1.0 INTRODUCTION

In accordance with the Fisheries Act, all mines in Canada regulated under the *Metal Mining Effluent Regulations* (*MMER*) are required to conduct periodic Environmental Effects Monitoring (EEM) studies as part of their authority to deposit effluent.

As a depositor of mine effluent, the Nanisivik Mine requires an EEM study to be conducted. The Nanisivik Mine is located in Nunavut on the Borden Peninsula, part of northern Baffin Island. Specifically, the mine is located on the southern shore of Strathcona Sound, approximately 33 kilometers by road from the nearest settlement, the Hamlet of Arctic Bay. The mine is located 750 kilometres north of the Arctic Circle at an approximate latitude of 73 degrees north (Figure 1.1). The Nanisivik Mine facilities, which are presently undergoing decommissioning, consisted of an underground mine and a 2,200 tonne per day concentrator using conventional crushing, rod and ball mill grinding, differential lead and zinc flotation, and concentrate drying. Ore concentrates were formerly shipped from a concentrate storage shed located adjacent to Strathcona Sound, where a deepwater wharf allows ocean-going vessels to moor. Concentrates were transferred to ships using a ship-loader. Process tailings were transported to and deposited at the West Twin Disposal Area (WTDA), and resulting effluent is discharged into Twin Lakes Creek. The mine was in full operation from its opening in 1976 until closure in September, 2002. Reclamation activities started in 2002. On July 30, 2003, Environment Canada officially received notification of the mine's intent to achieve recognized closed mine status.

The objective of this document is to outline and present a Study Design for EEM at the Nanisivik Mine, as required by the *MMER*. This Introduction includes a brief description of the regulatory basis under which the mine has operated, and under which the EEM study will be carried out, as well as an outline of the further contents of this document. Subsequent sections of the document will be as follows:

- Chapter 2 Site Characterization Information, including descriptions of the mine production processes, effluent mixing zones, and locations of exposure and reference areas.
- Chapter 3 Describes the Fish study (including supporting environmental measurements) proposed for the Nanisivik Mine
- Chapter 4 Describes the Benthic Invertebrate Survey (including supporting environmental measurements) proposed for the Nanisivik Mine
- Chapter 5 Describes the Effluent and Water Quality Monitoring program proposed for the Nanisivik Mine.
- Chapter 6 Describes the program of Sublethal Toxicity Testing proposed for the Nanisivik Mine.

- Chapter 7 Provides a Summary of the document, including a timetable for the implementation of the various studies.
- Chapter 8 Provides References and other cited material.

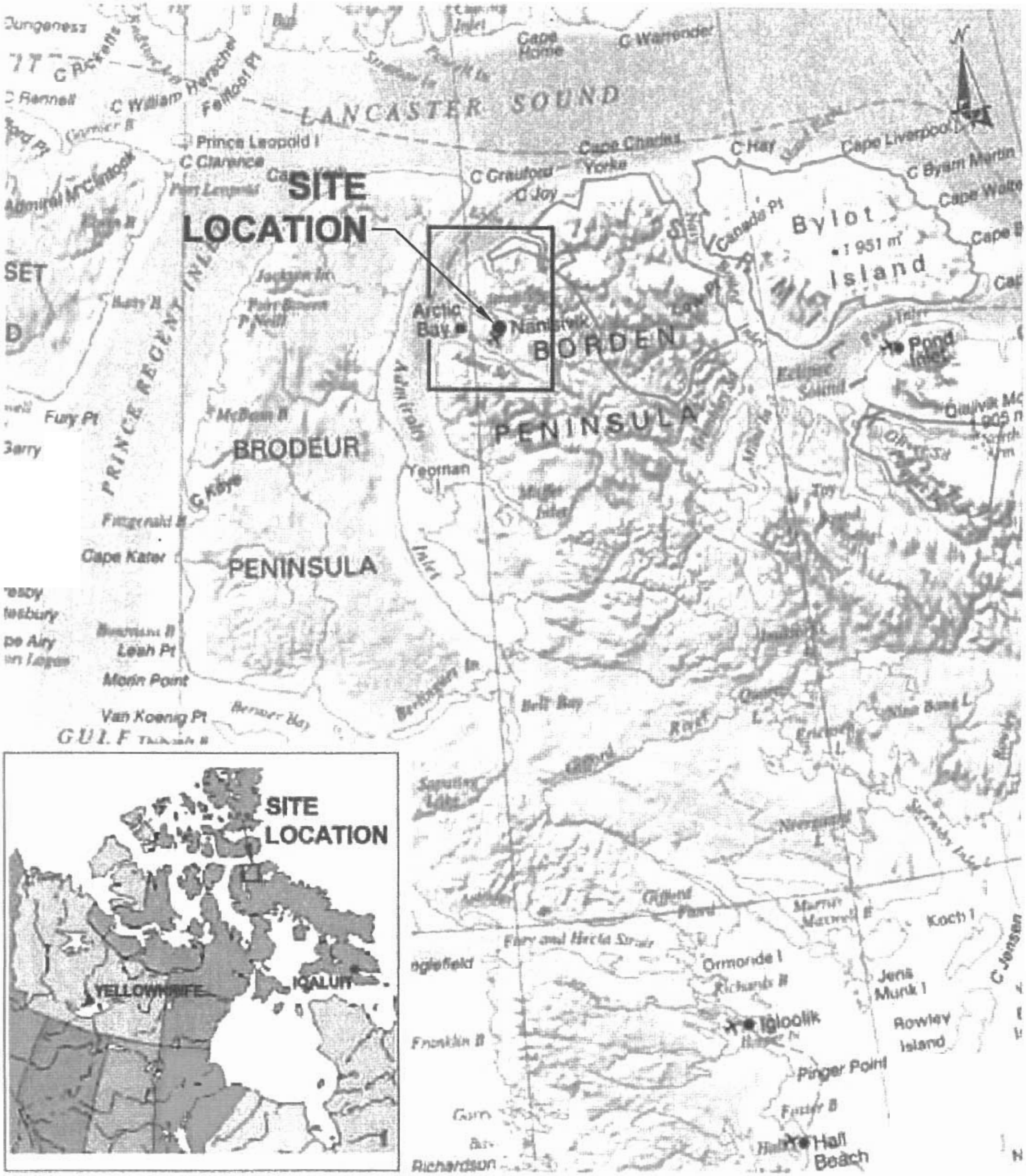
The internal structure of Chapters 3, 4, 5 and 6 has been made as consistent as possible, in order to facilitate the review process and to ensure that all of the required and requested information is presented in an orderly and easily understood manner. This generalized structure is based on the following general Subsections within each Chapter:

