Gartner Lee

MN-045

Ketza River Mine Site – Phase 1 Environmental Site Investigation

Prepared For:
Ross River Dena Council and
DIAND Contaminants/Waste Program

Prepared By:
Gartner Lee Limited
Mehling Environmental Management Inc.
BGC Engineering Inc.
Sheila C. Greer

GLL 99-914

March, 2001

Distribution

2 Ross River Dena Council
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Ross River Dena Council

ROSS RIVER, YUKON
Y0B 1S0

PHONE 969-2278

March 31, 2001

DIAND – Waste Management Program
Room 345-300 Main Street
Whitehorse, Y.T.
Y1A 2B5

Attn: Brett Hartshorne

Dear Mr. Hartshorne

Re: Ketza River Mine – Phase 1 Environmental Assessment Final Report

The Ross River Dena Council is pleased to provide DIAND ten copies of the Final Report on the Ketza River Mine Phase 1 Environmental Site Assessment. We would like to thank DIAND for involving the Ross River Dena in this important project. As you know, protecting the environmental quality of our Traditional Territory is a high priority for the Kaska people. We look forward to working with DIAND to address environmental issues at the Ketza River Mine and other sites in our Traditional Territory.

We have enjoyed working with you and the technical team on this project, and hope the report meets your current needs.

Mussi Cho,

Vera Sterriah

Vera Sterriah, Land Claims
Ross River Dena Council

.cc Chief & Council

Gartner
Lee
Limited

206 Lowe Street
Suite C
Whitehorse, Yukon
Y1A 1W6

Tel: (867) 633-6474
Fax: (867) 633-6321
www.gartnerlee.com

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March 31, 2001 99-914

Ross River Dena Council
Ross River Yukon
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Attn: Norman Sterriah

Dear Mr. Sterriah:

Re: Ketza River Mine Site – Phase 1 Environmental Site Investigation FINAL Report

The Gartner Lee project team is please provide our Final Report on the Ketza River Mine Phase 1 Environmental Site Investigation. I would like to thank you for your patience and cooperation on this complex project.

We have very much enjoyed working with Ross River Dena Council on this project, and hope that this report meets your current needs. If you have any questions, or wish to discuss the finding of this report, please do not hesitate to call me at (867) 633-6474 extension 23.

Mussi cho,
GARTNER LEE LIMITED

Forest Pearson,
Engineering Geologist, EIT

Executive Summary

Gartner Lee Limited was retained by the Ross River Dena Council and the Department of Indian and Northern Affairs (DIAND) Contaminants/Waste Program to conduct a Phase 1 Environmental Site Assessment (ESA) of the former Ketza River Mine. It was GLL's understanding that the ESA was ultimately intended to be utilized by DIAND as information relevant to the devolution of certain responsibilities from the Government of Canada to the Yukon Territorial Government.

The Ketza River Mine site is located in the Pelly Mountains, approximately 85 km south of Ross River, Yukon. The Ketza River Mine was an underground and open pit gold mine that was operated from March 1988 to November 1990. The mine is located on a Surface Lease (Number 105F09-0000-00001), titled under the *Territorial Lands Act.*

The overall objective of the Ketza River Mine environmental site investigation was to identify significant and potentially significant environmental liabilities. The specific objectives were:

- To determine and summarize historical and current activities which may have impacted the environment or might impact the environment in the future;
- To determine and summarize traditional use and heritage resources in the Ketza area and assess impacts related to mine activities;
- To provide the Ross River Dena members with training opportunities;
- To identify contaminant sources and discharge points;
- To define the significance of the potential contaminant sources;
- To summarize the information in a status report;
- To ensure that the community of Ross River was consulted with respect to this project and provided the results of the Phase 1 ESA.

To achieve the project objectives, the following activities were carried out:

a) Desk-top review of site specific background, historical and regulatory information.
b) Preliminary impact assessment on traditional land use and heritage/archaeological resources in the study area including consultation with the community of Ross River.
c) Interviews with DIAND personnel and former mine staff.
d) Site investigation conducted on September 24th, 1999; including buildings, site conditions, mining locations, tailings impoundment and other facilities with limited collection and analysis of grab samples of soil, water, and rock;
e) Documentation and reporting to provide an assessment of the environmental liabilities associated with land use activities at the Ketza River mine.
f) Workshop to present the environmental site assessment conclusions to the community of Ross River, held on April 18th, 2000.

A few issues were identified as a result of these activities, and they are as follows:

Traditional Land Use and Heritage Resources

1. The information offered in the interview sessions (Greer 2000) showed that:

   - The Ketza area features one of the highest concentrations of key land use features, such as the game licks, in the Pelly Mountains area that are known and used by the Ross River people.
   - Use of the Ketza area as a key hunting area, especially as a summer hunting area, is likely old; it predates the mine and the mine road and the 1940s.
   - Prior to mine development, the Ketza area was used by certain specific Ross River families, not by all members of the Ross River community. It would be desirable to confirm who these families were, i.e., what families had stewardship responsibilities over the Ketza area.
   - The available evidence (e.g., high concentration of key land use features such as the licks, known camping spot, cache location and sacred mountain) suggests that the Ketza area has a very, very high heritage site potential. There likely are both archaeological and historic period sites here that have not been documented. Some heritage sites may already have been destroyed or damaged by the mine development, however.

2. Based on the review of background information, it is apparent that little consideration was given to impacts on heritage resources or on traditional uses of the mine area prior to development. Consequently, base-line information on traditional use and heritage resources in the Ketza area before the mine was not assembled.

3. Both positive and negative comments about the effect of the Ketza mine development on their use of the area were received from the individuals interviewed. It must be noted that the data is general, not specific, and must be evaluated in light of the bigger context of socio-economic impacts that include other projects.

4. The impact of the mine development on the values of the Ross River people is important. The mine was built beside the sacred mountain known as *Dene Nezedi*. While specific information is lacking on just how this would have affected the community, the importance of this issue should be acknowledged.

5. Although no heritage sites are on record in the area, it cannot be stated that no sites were affected by the development simply because no effort has been made to document them in the area. The Pelly Mountains are not well known archaeologically. The traditional land use data assembled in the December 1999 interviews suggests that the Ketza area has a very, very high potential for heritage sites.

Human Health & Safety

1. The Ketza River mine site does not currently have an on-site caretaker and the front gate is not locked, which exposes the public to safety hazards on the mine site.

2. There are many hazardous and non-hazardous wastes and chemicals still on site, including sodium cyanide, acids and other reagents, which are not stored in a safe manner that minimizes hazards to the public.

3. The mill building is open and unlocked. The building is poorly lit and the second level contains many holes in the decking and areas without guardrails. The mill also contains numerous chemicals and milling equipment/tanks that may contain reagents. These issues constitute a series of human health and safety hazards in the mill building.

4. The 1430 and 1510 adits are poorly sealed. The seals do not adequately prevent public exposure to safety hazards in the underground mine.

5. The status of the 1550 backfill raise to the surface is unknown. If the raise is open and accessible, then it represents a public safety hazard.

6. The SO_2 tank was investigated by DIAND personnel in October 1999 and found to be generally empty of sulphur dioxide, although some residual fluid was observed in the bottom of the tank. The human health hazard would be reduced if the tank were ballasted with an inert material, such as sand.

Environmental

Soils Quality

1. Elevated arsenic concentrations above the CCME Industrial Guideline were found in all 22 samples collected on site. Geochemical surveys conducted for mineral exploration in this area have encountered arsenic concentrations ranging from 200 ppm to 5000 ppm. A Tier-3 site-specific guideline (as permitted by CCME Guidelines) for arsenic would be beneficial in interpreting arsenic concentrations in an appropriate context.

2. Several other metals exceeded the CCME Industrial Guideline including copper, nickel and zinc.

3. A large volume diesel spill occurred onsite in 1992. Mine operators estimated that approximately 14,000 L of diesel was not recovered and could have been retained in the soils. Two surficial soil samples collected from the spill area contained 1.5% and 3.26% light extractable petroleum hydrocarbons (LEPH), which were greater than the Yukon Contaminated Sites Regulations Industrial Standard (YCSR IL).

4. Other areas of hydrocarbon staining were observed around the site including:

    - 1510 AST (soil sample contained LEPH and HEPH concentrations > YCSR IL)
    - The Upper Boneyard (soil sample contained 1.24% HEPH, > YCSR IL)
    - Contractors' Quonset hut
    - Oil, grease and lubricant storage yard
    - Tank farm
    - Vehicle re-fuelling island
    - Vehicle parking area north of mill dry
    - South mill yard (outside of vehicle repair bays)
    - Camp generator & maintenance sheds
    - Waste oil storage area
    - Former re-fuelling/waste oil storage area near Peel Creek (interpreted, not visited during Phase 1 ESA)

5. Total sulphur (sulphate) concentrations greater that the YCSR IL were found in a sample collected from discoloured soils near the SO_2 tank.

6. A sample of tailings contained the following metals that exceed the YCSR IL:
    - Arsenic (37,300 ppm)
    - Copper (675 ppm)
    - Antimony (145 ppm)

Water Quality

1. Elevated total arsenic concentrations above the CCME Aquatic Life Guideline were found in all 10 surface water samples collected on site. Since arsenic concentrations in water samples have been elevated historically, a Tier-2 or Tier-3 site-specific guideline (as permitted by CCME Guidelines) for arsenic would be beneficial in interpreting arsenic concentrations in an appropriate context. The sample locations were restricted to the mine site and did not include the receiving water downstream of the mine site.

2. Copper concentrations in excess of the CCME Aquatic Life Guideline were detected in four water samples. The water sample collected from the vat leach sump contained elevated cyanide and lead concentrations. Two water samples collected from the Peel Creek drainage contained aluminum and zinc above the CCME Aquatic Life guideline; one of the samples also exceeded the YCSR Aquatic Life Standard. Four water samples from the mining area and the polishing pond contained cadmium concentrations that exceeded the CCME Guideline.

3. Cyanide concentrations were generally low and less than the CCME and YCSR IL Guidelines including samples of the tailings pond water and tailings dam seepage water.

4. Others have reported that ammonia in the tailings pond seepage remains slightly elevated (up to 1.5 mg/L), but displays a generally decreasing trend (YGC 1997). Receiving water quality at KR-8 has consistently met receiving water criteria (Brodie 1998).

5. Arsenic in the tailings pond water continues to remain in the 1 to 2 mg/L range and is not decreasing.

6. Arsenic in tailings dam seepage water has remained at lower levels than most other samples. SRK (1996) has postulated that adsorption of arsenic by the dam and foundation soils is minimizing mobilization into the receiving water. The adsorption mechanism may be effective for the reduction of arsenic concentrations in the tailings pond seepage but in the opinion of this project team, this mechanism can not be relied upon to prevent future problems from arsenic and metal leaching from other areas of the site.

7. SRK (1996) has suggested that the mobilization of arsenic to the receiving water could be reduced by minimizing the areal extent of the tailings pond such that seepage volumes are minimized. SRK (1996) also suggested that minimizing the areal extent of the tailings pond size might reduce the amount of arsenic released to the overlying pond such that less arsenic would be available for release to the receiving environment during discharge events.

Acid Rock Drainage

1. The limited rock characterization program performed for the Phase 1 ESA provides some general indications of ARD potential but additional sampling and assessment is required to appropriately and completely quantify the potential for continued ARD and/or metal leaching from the waste rock dumps and open pits.

2. The low pH and low neutralization potential of the Gully Zone sample suggests that acid generation is occurring the Gully Zone area.

3. Other grab samples contained relatively low sulphide content, and sufficient buffering capacity to be classified as acid consuming.

4. Soluble metal extraction tests indicated that three grab samples did not release substantial amounts of metals of environmental concern.

5. The various waste rock piles sampled displayed a wide range of metal and ARD characteristics, there are numerous discrete unsampled rockpiles on site, and the mill ore stockpile visibly contained discrete rock types.

6. Areas of greatest concern for release of acidic drainage or metal leaching are the mill ore stockpile and mine workings in vein deposits hosted in the Proterozoic phyllite and quartzite basal unit (Gully and QB area).

Geotechnical

1. A revised water balance assessment was conducted as part of this Phase 1 ESA in light of increased water levels in the tailings pond and increased ditch leakage due to observed ditch failures.

    - Based on this assessment, critical (overflow) water levels in the tailings pond could occur from 3 to 11 days after the onset of freshet in the spring of 2000 if the Lower Subsidiary Creek Ditch is blocked with ice causing flow into the tailings pond. The onset of freshet varies but typically occurs in late May and early June. Extreme events, such as rapid melting of the snow pack due to warm weather, could result in critical water levels in less than two days.
    - If the Lower Subsidiary Creek ditch is not blocked, water levels could reach the critical (overflow) elevation in September 2001 or July 2002, depending on ditch leakage and dam seepage rates.

2. Diversion ditches and culverts (Cache Creek, Lower Subsidiary Creek and the Northwest Interceptor Ditch) will require ongoing maintenance to prevent excess flows from entering the tailings impoundment. Specifically these maintenance issues include:

    - Piping failure of the Northwest Interceptor Ditch.
    - Slumping and blockage of the Northwest Interceptor Ditch.
    - Erosion evidence of overtopping (blockage) of the Lower Subsidiary Creek Diversion.
    - Partial blockage of the Lower Subsidiary culverts.
    - Slumping (due to permafrost degradation) of the Cache Creek Diversion.
    - Erosion of the friable bedrock underlying the Cache Creek drop structure.

3. There is insufficient equipment on site to provide the necessary ongoing maintenance.

4. The main access road requires ongoing maintenance, especially to allow heavy equipment to access the site for tailings impoundment maintenance.

5. Static stability of the dams does not appear to be an issue. Observations indicate that the dams are stable against slope failure and piping

6. The seismic stability of the North Dam has been reviewed by two competent consultants. One concluded that there is a stability issue while one concludes there is little concern. A detailed slope stability assessment with drilling is recommended by Brodie (1998) to determine if the stability is acceptable. However, a staged approach starting with a seismic assessment and a stability analysis using existing data would be beneficial to determine if drilling is required.

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1 Introduction

1.1 Overview of the Ketza River Mine

The Ketza River Mine is an underground and open-pit gold mine that is located in the Pelly Mountains of south-central Yukon Territory. The mine is located at 61° 32' 18" N and 132° 16' 10" W as illustrated on Figure 1. The closest community, Ross River, is approximately 85 km north by road.

The property was first explored in 1955 and 1956, with extensive drilling occurring in 1958-59. The key claims were surveyed and leased in 1974. Canamax Resources Inc. ("Canamax") acquired the property in 1984 through a joint-venture arrangement with Pacific Trans-Oceans. Canamax became 100% owner of the mine property in 1989. Ownership of the property was held by Wheaton River Minerals and, subsequently, Ketza River Holdings Ltd. (then a wholly owned subsidiary of Wheaton River Minerals) from 1992 to 1994. YGC Resources Ltd. ("YGC") purchased the property via purchase of Ketza River Holdings Ltd. and is the current owner of the property.

Canamax conducted extensive exploration work from 1984 to 1987 including the development of three exploration adits. Construction of the mill started in 1987 and production began in April 1988. Canamax operated the mine until September 1990 using both open pit and underground mining methods. Approximately 342,395 tonnes of ore were processed (DIAND 1996) using a conventional carbon-in-pulp ("CIP") process at a nominal rate of 364 tonnes per day to produce approximately 3.1 million grams of gold and approximately 342,000 tonnes of process tailings. The mine has not been operated since 1990.

Process tailings are contained in a surface impoundment behind two earth-fill water retaining dams as illustrated on Figure 2. During the period of mine operations, water was recycled from the tailings impoundment for use in ore processing. Excess water from the tailings impoundment was treated for removal of cyanide and heavy metals prior to release to the environment.

Mine facilities include the mill building and ancillary facilities, the camp complex and ancillary facilities, a former exploration camp and a tank farm that consists of four 90,000 gallon diesel fuel tanks plus one 20,000 litre (estimate) gasoline tank as illustrated on Figure 3. Some equipment was removed from the minesite in 1998 by the owner. This included primary components of the water treatment system, the grinding mills and primary components of the crushing system.

1.2 Regulatory Framework

Water Licence IN87-06L for the Ketza River Mine expired on December 31, 1998. There is currently no Water Licence in effect for the mine.
A Decommissioning Plan was filed with the Yukon Territory Water Board in 1994 per the requirements of the Water Licence. A CEAA screening report was subsequently issued by DIAND. An Addendum to the Decommissioning Plan was filed in 1996.

The mine property occupies mineral leases leased from the Government of Canada under the Yukon Quartz Mining Act. There are 62 full and fractural mineral leases held by Ketza River Holdings Ltd. The leases in the immediate area of the mine (approximately 25) are due to expire on December 14, 2009.

1.3 Overview of Environmental Site Assessment

Gartner Lee Limited (GLL) was retained by the Ross River Dena Council and the Department of Indian and Northern Affairs (DIAND) Contaminants/Waste Program to conduct a Phase 1 Environmental Site Assessment (ESA) of the Ketza River Mine. It was GLL's understanding that the ESA was ultimately intended to be utilized by DIAND as information relevant to the devolution of certain responsibilities from the Government of Canada to the Yukon Territorial Government (YTG).

The overall objective of the Ketza River Mine environmental site assessment was to identify significant and potentially significant environmental liabilities. The specific objectives were:

- To determine and summarize historical and current activities which may have impacted the environment or might impact the environment in the future;
- To determine and summarize traditional use and heritage resources in the Ketza area and assess impacts related to mine activities;
- To provide the Ross River Dena members with training opportunities;
- To identify contaminant sources and discharge points;
- To define the significance of the potential contaminant sources;
- To summarize the information in a status report;
- To ensure that the community of Ross River was consulted with respect to this project and, upon approval from INAC, provided the results of the Phase 1 ESA.

Site Name:	Ketza River
File Name:	FIG1.WOR

Gartner Lee Limited

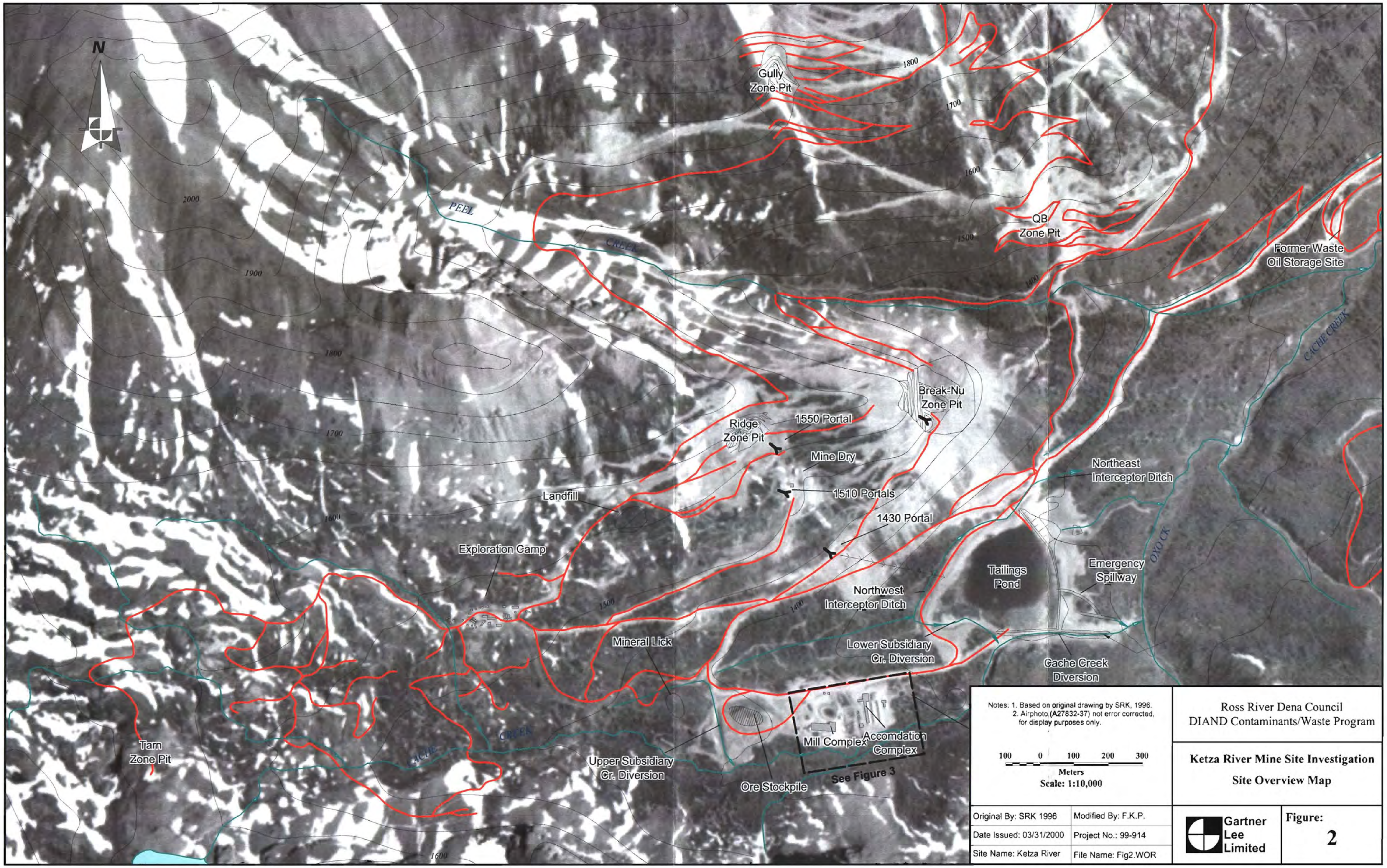
Scale: 1: 6,000,000

Ross River Dena Council
DIAND Contaminants/Waste Program

Ketza River Mine
Phase 1 Environmental Site Assessment
Project Location Map

Project No:	99-914
Date Issued:	March 2000

Figure 1



Notes: 1. Based on original drawing by SRK, 1996.
2. Airphoto (A27832-37) not error corrected, for display purposes only.

100 0 100 200 300
Meters
Scale: 1:10,000

Ross River Dena Council
DIAND Contaminants/Waste Program

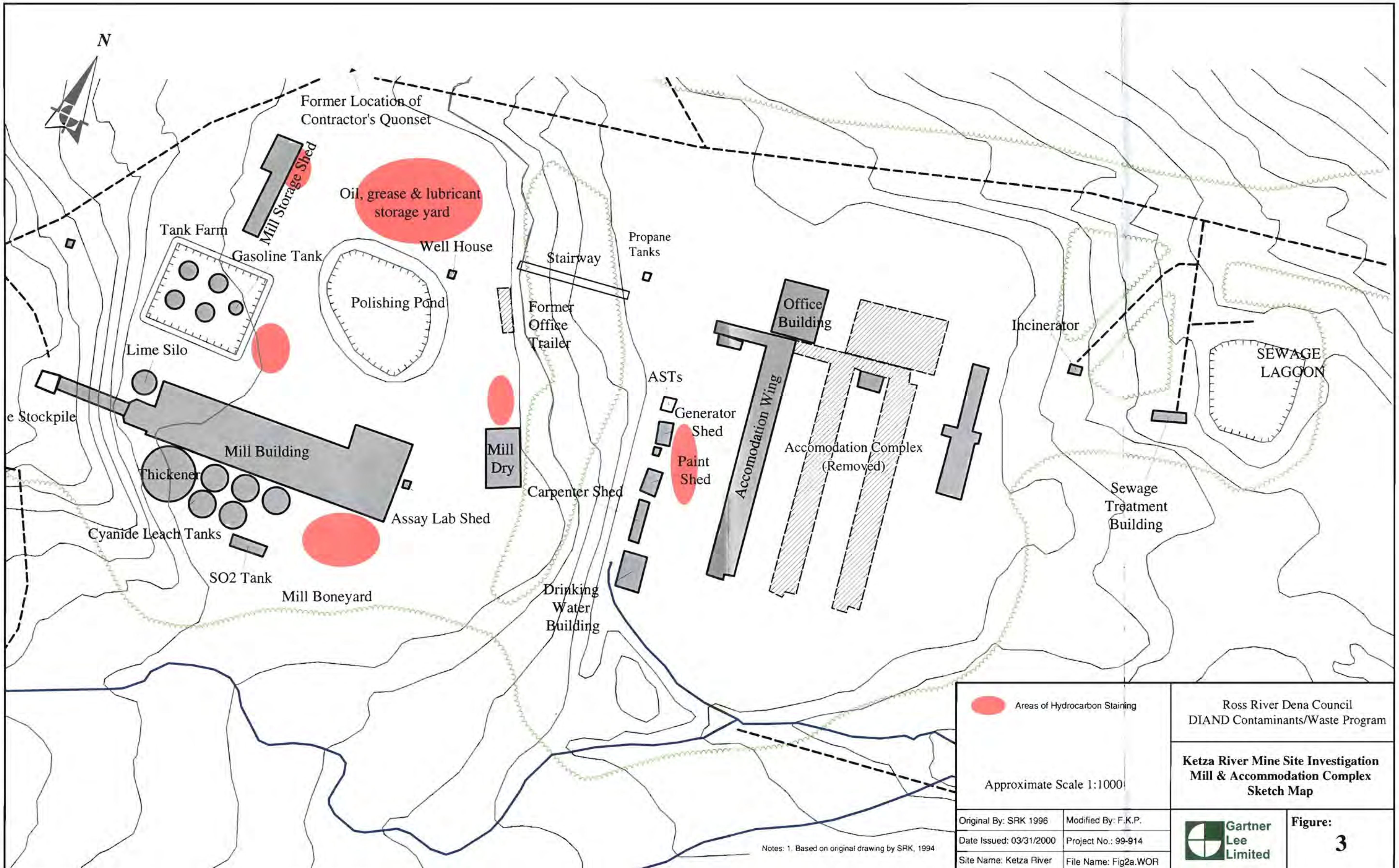
Ketza River Mine Site Investigation

Site Overview Map

Original By: SRK 1996	Modified By: F.K.P.
Date Issued: 03/31/2000	Project No.: 99-914
Site Name: Ketza River	File Name: Fig2.WOR

Gartner Lee Limited

Figure: 2



Ross River Dena Council
DIAND Contaminants/Waste Program

Ketza River Mine Site Investigation
Mill & Accommodation Complex
Sketch Map

Original By: SRK 1996	Modified By: F.K.P.
Date Issued: 03/31/2000	Project No.: 99-914
Site Name: Ketza River	File Name: Fig2a.WOR

Gartner Lee Limited

Figure: 3

1.4 Methodology

Federal and Territorial guidelines for decommissioning industrial properties prescribe a phased approach for the identification and management of contaminated sites (CCME 1991 and YTG 1996). The first phase of the environmental site assessment process consists of a review of all available information relating to historic and current mine site operations to identify areas of potential environmental concern.

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

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

Task 2: Preliminary impact assessment on traditional land use and heritage/archaeological resources in the study area including consultation with the community of Ross River.

Task 3: Interviews with DIAND personnel and former mine staff.

Task 4: Site investigation, including buildings, site conditions, mining locations, tailings impoundment and other facilities with overview sampling of soil, water, and rock.

Task 5: Documentation and reporting to provide an assessment of the environmental liabilities associated with land use activities at the Ketza River mine.

Task 6: Workshop to present the environmental site assessment conclusions to the community of Ross River.

1.5 Report Structure

This report summarizes the work completed, the results obtained and the conclusions reached during the Phase 1 Environmental Site Assessment of the Ketza River Mine:

- **Section 1** provides an overview introduction to the project.
- **Section 2** provides an assessment of traditional land uses and heritage/archeological resources in the Ketza River mine area.
- **Sections 3 and 4** describe the Environmental, Geological and Regulatory setting for the mine site.
- **Section 5** provides an overview description of the mine site, its layout, operating procedures.
- **Sections 6 and 7** document review findings and provide a summary of the site investigation.
- **Section 8** presents a summary of the soil, water and rock sampling conducted at the site.
- **Section 9** presents an updated water balance for the tailings pond.
- **Section 10** presents the conclusions from the project.

2 Traditional Land Use and Heritage Resources

There were two objectives for the assessment of traditional land use and heritage resources. The first objective was to assemble data on First Nations' traditional use of and heritage resources located in the Ketza mine area. The second objective was to consider how these have been or may have been impacted by the mine development and operation.

This assessment was led by Sheila Greer who was sub-contracted by Gartner Lee for this task.

2.1 Definitions

2.1.1 Study Area

For the purposes of this study, the geographic area of concern is defined as the Ketza River valley, upstream from the Campbell Highway. Thus, it includes the mine site area, as well as the road into the mine. It includes lands within the Pelly Mountains, or immediately adjacent to these mountains in the Pelly River basin.

In the Pelly Mountains, the Ketza valley is a relatively narrow, defined space, not more than a couple kilometers wide. The valley widens once it leaves the Pelly Mountains.

In all cases, the land use activities and features described below are located within a couple and less than 10 kilometers of the mine site or mine access road.

2.1.2 Traditional Use

Under CEAA and related legislation, traditional use is considered when reviewing the potential Socio-Economic impacts of a proposed development. Traditional use refers to First Nation's activities such as hunting, trapping, fishing, and gathering of plant resources.

Social activities such as gatherings, teaching of skills and cultural values, are also part of traditional use activities. This is an important consideration, as it is also now recognized that, for societies based on hunting, harvesting activities are not just the means to make a living; land use and animal harvesting are also critical elements of satisfaction and giving meaning to one's life (cf., Usher and Weinstein 1991).

Traditional use is most commonly established through the mapping of traditional use sites. Traditional use sites are geographically defined places, on land or water, where such activities take place, e.g., hunting locale, berry picking area, game lick, camping place. These sites may lack the physical evidence of human-made artifacts or structures, yet maintain cultural significance to a living community of people. Trails and travel routes would also be considered traditional use areas.

Traditional use sites are usually documented through oral, historical and archival sources. A summation of the various types of traditional use activities of the Ross River Dena and how these have changed during the past century of historic times can be found in Weinstein (1992:49-67).

2.1.3 Heritage Resources

The term heritage resource most often is used to refer to material remains that relate to human history. Of present concern are locale-specific resources, or sites; places where old things or structures are found. Natural landscape features, such as legend places and named places that are of historic or cultural significance can also be considered heritage resources even though they don't have material remains. This is because they have heritage value to a group, such as the First Nations who have traditionally lived in the area.

Archaeological sites are the most commonly recognized heritage resources in Yukon. They are an important part of the Yukon's human history record since, for the Territory's First Nations, they represent the material remains of their ancestor's way of life in precontact or prehistoric times.

Many historic sites, featuring buildings or structures, have also been documented in Yukon. The upper cut-off or most recent date for historic sites varies, but currently the Heritage Branch of the Yukon Government is using a date of ca. 1950. In contrast to archaeological sites, historic sites most often, but not always, consist of above ground remains or structures. There are, however, historic sites which are largely known through buried remains, just as there are prehistoric sites which include above ground structures such as caches and hunting blinds.

The Yukon Land Claim formally recognizes First Nations' interest in the region's archaeological and heritage sites. Under the terms of the Yukon Land Claim agreement, First Nations own all heritage sites on Settlement Lands and artifacts from sites that have a direct connection to their history.

In Yukon, a definition of Heritage Resources also potentially includes paleontological sites. There are no known paleontological find locales in the Ketza mine area.

2.2 Methodology

2.2.1 Literature Review

2.2.1.1 Traditional Use

No detailed studies of traditional First Nations' use of the Ketza valley area are known to exist. There may be some relevant data in the CYI Resource Atlas land use data assembled in the 1970s, but the text and map sheet for the Ketza area (105F) could not be traced for the present study.

Various anthropological studies related to the Ross River and Kaska people refer to traditional land use activities, especially hunting, in the Pelly Mountains (Honigmann 1981; Denniston 1966; R. McDonnell 1975). Such comments could be referring to the Ketza area. In recounting the land use activities of one Ross River family, for example, V. McDonnell (1997) refers to a gopher hunting camp at "the Ketza", as well as a fishing camp on the Ketza River. The specific location of either camp is not reported, nor is the time period it was used; though the gopher hunting camp would appear to be after the mine development. The fishing camp is thought to be located near the mouth of the Ketza River, i.e., outside the present study area.

There is also reference to use of the Ketza area in interviews conducted with Ross River Elders for the Cominco Kudz Ze Kayah mine development (Doris Bob interview with Tom Smith, in Rutherford 1995). A program of Ross River Dena land use documentation completed in the early 1980s (Dimitrov et al. 1984) noted Ketza as a hunting area both prior to and after the development of the Faro mine in the 1960s (maps reproduced in Weinstein 1992, Figures 13-19).

Aboriginal language toponyms, or place names, are another significant data source. Place names often encode historical information. They are also an important source of traditional land use data, as key land use and important resource locales are usually named (Andrews 1990, Cruikshank 1990, Greer 1990, Hanks and Winters 1983).

At present, thoroughly researched Kaska language toponymic data for the Ross River community is available for only 2 topographic map sheets, 105F Ross River and 105K Tay River (Kaska Tribal Council 1997, Moore 1999). A few select names in other parts of the Ross River traditional territory have also been studied (Moore 1994). Some place names data for the Ross River area, although not researched by a linguist, can also be found in Greer (1996, 1996a) and Gotthardt (1993).

In the sources available for consultation, the only published name that is relevant to the Ketza area is *Dene Nezedi Tuė*. This name, which roughly translates as 'person standing river' refers to the Ketza River. The river takes its name from a mountain that represents people who were turned to stone. The mountain from which the river is named is the one at the head of the river just behind the Ketza mine site (Kaska Tribal Council 1997).

Note that the Ketza name proper is not a Kaska language term. The river was so named by the Hudson Bay Company explorer Robert Campbell during his journey down the Pelly River in 1843, after his Iroquois/Metis traveling companion (Coutts 1980; see also Kaska Tribal Council 1997).

2.2.1.2 Registered Heritage Sites

Two databases were consulted, the CHIN (Canadian Heritage Inventory Network), maintained by the Canadian Museum of Civilization (copy at Yukon Heritage Branch as well), which is the register for archaeological sites, and the Yukon Historic Sites Inventory database, maintained by Yukon Heritage Branch.

There are no sites registered in either database for the Ketza area. The closest known archaeological sites are JkUa-1, JkUa-2 and JkUa-3[1] which are ca. 30 km north of the Ketza mine, near Hoole Canyon on the Pelly River. The closest sites in the Yukon Historic Sites Inventory database are ones located along the Pelly River near Blind Creek and Faro. There is no reason to believe any of the aforementioned sites would have been affected or impacted by the Ketza mine development or operation, either directly or indirectly.

A lack of registered sites does not mean that sites may not have been affected by the Ketza development, as no site inventory and assessment work was completed prior to the mine. This issue is considered further below.

2.2.2 New Data Collection

Given the lack of data on either heritage sites or traditional use in the Ketza area, further data collection was recognized as necessary. Accordingly, a series of interviews were held with selected Elders or adult members of the Ross River Dene Council in the community of Ross River in December of 1999.

Field research in the Ketza mine area to document traditional use sites and heritage sites would have been desirable, but was not possible given the winter project season.

The purpose of the interview sessions was to assemble data on First Nation's traditional use in the Ketza area, both prior to, and after mine development, if possible. A second reason for assembling traditional land use data was to use this information to gain insight into the heritage site potential of the Ketza area. Past heritage studies have shown the close link or correspondence between traditional First Nations land use sites and heritage site locations in the Yukon (Gotthardt 1993; Greer 1997).

Staff of the Ross River Dene Council Land Claims office suggested individuals that would be appropriate to interview. Sessions were held, over a three day period, with Robertson Dick, Charlie Dick, Grady Sterriah, Betty Souza, Doris Bob, Doris Etzel, Gracie Tom, Tootsie Charlie, Mary Charlie, Robert Etzel, Frank Shorty and Margaret Shorty.

Greg McLeod and Alex Shorty, who were assisting the project team with other aspects of the Ketza River Mine Phase 1 ESA, arranged the interviews. Greg and Alex also sat in on most of the interview sessions. The interviews took place in the RRDC Land Claims office. Topographic and computer generated maps

[1] Archaeological sites are referred to by their respective Borden number, e.g., JkUa-1, following the standardized system of site registration used in Canada, which assigns letter codes to sites based on their geographic location (latitude and longitude).

were used as research aids and for documenting locational information. Most but not all interview sessions were tape recorded; notes were taken for those not recorded.

An open-ended format was employed in the interview sessions. The Elders were asked to discuss their use of and their knowledge of important resources in the Ketza area. They were also asked about their knowledge of heritage sites in the region, such as hunting blinds, hunting fences, graves, campsites, and caches. Considerable information was offered on land use and heritage sites in other parts of the traditional territory as well. Information on traditional use and heritage sites in the Faro mine area was documented during these same sessions.

Most interview sessions lasted somewhere between one and three hours; the longest sessions were with Grady Sterriah and Charlie Dick.

A rough, not verbatim, transcript of the interview sessions and notes taken has been prepared (Greer 2000). This set of notes includes latitude and longitude co-ordinates for the spatial data provided.

2.3 Traditional Use Data

2.3.1 Description

The interview sessions showed that Ketza was and is an important land use area within the Pelly Mountains. Elder Charlie Dick provided a summary of the pattern of traditional use of the Ketza area.

> *They go up there to hunt, for dry meat, in summer. Old People go up there all the time. Cache in there. They set gopher snare all over that mountain. Cut willows, for setting snare...People live, make gopher blanket. Hunt sheep up there too. Make blanket of sheep...*
>
> *Ketza, that's an Indian trail, right from here, it goes up the right side. There's a cache up there, 10-12 miles up. They store dry meat. They go up other side, place where I see spring pole for gopher....A lot of people go up there from down here, after they dry fish. Last part of July, everything gets fat. Five-six families go. Women's do hides, snaring gophers. Men hunting moose and caribou. After they get 5-6, they move camp. They use that Ketza before mine....* (Charlie Dick, with Sheila Greer, December 1/99)

The time period being referred to in the foregoing description isn't certain, but is before the mine. Moreover, it is known that Kaska families still walked from the Pelly River up into the head of the Ketza basin for these summer hunting trips after the Canol Road and Campbell Highways were built.

Charlie Dick added that sometimes people would go into the Pelly Mountains in winter too, to get caribou. It all depended on snow conditions; if snow wasn't deep in the mountains, the caribou would still be up there, and people would go there to get them. Caribou are also found in the area in summer too.

Charlie Dick added that his family wasn't one of the ones that went up to the Ketza; they went east, towards McPherson Lake.

Other general comments on the use of the Ketza area are as follows:

- Everyone interviewed knew that the mountain above the mine site area, *Dene Nezedi* is special, to be treated with respect. They all knew that this was an old, old name. This mountain represents a man and his dog that were turned to stone after he broke a cultural rule (taboo). It is considered sacred. There are lots of mountains in the traditional territory of the Ross River people, and many of these mountains are named, but only a very few mountains, such as *Dene Nezedi*, are considered special like this.
- For many years, families traveled up the Ketza valley, for summer hunting camps. People walked, traveled with dog packs. Quite a few families went there; names mentioned include Gordon Peter, John Acklack, Peter Acklack, and all the Shorty's.
- Gopher, groundhog, sheep, and moose hunting as well as berry picking all took place in the Ketza valley. Family has been going up there for a long, long time. The lick on the other side [McNeil drainage] is named for my grandfather.
- The northeastern face of the Pelly Mountains (St. Cyr Range), overlooking the Pelly valley between the Ketza and Lapie valleys is known as a good place to get sheep. This would be the mountain area on the right side as you head up the Ketza mine road, but before you enter the narrow Ketza valley.
- Important groundhog and sheep hunting area, right around where the mine is. A good place to get bear is the area between the upper Ketza valley and the head of Star Creek. The Shorty family knows that area well.
- The mountains immediately around the mine site area around *Dene Nezedi* is known as a good place for moose, sheep and caribou.
- Various trails in the Ketza area were mentioned. The road route to the mine more or less follows the traditional foot trail that has been long in use by the Ross River Dena to access this important hunting area from the Pelly River. A trail from *Dene Nezedi* at the head of the Ketza valley, over to Beautiful Mountain, was also mentioned, as was the route from *Dene Nezedi* over to the head of McNeil Creek.

Besides these general characterizations, several of the people interviewed reported a number of quite specific land use features that were and are key to their land use activities in the Ketza area.

The easiest way to report these features is by listing their order as one heads south, up the mine access road from the Campbell Highway. All features are within two kilometres of the mine or access road:

- Trail; the road route up the Ketza valley more or less follows the traditional foot trail to this important hunting area and *Dene Nezedi*. The trail goes up the right side of the Ketza River.
- Moose lick, known as Frank Elḗs (elḗs = lick in Kaska), on the west side of the Ketza River and mine access road, before you enter the Pelly Mountains.
- Moose Lick, known as Tommy Elḗs, or Old Tommy Elḗs, on the east side of the Ketza River and mine access road, before you enter the Pelly Mountains.
- Sheep crossing (where sheep cross the Ketza valley and since the mine, the Ketza road), and First Sheep Lick on right/west side of Ketza valley within the mountains.
- Berry Picking Area, on the left/east side of the Ketza River and mine access road within the mountains, across from First Sheep Lick.
- Sheep crossing (where sheep cross the Ketza valley and since the mine, the Ketza road), and Second Sheep Lick on right/west side of Ketza valley within the mountains.
- Berry Picking Area, on the left/east side of the Ketza River and mine access road within the mountains, across from Second Sheep Lick.
- Camping Area, around Cache Creek (also known as Little Cache Creek), just below *Dene Nezedi* in the upper Ketza valley, just west of the airstrip and mine area.
- Cache location, around Cache Creek (also known as Little Cache Creek), just below *Dene Nezedi* in the upper Ketza valley, just west of the airstrip and mine area. [not sure if cache or caches are still standing]
- Groundhog hunting area, high country above Cache Creek, immediately south of mine area, and just to south of *Dene Nezedi*.
- Third Sheep Lick, on the south side of the valley, around Cache Creek (also known as Little Cache Creek), just below *Dene Nezedi* in the upper Ketza valley, just west of the airstrip and mine area. Large rams were commonly seen at this lick, prior to the mine
- *Dene Nezedi*, the mountain above the mine; the mountain's Kaska name translates roughly as "person standing". This is a sacred mountain.

Just over the divide from the mine site area, into the headwaters of the McNeil River, is another Moose Lick, known as Shorty Elḗs or Old Shorty Elḗs. A cache, for storing dry meat is located by this moose lick.

2.3.2 Summary

Critical land use data was assembled during the December 1999 interview sessions. Moreover, because the interviews were open ended, information was assembled both on the Ketza area, as well as other parts of the traditional territory. This broader data set helps us to see the significance of the Ketza area, compared to other locales in the Pelly Mountains. The information offered in the interview sessions (Greer 2000) showed that:

1. The Ketza area features one of the highest concentrations of key land use features, such as the game licks, in the Pelly Mountains area that are known and used by the Ross River people.
2. Use of the Ketza area as a key hunting area, especially as a summer hunting area, is likely old; it predates the mine and the mine road and the 1940s.
3. Prior to mine development, the Ketza area was used by certain specific Ross River families, not by all members of the Ross River community. It would be desirable to confirm who these families were, i.e., what families had stewardship responsibilities over the Ketza area.
4. The available evidence (e.g., high concentration of key land use features such as the licks, known camping spot, cache location and sacred mountain) suggests that the Ketza area has a very, very high heritage site potential. There likely are both archaeological and historic period sites here that have not been documented. Some heritage sites may already have been destroyed or damaged by the mine development, however.

2.4 Post Impact Assessment

Based on the review of background information, it is apparent that little consideration was given to impacts on heritage resources or on traditional uses of the mine area prior to development. Consequently, base-line information on traditional use and heritage resources in the Ketza area before the mine was not assembled.

The absence of pre-development comparative data has made it difficult to consider how mine development and operation affected First Nations' traditional use and heritage resources. As a result, only the most general of information on the impact of the mine can be offered. This assessment, therefore, can best be described as a initial examination of how traditional use and heritage resources in the Ketza area have been affected by the mine, rather than a full retrospective impact assessment.

2.4.1 Traditional Use

Both positive and negative comments about the effect of the Ketza mine development on their use of the area were received from the individuals interviewed. It must be noted that the data is general, not specific, and must be evaluated in light of the bigger picture of socio-economic impacts as mentioned above.

Although Ross River families have continued to go up the Ketza to hunt and collect berries since the development, it is impossible to gauge whether use of the Ketza area has increased, or decreased.

The road to the mine made the area more accessible, and as a result, Ross River families or individuals that traditionally did not go up to the Ketza area, now did so occasionally. Other non-Kaska people now also began using the area. Use by other Ross River families would mean that food and resources from

Ketza could still be shared within the Ross River Dena community. Use by other non-Kaska people means it isn't.

It seems that with the mine development, the few families that traditionally used Ketza essentially lost their apparently exclusive rights of use of what is said to be a very productive hunting area. Further research is needed to confirm if their use was indeed exclusive, and what the consequences of this loss was. It is not known if the families that traditionally relied on the Ketza shifted to other areas. That is, if these families shifted or were bumped to other areas, as was the case with the Faro mine development (cf., Weinstein 1992). Further interview work would be needed to establish if this were the case. If this did happen, then families in other areas would have similarly been negatively affected.

How the families that have traditionally used the Ketza area have done so since the mine was developed, has definitely been altered. For example, the road and the mine disturbance has meant that trips to Ketza are now commonly done as day excursions, instead of as extended family hunting trips. Thus among other things, opportunities for teaching traditional skills, and enjoying their time out on the land, have been greatly reduced.

Perception of the quality of the environment in the Ketza area has also been affected by the mine development. Individuals expressed concern over the purity of the water, and of plants and animals from the Ketza area.

Some quite specific changes in use were mentioned by members of one of the families who had used to Ketza area prior to the mine. These include:

- The traditionally used camping site in the Cache Creek area of the upper Ketza area has been disturbed by the mine development, and is not used much, if at all.
- It was noted that although sheep are still seen at the First and Second Licks in the lower part of the Ketza valley within the mountains, since the mine development, sheep no longer frequent the Third Lick, in the upper valley, below *Dene Nezedi*.
- There is concern that animals were affected by all the noise and other disturbance that occurred with mine development.
- There is concern over toxic chemicals having been released in the Ketza valley as a result of the mine. Therefore animals relying on these waters may be negatively affected. People also wondered if the berries from up there would be safe to eat.

The impact of the mine development on the values of the Ross River people must also be mentioned. The mine was built beside the sacred mountain known as *Dene Nezedi*. While specific information is lacking on just how this would have affected the community, the importance of this issue should be acknowledged.

In summary, it is not unreasonable to assume that all Ross River Dena were in some way affected by the Ketza development. The land use patterns of those families that were key users and stewards of the area prior to the mine are known to have been significantly altered. Although the information on hand is limited, and must therefore be qualified, it suggests that more than just meat has been lost by the Ross River people, with the Ketza development.

In conclusion, even small scale mining developments such as Ketza can have significant impact on certain individuals and families. These effects need to be seriously considered and , in this case, further studies may be warranted.

2.4.2 Heritage Resources

Although no sites are on record in the area, it cannot be stated that no sites were affected by the development simply because no effort has been made to document them in the area. The Pelly Mountains are not well known archaeologically.

As noted above, the traditional land use data assembled in the December 1999 interviews suggests that the Ketza area has a very, very high potential for heritage sites.

Unfortunately, some of these potential sites may have already been destroyed. Heritage sites, whether archaeological sites or historic camps, are most often situated in valley bottom situations. This is where mine support features such as the airstrip and the access road are located. Gravel extraction for building such features is known to be one of the worst culprits for destroying heritage sites. Thus, it is highly likely that heritage sites in the Ketza area have been negatively affected by the mine development.

Given that the Ketza area was not checked for sites prior to development, it would be beneficial for a post-development heritage impact assessment to be undertaken, to document existing sites before they suffer further damage through such things as artifact collecting and erosion.

2.4.3 Other Impacts

The Ketza mine development and operation most likely would have had other social and economic impacts besides the impacts on traditional use of the Ross River First Nations community. Various reports have discussed the broader socio-economic impacts of the Faro mine development, for example, on the Ross River Indian community (Dimitrov, Weinstein, Usher, Ross River Indian Band 1984; Miller, 1972; Reid, Crowther and Partners 1983; Sharp 1977; Weinstein 1992). They include such things as increased rates of alcoholism, violence, sexual exploitation, premature deaths, and the transformation of their community. Readers should note that older socio-economic impact assessment studies e.g., Reid, Crowther and Partners 1983, did not consider hunting, fishing and gathering as economic activities, as production was not geared to a market.

No comparable studies have been completed for the Ketza development. As it was of a much smaller scale than Faro, it is likely that these broader issues are of less concern for Ketza.

The cumulative socio-economic impact of various mine developments on the Ross River Dena is also acknowledged, but not addressed here.

3 Environmental and Geological Setting

3.1 Environmental Setting

3.1.1 General

The Ketza River Mine is located within the discontinuous permafrost sub-zone of the Pelly Mountain Ecoregion. Zones of permafrost are known to be present in the mine area. The site is located at the treeline in a transition zone from stunted black spruce and alpine fir to birch, willow and sphagnum moss. Upper slopes are barren or support very sparse vegetation in the form of low shrubs, willow and lichen (Wheaton River Minerals 1993).

Mean annual precipitation from 1985 to 1995 as measured on site ranged from 718 to 728 mm per year (SRK 1996).

The mine site is located in the Cache Creek valley. The creek flows eastward and drains into Ketza River. The Cache Creek valley dips moderately eastward at slopes ranging from about 7% to 16%. The adjacent valley walls are steeper with slopes ranging from 30% to 80%.

