AQUATIC EFFECTS TECHNOLOGY EVALUATION (AETE) PROGRAM

1996 Preliminary Field Survey
Levack/Onaping Mine Sites,
Ontario

AETE Project 4.1.2

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Sponsored by :

Canada Centre for Mineral and Energy Technology (CANMET)
Mining Association of Canada (MAC)

on Behalf of :

Aquatic Effects Technology Evaluation (AETE) Program

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AQUATIC EFFECTS TECHNOLOGY EVALUATION PROGRAM

Notice to Readers

Aquatic Effects Monitoring
1996 Preliminary Field Surveys

The Aquatic Effects Technology Evaluation (AETE) program was established to review appropriate technologies for assessing the impacts of mine effluents on the aquatic environment. AETE is a cooperative program between the Canadian mining industry, several federal government departments and a number of provincial governments; it is coordinated by the Canada Centre for Mineral and Energy Technology (CANMET). The program is designed to be of direct benefit to the industry, and to government. Through technical evaluations and field evaluations, it will identify cost-effective technologies to meet environmental monitoring requirements. The program includes three main areas: acute and sublethal toxicity testing, biological monitoring in receiving waters, and water and sediment monitoring. The program includes literature-based technical evaluations and a comprehensive three year field program.

The program has the mandate to do a field evaluation of water, sediment and biological monitoring technologies to be used by the mining industry and regulatory agencies in assessing the impacts of mine effluents on the aquatic environment; and to provide guidance and to recommend specific methods or groups of methods that will permit accurate characterization of environmental impacts in the receiving waters in as cost-effective a manner as possible. A pilot field study was conducted in 1995 to fine-tune the study design.

A phased approach has been adopted to complete the field evaluation of selected monitoring methods as follows:

Phase I: 1996- Preliminary surveys at seven candidate mine sites, selection of sites for further work and preparation of study designs for detailed field evaluations.

Phase II: 1997-Detailed field and laboratory studies at selected sites.

Phase III: 1998- Data interpretation and comparative assessment of the monitoring methods: report preparation.

Phase I is the focus of this report. The overall objective of this project is to conduct a preliminary field/laboratory sampling to identify a short-list of mines suitable for further detailed monitoring, and recommend study designs. The objective is NOT to determine the detailed environmental effects of a particular contaminant or extent and magnitude of effects of mining at the sites.

In Phase I, the AETE Technical Committee has selected seven candidates mine sites for the 1996 field surveys:

1) Myra Falls, Westmin Resources (British Columbia)
2) Sullivan, Cominco (British Columbia)
3) Lupin, Contwoyto Lake, Echo Bay (Northwest Territories)
4) Levack/Onaping, Inco and Falconbridge (Ontario)
5) Dome, Placer Dome Canada (Ontario)
6) Gaspé Division, Noranda Mining and Exploration Inc. (Québec)
7) Heath Steele Division, Noranda Mining and Exploration Inc. (New-Brunswick)

Study designs were developed for four sites that were deemed to be most suitable for Phase II of the field evaluation of monitoring methods (Myra Falls, Dome, Heath Steele, Lupin). Lupin was subsequently dropped based on additional reconnaissance data collected in 1997. Mattabi Mine, (Ontario) was selected as a substitute site to complete the 1997 field surveys.

For more information on the monitoring techniques, the results from their field application and the final recommendations from the program, please consult the *AETE Synthesis Report* to be published in September 1998.

Any comments regarding the content of this report should be directed to:

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PROGRAMME D'ÉVALUATION DES TECHNIQUES DE MESURE D'IMPACTS EN MILIEU AQUATIQUE

Avis aux lecteurs

Surveillance des effets sur le milieu aquatique
Études préliminaires de terrain - 1996

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA) vise à évaluer les différentes méthodes de surveillance des effets des effluents miniers sur les écosystèmes aquatiques. Il est le fruit d'une collaboration entre l'industrie minière du Canada, plusieurs ministères fédéraux et un certain nombre de ministères provinciaux. Sa coordination relève du Centre canadien de la technologie des minéraux et de l'énergie (CANMET). Le programme est conçu pour bénéficier directement aux entreprises minières ainsi qu'aux gouvernements. Par des évaluations techniques et des études de terrain, il permettra d'évaluer et de déterminer, dans une perspective coût-efficacité, les techniques qui permettent de respecter les exigences en matière de surveillance de l'environnement. Le programme comporte les trois grands volets suivants : évaluation de la toxicité aiguë et sublétale, surveillance des effets biologiques des effluents miniers en eaux réceptrices, et surveillance de la qualité de l'eau et des sédiments. Le programme prévoit également la réalisation d'une série d'évaluations techniques fondées sur la littérature et d'évaluation globale sur le terrain.

Le Programme ÉTIMA a pour mandat d'évaluer sur le terrain les techniques de surveillance de la qualité de l'eau et des sédiments et des effets biologiques qui sont susceptibles d'être utilisées par l'industrie minière et les organismes de réglementation aux fins de l'évaluation des impacts des effluents miniers sur les écosystèmes aquatiques; de fournir des conseils et de recommander des méthodes ou des ensembles de méthodes permettant, dans une perspective coût-efficacité, de caractériser de façon précise les effets environnementaux des activités minières en eaux réceptrices. Une étude-pilote réalisée sur le terrain en 1995 a permis d'affiner le plan de l'étude.

L'évaluation sur le terrain des méthodes de surveillance choisies s'est déroulée en trois étapes:

Étape I 1996 - Évaluation préliminaire sur le terrain des sept sites miniers candidats, sélection des sites où se poursuivront les évaluations et préparation des plans d'étude pour les évaluations sur le terrain.

Étape II 1997- Réalisation des travaux en laboratoire et sur le terrain aux sites choisis

Étape III 1998 -Interprétation des données, évaluation comparative des méthodes de surveillance; rédaction du rapport.

Ce rapport vise seulement les résultats de l'étape I. L'objectif du projet consiste à réaliser des échantillonnages préliminaires sur le terrain et en laboratoire afin d'identifier les sites présentant les caractéristiques nécessaires pour mener les évaluations globales des méthodes de surveillance en 1997 et de développer des plans d'études. Son objectif N'EST PAS de déterminer de façon détaillée les effets d'un contaminant particulier, ni l'étendue ou l'ampleur des effets des effluents miniers dans les sites.

À l'étape I, le comité technique ÉTIMA a sélectionné sept sites miniers candidats aux fins des évaluations sur le terrain:

1) Myra Falls, Westmin Resources (Colombie-Britannique)
2) Sullivan, Cominco (Colombie-Britannique)
3) Lupin, lac Contwoyto, Echo Bay (Territoires du Nord-Ouest)
4) Levack/Onaping, Inco et Falconbridge (Ontario)
5) Dome, Placer Dome Mine (Ontario)
6) Division Gaspé, Noranda Mining and Exploration Inc.(Québec)
7) Division Heath Steele Mine, Noranda Mining and Exploration Inc.(Nouveau-Brunswick)

Des plans d'études ont été élaborés pour les quatres sites présentant les caractéristiques les plus appropriées pour les travaux prévus d'évaluation des méthodes de surveillance dans le cadre de l'étape II (Myra Falls, Dome, Heath Steele, Lupin). Toutefois, une étude de reconnaissance supplémentaire au site minier de Lupin a révélé que ce site ne présentait pas les meilleures possibilités. Le site minier de Mattabi (Ontario) a été choisi comme site substitut pour compléter les évaluations de terrain en 1997.

Pour des renseignements sur l'ensemble des outils de surveillance, les résultats de leur application sur le terrain et les recommandations finales du programme, veuillez consulter le *Rapport de synthèse ÉTIMA* qui sera publié en septembre 1998.

Les personnes intéressées à faire des commentaires sur le contenu de ce rapport sont invitées à communiquer avec M^{me} Diane E. Campbell à l'adresse suivante :

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EXECUTIVE SUMMARY

Information relevant to specific study elements for the Onaping/Levack mine site are summarized in the following table.

Summary Information for Specific Study Elements for the Onaping/Levack Mine Site

Element	Sampled 1996	Summary/Comments
1.0 Historical Data Review 1.1 Effluent Characterization	N/A	Inco and Falconbridge both have detailed effluent chemistry data in background reports
1.2 Water Chemistry	N/A	Good background water chemistry data available
1.3 Sediment Chemistry	N/A	Limited sediment chemistry data due to erosional nature of the Onaping River
1.4 Benthos	N/A	Good benthic data available back to the 1970's
1.5 Fisheries 1.5.1 Population	N/A	Qualitative catch data available in several reports but no population estimates
1.5.2 Tissue	N/A	No known tissue data available
2.0 Study Area 2.1 Site Access	N/A	Site is readily accessible in Exposure area, difficult access in Reference area
2.2 Availability of Multiple Reference and Exposure Areas	N/A	Multiple Reference and Exposure areas are available on this river system
2.3 Confounding Discharges	N/A	Sewage treatment plant discharges immediately above mine effluents. Interpretation is confused by discharge from two mines to one receiving location
3.0 Effluent/Sublethal Toxicity 3.1 Frequency of Effluent Discharge	N/A	Falconbridge effluent available year round. INCO discharge is not continuous
3.2 Sublethal Toxicity 3.2.1 *Ceriodaphnia dubia*	Y	Falconbridge and INCO effluent inhibited reproduction samples in 1996
3.2.2 Fathead minnow	Y	Falconbridge effluent not toxic in 1996 INCO effluent inhibited growth but not survival
3.2.3 *Selenastrum capricornutum*	Y	Falconbridge and INCO effluent inhibited growth in 1996
3.2.4 *Lemna minor*	Y	Falconbridge and INCO effluent inhibited growth in 1996
3.2.5 Trout embryo	Y	Falconbridge and INCO effluent were not toxic to trout eggs
4.0 Habitats	Y	Reference and Exposure areas very similar in habitat
5.0 Water Chemistry	Y	Water concentrations statistically greater in Exposure area relative to Reference area for several metals and general chemistry

Summary Information for Specific Study Elements for the Onaping/Levack Mine Site

Element	Sampled 1996	Summary/Comments
6.0 Sediments	Y	Depositional sediments are present but not common in either Exposure or Reference area. Differences in sediment chemistry not pronounced between the areas
7.0 Benthos	Y	Exposure area displayed more abundant and diverse benthic community compared with Reference area
8.0 Fisheries 8.1 Communities	Y	Insufficient data to compare fish communities in Exposure and Reference areas Some sensitive species (i.e. Rainbow trout) captured in Exposure area
8.2 Tissues	Y	Metal and metallothionein levels higher in white sucker in Exposure area but small sample sizes precluded statistical analysis No barriers to fish migration

Tableau ES-1. Suite.

SOMMAIRE

Le tableau ci-dessous résume l'information concernant certains éléments de l'étude relative à la mine Onaping/Levack.

Résumé de l'information concernant certains éléments de l'étude relative à la mine Onaping/Levack

Élément	Échantillons prélevés en 1996	Sommaire/remarques
1.0 Revue des données historiques 1.1 Caractérisation de l'effluent	s.o.	Les sociétés INCO et Falconbridge possèdent des documents de base renfermant des données détaillées sur la composition chimique de l'effluent.
1.2 Chimie de l'eau	s.o.	Bonnes données de base disponibles concernant la chimie de l'eau.
1.3 Chimie des sédiments	s.o.	Données restreintes sur la chimie des sédiments à cause de la forte érosion dans la rivière Onaping.
1.4 Benthos	s.o.	On dispose de données satisfaisantes remontant aux années 70 concernant le benthos.
1.5 Pêches 1.5.1 Population	s.o.	Des données qualitatives sur les prises figurent dans plusieurs rapports, mais il n'y a pas d'estimations des populations.
1.5.2 Tissus	s.o.	Il n'existe pas de données connues sur les tissus.
2.0 Zone d'étude 2.1 Accès au site	s.o.	Le site est facilement accessible dans la zone d'exposition, mais l'accès à la zone de référence est difficile.
2.2 Disponibilité de plusieurs zones de référence et d'exposition	s.o.	Plusieurs zones de référence et d'exposition sont disponibles dans le réseau hydrographique.
2.3 Rejets au même endroit	s.o.	La station d'épuration des eaux usées rejette son effluent immédiatement en amont des effluents miniers. Comme les deux mines rejettent leurs effluents au même endroit, l'interprétation des résultats peut être faussée.
3.0 Effluent et toxicité sublétale 3.1 Fréquence des rejets d'effluent	s.o.	La Falconbridge rejette son effluent à longueur d'année, mais le rejet de l'effluent de l'INCO n'est pas continu.
3.2 Toxicité sublétale 3.2.1 *Ceriodaphnia dubia*	Oui	À cause des effluents de l'INCO et de la Falconbridge, la reproduction a été inhibée dans les échantillons prélevés en 1996.
3.2.2 Tête-de-boule	Oui	L'effluent de la Falconbridge n'était pas toxique en 1996. L'effluent de l'INCO a inhibé la croissance de l'organisme sans empêcher sa survie.
3.2.3 *Selenastrum capricornutum*	Oui	Les effluents de l'INCO et de la Falconbridge ont inhibé la croissance de l'organisme en 1996.
3.2.4 *Lemna minor*	Oui	Les effluents de l'INCO et de la Falconbridge ont inhibé la croissance de l'organisme en 1996.
3.2.5 Embryon de truite	Oui	Les effluents de l'INCO et de la Falconbridge n'étaient pas toxiques pour les œufs de truite.
4.0 Habitats	Oui	Les habitats sont très similaires dans les zones de référence et d'exposition.

Tableau ES-1. Suite.

Élément	Échantillons prélevés en 1996	Sommaire/remarques
5.0 Chimie de l'eau	Oui	Statistiquement, les concentrations de plusieurs métaux dans l'eau sont plus élevées dans la zone d'exposition que dans la zone de référence; même situation en ce qui a trait à la chimie générale de l'eau.
6.0 Sédiments	Oui	Des sédiments déposés sont présents mais peu abondants dans les zones de référence et d'exposition. Les deux types de zones ne présentent que de faibles différences dans la chimie des sédiments.
7.0 Benthos	Oui	La zone d'exposition présente une communauté benthique plus abondante et diversifiée que la zone de référence.
8.0 Pêches 8.1 Communautés	Oui	Données insuffisantes pour comparer les communautés benthiques de la zone d'exposition et de la zone de référence. Certaines espèces vulnérables (p. ex., truite arc-en-ciel) capturées dans la zone d'exposition.
8.2 Tissus	Oui	Les concentrations de métaux et de métallothionéine étaient plus élevées chez le meunier noir de la zone d'exposition, mais à cause de la petite taille des spécimens, l'analyse statistique n'a pas été possible. Aucun obstacle physique à la migration.

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APPENDICES

1. INTRODUCTION

The Aquatic Effects Technology Evaluation (AETE) Program was established to conduct field and laboratory evaluation and comparison of selected environmental effects monitoring technologies for assessing impacts of mine effluents on the aquatic environment. The focus of the Program is on robustness, costs, and the suitability of monitoring sites.

Building upon previous work, which includes literature reviews, technical evaluations, and pilot field studies, the AETE Program sponsored preliminary evaluations of aquatic effects monitoring at seven candidate mine sites in 1996. Based on the results of these preliminary evaluations, some of these sites have been recommended for further work in 1997.

This final field survey report provides detailed information on work conducted at the Onaping/Levack mine sites near Levack, Ontario. Separate reports are provided for each of the other six sites. Recommendations regarding selection of sites for 1997 work are provided under separate cover together with a field study design for each of the recommended sites.

2. SITE SPECIFIC BACKGROUND INFORMATION

2.1 Site Description

Mineral deposits in the Levack area were first discovered in 1887 by a prospector who had studied the geological formations near Sudbury. The Levack mine was the first mine to began operation in 1913. Subsequently, three other mines opened in the area. The International Nickel Co. (now INCO) was formed in 1929. The Levack mill was opened in 1959, and another two mines, the Coleman mine and Levack West mines were opened in 1971 and 1974, respectively.

Falconbridge Nickel Mines Ltd. became interested in the area about 1935 and opened the Hardy mine. In 1948, the Fecunis mine was developed, with opening of the Strathcona mine a short distance away in 1951.

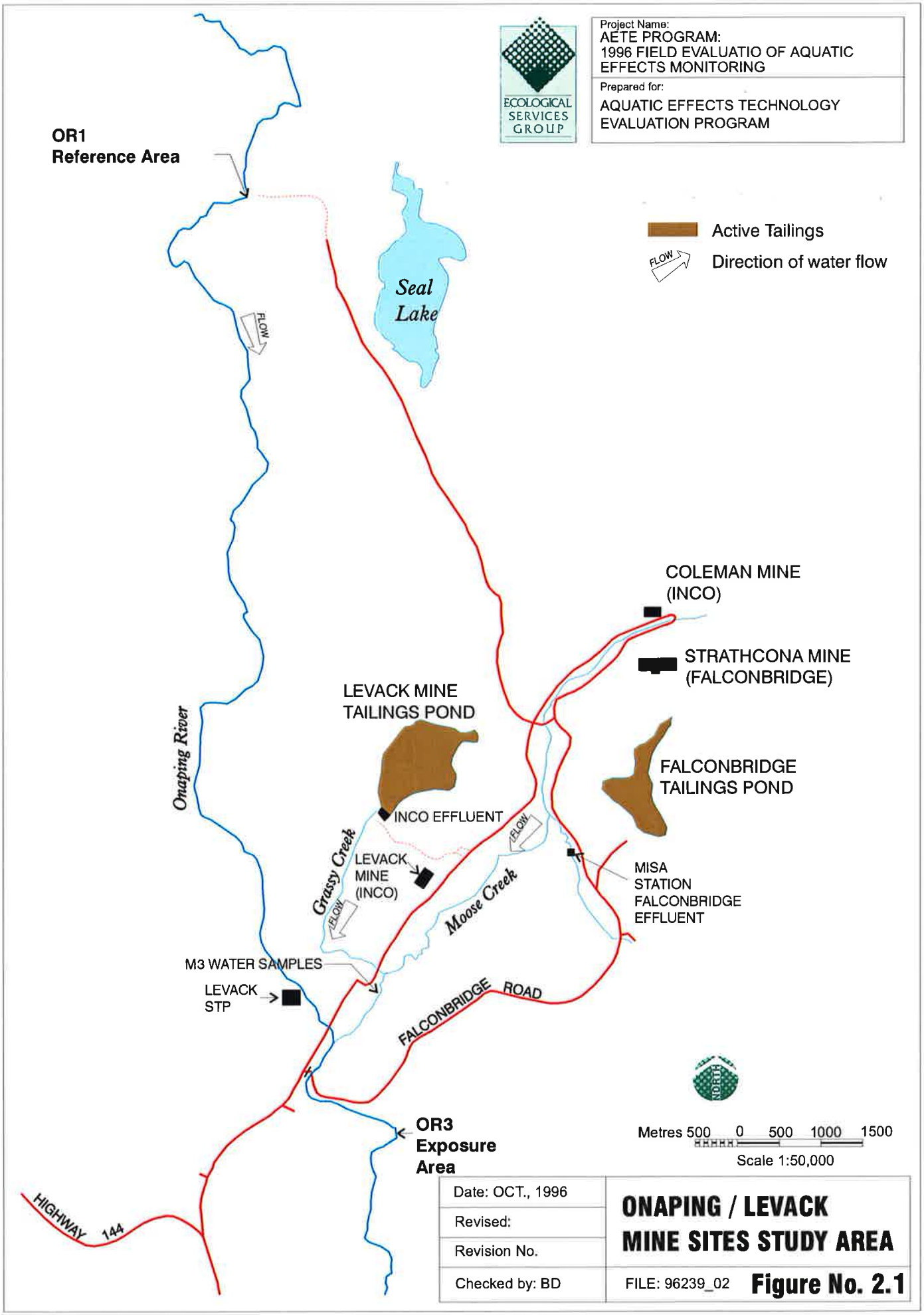
By 1977, 9 mines and 4 concentrator plants were operating in the Levack area. Prior to 1954, all mining effluent was being discharged to the Onaping River untreated (Bolger 1980). The first mill concentrator plant at Levack was built in 1954, and used a tailings pond for removal of suspended solids. Treatment of wastewater increased during the 1970's toward removal of acidity and metals of effluent primarily through use of limestone and settling ponds.