- Goals and Objectives of this EEM Component Study;
- Past Monitoring Results and Conclusions;
- Rationale, Hypotheses, Confounding Factors;
- EEM Component Study Design
- EEM Component Study Data Analysis and Interpretation.
- Quality Assurance and Quality Control

As described in the Metal Mining EEM Guidance Document (Environment Canada 2002), and in Schedule 5, Section 10 of the *MMER*, the Study Design is expected to provide certain information. The information requirements, and a guide to where in the present document the information can be found, are summarized in Table 1.1, below.

Prior to the submission of this study design, the Nanisivik Mine and its consultant, Jacques Whitford Environment Limited (JWEL), engaged in discussion with the Technical Advisory Panel (TAP). The purpose of those discussions was to consult with the TAP, to explore, the unique characteristics of the Nanisivik Mine, and to reach a consensus in advance regarding how the requirements of the *MMER* can best be implemented at Nanisivik. This Study Design, prepared by JWEL, reflects those discussions, and the consensus achieved.

FILE: SITE



SITE LOCATION MAP NANISIVIK MINE BAFFIN ISLAND, NUNAVUT	Date: 2003 01 28	Scale: NTS	Jacques Whitford Consulting Engineers Environmental Scientists
	Job No.: 15058	Fig. No.: 1.1	

Table 1.1 Correspondence Between EEM Study Design Information Requirements and the Structure of This Document

Study Design Information Requirement (from Schedule 5, Section 10)	Location of the Information in the Present Document
A detailed timetable for conducting each of the biological monitoring study requirements.	See Chapter 7.
A description of site characterization information.	See Chapter 2.
A description of how the fish study will be conducted in order to determine if there are effects on fish population and fish usability (tissue analysis).	See Chapter 3.
A description of how the benthic invertebrate community survey will be conducted in order to determine if there are effects on fish habitat.	See Chapter 4.
Identification of the quality assurance and quality control measures that will be taken to ensure the validity of the data.	See the relevant sections of Chapters 3 and 4.
A summary of any previous biological monitoring conducted for EEM.	See the relevant sections of Chapters 3 and 4.
Other Recommended Details of the Study Design	
The goals and expectations of the EEM Study.	See Section 1.3 of this introductory Chapter, as well as the relevant sections of Chapters 3, 4, 5 and 6.
The overall approach, including rationale based on site characterization information and previous monitoring results.	See Chapter 2, as well as the relevant sections of Chapters 3 and 4.
Statistical design, development of hypotheses, selection of statistical methods, determination of sample size (statistical significance and power analysis).	See the relevant sections of Chapters 3, 4, 5 and 6.
The design of the monitoring study, taking into account confounding factors (if any), where to sample, what to measure, how frequently to sample.	See Chapter 2, as well as the relevant sections of Chapters 3, 4 and 5.
Operating plans and procedures, sampling procedures, laboratory analysis procedures, quality assurance and quality control procedures, data storage and retrieval, data analysis.	JWEL Standard Operating Procedures for this project are proprietary documents, but will be made available upon request for inspection by Environment Canada.
A plan for data interpretation and evaluation.	See the relevant sections of Chapters 3, 4, 5 and 6.

