quality but are not generally of concern in soil unless, perhaps, the soil acts as a direct source of contaminants to a sensitive receiving environment.

Nitrogen compounds in soil were not specifically investigated as part of the Nanisivik ESA process because of the absence of CCME guidelines for soil quality and because Twin Lakes Creek does not contain fish or other aquatic species that are likely to be adversely affected by nitrogen loading. Further, water quality information at the mouth of Twin Lakes Creek during 2000, when the mine was operating and ANFO was being used, did not contain concentrations of total ammonia-NH_3 that would be indicative of a need for investigation of soil contamination (i.e., all SNP 159-6, mouth of Twin Lakes Creek, results for NH_3 were less than 0.95 mg/L, which is less than the pH and temperature dependent CEQG FWAL).

2.3.4 Spill Events

That CanZinco provide as an appendix in the forthcoming ESA, a list of all reported spill events that occurred during the operating history of the mine. The list should include the time, type of chemical, extent and location of the spills.

Appendix C herein contains both a summary listing and a complete documentation of all reported spill events that occurred during the operating history of the mine. This listing was compiled from the Nanisivik Mine database as well as from a request of and information provided from DIAND Water Resources, who provide inspection and enforcement of the Water License.

The reports describe, primarily, three types of events:

1. Releases of tailings along the tailings pipeline route;
2. Releases of untreated water from the East Adit treatment facility; and
3. Spills onto the ground of diesel from various storage and dispensing locations.

The environmental impacts of the reported events have been investigated through the ESA process either directly (i.e., diesel spills at the K-Baseline garage area) or indirectly (i.e., investigation of a representative number of home heating fuel tanks and intrusive investigations downgradient of fuel tanks).

2.3.5 Hydrocarbon Storage Tanks

That CanZinco, in the discussion of hydrocarbon impacted soils, present a comprehensive list of the past and present locations of Above ground Storage Tanks (AST) *and Underground Storage Tanks* (UST).

A listing of the known past and present (in use or not empty as of October 2003) locations of hydrocarbon storage tanks is provided herein in Table A. This excludes mobile tanks that were/are truck mounted or used on a strictly temporary basis for small short-term jobs.

Table A. Listing of Past and Present Hydrocarbon Storage Tanks

	Location	AST/UST	Product Stored	Past/Present
1	Strathcona Sound Tank Farm	AST	Diesel, Jet Fuel, Gasoline	Present
2	Industrial Complex Tank Farm	AST	Diesel	Present
3	Carpenter Shop	AST	Diesel	Past
4	West Adit/ANFO Plant	UST	Diesel	Past
5	Town Home Heating Oil Tanks	AST	Home Heating Fuel	Past/Present
6	East Adit	AST	Diesel	Past
7	K-Baseline Adit	AST	Diesel	Past
8	Area 14	AST	Diesel	Past
9	Oceanview	AST	Diesel	Past
10	Main Adit	AST	Diesel	Present

Each of these locations are mentioned in the discussions of hydrocarbon impacted soils in either or both of the Phase 2 and Phase 3 ESA Reports.

2.3.6 Surface Water Quality

That CanZinco include a discussion on the effects of contamination to fresh water receiving bodies with particular emphasis to Twin Creek, Chris Creek and Kuhulu Lake, as well as shallow ground water. The impacts on the Metal Mining Effluent Regulations shall be addressed within this discussion.

The ESA process is fundamentally focussed on the identification and delineation of contaminants in the soil and, therefore, a detailed assessment of surface water or receiving water is not typically included within the scope of a Phase 2 or 3 ESA, unless it is directly relevant to the identification and delineation of soil contaminants. For example, a review of ammonia concentrations in Twin Lakes Creek was undertaken as an aid in assessing the need for investigation of ammonia as a soil contaminant, as described above in Section 2.3.3.

Nonetheless, an overview of surface water quality studies that had been compiled from various sources was provided in the Phase 2 ESA Report as a means of providing additional context regarding the environmental setting of the site. An expanded description of surface water quality that includes Chris Creek and Kuhulu Lake is provided herein in Section 3.3.

In accordance with the *Fisheries Act*, all mines 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. Environment Canada received notification of Nanisivik Mine's intent to achieve Recognized Closed Mine status on July 30, 2003. Therefore, the mine is subject to Part 4 of the *MMER*, which deals specifically with closed mines. As described in Part 4 of the *MMER*, the mine is required to conduct a Final Monitoring study within 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*.

To this end, CanZinco has submitted a study design proposal to Environment Canada, as required under the MMER, for EEM studies. The study will be conducted by JWEL and includes the following components:

- the EEM will focus on the effluent discharged from the WTDA, although a contingency plan has been written for effluent and water quality monitoring at the East Adit Treatment Facility in the event that discharge is resumed in 2004, 2005 or 2006;
- a fish study to be undertaken in Strathcona Sound (since Twin Lakes Creek is devoid of fish);
- a benthic invertebrate community survey in Twin Lakes Creek;
- effluent and water quality monitoring during periods of effluent discharge into Twin Lakes Creek; and
- sublethal toxicity testing carried out twice per year.

