Polychlorinated Biphenyl (PCB) Water and Oil Analysis QA/QC Report					
QA/QC Parameter:	Spikes:			Blanks:	
	WSPM442			Water	Oil
				WBLK600	OBLK608
Sample Units (ng/L)	Determined	Expected	Recovery %		
Aroclor 1242	390	450	87	<1.1	<140
Aroclor 1254	390	460	85	2.6	<160
Aroclor 1260	390	460	85	<2.0	<90

QA/QC Parameter:	Field/Analytical Duplicates:			Analytical Duplicates:	
Sample	MD1GW002	MD1GW001	MD1GW001	JULSS021	JULSS021
Units (ng/L)					
Aroclor 1242	<2.6	<1.3	<1.2	<28	<68
Aroclor 1254	5.6	7.7	3.5	<210	<220
Aroclor 1260	<2.0	<3.6	<1.9	<100	<130

PCB Surrogate Standards - Water				
	BL1GW006	BL1GW009	Average	SD.
13C-PCB 101	85	94	90	±6
13C-PCB 180	100	100	100	±0

PCB Surrogate Standards - Oil					
	OBLK608	JULSS021	JULSS021	Average	SD.
PCB209	99	75	92	89	12

Table 8.2.13
Phenoxyacid Herbicide Analysis QA/QC Report

QA/QC Parameter:		Spikes:			Soil		
Sample:		Water			Soil		
		Determined	Expected	Recovery	Determined	Expected	Recovery
Units		µg/L	µg/L	%	µg/g	µg/g	%
Dicamba		0.081	0.1	81	0.032	0.04	81
2,4-D		0.33	0.38	84	0.13	0.15	86
2,4-DB		0.82	0.99	83	0.31	0.4	78
MCPA		18	24	74	8.1	9.5	85
MCPP		88	104	85	40	42	95
Picloram		0.14	0.19	72	0.043	0.074	58
2,4,5-T		0.089	0.11	81	0.038	0.044	87
2,4,5-TP		0.07	0.09	82	0.03	0.034	88

QA/QC Parameter:		Method Blanks:		Field Duplicates:		
				Water	Soil	
Sample:		Water	Soil	MD1GW002	MD1GW001	MD1S007 MD1S006
Units:		µg/L	µg/g	µg/L		µg/g
Dicamba		<0.1	<0.002	<0.1	<0.1	<0.002 <0.002
2,4-D		<0.4	<0.005	<0.4	<0.4	<0.005 <0.005
2,4-DB		<1.0	<0.03	<1	<1	<0.03 <0.03
MCPA		<50	<0.4	<50	<50	<0.4 <0.4
MCPP		<110	<2.0	<110	<110	<2.0 <2.0
Picloram		<0.1	<0.1	<0.1	<0.1	<0.1 <0.1
2,4,5-T		<0.1	<0.002	<0.1	<0.1	<0.002 <0.002
2,4,5-TP		<0.1	<0.002	<0.1	<0.1	<0.002 <0.002

APPENDIX C
SAMPLE DESCRIPTIONS

C. SAMPLE DESCRIPTIONS

MILE 207.6 SPILL SITE

Sample	Field Code	Type	Location	Description ¹
SP1SS001	SS-01	Soil	22 m from pipeline right of way near centre of spill area	33 cm profile in silt sand substrate;
SP1SS002	SS-02	Soil		15-20 cm profile in organic substrate/root mat
SP1SS003	SS-03	Soil	213 m down from pipeline right of way	33 cm profile in silty clay near permafrost
SP1SS004	SS-04	Soil		15 cm profile in black organic soil with roots; HC ² odour
SP1SS005	SS-05	Soil	290 m down from pipeline right of way	25 cm profile in black organic & silty-clay soil; HC odour
SP1SS006	SS-11	Soil	Station 4: 102 m NE from eastern fork in old service road at edge of spill area along channel	13-15 cm profile in organic top soil
SP1SS007	SS-12	Soil		38-43 cm profile in moist clay-silt substrate
SP1SS008	SS-13	Soil		56-58 cm profile at permafrost in clay substrate
SP1SS009	SS-14	Soil	Station 2: 50 m E of eastern fork in old service road in open area roughly 30 m wide; 52 m W from Station 4	15 cm profile in organic soil
SP1SS010	SS-15	Soil		40 cm profile in clay substrate
SP1SS011	SS-16	Soil		51-56 cm profile at permafrost in clay substrate; slight HC odour
SP1SS012	SS-17	Soil	Station 5: 22 m W of eastern fork in old service road; 7-8 m S.E. of SS-05 on slight rise	20-23 cm profile in organic soil; slight HC odour
SP1SS013	SS-18	Soil		38-41 cm profile in clay permafrost substrate
SP1SS014	SS-19	Soil	Station 6: 11.5 m NW of Station 5 in depression, W of eastern fork in service road	18-23 cm profile in very organic soil; strong HC odour
SP1SS015	SS-20	Soil		25-30 cm profile in HC stained clay

¹ All samples, including those used for field screening were retained for follow-up analysis, if needed.

² Hydrocarbon, usually petroleum.

MILE 207.6 SPILL SITE (CONT.)

Sample	Field Code	Type	Location	Description
SP1SS016	SS-21	Soil		36-41 cm profile in clay permafrost layer; slight HC odour
SP1SS017	SS-22	Soil		30-51 cm profile in clay permafrost layer; composite; slight HC odour; for lab
SP1SS018	SS-23	Soil	Station 7: 30 m NW of Station 5; W of eastern fork in old service road; 18 m NW of Station 6 along knoll in small clearing	25-30 cm profile in organic & sand substrate near permafrost
SP1SS019	SS-24	Soil	Station 8: 1st point along transect by western fork of old pipeline service road; W edge of spillway marked by dead trees	38-43 cm profile in brown clay permafrost substrate
SP1SS020	SS-24B	Soil	Station 9: 2nd point along spillway transect by western fork of old pipeline service road; 22 m SE of Station 8; in centre of spillway	8-20 cm profile in organic clay substrate
SP1SS021	SS-25	Soil		8-20 cm profile in organic clay substrate; for organic lab analysis
SP1SS022	SS-26	Soil		8-20 cm profile in organic clay substrate; for inorganic lab analysis
SP1SS023	SS-27	Soil		36-41 cm profile in sandy clay permafrost substrate
SP1SS024	SS-28	Soil	Station 10: 3rd point along transect by western fork of old pipeline service road; 47 m SE of Station 8 and 25 m SE of Station 9; along far SE edge of spillway marked by dead trees; adjacent to old burned low-lying area	23-38 cm profile composite including silty clay and permafrost layers
SP1SS025	SS-29	Soil	Station 11: 1st. point of transect running E & 20 m parallel to pipeline right of way; 22 m E of SS01/02; along S edge of spillway marked by dead trees	28-36 cm profile in dark brown clay substrate

MILE 207.6 SPILL SITE (CONT.)

Sample	Field Code	Type	Location	Description
SP1SS026	SS-30	Soil	22 m from pipeline right of way near centre of spill area	51-58 cm profile in light clay permafrost substrate
SP1SS027	SS-31	Soil		20-30 cm profile in organic clay substrate; organic lab analysis
SP1SS028	SS-32	Soil		8-20 cm profile in organic clay substrate; inorganic lab analysis
SP1SS029	SS-33	Soil		8-20 cm profile in organic clay substrate; screening analysis
SP1SS030	SS-34	Soil	Station 13: 3rd. point of transect running E & 20 m parallel to pipeline right of way; 38 m E of Station 11; N of centre of spillway marked by dead trees	8-20 cm profile in organic clay substrate; HC odour
SP1SS031	SS-35	Soil		20-25 cm profile in organic clay near permafrost
SP1SS032	SS-36	Soil	Station 14: last point of transect running E & 20 m parallel to pipeline right of way; 64 m E of Station 11; along far N edge of spillway marked by dead trees	33-38 cm profile in dry, dark brown organic substrate; slight HC odour
SP1SS033	SS-113	Soil	Station 6: 11.5 m W. of Station 5 in depression, W of eastern fork in old service road	53 cm profile in clay permafrost soil
SP1SS034	SS-114	Soil	Station 8A: 18 m from Station 8; parallel with old service road along W edge of spillway marked by dead trees; 38 m from Station 9	47 cm profile in clay permafrost soil
SP1SS035	SS-115	Soil	Station 8: 1st point along transect by western fork of old pipeline service road; W edge of spillway marked by dead trees	46 cm profile in clay permafrost soil

HAINES JUNCTION PUMP STATION

Sample	Field Code	Type	Location	Description
JU1SS001	SS-37	Soil	Test Pit 1: Landfill (S side of site) near centre; 2.5 m depth; various debris including scrap metal & pipe, batteries, bottles, wood scraps; barrels and oily substance in profile	2 m profile from clay sand substrate at pit base; composite
JU1SS002	SS-38	Soil		2 m profile from clay sand substrate at pit base; various debris; composite; inorganic lab analysis
JU1SS003	SS-39	Soil	Test Pit 2: Landfill (S side of site) along SW side; 6 m SW of Pit 2; 0.5 m depth; single barrel excavated	0.5 m profile from native clay substrate at pit base; drum; composite; inorganic lab analysis
JU1SS004	SS-40	Soil	Test Pit 1: Landfill (S side of site) near centre; 2.5 m depth; various debris including scrap metal & pipe, batteries, bottles, wood scraps; barrels and oily substance in profile	2.5 m profile from native grey clay substrate at pit base; organic lab analysis
JU1SS005	SS-41	Soil		2.5 m profile from native grey clay substrate at pit base; inorganic lab analysis
JU1SS006	SS-42	Soil	Test Pit 3: Landfill (S side of site) near S end of landfill; 2.5 m depth; various debris including large piping, tires, barrels with HC product, tires, metal siding, heavy equipment parts, bed springs, scrap metal	Composite sample from sandy clay soil around debris for inorganic analysis
JU1SS007	SS-43	Soil		Composite sample from brown mineral soil around debris for organic analysis
JU1SS008	SS-44	Soil		2.5 m profile at base of pit in native grey clay soil; some stones
JU1SS009	SS-45	Soil	Test Pit 4: Landfill (S side of site) 2.5 m N of Pit 3; 6 m SE of Pit 2; 2 m depth; various debris including barrels with HC product, large cans, plastic tubing, wood debris, metal scraps	Composite of mineral soil around drums

HAINES JUNCTION PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
JU1SS010	SS-46	Soil		Composite of mineral soil around drums; for lab organic analysis
JU1SS011	SS-47	Soil		Composite of mineral soil around drums for lab inorganic analysis
JU1SS012	SS-48	Soil		Native grey clay soil from base of pit
JU1SS013	SS-49	Soil	Test Pit 1: Landfill (S side of site) near centre; 2.5 m depth; various debris including scrap metal & pipe, batteries, bottles, wood scraps; barrels and oily substance in profile	Base of pit 30-50 cm deeper than SS-40 in native soil
JU1SS014	SS-50	Soil		Base of pit 30-50 cm deeper than SS-41; lab organic analysis
JU1SS015	SS-51	Soil	Landfill drainage in woods on E side; 50 m from edge of clearing delineating facility	25-76 cm composite profile in sandy clay
JU1SS016	SS-52	Soil	Test Pit 8: by gravel and pipe-construct ramp area at N end of station; no debris	15 cm profile in gravel clay layer for lab inorganic analysis
JU1SS017	SS-53	Soil		25 cm profile in brown clay layer for lab inorganic analysis
JU1SS018	SS-54	Soil		46 cm profile in hard-packed gravelly clay layer for lab inorganic analysis
JU1SS019	SS-55	Soil		Composite of all layers
JU1SS020	SS-56	Soil	Test Pit 9: across from 2nd old downed shack along old E service road in wooded area; old vehicle part excavated	Sandy clay fill below car part; over silt layer
JU1SS021	BS-1	Oil	Test Pit 4: Landfill (S side of site) 2.5 m N of Pit 3; 6 m SE of Pit 2; 2 m depth; various debris including barrels with HC product, large cans, plastic tubing, wood debris, metal scraps	Sample of fluid from barrel contents; oil

MILLION DOLLAR FALLS

Sample	Field Code	Type	Location	Description
MD1GW001	WS-5	Water	Campsite well near centre of recreation area	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
MD1GW002	WS-9	Water		One 60 ml purgeable; one 1L; one 4L; one 500 ml
MD1S001	SS-06	Sediment	N end of small creek near Takhanne R.	Sandy-organic surface sediment
MD1S002	SS-07	Soil	Base of large dump along slope at W end of site; 3 m from edge of creek leading to Takhanne R.	Top 10 cm in dark organic soil
MD1S003	SS-79	Soil	Base of large dump along slope at W end of site; 3 m from edge of creek leading to Takhanne R.; 45 cm Test pit next to SS-07	5 cm of surface organic clay topsoil with roots and charred wood; field screen
MD1S004	SS-80	Soil		5 cm of surface organic clay topsoil with roots and charred wood; lab inorganic analysis
MD1S005	SS-81	Soil		Field duplicate of SS-80
MD1S006	SS-82	Soil	Base of large dump along slope at W end of site; 3 m from edge of creek leading to Takhanne R.; 45 cm Test pit next to SS-07	5 cm of organic clay topsoil with roots and charred wood; lab organic analysis
MD1S007	SS-83	Soil		Field duplicate of SS-882
MD1S008	SS-85	Soil	In creek, 30 m N of SS-79; 16 m before it joins Takhanne R.	Surface sample of fine silty sand sediment along edge of bank; inorganic analysis
MD1S009	SS-86	Soil	By "homemade" hatchery in stream 114 m S of SS-79 and dump	Surface sample of fine silty sand sediment from streambed; lab organic analysis
MD1S010	SS-87	Soil		Surface sample of fine silty sand sediment from streambed; lab inorganic analysis
MD1S011	SS-88	Soil		Surface sample of fine silty sand sediment from streambed; field test

MILLION DOLLAR FALLS (CONT.)

Sample	Field Code	Type	Location	Description
MD1SS001	SS-08	Soil	Base of large dump along slope at W end of site; 3 m from edge of creek leading to Takhanne R.; 45 cm Test pit next to SS-07	45 cm profile in silty fluvial soil with wood debris
MD1SS002	SS-84	Soil	Base of large dump along slope at W end of site; 3 m from edge of creek leading to Takhanne R.; 45 cm Test pit next to SS-07	60 cm profile in clay sand in water table
MD1W001	WS-6	Water	Stream at toe of dump along slope at W end of site, near SS-79	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
MD1W002	WS-7	Water	In stream 30 m N of SS-79; 16 m before it joins Takhanne R.; near SS-85	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
MD1W003	WS-8	Water	By "homemade" hatchery in stream 114 m S of SS-79 and dump; by SS-86	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
MD1W004	Blank 4	Water	Travelling blank	Opened at site; one 60 ml purgeable

BLANCHARD RIVER PUMP STATION

Sample	Field Code	Type	Location	Description
BL1GW001	WS-1	Water	Well used for drinking by maintenance camp	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW002	WS-2	Water	Rafting operator's water supply S of site	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW003	WS-3	Water	Ledge above river at SW side of site; mini-piezometer	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW004	WS-4	Water	Red leachate spring near top of slope at N end of site	Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW005	MW1	Water	Monitoring Well 1: in Drill Hole 1, 8 m S of N border fence of site near station entry road; 0.6 m increments to 5.5 m	1.2 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW006	MW2	Water	Monitoring Well 2: in Drill Hole 2, 20 m E of Drill Hole 1 along fence; 0.6 m increments to 18'	3 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW007	MW3	Water	Monitoring Well 3: in Drill Hole 3, 40 m N of Hole 2 on opposite side of fence and service road; 0.6 m increments to 5.5 m	2.4 m groundwater depth; one 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW008	MW4	Water	Monitoring Well 4: in Drill Hole 4, 17 m W of Hole 3; 40 m N of Hole 2 on opposite side of fence and service road at N end of station; 0.6 m increments down to 4.3 m	2.4 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml

BLANCHARD RIVER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BL1GW009	MW5A	Water	Monitoring Well 5: in Drill Hole 5, S side of station; 3 m N of border fence; top of slope above terrace along river	8.25 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1GW010	MW5B	Water		Field duplicate of MW-5A; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BL1S001	SS-09	Sediment	East side of site in rusty leachate spring into river	Surface silt sediment; HC odour
BL1S002	SS-10	Soil	W side of site next to Blanchard R.; percolating water with dead vegetation in vicinity	Sandy organic surface soil with dead vegetation; HC odour
BL1S003	SS-69	Soil	Below terrace, 2 m from river, at SW side of site	Dead moss over coarse sand-gravel soil; lab organic analysis
BL1S004	SS-70	Soil		Dead moss over coarse sand-gravel soil; lab inorganic analysis
BL1S005	SS-71	Soil		Dead moss over coarse sand-gravel soil; field screen
BL1S006	SS-72	Soil		Field duplicate of SS-71
BL1S007	SS-75	Soil	Drainage at bottom of N slope of site, approximately 30 m from Blanchard R.	Surface sediment of fine organic silt
BL1P001	SS-75P1	Plant		<i>Equistem</i> sp.; whole; separate organic and inorganic subsamples
BL1P002	SS-75P2S	Plant		<i>Salix</i> sp.: shoots; separate organic and inorganic subsamples
BL1P003	SS-75P2R	Plant		<i>Salix</i> sp.: roots; separate organic and inorganic subsamples
BL1S008	SS-76	Soil	Rust coloured drainage half way down N slope of site	Surface sediment of red over dark-coloured organic silt; field screening
BL1S009	SS-77	Soil	Rust coloured drainage half way down N slope of site	Surface sediment of red over dark-coloured organic silt; lab inorganic analysis
BL1S010	SS-78	Soil		Surface sediment of red over dark-coloured organic silt; lab organic analysis

BLANCHARD RIVER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BL1P004	SS-76P1	Plant		<i>Equistem</i> sp.; whole; separate organic and inorganic subsamples
BL1P005	SS-76P2S	Plant		<i>Salix</i> sp.: shoots; separate organic and inorganic subsamples
BL1P006	SS-76P2R	Plant		<i>Salix</i> sp.: roots; separate organic and inorganic subsamples
BL1S011	SS-89	Soil	Red rusty spring on north slope of site; near top where effluent appears	Surface sample of silty organic sediment over dark organic layer; field screen
BL1S012	SS-90	Soil		Surface sample of silty organic sediment over dark organic layer; lab organic analysis
BL1S013	SS-91	Soil		Surface sample of silty organic sediment over dark organic layer; lab inorganic analysis
BL1S014	SS-165	Soil	Background location along stream in foothills, roughly 200 m E of station; 100 m upstream from culvert bridge	Surface sample in coarse-medium sand with silt; lab organic analysis
BL1S015	SS-166	Soil		Surface sample in coarse-medium sand with silt; lab inorganic analysis
BL1P007	SS-165P	Plant		<i>Equistem</i> sp.; whole; separate organic and inorganic subsamples
BL1SS001	SS-57	Soil	Test Pit 1: NE side of site in NE direction; 2 m depth; various debris including logs, plywood, metal strapping and siding, plastic tubing, metal bumper, concrete/wood footings, metal heat exchanger block, metal and wood debris	2 m profile in medium-coarse sand below water table
BL1SS002	SS-58	Soil		2 m profile in medium-coarse sand below water table; lab inorganic analysis
BL1SS003	SS-59	Soil		Composite of sandy clay and gravel substrate above water line

BLANCHARD RIVER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BL1SS004	SS-60	Soil		Composite of sandy clay and gravel substrate above water line; lab inorganic analysis
BL1SS005	SS-61	Soil	Test Pit 3: along S side of road at N end of station; 3 m depth; various debris including metal strapping, wood, tape, transformer casing, junction pipe, burnt timber, pump pistons (remains of pumphouse equipment)	Sandy clay soil with some insulation from within casing of excavated transformer
BL1SS006	SS-62	Soil		Composite of top 2 m fine sand substrate; field screening
BL1SS007	SS-63	Soil		Composite of top 2 m fine sand substrate; lab inorganic analysis
BL1SS008	SS-64	Soil		1.5 m profile in free HC containing coarse sand-gravel substrate in water table
BL1SS009	SS-65	Soil		1.5 m profile in free HC containing coarse sand-gravel substrate in water table; lab organic analysis
BL1SS010	SS-66	Soil	Test Pit 3: along S side of road at N end of station; 3 m depth; various debris including metal strapping, wood, tape, transformer casing, junction pipe, burnt timber, pump pistons (remains of pumphouse equipment)	1.5 m profile in free HC containing coarse sand-gravel substrate in water table; lab organic analysis
BL1SS011	SS-67	Soil	Test Pit 4: far S end of site beyond outfitters; crushed drums-probable old pallet line; crushed barrels, scrap metal, cable	1.2 m profile in fine sandy gravel below drum
BL1SS012	SS-68	Soil		1.2 m profile in fine sandy gravel below drum; lab inorganic analysis
BL1SS013	SS-73	Soil	Test Pit 5: in terrace above Blanchard R. on SW side of site; 20 m downslope from station border fence and 25 m upgrade from river; no debris	11' profile in well-graded sandy gravel containing free HC

BLANCHARD RIVER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BL1SS014	SS-74	Soil	Test Pit 6: in terrace above Blanchard R. on SW side of site; 20 m S of Pit 5; no debris	2.4 m profile in HC containing sand-gravel substrate
BL1SS015	SS-92	Soil	Drill Hole 1: 8 m S of N border fence of site near station entry road; 0.6 m increments to 5.5 m depth	0-0.6 m profile in sand fill with gravel substrate; no odour
BL1SS016	SS-93	Soil		0.6-1.2 m profile in sand fill with gravel substrate; no odour
BL1SS017	SS-94	Soil		1.2-1.8 m profile in medium sand-gravel substrate
BL1SS018	SS-95	Soil		1.8-2.4 m profile in dry silt grey till
BL1SS019	SS-96	Soil		3-3.7 m profile in moist sand with gravel
BL1SS020	SS-97	Soil		3.7-4.3 m profile in silty sand till; HC odour
BL1SS021	SS-98	Soil		3.7-4.3 m profile in moist silty grey clay substrate
BL1SS022	SS-99	Soil		3.7-4.8 m profile in moist silt with clay; faint HC odour
BL1SS023	SS-100	Soil		3.7-5.5 m profile in moist silt with clay; faint HC odour
BL1SS024	SS-101	Soil		3-3.7 m profile in silty sand till substrate; lab organic analysis
BL1SS025	SS-102	Soil		3-3.7 m profile in silty sand till substrate; lab inorganic analysis
BL1SS026	SS-103	Soil	Drill Hole 2: 20 m E of Drill Hole 1 along fence; 0.6 m increments to 5.5 m	1.8-2.4 m profile in sand gravel substrate
BL1SS027	SS-104	Soil		2.4-3 m profile in gravel-sand substrate; strong HC odour
BL1SS028	SS-105	Soil		3-3.6 m profile in sand-gravel substrate
BL1SS029	SS-106	Soil		2.4-3 m profile in gravel-sand substrate; strong HC odour; lab organic analysis
BL1SS030	SS-107	Soil		2.4-3 m profile in gravel-sand substrate; strong HC odour; lab inorganic analysis