INCO Ltd. operates the Levack mine among several other properties in the Sudbury area. Effluent from the Levack property is discharged into Grass Creek which flows into Moose Creek and subsequently into the Onaping River. Effluent from two other INCO properties (Coleman Mine, McCreedy Mine) is treated by Falconbridge at their Onaping site, which includes the Moose Lake discharge. The Falconbridge effluent is discharged in Moose Creek, which joins the Onaping River a short distance downstream.

Effluent treatment for the Falconbridge Moose Lake tailings includes the addition of crushed lime solution to help precipitate solids into the lake. CO2 is added before the effluent is released into Moose Creek to lower the pH. Only trace amounts of cyanide are used in the copper recirculation unit, therefore, additional effluent treatment is not required.

The Onaping River is the ultimate receiver for effluent from the INCO and Falconbridge operations (Figure 2.1). The Onaping River also receives input from the town of Levack sewage treatment facility in the vicinity of the mines. Nutrient input has influenced water quality in the area. Recent aquatic surveys below the mine effluent indicated greater benthic biodiversity below the mine outfall compared with upstream reference stations, possibly as a result of nutrient loading (ASI, 1995).

The Onaping River is a large, fast flowing river with an average gradient of 2m/km. In 1946, water from Onaping Lake was diverted to the Spanish River to generate electricity for the E.B. Eddy paper mill at Espanola. As a result of the diversions, the watershed of the Onaping River was reduced by approximately 50% (from 1645


ECOLOGICAL SERVICES GROUP
Project Name:
AETE PROGRAM:
1996 FIELD EVALUATIO OF AQUATIC EFFECTS MONITORING
Prepared for:
AQUATIC EFFECTS TECHNOLOGY EVALUATION PROGRAM
OR1
Reference Area
Active Tailings
FLOW
Direction of water flow
Seal Lake
FLOW
COLEMAN MINE
(INCO)
STRATHCONA MINE
(FALCONBRIDGE)
LEVACK MINE
TAILINGS POND
FALCONBRIDGE
TAILINGS POND
Onaping River
INCO EFFLUENT
FLOW
Grassy Creek
LEVACK
MINE
(INCO)
FLOW
Moose Creek
MISA
STATION
FALCONBRIDGE
EFFLUENT
M3 WATER SAMPLES
LEVACK
STP
FALCONBRIDGE ROAD
NORTH
OR3
Exposure
Area
Metres 500 0 500 1000 1500
Scale 1:50,000
HIGHWAY 144
Date: OCT., 1996
Revised:
Revision No.
Checked by: BD
ONAPING / LEVACK
MINE SITES STUDY AREA
FILE: 96239_02
Figure No. 2.1

to 845 sq.km.). Overflow from Onaping Lake into the river only occurs during periods of high runoff in the early spring and sometimes in the autumn.

2.2 Historical Data Review

The background reports provided for this study are listed in Table 2.1 and their primary findings summarized in Table 2.2. According to Bowman and Mise (1992), three other studies of the Onaping River were undertaken in 1965 (Johnson and Owen 1966), 1983 (Lindquist 1985) and 1991 (Jorgensen 1991), although these reports were not provided as part of the AETE program. The latter two studies conducted benthic surveys which are briefly discussed in Bowman and Mise (ibid).

Table 2.1 Summary List of Available Background Reports for the Onaping/Levack Study Site, Ontario

Bolger, P. 1980. Ecological effects of liquid mining effluents on the Onaping River system in Ontario. M.Sc. thesis, Department of Biology, Laurentian University. Sudbury, Ontario. 194 pp + appendices.
Bowman, A.B. and J. Mise. 1992. A water quality and biological survey of the Onaping River. Report for Falconbridge Ltd. and INCO Ltd. 66 pp.
ASI. 1995. Onaping River and Moose Creek aquatic environmental assessment. Report by Aquatic Sciences Inc., St. Catharines, Ontario. Prepared for Inco Ltd. and Falconbridge Ltd. 64 pp + appendices.

Background Water Chemistry

The Ontario Water Resources Commission (OWRC, predecessor to the OMOEE) was established in 1957. In 1960 the OWRC reported high fecal coliform and elevated BOD (Biochemical Oxygen Demand) in the Onaping River due to the sewage treatment plants. The first chemical and biological study of the area to examine impacts of mining activities was undertaken in 1965 (Johnson and Owen 1966). The authors reported poor environmental conditions in Moose Creek, and impaired biota and water quality of the Onaping River.

High metal levels and depressed pH in the Onaping River were still reported in the 1970's, and were the focus of graduate studies in 1977 (Bolger 1980). That study provides a detailed documentation of chemical and biological conditions at 18 stations in the Onaping River and tributaries. Sampling stations established by Bolger were generally used in subsequent ecological surveys including this study (OR1 - reference, OR3- exposure).

Table 2.2 Summary of Background Information for the Onaping/Levack, Ontario

Source	Water Quality	Sediment Quality	Toxicity Bioassays	Fish	Benthos	Plankton Macrophytes	Summary
Bolger. 1980	yes	no	no	yes	yes	yes	Benthos, macrophytes and fish communities in Onaping River downstream of Levack substantially altered by mining effluent. Significant loading of copper, nickel and sulphur compounds.
Bowman and Mise. 1992	yes	yes	no	yes	yes	no	Nickel and copper loading to Onaping River continues, but proportion from non-point sources has increased. Upstream reference sites thought to be influenced by non-point sources. Benthic community has improved somewhat in response to improved water quality in exposure area but still altered relative to reference area. Area not suitable for sediment collection. Suitability of area for fisheries habitat affected by water diversion.
ASI. 1995	yes	no	no	yes	yes	no	Point source loadings of metals continue to decrease resulting in improved water quality in exposure area. Observed seasonal differences in levels of some water quality parameters. Benthic community generally more diverse and more taxa in exposure area. Reported brook trout for first time in reference area.

An important observation by Bolger was depressed pH levels (3.5-4.0) in the Onaping River particularly during low flow periods downstream of the confluence of Moose Creek. However, pH was not depressed at the first downstream station (OR3), only at stations further downstream (OR4, OR5). It was subsequently discovered that it took several hours for oxidation of partially oxidized sulphur compounds to occur in the receiving environment, hence resulting in severe pH and oxygen depressions further downstream.

In 1977, water concentrations of copper and nickel levels in the Onaping River were substantially elevated downstream (OR3) of Moose Creek compared with the upstream (OR1) refrence area (Table 2.3). The levels of several other parameters including nitrogen, phosphorous, sulphate, chlorides and conductivity were also elevated immediately below Moose Creek.

Table 2.3 Summary of Average Concentrations (mg/L) in Onaping River from Background Studies

	Nickel	Copper	Sulphate	Conductivity (µ/s)
OR1				
1977	0.004	0.005	14	40
1991	<0.17	<0.03	8.3	30
1995	0.011	ND	6	38
OR3				
1977	0.254	0.022	71	145
1991	0.15	0.02	64	143
1995	0.041	0.003	21	105

The water concentrations of many metals decreased appreciably in Moose Creek (M1, M2) between 1977 to 1995 (Table 2.4 (Table 4.2 from ASI 1995)). Similarly, the average, 1995 concentrations of iron, nickel, copper and zinc were lower in the Onaping River at OR3 than in previous surveys (Table 2.4). The authors commented that some comparisons with historical data, and even within-study comparisons were difficult due to different analytical labs being used and different detection limits (ASI, 1995).

Table 2.4 Comparison of Chemical Parameters Among Years (units in mg/L) from ASI, 1995

	1995	1991[1]	1990[2]	1977[3]
Location M1				
Iron	0.097	0.18	0.51	0.46
Nickel	0.034	0.11	0.40	11.7
Copper	0.005	0.02	0.035	0.59
Zinc	0.006	0.01	0.014	0.86
Manganese	0.013	--	0.096	--
Aluminum	0.108	--	0.270	--
Location M2				
Iron	0.753	0.34	1.380	1.75
Nickel	0.313	0.57	0.750	6.29
Copper	0.037	0.05	0.141	0.42
Zinc	0.010	0.04	0.026	0.31

Table 2.4 Comparison of Chemical Parameters Among Years (units in mg/L) from ASI, 1995

	1995	1991[1]	1990[2]	1977[3]
Manganese	0.059	--	0.130	--
Aluminum	0.250	--	1.205	--
Location G1				
Iron	1.811	0.89	3.100	17.79
Nickel	0.210	0.85	0.535	0.94
Copper	0.013	0.20	0.078	0.10
Zinc	0.014	0.22	0.023	0.03
Manganese	0.893	--	0.795	--
Aluminum	0.207	--	0.520	--
Location OR3				
Iron	0.278	0.29	0.368[4]	0.46
Nickel	0.041	0.15	0.054[4]	0.254
Copper	0.003	0.02	0.021[4]	0.022
Zinc	0.007	0.01	0.008[4]	0.017
Manganese	0.069	--	0.071[4]	--
Aluminum	0.040	--	0.145[4]	--

[1] Bowman and Mise (1992); [2] Jorgenson (1991); [3] Bolger (1980); [4] between Moose Creek and OR3

Mass balance loading estimates undertaken in 1992 and 1995 strongly suggest that the proportion of nonpoint loading of metals has increased substantially in the past several years with up to 50% of the nickel in the Onaping River from non-point sources. The Levack sewage treatment plant is considered to be a substantive source of copper to the Onaping River.

Although nutrient loading is not an obvious problem from the concentrations of nitrogen and phosphorous actually measured in the river, several observations demonstrate that primary and secondary productivity is clearly elevated immediately below the Levack STP. Different studies have observed dense algal and plant growth below the STP.

Sediment Chemistry

Very limited background sediment quality data are available for the study area. In fact, Bowman and Mise (1995) note that "in general... the Onaping River is not suited

to the collection of sediment chemistry samples because of its erosional characteristics." The authors collected sediments from two downstream depositional locations; one in the Onaping River and one in Vermillion Lake. Results of metal concentrations with comparison to the Provincial Sediment Quality Guideline (PSQG) Severe Effect Level (SEL) are summarized in Table 2.5.

Table 2.5 Summary of Mean Metal Concentrations (mg/g) in Sediments from Study Area in 1991 (values are mean of three replicate samples)

	Onaping River	Vermillion Lake	PSQG
Copper	520	143	110
Nickel	726	890	75
Lead	17	30	250
Zinc	153	143	820
Iron (%)	3.3	3.0	4.0

Benthic Community Surveys

Results of the biological surveys by Bolger (1980) showed that the benthic and aquatic macrophytes were altered downstream of Levack as a result of metal loading and low pH. Bolger (1980) collected triplicate surber samples in riffle areas in June and September. He reported a total of 118 different benthic taxa in the Onaping River, with over 70 taxa present at the upstream station (OR1) alone. Immediately downstream of Moose Creek, the number of taxa fell to 10 - 20.

Bowman and Mise (1992) used surber samplers to collect benthos in June of 1991, and artificial substrates deployed for four weeks in late August. The change to artificial substrates was considered appropriate due to the absence of suitable substrate and low sampling efficiency of the Surber.

Caution must be used when making direct comparison of the Bolger data with subsequent surveys, however, as the raw data suggest that different lifestages (eg. pupae, larvae, adult) for a particular organism may have been counted as individual taxa. Even accounting for this anomaly, however, the number of taxa at the upstream stations far exceeded the number of taxa reported in these areas in later surveys.

Bowman and Mise (1995) noted a dramatic reduction in benthic organisms at OR1, and suggest that non-point source loading of metals at the upstream reference area could be contributing to this decline. However, the water quality data do not seem to openly support this hypothesis. A secondary explanation put forth by the authors is one of low water levels in the river leading to desiccation of the benthic community.

This seems plausible, and detailed evaluation of flow data relative to water cover of the river bottom would be required to evaluate this hypothesis.

Fisheries

None of the background fisheries surveys have caught high numbers of any single fish species from more than one station. In fact, the sampling requirements for metal and metallothionein analysis for this study were not achieved in any of the previous background surveys despite fishing in more than one season. Bolger (1980) using electroshocking gear and seine nets generally caught few fish with exception of very high numbers of small white suckers at the first stations downstream of Moose Creek and the Levack STP.

3. METHODS

3.1 Study Area

The study area is situated on the Precambrian Shield. Photographs of sampling locations in the Reference and Exposure areas are provided in Appendix B.

3.2 Effluent Characterization and Sublethal Toxicity

Grab samples of the effluents were collected for chemical analysis and for sublethal toxicity testing. The biological assays were conducted by BAR Environmental in Guelph and ECO-CNFS in Montreal.

The sublethal toxicity tests performed by BAR Environmental are as follows: *Lemna minor* growth inhibition, *Ceriodaphnia dubia* survival and reproduction, and fathead minnow survival and growth inhibition and salmonid embryo tests. The sublethal toxicity test performed by Eco-CNFS was *Selenastrum capricornutum* microplate growth inhibition test.

Methods for receiving water and effluent collection are specified in Project # 4.1.2a, Extrapolation Study (August 23, 1996). Receiving water samples for acclimation were collected by mine personnel from the reference station prior to commencement of the 1996 field program. These samples were used to determine if receiving waters (upstream of effluent discharge) cause toxicity to either *Ceriodaphnia dubia* or fathead minnow and if so, to acclimate these organisms to the water before toxicity evaluation.

Receiving water (840 L) was collected from the reference site and shipped cooled to BAR Environmental to be used for dilution during the toxicity bioassays. Because two effluents were involved at the Onaping/Levack area twice as much dilution water was required (approximately 44 x 20L pails). Approximately 0.2 L was shipped cooled to Eco-CNFS.

Effluent samples for toxicity testing from INCO and Falconbridge were collected by ESP staff on October 1. Falconbridge effluent was collected at the MISA sampling location. It was subsequently determined that the INCO mill was not producing effluent at that time and possibly only rain runoff from the tailings area was collected. Therefore, the bioassays were halted, and were rescheduled following collection of the effluent sample by INCO personnel on November 4, 1996. Also, some of the effluent samples collected for chemical analysis at Falconbridge froze in their laboratory refrigerator. Some glass bottles broke and therefore, samples for total mercury, dissolved organic carbon, dissolved inorganic carbon and ammonia were lost. Water chemistry samples for the Falconbridge effluent were collected again on October 5.

All effluent samples were delivered within 72 hours of sampling to BAR Environmental (139 L) and Eco-CNFS (0.2 L). All sample containers, chain of custody forms were provided by BAR Environmental.

3.3 Habitat Characterization, Classification and Sample Station Selection

Objective

Habitat characterization and classification were conducted to identify substrate types in both reference and exposure areas. This information was used to select benthic and fish sampling stations of uniform habitat type. Habitat characterization included identification of depositional areas for sediment sampling.

Habitat Classification Methods

Habitat was characterized and classified following the guidelines described in the New Brunswick Stream Survey and Habitat Assessment Guide (DFO/NBDNR, 1994) which is included in Appendix F1. The approach to site selection and subsequent habitat characterization followed a watershed approach.

Habitat was classified for the reference and exposure sections in detail within the river and extended 15 m on either bank. The linear extent of habitat classification for reference and exposure areas contained all sampling sites for each area. Stream type was determined from a list of fast water or pools as described in the guidelines. Channel type was described as main channel, side channel, split or bogan. The average net width was measured from wetland perimeters perpendicular to flow at the point of sampling. The width at the high water mark was measured when feasible. Depth was measured at 1/4, 1/2, 3/4 of net channel width.

Substrate was measured with a gauging rod with spot samples taken throughout each unit. Area per substrate type was estimated and particle size was confirmed during sediment sampling. Where possible, substrate surrounding larger particles (boulders) was quantified to determine embeddedness. Banks were examined for undercuts and overhanging vegetation and were quantified per bank.

Dissolved oxygen was measured at each station using a YSI model dissolved oxygen meter. Similarly, pH was measured in each station using hand-held meters. Flow was measured with a Marsh-McBirney Flowmate 2000 velocity meter at locations suitable to quantify discharge. Road crossings with culverts near the reference and exposure reaches were used as sites of discharge measurement.

Sample Station Selection

The Onaping River is a river with many pools and riffles. As such, attempts were made to find study sections that contained pool habitat and depositional sediments. The ASI (1995) report was used as a guide to selecting study sites. In this regard, their reference site (OR1) remained as our reference site (also OR1). There was, however, a slight difference in exposure sites between the two studies. ASI (1995) used an area best described as run type habitat (Station OR3). This area was absent of sediment so a pool location was chosen approximately 200 m downstream (ESP's OR3) which contained similar type sediment as OR1 for this study.

Photographs and detailed field notes were taken at each sampling station during the habitat characterization.

3.4 Water Samples

Six water sample stations were established in the Reference area and six stations were established in the Exposure area. Three water samples were also collected in Moose Creek, downstream of the confluence of Grassy Creek, which carries INCO effluent discharge and Moose Creek, which carries Falconbridge effluent discharge.

For each station, 7 different sampling containers were filled to coincide with different analysis requested. The bottles and preservatives used for water chemistry sampling are described in Table 3.1. Unfiltered water samples were analyzed for total metal levels. Dissolved metal levels were analyzed on water filtered through a 0.45 µm filter. The dissolved sample was filtered in the field according to standard methods (APHA 1995 -Section 3030B) using a Whatman 11 cm Filter, Ashless #42. Prior to use, each filter was washed with nitric acid and rinsed with distilled water in the field.

Table 3.1 Summary of Bottles and Preservatives Used and Analyses Conducted on Water Chemistry Samples Collected at Each Sampling Station

Sample Bottle	Preservative	Analyses
1 - 500 mL HDPE	none	Total Suspended Solids (TSS) (Onaping/Levack only)
1 - 1 500 mL HDPE	none	General Chemistry Cations and Anions (*Alkalinity as $CaCO_3$, Chloride, Sulphate, Anion Sum., Bicarbonate as $CaCO_3$, Carbonate as $CaCO_3$, Cation Sum., Colour, Conductivity, Hardness as $CaCO_3$, Ion Balance, Langelier Index at 20°C, Saturation pH at 4°C, Total Dissolved Solids, Turbidity)*
1 - 100 mL glass	none	Dissolved organic carbon (DOC) Dissolved inorganic carbon (DIC)
1 - 250 mL glass	$H2SO_4$	Nutrients (*Nitrate, Nitrite, Ammonia, Total Kjeldahl Nitrogen, Phosphorus, Orthophosphate)*
1 - 250 mL HDPE	HNO_3	Total Metals (*Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Cadmium, Chromium, Cobalt, Copper, Calcium, Free and Total Cyanide, Iron, Lead, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Reactive Selenium, Silica (SiO_2), Silver, Sodium, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc)*
1 - 250 mL HDPE	HNO_3	Dissolved Metals (as for total metals)

Water samples were collected by submerging the container while removing the cap below the surface to avoid any surface contamination, and completely filling.

In the laboratory, samples were analyzed for the following parameters: total and dissolved metals (a ICP_MS low level metals scan), cations and anions, nutrients, hardness, alkalinity, dissolved organic and inorganic carbon, turbidity, and total suspended solids.

Field measurements of temperature, conductivity, dissolved oxygen, and pH were recorded at each station using a YSI meter. Conductivity measurements were routinely taken to characterize mixing zones and exposure zones, and to identify other possible sources of contaminants to the receiving environment.

Data Analysis

Several general water chemistry and water metal concentration parameters were selected for statistical analysis. The data were tested for assumptions of homogeneity of variances and normal distribution using Bartlett's test for homogeneity of variance and by examining scatter plots of the predicted versus residual values using SYSTAT (Wilkinson, 1988). Parameters which failed the assumptions of homogeneity of variance and normal distribution were log transformed ($\log base_{10}$). The Bartlett's test was reapplied and the scatter plot of predicted versus residual values for the transformed data was re-examined. If the Barlett's value and the scatter plot of predicted versus residual values were improved by the log transformation of the data, log transformed values were used in further analysis.

Exposure station data were statistically compared with Reference station data using a two sample (or independent) two tailed Student's t-tests for each parameter examined. Means were considered significantly different when the probability level of the t-value was less than 0.05.

QA/QC

In addition to regular laboratory QA/QC procedures (described separately), field QA/QC measures included:

1) one field replicate
2) analysis of one transport or trip blank
3) one filter blank

Replicate Samples

Replicate samples were taken at OR3-6. Samples for filtered metal (1 per site) and filtered mercury (1 per site) analysis were taken with a 500 ml, plastic jar (MDS "C" type). The container was filled 15 cm below the surface, rinsed 3 times and then a sample taken. The filter apparatus (flask, stopper and funnel) were thoroughly rinsed with distilled water. One filter was removed from its sterile package, cover and grid paper removed and the filter rinsed thoroughly with 5% nitric acid and the cover replaced. Approximately 400ml of sample water stored in a "C" type plastic jar was poured and simultaneously filtered through the pump, filter and collection apparatus.