The valley bottom consists primarily of limestone bedrock overlain by shallow deposits of compacted glacial till, which is in turn covered by a thin layer of relatively permeable outwash materials. The lower valley walls are commonly tills deposited as lateral moraines mixed with talus and colluvium. Upper slopes and mountain ridges are predominantly scree or rock outcrop (Canamax 1990).

The mine area has been identified as year-round sheep habitat that is utilized by thin-horn (Stone and Fannin) sheep. Wildlife habitat areas as identified in a 1999 study (Yukon Key Wildlife Habitat Inventory) are highlighted in Figure 4. Caribou and moose also utilize the mine area.

The 49 km long Ketza River road connects the mine to the Robert Campbell Highway. The road passes through a documented active sheep habitat area. A study of the short-term effects of road and mine activities on sheep was conducted by YTG between 1986 and 1988. This study compared sheep population demographics in the Ketza River Mine area to a population of sheep in a similar area, adjacent to the Ketza River area and within the Pelly Mountain Ecoregion (Barichello et al. 1989). This study found no negative effects on the sheep in the vicinity of the Ketza River Mine during mine development.

YTG Renewable Resources and the Department of Fisheries and Oceans (DFO) performed an assessment of the fishery resources of Cache Creek in 1991. The study was designed and implemented with the participation of the Ross River Dena Council. The study found Slimy Sculpin, Round Whitefish and Arctic Grayling utilized Cache Creek as far upstream as the confluence of Oxo Creek.

Members of the Ross River Dena Council have stated that Ketza River was and is used by salmon species. No salmon species were found in Cache Creek in either the 1991 YTG/DFO study or a previous, 1986, fisheries assessment.

3.1.2 Background Geochemistry

Metal mines are constructed in areas where high concentrations of meals occur natively in rock. If adequate concentrations are found in the rocks, extraction of the metal from the rock is economically viable and a mine is can be built. Therefore, mines are located in areas where very high concentrations of metals are found in the environment naturally. The issue of contamination occurs when human activity at the mine causes these metals to escape into the environment at higher concentrations than that which is naturally found that area.

In the Ketza River area, naturally occurring elevated metal concentrations in both soil and water are likely to be found. Systematic soil sampling for exploration purposes has been conducted in the Ketza River mine area by YGC Resources during the mid-1990's. The results of this sampling was used by the exploration company to help locate future mineral deposits, but it also documents the naturally occuring elevated concentrations of metals in soils—specifically arsenic. Maps showing arsenic concentrations in soil in undisturbed areas of the Cache Creek and Peel Creek valleys which were prepared by YGC Resources (1996) frequently show arsenic concentrations in soils in the 500 to 4,000 ppm range, and occasionally as high as 10,000 ppm. Based on these findings, it will be important establish site specific criteria for metal concentration in the environment at this site as generic, or Tier 1 CCME guidelines, may not be applicable.

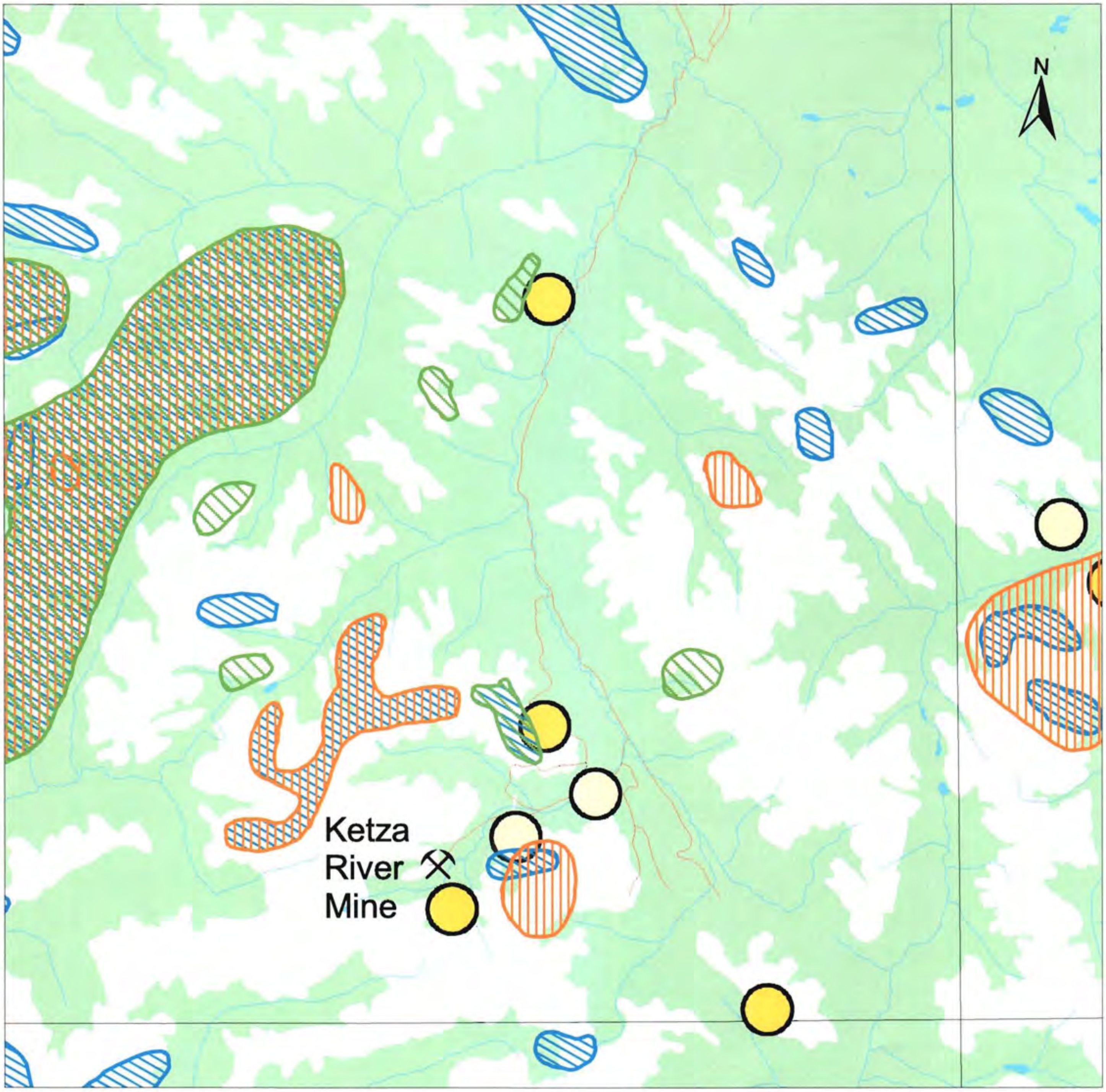
Surface water samples have been collected before, during and after mining in the Ketza River area from Cache Creek upstream of the mine to determine the natural metal levels in water. The results of these analysis by DIAND over the last 14 years is summarized in Table 3.1.

Table 3.1. Metal Concentrations in Cache Creek, Ketza River Mine Site

Metal	CCME Aquatic Life Guideline	"Upstream" Metal Concentrations (1986 to 1996) for Cache Cr[1]
Arsenic	0.005 mg/L	0.020 - 0.060 mg/L
Cadmium	0.000017 mg/L	0.0001 – 0.003 mg/L
Copper	0.004 [2] mg/L	0.002 - 0.030 mg/L
Lead	0.007 [2] mg/L	≤0.001 mg/L
Zinc	0.03 mg/L	0.002 – 0.02 mg/L

1. DIAND Water Laboratory Data, 1988 to 1999

2. depends on hardness, assumed 200 mg/L CaCO3



Ketza River Mine Site Key Wildlife Habitat Areas

Ketza River Mine Site Assessment

Legend
- Thinhorn Sheep (early winter rutting)
- Thinhorn Sheep (spring lambing)
- Thinhorn Sheep (winter range)
- Thinhorn Sheep (migration corridor)
- Mineral Lick
- Unidentified ungulate (mineral lick)

Scale 1:150 000

2000 0 2000 4000 Meters

Yukon Albers Equal Area projection

DATA SOURCE:
Key Habitats Areas compiled by Fish and Wildlife Branch of Yukon Renewable Resources at 1:250,000.

Drawn By: K. Svec and N. Guy
Site Name: Ketza River Mine
Project No. 99-914
Date: 23 March 2000

Figure 4

Gartner Lee Limited

Based on the water sample analyses conducted by DIAND, it is apparent that background, natural concentrations of arsenic, cadmium and occasionally copper in surface water at this site likely exceed CCME guidelines for the protection of aquatic life.

3.1.3 Terrain Analysis

Airphoto interpretation of terrain features in the vicinity of the Ketza River Mine Site is shown on Figure 5. As stated earlier, metal concentrations in soils in the study area are naturally elevated, and therefore understanding soil genesis and terrain features is key to interpreting metal concentrations in soils.

Owing to the steep, mountainous topography of the site, most of the study area is dominated by weathered, frost shattered and colluviated bedrock. Glacial activity has over steepend the valley wall, forming dramatic cliffs provide the backdrop of the mine site. Abundant talus slopes, or colluvial cones have formed at the base of these over steepend slopes. The base of the Cache Creek valley is characterized by a mix of rubbly colluvium form the valley walls and glacial till, or moranial deposits. Glacial outwash sands and gravels or terminal moraine form a portion of the tailings impoundment and are found in the Cache Creek valley downstream of the mine site.

3.2 Geological Setting

3.2.1 Description

The mine property lies near the center of a regionally up-faulted and domed area (the Ketza Uplift). This consists of a three kilometer diameter core of Late Proterozoic phyllite and quartzite strata, ringed by Lower Cambrian and younger Paleozoic carbonate and clastic strata. Stocks of Eocene to Cretaceous age have locally intruded, hydrothermally altered and mineralized these sediments.

Strata are generally flat-lying, although there are numerous folds and faults. Mineralization predated most of the faulting. There are two general types of mineralization: limestone replacement deposits of sulphides and their oxidized equivalents, and quartz-sulphide fissure vein and stockwork systems.

Eight stratigraphic units are present on the property, of which four have economic significance.

The Late Proterozoic phyllite and quarzite basal unit occupies the area between Peel and Misery Creeks and hosts a complex system of gold-bearing quartz-sulphide veins, including those mined as the QB and Gully Zones. The strata are variably metamorphosed (to hornfels) particularly in the southeast sector. Strata are subhorizontal, weathered and weakly magnetic due to the presence of minor disseminated pyrrhotite related to the hornfelsing.

The Lower Cambrian limestone unit is roughly 200 meters thick, and hosts the main gold deposits at the mine property. The deposits consist of an extensive replacement type system, including both chimney (roughly perpendicular to bedding) and manto (roughly parallel to bedding) components. Mineralization is typically located in the top 100 meters of the grey, clean and uniformly bedded limestone unit. The flat lying manto deposits are located along the axis of gentle anticlines (Peel East Open pit), adjacent to normal faults (Peel Oxide Zone was bounded by such faults), and, in the majority of cases, with no apparent control. The steeply-plunging chimney deposits, less numerous than the mantos, are localized along shear zones (Ridge Zone) or zones of fracturing (Break, Nu Zones).

Above the Lower Cambrian limestone is a green mudstone that formed a distinct marker unit on the property. Where mineralization occurred at the upper limestone contact immediately beneath the green mudstone, mining was more difficult due to the weaker nature of the mudstone unit. Above the green mudstone, Upper Cambrian black carbonaceous shale grades upward into phyllitic limestone, the host rock for the Knoll Zone.

The sulphide mantos typically consists of pyrrhotite (80%), arsenopyrite (10%), pyrite (5%), chalcopyrite (trace) and quartz. Magnetite and ankerite are present in mantos south of Cache Creek (i.e. Tarn Zone area), and magnetite is abundant as replacements in limestone immediately south of the 1430 East Oxide Zone. Inclusions of limestone could account for up to 30% of individual sulphide mantos. Gold occurs on the grain margins of all sulphide mineral species and also as submicroscopic inclusions within arsenopyrite. Visually, there is no difference between gold-bearing and barren sulphide mantos, however, an absence of arsenopyrite generally indicates an absence of gold. The economic gold zones terminate by grading laterally into barren sulphides, or by a lateral decrease in both sulphide thickness and gold grade. The limestone is locally dolomitized and recrystallized in the immediate vicinity of mineralization, notably at the Tarn and Knoll Oxide zones. Otherwise, alteration of the limestone wall rock adjacent to the mantos mineralization is almost non-existent. No skarn silicate minerals have been noted either within or peripheral to the deposits except for minor tremolite at the Break and 1430 East Zones.

The oxide mantos and chimneys, which were the focus of mining at the site, developed from oxidation of sulphide mantos in areas where:

- The slopes were south facing, without the presence of permafrost;
- There was moderate relief and consequently a deep water table; and
- The presence of faults provided access for oxidizing groundwater.

The oxide ore consists of limonite and hissingerite (a vitrous siliceous iron oxide). Generally, gold grade is directly proportional to the presence of hissingerite. There is very little gradation between sulphide and oxide deposits, although the oxides do contain minor remnants of sulphide inclusions.

LEGEND:

Texture
- d - mixed fragments
- g - gravel
- r - rubble
- s - sand
- x - angular fragments

Surficial Material
- A - Anthropogenic
- C - Colluvium
- F - Fluvial
- FG - Glaciofluvial
- M - Morainal (Till)
- R - Bedrock

Surface Expression
- b - blanket
- c - cone
- f - fan
- h - hummocky
- k - moderately steep slope
- p - plain
- s - steep slope
- t - terrace
- v - veneer

Geomorphological Processes
- A - Snow avalanches
- Rb - Rockfalls
- S - Solifluction
- U - Inundation
- X - Permafrost process
- " - Zone of initiation

100 0 100 200 300
Meters

Source of Drawing: Aiphoto A27832-37. 1:40,000 scale. June 1992	TERRAIN ANALYSIS
Reviewed By: F.K.P.	Ketza River Mine Site Investigation Ketza River, Yukon Ross River Dena Council / DIAND
Drawn By: F.K.P.	
Date Issued: 04.11.01	
Project Number: 99-914	Gartner Lee Limited
File Name: Fig5_2.WOR	Figure No. 5
Revision: 0	

The quartz-sulphide fissure veins and stockwork deposits (Gully and QB Zones) are characterized by a brecciated texture, with quartz fragments surrounded by a matrix of green scorodite (an oxidation product of arsenopyrite). The larger veins are up to 5 m wide and 100 m in strike length. Oxidation is generally restricted to the top several meters.

3.2.2 Environmental Implications

Mining and milling was reportedly limited to oxide ore (Canamax 1990). Oxide reserves were to be depleted by October 1990, at which time milling of sulphide ore was requested to keep the mine open (Canamax 1990), but was apparently never undertaken (SRK 1994).

From the geological description of the deposits, it appears that there is a potential for some sulphides to have been exposed during open pit mining, by excavating too deeply into the oxide zones. These sulphides present a potential source of acidic drainage and metals of environmental interest, particularly pyrrhotite, a relatively reactive sulphide, and arsenopyrite, a potential arsenic source. Most of the manto deposits located in the limestone host unit (Break, Nu, Ridge, Peel, 1430, Tarn and Knoll Zones), are likely to contain significant neutralization potential, which would offset the acid generating potential. Dolomitization of the limestone, reported in the Tarn and Knoll Zones, may render the limestone slightly less reactive and available. There is a greater potential for acidic drainage and metal leaching to occur in the vein and stockwork deposits hosted in the Late Proterozoic phyllilte and quartzite basal unit limestone (i.e. Gully and QB Zones, and miscellaneous exploration excavations) due to lack of limestone and its neutralization capacity.

In addition, the oxide zones are a potential source of leachable metals. In particular, scorodite (an oxidation product of arsenopyrite) has been identified in the oxide portions of the veins and stockwork deposits (Gully, QB), which represents a potential source of leachable arsenic (SRK, 1994).

4 Regulatory Setting

4.1 Water Licence

Water use, tailings disposal and effluent discharge at the Ketza River Mine were governed by a Water Licence issued by the Yukon Territory Water Board under the Yukon Waters Act.

The initial Water Licence application was submitted to the Yukon Territory Water Board in January 1987. Water Licence No. Y-IN87-06L was subsequently issued to Canamax Resources on May 1, 1987, following public hearings on March 3rd and 4th, 1987. The term of the Water Licence was from May 1987 to December 1998.

An amendment to Water Licence No. Y-IN87-06L was issued in 1989, primarily to increase the capacity of the water treatment plant and allow larger volumes of treated water to be discharged to Cache Creek.

Canamax submitted a Water Licence Amendment application in April 1990 to allow for the mining and milling of sulphide ore reserves. In February 1992, Wheaton River Minerals (the new mine owner) asked the Minister of DIAND not to sign the Water Licence amendment.

The Water Licence was assigned to Wheaton River Minerals in June, 1992.

The Water Licence was assigned to Ketza River Holdings Ltd. in February 1994. Ketza River Holdings Ltd. was a wholly owned subsidiary of Wheaton River Minerals.

Water Licence Y-IN87-06L expired on December 31 1998. An application for a Class B Water Licence was filed in 1999 by YGC. The application was rejected by the Yukon Territory Water Board who requested that an application for a Class A licence be made.

Annual reports describing water quality, water usage and annual geotechnical inspections were filed by the mine owners with the Yukon Territory Water Board as required by the Water Licence from 1987 to 1998. Geotechnical inspections of the mine site have also been conducted by DIAND on an annual basis.

A Decommissioning Plan was filed with the Yukon Territory Water Board in February 1994 as required by the Water Licence. In response to a screening report issued by DIAND, an addendum detailing a decommissioning strategy for the Tailings Management Facility (Tailings Pond) was issued by YGC in 1996.

Regular site inspections are carried out by INAC. The inspection reports are on file at INAC Water Resources' Whitehorse office.

4.2 Land Tenure

The mine property consists of a 200 ha. surface lease held under the *Territorial Lands Act* and is registered with INAC Land Resources. The lease (Parcel ID No. 105F09-0000-00001) is titled to Ketza River Holdings Limited, and is valid until July 2002.

Subsurface right are held with 62 full and fractional mineral leases under the Yukon Quartz Mining Act. The leases in the immediate area of the mine site (approximately 25) are due to expire on December 14th, 2009 with the leases for the peripheral areas due to expire on February 12, 2011. All of these mineral leases are currently held in the name Ketza River Holdings Ltd.

The area surrounding the mine site is held by mineral claims under the *Yukon Quartz Mining Act*. This package consists of approximately 232 full and fractional KON Quartz Claims, also registered to Ketza River Holdings Ltd.

5 Description of Mine Development and Operation

The general layout of the mine site is illustrated on Figure 2. Details of the mill and accommodation complex are illustrated on Figure 3.

In 1998, the water treatment plant, the grinding and crushing mills, and mill control systems were removed from the mine and taken to the Mt. Nansen Mine, located near Carmacks Yukon. The mine's power plants were removed after the mine closed, but three small generators for camp power are still on-site.

5.1 Mine History

The following summary of the property history is modified from that provided in the 1994 Decommissioning Plan (SRK 1994):

Gold was first discovered on the Ketza River Property by prospectors working for Conwest Exploration Company Limited in 1954 and 1955. Development of the property was delayed due to its remote location, difficulties of access and associated economic considerations.

The property was optioned by Pacific Trans-Ocean Resources in late 1983. A joint venture agreement with Canamax Resources Ltd. followed in early 1984. Canamax was designated the operating partner. A decision to proceed with development of the property to the production phase was made at the beginning of 1987, following three years of intensive exploration. Water and sediment quality baseline information was collected in 1985 and 1986. Exploration work included the construction of two exploration adits (1510 and 1430) to facilitate underground mapping and drilling.

Construction of the mining and milling facilities commenced in 1987 and continued through 1988. Mill operations commenced in March and the first gold bar was poured on April 28th, 1988. A 1987 report by Golder Associates (no. 862-1054A) provides as-built cross sections of the tailings dam.

In April 1989, Canamax Resources completed an agreement to purchase Pacific Trans-Oceans share of the property to become 100% owner of the Ketza River Mine.

The Ketza Mine was in operation from March 1988 to November 1990. Mining ceased due to the exhaustion of the oxide ore reserves (YGC Resources Ltd. 1997). Production was an average 364 tonnes/day with a total mine production of 3,112,407 grams of gold over the mine's operating period. The mine was put into a care and maintenance state. Two of the three wings of the ATCO trailer camp, along with the mill power plants and other equipment was removed from the mine site.

On August 24, 1992 Wheaton River Minerals Limited purchased the property from Canamax Resources Inc. and, subsequently, transferred ownership to a wholly owned subsidiary, Ketza River Holdings Ltd. YGC Resources purchased all of the Ketza River Holdings' shares in April 1994, making YGC the owner and operator of the Ketza River Mine. At that time, Wheaton River Minerals obtained a controlling interest (60%) in YGC Resources. YGC Resources conducted drilling exploration programs primarily focused on the Shamrock Zone between 1994 and 1996.

Wheaton River's 60% interest in YGC Resources was sold to BYG Natural Resources Inc. (approximatly 10%) and others (50%) in March 1997. In 1997, primary components of the water treatment plant, mill control circuitry, grinding mills, the crushing plant and some stockpiled ore were removed from the Ketza mine and transferred to the Mt. Nansen Mine, located near Carmacks, Yukon, which was owned by BYG Natural Resources Inc.

Current possible reserves remaining at Ketza are estimated at 234,000 tonnes containing 11.1 g/t gold (DIAND 1998).

5.2 Mine Workings

Underground mining was conducted primarily in the Ridge and Peel zones. Open pit mining was conducted in a series of small pits. A summary of mine production is provided in Table 5.1.

Table 5.1: Ketza River Mine Zones and Production (from SRK 1994)

Zone	Production Date	Tonnes
Underground Production		
Ridge	1988-1990	74,653
Peel	1988-1990	148,843
Break	1990	813
Nu	1990	1,578
Open Pit Production		
Break Nu	1989-1990	52,309
Tarn	1989	15,129
Ridge	1989-1990	21,137
QB	1990	1,987
Knoll	1990	2,936
Gully	1990	8,136
1430 East	1990	601
1430 South	1990	11,233
Tarn	1990	3,040
TOTAL		**342,395**

5.2.1 Open Pit

Open pit mining was undertaken by truck and backhoe in the Ridge, Break, Nu, QB, Knoll, Tarn and Gully Zones, with some blasthole drilling being undertaken where the waste rock was too hard to be ripped by dozers (SRK, 1994).

5.2.2 Underground

Underground mining occurred in the Peel and Ridge Zones from 1988 to 1990. Portals into these zones were driven at the 1550, 1510 (2) and 1430 levels as illustrated in Figure 2. A backfill raise from surface (1530) connected to several levels of the mine. The 1550 level served as top access for stopes above the 1510 level. The 1550 and 1510 portals were connected to the 1430 portal by a series of declines and drifts in generally stable rock.

The 1490 portal was driven in the Break-Nu Zone in 1990.

The workings were described as being dry during operations (Canamax 1990). Upon closure, the groundwater entering the workings was anticipated to percolate down through the fractured limestone host rock, such that no direct discharges were anticipated (Canamax 1990).

The Peel Zone is about 300m long by 100m wide and up to 20m thick. It is an elongated, sheet-like ore body lying in the limestone and dipping about 10 to 30° to the east. The hanging wall is 20 to 30 m below surface at the south end and more than 85 m below surface at the north end.

The Ridge Zone is steeply dipping about 8 m by 50 m in plan and 100 m long down dips. The Ridge Pit extracted the uppermost section of this ore zone. The ore zone consisted of incompetent iron oxides in a limestone host. The hanging wall was massive to rubbly limestone.

Stopes above the 1550 level were mined by square set methods and came up under the Ridge Pit. Square sets were used because of the extremely poor ground conditions. Other stoping was by cut and fill methods (see SRK Figure 2-8 in Appendix B). Stope voids were filled with waste rock and surface till. Cement was added to the fill in some cases to allow mining in adjacent areas or for extra support. A backfill raise to the surface near the 1550 adit was used to dump backfill underground from the surface.

Waste rock generated during the mining of oxide ores was dumped on the slopes adjacent to and below the open pits and access portals. This material is described (SRK, 1994) as generally being a mixture of oxide waste and limestone waste. Limited records were kept regarding the quantities and locations of the waste rock dumps (SRK, 1994).

Water collected from the underground flowed out of the mine at the 1430 adit. Originally a sump was located below the 1430 waste rock dump, and this mine water discharge was monitored as part of the Water Licence (location KR-03). Flocculant was added to this sump on an intermittent basis to precipitate metals in the mine water. By 1989 this sump was replaced with a pipeline that discharged directly into the tailings pond.

5.3 Mill

5.3.1 Process Description

The Ketza River mill was a conventional carbon-in-pulp cyanide extraction process (CIP) and milled an average of 364 tonnes/day with a total production of 3,112,407 grams of gold (as gold d'ore bars poured on site) over the three years of production.

The mill and services building is located in the valley below the mine and upstream of the tailings pond. The building includes mill, offices, power generators, warehouse, maintenance shops and assay lab.

The mill contained a semi-autogenous grinding (SAG) mill, thickeners, cyanide leach tanks, CIP extraction tanks, carbon stripping tanks, electroplating tanks, bullion furnace and carbon regeneration furnace, tailings treatment equipment, assay lab and chemical storage. There are a series of sumps in the floor of the mill buildings. Interviews with former mine staff suggest that sump pumps pumped water back into the mill feed/process stream (Henry pers comm, 2000).

Tailings slurry was treated using the Inco SO_2/ air process prior to discharge to the tailings pond or Cache Creek.

5.3.2 Process Reagents

Table 5.2 below provides a summary of the mill and process reagents used at the Ketza River Mine site.

Table 5.2: Mill and Process Reagents Usage, Storage and Dispensing

Reagent	Usage (kg/tonne of ore)*	Storage, Use and Dispensing
Sodium Cyanide (NaCN)	0.79	Delivered in dry pellet form in sealed wooden crates, stored in mill building. Cyanide pellets added to water in cyanide tank in mill building to make the cyanide solution.
Lime (CaO)	7.55	Delivered in bulk to mine, stored in external silo at west end of mill. Added directly to mill feed.
Lead Nitrate ($PbNO_3$)	0.2	Used as additive to leach circuit. Stored in small drums near coarse ore bin on upper level of mill building.
Sulphur Dioxide (SO_2)	1.72	Deliver to site in bulk tanks. Stored in converted rail car tank next to water treatment plant. Used in INCO cyanide destruction circuit.
Copper Sulphate ($CuSO_4$)	0.26	Used in cyanide destruction circuit. Storage location unknown. Delivery method unknown, but typically in 25 kg bags.
Ferric Sulphate	-	Used in arsenic precipitation circuit in water treatment plant. Storage location and delivery method unknown. Large ferric sulphate tank observed in mill building.
Percol	-	Flocculent used in arsenic precipitation circuit in water treatment plant. Stored in 25 kg bags on pallets in upper level of mill building.
Sulphuric acid (H_2SO_4)	-	Delivered to site in 45-gallon drums. Storage location unknown. Used to dissolve steel wool in a dip tank after electrowinning process. Process later in mine life changed to using stainless wood which could be washed & reused**
Hydrochloric acid (HCl)	-	Delivered in 5-gallon pails. Storage location unknown. Used for backwashing carbon columns. Solution typically circulated 10-12 hours to clean-up columns.**
Caustic Soda (NaOH)	-	Delivered in 45-gallon drums. Storage location unknown, potentially upper level of mill building. Used for pH control when mixing cyanide solution to prevent formation of cyanide gas. Also used as a backwash in the carbon column to raise pH after an acid backwash rinse.**

Source: ** Canamax 1990*

*** Henry pers comm, 2000*

5.4 Tailings Management

5.4.1 Tailings Containment

Approximately 342,393 tonnes of mill tailings were deposited into a surface impoundment located below the mill site (SRK 1996). The tailings dam is a cross-valley, water retaining structure with a zoned cross section. The dam has a central core built of lower permeability material surrounded by coarser sand and a protective layer of gravel with some sand and cobbles. The design section and grain size curves are shown on SRK Drawing 2-10 in Appendix B. The total length of the dam (400 m) is divided by a topographic high in the valley centre into two portions that are referred to as the Northern and Southern dams. A detailed plan of the impoundment is provided on SRK Drawing 3-1 in Appendix B.

Natural ground with a slope of 3 horizontal to 1 vertical (3H:1V) forms the northwest perimeter of the pond. Natural surface run off from the area to the north west of the impoundment (1.36 sq km) is captured in the Northwest Runoff Interceptor Ditch and diverted around the impoundment.

The area to the southwest of the impoundment is relatively flat with slopes of approximately 5H:1V. Natural run off from this area is captured in the Subsidiary Creek Diversion Ditch and diverted around the impoundment and into the Cache Creek Diversion via a 300 mm diameter corrugated steel pipe culvert.

5.4.2 Water Treatment

The milling process used cyanide to extract the gold from the ore. The tailings pulp had residual total cyanide concentrations up to a few hundred parts per million (ppm), which was in excess of the Water Licence allowable discharge limit. The tailings stream was treated using the INCO SO_2-air cyanide destruction process prior to entry into the tailings impoundment. The tailings pond supernatant was treated with the INCO SO_2-air treatment for destruction of cyanide and with ferric sulphate for precipitation of metals prior to being discharged to the polishing pond, which provided a design 48-hours retention time (SRK 194). The pond effluent was then discharged to the environment. Treatment sludge was deposited back into the tailings impoundment.

Seepage at the toe of the north dam was recycled back to the tailings impoundment until 1991 (SRK 1994) due to elevated concentrations of arsenic and cyanide.

5.4.3 Decommissioning

The 1994 decommissioning plan (SRK 1994) required the continued maintenance of the Cache Creek Diversion, the lower Subsidiary Creek Diversion, and the Northwest Interceptor Ditch. The plan required that the tailings pond spillway be capable of handling increased flow in the event that the Subsidiary Creek Diversion and the Northwest Interceptor Ditch failed and passed water into the tailings impoundment. The decommissioning plan also required that the spillway be capable of handling 50% of the Probable Maximum Flood for the entire upstream catchment area, including the areas of the diversion ditches.

A contingency plan was proposed in 1996 (SRK 1996) that was intended to control the release of contaminants from the tailings pond. The contingency plan included:

- applying ferric sulphate to precipitate arsenic prior to draining of the pond water to the environment,
- relocating tailings to the north area of the tailings facility,
- breaching the South Dam and using that material to cover the tailings in the north portion of the tailings facility,
- rerouting the Cache Creek Diversion to the south of the knoll that separates the north and south areas of the existing tailings facility,
- relocating the lower Subsidiary Creek Diversion to a lower elevation, passing below the toe of the relocated tailings.

5.5 Ore Storage

Ore from the underground workings was hauled out of the 1430 portal and stockpiled outside the adit. The ore was then sorted (based on grade) and transported to the mill ore stockpile located on a flattened hilltop immediately west of the mill building. Ore that did not have sufficient grades for milling was pushed over the waste rock dump at the 1430 portal.

Ore from the open pits was hauled by truck to the ore stockpile pad. The ore was fed through grizzly screen into a jaw crusher and was subsequently conveyed into the mill building for grinding. Most residual ore on the stockpile was milled prior to mine closure, and only fine residual material is left of the ore storage pad. (Burke pers comm, 2000). The ore stockpile is estimated to be 2 ha in area. (Wheaton River Minerals 1993). A large ditch for the Upper Subsidiary Creek diversion is located to the west of the ore stockpile area.

5.6 Accommodations

On-site accommodations consisted of an interconnected ATCO trailer camp. The camp is located on a constructed terrace of compacted gravel to the west and down slope from the mill complex. The complex provided accommodations for 126 people in three separate dormitory style wings (Canamax 1987). Kitchen, dining and recreation facilities were located on the eastern side of the camp. An office complex was located on the northwest side of the accommodation complex.

At the western edge of the accommodation complex area are small buildings for ancillary services. A drainage ditch and piping for the water discharge line runs behind these buildings and into Cache Creek.

5.7 Exploration Camp

Prior to construction of the mine, an exploration camp was located on the road between the current location of the mill complex and the 1550 adit. This camp consisted of two double-wide trailers, tent frames and drill core storage shacks. SRK (1994) indicated that most of the camp had been removed by that time.

5.8 Ancillary Services

Other services not described elsewhere include:

- ***Other Buildings***
  - Mine dry at 1510 portal.
  - Road maintenance contractor's Quonset hut (Grant Stewart of Watson Lake) and carpenter's shop/sawmill addition—located north of mill complex.
  - Mill dry located between mill and accommodation complex.
  - Miscellaneous pump house buildings (~15) (Brodie 1998).

- ***Airstrip***
  - An emergency airstrip is located at the mouth of Cache Creek where it joins Ketza River. The status of this strip is unknown.

- ***Access Road***
  - A 45 kilometre gravel road connects the mine site to the Robert Campbell Highway at a point 40 kilometers southeast of Ross River.

5.9 Water and Sewage

5.9.1 Water Supply

Camp drinking water was provided from a groundwater well installed upstream of the Upper Subsidiary Creek diversions. This water was monitored quarterly for use and quality during mine operations as a requirement of the Water Licence (sample location KR-2).

During mine operations, approximately 80%-90% of the mill process water was recycled from the tailings impoundment (Canamax 1987). Fresh make-up water for the mill came from two groundwater wells near the mill site. The well adjacent to the polishing pond was reported to be artesian, but contained unacceptable arsenic concentrations for drinking water use. This well was used for mill process water. (Henry pers comm, 2000)

5.9.2 Sewage System

The sewage and grey water from the accommodation complex was collected and piped to an aeration tank located east (downslope) of the camp complex. Sewage from the aeration tank was then discharge to the sewage lagoon. It is possible that the sewage lagoon contents then infiltrated into the native surrounding soils. Sewage from the mill may have been plumbed into the tailings discharge line (Henry pers comm, 2000).

5.9.3 Runoff Water

Surface runoff from the roads, mill, mine, and camp sites is controlled by surface ditches. No drainage plans were located during this study, but it is assumed that all ditches directed surface water flow either into Cache Creek, Subsidiary Creek, or the tailings pond interceptor ditches.

5.10 Fuel, Lubrication Oil, Grease and Solvents – Storage, Use and Dispensing

5.10.1 Diesel Fuel and Gasoline

Fuel was trucked to the mine to supply the mine diesel generators. A list of the mine's fuel storage tanks are in Table 5.3.

Table 5.3: Above Ground Fuel Storage Tanks

Location	Estimated Capacity (gallons)
Mill Tank Farm	4 - 90,000 gallon tanks 1 gasoline tank (est. 20,000 gallons)
Mill day tanks (inside mill building)	2 – 500 gallon
Road Maintenance Quonset Hut	est. 3000 gallon tank labeled "gasoline"
Camp Generator Tanks	2 – 1000 gallon tanks
Incinerator	100 gallon
1510 Portal	2500 gallon

The mill generator day-tanks and the camp generator tanks were connected to the tank farm by either buried or surface pipelines. Other fuel tanks were likely refilled directly from mobile fuel trucks. A fuel dispensing pump island is located adjacent to the tank farm for refueling surface vehicles. All underground equipment was refueled from the storage tank located at the 1510 portal (Burke pers comm, 2000).

The mine's spill contingency plan (Colman 1988) indicated that 23,000 L of gasoline and 2,600,000 L of diesel fuel was transported to the site annually while the mine was in operation.

There were no reported underground storage tanks at the site.

5.10.2 Lubrication Oil, Grease and Solvents

A variety of hydraulic and lube oils were used for stationary, mobile and power generation equipment. Drums of "Varsol" were observed during the site investigation. A degreasing/solvent tank was located along the eastern wall of the vehicle repair bay in the mill building. The oils, solvents, hydraulic and lube oils and grease were delivered in 45-gallon (205 L) drums. Most of these items were stored either vertically on pallets, or stacked horizontally on the ground north of the polishing pond in the mill complex yard and were labeled accordingly. Waste solvent was placed in 45-gallon drums with waste oil and is currently stored near the tailings pond. (Webb pers comm, 2000)

5.10.3 Antifreeze/Glycol

Antifreeze/glycol was used as coolant in the mine's power plants and in vehicles. Antifreeze was delivered to the site in 45-gallon drums and was stored in the mill yard with the lubrication oil, grease and solvents. Antifreeze was re-used where possible. When the mill power plants were removed from the site, the glycol from their radiators was placed in 45-gallon drums and taken offsite along with the generators. Upon mine shutdown, any remaining antifreeze on site was put in the tailings line to prevent it from freezing and would have ultimately reported to the tailings impoundment (Webb pers comm, 2000).

5.10.4 Propane

Propane was used primarily for the heating of ventilation air for the underground mine during the winter. Propane was also used in the accommodations complex for cooking and other domestic uses. Propane was also in the assay office and the gold furnace in the mill building. Small propane bottles were refilled at the mill site for use around the mine area (such as thawing water lines in the winter) The mine's Spill Contingency plan estimated that the mine used 2,000,000 L of propane annually.

6 Records Review

6.1 Spill History

Environment Canada's Spill files were reviewed as part of this Phase 1 ESA. Interviews with former mine employees did not reveal any spills beyond those on file.

1. In 1989, 1,360,000 liters of effluent containing elevated copper concentrations was discharged accidentally to Cache Creek due to a malfunction of the treatment plant. The discharge occurred over 6 to 12 hours. Since this discharge was primarily liquid in nature, no residual impacts to the site are expected.
2. Used oil was stored just off the mine access road downstream of the mine site west of Peel Creek at the former refueling station. An inspection on April 25th, 1989 revealed that several of the 45-gallon drums of waste oils were leaking due to loose bungs. Visible staining of surficial soils and snow was observed. The drums were relocated to the tailings pond storage areas and it is reported that contaminated soils were also hauled to this area. No further documentation was found with respect to the extent of this clean-up or if any follow-up investigations were conducted.
3. A 40,000 litre spill of diesel occurred in the spring of 1992 from one of the bulk storage tanks. A pipe elbow failed west of the mill building (behind the mill dry), allowing the tank contents to flow down slope to Lower Subsidiary Creek. Canamax estimated that approximately 26,000 L of fuel was recovered in a series of check dams and snow pits. The fuel was burned off in these collection pits daily. Follow-up site investigation consisting of a test pitting program was conducted by Seacor Environmental in the summer of 1992. No reports detailing the results of this work were found.

6.2 Interviews

The following former employees were interviewed about the operational history of the Ketza River Mine:

- Mike Burke: former Mine Geologist, Canamax
- Robert Stroshien: Vice President YGC Resources
- Paul Henry: former Mill Shift Supervisor, Canamax/BYG
- Sam Webb, former Surface Crew Supervisor and Caretaker, Canamax/YGC

The following regulators were interviewed with respect to environmental concerns that the Ketza River Mine Site:

- Bud McAlpine, Administrator Water Rights, DIAND Water Resources
- Marg Crombie, former Director, DIAND Environment Directorate

The information gathered from these interviews is incorporated into this report.

7 Site Investigation

The Gartner Lee project team conducted a site investigation on September 24th, 1999. The investigation did not include areas that were inaccessible due to time constraints, such as the Tarn Pit.

The site investigation team consisted of:

- Forest Pearson, Project Manager, Gartner Lee Limited
- Eva Gerencher, Senior Environmental Scientist, Gartner Lee Limited
- Tony Keen, P. Eng., Mining Engineer, A.J. Keen Mining Consultants Inc.
- Karin Svec, Environmental Technician, Gartner Lee Limited
- Iain Bruce, P. Eng., Geotechnical/Geological Engineer, BGC Engineering Inc.
- Peri Mehling, P. Eng., Geochemical Engineer, Mehling Environmental Management Inc.

Mr. Bruce and Ms. Mehling were available to the project through a strategic alliance with Gartner Lee.

Two trainees from Ross River (Greg McLeod and Alex Shorty) were unable to participate in the site investigation due to other commitments.

At the time of the investigation, the weather was overcast with light snow falling. Some minor accumulations of snow were present but did not obscure the ground surface or negatively affect the investigation. The air temperature was near freezing and some ice had formed on small puddles. Larger ponds and creeks were not frozen at the time of the site visit.

Selected photographs from the site investigation are provided in Appendix A.

7.1 Rock Dumps

The rock dumps were developed by end dumping waste off the slopes, leading to local crest oversteepening. Most of the waste dumps were small and blended in with the natural slopes. The waste dumps have left scars where vegetation had been removed by the dumping. Waste dumps created using this methodology generally have factors of safety close to unity.

Tension cracks were observed in the Ridge Zone side-cast waste rock pile (Photo 9). This indicates that the factor of safety of some dumps has dropped slightly below unity at some point in their existence.

SRK (1994) noted that the mining company (Wheaton River Minerals Limited) considered the existing mine rock piles to be comparable to regional slopes in terms of angle of repose and stability. Settlement and consolidation of the rock piles was considered a dynamic process, characterized by vertical displacements, tension cracks and bulging of the slope. Therefore, no specific action relating to improving the physical stability of those slopes was proposed in the Abandonment Plan (SRK, 1994). Brodie (1998) suggested that material should be removed from the crest area of waste rock dumps that are creeping.

The dumps, particularly the oversteepened Ridge Zone dump, are expected to creep in response to varying freezing and thawing and precipitation events. The dumps may also move due to a seismic event. However, the dumps are small and the impact of any movement would likely be limited to small runout distances. A cost benefit evaluation of moving the crest materials could be undertaken as part of a risk assessment to determine if movement of the rock is a suitable solution.

Members of the Ross River Dena have observed a white precipitate on the bottom of Tarn Lake near the Tarn Pit. RRDC have expressed concerns relating to the water quality in Tarn Lake.

7.2 Adits

The 1550 adit portal (Photo 8) was blocked with a cemented backfill plug in 1990. A 610mm culvert was placed in the plug to allow human access, but it is likely this level may be blocked by rockfalls in poor ground locations.

The 1430 adit portal has a timber and tarpaulin bulkhead (Photos 2 & 6). Water drains from the adit into a pipe under the road to an open discharge down the hill towards the tailings pond. The pipe that conveyed flow to the tailings pond is no longer intact, and uncontrolled flow now discharges down to the 1430 waste rock dump and, eventually, into the interceptor ditches.

The 1490 portal is buried in rock on the Break Zone pit.

The two 1510 portals are open. The left hand portal contains ventilation pipes and fans. The right hand portal has a tarpaulin and wire mesh cover over the entrance (Photo 7). Access into the adit is possible and ground conditions appear to be good.

The mine dry building is located adjacent to the 1510 adit (Photo 4). Grey water appears to have been discharged over the bank behind the dry. A large above ground storage tank (AST) used for fueling underground equipment is also located at the 1510 portal (Photo 5). The AST is located in a small containment berm which has a geosynthetic liner. The tank contained approximately 15 cm of product. No environmental issues were identified by the mine dry. The concrete foundation for a large propane tank is also located near the 1510 portals. This tank would have been used to fuel mine ventilation heaters, but the tank, the ventilation heaters and fans have been removed from the site.

Electric cables, air lines and water lines have been removed from the mine except at the 1430 and 1510 portals. A 1m high dam is reported to be located on the 1510 level that directs water down into the mine workings.

7.3 Landfill

Incinerated domestic camp waste and other mine waste materials were disposed of at the mine landfill. The landfill is a small side slope dump area located along the 1550 portal access road. The dump is approximately 30 m long by 15 m wide by 5 m high (Photo 14). The dump appears to have been covered by clean fill during mine operation, but more recent burnt debris is piled on the upper surface of the landfill area (Photo 15). Some material has been pushed over the crest of the landfill. There appears to be some water ponding/collecting in the toe berms below the landfill, which was frozen. SRK (1994) reported that, during mine operation, the refuse was covered by native soils as it was deposited into the landfill.

7.4 Upper Boneyard

A laydown area or "boneyard" for scrapped and discarded equipment and metal is located along the access road between the 1430 adit and the 1510 adit. The boneyard consists of a long narrow terraced area (100 m long by 25 m wide) on a side slope above Subsidiary Creek. Materials stored in the boneyard consist of used pipe, drill steel, scrap tanks, drums, drilling equipment, used pumps, and cables (Photo 16). Discolored surface soils across the entire boneyard area were observed with significant hydrocarbon staining of the soils near the eastern end of the boneyard.

7.5 Exploration Camp

The exploration camp showed no signs of any recent maintenance (Photo 12). The camp consists of the following:

- assay office trailer, stands for oil furnace fuel tank behind trailer;
- generator shed building—location of fuel tank unknown, significant hydrocarbon staining of floor in generator shed. 1 partially full 45-gallon drum. 3 transformers on power pole;
- core logging tent frame with 45-gallon drum behind tent frame;
- avalanche gun foundation;
- office trailer buildings, mostly empty. Oil furnace in northwest corner;
- 2-hole outhouse knocked over with pits exposed;
- water supply building, no holding tank;
- core boxes and core sheds;

- tent frames (most collapsed);
- 1 partially full drum of Jet B fuel (marked Aurum Geological); and
- grease ramp for conducting oil changes (Photo 13)– some hydrocarbon staining of soils down gradient of ramp.

The access road below the exploration camp has significant erosion gullies caused by water running across the road surface.

A brief investigation of the core shacks was also made. Readily viewable core sections appeared to represent largely mineralized (sulphidic) material in a limestone host.

7.6 Mill Building

The mill building was found to be unlocked and open. The mill and services building had previously been stripped of some equipment including the diesel generators and switchgear, jaw crusher, some ancillary mill equipment and the cyanide leach circuit. The SAG mill was previously removed and was sitting in the mill yard. The mill equipment had not been cleaned or emptied completely.

The vehicle maintenance bay has a floor sump. Former mine staff indicated that this sump collected water that melted off vehicles or vehicles' wash water. This sump was pumped out periodically to the yard outside the vehicle bay (Webb, pers comm, 2000). Four vehicle batteries, three 45-gallon drums of used oil and a gasoline-dispensing drum were found in the vehicle bay.

The assay office was found to be empty with the exception of a small quantity of reagents. A complete list of materials found in this area is provided in Table 7.1.

Some mill reagents (i.e. percol, caustic soda etc.) were found in the upper level of the mill as listed on Table 7.1. The upper level decking contained numerous holes where equipment had been removed and these holes were considered to represent a significant safety hazard. MSDS sheets were found in the mill foreman's office on the upper level of the mill building. Many of the reagent and mixing tanks were empty, but some contained some residual sludge.

The liquid SO_2 tank was located at the rear of the mill. Reports from previous employees indicated that this tank was empty. The lime silo was also reported to be "empty" but may contain some residual lime.

Table 7.1: Summary of Hazardous and Non-Hazardous Wastes at Ketza River Mine Site

Location	Hazardous and Non-Hazardous Wastes
Mill Building	
Vehicle Repair Bays	• 4 industrial/vehicle batteries • 3 45-gallon drums of used oil • 1 45-gallon drum for gasoline (with hand pump)
Assay Labs	• 20 10L pails of Fire Assay Flux, containing: • 30% lead monoxide, 11.3% sodium carbonate, 3.8% sodium tetraborate, 5.6% silica, 1.9% florospar • 1 box soda ash • 1 box borax • 1 box nitre (potassium nitrate) • 1 small drum sodium tetraborate • sodium bicarbonate solution (for HF burns) • ½ bottle calcium sulfate • 2 pails ethyl alcohol Ganulite bicardium (Super R Grit) • Silica sand
Lower Level Mill Area/Powerhouse	• 2 empty(?) day-tanks for generators • 2 empty wooden crates for sodium cyanide
Upper Level Mill Area	• Empty HCl tank • Ferric sulphate tank with bottom sludge • 1 pallet of Percol flocculent bags (approx. 15 bags) • 2 45-gallon drums of caustic soda • small drum of lead nitrate • small drum of potassium permanganate • 1 oil drum near ore feed bin • 3 cans of Nordback (mill hardening)
Mill Yard	
South Mill Yard/Mill Boneyard	• Sulphur Dioxide Railcar Tank – Leaking • 5 electrical transformers – marked < 50 ppm PCBs • 1 unlabeled full 45-gallon drum in laydown area • 1 horizontal 45-gallon drum between repair bay doors • 2 unlabelled full 45-gallon drums beside bay doors • numerous drums of used mill balls
Assay Office Shed	• 6(?) 20 gallon pails of borax • 2 pails florospar • 1 pail soda ash • 1 amber bottled labeled waste pyridine • 2 tins of lead monoxide (Aarco) • 1 large carboy of "new standard flux"

Location	Hazardous and Non-Hazardous Wastes
Tank farm	• All 4 diesel storage tanks appear empty • ½ full 45-gallon fuel drum
Enclosed Mill Storage Shed	• 8 4L jugs of muriatic acid • 4 glass jugs of nitric acid in styrofoam crate • 1 partially full 20L pail of "Frostfree" compressed air line deicing fluid
Open Shed	• 4 55-gallon drums of potassium permanganate • 1 partially full 45-gallon drum labeled "Gas" • 1 horizontal 45-gallon diesel drum • 7 pallets of 25 kg bags of hydrated lime • 1 Caterpillar generator • 2 20L pails of engine oil • 1 partially full 45-gallon drum of gasoline or Jet B
Lubricant Storage Area	• 1 unmarked horizontal 45-gallon drum in "Antifreeze" area • 3 full 55kg drums of grease • 1 unlabelled 45-gallon drum • 2 empty modified household style ASTs • 24 sealed unmarked 45-gallon drums on pallets – from Imperial Oil, Esso, & PetroCanada • 1 20L pail of Varsol on cable spool platform • puddle of hardened grease under ball mill housing/guard
Tailings Pond	
Tailings Pond Storage Area	• 100 (approx.) empty or partially empty blue plastic 45-gallon sulphuric acid drums; • waste pile of coconut fiber; • 1 unopened crate of sodium cyanide; • 100 (approx.) drums of waste oil; • 1 pallet (12 5-gallon pails) of black plastic pails of hydrochloric acid; • 1 pallet of industrial (caterpillar) batteries; • 4 45-gallon drums of caustic soda (NaOH)

7.7 Mill Yard

The yard around the north and south side of the mill building was mainly used for materials and vehicle storage (Photo 18). The main mill yard is to the north of the mill building and generally consists of the polishing pond, the mill dry, the tank farm, the mill storage shed, and the oil, grease and lubricants storage area. The south side of the mill was primarily used for vehicle maintenance and scrap material storage (the mill "boneyard"). The road maintenance contractor had a Quonset hut for vehicle maintenance across the mine access road, north of the mill yard.