BLANCHARD RIVER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BL1SS031	SS-108	Soil		4.8-5.4 m profile in moist grey clay substrate; HC odour
BL1SS032	SS-109	Soil		3.6-4.2 m profile in damp sand with gravel; slight HC odour
BL1SS033	SS-110	Soil	Drill Hole 3: 40 m N of Hole 3 on opposite side of fence and service road; 0.60 m increments to 5.5 m depth	2.4-3 m profile in silt-sand substrate with stones; slight HC odour
BL1SS034	SS-111	Soil		3-3.6 m profile in medium to coarse gravel-sand; trace HC odour
BL1SS035	SS-112	Soil		3.6-4.2 m profile in mixed sand and underlying grey-brown clay substrates
BL1SS036	SS-116	Soil	Drill Hole 4: 17 m N of Hole 3 on opposite side of fence and service road at N end of station; 0.60 m increments down to 4.3 m depth	2.4-3 m profile in coarse damp sand and gravel
BL1SS037	SS-117	Soil	Drill Hole 5: S side of station; 3 m N of border fence; top of slope above terrace along river; 0.6 m increments down to 12 m depth	7.3-7.9 m profile medium dry sand; HC odour
BL1SS038	SS-118	Soil		7.9-8.5 m profile in dry clay; strong HC odour
BL1SS039	SS-119	Soil		8.5-9.1 m profile in dry clay soil; strong HC odour
BL1SS040	SS-120	Soil		9.1-9.7 m profile in dry clay; moderate HC odour
BL1SS041	SS-121	Soil		9.7-10.4 m profile in sandy gravel with clay; HC odour
BL1SS042	SS-122	Soil		9.1-9.7 m profile in dry clay; moderate HC odour; lab inorganic analysis
BL1SS043	SS-123	Soil	Drill Hole 5: S side of station; 3 m N of border fence; top of slope above terrace along river; 0.6 m increments down to 12 m depth	9.1-9.7 m profile in dry clay; moderate HC odour; lab organic analysis
BL1SS044	SS-124	Soil		7.3-7.9 m profile medium dry sand; HC odour; lab organic analysis
BL1SS045	SS-125			11.5-12.2 m profile in clay substrate; no odour
BL1W001	WS-10	Water	Horsetail marsh at base of slope on N side of site, 30 m S of Blanchard R., 50 m NW of outhouse	Surface sample in standing water near N shore of marsh

BORDER PUMP STATION

Sample	Field Code	Type	Location	Description
BO1GW001	MW-8A	Water	Monitoring Well 8A; in Drill Hole 8: 69 m E of Hole 7, 15 m N of old Haines Rd near site entry point	16.8 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BO1GW002	MW-8B	Water	Monitoring Well 8B; in Drill Hole 8: 69 m E of Hole 7, 15 m N of old Haines Rd near site entry point	8.85 m groundwater depth; Two 60 ml purgeables; one 1L; one 4L; one 500 ml
BO1S001	SS-163	Soil	Soil stain (4 x 5 m) at W end of site, N of old accommodations site, possible storage area	Surface sample (10 cm depth) in medium-coarse sand; HC odour throughout; lab inorganic analysis
BO1S002	SS-164	Soil		Surface sample (10 cm depth) in medium-coarse sand; HC odour throughout; lab organic analysis
BO1SS001	SS-126	Soil	Drill Hole 6: E side of site, 10 m N of old Haines Rd.; 84 m E of Drill Hole 7; 0.6 m increments to 23 m depth	0.6-1.2 m profile in medium sand; no odour
BO1SS002	SS-127	Soil		1.8-2.4 m profile in coarse sand gravel; no odour
BO1SS003	SS-128	Soil		3-3.7 m profile in coarse sand with clay
BO1SS004	SS-129	Soil		0.6-1.2 m profile in medium sand; no odour; lab inorganic sample
BO1SS005	SS-130	Soil		0.6-1.2 m profile in medium sand; no odour; lab organic sample
BO1SS006	SS-131	Soil	Drill Hole 7: 84 m W of Hole 6, 8 m N of old Haines Rd., 10 m S of DDT facility; 0.6 m increments to 24 m depth	0.6-1.2 m profile in medium sand; no odour

BORDER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BO1SS007	SS-132	Soil	Drill Hole 7: 84 m W of Hole 6, 8 m N of old Haines Rd., 10 m S of DDT facility; 0.6 m increments to 24 m depth	1.8-2.4 m profile in medium sand with gravel
BO1SS008	SS-133	Soil		3-3.7 m profile in wet silt; faint HC odour
BO1SS009	SS-134	Soil		4.3-4.8 m profile in coarse sand; HC odour
BO1SS010	SS-135	Soil		5.5-6.1 m profile in fine-medium sand
BO1SS011	SS-136	Soil		6.7-7.3 m profile in fine-medium sand (granular till); trace HC odour
BO1SS012	SS-137	Soil		7.9-8.5 m profile in silty sand with gravel (clean fill); faint HC odour
BO1SS013	SS-138	Soil		9.8-10.4 m profile in medium sand; HC odour
BO1SS014	SS-139	Soil		10.9-11.6 m profile in medium coarse sand with gravel, some silt; strong HC odour
BO1SS015	SS-140	Soil		11.5-12.2 m profile in medium coarse sand; bad HC odour
BO1SS016	SS-141	Soil		13.4-14 m profile in moist sandy till; HC odour
BO1SS017	SS-142	Soil		15.2-15.8 m profile in fine sand with stones; HC odour
BO1SS018	SS-143	Soil		3-3.7 m profile in wet silt; faint HC odour; lab organic analysis
BO1SS019	SS-144	Soil		3-3.7 m profile in wet silt; faint HC odour; lab inorganic analysis
BO1SS020	SS-145	Soil		10.9-12.2 profile composite in medium-coarse sand; lab organic analysis
BO1SS021	SS-146	Soil		10.9-12.2 m profile composite in medium-coarse sand; lab inorganic analysis
BO1SS022	SS-147	Soil		20.1-20.7 m profile in silty sand; slight HC odour

BORDER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BO1SS023	SS-148	Soil		22.6-23.2 m profile in silty sand; slight HC odour
BO1SS024	SS-149	Soil		23.8-24.4 m profile in silty sand; slight HC odour
BO1SS025	SS-150	Soil		23.8-24.4 m profile in silty sand; slight HC odour; lab organic analysis
BO1SS026	SS-151	Soil		23.8-24.4 m profile in silty sand; slight HC odour; lab inorganic analysis
BO1SS027	SS-152	Soil	Drill Hole 8: 69 m E of Hole 7, 15 m N of old Haines Rd near site entry point; 0.6 m increments to 23 m depth	3-3.6 m profile in medium-fine sand; no odour
BO1SS028	SS-153	Soil		7.9-8.5 m profile in coarse granular mix of silt, sand and gravel; HC odour; lab organic analysis
BO1SS029	SS-154	Soil		9.1-9.7 m profile in damp coarse sand with gravel; HC odour; lab organic analysis
BO1SS030	SS-155	Soil		12.2-12.8 m profile in silt with fine sand; strong HC odour; lab organic analysis
BO1SS031	SS-156	Soil		15.8-16.5 m profile in medium-coarse sand; strong HC odour; lab organic analysis
BO1SS032	SS-157	Soil		12.1-12.3 m profile in silt with fine sand; strong HC odour; lab inorganic analysis
BO1SS033	SS-158	Soil		15.8-16.5 m profile in medium-coarse sand; strong HC odour; lab inorganic analysis
BO1SS034	SS-159	Soil		22-22.6 m profile in damp fine sand with silt; trace HC odour; lab organic analysis
BO1SS035	SS-160	Soil		Field duplicate of SS-159
BO1SS036	SS-161	Soil		22-22.6 m profile in damp fine sand with silt; trace HC odour; lab inorganic analysis
BO1SS037	SS-162	Soil		Field duplicate of SS-161

BORDER PUMP STATION (CONT.)

Sample	Field Code	Type	Location	Description
BO1SS038	SS-167	Soil	Drill Hole 9: 63 m west of Hole 8, 16 m N of old Haines Rd.; 0.6 m increments to 22 m depth	3-3.6 m profile in medium-coarse sand
BO1SS039	SS-168	Soil		13.4-14 m profile in medium-coarse sand with silt and gravel
BO1SS040	SS-169	Soil		14-14.6 m profile in medium to fine grain sand with gravel; strong HC odour
BO1SS041	SS-170	Soil		14.6-15.2 m profile in medium to fine grain sand with gravel; strong HC odour; lab organic analysis
BO1SS042	SS-171	Soil		15.2-15.8 m profile in medium to fine grain sand with gravel; strong HC odour
BO1SS043	SS-173	Soil		15.8-16.5 m profile in silt clay soil with some sand; strong HC odour
BO1SS044	SS-174	Soil		16.5-17.1 m profile in clay with some silt; slight HC odour
BO1SS045	SS-175	Soil	Drill Hole 9: 63 m west of Hole 8, 16 m N of old Haines Rd.; 0.6 m increments to 22 m depth	17.1-17.7 m profile in fine sand with clay and gravel; no HC odour
BO1SS046	SS-176	Soil		21.3-21.9 m profile in fine-coarse sand; slight odour; lab organic analysis
BO1SS047	SS-177	Soil		17.7-18.3 m profile in silt-fine sand with gravel; no odour
BO1SS048	SS-178	Soil		18.2-18.9 m profile in silt and fine- coarse sand; trace HC odour
BO1SS049	SS-179	Soil		14.6-15.2 m profile in medium to fine grain sand with gravel; lab inorganic analysis
BO1SS050	SS-180	Soil		17.1-17.7 m profile in fine sand with clay and gravel; no HC odour; lab inorganic analysis
BO1W001	Blank 2	Water	Travelling blank	Opened at site; one 60 ml purgeable

APPENDIX D
SOIL TEST PIT LOGS

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-1	
Testpit Co-ordinates: 13N, 27W		Location: LANDFILL		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0			ORGANIC CLAY, rootlets, brown, damp			0.0
			CLAY, and silt, fill, brown, dry to damp, some gravel, refuse including car battery, bottles, steel pieces, 1 - 45 gallon drum, plastic and tin cans - trace gravel			
1.0						
2.0						
			CLAY, silty, grey, hard, damp to moist, medium plastic, numerous grey pebbles or shale pieces			
			END OF TESTHOLE AT 2.5 m DRY, SOME SLOUGHING OF FILL SOILS			
3.0						10.0
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 2.5 m
		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

[illegible]

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-3	
Testpit Co-ordinates: 2S, 33W		Location: LANDFILL		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)		SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0	◆ SOIL VAPOUR (ppm) HNU ◆ 10 ¹ 10 ²		ORGANIC MAT, rootlets, brown, damp			0.0
			CLAY, and silt, fill, brown, damp, medium plastic, refuse including 45 gallon drums, tires, pipe, sheet metal, steel wire, bulldozer parts			
-1.0						
					-SS006 Field Screening and Lab Inorganic Analysis SS007 Lab Organic Analysis	-5.0
-2.0			CLAY, silty, grey, hard, damp to moist, medium plastic, numerous grey pebbles or clay shale pieces		-SS008 Field Screening	
			END OF TESTHOLE AT 2.2 m DRY, NO SLOUGHING			
-3.0						-10.0
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 2.2 m
		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA	Client: DIAND	TESTPIT No: 95-4
Testpit Co-ordinates: 1N, 26.5W	Location: LANDFILL	Project No: 4440-033-00-02
Location: HAINES JUNCTION STATION	Excavation Method: RUBBER-TIRED BACKHOE	ELEVATION: 0.000 (m)
SAMPLE TYPE ☒ GRAB	☒ SHELBY TUBE	☒ LAB SUBMITTED
	☐ NO RECOVERY	☐ CORE BARREL
		☐ WIRE LINE TYPE

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0	10 ¹ 10 ²		ORGANIC MAT, rootlets, brown, damp			0.0
			CLAY, and silt, fill, brown, damp, medium plastic, refuse including 45 gallon drums, tubing			
-1.0					-SS009 Field Screening SS010 Lab Organic Analysis SS011 Lab Inorganic Analysis	
			CLAY, silty, grey, hard, damp, medium plastic, numerous pebbles		-SS012 Field Screening	
			END OF TESTHOLE AT 1.5 m DRY, SOME CAVING OF ONE SIDE			-5.0
-2.0						
-3.0						-10.0
4.0						

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Fig. No:

COMPLETION DEPTH: 1.5 m
COMPLETE: 07/06/95

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-5	
Testpit Co-ordinates: 11S, 4W		Location: LANDFILL		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
	10 ¹ 10 ²					
0.0			ORGANIC CLAY, rootlets, brown, damp CLAY, and silt, brown, damp to moist, trace gravel, medium plastic, rootlets throughout			0.0
1.0			CLAY, silty, grey, hard, damp to moist, medium plastic, numerous grey pebbles or shale pieces			5.0
2.0			END OF TESTHOLE AT 1.6 m DRY, NO SLOUGHING			10.0
3.0						
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 1.6 m
		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

[illegible]

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-7	
Testpit Co-ordinates: 27N, 27W		Location: LANDFILL		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0	10 ¹ 10 ²		ORGANICS, rootlets, brown, damp, 0.45 m pipe section			0.0
			CLAY, and silt, brown, damp to moist, trace gravel, medium plastic, rootlets throughout			
-1.0			CLAY, silty, grey, hard, damp to moist, medium plastic, numerous grey pebbles or shale pieces			
			END OF TESTHOLE AT 1.5 m DRY, NO SLOUGHING			5.0
-2.0						
-3.0						10.0
-4.0						

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		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-8	
Testpit Co-ordinates: 123N, 39E		Location: RAMP AREA NORTH OF STATION		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0	10 ¹ 10 ²		ORGANICS, brown, damp, powdery, roots			0.0
			CLAY, gravelly, grey, damp to moist, medium plastic	☒	SS016 Lab Inorganic Analysis	
			CLAY, sandy, brown, very stiff, medium plastic, damp, crumbly, occasional to trace gravel	☒	SS017 Lab Inorganic Analysis	
				☒	SS018 Lab Inorganic Analysis	
-1.0					SS019 Composite of Testpit	
			END OF TESTPIT AT 1.8 m DRY, NO SLOUGHING			-5.0
-2.0						
						-10.0
-3.0						
-4.0						

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		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-9	
Testpit Co-ordinates:		Location: AREA EAST OF STATION		Project No: 4440-033-00-02	
Location: HAINES JUNCTION STATION		Excavation Method: RUBBER-TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code JU1)	DEPTH (ft)
0.0	◆		CLAY FILL, sandy, damp, crumbly, brown, rootlets throughout - truck hood at 150 mm depth		-SS020 Field Screening	0.0
			SILT, some sand, original ground, reddish brown, powdery, dry to damp			
1.0			END OF TESTPIT AT 1.0 m DRY, NO SLOUGHING			
						5.0
						10.0
2.0						
3.0						
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 1.0 m
		REVIEWED BY:	COMPLETE: 07/06/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-1	
Testpit Co-ordinates: 70N, 78E		Location: NORTH OF STATION		Project No: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Excavation Method: RUBBER TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	DEPTH (ft)
0.0			ORGANIC MAT, brown, rootlets			0.0
			SAND FILL, clayey, brown, damp to moist, some gravel, refuse including wood, concrete, sheet metal, metal block - trace clay, moist becoming very moist with depth		-SS003 Field Screening SS004 Lab Inorganic Analysis	
-1.0			- seepage			
			SAND, medium to coarse grained, gravelly, grey, occasional cobble, saturated		-SS001 Field Screening SS002 Lab Inorganic Analysis	
-2.0			END OF TESTPIT AT 1.7 m WATER TO 1.5 m, SLOUGHING OF LOWER SAND			-5.0
-3.0						-10.0
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 1.7 m
		REVIEWED BY:	COMPLETE: 07/08/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-2	
Testpit Co-ordinates: 10N, 65E		Location: NORTH OF STATION		Project No: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Excavation Method: RUBBER TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU		SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	DEPTH (ft)
	10 ¹	10 ²					
0.0				PIT-RUN SAND AND GRAVEL FILL, brown, damp becoming moist with depth, occasional cobble sizes, refuse including wire, tin, steel cable			0.0
1.0							
				SILT, grey, damp, trace clay, low plastic			5.0
2.0				END OF TESTPIT AT 1.8 m DRY, SOME MINOR SLOUGHING			
3.0							10.0
4.0							

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		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-3	
Testpit Co-ordinates: 10N, 60E		Location: NORTH OF STATION		Project No: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Excavation Method: RUBBER TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	DEPTH (ft)
0.0	◆ SOIL VAPOUR (ppm) HNU ◆ 10¹ 10²		PIT-RUN SAND AND GRAVEL FILL, brown, damp becoming moist with depth, frequent debris including pumphouse components, pipe connections, concrete blocks, burnt wood, etc.			0.0
1.0					-SS005 Field Screening -SS006 Field Screening SS007 Lab Inorganic Analysis	
2.0			- moist becoming very moist with depth			
3.0			SAND, medium to coarse grained, gravelly, numerous cobbles and boulders, grey, saturated, strong hydrocarbon odour		-SS008 Field Screening -SS009 Lab Organic Analysis -SS010 Lab Organic Analysis	
			END OF TESTPIT AT 2.9 m WATER, SLOUGHING TO 2.75 m			10.0
4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 2.9 m
		REVIEWED BY:	COMPLETE: 07/08/95
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-4	
Testpit Co-ordinates: 18N, 15E		Location: SOUTH OF STATION		Project No: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Excavation Method: RUBBER TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB ☒ SHELBY TUBE ☒ LAB SUBMITTED ☒ NO RECOVERY ☐ CORE BARREL ☐ WIRE LINE TYPE					
DEPTH (m)	◆ SOIL VAPOUR (ppm) HNU ◆ 10 ¹ 10 ²	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)
0.0			FOREST FLOOR, black, rootlets		0.0
			GRAVEL FILL, fine sandy, brown, damp, large boulder to 0.8 m, refuse including geosynthetic liner, 3 barrels, steel cable, pipe, board, various steel pieces		-SS011 Field Screening SS012 Lab Inorganic Analysis
1.0			END OF TESTPIT AT 1.2 m DRY, NO SLOUGHING		
2.0					5.0
3.0					10.0
4.0					
UMA Engineering Ltd. Edmonton, Alberta			LOGGED BY: BWF REVIEWED BY: Fig. No:	COMPLETION DEPTH: 1.2 m COMPLETE: 07/08/95 Page 1 of 1	

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TESTPIT No: 95-5	
Testpit Co-ordinates: 115S, 35E		Location: NEAR BLANCHARD RIVER		Project No: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Excavation Method: RUBBER TIRED BACKHOE		ELEVATION: 0.000 (m)	
SAMPLE TYPE ☒ GRAB		☒ SHELBY TUBE		☒ LAB SUBMITTED	
		☐ NO RECOVERY		☐ CORE BARREL	
				☐ WIRE LINE TYPE	

DEPTH (m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	DEPTH (ft)
0.0	10¹ 10²		ORGANIC MAT, brown, roots SAND, fine to medium grained, gravelly, brown, damp, occasional cobble			0.0
-1.0						
-2.0						
-3.0			- well graded, very moist - hydrocarbon odour END OF TESTPIT AT 3.2 m DRY, SOME MINOR SEEPAGE AT BOTTOM			
-4.0						

UMA Engineering Ltd. Edmonton, Alberta		LOGGED BY: BWF	COMPLETION DEPTH: 3.2 m
		REVIEWED BY:	COMPLETE: 07/08/95
		Fig. No:	Page 1 of 1

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APPENDIX E
SOIL DRILLING LOGS AND SIEVE ANALYSES

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-1	
Testhole Co-ordinates: 6.2S , 50E		Location: NORTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 98.85 (m)	
SAMPLE TYPE	☒ GRAB SAMPLE	☐ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND

DEPTH(m)	◆ SOIL VAPOUR (ppm) HNU ◆	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	SLOTTED PIEZOMETER	DEPTH(ft)
0.0			SAND (fill) - with gravel (50mm dia) - dry - no odour		-SS015 Field Screening		0.0
1.0					-SS016 Field Screening		
2.0			SAND - medium grained - some gravel (15mm dia) - clean - dry - no odour		-SS017 Field Screening		5.0
3.0			SILT (till) - grey - dry - occasional stones and boulders		-SS018 Field Screening		
4.0			SAND - medium to coarse grained - with gravel (15mm dia.) - moist - strong odour		-SS019 Field Screening		10.0
5.0			SAND - medium to coarse grained - with gravel (25mm dia.) - some silt - wet - strong odour		-SS020 Field Screening SS024 Lab Organic Analysis SS025 Lab Inorganic Analysis		
6.0			CLAY - some silt - trace fine gravel - grey - firm to stiff - moist		-SS021 Field Screening		15.0
7.0			SILT - with clay - grey - moist - faint odour		-SS022 Field Screening		
					-SS023 Field Screening		
			END OF TESTHOLE IN SILT @ 5.49m MW-1 (Monitoring Well Installed) - Top of 50mm PVC pipe = el. 99.51m - Water level in piezometer 3.33m below top of 50mm PVC pipe (el. 96.18m) 95/07/12 10:00pm - Elevations relative to an arbitrary local bench mark set as elev. 100.0m				20.0

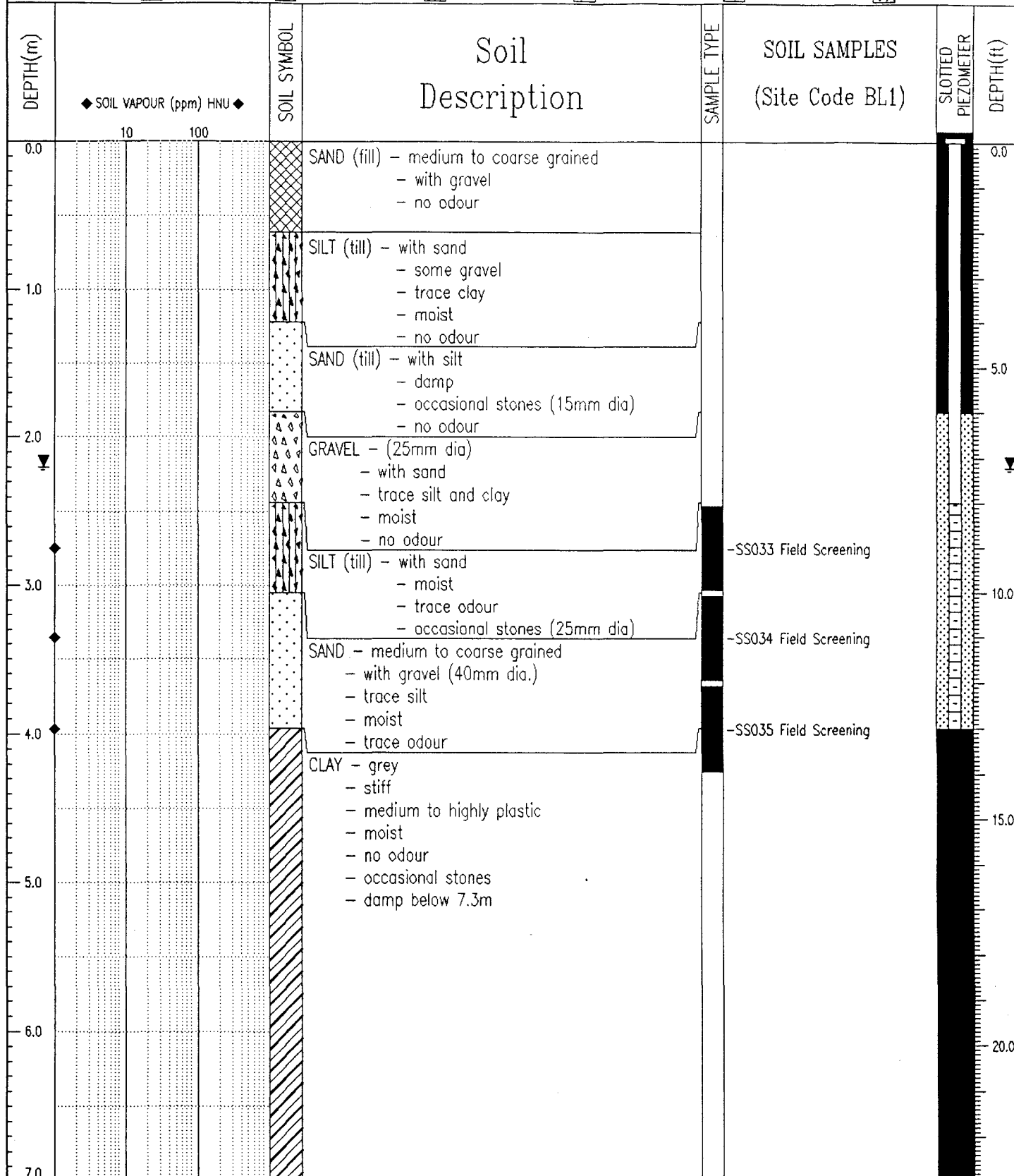
UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW	COMPLETION DEPTH: 5.5 m
		REVIEWED BY:	COMPLETE: 95/07/11
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-2	
Testhole Co-ordinates: 0N , 70E		Location: NORTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 99.60 (m)	
SAMPLE TYPE	☒ GRAB SAMPLE	☐ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND

DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	SLOTTED PIEZOMETER	DEPTH(ft)
0.0			SAND (fill) - with gravel (50mm dia.) - trace silt - dark brown - dry - no odour				0.0
1.0			SAND - fine to medium grained - trace gravel - loose - dry - no odour				5.0
2.0			SILT (till) - fine to medium grained - with silt - loose - dry - occasional stones (25mm dia) - no odour		-SS026 Field Screening		
3.0			SAND - with gravel (25mm dia) - well graded - damp - faint odour		-SS027 Field Screening SS029 Lab Organic Analysis SS030 Lab Inorganic Analsi		
4.0			GRAVEL - with sand (50mm dia.) - moist - strong odour		-SS028 Field Screening		
5.0			SAND - medium to coarse grained - with gravel (50mm dia.) - damp - strong odour decreasing with depth		-SS032 Field Screening		
6.0			CLAY - grey - stiff - plastic - moist - some odour		-SS031 Field Screening		15.0
7.0			END OF TESTHOLE IN CLAY @ 5.49m MW-2 (Monitoring Well Installed) - Top of 50mm PVC pipe = el. 99.40m - Water level in piezometer 2.87m below top of 50mm PVC pipe (el. 96.53m) 95/07/12 10:00pm - Elevations relative to an arbitrary local bench mark set as elev. 100.0m - Well completed below grade and covered				20.0

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		REVIEWED BY:	COMPLETE: 95/07/11
		Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND	TEST HOLE NO: TH-3
Testhole Co-ordinates: 35N , 50E		Location: NORTH OF STATION	PROJECT NO: 4440-034-00-02
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER	ELEVATION: 98.35 (m)
SAMPLE TYPE	☒ GRAB SAMPLE	☐ SHELBY TUBE	☒ LAB SUBMITTED
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ NO RECOVERY
		☐ SLOUGH	☐ CORE BARREL
		☐ GROUT	☐ WIRE LINE-TYPE
		☒ DRILL CUTTINGS	☐ SAND



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COMPLETION DEPTH: 9.1 m

COMPLETE: 95/07/11

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Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-3	
Testhole Co-ordinates: 35N , 50E		Location: NORTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 98.35 (m)	
SAMPLE TYPE ☒ GRAB SAMPLE ☐ SHELBY TUBE		☒ LAB SUBMITTED ☐ NO RECOVERY		☐ CORE BARREL ☐ WIRE LINE-TYPE	
BACKFILL TYPE ☒ BENTONITE ☐ PEA GRAVEL		☐ SLOUGH ☐ GROUT		☒ DRILL CUTTINGS ☐ SAND	

DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	SLOTTED PIEZOMETER	DEPTH(ft)	
7.0	10 100		END OF TESTHOLE IN CLAY @ 9.14m MW-3 (Monitoring Well Installed) - Top of 50mm PVC pipe = el. 99.01m - Water level in piezometer 2.85m below top of 50mm PVC pipe (el. 96.16m) 95/07/12 10:00pm - Elevations relative to an arbitrary local bench mark set as elev. 100.0m				25.0	
8.0								
9.0								
10.0								
11.0								
12.0								
13.0								
14.0								

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		REVIEWED BY:	COMPLETE: 95/07/11
		Fig. No:	Page 2 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-4	
Testhole Co-ordinates: 35N , 35E		Location: NORTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 98.70 (m)	
SAMPLE TYPE	☒ GRAB SAMPLE	☒ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND

DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	SLOTTED PIEZOMETER	DEPTH(ft)
0.0		X	SAND (fill) - some gravel (25mm dia) - some silt - dry - no odour				0.0
1.0							
2.0		.	SAND - fine to medium grained - some gravel (25mm dia) - trace silt - moist - no odour				5.0
3.0							
4.0		/	CLAY - grey - plastic - soft - moist to wet - no odour				15.0
5.0			END OF TESTHOLE IN CLAY @ 4.27m MW-4 (Monitoring Well Installed) - Top of 50mm PVC pipe = el. 99.37m - Water level in piezometer 2.98m below top of 50mm PVC pipe (el. 96.39m) 95/07/12 10:00pm - Elevations relative to an arbitrary local bench mark set as elev. 100.0m				20.0
6.0							
7.0							

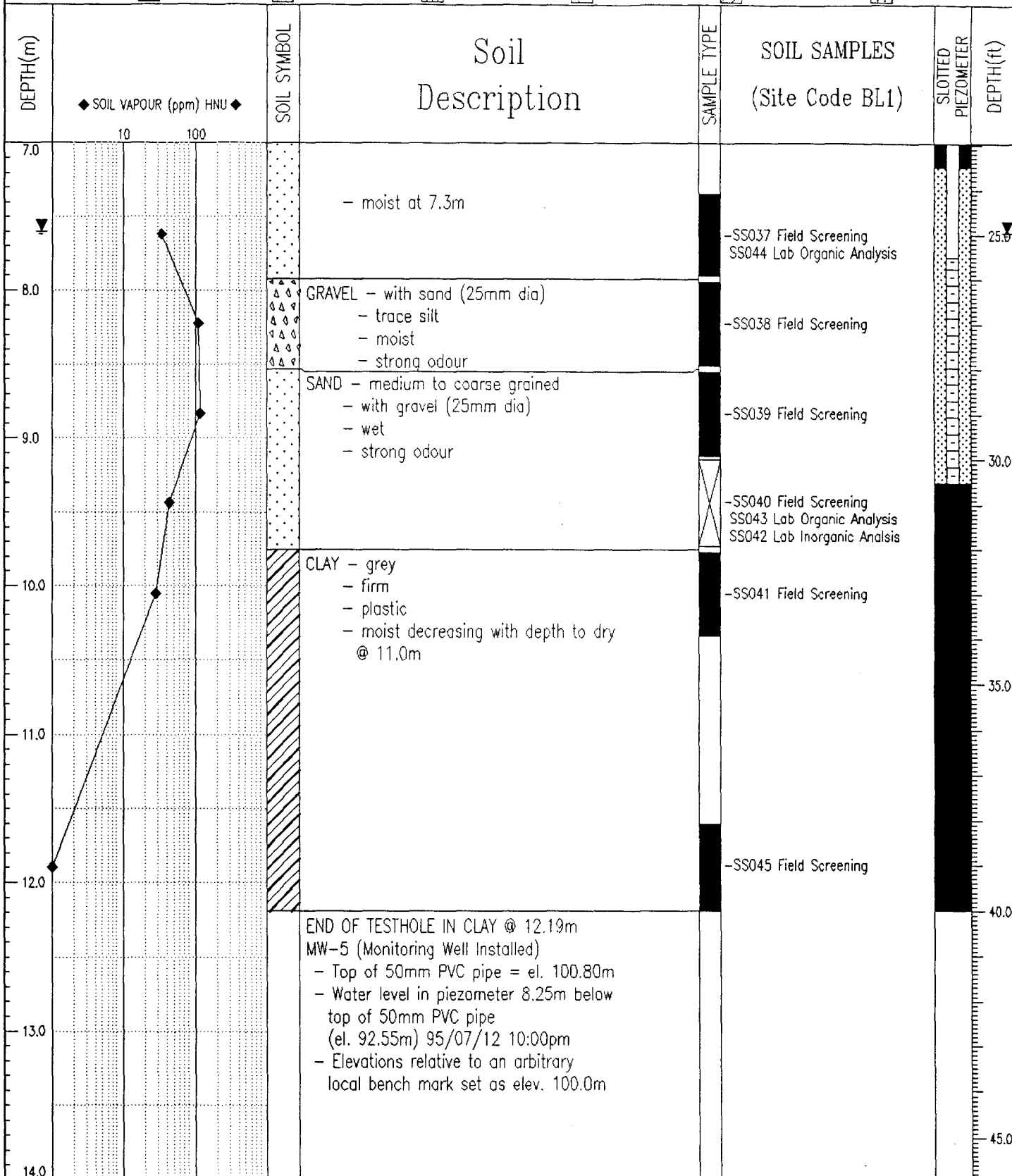
UMA Environmental Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 4.3 m
	REVIEWED BY:	COMPLETE: 95/07/12
	Fig. No:	Page 1 of 1

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-5	
Testhole Co-ordinates: 125S , 75E		Location: SOUTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 100.15 (m)	
SAMPLE TYPE	☒ GRAB SAMPLE	☒ SHELBY TUBE	☒ LAB SUBMITTED	☒ NO RECOVERY	☒ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☒ PEA GRAVEL	☒ SLOUGH	☒ GROUT	☒ DRILL CUTTINGS
☒ SAND					

DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code BL1)	SLOTTED PIEZOMETER	DEPTH(ft)
0.0	10 100		GRAVEL (fill) - with sand - trace silt - no odour				0.0
1.0			SAND - medium to coarse grained - some gravel (25mm dia.) - trace silt - damp - trace odour 1.2m to 1.8m				5.0
2.0							10.0
3.0							15.0
4.0							20.0
5.0							
6.0							
7.0							

UMA Environmental Winnipeg, Manitoba	LOGGED BY: TW	COMPLETION DEPTH: 12.2 m
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	Fig. No:	Page 1 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-5	
Testhole Co-ordinates: 125S , 75E		Location: SOUTH OF STATION		PROJECT NO: 4440-034-00-02	
Location: BLANCHARD RIVER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION: 100.15 (m)	
SAMPLE TYPE	☒ GRAB SAMPLE	☒ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND



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Fig. No:

COMPLETION DEPTH: 12.2 m

COMPLETE: 95/07/12

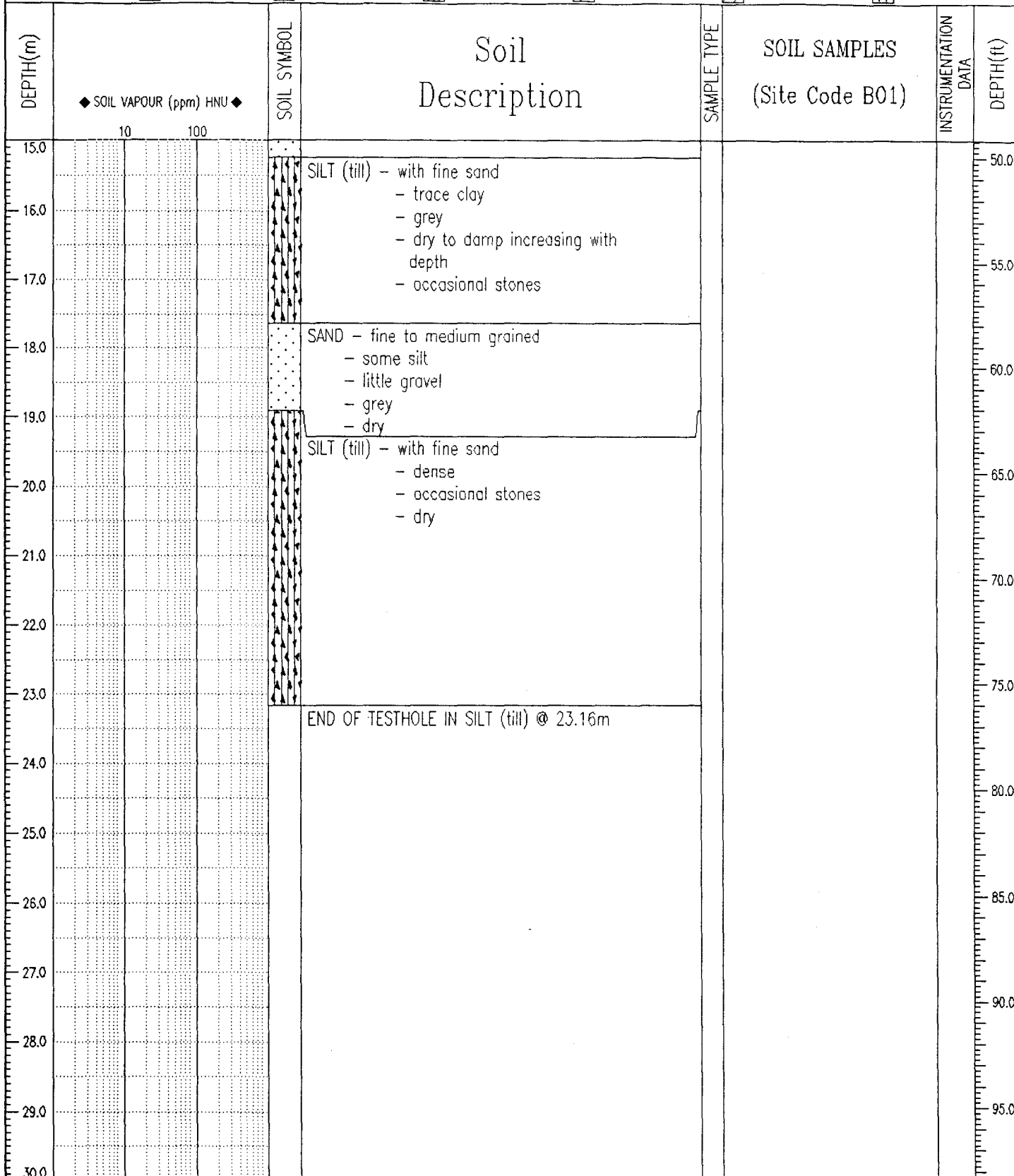
Page 2 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-6	
Testhole Co-ordinates: 12N , 233E		Location: SOUTHEAST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE	☒ GRAB SAMPLE	☐ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND

DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code B01)	INSTRUMENTATION DATA	DEPTH(ft)
0.0			SAND - predominantly medium grained (varies fine to coarse grained) - some gravel (25mm dia) - trace silt - brown - no odour - grey at 2.4m	☒	-SS001 Field Screening SS004 Lab Inorganic Analysis SS005 Lab Organic Analysis		0.0
1.0				☒	-SS002 Field Screening		5.0
2.0				☒	-SS003 Field Screening		10.0
3.0							15.0
4.0							20.0
5.0							25.0
6.0							30.0
7.0							35.0
8.0							40.0
9.0							45.0
10.0							50.0
11.0							55.0
12.0							60.0
13.0							65.0
14.0							70.0
15.0							75.0

UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW	COMPLETION DEPTH: 23.2 m
		REVIEWED BY:	COMPLETE: 95/07/12
		Fig. No:	Page 1 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-6	
Testhole Co-ordinates: 12N , 233E		Location: SOUTHEAST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE ☒ GRAB SAMPLE ☒ SHELBY TUBE ☒ LAB SUBMITTED ☒ NO RECOVERY ☒ CORE BARREL ☒ WIRE LINE-TYPE					
BACKFILL TYPE ☒ BENTONITE ☒ PEA GRAVEL ☒ SLOUGH ☒ GROUT ☒ DRILL CUTTINGS ☒ SAND					



UMA Environmental		LOGGED BY: TW	COMPLETION DEPTH: 23.2 m
Winnipeg, Manitoba		REVIEWED BY:	COMPLETE: 95/07/12
		Fig. No:	Page 2 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-7	
Testhole Co-ordinates: 13N , 142E		Location: SOUTH OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE ☒ GRAB SAMPLE ☐ SHELBY TUBE ☒ LAB SUBMITTED ☐ NO RECOVERY ☐ CORE BARREL ☐ WIRE LINE-TYPE					
BACKFILL TYPE ☒ BENTONITE ☐ PEA GRAVEL ☐ SLOUGH ☐ GROUT ☐ DRILL CUTTINGS ☐ SAND					
DEPTH(m) 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0		SOIL SYMBOL SOIL VAPOUR (ppm) HNU 10 100 15.9m to 22.0m SAND - some silt - little gravel - dense - moist to dry with depth - no odour END OF TESTHOLE IN SAND @ 24.38m		SAMPLE TYPE -SS017 Field Screening -SS022 Field Screening -SS023 Field Screening -SS024 Field Screening SS025 Lab Organic Analysis -SS026 Lab Inorganic Analysis	
		SOIL DESCRIPTION SOIL TYPE SOIL SAMPLES (Site Code B01)		INSTRUMENTATION DATA DEPTH(ft) 50.0 55.0 60.0 65.0 70.0 75.0 80.0 85.0 90.0 95.0	
UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW REVIEWED BY: Fig. No:		COMPLETION DEPTH: 24.4 m COMPLETE: 95/07/13	
				Page 2 of 2	

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-8	
Testhole Co-ordinates: 15N, 73E		Location: SOUTHWEST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE	☒ GRAB SAMPLE	☒ SHELBY TUBE	☒ LAB SUBMITTED	☒ NO RECOVERY	☒ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☒ PEA GRAVEL	☒ SLOUGH	☒ GROUT	☒ DRILL CUTTINGS
					☒ WIRE LINE-TYPE
					☒ SAND

DEPTH(m)	◆ SOIL VAPOUR (ppm) HNU ◆	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code B01)	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	DEPTH(ft)
0.0		△△△	GRAVEL - with sand					0.0
1.0		△△△	- trace silt					
2.0		△△△	- moist					
3.0		△△△	- no odour					
4.0		△△△	SAND - predominantly medium grained					5.0
5.0		△△△	(coarse with depth)					
6.0		△△△	- some gravel (25mm dia.)					
7.0		△△△	- moist to dry with depth					
8.0		△△△	- no odour					10.0
9.0		△△△	SILT - with fine grained sand					
10.0		△△△	- little gravel (15mm dia.)					
11.0		△△△	- dry					15.0
12.0		△△△	- no odour					
13.0		△△△	SAND - predominantly medium grained					
14.0		△△△	(varies fine to coarse grained)					
15.0		△△△	- some gravel (15mm dia.)					25.0
		△△△	- trace silt					
		△△△	- moist					
		△△△	- no odour					30.0
		△△△	- strong odour (7.9m to 10.7m)					
		△△△						35.0
		△△△	SILT - with fine grained sand					
		△△△	- wet					40.0
		△△△	- moderate HC odour					
		△△△	- faint odour @ 11.5m					
		△△△	- strong odour @ 12.2m					45.0
		△△△	SAND - predominantly medium grained					
		△△△	(varies fine to coarse grained)					
		△△△	- little silt					
		△△△	- little gravel					
		△△△	- moist					
		△△△	- faint odour					

UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW	COMPLETION DEPTH: 22.6 m
		REVIEWED BY:	COMPLETE: 95/07/13
		Fig. No:	Page 1 of 2

Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-8	
Testhole Co-ordinates: 15N, 73E		Location: SOUTHWEST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE ☒ GRAB SAMPLE ☒ SHELBY TUBE ☒ LAB SUBMITTED ☐ NO RECOVERY ☐ CORE BARREL ☐ WIRE LINE-TYPE					
BACKFILL TYPE ☒ BENTONITE ☐ PEA GRAVEL ☐ SLOUGH ☐ GROUT ☐ DRILL CUTTINGS ☐ SAND					

DEPTH(m)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code B01)	SLOTTED PIEZOMETER	SLOTTED PIEZOMETER	DEPTH(ft)							
15.0	◆ SOIL VAPOUR (ppm) HNU ◆	- strong odour (13.4m to 17.0m)	X	-SS031 Lab Organic Analysis SS033 Lab Inorganic Analysis	50.0	55.0	60.0							
16.0		- faint odour (17.0m to 21.3m)						X	-SS034 Lab Organic Analysis SS035 Field Duplicate SS034 SS036 Lab Inorganic Analysis SS037 Field Duplicate SS036	65.0	70.0			
17.0		- no odour (21.3m to 22.5m)										X	75.0	80.0
18.0		END OF TESTHOLE IN SAND @ 22.56m												
19.0	MW-8a (Monitoring Well Installed)	X	95.0											
20.0	MW-8b (Monitoring Well Installed)			X										
21.0	- Top of 50mm PVC pipes = 8a el. 119.00m				X									
22.0	8b el. 119.03m					X								
23.0	- Both Monitoring Wells Installed in Hole	X												
24.0	- Water level in 8a 9.45m below top		X											
25.0	of 50mm PVC pipe (el. 109.55m) 95/07/13			X										
26.0	- Water level in 8b 17.5m below top				X									
27.0	of 50mm PVC pipe (el. 101.53m) 95/07/13	X												
28.0			X											
29.0				X										
30.0					X									

UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW REVIEWED BY: Fig. No:	COMPLETION DEPTH: 22.6 m COMPLETE: 95/07/13 Page 2 of 2
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Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-9	
Testhole Co-ordinates: 16N , 10E		Location: SOUTHWEST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE ☒ GRAB SAMPLE ☐ SHELBY TUBE ☒ LAB SUBMITTED ☐ NO RECOVERY ☐ CORE BARREL ☐ WIRE LINE-TYPE					
BACKFILL TYPE ☒ BENTONITE ☐ PEA GRAVEL ☐ SLOUGH ☐ GROUT ☐ DRILL CUTTINGS ☐ SAND					

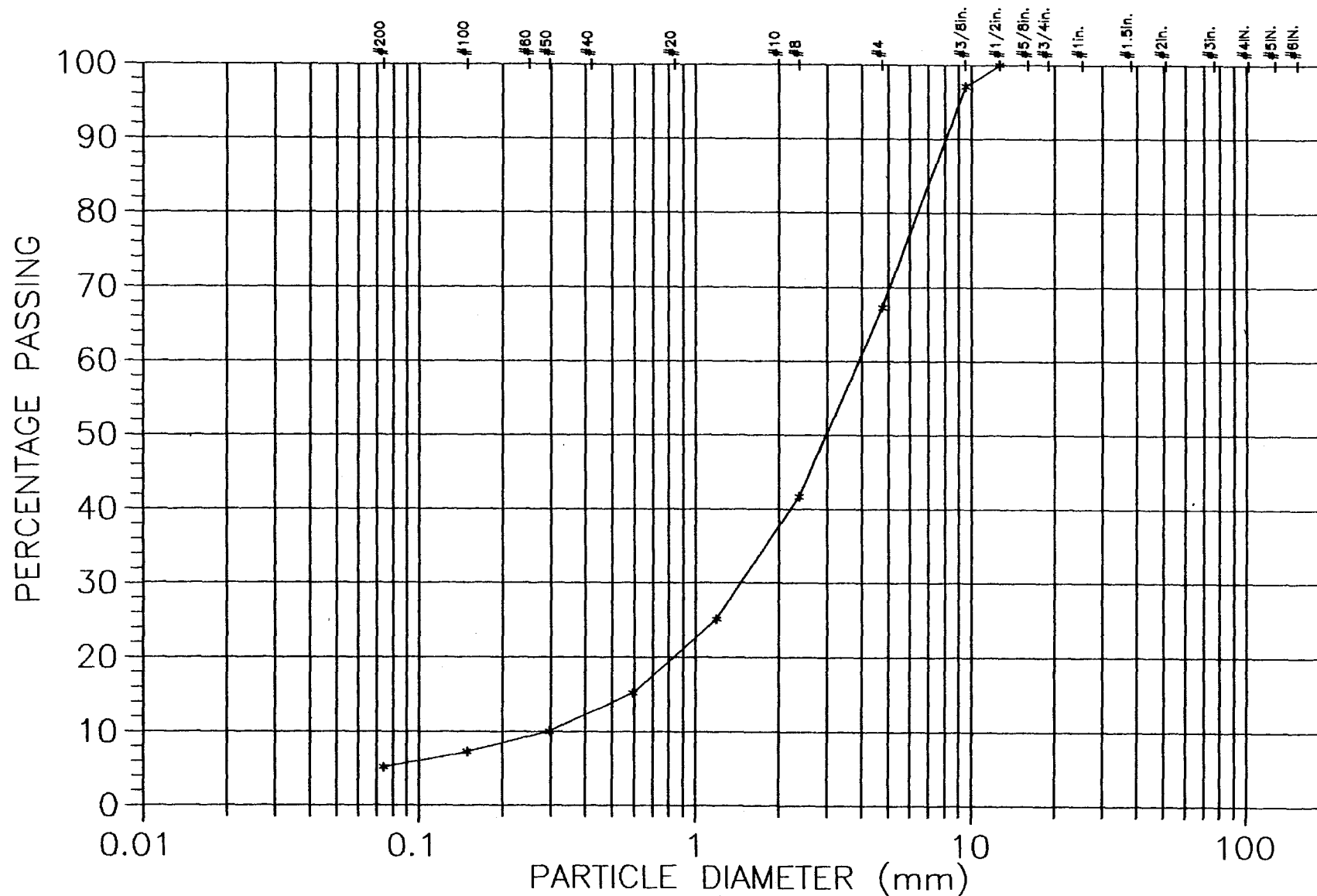
DEPTH(m)	SOIL VAPOUR (ppm) HNU	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code B01)	INSTRUMENTATION DATA	DEPTH(ft)
0.0			SAND - predominantly medium grained (varies fine to coarse grained) - some gravel (15mm dia.) - trace silt - dry - no odour				0.0
1.0							5.0
2.0							10.0
3.0							15.0
4.0			SILT - with fine grained sand - some gravel (15mm dia.) - moist - no odour				25.0
5.0			SAND - predominantly medium grained (varies fine to coarse grained) - some gravel (15mm dia.) - trace silt - moist - no odour				30.0
6.0							35.0
7.0							40.0
8.0							45.0
9.0							
10.0							
11.0							
12.0							
13.0			- faint odour (5.5m to 9.1m)				
14.0							
15.0			- strong odour (9.8m to 14.0m)				