These EEM studies will be directly linked to CanZinco's environmental monitoring plan that will be proposed as part of the Final Closure and Reclamation Plan.

2.3.7 Methodologies

That CanZinco ensure that sampling, analytical and QA/QC methodologies are described with full rationales provided.

The procedures and rationales referenced above are provided herein in the relevant sections of this report. All of the sampling, analytical and QA/QC methodologies that have been utilized through the ESA process have followed standard CCME, Gartner Lee or general industry guidelines, procedures and protocols.

2.3.8 Roads

That CanZinco, in its investigation of roadway materials, ensure that protocols used to identify mineralized waste rock are provided. A presentation of a vertical cross section of roads that identifies where mineralized rock have been identified as a building material would be a valuable addition to the forthcoming ESA.

An expanded rationale for investigation of mine roads in the 2002 Phase 2 ESA program was initially provided to the NWB by CanZinco/Gartner Lee in a response to review comments dated May 19, 2003 that is included herein in Appendix B. That rationale has been reviewed and expanded on below and is further described, in the context of the 2003 ESA work, herein in Section 4.

The roads around the mine site (excluding the main road from the dock to the town) are constructed of locally available materials, which is primarily shale. Shale has been used as the main construction material due to its availability and ease of working. Several shale borrow areas have been developed around the mine site (i.e., along the Area 14 road), in part to provide construction material for roads. Shale has favourable geochemical characteristics as determined through testing conducted and reported on by Lorax Environmental (Lorax 2001) and summarized in section 3.4 of the Phase 2 ESA report as follows:

> The acid base accounting analyses confirmed that the shale is acid consuming. The shale samples contained low concentrations of total sulphur (0.11 to 2.34%) of which most was in the form of sulphides (0.09 to 2.10%). The shale samples contained large neutralizing potential (315 to 600 kg$CaCO_3$/t) that was primarily in the form of carbonates (224 to 593 kg$CaCO_3$/t). The resulting net neutralization potential for tailings was large and positive (+373 kg$CaCO_3$/t) and the resulting NP/AP ratio was much generally greater than one (4.7 to 49.2), which demonstrates their classification as acid consuming.

Dolostone, a harder rock than shale, has also been used for road construction but to a lesser extent. Dolostone contains, by definition, a relatively large concentration of acid consuming carbonate minerals and is, therefore, appropriate for road construction. Dolostone was not used as extensively as shale for road construction because it is not as locally abundant on surface and is more difficult to work. Dolostone is the common rock type for use as riprap for erosion protection.

Rock containing sulphide mineralization was generally not used for road construction. Shale was the preferred road construction material because of its abundance in conveniently located borrow areas and its beneficial geochemical properties. The ARD testing reports prepared by Lorax Environmental (Lorax 2001) that are summarized in Section 3.4 of the Phase 2 ESA report indicate that the short road segment from the 09 Adit area to the industrial complex contains some sulphide mineralization.

Nanisivik road construction materials are visually distinct and can be readily identified from visual observation. Therefore, as part of the Phase 2 ESA, the Oceanview and Area 14 roads were visually inspected by a geologist experienced in acid rock drainage assessments. The results of the inspection are illustrated on Figure 6 of the Phase 2 ESA Report. The inspection identified several isolated areas where small quantities of mineralized rock were observed on the roadside due, presumably, to rocks falling out of the haul trucks and remnants of small, temporary stockpiles of mineralized rock. This residual material occurred in limited quantities and there is no indication that it was used for road construction. Additionally, several test pits were excavated into the roadfill along the road to Area14 as part of the Phase 2 investigations. There were no indications from the Phase 2 ESA investigations that any of the roads had been constructed using potentially acid generating materials as bulk road fill.

The Phase 2 ESA information was followed up on and expanded upon as part of the 2003 Phase 3 program. Further investigation of the mine roads was deemed appropriate due, in part, to the potential importance to remedial planning and, in part, to the level of concern expressed by reviewers of the Phase 2 ESA Report. The 2003 Phase 3 investigation methodologies and results are described in full herein in Section 4.

The Final Closure and Reclamation Plan will include relevant drawings of roads that require remediation.

2.3.9 On-Site Laboratory and Sample Selection for Chemical Analysis

That CanZinco, in regards to its soil sample analysis, provide an explanation as to why samples processed in the on-site laboratory were not used despite their inclusion in the January 30, 2003 ESA. An inventory of unanalyzed soil samples should be provided so that regulators will have an idea of what information is available for further examination.

On-Site Laboratory

An expanded rationale regarding the use of data from the on-site laboratory was initially provided to the NWB by CanZinco/Gartner Lee in a response to review comments dated May 19, 2003 that is included herein in Appendix B. That rationale has been reviewed and expanded on below.