7.7.1 South Mill Yard

The south side of the mill building was the location of five cyanide vat leach tanks, the former location of the water treatment plant (Photo 19) and the vehicle maintenance bay doors. The tailings thickener tank is located behind the vat leach tanks. The leach tanks are surrounded by a low (0.5 m) concrete containment wall. A small sump is attached by a pipe to the interior of the containment area. Water and fine sediments were observed in the containment area and water was observed in the sump.

The water treatment plant was removed from the site in 1997. The sulphur dioxide (SO_2) tank, which is a converted rail car, is still on-site. At the time of the site investigation, the tank was observed to be venting but no odours were noted. The SO_2 tank was further investigated by DIAND personnel in October 1999, and it was determined that the tank was empty, but had been re-pressurized by BYG staff in 1997 to prevent corrosion of the tank interior. Excess gas was vented by the DIAND staff, and a small amount of liquid was observed in the base of the tank (Latoski pers comm, 1999). Paul Henry (pers comm, 2000), a former mill shift supervisor, indicated that the tank was almost completely empty at the time of mine shut-down, and that a small amount of residual sulphuric acid may be in the base of the tank. He also indicated that INCO had raised concerns with the plumbing and operation of the SO_2 tank when the mine was in operation. Surface soils around and under the tank were observed to have a slightly yellowish coloration.

Adjacent to the vat leach tanks, the mill building has two large bay doors for equipment maintenance and a smaller bay door for light vehicle maintenance. Soils in front of these doors were observed to be heavily hydrocarbon stained. Three 45-gallon drums, which were partially full (contents unknown), were found between the large bay doors.

The south side of this portion of the mill yard is the mill "boneyard" (Photo 20) and contained:

- multiple drums of steel mill balls, some of which have tipped and spilled their contents. Mill balls were removed from the grinding mills upon shutdown to relieve stress from the mills' axles;
- a large (est. 2000 gallon) fuel or water storage tank;
- 5 electrical transformers, labeled "PCB free";
- one unlabelled, full 45-gallon drum;
- scrap metal and piping; and
- a highway truck trailer.

7.7.2 West Mill Yard

This area is on the west end of the mill between the main mill yard and the south mill yard. This area contains a small propane bottle refilling shed, the foundation of a large propane tank (removed), and the mill dry building. No environmental issues were identified with respect to the mill dry building. A wooden, partially collapsed stairway leads down to the accommodation complex. Fuel, tailings and discharge pipes pass under the road through a culvert from the northwest corner of the mill building to the utility trench behind the mill dry building. This is the location of the failed fuel line that resulted in the 1992 diesel spill that is on file with Environment Canada.

A small storage shed of the assay office is located next to the mill building. The shed door was not locked, and the shed contained:

- est. 6 - 20 gallon pails of borax
- 2 pails florospar
- 1 pail soda ash
- 1 amber bottled labeled waste pyridine
- 2 tins of lead monoxide (Aarco)
- 1 large carboy of "new standard flux"

7.7.3 Main Mill Yard

The main mill yard is occupied by the polishing pond, the tank farm, the mill storage shed and the oil, grease and lubricants storage area.

The polishing pond is circular, 30 metres in diameter with 1 to 2 meter high berms. The base of the pond is approximately 3 to 4 meters below the berm crests. Some water was present in the pond (Photo 27). The pond has fine-grained sediments around the perimeter and an undetermined geosynthetic material was observed. A process water well is located at the northeast corner of the pond. This well was reported as being artesian and containing elevated arsenic levels (Henry pers comm, 2000).

The oil, lubricants, grease and antifreeze storage area is located north of the polishing pond (Photos 23 & 24). This area contained a grinding mill, pumps, and metallic debris from the grinding mills. Oil, lubricants, grease, antifreeze and other liquid products were stored in 45-gallon drums, stacked horizontally. Many drum labels were either missing, or weathered beyond legibility. There were 2 full 45-gallon drums with unknown contents in this area, as well as 3 full 55 kg drums of grease. Soils in the lubricant storage area appeared hydrocarbon stained. Across from the lubricant storage area, 24 sealed 45-gallon drums were stored on pallets with unknown contents. The labels on these drums were weathered beyond legibility, but most were marked as being either Imperial Oil, Esso or PetroCanada products, and, therefore, are likely to be lubricants and oils.

Adjacent to the mill dry, surface soil was heavily stained by hydrocarbons and was covered with a tarry substance.

7.7.4 Tank Farm

The tank farm consists of four 90,000 gallon diesel fuel tanks and one smaller gasoline tank (Photos 21-22). The volume of the gasoline tank is unknown, but estimated at 20,000 gallons. The storage area is on a 1 metre high raised pad of gravel with a low (30 cm) high containment berm. No geosynthetic liner was observed, but the bermed area appeared to be lined with lime or a concrete slurry. Some staining of soils below tank valves was observed. A covered sump is located inside the bermed area and consists of a short segment of vertical 600 mm culvert. A fuelling island with fuel pumps is located next the containment berm. A partially full 45-gallon drum (contents unidentified) was located next to the fuel pump. Heavy hydrocarbon staining of soils was observed around the fuelling station. Some fibrous debris was piled against the south side of the tank farm berm (next to the mill building).

7.7.5 Mill Storage Shed

Next to the tank farm is a large open front storage shed. The shed contents, from north to south included:

- 1 cat generator—with hydrocarbon staining of surface soils around the generator;
- 1 partially full 45-gallon drum of gasoline or Jet B fuel;
- 2 - 20 L pails of engine oil;
- 7 pallets for 25kg bags of hydrated lime;
- 1 – 45 gallon drum of diesel;
- 1 partially full 45-gallon drum marked "gas";
- 4 drums of potassium permanganate; and
- 1 avalanche cannon (on upper level/loft).

The south end of the shed is closed in, but the door was unlocked. Inside the shed was found:

- 8 4L jugs of muriatic acid;
- styrofoam carton containing 4 glass jugs of nitric acid; and
- 1 partially full pail (20L) of Frostfree (compressed air line deicing fluid).

7.7.6 Quonset Hut

A Quonset hut used by the road maintenance contractor was formerly located across the mine access road from the main mill yard. The hut had a small shed built on the back that served as the carpentry shop and was referred to as the "sawmill". The Quonset hut had been removed prior to the September 1999 site investigation, but the sawmill shed and the concrete foundation for the hut were present (Photo 25). Much of the Quonset hut appeared to have had an earthen floor, and heavy hydrocarbon staining of the soils was observed. A large (est. 2000 gallon) fuel tank is located at the back of the Quonset hut area. The tank is labeled "gasoline", but was empty. North of the Quanset hut area is a bank leading down to Subsidiary Creek. This bank appears to have waste materials and earth pushed over the edge (see Photo 26). No environmental issues were identified associated with the sawmill shed.

7.8 Accommodation Complex

Only one wing of the reported original three wings of the accommodation complex was present at the time of the investigation. The office complex was present (attached to the accommodation wing), and a kitchen and dining hall is contained in a separate set of ATCO trailers (Photo 28). Both building complexes were locked and inaccessible at the time of the site investigation. No environmental issues were identified with the kitchen and accommodation/office trailers.

The camp incinerator is located east of the kitchen building (near the sewage lagoon) and appeared to be operational. The incinerator is fueled by a 100 gallon tank, which contained some hydrocarbon product. The sewage treatment building, with its aeration tank, is located next to the sewage lagoon, but the camp plumbing has been disconnected from the treatment plant, and the sewage line now discharges directly to the sewage lagoon. The sewage lagoon consists of a 25 m square by 2 m deep pond. A 6-inch overflow pipe is located on the north edge of the lagoon, but there is no sign of historic discharge from this point. The lagoon was dry.

Drilling supplies and equipment are stored in front of the accommodation complex.

West of the accommodation complex is a row of ancillary buildings and sheds (Photo 29). With the exception of the accommodation and kitchen complex, all other camp ancillary buildings are of wood frame and plywood construction. These buildings/facilities include (from north to south):

- three large horizontal propane tanks and associated small valve house;
- two above ground fuel storage tanks (1000 gallon estimated capacity) in a small lined wooden containment berm (Photo 30). These tanks are connected to the main tank farm at the mill complex by 1 inch above ground pipes. Some ponded fuel and water was observed inside the containment berm;
- a small portable steel generator building (orange) and generator used to supply camp power during exploration projects in the 1990's;
- a larger wooden generator shack with one large Caterpillar camp backup generator;
- a small building with miscellaneous electrical supplies and switching equipment;
- a larger shed with paint and other supplies;
- a open front carpenters shop; and
- a large building with two large water storage tanks and water treatment and filtration equipment (Petwa Canada Treatment Systems).

Near the generator buildings, there were several used industrial batteries and 5 partially full 45-gallon drums (one drum was labeled as used oil). Hydrocarbon staining of surface soils was observed in front of the generator shed and the paint shop building.

7.9 Tailings Pond & Diversions

7.9.1 North Dam

The north dam was observed to be about 18 to 20 m high and has been built with downstream slopes of 2.5 H:1V (Photo 39). The dam slopes appear to be stable and there are no signs of cracking or deformation. The crest of the dam is approximately 5 to 6 m wide and shows no signs of distress.

Seepage was observed to be exiting from the toe of the dam. The seepage was clean and there was no sign of solids moving out of the dam at the toe. It is not known how much of the seepage exiting the toe is tailings pore water versus natural seepage from groundwater flow. Environment Protection estimated that of the 7.5 L/s observed seeping from the toe of the dam, 5.0 L/s could be attributed to the tailings pond (SRK 1996).

The area near the toe is spongy which implies that the soils are loose at the toe. The depth of loose soil is unknown. SRK (1994) have undertaken stability analyses at the site based on previous geotechnical work by Golder Associates. SRK have indicated that the stability of the dam meets acceptable standards for both static and dynamic criteria. SRK note that a horizontal acceleration of 0.078 has been used. SRK conclude that the foundation soils will not liquefy under this level of shaking. The design earthquake shaking level corresponds to an earthquake with a return period of 475 years (10% chance of exceedance in 50 years) multiplied by an amplification factor of 1.25.

Brodie (1998) concludes that there is evidence of a larger zone of loose sands and gravels than estimated by SRK and concludes that liquefaction of the dam is major concern. Brodie recommends undertaking drilling and then, if liquefaction is proven to be an issue, constructing a berm to assist in stabilizing the slope.

Liquefaction of loose soils is not usually a concern when the ground accelerations are expected to be less than 0.1 g. However, at this site, where closure is being considered, an earthquake with a return period greater than 1 in 475 years should probably be considered. Under this scenario, an acceleration greater than 0.1 g could possibly occur. An assessment of the various ground accelerations possible for various scenarios could be undertaken initially to determine if a problem does exist.

7.9.2 South Dam

The South Dam was also observed to be in stable condition with no signs of distress on the downstream slope or at the crest of the dam (Photo 40). Seepage was not observed at this location, possibly as a result of a larger tailings beach, a higher valley elevation than at the north dam and hence less groundwater flow or as a result of less pervious foundation soils.

7.9.3 Northwest Diversions

The Northwestern Perimeter ditch has failed and water from the catchment above the slope was not being intercepted. However, the perimeter ditch was only intercepting surface water and groundwater flowing past the ditch may be responsible for the high seepage rates being observed at the toe. The perimeter ditch should not be relied upon to divert any large quantities of water in any future water balances.

Diversion ditches upstream of the tailings facility were observed to be breached in several places (Photos 31 to 33). Erosion features suggested that the breaches were due to piping, rather than overtopping of the ditches. Water was pooled in several areas of the ditches, indicating that grading of the diversion ditches is not ideal, and may be influenced by sloughing from the sides of the ditches. From site observations, it appears that the ditches require ongoing maintenance in order to continue to divert water around the tailings impoundment, as recommended in the 1996 abandonment plan (SRK 1996).

7.9.4 Subsidiary Creek Diversion Ditch

The diversion ditch carrying Subsidiary Creek around the tailings impoundment to the Cache Creek diversion showed evidence of sloughing failures. The failures had plugged the diversion and significant erosion channels had formed, directing surface water into the tailings impoundment. In addition, the two – 12 inch culverts carrying Subsidiary Creek under the mill access road were half full of rocks and soil, and had significantly diminished water carrying capacity. Without maintenance and clearing of the ditches and culverts, the access road above those culverts is likely to be damaged, and Subsidiary Creek flow inadvertently redirected into the tailings impoundment.

7.9.5 Cache Creek Diversion

The Cache Creek Diversion presently directs water past the south perimeter of the impoundment. The flow from the 5.6 sq km catchment is contained in a combination ditch berm. The north-facing slope that forms the south side of the ditch has permafrost in the slope. The slope is actively creeping and the possibility of ongoing slope movement in response to thawing ground is high. If the slope creeps slowly, the flow from the creek may remove any debris that accumulates in the diversions from the slope. However, if the slope fails suddenly, the diversion could plug and uncontrolled flow could erode the dyke and the right abutment of the southern dam.

Slumping on the south bank of the Cache Creek Diversion was observed. This appears to be in an area identified as containing permafrost in SRK reports (1994, 1996).

Additional armouring and ongoing inspection are required to confirm that the diversion remains clear.

7.10 Tailings Pond Waste Storage Area

Waste material such as used oil, empty drums, coconut fiber, sulphuric acid drums, batteries, scrap culverts and hydrochloric acid are stored alongside the Subsidiary Creek interceptor ditch (inside the tailings dam catchment). The following wastes are stored in this area (Photos 35 to 38):

- 100 (approx.) empty or partially empty blue plastic 45-gallon sulphuric acid drums;
- waste pile of coconut fiber;
- 1 crate of sodium cyanide;
- 100 (approx.) drums of waste oil;
- scrap culverts;
- 1 pallet (12 5-gallon pails) of black plastic pails of hydrochloric acid;
- 1 pallet of industrial (caterpillar) batteries;
- 4 45-gallon drums of caustic soda (NaOH)
- pile (~160) of empty 45-gallon drums.

Hydrocarbon staining of the soils around the waste oil drums was observed.

7.11 Access Road

The access road to the mine site was in relatively good condition except for two locations where the road had been eroded. Lessor erosion at the lower site is shown in Photo 40. At the second location, nearly half of the access road had been removed by the adjacent river (Photo 41). This would impair the ability to transport equipment to the site for any required maintenance (regular or emergency).

7.12 Hazardous & Non-Hazardous Wastes

Domestic waste from the mine was incinerated and disposed of in the mine landfill. Some wastes appear to have been burned at the landfill. Large metallic debris was disposed of in either the mill boneyard or the upper boneyard. A summary of all other hazardous and non-hazardous wastes is presented in Table 7.1. No explosives were found on-site.

7.12.1 PCB's

A PCB sampling program was conducted by Wheaton River Minerals and one transformer was identified as containing PCB's (SRK 1994). Sam Webb, the mine caretaker (pers comm, 2000) indicated that the transformer was located on the tailings dam (to operate the reclaim water pumps), and was drained of the PCB's in 1990. The PCB contaminated oil was taken to a firm in Whitehorse that was accepting PCB wastes at that time. Transformers in the mill boneyard were labeled as "PCB free". Site information makes reference to a transformer located underground near the 1510 portal, but a letter to YTG Mine Safety stated that all electrical equipment had been removed from underground. Mr. Webb (pers comm, 2000) also said that all electrical equipment, switching gear and the transformer was removed from the underground.

7.12.2 Asbestos Containing Materials (ACMs)

SRK (1994) stated it was not aware of any asbestos used on site. Paul Henry (pers comm, 2000) was also unaware of any asbestos on site other than clothing (i.e. gloves) used in the gold refinery.

7.12.3 Waste Oil, Lubricants, Solvents and Glycol

Waste oil and solvents were collected in 45-gallon drums, and originally stored approximately 2 km from the site along the access road, west of Peel Creek. INAC inspectors instructed the mine operators to relocate the drums. These drums (approximately 100) are now stored near the tailings pond along the Subsidiary Creek diversion. Antifreeze (glycol) was re-used where possible. Upon mine closure, the remaining glycol was put into the tailings line to prevent freezing from where it may have discharged to the tailings pond. Some 45-gallon drums of waste oil, fuel and lubricants were also observed around the mill and the accommodation complex as listed in Table 7.1. Glycol from the generator radiators was taken off-site when the generators were removed from the site.

7.12.4 Batteries

Waste industrial batteries are stored next to the waste oil near the tailings pond. Batteries were also found in the vehicle repair bay of the mill and around the accommodation complex ancillary buildings. It is unknown if batteries were disposed of into the landfill during and/or after mine operation.

7.12.5 Lead Paint

The use of lead in interior paint was stopped in 1950 and exterior paint in 1985. The mine complex was built in 1987 and the exterior surfaces of the mill complex are painted a rust red colour.

7.12.6 Radioactive Materials

A nuclear density gauge (utilizing Cesium 137) was identified as being located in the Mill building in Canamax's 1990 Water Licence Amendment Application. Paul Henry (pers comm, 2000) reported that the density gauge was looked for in 1997 when some equipment was transported to the Mt. Nansen mine but that the density gauge was not found at that time.

7.12.7 Mercury

The mill building was lit by high intensity lamps and florescent light fixtures. These likely contain a small amount of mercury in the lamps. Since there are many of these fixtures on site, proper disposal of the lamps and fixtures should be considered.

7.12.8 Other Chemicals

Miscellaneous lab related reagents and chemicals were found in the assay lab and its associated storage shed. Mr. McAlpine (pers comm, 2000) stated that Mine Safety Branch had ordered BYG in 1998 to remove all dangerous reagents and materials in the Ketza River Mine assay lab. During the 1999 site investigation, the lab was relatively empty with very little reagents left in the building. A complete list of these chemicals, along with all other liquid hazardous and non-hazardous wastes is presented in Table 7.1.

7.13 Areas of Potential Environmental Concern

On the basis of the records review, interviews and site investigation, several areas of potential environmental concern ("APEC's") have been identified. The APEC's are summarized in Table 7.2 below and are shown on Figure 6.

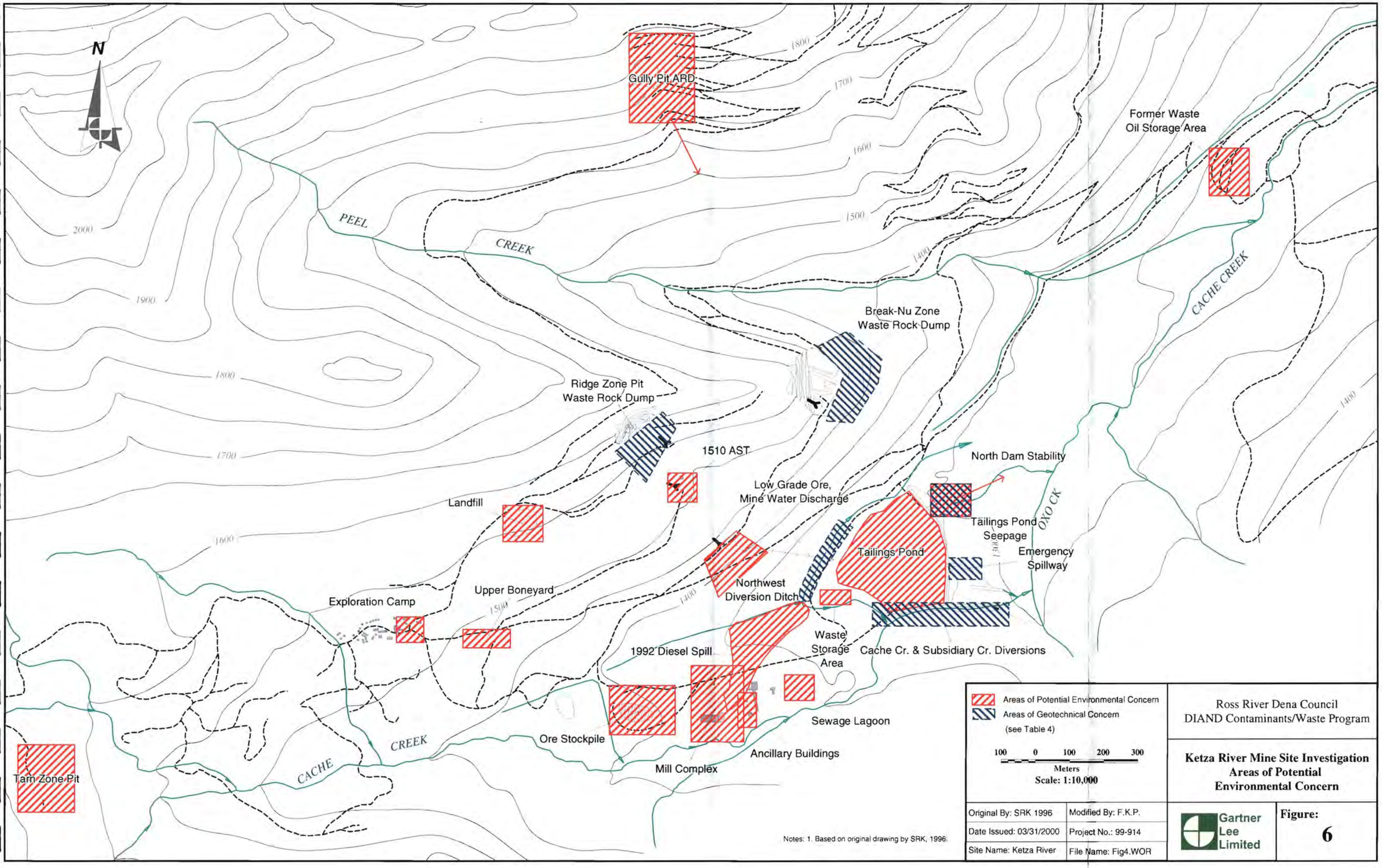
Table 7.2: Areas of Potential Environmental Concern (APECs)

Location	APEC	Environmental Concern	Description
Open Pits	Gully Pit	Metals and ARD	Potential acid rock drainage
	Ridge Pit	Geotechnical	Slumping of waste rock dump
	Break-Nu Pit	Geotechnical	Slumping of waste rock dump
Underground Adits	1430	Metals, ARD, health & safety	Low grade ore pushed over waste rock dump Mine water discharge containing metal. Adit not secured.
	1510	Hydrocarbons, health & safety	Soil contamination around AST from vehicle refueling. Adit not secured.
	1550	Heath & safety	Open backfill raise and un-secured portal
General Mining Area	Exploration Camp	Hydrocarbons, health & safety, geotechnical	Soil contamination near grease ramp and generator shack. Open outhouse pits. Road washing out.
	Landfill	Hydrocarbons, metals, PAHs	Soil and water contamination from waste burning & disposal
	Upper Boneyard	Hydrocarbons & metals	Soil contamination from equipment storage & disposal
Mill Building	Mill Area	Health & safety, metals	Mill building not secured, open holes in upper deck, dangerous conditions, poor lighting. Chemicals in tanks and in storage. Metals in sump sediments and other dispersion of ore.
	Assay Lab & Storage Shed	Health & safety	Chemicals stored in lab and shed
	Vehicle Maintenance Bay	Hydrocarbons	Waste oil drums, solvent tank, sump (pumped out to south mill yard).

Location	APEC	Environmental Concern	Description
Mill Yard	Ore Stockpile	Metals, ARD	Soil and water contamination from ore storage
	South Mill Yard (Mill Boneyard)	Metals, health & safety, sulphur, and hydrocarbons	Metal contamination from ore storage, milling and mill balls. Cyanide contamination from leach tanks. Sulphur (soils, air and health & safety) from SO_2 tank. Human heath & safety associated with leach tanks. Hydrocarbon contamination from vehicle maintenance.
	Main Mill Yard	Hydrocarbons & metals	Hydrocarbon contamination from oil, lubricant & grease storage and spillage. Metal contamination from reagent storage and ore dispersion. Significant hydrocarbon contamination of down gradient soils from 40,000 L diesel spill—potential surface and groundwater impact.
	Tank Farm	Hydrocarbons	Hydrocarbon contamination of soils from leakage and spills from refueling
	Mill Storage Shed	Hydrocarbons, health & safety	Hydrocarbon storage and spillage. Health & safety concern from acid storage.
	Polishing Pond	Metals	Metal contamination of sediments and ponded water from mine water discharge.
	Contractor's Quonset	Hydrocarbon, metals	Hydrocarbon contamination of soils from gasoline tank and vehicle maintenance. Potential metal contamination from waste disposaL/snow dump over bank.
Accomm. Complex	Ancillary Buildings	Hydrocarbons, metals	Hydrocarbon contamination of soils and ditch water from used oil and generator ASTs as well as 40,000 L diesel spill. Industrial batteries near paint shop.
	Sewage Lagoon	Human health & safety	Bacteriological.

Table 7.2 Continued: Areas of Potential Environmental Concern (APECs)

Location	APEC	Environmental Concern	Description
Tailings Pond	Diversion Ditches	Geotechnical	Slumping of Cache Creek diversion, erosion of drop structure. Spring overtopping (& leakage) of Subsidiary Creek diversion, & blockage of culverts. Erosion & slumping of northwest interceptor ditch.
	Waste Storage Area	Hydrocarbons, health & safety	Waste oil and solvent drums, crate of cyanide, drums of sulphuric and hydrochloric acid, caustic soda.
	Tailings	Metals, ammonia, cyanide	Metal (arsenic) in tailings, arsenic and ammonia (cyanide potentially) in pond water.
	Tailings dam	Geotechnical, metals, cyanide	Inadequate spillway, seepage from north dam, north dam stability. Potential arsenic and cyanide contamination of seepage water.
Mine Access Road	Access Road	Geotechnical	Erosion of road surface and undercutting by Ketza River.
	Former Waste Oil Storage Area	Hydrocarbons	Potential soil and groundwater contamination from waste oil storage and vehicle refueling from AST.



N
Gully Pit ARD
Former Waste Oil Storage Area
PEEL CREEK
CACHE CREEK
Break-Nu Zone Waste Rock Dump
Ridge Zone Pit Waste Rock Dump
1510 AST
North Dam Stability
Low Grade Ore, Mine Water Discharge
Landfill
Tailings Pond Seepage
OXO CK
Tailings Pond
Emergency Spillway
Upper Boneyard
Northwest Diversion Ditch
Exploration Camp
Waste Storage Area
Cache Cr. & Subsidiary Cr. Diversions
1992 Diesel Spill
Sewage Lagoon
Ore Stockpile
CACHE CREEK
Ancillary Buildings
Mill Complex
Tarn Zone Pit
2000
1900
1800
1700
1600
1500
1400
1300
Areas of Potential Environmental Concern
Areas of Geotechnical Concern
(see Table 4)
100 0 100 200 300
Meters
Scale: 1:10,000
Ross River Dena Council
DIAND Contaminants/Waste Program
Ketza River Mine Site Investigation
Areas of Potential
Environmental Concern
Original By: SRK 1996
Modified By: F.K.P.
Date Issued: 03/31/2000
Project No.: 99-914
Site Name: Ketza River
File Name: Fig4.WOR
Gartner Lee Limited
Figure:
6
Notes: 1. Based on original drawing by SRK, 1996.

8 Mine Site Sampling Program and Results

8.1 Overview

At the request of DIAND Contaminants/Waste Program, soil, rock, and surface water grab samples were collected from the Ketza River Mine site during the September 1999 site investigation. Sampling consisted of judgmental grab samples—systematic or thorough sampling was not conducted as part of this project. The results of the sampling presented in this section only represent an example of chemical concentrations that can be found in soil and water at the site. A Phase 2 Environmental Site Assessment (ESA) is required to characterize the occurrence and extent of contamination identified as part of this Phase 1 ESA.

The field-sampling program was conducted on September 24th, 1999. Sample locations are illustrated on Figures 7 and 8. The program consisted of:

1) Collection of rock samples for acid rock drainage (ARD) testing.
2) Surficial soil judgmental sampling.
3) Surface water grab sampling.

Water samples have been collected historically either by the mine operator in fulfillment of Water Licence requirements or by INAC Water Resources.

The potential chemicals of concern at the mine site include metals, predominantly arsenic resulting from the mining, milling and disposal of ore, and petroleum hydrocarbons from fuel storage, dispensing and disposal. Other chemicals of potential concern include: cyanide, acids (sulphuric and hydrochloric), sulphur dioxide (SO_2), copper sulphate, lead nitrate, glycol, varsol and others.

Potential chemicals of concern at the Ketza River Mine site as they relate to specific industrial activities are described below:

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

- Petroleum Hydrocarbons, including diesel fuel, lubricating and hydraulic oils
  Potential contamination from the storage, transfer, use, spills and disposal of petroleum hydrocarbon products. Source areas at the mine site include:
  - bulk fuel storage tanks (tank farm);
  - the vehicle fuelling station;

- bulk fuel spills;
- fuel pipelines;
- outdoor lube and hydraulic oil storage;
- current and former aboveground fuel storage tank installations at the camp backup generators;
- the 1510 adit;
- the former refueling site (along mine access road near Peel Creek);
- the exploration camp generator; and
- leakage and spills from vehicle storage and maintenance.

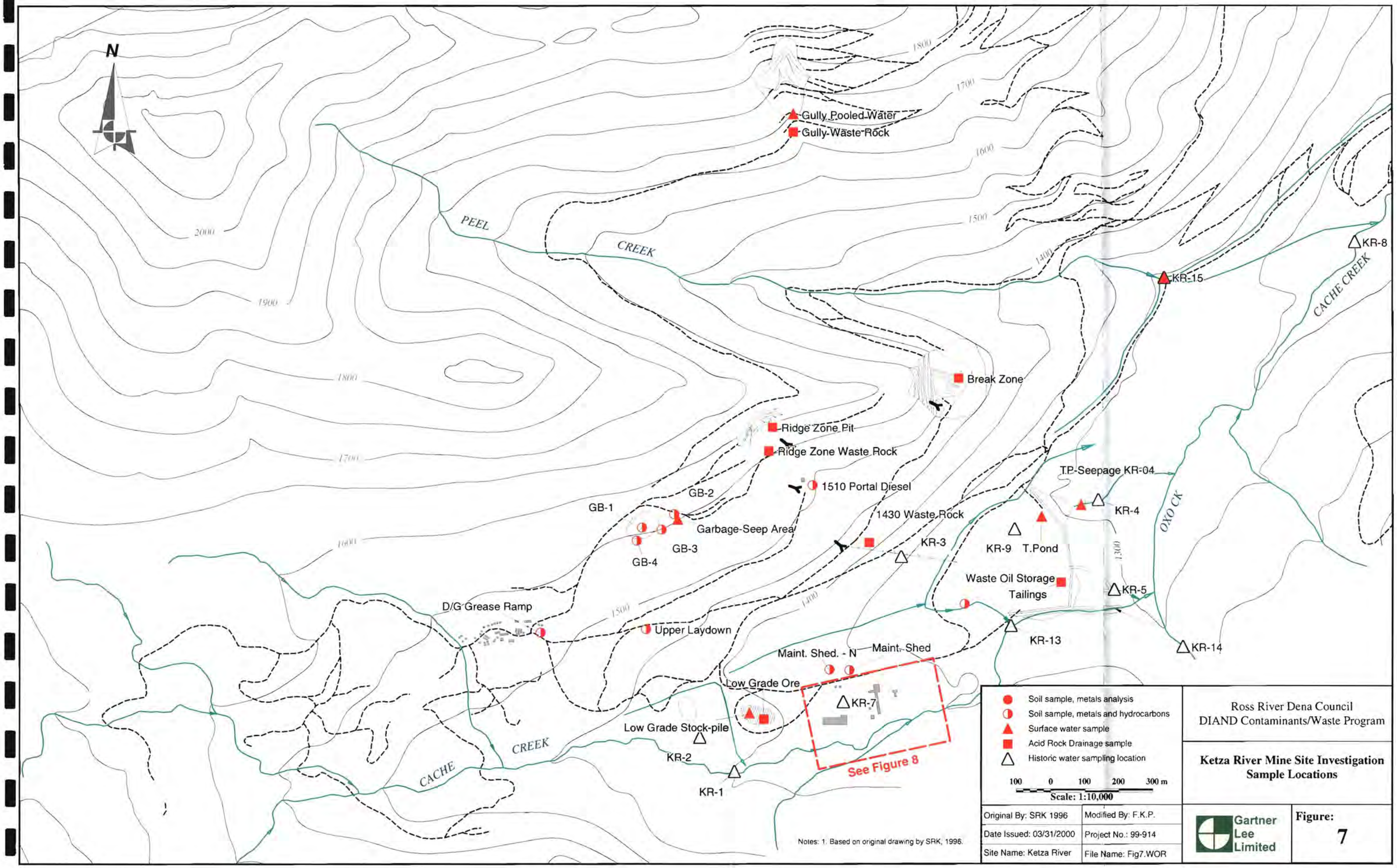
- Mill Process Chemicals
  Potential sources of contamination from the storage, handling, use and disposal of bulk chemicals used in the mill processes include: the outdoor chemical storage in the mill yard, the mill storage shed, and the reagent storage room in the mill building.

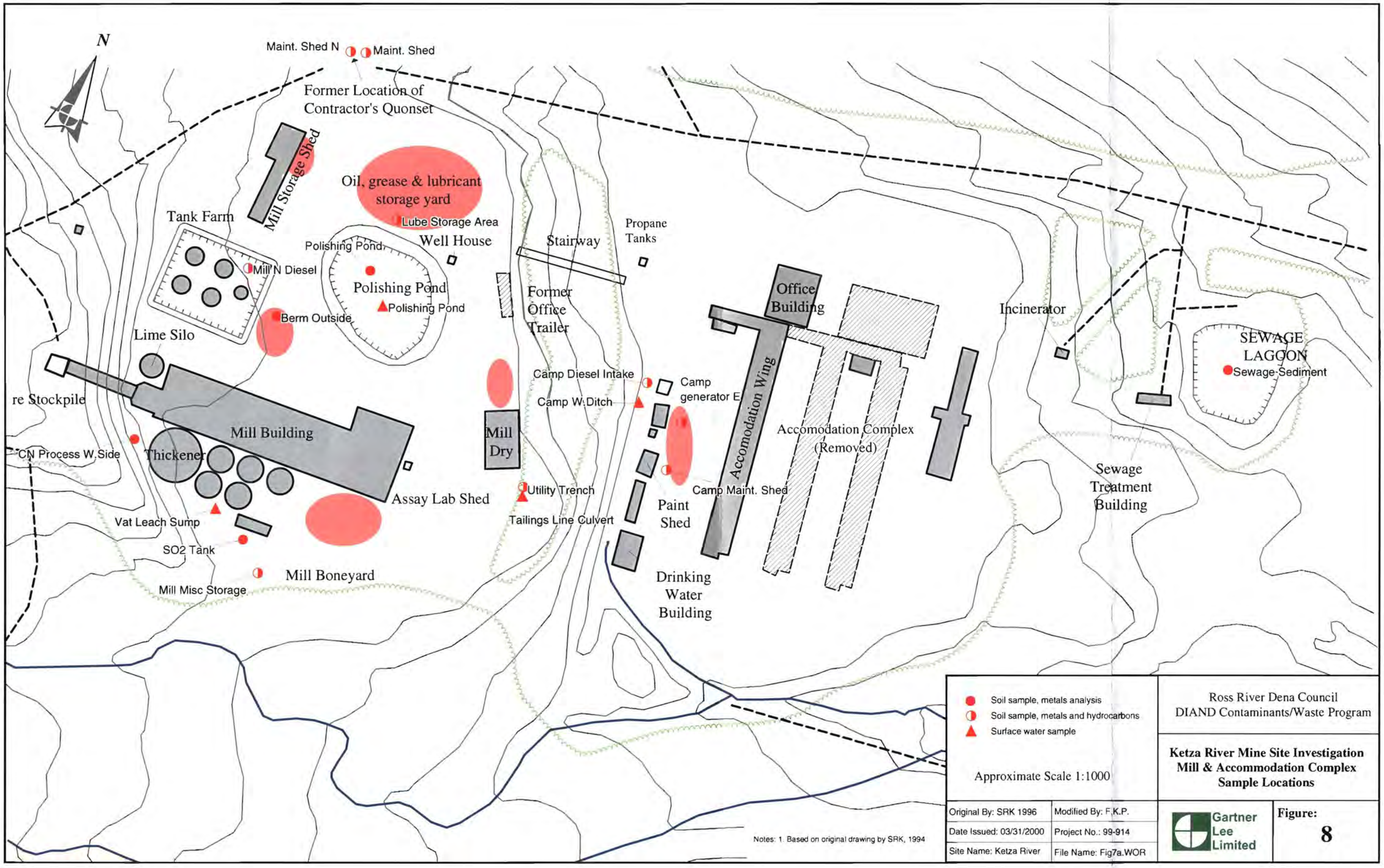
8.2 Environmental Regulations and Guidelines

The Ketza River Mine occupies land leased from the Government of Canada under the Territorial Lands Act. Accordingly, environmental regulations developed for both Federal legislation and Yukon Territory were used for the evaluation of contaminated site issues at the Ketza River mine site. The Yukon Contaminated Sites Regulations provide a series of steps for the identification, assessment and remediation of contaminated sites. The required degree of remediation cited in the guidelines is determined by the CCME Criteria and Guidelines. Therefore, the Canadian Environmental Quality Guidelines, published by the CCME in 1999 were used as the primary regulatory limits in the evaluation of environmental quality data at the Ketza River mine site. The Yukon Contaminated Sites Regulations typically has higher (less stringent) standards than the CCME, but may be more applicable to the Yukon setting where elevated metal concentrations can be naturally occurring (i.e. cadmium).

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

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


N
2000
1900
1800
1700
1600
1500
1400
1300
PEEL
CREEK
CACHE CREEK
OXO CK
CACHE
CREEK
Gully Pooled Water
Gully Waste Rock
Break Zone
Ridge Zone Pit
Ridge Zone Waste Rock
1510 Portal Diesel
1430 Waste Rock
GB-1
GB-2
GB-3
GB-4
Garbage-Seep Area
KR-3
KR-9
T.Pond
T.P-Seepage KR-04
KR-4
KR-5
KR-8
KR-15
KR-13
KR-14
Waste Oil Storage
Tailings
D/G Grease Ramp
Upper Laydown
Maint. Shed. - N
Maint. Shed
Low Grade Ore
KR-7
Low Grade Stock-pile
KR-2
KR-1
See Figure 8
Soil sample, metals analysis
Soil sample, metals and hydrocarbons
Surface water sample
Acid Rock Drainage sample
Historic water sampling location
100 0 100 200 300 m
Scale: 1:10,000
Ross River Dena Council
DIAND Contaminants/Waste Program
Ketza River Mine Site Investigation
Sample Locations
Original By: SRK 1996
Modified By: F.K.P.
Date Issued: 03/31/2000
Project No.: 99-914
Site Name: Ketza River
File Name: Fig7.WOR
Gartner Lee Limited
Figure:
7
Notes: 1. Based on original drawing by SRK, 1996.



N
Maint. Shed N
Maint. Shed
Former Location of
Contractor's Quonset
Mill Storage Shed
Oil, grease & lubricant
storage yard
Lube Storage Area
Tank Farm
Polishing Pond
Well House
Mill N Diesel
Polishing Pond
Polishing Pond
Berm Outside
Lime Silo
Stairway
Propane
Tanks
Former
Office
Trailer
Office
Building
Incinerator
SEWAGE
LAGOON
Sewage-Sediment
re Stockpile
Mill Building
CN Process W.Side
Thickener
Mill
Dry
Camp Diesel Intake
Camp W.Ditch
Camp
generator E
Accomodation Wing
Accomodation Complex
(Removed)
Assay Lab Shed
Utility Trench
Camp Maint. Shed
Sewage
Treatment
Building
Vat Leach Sump
Tailings Line Culvert
Paint
Shed
SO2 Tank
Mill Boneyard
Mill Misc Storage
Drinking
Water
Building
Soil sample, metals analysis
Soil sample, metals and hydrocarbons
Surface water sample
Approximate Scale 1:1000
Ross River Dena Council
DIAND Contaminants/Waste Program
Ketza River Mine Site Investigation
Mill & Accommodation Complex
Sample Locations
Original By: SRK 1996
Modified By: F.K.P.
Date Issued: 03/31/2000
Project No.: 99-914
Site Name: Ketza River
File Name: Fig7a.WOR
Gartner
Lee
Limited
Figure:
8
Notes: 1. Based on original drawing by SRK, 1994

The Yukon Territorial *Contaminated Sites Regulation* (CSR) provides standards for soil assessment as either a generic or matrix numerical standard for a given chemical parameter. Generic numerical soil standards are specified on the basis of current or proposed land use, including: agricultural (AL), urban park (UL), residential (RL), industrial (IL) or commercial (CL). Matrix numerical soil standards consider both land use and site-specific factors for the protection of human health and the environment. For evaluation of chemical concentration data using the matrix soil standards, the site-specific factors of human intake of contaminated soil and toxicity to soil invertebrates and plants apply at all sites.

The sampling conducted as part of the September 1999 Site Investigation does not represent complete or definitive identification and delineation of contaminant distribution. Rather, the results collected in 1999 represent examples of contaminant concentrations that can be encountered at the site. More intensive, systematic sampling work would need to be conducted to adequately identify contaminant distribution.

8.2.1 Soil Quality

The CCME tier 1 soil quality guidelines are derived to protect human health and ecological receptors for four generic land use categories: agricultural, residential/parkland, commercial and industrial. The recommended soil quality guideline for each chemical parameter is developed using different receptors and exposure scenarios for each land use category. Sensitivity among ecological and human health components increases for land dependent activities such as agriculture and residential occupation.

For the evaluation of soil quality at the Ketza River mine site, the CCME soil quality guidelines and the YCSR Standards for the industrial land use category are the primary numerical limits used to evaluate the data. The receptors and exposure pathways considered in the derivation of environmental soil quality guidelines for industrial land use include: soil nutrient cycling processes, direct soil contact by soil-dependent biota and wildlife. For human health protection, the industrial land use scenario considers exposure to soil by direct means (ingestion, dermal contact, inhalation) and indirect means (groundwater used as drinking water, contamination of indoor air via contaminant volatilization, and off-site migration of soil/dust).

For parameters not addressed in the CCME Soil Quality Guidelines, specifically the petroleum hydrocarbon parameters light and heavy extractable petroleum hydrocarbons, reference is made to the soil standards specified in the Yukon Territorial Contaminated Sites Regulation (YCSR). Where the CCME guidelines represent a recommended limit for a substance in environmental media, the YSCR standards represent a legally enforceable numerical limit.

8.2.2 Surface Water Quality

Surface water quality was initially evaluated using the CCME water quality guidelines for the protection of aquatic life. The Yukon Contaminated Sites Regulations also provide Generic Water Quality Standards for Aquatic Life and Drinking Water Quality. The YCSR Standards and CCME Guidelines have both been presented with the analytical data to provide a comparison for the surface water quality data.

8.3 Soil Quality Assessment

8.3.1 Overview

Surficial soil sampling consisted of the collection of the upper 0.1 metres of the soil surface using a stainless steel trowel or a mattock to break the compacted surface. The locations for the soil samples were noted on site sketches. Soil samples were inspected and collected directly into cleaned, laboratory certified 250 mL capacity jars. All soil was kept cool until delivery to the analytical laboratory. Standard chain-of-custody forms were completed for each sample and the form accompanied the samples to the laboratory.

A total of 23 soil samples were collected for a full metal scan by ICP. A total of 16 samples were analyzed for Extractable Petroleum Hydrocarbons. Soil samples tested to determine the concentration of diesel fuel residuals with a carbon range of C10-C19 were analyzed for light extractable petroleum hydrocarbons (LEPH). Lube and hydraulic oils were assessed by analysis of heavy extractable petroleum hydrocarbons (HEPH with a carbon range of C19-C32). Selected samples were also analyzed to determine concentrations of polycyclic aromatic hydrocarbons (PAHs; components of lube and hydraulic oils and byproducts of low temperature burning). One sample collected near the SO_2 tank was also analyzed to determine concentrations of sulphate, sulphide and total sulphur.

The analytical results for the grab soil samples are summarized on the following tables:

- Table 8.1: Metal concentrations in surface soil samples;
- Table 8.2: Extractable petroleum hydrocarbon (EPH) concentrations in surface soil samples;
- Table 8.3: Polycyclic aromatic hydrocarbons in surface soil samples.

The applicable regulatory guidelines and/or standards for each analytical parameter are included with the analytical data in each table. The laboratory reports and results of the QA/QC program are included in Appendix D. Figures 8 and 9 illustrate the location of elevated metal and hydrocarbon concentrations in surface soil samples collected from the mine site.