The sample was then transferred to one MDS "D", 125ml plastic bottle with HN03 preservative and one MDS "E", 100ml glass bottle with HN03 plus 5% K2CR207 preservative. The complete set of 9 bottles per sample site were then labelled, stored and maintained on ice until transfer to MDS. Replicate samples (i.e. EXP 6 and EXP 6 replicate) were obtained in the same manner, except that both filtered metals and filtered mercury samples were split samples from filtering through one 500ml "C" plastic jar using the same filter.

Travel Blanks
Travel blanks were received from MDS for all requested analyses except filtered metals (i.e. 7 bottles). These six samples were taken to the bank of Moose Creek (M3) where they were opened and immediately closed. These samples (already labelled "Blank" by MDS) were then stored and maintained on ice prior to transfer to MDS.

Filter Blanks
Two filter blanks were processed in the lab using commercial distilled water. The filter apparatus (flask, stopper and funnel) were thoroughly rinsed with distilled water. One filter was removed from its sterile package, cover and grid paper removed and the filter rinsed thoroughly with 5% nitric acid and the cover replaced. Approximately 200ml is distilled water was poured and simultaneously filtered through the pump, filter and collection apparatus. The sample was then transferred to one MDS "D", 125ml plastic bottle with HN03 preservative and one MDS "E", 100ml glass bottle with HN03 plus 5% K2CR207 preservative. These samples were also taken to Moose Creek (M3) and opened as travel blanks (the 8th and 9th bottles).

The transport blank water was provided by the analytical laboratory. Details of the QA/QC procedures followed are included in the Quality Management Plan (Appendix A).

3.5 Sediment Samples

Samples were collected using an Ekman grab. Problems for sediment sample collection were encountered in the Onaping River due to the very coarse nature of the substrate and difficulty finding potential depositional areas. Therefore, only 3 sediment samples were submitted for chemical analysis from each of the exposure and reference areas.

Only the upper two cm of the sediment column was retained from each grab. A composite sample was prepared for each station by mixing 5 replicate grab samples. The upper two cm of substrate from each of the 5 grabs was placed in a glass mixing bowl and homogenized using a plastic spoon.

Mixing bowls and plastic utensils were cleaned between sampling stations using the following protocol: a) water rinse, b) phosphate-free soap wash, c) deionized water rinse, d) 20% HNO3 rinse, and e) deionized water rinse. The following guidelines were used to determine the acceptability of a grab sample: a) the sampler is not over-filled, b) overlying water is present indicating minimal leakage, c) overlying

water is not excessively turbid indicating minimal disturbance, d) the desired penetration depth is achieved (i.e., 4-5 cm for a 2 cm deep surficial sample).

All samples were cooled and shipped to MDS Laboratories for analyses. Each sample was analyzed for site specific metals, total organic carbon, particle size and loss on ignition.

Data Analysis

Metals tend to have a greater affinity for smaller size particles. Therefore, to correct sediments for potential bias due to different particle sizes between samples, all sediment metal data were normalized to percent fines using the following equation:

$$Metal_{NF} = \frac{Metal}{Fines}$$

where: $Metal_{NF}$ = Metal concentration normalized to fines
Metal = Reported sediment metal concentration (mg/kg)
Fines = Proportion of fines (silt + clay fractions) in sediment

The normalized metal data for selected metals were tested for assumptions of homogeneity of variances and normal distribution using Bartlett's test for homogeneity of variance and by examining scatter plots of the predicted versus residual values using SYSTAT (Wilkinson, 1988). Parameters which failed the assumptions of homogeneity of variance and normal distribution were log transformed ($logbase_{10}$). The Bartlett's test was reapplied and the scatter plot of predicted versus residual values for the transformed data was re-examined. If the Barlett's value and the scatter plot of predicted versus residual values were improved by the log transformation of the data, log transformed values were used in further analysis.

Exposure station data were statistically compared with Reference station data using a two sample (or independent) two tailed Student's t-tests for each parameter examined. Means were considered significantly different when the probability level of the t-value was less than 0.05.

QA/QC

QA/QC for sediment sampling included: a) a split sample from the exposure station, b) grab samplers cleaned between samples and stations using a phosphate-free detergent wash and a rinse with de-ionized water, and c) a swipe blank collected to determine the effectiveness of field decontamination procedures (e.g., an acid-wetted, ashless filter paper was used to wipe down the mixing bowl/spoon surfaces likely to contact sample media). Details of the QA/QC procedures are included in the Quality Management Plan (Appendix A).

3.6 Benthos Samples

3.6.1 Sample Collection

Three samples from the Reference and Exposure areas were collected from similar habitat types using a Ponar sampler and the samples passed through 250 μm mesh sieve.

Due to the difficulty in finding depositional sediments, a Surber Sampler was also used to collect benthos in riffle areas in the Onaping River. Three Surber samples were collected from the Exposure area and three Surber samples were collected from Reference area.

All benthic samples were placed into plastic containers and preserved in 10% buffered formalin as recommended by our selected taxonomist, Danuta Zaranko.

3.6.2 Sorting and Taxonomy

Sample Processing

Upon arrival at the laboratory, benthic macroinvertebrate samples were logged and inspected as a quality control measure. Samples were checked for proper labelling and cross-checked with submission sheets. In addition, a subset of samples was randomly opened and checked for proper preservation.

To expedite sorting all samples were stained with a protein dye that is absorbed by aquatic organisms but not by organic material such as detritus and algae. Samples were gently washed using a 500 μm sieve. The material retained on the sieve was set aside in a petri dish for further processing. A small amount of material was retrieved from the petri dish and placed in a gridded tray. An adequate amount of water was added to the gridded tray so that the material was evenly distributed and suspended. Using a 10X stereomicroscope, the petri dish was sorted along the grid lines and quickly scanned a second time to ensure that all organisms had been removed. The sorted material was discarded into a holding tray and the procedure repeated for the next amount of debris until all material was processed.

Sorted organisms were placed in glass vials and represerved in 80% ethanol. Each bottle was labelled internally with the survey name, date, station and replicate number.

Detailed Identification

All invertebrates were identified to the lowest practical level, usually genus, with the exception of bivalves (*Sphaerium* and Unionidae), snails, leeches, oligochaetes, the amphipod *(Hyalella)*, and phantom midge (*Chaoborus*). In some cases identification of individuals to the genus or species level was not possible, (i.e., early instar and immature forms). As a result, these individuals were enumerated under the next higher level of identification, (i.e., usually family). Chironomids and oligochaetes were mounted on glass slides in a clearing media prior to identification using a compound microscope. In samples with large numbers of oligochaetes, a random sample of no less than 20% of the picked individuals from each group were removed for

identification, up to a maximum of 100 individuals. Similarly, in samples with a large number of chironomids, individuals that could be identified using a dissecting scope, (e.g., *Cryptochironomus,* and *Chironomus*), were enumerated and removed from the sample. The remaining individuals were sorted into three groups: Tanypodinae, Orthocladiinae (with Diamesinae), and Chironominae. A random sample of no less than 10% of the individuals from each group were removed for identification, up to a maximum of 50 individuals.

Subsampling

Of the twelve benthic invertebrate samples collected, subsampling was necessary in five samples due to high organism abundance. Of these, two were sampled to 1/2 and three were sampled to 1/4 (prior to calculation of subsampling error). Samples that required subsampling included samples with large amounts of loose organic matter (i.e. detritus) and samples with high densities (>100) of major taxa. In these cases, samples were first washed through a large mesh sieve to remove all coarse detritus, leaves, etc. Large organisms such as leeches, crayfish and molluscs retained in the sieve were removed from the associated debris.

The remaining sample fraction was distributed evenly on a 500 µm sieve and divided in two. The procedure was repeated until an appropriate subsample fraction remained. In cases where organism density was high, a minimum of 200 organisms were sorted from each sample, up to a maximum of 500.

Data Analysis

The total number of benthic invertebrates in each sample was divided by the area of the Ponar or Surber sampler to give a measurement of organism density in each sample. The data were tested for assumptions of homogeneity of variances and normal distribution using Bartlett's test for homogeneity of variance and by examining scatter plots of the predicted versus residual values using SYSTAT (Wilkinson, 1988). Parameters which failed the assumptions of homogeneity of variance and normal distribution were log transformed ($\log base_{10}$). The Bartlett's test was reapplied and the scatter plot of predicted versus residual values for the transformed data was re-examined. If the Barlett's value and the scatter plot of predicted versus residual values were improved by the log transformation of the data, log transformed values were used in further analysis.

The exposure station data were statistically compared with Reference station data using a two sample (or independent) two tailed Student's t-tests for each parameter examined. Means were considered significantly different when the probability level of the t-value was less than 0.05. Only the density variable for benthos was suitable for statistical analysis.

EPT Richness was reported separately for benthos samples collected using the Ponar sampler and the Surber sampler. EPT Richness is the number of ephemeroptera, plecoptera and trichoptera taxa in a sample and is a useful measure of water quality (Wallace *et al.*, 1996). The recognition of ephemeroptera (mayflies), plecoptera

(stoneflies) and tricoptera (caddisflies) as intolerant taxa dates back to the early 1950s (Gaufin and Tarzwell, 1952).

Quality Assurance/Quality Control
As part of the QA/QC measures, the sorted sediments and debris were represerved. In conjunction with invertebrate sample processing, the following QA/QC procedures were provided.

1) For a confirmation of sorting efficiency, 10% of the processed samples were resorted by a second taxonomist to confirm 95% recovery of all organisms. In most cases, 95% recovery of organisms is desirable and a reachable target, however, exceptions exist to this target recovery. For example, when a sample contains a large volume of organic matter (> 1/2 litre) and a low density of organisms. In such a sample, if the sorter was to miss 1 or 2 out of 10 organisms, this would mean a recovery of only 90% and 80% of the organisms respectively. In this case, it is doubtful if this lesser recovery would make much difference in the interpretation of the data. Approximately ninety-five percent recovery of organisms was achieved in the samples selected for resorting (Appendix E2).

2) A second fraction was sorted from two samples, therefore sorting and identification was completed on half of each of these two samples.

3) A voucher collection was prepared for all identified taxa to ensure continuity of taxonomy.

3.7 Fisheries

3.7.1 Collection

The fish survey used gill nets, minnow traps and a modified hoop net (giant minnow trap). Fishing effort at the areas is presented with the Results in Section 4.7. Two types of minnow traps were used. A standard trap of opening diameter 1-2 cm was used as was a modified trap of opening diameter 5-7 cm. Traps were placed at depths of 0.5 m to 2.0 m and placed evenly throughout both exposure and reference areas. Minnow traps were baited with a combination of baits (i.e. bread, cheese and meat). Depths were not sufficient to allow good coverage of the study reaches with gill nets. Nets were placed at angles as close to perpendicular as possible to the flow without causing loss of fishing efficiency (i.e. net billowing in current). Gill nets were set from near shore 0.5 m to depths of 3.7 m. Nets were placed to sufficiently cover areas potentially used by species (trout and sucker) which were known to occur in the Onaping River at these locations. Deep areas and back eddy features were all sampled to ensure appropriate fishing coverage of study areas.

3.7.2 Tissue Processing for Metal and Metallothionein (MT) Analysis

Processing of fish for metal and metallothionein analysis followed the revised protocol of 29 August 1996. If the fish were large enough (> 15 cm), tissue samples were dissected out and divided for metals and metallothionein analyses. Fish less than 10

cm were frozen whole, while fish between 10 - 15 cm were not kept. The detailed protocol for tissue processing is presented in Appendix F3.

A considerable amount of effort was spent attempting to collect fish from the reference and exposure areas, however, very few fish were caught. Two common white suckers from the reference area and two from the exposure area were dissected out and the tissues frozen whole on dry ice. The samples were sent to Dr. J.F. Klaverkamp at the Freshwater Institute for analysis of MT and metal levels in the tissue.

Scale samples from each fish were sent to Dr. John Tost, Northshore Environmental, for aging analysis.

Data Analysis

Where appropriate, the mean and standard error of MT and metal levels were calculated. The small number of fish subject to MT and metal analysis (maximum of 2) precluded statistical analysis.

4. RESULTS

4.1 Dates of Sample Collection and Analysis

Table 4.1 Dates of Sample Collection

Sample Element	Date Samples Collected	
	Reference Stations	Exposure Stations
Water Chemistry	Oct. 3,4	Oct. 2
Sediment Chemistry	Oct. 3,4	Oct. 2
Sediment Particle Size	Oct. 3,4	Oct. 2
Swab Analysis	Oct. 3,4	Oct. 2
Benthos Taxonomy	Oct. 3,4	Oct. 2,4
Fish Tissue Analysis	October 2,3,4,5	
Sublethal Toxicity		
i) Dilution Water Chemistry	Oct. 1	
ii) Effluent Chemistry	Oct. 1	
ii) Toxicity Assays (BAR)	Falconbridge Oct. 1 - INCO Nov. 4	

4.2 Effluent Characterization and Sublethal Toxicity

4.2.1 Chemistry

General water chemistry parameters for the effluent and dilution water are presented in Table 4.2.1. Total and dissolved metal concentrations for the effluent and dilution water are presented in Table 4.2.2.

Dilution water for toxicity testing was collected from the upstream Reference area (OR1), so these results from one water sample provide some indication of water quality at the Reference station.

It should be noted that the INCO effluent results are for a sample collected on October 1, 1996. It was subsequently learned that INCO had not actually discharged effluent for some time. Therefore, the "effluent" sample in this case may represent surface runoff. Effluent samples for toxicity testing were collected by INCO personnel on November 4, 1996. Effluent samples for chemical analysis were not collected at that time.

Mine water is continuously discharged from the mine into the tailings area. Occasionally, during a dry spell, the demand for recycled water in the backfilling operation equals or surpasses the discharge. When this occurs, there is no overflow (effluent) from the tailings impoundment area.

Table 4.2.1 General Chemistry of Effluent and Dilution Water from Onaping/Levack site

Table 4.2.1 : General Chemistry (mg/L) of Effluent and Dilution Water From the Onaping/Levack Mine Sites							
Parameter	LOQ	INCO Effluent	Falconbridge Effluent 1-Oct	Falconbridge Effluent 5-Oct	Falconbridge Effluent 5-Oct Lab Replicate	Onaping River	Onaping River Lab Replicate
Nitrate	0.05	4.32	0.54	0.50	0.50	0.11	0.10
Nitrite	0.01	0.23	nd	nd	nd	nd	-
Ammonia	0.05	0.49	lost	0.79	-	nd	-
TKN	0.05	0.89	0.82	-	-	3.05	-
Phosphorus	0.1	nd	nd	nd	nd	nd	nd
Orthophosphate	0.01	nd	nd	nd	nd	nd	nd
Alkalinity	1	16	18	21	21	7	7
Chloride	1	112	170	159	159	1	1
Sulphate	2	899	642	651	651	5	5
Bicarbonate	1	11	18	21	20	7	-
Carbonate	1	4	nd	nd	nd	nd	-
Colour (TCU)	5	nd	6	nd	nd	37	36
Conductivity (us/cm)	1	1940	1640	1670	1670	36	36
Hardness	0.1	909	657	786	776	14.2	-
Turbidity	0.1	0.1	0.2	0.2	0.1	0.4	0.5
Anion Sum (meq/L)	na	22.5	18.5	18.5	18.5	0.289	-
Cation Sum (meq/L)	na	23.8	16.9	19.8	19.5	0.371	-
Ion Balance	0.01	2.86	4.5	3.32	2.71	12.4	-
pH (units)	0.1	9.6	6.9	7.8	7.8	6.3	6.2
DIC	0.5	3.5	lost	4.9	-	2.1	-
DOC	0.5	2.6	lost	2.5	-	5.9	-
TDS	1	1540	1190	1250	1240	22	-
TSS	5	nd	5	-	-	nd	-

Table 4.2.2 : Dissolved and Total Metals (mg/L) in Effluent and Dilution Water From the Onaping/Levack Mine Sites

Metal (mg/L)	LOQ	INCO Effluent		Falconbridge Effluent		Falconbridge Effluent			Onaping River		
				1-Oct		5-Oct					
		Dissolved	Total	Dissolved	Total	Dissolved	Total	Total	Dissolved	Dissolved	Total
								Lab		Lab	
								Replicate		Replicate	
Aluminum	0.01	0.03	nd	0.06	0.1	0.06	0.05	0.05	0.02	0.02	0.03
Antimony	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	0.022	0.022	0.029	0.028	0.033	0.032	0.033	0.007	0.006	0.006
Beryllium	0.005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Bismuth	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	0.044	0.056	0.033	0.023	0.036	0.037	0.040	nd	nd	0.006
Cadmium	0.0005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	341	345	259	231	309	310	306	3.8	3.7	3.6
Chromium	0.002	0.004	0.004	nd	nd	nd	nd	nd	0.002	0.002	nd
Cobalt	0.001	nd	nd	0.003	0.004	0.003	0.003	0.003	nd	nd	nd
Copper	0.002	nd	nd	nd	0.020	0.016	0.013	0.013	nd	nd	nd
Iron	0.02	nd	nd	0.05	0.14	0.04	0.06	0.04	0.29	0.3	0.34
Lead	0.0001	nd	0.0018	0.0001	nd	nd	nd	nd	nd	nd	nd
Magnesium	0.1	14	15.6	2.4	2.6	2.9	2.8	2.8	1.1	1.1	1.1
Manganese	0.002	nd	0.002	0.018	0.023	0.016	0.016	0.016	0.003	0.003	0.011
Mercury (ug/L)	0.1	nd	nd	nd	lost	-	nd	-	nd	-	nd
Molybdenum	0.002	0.002	0.002	nd	nd	nd	nd	nd	nd	nd	nd
Nickel	0.002	0.019	0.027	0.107	0.102	0.095	0.097	0.098	nd	nd	nd
Potassium	0.5	33.1	37.5	18.6	12.8	20	22.4	20.2	0.8	0.5	3.1
Reactive Silica	0.5	1.6	-	4.8	5.2	5.6	-	-	3.6	3.7	-
Silver	0.0003	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Selenium	0.002	nd	nd	0.005	0.004	0.004	0.004	0.005	nd	nd	nd
Sodium	0.1	109	125	52.5	75.6	81.6	79.1	79.2	1.5	1.4	1.6
Strontium	0.005	1.09	1.04	0.785	0.759	0.858	0.858	0.858	0.014	0.014	0.014
Thallium	0.0001	nd	nd	nd	0.0003	0.0003	0.0002	0.0003	nd	nd	nd
Tin	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Uranium	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	0.015	0.012	nd	nd	nd	nd	nd	0.017	0.01	0.012
Zinc	0.002	nd	0.059	0.167	0.005	0.022	nd	nd	0.005	0.005	0.006
Total Cyanide	0.005	nd	-	nd	-	-	-	-	nd	-	-
Free Cyanide	0.002	nd	-	nd	-	-	-	-	nd	-	-

4.2.2 Toxicity

The results of the effluent toxicity bioassays are summarized in Table 4.2.3. Data are presented for both INCO and Falconbridge. The two companies discharge at different locations, but the effluents eventually combine in Moose Creek before flowing into the Onaping River.

In preliminary screening tests the receiving water was not toxic to fathead minnows or *Ceriodaphnia*, therefore, acclimation was not required.

The results suggest that both effluents exhibited greater toxicity to the two plant species tested than to the other organisms.

Effluent from Falconbridge inhibited growth of both *Selenastrum* and *Lemna* at less than 50% effluent concentration. There was a 25% effect on *Ceriodaphnia* reproduction, but a 50% effect (IC50) was not observed . The effluent did not affect survival of *Ceriodaphnia* or fathead minnows. Growth rate of fathead minnows was not measurably affected. Similarly, there was no measurable effect on development of Rainbow trout embryos.

Effluent from INCO inhibited growth of *Selenastrum* and *Lemna* at concentrations ranging from 37 to 72% by volume. The effluent elicited a 50% reduction in *Ceriodaphnia* reproduction and also affected *Ceriodaphnia* survival. A 25% effect on Fathead minnow growth was measured, but the effluent did not affect the survival of fathead minnows. Rainbow trout embryos were not affected by the effluent.

