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PHASE II ENVIRONMENTAL ASSESSMENT OF THE HIGHLANDER ABANDONED MINE SITE

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EXECUTIVE SUMMARY

The Highlander abandoned mine site (63°57'22"N, 135°14'33"W) was likely first staked in 1919-1920. The development work to 1929 consisted of open-cuts and an eight metre shaft with 14.6 metres of underground drifting. No records could be located in public files regarding recent work history on the claims. The condition of the buildings, extent of natural revegetation of the site and volume of mine rock indicate that additional underground development occurred at the site sometime in the last 20 to 40 years.

DIAND Technical Services completed a Phase I environmental assessment on the property in 1993. The initial assessment (DIAND, 1994) identified safety concerns associated with dilapidated buildings (note that the site was incorrectly identified as the Gambler site in DIAND, 1994). No rock, soil, water, or product samples were collected in the 1994 overview assessment, and further investigation was recommended. A Phase II environmental assessment was conducted at the Highlander abandoned mine site in September, 1996, by Steffen, Robertson and Kirsten.

The following are the key conclusions and recommendations of this investigation:

- The existing buildings are in various states of collapse and pose a health and safety hazard on a popular hiking trail. It is recommended that all but two of the buildings be demolished. The local tourism association has expressed interest in preserving historic artifacts. They would likely be willing to take responsibility for the care and maintenance of the remaining cabin and the ore processing building.

- The waste rock appears to be physically and chemically stable. No mitigation measures are recommended regarding the waste rock.

- The debris and garbage remaining at the site presents an aesthetic concern. It is recommended that this material be incinerated and buried.

- All adits are securely sealed and pose no safety hazard. An inaccessible shaft reported to be on the site (Boyle, 1961) could not be located in the field, and has either caved and grown over, or is actually located on one of the adjacent claims. The danger of unidentified mine openings is present throughout the Keno Hill - Galena Hill mining camp. The local tourism association has posted signs cautioning hikers to "keep only to the trails marked and do not enter buildings, or shafts."

P118401

PHASE II ENVIRONMENTAL ASSESSMENT
OF THE
HIGHLANDER ABANDONED MINE SITE

TABLE OF CONTENTS

1.0 INTRODUCTION 1
  1.1 Background 1
  1.2 Location and Access 2
  1.3 Overview of Site Development 2

2.0 OBJECTIVES AND SCOPE 3
  2.1 Objectives 3
  2.2 Review of Available Information 3
  2.3 Site Investigation 3
  2.4 Review and Cost Estimates 4

3.0 SITE INVESTIGATION METHODOLOGY 6
  3.1 Area Investigated 6
  3.2 Assessment Criteria 6
  3.3 Components Investigated 7
  3.4 Sampling Methods and Quality Assurance 9
  3.5 Analytical Methods 11

4.0 ENVIRONMENTAL SETTING 12
  4.1 Mineralization 12
  4.2 Surface Hydrology 12
  4.3 Climate 12
  4.4 Vegetation 13

4.5 Fish and Wildlife Resources 13
4.6 Site Topography and Soils 13
4.7 Permafrost 14

5.0 SITE DESCRIPTION AND FINDINGS 15
5.1 Buildings, Infrastructure, and Equipment 15
5.2 Non-Hazardous Waste Material 16
5.3 Hazardous Materials 16
5.4 Water Quality 16
5.5 Waste Rock Disposal Areas 18
5.6 Mine Openings and Excavations 19
5.7 Tailings 20

6.0 RISKS AND CONCERNS 21
6.1 Health and Safety Risks 21
6.2 Environmental Risks 21
6.3 Aesthetic Concerns 21

7.0 RECOMMENDATIONS 22

8.0 REFERENCES 23

LIST OF TABLES

TABLE 1 Non-Hazardous Waste Materials 16
TABLE 2 Surface Water Samples 17
TABLE 3 Waste Rock Sample Descriptions and Select ABA and ICP Results . . . 19

LIST OF FIGURES

FIGURE 1 Vicinity Map
FIGURE 2 Location Map
FIGURE 3 Site Plan

LIST OF APPENDICES

APPENDIX A Photos
APPENDIX B Water Quality Analytical Results
APPENDIX C Waste Rock Test Results

P118401

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1.0 INTRODUCTION

1.1 Background

As part of the 1993 Arctic Environmental Strategy Action on Waste program, DIAND Technical Services completed Phase I environmental assessments of abandoned exploration and mine sites. The initial assessments provided a general overview of historical activities, described site infrastructure, mine workings and wastes, summarized environmental and/or safety concerns on each site, and provided general recommendations for remediation work. On the basis of the initial assessments, selected sites were chosen for further investigation.

The abandoned Highlander (Gambler) mine was one of the sites chosen for further investigation. The initial assessment (DIAND, 1994) identified safety concerns associated with dilapidated buildings. A second lower site, thought to be on the Gambler [sic] claim, consisting of buildings and a waste dump was photographed but not inspected during the initial assessment. No rock, soil, water, or product samples were collected in the initial assessment.

Environmental Services, Public Works and Government Services Canada, retained Steffen Robertson and Kirsten (SRK) to do further investigation. SRK staff were at the site September 18, 1996.

In its 1993 assessment, DIAND Technical Services incorrectly identified the site as the Gambler site. The 1996 site inspection confirmed that the site assessed by DIAND was, in fact, the Highlander mine site, not the Gambler (which is located in an adjacent gulch). The Gambler site proper is located on the west side of Faro Gulch, 1.5 km east of

Gambler Gulch and was inspected separately by SRK (Phase II Environmental Assessment of the Gambler Mine Site, SRK 1997).

The second, lower site photographed by DIAND in 1993 was the Stone mine site, 1 km to the northeast of the Highlander site, on the western side of Faro Gulch. The waste rock pile observed by DIAND was created during the development of adits. Much of the development work was through overburden (GSC Memoir 284, p. 604., pers. comm. J.B. O'Neill). The Stone mine site was not inspected during the SRK assessment.

1.2 Location and Access

The Highlander abandoned mine site is located 6 km north-northeast of the community of Keno Hill and 2 km northwest of Keno Summit, at 1370 metres to 1440 metres (4500 to 4700 feet) above sea level. Access to the property is via the Silver Trail Tourism Association's Keno City trail network, Trail Number 4 - Gambler Gulch Trail, and Trail Number 5 - Faro Gulch Trail. An unserviced gravel road, with rough sections, from Keno City provides vehicle access to within 1 km of the site (Photo 1). The last kilometre is a footpath that is suitable for all terrain vehicles, with minor upgrading.

1.3 Overview of Site Development

The Highlander property was likely staked in 1919-1920, following the discovery of the rich No. 9 vein on Keno Hill. Work on the Highlander claim and adjacent claims to 1929 included six open-cuts (most of which sloughed in by 1929), and an inaccessible 8 metre shaft that terminated in a drift, 14.6 metres long (GSC Memoir 284, p.603.). Inaccessible open-cuts and a shaft on the Highlander claim are also described by RW. Boyle (GSC Bulletin 111, p. 35.) after visiting the site between 1953 and 1955. The work history for the site has not been compiled (No Yukon Minfile exists) and no assessment files are available to the public.

The buildings appear to have been built between 20 and 40 years ago, and the 10,000 to 15,000 tonnes of waste rock on the site was probably generated at least that long ago. The volume of waste rock indicates that at least 500 metres of underground development occurred at the Highlander site. The extent of underground development and the dates when this development occurred are inferred from observations made during the 1996 assessment, since little information is available in public files.

2.0 OBJECTIVES AND SCOPE

2.1 Objectives

SRK personnel completed this investigated with the assistance of Yaanatun Consulting of Whitehorse, YT. The objectives of the investigation were to:

- Identify potential environmental and human safety risks and/or aesthetic concerns; and,
- Provide recommendations and preliminary cost estimates for mitigation of those risks and/or concerns.

The level of effort in the assessment was appropriate for identifying potential risks. The site investigation was limited to a single day. The objective of the sampling and testing was to identify potential chemical and stability issues associated with the site, to determine the nature of those issues, and to recommend what, if any, mitigation or further investigation are required.

2.2 Review of Available Information

The investigation was initiated with a review of background information. Available public information was consolidated from the Geological Survey of Canada, Yukon Assessment files, and DIAND Exploration and Geological Services. Indian and Northern Affairs Canada provided an overview of the Highlander mine site titled Yukon Assessment Report 105M-14-8 Gambler [sic.] Abandoned Mines Assessment, (DIAND, 1994). Other published information sources were examined for site or regional information as applicable. A list of references examined is included in Section 8.0 of this report. J.B. O'Neill, a retired miner with personal experience in the Keno Hill area, was contacted to confirm site names, locations, and history of development.

