Phase I & II Environmental Site Assessment

Former Military Site
Koidern River - Long's Creek
Mile Post 1155 Alaska Highway
(DIAND Site 32)

Prepared for:

Arctic Environmental Strategy - Action on Waste
Indian and Northern Affairs Canada
Whitehorse, Yukon

Prepared by:

Hycal ENVIRONMENTAL SCIENCES LTD.

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EXECUTIVE SUMMARY

Hycal Environmental Sciences Ltd. was retained by Action on Waste, Arctic Environmental Strategy, Indian and Northern Development, Canada to carry out an environmental assessment of a former military site, known as Koidern River - Long's Creek, at Mile Post 1155 of the Alaska Highway, in the western Yukon Territory.

The purpose of the investigation was to gather preliminary information on the site in order to determine whether further site assessment or remediation is required and to make recommendations on future assessments or remediation, where necessary. Previous reports indicated that debris was present on the site and there was the possibility of some environmental concerns related to the property.

The investigation consisted of six tasks:

1. Historical Site Assessment
   A history of the site was developed to provide an understanding of the past uses of the site and adjacent properties, to identify conditions or events which could have adversely affected the site, and to facilitate site location, inspection, and sampling.

2. Site Inspection
   The site was visually inspected to identify conditions of environmental concern including signs of surface contamination, evidence of the use or storage of hazardous materials, the presence of equipment or materials that might contain PCBs, indications of pits or sumps, indications of waste incineration, and conditions of concern on adjacent properties.

3. Site Sampling
   Soil sampling was carried out to confirm the presence or absence of contaminants. Geophysical investigation was carried out to determine whether buried metal debris was present on the site.

4. Sample Analysis
   A soil sample from the subject site was analyzed for the presence of contaminants which have been associated with military activities in the Yukon.

5. Risk Assessment

   A preliminary risk evaluation was carried out to determine the degree of risk to humans, or to the environment in general, that might be associated with conditions identified on the site.

6. Recommendations for Further Investigation / Remediation

   Methods and results of each of the tasks undertaken were documented. Recommendations for further investigation were then developed.

Investigation of the subject site was limited by the scope of the study, including the allocated budget and time. Further investigation would be required to more fully assess all of the areas within the site or to allow for more precise risk analysis. However, given the results of the investigation, the following conclusions and recommendations can be offered:

- the nature of the debris on the site, combined with results of the historical records search, indicated that this site was, indeed, occupied by the military during World War II.

- while historical searches yielded some useful information, the site appears to have been subject to activities which were poorly or never documented. Therefore, **further historical record searches are not indicated at this time.**

- some metal and wood debris was evident on the surface of the site. **This debris does not appear to pose any imminent risk to human health or the environment. and, given it possible historical value, might be left on the site.**

- geophysical surveying indicated the presence of significant quantities of buried metal on the site. It is not known whether this metal includes any drums or canisters, and whether any contaminants might be present within these areas. The climate and age of the site would suggest that any buried drums would have been subject to deterioration. **Leachate monitoring would provide information on potential migration from areas of buried metal with less damage to the ground surface than excavation of the metal would entail. Further geophysical work, to identify all major areas of metal burial should be conducted prior to planning the location of any monitoring wells.**

- analysis of a soil sample from the site indicated that while metals were present in the soil at levels above CCME Assessment Criteria, these levels did not exceed remediation criteria. Organo-chloride and organo-phosphate pesticides, fenuron (an organo-nitrogen pesticides), and picloram (a phenoxy/acid herbicide) were not detected in the soil sample that was analyzed. The hydrocarbon level of the sample was found to be well below Alberta Tier I criteria for hydrocarbons. Given the large aerial extent of the site, **further soil sampling and analysis would be required to confirm the results of the initial soil analysis and more adequately assess soil conditions on the site.**

- spills of ammonium nitrate, which were observed in the northern portion of the site, where current road building materials are stored, may adversely affect that area and preclude proper vegetative regrowth. **Spilled ammonium nitrate should be removed from the site. Environmental practices being used during the construction should be reviewed and upgraded to ensure that further materials are not spilled.**

- a small amount of post-war materials have been dumped on the site. **Measures should be taken to deter future dumping on the site.**

A preliminary risk evaluation suggests that the ecological risk associated with contaminants found on this site is low. This conclusion is based upon the observed health of the ecosystem, relative concentration of contaminants and relative toxicity of the compounds found to date. However, information about surface and subsurface conditions on the site is limited. **If a greater level of confidence as to risks associated with the subject site is required, further investigative work would be required and a Level 1 CCME Risk Assessment should be carried out to assess whether there has been uptake of contaminants from the site.**

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1. INTRODUCTION

1.1 Project Background

This investigation was carried out as part of investigations of abandoned waste and disposal sites throughout the Yukon by Action on Waste, Arctic Environmental Strategy, Indian and Northern Development, Canada. These sites were associated with activities such as exploration, mining, industrial and military operations.

The purpose of the investigations was to gather preliminary information in order to determine whether further site assessment or remediation is required and to make recommendations on future assessments or remediation, where necessary. A primary objective was to determine whether contaminants are present on the site, and if they are, whether they are migrating from the site. A secondary objective was to identify physical hazards. If contaminants were identified on the site, a preliminary risk assessment was to be carried out to determine the degree of risk to humans or the environment in general.

Hycal Environmental Sciences Ltd. (Hycal) was retained by Action on Waste, Arctic Environmental Strategy, Indian and Northern Development, Canada to carry out environmental assessment of four separate sites. This report outlines the investigation of one of these sites, known as "Site 32". Site 32, also known as the Koidern River - Long's Creek site, is located in the western Yukon Territory, approximately 62 miles (100 kilometres) west of Burwash Landing, at Alaska Highway Mile Post 1155 (Figure 1).

Limitations of the investigation are presented in Appendix A.

1.2 Previous Investigations

Previous investigations which discussed the subject site included:

- the Operation Clean Up Inventory (1973), which identified sites of environmental concern;
- a study on the Alaska Highway - Haines Road Clean Up (Edey, 1976), carried out for the Department of Indian and Northern Development, which included a sketch of the subject site identifying some wastes on the subject site;

- a Summary of Waste Disposal Sites in the Yukon Territory (Reger, 1983), prepared for Environmental Protection Service, Environment Canada, which identified land disposal sites in the Yukon;

- Gray's Alaska Highway Camp and Refuse Locations Preliminary Inventory, and

- a summary of previous work, interviews and historical research by Bisset (1995).

Relevant portions from the above work have been compiled in Appendix B.

Most of the previous work was very general and often repeated the same information. While previous work offered a start to investigation of the subject site, it was necessary to augment previously gathered material in order to more adequately assess the site.

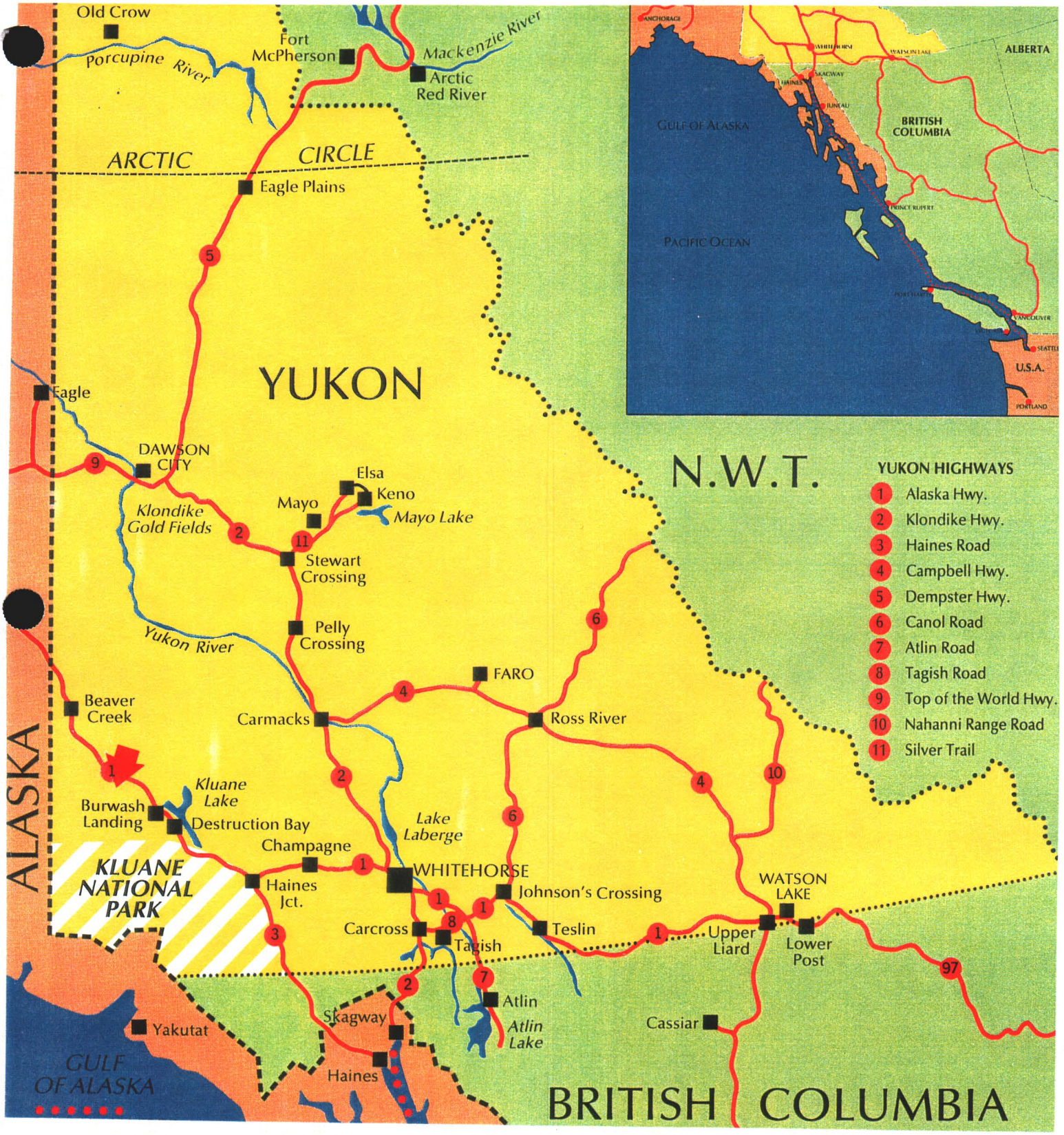


Figure 1. Site Location.

2. SCOPE AND METHODOLOGY

2.1 Site Location and History

A review of records of previous investigations, aerial photographs, and historical material from the Yukon Archives, and interviews with area residents and the local wildlife officer were used to determine the location of the subject site. An investigator from Hycal then proceeded to the approximate area of the site and carried out a reconnaissance of the area to pinpoint the exact location and access to the site.

2.2 Site Reconnaissance

Site reconnaissance was carried out by Hycal in September 1996 to determine:

- the precise location of the subject site;
- the aerial extent of the subject site;
- vegetative and topographic considerations in planning a sampling program and geophysical investigation;
- surficial evidence of site occupation; and
- a local wildlife and vegetation inventory.

The site reconnaissance was carried out during a period of "fall weather" prior to snow covering the subject site. Site visibility was good with only minor obscuring of some ground surface by deciduous leaves which had fallen from some trees.

2.3 Geophysical Investigation

Geophysical methods were used to augment other methods of site assessment. Geophysical investigation was required due to:

- the age of the sites and the possibility of vegetation and other materials obscuring and covering materials on the site;
- the site history in which materials were reported buried or bulldozed over;
- the metallic nature of some of the materials which would have been buried; the extent of the sites and scope of the project precluding grid soil sampling and borehole investigations;

Geophysical investigation was carried out in October 1996. The ground surface was covered with snow at the time. Temperatures during the investigation ranged from approximately -5°C to -18°C.

2.3.1 Geophysical Methodology

The time domain electromagnetic method is generally the preferred geophysical technique for the delineation of subsurface metals due to the speed of data acquisition, high sample density and relative insensitivity to adjacent surficial metals. However, relatively dense vegetation growth at many of the survey regions, precluded its use. At those sites where utilization of electromagnetic instrumentation was not feasible, the magnetic method was employed.

Electromagnetic Method

A time-varying electromagnetic (EM) field produced at surface results in currents flowing within subsurface conductors in configurations defined by the laws of magnetic induction. Resulting secondary EM fields distort the primary field. The resultant field, measurable at any point on the surface of the ground, differs from the primary field in intensity, phase and direction to an extent dependent on the magnitude and geometry of the subsurface conductor(s).

The Geonics Limited EM61 is a high-powered time domain EM metal detector. The decay of secondary currents produced by a pulsed primary field is measured a relatively long time after the primary pulse is terminated. This technique results in a method where results are essentially independent of ground conductivity.

Results of the EM61 surveys are presented as coloured contour maps illustrating lateral variations in electromagnetic response (millivolts [mV]0 at each site area. The use of two vertically displaced receiver coils enables a filtering, of sorts, of near-surface anomalies. The lower coil response (Channel 2) identifies all buried and surficial metal with the sphere of effect of that coil. The differential channel is the algebraic difference of the upper coil responses, resulting in partial filtering of near-surface sources. In general, upper coil response (Channel 1) is biased towards metallic objects occurring at shallow depth.

Total Magnetic Field Method

Magnetometers measure the intensity of the geomagnetic field. The geomagnetic field is comprised of two main parts:

- the earth's magnetic field; and
- local magnetic anomalies in the relatively near-surface. These consist of variations caused by geological features and by man-made magnetic objects.

Over relatively small areas, geological features contribute minimally to the geomagnetic field and local magnetic anomalies are generally entirely due to above surface magnetic/electromagnetic sources and to buried metal objects. Dependent upon instrument and source coupling geometry, both positive and negative magnetic anomalies are significant in the identification of subsurface metals, as illustrated in Figure 2.

The magnetic response at base stations, located adjacent to each survey grid, were repeatedly measured and recorded at small time intervals (less than 90 minutes) to compensate for diurnal variations in the earth's magnetic field.

Results of the corrected total field magnetometer surveys are presented as coloured contour maps illustrating lateral variations in magnetic intensity (nanoTeslas [nT]). Background magnetic intensity was subtracted from the field measurements, as indicated within each figure, to further clarify data presentation.