TABLE 8.1: RESULTS OF SOIL ANALYSIS - TOTAL METALS
Surface Soil Samples (ppm)

Sample ID	CCME Industrial Guideline[a]	YCSR Industrial Standard[b]	General Mining Area							Accomodation Complex Area			
			GB-1	GB-2	GB-3	GB-4	D/G Grease Ramp	Upper Laydown	1510 Portal Diesel	Sewage Sediment	Camp Generator E	Camp Maint. Shed	Camp Diesel Intake
Sample Date			99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Physical Tests													
Moisture	-	-	10.4	12.8	28.8	28.9	10.1	28.9	15.3	12.2	12.3	18.6	11.4
pH	6-8	-	8.00	6.45	6.56	6.56	7.99	7.87	8.08	7.6	4.22	8.03	8.31
Dissolved Anions													
Sulphate	-	-	-	-	-	-	-	-	-	-	-	-	-
Inorganic Parameters													
Sulphide	-	-	-	-	-	-	-	-	-	-	-	-	-
Total Sulphur	-	40	-	-	-	-	-	-	-	-	-	-	-
Total Metals													
Antimony	40	40	<20	<20	<20	<20	<20	<40	<40	<20	<20	<20	<20
Arsenic	12	60	***485***	***91***	***720***	***1240***	***405***	***10300***	***7470***	***113***	***538***	***164***	***262***
Barium	2000	2000	107	63	88	103	161	96	63	34	72	222	24
Beryllium	8	8	1.5	<0.5	0.6	1.8	<0.5	<1	<1	0.6	1.3	<0.5	<0.5
Cadmium	22	8-650[c]	<0.5	<0.5	2.8	4.5	0.6	1.0	2.9	<0.5	4.4	0.6	<0.5
Chromium	87	60	39	8	16	45	19	18	22	40	38	24	22
Cobalt	300	300	22	4	10	22	12	19	13	11	18	10	13
Copper	91	250	78	18	47	81	49	***657***	***294***	36	57	25	28
Lead	600	2000	<50	<50	<50	160	<50	<100	<100	<50	<50	<50	<50
Mercury	50	10	0.008	0.026	0.026	0.014	0.021	0.013	0.015	0.020	0.008	0.029	0.009
Molybdenum	40	40	<4	19	10	<4	5	<8	<8	<4	<4	<4	<4
Nickel	50	500	40	15	38	43	35	*60*	32	38	31	27	26
Selenium	10	10	<2	<2	<2	<2	<2	<10	<2	<2	<2	<2	<2
Silver	40	20	<2	<2	<2	<2	<2	<4	<4	<2	<2	<2	<2
Tin	300	300	<10	<10	<10	<10	<10	<20	<20	<10	<10	<10	<10
Vanadium	130	-	28	12	31	41	59	30	30	17	28	36	17
Zinc	360	600	52	45	***1270***	*461*	72	*439*	286	121	*480*	68	82

Sample ID	CCME Industrial Guideline[a]	YCSR Industrial Standard[b]	Mill Complex Area										T. Pond
			Polishing Pond	Lube Storage Area	Utility Trench	Mill Misc Storage	Maint. Shed - N	Mill N-Diesel	Maint. Shed	Berm Outside	CN Process W.Side	SO2 Tank	Waste Oil Storage
Sample Date			99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Physical Tests													
Moisture	-	-	39.7	8.9	10.7	11.7	10.1	9.4	13.0	11.3	10.0	21.8	6.6
pH	6-8	-	7.89	8.55	8.24	8.35	8.33	8.47	8.35	8.22	8.11	3.31	7.87
Dissolved Anions													
Sulphate	-	-	-	-	-	-	-	-	-	-	-	20000	-
Inorganic Parameters													
Sulphide	-	-	-	-	-	-	-	-	-	-	-	<0.2	-
Total Sulphur	-	40	-	-	-	-	-	-	-	-	-	***16000***	-
Total Metals													
Antimony	40	40	<20	<20	<20	<20	<40	<20	<20	<20	<20	<20	<20
Arsenic	12	60	***1900***	*20*	***155***	***1330***	***370***	***2270***	***5870***	***1560***	***6170***	***8810***	***411***
Barium	2000	2000	1120	625	22	171	22	88	161	87	84	63	94
Beryllium	8	8	0.7	0.5	<0.5	1.1	<1	1	0.5	1.3	1.3	0.6	1.6
Cadmium	22	8-650[c]	6.3	0.9	<0.5	2.7	<0.5	2.2	0.8	3.6	1.9	0.8	1.1
Chromium	87	60	27	21	25	35	24	45	46	42	41	43	52
Cobalt	300	300	56	7	12	14	14	14	13	18	14	6	21
Copper	91	250	***1060***	23	29	151	28	119	162	78	160	231	53
Lead	600	2000	<50	<50	<50	77	<100	<50	<50	56	54	63	<50
Mercury	50	10	0.742	0.078	0.008	0.036	0.008	0.029	0.029	0.026	0.021	0.014	0.015
Molybdenum	40	40	12	<4	<4	<4	<8	<4	<4	<4	5	6	<4
Nickel	50	500	*132*	27	31	30	31	40	40	39	32	20	41
Selenium	10	10	2	<2	<2	<2	<4	<2	<2	<2	<2	<2	<2
Silver	40	20	6	<2	<2	<2	<4	<2	<2	<2	<2	<2	<2
Tin	300	300	<10	<10	<10	<10	<20	<10	<10	<10	<10	<10	<10
Vanadium	130	-	*135*	49	15	32	15	35	35	32	36	42	38
Zinc	360	600	*427*	120	67	330	78	166	166	362	160	147	275

NOTES:
"-" not analyzed or no standard
<2 less than detection limit
a CCME. 1999. Canadian Soil Quality Guidelines for Protection of Environmental and Human Health. Soil Quality Guidelines and Interim Guidelines.
b Government of Yukon. 1997. Contaminated Sites Regulations. Generic and Matrix Numerical Soil Standards
Site-specific Factors = groundwater flow to surface water used by aquatic life, toxicity to soil invertebrates and plants, or intake of contaminated soil
c Standard Varies with pH
italics Sample exceeds CCME Industrial Guideline
bold, italics Sample exceeds Yukon CSR Industrial Standard

TABLE 8.2: RESULTS OF SOIL ANALYSIS - EXTRACTABLE PETROLEUM HYDROCARBONS
Surface Soil Samples (ppm)

Sample ID	CCME	YCSR	Mining Area						Accomodation Complex			Mill Complex						T. Pond
	Industrial Guideline [a]	Industrial Standard [b]	GB-1	GB-2	GB-4	Upper Laydown	1510 Portal Diesel	D/G Grease Ramp	Camp Maint. Shed	Camp Diesel Intake	Camp Generator E	Lube Storage Area	Utility Trench	Mill Misc Storage	Maint. Shed - N	Mill N-Diesel	Maint. Shed	Waste Oil Storage
Sample Date			99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Extractable Hydrocarbons																		
EPH 10-19	-	2000	<200	<200	<200	<200	***3610***	<200	331	***15000***	<200	<200	***32600***	207	<200	***2990***	<200	411
EPH 19-32	-	5000	<200	<200	<200	***12400***	***8210***	247	***6500***	3430	***6200***	<200	4500	311	<200	1060	2630	***27800***
LEPH	-	2000	<200	<200	<200	-	-	-	-	-	-	-	-	-	-	-	-	-
HEPH	-	5000	<200	<200	<200	-	-	-	-	-	-	-	-	-	-	-	-	-

NOTES:
"-" not analyzed or no guideline/standard
<2 less than detection limit
a CCME. 1999. Canadian Soil Quality Guidelines for Protection of Environmental and Human Health. Soil Quality Guidelines and Interim Guidelines.
b Government of Yukon. 1997. Contaminated Sites Regulations. Generic and Matrix Numerical Soil Standards

italics	Sample exceeds CCME Industrial Guideline
bold, italics	Sample exceeds Yukon CSR Industrial Standard

TABLE 8.3: RESULTS OF SOIL ANALYSIS - POLYCYCLIC AROMATIC HYDROCARBONS
Surface Soil Samples (ppm)

Sample ID / *Sample Date*	CCME Industrial Guideline [a]	YCSR Industrial Standard [b]	GB-1 99/09/24	GB-2 99/09/24	GB-4 99/09/24
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	-	-	<0.01	<0.01	<0.01
Acenaphthylene	-	-	<0.01	<0.01	<0.01
Anthracene	-	-	<0.01	<0.01	<0.01
Benz(a)anthracene	10	10	<0.01	<0.01	<0.01
Benzo(a)pyrene	0.7	10	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	10	10	<0.01	<0.01	<0.01
Benzo(g,h,l)perylene	-	-	<0.01	<0.01	<0.01
Benzo(k)fluorene	-	10	<0.01	<0.01	<0.01
Chrysene	-	-	<0.01	<0.01	<0.01
Fluoranthene	-	-	<0.01	<0.01	<0.01
Fluorene	-	-	<0.01	<0.01	<0.01
Indeno(12,3)pyrene	10	10	<0.01	<0.01	<0.01
Napthalene	22	50	<0.01	<0.01	0.01
Phenanthrene	50	50	<0.01	<0.01	0.01
Pyrene	100	100	<0.01	<0.01	0.01

NOTES:

"-" not analyzed or no standard

<0.01 less than detection limit

[a] CCME. 1999. Canadian Soil Quality Guidelines for Protection of Environmental and Human Health. Soil Quality Guidelines and Interim Guidelines.

[b] Government of Yukon. 1997. Contaminated Sites Regulations. Generic and Matrix Numerical Soil Standards

Site-specific Factors = groundwater flow to surface water used by aquatic life, toxicity to soil invertebrates and plants, or intake of contaminated soil

italics Sample exceeds CCME Industrial Guideline

bold, italics Sample exceeds Yukon CSR Industrial Standard

As a general observation, *all* soil samples exceeded the CCME Industrial Guideline for arsenic of 12 ppm. All but one of the 22 samples collected exceed the Yukon Contaminated Sites Regulation (YCSR) Matrix Standard for arsenic of 60 ppm (groundwater flow to surface water used by aquatic life). The average arsenic concentration in the 22 samples was 2,302 ppm with a standard deviation of 3,174 ppm. Based on this observation, no further discussion of arsenic concentrations in soil will be made. The development of a tier 2 or tier 3 arsenic objective would be appropriate for the Ketza River mine site.

8.3.2 General Mining Area

Sample locations for this area are shown on Figure 6. Analytical results are presented on Tables 8.1, 8.2 and 8.3 and shown graphically on Figure 9.

Four soil samples were collected from around the landfill area. Zinc concentrations above the CCME Industrial Guideline were found in samples GB-3 and GB-4, which were collected from the toe of the landfill. GB-3 also exceeded the YCSR Industrial Standard for zinc. No extractable petroleum hydrocarbons (EPH) or Polycyclic Aromatic Hydrocarbons (PAH) were found in these samples.

One sample was collected down gradient from the "grease ramp" at the exploration camp. Sample "D/G Grease Ramp" was collected to test the down gradient extent of obvious surficial hydrocarbon staining. Heavy extractable petroleum hydrocarbons (HEPH) were detected in the sample, but were well below the HEPH Standard. Metal concentrations in the sample, other than arsenic, did not exceed any Guidelines or Standards.

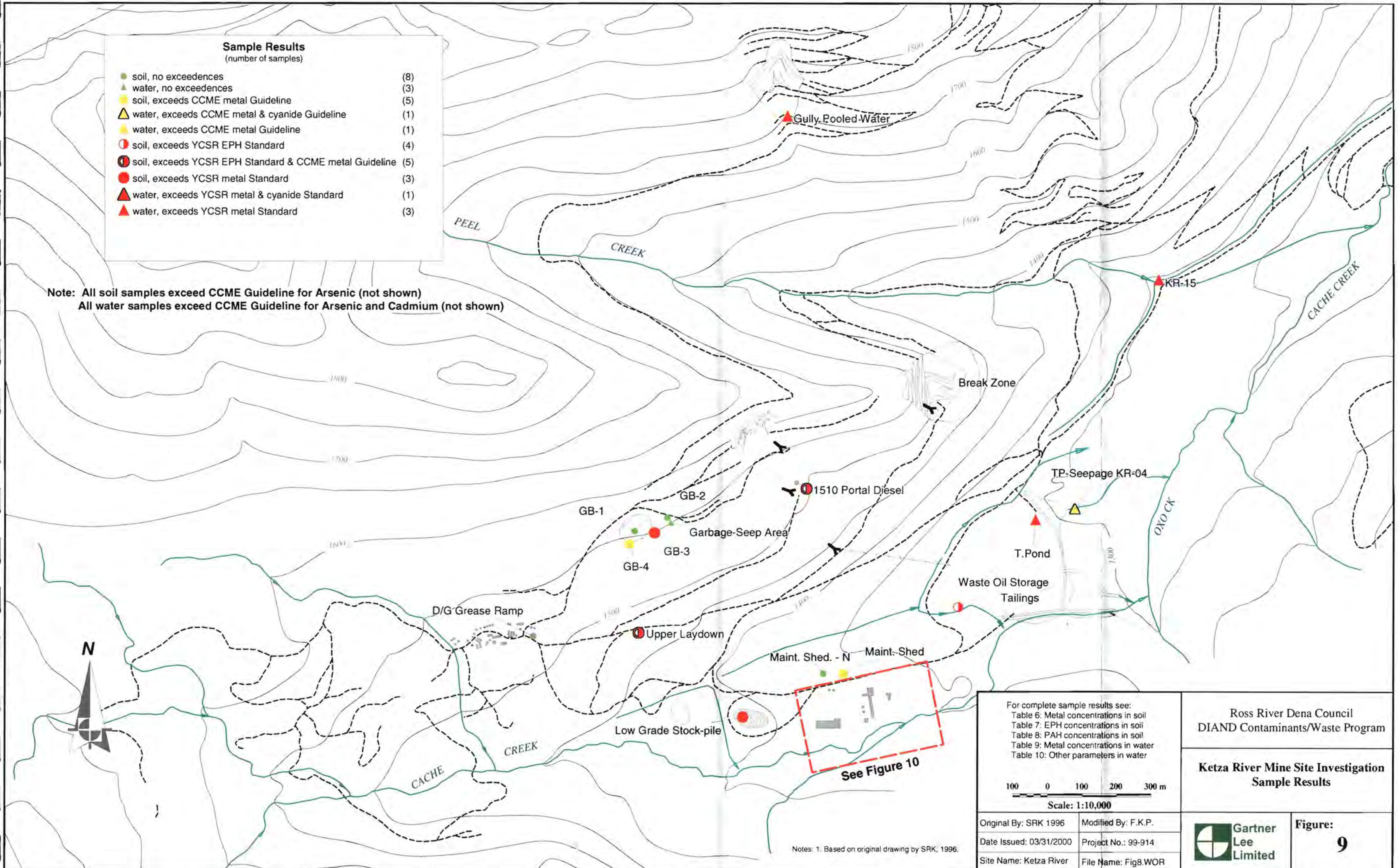
One surficial soil sample was collected from the eastern end of the Upper Boneyard. This area of the boneyard showed extensive surface staining. This sample, "Upper Laydown" contained copper concentrations above the YCSR Industrial Standard, and nickel and zinc concentrations above the CCME Industrial Guideline. The sample also contained over 1% arsenic (10,300 ppm). The sample also exceeded the YCSR Industrial Standard for Heavy EPH—the sample contained 1.2% HEPH.

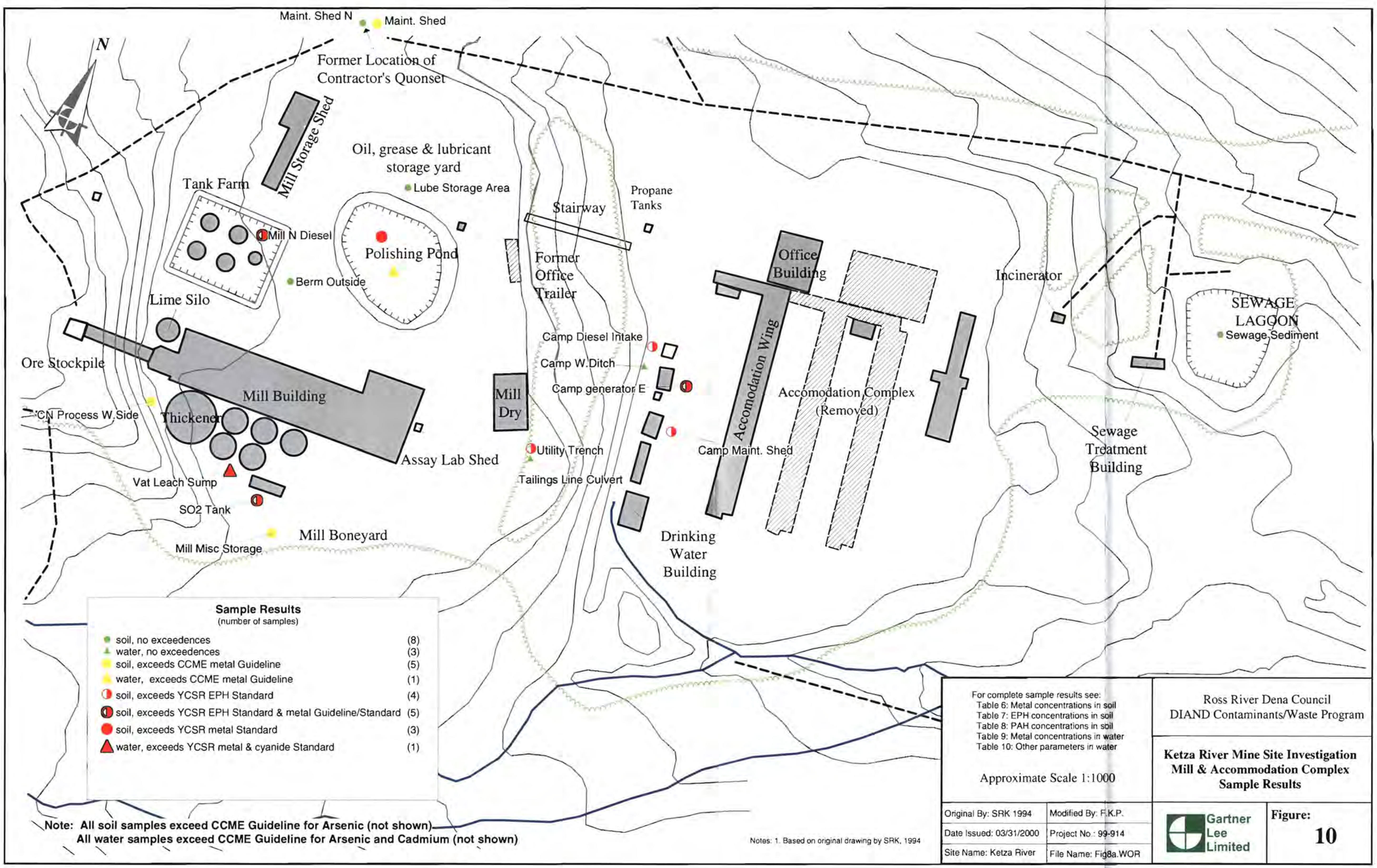
One soil sample was collected adjacent to the Aboveground Storage Tank (AST) at the 1510 portal. This sample exceeded the YCSR Industrial Standards for both copper and arsenic at 294 ppm and 7,470 ppm, respectively. The sample also exceeded the Industrial Standard for both Light and Heavy Extractable Petroleum Hydrocarbons, LEPH and HEPH.

8.3.3 Accommodation Complex

Sample locations for this area are shown on Figure 8. Results are presented on Tables 8.1 and 8.2 and shown graphically on Figure 10.

Three soil samples were collected around the ancillary buildings near the accommodation complex. One sample from near the camp backup generators (sample "Camp Generator E") contained zinc concentrations in excess of the CCME Industrial Guideline.


Sample Results
(number of samples)
soil, no exceedences (8)
water, no exceedences (3)
soil, exceeds CCME metal Guideline (5)
water, exceeds CCME metal & cyanide Guideline (1)
water, exceeds CCME metal Guideline (1)
soil, exceeds YCSR EPH Standard (4)
soil, exceeds YCSR EPH Standard & CCME metal Guideline (5)
soil, exceeds YCSR metal Standard (3)
water, exceeds YCSR metal & cyanide Standard (1)
water, exceeds YCSR metal Standard (3)
Note: All soil samples exceed CCME Guideline for Arsenic (not shown)
All water samples exceed CCME Guideline for Arsenic and Cadmium (not shown)
Gully Pooled Water
PEEL
CREEK
KR-15
CACHE CREEK
Break Zone
TP-Seepage KR-04
1510 Portal Diesel
GB-2
GB-1
Garbage-Seep Area
GB-3
GB-4
T.Pond
OXO CK
Waste Oil Storage
Tailings
D/G Grease Ramp
Upper Laydown
Maint. Shed. - N
Maint. Shed
N
Low Grade Stock-pile
CREEK
CACHE
See Figure 10
For complete sample results see:
Table 6: Metal concentrations in soil
Table 7: EPH concentrations in soil
Table 8: PAH concentrations in soil
Table 9: Metal concentrations in water
Table 10: Other parameters in water
100 0 100 200 300 m
Scale: 1:10,000
Ross River Dena Council
DIAND Contaminants/Waste Program
Ketza River Mine Site Investigation
Sample Results
Original By: SRK 1996
Modified By: F.K.P.
Date Issued: 03/31/2000
Project No.: 99-914
Site Name: Ketza River
File Name: Fig8.WOR
Gartner Lee Limited
Figure:
9
Notes: 1. Based on original drawing by SRK, 1996.


N
Maint. Shed N
Maint. Shed
Former Location of
Contractor's Quonset
Mill Storage Shed
Oil, grease & lubricant
storage yard
Lube Storage Area
Tank Farm
Mill N Diesel
Polishing Pond
Berm Outside
Stairway
Propane
Tanks
Former
Office
Trailer
Office
Building
Incinerator
SEWAGE
LAGOON
Sewage Sediment
Lime Silo
Ore Stockpile
Mill Building
CN Process W.Side
Thickener
Mill
Dry
Assay Lab Shed
Camp Diesel Intake
Camp W.Ditch
Camp generator E
Accomodation Wing
Accomodation Complex
(Removed)
Utility Trench
Tailings Line Culvert
Camp Maint. Shed
Sewage
Treatment
Building
Vat Leach Sump
SO2 Tank
Mill Boneyard
Mill Misc Storage
Drinking
Water
Building
Sample Results
(number of samples)
soil, no exceedences (8)
water, no exceedences (3)
soil, exceeds CCME metal Guideline (5)
water, exceeds CCME metal Guideline (1)
soil, exceeds YCSR EPH Standard (4)
soil, exceeds YCSR EPH Standard & metal Guideline/Standard (5)
soil, exceeds YCSR metal Standard (3)
water, exceeds YCSR metal & cyanide Standard (1)
Note: All soil samples exceed CCME Guideline for Arsenic (not shown)
All water samples exceed CCME Guideline for Arsenic and Cadmium (not shown)
Notes: 1. Based on original drawing by SRK, 1994
For complete sample results see:
Table 6: Metal concentrations in soil
Table 7: EPH concentrations in soil
Table 8: PAH concentrations in soil
Table 9: Metal concentrations in water
Table 10: Other parameters in water
Approximate Scale 1:1000
Ross River Dena Council
DIAND Contaminants/Waste Program
Ketza River Mine Site Investigation
Mill & Accommodation Complex
Sample Results
Original By: SRK 1994
Modified By: R.K.P.
Date Issued: 03/31/2000
Project No.: 99-914
Site Name: Ketza River
File Name: Fig8a.WOR
Gartner
Lee
Limited
Figure:
10

Two samples collected from an area of observed soil staining in front of the ancillary buildings contained HEPH concentrations greater than the YCSR Industrial Standard (IL). The sample collected from behind the camp generator ASTs (sample "Camp Diesel Intake") contained 1.5% LEPH, exceeding the YCSR Industrial Standard for LEPH. This high concentration of light extractable petroleum hydrocarbon is likely related to the spill in 1992 of 40,000 L of diesel fuel.

One sample of the sewage lagoon sediment was collected. No Standards or Guidelines, other than arsenic, were exceeded for the parameters tested.

8.3.4 Mill Complex

Sample locations for this area are shown on Figure 7. Results are presented on Tables 8.1 and 8.2 and shown graphically on Figure 9.

Four soil samples were collected from the south side of the mill building. Sample "CN Process W.Side" was collected from behind/west of the tailings thickener and contained copper concentrations in excess of the CCME Industrial Guideline. This sample also had an arsenic concentration of 6,170 ppm. The second sample was collected from near the SO_2 tank also had copper concentrations greater than the CCME Industrial Guideline and elevated arsenic concentration (8,810 ppm). This sample (SO_2 Tank) was also analyzed for sulphate, sulphide and total sulphur due to yellow discoloration of soils in the vicinity. The sample contained 1.6% total sulphur, which exceeds the YCSR Industrial Standard (IL) of 40 ppm for total sulphur. The third sample, "Mill Misc Storage" was collected from near the drums of used mill balls and this sample also contained copper concentrations greater than the CCME Industrial Guideline. The fourth sample was collected from the utility trench east of the mill building. This location is interpreted to be where the 1992 diesel spill occurred. The sample, "Utility Trench" had 3.2% LEPH which exceeds the YCSR IL for this parameter.

Four samples were collected from the main mill yard, north of the mill building. The first sample was collected from within the containment berm of the tank farm and contained LEPH concentrations greater than the YCSR IL; this sample also had copper concentrations greater than the CCME Industrial Guideline. The second soil sample was collected from an area of obvious hydrocarbon staining in front of he re-fuelling island. The sample, "Berm Outside" was only analyzed for metal contamination due to the obvious hydrocarbon contamination in this area. The sample did not exceed any metal Standards or Guidelines other than arsenic. The third sample was collected from the oil, grease and lubricant storage area and, curiously, did not contain any detectable concentrations of extractable petroleum hydrocarbons. This sample also had the lowest arsenic concentration (20 ppm) of any sample collected during the 1999 Phase 1 ESA. The last sample from this area was a sample of sediment collected in the polishing pond. The polishing pond soil sample exceeded the YCSR IL for copper and the CCME Industrial Guideline for copper, nickel, vanadium and zinc.

Two soil samples were collected from around the road maintenance contractor's Quonset hut location. Sample "Maint. Shed" was collected from the yard in front of the Quonset hut foundation and did not contain hydrocarbon concentrations greater than the YCSR IL. The sample contained copper concentrations greater than the CCME Industrial Guideline. Sample "Maint. Shed – N" was collected from near the gasoline AST at this location and no Standards or Guidelines were exceeded for the parameters analyzed in this sample.

8.3.5 Tailings Pond

One sample was collected from the waste oil storage area near the tailings pond. The sample location is shown on Figure 6. Results are summarized on Tables 8.1 and 8.2 and shown graphically on Figure 8. The sample from this area contained 2.8% HEPH which exceed the YCSR IL. With the exception of arsenic, all other metal concentrations in this sample were less than the applicable Standards and Guidelines.

Tailings in the impoundment originated from the milling of oxide ore deposits. No sulphide ores were milled (Canamax 1990). SRK (1994) indicates that geothite and hissingerite (a rare form of iron oxide) were the most abundant minerals present. Residual sulphide particles, mostly in the form of pyrite, were also present. Arsenic mineralization was predominantly in the form of scorodite (oxidized arsenopyrite). Analyses of tailings samples reported by SRK (1994) indicate high arsenic content (3.63 to 7.13%), low sulphide sulphur content (0.10 to 0.17%), and variable sulphate - sulphur content (0.01 to 0.22%). Porewater within the tailings mass was reported as containing 12.6 to 40 mg/L arsenic (SRK, 1996).

8.4 Water Quality Assessment

8.4.1 Overview

Surface water samples were collected directly from surface water bodies per established protocols specified in the *Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites* (CCME, 1993). Water samples were collected into pre-cleaned laboratory certified containers, specific for each chemical parameter to be analyzed. A 1 litre capacity plastic bottle was used for conventional parameters analysis. Samples collected for extractable petroleum hydrocarbons (EPH) were placed in 1 litre plastic bottles due to the unavailability of glass bottles. Samples for total metal analysis were placed in plastic 125 mL bottles and preserved with nitric acid. Samples to be submitted for the analysis of dissolved metal concentrations were filtered in the field using an in-line filter apparatus and then preserved with nitric acid. Samples for total cyanide analysis were collected in 1 litre plastic bottles containing the appropriate preservative for cyanide parameters. Immediately after collection, each sample was placed in a cooler and stored at approximately 4°C until delivered to the analytical laboratory. Standard chain-of-custody forms accompanied all samples submitted to the laboratory.

The water samples were submitted to Analytic Services Laboratories Ltd. (ASL) in Vancouver, B.C. to determine concentrations of total and dissolved metals, total cyanide, extractable petroleum hydrocarbons, acidity, alkalinity and sulphate.

The surface water sample results are summarized on the following tables:

- Table 8.4: Metal concentrations in surface water samples
- Table 8.5: Extractable petroleum hydrocarbon (EPH) and other parameters in surface water samples

The applicable regulatory guidelines and/or standards for each analytical parameter are included with the analytical data in each table. The laboratory reports and results of the QA/QC program are included in Appendix D. Figures 8 and 9 illustrate the location of elevated metal and cyanide concentrations in surface water samples collected from the mine site.

As a general observation, all surface water samples exceeded the CCME Aquatic Life Guideline for total arsenic (0.005 mg/L). Although the analytical detection limit for cadmium was greater than the CCME Aquatic Life Guideline for many samples, four samples (from the "Mining Area" and the "Polishing Pond" as described below) exceeded the CCME guideline for total cadmium (0.000017 mg/L). Most of the water samples collected also exceeded the Canadian Drinking Water Guideline for arsenic of 0.025 mg/L. Based on these observations, no further discussion of arsenic and cadmium concentrations in water is provided. The development of tier 2 or tier 3 arsenic and cadmium objectives would be appropriate for this site.

8.4.2 General Mining Area

Three water samples were collected from mining areas. The locations are shown on Figure 6, and analytical results are summarized on Tables 8.4 and 8.5 and shown graphically on Figure 8.

The first sample was collected from water pooled in the Gully Zone Pit. This sample exceeded the YCSR Aquatic Life (AW) Standard for zinc. The sample also exceeded the CCME Aquatic Life Guideline for aluminum, arsenic, cadmium and zinc.

The second sample was collected from Peel Creek at monitoring site KR-15, downstream of the Gully Zone Pit. This sample contained total aluminum and iron concentrations that exceeded the YCSR Aquatic Life (AW) Standard. The sample also exceeded the CCME Aquatic Life Guidelines for arsenic, cadmium, copper and zinc. Anecdotal information suggests that Peel Creek may historically have contained poor water quality and, therefore, a review of historical water quality is necessary to ensure that current water quality results are interpreted in an appropriate context.

TABLE 8.4: RESULTS OF WATER ANALYSIS - TOTAL AND DISSOLVED METALS

Surface Water Samples (mg/L)

Sample ID	CCME Aquatic Life	Yukon CSR Aquatic Life Standard [b]	Mining Area			Mill & Accommodation Complex					Tailings Pond	
			Gully Polled Water	KR-15	Garbage-Seep Area	Low Grade Stock-	Camp W.Ditch	Polishing Pond	Vat Leach Sump	Tailings Line Culvert	TP-Seepage KR-04	T.Pond
Sample Date	Guideline [a]		99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Physical Test												
Hardness CaCO3			4.03	322	187	499	339	68.8	50.5	143	342	254
pH			7.03	7.83	8.04	7.66	799	8.18	8.11	8.14	7.89	8.18
Total Metals												
Aluminum	0.1	0.5	*0.130*	***0.75***	0.081	<0.01	0.02	0.090	0.0011	0.026	<0.01	0.020
Antimony	-	0.3	<0.0001	<0.0002	0.0002	0.0036	<0.0002	0.0005	0.0004	0.0010	0.0003	0.0019
Arsenic	0.005	0.5	*0.0132*	*0.0623*	*0.0778*	***0.586***	*0.0055*	*0.0877*	*0.303*	*0.321*	*0.0328*	***1.17***
Barium	-	10	<0.01	0.01	<0.01	<0.01	0.001	0.03	<0.01	0.01	0.01	<0.01
Beryllium	-	0.053	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.002	<0.001
Boron	-	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	0.000017	0.002-0.018 [c]	*0.00068*	*0.0002*	*0.00005*	*<0.0001*	*<0.0001*	*0.00005*	*<0.00005*	*<0.00005*	*<0.0001*	*<0.0005*
Calcium	-	-	1.32	92.6	62.8	1.76	113	25.1	18.5	48.8	114	81.1
Chromium	0.001-0.0089 [d]	0.02	<0.0005	<0.001	<0.0005	<0.001	<0.001	<0.0005	<0.0005	<0.0005	<0.001	<0.0005
Cobalt	-	0.5	0.0024	0.0199	<0.0001	<0.0002	0.0013	0.0002	0.0005	0.0013	0.0029	0.0002
Copper	0.002-0.004 [c]	0.02-0.09 [c]	0.0014	*0.0047*	0.0003	0.0029	0.002	0.0161	*0.0032*	*0.013*	*0.0049*	0.0019
Iron	0.3	3	0.20	***5.88***	0.06	0.05	<0.03	0.07	***2.69***	0.07	<0.03	0.15
Lead	0.001-0.007 [c]	0.04-0.16 [c]	0.00078	<0.0001	0.00048	0.0001	0.0005	0.00044	*0.00121*	0.00016	0.002	0.00101
Magnesium	-	-	0.4	22.2	7.4	12.3	13.6	1.5	0.7	5.0	2	12.6
Manganese	-	1	0.172	0.076	<0.005	0.049	0.021	<0.005	0.051	<0.05	<0.002	0.013
Mercury	0.0001	0.001	<0.00002	<0.000002	<0.00002	<0.00002	<00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	0.073	10	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	0.025-0.15 [c]	0.25-1.5 [c]	0.002	0.009	<0.001	<0.002	<0.002	0.002	0.001	0.001	<0.001	<0.001
Potassium	-	-	<2	<2	<2	<2	<2	<2	<2	<2	2	<2
Selenium	0.001	0.01	<0.001	<0.002	<0.001	<0.002	<0.002	<0.001	<0.001	<0.001	<0.002	<0.001
Silver	0.0001	0.001	<0.00001	<0.00002	<0.00002	<0.00002	<0.00002	*0.0009*	0.00001	0.00001	<0.00002	<0.00001
Sodium	-	-	<2	<2	<2	<2	2	<2	5	5	9	4
Thallium	0.0008	0.003	<0.00005	<0.0001	<0.00005	<0.0001	<0.0001	<0.00005	<0.00005	<0.00005	<0.0001	<0.00005
Titanium	-	-	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	-	3	<0.0001	0.0011	0.001	<0.0002	0.0012	0.0009	<0.0001	0.0015	0.0017	0.0014
Vanadium	-	-	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	0.03	0.3	***0.475***	*0.045*	<0.005	<0.0 05	0.01	0.014	0.014	0.014	<0.03	<0.005

Sample ID	Mining Area		Mill Complex		Tailings Pond	
	Gully Polled Water	KR-15	Low Grade Stock-	Vat Leach Sump	TP-Seepage KR-04	T.Pond
Sample Date	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Physical Test						
Hardness CaCO3	4.03	322	499	50.5	342	254
pH	7.03	7.83	7.66	8.11	7.89	8.18
Dissolved Metals						
Aluminum	0.016	0.06	<0.01	<0.005	<0.01	0.005
Antimony	<0.0001	<0.0002	0.0035	0.0003	0.0003	0.0018
Arsenic	0.0041	*0.0052*	***0.552***	0.0432	*0.0306*	***1.12***
Barium	<0.01	0.01	<0.01	<0.01	0.01	<0.01
Beryllium	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001
Boron	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	*<0.00005*	*0.0002*	*<0.0001*	*<0.00005*	*<0.0001*	*<0.00005*
Calcium	1.34	92.3	179	19.1	113	81.0
Chromium	<0.0005	<0.001	<0.001	<0.0005	<0.001	<0.0005
Cobalt	<0.0001	0.0211	<0.0002	0.0004	0.00028	0.0001
Copper	0.0004	0.0008	0.0015	0.0016	*0.0044*	0.0011
Iron	<0.03	***3.87***	<0.03	0.06	<0.03	<0.03
Lead	<0.001	<0.0002	<0.0002	<0.0001	<0.0002	<0.0001
Magnesium	0.2	22.3	12.5	0.7	14.5	12.5
Manganese	<0.005	0.074	0.048	0.045	0.417	<0.005
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	<0.001	0.010	<0.002	<0.001	0.002	<0.001
Potassium	<2	<2	<2	<2	2	<2
Selenium	<0.001	<0.002	<0.002	<0.001	<0.002	<0.001
Silver	<0.00001	<0.00002	<0.00002	<0.00001	<0.00002	<0.00001
Sodium	<2	<2	<2	<2	9	4
Thallium	<0.00005	<0.0001	<0.0001	<0.00005	<0.0001	<0.00005
Titanium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	<0.0001	0.0010	<0.0002	<0.0001	0.0014	0.0012
Vanadium	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	<0.005	*0.030*	<0.005	0.0001	<0.005	<0.005

NOTES:

"-" not analyzed or no standard

<0.005 less than de

[a] CCME, 1999. Canadian Water Quality Guidelines for Protection of Aquatic Life.

[b] Government of Yukon. 1997. Contaminated Sites Regulations. Generic Numerical Water Standards

[c] Guideline/Standard varies with water hardness

[d] Guideline is valance dependent

italics Sample exceeds CCME Aquatic Life Guideline

bold, italics Sample exceeds Yukon CSR Aquatic Life Standard

TABLE 8.5: RESULTS OF WATER ANALYSIS - EPH AND OTHER PARAMETERS

Surface Water Samples (mg/L)

Sample ID	CCME Aquatic Life Guideline [a]	Yukon CSR Aquatic Life Standard [b]	Mining Area			Mill & Accommodation Complex					Tailings Pond	
			Gully Polled Water	KR-15	Garbage-Seep Area	Low Grade Stock-	Camp W.Ditch	Polishing Pond	Vat Leach Sump	Tailings Line Culvert	TP-Seepage KR-04	T.Pond
Sample Date			99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24	99/09/24
Physical Test												
Conductivity (umhos/cm)			12	644	373	937	639	148	<2	312	694	513
Hardness CaCO3			4.03	322	187	499	339	68.8	50.5	143	342	254
pH			7.03	7.83	8.04	7.66	799	8.18	8.11	8.14	7.89	8.18
Total Suspended Solids			9	17	3	<3	-	<3	9	<3	<3	7
Dissolved Anions												
Acidity (to pH8.3)			3	9	1	8	-	2	<1	2	9	2
Alkalinity - Total			2	75	157	22	-	54	15	100	194	123
Sulphate	-	1000	2	268	40	490	-	14	43	61	183	144
Cyanides												
Total Cyanides	0.005 (free CN)	0.05 (WAD)	-	-	-	-	-	<0.005	0.022	-	0.009	<0.005
Extractable Hydrocarbons												
EPH 10-19	-	0.5 [c]	-	-	-	-	<0.6	-	-	<0.6	-	-
EPH 10-32	-	not present [c]	-	-	-	-	<2	-	-	<2	-	-

NOTES:

"-"	not analyzed or no standard
<0.005	less than detection limit
a	CCME. 1999. Canadian Water Quality Guidelines for Protection of Aquatic Life.
b	Government of Yukon. 1997. Contaminated Sites Regulations. Generic Numerical Water Standards
italics	Sample exceeds CCME Aquatic Life Guideline
bold, italics	Sample exceeds Yukon CSR Aquatic Life Standard

The third water sample was collected from a small are of ponded water near the mine landfill. This sample, "Garbage Seep Area" did not exceed any applicable Guidelines and Standards for the parameters tested, other than arsenic and cadmium.

8.4.3 Mill & Accommodation Complex

Five water samples were collected from the mill and accommodation complex area. The sample locations are shown on Figure 7, and analytical results are summarized on Tables 8.4 and 8.5 and shown graphically on Figure 9.

A water sample was collected from the drainage ditch behind the camp ancillary buildings (sample "Camp W.Ditch"), but did not did not exceed any applicable Guidelines and Standards for the parameters tested, other than arsenic. The concentrations of extractable petroleum hydrocarbons were less than detection limit in this sample.

The second water sample was collected from ponded water in the utility trench near the 1992 fuel line break. This sample, "Tailings Line Culvert" had arsenic and copper concentrations greater than the CCME Aquatic Life Guideline. The concentrations of extractable petroleum hydrocarbons were less than detection limit in this sample.

The third water sample from the mill area was collected from the polishing pond. This sample exceeded the CCME Aquatic Life Guideline for arsenic, cadmium, and silver. The concentration of total cyanide was less than detection limit in this sample.

The fourth water sample was collected from the sump below the cyanide vat leach tanks. This sample contained arsenic (0.3 mg/L), copper, iron, and lead concentrations greater than the CCME Aquatic Life Guideline. The sample also contained a total cyanide concentration of 0.022 mg/L. This can not be directly compared to the CCME Aquatic Life Guideline and the YCSR Aquatic Life Standard because these guidelines are stated in terms of weak-acid-dissociable (WAD) cyanide.

The fifth sample from the mill area was collected from ponded water on the ore stockpile pad. This sample contained an arsenic concentration of 0.586 mg/L which is greater than the YCSR Aquatic Life Standard and the drinking water quality guideline.

8.4.4 Tailings Pond Water Quality

Brodie (1998) reported that arsenic in the tailings supernatant had remained in the range of 1.5 to 2 mg/L for the period from 1993 to 1996, and that arsenic concentrations in the porewater ranged from 2.54 to 39.7 mg/L. Of the other heavy metals that were present at elevated concentrations in the tailings pond during operations, such as copper, nickel and zinc, only arsenic remained elevated (SRK, 1996). Brodie (1998) noted that a report by SRK in 1995 concluded that arsenic release from the tailings to occurred at about the same rate for submerged and exposed tailings, although SRK (1996) indicated that a water cover may, in fact, lead to increased arsenic release.

Total and weak acid dissociable cyanide were undetectable (< 0.005 mg/L) throughout 1996. Ammonia was less than 0.08 mg/L throughout the year (YCG Resources Ltd. 1997).

In order to minimize the release of soluble arsenic to the environment, the SRK Abandonment Plan (1996) proposed to maintain the tailings pond at the then current 1309 to 1310 meter elevation, and minimize the water flowing through the tailings pond which could mobilize soluble arsenic to the receiving environment. The plan was based on the assumption that:

1. chemical contaminants within the stored tailings such as arsenic would be contained within the impoundment;
2. contaminant levels in the seepage emerging from the facility would remain at current concentrations (although they noted that the available data were insufficient to determine if the arsenic retention in the soils beneath the tailings dam then observed would continue indefinitely); and
3. the flux of arsenic from the tailings into the pond water would remain constant, or improve.

The critical period for potential receiving environment impact was anticipated to be during the low flow periods from December to April, when available dilution in Cache Creek was at a minimum.

The sample of tailings pond water collected during the Phase 1 ESA contained 1.17 mg/L total arsenic, which is the only parameter that exceeded both CCME and YCSR Aquatic Life Guidelines/Standards. The concentration of total cyanide was less than detection limit in this sample (Tables 8.4 and 8.5).

8.4.5 Tailings Seepage Water Quality

Brodie (1998) reported that treatment and discharge of tailings pond water ceased in August 1991, and that, since that time and until 1998, the pond level fluctuated within a 1.5 m range. He noted that this implied that all water entering the pond (groundwater from the north side of the pond, leakage from the diversion ditches and incident precipitation) escaped by seepage through or under the dams. Trends in seepage volumes are not available since monitoring ceased several years ago.

While tailings pond water continued to show high arsenic concentrations (Brodie 1998), the seepage water from the impoundment generally showed lower arsenic levels (< 0.01 mg/L) than were present at the Cache Creek background site at KR-1 (SRK 1996). SRK (1994 and 1996) postulated that the arsenic was adsorbed by the tailings, dam and underlying foundations soils as seepage water passed through the system. Monitoring wells in the dam showed much lower arsenic concentrations than were present in the tailings pond or tailings pore water, and only slightly higher that the seepage water quality.

Cyanide species were undetectable (<0.005 mg/L) in the seepage and ammonia ranged from <0.005 to 1.5 mg/L throughout 1996 but is reported as showing a generally decreasing trend since mine closure (YCG Resources Ltd. 1997).

The seepage water sample (KR-04) collected in September 1999 contained arsenic and copper concentrations greater than the CCME Aquatic Life Guideline. The sample contained 0.009 mg/L total cyanide, which is less than the YCSR Aquatic Life Standard for WAD cyanide (see Tables 8.4 and 8.5).

8.4.6 Receiving Water Quality

Brodie (1998) noted that receiving water quality, as measured at station KR-08 in Cache Creek about one kilometer downstream of the tailings pond, consistently met permit criteria and standards for the protection of aquatic life. However, this site does not include potential impacts from the Gully Zone, QB Zone, or Knoll Zone Pits and associated waste rock dumps. Brodie provided a summary of flows, arsenic concentration and arsenic loads at an upstream site (KR-1), the tailings seepage (KR-04 and 05) and the downstream site (KR-08), and conducted a mass balance check. These indicated a reasonable mass balance.

Brodie (1998) noted that arsenic concentrations appeared to decrease as water passed through or by the mine site. He indicated that SRK (1996) postulated that this was due to adsorption of arsenic onto soils in the mine site area and conducted adsorption tests on soil samples. However, Brodie noted that a mechanism for the adsorption of arsenic onto native soils was not proposed, that the soil capacity to retain arsenic decreased after 200 pore volumes passed over the sample, that the more absorptive soil is located on the valley walls rather than in the valley bottom, and that there were no tests to confirm what type of soils the water might be passing through. He concluded that there was insufficient information to assume little or no potential for future water quality problems associated with the release of arsenic on the basis of soil adsorption potential.

SRK (1996) suggested that there was a valid mechanism for arsenic removal as the tailings pond seepage moved through the underlying soils. They also estimated that the input of arsenic from the tailings seepage was only about 2% of the upstream load (SRK, 1996).

It is the opinion of the Phase I investigation team that the adsorption mechanism may be effective for the reduction of arsenic concentrations in the tailings pond seepage but that this mechanism can not be relied upon to prevent future problems from arsenic and metal leaching from other areas of the site. In general, there has been insufficient study of ARD and metal leaching potential in other areas of the site to confidently assume that the Gully Zone is the only potential source of current and future contamination.

8.5 ARD Assessment

As part of the Phase I investigation, 7 rock and tailings samples were collected for static ARD tests from various areas around the site, including:

- Waste rock at the1430 Portal
- Fine waste rock at the Break Zone Pit
- Waste rock from below the Ridge Zone Pit
- Waste Rock at the Ridge Zone Pit
- Gully Pit waste rock
- Low Grade Ore Stockpile, and,
- Tailings

Sample locations are shown on Figure 6. Samples were submitted to Canadian Environmental and Metallurgical Inc., Vancouver, BC, for analyses of:

- Standard Sobek acid-base accounting, including rinse pH, paste pH, and inorganic carbon.
- Sulphur species, including total sulphur and sulphate sulphur.
- Inductive Coupled Plasma (ICP) Metals scan on the solids after aqua regia digestion.
- Atomic Adsorption (AA) analyses for arsenic.

Three of the samples were submitted for soluble metal extraction tests, conducted at a water:solids ratio of 3:1, over a 24 hour extraction period.

8.5.1 Underground Workings

There was no evidence of seepage at the 1430 portal. Litmus paper testing of the pooled surface water outside the portal indicated a pH of about 5.5. A discharge pipe was evident on the outer edge of the waste rock pad, outside the portal, but there was no discharge from the pipe at the time of the site investigation. Brodie (1998) reported that seepage from the 1430 portal had an arsenic concentration of 0.326 mg/L (presumably in a sample collected during the October 28,1998 site visit). This value was noted by Brodie (1998) as being above the Water Licence grab sample limit for arsenic of 0.3 mg/L for the discharge from the portal settling pond.

A rock sample was collected from the 1430 Portal area. Static acid-base accounting analyses indicated that the sample was alkaline (rinse pH of 8.1), with a low sulphide content (0.08%S) and high neutralization potential (NP of 186.9 kg $CaCO_3$ equivalent/tonne). Thus the sample would be classified as acid consuming. The majority of the neutralization potential was likely due to limestone, given a calcium content of 5.96% and a total inorganic carbon analysis providing an equivalent of 120.8 kg $CaCO_3$/tonne. Crushed pH was 8.8, higher than the rinse pH, suggesting that fresh carbonates were released from the crushing of the particles, and that the particle surfaces were slightly weathered. Leachable metals may be present, due to a sulphate content of 0.05 %S, suggesting the sample was partially weathered. The sample solids contained 0.82-0.89 % arsenic, 225 ppm copper and 199 ppm zinc.

Litmus paper testing of water pooled just inside the 1510 Portal indicated a pH of about 5.8. There was no visible drainage from the 1510 Portal at that time. Brodie (1998) reported that an internal dam behind the1510 Portal directs drainage to the 1420 level. Water from the 1420 level was historically directed to the tailings impoundment via a small pipeline. During the September 24, 1999 site investigation, no water was exiting from the boarded up 1420 portal. The pipe designed to carry water from the 1420 portal was broken above the mine site access road, such that any discharge from that pipe could enter the diversion ditches and, thereby, enter the receiving environment (Photo 2).

The 1550 Portal was not visited due to time constraints.

8.5.2 Open Pits and Associated Waste Rock Piles

There are nine open pits at the mine (Table 5.1), which are all reported as being side-hill excavations without significant depressions (SRK, 1994; Brodie, 1998). During the site investigation, the Ridge Zone, Break Zone and Gully Zone pits were visited. This included a special effort to reach the Gully Zone Pit, since Brodie (1998) reported that the site was a source of low pH water. The QB Zone, Tarn Zone and Knoll Zones Pits were not visited due to time constraints, difficulty of access, and the onset of snow during the site investigation.

Waste rock samples were collected from a pile of fine waste at the Break Zone Pit, from a waste rock pile on the plateau below the Ridge Zone Pit, from the waste rock side-cast immediately adjacent to the Ridge Zone Pit, and from the Gully Zone during the September 24, 1999 site investigation.

Break Zone Pit

There was no visible drainage or seepage from the Break Zone pit or waste rock. A sample was collected from a pile of fine-grained dark-coloured waste rock in the pit (see Photo). The static test results (Appendix A) indicate that the sample was alkaline (rinse and crushed pH of 8.3), with low sulphide content (0.02%S) and relatively low neutralization potential (NP of 34.4 kg $CaCO_3$ equivalent/tonne). The sample would be classified as acid consuming. Only 44% of the neutralization potential can be attributed to limestone, given a calcium content of 1.09% and a total inorganic carbon analysis providing an equivalent of 15 kg $CaCO_3$/tonne. Leachable metals may be present, due to a sulphate content of 0.05 %S, suggesting the sulphur in the sample was predominately weathered. The sample solids contained 1.89 % arsenic and 772 ppm copper.

Due to the relatively low neutralization potential displayed by this sample, this sample was selected for a soluble metal extraction test, in which the sample was mixed with distilled water at a 3:1 water:solids ratio, shaken for 24 hours, and the resultant solution extracted, filtered and analysed. Few metals were detectable in the resulting solution, other than calcium typical of limestone. Sulphate was 6 mg/L in the solution, and arsenic was less than 0.2 mg/L, representing a release of less than 0.6 g/tonne of waste rock.

Ridge Zone Pit

There was no visible drainage or seepage from the Ridge Zone pit or waste rock. Visible slump and/or tension cracks in the side-cast Ridge Zone waste rock dump re shown in Photo 9.

A sample was collected from a pile of side-cast waste rock in the pit. The static test results (Appendix D) indicate that the sample was alkaline (rinse pH of 8.1 and crushed pH of 8.4), with low sulphide content (0.01%S) and a high neutralization potential (NP of 313.8 kg $CaCO_3$ equivalent/tonne). The sample would be classified as strongly acid consuming. Almost 83% of the neutralization potential can be attributed to limestone, given a total inorganic carbon analysis providing an equivalent of 260 kg $CaCO_3$/tonne and a calcium content of 10.7%. Leachable metals may be present, due to a sulphate content of 0.07 %S, suggesting the sulphur in sample was predominately weathered. Moreover, the sample solids contained 3.25% arsenic, more typical of ore or tailings (SRK, 1994). The copper content was 529 ppm.

A sample was also collected from a distinct pile of rock located on the plateau below the Ridge Zone Pit. Static acid-base accounting analyses indicated that the sample was alkaline (rinse pH of 8.0 and crushed pH of 8.1), with relatively high sulphide content (0.28%S) and a moderately high neutralization potential (NP of 116.3 kg $CaCO_3$ equivalent/tonne). The sample would be classified as acid consuming, with an NP/AP ratio of 13.3. Approximately 36% of the neutralization potential can be attributed to limestone, given a total inorganic carbon analysis providing an equivalent of 42 kg $CaCO_3$/tonne and a calcium content of 4.04%. Leachable metals may be present, due to a sulphate content of 0.04 %S, suggesting the sulphur in sample was partially weathered. The sample solids contained little arsenic (0.05%) or copper (59 ppm) but higher zinc (374 ppm) than other waste rock samples.

Due to the high sulphide content, this sample was selected for a soluble metal extraction test. Few metals were detectable in the resulting solution, other than calcium typical of limestone. Sulphate was 75 mg/L in the solution, and arsenic was less than 0.2 mg/L, representing a release of less than 0.6 g/tonne of waste rock.

Gully Zone Pit

A special effort was made to reach the Gully Pit area, since it had been reported as a source of low pH water (Brodie 1998).