1.1 Regulatory Basis of Nanisivik Mine

The Nanisivik Mine is subject to all of the laws and statutes of Canada, and Nunavut. However, those that are of special relevance to the operation of the mine are outlined below.

1.1.1 Fisheries Act

The *Fisheries Act* is one of the major federal *Acts* dealing with the environment, and in particular with fish habitat. The *Fisheries Act* enables a number of *Regulations*, and these include the *MMER*. The *MMER* provides the regulatory basis under which mines are permitted to discharge liquid effluent to the environment. Within the *MMER* are specific discharge limits or concentrations that shall not be exceeded in mine effluent waters that are discharged to fish habitat or waters that drain to fish habitat.

All mines regulated under the *MMER*, as part of the federal Fisheries Act, are required to conduct periodic EEM studies as part of their authority to deposit effluent. Section 7 of the *MMER* obliges the mine to conduct EEM studies, submit reports within prescribed timelines, and use standards of good scientific practice to conduct studies and interpret results. Specifically, Section 7 states:

(1) The owner or operator of a mine shall conduct environmental effects monitoring studies of the potential effects of effluent on the fish population, on fish tissue and on the benthic invertebrate community in accordance with the requirements and within the periods set out in Schedule 5.
(2) The owner or operator shall record the results of the studies and submit the reports and required information to the authorization officer as set out in Schedule 5.
(3) The studies shall be performed and their results interpreted and reported on in accordance with generally accepted standards of good scientific practice at the time that the studies are performed

Nanisivik Mine provided notification of their intent to achieve recognized closed mine status to the Regional Director, Prairie and Northern Region, and this was received by Environment Canada, on July 30, 2003. This notification results in the mine becoming subject to Part 4 of the *MMER*, dealing with Recognized Closed Mines. As described in Part 4 of the *MMER*, the mine is required to conduct a biological study during a three year period following the receipt of this notification by Environment Canada, in accordance with Division 3 of Part 2 of Schedule 5 of the *MMER*.

Schedule 5 also describes the required studies that make up an EEM program under the *MMER*. These include:

- Effluent Characterization;
- Sublethal Toxicity Testing;
- Water Quality Monitoring; and
- Biological Studies.

1.1.2 Other Relevant Federal Laws

The Nanisivik Mine occupies land leased from the Government of Canada under the *Territorial Lands Act* and the *Territorial Lands Regulations*.

Mineral title to the Nanisivik Mine is held under mineral leases. Mineral leases were issued for 21-year periods, with rights of renewal. The leases have historically been renewed as required, with the next renewal date being 2009.

In addition to the mineral title requirements, surface title is also required for certain operations. The Federal Government controls all of the surface title in the Nanisivik Mine area. However, at mine start-up, the surface rights to one block, called the Block Transfer, were transferred to the Government of the Northwest Territories (and subsequently to the Government of Nunavut).

Mine operating and other activities at the Nanisivik Mine are subject to an agreement signed June 18, 1974 (the "Master Agreement") between Nanisivik Mines Ltd. (as assignee of Mineral Resources International Limited) and the Department of Indian Affairs and Northern Development ("DIAND"), which provided for the development and operation of the Nanisivik Mine. Based upon the original mineral reserves and initial design capacity of the mine and mill, a mine life of 12 years was contemplated.

A portion of the dock area occupies a surface lease administered by the Department of Fisheries and Oceans ("DFO").

1.1.3 Provincial/Territorial Acts and Statutes

Operations at the Nanisivik Mine are governed by a water license. The Northwest Territories Water Board under the Northwest Territories Waters Act granted the original water license. The Nunavut Water Board assumed the responsibility for current water licenses in 1996 under the mandate of the Nunavut Land Claims Agreement Act.

The final "operating" water license (Water License NWB1NAN9702) came into effect July 1, 1997 and had an initial expiry date of June 30, 2002. The expiry date was extended to September 30, 2002 following CanZinco's announcement that mine closure was scheduled for September 2002. The extension of the term of the License also stipulated that a Closure and Reclamation Plan be filed with the Nunavut Water Board by February 28, 2002.