UMA Environmental Winnipeg, Manitoba		LOGGED BY: TW	COMPLETION DEPTH: 23.2 m
		REVIEWED BY:	COMPLETE: 95/07/13
		Fig. No:	Page 1 of 2

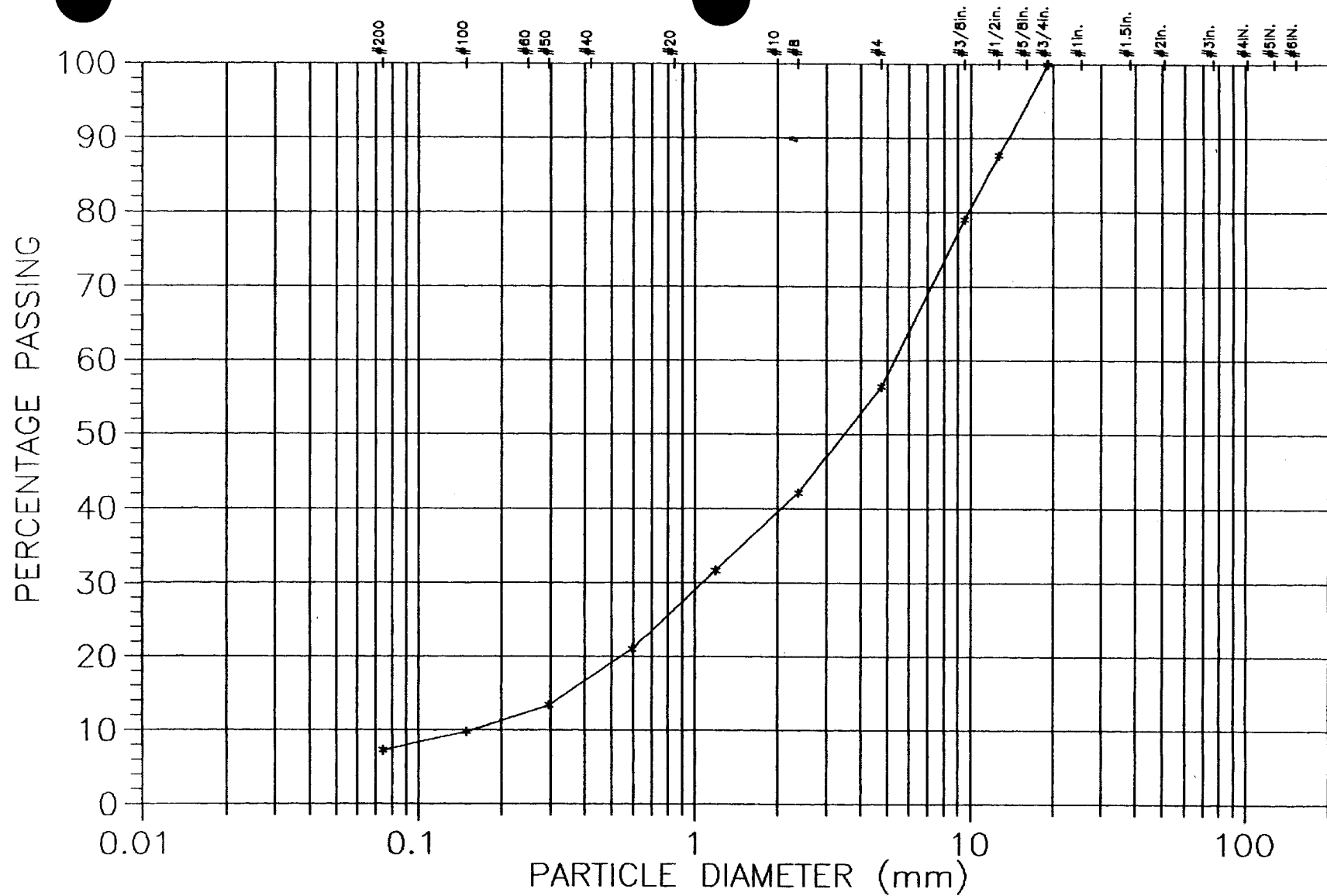
Project: HAINES-FAIRBANKS PIPELINE ESA		Client: DIAND		TEST HOLE NO: TH-9	
Testhole Co-ordinates: 16N , 10E		Location: SOUTHWEST OF DDT STORAGE		PROJECT NO: 4440-034-00-02	
Location: BORDER STATION		Drill Type: ROTARY CASING HAMMER		ELEVATION:	
SAMPLE TYPE	☒ GRAB SAMPLE	☒ SHELBY TUBE	☒ LAB SUBMITTED	☐ NO RECOVERY	☐ CORE BARREL
BACKFILL TYPE	☒ BENTONITE	☐ PEA GRAVEL	☐ SLOUGH	☐ GROUT	☐ DRILL CUTTINGS
					☐ WIRE LINE-TYPE
					☐ SAND

DEPTH(m)	SOIL SYMBOL	Soil Description	SAMPLE TYPE	SOIL SAMPLES (Site Code B01)	INSTRUMENTATION DATA	DEPTH(ft)
15.0			☒	SS049 Lab Inorganic Analysis		50.0
			☒	-SS042 Field Screening		
16.0			☒	-SS043 Field Screening		
			☒	-SS044 Field Screening		
17.0			☒	-SS045 Lab Organic Analysis		55.0
			☒	SS050 Lab Inorganic Analysis		
18.0			☒	-SS047 Field Screening		60.0
			☒	-SS048 Field Screening		
19.0						65.0
20.0						
21.0						70.0
			☒	-SS046 Lab Organic Analysis		
22.0						75.0
23.0						80.0
24.0						85.0
25.0						90.0
26.0						95.0
27.0						
28.0						
29.0						
30.0						
END OF TESTHOLE IN SAND @ 23.16m						

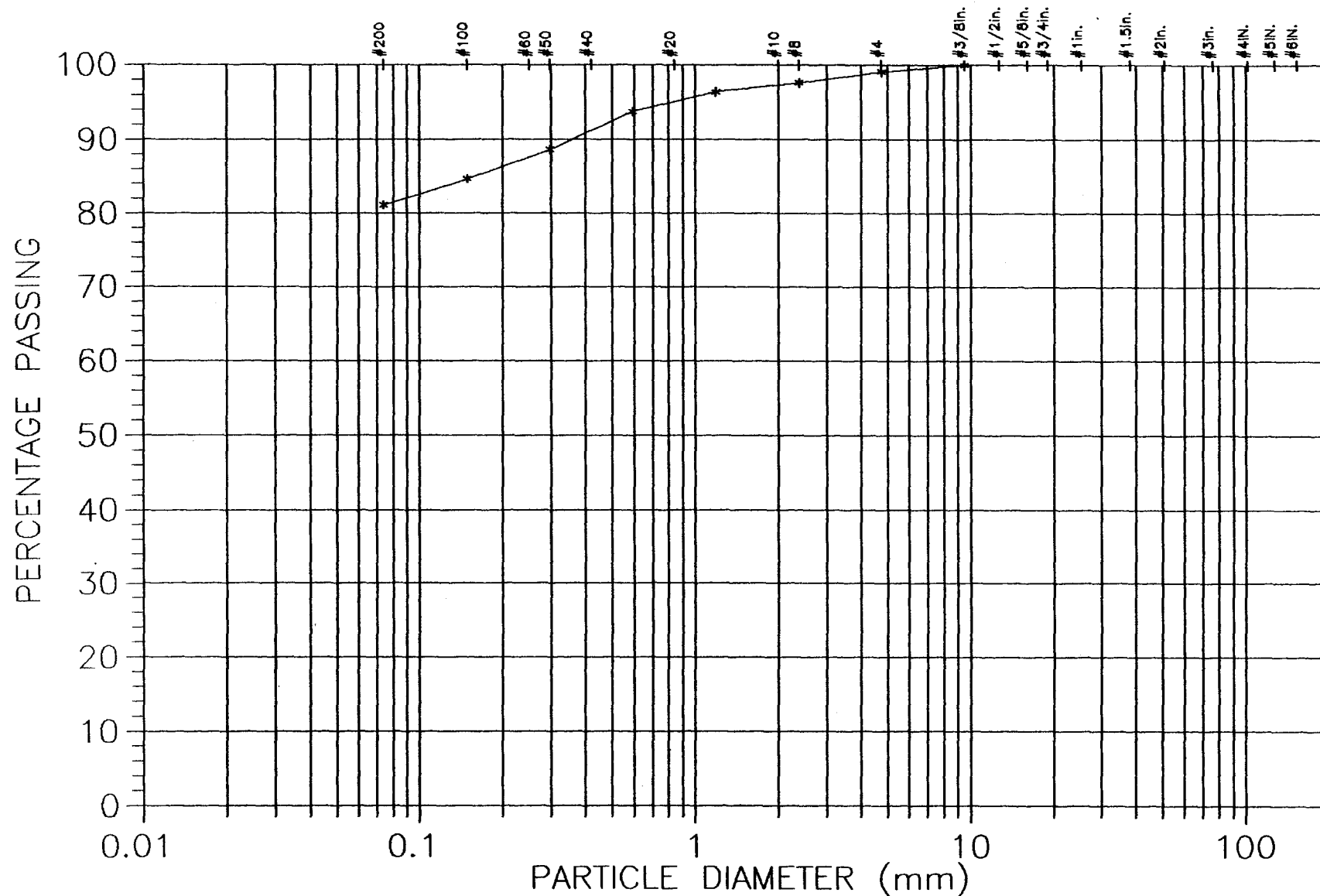
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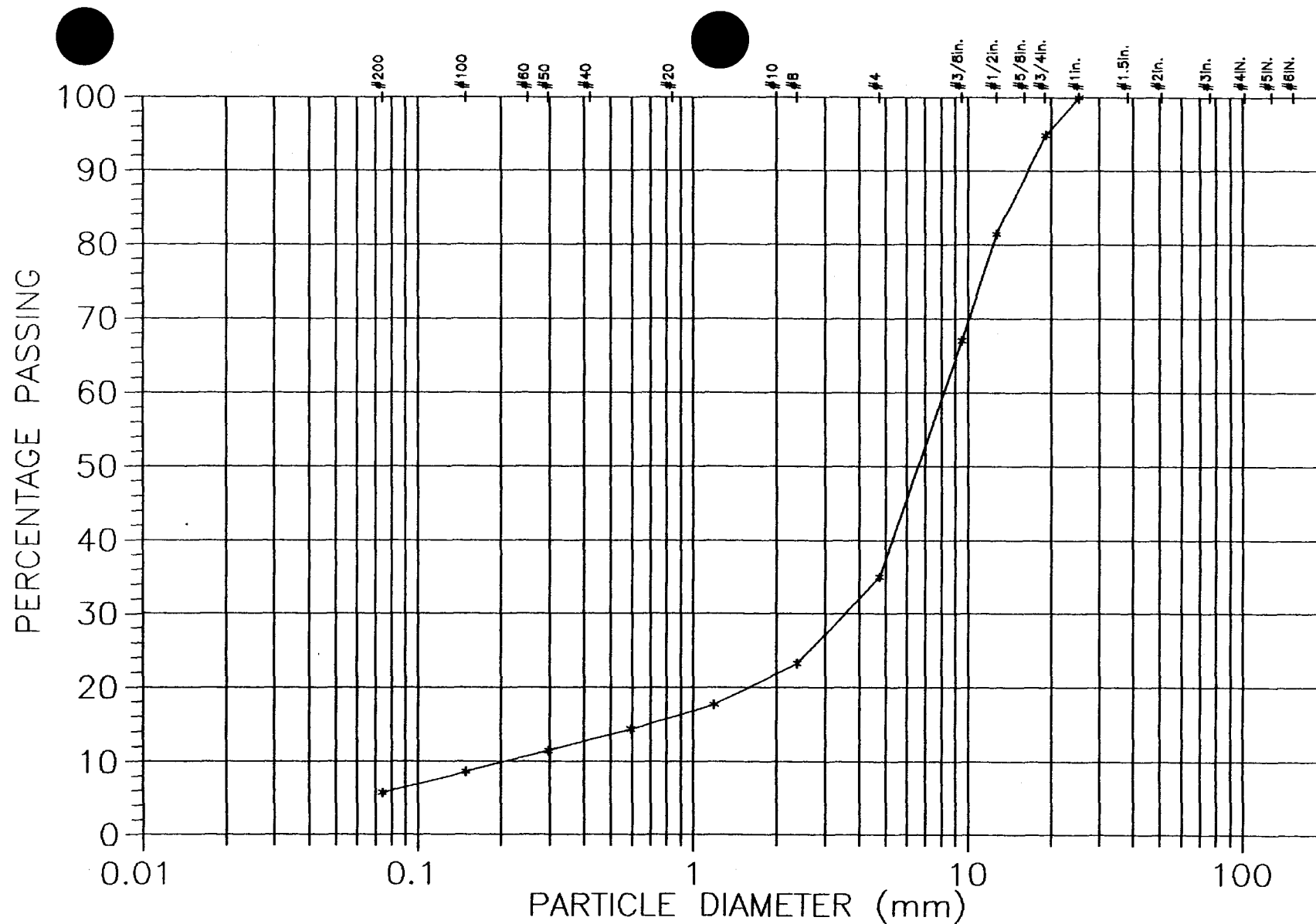
CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 32.7 % SAND: 62.1 % SILT & CLAY: 5.2 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 1 DEPTH: 2.44-3.05 m SPL. NO.: 55 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			



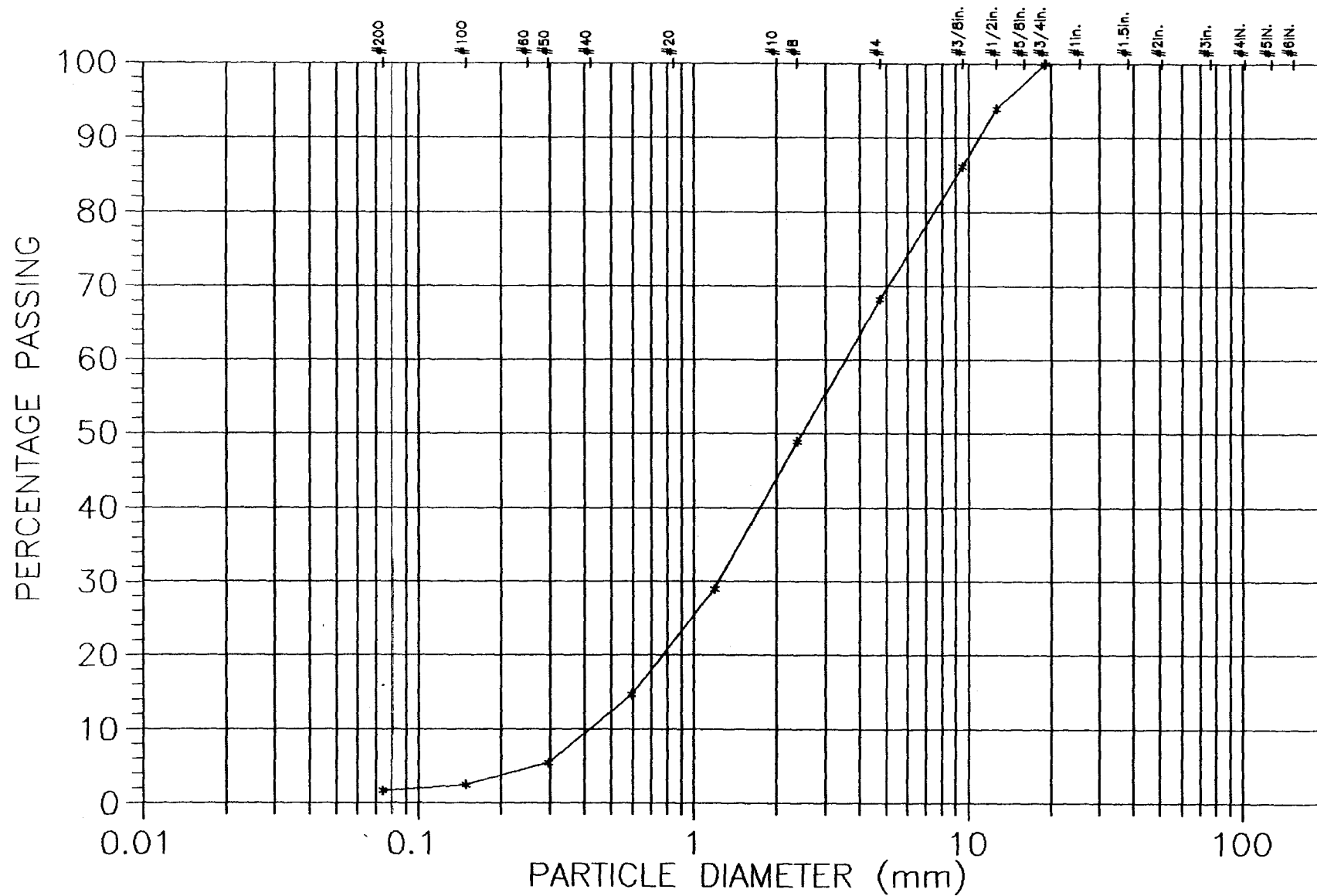
CLAY & SILT	SAND	GRAVEL	COBBLES				
<table border="1"> <tr> <td> SAMPLE DESCRIPTION GRAVEL: 43.6 % SAND: 49.1 % SILT & CLAY: 7.3 % </td><td> UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline </td><td colspan="2"> LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 1 DEPTH: 3.05-3.66 m SPL. NO.: 56 DATE: July 1995 </td></tr> </table>				SAMPLE DESCRIPTION GRAVEL: 43.6 % SAND: 49.1 % SILT & CLAY: 7.3 %	UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline	LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 1 DEPTH: 3.05-3.66 m SPL. NO.: 56 DATE: July 1995	
SAMPLE DESCRIPTION GRAVEL: 43.6 % SAND: 49.1 % SILT & CLAY: 7.3 %	UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline	LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 1 DEPTH: 3.05-3.66 m SPL. NO.: 56 DATE: July 1995					



CLAY & SILT	SAND	GRAVEL	COBBLES
SAMPLE DESCRIPTION GRAVEL: 0.9 % SAND: 18.0 % SILT & CLAY: 81.1 %		UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline	
		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 1 DEPTH: 3.66-4.27 m SPL. NO.: 57 DATE: July 1995	

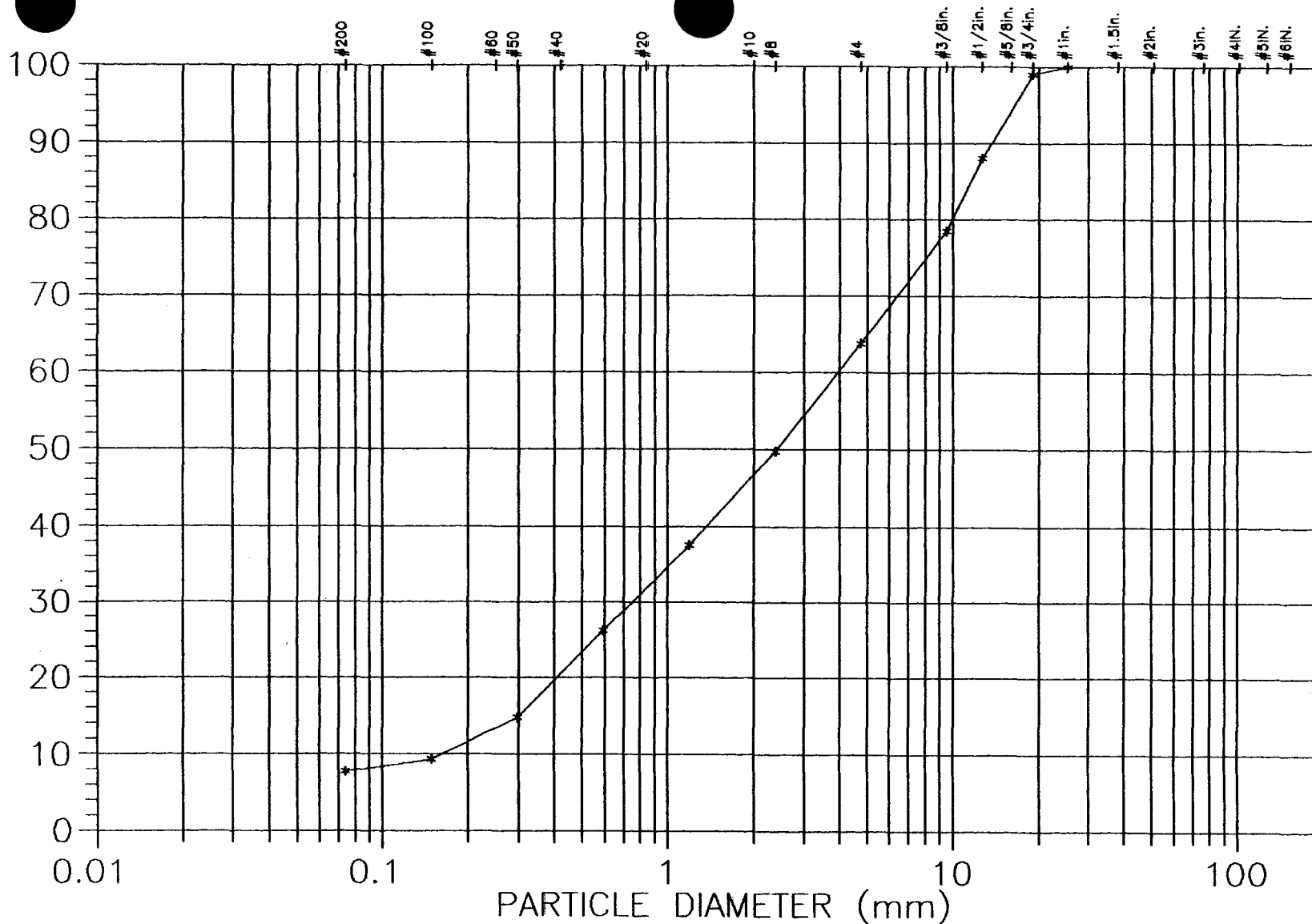


CLAY & SILT	SAND	GRAVEL	COBBLES
SAMPLE DESCRIPTION GRAVEL: 65.0 % SAND: 29.2 % SILT & CLAY: 5.8 % UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 2 DEPTH: 2.44-3.05 m SPL. NO.: 514 DATE: July 1995			