Table 4.2.3 Summary of Sublethal Toxicity Tests with INCO and Falconbridge Effluent. Values expressed as % volume effluent

Source	Test Organism	Endpoint	Effect Value (% v/v)	Effect?
Falconbridge	*Selanastrum*	IC25 IC50	30.8 49.8	Yes Yes
	Lemna	IC25 IC50	14.2 19.8	Yes Yes
	Ceriodaphnia reproduction	IC25 IC50	80.7 >100	Yes No
	survival	LC50	>100	No
	Fathead minnow growth	IC25 IC50	>100 >100	No No
	survival	LC50 IC25	>100 >100	No No
	Rainbow embryo	EC50	>100	No
INCO	*Selanastrum*	IC25 IC50	47.6 64.4	Yes Yes
	Lemna	IC25 IC50	37.0 72.1	Yes Yes
	Ceriodaphnia reproduction	IC25 IC50	67.0 85.2	Yes Yes
	survival	LC50	>50	Yes
	Fathead minnow growth	IC25 IC50	82.1 >100	Yes No
	survival	LC50 IC25	>100 >100	No No
	Rainbow embryo	EC50	>100	No

4.3 Habitat Characterization and Classification

Habitat characterization and classification for the exposure (OR3) and reference (OR1) areas was conducted using the DFO/NBDNR stream survey and habitat assessment forms. Completed forms are included in Appendix F1. Habitat was assessed in the exposure and reference areas on October 3, 1996.

4.3.1 Reference Area

Habitat features of the Reference area in the Onaping River are shown in Figure 4.1. Stream type in the reference area of the Onaping River was a combination of mid-channel and eddy pools. Channel type was a combination of split and main channels. Average wet width of the channel was 32 m. Average wet depth was 1.45 m.

Substrate particle size was a combination of 2% boulder, 30% rock, 35% rubble, 18% gravel, 15% sand and less than 1% fines. Mean substrate particle size was rubble (54-179 mm). Woody debris was present in half of the sampling sites with a cumulative length of 9 m.

No undercut banks were present in the reference sites. Both river banks combined for 100% overhanging vegetation which provided 3% shade to this reach. Banks were well vegetated with an average of 80% shrubs and 20% trees. Bank stability totalled 100%. Surrounding land use attributes include: an inactive beaver dam, ATV access and trail access.

Field measurements are presented in Table C3-6 of Appendix C. Air temperature was 5.0°C and water temperature was 11.0°C. Dissolved oxygen ranged from 11.1 to 11.8 and measured pH ranged from 7.5 to 7.8. Discharge was calculated at 9.5 m^3/s above a riffle approximately 400 m upstream of the sampling sites.

4.3.2 Exposure Area

Habitat features in the Exposure area are presented in Figure 4.2. Stream type in the exposure area of the Onaping River was an eddy of a large pool. Channel type was a side channel where stream flow was diverted by an island. Average wet width was 30 m. Average wet depth was 2.1 m.

Mean substrate particle size was rubble (54-179 mm). Larger particle size dominated the substrate (boulder, rubble, gravel) with sand and finer particles found in sparse patches. No large woody debris was present within the exposure sites.

No undercut banks were present. No overhanging vegetation was present on the left bank (island). All of the right bank had overhanging vegetation for a total coverage of 50% providing less than 2% shade. Banks were well vegetated with an average of 70% shrubs, 20% grasses and 10% trees. Bank stability totalled 100% for both banks. Surrounding land use attributes include inactive beaver dam, mining and truck/car access.

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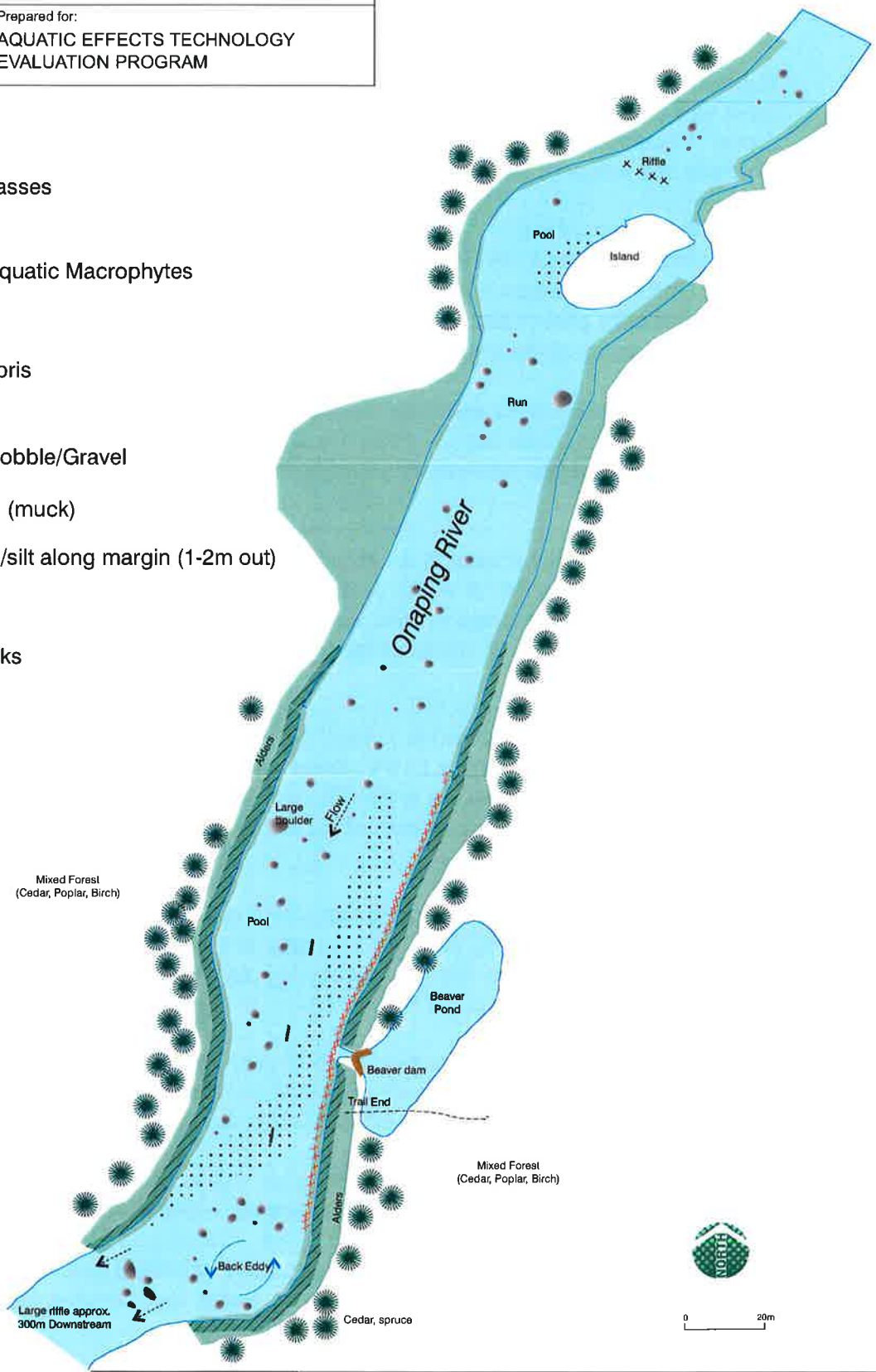
- Cattails
- Sedges/grasses
- Alders
- Extent of Aquatic Macrophytes
- Logs
- Woody Debris
- Flow
- Boulders/Cobble/Gravel
- Sand/Fines (muck)
- X Fine muck/silt along margin (1-2m out)
- Spruce
- Steep banks
- Riffle



Date: OCT., 1996	**ONAPING / LEVACK MINE SITES REFERENCE AREA HABITAT MAPPING**
Revised:	
Revision No.	
Checked by: BD	FILE: 96239_25 **Figure No. 4.1**

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Prepared for:
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- Cattails
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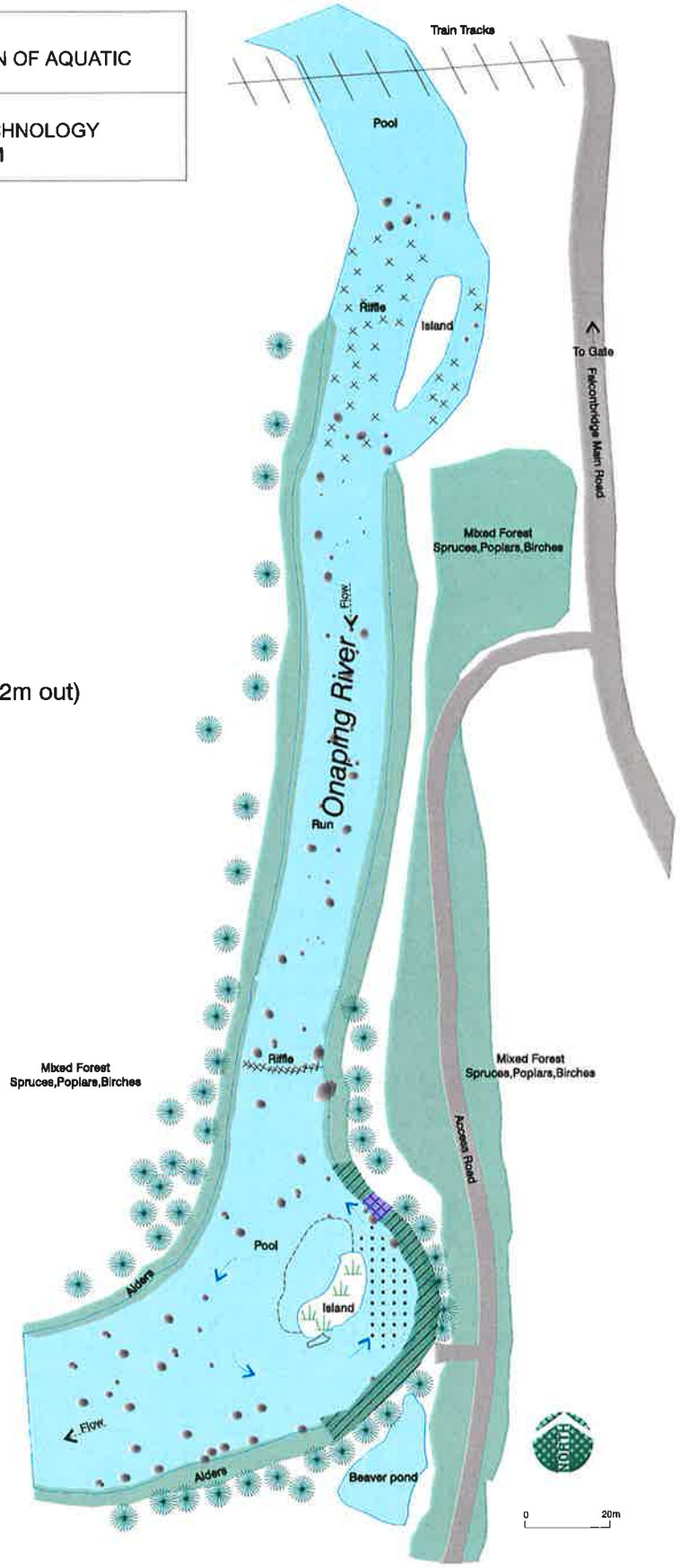
- Flow
- Boulders/Cobble/Gravel
- Sand/Fines (muck)
- x Fine muck/silt along margin (1-2m out)
- Spruce
- Steep banks
- Riffle



Date: OCT., 1996	**ONAPING / LEVACK MINE SITES EXPOSURE AREA HABITAT MAPPING**
Revised:	
Revision No.	
Checked by: BD	FILE: 96239_26 **Figure No. 4.2.**

Field measurements are presented in Table C3-6 of Appendix C. Air temperature was 5.0°C and water temperature was 11.0°C. Dissolved oxygen ranged from 10.1-10.3 mg/L and pH ranged between 7.8 and 7.9. River discharge as measured at a riffle approximately 300 m upstream of the sampling sites was 10.5 m^3/s.

4.3.3 Summary

We are very confident that river geomorphology and habitat types were similar between the Reference (OR1) and Exposure (OR3) areas in the Onaping River. Both the reference and exposure areas had split and main channels and eddy pools. Discharge rates were 9.5 and 10.5 m^3/s in the reference and exposure areas respectively. Substrates were very similar in both areas and bank stability was 100%.

4.4 Sample Station Selection

Sampling locations in the Reference and Exposure areas in the Onaping River are presented in Figures 4.3 and 4.4, respectively.

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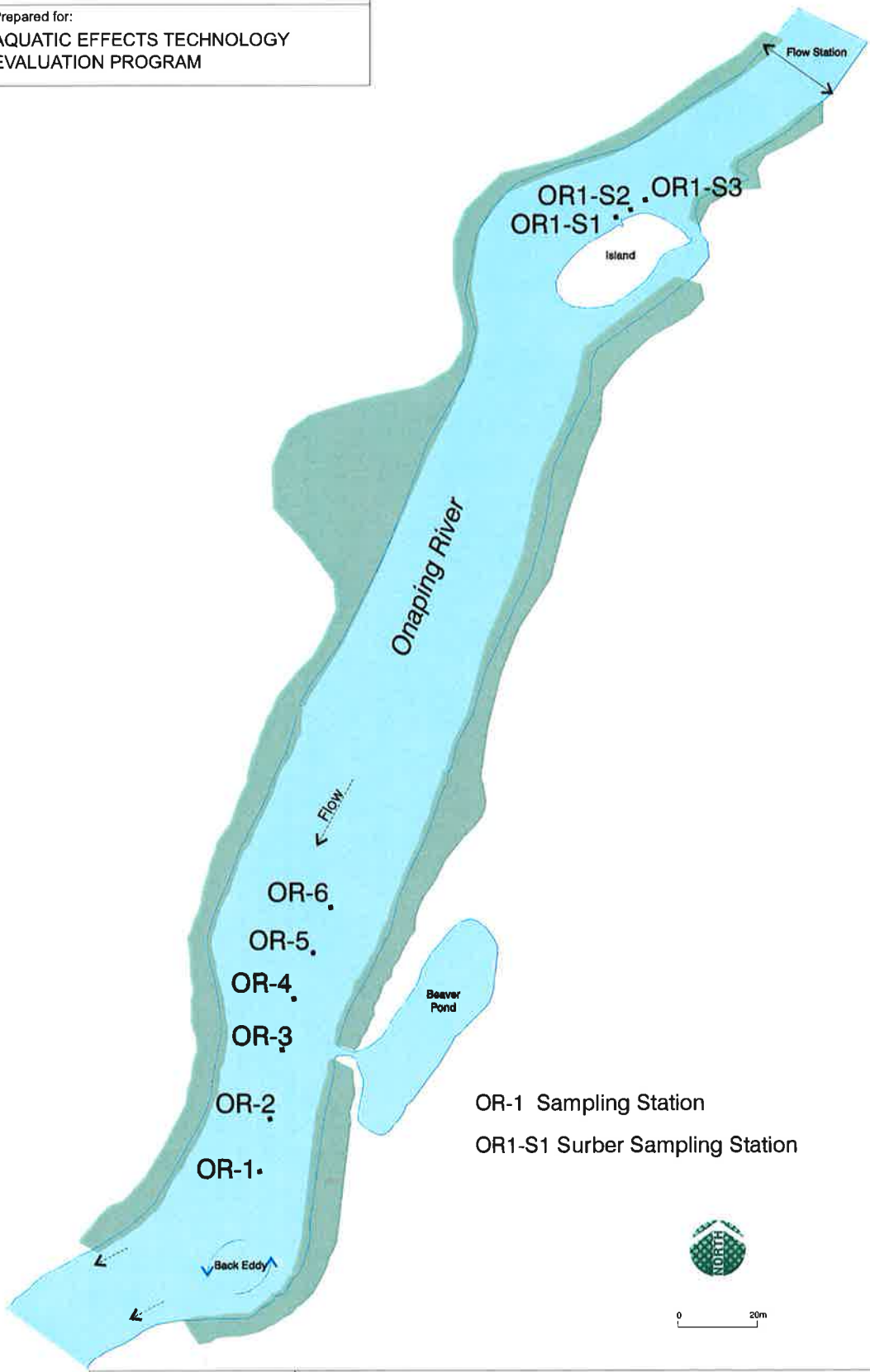

OR-1 Sampling Station

OR1-S1 Surber Sampling Station

Date: OCT., 1996	**ONAPING / LEVACK MINE SITES REFERENCE AREA SAMPLING LOCATIONS**
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Revision No.	
Checked by: BD	FILE: 96239_25 **Figure No. 4. 3**

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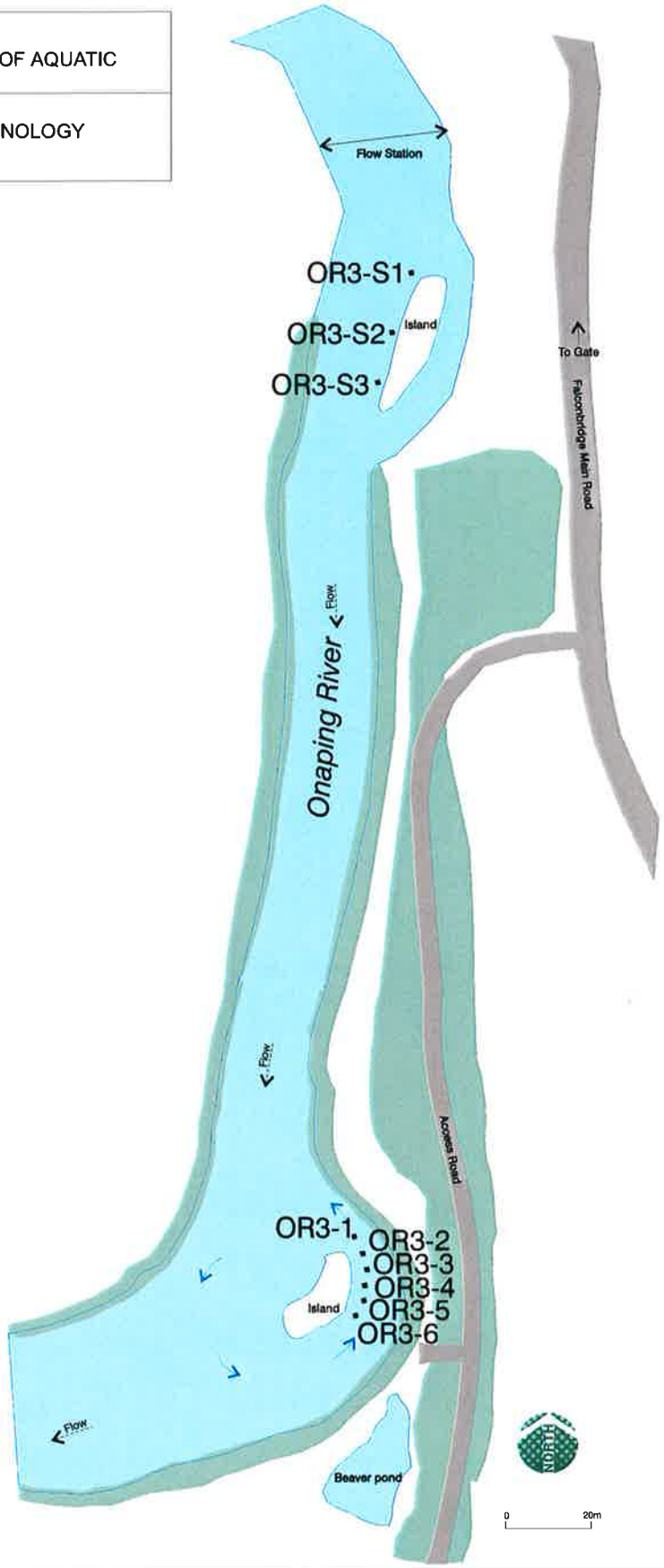


OR-3 Sampling Station

OR3-S1 Surber Sampling Station

Date: OCT., 1996	**ONAPING / LEVACK MINE SITES EXPOSURE AREA SAMPLING LOCATIONS**
Revised:	
Revision No.	
Checked by: BD	FILE: 96239_26 **Figure No. 4. 4**

4.5 Water Chemistry

4.5.1 QA/QC

The findings of the water chemistry QA/QC program are discussed in this section, with the detailed QA/QC results being presented in Appendix C2.