2.3 Site Investigation

The site investigation followed a procedure that was designed to apply to all of the sites included in the 1996 program. The procedure included:

- Visual inspection of mine openings and workings, buildings and infrastructure, and waste disposal areas;
- Photo documentation and mapping of relevant site features;
- Sampling of waste rock disposal areas, stained soils, surface water (including waste rock seeps and receiving waters) and barrel contents;
- Identification and inventory of hazardous and non-hazardous materials on the site;
- Identification of pathways and receptors for site contaminants; and,
- Assessment of human safety hazards and access to hazardous areas.

2.4 Review and Cost Estimates

Samples taken in the field investigation were submitted for analysis. The results were compiled and reviewed by SRK staff. Preliminary cost estimates were then prepared for the following mitigation measures, as appropriate:

- Sealing of all mine openings;
- Physical stabilization of waste rock disposal areas;
- Chemical stabilization of the waste rock disposal areas, taking into account impact, on-site resources, and accessibility;
- Consolidation and landfill of all non-hazardous, non-combustible solid wastes;
- Remediation and/or removal and disposal of contaminated soils;
- Removal and disposal of hazardous solid wastes;
- Draining, cleaning, and disposal of drums, storage tanks, or other containers containing petroleum products or other liquid hazardous wastes;

- On-site flaring or removal and off-site disposal of petroleum products and other liquid hazardous wastes; and,

- Demolition of buildings and infrastructure to foundation level and burning of combustible non-hazardous materials in an approved location.

3.0 SITE INVESTIGATION METHODOLOGY

3.1 Area Investigated

The investigation was limited to the area specifically developed, or occupied during, exploration and mining purposes, immediately-adjacent areas, and the resources believed to be affected by these activities. The trails to the mine site were not included in the investigation. The assessment was limited to the Highlander mine site and did not include the second lower site, the Stone site (note that the site was incorrectly identified as the Gambler site in DIAND, 1994, as discussed in Section 1).

3.2 Assessment Criteria

The *Mine Reclamation in Northwest Territories and Yukon* (INAC, 1992) provides guidelines for the clean up and reclamation of mine sites operating in northern climates. These guidelines were applied in the assessment of the following mine features:

- open pit and underground workings;
- waste rock and tailings disposal areas; and,
- acid generation and metal leaching.

The *Interim Canadian Environmental Quality Criteria for Contaminated Sites* (CCME criteria, 1992) are numerical limits for contaminants in soil and water intended to protect, maintain or improve environmental quality and human health at contaminated sites in general.

CCME criteria include two types of benchmarks for soil and water quality: assessment criteria and remediation criteria. Assessment criteria are approximate background concentrations or approximate analytical detection limits for contaminants in soil and water, and remediation criteria are for specified uses of soil and water. Remediation criteria are for generic use and do not address site-specific conditions. They are considered generally protective of human and environmental health for specified uses of soil and water at contaminated sites.

The remediation criteria for soil are classified by land uses: agricultural, residential/parkland, and commercial/industrial. Remediation criteria for water are classified by four uses of water likely of concern at contaminated sites: freshwater aquatic life, irrigation, livestock watering, and drinking water.

For the Yukon mine assessments, commercial/industrial remediation criteria were used to assess soil contaminants (excluding waste rock and tailings) and the freshwater aquatic life remediation criteria were used to assess surface water quality.

3.3 Components Investigated

The following components were investigated, when present, to identify existing or potential safety and environmental risks on the mine site:

Water samples were to be collected from receiving water bodies upstream and downstream of potential sources on contamination. Observations of flow, flora, and fauna habitat, fisheries resources, and field pH and conductivity measurements were recorded. The field observations and a comparison of downstream water quality to the upstream were to be used to assess impact. Since water sampling was restricted to a single sampling event it does not necessarily reflect seasonal variations.

Waste Rock disposal areas were to be inspected and sampled by a professional geologist to assess acid rock drainage and metal leachate potential by:

- Identifying variations in rock type, mineralization and alteration;
- Mapping and logging waste rock, tailings, pit walls and rock faces; and,
- Collecting and field testing representative samples of mine wastes.
- Collecting and field testing (paste pH and paste conductivity) representative samples of mine wastes.
- Laboratory testing of selected samples, including whole rock analysis (solids assay) and acid base accounting (ABA). Laboratory leach tests (static or kinetic) were not included in the Phase II assessment.

Mine Openings and Excavations were to be visually inspected from surface and documented to identify safety concerns and closure requirements.

Non-Hazardous Site Debris was to be inventoried.

Potentially Contaminated Soil Areas were to be identified, measured and sampled to determine the degree and type of contamination and estimate soil volumes for remediation. Samples collected were analysed for total organic halogens (TOX), polychlorinated biphenols (PCB's), and metals, as appropriate.

Hazardous Materials were to be inventoried and sampled for analyses of contaminant constituents, as necessary.

Barrels, Pails, and Storage Tanks containing petroleum products were to be sampled and analysed for total organic halogens (TOX), polychlorinated biphenols (PCB's), and metals, as appropriate, to determine suitability for on-site incineration. Drums containing substances other than petroleum products were to be sampled to identify hazardous constituents.

Buildings and other Structures were to be inspected for hazardous materials and assessed for stability.

Borrow Sources were to be identified, if required, and assessed for accessibility and approximate quantity and type of granular material as applicable.

Site plans were prepared to identify the type, dimensions and locations of site structures, mine workings and adits, waste rock disposal areas, on-site sampling locations, the distribution and type of debris observed, and other pertinent information. The inventories made recorded the type, quantity, condition and general location of equipment and products found.

3.4 Sampling Methods and Quality Assurance

Mine Waste Sampling

Samples were collected from the mine wastes (waste rock piles, ore stockpiles and mill tailings). Sampling was restricted to hand methods; no drills or excavators were used. The samples were submitted to Cominco Engineering Services Ltd. (CESL) of Vancouver, BC, for acid base accounting and solids analysis.

Test pits were excavated to a depth of about 0.3 to 1.0 metres. Horizons in the test pit walls were logged, noting colour/weathering, rock composition, primary and secondary mineralization, particle size distribution, paste pH and paste conductivity, and moisture content. The test pit was photographed and its location was recorded on the field map.

Approximately 2 kg of rock was collected at each sample site. For test pits showing a homogeneous wall face, a plastic sheet was placed at the bottom of the test pit and the pit wall was cut vertically with a cleaned pick. All rock fragments larger than 75 mm in size was discarded. For test pit walls showing clearly-separate horizons (distinguishable by the sulphide and carbonate contents), the horizons were sampled individually.

Water Sampling

Samples were collected from surface streams upstream and downstream of mine related flows, and from representative seeps emanating from waste rock, tailings, pit walls, and adits. The samples were submitted to Analytical Service Laboratories Ltd. (ASL) of Vancouver, BC, for analysis of total metals, pH, conductivity, hardness, acidity, alkalinity and sulphate.

250 ml water samples were collected by hand, facing upstream, ensuring that the sample was not contaminated by disturbed sediment, debris and other floating materials. Sample bottles were rinsed three times with water from the sample stream prior to collecting the sample.

2 ml of nitric acid (HNO_3) were immediately added to water samples destined for metals analyses. For analyses of non-metallic parameters, water samples were brim-filled to minimise head space. The water samples were stored in a cooler, with freezer packs, to maintain a temperature of approximately 4° C until delivery to the laboratory.

Soil Sampling

Samples were collected from areas suspected of hazardous waste contamination due to their appearance or their location with respect to fuel storage areas or workshops.

Soil lithology was recorded from observations of the side walls of the test pit, and soil samples for both field and laboratory testing were collected. Observations were recorded for each soil sample site, including soil particle size, consistency, colour, moisture, discolouration, stratification, odour, and any other significant observations.

Samples were collected at depth intervals selected on the basis of stratigraphic observations and anticipated or apparent contamination. The lab samples were collected using disposable latex gloves and decontaminated stainless steel sampling utensils. All samples intended for organic analyses were stored in laboratory-cleaned 250 ml glass jars. Samples intended for metals analyses were placed in new, sealable, plastic bags. All samples were placed in a cooler for shipment to the laboratory.

Barrel and Pail Sampling

Barrels and pails containing hydrocarbons were sampled with 1.2 metre clean hollow glass tubes ("drum thieves") capable of extracting up to 25 ml of product. The rods were inserted into the drum or pail, and the uppermost open tip was sealed to maintain the sample within the rod as it was extracted from the drum or pail. The sampled hydrocarbon was then drained into a 40 ml laboratory-cleaned vial. The extractions were repeated until the vial was filled to form a meniscus above the rim. The vial was then sealed, making sure no air bubbles formed in the closed head space, and placed in a container for shipment to the laboratory. Each used sampling tube was subsequently destroyed to prevent accidental re-use.