The current water license (Water License NWB1NAN0208) came into effect October 1, 2002 and has an expiry date of May 1, 2008. This water license is focussed on mine closure and does not allow any commercial production from the mine.

1.2 Goals and Expectations of the EEM Study

The objective of metal mining EEM is to evaluate the effects of mine effluent on fish, fish habitat, and the use of fisheries resources. This information may be used by Environment Canada to assess the adequacy of the overall *MMER* as it applies more generally to mines in Canada.

The required EEM program will consist of two general components, namely ***biological monitoring studies*** (fish study and benthic invertebrate community survey), and ***effluent and water quality monitoring studies*** (effluent characterization, water quality monitoring, and sublethal toxicity testing).

For the purposes of the EEM program, an ***effect*** is defined as follows:

- an effect on the fish population means a statistical difference between fish population measurements taken in an exposure and a reference area;
- an effect on fish tissue means measurements of total mercury in fish tissue taken from the exposure area that exceed 0.45 μg/g wet weight and that are statistically different from measurements of total mercury taken in a reference area;
- an effect on the benthic invertebrate community means a statistical difference between benthic invertebrate community measurements taken in an exposure area and a reference area.

The guiding principles of the metal mining EEM program are that the program be scientifically defensible, cost effective, and provide flexibility for site-specific requirements, without subjecting field crews to unsafe sampling conditions.

The metal mining EEM program normally follows a tiered approach where results from previous biological monitoring studies are evaluated to trigger the next tier or division of monitoring studies, in accordance with a pre-defined monitoring frequency. Three divisions of biological monitoring studies are identified in Schedule 5 of the *MMER*. These include:

- First Biological Monitoring studies;
- Subsequent Biological Monitoring studies; and
- Final Biological Monitoring study prior to closing mine.

Since the Nanisivik mine has provided to the authorization officer an application for recognized closed mine status under Subsection 32(1) of the *MMER*, the mine is subject only to the Final Biological Monitoring study provisions of Schedule 5 of the *MMER*.

The Final Study Design (*i.e.*, this document) is required to include:

- site characterization information as outlined in Section 11 of Schedule 5;
- a description of how the fish population study will be conducted, if the effluent concentration in the exposure area is greater than 1% in the area located within 250 m of a final discharge point;
- a description of how the fish tissue study will be conducted, if the total mercury concentration in the final effluent is equal to or greater than 0.1 µg/L;
- a description of how the benthic invertebrate community study will be conducted;
- the dates and times that samples will be collected for the biological monitoring;
- a description of the quality assurance and quality control measures that will be implemented to ensure the validity of the data; and
- a summary of the results of any previous biological monitoring studies that were conducted after June 6, 2002 (the date of registration of the *MMER*) respecting the fish population, fish tissue, and the benthic invertebrate community.

2.0 SITE CHARACTERIZATION INFORMATION

Much of the following Site Characterization information is taken directly from a Phase II Environmental Site Assessment document, recently prepared for the Nanisivik Mine in support of the mine decommissioning process, by Gartner Lee Limited (GLL, 2002). JWEL is pleased to acknowledge the generosity of Mr. Eric Denholm of Gartner Lee Limited, in making an electronic copy of that document available for our use.