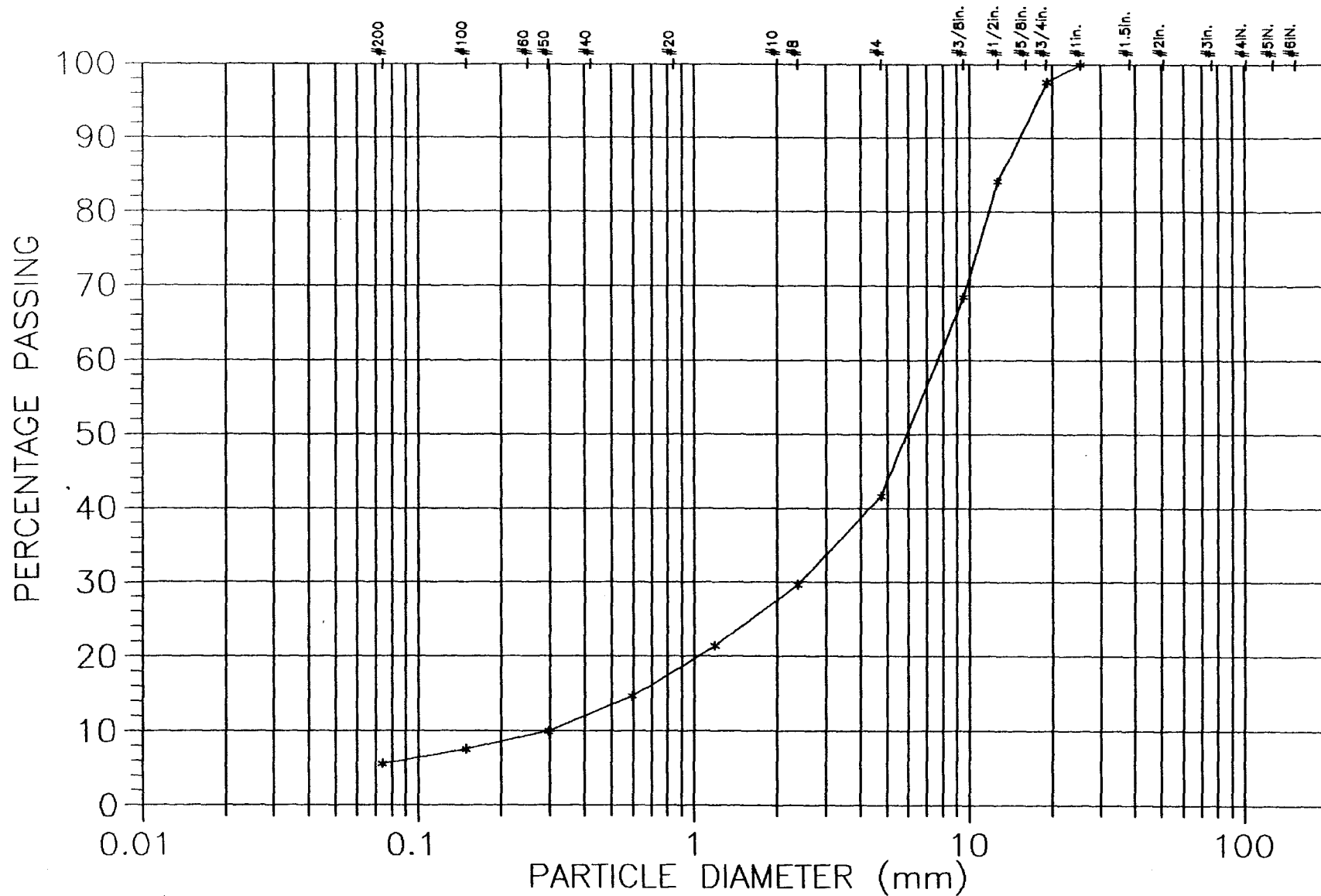


CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 31.8 % SAND: 66.5 % SILT & CLAY: 1.7 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 2 DEPTH: 3.05-3.66 m SPL. NO.: 515 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			

PERCENTAGE PASSING

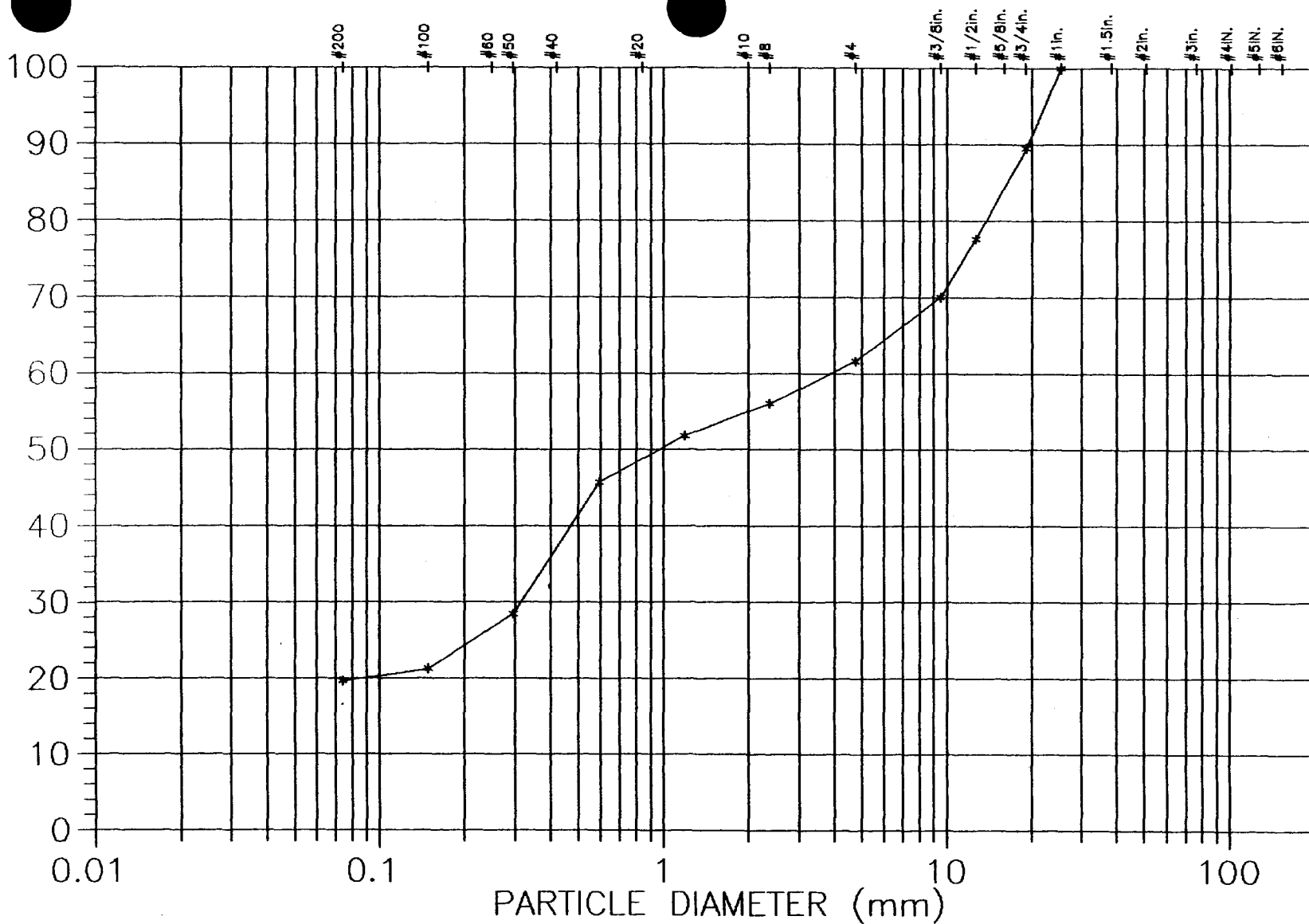


CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 36.2 % SAND: 56.0 % SILT & CLAY: 7.8 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 2 DEPTH: 3.66-4.27 m SPL. NO.: 516 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			

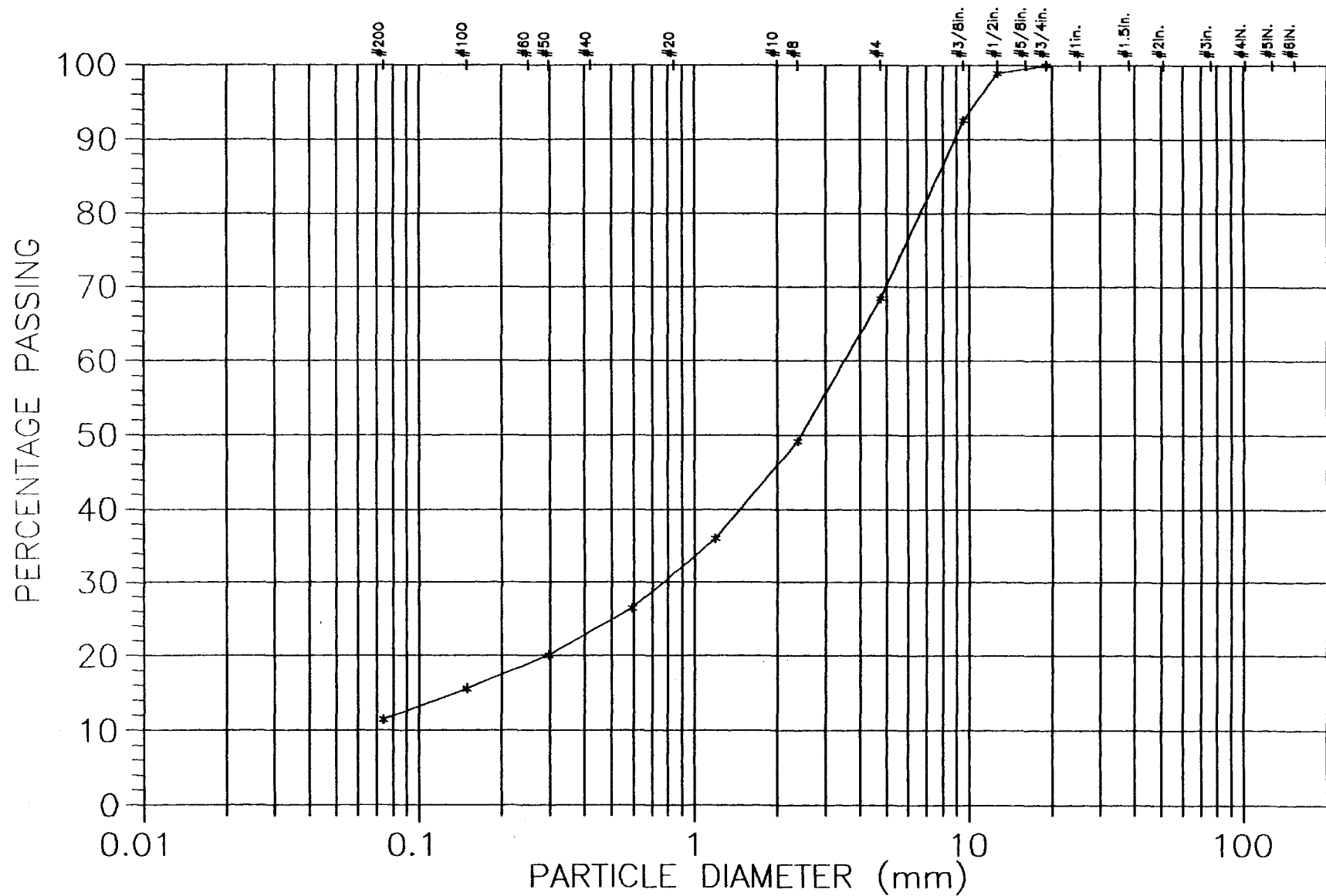


CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 58.3 % SAND: 36.1 % SILT & CLAY: 5.6 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 5 DEPTH: 7.92-8.53 m SPL. NO.: 519 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			

PERCENTAGE PASSING

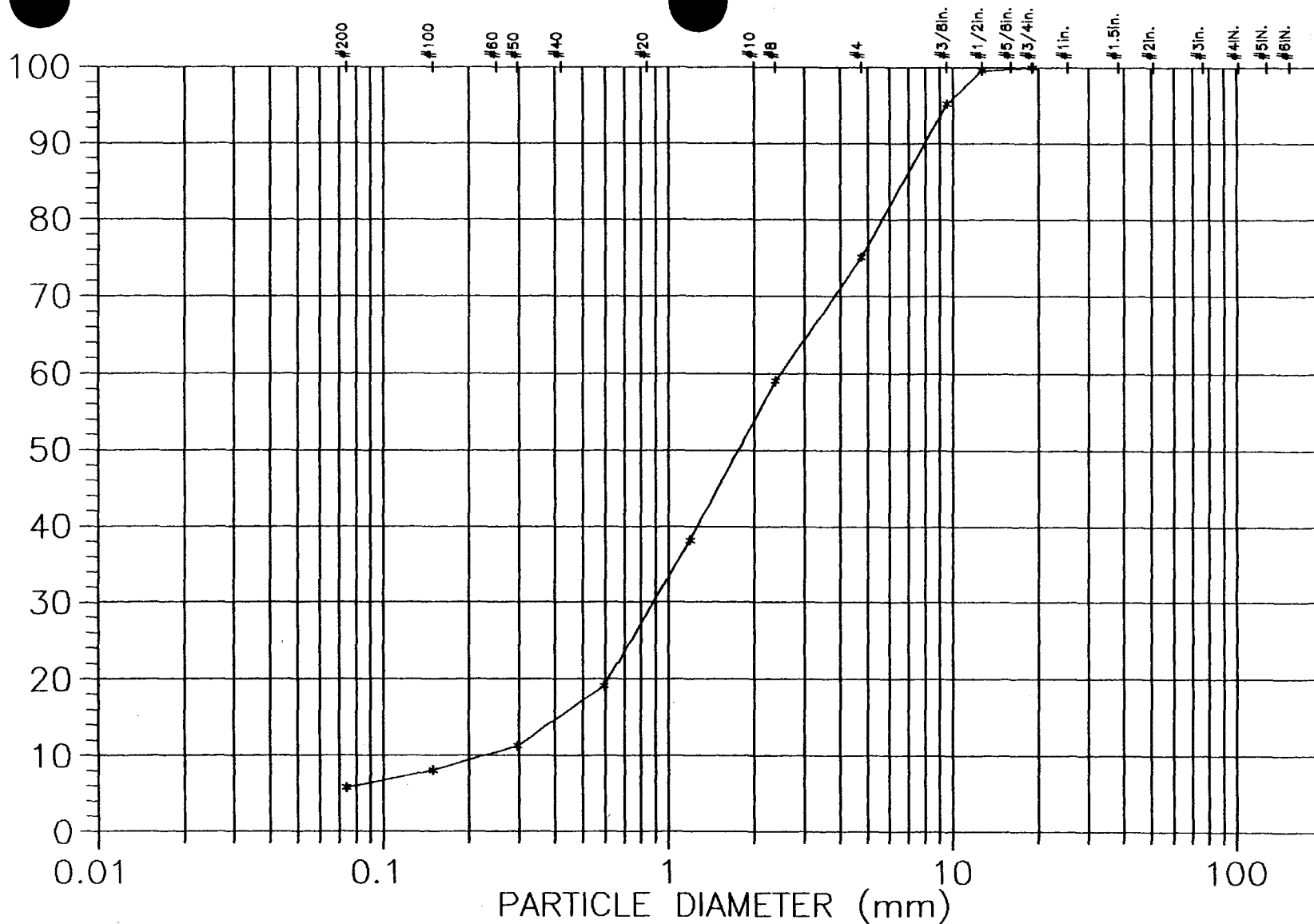


CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 38.4 % SAND: 41.9 % SILT & CLAY:19.7 %		UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Blanchard River Pump Stat. JOB NO.: 4440-034-00-02 HOLE NO.: 5 DEPTH: 9.14-9.75 m SPL. NO.: 520 DATE: July 1995			
		CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline					

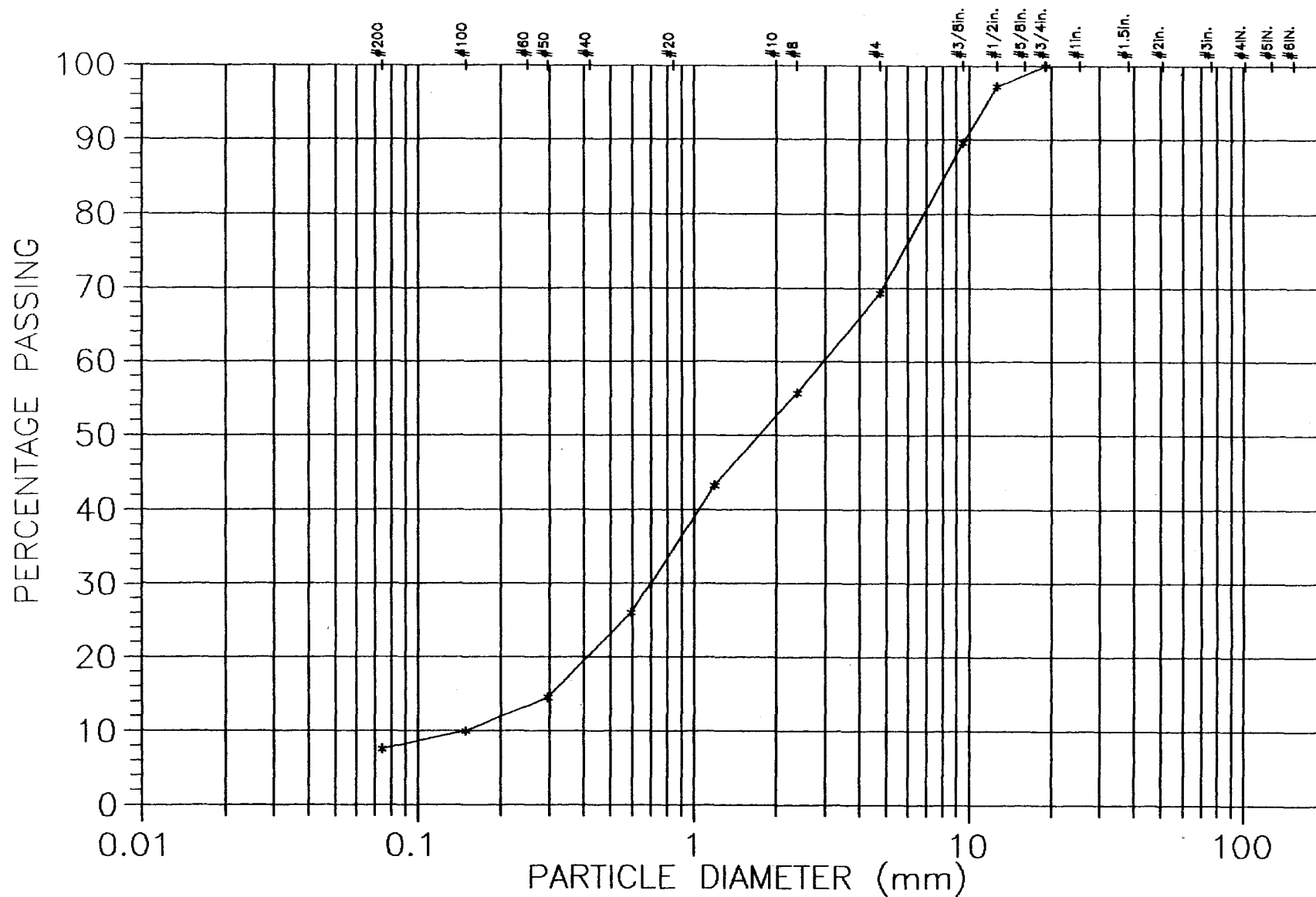


CLAY & SILT	SAND	GRAVEL	COBBLES
SAMPLE DESCRIPTION GRAVEL: 31.6 % SAND: 56.9 % SILT & CLAY: 11.5 %		UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline	
		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 8.53-9.14 m SPL. NO.: 530 DATE: July 1995	

PERCENTAGE PASSING

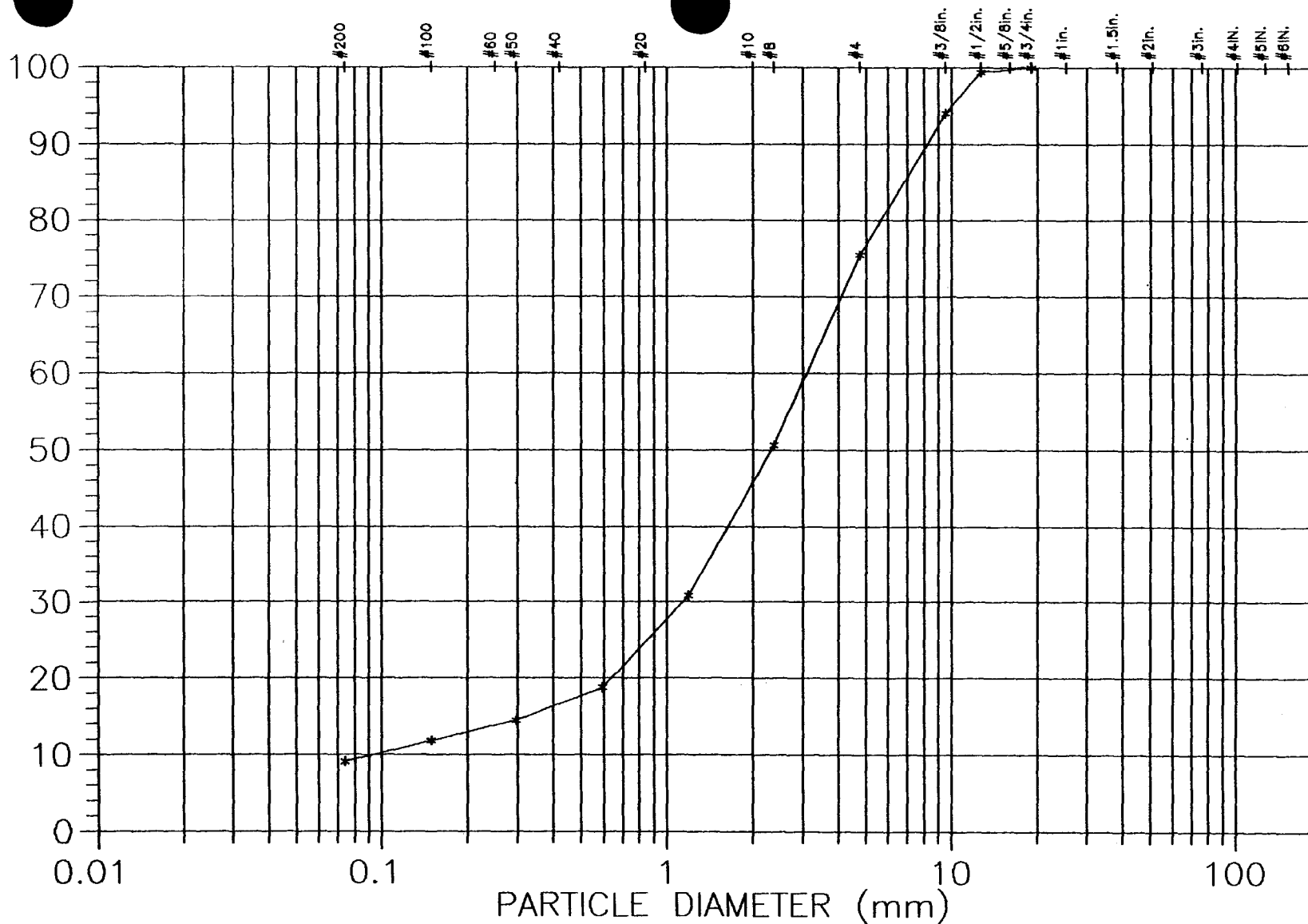


CLAY & SILT	SAND	GRAVEL	COBBLES
SAMPLE DESCRIPTION GRAVEL: 24.9 % SAND: 69.3 % SILT & CLAY: 5.8 %		UMA ENGINEERING LTD. ***** SIEVE ANALYSIS ***** CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline	
		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 9.14-9.75 m SPL. NO.: 531 DATE: July 1995	