Quality Assurance

Quality Assurance (QA) is a set of procedures for ensuring that the results of chemical analyses are, and can be shown to be, accurately representative of field conditions. A complete QA program includes both a field component and a laboratory component.

In addition to the standard sample collection methods outlined above, the field QA measures that were implemented for this assessment study include:

- chain of custody procedures and forms;
- a sample labelling and sample location identification scheme;
- laboratory preparation of all sampling containers;
- laboratory defined sample preservation and shipping procedures; and,
- regular maintenance (including re-calibration) and cleaning of field equipment.

Laboratory QA measures included replicate analyses of selected soil and water samples. Replicate analytical results were submitted with each analytical report.

3.5 Analytical Methods

Water Quality methods of analysis are outlined in ASL's Chemical Analysis Report included in Appendix B of this study.

Field paste pH and paste conductivity measurements were taken while on site to characterize the current state of the mine waste. The testing methodology is described in the *Public Works and Government Services Canada ARD Reconnaissance Handbook* (SRK, 1996) prepared for the surveys of abandoned mine sites in the Yukon Territory.

Acid Base Accounting (ABA) is a set of analyses used to determine the balance between potentially acid generating (sulphide) minerals, expressed as the acid generating potential (AP), and potentially acid consuming minerals expressed as the neutralizing potential (NP). The modified acid base accounting procedure used in this study is based on the standard Environmental Protection Agency (EPA) test procedure and is described in *Guidelines for Acid Rock Drainage Prediction in the North* (INAC, 1992).

Solids Analysis was conducted on a fraction of the pulverized mine waste material. Inductively Coupled Plasma - Atomic Emission Spectrophotometry (ICP-AES) was used to determine total sulphur, sulphate sulphur and 31 additional elements (metals).

4.0 ENVIRONMENTAL SETTING

4.1 Mineralization

The Highlander site is one of several small abandoned mine sites located within the Keno Hill - Galena Hill mining camps. The commodities of interest at the Highlander site are silver, lead and zinc. The Keno Hill - Galena Hill silver-lead ores occur in erratic shoots and lenses lying in vein-faults that cut fine-bedded to massive quartzite, intercalated greenstone sills and lenses, and various schistose rocks (GSC Paper 68-68, p.21). These rocks are intruded by gabbro and diabase sills.

Mineralization at the Highlander site consists of pyrite (FeS_2), galena (PbS), sphalerite ($(Zn,Fe)S$) and freibergite (silver - bearing tetrahedrite ($((Cu,Fe)_{12}Sb_4S_{13})$) in quartzite and siderite ($FeCO_3$) gangue (GSC Bulletin 111, p.36.).

4.2 Surface Hydrology

Regional drainage flows west to east along Keno Ladue River (Figure 2), which joins up with Beaver River, which, in turn, is a tributary of Stewart River. No hydrological data is available for the Keno Ladue River.

The Highlander mine site is located near the head of the Gambler Gulch catchment, and all surface runoff from the mine site flows into Gambler Gulch stream. Where the stream passes through the camp (see Figure 3), it was shallow and approximately 0.5 metres wide, and was flowing at a rate of 2 to 3 L/sec (visual estimate) at the time of the site inspection. Below the camp, approximately 300 metres, the stream becomes steep (20°) and its flow increases to 6 L/sec.

4.3 Climate

The area has a continental climate characterized by low precipitation and a wide temperature range. Winters are cold and long but the short summer has almost continuous daylight during June and July (GSC Memoir 364, pp.3-4). The nearest climatological information, compiled in Environment Canada's Canadian Climatic Normals, 1951 to 1980, is from the town of Elsa 13 km southwest of the site (Latitude 63°55', longitude 135°29', elevation 814 metres above mean sea level). Total annual precipitation is approximately 410 mm, with the highest snowfall period being October to December and the highest rainfall period in July and August. Elsa has on average 122 days with precipitation per year. Temperatures typically range from - 28°C in January and 20°C in July. The mean annual temperature is -4°C. Both Elsa and Highlander are on the northern side of the Gustavus Range; however, the Highlander site is approximately 600 metres higher in elevation than Elsa and therefore likely colder.

4.4 Vegetation

The Highlander mine site occurs within the Yukon Plateau, North ecoregion. The mine site is located in a well vegetated area of the subalpine (except on talus slopes and the waste rock piles were vegetation is sparse). The following trees and shrubs were identified during the site assessment: stunted black spruce, a variety of willow (2 to 3 metres high), scrub brush, heather, hudson bay tea, a variety of mosses and lichens, black berries, low bush cranberries, fireweed and sedges (Photo 1). The stream in Gambler Gulch runs through dense willow thickets.

4.5 Fish and Wildlife Resources

The Highlander site is a good wintering site for moose. Signs indicating the presence of moose, fox and ptarmigan were observed during the assessment. Gambler Gulch is not suitable for fish due to the steepness of the stream.

4.6 Site Topography and Soils

The site is found on the south side of Gambler Gulch at 1430 metres above sea level. Gambler Gulch is on the north side of Keno Hill. Keno Hill is part of the Yukon plateau where hills are predominantly flat-topped and separated by broad, deep valleys. Keno Hill trends northeast and lies between Keno Ladue-McQuesten River valley and Allen, Faith, Lightning, and Christal Creeks. It is 16 km long by 9.5 km wide at the western end, tapering to the east, and is surmounted by five hillocks known as Keno, Minto, Monument (the highest point on Keno Hill, elevation 1849 metres), Caribou, and Beauvette. The northern slope of the hill is steep, but is broken by a series of benches. The southern slope is more gentle (GSC Bulletin 284, p.509).

It is dominated by well drained, coarse textured soils.

4.7 Permafrost

The Highlander site is in an area of discontinuous permafrost on a north facing slope. No surface indications of permafrost were observed during the site visit.

5.0 SITE DESCRIPTION AND FINDINGS

The Highlander mine site is shown in plan in Figure 3. Site features include a collapsed adit, two waste rock piles and a number of wood frame buildings located immediately adjacent to the stream in Gambler Gulch, and a second adit and waste rock complex located to the southwest on the hillside above the stream. These components are discussed below.

5.1 Buildings, Infrastructure, and Equipment

Camp

At present there are six (6) wooden buildings of varying size and condition on site. Photographs of the buildings are included in Appendix A, and building locations are shown in Figure 3. The buildings on the site are described below with the designation letter used in the site plan.

A: The main living quarters is a 9.5 x 6.5 metre wooden framed, clapboard structure with partially collapsed porches (Photos 1, 2, and 3). The building contains two wooden frame beds, various wooden shelves, large table, and the remnants of a wood burning stove. The floor, roof, and ceiling joists (2"x 6" construction on 2 foot centre) of the building are in fair to reasonable condition. The nearby outhouse has been overturned.

B: An empty 9.5 x 5.5 metre wooden framed, clapboard bunkhouse has a collapsed porch (Photos 1 and 2). The floor is in poor condition due to collapsed supports along the south wall. The roof and ceiling joists (2"x 6" construction on 2 foot centre) of the building are in fair to reasonable condition. The nearby outhouse has been overturned.

C: A three level, 6 x 7 metre wooden framed structure presumably was used for ore processing (Photos 1, 2, 3, and 4). It appears to have had a rail track running through the upper doors, cross the top section along an open frame work, and extending out onto the waste pile. The floors, roof, and ceiling joists of the building are in good to fair condition.

D: Two small wooden framed sheds (2.5 x 2.5 m) are located at the adit entrance. One is leaning and about to collapse (Photo 5), and the other has collapsed.

E: A small wooden shed (2 x 2 metre) in fair to poor condition, possibly used for explosives storage, is partially hidden by shrubs and trees to the west of the ore processing building.

Mine Workings

Remnants of a rail track are found outside of the adit beside the ore processing building. An ore car is located next to the track and has been tipped over onto its side.

5.2 Non-Hazardous Waste Material

No significant non-hazardous waste was observed on the site. There are minor amounts of debris in the cabins consisting of tin cans, bottles, etc.

TABLE 1
Non-Hazardous Waste Materials

Waste Material	Number / Volume	Location	Comments
metal scrap, bottles, food cans	< 0.5 m^3	scattered in and around cabins	non-burnable, rusted

5.3 Hazardous Materials

No hazardous materials were observed at the site.

5.4 Water Quality

To identify potential environmental impact on the surrounding surface water, samples were collected from upstream and one downstream of the site in the small creek flowing through the site, and from the water seeping from the mine workings.