2.4 Soil and Vegetation Sampling

Soil and vegetation samples were taken by Hycal so that chemical analyses for contaminants that might be associated with former site activities could be carried out. Soil and vegetation samples were taken in areas suspected to be sites of contamination as indicated by proximity to buildings or activities of concern, areas of stressed vegetation, and in areas in which empty barrels or other metal containers were identified. Baseline soil and vegetation samples were taken at locations inferred to represent baseline conditions due to age of vegetation and location away from signs of past occupation.

Detailed grid soil sampling was precluded by the scope of the project (time and laboratory analysis budgets). The presence of permafrost at the time of the investigation (in October 1996, with surface air temperatures approximately -5°C to -18°C) precluded soil sampling at depths greater than approximately 0.5 metres. Use of a drilling rig or large equipment would have been required to advance sampling past this depth and such equipment was not included in the scope of work.

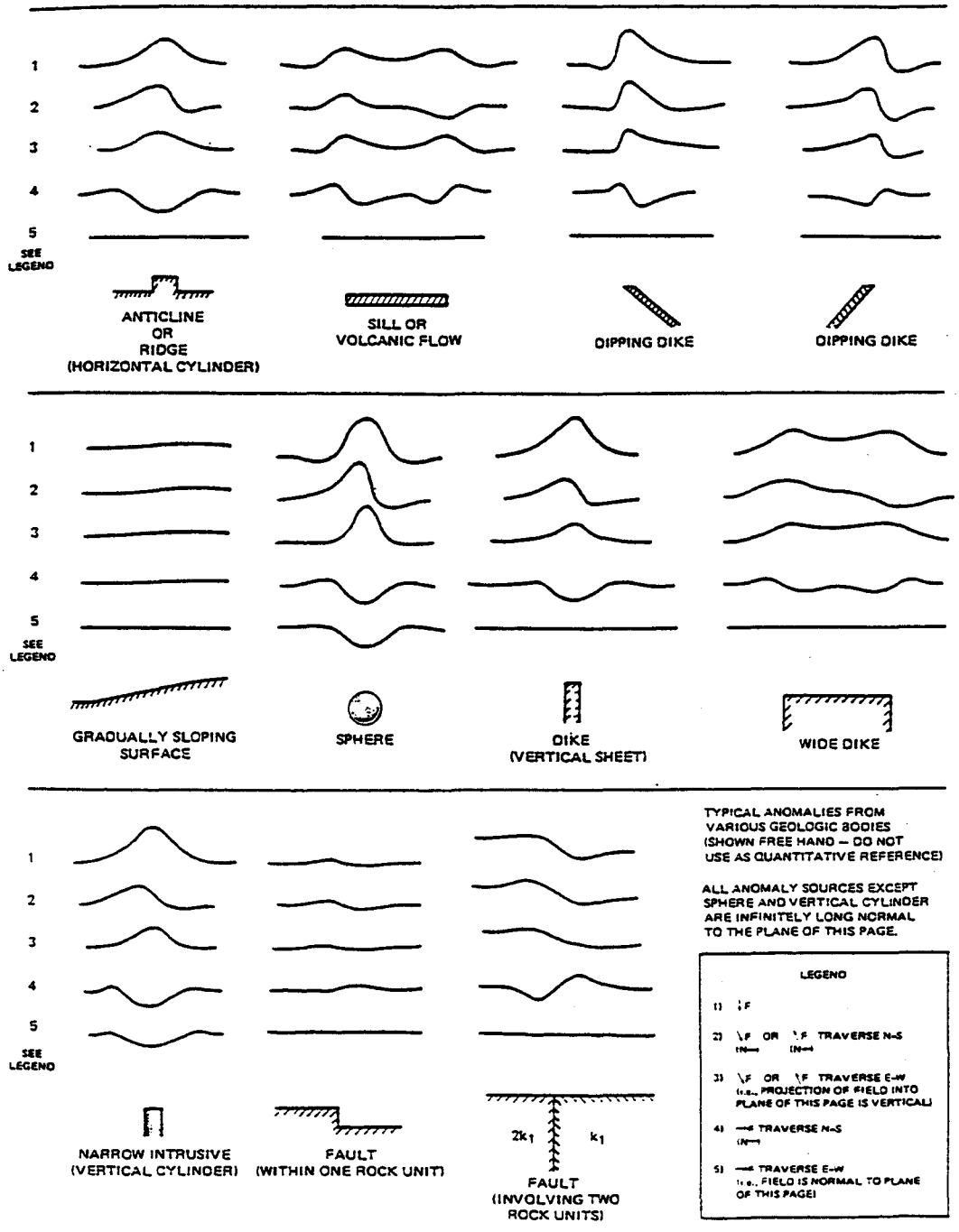


Figure 2. Anomalies of Geologic Bodies at Various Orientations and Different Inclinations of the Field. (Breiner, 1973)

Soil samples were visually and olfactorily examined for indications of hydrocarbons and other contaminants, then promptly placed in clean, glass jars with teflon lids. The soil samples were packed with no headspace and retained in darkness at approximately 4°C.

Samples of vegetation were taken by using a trowel to extract the plants as intact as possible. Vegetation samples were placed in plastic bags with as little surrounding air as possible, then they were retained in darkness at approximately 4°C.

A soil sample was analyzed for the presence of metals, pesticides (organo-chloride and organo-phosphate, and for fenuron, an organo-nitrogen), picloram (a herbicide), and hydrocarbons. The analytical parameters were selected on the basis of site history and on contaminants which have been previously associated with military activities in the Yukon, as outlined by Bisset (1995).

Additional soil samples (including duplicates) and vegetation samples were not analyzed due to a limited sample analysis budget.

2.5 Analytical Methods

Analyses of the soil sample was carried out by Norwest Laboratories of Calgary, Alberta. The laboratory is accredited by the Standards Council of Canada and the Canadian Association of Environmental Analytical Laboratories.

Specific analytical methods used in the sample analyses are presented in Appendix B with the laboratory results.

2.6 Preliminary Risk Evaluation

Due to time limitations and budget constraints associated with this project it was not possible to complete a full Level One Ecological Risk Assessment (ERA) as defined in the CCME Framework for Ecological Risk Assessment. However a preliminary evaluation of ecological risk was completed in which site specific data on habitat, species, land use, contaminants, environmental fate and toxicity were used to develop an overview of ecosystem components potentially at risk.

A site specific probabalistic model was not developed therefore fate, effects, conclusions and recommendations are based solely on scientific literature and professional experience with these contaminants. It should, therefore, be

recognized that conclusions pertaining to fate and effects will carry a high degree of uncertainty at the site specific level.

2.7 Personnel

Personnel who participated in the investigation are listed in Appendix C.

3. INVESTIGATION RESULTS

3.1 Site Location and Description

3.1.1 Location

Site #32 was located in the Koidern River - Long's Creek area, at Mile Post (MP) 1155 (1859 km) of the Alaska Highway (Figure 3). The site was at approximately 61°53'5" latitude and 140°13' longitude, within NTS 115 F/16. The northern portion of the site is currently occupied by a equipment yard associated with current highway construction. The yard was located in a clearing flanked by vegetation to the northwest, south and south east. The current Alaska Highway runs along the north side of the site. The south side of the subject site was bounded by a meander of the Koidern River.

The subject site was approximately 250 metres by 175 metres in aerial extent.

Metal debris, including vehicle parts, pieces of storage tanks, pails, fencing and other material was scattered throughout the site (Photographs 2 and 3). Abandoned equipment was also visible in the Koidern River, adjacent to the site (Photograph 4).

Some wooden building outlines remained visible. Several depressions were present in areas formerly occupied by buildings (Photograph 5).

Mounds of one to two metres elevation were present throughout the southern portion of the site (Photographs 6 and 7). Some of these mounds were attributed to human activities, due to the protrusion of metal and wooden debris from within them. Visual inspection could not determine whether other mounds on the site were related to human activities or were the result of frost heaving. A one-metre high mound was also noted in the clearing on the north side of the site (Photograph 8). In order to determine their possible origin, some of the mounds were investigated using geophysical methods.

3.1.2 Topography, Geology and Soils

The subject site is underlain by postglacial alluvial deposits consisting of sand and gravel with a thin veneer of fine sediment (Rampton, 1977).

The subject site is located in the discontinuous permafrost zone (Geological Survey of Canada, 1967). Topography over the subject site was variable with 1 to 2 metre localized changes in elevation that appeared to be the result of thermokarsting. Mapping by Rampton (1977) indicated extensive thermokarsting along the banks of Koidern Creek.

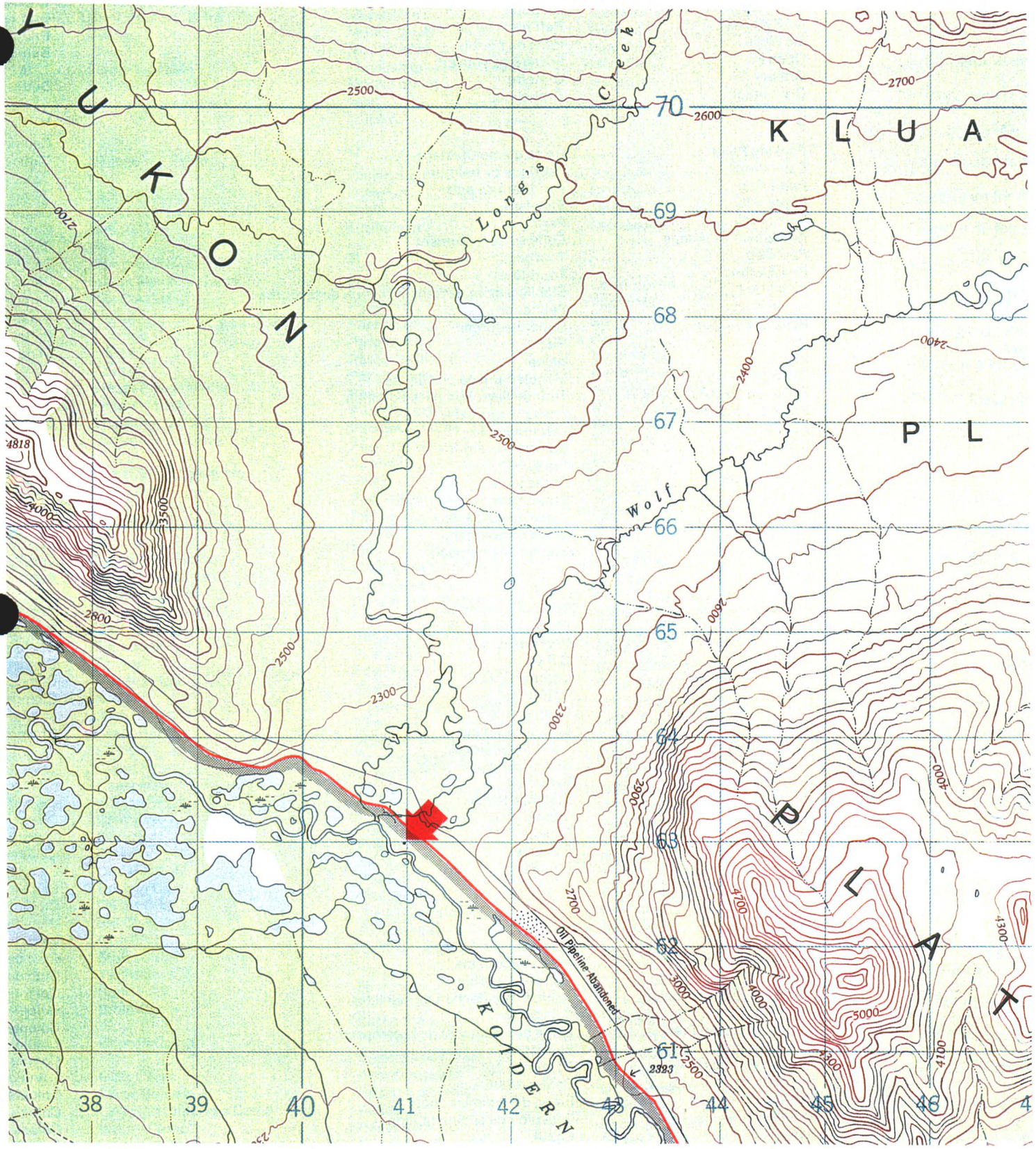


Figure 3. Detailed Site Location.

Photograph 2. Discarded vehicle parts on the ground surface at the subject site. September 1996.

Photograph 3. Metal debris at surface on subject site. September 1996.

Photograph 4. Abandoned equipment in the Koidern River, adjacent to the subject site. September 1996.

Photograph 5. Former building foundation on subject site. September 1996.

Photograph 6. Mound on subject site. September 1996.

Photograph 7. Mound on subject site. September 1996.

Photograph 8. Mound at centre of equipment yard on subject site. September 1996.

Soil was poorly developed in the area. Soil sampling indicated that the soil is organic and silty. If thawed, the permeability of the soil would be considered to be moderate.

3.1.3 Surface and Subsurface Water

Regional groundwater flow direction would be anticipated to be towards the Koidern River. However, given the presence of permafrost and dense vegetative cover, shallow groundwater flow in the area may be limited. The vegetative cover may limit the amount of permafrost thawing during the summer and therefore, shallow groundwater flow may be minor to absent in vegetated areas.

No areas of surficial water ponding were observed on the subject site during the assessment. However, given the one to two metre localized changes in elevation over the site, some water ponding would be anticipated to occur during snow thaw and periods of heavy precipitation. No general dip in surficial elevation was discernible on the site.

No streams were noted on the subject site at the time of the site assessment. However, contiguous low areas on the site might act as ephemeral streams during snow melt or after significant rainfall.

3.1.4 Vegetation

The subject area was largely covered by dense vegetation which consisted predominantly of white spruce, black spruce, alder, aspen and some scrub willow and birch. Moss was present over much of the ground surface. The vegetative assemblage was indicative of poor site drainage.

Vegetation was sparse to absent in several areas which appeared to have been formerly occupied by buildings (Photograph 9) In other areas, vegetation was well-established in areas of former human occupation (Photographs 10 and 11).