Some of the initial analyses of metal concentrations in soils for the 2002 ESA samples were conducted using the on-site laboratory. This was initiated with the intent of providing a rapid turn around of results that would help to direct the 2002 sample collection work, with quality control provided by the off-site laboratory. However, the large number of samples generated for the ESA exceeded the physical capability of the on-site laboratory for a rapid turn around of results and, therefore, the approach to analysis of samples was amended to have all analyses conducted at the off-site laboratory. The approach to selection of samples for analysis was amended to the methods described below and to have these analyses all conducted at the off-site laboratory. The amended approach provided the added benefit of consistency of analytical data from a laboratory certified by the Canadian Association for Environmental Analytical Laboratories.

In order to maintain consistency in the data used for the ESA investigation, the limited data provided by the on-site laboratory has not been utilized in the Phase 2 or Phase 3 report conclusions or illustrated on any of the Figures.

Nonetheless, the data provided from the on-site laboratory is of interest and is a component of the information collected at the site. Therefore, the data from the on-site laboratory was referred to in the discussion of Phase 2 results (Section 5.3 of the Phase 2 ESA report) as a means of documenting all available information. Table 12 of the Phase 2 ESA report provides a complete listing of the data provided by the on-site laboratory.

Sample Selection for Chemical Analysis

An expanded rationale for the selection for chemical analysis of a subset of the total soil samples collected was initially provided to the NWB by CanZinco/Gartner Lee in a response to review comments dated May 19, 2003 that is included herein in Appendix B. That rationale has been reviewed and expanded on below.

The ESA process is iterative and typically involves multiple phases of excavation and analyses. For remote sites such as the Nanisivik mine, emphasis is placed on conducting an intense initial stage of sample collection because of the difficult logistics and costs of implementing a series of small sampling programs. Therefore, as reported in the Phase 2 ESA Report, not all of the soil samples that were collected as part of the 2002 Phase 2 ESA work were analysed and this is the same approach that was applied by Gartner Lee for the 1999 and 2000 ESA investigations at the Polaris mine. This approach provides for the initial collection of a large number of samples, of which a subset is initially analysed, and the remainder are placed into storage for possible future analyses.

The guiding objective for the selection of samples for laboratory analysis for the Nanisivik ESA were to:

- investigate areas of potential environmental concern;
- follow up on observations made in the field during the investigation; and
- provide a general coverage of potentially affected areas.

The methods employed for the screening of samples for analysis included:

- the observations and judgement of the field investigator including: knowledge of the mine development and operational history; observed surface staining; observed ground disturbances; material or particle size anomalies; olfactory (odour) indications of hydrocarbons;
- the indications from field testing instruments of hydrocarbon vapours (i.e., portable photoionization detector (PID));
- consultation with the client and review of existing information regarding previous activity, testing, analyses and assessment reports; and
- providing a general coverage of all areas of the mine site.

In the case of the Nanisivik ESA program, some soil samples remain in storage. These samples may continue to be used in the future to augment the existing data.

In general, chemical analysis of soil samples for hydrocarbon content must be conducted within specific, short timeframes that typically preclude any opportunity to conduct repeat or additional analyses after the initial sample submission. This is due to the chemically volatile nature of the compounds. Chemical analysis of soil samples for metal concentrations can commonly be conducted for substantial timeframes after sample submission.

A complete listing of soil samples collected during the 2002 Phase 2 and 2003 Phase 3 investigations is provided herein in Appendix D.

2.3.10 Boneyard

That CanZinco clarify whether it considers its sampling activities at the Boneyard to be adequate despite the observation of samples with high levels of lead and zinc in the January 30, 2003.

One of the purposes of the Phase 3 investigation was to build upon the indications and needs identified through the Phase 2 program. The Phase 3 investigations, therefore, included additional investigations at the boneyard as reported herein in Section 4.

2.3.11 Contaminants in the Dock Area and Marine Sediments

That CanZinco include further discussion on issues concerning the dock and related facilities including; hydrocarbon and process chemical contamination at the chemical and fuel storage area; conclusions regarding metal-rich sediments in Strathcona Sound. Results documenting contaminant levels near the mouth of Twin Creek and/or Strathcona Sound be included and discussed in greater detail than was presented in the January 30, 2003 ESA.

Contaminants in the Dock Area

One of the purposes of the 2003 Phase 3 ESA investigations was to build upon the indications and needs identified through the 2002 Phase 2 program. Soil contamination in the dock area is one of the locations that were targeted for further investigation and, as a result, further investigation was carried out, as reported herein in Section 4.

Marine Sediments

An expanded rationale regarding the reporting of information on marine sediments was initially provided to the NWB by CanZinco/Gartner Lee in a response to review comments dated May 19, 2003 that is included herein in Appendix B. That rationale has been reviewed and expanded on below. This rationale is supplemented by a more comprehensive description that is provided herein in Section 3.4.