Three samples were collected. Field measurements and a summary of the laboratory analysis are listed in Table 2. Analytical results are presented in Appendix B. Sample GA/WQ/Str004 was collected approximately 150 metres upstream of the drainage from the mine workings and waste rock pile in a small, fast flowing creek. Sample GA/WQ/Str005 was collected from the same small stream approximately 300 metres below the mine workings.

Groundwater was observed to be flowing out of the lower, collapsed adit at 1 L/sec (visual estimate). A sample, GA/WQ/S101, was collected (Figure 3) and submitted for chemical analysis. No seepage was observed from the upper adits or emanating from the waste rock piles.

The neutral pH, low sulphate and low acidity measured in the sample collected from the seepage from the lower adit (GA/WQ/S101) suggests that acid generation is not occurring in the collapsed underground workings. Metal concentrations in the adit discharge water were all below CCME criteria for protection of freshwater aquatic life.

TABLE 2
Surface Water Samples

Sample ID	Location	Flow L/sec	pH	Cond. μS/cm	Comments
GA/WQ/Str004	150 metres upstream of the seep from the adit	2	5.74	0	meets CCME criteria for freshwater aquatic life
GA/WQ/Str005	300 metres downstream of mine site	5	7.35	70	Al elevated above CCME freshwater aquatic life criteria
GA/WQ/S101	beside ore car at lower adit	1	7.83	160	meets CCME criteria for freshwater aquatic life

CCME = Canadian Council for the Ministers of the Environment
L/sec = litres per second
pH = field measurement
Cond. = Conductivity, field measurement

No significant increases over "background" concentrations are observed when upstream sample GA/WQ/Str004 is compare to downstream sample GA/WQ/Str005. Arsenic and magnesium levels are slightly higher in the downstream sample and zinc levels are lower in the downstream sample suggesting that, at the time the samples were collected, drainage from the Highlander site was having little impact on the water quality in Gambler Gulch. Metal concentrations in both the upstream and downstream samples generally fell within CCME guidelines, with the exception of aluminum.

5.5 Waste Rock Disposal Areas

There are three piles of mine rock on the site as shown in Figure 3: two piles on either side of the ore processing shack outside the lower adits and one pile outside the upper adits.

There is up to 10,000 tonnes in the lower waste rock piles. The piles appear to have been formed by end dumping from ore cars on tracks. The slope angle of the eastern pile is between 25° and 30°. The slope angle of the western pile is between 35° and 40°. No evidence of slumping or tension cracks were observed on either pile.

There is less than 5,000 tonnes in the upper waste rock pile. The rock is unsorted and the slopes appear to be stable.

Four samples were collected in the waste rock at the locations shown in Figure 3. Sample GA/WR/P204 was collected from the upper waste rock pile. Samples GA/WR/P205, GA/WR/P206 and GA/WR/P207 were collected from the waste rock at the lower adit, beside the ore processing building. 10% of the lower pile is covered with gabbroic rock.

Paste pH and conductivity values of the waste rock were measured in the field. The samples were submitted for ABA tests and determination of metals by ICP-AES. Results of the laboratory analyses are presented in Appendix C. The waste rock sample descriptions and the analytical results are summarized in Table 3.

All the samples collected had positive net neutralizing potentials and all but one sample had NP:AP ratios greater than 6, indicating that the samples are not potentially acid generating. The one exception was the sample collected from the upper rock pile which had an NP:AP ratio of 1.8, indicating that the material is potentially acid generating. The pile has been in place for at least 20 years (based on development history, surface vegetation, and the condition of adjacent adits) and is not currently acid generating (paste pH is neutral). There is little to no iron oxide staining on the surface. There is no staining visible at the base of the pile to indicate contaminated seepage or surface runoff. Nor were there any signs of adverse impact on the surrounding vegetation.

TABLE 3
Waste Rock Sample Descriptions and Select ABA and ICP Results

Sample ID	Location and Description	Comments
GA/WR/P204	Upper adit. Sample collected over a thickness of 20 cm from chlorite schist. Sand and gravel size material with fragments up to 10 cm x 1 cm.	The field paste pH was 6.1, paste conductivity 10 μS/cm, NP:AP ratio 1.8. High concentrations of silver.
GA/WR/P205	Lower adit, east side of ore processing building. Sample collected over a thickness of 35 cm homogenous dark grey coloured sand. 30% quartz crystals in the sand.	The field paste pH was 8.3, paste conductivity 90 μS/cm, NP:AP ratio 6.7. High concentrations of manganese.
GA/WR/P206	Lower adit, unmineralized gabbro. Angular fragments up to 10 cm x 6 cm in 60% green coloured sand.	The field paste pH was 9.0, paste conductivity 50 μS/cm, NP:AP ratio 25.6
GA/WR/P207	Lower adit, iron carbonate stained chlorite/graphite schist rock. 95% sand sized.	The field paste pH was 8.7, paste conductivity 80 μS/cm, NP:AP ratio 6.5

The sample from the upper waste rock pile (GA/WR/P204) contained relatively high metal concentrations of silver (>200 ppm), manganese (6730 ppm), and zinc (4545 ppm). Sample GA/WR/P205 also contained relatively high concentrations of manganese (>10,000 ppm). The high metal concentrations in the waste rock are not evident in the adjacent stream.

5.6 Mine Openings and Excavations

Mine workings are located in two areas at the Highlander site (Figure 3) The main workings are located at the southeast edge of the lower waste rock piles. The rail tracks, spring (seepage) and collapsed timber sets are the only evidence that an adit once existed here. Collapsed timber sets indicate that two, maybe three, adits or deep open-cuts existed at the upper waste rock pile. All adits are securely sealed.

The shaft reported in Boyle (1961) could not be located in the field. The shaft has either caved and overgrown, or is located on one of the adjacent claims.

5.7 Tailings

Ore handling on the site appears to have consisted of crushing to less than one inch inside the processing building. No milling of ore was done on the site; therefore, no tailings are present.

6.0 RISKS AND CONCERNS

6.1 Health and Safety Risks

The existing buildings are in various states of collapse and pose a health and safety hazard. Because the site is on a popular hiking trail and receives many visitors each year, the potential exposure to personal injury is high. Therefore, the risk associated with the buildings is considered high.

The adits are securely sealed and do not pose a health and safety hazard.

6.2 Environmental Risks

The amount of waste rock at the site is small and it does not appear to be adversely impacting the downstream environment. There is no evidence to indicate that acid generation is occurring in the underground workings or in the waste rock piles. Therefore, the chemical stability risk associated with the waste rock is considered low.

No physical stability concerns were identified.

6.3 Aesthetic Concerns

The site is an attraction for local tourism. The buildings and equipment are of historic interest and should be preserved to the extent possible while still meeting the objectives of safety and environmental protection.

The local Silver Trails Tourism Association has expressed concern that no additional buildings be demolished on Keno Hill without first consulting the local tourism association. Several mine buildings on Keno Hill are being promoted as attractions.

7.0 RECOMMENDATIONS

Prior to undertaking any additional work on the Highlander mine site it is recommended that the Silver Trails Tourism Association be contacted.

The following reclamation activities are recommended for the Highlander mine site:

- Demolishing five of the seven shacks, by incineration.
- Collecting all other wood debris at the camp and burning it (on site).
- Collecting metal and other non-wood debris and transporting to landfill (offsite).
- Refurbishing the main living quarters and the ore processing shed.

Five of the seven buildings should be demolished and burned as they are in various states of collapse. The remaining buildings require minor repairs to the roofs and floors to both preserve and make the buildings safe. If refurbished, these buildings will require periodic care and maintenance. However, the local residents and the tourism association show a keen interest in maintaining historic sites and artifacts, and would likely be willing to take responsibility of its long-term maintenance. The local tourism association may also be interested in organizing and carrying out the reclamation work.

Heavy equipment, such as the ore car and tracks, should be left on site for its historic value.

Additional investigations to assess chemical stability of the mine rock piles are not considered necessary.

8.0 REFERENCES

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This report, **P118401 - Phase II Environmental Assessment of the Highlander Abandoned Mine Site**, has been prepared by:

STEFFEN, ROBERTSON AND KIRSTEN (CANADA) INC.