Field QA/QC Checks

Replicate Samples

A replicate water sample was collected in the Exposure area (sample #OR3-6) for analysis. The results are presented in Appendix C with separate tables for results for general water chemistry, dissolved and total metals. For general chemistry parameters the replicate results are within ± 5% which is considered very good, with the exception of nitrate and TKN, where the replicate results differed by 64 and 61%. Both these parameters also exhibited the greatest range of concentrations within the six samples collected within the Exposure area. Laboratory replicates for these parameters were fine, indicating that there is potential for substantial spatial variability and possible sampling error associated with these parameters.

Total metal levels did not differ between replicate field samples with the exception of potassium (±28%). However, the actual difference in values (0.8 mg/L) is only slightly higher than the routine detection limit (0.5 mg/L) so the results are generally considered acceptable.

Dissolved metal levels between replicate field samples were generally less than 8%, with the exception of sodium, which exhibited a 46% difference between samples.

Travel Blanks

Travel blanks containing ultrapure distilled water were provided by MDS Laboratories. No substances were detected during analysis of the travel blanks with the exception of very trace levels of sodium and nickel (Appendix C3).

Filter Blanks for Dissolved Metals

Samples of distilled water filtered in the field were shown to contain various levels of calcium, zinc, magnesium, copper, lead and nickel. Subsequent analysis showed that in fact the commercial grade distilled water used for the field filtered blank did contain calcium, copper, nickel and zinc at appreciable concentrations. MDS conducted further testing using ultrapure distilled water, and demonstrated that some metals were leached out of the filter during the filtering process, even after being rinsed with acid.

Therefore, there may be some nonquantifiable error associated with the dissolved metal results such that interpretation of these data should be made with caution. Further attention should be devoted to this aspect of the sampling program in 1997.

Laboratory QA/QC Checks

Replicate Analysis

The laboratory replicate analysis for general chemistry, total and dissolved metals was generally excellent with replicate results < ±10%.

Spike Samples

QA/QC results from MDS are presented in Appendix C2. The analytical results of spiked samples are generally within ±10% of the target value which is acceptable.

4.5.2 Water Chemistry

Water chemistry results are summarized in Tables 4.5.1 to 4.5.6 with individual results presented in Appendix C. General water chemistry data are shown in Table 4.5.1 which summarizes the results (mean, standard error) of six water samples collected in each of the Exposure and Reference areas. In previous studies sponsored by INCO and Falconbridge these study locations were labelled OR1 and OR3, respectively. The levels of many nutrients and general water chemistry variables (eg. nitrate, TKN, chloride, sulphate, conductivity, hardness, TDS) are much higher in the Exposure area relative to the Reference area. Statistical analysis (Table 4.5.4) indicated that parameters such as conductivity are significantly ($p < 0.001$) greater in the Exposure area. Complete statistical analysis were not conducted on each parameter. For some variables, the concentrations in the Reference area displayed no variation at all, which invalidates statistical analysis.

The concentration of total metals is greater in the Exposure area compared with the Reference area (Table 4.5.2) for several metals including Al, Ca, Co, Cu, Mn, Ni and Sr. A similar pattern was observed for dissolved metals (Table 4.5.3) with substances such as dissolved copper being significantly ($p< 0.001$) greater in the Exposure area as presented in Table 4.5.4.

The concentration of total metals was greater than dissolved metals for most parameters with the exception of iron and zinc. From a chemical speciation perspective it is not possible to have dissolved levels greater than total. This anomaly may be related to contamination from the filters used as discussed in Section 4.5.1.

The levels of some total metals (Al, Ba, Cu) in the Exposure area exceeded their respective CCME guidelines, but in general, water quality in the Onaping river in the Exposure area complied with federal guidelines.

Three water samples were collected in Moose Creek below the confluence of the effluents from INCO and Falconbridge. The general water chemistry of Moose Creek is presented in Table 4.5.5 with total and dissolved metal levels summarized in Table 4.5.6. As would be expected due to the high effluent content, the concentrations of several parameters and metals are very high. For example, conductivity is 1530 us/cm and sulphate is 588 mg/L. The mean concentrations of Al, Co, Cu, Hg, Ni, Se and Zn in Moose Creek exceed their respective CCME guidelines.

Table 4.5.1 General Water Chemistry Analysis of Samples Collected from Reference and Exposure Areas at the Onaping/Levack Mine Site

Table 4.5.1 : General Water Chemistry Analysis of Samples Collected from Reference and Exposure Areas at the Onaping/Levack Mine Site

Parameter	LOQ	Reference		Exposure	
		MEAN	**SE**	**MEAN**	**SE**
Nitrate	0.05	0.198	0.078	0.289	0.142
Nitrite	0.01	nd	na	nd	na
Ammonia	0.05	-	-	0.13	na
TKN	0.05	0.090	0.031	0.270	0.097
Phosphorus	0.1	nd	na	nd	na
Orthophosphate	0.01	nd	na	nd	na
Total Phosphorus	0.004				
Alkalinity	1	5.000	0.447	6.500	0.224
Chloride	1	1.167	0.167	9.167	0.167
Sulphate	2	6.000	0.000	35.500	0.500
Bicarbonate	1	5.000	0.447	6.500	0.224
Carbonate	1	nd	na	na	na
Colour (TCU)	5	35.000	0.577	41.000	0.683
Conductivity (us/cm)	1	35.833	0.543	131.333	2.011
Hardness	0.1	12.333	0.109	46.050	0.395
Turbidity	0.1	0.317	0.017	0.433	0.021
Anion Sum (meq/L)	na	0.273	0.003	1.153	0.017
Cation Sum (meq/L)	na	0.331	0.003	1.232	0.031
Ion Balance	0.01	9.632	0.778	3.842	1.432
pH (units)	0.1	6.300	0.026	7.267	0.076
DIC	0.5	1.717	0.040	1.733	0.128
DOC	0.5	5.667	0.120	5.417	0.142
TDS	1	21.000	0.258	79.000	0.775
TSS	5	nd	na	nd	na

Table 4.5.2 Total Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

Table 4.5.2 : Total Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

Metal (mg/L)	LOQ	Reference		Exposure	
		MEAN	SE	MEAN	SE
Aluminum	0.01	0.0400	0.0000	0.078	0.003
Antimony	0.002	nd	na	nd	na
Arsenic	0.002	nd	na	nd	na
Barium	0.005	0.0072	0.0002	0.0092	0.0002
Beryllium	0.005	nd	na	nd	na
Bismuth	0.002	nd	na	nd	na
Boron	0.005	0.0040	0.0011	0.0043	0.0014
Cadmium	0.0005	nd	na	nd	na
Calcium	0.1	2.93	0.03	13.48	0.09
Chromium	0.002	nd	na	nd	na
Cobalt	0.001	nd	na	0.0020	0.0000
Copper	0.002	nd	na	0.0085	0.0005
Iron	0.02	0.218	0.002	0.2667	0.0033
Lead	0.0001	0.0011	0.0010	0.0001	0.0001
Magnesium	0.1	1.017	0.017	1.55	0.05
Manganese	0.002	0.0138	0.0004	0.0480	0.0004
Mercury (ug/L)	0.1	0.0583	0.0083	0.083	0.025
Molybdenum	0.002	nd	na	nd	na
Nickel	0.002	nd	na	0.06	0.00
Potassium	0.5	1.87	0.27	2.43	0.33
Reactive Silica	0.5	3.67	0.03	4.22	0.03
Silver	0.0003	nd	na	nd	na
Selenium	0.002	nd	na	0.0012	0.0002
Sodium	0.1	3.17	0.02	5.80	0.03
Strontium	0.005	0.0148	0.0002	0.0525	0.0003
Thallium	0.0001	nd	na	nd	na
Tin	0.002	nd	na	nd	na
Titanium	0.002	nd	na	nd	na
Uranium	0.0001	nd	na	nd	na
Vanadium	0.002	nd	na	nd	na
Zinc	0.002	0.0028	0.0013	0.0052	0.0009
Total Cyanide	0.002				
Free Cyanide	0.002				

Table 4.5.3 Dissolved Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

Table 4.5.3 : Dissolved Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

Metal (mg/L)	LOQ	Reference		Exposure	
		MEAN	SE	MEAN	SE
Aluminum	0.01	0.032	0.002	0.055	0.002
Antimony	0.002	nd	na	nd	na
Arsenic	0.002	nd	na	nd	na
Barium	0.005	0.007	0.000	0.010	0.000
Beryllium	0.005	nd	na	nd	na
Bismuth	0.002	nd	na	nd	na
Boron	0.005	0.003	0.001	0.0045	0.0013
Cadmium	0.0005	nd	na	nd	na
Calcium	0.1	2.517	0.781	16.20	0.14
Chromium	0.002	nd	na	nd	na
Cobalt	0.001	nd	na	0.001	0.000
Copper	0.002	0.001	0.000	0.007	0.000
Iron	0.02	0.242	0.006	0.288	0.009
Lead	0.0001	0.0001	0.0000	nd	na
Magnesium	0.1	0.72	0.02	1.38	0.02
Manganese	0.002	0.004	0.000	0.033	0.000
Mercury (ug/L)	0.1	0.058	0.008	nd	na
Molybdenum	0.002	nd	na	nd	na
Nickel	0.002	nd	na	0.059	0.001
Potassium	0.5	nd	na	nd	na
Reactive Silica	0.5	3.6	0.0	4.30	0.04
Selenium	0.002	nd	na	nd	na
Silver	0.0003	nd	na	nd	na
Sodium	0.1	1.82	0.02	7.10	1.23
Strontium	0.005	0.015	0.000	0.0528	0.0005
Thallium	0.0001	nd	na	nd	na
Tin	0.002	nd	na	nd	na
Titanium	0.002	nd	na	0.001	0.000
Uranium	0.0001	nd	na	nd	na
Vanadium	0.002	nd	na	nd	na
Zinc	0.002	0.040	0.010	0.024	0.012
Total Cyanide	0.002	0.0035	0.0025	nd	na
Free Cyanide	0.002	nd	na	nd	na

Table 4.5.4 Statistical Analysis Results for Selected Water Chemistry Parameters from Reference and Exposure Areas at Onaping/Levack Mine Sites

Parameter[1]	OR1 Reference Area	OR3 Exposure Area	t - value (d.f.=10)	p-value
	Mean (±s.e.)	Mean (±s.e.)		
Conductivity (µs/cm)	35.8 (±0.54)	131.3 (±2.0)	60.996[a]	.000
Sulphate	6.0 (±0.0)	35.5 (±0.5)	na	
Total Copper	.0010 (±0.00)	.085 (±0.005)	na	
Dissolved Copper	.00133 (±0.003)	.00733 (±0.0033)	12.728	.000
Total Nickel	.0010 (±0.00)	.0592 (±0.00048)	na	
Dissolved Nickel	.0010 (±0.00)	.0593 (±0.00067)	na	

[1] all values in mg/L unless otherwise stated
[a] t-value calculated from log transformed data
na t-test not valid due to absence of variance in reference area

Table 4.5.5 General Water Chemistry in Moose Creek; Onaping/Levack Mine Sites

Table 4.5.5 General Water Chemistry in Moose Creek: Onaping/Levack Mine Sites

Parameter	LOQ	CCME Guideline+	M3	
			Mean	Std Error
Nitrate	0.05	na	0.49	0.01
Nitrite	0.01	0.06	nd	na
Ammonia	0.05	1.5**	0.62	0.01
TKN	0.05	na	0.76	0.02
Phosphorus	0.1	na	nd	na
Orthophosphate	0.01	na	nd	na
Alkalinity	1	na	15.0	0.0
Chloride	1	na	146.3	0.9
Sulphate	2	na	588.0	1.2
Bicarbonate	1	na	15.0	0.0
Carbonate	1	na	nd	na
Colour (TCU)	5	na	15.7	1.9
Conductivity (us/cm)	1	na	1530.0	5.8
Hardness	0.1	na	715.7	11.1
Turbidity	0.1	10% change	1.3	0.0
Anion Sum (meq/L)	na	na	16.7	0.0
Cation Sum (meq/L)	na	na	18.0	0.3
Ion Balance	0.01	na	3.8	0.7
pH (units)	0.1	6.5 - 9.0	7.0	0.0
DIC	0.5	na	3.8	0.0
DOC	0.5	na	1.9	0.1
TDS	1	na	1130.0	5.8
TSS	5	increase of 10	nd	na

Table 4.5.6 Metal Concentrations in Moose Creek; Onaping/Levack Mine Sites

Table 4.5.6 Metal Concentrations in Moose Creek: Onaping/Levack Mine Sites						
Metal (mg/L)	LOQ	CCME Guideline+	Dissolved Metals M3		Total Metals M3	
			Mean	Std Error	Mean	Std Error
Aluminum	0.01	0.1	0.14	0.00	0.25	0.00
Antimony	0.002	0.02*	nd	na	nd	na
Arsenic	0.002	0.05	nd	na	nd	na
Barium	0.005	na	0.042	0.001	0.0267	0.0003
Beryllium	0.005	1.1*	nd	na	nd	na
Bismuth	0.002	na	nd	na	nd	na
Boron	0.005	0.2*	0.033	0.001	0.027	0.001
Cadmium	0.0005	0.0018	nd	na	nd	na
Calcium	0.1	na	255.7	14.3	277.7	2.4
Chromium	0.002	0.002	nd	na	nd	na
Cobalt	0.001	0.0006*	0.023	0.000	0.020	0.001
Copper	0.002	0.004	0.089	0.003	0.094	0.002
Iron	0.02	0.3	0.27	0.01	0.37	0.01
Lead	0.0001	0.007	0.0008	0.0000	nd	na
Magnesium	0.1	na	5.8	0.0	5.3	0.12
Manganese	0.002	na	0.132	0.003	0.12	0.00
Mercury (ug/L)	0.1	0.0001	0.07	0.02	nd	na
Molybdenum	0.002	0.01*	nd	na	nd	na
Nickel	0.002	0.15	0.835	0.043	0.736	0.422
Potassium	0.5	na	21.4	0.3	14.7	8.2
Reactive Silica	0.5	na	7.1	0.1	-	-
Selenium	0.002	0.001	0.003	0.000	nd	na
Silver	0.0003	0.0001	nd	na	nd	na
Sodium	0.1	na	79.7	0.8	68.8	39.1
Strontium	0.005	na	0.645	0.004	0.604	0.347
Thallium	0.0001	0.0003*	0.0003	0.0000	nd	na
Tin	0.002	na	nd	na	nd	na
Titanium	0.002	na	nd	na	nd	na
Uranium	0.0001	0.005*	nd	na	nd	na
Vanadium	0.002	0.005*	0.002	0.001	0.008	0.005
Zinc	0.002	0.03	0.037	0.002	0.021	0.012
Total Cyanide	0.005	na	nd	na	-	-
Free Cyanide	0.002	0.005	nd	na	-	-

4.6 Sediment Chemistry

4.6.1 QA/QC

The sediment chemistry QA/QC results are discussed below with detailed information and analytical results presented in Appendix D.

Field QA/QC Checks

Replicate Samples

A replicate field sample was collected in the Exposure Area (OR3-6). The results of the analysis on replicate the sample are presented in Appendix D3. The comparison of results with the replicate samples suggests that analytical results are generally consistent, with differences < 10%. A few exceptions were noted, with replicate copper analysis differing by 23% and silver by 46%. For most parameters, however, the difference between replicate samples was no greater than the difference observed between laboratory duplicate analysis. This indicates that the method of compositing five grab sediment samples was valuable to accurately characterize sediment chemistry.

Results of Swab Analysis

Paper swabs were used to wipe down the bowls used to mix the composite sediment samples after each sample was prepared. The swabs were subsequently sent for analysis, with results presented in Table 4.6.1. The concentration of most parameters was below detection limits, with the exception of trace levels of barium, boron and copper. However, the concentration of zinc in the swabs was notable, with levels ranging from 2.3 to 75.3 µg/tot. Since only zinc was present in significant quantities, we are confident the methods of field washing the sampling equipment was effective. However, some source of zinc contamination was present.

The suspected source of zinc was the powder present in the latex gloves used by the field personnel. The talc powder is known to contain zinc which is used as a bactericidal agent. To test this suspicion, we rinsed the latex gloves with clean distilled water and submitted the solution for analysis. The results revealed the potential for some contamination by magnesium, calcium, potassium, sodium and zinc (data Appendix C).

The swab metal levels were lower than the levels measured in the actual sediments (see below). This, coupled with the relative proportion of powder that would likely be present in the samples, suggests that it is unlikely this source of potential contamination would mask or invalidate any trends observed in the sediment data.

Laboratory QA/QC Checks

Replicate Analysis

The results of the laboratory replicate analysis are, for the most part < 10%, and considered very acceptable. A few exceptions were noted including duplicate cobalt results which differed by 11%, nickel by 13% and silver by 33%.

Laboratory QA/QC Checks

Replicate Analysis

The results of the laboratory replicate analysis are, for the most part < 10%, and considered very acceptable. A few exceptions were noted including duplicate cobalt results which differed by 11%, nickel by 13% and silver by 33%.

4.6.2 Chemistry

Sediment chemistry results are summarized (mean, standard error) in Table 4.6.2. Due to the limited availability of depositional sediments only three sediment samples were collected from each of the Exposure and Reference areas. Results are presented for both "raw' data, as well as results that were normalized for percent fines. The proportion of fine particles did differ substantially between some samples. For example, the percent fines in sediments from the Reference area ranged from about 0.9 to 15.4%, while in the Exposure area it ranged from 1.8 to 31.9%. Similarly, the mean Total Carbon in the Reference area was only 0.89% compared with 6.9% in the Exposure area. The latter value was strongly influenced by one sample with a carbon content of 19.2%.

The data show that the "uncorrected" concentrations of cobalt, copper, zinc and nickel in the Exposure area was much higher than in the Reference area. However, when the data were normalized for percent fines, this difference either disappeared, or in some cases the trend reversed itself (e.g. lead). For example, the mean concentration of copper in the Exposure area (146.6 mg/kg) was significantly greater ($p < 0.05$, table 4.6.3) than in the Reference area (12.3 mg/kg). When normalized for percent fines in the samples, the mean copper level in the Exposure area (1188 mg/g) was not significantly different ($p > 0.05$) than in the Reference area (689 mg/kg). The large variability between samples, coupled with small samples sizes makes it difficult to measure statistical differences.

Table 4.6.1: Swab Analysis of Sediment Mixing Bowls After Cleaning from Reference and Exposure Stations at Onaping/Levack Mines											
		Reference Stations			Exposure Stations				Swab	Swab	Swab
Metal (ug/tot)	LOQ	OR1	OR1	OR1	OR3	OR3	OR3	OR 3	Blank	Blank	Blank
		REF 2	REF 3	REF 5	EXP 2	EXP 2	EXP 4	EXP 5	1	1	2
						Lab				Lab	
						Replicate				Replicate	
Barium	0.1	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.4	0.2
Beryllium	0.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.5	0.8	nd	2.2	1.2	1.0	nd	nd	2.2	2.4	0.9
Cadmium	0.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chromium	0.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cobalt	0.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Copper	0.2	0.6	0.6	0.4	0.9	0.8	0.8	0.5	0.6	0.5	0.4
Lead	1.3	1.4	nd	nd	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Nickel	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.2	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.3	2.3	4.6	5.2	72.3	75.3	2.4	51.8	1.0	1.2	1.1

Table 4.6.2 Metal Concentrations in Sediments (mg/kg) from the Onaping River

Parameter	Reference				Exposure			
			Normalized (% fines)				Normalized (% fines)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Barium	22.53	3.23	1010.9	576.6	27.30	5.74	263.6	126.8
Cadmium	0.13	0.08	3.12	1.22	0.15	0.08	1.02	0.29
Chromium	19.87	1.77	1008.9	561.3	25.57	5.70	273.1	157.2
Cobalt	7.70	0.82	353.5	199.1	39.83	13.54	298.1	83.3
Copper	12.27	1.77	689.9	845.3	146.57	48.06	1188.3	432.7
Lead	6.33	1.24	273.4	156.6	9.63	2.90	85.8	38.4
Mercury	0.02	0	1.03	0.62	0.03	0.01	0.22	0.08
Nickel	16.87	1.04	805.8	447.1	374.67	374.66	2466	776
Silver	1.94	0.33	79.9	38.8	0.65	0.10	10.39	8.09
Vanadium	23.20	0.78	1238.3	760.9	24.13	4.98	257.2	146.4
Zinc	43.77	6.57	1915.3	1051.4	64.87	17.98	602.1	286.5
Total Organic Carbon	1.35	0.97	n/a	n/a	7.46	5.95	n/a	n/a

n/a: not applicable

Table 4.6.3 Statistical Analysis Results for Selected Sediment from Reference and Exposure Areas at Onaping/Levack Mine Sites

Parameter	mg/kg				Normalized to mg/kg Fines			
	Reference Mean (±s.e.)	Exposure Mean (±s.e.)	t-value (d.f.=4)	p-value	Reference Mean (±s.e.)	Exposure Mean (±s.e.)	t-value (d.f.=4)	p-value
Copper	12.3 (±1.77)	146.6 (±48.1)	5.973[a]	0.004	689.9 (±488.0)	1188.3 (±432.7)	0.764	0.487
Lead	6.33 (±1.24)	9.63 (±2.90)	1.046	0.355	273.4 (±156.6)	85.8 (±38.4)	-1.198[a]	0.297
Nickel	16.9 (±1.0)	374.7 (±216.3)	na		805.8 (±447.1)	2466.2 (±776.3)	1.853	0.137

[a] t-value calculated from log transformed data
na failed assumption of equal variances

4.7 Benthic Invertebrate Community Structure

4.7.1 QA/QC

Four of the twelve benthic samples were subsampled in the laboratory due to the large number of organisms present. Either a ¼ or a ½ sample was taken for sorting and enumeration (Appendix E2). Two of the samples (Ref OR1-1, Exp OR3-6), representing approximately 20% of the samples, were dividied, and then both fractions processed to determine potential subsampling error. The coefficients of variation between the sorted fractions were 9.5% and 2.8%, indicating very good representation of the subsamples.