3.1.5 Wildlife

Wildlife which was observed in the area of the site (through tracks and scat, or through actual sightings) included bear, moose, muskrat, beaver, mice, rabbits, coyotes, golden eagles, ptarmigan, jays, ducks, raven and geese. Some Trumpeter swans were observed in the area during reconnaissance in September. Other wildlife reported in the area include muskrat, lynx, caribou and fox (Agriculture and Agri-Food Canada and Environment Canada, 1996).

Photograph 9. Poorly vegetated area on the subject site. September 1996.

Photograph 10. Vegetation growing through former building site. September 1996.

Photograph 11. Vegetation growing through former building site. September 1996.

Wildlife officials reported that the Koidern River, which is adjacent to the subject site, contains whitefish, chub, chum salmon and grayling (LaRoque, pers.comm.)

3.1.6 Climate

Environment Canada (Agriculture and Agri-Food Canada and Environment Canada, 1996) describes the climate in the area as follows:

> The climate is characterized by short, cool summers and long, cold winters. Winter temperature inversions are common, giving milder temperatures at higher elevation. Maritime air from the Gulf of Alaska periodically invades the ecoregion during the winter to produce mild spells with near-thawing temperatures. The mean annual temperature for the area is approximately -3°C with a summer mean of 10°C and a winter mean of -17°C. Mean annual precipitation ranges 250-300 mm.

3.1.7 Land Use

The northern portion of the subject site is currently in use as a storage area for road construction equipment and materials. The remainder of the site is not in formal use.

Trapping and hunting is reported to occur in the general region of the site. Environment Canada has reported that "Land Use recollects high recreational, tourism and hunting values. (Agriculture and Agri-Food Canada and Environment Canada, 1996). Hunting is, however, prohibited within 1 kilometre of the Alaska Highway, so hunting is not allowed in the immediate site area.

The site is currently held by the Crown.

The closest known human residence is a road construction camp, approximately 1/2 kilometre to the west of the site. The site is located in an area of sparse human habitation.

3.2 Site History

The first known occupation of the subject site was during World War II when it was occupied by United States military camps associated with the building of the Alaska Highway. The bridge at the Koidern River was known as the "Moosehead Bridge" (Photograph 1, cover page).

The regimental historian of the 18th Engineers Regiment (U.S.) recorded the subject site was a camp for the "A" Company's 1st, 2nd, and 3rd Units and HQ from mid- to late-September in 1942 (Rust, 1944).

In a 1943 map, the Utah Construction Camp No. 259 was present at MP 1155.6 (Figure 4). 16 buildings were indicated on the site. The Royal Canadian Engineers Highway Maintenance book recorded a maintenance camp at MP 1156.

Sources on the demobilization of the American army from the Alaska Highway and subsequent disposition of material associated with the highway construction vary on how much and what kinds of material were abandoned on military sites. The Vancouver Daily Province and the Edmonton Journal reported that one dump "was littered with cans, debris and decaying food" and that another contained barrel heaters, water heaters and hot-air chambers for furnaces (Remley, 1976, p.171). Contrary to these reports, a study by the House Roads Committee of the United States Congress, whose investigations included flying the length of the road to ascertain the amount of debris left behind, concluded that "rumors of abandoned equipment, wild extravagances, fraud and corruption" were vastly exaggerated and not borne out by investigation.

The Operation Clean Up inventory in 1973 recorded garbage at MP 1154.6 and 1155.6 (Document 1, Appendix B). The garbage was reported to consist of building debris, kitchen refuse and other material. Two vehicle bodies were visible at MP 1155.6 at this time. Use of the site as a dump was reported to have been discontinued by this time.

C.E. Edey (1976) reported that the site contained wood debris, vehicle parts and a fuel tank (Figure 5).

Two pages of information on the site were assembled in 1983, as part of an Environment Canada program identifying land disposal sites in the Yukon Territory (Document 2, Appendix B).

An undated and unattributed set of notes housed at the Yukon Archives (Document 3, Appendix C) indicated that a large amount of debris remained on the site. Aerial photographs accompanying the notes showed new growth of vegetation.

The site was inspected in May 1996 and inventoried as "Site 94" in the Waste Management Inventory for the Beaver Creek District, Indian and Northern Development, Canada (Document 4, Appendix D).

Local residents who were interviewed during the course of the investigation included the DIAND officer at Beaver Creek, and Jim and Dorothy Cook at the

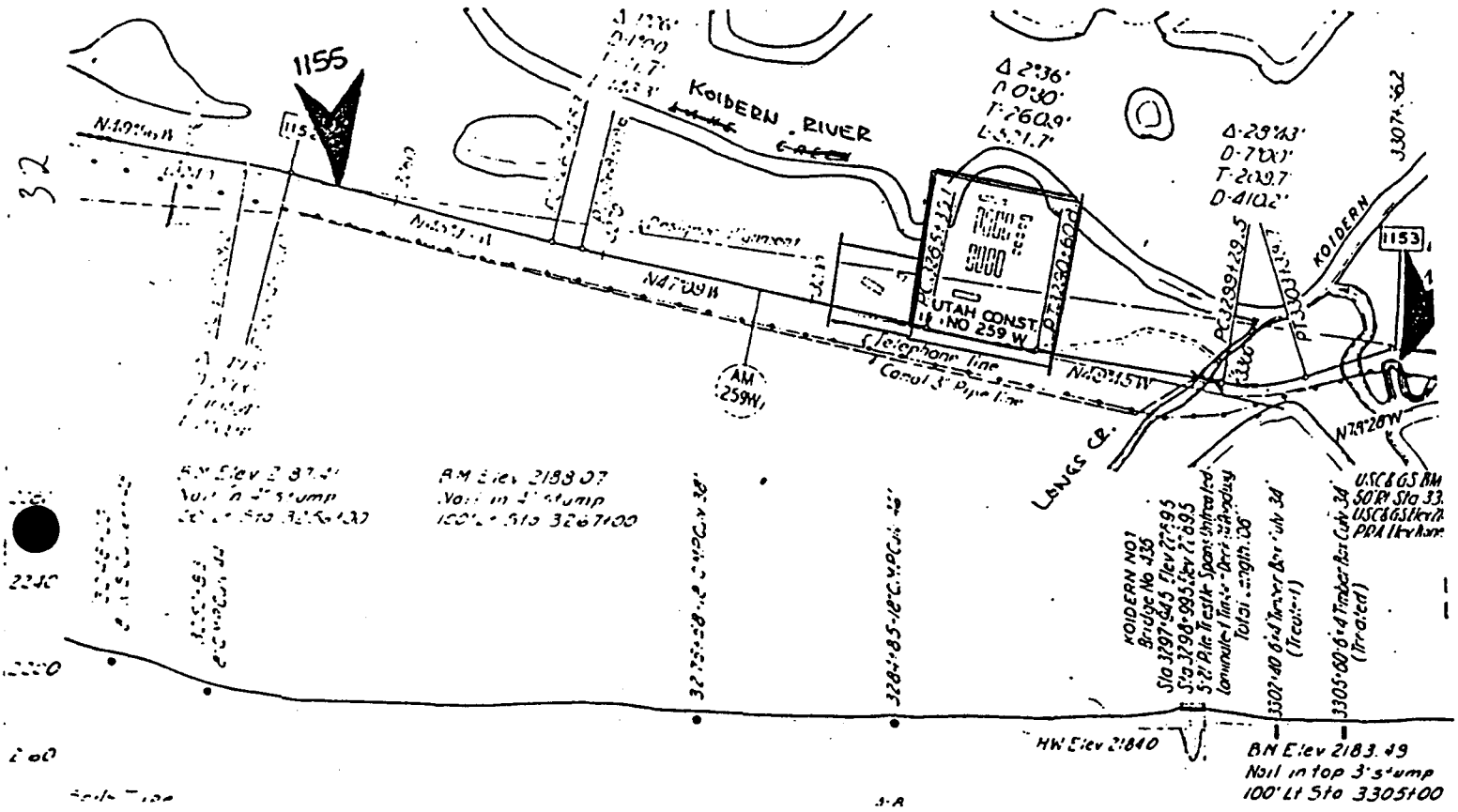


Figure 4. Public Roads Administration Map of the Subject Area (with later amendments).

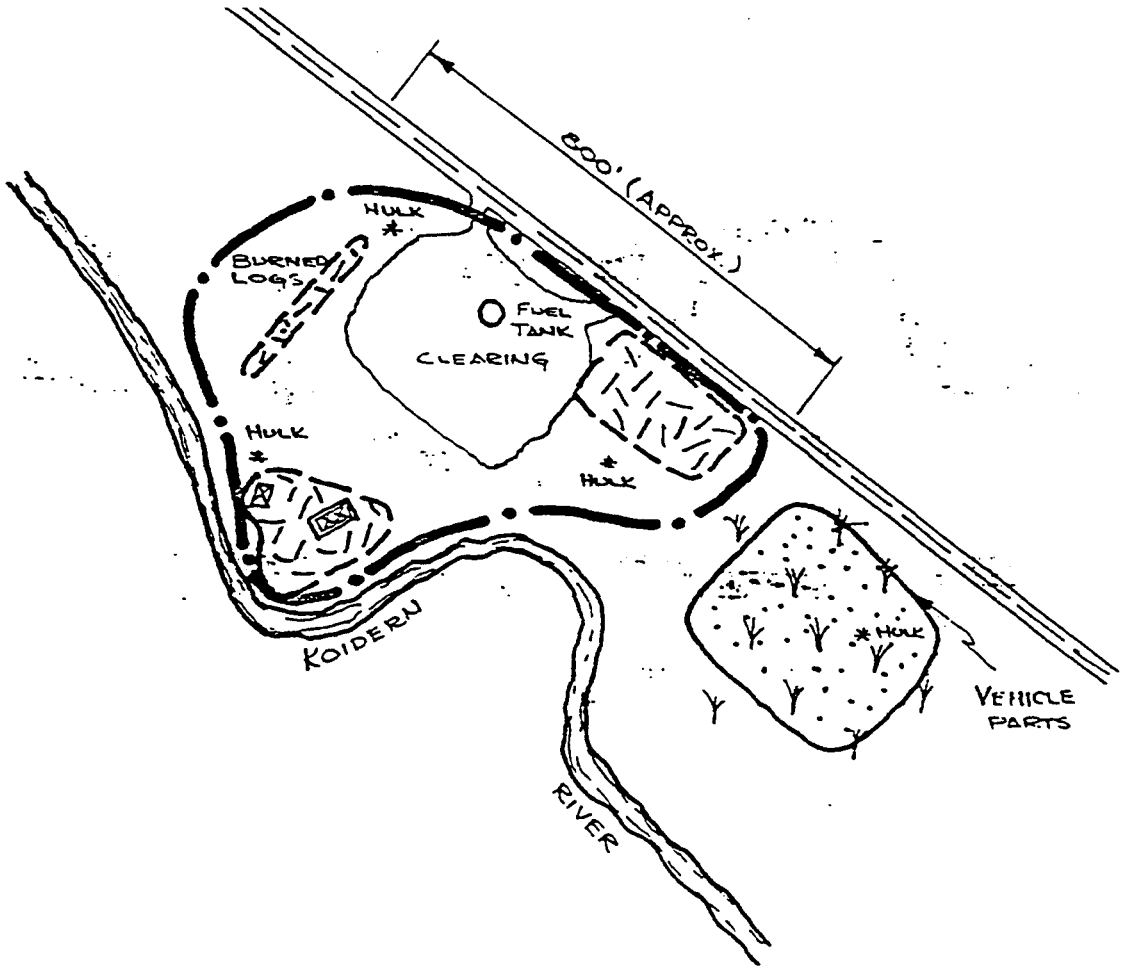


Figure 5. 1976 Mapping of the Subject Site by Edey.

Koidern River Lodge, and members of the road construction crew who were headquartered approximately 1 kilometre west of the site. Members of the area's aboriginal community were contacted through the investigation's field assistant, Rosemarie Vander Meer, of the White River Nation.

Aerial photographs of the site housed at the Yukon Archives and at the University of Calgary were reviewed. Available aerial photographs of the area were sparse and were, for the most part, at very poor scale, with little detail being discernible at the site level. Aerial photographs from 1964 (Figure 6) show the site after demolition of buildings on the site but prior to regrowth of vegetation over much of the area.

Public Roads Administration mapping (Figure 4) showed that a Canol 3" pipeline was present north of the site in 1943. The pipeline has been subsequently abandoned. The history of pipeline leaks or breaks along this line is unknown, but given the nature of pipeline operations some spills may have occurred in the area of the site.