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Geologist

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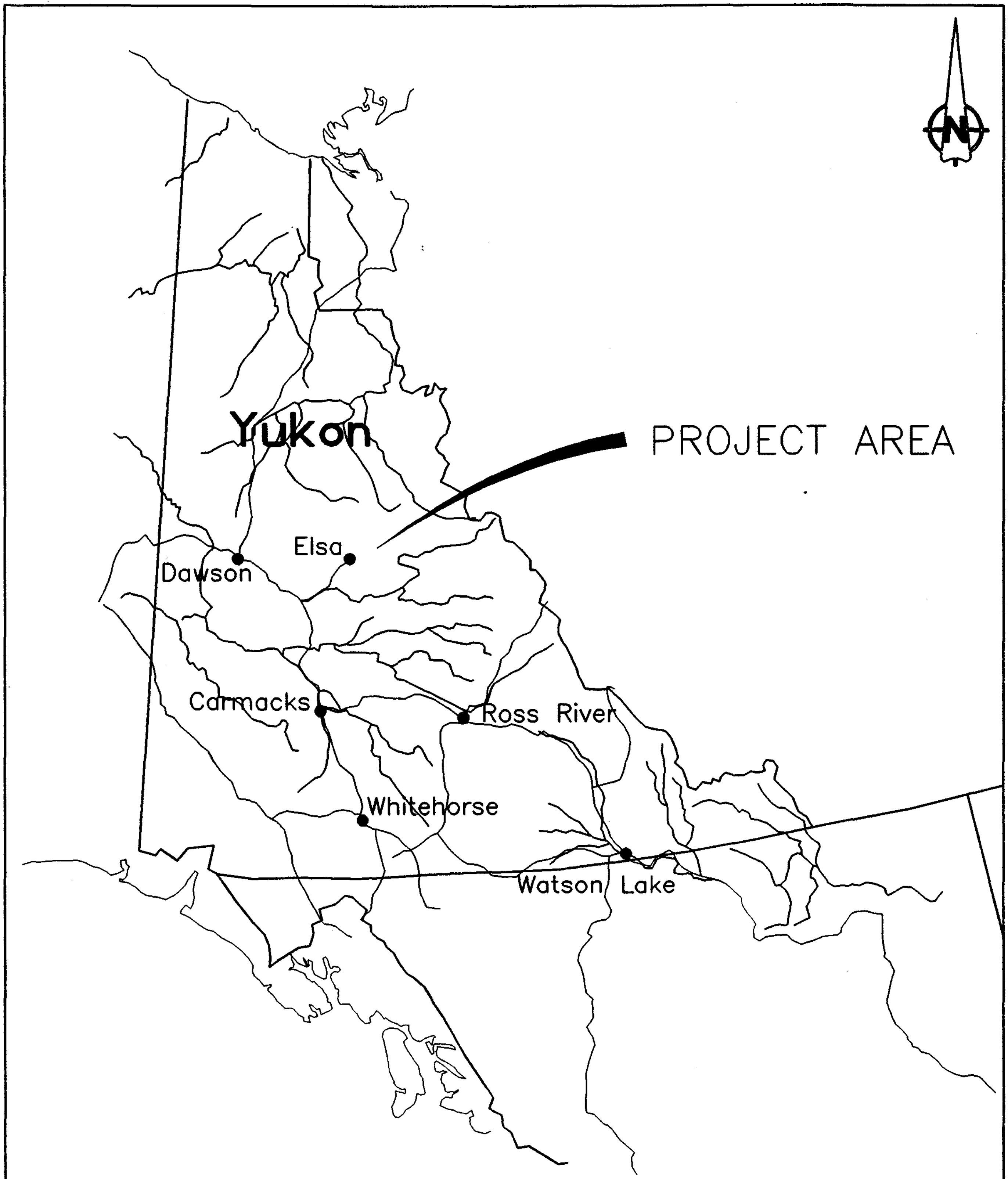
Michael Royle, M.App.Sci.
Hydrogeologist