A primary objective of the ESA investigations is to investigate soil contamination to provide information required for the ultimate development of a soil remediation plan. Therefore, the 2002 and 2003 ESA investigations were focussed on investigating soils on land. An assessment of effects in the receiving environment is not generally included in the scope of an ESA, and an investigation of environmental effects in the marine receiving environment was not part of the scope of the Nanisivik ESA.

Nonetheless, a summary of metal concentrations in marine sediments in Strathcona Sound from a number of studies that were conducted by various organizations prior to and during mine operations was included into the Phase 2 ESA Report as part of the "environmental setting". The purpose of providing this information was to provide a complete description of the site and the local environment. This information will be of direct interest to future investigations of environmental effects in the receiving environment.

The most recent study documented in the Phase 2 ESA report was conducted in 2000 by Dr. Bo Elberling of the University of Copenhagen. However, a more recent study was conducted in 2003 by JWEL for CanZinco that provides additional insight into sediment metal concentrations and the nature of the sediments in the near-shore area and this information is provided herein in Section 3.4.4.

2.3.12 Areas of Specific Concern

That CanZinco consider further characterization of the following items of concern: White crystal substance found at TP02-94 and TP02-97 near the solid waste facility; areas around TP02-88 and TP02-90 where hydrocarbon impacted water was encountered; soil stained blue and green at the industrial complex; reagent storage area.

One of the purposes of the 2003 Phase 3 ESA investigations was to build upon the indications and needs identified through the 2002 Phase 2 program. The three areas listed above (landfill, area near TP02-88 and TP02-90 and reagent storage area) were included into the 2003 Phase 3 program as described herein in Section 4.

2.3.13 Landfill

That CanZinco clarify whether it believes that leachate generated from burning at the Solid Waste Landfill is an environmental concern that warrants further examination.

The landfill is recognized as a critical feature of the mine site due to the concerns raised regarding the possibility of release of contaminated leachate. The Phase 2 ESA program included substantial investigation of the landfill including a review of previous assessment work and analysis of soil samples from test pits around the toe of the facility, seepage water samples and shallow subsurface water samples. These investigation indicated that there was no release of contaminated leachate from the facility.

One of the purposes of the 2003 Phase 3 ESA investigations was to build upon the indications and needs identified through the 2002 Phase 2 program. It was deemed appropriate that the landfill area be the target of additional investigations due to its potential importance for remedial planning and in response to the level of concern expressed by the community of Arctic Bay regarding the facility. The 2003 Phase 3 investigations included additional test pit sampling of soils and seepage water sampling. Additionally, a borehole with thermistors (ground temperature measurements) was installed by BGC Engineering Inc. earlier in 2003 to assist with geothermal modeling and reclamation planning.

The results and implications of the Phase 3 investigations are reported herein in Section 4. The Final Closure and Reclamation Plan will include a description of specific mitigation measures for the Landfill Facility.

2.3.14 Air Quality Monitoring

That CanZinco, in regards to air quality monitoring, clarify whether additional monitoring will be required.

An overview of historical air quality monitoring data was provided in the Phase 2 ESA Report as a means of providing context regarding the environmental setting and history of the mine. However, an investigation and assessment of air quality was beyond the scope of the ESA.

Air quality monitoring is not required for the ESA process. If there is a need for air quality monitoring in the future, this will be addressed in the Final Closure and Reclamation Plan.

2.3.15 Completion of ESA Investigations

That CanZinco identify in the upcoming ESA if it believes that additional investigation required or whether its ESA studies are complete.

The Phase 3 ESA program, as reported herein, is considered to fulfill the needs of the Nanisivik ESA process and no further ESA investigations are considered necessary or beneficial to development of a closure and reclamation plan.

A soil remediation plan will be developed that addresses the means of remediating contaminated soils, including confirmatory sampling, according to the SQROs and closure objectives.

3. Expanded Description of Environmental Setting

3.1 Introduction

A description of the environmental setting of the Nanisivik mine was provided in the Phase 2 ESA Report.

Several of the comments received through the NWB review of the Phase 2 ESA Report and several of the conditions attached to the NWB's conditional approval of the Phase 2 ESA Report (as described in Section 2) requested additional detail regarding some of the items included as part of the description of the environmental setting. The requested information is provided below in Sections 3.2 to 3.4.

3.2 1985 Soil Geochemistry Survey

3.2.1 Overview

Section 2.7 of the Phase 2 ESA Report included this description of Soil and the 1985 Soil Geochemistry Survey which has been brought forward, below, to provide an overview.

Soil

Soil studies were conducted by B. C. Research Inc. in conjunction with the 1974 vegetation mapping 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 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.

Soil Geochemistry

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. This data documents the range of metal concentrations that were present in surface soils in areas peripheral to mining activities as well as across some of the mineralized zones. Prior to this 1985 survey, tailings were deposited underwater in West Twin Lake such that the dispersion of wind blown tailings (that 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.