Two samples (Ref OR1-4, Exp Surber-3) were sorted a second time by a different person to determine if organisms were missed during the first sorting process. The second resort showed that the original sorting was >95% complete, indicating excellent recovery of organisms by the benthic technician.

4.7.2 Community Structure

Results of the invertebrate survey (Table 4.7.1) show how sampling method and location can influence results. Ponar samples were collected in comparatively slow-moving water, while Surber samples were collected in gravel riffle areas. Ponar samples had higher overall density of organisms but a lower number of taxa. The number of chironomid taxa was higher in the Ponar samples than in Surber samples. The EPT Richness was lower among Ponar samples compared with Surber samples (Table 4.7.1). These differences reflect habitat differences.

Mean organism density and the total number of taxa were significantly lower in upstream reference area compared with downstream exposure area for both sample methods (Table 4.7.1). The EPT Richness was also lower in the reference area compared with the exposure area for both sample methods. However, the number of chironomid taxa was higher in the exposure area for both sample methods, which can be indicative of a stressed benthic community.

The presence of stress-sensitive and stress-tolerant organisms in the Onaping River is presented in Tables 4.7.2 and 4.7.3 respectively. Of the seven stress-sensitive organisms found in the reference area, only one, *Pseudorthocladius*, was not found in the exposure area. *Glossosma* and *Xenochironomus*, both considered sensitive to stress, were found in the exposure area but not the reference area. *Xenochironomus*, is considered indicative of clean water as it feeds on freshwater sponges which require clean water. However, it only occurred in one of the three Ponar samples collected in the exposure area.

Caenis, *Cladopelma*, *Cryptochironomus* and *Stictochironomus* are stress tolerant organisms which were found in the exposure area (Table 4.7.3). They were not represented in the reference area samples. Only one stress-tolerant organism, *Physella*, was present in the reference area and not represented in the exposure area samples.

Table 4.7.1 Summary of Benthic Invertebrate Data from Onaping/Levack Mine Sites, October, 1996

	Sampler	Reference Mean (±s.e.)	Exposure Mean (±s.e.)	t-values (d.f.=4)	p-value
Organism Density (per m^2)	Ponar	6,271.6 (±3,021.8)	42,938.2 (±11,764.6)	3.714[a]	0.021
	Surber	1,103.7 (±369.3)	5,618.5 (±1,487.3)	3.895[a]	0.018
Total No. of Taxa[b]	Ponar	34	57	na	
	Surber	46	80	na	
Mean No. of Taxa	Ponar	18.3 (±6.0)	31.0 (±5.2)		
	Surber	23.0 (±8.9)	51.0 (±1.0)		
EPT Richness[b]	Ponar	4	7	na	
	Surber	20	35	na	
No. of Ephemeroptera Taxa[b]	Ponar	1	1	na	
	Surber	5	8	na	
No. of Chironomid Taxa[b]	Ponar	15	26	na	
	Surber	13	22	na	

[a] t-value calculated from log transformed data
[b] pooled replicates

Table 4.7.2 Occurrence of selected stress-sensitive organisms in the Onaping River

Taxa	Reference		Exposure	
	Surber	Ponar	Surber	Ponar
Annelids				
Lumbriculidae	-	✓	-	✓
Ephemeroptera				
Stenonema vicarium	✓	-	✓	-
Isonychia	✓	-	✓	-
Plecoptera				
Acroneuria	✓	-	✓	-
Taeniopteryx	✓	-	✓	-
Trichoptera				
Glossosoma	-	-	✓	-
Hydropsyche dicantha	✓	-	✓	-
Lepidostoma	-	-	✓	-
Diptera (*Chironomidae*)				
*Pagastiella**	-	✓	-	✓
*Xenochironomus**	-	-	-	✓
Pseudorthocladius	✓	-	-	-

**Pagastiella:*

higher absolute numbers downstream (ponar) but higher relative abundance upstream

**Xenochironumus*

feeds on freshwater sponges which require clean water, therefore Xenochironomus is an indicator of clean water - only occurrence was at EXP station in one of three ponar grabs

Table 4.7.3 Occurrence of selected stress-tolerant organisms in the Onaping River

Taxa	Reference		Exposure	
	Surber	Ponar	Surber	Ponar
Tubificids	-	✓	-	✓
Ephemeroptera				
Caenis	-	-	-	✓
Diptera (*Chironomidae*)				
Cladopelma	-	-	-	✓
Cryptochironomus	-	-	-	✓
Micropsectra	✓	✓	✓	✓
Parachironomus	-	✓	-	✓
*Polypedilum**	✓	✓	-	✓
Stictochironomus	-	-	-	✓
Ablabesmyia	-	✓	-	✓
Procladius	-	✓	-	✓
Molluscs (*Gastropoda*)				
Physella	✓	-	-	-

* Polypedilum
had greatest relative abundance downstream with Ponar

4.8 Fisheries

4.8.1 Community

In generaly, very few fish were caught during the survey. The fish catch in the exposure area consisted of white sucker (*Catostomus commersoni)*, yellow perch (*Perca flavescens)* and rainbow trout (*Oncorhynchus mykiss)*. All fish were captured by gill net. All fish were measured, weighed and kept for further analysis.

The fish catch in the reference area consisted of white sucker, northern pike (*Esox lucius)*, brook trout (*Salvelinus fontinalis)* and pearl dace (*Margariscus margarita)*. All fish were captured by gill net except one pearl dace. All fish were measured, weighed and kept for further analysis.

Exposure Area

Relative abundance for fish captured by gill net in the exposure area are presented in Table 4.8.1.

Table 4.8.1. Relative Abundance of Fish Captured by Gill Net in the Exposure Area of the Onaping River, October, 1996

Species	# Caught	Method of Capture	Effort (hours)	Relative Abundance (%)
White sucker	2	15 m 1.5" gill net 15 m 2.5" gill net	60	50
Yellow perch	1	15 m 1.5" gill net 15 m 2.5" gill net	60	25
Rainbow trout	1	15 m 1.5" gill net 15 m 2.5" gill net	60	25
Total	**4**			**100**

A total of 74 hours was expended on fishing minnow traps in the exposure area yielding no catch.

Reference Area

The relative abundance of fish captured by gill net in the reference area are presented in Table 4.8.2. Northern pike made up 72.7% of the catch, white sucker and brook trout made up 18.2 and 9.1%, respectively.

Table 4.8.2. Relative Abundance of Fish Captured by Gill Net in the Reference Area of the Onaping River, October, 1996

Species	# Caught	Method of Capture	Effort (hours)	Relative Abundance
White sucker	2	15 m 1.5" gill net 15 m 2.5" gill net	48	18.2
Northern pike	8	15 m 1.5" gill net 15 m 2.5" gill net	48	72.7
Brook trout	1	15 m 1.5" gill net 15 m 2.5" gill net	48	9.1
Total	**11**			**100**

A total of 96 hours was expended on fishing minnow traps in the reference area with only one pearl dace captured.

A total of 189 hours was expended on fishing modified minnow traps in the reference area yielding no catch.

4.8.2 Tissue Analysis

Two white suckers were submitted from the reference and exposure areas, respectively, for MT analysis. The size of these fish were:

	Length (mm)	Weight (g)	Age (yrs)
Exposure			
E-01	173	53.5	1
E-03	281	285.7	3
Reference			
R-01	336	471	4
R-02	158	47	1

The results of metal and metallothionein analysis of white sucker liver, kidney and gill tissues are summarized in Table 4.8.3 (raw data Appendix F3). Although statistical analysis could not be conducted on these small samples sizes, metallothionein levels appear higher in liver, kidney and gill tissues from fish collected in the exposure area compared with fish collected in the reference area.

The metal values in Table 4.8.3 are expressed as uMoles/g tissue. This value represents the sum of the concentrations of zinc, cadmium and copper which were analyxed separately. Although statistical analysis could not be conducted on these small sample sizes, the tissue metal levels in kidney are not very different between

the reference and exposure areas. However, fish collected in the exposure area had higher tissue metal levels in liver and gill samples compared with fish collected in the reference area.

Table 4.8.3 Summary of Metal and Metallothionein Results (Means ±s.e.)

Species/Parameter	Reference	Exposure
Common White Sucker		
Liver		
Metallothionein (µg/g)	103 (n=1)	480 ± 193 (n=2)
Metals (µM/g)	0.39 (n=1)	0.64 ± 0.04 (n=2)
Kidney		
Metallothionein (µg/g)	115 (n=1)	406 (n=1)
Metals (µM/g)	0.66 (n=1)	0.62 (n=1)
Gill		
Metallothionein (µg/g)	28.5 ± 0.8 (n=2)	49.7 ± 2.1 (n=2)
Metals (µM/g)	0.24 ± 0.01 (n=2)	0.35 ± 0.02 (n=2)

4.9 Level of Effort

The relative level of effort (person hours) for different study components is summarized in Table 4.9.1. Table 4.9.2 presents expenses and disbursements incurred during the study. The effort summarized below does not include time spent comparing the Onaping/Levack site for suitability for testing hypotheses in 1997 or scoring the site criteria.

Table 4.9.1 Estimated Level of Effort for Each Program Element in the Onaping/Levack Mine Sites to October 18, 1996

Task			Level Effect (person hours)
Project Initiation Meeting			11.0
Literature Review and 1996 Study Design			37.0
Field Surveys	Planning and Preparation of Field Logistics		142 (includes 32 hours of safety and orientation training at INCO)
	Site Reconnaissance, Habitat Characterization and Station Selection		54
	Sublethal Toxicity Sample Collection		28
	Water Chemistry		25
	Sediment Chemistry		66
	Benthos		53
	Fish	Population	28
		Tissue Processing	35
Data Analysis Interpretation			58
Preliminary Surveys and Recommendations Report			75
Final Survey Report			95
Progress Reports			10.5
Conference Calls			13.5

Table 4.9.2 Expenses and Disbursements ($) for the Preliminary Field Survey at the Onaping/Levack Mine Sites

Expense	Sublethal Toxicity Sample Collection	Water Chemistry	Sediment Chemistry	Benthos	Fish
Travel	1944				
Accommodations[1]	738				
Meals[1]	789				
Miscellaneous Supplies	1745				
Shipping	906				
Analyses	na	5545	1385	2400	na

5. DISCUSSION

5.1 Comparison of Results with Historical Data

Select water chemistry from the Reference area are compared with historical water quality data for the reference area (Table 5.1.1).

Table 5.1.1 Summary of Select Water Chemistry Parameters (mg/L) at Reference Area (OR1)

	1977	1991	1995	1996
Conductivity (µ/s)	40	30	38	36
Sulphate	14	8.3	6	6
Copper	.005	<0.03	ND	<.002
Nickel	.004	<0.17	0.011	<.002

These data would suggest that water quality in the Reference area has not changed in the past 20 years. Detection limits in this study are also likely much lower than previous surveys.

The concentrations of a few water chemistry variables for Moose Creek from different studies are summarized in Table 5.1.2. The results show that substantial reductions in loading of most parameters (eg. sulphate, iron, nickel, copper) were realized between 1977 and 1991. Water chemistry from 1991 to the 1996 study was relatively constant.

Table 5.1.2 Summary of Select Water Chemistry In Moose Creek (M3). Values are means (mg/L) of replicate samples. Metals are total metal levels

	1977	1991	1995	1996
Conductivity (µS/cm)	1337	1240	1310	1535
Sulphate	1470	612	559	588
Iron	4.73	0.34	0.67	0.37
Nickel	3.23	0.56	0.283	0.74
Copper	0.21	0.05	.025	0.094

Water chemistry for some parameters in the Exposure area from background studies are compared with the 1996 results in Table 5.1.3.. The data suggest that conditions in the Onaping River have responded to decreased loading from Moose Creek, with notable reductions in the levels of sulphate, iron, nickel and copper since 1977. Previous studies that sampled frequently during a several week or month period noted substantial fluctuations in the levels of some parameters in the Onaping River. These fluctuations are attributed to changes in effluent chemistry, changes in water flow (and hence dilution) in the Onaping River, and changes in surface and groundwater runoff which would affect loading rates from nonpoint sources. Since this study only sampled on one occasion, comparisons with previous studies should be made with caution.

Table 5.1.3 Summary of Select Water Chemistry (mg/L) in Onaping River Below Mine Effluent (OR3)

	1977	1991	1995	1996
Conductivity (µS/cm)	135	130	105	131
Sulphate	60	64	22	35
Iron	0.46	.29	.278	0.267
Nickel	0.254	.15	.041	.06
Copper	0.022	.02	.003	.008

There are limited historical sediment quality data in the Onaping River. Table 5.1.4 presents a comparison of mean sediment concentrations of some parameters from this study with those of Bowman and Mise (1992). The results are from our exposure area and from another depositional site further down river for the 1991 data. There appears to be a trend toward decreasing sediment metal concentrations during the past 5 years but the results are based on limited sampling and are from different areas.

Table 5.1.4 Comparison of Downstream Mean Sediment Metal Concentrations (µg/g)

	1991	1996
Copper	520	146
Nickel	726	375
Lead	17	9.6
Zinc	153	65

The results of benthic data in the Exposure area from different background studies are compared with the 1996 results in Table 5.1.5. Data from the background reports were selected that were as comparable as possible to the timing (eg. fall) and method (Surber or Ponar) to the 1996 study. A number of benthic indicator measures including total number of taxa, mean number of taxa and EPT index demonstrate a clear improvement in the benthic community from 1997 to the present time.

Some caution must be exercised when attempting to directly compare studies as results are sometimes reported differently, or organisms are grouped differently depending on the level of expertise of the person sorting and identifying the benthic organisms. For example, the number of benthic taxa possibly reported in a study is directly dependant upon the level of identification. From the background reports there do seem to be differences as indicated by the following:

Study	**# of taxa categories considered**
Bolger (1977)	72
Bowmand and Mise (1991)	46
Aquatic Sciences (1995)	76
ESP (1996)	125

Notwithstanding these concerns, the benthic community in the Exposure area of the Onaping River appears to have responded to decreased loading of metals in the water, and possibly in the sediments as well.

Table 5.1.5 Summary of Benthic Invertebrate Data Collected in Onaping River Below Mine Effluent (OR3)

	1977[1]	1991[2]	1995[3]	1996[4]	
				S	P
Density (#/m^2)		1223	920	5,619	34,127
Total # Taxa	18		33	80	57
Mean # Taxa		10.2	31	51	31
# Mayflies (% of total)					
EPT index	1.0		10	35	7
Shannon Weiner			4.08	3.4	3.01
% chironomids by abundance	32.0			20.4	37.3

1 data are from September, Surber, n=3 reps

2 September, Surber, n=6 reps

3 October: air-lift n=3 reps

4 October: S = Surber, n=3 reps; P = Ponar, n=3 reps

A comparison of fish species caught in the study area from four different surveys is presented in Table 5.1.6. With the exception of white suckers, there are few similarities in species composition either between years or between Reference and Exposure areas. Our study caught two species (although only 1 specimen each) of fish (Rainbow trout, yellow perch) in the exposure area not previously recorded. This may be a result of improved water quality in the Exposure area. Gamefish caught in the Reference area in this study included Brook trout and Northern pike.

Table 5.1.6 Summary of Fish Species Captured in Study Area

Collection Year (source)	Reference Area (OR1)	Exposure Area (OR3)
1977[a] (Bolger, 1980)	White sucker Ling Finescale dace	White sucker Brook stickleback Brown bullhead Finescale dace
1991[b] (Bowman and Mise, 1992)	Lake chub	Lake chub White sucker Lake herring Creek chub
1995[c] (ASI, 1996)	Trout perch White sucker Brook trout Shiners Common shiner Central mudminnow	White sucker Common shiner Chub Mottled sculpin
1996[d] (ESP, 1996)	Brook trout White sucker Northern pike Pearl dace	White sucker Rainbow trout Yellow perch

[a] July survey
[b] July and September results
[c] June and September
[d] October

5.2 Comparison of Reference Versus Exposure Areas

The data presented in Section 4.5.2 clearly show that the concentration of several metals and general water chemistry parameters are elevated in the Exposure area relative to the Reference area. The sources of these substances will include the INCO and Falconbridge effluents into Moose Creek, the Levack sewage treatment plant (STP) and nonpoint sources from groundwater discharge and surface runoff.

We are very confident that river geomorphology and habitat types were similar between the Reference (OR1) and Exposure (OR3) areas in the Onaping River. Both

the reference and exposure areas had split and main channels and eddy pools. Discharge rates were 9.5 and 10.5 m^3/s in the reference and exposure areas respectively. Substrates were very similar in both areas and bank stability was 100%.

The sediment chemistry results indicate some metals are elevated in the Exposure area relative to the Reference area (Figure 5.2.1). The mean nickel concentration is also much higher in the Exposure area (374 ± 375 µg/g) than the Reference (16.8 ± 1.8 µg/g) area (also see Table 4.6.2).

The differences in metal levels between the Exposure and Reference area were less pronounced when the data were normalized for percent fines. From an ecological perspective, however, it may not be important to normalize for percent fines since benthic organisms will be exposed to the total metal concentrations present. It may be appropriate to determine biologically available metal concentrations through analysis of acid volatile sulphides (AVS) or other indicators of availability.