Litmus paper testing during the September 24, 1999 site investigation of pooled water on the access road in the Gully Pit area indicated a pH of about 5.0. A sample of waste rock was collected from the Gully Zone Pit (see Photo 10). The static test results (Appendix D) indicate that the sample was acidic, with a rinse pH of 4.5 and a crushed pH of 5.3. This suggests that the outside of the particles were more acidic than the core of the particles, which provided additional alkalinity when crushed. The sample contained low sulphide content (0.01%S) and a low neutralization potential (NP of 0.9 kg $CaCO_3$ equivalent/tonne). The sample would be classified as acidic, with a limited potential for additional acid generation. There was low carbonate present, as indicated by a total inorganic carbon analysis giving an equivalent of 0.8 kg $CaCO_3$ equivalent/tonne. Most of the sulphur present in the sample was in the form of sulphate (0.11%S), suggesting that leachable metals may be present. Sample solids contained 0.44% arsenic, copper of 73 ppm, and few other trace metals of environmental interest.

Due its acidic nature, this sample was selected for a soluble metal extraction test. Calcium was evident in the resultant solution, possibly from gypsum, as total inorganic carbon indicated that low carbonate was present. Dissolved iron (0.09 mg/L) and zinc (0.007) were at detectable levels in this sample (as compared to other samples subjected to soluble metals tests) due to the acidic nature of the sample. These represent potential release rates of 0.27 and 0.021 g/tonne for iron and zinc, respectively. Sulphate was 60 mg/L in the solution, and arsenic was less than 0.2 mg/L, representing a release of less than 0.6 g/tonne of waste rock.

Water draining from the Gully Pit was reported as having a pH of 2.74, elevated sulphate (1,940 mg/L), elevated arsenic (2.6 mg/L), elevated copper (43.8 mg/L) and elevated zinc (2.99 mg/L) (Brodie 1998 referring to SRK 1995,Table 2). Additional monitoring in the Gully Pit area does not appear to have been undertaken on a regular basis.

Brodie (1998) notes that the impacts from water draining the Gully Pit and associated waste rock are not incorporated in the sampling conducted at Station KR-08 because this station is located in Cache Creek above the confluence with Peel Creek. A monitoring station in Peel Creek, adjacent to the mine access road (KR-15) has been located to monitor impacts from the Gully Zone area. However, this site does not appear to be identified as a required monitoring location in the current water licence, as no data for this site is reported in the 1996 Annual Report (YCG 1997).

Other Pits

Topographic maps indicate that potential impacts from the QB Zone may be captured by monitoring at the KR-15 site in Peel Creek. However, no data for this site is reported in the 1996 Annual Report (YCG, 1997). Potential impacts from the Knoll Zone area would not be captured by monitoring at KR-15 or any other known monitoring site.

Brodie (1998) referred to the Ketza River Mine Tailings Testing Report (SRK 1995) which indicated elevated levels of arsenic of 0.122 mg/L in drainage from the Tarn Pit. September 24, 1999 site investigation did not include a visit to the Tarn Zone.

Brodie (1998) noted that it is not known whether the water draining from the other mine workings (i.e. open pits and underground workings) meets water licence criteria. However, he reported that the results of a single sampling (ref. SRK 1995, Table 2) indicated that water quality is "probably acceptable". Brodie (1998) noted that sampling of water emanating from the waste rock dumps has not been conducted. He commented that it is believed that there are not water quality issues associated with the waste dumps, although the basis for this belief is not stated.

8.5.3 Low Grade Ore Stockpile

Brodie (1998) noted that sampling of water emanating from the low grade ore stockpile had not been conducted, and that the stockpile could contain elevated concentrations of arsenic or other metals.

During the September 24, 1999 site investigation, a single grab sample was collected from a portion of the low grade ore stockpile that appeared to contain predominantly grey limestone. This sample was not considered to be representative of the stockpile as a whole. The stockpile visibly consisted of a variety of distinct rock types. Some appeared to be heavily oxidized, being siliceous and rust coloured, and almost clinkered. It is believed that this may be hissingerite referred to in the geological descriptions. Litmus paper testing of pooled surface water on the top of the stockpile indicated a pH of about 5.3.

Static test analyses of the rock sample indicated that the sample was alkaline, with a rinse pH of 7.8 and a crushed pH of 8.1. This suggests that the outside of the particles were more weathered than the core of the particles, which provided additional alkalinity when crushed. The sample contained low sulphide content (0.08%S) and a high neutralization potential (NP of 445 kg $CaCO_3$ equivalent/tonne). The sample would be classified as strongly acid consuming. Nearly 99% of the neutralization potential in the sample could be attributed to carbonates, based on a total inorganic carbon analysis giving an equivalent of 439 kg $CaCO_3$ equivalent/tonne, and a calcium content of 17.1%. Little of the sulphur present in the sample was in the form of sulphate (0.01%S). Sample solids contained 0.16% arsenic and 45 ppm copper.

Representative samples from other rock types present in the low grade ore stockpile should be collected for ABA and soluble metal extraction tests to determine the potential of arsenic and other metal release from this source as a whole.

8.5.4 Tailings

A tailings sample, as well as a sample of tailings pond supernatant, was collected during the September 24, 1999 site investigation. Static acid-base analyses of the tailings sample indicated that the sample was alkaline, with a rinse pH of 7.9 and a crushed pH of 8.2. This suggests that the outside of the tailings particles were more weathered than the core of the particles, which provided additional alkalinity when crushed. The sample contained low sulphide content (0.13%S) and a moderately high neutralization potential (NP of 112 kg $CaCO_3$ equivalent/tonne). The sample would be classified as strongly acid consuming. Nearly 99% of the neutralization potential in the sample could be attributed to carbonates, based on a total inorganic carbon analysis giving an equivalent of 111 kg $CaCO_3$ equivalent/tonne, and a calcium content of 4.4%. Some of the sulphur present in the sample was in the form of sulphate (0.07%S). Sample solids contained 3.73% arsenic, typical of ore and tailings (Brodie 1998; SRK 1994 and 1996). Copper content was 675 ppm, and slightly higher concentrations of lead (130 ppm), antimony (145 ppm) and zinc (225 ppm) were found than in the waste rock and low grade ore samples.

9 Tailings Pond Water Balance Assessment

In the spring of 1999 the Subsidiary Creek diversion spilled water into the tailings pond, which caused the water level to rise significantly. This is demonstrated by the development of erosion channels across the roadway between the Subsidiary Creek diversion and the tailings pond. This flow may have been caused by blockage of the diversion ditch by glaciation ice, causing spring melt water to flow out of the ditch and into the pond. The efficiency of the diversion ditches has also been reduced by the blowout of the Northwest interceptor ditch.

There are two concerns with respect to rising water levels in the tailings pond that are related to an uncontrolled release of tailings pond water through the existing spillway:

1) A discharge of water containing elevated arsenic concentrations to Cache Creek; and
2) The geotechnical stability of the emergency spillway and underlying sediments if water is to flow over the spillway.

An updated water balance assessment for the tailings pond has been developed as described below in order to evaluate the risk of an uncontrolled release of water from the pond. The exact elevation of the emergency spillway invert is unknown. Elevations in various reports have varied from 1312.5 m ASL to 1311.7 m ASL. The lower spillway elevation has been used, in the interests of conducting a conservative assessment.

9.1 Methodology

This water balance model follows that described in Appendix C of the SRK 1996 Abandonment Plan, using the annual precipitation and runoff values obtained from site records. Initial storage was determined from a measurement taken during a DIAND site inspection on June 19, 1999. The pond elevation was measured at 1.2m below the spillway (with an assumed elevation of 1311.7m), giving an elevation of 1310.5 for initial storage. Using the Elevation-Area-Capacity curve presented in SRK 1996, initial storage was calculated to be 508,320 m^3, with a maximum storage capacity of 602,100 m^3. An on-site observation was made on October 1, 1999 by Vic Enns (EP-Yukon) that the tailings pond was not more than one meter below the spillway elevation. The data used in the updated water balance was calibrated to provide a tailings pond water elevation of approximately 1310.7 on September 30, 1999.

Two models have been developed to predict when an uncontrolled discharge (via the spillway) from the tailings pond may occur. These models are:

- Model 1 – No Spring Overflow of Subsidiary Creek Diversion
- Model 2 – Spring Overflow from Subsidiary Creek Diversion

For both models, two scenarios were used:

- Scenario 1 – Standard Water Balance
- Scenario 2 – Increased Dam Seepage

Scenario 1 makes the assumption that nothing has changed in the water balance model except for a one percent reduction in the diversion ditch efficiency, from 97.2% (SRK 1996) to 96.2%. This is in part due to the failure of the Northwest interceptor ditch. Scenario 1 assumes a total dam seepage rate of 5.45 L/s, as estimated by the Environment Protection Service of Environment Canada.

Scenario 2 assumes that the tailings pond seepage rate has increased due to the higher hydraulic head caused by increased water levels in the pond. A seepage rate of 6 L/s was used, which is between the 5.45 L/s used in Scenario 1 and a high-end estimate of 7 L/s as estimated by SRK (1996). The ditch diversion efficiency was decreased by 0.12% to 96% in order to calibrate the model to the observed water balance in 1999.

Complete water balance calculations are presented in Appendix C of this report.

9.2 Model 1 - No Overflow from Subsidiary Creek Diversion

Scenario 1 – Standard Water Balance
In this scenario (Figure 11), the model predicts that water levels would continue to rise (with seasonal fluctuations) and that water would spill over the spillway in September/October of 2001 (estimated at 3,300 m^3 total). In 2002, the predicted period of overflow is extended from July to November.

Scenario 2 – Increased Dam Seepage
Scenario 2, with increased dam seepage, is also shown on Figure 10. Overflow from the tailings pond is not predicted to occur until 2002, occurring from July to November.

9.3 Model 2 - Spring Overflow from Subsidiary Creek Diversion

In this model, it was assumed that glaciation and blockage of the Subsidiary Creek Diversion would cause spring flood waters to flow directly into the tailings pond. A similar event in the spring of 1999 may have caused the observed rise in the pond water level.

Flood frequency analysis was conducted using the methodology outlined in: "Design Flood Estimating Guidelines for the Yukon Territory" (Janowicz 1989). Flood frequency analysis was conducted for the following flood return periods:

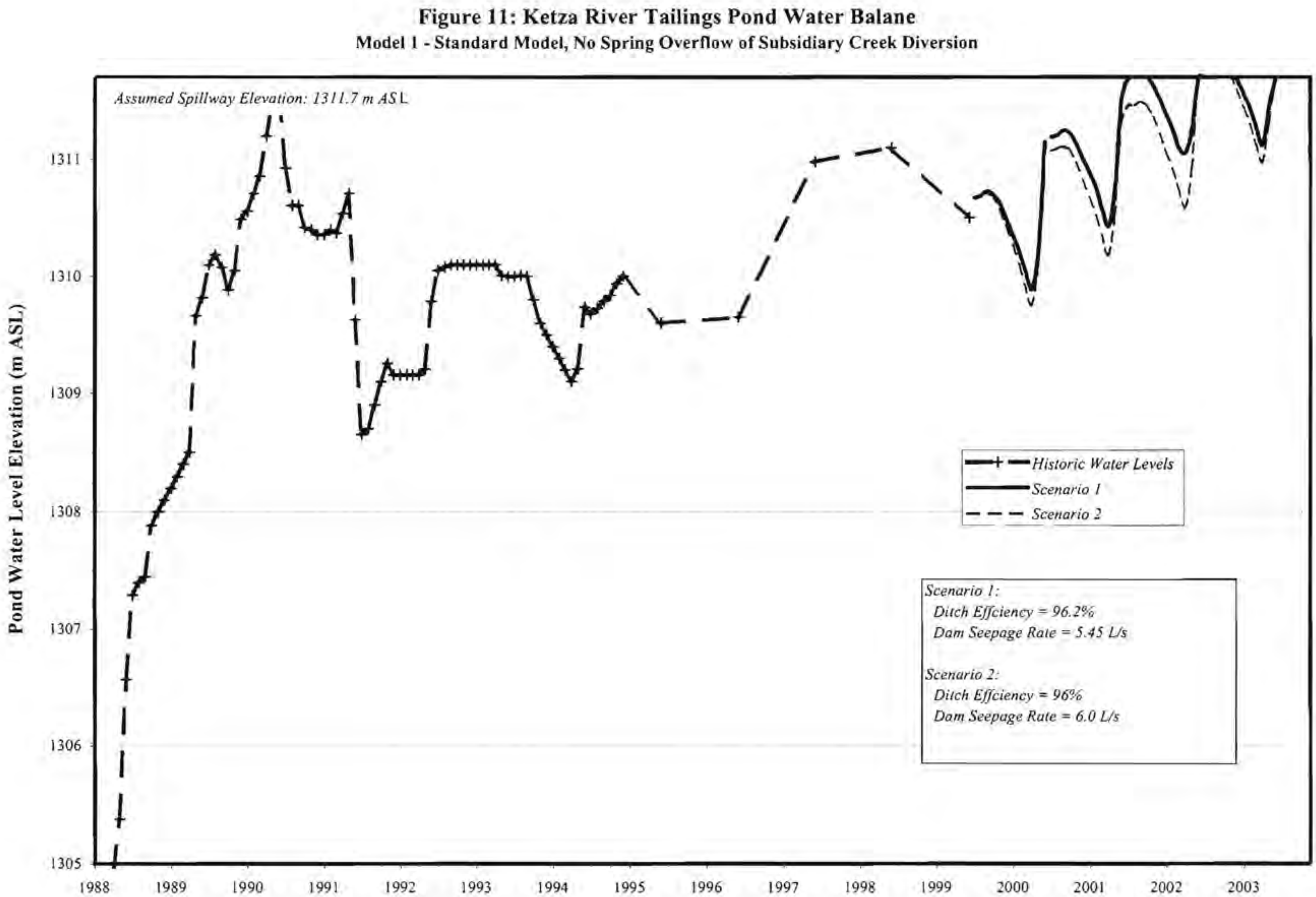


Figure 11: Ketza River Tailings Pond Water Balane
Model 1 - Standard Model, No Spring Overflow of Subsidiary Creek Diversion
Assumed Spillway Elevation: 1311.7 m ASL
Pond Water Level Elevation (m ASL)
1305
1306
1307
1308
1309
1310
1311
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Historic Water Levels
Scenario 1
Scenario 2
Scenario 1:
Ditch Effciency = 96.2%
Dam Seepage Rate = 5.45 L/s
Scenario 2:
Ditch Effciency = 96%
Dam Seepage Rate = 6.0 L/s

- Dry Year (2 year return period)
- Average Year (Mean Annual Flood, MAF)
- Wet Year (10 year return period)
- Extreme Event (100 year return period)

Input from the Lower Subsidiary Creek Diversion was taken into account in the water balance model from June 1, 2000 (usual spring freshet occurs late May - early June), to estimate the time interval for the tailings pond elevation to rise above the spillway elevation.

Results of this analysis for Scenario 1 (Standard Water Balance) are shown on Figure 12, and for Scenario 2 (Increased Dam Seepage) are shown on Figure 13. This model predicts that the pond would fill to the overflow elevation 3 days and 12 days after the onset of freshet for a wet year and a dry year, respectively. This assumes that the Subsidiary Creek diversion ditch is completely blocked and that 100% of the flow in Lower Subsidiary Creek flows into the tailings pond. Extreme events (i.e. 100-year floods) are not shown on Figures 12 and 13, but the model predicts that an extreme event would fill the tailings pond to the overflow elevation in less than 2 days.

9.4 Discussion of Water Balance Assessment

Based on an assessment of the updated water balance described above, the water level in the tailings pond is predicted to reach the assumed spillway invert elevation (resulting in an uncontrolled release of water) as shown on Table 9.1:

Table 9.1: Summary of Water Balance Modelling Results

	Scenario 1	**Scenario 2**
Model 1 – No Spring Overflow from Subsidiary Cr.		
No Overflow from Subsidiary Creek	September 2001	July 2002
Model 2 - Spring Overflow from Subsidiary Cr.		
Dry Year (2-Year Flood)	10 days*	11 days*
Standard Year (Mean Annual Flood)	7 days*	7 days*
Wet Year (10-Year Flood)	3 days*	3 days*
Extreme Event (100-Year Flood)	1 to 2 days*	1 to 2 days*

** from start of freshet (assumed June 1st, 2000)*

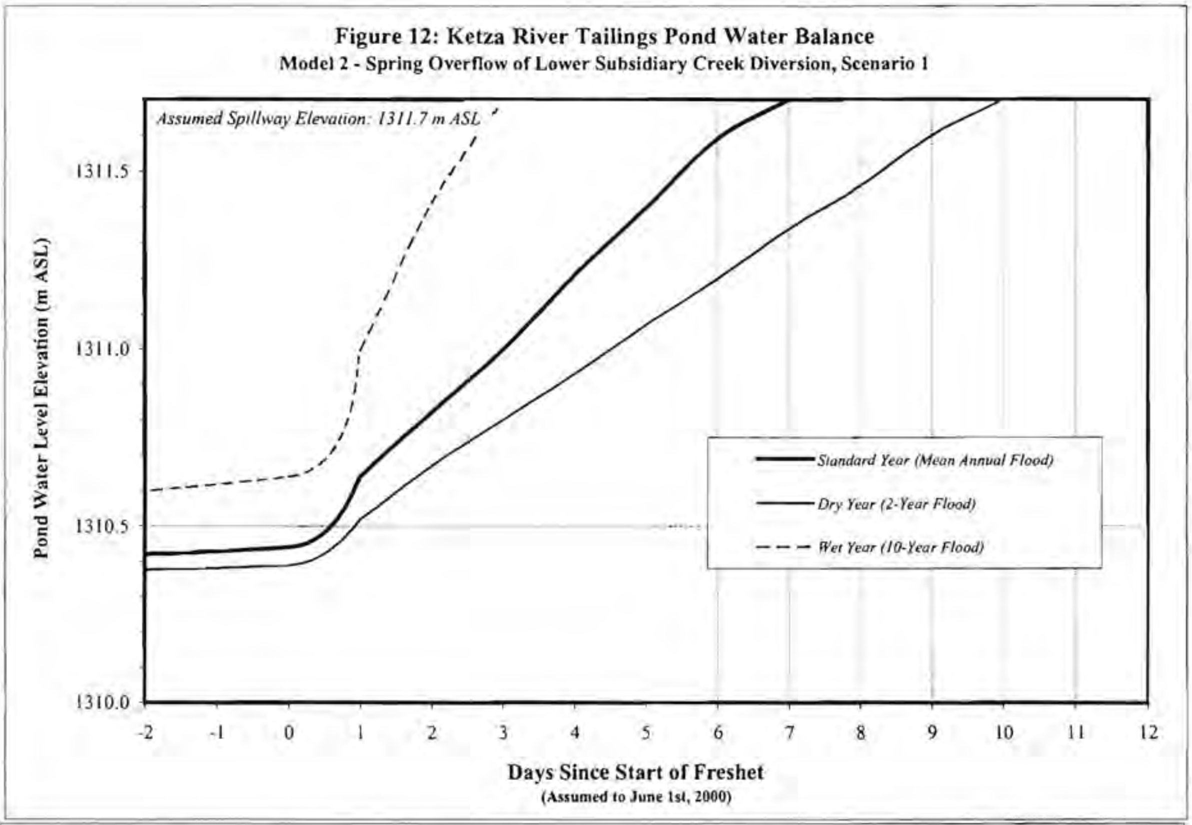


Figure 12: Ketza River Tailings Pond Water Balance
Model 2 - Spring Overflow of Lower Subsidiary Creek Diversion, Scenario 1
Assumed Spillway Elevation: 1311.7 m ASL
Pond Water Level Elevation (m ASL)
1311.5
1311.0
1310.5
1310.0
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
Standard Year (Mean Annual Flood)
Dry Year (2-Year Flood)
Wet Year (10-Year Flood)
Days Since Start of Freshet
(Assumed to June 1st, 2000)

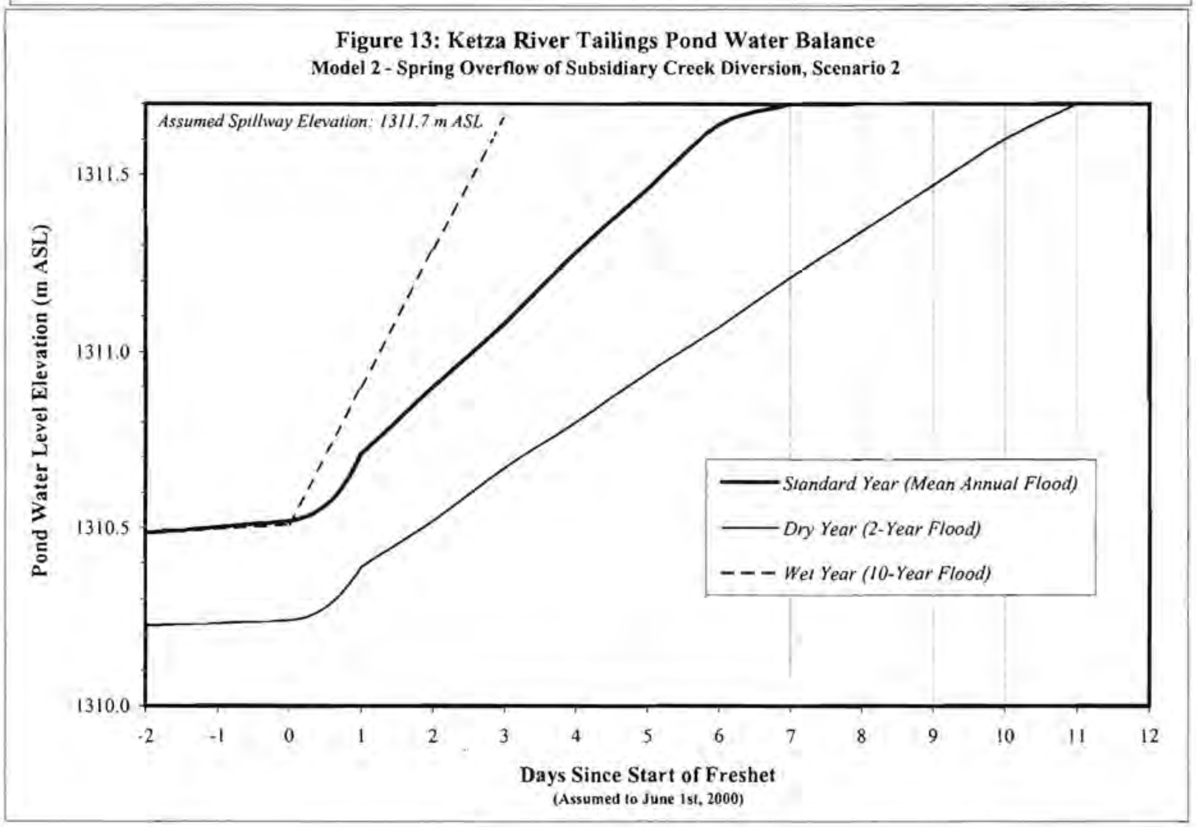


Figure 13: Ketza River Tailings Pond Water Balance
Model 2 - Spring Overflow of Subsidiary Creek Diversion, Scenario 2
Assumed Spillway Elevation: 1311.7 m ASL
Pond Water Level Elevation (m ASL)
1311.5
1311.0
1310.5
1310.0
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
Standard Year (Mean Annual Flood)
Dry Year (2-Year Flood)
Wet Year (10-Year Flood)
Days Since Start of Freshet
(Assumed to June 1st, 2000)

The overflow condition could occur from 3 to 11 days after the onset of freshet in the spring of 2000 if the Subsidiary Creek Ditch is blocked with ice causing flow into the tailings pond. The onset of freshet varies but typically occurs in late May and early June. Extreme events, such as rapid melting of the snow pack due to warm weather could result in an overflow water level in less than two days. If the ditch is not blocked, water levels are predicted to reach the overflow elevation in September 2001 or July 2002, depending on ditch leakage and dam seepage rates.

10 Conclusions

This section provides an overall summary of the environmental issues identified in the Phase 1 Environmental Site Assessment (ESA) that was conducted at the Ketza River mine site located in the Pelly Mountains of Yukon Territory.

10.1 Traditional Land Use and Heritage Resources

1. The information offered in the interview sessions (Greer 2000) showed that:

   - The Ketza area features one of the highest concentrations of key land use features, such as the game licks, in the Pelly Mountains area that are known and used by the Ross River people.
   - Use of the Ketza area as a key hunting area, especially as a summer hunting area, is likely old; it predates the mine and the mine road and the 1940s.
   - Prior to mine development, the Ketza area was used by certain specific Ross River families, not by all members of the Ross River community. It would be desirable to confirm who these families were, i.e., what families had stewardship responsibilities over the Ketza area.
   - The available evidence (e.g., high concentration of key land use features such as the licks, known camping spot, cache location and sacred mountain) suggests that the Ketza area has a very, very high heritage site potential. There likely are both archaeological and historic period sites here that have not been documented. Some heritage sites may already have been destroyed or damaged by the mine development, however.

2. Based on the review of background information, it is apparent that little consideration was given to impacts on heritage resources or on traditional uses of the mine area prior to development. Consequently, base-line information on traditional use and heritage resources in the Ketza area before the mine was not assembled.

3. Both positive and negative comments about the effect of the Ketza mine development on their use of the area were received from the individuals interviewed. It must be noted that the data is general, not specific, and must be evaluated in light of the bigger context of socio-economic impacts that include other projects.

4. The impact of the mine development on the values of the Ross River people is important. The mine was built beside the sacred mountain known as *Dene Nezedi*. While specific information is lacking on just how this would have affected the community, the importance of this issue should be acknowledged.

5. Although no sites are on record in the area, it cannot be stated that no sites were affected by the development simply because no effort has been made to document them in the area. The Pelly Mountains are not well known archaeologically. The traditional land use data assembled in the December 1999 interviews suggests that the Ketza area has a very, very high potential for heritage sites.

10.2 Human Health & Safety

1. The Ketza River mine site does not currently have an on-site caretaker and the front gate is not locked, which exposes the public to safety hazards on the mine site.

2. There are many hazardous and non-hazardous wastes and chemicals still on site, including sodium cyanide, acids and other reagents, which are not stored in a safe manner that minimizes hazards to the public.

3. The mill building is open and unlocked. The building is poorly lit and the second level contains many holes in the decking and areas without guardrails. The mill also contains numerous chemicals and milling equipment/tanks that may contain reagents. These issues constitute a series of human health and safety hazards in the mill building.

4. The 1430 and 1510 adits are poorly sealed. The seals do not adequately prevent public exposure to safety hazards in the underground mine.

5. The status of the 1550 backfill raise to the surface is unknown. If the raise is open and accessible, then it represents a public safety hazard.

6. The SO_2 tank was investigated by DIAND personnel in October 1999 and found to be generally empty of sulphur dioxide, although some residual fluid was observed in the bottom of the tank. The human health hazard would be reduced if the tank were ballasted with an inert material, such as sand.

10.3 Environmental

Soils Quality

1. Elevated arsenic concentrations above the CCME Industrial Guideline were found in all 22 samples collected on site. Geochemical surveys conducted for mineral exploration in this area have encountered arsenic concentrations ranging from 200 ppm to 5000 ppm. A Tier-3 site-specific guideline (as permitted by CCME Guidelines) for arsenic would be beneficial in interpreting arsenic concentrations in an appropriate context.

2. Several other metals exceeded the CCME Industrial Guideline including copper, nickel and zinc.

3. A large volume diesel spill occurred onsite in 1992. Mine operators estimated that approximately 14,000 L of diesel was not recovered and could have been retained in the soils. Two surficial soil samples collected from the spill area contained 1.5% and 3.26% light extractable petroleum hydrocarbons (LEPH), which were greater than the Yukon Contaminated Sites Regulations Industrial Standard (YCSR IL).

4. Other areas of hydrocarbon staining were observed around the site including:

   - 1510 AST (soil sample contained LEPH and HEPH concentrations > YCSR IL)
   - The Upper Boneyard (soil sample contained 1.24% HEPH, > YCSR IL)
   - Contractors' Quonset hut
   - Oil, grease and lubricant storage yard
   - Tank farm
   - Vehicle re-fuelling island
   - Vehicle parking area north of mill dry
   - South mill yard (outside of vehicle repair bays)
   - Camp generator & maintenance sheds
   - Waste oil storage area
   - Former re-fuelling/waste oil storage area near Peel Creek (interpreted, not visited during Phase 1 ESA)

5. Total sulphur (sulphate) concentrations greater that the YCSR IL were found in a sample collected from discoloured soils near the SO_2 tank.

6. A sample of tailings contained the following metals that exceed the YCSR IL:
   - Arsenic (37,300 ppm)
   - Copper (675 ppm)
   - Antimony (145 ppm)

Water Quality

1. Elevated total arsenic concentrations above the CCME Aquatic Life Guideline were found in all 10 surface water samples collected on site. Since arsenic concentrations in water samples have been elevated historically, a Tier-2 or Tier-3 site-specific guideline (as permitted by CCME Guidelines) for arsenic would be beneficial in interpreting arsenic concentrations in an appropriate context. The sample locations were restricted to the mine site and did not include the receiving water downstream of the mine site.

2. Copper concentrations in excess of the CCME Aquatic Life Guideline were detected in four water samples. The water sample collected from the vat leach sump contained elevated cyanide and lead concentrations. Two water samples collected from the Peel Creek drainage contained aluminum and zinc above the CCME Aquatic Life guideline; one of the samples also exceeded the YCSR Aquatic Life Standard. Four water samples from the mining area and the polishing pond contained cadmium concentrations that exceeded the CCME Guideline.

3. Cyanide concentrations were generally low and less than the CCME and YCSR IL Guidelines including samples of the tailings pond water and tailings dam seepage water.

4. Others have reported that ammonia in the tailings pond seepage remains slightly elevated (up to 1.5 mg/L), but displays a generally decreasing trend (YGC 1997). Receiving water quality at KR-8 has consistently met receiving water criteria (Brodie 1998).

5. Arsenic in the tailings pond water continues to remain in the 1 to 2 mg/L range and is not decreasing.

6. Arsenic in tailings dam seepage water has remained at lower levels than most other samples. SRK (1996) has postulated that adsorption of arsenic by the dam and foundation soils is minimizing mobilization into the receiving water. The adsorption mechanism may be effective for the reduction of arsenic concentrations in the tailings pond seepage but in the opinion of this project team, this mechanism can not be relied upon to prevent future problems from arsenic and metal leaching from other areas of the site.

7. SRK (1996) has suggested that the mobilization of arsenic to the receiving water could be reduced by minimizing the areal extent of the tailings pond such that seepage volumes are minimized. SRK (1996) also suggested that minimizing the areal extent of the tailings pond size might reduce the amount of arsenic released to the overlying pond such that less arsenic would be available for release to the receiving environment during discharge events.

Acid Rock Drainage

1. The limited rock characterization program performed for the Phase I ESA provides some general indications of ARD potential but additional sampling and assessment is required to appropriately and completely quantify the potential for continued ARD and/or metal leaching from the waste rock dumps and open pits.

2. The low pH and low neutralization potential of the Gully Zone sample suggests that acid generation is occurring the Gully Zone area.

3. Other grab samples contained relatively low sulphide content, and sufficient buffering capacity to be classified as acid consuming

4. Soluble metal extraction tests indicated that three grab samples did not release substantial amounts of metals of environmental concern.

5. The various waste rock piles sampled displayed a wide range of metal and ARD characteristics, there are numerous discrete unsampled rockpiles on site, and the mill ore stockpile visibly contained discrete rock types.

6. Areas of greatest concern for release of acidic drainage or metal leaching are the mill ore stockpile and mine workings in vein deposits hosted in the Proterozoic phyllite and quartzite basal unit (Gully and QB area).

10.4 Geotechnical

1. A revised water balance assessment was conducted as part of this Phase I ESA in light of increased water levels in the tailings pond and increased ditch leakage due to observed ditch failures.

    - Based on this assessment, critical (overflow) water levels in the tailings pond could occur from 3 to 11 days after the onset of freshet in the spring of 2000 if the Lower Subsidiary Creek Ditch is blocked with ice causing flow into the tailings pond. The onset of freshet varies but typically occurs in late May and early June. Extreme events, such as rapid melting of the snow pack due to warm weather, could result in critical water levels in less than two days.
    - If the Lower Subsidiary Creek ditch is not blocked, water levels could reach the critical (overflow) elevation in September 2001 or July 2002, depending on ditch leakage and dam seepage rates.

2. Diversion ditches and culverts (Cache Creek, Lower Subsidiary Creek and the Northwest Interceptor Ditch) will require ongoing maintenance to prevent excess flows from entering the tailings impoundment. Specifically these maintenance issues include:

   - Piping failure of the Northwest Interceptor Ditch.
   - Slumping and blockage of the Northwest Interceptor Ditch.
   - Erosion evidence of overtopping (blockage) of the Lower Subsidiary Creek Diversion.
   - Partial blockage of the Lower Subsidiary culverts.
   - Slumping (due to permafrost degradation) of the Cache Creek Diversion.
   - Erosion of the friable bedrock underlying the Cache Creek drop structure.

3. There is insufficient equipment on site to provide the necessary ongoing maintenance.

4. The main access road requires ongoing maintenance, especially to allow heavy equipment to access the site for tailings impoundment maintenance.

5. Static stability of the dams does not appear to be an issue. Observations indicate that the dams are stable against slope failure and piping

6. The seismic stability of the North Dam has been reviewed by two competent consultants. One concluded that there is a stability issue while one concludes there is little concern. A detailed slope stability assessment with drilling is recommended by Brodie (1998) to determine if the stability is acceptable. However, a staged approach starting with a seismic assessment and a stability analysis using existing data would be beneficial to determine if drilling is required.

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Appendix A

Photographs

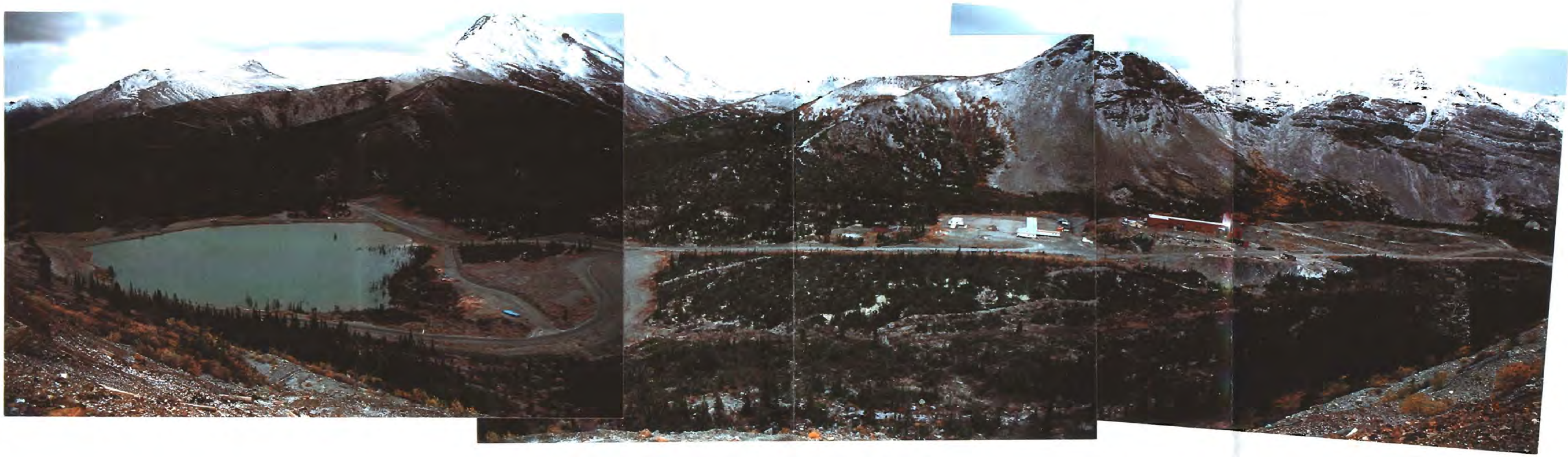


Photo 1: View of Ketza River Mine Site looking south. Mine features from left to right (east to west) including: tailings pond, Cache Creek diversion (in background), waste oil and battery storage, waste coconut fiber, used sulphuric acid drums (blue), Subsidiary Creek diversion, Subsidiary Creek valley in foreground, sewage lagoon and sewage treatment building, camp kitchen trailers, remainder of accommodation and office complex, mill complex and yard, foundation of road maintenance contractor's Quonset hut (in foreground) and ore stockpile pad at left-edge of photo.

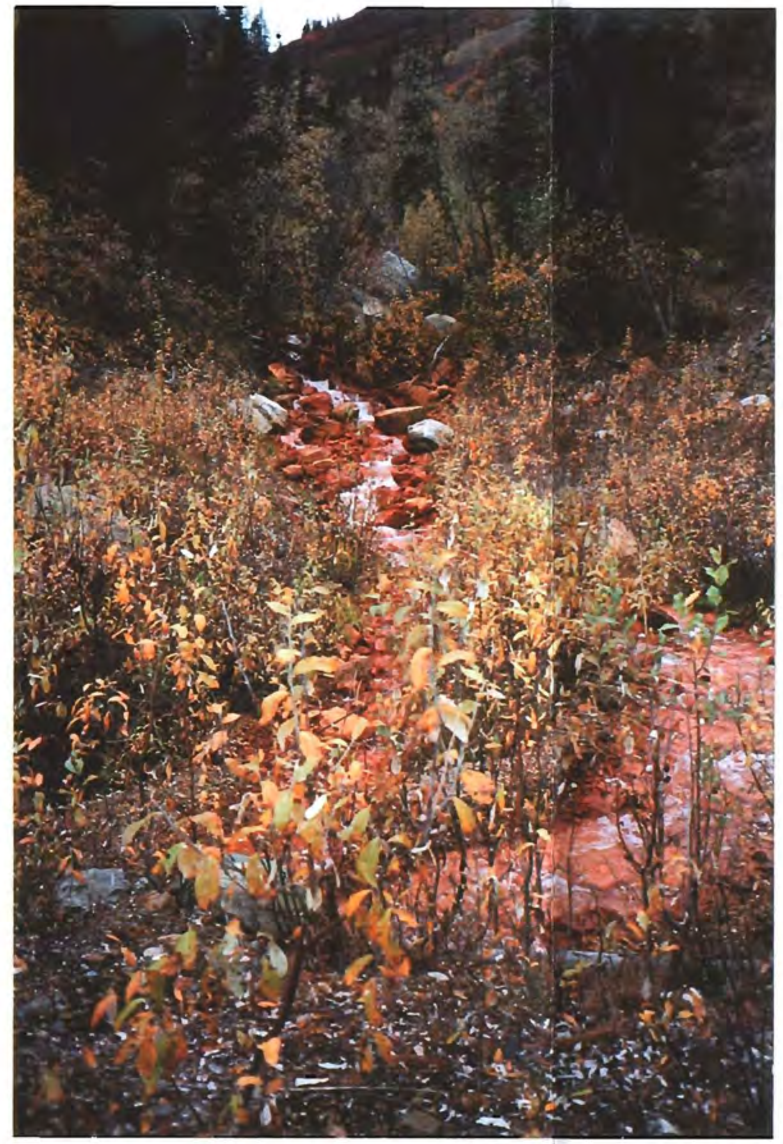


Photo 2: Waste rock dump below portal 1430.

Photo 3: Location of water sample 5, collected at KR-15

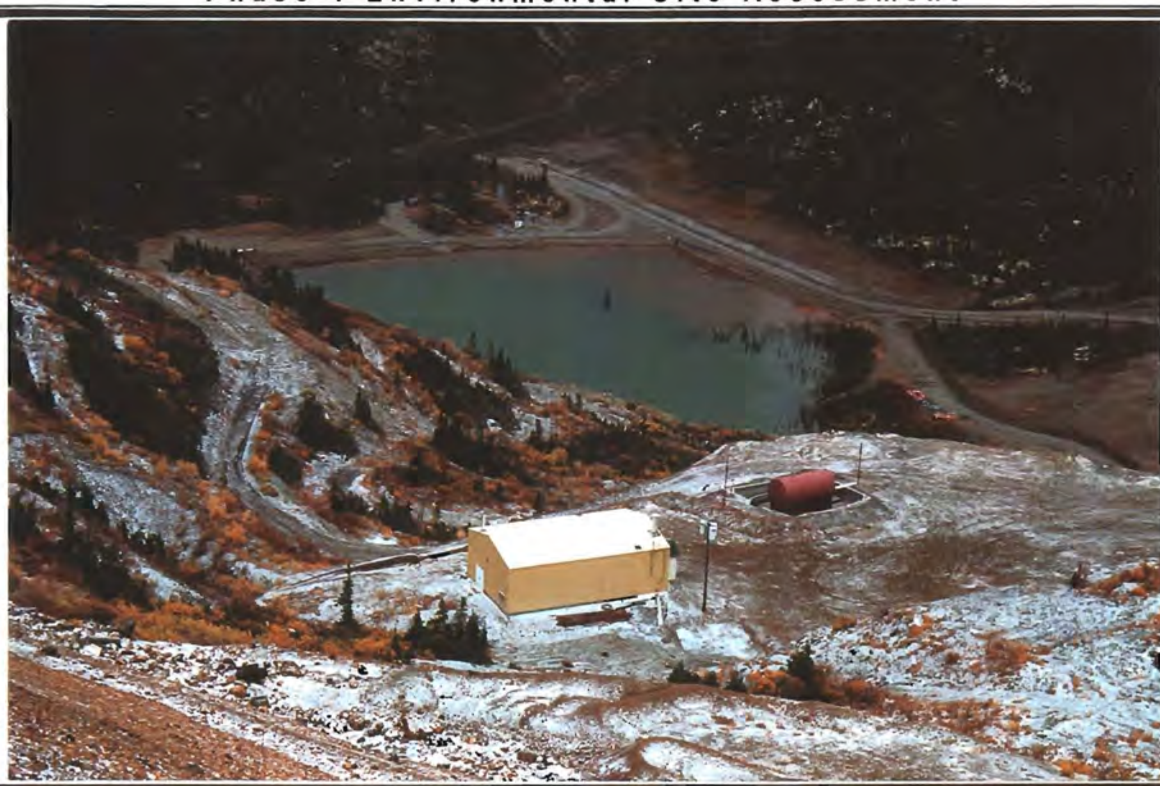


Photo 4: Mine dry and Aboveground Storage Tank (AST) at 1510 portal. Tailings pond and Cache Creek diversion in background.

Photo 5: AST at 1510 portal used for fuelling underground equipment.

Photo 6: 1430 adit.

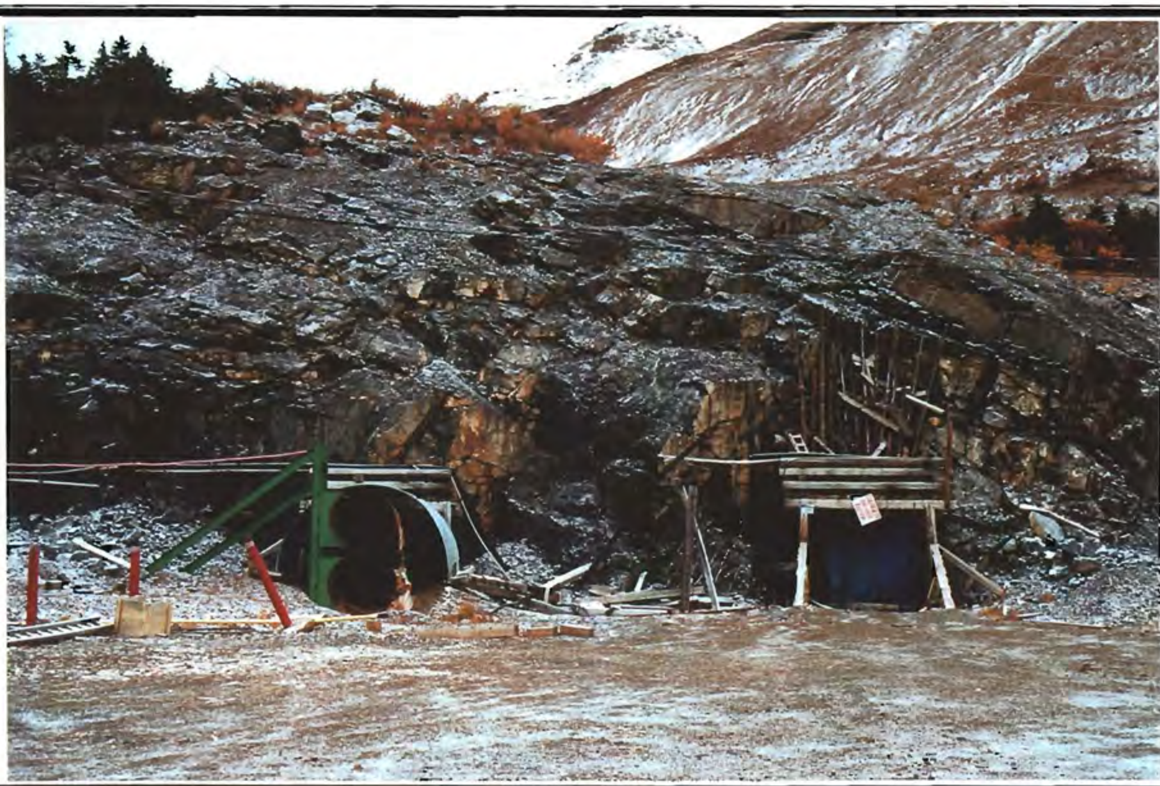


Photo 7: 1510 portal, mine ventilation portal to left.

Photo 8: 1550 adit.

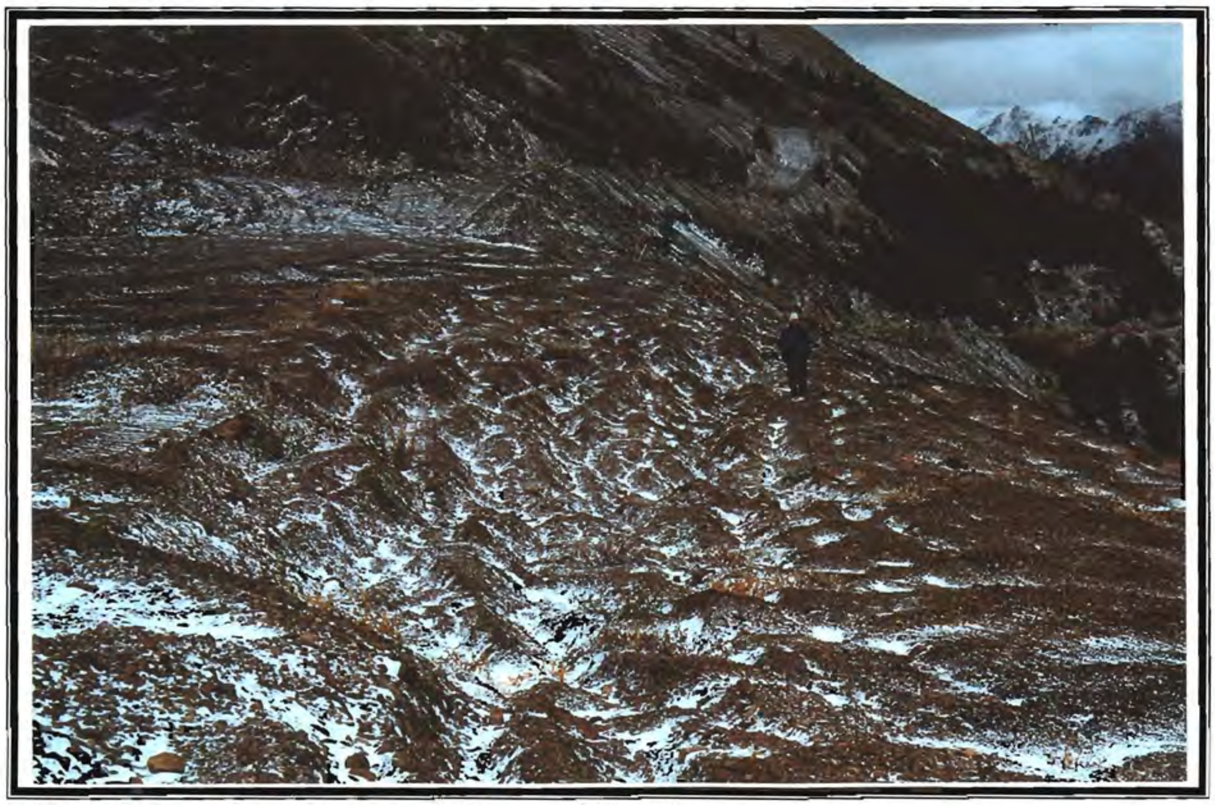


Photo 9: Slumping of waste rock dump at Ridge Pit.

Photo 10: Gully Pit.

Photo 11: QB Pit, Peel Creek in foreground.

Photo 12: View of core racks and exploration camp, looking west. Generator shed in middle, office trailer to left.

Photo 13: Grease ramp at exploration camp, some surface hydrocarbon staining in right foreground.

Photo 14: View of landfill crest and toe looking eastward.

Photo 15: Burnt debris on upper surface of landfill.

Photo 16: Upper boneyard.

Photo 17: Upper surface of ore stockpile looking westward. Upper Subsidiary Creek diversion in background.

Photo 18: View of mill conveyor and mill yard, looking eastward. Site features looking left to right (north to south): Foundation of contractor's Quonset hut, mill reagent storage shed, lubricant storage area (in background), tank farm, polishing pond, mill dry building (accomodation complex in background), mill building with lime silo in foreground, tailings thickener and cyanide leach vats in background, mill boneyard including mill balls in red 45-gallon drums and transformers (5), Cache Creek valley along right (south) edge of photo.