Rod Olauson, P.Eng.
Senior Review

R-133/tg

FIGURES



NOT TO SCALE

STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers

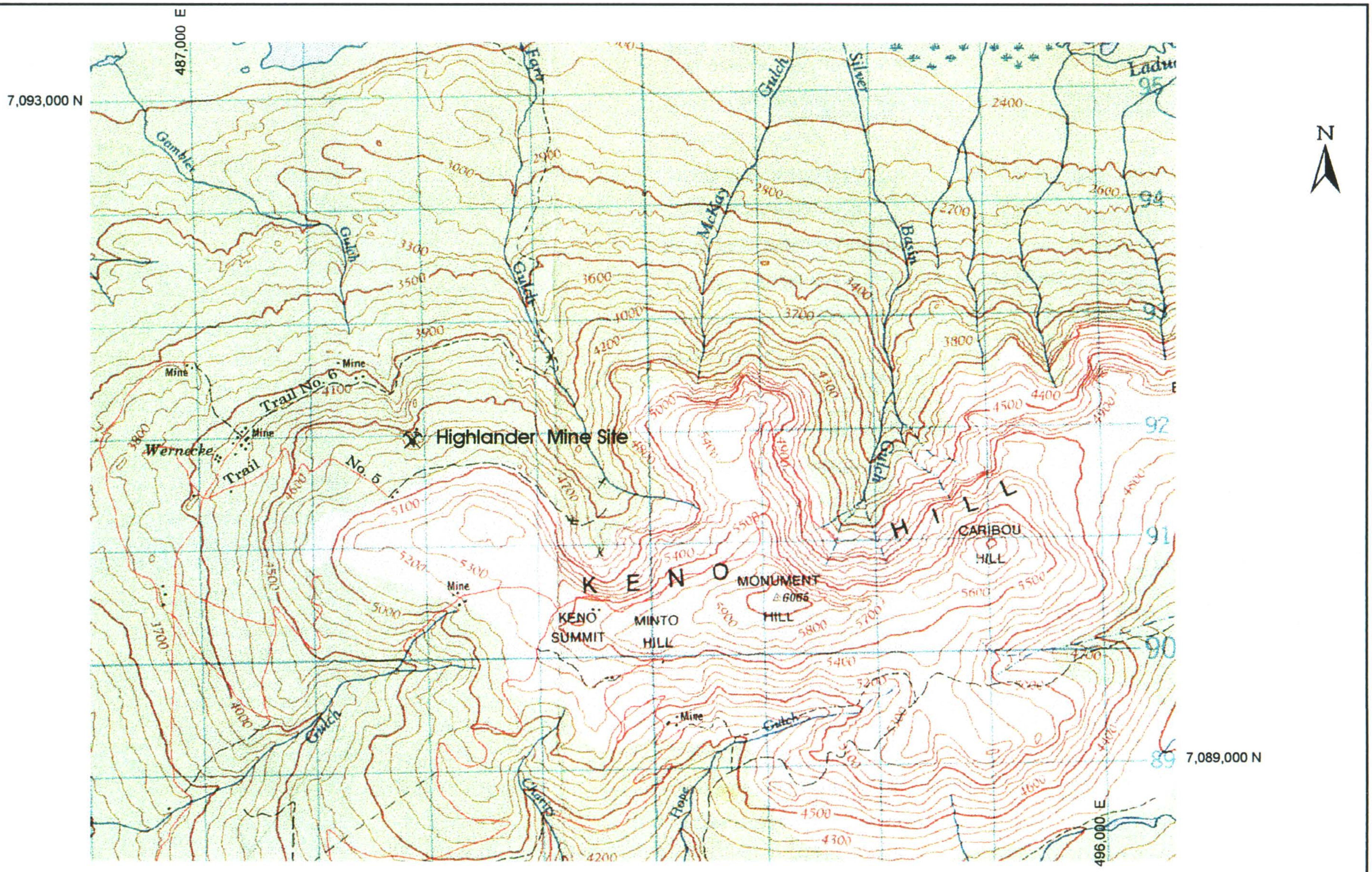
Public Works & Government
Services

Phase II Environmental Assessment

Vicinity Map

PROJECT NO.	DATE	APPROVED	FIGURE
P118401	Feb. 1997		1

NAME: C:\PROJECTS\EMPR\P118401\YUKON.DWG DATE: FEB 13, 1997 TIME: 4:58 AM



Scale: 1:50,000

Mapsheet: NTS 105M14

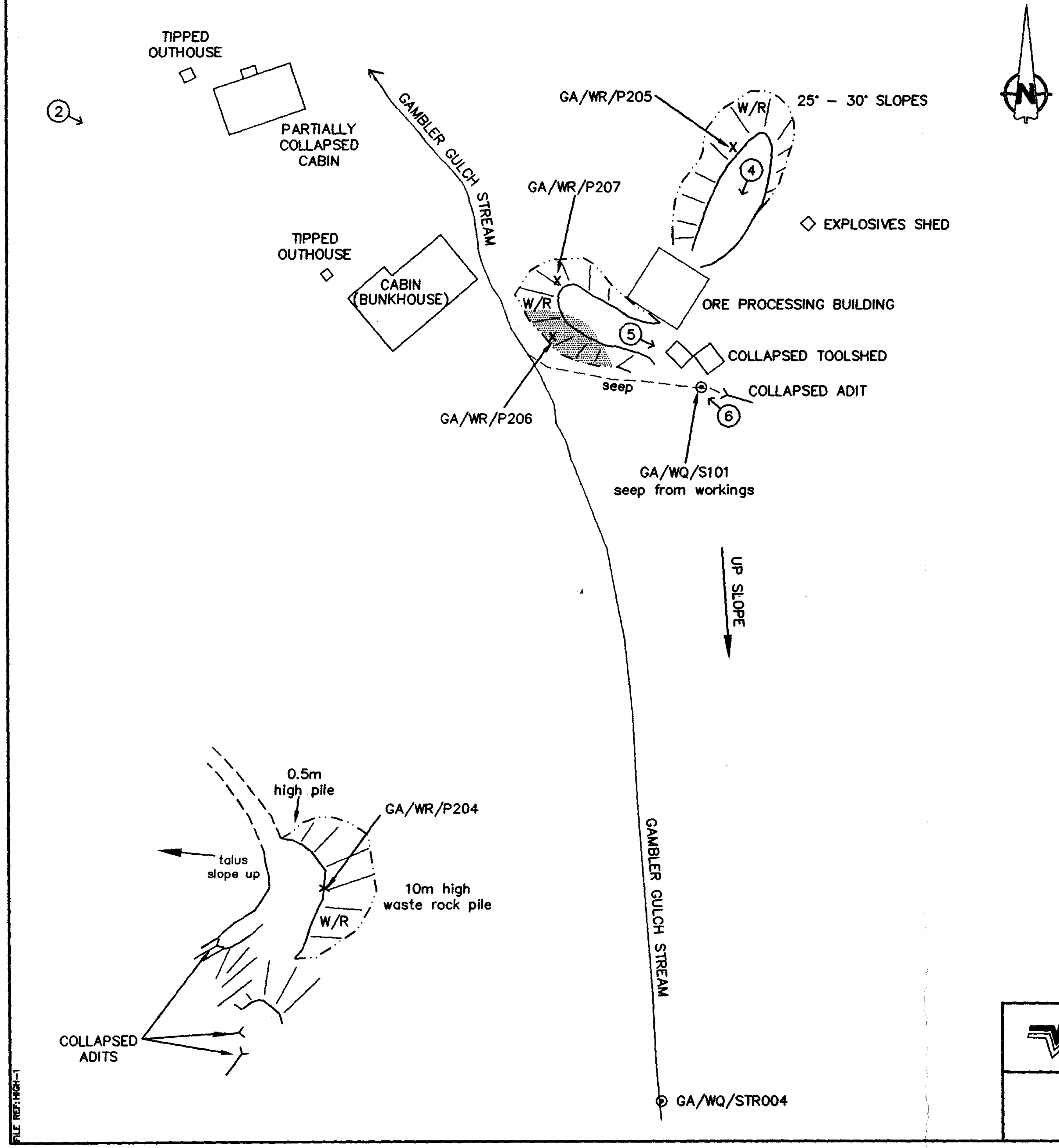
STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers

Public Works and
Government Services Canada

Phase II Environment Assessment

Highlander Mine Site Location Map

PROJECT NO.	DATE	APPROVED	FIGURE
P118401	Feb., 1997		2



LEGEND

W/R	WASTE ROCK
═══	ROAD
– – – – – –	ROAD (APPROXIMATE)
–··–··–··–	EXTENT OF WASTE ROCK
X GA/WR/P202	WASTE ROCK SAMPLE (SITE DESIGNATION)
⦿ GA/WQ/100	WATER QUALITY SAMPLE (SITE DESIGNATION)
⊓⊓⊓⊓	SLOPE DOWN
▨	GABBROIC WASTE ROCK
>——	ADIT
□	BUILDING OR FOUNDATION
①	PHOTOGRAPH NO. AND DIRECTION

NOTES :

1. LOCATIONS OF FEATURES SHOWN ON THIS PLAN WERE SURVEYED USING HIP CHAIN AND HAND-HELD COMPASS. ACTUAL LOCATIONS AND DIMENSIONS COULD DIFFER FROM THOSE SHOWN.
2. ALL BUILDINGS ARE WOOD FRAME CONSTRUCTION WITH TAR PAPER AND WOODEN CLAPBOARD SIDING.

0 10 20 30 40 50 metres
1:1000

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PUBLIC WORKS AND
GOVERNMENT SERVICES

PHASE II ENVIRONMENTAL ASSESSMENT

HIGHLANDER MINE
SITE PLAN

PROJECT NO.	DATE	APPROVED	FIGURE
P118401	FEB. 1997		3

APPENDIX A

PHOTOS

Photo 1: Highlander Mine Site, Gambler Gulch, Keno Hill. Faro - Gulch Trail No. 5 branches above site, looking southeast.

Photo 2: Cabins, tipped outhouse and ore processing building, looking east.

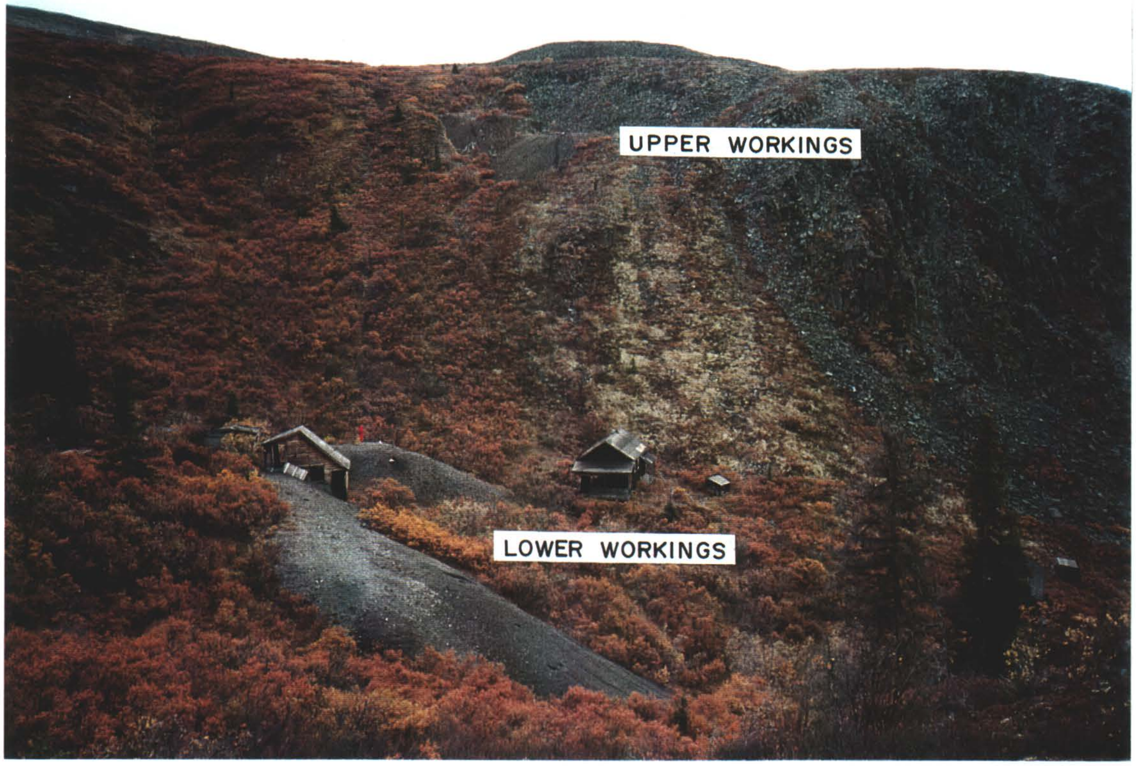

Photo 3: Highlander Mine Site, looking southwest towards Lucky Queen Mine Site.

Photo 4: Ore processing building, tool sheds behind trees, looking southwest.