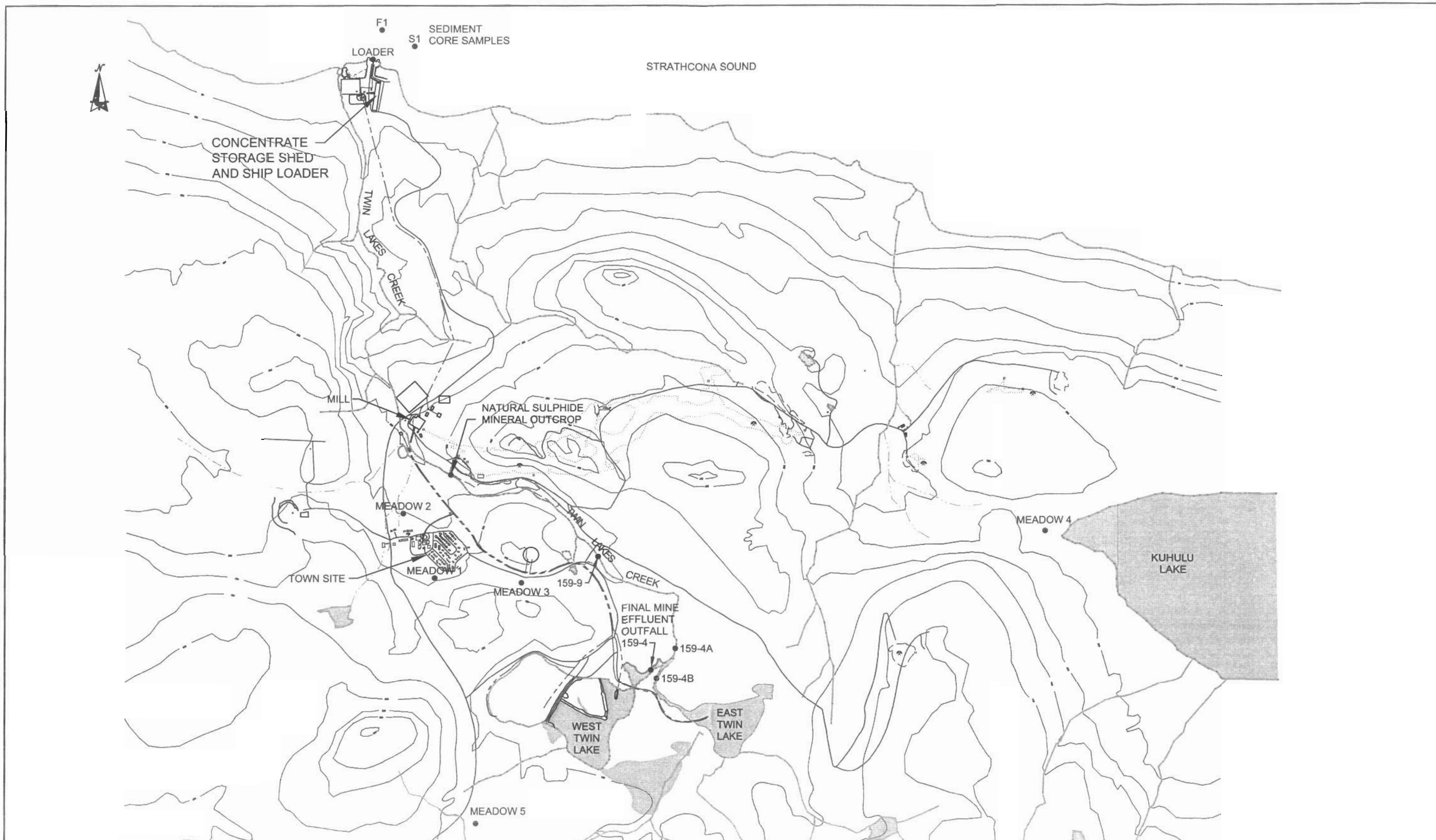
2.1 General Site Description and Mine Production Processes

The Nanisivik Mine is located on the Borden Peninsula on northern Baffin Island in the Canadian Arctic at a latitude of approximately 73 degrees north (Figure 1.1). The mine site is on the south side of Strathcona Sound approximately 30 km from the inlet to the Sound. The community of Arctic Bay is located approximately 25 km to the west of Nanisivik. The two communities are linked by a 33 km all-weather road.

A concentrate storage shed, ship loading facility, dock, fuel tank farm and reagent storage area are located near the mouth of Twin Lakes Creek at Strathcona Sound. The Canadian Coast Guard uses the dock as a storage facility for marine environmental emergency response equipment and also as a fueling station. The land rises steeply away from the sound, and the local height of land is a peak known locally as Mt. Fuji, with an elevation of approximately 650 m, located approximately 6 km south of Strathcona Sound. The mill and mine are located approximately 3 km south of Strathcona Sound. The town is located at an elevation of 325 m, approximately 4 km from the Sound, and the tailings disposal facility is located at an elevation of 375 m, approximately 7 km from the Sound. All of these facilities are located within the general watershed of Twin Lakes Creek.

Most mine employees lived in the town of Nanisivik, built approximately 1 km south of, and uphill from the mine/mill area, specifically to house mine workers. The town included a church, recreation centre, school, housing, post office, store, diesel electric power plant and other amenities to provide comfortable living for employees and their families. Construction of the town was partially funded by the Government of the Northwest Territories and the Government of Nunavut currently owns some of the town facilities. Some employees commuted from the community of Arctic Bay.

The mine was primarily an underground operation (primary workings plus 3 satellite areas) with smaller contributions of ore from four open pits. The primary underground workings extend in an approximate east-west alignment (approximately 3 km long × 100 metres wide × 10 metres thick) and daylight on either side of a topographic ridge as indicated on Figure 2.1. Vehicle access into the underground mine is via several adits that allow passage of both heavy and light equipment.