Results of the 1985 soil survey for total lead, zinc and copper concentrations are shown on Figure 4 *(of the Phase 2 ESA Report)* along with results of geological mapping from the same time period showing the locations of natural exposures of gossan, highly mineralized and weathered bedrock occurrences.

The natural soils at Nanisivik generally displayed elevated metal concentrations when compared to generic CEQG Commercial land use (CL) and/or Residential/Parkland land use (RL/PL) guidelines. The generic CEQG CL guidelines are 260 μg/g lead, 360 μg/g zinc and 91 μg/g copper and the RL soil quality objectives are 140 μg/g lead, 200 μg/g zinc and 63 μg/g copper.

Fully 63% of the soil metal concentrations shown on Figure 4 *(of the Phase 2 ESA Report)* are greater than the PL guidelines for lead, zinc or copper. Lead concentrations, as shown on Figure 4 *(of the Phase 2 ESA Report)* ranged from <20 ppm to 12154 ppm, with an average concentration of 227 ppm. Zinc concentrations ranged from <20 ppm to 3383 ppm, with an average concentration of 314 ppm and copper concentrations ranged from <20 ppm to 453 ppm with an average concentration of 64 ppm.

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 because it is an area containing a surficial trend of naturally occurring mineralized soil. Eleven soil samples were collected in this area, which contained metal concentrations that were, on average, greater than the CEQG CL and RL/PL guidelines and that correlate with the mapping of natural exposures of a weathered and highly mineralized (gossan) zone on surface, as illustrated on Figure 4 *(of the Phase 2 ESA Report)*. Lead concentrations in these samples ranged from 48 ppm to 2296 ppm, with an average concentration of 662 ppm. Zinc concentrations ranged from 93 ppm to 1404 ppm, with an average concentration of 825 ppm.

3.2.2 Scope of the 1985 Survey

Areal Extent and Sample Density

The 1985 soil geochemistry survey covered a broad area of approximately 336 km^2. The area of coverage is illustrated on Figure 4 and extended from Strathcona Sound to the north, east of Kuhulu Lake to the east, close to the jet airstrip to the south and close to the Town of Arctic Bay water supply reservoir to the west. Over 1,300 soil samples were collected and analysed throughout this area.

For the purposes of the Phase 2 ESA Report, a subset of this total area was presented that illustrated the area of interest containing and immediately surrounding the mine site. This subset area was approximately 40 km^2 in size, as illustrated on Figure 4, and included over 280 sample analyses.

Sample Collection and Analytical Methodologies

Overview

A description of the sample collection and analytical methodologies was provided to the NWB by CanZinco/Gartner Lee in a response to review comments dated May 19, 2003 that is included herein in Appendix B.

The sample collection and analytical methodologies were also confirmed with the geologist who oversaw and took part in the work, Mr. Doug Dumka, P.Geol., now of Strathcona Mineral Services. A letter was provided by Mr. Dumka verifying the methodology, which is provided herein in Appendix E.

Sample Collection Methodology

The provided sample collection methodology was reviewed by Gartner Lee professional geologists and engineers who are qualified and experienced to provide professional opinion on such work. This review verified that the methodology was appropriate and adequate for the locale and purpose of the study. Further, the methodology was also appropriate for inclusion of the survey into the Phase 2 and Phase 3 ESA Reports on the condition that a description of the 1985 Survey methodology was also provided.

The nature of and, in most locations, absence of surficial organic soils in the North Baffin region and, specifically, within the 1985 Survey area (Figure 4) is of particular importance regarding the sample collection methodology. For example, in southern areas, this nature of soil geochemistry survey might require the sampling only of soils beneath the surficial organic layer such that samples are reported over a specific depth interval. In northern arctic areas such as the 1985 Survey area, no surficial organic soils are present, except in small and isolated areas, such that it is necessary, and appropriate, to sample the coarse soils that are present on surface to whatever limited depth is readily available to excavation with a small hand shovel. This is the reason why all of the samples collected during the 1985 Survey are "surface" samples.

Analytical Methodology

The laboratory analyses of metal concentrations were conducted in the on-site assay laboratory. Although the specific laboratory methodology was not documented, it is reasonable to assume that the laboratory procedures used were consistent with the general procedures used for other samples. For example, the on-site laboratory had been approved, at that time, for the analysis of water samples for compliance reporting. Also, it is reasonable to assume that the importance of an accurate analyses of the soil samples as regards identifying possible increased mineral resources would have ensured that appropriate laboratory procedures were specified and followed. Therefore, although the laboratory procedures were not documented to the degree of the 2002 ESA sampling activities, the 1985 procedures are assumed to be adequate for the proposed use of the data as part of the description of natural conditions.

Implications of Mining Activities on the 1985 Survey

Overview

Mining activities had been underway at the Nanisivik mine for approximately nine years prior to the 1985 Survey and the possible implications of these activities for the 1985 Survey data were considered in the Phase 2 ESA Report. An expanded description of the possible implications was provided to the NWB in a response to review comments dated May 19, 2003 that is included herein in Appendix B.