3.3 Geophysical Results

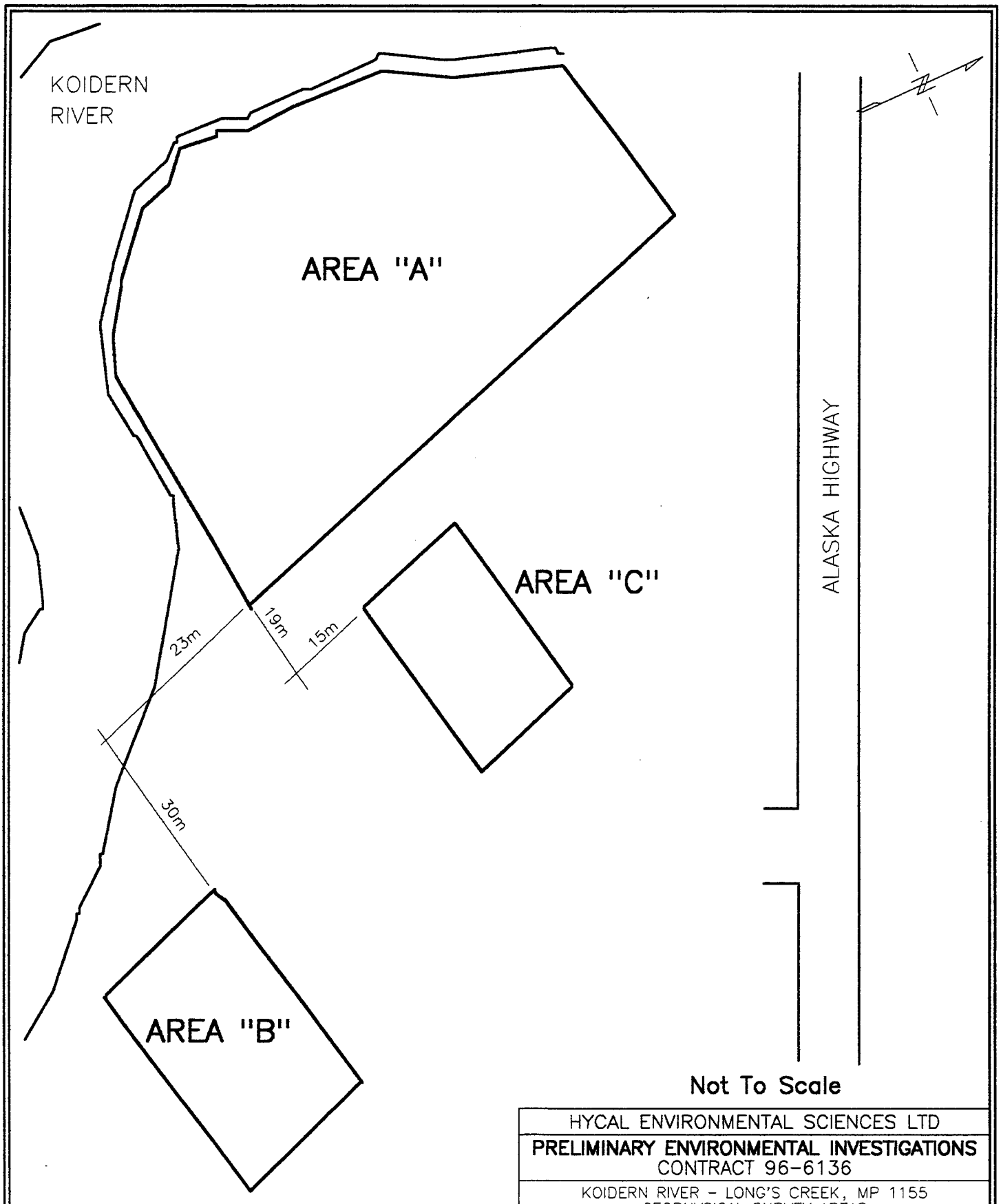
The scope of the project prevented the undertaking of a detailed geophysical study over the full extent of the site. Instead, areas were prioritized for geophysical evaluation based upon site inspection.

Three separate areas were assessed by magnetic methods at the site. Area "A" (Figure 7) encompassed a relatively large area adjacent to the Koidern River. Surficial metals observed on the ground surface included coiled wire, large bell housings, and a vehicle. Relatively dense vegetation, consisting mainly of white spruce, poplar and willow, precluded the use of the EM61 instrumentation within this area. A magnetometer was used in surveying this area.

Area "B", positioned to the southeast of Area "A", encompassed numerous mounds of partially buried metallic objects, including a vehicle. Relatively dense vegetation and, to a lesser extent, variable topography, resulted in the use of a magnetometer.

Area "C" was established within a large open area which, at the time of the survey, was used as an equipment and material storage compound for road maintenance operations. The Area "C" survey grid was centred over a rubble pile within which evidence of scrap metal existed. The EM61 method was employed to delineate the lateral extent of possible buried metal.

Figure 6. Aerial Photograph of Subject Site, 1964. 1:6000.
(115F 18 1964 A 18395-87 x 300%)



Not To Scale

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PRELIMINARY ENVIRONMENTAL INVESTIGATIONS
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KOIDERN RIVER - LONG'S CREEK, MP 1155
GEOPHYSICAL SURVEY AREAS
November, 1996 - Figure 7

ASSOCIATED MINING CONSULTANTS LTD - PG93

3.3.1 Area "A"

Collected at 5 metre by 5 metre sample intervals, the measured magnetic response over Area "A" is presented in Figure 8. The region of anomalous magnetic response was relatively extensive within the surveyed area. Identified anomalies were as follows:

32a Attributed exclusively to reinforcement steel bars (rebar) within an existing concrete pad (approximately 10 metres by 10 metres). However, the negative magnetic anomaly extending further to the southeast is likely unrelated to the concrete pad and is, instead, likely the result of buried metal.

32b Laterally extensive magnetic anomaly attributed to buried metal. No visible metal at surface.

33c Located at northern corner of the survey area, due exclusively to surface metal.

32d Large anomaly centred around surface metals which included a vehicle (early 1960s vintage). Additional surficial material was evident around the perimeter of the mapped magnetic anomaly.

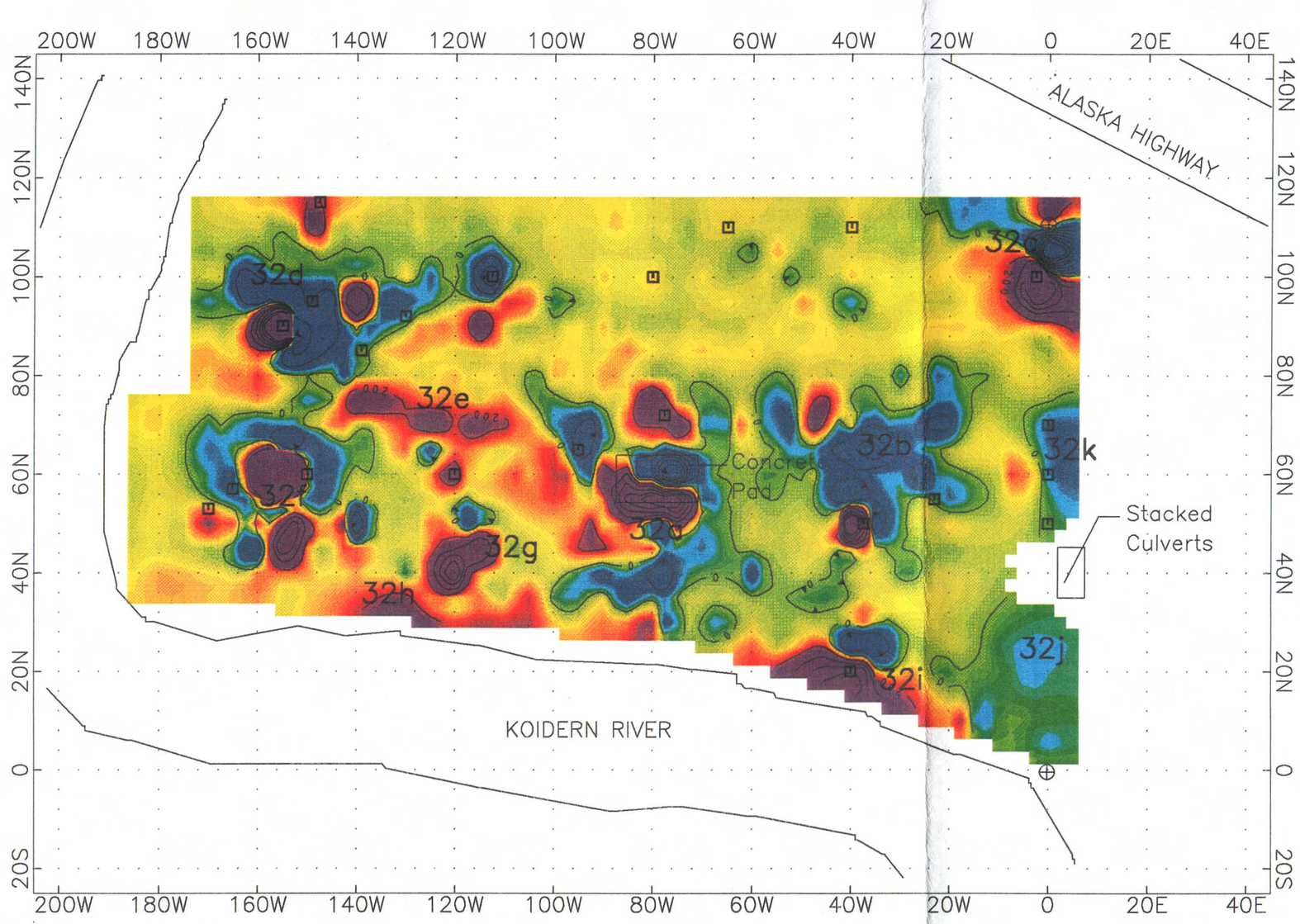
32e Although metal was evident at the surface along the southeastern extent of the anomaly, the northern extent was likely a result of buried metal.

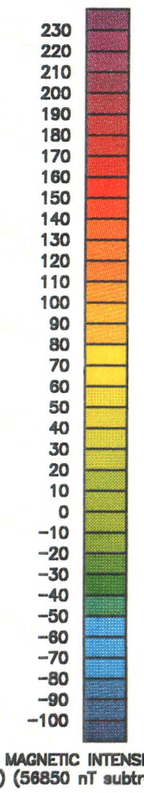
32f A relatively large anomalous magnetic response in the immediate vicinity of surficial metals. The magnitude and lateral extent of the anomaly suggests the occurrence of additional buried metals in this area.

32g Relatively large magnetic anomalies. No evidence of surficial metal in the immediate vicinities, suggesting the presence of buried metal.

32h Relatively large magnetic anomalies. No evidence of surficial metal in the immediate vicinities, suggesting the presence of buried metal.

32i Surficial metal was evident. The magnitude of the anomaly suggests the existence of additional metal buried at depth.





Scale 1:1000

10 0 10 20 30 40 50 60

(meters)

32a Magnetic Anomaly

⊡ Surface Metal

⊕ Survey Grid Markers

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CONTRACT 96-6136

KOIDERN RIVER - LONG'S CREEK, MP 1155
TOTAL FIELD MAGNETOMETER SURVEY - AREA 'A'
November, 1996 - Figure 8

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32j Relatively weak negative magnetic response extending to the southeastern region of the survey area, indicative of buried metal in the immediate vicinity.

32k Anomalous magnetic response attributed exclusively to surficial metal (culverts).

Additional areas of anomalous magnetic response, indicated on Figure 8, by gradations to warmer colours, suggest the occurrence of buried metal.

3.3.2 Area "B"

Magnetic measurements were acquired at 2.5 metre by 5 metre intervals within Area "B". The survey grid was positioned to evaluate several mounds suspected of containing scrap metal. Three main magnetic anomalies were apparent within the survey results, as illustrated in Figure 9.

32l Anomaly 32l is attributed exclusively to a partially buried vehicle evident at Station 15N,32E.

32m and 32n A positive magnetic anomaly at 32m and a negative anomaly at 32n are likely the result of buried metal occurring in the northwest corner of the study area.

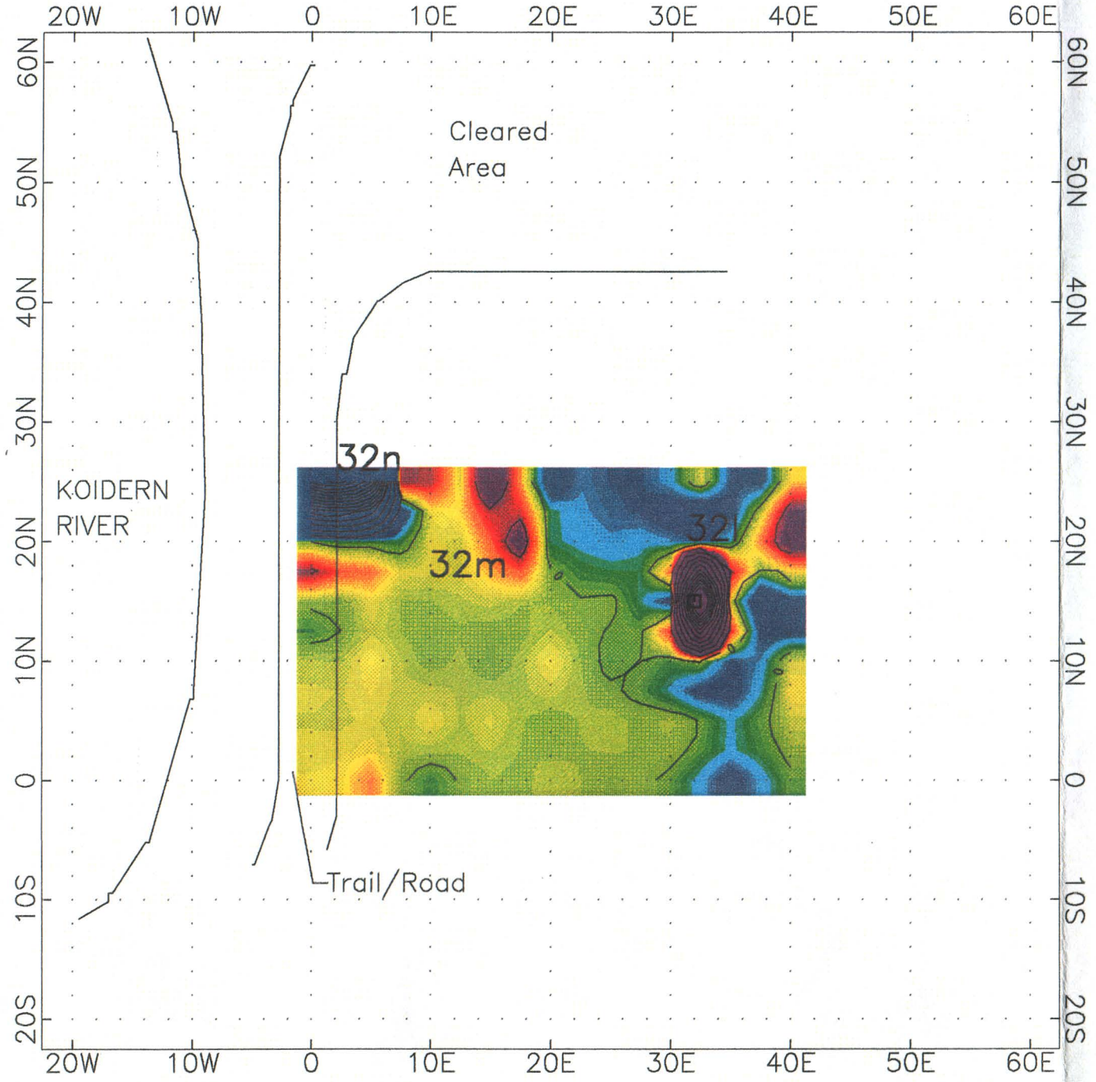
Magnetic interference resulting from road equipment stationed within the cleared area adjacent to Site "B" prevented extension of the survey grid further to the north. Discussions with the road crew revealed that the equipment was in disrepair and could not be moved.