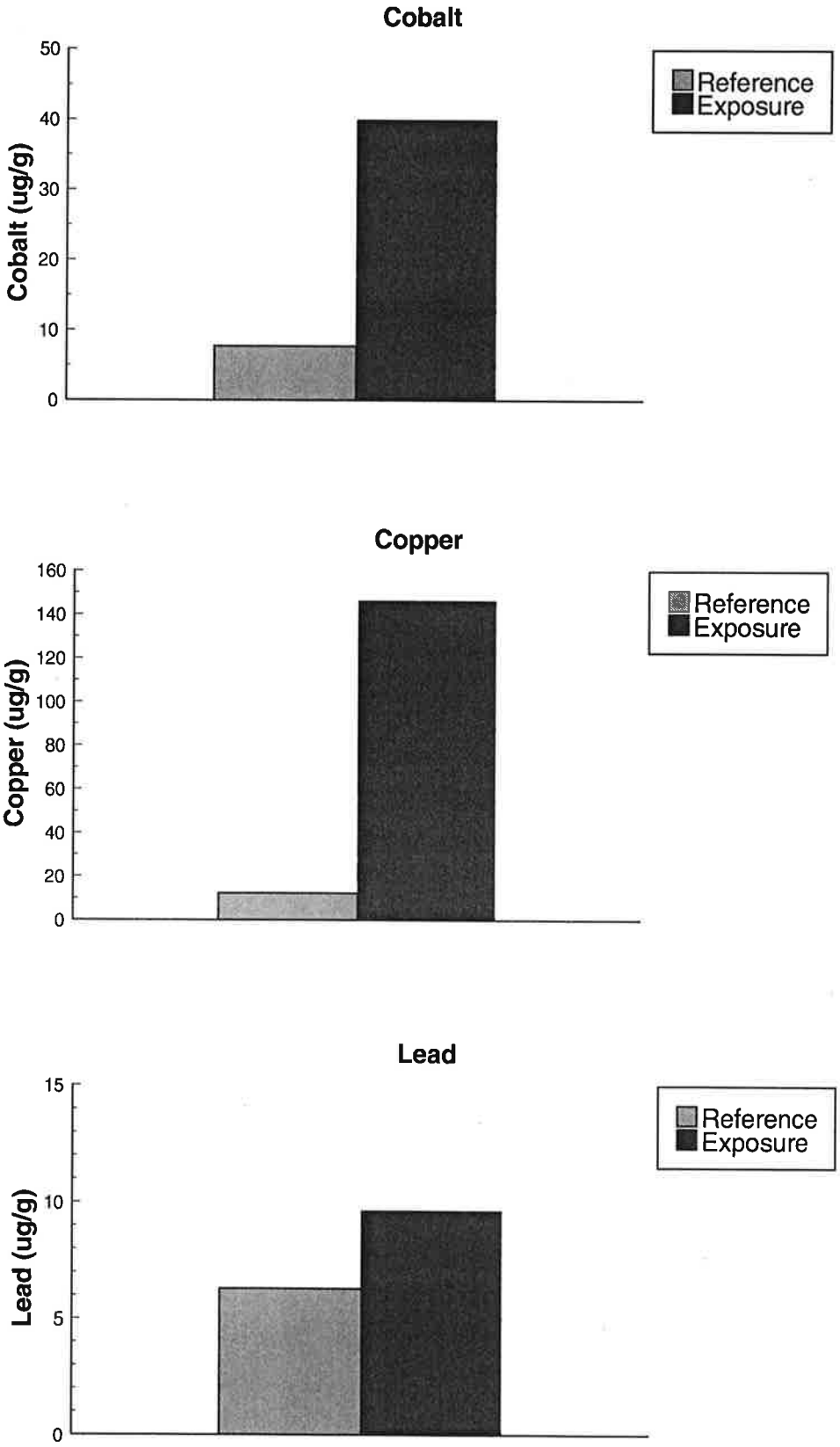
Results of the invertebrate survey (Table 4.7.1) show how sampling method and location can influence results. Ponar samples were collected in comparatively slow-moving water in substrates composed largely of sand, while Surber samples were collected in gravel riffle areas. Ponar samples had higher overall density of organisms but a lower number of taxa. The number of chironomid taxa was higher in the Ponar samples than in Surber samples. The EPT Richness was lower among Ponar samples compared with Surber samples (Table 4.7.1).

Mean organism density and the total number of taxa were significantly lower in upstream reference area compared with downstream exposure area for both sample methods (Table 4.7.1). The EPT Richness was also lower in the reference area compared with the exposure area for both sample methods, suggesting better water quality in the exposure area compared with the reference area. However, the number of chironomid taxa was higher in the exposure area for both sample methods, which can be indicative of a stressed or nutrient enriched benthic community. These indicators suggest a healthier benthos community in the Exposure area compared with the Reference area.

The most likely explanation for the observed pattern in the benthic community is the sewage treatment plant (STP) at Levack. The STP could influence the benthic community directly in two ways: 1) provide nutrients and organic substrate to act as a food base to stimulate the benthic invertebrates, and 2) loading of organic material could act to scavenge and bind metals in the water, thereby reducing their toxicity. It is well established that the toxicity of some metals, especially copper, is greatly reduced by the presence of organic material (Winner et. a. 1984; 1985; Borgmann and Ralph 1983). Elevated water hardness in the Exposure area could also be acting to ameliorate some of the potential metal toxicity (eg. Sprague 1985).

The total fish catch per unit effort (CPUE) for gill nets was higher in the Reference area (5.5 fish/24 hr/30 m net) than the Exposure area (1.6/24 hr/30 m). However, the overall fisheries catch was low considering the amount of effort and little information

Figure 5.2.1 Comparison of select metal concentrations (ug/g) in sediments from the Onaping River



is provided on relative abundance of species or fish community structure.

The fish tissue analysis did suggest that both metals and metallathioneins were higher in fish from the Exposure area compared with the Reference area. This trend is consistent with the pattern of environmental exposure in water and sediments.

6. CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE SAMPLING

Evaluation of the suitability of the Onaping/Levack site for testing hypotheses in 1997 was presented in a separate report. In that document, the site specific characteristics of the site are summarized and the site is compared against specific selection criteria and individual hypotheses. The site has many positive attributes but these must be weighed against confounding factors including the presence of the sewage treatment plant at Levack, and combined effluents from INCO and Falconbridge. It would be difficult to isolate the relative effects of these influences.

The 1996 preliminary field survey shows that the Onaping Site meets some of the criteria for hypothesis testing in 1997. The river geomorphology and habitats are very similar between the Exposure and Reference area. The site is readily accessible by road, particularly the Exposure area. There is good potential for multiple sampling stations in both the Exposure and Reference areas. There is a good database of background information. Both INCO and Falconbridge will have effluent characterization for toxicity and chemistry under the Ontario MISA program, although that information was not used as part of this study.

The effluents from both INCO and Falconbridge demonstrated sublethal effects on the test organisms. In particular, growth of both Lemna and Selenastrum were inhibited. The effluents both inhibited reproduction of Ceriodaphnia to some degree, while the INCO effluent also affected Ceriodaphnia survival as well as growth of fathead minnows. Repeated sublethal toxicity testing, simulataneously for both effluents, at different times would better characterize the potential toxicity of these effluents.

There is a clear difference in metal concentrations and water chemistry parameters between the Exposure and Reference area. Metals are being contributed from both point and nonpoint sources. Detailed mass balance investigations would be required to identify the relative contributions of these sources to the Onaping River in the vicinity of the mines. From comparison with background reports, it appears that metal levels in the Exposure area have decreased during the past 20 years as a direct result of decreased discharge in the mine effluents.

Depositional sediments are not common within the Onaping River due to its relatively steep gradient and erosional nature of the watercourse. However, sediments were located during the 1996 field survey and sampled for chemistry and benthos using a Ponar sampler. The "raw" sediment chemistry results clearly indicated higher metal levels in the Exposure area compared with the Reference area. However, when normalized for percent fines, some of these differences dissappeared. There was substantial between sample variability in some of the sediment metal concentrations, percent fines, and organic carbon content. A greater number of sediment samples would have to be collected and analyzed to better detect differences or gradients in sediment chemistry in future studies.

The benthic invertebrate survey results were interesting in that the expected effect of exposure to mining effluent was not observed. In fact, by most indicators and measures, the benthic community in the Exposure area was more diverse and more abundant than in the Reference area. This may largely be attributed to the Levack sewage treatment plant which contributes nutrients and organic matter to the Onaping River near where the effluents are discharged. In addition, the benthic community in the Reference area may be affected by periodic low water levels due to water regulation and water diversion of the Onaping River upstream of the study area for hydroelectric purposes.

Comparison of the benthic survey results with historical data suggests that the benthic community in the Exposure has improved substantially during the past 20 years. This is likely a response to decreased metal levels in water and possibly in sediments.

The results of the 1996 benthic survey were also interesting in that two collection techniques were used; Ponar sampler in soft depositional sediments, and a Surber sampler in coarser substrate in riffle areas. The data were summarized and presented separately for both methods. The results showed similar trends and gradients between the Exposure and Reference areas, but the data clearly reflected the different types of habitat sampled. For example, the Ponar sampler tended to collect more chironomids, while the Surber sampler clearly contained more taxa and organisms within the EPT groups. The results emphasized the importance of comparing benthic data collected by similar techniques. We would recommend any future studies to utilize both techniques to capture as wide a variety of benthic organisms as possible.

The fishing surveys yielded relatively few fish, and greater effort would be required to better characterize the fish community in the Onaping River. The 1996 survey did capture yellow perch and rainbow trout which had not previously been reported in the Exposure area.

Samples of white sucker were submitted for metals and metallothionein analysis in 1996. Based on a small sample size, the data showed elevated metals and metallothionein in fish tissues from the Exposure area. Future studies should consider sampling fish at a different time of the year. An early spring survey shortly after ice-out and before spawning would be ideal. Suckers are schooling for spawning at this time and it would be possible to capture large numbers once spawning congregations were located. Also, the gonads would be fully developed making it possible to destablish good measures of fecundity and other reproductive performance. Future studies would have to take into consideration the lack of major obstacles to fish migration which allows fish to travel freely along the length of the river.

Overall, the Onaping/Levack is clearly suitable for future testing of a few hypotheses, while it is partially suitable for several of the proposed hypotheses in the AETE program.

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APPENDIX A

Quality Management Plan

INTRODUCTION

Appropriate quality assurance and quality control (QA/QC) protocols are essential to ensure that environmental data achieve a high level of quality commensurate with the intended use of the data. This quality management plan (QMP) served as a general set of protocols covering both laboratory and field operations to be used by all members of the EVS-ESP-JWEL consortium. Use of this QMP ensured both a high quality of data as well as uniformity and comparability in the data generated at each study site.

DATA QUALITY OBJECTIVES

For all field and laboratory measurements, data quality objectives (DQOs) have been set where applicable. Data quality objectives are defined by the US EPA as "qualitative and quantitative statements of the level of uncertainty that a decision maker is willing to accept in decisions made with environmental data" (QUAMS; 1986, 1990). The DQOs define the degree to which the total error in the results derived from the data must be controlled to achieve an acceptable confidence in a decision that will be made with the data. In terms of this project, the AETE committee has already stipulated that analytical measurements will achieve a detection limit of 1/10 that of the CCME guidelines for protection of the aquatic environment. The quality control officer ensured that the required detection limits were made known to the analytical laboratory well in advance. In this way, the correct methodology, volume of samples and methods of preservation were established before the field work was underway. Detection limits for field instruments (Hydrolab, YSI etc.) and the gravimetric measurements for biological analyses (e.g. fish organ weights) were also sent to each team.

QUALITY CONTROL OFFICER

The quality control officer (QCO) for the project (Ms. Monique Dubé) has the following responsibilities:

- to ensure that all data quality objectives are known to both field personnel and the chosen analytical laboratory
- to ensure that standard operating procedures (SOPs) are followed for each field component at each study site
- to ensure that both the toxicity and analytical laboratories follow established SOPs for each analysis
- to ensure the all analyses were under statistical control during each analytical run. This requires that the quality control data for each analysis be reviewed and compared with historic control limits to be requested from the analytical and toxicity laboratories. The QC

data will include percent recoveries of spiked samples, and results for blanks, replicates and certified reference materials. Logical checks of the data will also be conducted, especially for toxicity.

The quality control officer (QCO) has authority for requiring corrective actions (e.g., repetition of the analysis) if the SOPs were not followed or the analytical systems were not under control. The QCO will also be made aware of all outliers.

FIELD PROTOCOLS FOR WATER, SEDIMENT AND BENTHIC SAMPLING

RESPONSIBILITIES AND TRAINING

For each field team, a team leader was chosen with authority to make decisions in the field related to implementation of the study plan. The team leader was responsible for ensuring that all field personnel were trained and competent in use of each field instrument, that all SOPs were followed and that adequate heath and safety measures were followed.

STANDARD OPERATING PROCEDURES

Whenever feasible, water, sediment and benthic samples were taken at the same sampling stations. The location of each station was recorded either as a GPS reading or with reference to a large scale map and known landmarks. The location of each station was known to the nearest 20 m. At each station the field information to be reported included:

- station location
- date and time
- field crew members
- habitat descriptions
- sampling methods
- depth
- wind and climatic conditions
- water temperature
- substrate type (sand/gravel/cobble/silt/clay)
- water velocity (rivers)

This information was recorded on field data sheets.

BENTHIC SAMPLING

Benthic collections were made by Eckman, standard (or petite) ponar grab, Hess sampler, Surber sampler or hand-inserted core tubes depending on substrate type. The Eckman is used primarily on soft sediments in deep water (>2 m), although a pole mounted version can be used in harder substrates and shallower waters. The ponar grab is used for substrates consisting of hard and soft sediments such as clay, hard pan, sand, gravel and mud where penetration of the substrate by the sampler is possible. The standard ponar is set with a spring loaded pin, lowered to the bottom and allowed to penetrate the substrate. When the ponar penetrates the sediment, the pin is released and the jaws are allowed to close on the sediment sample when the sampler is withdrawn. The ponar (plus sample) is then pulled through the water column and placed in a plastic basin on the bottom of the boat. Because of the weight of the standard ponar a frame and electrically driven winch should be used to raise and lower the grab. After the sample has been removed and whenever the ponar is not being used, the safety pin must be inserted into the lever bar to prevent the bar from closing on the operator. Care must also be taken when using the winch to avoid catching hands and clothes. The petit ponar is considerably lighter, safer and easier to use. A winch may not be necessary under most conditions.

Both the Eckman and ponar samplers were made of stainless steel rather than brass. The choice of using an Eckman or ponar sampler depends on the nature of the sediment and the depth of the water column. In hard sediments, use of the Eckman sampler is limited as penetration is poor. The pole mounted Eckman is able to penetrate some hard substrate, but its use is limited to shallow depths. If sediments are very soft, the Eckman may be preferable to the ponar because the latter tends to fill entirely with sediments, thereby obliterating the sediment-water interface. At depths greater than 20 m the ponar may be more successful because of its greater weight and stability in the water column. If both samplers are available, a certain amount of trial and error may be required to determine the most appropriate sampler.

The Surber sampler was used in shallow (<32 cm), flowing waters on rocky substrates where a grab sample cannot be taken. The Surber sampler consists of two square frames hinged together; one frame rests on the surface while the other remains upright and holds a nylon collecting net and bucket. A base extension is used when sampling areas of fine, loose sediments or rubble. The base frame fits into the base extension which is pushed into the sediments to decrease the lateral movement of invertebrates out of the area to be sampled. The sampler is positioned with its net mouth open facing upstream. When in use, the two frames are locked at right angles, the base frame (and base extension) marking off the area of substrate to be sampled and the other frame supporting a net to strain out organisms washed into it from the sample area.

The Hess sampler is especially useful for sampling gravel and cobble bottoms in streams. The Hess sampler consists of a stainless steel cylinder with two large windows and a pair of handles for pushing the cylinder while rotating it into the gravel or cobble. Penetration depths of 75 or 150 mm can be varied by attaching the handles to either end of the

sampler. Water flows in through the upstream window of the Hess sampler and out through the downstream window and into the collecting net and bucket.

General operating procedures for the Surber and Hess samplers were as follows:

- Position the sampler securely to the bottom substrate, parallel to the water flow with the net pointing downstream.

- The sampler is brought down quickly to reduce the escape of rapidly-moving organisms.

- There should be no gaps under the edges of the frame that would allow for washing of water under the net and loss of benthic organisms. Eliminate gaps that may occur along the edge of the Hess/Surber sampler frame by shifting of rocks and gravel along the outside edge of the sampler.

- To avoid excessive drift into the sampler from outside the sample area, the substrate upstream from the sampler should not be disturbed.

- Once the sampler is positioned on the stream bottom, it should be maintained in position during sampling so that the area delineated remains constant.

- Hold the sampler with one hand or brace with the knees from behind.

- Heavy gloves should be required when handling dangerous debris; for example, glass or other sharp objects present in the sediment.

- Turn over and examine carefully all rocks and large stones and rub carefully in front of the net with the hands or a soft brush to dislodge the organisms and pupal cases, etc., clinging to them before discarding.

- Wash larger components of the substrate within the enclosure with stream water; water flowing through the sampler should carry dislodged organisms into the net.

- Stir the remaining gravel and sand vigorously with the hands to a depth of 5-10 cm where applicable, depending upon the substrate, to dislodge bottom-dwelling organisms.

- It may be necessary to hand pick some of the heavier mussels and snails that are not carried into the net by the current.

- Remove the sample by washing out the sample bucket, if applicable, into the sample container (wide-mouthed jar) with 10% buffered formalin fixative.

- Examine the net carefully for small organisms clinging to the mesh, and remove them (preferably with forceps to avoid damage) for inclusion in the sample.

- Rinse the sampler net after each use.

In the case of soft sediments at shallow depths, plastic core tubes (2.5 " ID) can be inserted by hand into the sediments. Stoppers are placed at each end as the tube is withdrawn.

Sieving of Benthic Samples

Samples were sieved in the field using a mesh size of 250 µm, and preserved with sufficient buffered formalin to produce a 10 % concentration. If further sieving was required (e.g., 500 µm sieve) to allow for data collected to be comparable across studies, then this additional step was done in the field, and both sized fractions were preserved and identified.

Quality Control Protocols for Benthic Identification

Invertebrate samples were sorted on a low power microscope and keyed to the generic level. A reference collection of identified organisms will be maintained for both the receiving and reference environments. Taxonomy will be verified by an independent expert. Sorting efficiency will be estimated by recounts of the sorted material on 10% of the samples. If subsampling is deemed necessary, an estimate will be made of the subsampling error. All unsorted and sorted fractions of the samples will be retained until taxonomy and sorting efficiency are confirmed. All data transcriptions will be checked for accuracy.

WATER CHEMISTRY

As indicated in the study plan, water quality samples were taken as grab samples at 12 sampling stations plus the effluent. In shallow receiving environments (<2m) 1 grab sample was collected at the surface from each station with clean bottles prepared by the analytical laboratory. Samples were collected by removing the cap below the surface (approximately 15 cm depth) to avoid any surface contamination. Latex (or nitryl) gloves were used during this procedure to avoid all contamination. In deeper receiving environments (> 2 m), one sub-surface grab were collected at each station using a Van Dorn-type sampler. Separate samples will be collected for total and dissolved metals. The dissolved sample will be field filtered according to standard methods (APHA 1995 -Section 3030B). Both metals samples (total and dissolved) were acidified with ultrapure HNO_3 (provided by the analytical laboratory) to a pH <2. Samples were also taken in separate bottles for analysis of other water quality parameters.

Field measurements of temperature, conductivity, dissolved oxygen and pH were also taken at each station using a Hydrolab H_20 or YSI meters. The analytical methods for calibration and use of each field instrument were those outlined in each respective instruction manual.

A log was kept of each field instrument indicating its usage and any problems encountered. In using an oxygen electrode, care was taken to change the membrane on a regular basis, or if it became dried out, torn or damaged in any way. Certain chemicals found in effluent discharge can interfere with oxygen measurements. Conductivity was used where appropriate to characterize mixing zones and exposure zones. All values including calibration readings were recorded on the field sheets.

Quality Control Protocols for Water Chemistry

At each mine site quality control samples for water chemistry included collection and analysis of one transport or trip blank, one filter blank and one field replicate (collected at the exposure station). If subsurface samples were collected using a Van Dorn-type sampler, then a sampler blank were also collected. The transport blank and filter blank water were provided by the analytical laboratory. The transport blank consisted of a sample bottle filled with distilled deionized water in the laboratory. The transport blank was brought to the field, opened, then shut immediately. A filter blank consisted of a field-filtered sample of distilled, deionized water provided by the analytical laboratory. When a van Dorn type bottle was used to collect samples, a sampler blank was also taken in which distilled, deionized water was poured into the sampler and then taken as a normal sample. One field replicate from a station in the affected area was taken using a separate bottle and separate filtration. These field QC samples were excusive of those analysed routinely in the laboratory as part of normal laboratory QC.

QC Requirements for Choice of an Analytical Laboratory

A common analytical laboratory was selected for all three regions (West, Ontario, East). The laboratory was certified by CAEAL and the project QCO ensured that the laboratory followed these quality control practices :

- Written (or referenced) SOPs for each analytical system
- Instrument calibration and maintenance records
- Clearly enunciated responsibilities of Q/A officer
- Adequate and training of personnel
- Good Laboratory Practices (GLPs)
- Sample preservation and storage protocols
- Sample tracking system (e.g., LIMS system)
- Use of QC samples to ensure control of precision and accuracy (Blanks, replicates, spikes, certified reference materials (minimum effort should be 15-20%)
- Maintenance of control charts and control limits on each QC sample
- Data handling and reporting (blanks, replicates, spike recovery, significant figures)
- Policy for reporting low level data (e.g., ASTM L,W)
- Participation in external audits and round robbins.

The QCO requested that all QC data (including control limits) be contained in the analytical reports and ensured that all analytical runs were under statistical control at the time of analysis. The QCO also ensured that the analytical laboratory attained the required detection limits or had a valid technical reason when these limits were not attained. These values were flagged in the analytical report. The QCO examined all outliers and can request repeat analysis if the data are questionable.