Of particular importance is the fact that tailings deposition had been underwater in West Twin Lake prior to the 1985 Survey such that wind blown tailings were not a consideration and such that the implications of mining activities were restricted to highly localized areas of activity.

Discussion

The mining activities that had been undertaken prior to 1985 included open pit mining at the West Open Pit, underground mining at the main lens, mining at Area 14 (two years), underwater tailings deposition in West Twin Lake, operation of the concentrator plant and associated facilities, operation of the concentrate storage shed and ship loading facility, operation of the town and ancillary facilities, and operation of the landfill. These activities were considered, in the Phase 2 ESA report, to have had only highly localized effects on soil metal concentrations.

Therefore, the effects of mining activities on the 1985 data is considered to be negligible with the exception of soil sampling locations within the immediate driving and working areas of the industrial complex, the concentrate storage and loading facility and the townsite. The specific effects of these "pre-1985" mining activities on soil metal concentrations were localized increases of lead and zinc directly related to vehicle tracking and spillage of concentrate dust. For example, Figure 4 of the Phase 2 ESA Report shows a 1985 soil sample containing high metal concentrations within the concentrate storage and loading work area. This sample is clearly within the immediate area of concentrate handling activities and the high metal concentrations are attributed to those activities.

Several samples from the 1985 data set that are located to the immediate north and northeast of the town show high metal concentrations. These high concentrations correspond to historical and current observations of a zone of natural sulphide mineralization and the 1985 data are considered representative of natural conditions within this zone. In addition to this visible surface zone, there are several natural outcroppings of sulphide mineralization along the north bank of Twin Lakes Creek that provide additional examples of the natural mineralization of the area.

Soil Metal Concentrations

Data Set

The data set for the 1985 Survey includes concentrations of copper (Cu), lead (Pb) and zinc (Zn) to a lower detection limit of 20 ppm. The entire data set is tabulated in Appendix E. The tabulated data set includes the original 1985 notations that identify samples for which special notation was deemed beneficial by the project geologist. There are four notations which are:

1. Di – indicative of diabase dyke (a specific geologic rock type that does not necessarily have a direct implication on the ESA work);
2. Go – indicative of a gossan zone which represents a surficial oxidized outcropping of sulphide mineralization with a direct implication on the ESA work as regards a source of naturally occurring and readily available metals;
3. Po – indicative of a zone of "contamination" as inferred by the project geologist based on observed effects of mine activities (i.e., haul roads); and
4. Py – indicative if visible pyrite which has a direct implication for the ESA work as regards a potential source of naturally occurring sulphide mineralization.

Summary Metal Concentrations

Metal concentrations over the entire 1985 Survey area are summarized in Table B. For this summary, metal concentrations that were reported as "<20" were included into the summary calculations as 20 mg/kg (ppm), which is a conservative approach to managing data reported at a detection limit.

Table B. Summary of 1985 Survey Metal Concentrations[1]

	Entire Survey Area (1,304 samples)			Mine Sub-Area (287 samples)		
	Lead	Zinc	Copper	Lead	Zinc	Copper
Maximum	12,154	2,545	1,974	12,154	2,545	453
Minimum	<20	<20	<20	<20	<20	<20
% less than detection	40%	61%	26%	14%	35%	26%
Average	108	112	74	228	318	66
CCME Generic Tier 1 Guideline for RL/PL Use (1999)	140	200	63	140	200	63

Note: All units are mg/kg (ppm) unless stated otherwise.

Application of the 1985 Survey Data

The 1985 Survey data were utilized in the Nanisivik HHERA to represent background soil concentrations (JWEL 2003a) over the areas illustrated on Figure 4.

In this regard, the use of this site-specific data is superior to the use of surrogate or generic data. In some situations, site-specific data is not available and, in those cases, it is necessary to obtain and use surrogate data that has been developed elsewhere and which may need modifications based on reasonable judgement before being used at the site in question.

3.3 Surface Water Quality

3.3.1 Twin Lakes Creek and Chris Creek

Hydrology

A description of the hydrology of the immediate mine area (Twin Lakes, Twin Lakes Creek and Chris Creek) was provided in the Phase 2 ESA Report. That description has been reviewed and updated below.

The primary surface drainage in the mine area is Twin Lakes Creek, which drains the East and West Twin Lakes, town area and west adit area watersheds into Strathcona Sound as illustrated on Figure 2.

The release of decant water from West Twin Lake is manually controlled according to the mine operating plan for maintaining water cover over tailings in the Reservoir. Water flow exiting East Twin Lake is not artificially controlled except to the extent that a relatively small volume of water is extracted from the lake for freshwater use in the town (and the mill prior to mine closure).