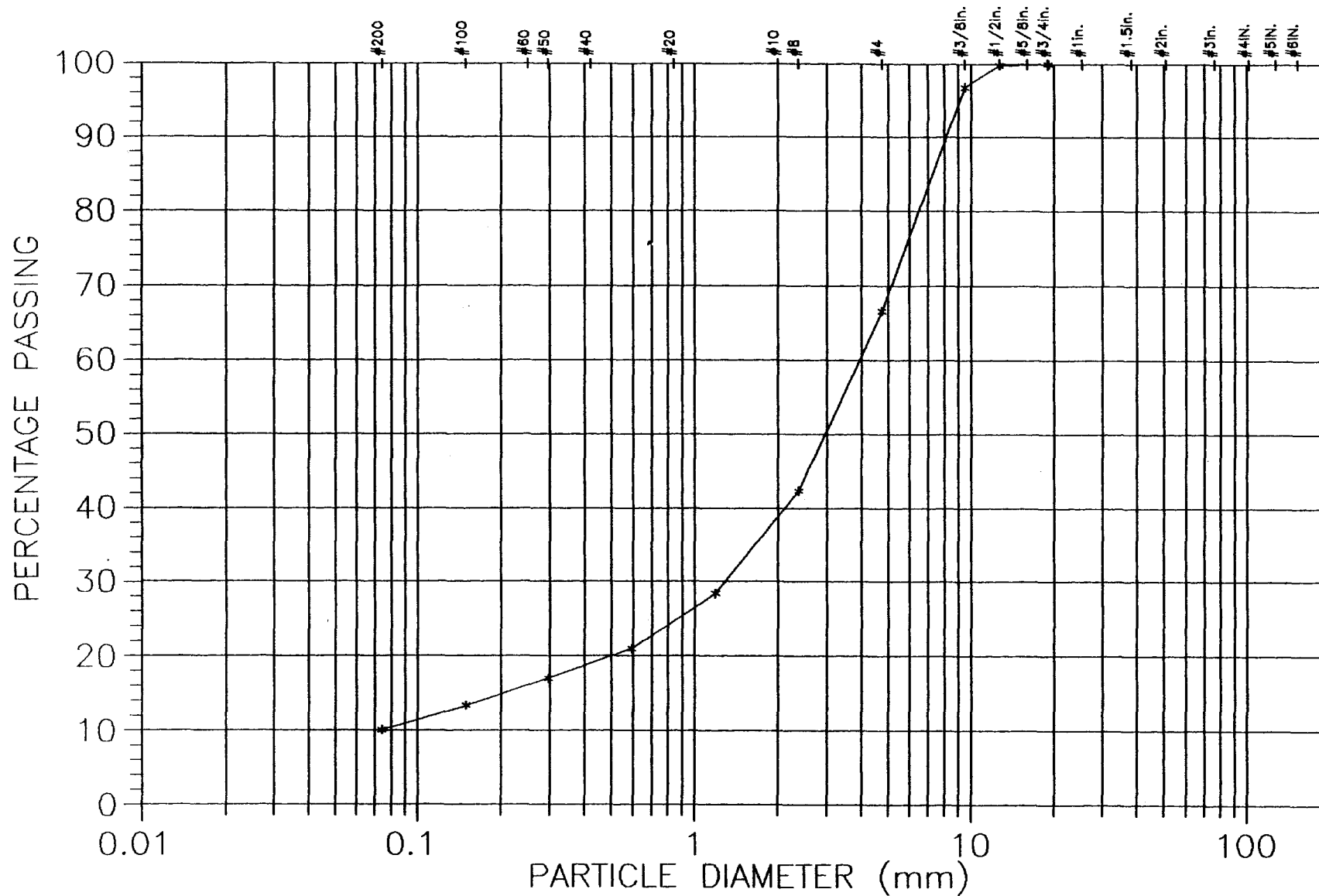


CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 30.7 % SAND: 61.7 % SILT & CLAY: 7.6 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 9.75-10.36 m SPL. NO.: 532 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			

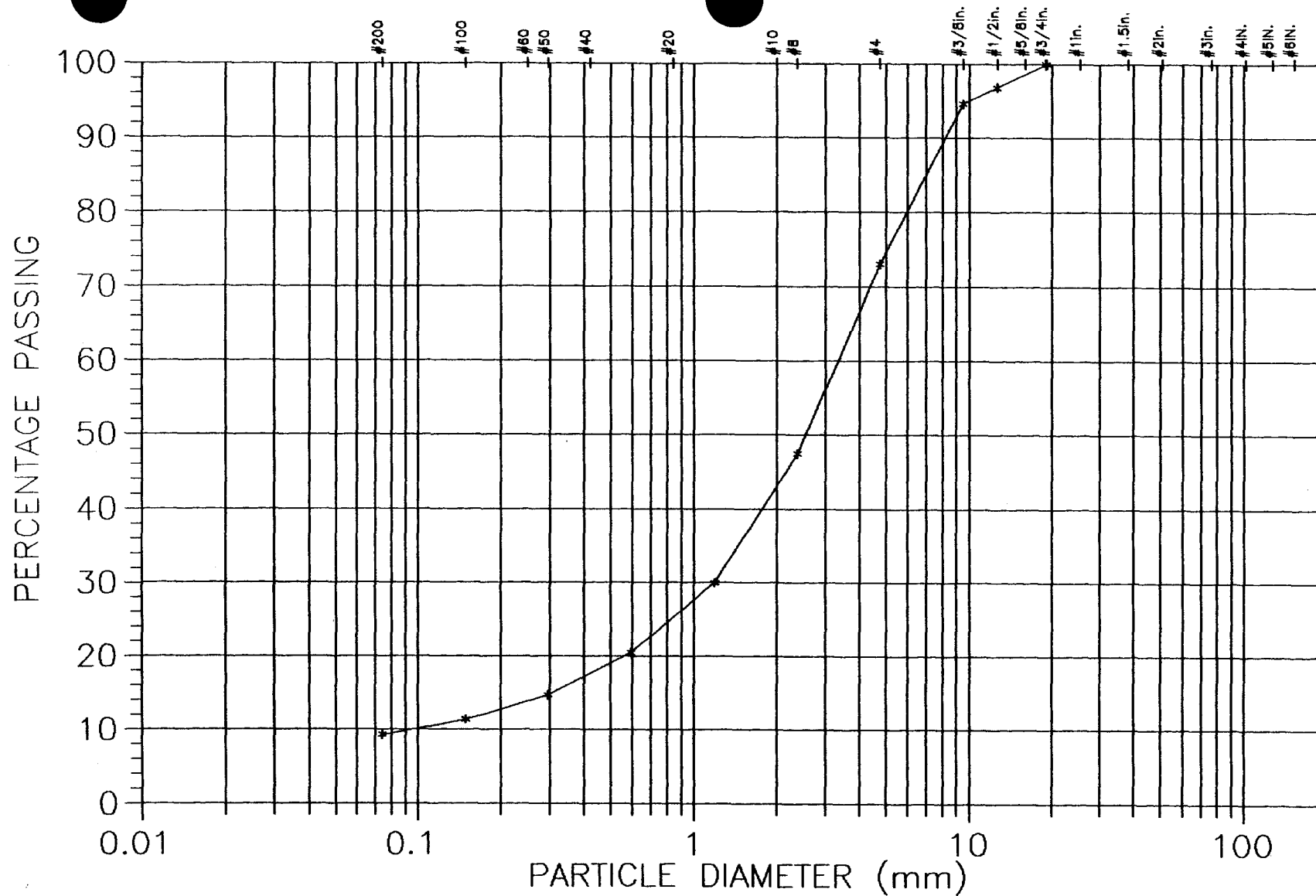
PERCENTAGE PASSING



CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 24.6 % SAND: 66.3 % SILT & CLAY: 9.1 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 15.85-16.46 m SPL. NO.: 533 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			



CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 33.4 % SAND: 56.5 % SILT & CLAY:10.1 %				UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 16.46-17.07 m SPL. NO.: 534 DATE: July 1995	
				CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline			



CLAY & SILT		SAND		GRAVEL		COBBLES	
SAMPLE DESCRIPTION GRAVEL: 27.0 % SAND: 63.7 % SILT & CLAY: 9.3 %		UMA ENGINEERING LTD. ***** SIEVE ANALYSIS *****		LOCATION: Border Pump Station JOB NO.: 4440-034-00-02 HOLE NO.: 8 DEPTH: 17.07-17.68 m SPL. NO.: 535 DATE: July 1995			
		CLIENT: D.I.A.N.D. PROJECT: Haines Pipeline					

APPENDIX F
GROUND CONDUCTIVITY SURVEYS

**A Report on Geophysical Surveys
Conducted at Three Sites
Along the Former**

**Alaskan Pipeline,
Yukon**

for
UMA Environmental

Hyd-Eng Geophysics Inc.
Project No.: H33

Hyd-Eng

GEOPHYSICS INC.

Project No.: H33
August 4, 1995

Mr. Tom Wingrove
UMA Environmental
1479 Buffalo Place
Winnipeg, Manitoba
R3T 1L7

TEL. (204) 284-0580
FAX. (204) 475-3646

Re: A Geophysical Investigation at Three Sites along the Former Alaskan Pipeline, Yukon

Dear Mr. Wingrove;

Please find accompanying this letter the submittal from Hyd-Eng Geophysics Inc. entitled:

**A Report on Geophysical Surveys
Conducted at Three Sites
Along the Former**

**Alaskan, Pipeline,
Yukon**

We trust that this information will prove useful to you in your investigations. If any questions arise, please do not hesitate to call.

Yours Sincerely,



D. Coulter P. Eng.

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Border Pumping Station

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A Report on
Geophysical Surveys
conducted at three sites along the former
Alaskan Pipeline,
Yukon

INTRODUCTION

Hyd-Eng Geophysics Inc. (HEG) was contracted by UMA Engineering Limited of Winnipeg, Manitoba, to conduct geophysical investigations at three separate sites along the former Alaskan Pipeline. The geophysical investigations were undertaken in order to locate anomalies that could be indicative of buried ferrous and non-ferrous metallic objects and/or to map the lateral extents of anomalous subsurface conductivities of interest at the sites.

SCOPE OF WORK

Electromagnetic geophysical surveys were conducted at the three separate areas along the Alaskan Pipeline. The surveys, were conducted between July 4 and 8, 1995, as part of the first phase of Environmental investigations at numerous sites along the pipeline. The work was initially commissioned by the Department of Indian Affairs and Northern Development (DIAND).

These geophysical surveys are intended to:

1. provide a preliminary characterization of the subsurface materials at the sites prior to subsurface investigations, and
2. to assist in the development of a subsurface work program.

Within the general objectives outlined above, there are several key features that have been identified and interpreted by this survey. These features include:

- the geophysical mapping of buried ferrous and non-ferrous metal objects (where possible),

- the geophysically differentiation between areas underlain by various fill and native material, and
- the geophysically identification of areas where dissolved inorganic chemicals may be affecting groundwater.

PHYSICAL PROPERTIES

The measurement of variations in the physical properties of the geological units are the basis of all geophysical surveys. One of the electrical properties of a material that can be measured is its electrical conductivity (milliSiemens/metre). In general, saturated and silty, overburden has conductivities ranging from 10 to 20 mS/m. A clean sand, or compact sandy/silty till unit, has a conductivity ranging from 1 to 10 mS/m. This apparent conductivity range (1-10 mS/m) is typical of "background" levels for the survey areas. Factors such as mineralogy, varying degrees of saturation, compaction, and anomalous porosity, can cause bulk material conductivities to change beyond these limits. In particular, variations in porewater conductivity can significantly influence the bulk apparent conductivity of the ground.

EQUIPMENT AND THEORY

The surveys were carried out with the GEONICS EM61 and the GEONICS EM31. These instruments generate an electromagnetic (EM) field by passing a current through a transmitter coil. As the field passes through the ground it induces a small current flow within the ground. These ground currents create a secondary EM field. The receiver coil measures the combined primary and secondary EM field.

The GEONICS EM31, is a frequency domain electromagnetic device designed for measuring apparent conductivity and is also well suited for buried metal detection. The EM31 utilizes the principle of electromagnetic (EM) induction to measure the electrical properties of the earth. The instrument converts the EM field properties into apparent conductivity measurements of the subsurface in units of milliSiemens per metre (mS/m) and inphase measurements in parts per thousand (ppt). Both the inphase and quadrature (apparent conductivity) readings were recorded. The inphase response is sensitive to metal and relatively insensitive to changes in the apparent conductivity of the ground. However, extremely high ground conductivities will affect the inphase values. The quadrature response is somewhat affected by metal and gives a value for the bulk apparent conductivity of the ground for a roughly hemispherical volume

of radius 5 to 6 metres centered at the operator. For a complete description of the theory of operation and technical details of the EM31 refer to McNeill, 1980.¹

The EM61 is a time domain electromagnetic device specifically designed for locating buried ferrous and non-ferrous metallic objects. The instrument measures the time-rate of decay of an induced electromagnetic field in the subsurface. Two receiver coils are used to help differentiate between surface and buried metal. The difference in the response of the two coils is calculated as the differential channel. The depth to the object can also be estimated by comparing the responses of the two coils. Note that the EM61 may not detect all linear anomalies (i.e. pipes and/or utilities) and this data should not be used for this purpose.

The EM31 was initially used at most sites as a reconnaissance device to approximately locate areas of anomalous conductivity and buried metal. The EM61 was then used to overlap areas interpreted to contain buried metal in order to screen the areas for surface and more deeply buried anomalies, to delineate the buried metal more accurately, and to calculate approximate a depth to the top of the anomalies. The EM61 and the EM31 identified identical buried metal related responses, but in addition the EM31 identified several areas of anomalous conductivity which are presented in this report.

FIELD PROCEDURES

Geophysical survey grids were established at all sites (refer to appropriate figures). The first site is the Haines Junction Pumping station located northwest of Haines Junction, Yukon. The second site, the Blanchard Pumping Station is located approximately 100 km south of Haines Junction and along the Alaskan highway. The third site, known as the Border Pumping station, is located approximately 60 km north of Haines, Alaska on the Canadian side of the Border. Refer to UMA Environmental map for exact locations.

At each site several areas that required geophysical surveying were identified by UMA representatives. The line and station spacing was also determined prior to surveying. The exact survey parameters varied depending on several factors: the size of the site, the priority attached to the site, and as the size of the suspected anomalous features. All of survey parameters were

¹ McNeill, J.D. 1980, Electromagnetic Terrain Conductivity Measurements at Low Induction Numbers, Geonics Ltd., Note TN-6, 16pp.

discussed with, and in consultation with an on-site UMA representative in order that adequate coverage be achieved. Listed below are the line and station spacing chosen for each grid.

Table 1:

Haines Junction Grid	Line Spacing (metre)	Station Spacing (metre)
1	2.0	0.75
2	2.0	0.75
3	2.0	0.75
4	2.0	0.75
5	10.0	1.5
6	5.0	1.5

Table 2:

Blanchard Grid	Line Spacing (metre)	Station Spacing (metre)
1	2.0	0.75
2	2.0	0.75
3	5.0	0.75
4	2.0	0.75

Table 3:

Border Grid	Line Spacing (metre)	Station Spacing (metre)
1	5	1.5

Generally a dense, two metre line spacing was chosen for areas having a high priority, or likely to contain subsurface anomalies. A more coarse line spacing, 5 or 10 metres, was used at grids where a large area had to be covered and/or a low priority was attached to these areas.

Generally all grids have base and tie lines every 25 to 50 metres. These lines were then flagged and staked at 25 metre, or denser intervals.

In order to be able to relocate all data collected at each grid and reestablish identical grid coordinates at a later time, each grid has a reference point attached to it. Where possible these reference points was chosen to be permanent landmarks that were not likely to change over time.

Both the quadrature and inphase readings were recorded using the EM31, while channel 1 and channel 2 readings for the EM61 were recorded into a data storage device (polycorder). All EM61 data were collected at approximately a 0.19 metre station interval, along lines spaced 2 metres apart. Over the detail grids EM31 readings were taken at 0.75 metre station spacing along lines spaced 2 meters apart.

The locations of the survey grids for the Haines junction and Blanchard pumping station, Figure 1 and 2 respectively. The grid location map (Figure 1) for the Haines Junction Pumping station has been digitized from an airphoto provided by UMA representatives.

DATA PROCESSING

At the completion of each survey day the EM31 and EM61 data, were transferred from the data logger to a portable computer. Survey line locations were adjusted as required. These data were then sorted, gridded, contoured, and plotted at an appropriate scale using *Geosoft* software, a data presentation program developed by Geosoft Limited of Toronto, Ontario.

The results of the EM31 surveys are displayed as colour, contoured plots of the apparent conductivity and inphase readings. A colour scheme was used to highlight the variations in the data. To display relative changes in the conductivity, the data were coloured and contoured in order to equally represent the complete range of values. Background values are generally shown in yellow and green. Red and blue areas represent anomalous readings above and below background respectively.

The results of the EM61 surveys are displayed as colour contoured plots of Channel 2 and Differential data. Channel 1, data collected by the top coil, is subtracted from Channel 2, bottom coil, to produce the Differential plot. Channel 2 contains information about all targets that are detectable by the EM61, while Channel 1 contains information mainly about shallow targets. Therefore the mathematically produced Differential Channel (the difference of Channels 1 and 2) emphasizes deeper targets, with the effects of surface metal being largely removed or suppressed. A consistent colour scheme between diagrams has been used to highlight variations in the data. Background values are generally shown as green and yellow. Red in the colour zone is used to distinguish anomalous readings above background

The electromagnetic data has been presented in the Appendix using the following format:

1. Haines Junction Pumping Station: **A** Series of Drawings (ex. Figure A.1.a)
2. Blanchard Pumping Station: **B** Series of Drawings (ex. Figure B.1.a)
3. Border Pumping Station: **C** Series of Drawings (ex. Figure C.1.a)

The interference from surface metal, buildings, reinforced concrete, etc. will affect the instruments' response to nearby subsurface anomalous features. When the extent of this interference is unknown, buried features located adjacent to or directly below the source of interference may go undetected.

RESULTS

Anomalous areas *not* attributed to cultural interference, or other explainable sources, are highlighted on the interpretation map for each area. Although it is difficult to assess the degree that cultural influence (fences, buildings, vehicles) and topography has on the conductivity and inphase data in certain areas, a background value has been estimated for each of the area interpretations. A background conductivity of between 1 and 10 mS/m is used in the interpretation of the data collected at all sites. These background values are typical conductivities for a highly resistive sandy/gravelly material. Inphase background values range between 1 and -1 ppt across the sites.

The apparent conductivity and the inphase response can also be used to detect metal related features. The letter "M" surrounded by a bold line appears on some of the area diagrams. This symbol represents the interpreted limits of metal related anomalies for which there is no visible object to explain the aberration. Typically buried metallic objects produce a negative (blue) instrument response with the EM31, and a positive (red) response with the EM61. However, we have experienced that when a buried metallic object's size is in the order of the instruments intercoil separation (4 metres), that the instrument response can be positive. A number of factors influence the size of an anomaly resulting from a buried metallic object including depth of burial, type of fill (background values), cultural interference, and the instruments orientation relative to the buried metallic object. Areas with anomalous conductivity variations have been labeled "C" and areas of anomalous inphase readings denoted "I".

Detection of inorganic and organic contaminant are highly site specific and is dependent on the concentration, depth to the contaminate, native materials present, and local sources of EM noise. We have however successfully mapped numerous inorganics, such as chlorides, mercury, lead, and chromium, in the past.

The interpreted results of the geophysically surveyed areas are discussed below. Due to the size and number of anomalous zones and features encountered, the anomalies at each grid are divided into groups based on similar response and characteristics at each area.

Haines Junction Pumping Station:

Grid 1:

M1 through M4 are broad areas of extremely positive EM61 readings. The area encompassed by **A1** also defines a large area of negative apparent conductivity and inphase readings which includes M1 through M4. The area A1, and M1 through M4 are interpreted to result from numerous buried metallic objects of varying depth of burial, shape, and size with M1 through M4 representing the main areas of concern .

m1 through m13 are localized, discrete geophysical anomalies which are interpreted to result from shallow metallic objects of varying size and shape. These anomalies are observed in the Channel 2 EM61 data set (Figure A.1.d.).

Grid 2 and 3:

M1 through M3 are broad areas of negative apparent conductivity and inphase EM31 readings. These anomalies are interpreted to result from buried metallic objects of varying depth of burial, shape, and size.

Grid 4 and 6:

m1 is a localized, discrete geophysical anomaly which is interpreted to result from shallow metallic object.

I1 is a broad positive inphase and apparent conductivity anomaly which occurs adjacent to a former loading platform. This anomaly likely results from extremely conductive fill, scattered, or "disseminated", metal and/or other anomalous soil conditions.

Grid 5:

No geophysical anomalies are observed at this grid

Blanchard Pumping Station:

Grid 1 and 3:

M1 through M4 are broad areas of extremely positive EM61 readings. These anomalies are interpreted to result from buried metallic objects of varying shape, size, and depth of burial.

m6 through m10 are localized, discrete geophysical anomalies which are interpreted to result from shallow metallic objects of varying size and shape. These anomalies are observed in the Channel 2 EM61 data set (Figure B.1.d.).

L1 and L2 are strong linear anomalies which appear in the inphase and apparent conductivity data. These anomalies likely result from buried pipes/utilities or similarly proportioned objects. M2, M3 and M4 may be associated with the construction of and/or access to L1 and L2.

L3a and L3b are weak linear anomalies which appear in the inphase and apparent conductivity data. These anomalies likely result from small buried pipes/utilities or similarly proportioned objects.

Grid 2:

L1, L1b and L2 are strong linear anomalies which appear in the inphase and apparent conductivity data. These anomalies likely result from buried pipes/utilities or similarly proportioned objects. It is likely that L1 is an extension of the major linear feature, also named L1, interpreted to exist at Blanchard Grid 1.

M1 through M3 are broad areas of extremely positive EM61 readings. These anomalies also have corresponding complex EM31 measurements associated with them. These anomalies are interpreted to result from buried metallic objects of varying shape, size, and depth of burial.

m4 through m9 are localized, discrete geophysical anomalies which are interpreted to result from shallow metallic objects of varying size and shape. These anomalies can be observed in the Channel 2 EM61 data set (Figure B.3.d.).

C1 is a broad zone of extremely elevated conductivity (greater than 35 mS/m). This zone is then surrounded by a broader zone (**C2**) of moderately elevated apparent conductivity (10 to 35 mS/m). **C1** encircles a gravel pile on the site and likely results from elevated porewater conductivities associated with a former salt pile and/or salt run off from the existing pile. **C2** in turn encircles **C1** and likely results from a combination of elevated porewater conductivities extending from **C1**, and/or elevated soil/porewater conductivities associated with **M1**, **M2**, and **L1**.

Grid 4:

M1 through M4 are broad areas exhibiting negative inphase and apparent conductivity readings. These anomalies are interpreted to result from buried metallic objects of varying shape, size, and depth of burial. Due the limited access, caused by dense vegetation, in and around the anomalous areas a gridded EM61 survey was not carried out. Instead each anomalies existence was verified and delineated more accurately with the EM61 by sampling continuously in real time. Each anomaly was then identified in the field with flagging tape and pin flags in order to facilitate future location.

m5 is a localized, discrete geophysical anomaly which is interpreted to result from a shallow metallic object(s).

C1 is a broad zone of moderately elevated apparent conductivity (greater than 30 mS/m). This zone is located west of **M1** through **M4** along an existing gravel roadway. It can not be determined from this data if this anomaly results from increased water content, elevated porewater conductivities, and/or from elevated soil conductivities, possibly caused by siltier conditions closer to the river.

Grid 5:

A fifth grid of geophysical data was collected in and around the area marked on Figure 2 as 'Hydrocarbon test area'. This data was collected in order to determine if a geophysical apparent conductivity variation existed and which may be indicative of a hydrocarbon plume. Unfortunately it was determined that the area exhibited a high degree of cultural interference and significant topographic change thereby making the interpretation of minor apparent conductivity variations, associated with the existence of possible hydrocarbons, impossible.

Border Pumping Station:

Grid 1:

The data collected in the northern extent (35N to 50N) of the survey grid are known to correspond to an area where buildings are known to have existed.

M1 through M2 are broad areas exhibiting negative inphase and apparent conductivity readings. These anomalies are interpreted to result from buried metallic objects of varying shape, size, and depth of burial.

A1 through A3 are broad areas exhibiting complex negative and positive inphase and apparent conductivity readings. These anomalies are interpreted to result from a combination of buried metallic objects of varying shape, size, and depth of burial, foundations, and/or pipes/utilities possibly associated with former buildings.

m1 through m16 are localized, discrete geophysical anomalies which are interpreted to result from shallow and/or relatively small metallic objects of varying size and shape.

C1, C2 and C3 are broad zones of moderately to extremely elevated conductivity (greater than 20 mS/m). These zones likely results from a combination of elevated soil or porewater conductivities, and/or the complex interaction of the surrounding interpreted features.

L1 and L2 are strong linear anomalies which appear in the inphase and apparent conductivity data. These anomalies likely result from buried pipes/utilities or similarly proportioned objects. L1 and L2 may be associated with the construction of and/or access to A1, A2 and M4.