Photo 5: Tool Shed beside lower adit, looking east

Photo 6: Ore car and rails in seep from lower adit, looking west

APPENDIX B

WATER QUALITY ANALYTICAL RESULTS

Water Quality Results - Highlander Site

Sample ID. Sample Date	GA/WQ/ Str004 18-Sep-96	GA/WQ/ Str005 18-Sep-96	GA/WQ/ S101 18-Sep-96	CCME Freshwater Aquatic Life
Physical Tests				
Conductivity (umhos/cm)	36	186	282	NA
Hardness (as $CaCO_3$)	13.1	85.3	135	NA
pH	6.52	7.53	7.79	6.5 - 9.0
Dissolved Anions				
Acidity (as $CaCO_3$)	6.1	1.0	1.0	NA
Alkalinity - Total (as $CaCO_3$)	7.1	49.4	94.4	NA
Sulphate (as SO_4)	8.3	42.4	52.2	NA
Total Metals				
Aluminum T-Al	0.008	**0.246**	0.044	0.005 to 0.1 *
Arsenic T-As	0.0001	0.0002	0.0018	0.05
Barium T-Ba	0.02	0.02	<0.01	NA
Beryllium T-Be	<0.005	<0.005	<0.005	NA
Boron T-B	<0.1	<0.1	<0.1	NA
Cadmium T-Cd	<0.0002	<0.0002	<0.0002	0.002 to 0.018 *
Calcium T-Ca	3.52	25.9	39	NA
Chromium T-Cr	<0.001	<0.001	<0.001	NA
Cobalt T-Co	<0.02	<0.02	<0.02	NA
Copper T-Cu	<0.001	<0.001	0.001	0.002 to 0.004 *
Iron T-Fe	<0.03	<0.03	0.15	0.3
Lead T-Pb	<0.001	<0.001	0.003	0.001 to 0.007
Lithium T-Li	<0.02	0.03	<0.02	NA
Magnesium T-Mg	1.06	4.97	9.12	NA
Manganese T-Mn	<0.005	<0.005	0.012	NA
Mercury T-Hg	<0.00005	<0.00005	<0.00005	0.0001
Molybdenum T-Mo	<0.03	<0.03	<0.03	NA
Nickel T-Ni	<0.02	<0.02	<0.02	0.025 to 0.150
Selenium T-Se	0.0006	0.0006	0.0008	0.001
Silver T-Ag	<0.0001	<0.0001	<0.0001	0.0001
Sodium T-NA	<2	<2	<2	NA
Vanadium T-V	<0.03	<0.03	<0.03	NA
Zinc T-Zn	0.009	<0.005	0.006	0.03

NOTES:
CCME = Canadian Council of Resource and Environmental Ministers
All concentrations are in mg/L unless stated otherwise.
0.004 = number in bold exceeds CCME criteria for parameter listed

str = stream sample
S = seep (groundwater) sample
A = adit sample

Aluminum: 0.005 mg/L if pH <6.5, Ca^{2+} <4.0 mg/L, and DOC <2.0 mg/L
0.1 mg/L if pH $\geq$6.5, Ca^{2+} $\geq$4.0 mg/L, and DOC $\geq$2.0 mg/L
Cadmium: 0.002 mg/L if hardness is 0 - 60 mg/L $CaCO_3$
0.008 mg/L if hardness is 60 - 120 mg/L $CaCO_3$
Chromium: 0.02 mg/L to protect fish and 0.002 mg/L to protect aquatic life, including zooplankton and phytoplankton.

Copper: 0.002 mg/L if hardness is 0 - 120 mg/L $CaCO_3$
0.003 mg/L if hardness is 120 - 180 mg/L $CaCO_3$
Lead: 0.001 mg/L if hardness is 0 - 60 mg/L $CaCO_3$
0.002 mg/L if hardness is 60 - 120 mg/L $CaCO_3$
0.004 mg/L if hardness is 120 - 180 mg/L $CaCO_3$
Nickel: 0.025 mg/L if hardness is 0 - 60 mg/L $CaCO_3$
0.065 mg/L if hardness is 60 - 120 mg/L $CaCO_3$

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CHEMICAL ANALYSIS REPORT

Date:	October 9, 1996
ASL File No.	G5281
Report On:	P118401 Water Analysis
Report To:	**Public Works & Gov't Services** Environmental Services 204-1166 Alberni Street Vancouver, BC V6E 3W5
Attention:	**Mr. Tim Sackmann**, Manager, Contaminated Sites
Received:	September 23, 1996

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

Heather A. Ross, B.Sc.
Project Chemist

Frederick Chen, B.Sc.
Supervisor, Trace Metals Lab

✓cc: Mr. Michael Royle -
SRK Vancouver

CANADA'S 50
BEST
MANAGED
PRIVATE
COMPANIES

ASL

RESULTS OF ANALYSIS - Water

File No. G5281

			GA/WQ/ Str001	GA/WQ/ Str002	GA/WQ/ Str003	GA/WQ/ Str004	GA/WQ/ Str005
			96 09 18	96 09 18	96 09 18	96 09 18	96 09 18
Physical Tests							
Conductivity (umhos/cm)			371	456	792	36.0	186
Hardness		CaCO3	166	228	396	13.1	85.3
pH			7.69	7.95	6.99	6.52	7.53
Dissolved Anions							
Acidity		CaCO3	2.0	2.0	7.1	6.1	1.0
Alkalinity - Total		CaCO3	42.5	73.2	12.7	7.1	49.4
Sulphate	SO4		131	143	403	8.3	42.4
Total Metals							
Aluminum	T-Al		0.111	0.337	0.138	0.008	0.246
Arsenic	T-As		0.0048	0.0009	0.0113	0.0001	0.0002
Barium	T-Ba		0.03	0.05	0.02	0.02	0.02
Beryllium	T-Be		<0.005	<0.005	<0.005	<0.005	<0.005
Boron	T-B		<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd		0.0040	<0.0002	0.0238	<0.0002	<0.0002
Calcium	T-Ca		46.5	70.9	88.6	3.52	25.9
Chromium	T-Cr		<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	T-Co		<0.02	<0.02	<0.02	<0.02	<0.02
Copper	T-Cu		0.003	<0.001	0.003	<0.001	<0.001
Iron	T-Fe		0.32	0.04	0.23	<0.03	<0.03
Lead	T-Pb		0.091	<0.001	0.074	<0.001	<0.001
Lithium	T-Li		<0.02	0.05	<0.02	<0.02	0.03
Magnesium	T-Mg		12.0	12.3	42.6	1.06	4.97
Manganese	T-Mn		0.142	<0.005	1.43	<0.005	<0.005
Mercury	T-Hg		<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02	0.03	<0.02	<0.02
Selenium	T-Se		0.0012	0.0014	0.0020	0.0006	0.0006
Silver	T-Ag		0.0005	<0.0001	0.0008	<0.0001	<0.0001
Sodium	T-Na		<2	<2	<2	<2	<2
Vanadium	T-V		<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn		0.350	0.008	3.58	0.009	<0.005

Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

File No. G5281

		GA/WQ/ S100	GA/WQ/ S101	CL/WQ/ A001
		96 09 18	96 09 18	96 09 18
Physical Tests				
Conductivity (umhos/cm)		79.2	282	317
Hardness	CaCO3	26.0	135	157
pH		6.99	7.79	8.08
Dissolved Anions				
Acidity	CaCO3	3.1	1.0	1.0
Alkalinity - Total	CaCO3	4.9	94.4	116
Sulphate	SO4	22.4	52.2	52.7
Total Metals				
Aluminum	T-Al	0.140	0.044	0.023
Arsenic	T-As	0.0738	0.0018	0.0002
Barium	T-Ba	<0.01	<0.01	0.01
Beryllium	T-Be	<0.005	<0.005	<0.005
Boron	T-B	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.0114	<0.0002	0.0024
Calcium	T-Ca	7.94	39.0	49.6
Chromium	T-Cr	<0.001	<0.001	<0.001
Cobalt	T-Co	<0.02	<0.02	<0.02
Copper	T-Cu	0.014	0.001	0.002
Iron	T-Fe	1.07	0.15	<0.03
Lead	T-Pb	0.805	0.003	0.004
Lithium	T-Li	<0.02	<0.02	<0.02
Magnesium	T-Mg	1.50	9.12	8.09
Manganese	T-Mn	0.275	0.012	0.011
Mercury	T-Hg	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.02	<0.02	<0.02
Selenium	T-Se	0.0006	0.0008	0.0006
Silver	T-Ag	0.0040	<0.0001	<0.0001
Sodium	T-Na	<2	<2	<2
Vanadium	T-V	<0.03	<0.03	<0.03
Zinc	T-Zn	1.05	0.006	0.319

Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).
< = Less than the detection limit indicated.