3.3.3 Area "C"

EM61 data were acquired at 0.2 metre intervals along survey lines spaced 1 metre apart in Area "C". Results of the EM61 Channel 2 survey identified five distinct areas of anomalous electromagnetic response (Figures 10 and 11).

32o 32p Anomalies 32o and 32p are coincident with surficial metals visible at the site,

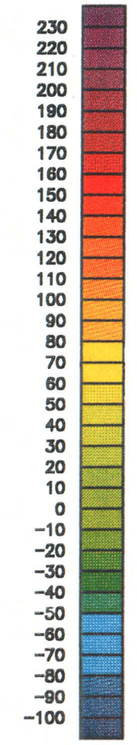
32q, 32r and 32s Anomalies 32q, 32r and 32s indicate the presence of relatively small metallic objects. Review of the EM61 Differential Channel survey reveals that the corresponding anomalies are significantly smaller, or non-existent, suggesting that the metal contributing to the anomalous Channel 2 response is buried within one metre of the ground surface.



321 Magnetic Anomaly

Surface Metal

Survey Grid Markers



Scale 1:500

5 0 5 10 15 20 25 30

(meters)

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KOIDERN RIVER - LONG'S CREEK, MP 1155
TOTAT FIELD MAGNETOMETER SURVEY - AREA 'B'
November, 1996 - Figure 9

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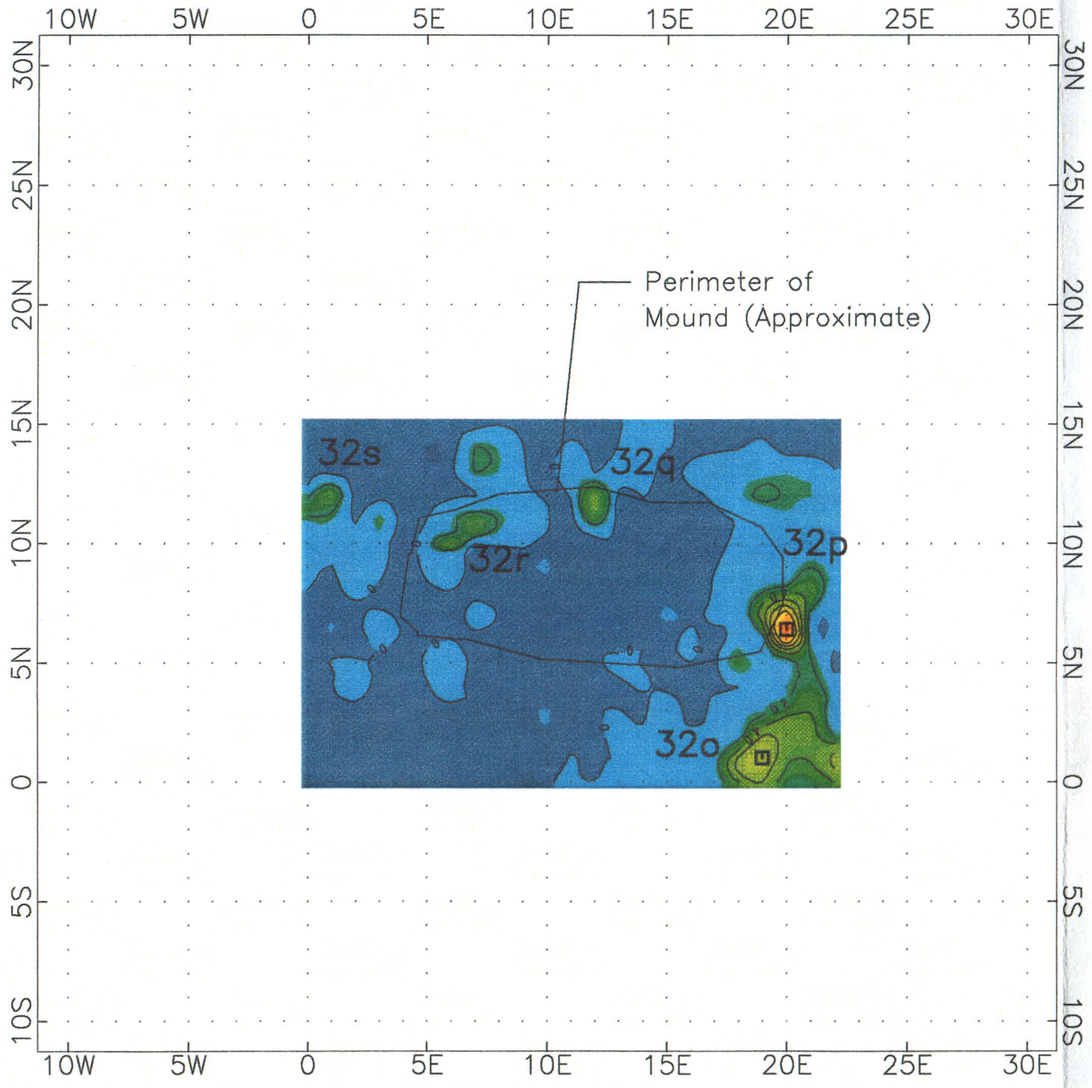
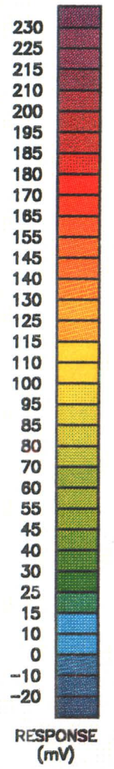


32o EM61 Anomaly

⊡ Surface Metal



Scale 1:250

2.5 0 2.5 5 7.5 10 12.5 15

(meters)

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KOIDERN RIVER - LONG'S CREEK, MP 1155
EM61 SURVEY - Channel 2 - AREA 'C'
November, 1996 - Figure 10

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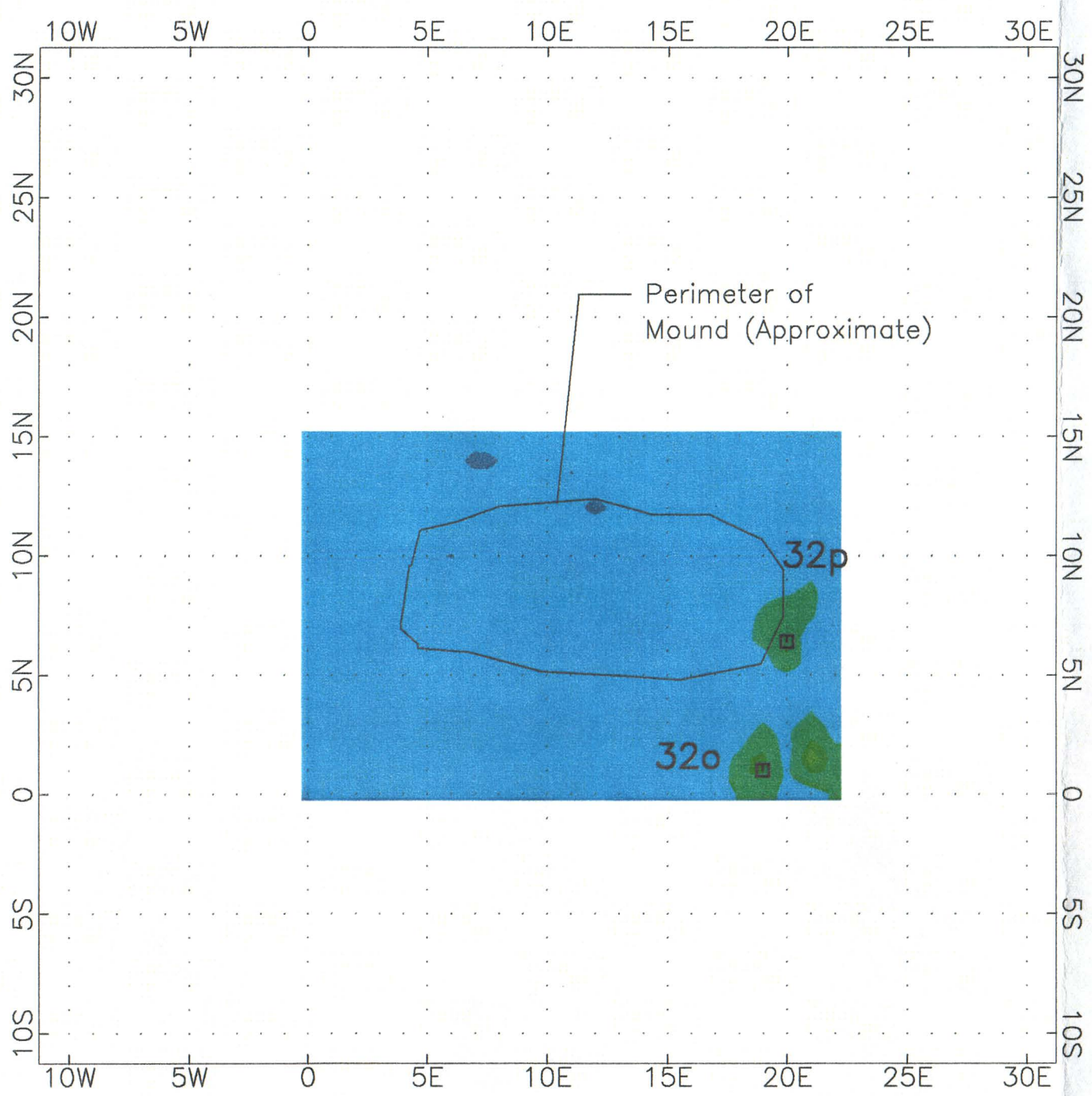

32o EM61 Anomaly

Surface Metal

230
225
215
210
200
195
185
180
170
165
155
145
140
130
125
115
110
100
95
85
80
70
60
55
45
40
30
25
15
10
0
−10
−20

RESPONSE (mV)

Scale 1:250

2.5 0 2.5 5 7.5 10 12.5 15

(meters)

HYCAL ENVIRONMENTAL SCIENCES LTD

PRELIMINARY ENVIRONMENTAL INVESTIGATIONS
CONTRACT 96-6136

KOIDERN RIVER - LONG'S CREEK, MP1155
EM61 SURVEY - Differential Channel - AREA 'C'
November, 1996 - Figure 11

ASSOCIATED MINING CONSULTANTS LTD - PG93

3.4 Adjacent Properties

Lands immediately east, south and west of the subject property were undeveloped and consisted of northern boreal forest, with black spruce, scrub willow, birch and moss. The Alaska Highway was located directly north of the subject property. While construction and other activities along associated with the highway have the potential to impact the subject site, no conditions were identified on adjacent properties that would suggest that the subject property has been adversely affected by activities on neighbouring land.

3.5 Current Site Usage

The northern portion of the subject property, is currently in use as a storage and staging area for construction along the Alaska Highway, as part of the Shakwak project. This area contained large equipment, such as backhoes and trucks, and some construction supplies at the time of the assessment. During the site reconnaissance, ammonium nitrate, which was stored in a number of sacks on the site, was observed leaking onto the ground surface (Photograph 12). Some surficial oil staining associated with equipment maintenance was also observed.

Some areas of the site appear to have been used for unauthorized dumping of waste materials postdating the military occupation. A 1960s vintage vehicle hulk was observed in the central portion of the site (Photograph 13) and a small amount of postwar material, including a desk, bottles, cans, and a used battery were also observed on the site.

3.5 Soil Analyses

Analysis of a soil sample (Sample V3) from a mound in Area "A" indicated the presence of arsenic, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, selenium, tin, vanadium, and zinc in excess of CCME Assessment Criteria (CCME, 1991). Analysis of the sample for organo-chloride and organo-phosphate pesticides, fenuron (a organo-nitrogen pesticide), and picloram (a phenoxy/acid herbicide) did not reveal detectable levels of these contaminants. The hydrocarbon level of the sample was found to be well below Alberta Tier 1 criterium for hydrocarbons. Results of the soil analyses are summarized in Figure 12. A copy of the laboratory report is presented in Appendix B.

Photograph 12. Ammonium nitrate leaking from sacks in the highway construction materials storage area on the subject site. September 1996.

Photograph 13. Derelict 1960s vehicle on the subject site. October 1996.

Figure 12: Summary of Soil Sample Analysis, Koidern River - Long's Creek, MP 1155

	CCME Assessment Criteria	CCME Remediation-Parkland/ Residential Criteria	Site 32 Sample #V3
METALS			
Arsenic	5	30	**13.7**
Antimony	20	20	3.08
Barium	200	500	122
Beryllium	4	4	0.178
Cadmium	0.5	5	**1.79**
Chromium	20	250	**75.9**
Cobalt	10	50	**12.9**
Copper	30	100	**91.6**
Lead	25	500	**34.1**
Mercury	0.1	2	**0.1**
Molybdenum	2	10	**4.14**
Nickel	20	100	**81.2**
Selenium	1	3	**2.3**
Silver	2	20	<0.001
Thallium	0.5	-	<0.20
Tin	5	50	**7.09**
Vanadium	25	200	**46.9**
Zinc	60	500	**145**
PESTICIDES			
Organo-Chloride Pesticides	-	-	BDL
Organo-Phosphate Pesticides	-	-	
Organonitrogen Pesticides	-	-	BDL
HERBICIDES			
Picloram	-	-	<0.1
OTHER			
Hydrocarbons	*	-	464
Moisture (wt%)	-	-	57
PCB's	0.1	5	

All soil values are in mg/kg dry weight (ppm) unless otherwise stated

BDL = Below Detection Limits for all constituent compounds

Exceeds Assessment Criteria

Exceeds Remediation-Parkland/ Residential Criteria

Exceeds Alberta Tier I for Hydrocarbons (1000 mg/kg)

**** No CCME Criteria for Hydrocarbons***

3.6 Preliminary Risk Evaluation

Based on the available information (refer to Section 3 for a detailed description of site location, soil characteristics, site drainage, adjacent water bodies, and land use), it is likely that the following factors will act to increase the ecological risk at this site:

1) Contaminants

   The presence of contaminants in exceedence of CCME assessment criteria increases the risk of an ecological impact. In addition, it is likely these contaminants will be taken up and concentrated within vegetation of the site due to the chemical characteristics of the contaminants found.