FILE: SAMPLE

REFERENCE DRAWING FROM GARTNER LEE LIMITED PROJECT # 21-957 FILE NAME: 21957-D3-02.DWG OCT. 1, 2002	LOCATIONS OF TERRESTRIAL AND MARINE SAMPLING STATIONS NANISIVIK MINE, JULY 2003	Date: 2003 11 25 Job No.: 15058	Scale: 1 : 30 000 Fig. No.: 1	Jacques Whitford Consulting Engineers Environmental Scientists

Ore processing at the mill involved dense media separation (installed in 2001) and conventional grinding, flotation and dewatering circuits. Zinc and lead mineral concentrates were produced and hauled in gravel trucks from the mill to the concentrate storage shed, which is located at the dock. Mineral concentrates were loaded onto ocean going ships during the ice-free season. The ship loading conveyor system was originally open, but was enclosed in the early 1980's to minimize losses and blowing of concentrate dust.

Process tailings were pumped approximately 4 km from the mill to the tailings disposal facility, West Twin Disposal Area (WTDA), formerly part of West Twin Lake. The WTDA storage capacity was increased in 1990 with construction of an internal dyke across the lake that created upper and lower storage areas. The upper portion of the lake became a surface tailings deposition area and has been the primary storage area since 1990. With the exception of a raised area that was developed for testing of covers for reclamation of the surface tailings, the lower portion of the lake has remained a subaqueous tailings disposal cell and reservoir for water decanted from the upper area. A large portion of the water in the WTDA was returned to the mill via an overland pump/piping system that was built for the purpose of water reuse in the concentrator. Surplus water was released seasonally through a polishing/retention system. The two WTDA internal dykes were constructed using frozen tailings core construction. The upper storage area dyke has been raised on an incremental basis since 1990 using upstream construction with tailings and shale.

For Nanisivik Mine, there are potentially two effluent discharge points that would be subject to the *MMER*. These are:

- mine effluent discharge from the WTDA into Twin Lakes Creek, also known as station 159-4; and
- the East Adit Treatment Facility.

The polishing pond at WTDA releases water that meets applicable regulations for water quality, although no chemical treatment (such as lime addition) is used. The effluent is released to Twin Lakes Creek via a manually operated control structure (weir). Natural water flows in Twin Lakes Creek are predominantly from East Twin Lake, which has a considerably larger watershed than the West Twin Lake basin. Effluent is normally released from the WTDA only during the months of June, July and August. During the winter months, the entire creek appears to freeze solid, so that there is no flow, natural or otherwise. The effluent control structure is located at the following coordinates (as determined using a hand-held GPS unit in July, 2003):

- 73° 01' 32.249" N, 84° 28' 33.841" W, at elevation approximately 370 m.

At the East Adit, there is a lime treatment pond that collects surface water flows from this area of the mine site. Metals are precipitated by lime in this pond, and the decant is released to a polishing pond.

The polishing pond is contained by a lined berm, and was formerly drained periodically when water levels required. Due to the shut-down of Nanisivik Mine, and mine closure activities that are ongoing, there was no discharge of mine effluent from the East Adit during 2002 or 2003, and it is not expected that there will be any discharge of mine effluent from this location in the future.

- 73° 02' 52.800" N, 84° 26' 13.200" W, at elevation approximately 250 m.

Therefore, the EEM program will focus on the effluent discharged from the WTDA. This would change if there was a need to resume discharge of effluent from the East Adit Treatment Facility at some future time, in which case it is understood that monitoring of effluent quality and water quality would be required at this location, and at a suitable reference area. These potential EEM requirements will be outlined in a "contingency plan" context, in the appropriate sections of this document.

2.2 Climate

Nanisivik is located in a climatic zone classified as "polar desert", which is characterized by cold temperatures and relatively low precipitation. Meteorological data have been collected by Atmospheric Environmental Services (AES) of Environment Canada since 1976 at the Nanisivik Airport (located approximately 10 km southwest of the mine site).

Over the period of record, the maximum daily temperature recorded was 23.0 °C, the minimum daily temperature recorded was -53.0 °C and the mean daily temperature recorded was -14.8 °C. Mean annual precipitation has been recorded at 231 mm, of which approximately 50 mm was in the form of rain. The greatest daily recording of snowfall was 68.4 cm and the greatest daily recording of rainfall was 36 mm. Annual evaporation data at the WTDA has been measured at an average of 187 mm during the period 1993 to 2001 (DIAND meteorological station).

The daily rainfall probable maximum precipitation ("PMP") event is estimated to be approximately 140 mm and the daily snowmelt PMP event is estimated to be 155 mm. The magnitude of these extreme events is low relative to southern Canada (for example, a daily PMP event in Northern Ontario is approximately 500 mm to 700 mm). These low precipitation and snow melt values reflect the characterization of the site as a "Polar Desert".