L3 through L9 are moderate to strong linear anomalies which appear in the inphase and apparent conductivity data. These anomalies likely result from buried pipes/utilities or similarly proportioned objects.

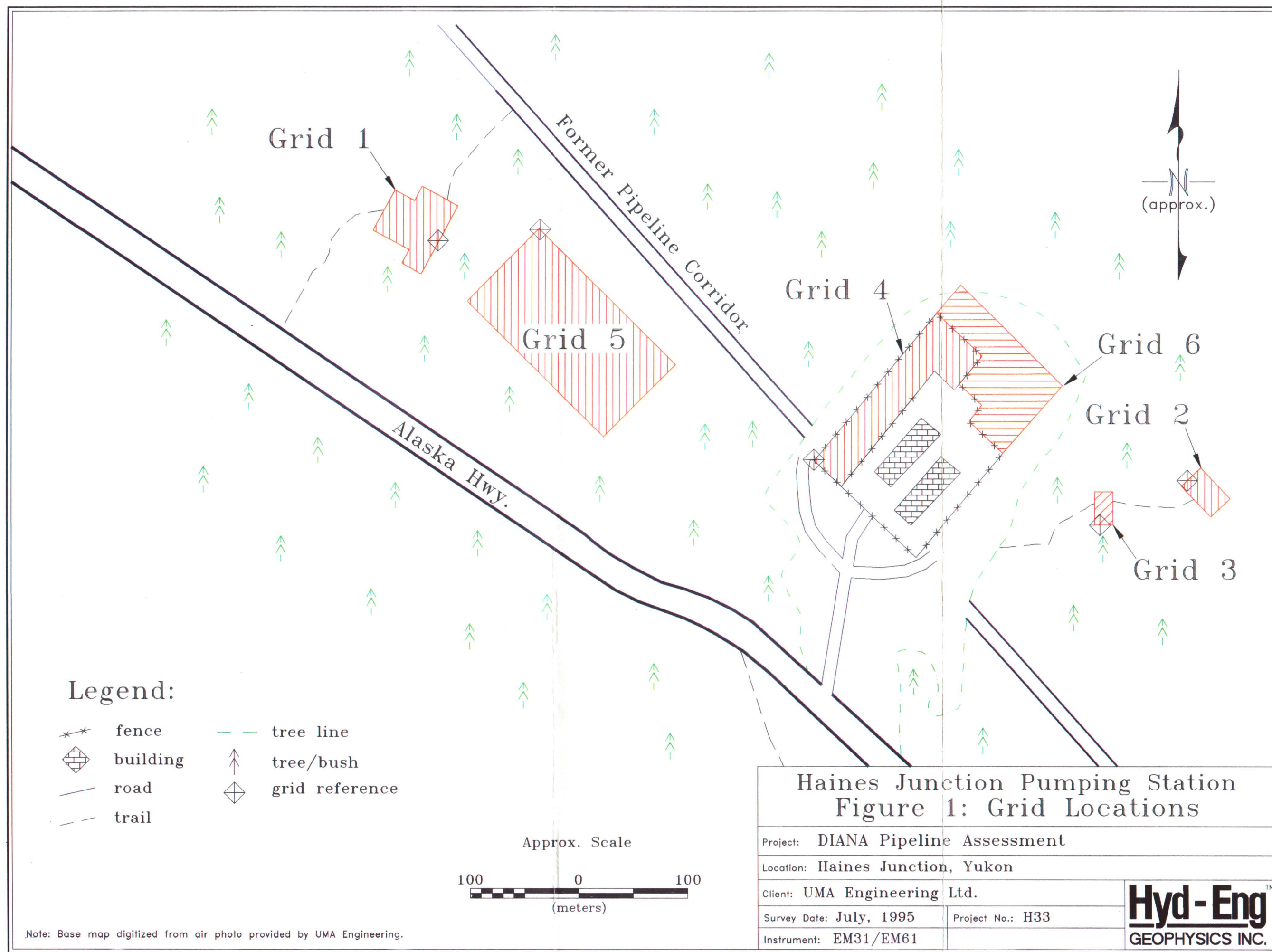
L10 is a wide linear anomaly which appears as a strong negative inphase and apparent conductivity response. This anomaly likely result from a buried metallic pipe/utility or similarly proportioned object. L10 may be associated with the anomalies identified as C2 and C3.

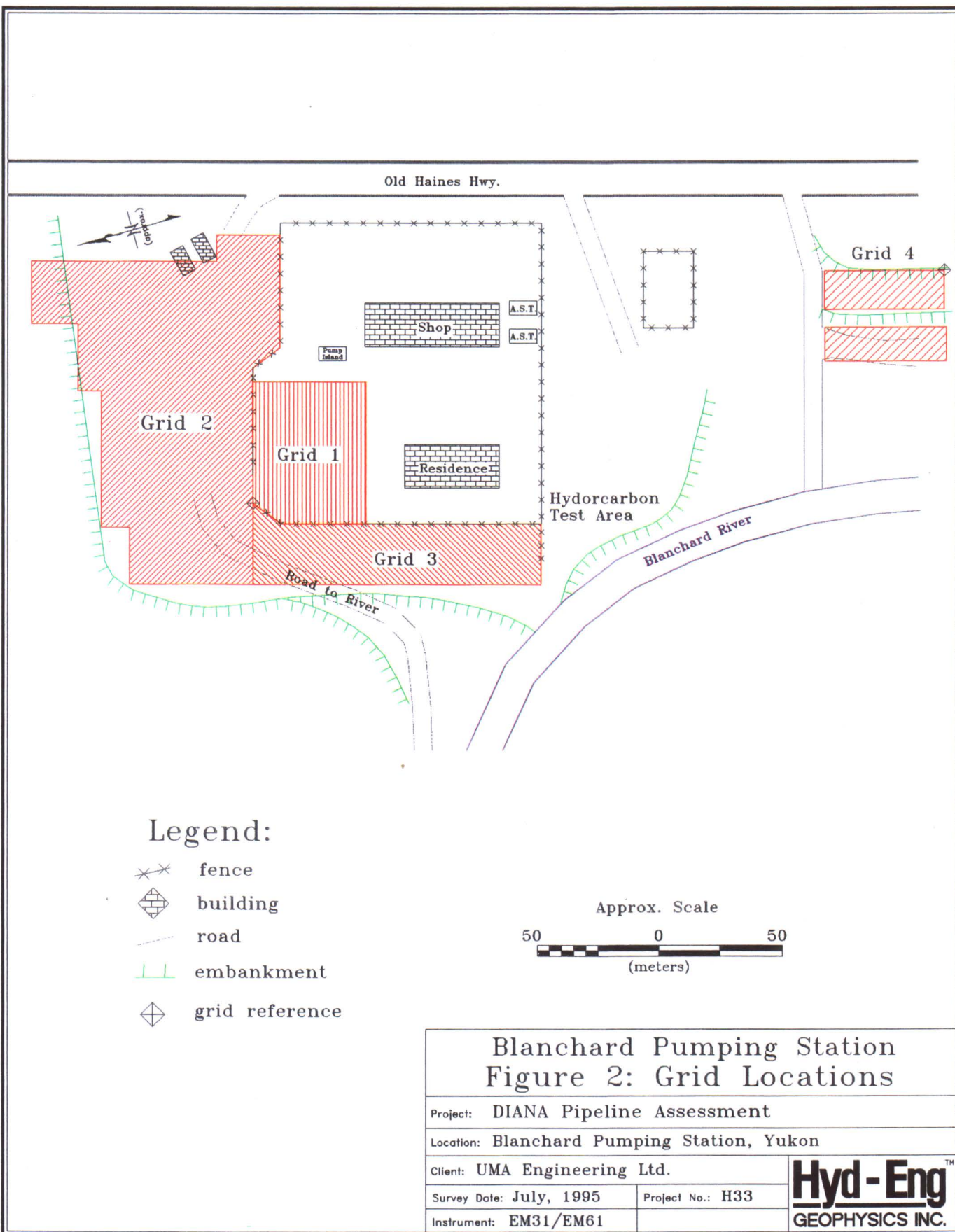
I1 is a broad zone observed primarily as a positive inphase anomaly (crosses) but also has an elevated apparent conductivity response. The inphase response of the instrument within this anomaly is saturated (above 35 ppt). Portions of this inphase anomaly may result from

conductive fill but more likely this strong positive inphase anomalies is a result of scattered or "disseminated" metal and/or anomalous soil conditions.

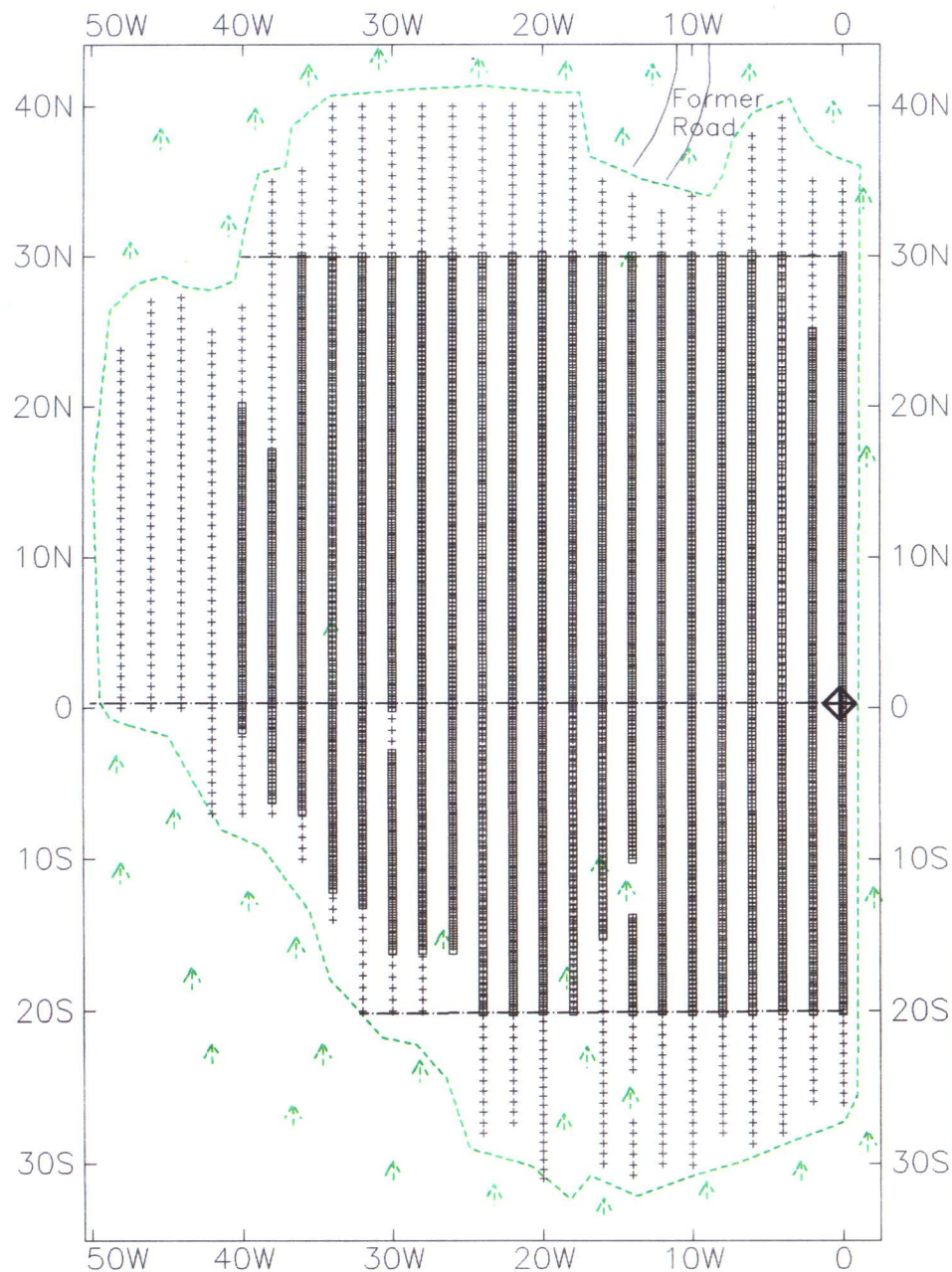
SUMMARY

In summary, numerous discrete and broad metal related anomalies, linear trends, anomalous conductivity variations, and several elevated inphase anomalies are interpreted to exist at the three separate sites surveyed using geophysical electromagnetic techniques. Grid 5 of the Haines Junction pumping station site has no geophysical subsurface anomalies associated with it.





HAINES JUNCTION PUMPING STATION



Legend:

-  grid reference
-  tie line
-  treeline, tree/bush
-  surface metal
-  Em31, EM61 data point



Scale 1:500

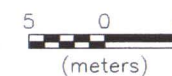


Figure: A.1.a Haines Junction Pumping Station Survey Stations: Grid 1 & 3

Project: DIAND Pipeline Assessment

Location: Haines Junction, Yukon

Client: UMA Engineering Ltd.