Twin Lakes Creek flows directly below the west adit area, which includes three portals (00, 01 and 09), two waste rock piles (02 and 09) and the West Open Pit at a distance of approximately 2.2 to 2.8 km downstream of the WTDA. The creek passes exposed natural highly mineralized outcrops in the creek channel at distances of approximately 1.8 km and 3.0 km downstream of the WTDA. The creek passes below the industrial complex site at a distance of approximately 3.8 km downstream of the WTDA and, ultimately, enters Strathcona Sound immediately west of the dock area at a distance of approximately 9.0 km downstream of the WTDA.

Water quality in Twin Lakes Creek is significantly affected by runoff from the areas listed above and contains seasonally variable loadings of heavy metals. The potential sources of metals in Twin Lakes Creek have been extensively investigated by CanZinco and others and are considered to include both naturally occurring exposures of sulphides and mine activities.

Chris Creek drains surface water into Strathcona Sound from the watershed on the east side of the mine area. Specifically, surface run off from the East Adit area, 39N/S rock piles, K-Baseline area and discharge from the east adit water treatment system enters Strathcona Sound via Chris Creek. Water quality in Chris Creek is also monitored.

Baseline studies (BCRI 1975a) indicated that neither Twin Lakes Creek nor Chris Creek supported fish populations prior to mine development due to steep gradients, waterfalls and generally unsuitable habitat. Baseline studies also indicated that neither East nor West Twin Lakes supported fish populations prior to mine development.

Overview of Water Quality Studies

An overview of the surface water quality studies that had been performed at the Nanisivik mine (up to 2000) was provided in the Phase 2 ESA Report. Section 3.3.1 of the Phase 2 ESA Report, which provided a summary of surface water quality in Twin Lakes Creek and Chris Creek, is repeated below.

A great deal of surface water quality data is available for the Nanisivik area. B.C. Research Inc. (BCRI) conducted initial baseline studies 1974. CanZinco conducted sampling per the terms of the Water License throughout the mine life. Additionally, discrete comprehensive studies have also been undertaken at times that collected detailed information in one area or over one time period.

The most important of the studies carried out in excess of the Water License Surveillance Network Program are a series of metal loading studies in Twin Lakes Creek. The first of these studies was conducted by Indian and Northern Affairs Canada (INAC) in 1987 and 1988. CanZinco conducted annual metal loading studies from 1995 to 2000 and reported these to the NWB. The most recent of these studies (for the year 2000) provides observations and conclusions of recent years.

The general observations provided by the water quality studies is that metal loadings entering Strathcona Sound from Twin Lakes Creek increased as a result of mine activities, even in light of the elevated concentrations of metals that pre-existed the mine. The studies show that the dominant source of the metals is run off in the west adit area, which includes both naturally occurring and anthropogenic sulphide exposures. Concentrations of zinc and cadmium generally follow similar trends with maximum concentrations typically observed in the west adit/mill area that are greater than the concentrations at the mouth of the creek. The record of compliance with the Water License maximum allowable discharge limits at the decant from West Twin Lake has been excellent over the life of the mine.

Water Quality in Twin Lakes Creek

Upstream: West Twin Disposal Area (WTDA)

During mine operations, excess mine water accumulated in the WTDA as a result of precipitation, natural inflows and inflow of tailings slurry water that exceeded, on an annual basis, the requirements for water recycle to the mill. This water passed through the Reservoir and polishing pond portions of the WTDA and was decanted, on seasonal basis, into Twin Lakes Creek. Lime treatment for removal of metals was not required at this location during the life of the mine.

The quality of water released from the WTDA was monitored at SNP location 159-4. Water quality at this location for select parameters from 1996 to 2001 is tabulated in Appendix F. Note that sampling is only required and reported for periods when release of water is taking place. Water quality at this location is generally excellent with respect to the discharge criteria. The maximum and average reported concentrations of total zinc were 0.205 mg/L and 0.06 mg/L, respectively, with pH in a range from 5.0 to 9.5 pH units.

Upstream: East Twin Lake

Water quality in East Twin Lake was monitored throughout mine operations as sampling location NML-23, which was not specified in the Water License SNP program. This location was sampled as the water that was pumped to the town and mill freshwater supply system. Water quality at this location for select parameters is tabulated in Appendix F. The maximum and average reported concentrations of total zinc were 0.679 mg/L and 0.001 mg/L (the method detection limit), respectively, with pH in a range from 2.5 to 10.6 pH units. However, the maximum reported concentration of total zinc is anomalous high given that the next highest concentration of total zinc is 0.294 mg/L. Similarly, the lowest reported pH is highly unusual and may also be anomalous given that the next lowest reported pH is 6.15.