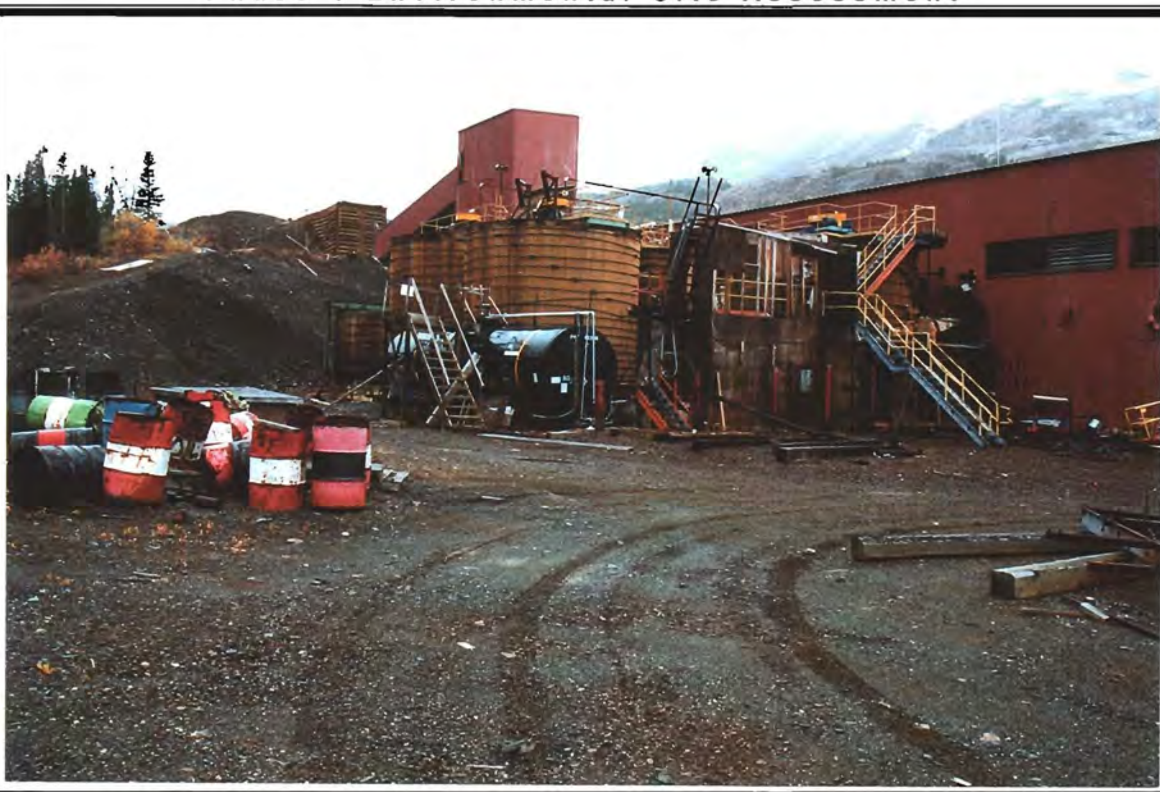


Photo 19: Cyanide leach vats and former location of water treatment plant in foreground. Note SO_2 railcar.

Photo 20: Portion of mill boneyard. Note drums of used mill balls in foreground. Tank in background is temporary storage.

Photo 21: Tank farm and fueling island. Note drum of gasoline.

Photo 22: Interior of tank farm. Note limey/concrete liner.

Photo 23: Oil, grease, lubricant and antifreeze storage area. Polishing pond in background. Mill dry behind pond.

Photo 24: Full oil/lubricant drums in mill yard. Daytanks are empty.

Photo 25: Foundation of road maintenance contractor's Quonset hut. Note heavy hydrocarbon staining of soil in front of gasoline tank. Ore stockpile in background.

Photo 26: Bank north of contractor's Quonset, looking upstream of Subsidiary Creek.

Photo 27: Polishing pond. Oil, lubricants and grease storage to right of photo behind pond. Mill reagent storage shed in background.

Photo 28: Remainder of accommodation/office complex, camp generator shed to right of photo. Note test pits in foreground from diesel spill.

Photo 29: Ancillary building next to accommodation complex. From left to right (south to north): camp water treatment building; storage shed/carpenter shop, paint(?) shop, electrical shed, backup generator shed, portable generator (orange).

Photo 30: ASTs for camp generators.

Photo 31: Erosion, failure and pounded water flowing towards failure in northwest diversion ditch.

Photo 32: Failure and erosion of northwest diversion ditch.

Photo 33: Ditch near confluence/Subsidiary Creek. Note failures and ponding, need for maintenance.

Photo 34: Sulphuric acid drums, some partially full. Coconut fiber and used oil drums in background. Tailings pond to left and Subsidiary Creek diversion to right of photo.

Photo 35: Industrial batteries and empty 45-gallon drums. Note pallet of black hydrochloric acid drums on left-edge of photo.

Photo 36: Waste coconut fiber for carbon-in-pulp cyanide extraction process.

Photo 37: Potentially full crate of Sodium Cyanide adjacent to tailings pond.

Photo 38: Tailings pond seepage sample (KR-04) taken from pipe-discharge from toe of North Dam.

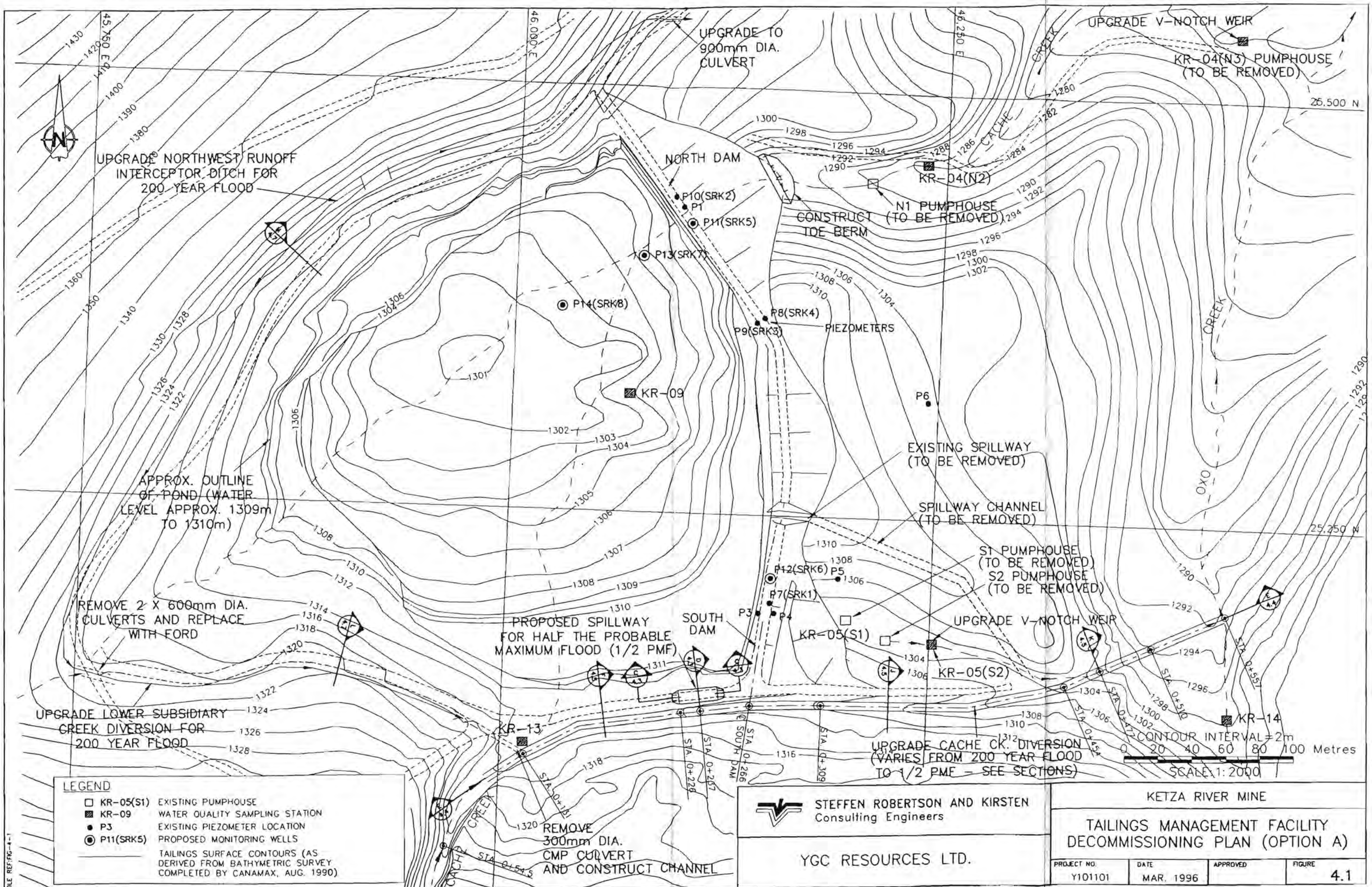
Photo 39: Sample location KR-5 (S1) – seepage from South Dam. Break Zone Pit and waste rock dump in background.

Photo 40: Erosion on access road

Photo 41: Ketza River washing out access road to mine

Appendix B

Drawings Referenced from Previous Reports


UPGRADE TO 900mm DIA. CULVERT
UPGRADE V-NOTCH WEIR
KR-04(N3) PUMPHOUSE (TO BE REMOVED)
25,500 N
45,750 E
46,000 E
46,250 E
UPGRADE NORTHWEST RUNOFF INTERCEPTOR DITCH FOR 200 YEAR FLOOD
NORTH DAM
P10(SRK2)
P1
P11(SRK5)
P13(SRK7)
P14(SRK8)
KR-04(N2)
N1 PUMPHOUSE (TO BE REMOVED)
CONSTRUCT TOE BERM
CACHE
CREEK
P8(SRK4)
P9(SRK3)
PIEZOMETERS
KR-09
P6
EXISTING SPILLWAY (TO BE REMOVED)
APPROX. OUTLINE OF POND (WATER LEVEL APPROX. 1309m TO 1310m)
SPILLWAY CHANNEL (TO BE REMOVED)
25,250 N
OXO
S1 PUMPHOUSE (TO BE REMOVED)
S2 PUMPHOUSE (TO BE REMOVED)
P12(SRK6)
P5
P7(SRK1)
P3
P4
REMOVE 2 X 600mm DIA. CULVERTS AND REPLACE WITH FORD
PROPOSED SPILLWAY FOR HALF THE PROBABLE MAXIMUM FLOOD (1/2 PMF)
SOUTH DAM
KR-05(S1)
UPGRADE V-NOTCH WEIR
KR-05(S2)
KR-14
UPGRADE LOWER SUBSIDIARY CREEK DIVERSION FOR 200 YEAR FLOOD
KR-13
UPGRADE CACHE CK. DIVERSION (VARIES FROM 200 YEAR FLOOD TO 1/2 PMF - SEE SECTIONS)
CONTOUR INTERVAL = 2m
0 20 40 60 80 100 Metres
SCALE 1:2000
STA. 0+226
STA. 0+247
℄ STA. 0+266 SOUTH DAM
STA. 0+309
STA. 0+454
STA. 0+472
STA. 0+510
STA. 0+551
STA. 0+161
STA. 0+54.5
CACHE CREEK
REMOVE 300mm DIA. CMP CULVERT AND CONSTRUCT CHANNEL
LEGEND
KR-05(S1) EXISTING PUMPHOUSE
KR-09 WATER QUALITY SAMPLING STATION
P3 EXISTING PIEZOMETER LOCATION
P11(SRK5) PROPOSED MONITORING WELLS
TAILINGS SURFACE CONTOURS (AS DERIVED FROM BATHYMETRIC SURVEY COMPLETED BY CANAMAX, AUG. 1990)
FILE REF:FIG-4-1
STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers
YGC RESOURCES LTD.
KETZA RIVER MINE
TAILINGS MANAGEMENT FACILITY DECOMMISSIONING PLAN (OPTION A)
PROJECT NO. Y101101
DATE MAR. 1996
APPROVED
FIGURE 4.1

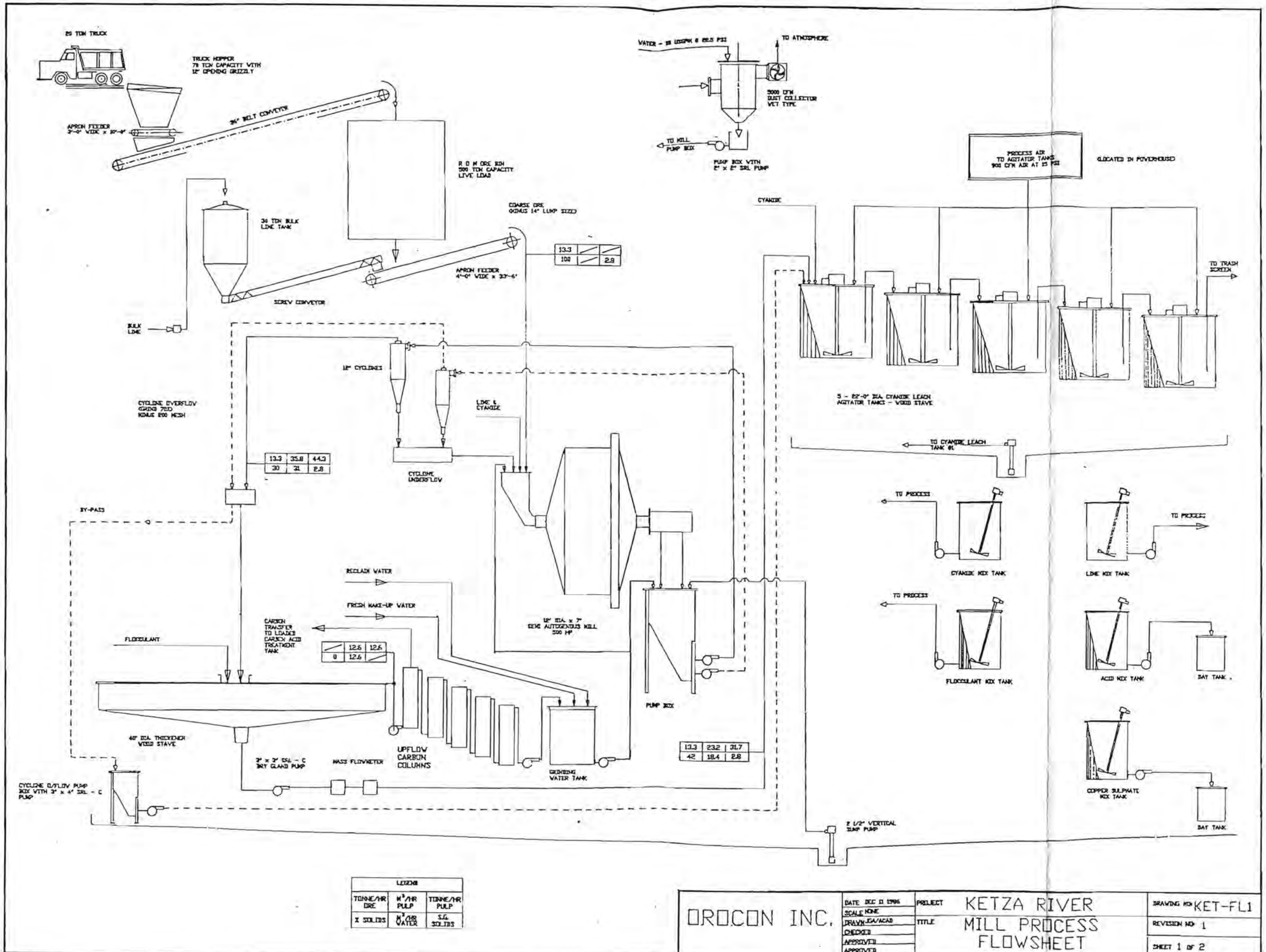
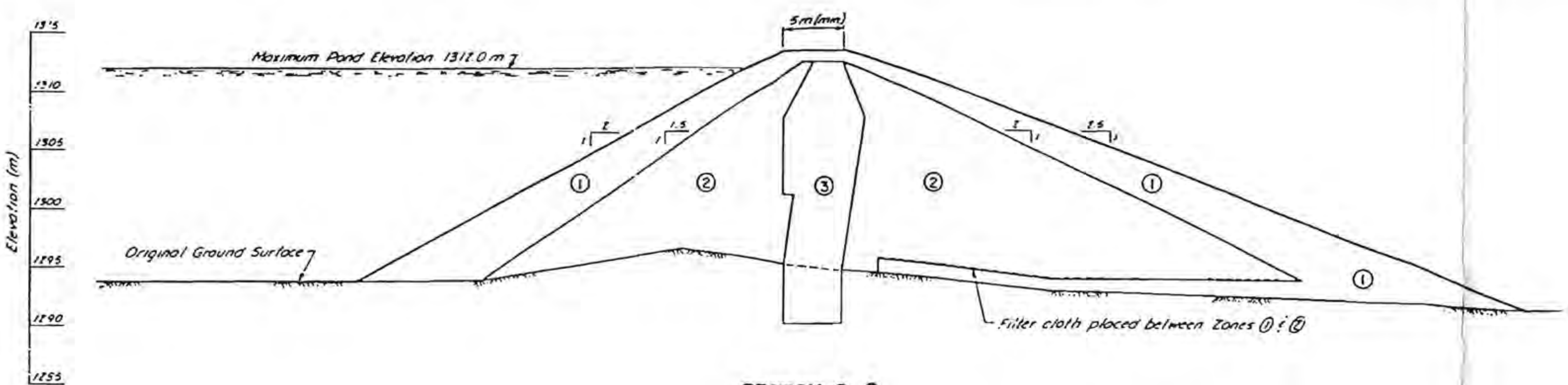
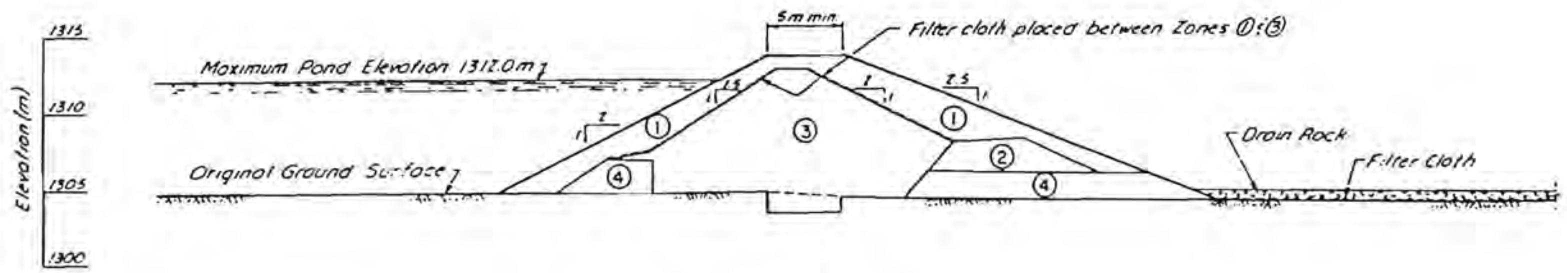

25 TON TRUCK
TRUCK HOPPER
36" BELT CONVEYOR
R O M ORE BIN
500 TON CAPACITY LIVE LOAD
30 TON BULK LIME TANK
COARSE ORE
SCREW CONVEYOR
BULK LIME
12" CYCLONES
CYCLONE UNDERFLOW
LIME & CYANIDE
BY-PASS
RECLAIM WATER
FRESH MAKE-UP WATER
FLOCCULANT
40' DIA. THICKENER WOOD STAVE
MASS FLOWMETER
UPFLOW
CARBON
COLUMNS
GRINDING WATER TANK
PUMP BOX
2 1/2" VERTICAL SUMP PUMP
TO ATMOSPHERE
5000 CFM DUST COLLECTOR WET TYPE
TO MILL PUMP BOX
CYANIDE
TO TRASH SCREEN
(LOCATED IN POWERHOUSE)
TO CYANIDE LEACH TANK #1
TO PROCESS
CYANIDE MIX TANK
LIME MIX TANK
FLOCCULANT MIX TANK
ACID MIX TANK
DAY TANK
COPPER SULPHATE MIX TANK
LEGEND
TONNE/HR ORE
M³/HR PULP
TONNE/HR PULP
% SOLIDS
M³/HR WATER
S.G. SOLIDS
ORECON INC.
DATE DEC 11 1986
SCALE NONE
DRAWN JGA/ACAD
CHECKED
APPROVED
APPROVED
PROJECT
KETZA RIVER
TITLE
MILL PROCESS
FLOWSHEET
DRAWING NO: KET-FL1
REVISION NO: 1
SHEET 1 OF 2

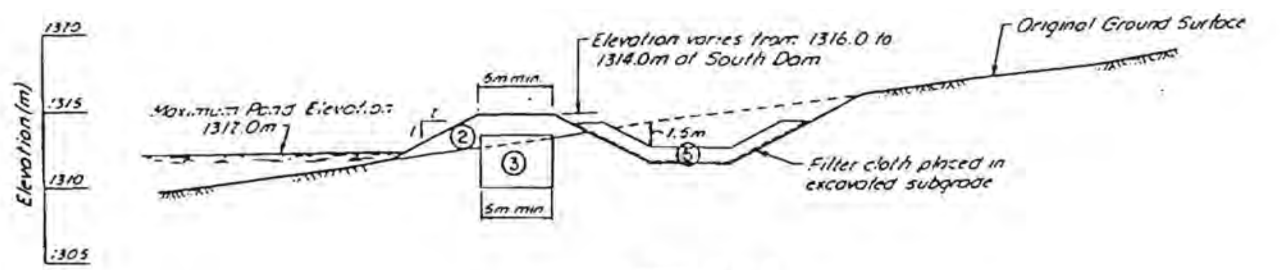
FIG. 13-1



SECTION G–G
SCALE 1:500



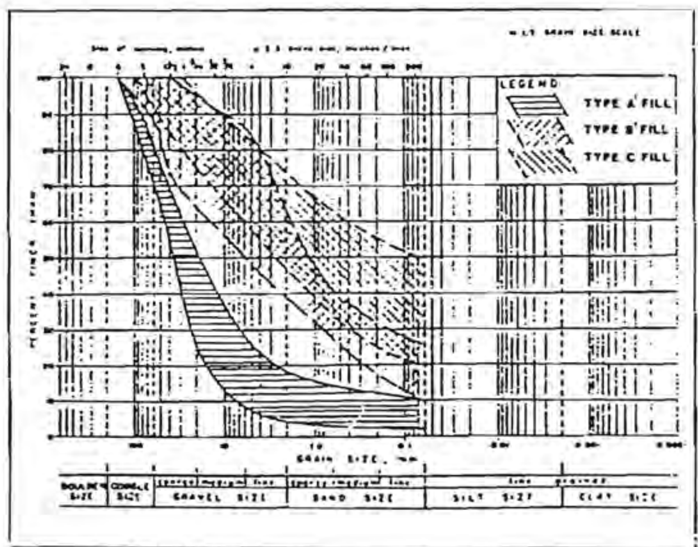
SECTION H–H
SCALE 1:500



SECTION I–I
SCALE 1:500

ZONES :

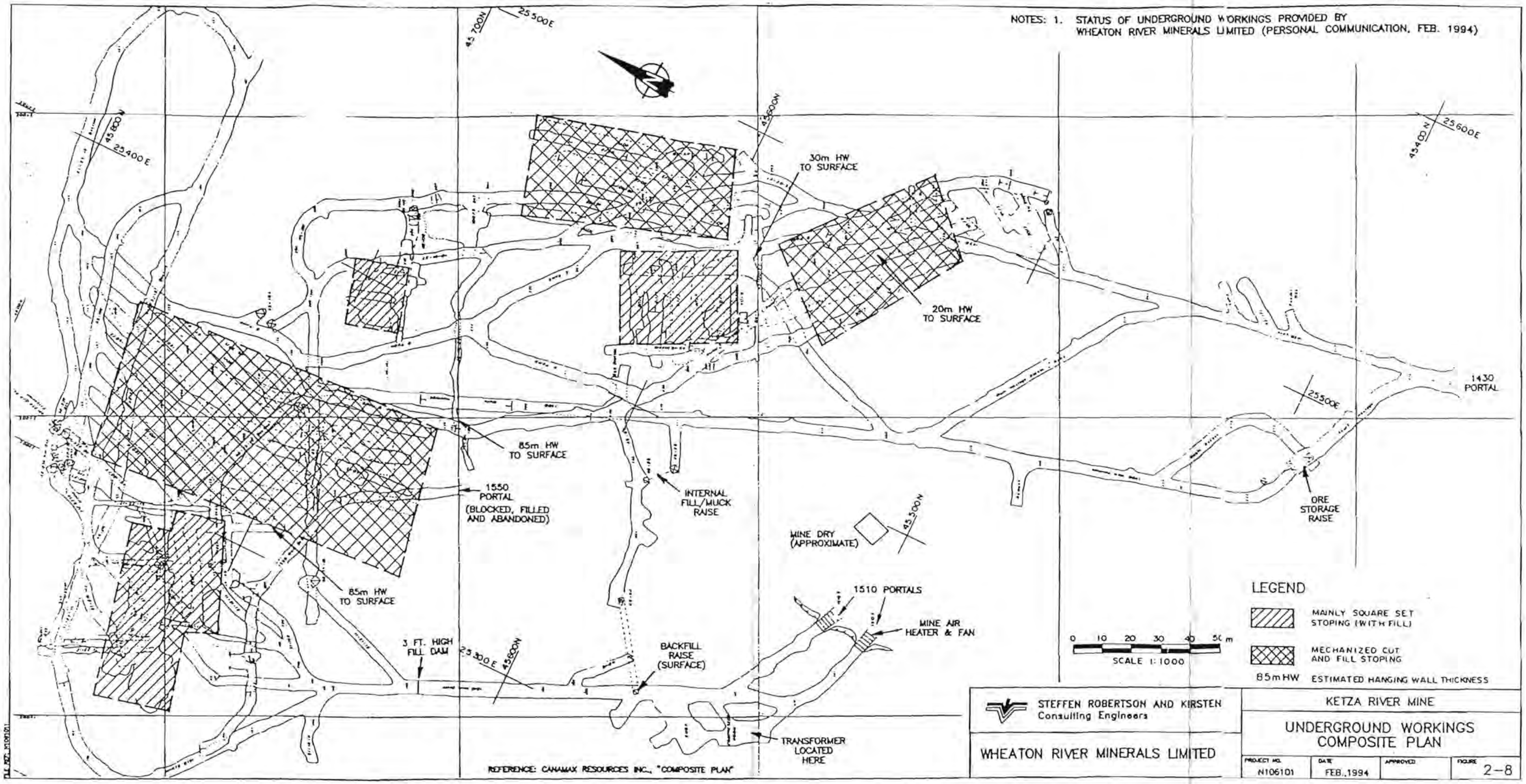
① TYPE A' FILL
② TYPE B' FILL
③ TYPE C FILL
④ TYPE B FILL
⑤ RIP RAP



SEE FIG. 9 FOR SECTION LOCATION

FROM GOLDER ASSOCIATES REPORT 862–1054A, NOV. 1987, FIGURE 2, "AS BUILT" CROSS SECTIONS"

WHEATON RIVER MINERALS INC.	KETZA RIVER MINE	DATE FEB 1994
TAILINGS IMPOUNDMENT – "AS BUILT" SECTIONS		PROJ. NO. N106101
		APPROVED
		NO. 2–10
STEFFEN ROBERTSON & KIRSTEN, Consulting Engineers		


NOTES: 1. STATUS OF UNDERGROUND WORKINGS PROVIDED BY WHEATON RIVER MINERALS LIMITED (PERSONAL COMMUNICATION, FEB. 1994)
45700N
25500E
45800N
25400E
45600N
45400N
25600E
25500E
45300N
25300E
45800N
30m HW TO SURFACE
20m HW TO SURFACE
85m HW TO SURFACE
85m HW TO SURFACE
1430 PORTAL
1550 PORTAL (BLOCKED, FILLED AND ABANDONED)
INTERNAL FILL/MUCK RAISE
MINE DRY (APPROXIMATE)
ORE STORAGE RAISE
1510 PORTALS
MINE AIR HEATER & FAN
3 FT. HIGH FILL DAM
BACKFILL RAISE (SURFACE)
TRANSFORMER LOCATED HERE
LEGEND
MAINLY SQUARE SET STOPING (WITH FILL)
MECHANIZED CUT AND FILL STOPING
85mHW ESTIMATED HANGING WALL THICKNESS
0 10 20 30 40 50 m
SCALE 1:1000
REFERENCE: CANAMAX RESOURCES INC., "COMPOSITE PLAN"
STEFFEN ROBERTSON AND KIRSTEN
Consulting Engineers
WHEATON RIVER MINERALS LIMITED
KETZA RIVER MINE
UNDERGROUND WORKINGS COMPOSITE PLAN
PROJECT NO. N106101
DATE FEB.,1994
APPROVED
FIGURE 2-8

Appendix C

Updated Tailings Pond Water Balance Calculations

SIMULATION OF CURRENT CONDITIONS: CASE 1

PRELIMINARY INFORMATION

TAILING IMPOUNDMENT

Initial Storage (June 19, 1999):	508.32 dam^3
Initial Elevation (June 19, 1999):	1310.5 m
Full Supply Capacity:	602.1 dam^3
Spillway Elevation:	1311.7 m
Undiverted Catchment Area:	0.11 km^2
Surface Area of Tailings Pond:	0.0754 km^2
Diverted Catchment Area:	6.84 km^2
Diversion Ditch Efficiency:	0.962
Tailings Pond Seepage:	0.4708 dam^3/day

FLOOD FREQUENCY ANALYSIS FOR LOWER SUBSIDARY CREEK

Drainage Area:	1.36 km^2
Mean Annual Flood (MAF):	0.164 m^3/s
2 - Year Return Period	0.116 m^3/s
10 - Year Return Period	0.341 m^3/s
100 - Year Return Period	0.821 m^3/s

HYDROLOGY/CLIMATE

Mean Annual Precipitation (MAP):	730 mm
Mean Annual Runoff (MAR):	610 mm

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YEAR
Runoff Distribution (% of MAR):	0.15	0.095	0.083	0.061	0.031	0.021	0.016	0.013	0.012	0.014	0.17	0.334	1
Evaporation (mm):	100	75	35	15	0	0	0	0	0	0	0	75	300

TAILING IMPOUNDMENT MASS BALANCE: CASE 1 - NO INPUT FROM LOWER SUBSIDIARY CREEK DIVERSION

	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	YEAR
	31	31	30	31	30	31	31	29	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	3.1659	1.94133	1.69104	1.23537	0.63159	0.43298	0.3377	0.28152	0.26572	0.31854	3.96134	7.35501	21.618
Diversion Ditch Leakage	23.7827	15.0624	13.1597	9.67162	4.91509	3.32958	2.53682	2.06117	1.90261	2.21972	26.9537	52.9561	158.551
Direct Precipitation	8.2563	5.30528	4.64119	3.4199	1.73346	1.16815	0.88067	0.70701	0.64561	0.74299	8.91038	18.0183	54.4292
TOTAL	35.2049	22.309	19.492	14.3269	7.28014	4.9307	3.75519	3.04969	2.81394	3.28125	39.8254	78.3294	234.598
OUTFLOWS													
Direct Evaporation	7.54	5.7375	2.681	1.152	0	0	0	0	0	0	0	5.5425	22.653
Tailings Pond Seepage	14.5886	14.5886	14.118	14.5886	14.118	14.5886	14.5886	13.6474	14.5886	14.118	14.5886	14.118	172.24
TOTAL	22.1286	20.3261	16.799	15.7406	14.118	14.5886	14.5886	13.6474	14.5886	14.118	14.5886	19.6605	194.893
STORAGE AT END OF MONTH													
TOTAL	521.396	523.379	526.072	524.658	517.821	508.163	497.329	486.732	474.957	464.12	489.357	548.026	
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL STORAGE	521.396	523.379	526.072	524.658	517.821	508.163	497.329	486.732	474.957	464.12	489.357	548.026	
POND SURFACE ELEVATION	1310.67	1310.69	1310.73	1310.7	1310.63	1310.5	1310.35	1310.21	1310.05	1309.89	1310.24	1311.15	
POND SURFACE AREA	0.0765	0.0766	0.0768	0.0766	0.0762	0.0754	0.0745	0.0737	0.0727	0.0718	0.0739	0.0794	

	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	YEAR
	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	3.06525	1.76168	1.53409	1.1163	0.57108	0.39327	0.30744	0.25614	0.24229	0.29121	3.6295	6.70305	19.8713
Diversion Ditch Leakage	23.7827	15.0624	13.1597	9.67162	4.91509	3.32958	2.53682	2.06117	1.90261	2.21972	26.9537	52.9561	158.551
Direct Precipitation	8.3877	5.52026	4.82902	3.5624	1.80587	1.21567	0.91688	0.73737	0.67364	0.7757	9.3075	18.7985	56.5305
TOTAL	35.2356	22.3443	19.5229	14.3503	7.29204	4.93851	3.76114	3.05468	2.81855	3.28663	39.8907	78.4577	234.953
OUTFLOWS													
Direct Evaporation	7.65	5.97	2.7895	1.2	0	0	0	0	0	0	0	5.7825	23.392
Tailings Pond Seepage	14.5886	14.5886	14.118	14.5886	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	14.118	171.769
TOTAL	22.2386	20.5586	16.9075	15.7886	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	19.9005	195.161
STORAGE AT END OF MONTH													
TOTAL	561.023	562.809	565.424	563.986	557.16	547.51	536.682	526.56	514.79	503.959	529.261	587.818	
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL STORAGE	561.023	562.809	565.424	563.986	557.16	547.51	536.682	526.56	514.79	503.959	529.261	587.818	
POND SURFACE ELEVATION	1311.19	1311.21	1311.25	1311.22	1311.13	1311	1310.88	1310.75	1310.57	1310.43	1310.77	1311.51	
POND SURFACE AREA	0.0796	0.0797	0.08	0.0798	0.0793	0.0785	0.0777	0.0769	0.0759	0.075	0.0771	0.0816	

	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	YEAR
	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	2.5986	1.58783	1.3822	1.01583	0.51624	0.35228	0.27718	0.23156	0.2196	0.26389	3.29766	5.90846	17.6513
Diversion Ditch Leakage	23.7827	15.0624	13.1597	9.67162	4.91509	3.32958	2.53682	2.06117	1.90261	2.21972	26.9537	52.9561	158.551
Direct Precipitation	8.9352	5.72831	5.01079	3.68263	1.8715	1.26473	0.95309	0.76679	0.7008	0.8084	9.70462	19.7494	59.1763
TOTAL	35.3165	22.3785	19.5527	14.3701	7.30283	4.94658	3.76709	3.05951	2.82301	3.292	39.956	78.614	235.379
OUTFLOWS													
Direct Evaporation	8.16	6.195	2.8945	1.2405	0	0	0	0	0	0	0	6.075	24.565
Tailings Pond Seepage	14.5886	14.5886	14.118	14.5886	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	14.118	171.769
TOTAL	22.7486	20.7836	17.0125	15.8291	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	20.193	196.334
STORAGE AT END OF MONTH													
TOTAL	600.386	601.981	604.521	603.062	596.247	586.605	575.783	565.666	553.9	543.074	568.442	626.863	
SPILL	0	0	2.42094	0.96193	0	0	0	0	0	0	0	24.7627	
TOTAL STORAGE	600.386	601.981	602.1	602.1	596.247	586.605	575.783	565.666	553.9	543.074	568.442	602.1	
POND SURFACE ELEVATION	1311.68	1311.7	1311.7	1311.7	1311.62	1311.51	1311.38	1311.25	1311.1	1311.06	1311.27	1311.7	
POND SURFACE AREA	0.0826	0.0827	0.0827	0.0827	0.0825	0.0816	0.0808	0.08	0.0791	0.0782	0.081	0.0827	

	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	YEAR
	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	2.49795	1.58204	1.3822	1.01583	0.51624	0.34971	0.26742	0.22363	0.21155	0.25535	3.19396	5.84734	17.3432
Diversion Ditch Leakage	23.7827	15.0624	13.1597	9.67162	4.91509	3.32958	2.53682	2.06117	1.90261	2.21972	26.9537	52.9561	158.551
Direct Precipitation	9.05565	5.73525	5.01079	3.68263	1.8715	1.26779	0.96477	0.77628	0.71044	0.81862	9.82872	19.8226	59.545
TOTAL	35.3363	22.3796	19.5527	14.3701	7.30283	4.94708	3.76901	3.06107	2.8246	3.29368	39.9764	78.626	235.439
OUTFLOWS													
Direct Evaporation	8.27	6.2025	2.8945	1.2405	0	0	0	0	0	0	0	6.0975	24.705
Tailings Pond Seepage	14.5886	14.5886	14.118	14.5886	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	14.118	171.769
TOTAL	22.8586	20.7911	17.0125	15.8291	14.118	14.5886	14.5886	13.1768	14.5886	14.118	14.5886	20.2155	196.474
STORAGE AT END OF MONTH													
TOTAL	614.578	616.166	618.706	617.247	610.432	600.791	589.971	579.855	568.091	557.267	582.655	641.065	
SPILL	12.4777	14.0662	16.6065	15.1475	8.33228	0	0	0	0	0	0	38.9654	
TOTAL STORAGE	602.1	602.1	602.1	602.1	602.1	600.791	589.971	579.855	568.091	557.267	582.655	602.1	
POND SURFACE ELEVATION	1311.7	1311.7	1311.7	1311.7	1311.7	1311.68	1311.55	1311.43	1311.27	1311.12	1311.46	1311.7	
POND SURFACE AREA	0.0827	0.0827	0.0827	0.0827	0.0827	0.0826	0.0818	0.0811	0.0801	0.0792	0.0813	0.0827	

TAILING IMPOUNDMENT MASS BALANCE: CASE 1 - MEAN ANNUAL FLOOD

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00	5-Jun-00	6-Jun-00	7-Jun-00	8-Jun-00
INFLOWS									
Runoff from Undiverted Catchment	3.96134	0.11011	0.10645	0.10279	0.09943	0.09608	0.09242	0.08876	0.0851
Diversion Ditch Leakage	26.953704	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276
Direct Precipitation	8.91038	0.26974	0.27412	0.2785	0.28251	0.28653	0.29091	0.29529	0.29967
Lower Subsidary Creek (MAF)	0	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951
TOTAL	39.825424	15.3677	15.3684	15.3692	15.3698	15.3705	15.3712	15.3719	15.3726
OUTFLOWS									
Direct Evaporation	0	0.24633	0.25033	0.25433	0.01075	0.0109	0.01107	0.01124	0.0114
Tailings Pond Seepage	14.5886	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706
TOTAL	14.5886	0.71693	0.72093	0.72493	0.48135	0.4815	0.48167	0.48184	0.482
STORAGE AT END OF MONTH									
TOTAL	489.35696	504.008	518.655	533.299	548.188	563.077	577.966	592.857	607.747
SPILL	0	0	0	0	0	0	0	0	5.64719
TOTAL STORAGE	489.35696	504.008	518.655	533.299	548.188	563.077	577.966	592.857	602.1
POND SURFACE ELEVATION	1310.24	1310.44	1310.64	1310.82	1311	1311.21	1311.4	1311.59	1311.7
POND SURFACE AREA	0.0739	0.0751	0.0763	0.0774	0.0785	0.0797	0.0809	0.0821	0.0827

TAILING IMPOUNDMENT MASS BALANCE: CASE 1 - 2-YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00	5-Jun-00	6-Jun-00	7-Jun-00	8-Jun-00	9-Jun-00	10-Jun-00	11-Jun-00
INFLOWS												
Runoff from Undiverted Catchment	3.96134	0.11011	0.10736	0.10523	0.10218	0.09974	0.0976	0.09486	0.09242	0.08998	0.087535	0.085095
Diversion Ditch Leakage	26.953704	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.79276	0.792756	0.792756
Direct Precipitation	8.91038	0.26974	0.27302	0.27558	0.27923	0.28215	0.2847	0.28799	0.29091	0.29383	0.296745	0.299665
Lower Subsidary Creek (2yr)	0	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.00936	10.00936
TOTAL	39.825424	11.182	11.1825	11.1829	11.1835	11.184	11.1844	11.185	11.1854	11.1859	11.1864	11.18688
OUTFLOWS												
Direct Evaporation	0	0.24633	0.24933	0.25167	0.255	0.25767	0.26	0.263	0.26567	0.26833	0.271	0.273667
Tailings Pond Seepage	14.5886	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706	0.4706
TOTAL	14.5886	0.71693	0.71993	0.72227	0.7256	0.72827	0.7306	0.7336	0.73627	0.73893	0.7416	0.744267
STORAGE AT END OF MONTH												
TOTAL	489.35696	499.822	510.285	520.745	531.203	541.659	552.113	562.564	573.013	583.46	593.905	604.3476
SPILL	0	0	0	0	0	0	0	0	0	0	0	2.247579
TOTAL STORAGE	489.35696	499.822	510.285	520.745	531.203	541.659	552.113	562.564	573.013	583.46	593.905	602.1
POND SURFACE ELEVATION	1310.24	1310.39	1310.52	1310.67	1310.8	1310.93	1311.07	1311.2	1311.34	1311.46	1311.6	1311.7
POND SURFACE AREA	0.0739	0.0748	0.0755	0.0765	0.0773	0.078	0.0789	0.0797	0.0805	0.0813	0.0821	0.0827

TAILING IMPOUNDMENT MASS BALANCE: CASE 1 - 10 YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00
INFLOWS					
Runoff from Undiverted Catchment	3.96134	0.11011	0.10279	0.09608	0.08845
Diversion Ditch Leakage	26.953704	0.79276	0.79276	0.79276	0.79276
Direct Precipitation	8.91038	0.26974	0.2785	0.28653	0.29565
Lower Subsidary Creek (10-yr)	0	29.4919	29.4919	29.4919	29.4919
TOTAL	39.825424	30.6645	30.666	30.6673	30.6688
OUTFLOWS					
Direct Evaporation	0	0.24633	0.25433	0.26167	0.27
Tailings Pond Seepage	14.5886	0.4706	0.4706	0.4706	0.4706
TOTAL	14.5886	0.71693	0.72493	0.73227	0.7406
STORAGE AT END OF MONTH					
TOTAL	489.35696	519.305	549.246	579.181	609.109
SPILL	0	0	0	0	7.00881
TOTAL STORAGE	489.35696	519.305	549.246	579.181	602.1
POND SURFACE ELEVATION	1310.24	1310.64	1311	1311.41	1311.7
POND SURFACE AREA	0.0739	0.0763	0.0785	0.081	0.0827

TAILING IMPOUNDMENT MASS BALANCE: CASE 1 - 100-YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00
INFLOWS			
Runoff from Undiverted Catchment	3.96134	0.11011	0.09303
Diversion Ditch Leakage	26.953704	0.79276	0.79276
Direct Precipitation	8.91038	0.26974	0.29018
Lower Subsidary Creek (100-yr)	0	70.9119	70.9119
TOTAL	39.825424	72.0845	72.0878
OUTFLOWS			
Direct Evaporation	0	0.24633	0.265
Tailings Pond Seepage	14.5886	0.4706	0.4706
TOTAL	14.5886	0.71693	0.7356
STORAGE AT END OF MONTH			
TOTAL	489.35696	560.724	632.077
SPILL	0	0	29.9767
TOTAL STORAGE	489.35696	560.724	602.1
POND SURFACE ELEVATION	1310.24	1311.17	1311.7
POND SURFACE AREA	0.0739	0.0795	0.0827

SIMULATION OF CURRENT CONDITIONS: CASE 2

PRELIMINARY INFORMATION

TAILING IMPOUNDMENT

Initial Storage (June 19, 1999):	508.32 dam^3
Initial Elevation (June 19, 1999):	1310.5 m
Full Supply Capacity:	602.1 dam^3
Spillway Elevation:	1311.7 m
Undiverted Catchment Area:	0.11 km^2
Surface Area of Tailings Pond:	0.0754 km^2
Diverted Catchment Area:	6.84 km^2
Diversion Ditch Efficiency:	0.96
Tailings Pond Seepage:	0.5184 dam^3/day

FLOOD FREQUENCY ANALYSIS FOR LOWER SUBSIDARY CREEK

Drainage Area:	1.36 km^2
Mean Annual Flood (MAF):	0.164 m^3/s
2 - Year Return Period	0.116 m^3/s
10 - Year Return Period	0.341 m^3/s
100 - Year Return Period	0.821 m^3/s

HYDROLOGY/CLIMATE

Mean Annual Precipitation (MAP):	730 mm
Mean Annual Runoff (MAR):	610 mm

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YEAR
Runoff Distribution (% of MAR):	0.15	0.095	0.083	0.061	0.031	0.021	0.016	0.013	0.012	0.014	0.17	0.334	1
Evaporation (mm):	100	75	35	15	0	0	0	0	0	0	0	75	300

TAILING IMPOUNDMENT MASS BALANCE: CASE 2 - NO INPUT FROM LOWER SUBSIDIARY CREEK DIVERSION

	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00	Mar-00	Apr-00	May-00	Jun-00	YEAR
	31	31	30	31	30	31	31	29	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	3.1659	1.94133	1.69104	1.23909	0.63349	0.43682	0.3416	0.28469	0.27084	0.32452	4.05467	7.53838	21.9224
Diversion Ditch Leakage	25.0344	15.8551	13.8524	10.1807	5.17378	3.50482	2.67034	2.16965	2.00275	2.33654	28.3723	55.7433	166.896
Direct Precipitation	8.2563	5.30528	4.64119	3.41545	1.7312	1.16355	0.876	0.70321	0.63948	0.73584	8.79869	17.7989	54.065
TOTAL	36.4566	23.1017	20.1846	14.8352	7.53846	5.10518	3.88794	3.15754	2.91307	3.3969	41.2257	81.0805	242.883
OUTFLOWS													
Direct Evaporation	7.54	5.7375	2.681	1.1505	0	0	0	0	0	0	0	5.475	22.584
Tailings Pond Seepage	16.0704	16.0704	15.552	16.0704	15.552	16.0704	16.0704	15.0336	16.0704	15.552	16.0704	15.552	189.734
TOTAL	23.6104	21.8079	18.233	17.2209	15.552	16.0704	16.0704	15.0336	16.0704	15.552	16.0704	21.027	212.318
STORAGE AT END OF MONTH													
TOTAL	521.166	522.46	524.412	522.026	514.012	503.047	490.865	478.989	465.831	453.676	478.832	538.885	
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL STORAGE	521.166	522.46	524.412	522.026	514.012	503.047	490.865	478.989	465.831	453.676	478.832	538.885	
POND SURFACE ELEVATION	1310.67	1310.69	1310.71	1310.68	1310.57	1310.43	1310.27	1310.1	1309.92	1309.75	1310.1	1310.9	
POND SURFACE AREA	0.0765	0.0766	0.0767	0.0765	0.0759	0.075	0.0741	0.073	0.072	0.0709	0.073	0.0779	

	Jul-00	Aug-00	Sep-00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	YEAR
	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	3.06525	1.80225	1.56953	1.14979	0.5881	0.40608	0.31818	0.26566	0.25254	0.30317	3.78505	7.02903	20.5346
Diversion Ditch Leakage	25.0344	15.8551	13.8524	10.1807	5.17378	3.50482	2.67034	2.16965	2.00275	2.33654	28.3723	55.7433	166.896
Direct Precipitation	8.3877	5.47172	4.78661	3.52232	1.78551	1.20034	0.90403	0.72599	0.66138	0.76139	9.12135	18.4084	55.7367
TOTAL	36.4874	23.1291	20.2085	14.8528	7.54738	5.11123	3.89254	3.16129	2.91667	3.4011	41.2787	81.1807	243.167
OUTFLOWS													
Direct Evaporation	7.65	5.9175	2.765	1.1865	0	0	0	0	0	0	0	5.6625	23.1815
Tailings Pond Seepage	16.0704	16.0704	15.552	16.0704	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	15.552	189.216
TOTAL	23.7204	21.9879	18.317	17.2569	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	21.2145	212.398
STORAGE AT END OF MONTH													
TOTAL	551.652	552.793	554.685	552.281	544.276	533.317	521.139	509.785	496.631	484.48	509.689	569.655	
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL STORAGE	551.652	552.793	554.685	552.281	544.276	533.317	521.139	509.785	496.631	484.48	509.689	569.655	
POND SURFACE ELEVATION	1311.07	1311.09	1311.11	1311.07	1310.97	1310.83	1310.67	1310.52	1310.35	1310.18	1310.52	1311.3	
POND SURFACE AREA	0.0789	0.079	0.0791	0.0789	0.0783	0.0774	0.0765	0.0755	0.0745	0.0735	0.0755	0.0803	

	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	YEAR
	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	2.71755	1.66896	1.45308	1.06049	0.54461	0.37533	0.29475	0.24742	0.23424	0.28267	3.5258	6.51968	18.9246
Diversion Ditch Leakage	25.0344	15.8551	13.8524	10.1807	5.17378	3.50482	2.67034	2.16965	2.00275	2.33654	28.3723	55.7433	166.896
Direct Precipitation	8.79285	5.63122	4.92597	3.6292	1.83756	1.23713	0.93206	0.74781	0.68328	0.78592	9.4316	19.018	57.6526
TOTAL	36.5448	23.1553	20.2314	14.8703	7.55594	5.11728	3.89715	3.16488	2.92027	3.40514	41.3297	81.2809	243.473
OUTFLOWS													
Direct Evaporation	8.03	6.09	2.8455	1.2225	0	0	0	0	0	0	0	5.85	24.038
Tailings Pond Seepage	16.0704	16.0704	15.552	16.0704	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	15.552	189.216
TOTAL	24.1004	22.1604	18.3975	17.2929	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	21.402	213.254
STORAGE AT END OF MONTH													
TOTAL	582.099	583.094	584.928	582.506	574.509	563.556	551.383	540.033	526.883	514.736	539.995	599.874	
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	
TOTAL STORAGE	582.099	583.094	584.928	582.506	574.509	563.556	551.383	540.033	526.883	514.736	539.995	599.874	
POND SURFACE ELEVATION	1311.45	1311.46	1311.49	1311.45	1311.36	1311.22	1311.06	1310.92	1310.75	1310.59	1310.92	1311.67	
POND SURFACE AREA	0.0812	0.0813	0.0815	0.0812	0.0807	0.0798	0.0788	0.078	0.0769	0.076	0.078	0.0826	