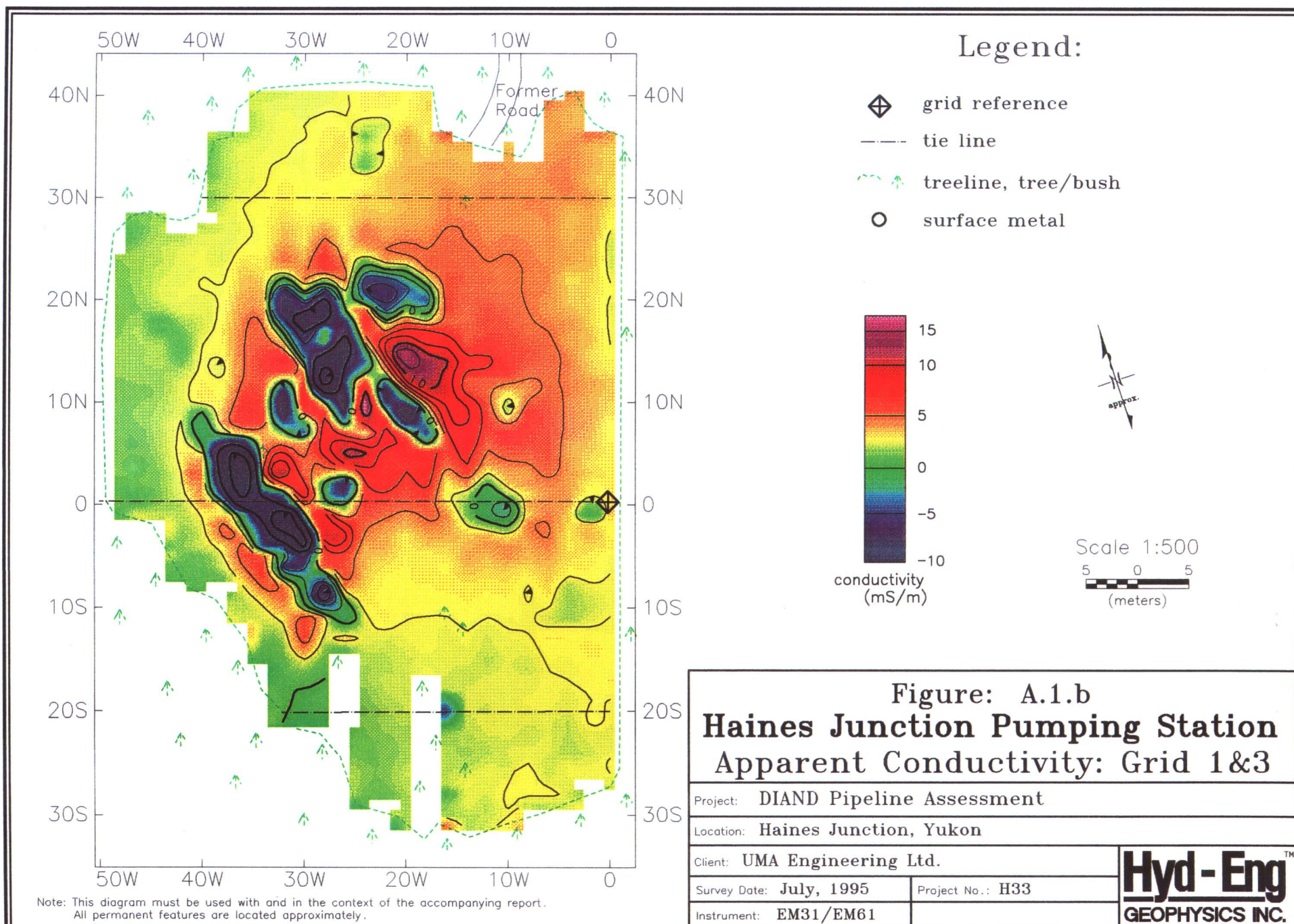
Survey Date: July, 1995

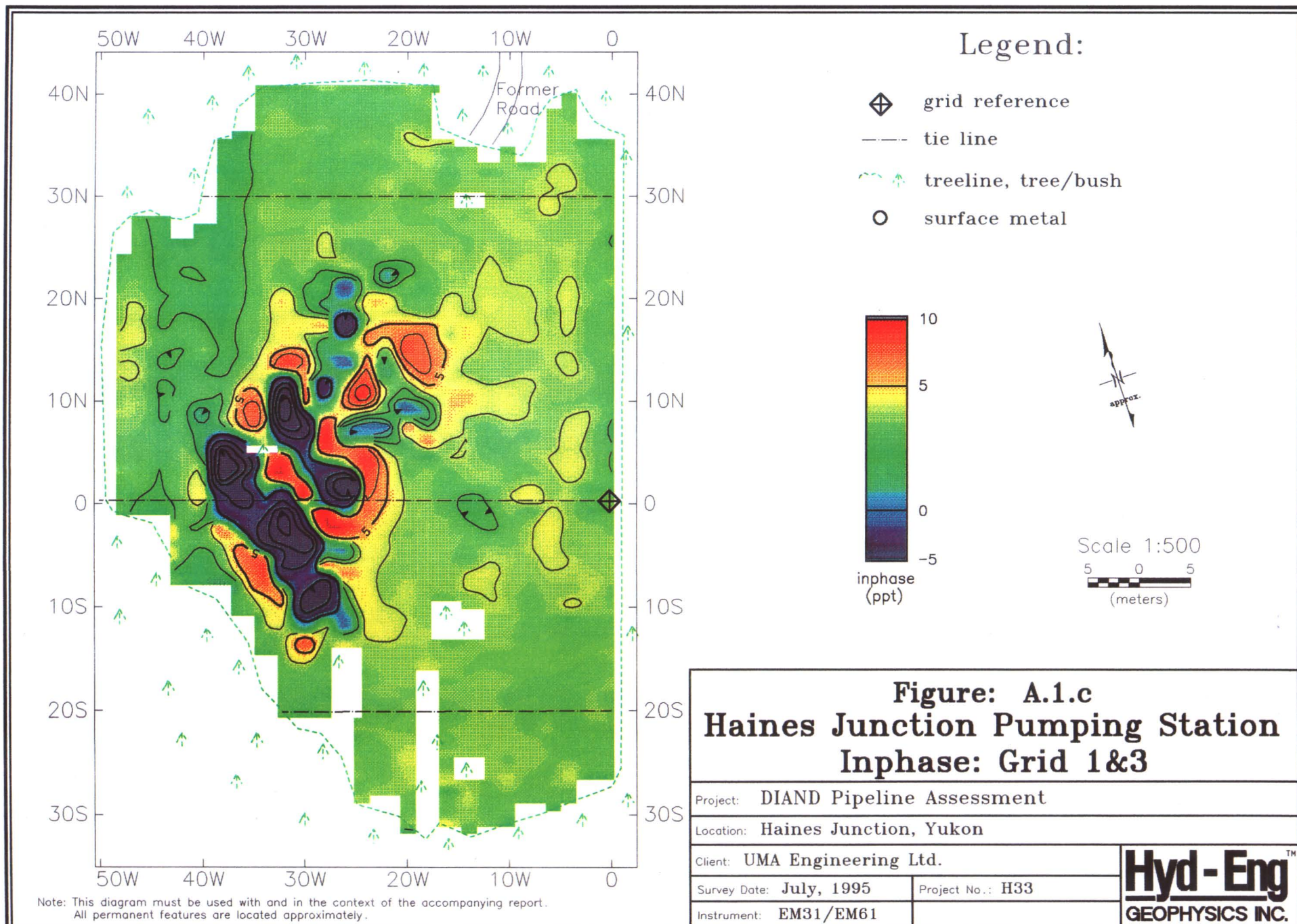
Project No.: H33

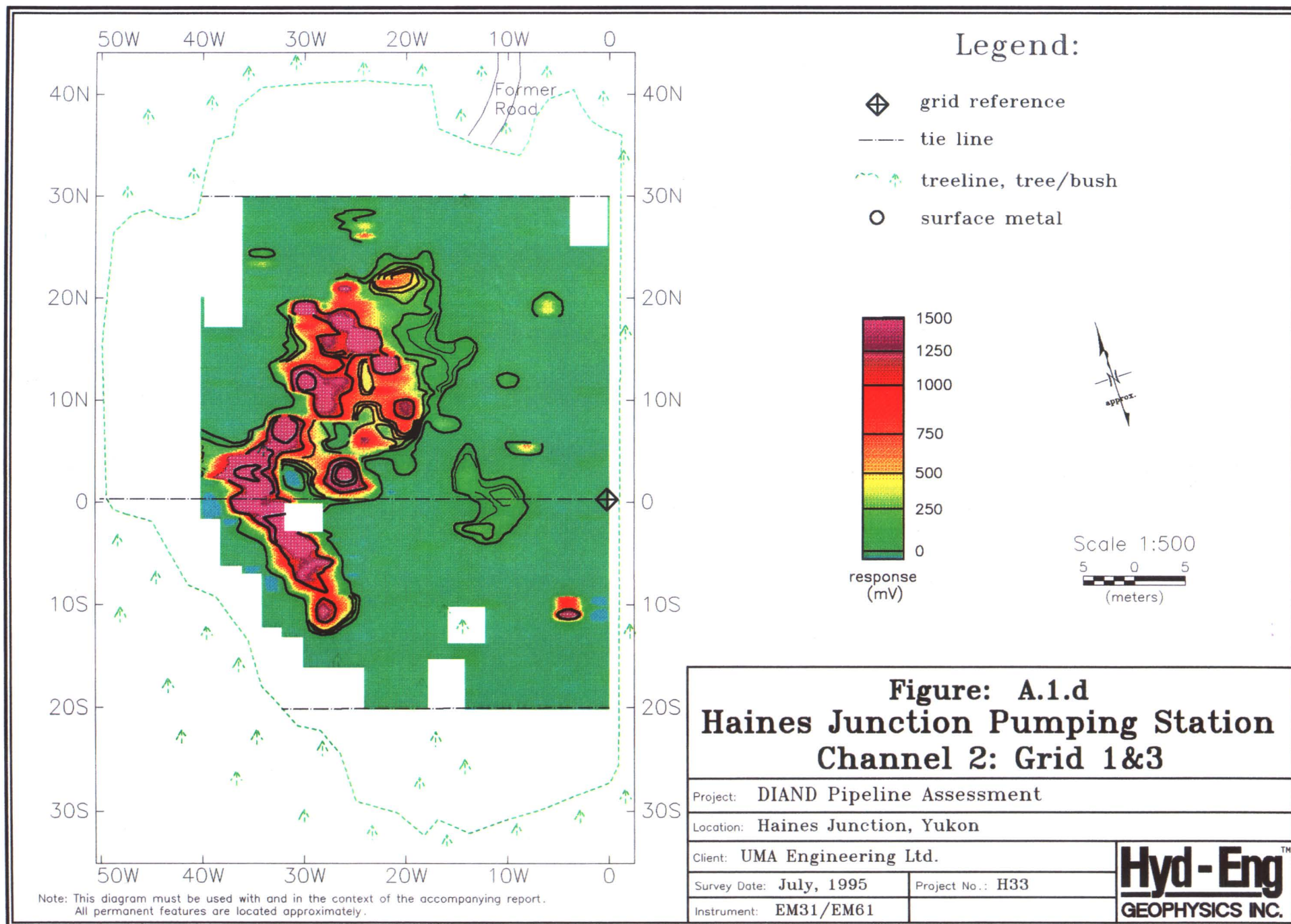
Instrument: EM31/EM61

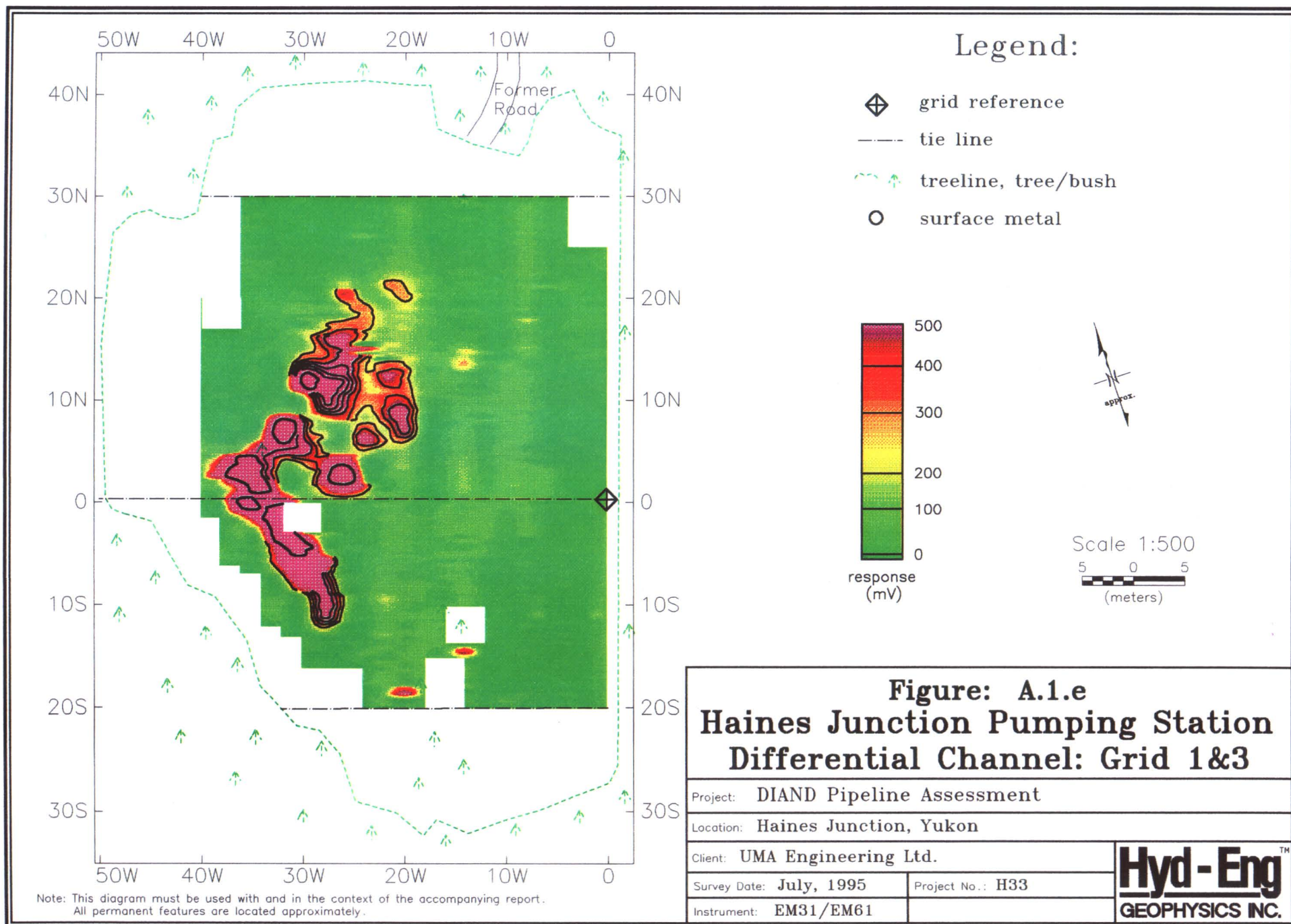
Hyd-EngTM
GEOPHYSICS INC.

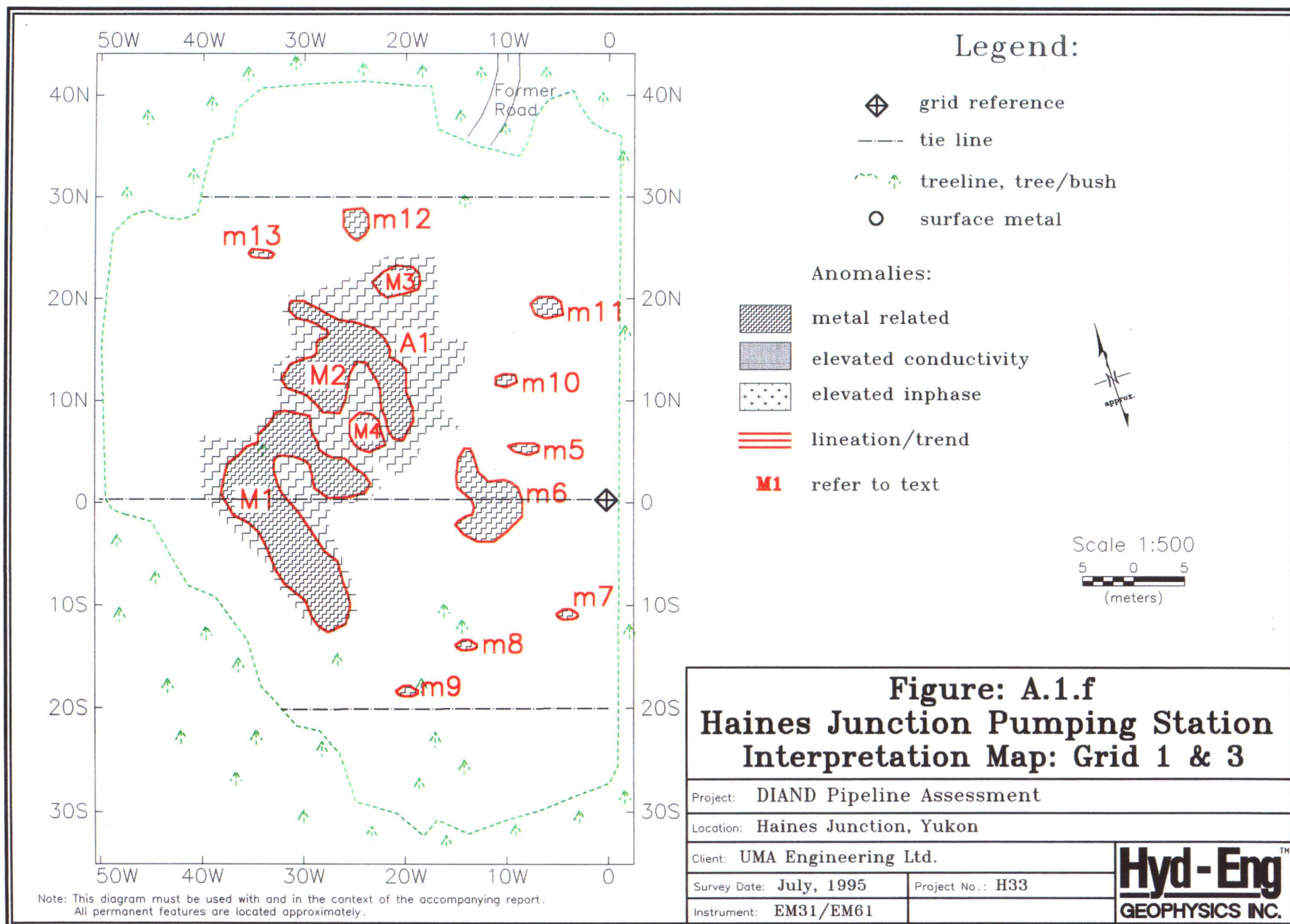
Note: This diagram must be used with and in the context of the accompanying report.
All permanent features are located approximately.



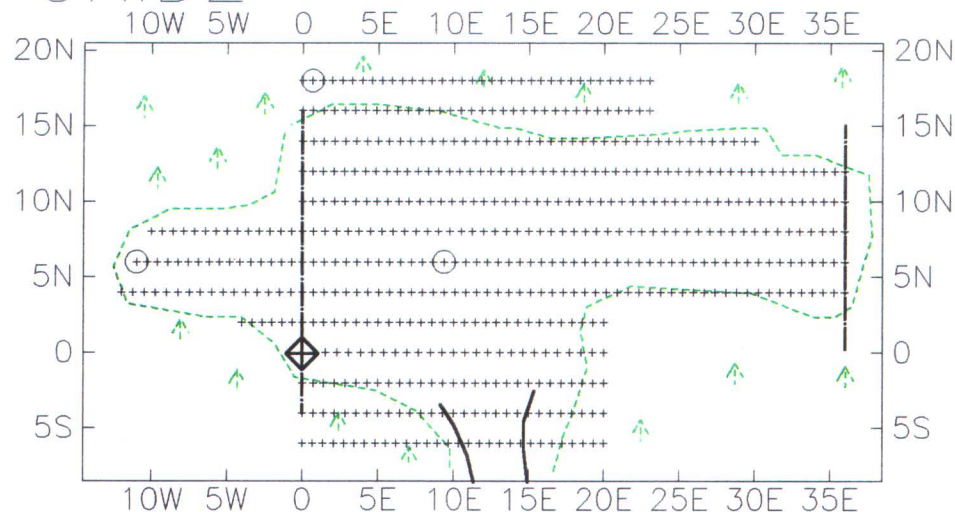




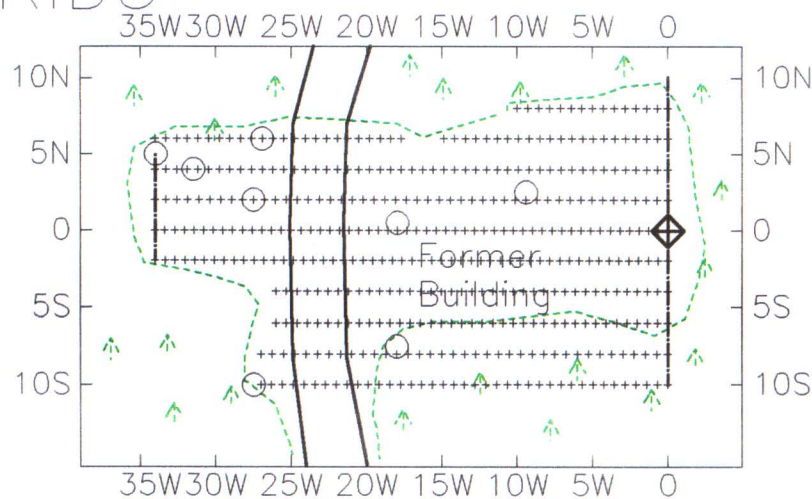




GRID2



GRID3



Legend:

- grid reference
- tie line
- treeline, tree/bush
- surface metal
- road
- EM31 data point



Scale 1:500
5 0 5
(meters)

Figure: A.2.a Haines Junction Pumping Station Survey Stations : Grid 2 and 3

Project: DIAND Pipeline Assessment

Location: Haines Junction, Yukon

Client: UMA Engineering Ltd.

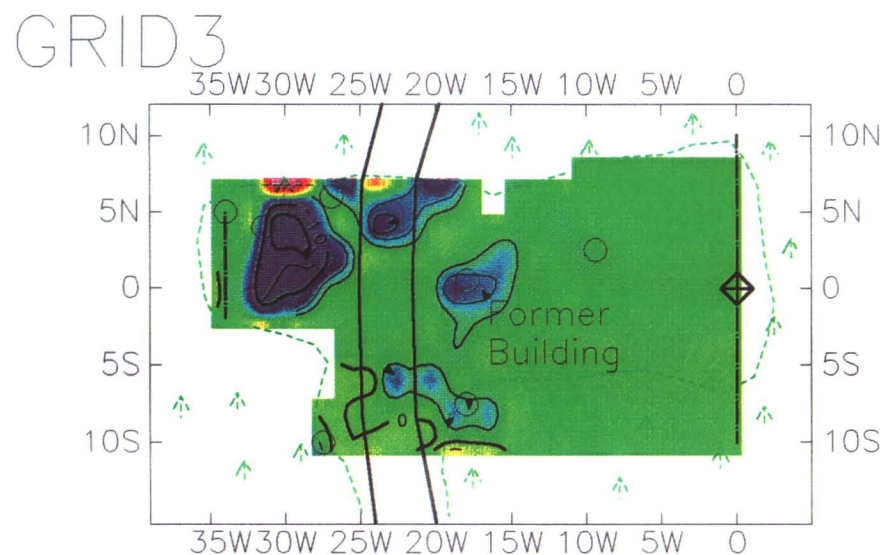
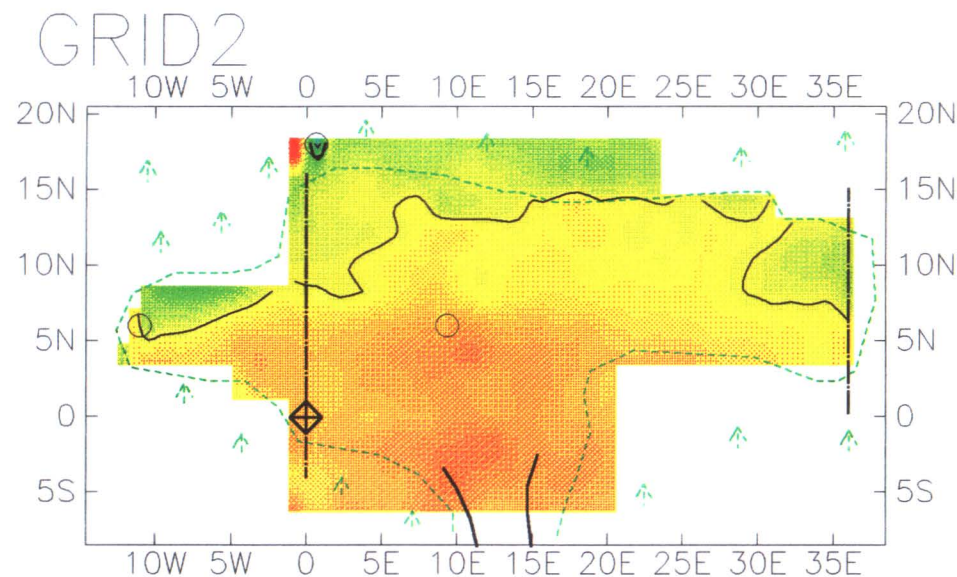
Survey Date: July, 1995

Project No.: H33

Instrument: EM31/EM61

Hyd-Eng
GEOPHYSICS INC.

Note: This diagram must be used with and in the context of the accompanying report.
All permanent features are located approximately.



Legend:

- grid reference
- tie line
- treeline, tree/bush
- surface metal
- road

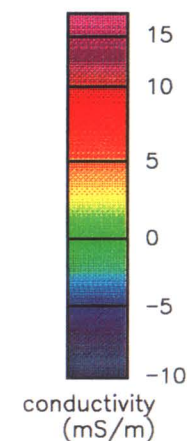


Figure: A.2.b
Haines Junction Pumping Station
Apparent Conductivity: Grid 2 & 3

Project: DIAND Pipeline Assessment

Location: Haines Junction, Yukon

Client: UMA Engineering Ltd.

Survey Date: July, 1995

Project No.: H33

Instrument: EM31/EM61

Hyd-EngTM
GEOPHYSICS INC.

Note: This diagram must be used with and in the context of the accompanying report.
 All permanent features are located approximately.

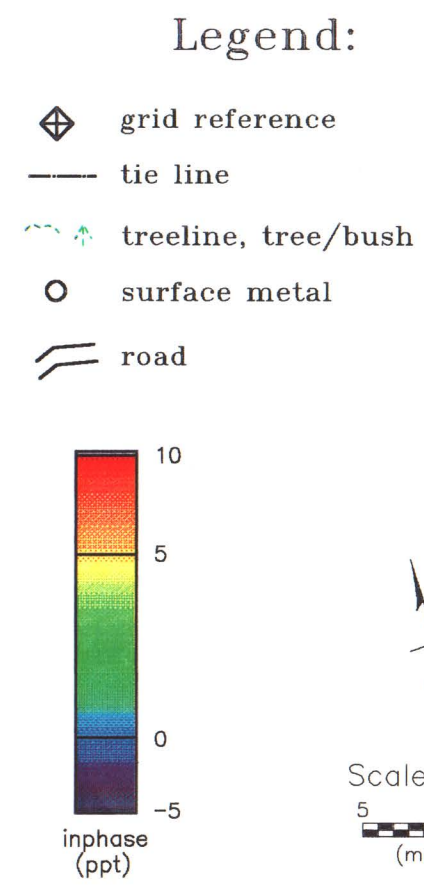
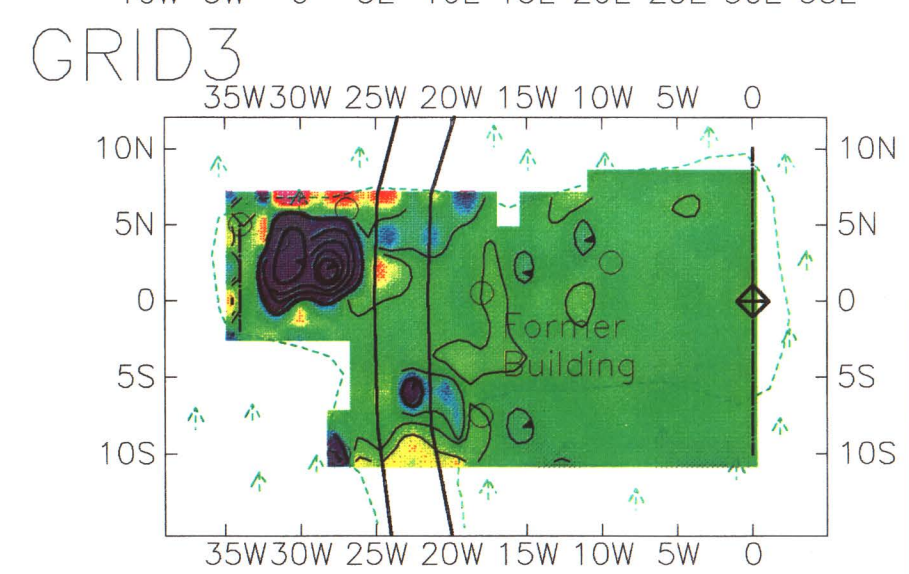
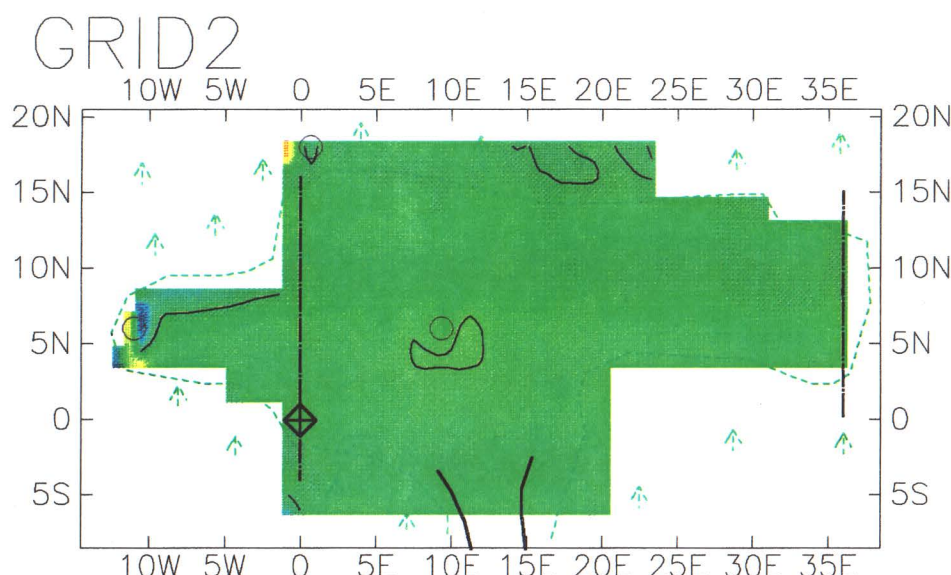


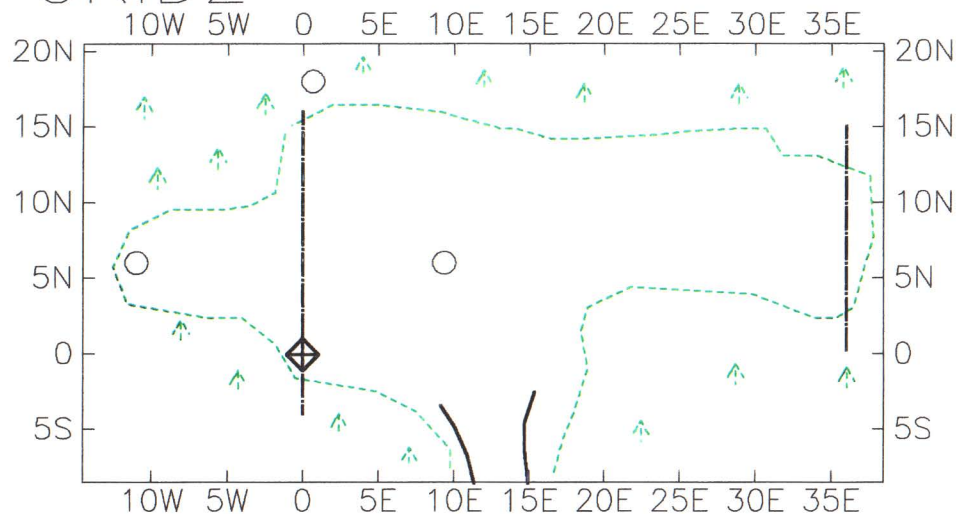
Figure: A.2.c
Haines Junction Pumping Station
Inphase: Grid 2 & 3

Project: DIAND Pipeline Assessment	
Location: Haines Junction, Yukon	
Client: UMA Engineering Ltd.	
Survey Date: July, 1995	Project No.: H33
Instrument: EM31/EM61	

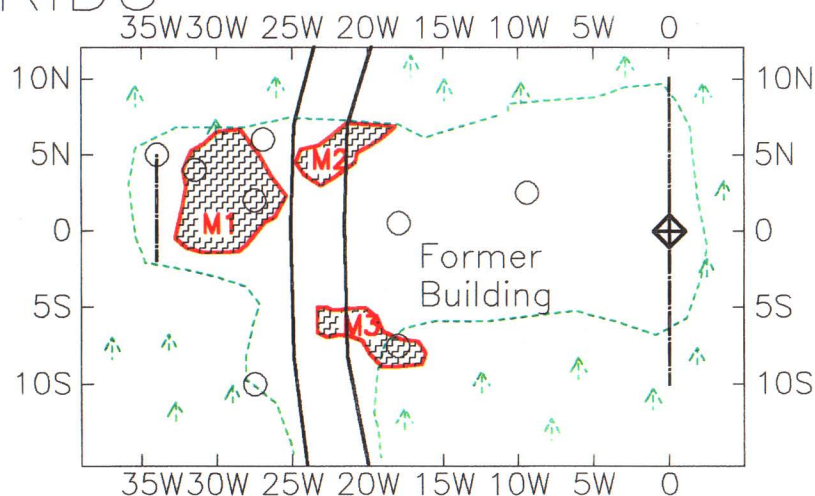
Hyd-Eng
GEOPHYSICS INC.

Note: This diagram must be used with and in the context of the accompanying report.
 All permanent features are located approximately.

GRID2



GRID3



Legend:

- grid reference
- tie line
- treeline, tree/bush
- surface metal
- road

Anomalies:

- metal related
- elevated conductivity
- elevated inphase
- lineation/trend



Scale 1:500
5 0 5
(meters)

Figure: A.2.d Haines Junction Pumping Station Interpretation Map: Grid 2 & 3

Project: DIAND Pipeline Assessment

Location: Haines Junction, Yukon

Client: UMA Engineering Ltd.

Survey Date: July, 1995

Project No.: H33

Instrument: EM31/EM61

Hyd-EngTM
GEOPHYSICS INC.

Note: This diagram must be used with and in the context of the accompanying report.
All permanent features are located approximately.