Outlet: Strathcona Sound

The outlet of Twin Lakes Creek that includes all inputs from mine and naturally occurring areas is sampled at SNP station 159-6. Water quality at this location for select parameters is tabulated in Appendix F. The maximum and average reported concentrations of total zinc were 15.2 mg/L and 1.37 mg/L, respectively with pH in a range from 4.8 to 8.6 pH units. The zinc concentrations are clearly substantially greater than at the two upstream sources areas (WTDA and East Twin Lake) and this is attributed to both natural and anthropogenic sources. Investigation and identification of individual source areas was the intent of the annual metal loading studies carried out by Nanisivik and filed with the NWB and these are available for a more detailed discussion of individual source areas.

The extended database of concentrations of total zinc that spans all available data from 1974 to 2001, as included in Appendix F, provides a longer term context and the data record for total zinc is also illustrated graphically in Appendix F. Peak concentrations of total zinc in Twin Lakes Creek generally increased beginning in around 1998. This may be attributed to the initiation of increased activity related to relocation of waste rock to the underground mine. It is possible that this activity disrupted otherwise stable rock piles such that fine grained materials became temporarily available for transport into Twin Lakes Creek. Otherwise, the concentration of total zinc in Twin Lakes Creek has been highly variable since 1974 but within a somewhat consistent range until 1998, as described above. It is important to note that the years 1974, 1975 and 1976 are represented by only one data point and that this effectively prevents the observation of seasonal variations for those years.

Metal Loading Study

This summary of the 2000 Metal Loading Study, as it was prepared and filed with the NWB by CanZinco was initially provided in the Phase 2 ESA Report and is repeated here for additional context regarding investigation of individual sources of metals entering Twin Lakes Creek.

Annual studies of metal loadings in Twin Lakes Creek were undertaken from 1995 to 2000. The studies involved detailed sampling along the length of Twin Lakes Creek and flow monitoring at the mouth. The 2000 metal loading study, as prepared by Nanisivik Mine, was submitted to the NWB in early 2001 and contained the following observations:

1. Zinc concentrations and loadings exiting the WTDA are a very minor contributor to metal loadings in Twin Lakes Creek;
2. Zinc concentrations and loadings generally increase from the East/West Twin Lakes area to Strathcona Sound with the greatest concentrations observed at various times in proximity to certain rock dumps and natural outcrops of massive sulphides;
3. An early season (spring) spike in zinc concentrations occurs in proximity to rock dumps, which may be related to the melting of snow and ice and subsequent flushing of rock dumps;
4. A second spike in zinc concentrations occurs in proximity to a natural sulphide outcrop, which may be related to slower (as compared to rock dumps containing very coarse material) melting of snow and ice and subsequent runoff from natural soils;
5. The late season spike in zinc concentrations is accompanied by high iron concentration, which may be related to natural runoff and the thawing of surface soils; and
6. The high late season iron concentrations result in a visible orange discolouration of the creek water and staining of creek sediments in Twin Lakes Creek, as well as other local creeks.

Water Quality in Chris Creek

Upstream: Chris Creek

The upstream reaches of Chris Creek are generally below (west of) the Area14 area and to the east of East Twin Lake. The furthest upstream routinely sampled water quality monitoring station is SNP location 159-15. This location is in Chris Creek on the downstream side of the Area14 access road crossing.

Water quality at this location for select parameters is tabulated in Appendix F. The maximum and average reported concentrations of total zinc were 0.361 mg/L and 0.074 mg/L, respectively, with pH in a range from 6.4 to 8.3 pH units.

Outlet: Strathcona Sound

The outlet of Chris Creek is sampled as SNP location 159-17, which includes all natural and anthropogenic inputs. Water quality at this location for select parameters is tabulated in Appendix F. The maximum and average reported concentrations of total zinc were 0.347 mg/L and 0.135 mg/L, respectively, with pH in a range from 7.4 to 8.6 pH units. Note that there is no data reported for the years 1997, 1998 and 1999 and that this will affect the summary results and comparison to other stations.

Nonetheless, the maximum reported zinc concentration appears to be consistent with that reported for upstream location 159-15, suggesting that there are no inputs of extremely high loadings along the creek. However, the average concentration of total zinc at 159-17 is greater than at upstream location 159-15, which suggests that there may be a source of zinc entering the creek between the two stations.

3.3.2 Kuhulu Lake

Overview

Kuhulu Lake is located to the east of the mine development area. Pre-mining mineral exploration activities were undertaken in the area, including the construction of an access road that served effectively as a small water retention dyke at the lake outflow. The Oceanview development area is proximal to Kuhulu Lake on the north side but is located entirely downgradient of the lake.

Kuhulu Lake was investigated as part of the 1974 baseline studies for the Nanisivk mine (BCRI 1975a). The studies completed at that time included lake bathymetry, lake volumes, chemical profiling and water quality. Fisheries and Marine Service (Winnipeg) had, in 1974, conducted a biological survey of Kuhulu Lake, including fish sampling, that was referenced in BCRI 1975a. The general conclusions and observations of that study were as follows:

- the volume of Kuhulu Lake was determined to be 16,300 million gallons with a depth measured to be in excess of 204 feet (62 m);