2) Proximity To Surface Water

   The Koidern river is adjacent to much of the site and a wetland area known as the "Koidern potholes" is located immediately north of the site.

3) Soils

   Surface and subsurface soils, comprised of silty sand, would, if thawed, be moderately permeable. If the soils were thawed, this would increase the risk of contaminant migration and exposure to additional receptors.

4) Land Use

   The use of adjacent land for hunting and trapping increases the risk of humans consuming animals exposed to contaminants through foraging or habitation on the site.

5) Wildlife

   The number of plant and animal species found at this site increases the likelihood that a species will be impacted by the contaminants found here.

The following site characteristics will act to decrease ecological risk:

1) Permafrost

   The ubiquitous presence of permafrost beneath surface soils will act as a natural barrier preventing contaminants from deep migration.

While wildlife observed in the area during the investigation is outlined in Section 3.1.4, a detailed inventory of wildlife in the area was precluded by the scope of

the investigation. Therefore, at this point in time, Valued Ecosystem Components (VEC) cannot be adequately assessed since this would require a detailed examination of interrelationships within the ecosystem of this site. If the site's ecosystem was better understood, keystone species as well as hypersensitive species could be identified and used in statistical models to predict impacts to the ecosystem.

Based on the limited species information readily available, no species listed as endangered by the World Wildlife Foundation of Canada (WWF) were identified on the site. The only site species listed as vulnerable that was identified on the site was the grizzly bear.

Contaminants of Concern

As detailed in Section 3.4, 13 metal contaminants (arsenic, cadmium, Chromium, cobalt, copper, lead, mercury, molybdenum, nickle, selenium, tin, vanadium and zinc) were found in excess of CCME Assessment Criteria in the one soil sample that was analyzed. The levels detected were, however, below CCME Remediation Criteria The primary concern for these types of contaminants is that they are readily taken up in vegetation as micronutrients where they are bioconcentrated. Animal species then consume this vegetation while foraging on site and receive a concentrated dose of metals.

Based on the limited soil analysis completed, no other contaminants of concern were found.

4. CONCLUSIONS AND RECOMMENDATIONS

Investigation of the subject site was limited by the scope of the study. Investigation was prioritized to fit with allotted time and budget. **Further investigation would be required to more fully assess all of the areas within the site or to allow for more precise risk analysis.**

A summary of geophysical and soil sample analyses results is presented in Figure 13. The investigation confirmed the presence of surficial and subsurface debris on the subject site. Given the history of the site and the visible materials, most of this material appears to have been related to military operations in the area during the construction of the Alaska Highway. Some postwar dumping of materials was, however, evident. The site also appears to have been affected by construction activities related to the current Shakwak Project.

4.1 Historical Data

While historical searches yielded some useful information, the site appears to have been subject to activities which were poorly or never documented. Therefore, **further historical record searches are not indicated at this time.**

4.2 Surficial Debris

Some metal and wood debris was evident on the surface of the site. **This debris does not appear to pose any imminent risk to human health or the environment.** The surficial debris is not visible from the road and does not result in any diminished aesthetic value, other than from within the site itself. The debris may, in fact, add some sense of history to the area, and may be considered to have a positive value.

4.3 Subsurface Metals

Geophysical surveying indicated the presence of significant quantities of buried metal on the site. Of the three geophysical survey areas on this site, evidence of buried metal was most widespread within Area "A". The nature of this debris is unknown. **Further detailed geophysical investigations would be required to more fully map subsurface metal on the site. Excavation would be required to determine whether this debris includes any canisters or barrels containing any contaminants.**

Magnetometer Results	
Anomaly	Description
Area "A":	
32a	attributed exclusively to rebar within an existing concrete pad, however, the magnetic anomaly extending to the southeast is likely the result of buried metal
32b	laterally extensive magnetic anomaly attributed to buried metal, no metal visible at surface
32c	located at northern corner of the survey area, due exclusively to surface metal
32d	large anomaly centered around surface metals which include a vehicle, additional surface metal evident around the perimeter of the mapped magnetic anomaly
32e	although metal is evident at surface along the southeastern extent of the anomaly, the northern extent is likely a result of buried metal
32f	a relatively large anomalous magnetic response in the immediate vicinity of surficial metals, the magnitude and lateral extent suggest additional buried metal in the region
32g & 32h	relatively large magnetic anomalies, no evidence of surface metal in the immediate vicinity, suggesting the presence of buried metal
32i	anomalous response due to surficial metal, the magnitude of the anomaly suggests the existence of additional metal buried at depth
32j	relatively weak negative magnetic response extending to the southeast region of the survey area indicative of buried metal in the immediate vicinity
32k	anomalous magnetic response attributed exclusively to surficial metal (culverts)
Area "B":	
32l	anomaly attributed exclusively to a partially buried vehicle
32m & 32n	positive and negative magnetic anomalies 32m and 32n, respectively, are likely a result of buried metal occurring in the northwest corner of the study area

EM61 Survey Results	
Area "C"	Five distinct areas of anomalous electromagnetic response were identified: 32o, 32p, 32q, 32r and 32s. Anomalies 32o and 32p are coincident with surficial metals. Anomalies 32q, 32r and 32s indicate the presence of relatively small metallic objects. Evidence suggests that the anomalies are buried within one meter of the ground surface.

Samples Analyzed	Criteria Exceeded		
	Assessment	Remediation	Other
B3	As,Cd,Cr,Co, Cu,Pb,Hg,Mo, Ni,Se,Sn,V,Zn	-	-

Legend
Vegetation or Soil Sample Location
CCME Assessment Criteria Exceedance
Evidence of Buried Metal

Yukon Environmental Strategy - Action on Waste
DIAND

Phase I & II ESA

Former Military Site - Mile Post 1155,
Koidern River - Long's Creek
DIAND Site 32

Summary of Geophysical & Soil Investigations

Figure 13	November, 1996	Not to Scale

Hycal ENVIRONMENTAL SCIENCES LTD.

Given the fragile nature of the environment in this area, and the severe damage to the permafrost and the ecosystem related to it that might result from disturbance of the ground surface, **the risk related to not determining the nature of subsurface metal debris must be weighed against the risk of disturbing the area's ecosystem**.

The climate and age of the site would suggest that any buried drums would have been subject to deterioration. **Leachate monitoring would provide information on potential migration from areas of buried metal with less damage to the ground surface than excavation of the metal would entail**. Further geophysical work, to identify all major areas of metal burial should be conducted prior to planning the location of any monitoring wells.

4.4 Soil Sample Analysis

While a number of soil samples were taken during the investigation of the subject site, the project budget allowed for the analysis of only one soil sample. Analysis of this sample indicated that while metals were present in the soil at levels above CCME Assessment Criteria, these levels did not exceed Remediation Criteria. No background sample was analyzed due to budgetary constraints.

Given the large aerial extent of the site, further soil sampling and analysis would be required to confirm the results of the initial soil analysis and more adequately assess soil conditions on the site.

Further soil analysis would be recommended for samples from:

- areas of stressed vegetation;
- topographic lows (where water ponding may occur and where runoff may be concentrated);
- the area along the bank of the Koidern River; and
- a background area.

Analysis of duplicate samples would be recommended to verify analytical results.

4.5 Current Site Practices

Spills of ammonium nitrate, which were observed in the northern portion of the site, where current road building materials are stored, may adversely affect that area and preclude proper vegetative regrowth. **Spilled ammonium nitrate should be removed from the site. Environmental practices being used**

during the construction should be reviewed and upgraded to ensure that further materials are not spilled.

A small amount of post-war materials have been dumped on the site. **Measures** (such as blocking means of driving onto the site) **should be taken to deter future dumping on the site.**

4.6 Risk Associated With the Site

A preliminary risk evaluation suggests that the ecological risk associated with contaminants found on this site is low. This conclusion is based upon the observed health of the ecosystem, relative concentration of contaminants and relative toxicity of the compounds found. **If a greater level of confidence as to risks associated with the subject site is required**, further investigative work would be required and **a Level 1 CCME Risk Assessment should be carried out**.

As noted previously, the risk evaluation associated with this investigation was limited in scope. It is not possible to predict ecological fate and effect without completing a more detailed environmental risk assessment where a probabalistic model is developed. No groundwater wells were present in the vicinity of the subject site and the permanence of the permafrost in the area could only be inferred. Installation of groundwater monitoring wells and an assessment of permafrost conditions in the area over time (including the summer months) would be required to assess possible contaminant migration pathways with more confidence. Further soil sample analysis would be required to assess possible soil contamination more fully. Animal and vegetation studies would be required to assess whether there has been uptake of contaminants from the site.

4.7 Project Implications for Assessments at Other Sites

Results of this investigation suggest that:

- **the presence of vegetative growth cannot be used to infer the absence of materials on a site**. Some areas of the site which were found to contain surficial and subsurface debris, were well-vegetated. Therefore, **aerial reconnaissance may not be effective in identifying areas of concern and sites of prior occupation.**

- **geophysical methods were invaluable in identifying dumping areas** which were either not obvious at surface or which were dubious due to the presence of frost heaving in the area.

- activities that occurred on the site, such as burial of materials, were not documented in historical background materials. While historical information may be valuable in locating sites and identifying some issues of concern, **on-site investigation is required to assess whether a site has been subject to activities of concern**.

5. REFERENCES

Agriculture and Agri-Food Canada and Environment Canada, 1996. Ecoregion Description: Ruby Ranges. http:/www.cciw.ca/eman-temp/ecozones/ecoregion-174.html, 5 November 1996.

Alberta Environmental Protection, 1994. Alberta Tier I Criteria for Contaminated Soil Assessment and Remediation. Alberta Environmental Protection, March 1994.

Bisset, K., 1995. Research of Former Military Sites & Activities in the Yukon. Action on Waste Program, Arctic Environmental Strategy, Indian and Northern Affairs Canada. April 1995.

Breiner, S., 1973. Applications Manual for Portable Magnetometer Geometrics.

Christy, J., 1979. Rough Road to the North. Toronto: Doubleday Canada Ltd.

CCME, 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Canadian Council of Ministers of the Environment, September 1991.

Cohen, S., 1979. The Trail of 42. Missoula: Pictorial Histories Publishing Co.

Department of Public Works, Canada and U.S. Department of Transportation, Federal Highway Administration, 1977. Canadian Department of Fisheries and the Environment, Pacific and Yukon Region, Comments on Environmental Impact Statement, Shakwak Highway Improvement, British Columbia and Yukon, Canada. in Fisheries and Environment Canada, Shakwak Highway Project: A Compendium of Written Submissions to the Environmental Assessment Panel. 23 March 1978, pp.92-131.

Duesenberg, H.M., 1994. Alaska Highway Expeditionary Force: A Roadbuilder's Story. Clear Lake, Iowa: H & M Industries Limited.

Edey, 1976. [set of maps obtained via the Department of Indian and Northern Development, Action on Waste]

Environment Canada, 1983. Identification and Verification of Active and Inactive Land Disposal Sites in the Yukon Territory.

Geological Survey of Canada, 1967. Permafrost in Canada. Map 1246A.

Godsell, P., 1944. Romance of the Alaska Highway. Toronto: The Ryerson Press.

Gray, L. Alaska Highway Camp and Refuse Locations Preliminary Inventory.

Indian and Northern Affairs Canada, 1994. Yukon Geoprocess File: Geological Processes and Terrain Hazards Inventory, Kluane Lake Map Area, NTS 115 F (E1/2) and 115G

Department of Indian and Northern Affairs Canada, undated (1976?). Information on Operation Clean-Up, Canol Road Clean-Up Assessment Study, Campsite & Dump Site Study. Government Records, Volume 1168-69.

Office of the Special Commissioners for Defense Projects in Northwest Canada, 1945. Road Log: Alaska Military Highway. Yukon Archives # PAM 1945-39.

Pictorial Histories Productions. The Trail of '42 - Building the Alaska Highway. Missoula, Montana: Pictorial Histories Productions.

Rainey, F., 1943. Alaska Highway An Engineering Epic. National Geopgraphic, Volume LXXXIII, pp.43-168.

Rampton, V.N., 1967. Surficial Geology and Geomorphology, Generc River, Yukon Territory. Geological Survey of Canada, Map 7-1978.

Remley, D.A., 1976. Crooked Road: The Story of the Alaska Highway. New York: McGraw-Hill Book Company.

Royal Canadian Engineers. Highway Maintenance. Yukon Archives.

Rust, F., 1944. The Eighteenth Engineers Regiment (Combat) in Yukon Territory: April 1942-January 1943. 65pp typescript. Yukon Archives #358-22

Yukon Archives:
Photograph
Cat 1505 Alaska Highway - Koidern River Bridge, 1942

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Whitehorse, Yukon

APPENDIX A
LIMITATIONS

LIMITATIONS

The information and data contained in this report, including without limitation the results of any sampling and analyses conducted by or for Hycal Environmental Sciences Ltd. (Hycal) pursuant to Hycal's engagement, have been set forth to the best of Hycal's knowledge, information and belief.

Although every effort has been made to confirm that all such information and data is factual, complete and accurate, Hycal makes no guarantees or warranties whatsoever, whether expressed or implied, with respect to such information or data and accept no responsibility for any loss or damage arising therefrom or related thereto.

Any use which a third party makes of this report, any reliance on or decisions to be made based on it, are the responsibility of such third parties. Hycal accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The conclusions and recommendations provided in this report are derived from information gathered from the sites identified in the report. They include Hycal's best judgments based on experience and in compliance with accepted investigative techniques. Hycal shall not by the act of issuing this report be deemed to have represented thereby that any sampling and analyses conducted by them have been exhaustive, and persons relying on the results thereof do so at their own risk.

APPENDIX B
PREVIOUS WORK

LIST OF DOCUMENTS

Document 1. Operation Clean Up file (1973) on the subject site.
Source: Yukon Archives File Gov 1168 F.1

Document 2. Environment Canada (1983) information sheets on the subject site.

Document 3. Undated and unattributed set of notes on the subject site from Yukon Archives Government Records Volumes 1168-69.

Document 4. Waste Management Inventory - Beaver Creek District, Indian and Northern Development Canada (1996)

Document 1. Operation Clean Up (1973) file on the subject site.