	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	YEAR

	31	31	30	31	30	31	31	28	31	30	31	30	
INFLOWS													
Runoff from Undiverted Catchment	2.5071	1.58204	1.3822	1.01583	0.51624	0.34971	0.27035	0.22918	0.2174	0.26218	3.28729	5.88809	17.5076
Diversion Ditch Leakage	25.0344	15.8551	13.8524	10.1807	5.17378	3.50482	2.67034	2.16965	2.00275	2.33654	28.3723	55.7433	166.896
Direct Precipitation	9.0447	5.73525	5.01079	3.68263	1.8715	1.26779	0.96126	0.76964	0.70343	0.81045	9.71703	19.7738	59.3483
TOTAL	36.5862	23.1724	20.2454	14.8791	7.56152	5.12232	3.90195	3.16846	2.92358	3.40917	41.3766	81.4052	243.752
OUTFLOWS													
Direct Evaporation	8.26	6.2025	2.8945	1.2405	0	0	0	0	0	0	0	6.0825	24.68
Tailings Pond Seepage	16.0704	16.0704	15.552	16.0704	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	15.552	189.216
TOTAL	24.3304	22.2729	18.4465	17.3109	15.552	16.0704	16.0704	14.5152	16.0704	15.552	16.0704	21.6345	213.896
STORAGE AT END OF MONTH													
TOTAL	612.13	613.029	614.828	612.396	604.406	593.458	581.289	569.943	556.796	544.653	569.959	629.73	
SPILL	10.0298	10.9293	12.7282	10.2964	2.30589	0	0	0	0	0	0	27.6299	
TOTAL STORAGE	602.1	602.1	602.1	602.1	602.1	593.458	581.289	569.943	556.796	544.653	569.959	602.1	
POND SURFACE ELEVATION	1311.7	1311.7	1311.7	1311.7	1311.7	1311.59	1311.44	1311.3	1311.13	1310.98	1311.3	1311.7	
POND SURFACE AREA	0.0827	0.0827	0.0827	0.0827	0.0827	0.0823	0.0811	0.0803	0.0793	0.0783	0.0811	0.0827	

TAILING IMPOUNDMENT MASS BALANCE: CASE 2 - MAF

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00	5-Jun-00	6-Jun-00	7-Jun-00	8-Jun-00
INFLOWS									
Runoff from Undiverted Catchment	4.05467	0.3355	0.10523	0.10157	0.09791	0.09486	0.09089	0.08723	0.08418
Diversion Ditch Leakage	28.37232	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448
Direct Precipitation	8.79869	0.26645	0.27558	0.27996	0.28434	0.28799	0.29273	0.29711	0.30076
Lower Subsidary Creek (MAF)	0	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951	14.1951
TOTAL	41.22568	15.6316	15.4104	15.4111	15.4118	15.4124	15.4132	15.4139	15.4145
OUTFLOWS									
Direct Evaporation	0	0.24333	0.25167	0.25567	0.25967	0.263	0.26733	0.27133	0.27467
Tailings Pond Seepage	14.5886	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184
TOTAL	14.5886	0.76173	0.77007	0.77407	0.77807	0.7814	0.78573	0.78973	0.79307
STORAGE AT END OF MONTH									
TOTAL	494.8923	509.762	524.402	539.04	553.673	568.304	582.932	597.556	612.178
SPILL	0	0	0	0	0	0	0	0	10.0775
TOTAL STORAGE	494.8923	509.762	524.402	539.04	553.673	568.304	582.932	597.556	602.1
POND SURFACE ELEVATION	1310.1	1310.52	1310.71	1310.9	1311.08	1311.28	1311.46	1311.64	1311.7
POND SURFACE AREA	0.073	0.0755	0.0767	0.0779	0.0789	0.0802	0.0814	0.0824	0.0827

TAILING IMPOUNDMENT MASS BALANCE: CASE 2 - 2-YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00	5-Jun-00	6-Jun-00	7-Jun-00	8-Jun-00	#######	#######	#######	#######
INFLOWS													
Runoff from Undiverted Catchment	4.05467	0.3355	0.11011	0.10736	0.10523	0.10218	0.09974	0.09791	0.09486	0.09242	0.08998	0.08754	0.0851
Diversion Ditch Leakage	28.37232	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448	0.83448
Direct Precipitation	8.79869	0.26645	0.26974	0.27302	0.27558	0.27923	0.28215	0.28434	0.28799	0.29091	0.29383	0.29675	0.29967
Lower Subsidary Creek (2-yr)	0	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094	10.0094
TOTAL	41.22568	11.4458	11.2237	11.2242	11.2246	11.2252	11.2257	11.2261	11.2267	11.2272	11.2276	11.2281	11.2286
OUTFLOWS													
Direct Evaporation	0	0.24333	0.24633	0.24933	0.25167	0.255	0.25767	0.25967	0.263	0.26567	0.26833	0.271	0.27367
Tailings Pond Seepage	14.5886	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184	0.5184
TOTAL	14.5886	0.76173	0.76473	0.76773	0.77007	0.7734	0.77607	0.77807	0.7814	0.78407	0.78673	0.7894	0.79207
STORAGE AT END OF MONTH													
TOTAL	494.8923	489.516	499.975	510.431	520.886	531.337	541.787	552.235	562.68	573.123	583.564	594.003	604.44
SPILL	0	0	0	0	0	0	0	0	0	0	0	0	2.33961
TOTAL STORAGE	494.8923	489.516	499.975	510.431	520.886	531.337	541.787	552.235	562.68	573.123	583.564	594.003	602.1
POND SURFACE ELEVATION	1310.1	1310.24	1310.39	1310.52	1310.67	1310.8	1310.94	1311.07	1311.21	1311.34	1311.47	1311.6	1311.7
POND SURFACE AREA	0.073	0.0739	0.0748	0.0755	0.0765	0.0773	0.0779	0.0789	0.0797	0.0805	0.0813	0.0821	0.0827

TAILING IMPOUNDMENT MASS BALANCE: CASE 2 - 10-YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00	3-Jun-00	4-Jun-00	5-Jun-00
INFLOWS						
Runoff from Undiverted Catchment	4.05467	0.3355	0.10523	0.09791	0.0854	0.08388
Diversion Ditch Leakage	28.37232	0.83448	0.83448	0.83448	0.83448	0.83448
Direct Precipitation	8.79869	0.26645	0.27558	0.28434	0.2993	0.30113
Lower Subsidary Creek (10-yr)	0	29.4919	29.4919	29.4919	29.4919	29.4919
TOTAL	41.22568	30.9284	30.7072	30.7087	30.7111	30.7114
OUTFLOWS						
Direct Evaporation	0	0.24333	0.25167	0.25967	0.27333	0.275
Tailings Pond Seepage	14.5886	0.5184	0.5184	0.5184	0.5184	0.5184
TOTAL	14.5886	0.76173	0.77007	0.77807	0.79173	0.7934
STORAGE AT END OF MONTH						
TOTAL	494.8923	508.998	538.935	568.866	598.785	628.703
SPILL	0	0	0	0	0	26.6033
TOTAL STORAGE	494.8923	508.998	538.935	568.866	598.785	602.1
POND SURFACE ELEVATION	1310.1	1310.51	1310.9	1311.29	1311.66	1311.66
POND SURFACE AREA	0.073	0.0755	0.0779	0.082	0.0825	0.0825

TAILING IMPOUNDMENT MASS BALANCE: CASE 2 - 100-YEAR FLOOD

	31-May-00	1-Jun-00	2-Jun-00
INFLOWS			
Runoff from Undiverted Catchment	4.05467	0.3355	0.09547
Diversion Ditch Leakage	28.37232	0.83448	0.83448
Direct Precipitation	8.79869	0.26645	0.28726
Lower Subsidary Creek (100yr)	0	70.9119	70.9119
TOTAL	41.22568	72.3483	72.1291
OUTFLOWS			
Direct Evaporation	0	0.24333	0.26233
Tailings Pond Seepage	14.5886	0.5184	0.5184
TOTAL	14.5886	0.76173	0.78073
STORAGE AT END OF MONTH			
TOTAL	494.8923	550.418	621.766
SPILL	0	0	19.6664
TOTAL STORAGE	494.8923	550.418	602.1
POND SURFACE ELEVATION	1310.1	1311.05	1311.7
POND SURFACE AREA	0.073	0.0787	0.0827

Appendix D

Analytical Reports

1988 Triumph Street, Vancouver, BC Canada V5L 1K5

analytical service laboratories ltd.

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

CHEMICAL ANALYSIS REPORT

Date:	October 27, 1999
ASL File No.	L1027
Report On:	99-914 Water & Soil Analysis Ketza River Mine
Report To:	**Gartner Lee Ltd.** Suite C 206 Lowe Street Whitehorse, YT Y1A 1W6
Attention:	**Mr. Forest Pearson**
Received:	September 28, 1999

ASL ANALYTICAL SERVICE LABORATORIES LTD.
per:

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

The detection limits for some of the metals for some of the soil and water samples have been increased due to analytical interferences.

The detection limits for Extractable Petroleum Hydrocarbons (EPH) have been increased for the samples "Camp W. Ditch" and "Tailings Line Culvert" due to limited sample volume.

For some of the submitted water samples, the measured concentration of specific dissolved metals is greater than the corresponding total metals concentration. The explanation for these findings is one or a combination of the following:

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

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

RESULTS OF ANALYSIS - Water[1,2]

File No. L1027

Sample ID			Gully Pooled Water	LowGrade Stock-pile	TP-Seepage KR-04	T.Pond	Camp W. Ditch
Sample Date			99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID			*1*	*2*	*3*	*4*	*5*
Physical Tests							
Conductivity	(umhos/cm)		12	937	694	513	639
Hardness	$CaCO_3$		4.03	499	342	254	339
pH			7.03	7.66	7.89	8.18	7.99
Total Suspended Solids			9	<3	<3	7	-
Dissolved Anions							
Acidity (to pH 8.3)		$CaCO_3$	3	8	9	2	-
Alkalinity-Total		$CaCO_3$	2	22	194	123	-
Sulphate	SO_4		2	490	183	144	-
Cyanides							
Total Cyanide	CN		-	-	0.009	<0.005	-

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

RESULTS OF ANALYSIS - Water[1,2] File No. L1027

Sample ID			KR-15	Garbage Seep Area	Polish-ing Pond	Vat Leach Sump	Tailings Line Culvert
Sample Date			99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID			*6*	*7*	*8*	*9*	*10*
Physical Tests							
Conductivity	(umhos/cm)		644	373	148	<2	312
Hardness	CaCO3		322	187	68.8	50.5	143
pH			7.83	8.04	8.18	8.11	8.14
Total Suspended Solids			17	3	<3	9	<3
Dissolved Anions							
Acidity (to pH 8.3)		CaCO3	9	1	2	<1	2
Alkalinity-Total		CaCO3	75	157	54	15	100
Sulphate	SO4		268	40	14	43	61
Cyanides							
Total Cyanide	CN		-	-	<0.005	0.022	-

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

RESULTS OF ANALYSIS - Water[1,2]

File No. L1027

Sample ID		Gully Pooled Water	LowGrade Stock-pile	TP-Seepage KR-04	T.Pond	Camp W. Ditch
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*1*	*2*	*3*	*4*	*5*
Total Metals						
Aluminum	T-Al	0.130	<0.01	<0.01	0.020	0.02
Antimony	T-Sb	<0.0001	0.0036	0.0003	0.0019	<0.0002
Arsenic	T-As	0.0132	0.586	0.0328	1.17	0.0055
Barium	T-Ba	<0.01	<0.01	0.01	<0.01	0.01
Beryllium	T-Be	<0.001	<0.002	<0.002	<0.001	<0.002
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.00068	<0.0001	<0.0001	<0.00005	<0.0001
Calcium	T-Ca	1.32	176	114	81.1	113
Chromium	T-Cr	<0.0005	<0.001	<0.001	<0.0005	<0.001
Cobalt	T-Co	0.0024	<0.0002	0.0029	0.0002	0.0013
Copper	T-Cu	0.0014	0.0029	0.0049	0.0019	0.0020
Iron	T-Fe	0.20	0.05	<0.03	0.15	<0.03
Lead	T-Pb	0.00078	0.0001	<0.0001	0.00101	0.0005
Magnesium	T-Mg	0.4	12.3	14.6	12.6	13.6
Manganese	T-Mn	0.172	0.049	0.419	0.013	0.021
Mercury	T-Hg	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	0.002	<0.002	0.002	<0.001	<0.002
Potassium	T-K	<2	<2	2	<2	<2
Selenium	T-Se	<0.001	<0.002	<0.002	<0.001	<0.002
Silver	T-Ag	<0.00001	<0.00002	<0.00002	<0.00001	<0.00002
Sodium	T-Na	<2	<2	9	4	2
Thallium	T-Tl	<0.00005	<0.0001	<0.0001	<0.00005	<0.0001
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	<0.0001	<0.0002	0.0017	0.0014	0.0012
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	0.475	<0.005	<0.005	<0.005	0.010

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

RESULTS OF ANALYSIS - Water[1,2]

File No. L1027

Sample ID		KR-15	Garbage Seep Area	Polish-ing Pond	Vat Leach Sump	Tailings Line Culvert
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*6*	*7*	*8*	*9*	*10*
Total Metals						
Aluminum	T-Al	0.75	0.081	0.090	0.011	0.026
Antimony	T-Sb	<0.0002	0.0002	0.0005	0.0004	0.0010
Arsenic	T-As	0.0623	0.0778	0.0877	0.303	0.321
Barium	T-Ba	0.01	<0.01	0.03	<0.01	0.01
Beryllium	T-Be	<0.002	<0.001	<0.001	<0.001	<0.001
Boron	T-B	<0.1	<0.1	<0.1	<0.1	0.1
Cadmium	T-Cd	0.0002	0.00005	0.00005	<0.00005	<0.00005
Calcium	T-Ca	92.6	62.8	25.1	18.5	48.8
Chromium	T-Cr	<0.001	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt	T-Co	0.0199	<0.0001	0.0002	0.0005	0.0013
Copper	T-Cu	0.0047	0.0003	0.0161	0.0032	0.0013
Iron	T-Fe	5.88	0.06	0.07	2.69	0.07
Lead	T-Pb	<0.0001	0.00048	0.00044	0.00121	0.00016
Magnesium	T-Mg	22.2	7.4	1.5	0.7	5.0
Manganese	T-Mn	0.076	<0.005	<0.005	0.051	<0.005
Mercury	T-Hg	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	0.009	<0.001	0.002	0.001	0.001
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.002	<0.001	<0.001	<0.001	<0.001
Silver	T-Ag	<0.00002	<0.00001	0.00009	0.00001	0.00001
Sodium	T-Na	<2	<2	<2	5	5
Thallium	T-Tl	<0.0001	<0.00005	<0.00005	<0.00005	<0.00005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.0011	0.0010	0.0009	<0.0001	0.0015
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	0.045	<0.005	<0.005	0.014	0.014

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

RESULTS OF ANALYSIS - Water[1,2] File No. L1027

Sample ID		Gully Pooled Water	LowGrade Stock-pile	TP-Seepage KR-04	T.Pond	KR-15
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*1*	*2*	*3*	*4*	*6*
Dissolved Metals						
Aluminum	D-Al	0.016	<0.01	<0.01	0.005	0.06
Antimony	D-Sb	<0.0001	0.0035	0.0003	0.0018	<0.0002
Arsenic	D-As	0.0041	0.552	0.0306	1.12	0.0052
Barium	D-Ba	<0.01	<0.01	0.01	<0.01	0.01
Beryllium	D-Be	<0.001	<0.002	<0.002	<0.001	<0.002
Boron	D-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	D-Cd	<0.00005	<0.0001	<0.0001	<0.00005	0.0002
Calcium	D-Ca	1.34	179	113	81.0	92.3
Chromium	D-Cr	<0.0005	<0.001	<0.001	<0.0005	<0.001
Cobalt	D-Co	<0.0001	<0.0002	0.0028	0.0001	0.0211
Copper	D-Cu	0.0004	0.0015	0.0044	0.0011	0.0008
Iron	D-Fe	<0.03	<0.03	<0.03	<0.03	3.87
Lead	D-Pb	<0.0001	<0.0002	<0.0002	<0.0001	<0.0002
Magnesium	D-Mg	0.2	12.5	14.5	12.5	22.3
Manganese	D-Mn	<0.005	0.048	0.417	<0.005	0.074
Mercury	D-Hg	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum	D-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	D-Ni	<0.001	<0.002	0.002	<0.001	0.010
Potassium	D-K	<2	<2	2	<2	<2
Selenium	D-Se	<0.001	<0.002	<0.002	<0.001	<0.002
Silver	D-Ag	<0.00001	<0.00002	<0.00002	<0.00001	<0.00002
Sodium	D-Na	<2	<2	9	4	<2
Thallium	D-Tl	<0.00005	<0.0001	<0.0001	<0.00005	<0.0001
Titanium	D-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	D-U	<0.0001	<0.0002	0.0014	0.0012	0.0010
Vanadium	D-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	D-Zn	<0.005	<0.005	<0.005	<0.005	0.030

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

RESULTS OF ANALYSIS - Water[1,2]

File No. L1027

Sample ID		Vat Leach Sump
Sample Date		99 09 24
ASL ID		*9*
Dissolved Metals		
Aluminum	D-Al	<0.005
Antimony	D-Sb	0.0003
Arsenic	D-As	0.0432
Barium	D-Ba	<0.01
Beryllium	D-Be	<0.001
Boron	D-B	<0.1
Cadmium	D-Cd	<0.00005
Calcium	D-Ca	19.1
Chromium	D-Cr	<0.0005
Cobalt	D-Co	0.0004
Copper	D-Cu	0.0016
Iron	D-Fe	0.06
Lead	D-Pb	<0.0001
Magnesium	D-Mg	0.7
Manganese	D-Mn	0.045
Mercury	D-Hg	<0.00002
Molybdenum	D-Mo	<0.03
Nickel	D-Ni	<0.001
Potassium	D-K	<2
Selenium	D-Se	<0.001
Silver	D-Ag	<0.00001
Sodium	D-Na	5
Thallium	D-Tl	<0.00005
Titanium	D-Ti	<0.01
Uranium	D-U	<0.0001
Vanadium	D-V	<0.03
Zinc	D-Zn	0.006

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

RESULTS OF ANALYSIS - Water[1,2]

File No. L1027

Sample ID	Camp W. Ditch	Tailings Line Culvert
Sample Date	99 09 24	99 09 24
ASL ID	*5*	*10*
Extractable Hydrocarbons		
EPH10-19	<0.6	<0.6
EPH19-32	<2	<2

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		Polish-ing Pond	GB-1	GB-2	GB-3	GB-4
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*11*	*12*	*13*	*14*	*15*
Physical Tests						
Moisture	%	39.7	10.4	12.8	28.8	28.9
pH		7.89	8.00	6.45	6.56	7.87

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	Upper Laydown	Sewage Sed.	Camp Generator E	D/G Grease Ramp	Camp Maint. Shed
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID	*16*	*17*	*18*	*19*	*20*
Physical Tests					
Moisture %	12.2	12.3	10.1	18.6	11.4
pH	7.96	4.22	7.99	8.03	8.31

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	Camp Diesel Intake	1510 Portal-Diesel	Waste Oil Storage	Lube Storage Area	Utility Trench
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID	*21*	*22*	*23*	*24*	*25*
Physical Tests					
Moisture %	14.7	15.3	6.6	8.9	10.7
pH	8.15	8.08	7.87	8.55	8.24

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	Mill Misc. Storage	Mainten-ance Shed N	Mill N-Diesel Pump	Mainten-ance Shed	Berm Outside
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID	*26*	*27*	*28*	*29*	*30*
Physical Tests					
Moisture %	11.7	10.1	9.4	13.0	11.3
pH	8.35	8.33	8.47	8.35	8.22

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		CN process W. side	SO2 Tank
Sample Date		99 09 24	99 09 24
ASL ID		*31*	*32*
Physical Tests			
Moisture	%	10.0	21.8
pH		8.11	3.31
Dissolved Anions			
Sulphate	SO4	-	20000

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		Polish-ing Pond	GB-1	GB-2	GB-3	GB-4
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*11*	*12*	*13*	*14*	*15*
Total Metals						
Antimony	T-Sb	<20	<20	<20	<20	<20
Arsenic	T-As	1900	485	91	720	1240
Barium	T-Ba	1120	107	63	88	103
Beryllium	T-Be	0.7	1.5	<0.5	0.6	1.8
Cadmium	T-Cd	6.3	<0.5	<0.5	2.8	4.5
Chromium	T-Cr	27	39	8	16	45
Cobalt	T-Co	56	22	4	10	22
Copper	T-Cu	1060	78	18	47	81
Lead	T-Pb	<50	<50	<50	<50	160
Mercury	T-Hg	0.742	0.008	0.018	0.026	0.014
Molybdenum	T-Mo	12	<4	19	10	<4
Nickel	T-Ni	132	40	15	38	43
Selenium	T-Se	2	<2	<2	<2	<2
Silver	T-Ag	6	<2	<2	<2	<2
Tin	T-Sn	<10	<10	<10	<10	<10
Vanadium	T-V	135	28	12	31	41
Zinc	T-Zn	427	52	45	1270	461

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		Upper Laydown	Sewage Sed.	Camp Generator E	D/G Grease Ramp	Camp Maint. Shed
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*16*	*17*	*18*	*19*	*20*
Total Metals						
Antimony	T-Sb	<40	<20	<20	<20	<20
Arsenic	T-As	10300	113	538	405	164
Barium	T-Ba	96	34	72	161	222
Beryllium	T-Be	<1	0.6	1.3	<0.5	<0.5
Cadmium	T-Cd	1.0	<0.5	4.4	0.6	0.6
Chromium	T-Cr	18	40	38	19	24
Cobalt	T-Co	19	11	18	12	10
Copper	T-Cu	657	36	57	49	25
Lead	T-Pb	<100	<50	<50	<50	<50
Mercury	T-Hg	0.013	0.020	0.008	0.021	0.029
Molybdenum	T-Mo	<8	<4	<4	5	<4
Nickel	T-Ni	60	38	31	35	27
Selenium	T-Se	<10	<2	<2	<2	<2
Silver	T-Ag	<4	<2	<2	<2	<2
Tin	T-Sn	<20	<10	<10	<10	<10
Vanadium	T-V	30	17	28	59	36
Zinc	T-Zn	439	121	480	72	68

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RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		Camp Diesel Intake	1510 Portal-Diesel	Waste Oil Storage	Lube Storage Area	Utility Trench
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*21*	*22*	*23*	*24*	*25*
Total Metals						
Antimony	T-Sb	<20	<40	<20	<20	<20
Arsenic	T-As	262	7470	411	20	155
Barium	T-Ba	24	63	94	625	22
Beryllium	T-Be	<0.5	<1	1.6	0.5	<0.5
Cadmium	T-Cd	<0.5	2.9	1.1	0.9	<0.5
Chromium	T-Cr	22	22	52	21	25
Cobalt	T-Co	13	13	21	7	12
Copper	T-Cu	28	294	53	23	29
Lead	T-Pb	<50	<100	<50	<50	<50
Mercury	T-Hg	0.009	0.015	0.015	0.078	0.008
Molybdenum	T-Mo	<4	<8	<4	<4	<4
Nickel	T-Ni	26	32	41	27	31
Selenium	T-Se	<2	<2	<2	<2	<2
Silver	T-Ag	<2	<4	<2	<2	<2
Tin	T-Sn	<10	<20	<10	<10	<10
Vanadium	T-V	17	30	38	49	15
Zinc	T-Zn	82	286	275	120	67

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID		Mill Misc. Storage	Mainten-ance Shed N	Mill N-Diesel Pump	Mainten-ance Shed	Berm Outside
Sample Date		99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID		*26*	*27*	*28*	*29*	*30*
Total Metals						
Antimony	T-Sb	<20	<40	<20	<20	<20
Arsenic	T-As	1330	370	2270	5870	1560
Barium	T-Ba	171	22	88	161	87
Beryllium	T-Be	1.1	<1	1.0	0.5	1.3
Cadmium	T-Cd	2.7	<0.5	2.2	0.8	3.6
Chromium	T-Cr	35	24	45	46	42
Cobalt	T-Co	14	14	14	13	18
Copper	T-Cu	151	28	119	162	78
Lead	T-Pb	77	<100	<50	<50	56
Mercury	T-Hg	0.036	0.008	0.017	0.029	0.026
Molybdenum	T-Mo	<4	<8	<4	<4	<4
Nickel	T-Ni	30	31	34	40	39
Selenium	T-Se	<2	<4	<2	<2	<2
Silver	T-Ag	<2	<4	<2	<2	<2
Tin	T-Sn	<10	<20	<10	<10	<10
Vanadium	T-V	32	15	34	35	32
Zinc	T-Zn	330	78	236	166	362

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2] File No. L1027

Sample ID		CN process W. side	SO2 Tank
Sample Date		99 09 24	99 09 24
ASL ID		*31*	*32*
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	6170	8810
Barium	T-Ba	84	63
Beryllium	T-Be	1.3	0.6
Cadmium	T-Cd	1.9	0.8
Chromium	T-Cr	41	43
Cobalt	T-Co	14	6
Copper	T-Cu	160	231
Lead	T-Pb	54	63
Mercury	T-Hg	0.021	0.014
Molybdenum	T-Mo	5	6
Nickel	T-Ni	32	20
Selenium	T-Se	<2	<2
Silver	T-Ag	<2	<2
Tin	T-Sn	<10	<10
Vanadium	T-V	36	42
Zinc	T-Zn	160	147

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RESULTS OF ANALYSIS - Sediment/Soil[1,2] File No. L1027

Sample ID	GB-1	GB-2	GB-4	Upper Laydown	Camp Generator E
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID	*12*	*13*	*15*	*16*	*18*
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	<0.01	<0.01	<0.01	-	-
Acenaphthylene	<0.01	<0.01	<0.01	-	-
Anthracene	<0.01	<0.01	<0.01	-	-
Benz(a)anthracene	<0.01	<0.01	<0.01	-	-
Benzo(a)pyrene	<0.01	<0.01	<0.01	-	-
Benzo(b)fluoranthene	<0.01	<0.01	<0.01	-	-
Benzo(g,h,i)perylene	<0.01	<0.01	<0.01	-	-
Benzo(k)fluoranthene	<0.01	<0.01	<0.01	-	-
Chrysene	<0.01	<0.01	<0.01	-	-
Dibenz(a,h)anthracene	<0.01	<0.01	<0.01	-	-
Fluoranthene	<0.01	<0.01	<0.01	-	-
Fluorene	<0.01	<0.01	<0.01	-	-
Indeno(1,2,3-c,d)pyrene	<0.01	<0.01	<0.01	-	-
Naphthalene	<0.01	<0.01	0.01	-	-
Phenanthrene	<0.01	<0.01	0.01	-	-
Pyrene	<0.01	<0.01	0.01	-	-
Extractable Hydrocarbons					
EPH10-19	<200	<200	<200	<200	<200
EPH19-32	<200	<200	<200	12400	6200
LEPH	<200	<200	<200	-	-
HEPH	<200	<200	<200	-	-

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	D/G Grease Ramp	Camp Maint. Shed	Camp Diesel Intake	1510 Portal-Diesel	Waste Oil Storage
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
Extractable Hydrocarbons					
EPH10-19	<200	331	15000	3610	411
EPH19-32	<200	6500	3430	8210	27800

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< = Less than the detection limit indicated.
EPH = Extractable Petroleum Hydrocarbons.
[1]Results are expressed as milligrams per dry kilogram except where noted.
[2]LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	Lube Storage Area	Utility Trench	Mill Misc. Storage	Mainten-ance Shed N	Mill N-Diesel Pump
Sample Date	99 09 24	99 09 24	99 09 24	99 09 24	99 09 24
ASL ID	*24*	*25*	*26*	*27*	*28*
Extractable Hydrocarbons					
EPH10-19	<200	32600	207	<200	2990
EPH19-32	<200	4500	311	<200	1060

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

RESULTS OF ANALYSIS - Sediment/Soil[1,2]

File No. L1027

Sample ID	Mainten-ance Shed	SO2 Tank
Sample Date	99 09 24	99 09 24
ASL ID	*29*	*32*
Inorganic Parameters		
Sulphide S	-	<0.2
Total Sulphur[3]	-	1.60
Extractable Hydrocarbons		
EPH10-19	<200	-
EPH19-32	2630	-

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[1]Results are expressed as milligrams per dry kilogram except where noted.
[2]LEPH & HEPH = Light and Heavy Extractable Petroleum Hydrocarbons.
[3]% = Percent, dry weight basis.

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1027

Sediment/Soil[1,2]		Polishing Pond	Polishing Pond
		99 09 24	QC # 174316
Physical Tests			
Moisture	%	39.7	39.4
pH		7.89	8.04
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	1900	1590
Barium	T-Ba	1120	1110
Beryllium	T-Be	0.7	0.8
Cadmium	T-Cd	6.3	5.7
Chromium	T-Cr	27	28
Cobalt	T-Co	56	55
Copper	T-Cu	1060	1010
Lead	T-Pb	<50	<50
Mercury	T-Hg	0.742	0.693
Molybdenum	T-Mo	12	11
Nickel	T-Ni	132	138
Selenium	T-Se	2	2
Silver	T-Ag	6	6
Tin	T-Sn	<10	<10
Vanadium	T-V	135	137
Zinc	T-Zn	427	440

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1027

Sediment/Soil[1,2]		Camp Diesel Intake 99 09 24	Camp Diesel Intake QC # 174317
Physical Tests			
Moisture	%	14.7	13.0
pH		8.15	8.21
Total Metals			
Antimony	T-Sb	<20	<20
Arsenic	T-As	262	343
Barium	T-Ba	24	31
Beryllium	T-Be	<0.5	<0.5
Cadmium	T-Cd	<0.5	<0.5
Chromium	T-Cr	22	23
Cobalt	T-Co	13	15
Copper	T-Cu	28	31
Lead	T-Pb	<50	<50
Mercury	T-Hg	0.009	0.009
Molybdenum	T-Mo	<4	<4
Nickel	T-Ni	26	31
Selenium	T-Se	<2	<2
Silver	T-Ag	<2	<2
Tin	T-Sn	<10	<10
Vanadium	T-V	17	18
Zinc	T-Zn	82	84
Extractable Hydrocarbons			
EPH10-19		15000	13900
EPH19-32		3430	3150

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1027

Water[1,2]			Gully Pooled Water 99 09 24	Gully Pooled Water QC # 174306
Physical Tests				
Conductivity	(umhos/cm)		12	10
Hardness	CaCO3		4.03	4.06
Total Suspended Solids			9	11
Dissolved Anions				
Acidity (to pH 8.3)		CaCO3	3	3
Alkalinity-Total		CaCO3	2	3
Sulphate	SO4		2	2
Total Metals				
Aluminum	T-Al		0.130	0.142
Antimony	T-Sb		<0.0001	<0.0001
Arsenic	T-As		0.0132	0.0130
Barium	T-Ba		<0.01	<0.01
Beryllium	T-Be		<0.001	<0.001
Boron	T-B		<0.1	<0.1
Cadmium	T-Cd		0.00068	0.00068
Calcium	T-Ca		1.32	1.31
Chromium	T-Cr		<0.0005	<0.0005
Cobalt	T-Co		0.0024	0.0024
Copper	T-Cu		0.0014	0.0014
Iron	T-Fe		0.20	0.20
Lead	T-Pb		0.00078	0.00078
Magnesium	T-Mg		0.4	0.4
Manganese	T-Mn		0.172	0.170
Mercury	T-Hg		<0.00002	<0.00002
Molybdenum	T-Mo		<0.03	<0.03
Nickel	T-Ni		0.002	0.002
Potassium	T-K		<2	<2
Selenium	T-Se		<0.001	<0.001
Silver	T-Ag		<0.00001	<0.00001
Sodium	T-Na		<2	<2
Thallium	T-Tl		<0.00005	<0.00005
Titanium	T-Ti		<0.01	<0.01
Uranium	T-U		<0.0001	<0.0001
Vanadium	T-V		<0.03	<0.03
Zinc	T-Zn		0.475	0.470

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

Appendix 1 - QUALITY CONTROL - Replicates

File No. L1027

Water[1,2]		Gully Pooled Water 99 09 24	Gully Pooled Water QC # 174306
Dissolved Metals			
Aluminum	D-Al	0.016	0.016
Antimony	D-Sb	<0.0001	<0.0001
Arsenic	D-As	0.0041	0.0042
Barium	D-Ba	<0.01	<0.01
Beryllium	D-Be	<0.001	<0.001
Boron	D-B	<0.1	<0.1
Cadmium	D-Cd	<0.00005	<0.00005
Calcium	D-Ca	1.34	1.36
Chromium	D-Cr	<0.0005	<0.0005
Cobalt	D-Co	<0.0001	<0.0001
Copper	D-Cu	0.0004	0.0004
Iron	D-Fe	<0.03	<0.03
Lead	D-Pb	<0.0001	<0.0001
Magnesium	D-Mg	0.2	0.2
Manganese	D-Mn	<0.005	<0.005
Mercury	D-Hg	<0.00002	<0.00002
Molybdenum	D-Mo	<0.03	<0.03
Nickel	D-Ni	<0.001	<0.001
Potassium	D-K	<2	<2
Selenium	D-Se	<0.001	<0.001
Silver	D-Ag	<0.00001	<0.00001
Sodium	D-Na	<2	<2
Thallium	D-Tl	<0.00005	<0.00005
Titanium	D-Ti	<0.01	<0.01
Uranium	D-U	<0.0001	<0.0001
Vanadium	D-V	<0.03	<0.03
Zinc	D-Zn	<0.005	<0.005

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

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

Conventional Parameters in Water

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

Metals in Water

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

Recommended Holding Time:

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

Mercury in Water

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

Recommended Holding Time:

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

Extractable Hydrocarbons in Water

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

Please note that in August of 1999, BCMELP replaced the EPH(C10-18) and EPH(C19-31) parameters with EPH(C10-19) and EPH(C19-32). These parameters were redefined so that they more accurately describe how the analysis is carried out. Results reported by ASL for the old and new parameters are equivalent. ASL implemented the new parameters on August 23, 1999.

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

Moisture in Sediment/Soil

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

Recommended Holding Time:

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

pH in Soil

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

Conventional Parameters in Sediment/Soil

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

Metals in Sediment/Soil

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

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

Recommended Holding Time:

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

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using a procedure adapted from EPA Methods 3500, 3630, and 8270 (Publ. #SW-846, 3rd ed., Washington, DC 20460) and 3545 (SW-846 Laboratory Manual - Update III, Federal Register, Vol 60, No.142/Tuesday, July 25, 1995, pg 37974-37980). The procedure uses an automated system to extract samples with a 1:1 mixture of hexane and acetone. A portion of the extract is exchanged to toluene, cleaned, and analysed by capillary column gas chromatography with mass spectrometric detection.

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

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out according to British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure uses an automated system to extract samples with a 1:1 mixture of Hexane and Acetone. The extract is exchanged to Toluene and analysed by capillary column gas chromatography with flame ionization detection. Reported results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbon (LEPH/HEPH).

Please note that in August of 1999, BCMELP replaced the EPH(C10-18) and EPH(C19-31) parameters with EPH(C10-19) and EPH(C19-32). These parameters were redefined so that they more accurately describe how the analysis is carried out. Results reported by ASL for the old and new parameters are equivalent. ASL implemented the new parameters on August 23, 1999.

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

Extractable Hydrocarbons in Sediment/Soil

This analysis is carried out according to British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure involves the extraction of the sample with a 1:1 mixture of Hexane and Acetone. The extract is then back extracted with water and analysed by capillary column gas chromatography with flame ionization detection. Reported results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy

Extractable Petroleum Hydrocarbon (LEPH/HEPH).

Please note that in August of 1999, BCMELP replaced the EPH(C10-18) and EPH(C19-31) parameters with EPH(C10-19) and EPH(C19-32). These parameters were redefined so that they more accurately describe how the analysis is carried out. Results reported by ASL for the old and new parameters are equivalent. ASL implemented the new parameters on August 23, 1999.

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

Light and Heavy Extractable Petroleum Hydrocarbons in Solids

These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated by subtracting selected Polynuclear Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for naphthalene and phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, and pyrene are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Solids by GC/FID"(Version 2.1, July 20, 1999).

Recommended Holding Time: n/a

Sulphide in Sediment/Soil

This analysis is carried out on a leachable basis. The procedure involves mixing the sample with a sodium hydroxide solution in a one to ten ratio and leaching for several hours. The leachate is then centrifuged and analyzed colorimetrically.

Total Sulphur in Sediment/Soil

The sample is combusted in a Leco induction furnace. The resulting sulphur vapour is detected by either an infrared detector or by titrimetric method depending upon the sulphur content.

Note: Sulphur analysis is subcontracted.

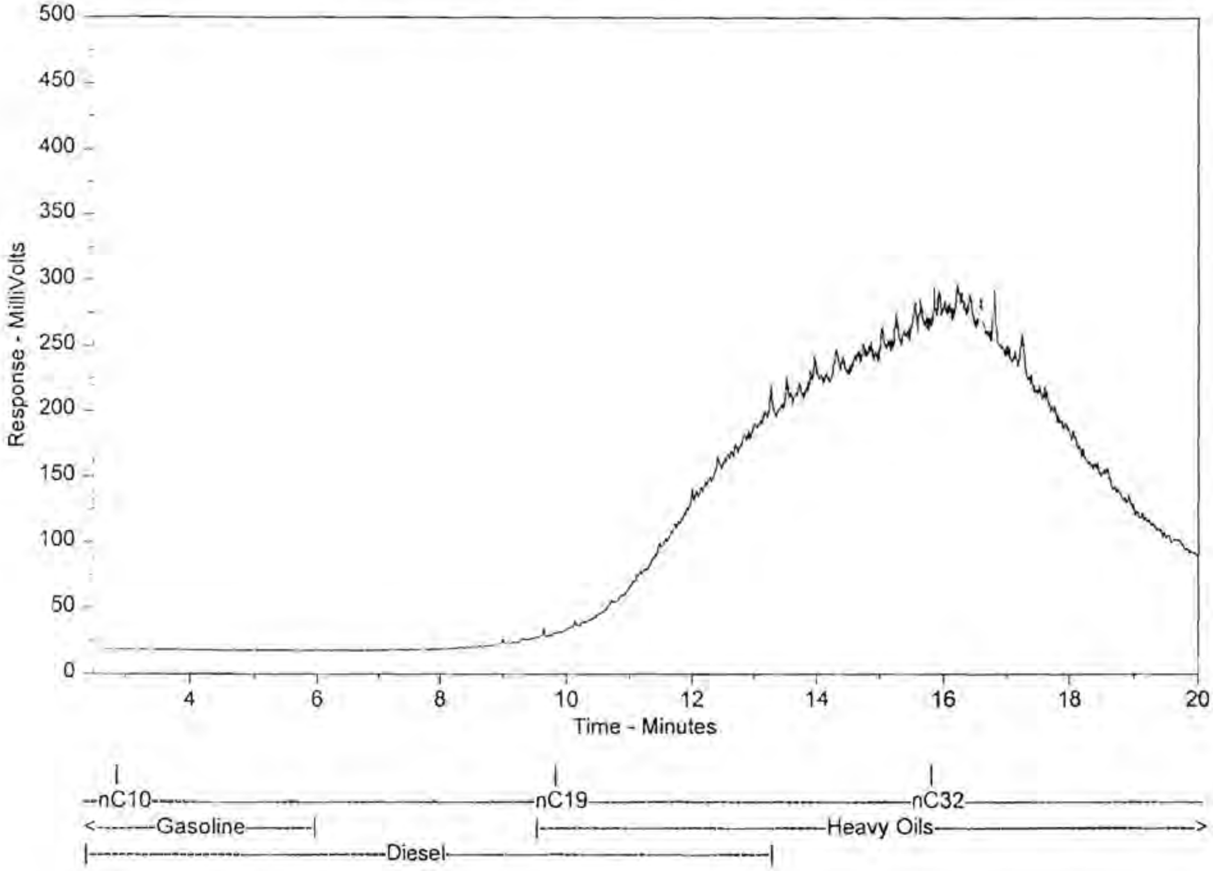
End of Report

APPENDIX

HYDROCARBON DISTRIBUTION REPORTS

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--16**
File Name: c:\chrom\gc12\data\gc12_01octB.0029.RAW
Run Information: Acquired on GC12, 10/2/99 6:20:28 AM



Sample Amount = 9.7 (g or mL) Dilution Factor = 80.0

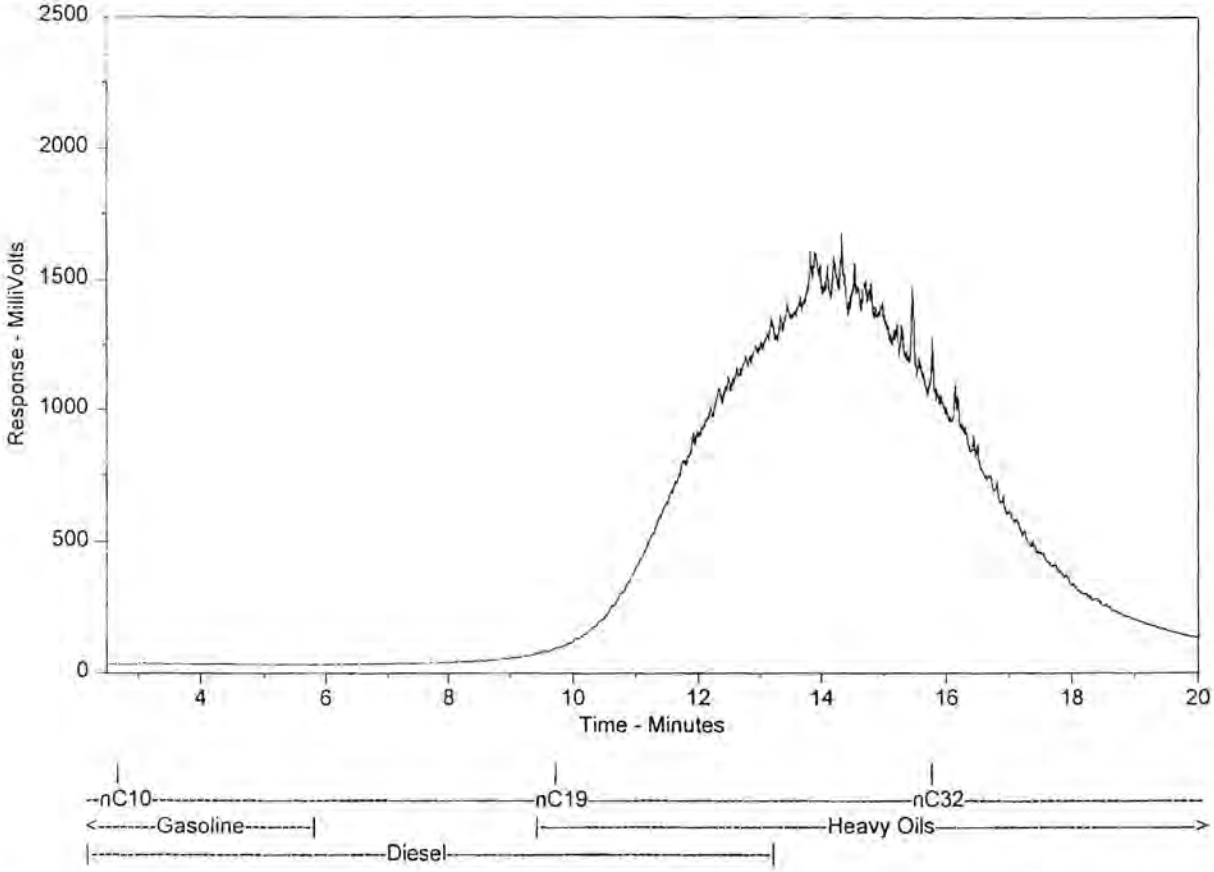
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--18**
File Name: c:\chrom\gc12\data\gc12_01octA.0031.RAW
Run Information: Acquired on GC12, 10/2/99 7:23:01 AM



Sample Amount = 9.4 (g or mL) Dilution Factor = 8.0

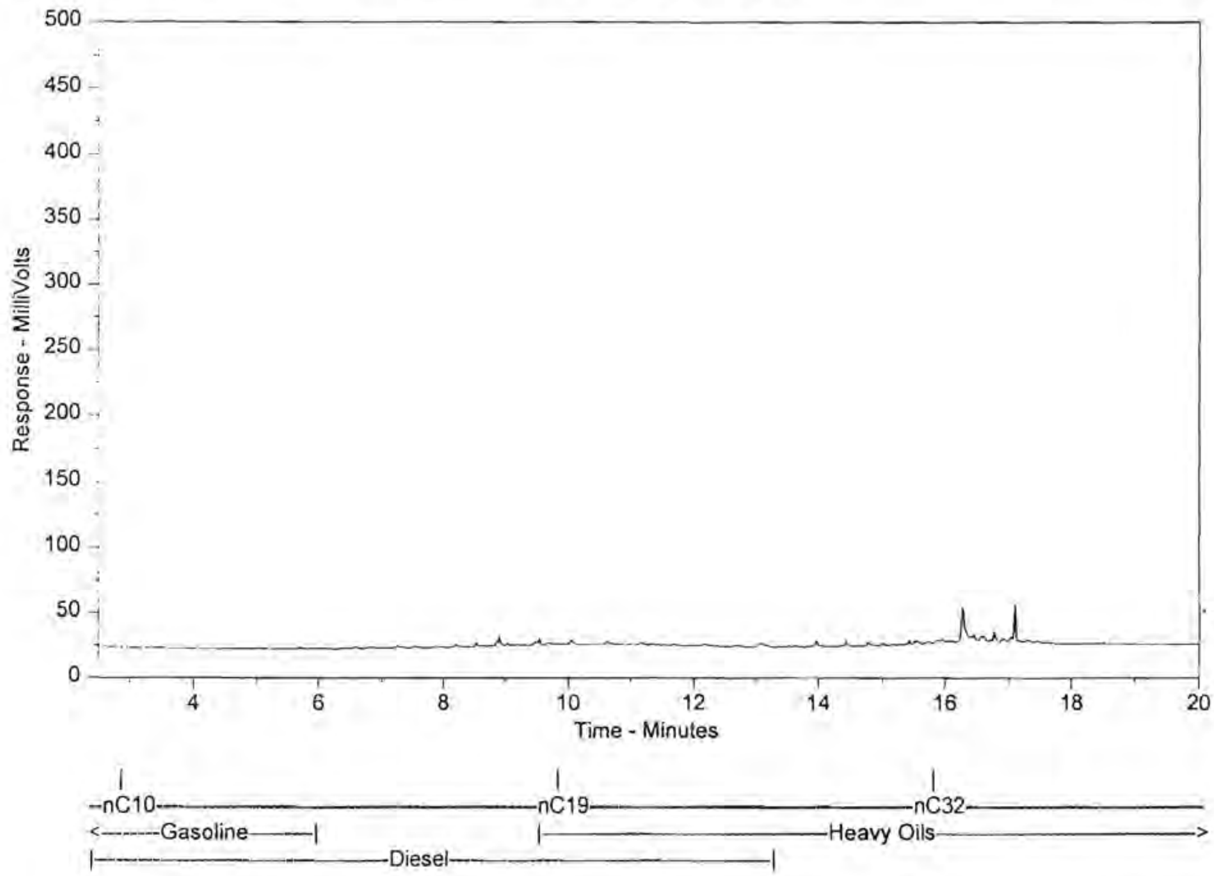
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--19#RR**
File Name: c:\chrom\gc12\data\gc12_02novB.0020.RAW
Run Information: Acquired on GC12, 11/3/99 12:06:45 AM



Sample Amount = 9.3 (g or mL) Dilution Factor = 8.0

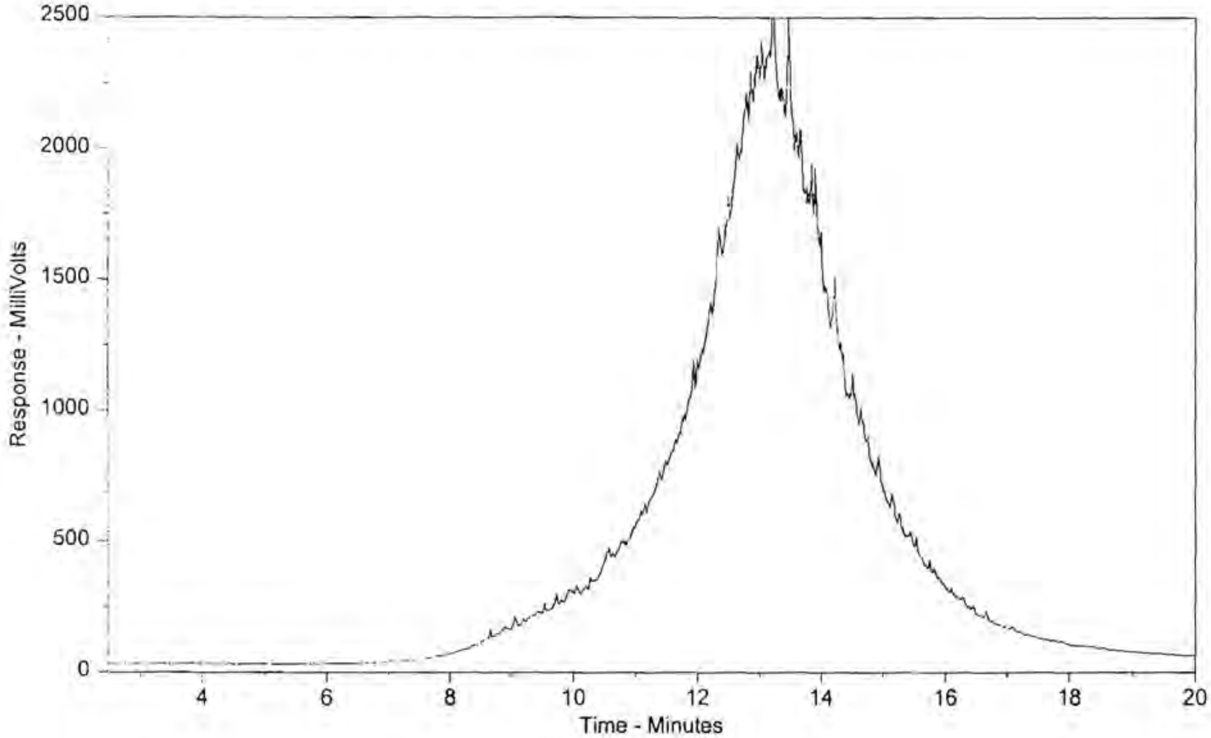
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--20**
File Name: c:\chrom\gc12\data\gc12_01octA.0032.RAW
Run Information: Acquired on GC12, 10/2/99 7:54:16 AM