2.3 Permafrost

Nanisivik is located in the permafrost region of the Canadian Arctic Archipelago where permafrost is characterized as "continuous" (i.e. existing over the landscape as a continuous layer).

The local permafrost conditions have been described as follows:

- permafrost at the northern end of Baffin Island has a potential for high amounts (>20%) of ground ice;
- permafrost at Nanisivik has been found to be deeper than 430 metres in a borehole drilled from the underground workings;
- the subsurface rock temperature was noted to range from -11.7 °C to -9.4 °C in the project feasibility study;
- baseline environmental studies noted that permafrost was encountered in two shallow test pits: at a depth of 25 cm on the north-facing slope of Mt. Fuji and at 60 cm on an exposed dry ridge and that permafrost was not encountered to 85 cm depth in another shallow test pit on an exposed dry ridge; and
- studies related to the reclamation testing covers indicated that on-land deposition of mine wastes leads to rapid permafrost aggradation into the waste material within a one to two winter timeframe.

2.4 Local Geology

The Nanisivik sulphide deposits are hosted in carbonate rocks within a Proterozoic sedimentary sequence. This sequence developed as a Neohelikian intracratonic basin, the Borden Basin, on a peneplaned gneiss complex of Archean-Aphebian age.

The present Borden Basin sequence consists of generally shallow water clastic and carbonate sediments up to 6,100 metres thick, called the Bylot Supergroup. The Supergroup is divided into three Groups, a lower clastic group (the Eqalulik Group), a middle carbonate group (the Uluksan Group) and an upper clastic group (the Nunatsiaq Group).

The Uluksan Group is made up of the lower Society Cliffs Formation and the upper Victor Bay Formation. The Society Cliffs Formation varies in thickness from 260 metres at Arctic Bay to 856 metres at Tremblay Sound. West of Tremblay Sound, it was deposited in a subtidal to intertidal environment. The Society Cliffs Formation is conformably overlain by the Victor Bay Formation, which consists of shales, siltstones, dolostones and coarse carbonate clastics and varies in thickness from 156 metres to 735 metres. The Victor Bay Formation is considered to have acted as a cap rock to mineralization in part of the mine area. All of the economic mineralization at the Nanisivik mine lies within the upper member of the Society Cliffs Formation.

The Nanisivik mine property is up to 7 km wide and up to 15 km long. Rocks outcropping on the property include small exposures of quartzite of the Adams Sound Formation on the southern edge of the lease area. The unit immediately below the Society Cliffs Formation, the Arctic Bay Formation, outcrops in the area but is not exposed on the property. The main units exposed are the Society Cliffs Formation and the overlying Victor Bay Formation, together with Paleozoic sandstones of the Gallery Formation.

In the mine area, dips are usually quite shallow and the main structure is faulting. Major structures that are recognized in the mine include the South Boundary Fault, which marks the southern margin of sulphide mineralization, and the Keystone Graben Fault, which defines the southern margin of the Main Ore Zone horst.

The various massive sulphide deposits contain more than 50 million tonnes of which barren massive pyrite (iron sulphide mineral) bodies occupy most of the area and contain the largest sulphide tonnages. Zones containing sphalerite (zinc sulphide mineral) are present within the massive pyrite bodies, but are confined to a restricted vertical interval. All of the known significant sphalerite deposits are in horsts adjacent to the Keystone Graben. Galena (lead sulphide mineral) mineralization increases in the eastern ore zones.

The South Boundary Zone is wedge-shaped and consists of massive pyrite. The zone is controlled by the South Boundary Fault. The Main Ore Zone is an elongated, sinuous, lenticular body, hosted in carbonate, with a nearly horizontal upper contact. A number of bodies are irregular subvertical veins, while some other bodies underlie gently dipping shale contacts. These variations in structural style occur both in the massive pyrite and in the sphalerite zones.

Each of the sphalerite-rich ore bodies is confined to a restricted vertical interval that varies in thickness and elevation from zone to zone. Flat sulphide contacts cut at low angles across dolostone bedding and sulphides rarely follow the beds.

The Main Zone deposit is about 3 km long. It is oriented east-west, although it is sinuous in plan. The deposit is broadly 'T' shaped, with a flat-topped upper section that is typically about 100 metres wide and 20 metres high. A remarkable feature of this deposit is the constant elevation of the top of the deposit over its entire length. The keel section of the deposit extends to about 80 metres below the upper section. While it is subvertical, no obvious controlling structures have been recognized to date. In places, flat-lying "wings" of sulphides extend out laterally from the keel zone.