OPERATION CLEAN UP

Beaver Creek R.M.O. Area

- U.S. Army Dump m.p. 1130 Alaska Hwy.
- U.S. Army Dump m.p. 1154.6 Alaska Hwy.
- U.S. Army Dump m.p. 1155.6 Alaska Hwy.
- U.S. Army Dump m.p. 1165.8 Alaska Hwy.
- U.S. Army Dump m.p. 1174.5 Alaska Hwy. - Y.F.S. cleaned this up this fall (1974)

Fed. Govt

U.S. Army

Site No. 4 Alaska Hwy.

GARBAGE SITES

Location

Location - Latitude [illegible] Longitude [illegible]
Highway Alaska Mile [illegible] Distance off Road ½ mile
Access By Road
Size of Clearing _____ Acres 2 Dimensions _____
Garbage occupies 2 Acres Site in use - ___ Yes X No
Distance from Improvements _____ Type of Improvements _____

Originator

___ Town or Village
X Lodge, Motel
___ Camp (Industrial)
___ Camp (Tourist, Roadside stop)
___ Official Campground

Type of Garbage

___ Vehicle Bodies - Amount _____
X Building Debris
X Kitchen Refuse
X Abandonned Site, Tires, etc.
___ Debris from Clearing
Age of Garbage was left behind by the U.S. Army after construction of the hiway.

Fire Hazard Involved

X High ___ Medium ___ Low
___ Paper, Debris, etc. scattered in adjacent area
Fire Guard - X Nil ___ Satisfactory ___ Unsatisfactory

Site

___ Natural Depression ___ Dug out, Hole X Piled on ground
Vegetation cover around site Black Spruce and Willow
Pollution Potential - X Nil ___ Existing ___ Future
Pollution would effect ___ Stream ___ Lake,
Remarks: Should be turned and buried.
Aesthetic Value Medium
Visible from Road ___ Yes X No

Recommendations for Site X Cleanup and abandon ___ Development

Remarks on Cleanup/Improvement Costs Approx. 56 man hrs. required.

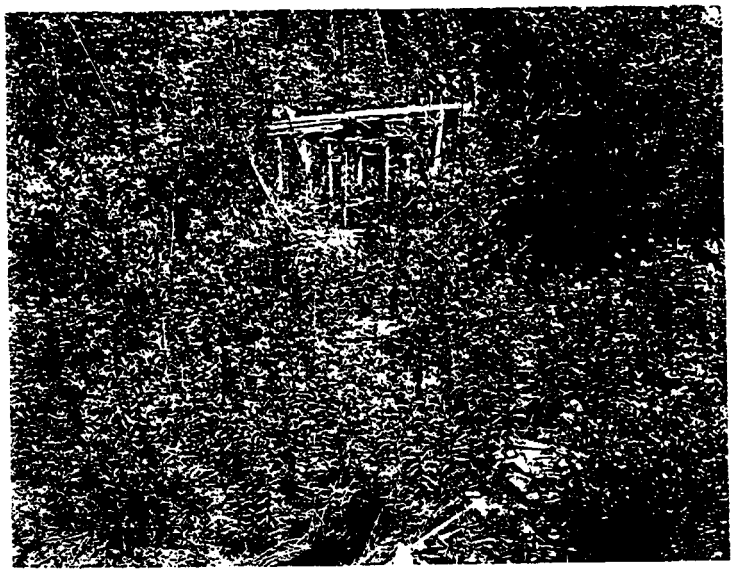
General Remarks on Site Site should be burned and then unburnables should be buried with a cat or bucket loader.

July 25/73 — Date

Glen Campbell — Inspecting Officer

_____ — Supervisor

MILE 1154.6 ALASKA HIGHWAY



MILE 1154.6 ALASKA HIGHWAY

Document 2. Environment Canada (1983) information sheets on the subject site.

32

Environment Canada
Environmental Protection Service

Site Code 104
NTS Sheet 115 F/16
Koidern

IDENTIFICATION AND VERIFICATION OF ACTIVE AND INACTIVE LAND DISPOSAL SITES IN THE YUKON TERRITORY

Community Landfill — Presently in use unknown

Community Name Koidern, Lorne Creek Region Southwestern Yukon

1.0 LOCATION mile 1156 Alaska Highway

1.1 Latitude N 61°53'50" Longitude W 140°13' Elevation 785 M.

1.2 Distance from disposal area to townsite N.A km. 2

1.3 Distance from disposal area to town water source N.A km.
Is there any chance of contamination? minimal 10

1.4 What type of water source unknown 7

1.5 Population served by water source less than 15 2

1.6 Distance from disposal area to major surface water 50 m Koidern River 10

1.7 Uses of major surface water recreational 7

1.8 Distance to nearest house more than 1 Km

1.9 Surrounding land use:

1/4 km radius	1/4 - 1 km radius	Beyond 1 km radius	
Koidern River	bush	Residential	5
Alaska Highway		Commercial	

2.0 DISPOSAL SITE CHARACTERISTICS

2.1 Dimensions: Length 250 meters Width 175 meters 8
Approximate depth of waste 0-1 meters

2.2 Present condition: Open yes
Covered no details - 5
Other - specify -

2.3 Source of waste U.S. Army

2.4 Types of waste:
Liquid sewage no Garbage biodegradable yes
Non degradable (appliances, car/truck bodies, metal scrap) yes 5
Industrial waste (specify) (oils, chemicals etc)
Inventory of other likely wastes

2.5 Operation:
Open Dump yes
Open Dump with Burning minimal

32

Dump with Occasional Cover perhaps
Sanitary Land Fill no
Other (specify)

2.6 Who had access to the site during operation? Public yes
Community Services Specify U.S. Army

2.7 Methods of containment for high concern wastes none

2.8 Evidence of leachate (liquids produced by garbage) YES ____ NO ✓

2.9 Leachate containment (liquids escaping from dump) YES ____ NO ✓

2.10 Evidence of methane gas or odours YES ____ NO ✓
Comments —

2.11 Period of operation 19 N.A to 19 unknown

2.12 Mean high temperature for July 18.5 °C

2.13 General soil type clay

2.14 Vegetation willow, alder, aspen black spruce

2.15 Depth to permafrost during the summer probably present at this site

2.16 Are there any sensitive environments or critical habitats such as endangered species breeding grounds in the area? NO ____ YES ✓
Specify muskrat, beaver, nesting ducks and geese are common in this area

2.17 How far from the landfill are they? 200 m

3.0 GENERAL NOTES : ANNUAL RAINFALL - 300 mm.

3.1 Property owner: Present N.A.
Past (during operation) N.A

3.2 Past or present problems with site unknown

3.3 Reason for closing or abandoning site U.S. Army left area

3.4 Closure procedures there appear to be none

3.5 Information source and/or references Alaska Highway - Clean-up Assessment Study of 1976

4.0 COMMENTS
I did not visually inspect this site. Site was former location of military maintenance camp (26 bldg in 1945).

JR Initials Date Aug 27 1983

Document 3. Undated and unattributed set of notes on the subject site from Yukon Archives Government Records Volume 1168-69.

#6 Mile 1156-0 Km 1559

This site was worked on but it has not been completed, from the air many boards + other debris was visible, wood frames steel barrels ~~truck cab etc~~ yellow truck cabs + Truck box this area was noticeable from the air noted in Photograph # ~~3, 4~~, 1, 2, 3, 4, The Metal storage Tank remains on site as required ~~The~~ This area requires a lot of clean up and while to do could be called cleaned up their remains to do which I would estimate hasn't been completed of the area it is scattered throughout the whole area.

EV-4-0.8-6-3.2

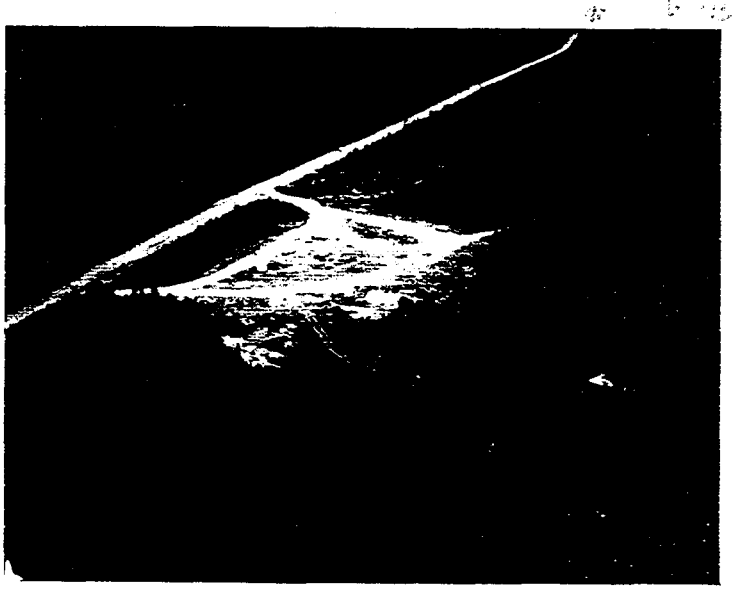
#6A Photo # 1 Area ~~[illegible]~~ of Cleanup noted on site throughout the land pieces of boards and other debris remains visible from the air.

#6-B Photo #2 Area of Cleanup Kitchen Area, fuel tank and Blasting Area.

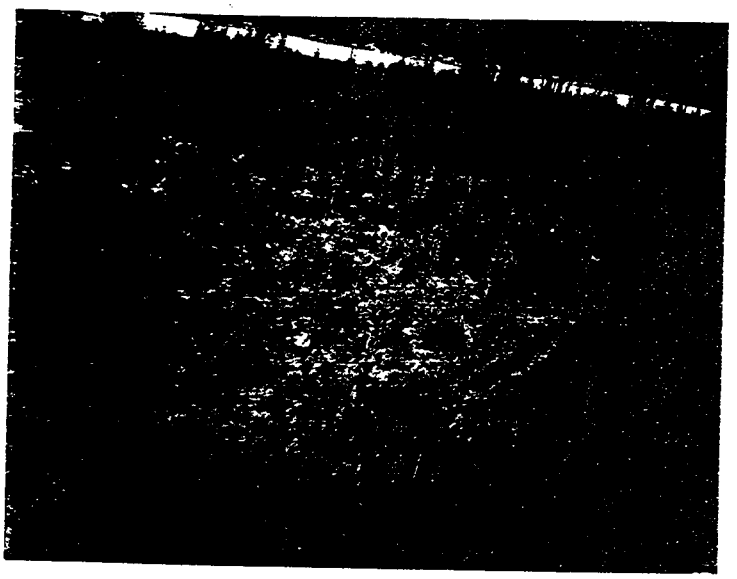
#6-C - Photo #3 Note Center of Photo Yellow cab of truck + below that truck box frames + other wood Debris.

#6-D, Photo #4 Note frames that should of been cleaned up. Still visible from the air as can be seen on this photo

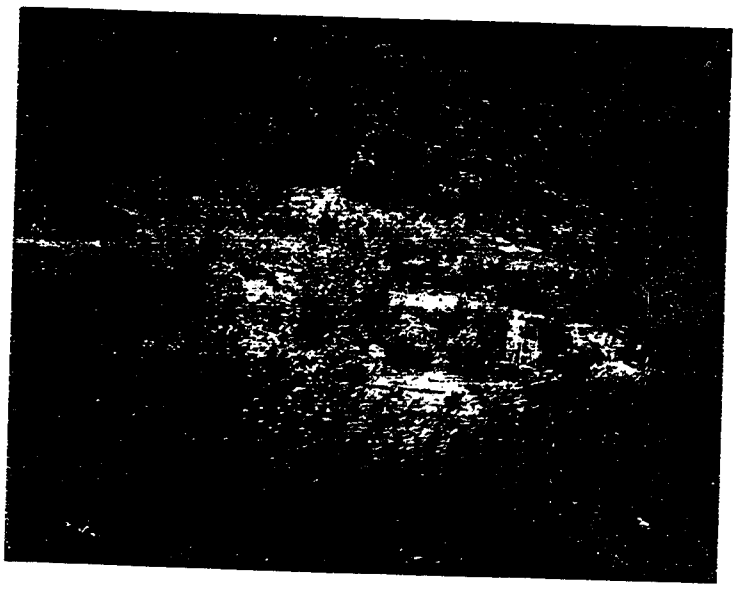
6A



6B



6C



6D

Mile 1156.0 -Koidern
-21 buildings
-maintenance camp (old 259)
-Crown
-km 1860 Ak Hwy Lat 61 53' 50" Long 140 13'
-26 buildings in 1945

Conditions:
-approx 4 vehicle hulks
-asphalt roofing material
-fuel storage tank
-wood debris
-1 partial building
-debris of Quonset hut
-accumulation of vehicle parts

Vegetation:
-willow, alder, aspen, black spruce

Restoration:
-Collect and burn wood debris
-remove metal and vehicle hulks to Mile 1130.1
-Retain fuel tank
-Leave area indicated as vehicle parts as is

Comments:
-This site is frequently used by YTG maintenance for road equipment storage
-Site indicated above is located in heavy muskeg with advanced growth black spruce, willow and heavy moss cover. It is likely that this area will maintain permafrost conditions. Removal of debris in this area will cause excessive disturbance.

Document 4. Waste Management Inventory - Beaver Creek District, Indian and Northern Development Canada (1996).

PAGE 1 SITE NO: 94

WASTE MANAGEMENT INVENTORY SITES - - BEAVER CREEK DISTRICT

LOCATION- GENERAL: LONG'S CREEK

LATITUDE: 65 53' LONGITUDE: 140 13'

LAND TENURE: FEDERAL STATUS: INVENTORIED

OCCUPANT:
ADDRESS:
CITY:
PROVINCE: POSTAL CODE:
PHONE NUMBER:
CLAIM NUMBER:

SITE DESCRIPTION ADJACENT TO LONGS CREEK AND ALASKA HIGHWAY

WIDTH: 100 M LENGTH: 100 M HECTARES:1

SITE ACTIVITY: DUMP SITE

WASTE MATERIAL:Old Culvert,vehicle bodies, concrete & Pipe
DRUMS NUMBER: FULL: EMPTY:
CONTENTS:
CHEMICAL TYPE:

ACCESS: Vehicle

ROAD NAME: Alaska Highway DISTANCE: KM

ABANDONED: Yes

PERMANENT IMPROVEMENTS: No

VEGETATION: Brush, open stands of small black spruce

POLLUTION POTENTIAL: 1

ASPECT AFFECTED: Aesthetics

IMPACT POTENTIAL: Minimal ?