--nC10------------------------------nC19------------------------nC32--------------------
<---------Gasoline--------| |----------------------------Heavy Oils------------------------>
|----------------------------Diesel----------------------------|

Sample Amount = 10.1 (g or mL) Dilution Factor = 8.0

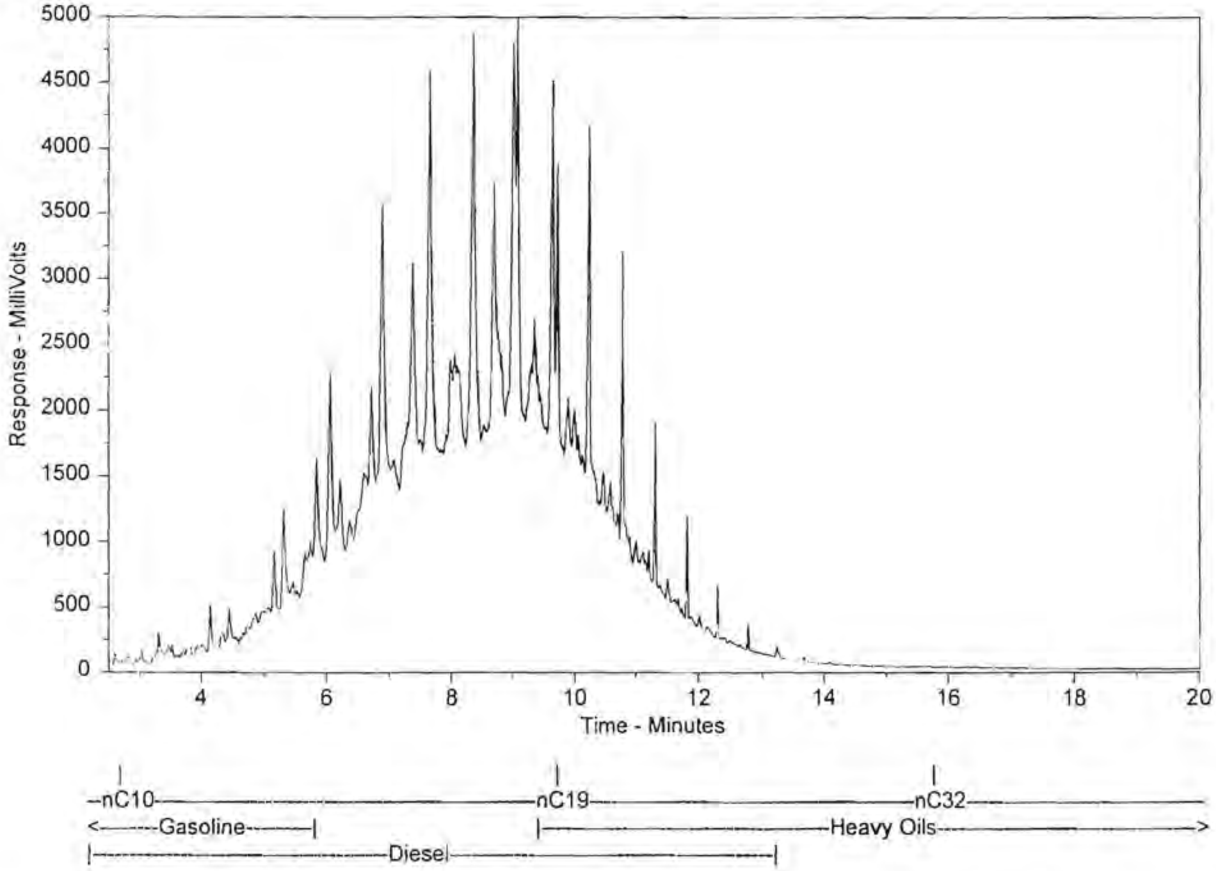
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--21**
File Name: c:\chrom\gc12\data\gc12_01octB.0032.RAW
Run Information: Acquired on GC12, 10/2/99 7:54:17 AM



Sample Amount = 8.8 (g or mL) Dilution Factor = 8.0

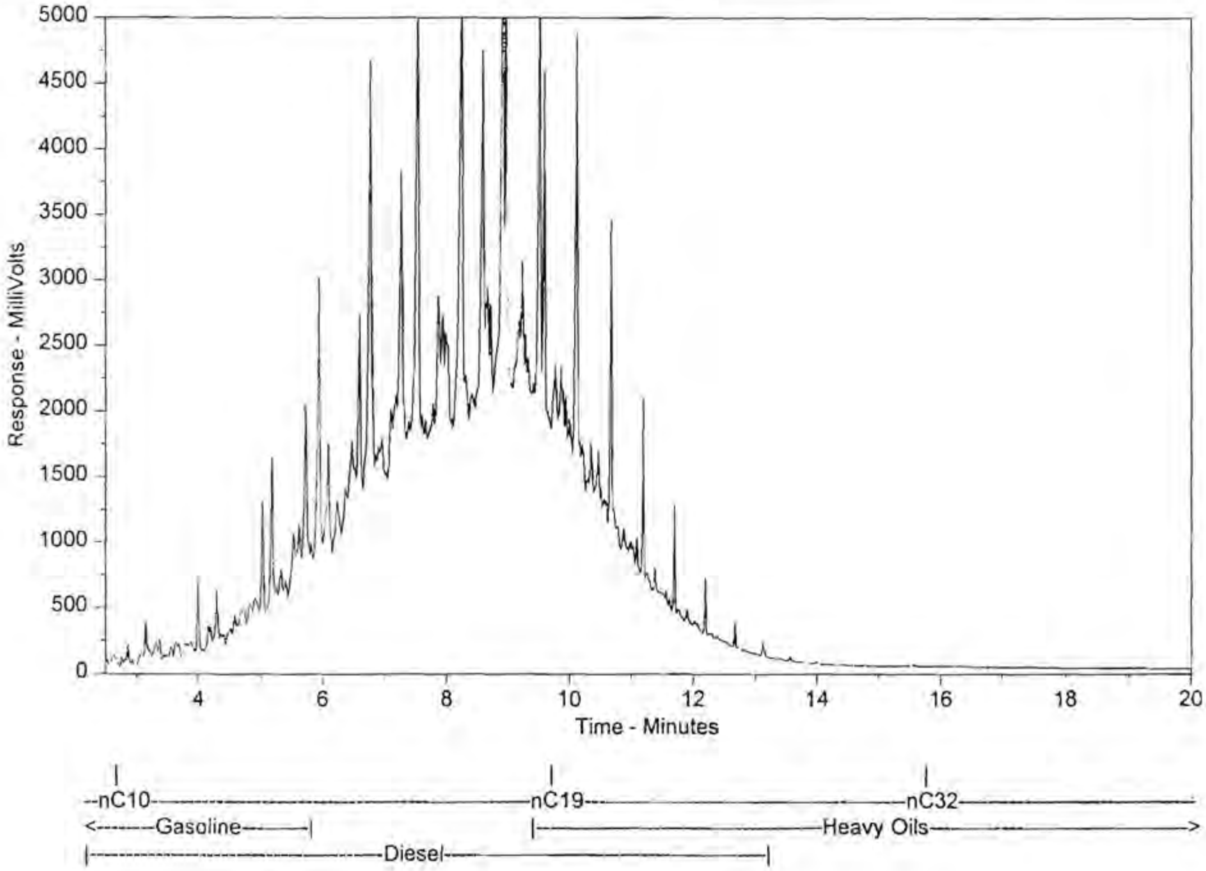
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **QC-T--174317#L1027 21DP**
File Name: c:\chrom\gc12\data\gc12_01octA.0033.RAW
Run Information: Acquired on GC12, 10/2/99 8:25:37 AM



Sample Amount = 7.8 (g or mL) Dilution Factor = 8.0

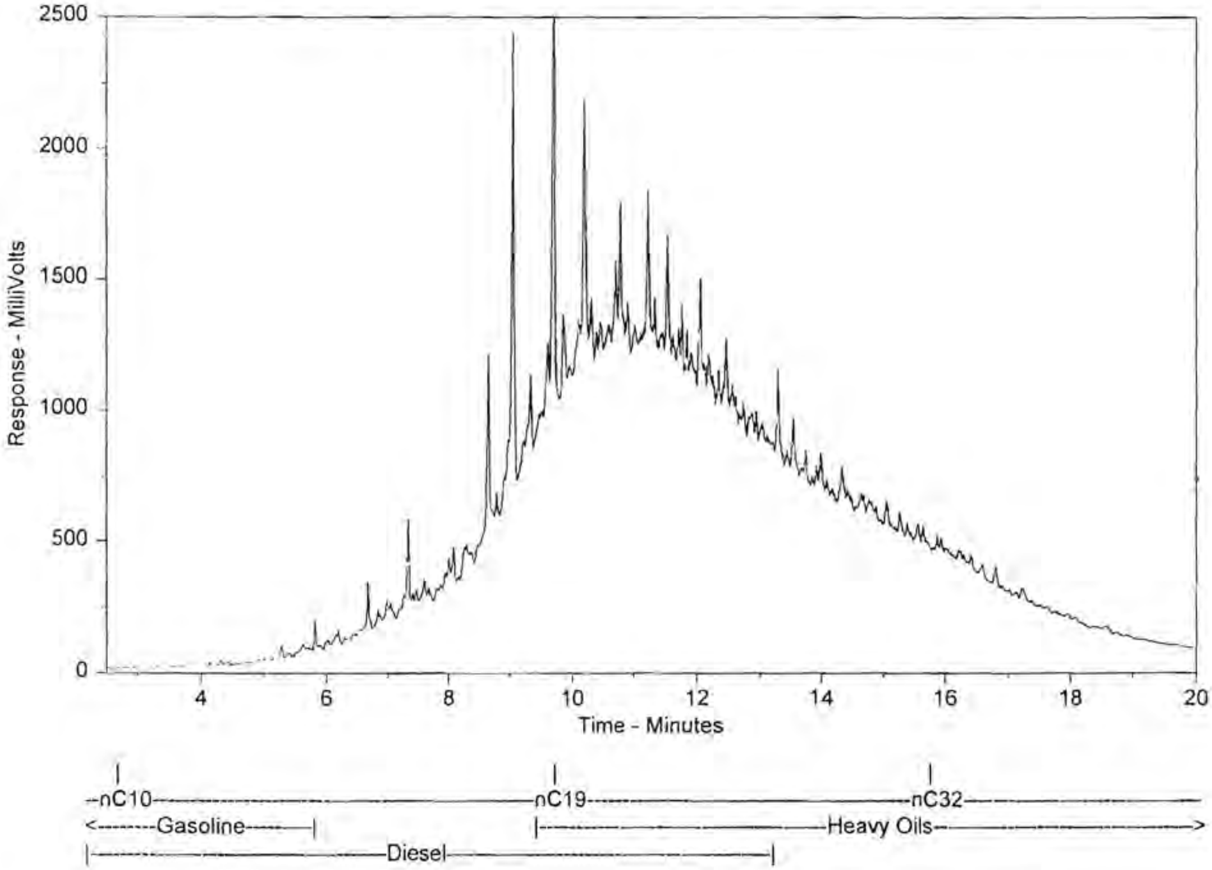
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--22**
File Name: c:\chrom\gc12\data\gc12_01octB.0033.RAW
Run Information: Acquired on GC12, 10/2/99 8:25:38 AM



Sample Amount = 8.9 (g or mL) Dilution Factor = 8.0

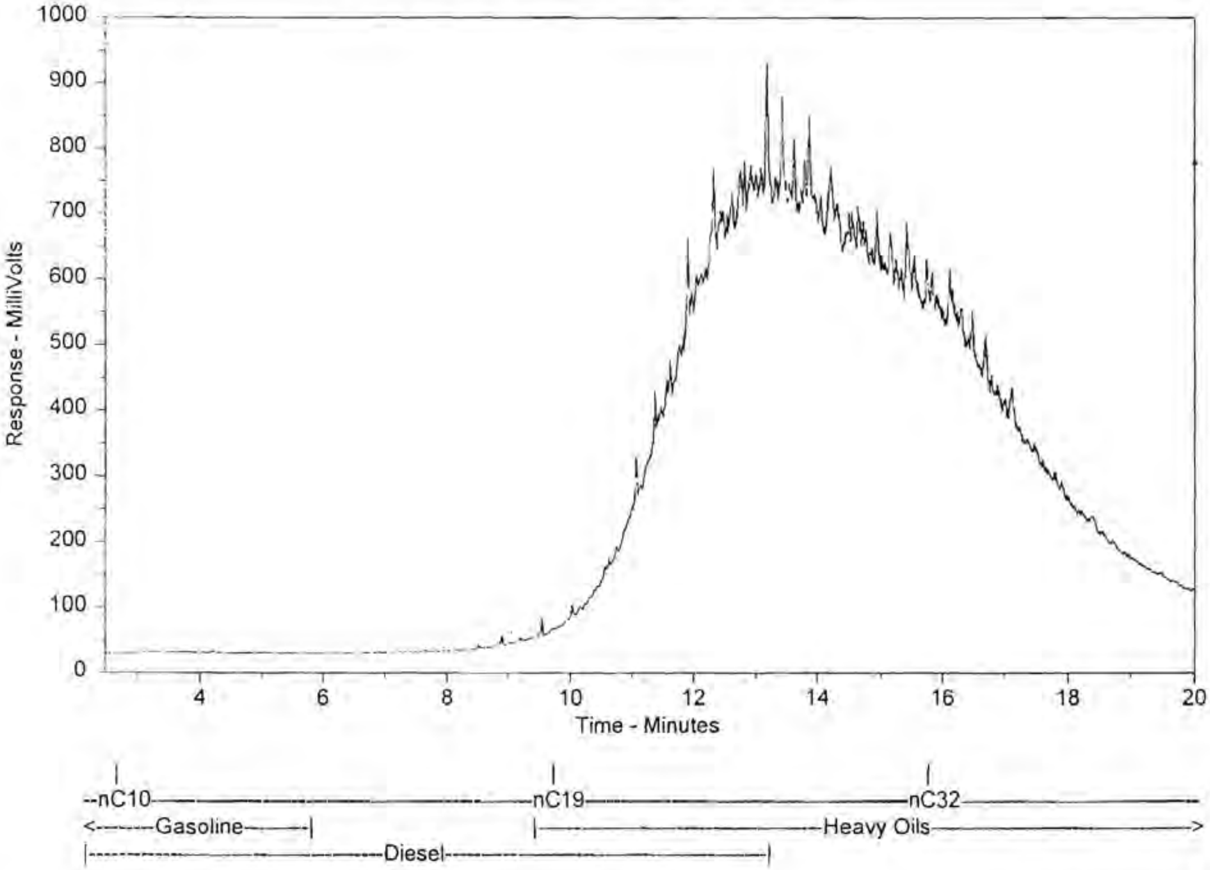
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--23**
File Name: c:\chrom\gc12\data\gc12_01octA.0034.RAW
Run Information: Acquired on GC12, 10/2/99 8:57:00 AM



Sample Amount = 11.2 (g or mL) Dilution Factor = 80.0

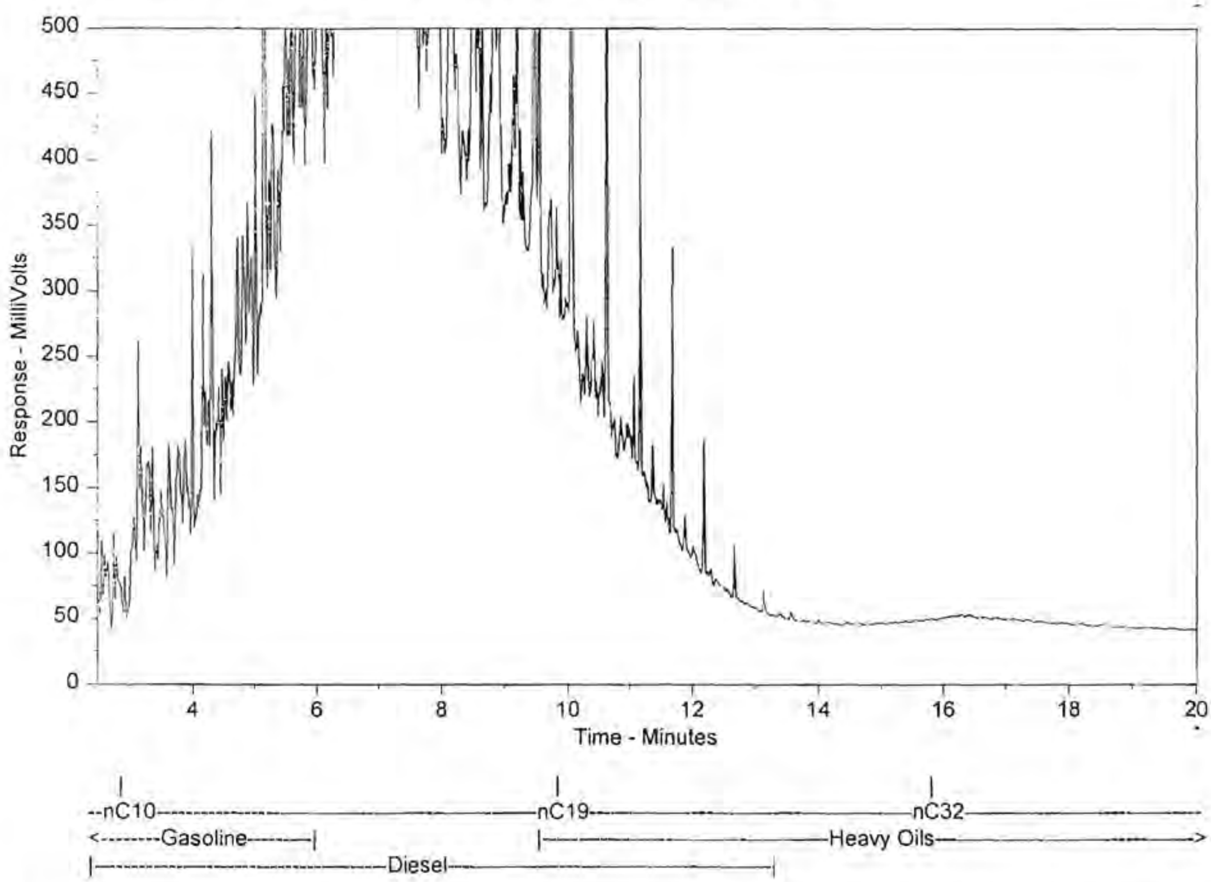
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--25**
File Name: c:\chrom\gc12\data\gc12_01octA.0035.RAW
Run Information: Acquired on GC12, 10/2/99 9:28:27 AM



Sample Amount = 9.3 (g or mL) Dilution Factor = 80.0

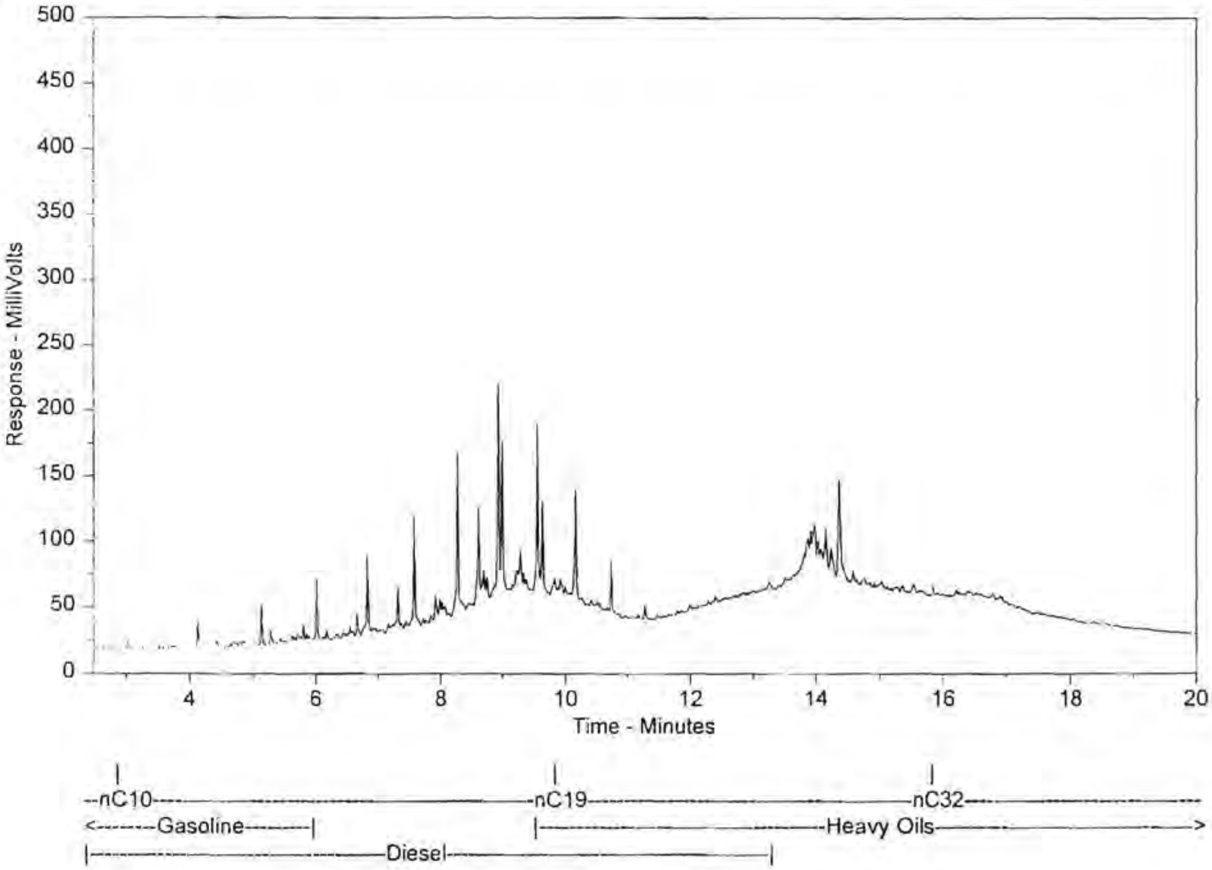
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--26**
File Name: c:\chrom\gc12\data\gc12_01octB.0035.RAW
Run Information: Acquired on GC12, 10/2/99 9:28:28 AM



Sample Amount = 10.7 (g or mL) Dilution Factor = 8.0

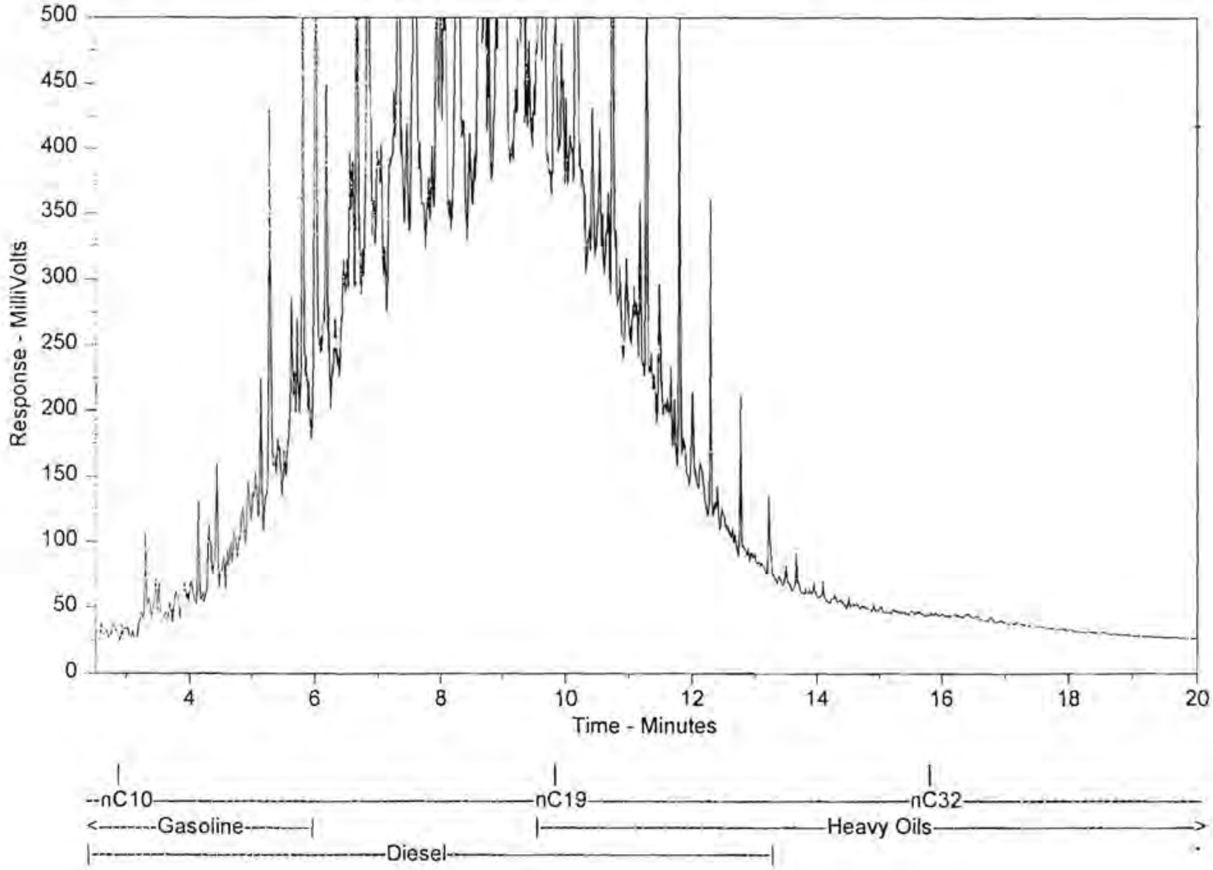
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--28**
File Name: c:\chrom\gc12\data\gc12_01octB.0036.RAW
Run Information: Acquired on GC12, 10/2/99 9:59:57 AM



Sample Amount = 9.6 (g or mL) Dilution Factor = 8.0

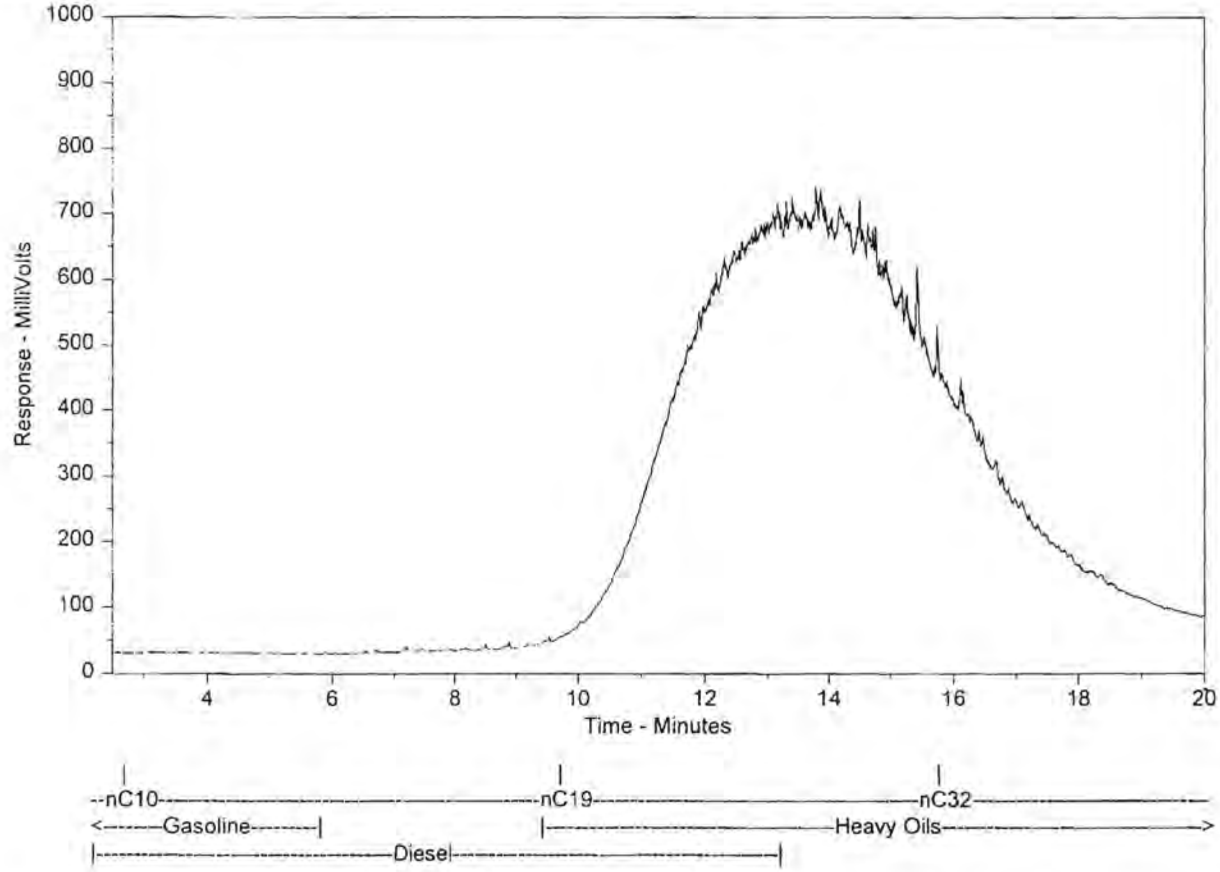
The Hydrocarbon Distribution Report is intended to assist you in characterizing hydrocarbon products that may be present in your sample. The scale at the bottom of the chromatogram indicates the approximate retention times of common petroleum products, and of three n-alkane hydrocarbon marker compounds.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

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

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

ASL Hydrocarbon Distribution Report

Client Sample ID:
ASL Sample ID: **L1027-T--29**
File Name: c:\chrom\gc12\data\gc12_01octA.0037.RAW
Run Information: Acquired on GC12, 10/2/99 10:31:26 AM



Sample Amount = 10.9 (g or mL) Dilution Factor = 8.0

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

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

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

APPENDIX

CHAIN OF CUSTODY FORMS

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243
FAX: (604) 253-6700
Specialists in Environmental Chemistry
analytical service laboratories ltd.

CLIENT: Gartner Lee Ltd

ADDRESS: Suite C, 206 Lowe St Whitehorse

CONTACT: Forest Pearson

TELEPHONE: (867) 633-6474 FAX: 633-6321

PROJECT NAME/NO.: Ketza River Mine / 99-914

QUOTE / P.O. NO.:

DATE SUBMITTED: ASL CONTACT: Heather

LAB USE ONLY: L1027

ANALYSIS REQUESTED

FOR LAB USE ONLY	SAMPLE IDENTIFICATION	Y	M	D	TIME	MATRIX	General Chemistry	Total Metals	Dissolved Metals	Cyanide	EPH	Sulphates	TSS	acidity/alkalinity						NOTES
1	Gully Zone Pooled Water (1)	99	09	24	: AM PM	surface water	X	X	X			X	X	X						3 b[illegible]
2	Low Grade Stockpile (2)				: AM PM		X	X	X			X	X	X						"
3	TP-Seepage (KR-04) (3)				: AM PM		X	X	X	X		X	X	X						4 bottles
4	T Pond (4)				: AM PM		X	X	X	X		X	X	X						"
5	Camp W Ditch				: AM PM		X	X			X									2 bottles
6	KR-15 (5)				: AM PM		X	X	X			X	X	X						5 bottles
7	Garbage Seep Area				: AM PM		X	X				X	X	X						2 bottles
8	Polishing Pond				: AM PM		X	X		X		X	X	X						3 bottles
9	Vat Leach Sump				: AM PM		X	X	X	X		X	X	X						4 bottles
10	Tailings Line Mill Culvert				: AM PM		X	X			X	X	X	X						2 bottles
					: AM PM															
					: AM PM															
					: AM PM															
					: AM PM															
					: AM PM															
					: AM PM															

TURN AROUND REQUIRED:

☒ ROUTINE (7 - 10 WORKING DAYS)

☐ RUSH (SPECIFY DATE):

SPECIAL INSTRUCTIONS:

SAMPLE CONDITION UPON RECEIPT:

☐ FROZEN

☐ COLD

☐ AMBIENT

RELINQUISHED BY:	DATE 09/27/99	RECEIVED BY:	DATE
F. Pearson	TIME		TIME
RELINQUISHED BY:	DATE	RECEIVED BY: AB	DATE 99/9/28
	TIME		TIME 10:03

7°C on arrival

REPORT COPY

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

1988 Triumph Street
Vancouver, BC
Canada V5L 1K5
TEL: (604) 253-4188
TOLL FREE: (800) 665-0243
FAX: (604) 253-6700
Specialists in Environmental Chemistry
analytical service laboratories ltd.

ANALYSIS REQUESTED

CLIENT: Gartner Lee Ltd.
ADDRESS: Suite C, 206 Lowe St, Whitehorse
CONTACT: Forest Pearson
TELEPHONE: (867) 633-6474 FAX: 633-6321
PROJECT NAME/NO.: Ketza River Mine / 99-914
QUOTE / P.O. NO.
DATE SUBMITTED: ASL CONTACT: Heather

FOR LAB USE ONLY

LAB USE ONLY: L9027

LAB USE ONLY	SAMPLE IDENTIFICATION	Y	M	D	TIME COLLECTED	MATRIX	Metals	EPH	PAH	NOTES
11	Polishing Pond	99	09	24	: PM	Soil	X			
12	GB-1				: AM		X	X	X	added by Forest Sept 28/99
13	GB-2				: AM		X	~~X~~	X	
14	GB-3				: AM		X			
15	GB-4				: AM		X	X	X	
16	Upper Laydown				: AM		X	X		
17	Sewage Sed.				: AM		X			
18	Camp Generator E				: PM		X	X		
19	D/g - Grass Ramp				:		X	X		
20	Camp Maint Shed				: AM		X	X		
21	Camp Diesel Intake				: PM		X	X		
22	1510 Portal - Diesel				:		X	X		
23	Waste oil storage - Tailings Pond				: PM		X	X		
24	Lube Storage area				: PM		X	X		
25	Utility trenches btwn Mill + Camp				: PM		X	X		
26	Mill Misc Storage - North Shed				: PM		X	X		

TURN AROUND REQUIRED:
☒ ROUTINE (7 - 10 WORKING DAYS)
☐ RUSH (SPECIFY DATE):
SPECIAL INSTRUCTIONS:

SAMPLE CONDITION UPON RECEIPT:
☐ FROZEN
☐ COLD
☐ AMBIENT

RELINQUISHED BY:	DATE 9/27/99	RECEIVED BY:	DATE
F Pearson	TIME		TIME
RELINQUISHED BY:	DATE	RECEIVED BY:	DATE
	TIME		TIME

Project: Gartner Lee Ltd. 99-914: Ketza River Mine Site

Status of Testing **Lab:** CEM Inc.

rqt'd = requested rec'd = received

Other:	
pH	x
alkalinity	x
acidity	x
sulphates	x
TDS	x
TSS	
hardness	x

		ABA Analyses		Standard Sobek											
Sample	Rock Type	Rinse pH		PPH		NP		TOT S		SO4		S		Inorg C	
		rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd
1 1430 Portal	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
2 Fines at Break Zone Pit	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
3 Below Ridge Zone Pit	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
4 Ridge Zone Pit	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
5 Gully Pit Waste	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
6 Low Grade Stockpile	broken rock	x	x	x	x	x	x	x	x	x	x			x	x
7 Tailings	tailings	x	x	x	x	x	x	x	x	x	x			x	x

	ICP		AA		Extraction(E)/Supernate/(S)											
Sample	Metals		As		Tot Metal		Diss Metal		Other		Minerlgy		Whole Rk		Grain Sze	
	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd	rqt'd	rec'd
1 1430 Portal	x	x	x													
2 Fines at Break Zone Pit	x	x	x				x	x	x	x						
3 Below Ridge Zone Pit	x	x	x				x	x	x	x						
4 Ridge Zone Pit	x	x	x													
5 Gully Pit Waste	x	x	x				x	x	x	x						
6 Low Grade Stockpile	x	x	x													
7 Tailings	x	x	x													

Contact at Gartner Lee Ltd.:
Forest Pearson
Gartner Lee Limited
Suite C - 206 Lowe Street
Whitehorse, Yukon Y1A 1W6
tel: (867) 633-6474 ext 23
fax: (867) 633-6321
Fpearson@gartnerlee.com

CLIENT : MEHLING ENVIRONMENTAL MANAGEMENT
PROJECT : KETZA RIVER MINE SITE
PROJECT # : 9929
TEST : STANDARD SOBEK METHOD ACID-BASE ACCOUNTING

SAMPLE	RINSE pH*	PASTE pH	Volume HCl added (mL)	pH BEFORE TITRATION	S(T) %	S(SO4) %	S(S2) % Calculated	AP Calculated	NP	NET NP Calculated	NP/AP Calculated	TIC** %	Carb.NP Calculated	Carb.NP/AP % Calculated
1430 Portal	8.1	8.8	80	0.53	0.13	0.05	0.08	2.5	186.9	184.4	74.8	1.45	120.8	64.6
Fines at Break Zone Pit	8.3	8.3	40	0.72	0.07	0.05	0.02	0.6	34.4	33.8	55.0	0.18	15.0	43.6
Below Ridge Zone Pit	8.0	8.1	40	1.16	0.32	0.04	0.28	8.8	116.3	107.5	13.3	0.50	41.7	35.8
Ridge Zone Pit	8.1	8.4	80	0.57	0.08	0.07	0.01	0.3	313.8	313.4	1004.0	3.12	259.9	82.8
Gully Pit Waste	4.5	5.3	20	1.95	0.12	0.11	0.01	0.3	0.9	0.6	2.8	0.01	0.8	95.2
Low Grade Stockpile	7.8	8.1	80	0.61	0.09	0.01	0.08	2.5	445.0	442.5	178.0	5.27	439.0	98.6
Tailings	7.9	8.2	80	0.44	0.20	0.07	0.13	4.1	111.9	107.8	27.5	1.33	110.8	99.0
1430 Portal RE	-	8.7	80	0.49	N/D	N/D		2.5	175.0	172.5	70.0	-		

AP = ACID POTENTIAL IN TONNES $CaCO_3$ EQUIVALENT PER 1000 TONNES OF MATERIAL.
AP IS BASED ON THE CALCULATED SULPHIDE SULPHUR [S(S2)] VALUE [= S(T) - S(SO4)]
NP = NEUTRALIZATION POTENTIAL IN TONNES $CaCO_3$ EQUIVALENT PER 1000 TONNES OF MATERIAL.
NET NP = NET NEUTRALIZATION POTENTIAL = NP-AP = TONNES $CaCO_3$ EQUIVALENT PER 1000 TONNES OF MATERIAL.
Carb NP = CARBONATE NEUTRALIZATION POTENTIAL IN TONNES $CaCO_3$ EQUIVALENT PER 1000 TONNES OF MATERIAL = TIC% * 83.3
NOTE - WHERE S(T) AND/OR S(SO4) IS REPORTED AS <0.01%, IT IS ASSUMED TO BE ZERO FOR THE AP CALCULATION.
RE = REPLICATE
N/D = NO DUPLICATE ASSAY. CALCULATIONS ARE BASED ON ASSAY RESULTS OF THE INITIAL SAMPLE.
*RINSE pH ON "AS-RECEIVED" MATERIAL, 50 GRAMS OF SAMPLE IN 50 MLS DISTILLED WATER.
**TIC = TOTAL INORGANIC CARBON.

CLIENT : MEHLING ENVIRONMENTAL MANAGEMENT
PROJECT : KETZA RIVER MINE SITE
PROJECT # : 9929
TEST : HEAD ANALYSES BY ICP

Sample:		1430 Portal	Fines at Break Zone Pit	Below Ridge Zone Pit	Ridge Zone Pit	Gully Pit Waste	Low Grade Stockpile	Tailings
Element								
Ag	ppm	0.2	1.0	<0.2	0.2	<0.2	<0.2	1.0
Al	%	3.13	0.32	6.04	1.34	0.76	1.10	0.28
As	ppm	8940	>10000	495	>10000	4360	1635	>10000
As	%	0.82	1.89	-	3.25	-	-	3.73
Ba	ppm	80	60	200	40	60	20	70
Be	ppm	1.0	<0.5	1.5	0.5	<0.5	<0.5	<0.5
Bi	ppm	105	750	<5	130	30	15	245
Ca	%	5.96	1.09	4.04	10.70	0.06	17.1	4.40
Cd	ppm	<1	<1	<1	<1	<1	<1	<1
Co	ppm	15	5	18	13	6	10	6
Cr	ppm	54	15	92	22	39	24	<1
Cu	ppm	225	772	59	529	73	45	675
Fe	%	11.48	40.2	5.32	14.18	6.20	3.60	38.4
K	%	0.67	0.05	1.34	0.22	0.20	0.08	0.04
Mg	%	1.02	0.15	1.57	0.43	0.30	0.91	0.44
Mn	ppm	615	890	560	755	170	490	1005
Mo	ppm	<2	<2	2	<2	<2	<2	<2
Na	%	0.16	0.01	0.34	0.04	0.01	0.01	0.02
Ni	ppm	39	15	44	26	14	22	22
P	ppm	560	400	600	470	470	400	370
Pb	ppm	38	74	58	36	36	16	130
Sb	ppm	15	20	5	25	5	5	145
Sc	ppm	4	<1	9	3	1	2	<1
Sn	ppm	<10	<10	<10	<10	<10	<10	<10
Sr	ppm	257	53	251	278	11	569	123
Ti	%	0.07	<0.01	0.14	0.02	0.01	<0.01	<0.01
V	ppm	40	30	53	27	12	10	24
W	ppm	<10	<10	<10	<10	<10	<10	<10
Y	ppm	7	4	7	10	3	9	7
Zn	ppm	199	72	374	56	29	30	225
Zr	ppm	11	21	6	11	4	5	16

Ketza River Mine

Solids ICP Data		Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids	Solids
		Al	Sb	As	Ba	Ca	Cr	Co	Cu	Mg	Pb	Ni	Zn
Location	Description	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Fines at Break Zone Pit	broken rock	3200	20	18900	60	10900	15	5	772	1500	74	15	72
Below Ridge Zone Pit	broken rock	60400	5	495	200	40400	92	18	59	15700	58	44	374
Gully Pit Waste	broken rock	7600	5	4360	60	600	39	6	73	3000	36	14	29

Extraction Solution ICP Data		Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct	Extrct
		Al	Sb	As	Ba	Ca	Cr	Co	Cu	Mg	Pb	Ni	Zn
Location	Description	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Fines at Break Zone Pit	broken rock	< 0.2	< 0.2	< 0.2	< 0.01	25.7	< 0.01	< 0.01	< 0.01	1.6	< 0.05	< 0.05	< 0.005
Below Ridge Zone Pit	broken rock	< 0.2	< 0.2	< 0.2	0.03	47.8	< 0.01	< 0.01	< 0.01	0.6	< 0.05	< 0.05	< 0.005
Gully Pit Waste	broken rock	< 0.2	< 0.2	< 0.2	0.02	19.9	< 0.01	0.02	< 0.01	2.1	< 0.05	< 0.05	0.007

Calculated Percent Extraction From Solids		Al	Sb	As	Ba	Ca	Cr	Co	Cu	Mg	Pb	Ni	Zn
Location	Description	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n	% extr'n
Fines at Break Zone Pit	broken rock	< 0.02	< 3.00	< 0.00	< 0.05	0.71	< 0.20	< 0.60	< 0.00	0	< 0.2	< 1.0	< 0.02
Below Ridge Zone Pit	broken rock	< 0.00	< 12.00	< 0.12	0.05	0.35	< 0.03	< 0.17	< 0.05	0.01	< 0.26	< 0.3	< 0.00
Gully Pit Waste	broken rock	< 0.01	< 12.00	< 0.01	0.10	9.95	< 0.08	1.00	< 0.04	0.21	< 0.42	< 1.07	0.07

Calculated Soluble Metal Load From Sample		Al	Sb	As	Ba	Ca	Cr	Co	Cu	Mg	Pb	Ni	Zn
Location	Description	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne	g/tonne
Fines at Break Zone Pit	broken rock	< 0.6	< 0.6	< 0.6	< 0.03	77.1	< 0.03	< 0.03	< 0.03	4.8	< 0.15	< 0.15	< 0.015
Below Ridge Zone Pit	broken rock	< 0.6	< 0.6	< 0.6	0.09	143.4	< 0.03	< 0.03	< 0.03	1.8	< 0.15	< 0.15	< 0.015
Gully Pit Waste	broken rock	< 0.6	< 0.6	< 0.6	0.06	59.7	< 0.03	0.06	< 0.03	6.3	< 0.15	< 0.15	0.021

Immediates

Location	Description	pH	SO4 mg/L	Alkalinity mg CaCO3/l	Acidity (pH 4.5) (mg CaCO3/L)	Acidity (pH 8.3) (mg CaCO3/L)	Conductivity (uS/cm)	TDS mg/L	Hardness mg CaCO3/l
Fines at Break Zone Pit	broken rock	8.01	6	67.5	0.0	2.0	137	60	70.5
Below Ridge Zone Pit	broken rock	7.90	75	54.5	0.0	3.0	259	173	122
Gully Pit Waste	broken rock	6.03	60	2.5	0.0	6.0	145	92	58.3

CLIENT : MEHLING ENVIRONMENTAL MANAGEMENT
PROJECT : KETZA RIVER MINE SITE
PROJECT # : 9929
TEST : LEACH EXTRACTION TEST

LEACHATE ANALYSIS BY ICP

Sample Name:		Fines at Break Zone Pit	Below Ridge Zone Pit	Gully Pit Waste
Dissolved Metals				
Al	mg/L	<0.2	<0.2	<0.2
Sb	mg/L	<0.2	<0.2	<0.2
As	mg/L	<0.2	<0.2	<0.2
Ba	mg/L	<0.01	0.03	0.02
Be	mg/L	<0.005	<0.005	<0.005
Bi	mg/L	<0.1	<0.1	<0.1
B	mg/L	<0.1	<0.1	<0.1
Cd	mg/L	<0.01	<0.01	<0.01
Ca	mg/L	25.7	47.8	19.9
Cr	mg/L	<0.01	<0.01	<0.01
Co	mg/L	<0.01	<0.01	0.02
Cu	mg/L	<0.01	<0.01	<0.01
Fe	mg/L	<0.03	<0.03	0.09
Pb	mg/L	<0.05	<0.05	<0.05
Li	mg/L	<0.01	<0.01	<0.01
Mg	mg/L	1.6	0.6	2.1
Mn	mg/L	<0.005	0.055	0.355
Mo	mg/L	<0.03	<0.03	<0.03
Ni	mg/L	<0.05	<0.05	<0.05
P	mg/L	<0.3	<0.3	<0.3
K	mg/L	<2	3	3
Se	mg/L	<0.2	<0.2	<0.2
Si	mg/L	1.17	1.97	1.51
Ag	mg/L	<0.01	<0.01	<0.01
Na	mg/L	<2	<2	<2
Sr	mg/L	0.084	0.212	0.057
Tl	mg/L	<0.2	<0.2	<0.2
Sn	mg/L	<0.03	<0.03	<0.03
Ti	mg/L	<0.01	<0.01	<0.01
V	mg/L	<0.03	<0.03	<0.03
Zn	mg/L	<0.005	<0.005	0.007
Total Dissolved Solids	mg/L	60	173	92
Hardness $CaCO_3$	mg/L	70.5	122	58.3

CLIENT : MEHLING ENVIRONMENTAL MANAGEMENT
PROJECT : KETZA RIVER MINE SITE
PROJ. # : 9929
TEST : LEACH EXTRACTION TEST

SAMPLE	DISTILLED WATER VOLUME (mL)	SAMPLE WEIGHT (g)	pH	CONDUCTIVITY (uS/cm)	ALKALINITY (mg CaCO3/L)	ACIDITY (pH 4.5) (mg CaCO3/L)	ACIDITY (pH 8.3) (mg CaCO3/L)	SULPHATE (mg/L)
Fines at Break Zone Pit	600	200	8.01	137	67.5	0.0	2.0	6
Below Ridge Zone Pit	600	200	7.90	259	54.5	0.0	3.0	75
Gully Pit Waste	600	200	6.03	145	2.5	0.0	6.0	60