Appendix 1 - QUALITY CONTROL - Replicates

File No. G5281

Water			**GA/WQ/ Str003** 96 09 18	**GA/WQ/ Str003** QC # 73596
Physical Tests				
Conductivity (umhos/cm)			792	792
Hardness		CaCO3	396	407
pH			6.99	6.99
Dissolved Anions				
Acidity		CaCO3	7.1	6.1
Alkalinity - Total		CaCO3	12.7	12.5
Sulphate	SO4		403	411
Total Metals				
Aluminum	T-Al		0.138	0.136
Arsenic	T-As		0.0113	0.0113
Barium	T-Ba		0.02	0.02
Beryllium	T-Be		<0.005	<0.005
Boron	T-B		<0.1	<0.1
Cadmium	T-Cd		0.0238	0.0233
Calcium	T-Ca		88.6	91.0
Chromium	T-Cr		<0.001	<0.001
Cobalt	T-Co		<0.02	<0.02
Copper	T-Cu		0.003	0.003
Iron	T-Fe		0.23	0.24
Lead	T-Pb		0.074	0.073
Lithium	T-Li		<0.02	<0.02
Magnesium	T-Mg		42.6	43.5
Manganese	T-Mn		1.43	1.47
Mercury	T-Hg		<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03
Nickel	T-Ni		0.03	0.03
Selenium	T-Se		0.0020	0.0019
Silver	T-Ag		0.0008	0.0008
Sodium	T-Na		<2	<2
Vanadium	T-V		<0.03	<0.03
Zinc	T-Zn		3.58	3.67

Results are expressed as milligrams per litre except for pH and Conductivity (umhos/cm).
< = Less than the detection limit indicated.

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

Conventional Parameters in Water

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

Metals in Water

This analysis is carried out in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analysis by atomic absorption spectrophotometry (EPA Method 7000), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

End of Report

APPENDIX C

WASTE ROCK TEST RESULTS

Waste Rock Test Results

Parameter	Units	Sample Number GAWR/			
		P204	P205	P206	P207
Field Paste pH		6.12	8.33	8.96	8.66
Field Cond	µS/cm	10	90	50	80
Lab Paste pH		6.68	7.83	8.47	8.46
Total Sulfur	%	0.11	0.71	0.30	0.70
Sulfate	%	0.05	0.18	0.17	0.16
AP		1.9	16.6	4.1	16.9
NP		3.4	111.3	103.9	109.0
NET NP		1.6	94.7	99.8	92.1
NP/AP		1.8	6.7	25.6	6.5
Aluminum	%	0.70	0.70	1.70	0.90
Antimony	ppm	715	14	<1	7
Arsenic	ppm	<1	87	165	101
Barium	ppm	123	37	53	51
Beryllium	ppm	<0.1	<0.1	<0.1	<0.1
Bismuth	ppm	13	<1	<1	<1
Cadmium	ppm	39.7	<0.1	<0.1	<0.1
Calcium	%	0.24	2.99	3.69	3.62
Chromium	ppm	52	45	95	50
Cobalt	ppm	25	27	23	20
Copper	ppm	980	39	137	56
Gallium	ppm	<1	<1	<1	<1
Iron	%	3.13	6.66	3.56	3.93
Lead	ppm	572	633	398	122
Lithium	ppm	3	10	25	15
Magnesium	%	0.21	1.55	2.06	1.31
Manganese	ppm	6730	>10000	1816	3675
Molybdenum	ppm	13	21	11	14
Nickel	ppm	52	119	62	60
Potassium	%	0.11	0.11	0.06	0.11
Phosphate	ppm	970	570	350	950
Silver	ppm	>200	6.7	4.7	3.3
Sodium	%	<0.01	<0.01	<0.01	0.01
Strontium	ppm	14	12	20	31
Thorium	ppm	<1	<1	<1	<1
Tin	ppm	4	10	6	5
Titanium	%	<0.01	<0.01	<0.01	<0.01
Tungsten	ppm	12	<1	3	<1
Uranium	ppm	<1	<1	<1	<1
Vanadium	ppm	15.9	24.5	52.0	26.4
Zinc	ppm	4545	1465	1760	459

AP = Acid Potential in tonnes $CaCO_3$ equivalent per 100 tonnes of material
NP = Neutralization Potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material
Net NP = Net Neutralization Potential = tonnes $CaCO_3$ equivalent per 1000 tonnes of material
na = no assay / analysis
< = lower detection limit
> = upper detection limit

CLIENT : **ASL LTD.**
PROJECT : **PWGSC**
PROJECT # : **P118041**
TEST : **MODIFIED SOBEK METHOD ACID-BASE ACCOUNTING**

SAMPLE #	PASTE pH	S(T) %	S(SO4) %	AP	NP	NET NP	NP/AP
CL/WR/P201	8.79	0.20	0.05	4.7	36.5	31.8	7.8
CL/WR/P202	7.90	1.40	0.56	26.3	370.6	344.4	14.1
CL/WR/P203	9.39	0.09	0.05	1.3	4.9	3.7	4.0
GA/WR/P201	7.62	0.07	0.05	0.6	-1.6	-2.2	<0.1
GA/WR/P202	5.71	3.75	0.24	109.7	7.8	-101.9	<0.1
GA/WR/P203/1	5.74	1.37	0.28	34.1	9.1	-24.9	0.3
GA/WR/P203/2	4.30	1.11	0.17	29.4	2.0	-27.4	<0.1
GA/WR/P204	6.68	0.11	0.05	1.9	3.4	1.6	1.8
GA/WR/P205	7.83	0.71	0.18	16.6	111.3	94.7	6.7
GA/WR/P206	8.47	0.30	0.17	4.1	103.9	99.8	25.6
GA/WR/P207	8.46	0.70	0.16	16.9	109.0	92.1	6.5
TI/WR/P1-1	8.65	0.82	0.57	7.8	669.5	661.7	85.7

AP = ACID POTENTIAL IN TONNES CaCO3 EQUIVALENT PER 1000 TONNES OF MATERIAL.
NP = NEUTRALIZATION POTENTIAL IN TONNES CaCO3 EQUIVALENT PER 1000 TONNES OF MATERIAL.
NET NP = NET NEUTRALIZATION POTENTIAL = TONNES CaCO3 EQUIVALENT PER 1000 TONNES OF MATERIAL.

CLIENT : ASL LTD.
PROJECT : PWGSC
PROJECT # : P118041
TEST : HEAD ICP

		CL/WR/P201	CL/WR/P202	CL/WR/P203	GA/WR/P201	GA/WR/P202	GA/WR/P203/1	GA/WR/P203/2	GA/WR/P204	GA/WR/P205	GA/WR/P206	GA/WR/P207
Ag	ppm	0.2	52.9	0.1	2.7	>200.0	108.3	17.3	>200.0	6.7	4.7	3.3
Al	%	0.17	1.75	0.33	0.22	0.23	0.16	0.46	0.7	0.7	1.7	0.9
As	ppm	18	38	20	1357	905	1135	1836	1	87	165	101
Ba	ppm	31	36	14	60	36	39	45	123	37	53	51
Be	ppm	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Bi	ppm	1	1	1	1	8	1	1	13	1	1	1
Ca	%	1.49	>15.00	0.15	0.09	0.3	0.54	0.26	0.24	2.99	3.69	3.62
Cd	ppm	0.1	10.7	0.1	0.1	>100.0	33.9	27.6	39.7	0.1	0.1	0.1
Co	ppm	13	19	19	6	9	6	3	25	27	23	20
Cr	ppm	39	22	67	142	84	92	114	52	45	95	50
Cu	ppm	27	62	52	16	635	101	20	980	39	137	56
Fe	%	3.01	4.59	3.36	1.82	4.84	3.95	2	3.13	6.66	3.56	3.93
Ga	ppm	1	1	1	1	1	1	1	1	1	1	1
K	%	0.09	0.05	0.06	0.05	0.05	0.06	0.07	0.11	0.11	0.06	0.11
Li	ppm	24	2	53	2	1	1	1	3	10	25	15
Mg	%	0.9	0.95	1.02	0.04	0.19	0.1	0.04	0.21	1.55	2.06	1.31
Mn	ppm	1278	8135	1055	372	9792	4399	940	6730	>10000	1816	3675
Mo	ppm	10	15	11	6	21	11	6	13	21	11	14
Na	%	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ni	ppm	32	56	44	18	57	33	12	52	119	62	60
P	ppm	360	390	400	420	450	650	500	970	570	350	950
Pb	ppm	1	>10000	1	547	>10000	>10000	1142	572	633	398	122
Sb	ppm	4	125	6	9	614	127	28	715	14	1	7
Sn	ppm	4	8	4	2	8	5	2	4	10	6	5
Sr	ppm	27	595	19	17	14	13	11	14	12	20	31
Th	ppm	1	1	1	1	1	1	1	1	1	1	1
Ti	%	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
U	ppm	1	1	1	1	1	1	1	1	1	1	1
V	ppm	12.2	6.8	12.3	6.4	5.8	6.2	3.6	15.9	24.5	52	26.4
W	ppm	1	17	1	8	97	14	10	12	1	3	1
Zn	ppm	94	7922	119	214	>10000	5383	2088	4545	1465	1760	459

Engineering