RECOMMENDATIONS: Clean up and haul to designated dump site.

CLEAN-UP COST ESTIMATE:

INSPECTOR: NEALE WORTLEY

INSPECTION DATE: 27 May 96 FORM DATE: 22 June 96

APPENDIX C
LABORATORY ANALYSES

Phone:
(604) 530-4344
1-800-889-1433
Fax:
(604) 534-9996

NORWEST LABS

203-20771 Langley Bypass
Langley, B.C. V3A 5E8

WO (Lang.) : 22032
WO (Other) : 96-10-2834
PO # :
Date Samp. :
Date Rec'd.: 14-Nov-96
Date Comp. : 27-Nov-96

Client		Received From	
Name	: Hycal Environmental	Name	: Norwest Labs
Address	: 1338A - 36th Ave. NE Calgary, Alberta CANADA T2E 6T6	Address	: Bay 6, 2712-37 Ave. NE Calgary, Alberta CANADA T1Y 5L3
Phone	: (403) 735-6454	Phone	: (403) 291-2022
Fax	: (403) 291-2795	Fax	: (403) 291-2021
Attn.	:	Attn.	:
Project	:		

Organo-Chloride Pesticides in Soil

Parameter	22032-1 #10 V3-R9371 Site 32 Koidern	22032-2 #11 B3-R9372 Site 31 Donjek	Detection Limit
Pesticide			
Aldrin	<0.05	<0.05	0.05 ppm
BHC (alpha isomer)	<0.05	<0.05	0.05 ppm
4,4'-DDD	<0.05	**0.24**	0.05 ppm
4,4'-DDE	<0.05	**0.08**	0.05 ppm
2,4'-DDT	<0.05	**0.15**	0.05 ppm
4,4'-DDT	<0.05	**0.58**	0.05 ppm
Dieldrin	<0.05	<0.05	0.05 ppm
Endosulfan I	<0.05	<0.05	0.05 ppm
Endosulfan II	<0.05	<0.05	0.05 ppm
Endrin	<0.05	<0.05	0.05 ppm
Heptachlor	<0.05	<0.05	0.05 ppm
Heptachlor epoxide	<0.05	<0.05	0.05 ppm
Hexachlorobenzene	<0.05	<0.05	0.05 ppm
Lindane	<0.05	<0.05	0.05 ppm
Methoxychlor	<0.05	<0.05	0.05 ppm
Mirex	<0.05	<0.05	0.05 ppm
Percent Moisture	53.8	43.97	

Results are expressed in ppm (mg/kg), dry weight, without correction for recovery data.
ND = Not Determined.

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PO # :
Date Samp. :
Date Rec'd. : 14-Nov-96
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Organo-Chloride Pesticides in Soil (cont.)

Definitions / Methods

Organo-Chloride Pesticides: This analysis is carried out in accordance with U. S. Environmental Protection Agency Method 8080 (#SW 846, 3rd Edition, Washington DC 20460) which involves extraction of the components with an organic solvent (EPA 3540) followed by analysis by capillary gas chromatography using an electron capture detector.

Percent Moisture: Percentage of the total wet weight of the sample as received. This analysis is carried out gravimetrically by drying the sample to constant weight at 105 C.

Comments

Quality Control Results

QA/QC		Analyst		
Compound	% Recovery	Analysis	Date	Analyst
Lindane	79	O-C Scan	26-Nov-96	Ken M.
Surrogate	101			

Supervisor

Note: All samples will be disposed of after 30 days following analysis unless other arrangements are made.

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PO # :
Date Samp. :
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Date Comp. : 27-Nov-96

Client		Received From	
Name	: Hycal Environmental	Name	: Norwest Labs
Address	: 1338A - 36th Ave. NE Calgary, Alberta CANADA T2E 6T6	Address	: Bay 6, 2712-37 Ave. NE Calgary, Alberta CANADA T1Y 5L3
Phone	: (403) 735-6454	Phone	: (403) 291-2022
Fax	: (403) 291-2795	Fax	: (403) 291-2021
Attn.	:	Attn.	:
Project	:		

Organo-Phosphate Pesticides in Soil

Parameter	22032-1 #10 V3-R9371 Site 32 Koidern	22032-2 #11 B3-R9372 Site 31 Donjek	Detection Limit
Pesticide			
Azinphos-Methyl (Guthion)	<0.25 ppm	<0.25 ppm	0.25 ppm
Chlorpyrifos	<0.25 ppm	<0.25 ppm	0.25 ppm
Coumaphos	<0.35 ppm	<0.35 ppm	0.35 ppm
Diazinon	<0.05 ppm	<0.05 ppm	0.05 ppm
Dichlorvos (DDVP, Vapona)	<0.15 ppm	<0.15 ppm	0.15 ppm
Dimethoate (Cygon)	<0.35 ppm	<0.35 ppm	0.35 ppm
Disulfoton (Disyston)	<0.15 ppm	<0.15 ppm	0.15 ppm
Ethion	<0.15 ppm	<0.15 ppm	0.15 ppm
Fonofos (Dyfonate)	<0.15 ppm	<0.15 ppm	0.15 ppm
Malathion	<0.15 ppm	<0.15 ppm	0.15 ppm
Methamidophos	<0.15 ppm	<0.15 ppm	0.15 ppm
Methyl Parathion	<0.15 ppm	<0.15 ppm	0.15 ppm
Mevinphos (Phosdrin)	<0.15 ppm	<0.15 ppm	0.15 ppm
Naled	<0.25 ppm	<0.25 ppm	0.25 ppm
Phorate (Thimet)	<0.10 ppm	<0.10 ppm	0.10 ppm
Phosalone	<0.35 ppm	<0.35 ppm	0.35 ppm
Terbufos	<0.15 ppm	<0.15 ppm	0.15 ppm
Percent Moisture	53.80	43.97	

Results are expressed in ppm (mg/kg), dry weight, without correction for recovery data.
ND = Not Determined.

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NORWEST LABS

203-20771 Langley Bypass
Langley, B.C. V3A 5E8

WO (Lang.) : 22032
WO (Other) : 96-10-2834
PO # :
Date Samp. :
Date Rec'd.: 14-Nov-96
Date Comp. : 27-Nov-96

Organo-Phosphate Pesticides in Soil (cont.)

Definitions / Methods

Organo-Phosphate Pesticides: This analysis is carried out in accordance with U. S. Environmental Protection Agency Method 8140 (#SW 846, 3rd Edition, Washington DC 20460) which involves extraction of the components with an organic solvent followed by analysis by capillary gas chromatography using a flame ionization detector.

Percent Moisture: Percentage of the total wet weight of the sample as received. This analysis is carried out gravimetrically by drying the sample to constant weight at 105 C.

Comments

Quality Control Results

QA/QC		Analyst		
Compound	% Recovery	Analysis	Date	Analyst
OPs	132	O-P Scan	26-Nov-96	Ken M.

Supervisor

Note: All samples will be disposed of after 30 days following analysis unless other arrangements are made.

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NORWEST LABS

203-20771 Langley Bypass
Langley, B.C. V3A 5E8

WO (Lang.) : 22032
WO (Other) : 96-10-2834
PO # :
Date Samp. :
Date Rec'd. : 14-Nov-96
Date Comp. : 28-Nov-96

Client		Received From	
Name	: Hycal Environmental	Name	: Norwest Labs
Address	: 1338A - 36th Ave. NE Calgary, Alberta CANADA T2E 6T6	Address	: Bay 6, 2712-37 Ave. NE Calgary, Alberta CANADA T1Y 5L3
Phone	: (403) 735-6454	Phone	: (403) 291-2022
Fax	: (403) 291-2795	Fax	: (403) 291-2021
Attn.	:	Attn.	:
Project	:		

Herbicide Analysis in Soil

Parameter	22032-1 #10 V3-R9371 Site 32 Koidern	22032-2 #11 B3-R9372 Site 31 Donjek	Detection Limit
Phenoxy/Acid Herbicides			
Picloram	<0.1	<0.1	0.1 ppm
Organonitrogen Pesticides			
Fenuron	<0.5	<0.5	0.5 ppm
Percent Moisture	53.8	43.97	

Results are expressed in ppm (mg/kg), dry weight, without correction for recovery data.

Phone:
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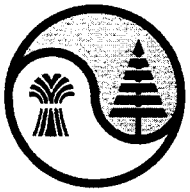
1-800-889-1433
Fax:
(604) 534-9996



NORWEST LABS

203-20771 Langley Bypass
Langley, B.C. V3A 5E8

WO (Lang.) : 22032
WO (Other) : 96-10-2834
PO # :
Date Samp. :
Date Rec'd. : 14-Nov-96
Date Comp. : 28-Nov-96

Herbicide Analysis in Soil (cont.)

Definitions / Methods

Phenoxy/Acid Herbicides: This analysis is carried out in accordance with U. S. Environmental Protection Agency Method 8151 (SW 846, 3rd Edition, Washington DC) which involves extraction of the components with an organic solvent followed by hydrolysis, derivatization and then analysis by gas chromatography using a mass selective detector.

Neutral Herbicides: This analysis is carried out in accordance with U.S. Environmental Protection Agency Method 8081 (SW-846, 3rd Edition, Washington DC) which involves extraction of the components with an organic solvent followed by derivatization and analysis by gas chromatography using an electron capture detector.

Percent Moisture: Percentage of the total wet weight of the sample as received. This analysis is carried out gravimetrically by drying the sample to constant weight at 105 C.

Comments

Quality Control Results

QA/QC		Analyst		
Compound	% Recovery	Analysis	Date	Analyst
2,4-D	52	herbicides	26-Nov-96	Ken M.
2,4,5-T	47			
Picloram	73			

R L Neumann
Supervisor

Note: All samples will be disposed of after 30 days following analysis unless other arrangements are made.

NORWEST LABS

INFORMATION SHEET - SOILS

WORK ORDER NO.

SHEET 1 OF 1

DATE STAMP

COMPANY: HYCAL Environmental
ADDRESS:

CITY/TOWN: Calgary
PROVINCE:
POSTAL CODE:
ATTENTION:
PROJECT:

PHONE: 735-6463
FAX:
RESULTS TO: Lisa-Henri Kirkland

P.O. NO.	REPORTING SELECTIONS
EG-243	Q.A. REPORT ☐
REF./QUOTE NO.	

REPORT RESULTS: MAIL ☐ FAX ☑ COURIER ☐

RUSH DATE REQUIRED: D M Y

SURCHARGE WILL APPLY ON RUSHES

SAMPLE CUSTODY	SAMPLED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
	LH Kirkland			
	COMPANY: Hycal	COMPANY: NWL	COMPANY	COMPANY
	DATE: 23 Oct 96	DATE: 3:00 23/10/96	DATE	DATE

DATE SAMPLED: D M Y

NUMBER OF SAMPLES: SOIL | WASTE | WATER | PLANT | OTHER SPECIFY

SPECIAL INSTRUCTIONS (SEE OVER FOR IMPORTANT SAMPLE INFORMATION INSTRUCTIONS AND ANALYSIS CODES)

hold all remaining samples for possible future analysis

future analysis may include dioxins/furans
esterone
tordon
fenuron

CLIENT NO.

INVOICE NO.

COMPLETION DATE: D M Y

	SITE I.D.	SAMPLE DESCRIPTION	DEPTH (CM)	ANALYSIS PACKAGE CODES (USE CODES LISTED ON THE REVERSE OF THIS SHEET)	LAB CODING
1	(1)	1130 Donjek Background	-	PCB 2, PP1, P01, H4, TM44	
2	(2)	Site 33 ~~Sample~~ Oil Pit #1	-	as above	
3	(3)	Site 33 Background	-	as above	
4	(4)	Pump Stn. G Sample 5	-	as above	
5	(5)	1130 Donjek Pit	-	as above	
6	(6)	Site 33 Koidern Sample #1	-	as above	
7	(7)	Pump Stn G Sample 6	-	as above	
8	(8)	Pump Stn G Sample 5	-	no analysis at this point	
9	(9)	Site 33 North Pit	-	no analysis at this point	
10			-		
11			-		
12			-		
13			-		
14			-		
15			-		
16			-		
17			-		
18			-		
19			-		
20			-		

NORWEST LABS

Calgary, AB	Phone (403) 291-2022	Fax (403) 291-2021
Edmonton, AB	Phone (403) 438-5522	Fax (403) 434-8586
Lethbridge, AB	Phone (403) 328-8266	Fax (403) 327-8527
Langley, B.C.	Phone (604) 530-4344	Fax (604) 534-9996
Winnipeg, MB	Phone (204) 982-8630	Fax (204) 275-6019

TO:	Hycal Environmental	**DATE SAMPLED:**	23-Oct-96
		DATE RECEIVED:	24-Oct-96
ATTN:	Lisa	**DATE REPORTED:**	01-Nov-96
	Henri Kirkland	**LAB FILE#:**	96-10-2834
		Project:	E6-243

POLYCHLORINATED BIPHENYLS IN SOIL

LAB #	R8864	R8865	R8866	R8867	R8868	Detection
CLIENT #	#1	#2	#3	#4	#5	Limit
	1130 Donjek	Site 33	Site 33	Pump Stn G	1130	
	Background	Oil Pit #1	Background	Sample 5	Donjek Pit	
PCB Content	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
Aroclor Type	----	----	----	----	----	

QUALITY ASSURANCE DATA

(This QA/QC data is representative of the lab based quality assurance program and is not to be utilized as field data.)

Surrogate Recovery %	75	83	83	74	73
Decachlorobiphenyl					

Results expressed in mg/kg dry wt. (ppm)

APPENDIX D
PROJECT PERSONNEL

PROJECT PERSONNEL

Personnel who participated in the project included:

Lisa-Henri Kirkland, B.A., B.Sc., P.Geol.	historical investigation, field sampling, data analysis and report preparation
Rod Ewacha,B.Sc., E.I.T.	field sampling, data analysis
Mark Bowman, B.Sc., P. Geoph.	geophysical investigation
Rosemarie van der Meer, White River Nation	assistance in field sampling and historical investigation
Douglas Lee, M.Sc., P.Biol.	preliminary risk evaluation
Alan MacDonald, M.E.Des.	report review