Internal structures in the ore zones tend to be complex, and range from massive and banded to chaotic or brecciated. Banding tends to be subhorizontal in both the upper section of the Main Zone and the keel section of the deposit, but it may be parallel to dipping dolostone contacts in some areas. As well, the ore is porous in places and large irregular zones of ice are present in some faces underground.

The accepted geological model is that the Nanisivik deposits are Mississippi-Valley Type. By definition, these are post-depositional, carbonate hosted deposits. Typically, they are coarse-grained and mineralogically simple. They tend to be sphalerite-rich, may be very large and may contain high base metal grades. However, Mississippi-Valley Type deposits include quite diverse deposits, different in shape, grade and mineralogy. This diversity appears to result from source fluid chemistry, rocks through which the fluids pass prior to deposition, source fluid temperature and the nature of the depositional environment.

2.5 Soil

Soil studies were conducted by BC Research Inc. in conjunction with the 1974 vegetation mapping (BC Research 1975a) and reported that virtually no soil formation has occurred in the mine area. The little soil that has developed was found to be located primarily in alluvial plains and meadows where eroded and wind blown material have settled.

Soil moisture varied widely between the various types of ground cover. Soil in the meadow area was wet with a water table near surface. Soil in the mid slope and moss-lichen areas was moist but no free water was observed. Soil in the dry ridge area was generally dry at surface although some isolated moist areas were also observed.

Soil texture was observed to vary widely based, primarily, on the underlying bedrock. Dolomitic rock was observed to produce a relatively small amount of fine material whereas shale was observed to produce abundant fine material. Sample sites were also noted as often having an unweathered surface "capping" overlying finer material.

Naturally occurring sulphide mineralization at surface is well documented throughout the mine area. Surficial soils in the area can be stained red due to oxidation. An extensive survey of metal concentrations in surficial soils throughout the mine area was conducted as part of mineral exploration activities in 1985. Samples were analysed for zinc, lead and copper at the on-site laboratory using a detection limit of 20 ppm. These data document the range of metal concentrations that were present in surface soils in areas peripheral to mining actives as well as across some of the mineralized zones. Prior to this 1985 survey, tailings were deposited underwater in West Twin Lake so that the dispersion of wind blown tailings (which commenced around 1991) did not affect the results. In addition, the East Open Pit, K-Baseline and Oceanview mining areas were undeveloped at the time of the 1985 soil survey mining.

Background soil metal concentrations at the Nanisivik site typically exceed CCME (1999) guidelines for lead, zinc or copper. Background lead concentrations in 1984 ranged from <20 to 12,154 mg/kg, with an average concentration of 227 mg/kg. Zinc concentrations ranged from <20 to 3,383 mg/kg, with an average concentration of 314 mg/kg and copper concentrations ranged from <20 to 453 mg/kg with an average concentration of 64 mg/kg. The generic CCME Commercial guidelines are 260 mg/kg, 360 mg/kg and 91 mg/kg for lead, zinc and copper, respectively. The Parkland soil quality guidelines are 140 mg/kg, 200 mg/kg and 63 mg/kg for lead, zinc and copper, respectively.

The area immediately northeast of the town of Nanisivik, from the fresh water supply tank to Twin Lakes Creek, is of particular relevance to the determination of natural metal concentrations in surface soils, and in the aquatic environment, because it is an area of naturally occurring mineralized soil. Eleven soil samples reported in the 1984 dataset were collected in this area. These samples contained metal concentrations that were, on average, greater than the CCME (1999) guidelines, and correlate with the mapping of natural exposures of a weathered and highly mineralized (gossan) zone on surface. Lead concentrations in these samples ranged from 48 to 2,296 mg/kg, with an average concentration of 662 mg/kg. Zinc concentrations ranged from 93 to 1,404 mg/kg, with an average concentration of 825 mg/kg. These observations will be linked in later sections of this report to the mineralized outcrop that is exposed in the banks and bed of Twin Lakes Creek, and to total metal loadings to Twin Lakes Creek.

2.6 Topography

The mine area consists of a few intermittent planar areas predominately surrounded by relatively steep high-relief hills rising out of Strathcona Sound.

The surface topography is moderately steep rising from sea level to a local high of 650 metres immediately west of the mine area ("Mt. Fuji"). The approximate elevations of several areas around the minesite are listed in Table 2.1 and shown in Figure 2.1.

Table 2.1 Approximate Elevations of Mine Facilities

Location	Approximate Elevation (m)
Industrial Complex	260
Town site	325
Freshwater storage tank	375
lower portion of WTDA (West Twin Lake)	370
Freshwater supply (East Twin lake)	372
01 Portal (main entrance to underground mine)	300
Oceanview Open Pit	260
Area14 mining area	450
Landfill/STOL air strip	360
Tank Farm	25