SEDIMENT SAMPLING

Sediment samples were collected only if a station had an area > 1 m^2 of depositional habitat. If not, detailed notes on the site were made and pictures taken to provide evidence that the station was not suitable for sediment collection (This information is important to indicate the occurrence or the non-occurrence of depositional sediments for the sediment toxicity testing in the 1997 field program). The sampling device to be used (Eckman or ponar samplers) depended on the nature of the substrate and depth of water (see benthic sampling). Again, all sampling devices were of stainless steel construction. Only the upper two cm of the sediment column were used and the sampler penetration was a minimum of 4-5 cm depth to ensure the upper two cm was not disturbed. One composite sediment sample, consisting of five grab samples was collected per station. The upper two cm of substrate from each of the 5 grabs were placed in a glass or plastic mixing bowl. The composite sample was then homogenized in the bowl with a plastic spoon. Sample jars provided by the laboratory (i.e., pre-cleaned glass with teflon-lined lids) were filled to the top to minimize air space. Duplicate jars were collected at all stations in case of breakage and suspected contamination.

Quality Control Protocols for Sediment Sampling

The following guidelines were used to determine the acceptability of a grab sample: a) the sampler is not over-filled, b) overlying water is present indicating minimal leakage, c) overlying water is not excessively turbid indicating minimal disturbance, d) the desired penetration depth is achieved (i.e., 4-5 cm for a 2 cm deep surficial sample). If any of the above criteria were not met, the sample was rejected. The samples were placed in sample jars provided by the analytical laboratory (precleaned glass, teflon lined lids). The grab samplers were cleaned between stations using a phosphate-free detergent wash and a rinse with deionized water. The plastic utensils and bowls were cleaned between sampling stations using the following protocol: 1) a water rinse, 2) a phosphate-free soap wash, 3) a deionized water rinse, 4) a 5% HNO_3 rinse and 5) a final rinse in deionized water. Three swipe blanks were collected, each in the reference and affected areas, to determine the effectiveness of field decontamination procedures. The swipes consisted of acid-wetted, ashless filter paper wiped along the inside of the sampler and mixing bowl/spoon surfaces that are likely to contact sample media. These samples were placed in whirl-pack bags and sent to the analytical laboratory for extraction and metals analysis. One of the duplicate samples taken at each station was analyzed as a field replicate.

All samples were cooled and shipped to the designated laboratory for analysis. Each sample was analyzed for site specific metals, total organic carbon (TOC), particle size and loss on ignition. The quality control procedures to be followed by the analytical laboratory and the review of the quality of the data were the same as outlined above for the water quality parameters.

TOXICITY SAMPLES

The laboratory (B.A.R.) has already been chosen for the sublethal toxicity analyses. The samples were taken with sample pails provided by the laboratory. The procedures for effluent sampling followed those outlined in the document *Aquatic Effects Technology Evaluation Program Project #4.1.2a Extrapolation Study*. B.A.R. is expected to comply with the following QA/QC protocols:

- Written or referenced SOPs for each test
- Adequate training of personnel
- Appropriate instrument calibration and maintenance
- GLPs
- Dilution water controls
- Test record sheets
- Dose selection
- Reference toxicants
- Control charts
- Adequate data handling and reporting procedures.

The QCO will review all the reports and determine whether the reference toxicants fall within control limits, control mortality is limited etc.

FISH SAMPLES

Metallothionein and metals analysis were, where possible and appropriate, conducted on a minimum of 8 fish of 2 species at both the reference and exposure areas (total of 32 fish for each mine site). Where possible, 4 females and 4 males of each species were collected. Only fish collected for metallothionein and metals analysis were sacrificed in the study and all measurements were conducted on these fish. No field splitting of organs for metallothionein and metals analysis (kidney, gill, liver) was done with whole tissue samples forwarded to Dr. Klaverkamp's laboratory for processing and handling. Where fish larger than 20 cm were not available, whole fish (i.e., 10-15 cm length) were used for analyses with no dissection of fish attempted. Fish smaller than 10 cm were not targeted for metallothionein and metals analysis. Tissue and whole fish samples were frozen on dry ice and forwarded to the laboratory for analysis.

Standard operating procedures for gill netting, trap netting and backpack electrofishing are presented below. The maximum effort to be expended on electrofishing was 1 full day per station (reference and exposed; total 2 days). The maximum fishing effort for gill netting was 2 days per station (reference and exposed; total 4 days). Gill nets were checked frequently to collect living fish.

Protocol for Gill Netting

The protocol employed during gill netting was as follows:

1) Individual panels of various mesh sizes were assembled to comprise a gang of nets of required sizes. The order of assembly of sizes was the same for each gang. A bridle was attached to each end, and anchor/float lines were attached to the bridle appropriate for the water depth in which the nets were deployed. The section of rope between the anchor and the bridle was of sufficient length that the anchor could be placed on bottom before any netting is deployed.

2) Netting locations were selected that were free of major bottom irregularities or obstructions (steep drop-offs, tree stumps, etc). Upon selection of the preferred site, the net was deployed in a continuous fashion along the selected route. Care was taken to avoid tangles or twists of the net, and to ensure that marker buoys at each end were visible (i.e., above water) after setting. Water temperatures were taken on the bottom and at 2 m above the bottom at each end of the net if other than isothermal conditions were present. The location and orientation of the net relative to shoreline features were marked on an appropriate map and/or obtained by electronic positioning equipment (GPS). The above

noted information, the water depth at each end of the net, the date, time of day and other relevant information (wind direction and weather conditions, wave height, etc) were recorded in the field book for each netting location.

3) Upon retrieval, the same information as noted above (as applicable) was recorded. All fish collected were identified and enumerated. Those fish not required for further testing/analysis were live released provided they were in good condition. The remaining fish were analyzed, packaged and preserved, or disposed of according to the requirements of the sampling program.

Protocol for Trap Netting

The protocol for trap netting was as follows:

1) Prior to use in the water, the net was spread out on land and examined for holes and signs of excessive wear (broken and/or frayed lines or attachment points) if the condition of the net could not be determined from previous users. The lead, wings, house and all attachment lines were examined, as well as the house access point opening. All damages were repaired, the house opening was secured and the net was repacked to facilitate ease of deployment.

2) Netting sites were selected that are relatively smooth bottomed, of a substrate suitable for anchoring (i.e. mud, sand, and/or gravel; smooth bedrock not suitable) and free of major irregularities (large boulders, tree stumps or snags, etc.). If water visibility permitted, the selected location was examined from above to confirm its suitability.

3) The net was set perpendicular to shore such that the lead was in shallow water near shore and the house was in deeper water offshore. The net was continuously deployed from the bow of the boat, while backing offshore, until all parts of the net and all anchors were in the water. Upon setting the house anchor, the net was then tensioned. The wing anchors were then lifted and repositioned such that the wings were aligned at a 45° angle to the lead, and lightly tensioned. The date, time of day, water temperature and other appropriate information were recorded in the field book.

4) When servicing the net, the house float was lifted and the boat was pulled under the anchor line between the house and the house anchor. The boat was then manually pulled sideways to the house of the net, which was then passed over the boat until all fish were concentrated at the near shore end of the house. The house access point was then opened and the fish were removed, identified and enumerated. The fish required for analysis were retained, while the remainder were released live. The catch and the ancillary environmental data (as above) were recorded in the field book. The house opening was then closed and the boat backed out from beneath the net. Anchors were lifted and reset to re-tension the net as required.

Protocols for Back-Pack Electrofishing

The operators of the electrofishing gear will follow procedures outlined in standard fisheries text books. Before the electrofishing operations began, the amount of effort, either by distance, time or desired sample size was agreed upon in order to calculate catch per unit effort.

Health and safely procedures were followed strictly. These are also outlined in standard text books.

Analysis of Fish

At least 8 (preferably adult) fish of each sentinel species were, where possible and appropriate, collected from the reference and exposure areas. The biological variables measured on large (i.e., >20 cm) fish included, where possible and appropriate:

- fork length
- fresh weight
- external/internal conditions
- sex
- age
- gonad weight
- kidney weight
- egg size and mass (if appropriate)
- liver weight

No internal variables were measured on fish of less than 20 cm in length. Information on each fish species were recorded on the data logging sheets provided.

Length was measured to the nearest ±2 mm. Fork length is the length from the tip of the snout to the depth of the fork in the tail. Fish were towel dried and weighed to the nearest 1 g or 5% of total body weight.

An external examination was conducted for lumps and bumps, secondary sexual characteristics, missing fins or eyes, opercular, fin or gill damage, external lesions, presence of parasites, and other anomalous features. All external lesions were recorded as to position, shape, size, colour, depth, appearance on cut surface and any other features of note. Photographs were taken of lesions to aid in their interpretation. The external conditions were assessed according to the health assessment index of Adams et al. (1993); or Goede (1993) on data logging sheets.

Age were determined by the appropriate structure (scales, otoliths, pectoral spines) following established protocols. A single person (John Tost; North Shore Environmental) will perform the age determinations on all the fish. Aging structures were archived for future reference. Fish age will be confirmed by a second expert (minimum 10%).

The body cavity were opened to expose the internal organs. The internal examination of each fish included the recording and/or photographing of evident tumors, neoplasms and lesions in major organs including the liver and skin. The internal conditions will be assessed according to the health assessment index of Adams et al. (1993) or Goede and Barton (1990) on data logging sheets.

All internal organs were examined for lumps, bumps or abnormal features. The lower intestine and oesophagus were cut to allow total removal of the gastrointestinal tract. The liver was removed and weighed on pre-weighed aluminum pans. The liver samples must be weighed immediately to avoid loss of water. Care was taken to avoid rupturing the gall bladder and to remove the spleen before weighing. If the liver tissue was diffuse, it was teased from the intestines starting from the posterior and proceeding anteriorly. The liver was weighed, divided in half and frozen in separate plastic bags for metals and metallothionein analysis (see latest protocols from AETE).

The gonads were removed from the dorsal wall of the body cavity from the anterior to the posterior and weighed on a pre-weighed pan to the nearest 0.01 g or ±1% of the total organ weight. Care was taken to remove external mesenteries and visceral lipid deposits before weighing the gonads; gonadal membranes, however, remained intact. Egg volume and mass were measured on fresh eggs. One hundred eggs were counted in a stereoscopic microscope and added to a small graduated cylinder containing a known volume of water. The cylinder was placed on a balance so that the mass of the 100 eggs could be measured. The volume of the eggs was then determined from the displacement of the water in the cylinder.

The kidneys were removed by making lengthwise incisions along each edge of the tissue and then detached using the spoon end of a stainless steel weighing spatula by applying firm but gentle pressure against the upper abdominal cavity wall (dorsal aorta). In this procedure the kidney was scraped away from the dorsal aorta and associated connective tissue. The kidney was divided in half, placed in separate whirlpack bags and frozen on dry ice for both metals and metallothionein analysis.

The gills arches and attached filaments were removed by severing the dorsal and ventral cartilaginous attachment of the arches to the surrounding oral cavity. The gill arches were placed in whirlpack bags and frozen on dry ice for metals and metallothionein analysis.

REFERENCES

Adams, S.M., A.M. Brown and R.W. Goede. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. Transactions of the American Fisheries Society. 122:63-73.

APHA (American Public Health Association). 1995. Standard methods for the examination of water and wastewater. APHA, American Water Works Association, Water Environment Federation.

Goede, R.W. 1993. Fish health/condition assessment procedures. Utah Division of Wildlife Resources, Fisheries Experiment Station, Logan, UT.

QAMS. 1986. Development of data quality objectives. Description of Stages I and II (draft). Quality Assurance Management Staff. Environmental Protection Agency, Washington, D.C.

QAMS. 1990. Proposed glossary of quality assurance related terms. Quality Assurance Management Staff. Environmental Protection Agency, Washington, D.C.

APPENDIX B

Selected Site Photographs

Photo 1. Moose Creek - combined Inco/Falconbridge effluent, Site M3-1

Photo 2. Moose Creek - combined Inco/Falconbridge effluent, Site M3-2

Photo 3. Moose Creek - combined Inco/Falconbridge effluent, Site M3-3

Photo 4. Onaping River - upstream of OR3, flow measurement site (pool tail) and Surber sampling site (riffle)

Photo 5. Flow measurement upstream of OR3

Photo 6. Onaping River - OR3 - Exposure sites (1-6)

Photo 7. Onaping River - OR3 - upstream view, note gill net set buoy

Photo 8. Flow measurement upstream of OR1

Photo 9. Onaping River - downstream view to OR1 from Surber sampling site

Photo 10. Onaping River - Reference OR1 (sites 1-6)

APPENDIX C

Water Quality and Chemistry

APPENDIX C1

Detailed Methods

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 10/96
MDS Ref#: 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

invoiced
26100

Certificate of Analysis

Analysis Performed:

Alkalinity
Anions(Cl,NO2,NO3,o-PO4 & SO4)
RCAP MS Package, 8 Element ICPAES Scan
Reactive Silica
RCAP MS Package, 22 Element ICP-MS Scan
RCAP Calculations
Manual Conventionals(pH,Turbidity,Conductivity,Color)
Mercury, Cold Vapour AA, Digestion Required
Ammonia
Total Kjeldahl Nitrogen, Digestion Required
Dissolved Inorganic Carbon, as Carbon(Autoanalyzer)
Dissolved Organic Carbon, as Carbon(Autoanalyzer)
Total Suspended Solids
Cyanide, Free
Cyanide, Total(UV-Visible)

Methodology:

1) Determination of alkalinity in water by automated colorimetry.
U.S. EPA Method No. 310.2

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 10/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

2) Analysis of anions in water by ion chromatography and/or by colorimetry.
U.S. EPA Method No. 300.0 or
U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.

3) Analysis of trace metals in water by inductively coupled plasma atomic emission spectrometry.
U.S. EPA Method No. 200.7

4) Analysis of silicon in water by ICPAES and conversion to silica.
Standard Methods(17th ed.) No. 4500-Si G

5) Analysis of trace metals in water by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 200.8(Modification)

6) Determination of theoretical RCAP parameters by calculation.
EPL Internal Reference Method

7) Analysis of water for pH(by electrode), conductivity(by measuring resistance in micro siemens/cm), turbidity(by nephelometry) and color(by UV Visible Spectrometry).
U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 10/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

8) Cold Vapour Atomic Absorption Analysis of water for mercury.
U.S. EPA Method No. 245.2
(Reference - Varian Method No. AA-51)

9) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

10) Analysis of total Kjeldahl Nitrogen in water by colourimetric determination in a continuous liquid flow.
ASTM Method No. D3590-84AFD
Refer - Method No. 1100106 Issue 122289

11) The determination of dissolved inorganic carbon by converting species to carbon dioxide and measuring the decrease in absorbance of a colour reagent.
MOE Method No. ROM - 102AC2.1
(Refer Method No. 1102106 Issue 122989)

12) Sample is filtered, followed by the colourimetric determination of dissolved organic carbon in a continuous liquid flow.
MOE Method No. ROM - 102AC2
Refer - Method No. 1102106 Issue 122989

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 10/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

13) The determination of Total Suspended Solids by weight.
U.S. EPA Method No. 160.2
14) Determination of free cyanide in water by UV-Visible Spectrophotometry.
15) Analysis of cyanide in water by Ultra Violet Spectophotometry.
U.S. EPA Method No. 335.2

Instrumentation:

1) Cobas Fara Centrifugal Analyzer
2) Dionex Ion Chromatograph, 4500i/4000i or Cobas Fara II Analyzer
3, 4) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
5) PE Sciex ELAN 6000 ICP-MS Spectrometer
6) Calculation from existing results; no instrumentation required.
7) Orion pH meter/Radiometer Conductometer/Turbidity meter/UV-Visible
8) Varian SpectrAA 400 Plus AA/VGA 76/MCA 90 Mercury Analyzer
9) Skalar Segmented Flow Analyzer, Model SA 20/40
10,11,12) Technicon Autoanalyzer
13) Precision Mechanical Convention Oven/Sartorius Basic Balance
14,15) Hach UV - Visible Spectrophotometer, Model DR/3000

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 10/96
MDS Ref#: 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Sample Description: Water

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

for Certified By
T. Munshaw, M.Sc.,C.Chem
Director, Laboratory Operations

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
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Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

INVOICE # 26100

Certificate of Analysis

Analysis Performed:

Alkalinity
Anions(Cl,NO2,NO3,o-PO4 & SO4)
RCAP MS Package, 8 Element ICPAES Scan
Reactive Silica
RCAP MS Package, 22 Element ICP-MS Scan
RCAP Calculations
Manual Conventionals(pH,Turbidity,Conductivity,Color)
Mercury, Cold Vapour AA, Digestion Required
Ammonia
Total Kjeldahl Nitrogen, Digestion Required
Dissolved Inorganic Carbon, as Carbon(Autoanalyzer)
Dissolved Organic Carbon, as Carbon(Autoanalyzer)
Total Suspended Solids
Cyanide, Free
Cyanide, Total(UV-Visible)
Acid Digestion

Methodology:

1) Determination of alkalinity in water by automated colorimetry.
U.S. EPA Method No. 310.2

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Tel: 905•673•3255 Fax: 905•673•7399 Toll Free: 1•800•701•7092

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 15/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

2) Analysis of anions in water by ion chromatography and/or by colorimetry.
U.S. EPA Method No. 300.0 or
U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.

3) Analysis of trace metals in water by inductively coupled plasma atomic emission spectrometry.
U.S. EPA Method No. 200.7

4) Analysis of silicon in water by ICPAES and conversion to silica.
Standard Methods(17th ed.) No. 4500-Si G

5) Analysis of trace metals in water by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 200.8(Modification)

6) Determination of theoretical RCAP parameters by calculation.
EPL Internal Reference Method

7) Analysis of water for pH(by electrode), conductivity(by measuring resistance in micro siemens/cm), turbidity(by nephelometry) and color(by UV Visible Spectrometry).
U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

8) Cold Vapour Atomic Absorption Analysis of water for mercury.
U.S. EPA Method No. 245.2
(Reference - Varian Method No. AA-51)

9) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

10) Analysis of total Kjeldahl Nitrogen in water by colourimetric determination in a continuous liquid flow.
ASTM Method No. D3590-84AFD
Refer - Method No. 1100106 Issue 122289

11) The determination of dissolved inorganic carbon by converting species to carbon dioxide and measuring the decrease in absorbance of a colour reagent.
MOE Method No. ROM - 102AC2.1
(Refer Method No. 1102106 Issue 122989)

12) Sample is filtered, followed by the colourimetric determination of dissolved organic carbon in a continuous liquid flow.
MOE Method No. ROM - 102AC2
Refer - Method No. 1102106 Issue 122989

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 15/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

13) The determination of Total Suspended Solids by weight.
U.S. EPA Method No. 160.2
14) Determination of free cyanide in water by UV-Visible Spectrophotometry.
15) Analysis of cyanide in water by Ultra Violet Spectophotometry.
U.S. EPA Method No. 335.2
16) Acid digestion of water for metal determination by Inductively Coupled Plasma Emission Spectrometry and/or flame or furnace Atomic Absorption Spectroscopy.
U.S. EPA Method No. 3020

Instrumentation:

1) Cobas Fara Centrifugal Analyzer
2) Dionex Ion Chromatograph, 4500i/4000i or Cobas Fara II Analyzer
3, 4) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
5) PE Sciex ELAN 6000 ICP-MS Spectrometer
6) Calculation from existing results; no instrumentation required.
7) Orion pH meter/Radiometer Conductometer/Turbidity meter/UV-Visible
8) Varian SpectrAA 400 Plus AA/VGA 76/MCA 90 Mercury Analyzer
9) Skalar Segmented Flow Analyzer, Model SA 20/40

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Instrumentation: (Cont'd)

10,11,12) Technicon Autoanalyzer
13) Precision Mechanical Convention Oven/Sartorius Basic Balance
14,15) Hach UV - Visible Spectrophotometer, Model DR/3000
16) Thermolyne Hotplate/Hot Block

Sample Description: Water

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

Certified By
T. Munshaw, M.Sc., C.Chem
Director, Laboratory Operations

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

invoice #26240

Certificate of Analysis

Analysis Performed:

30 ELEMENT ICPAES AND ICP-MS SCAN
Alkalinity
Anions(Cl,NO2,NO3,o-PO4 & SO4)
RCAP MS Package, 8 Element ICPAES Scan
Reactive Silica
RCAP MS Package, 22 Element ICP-MS Scan
RCAP Calculations
Manual Conventionals(pH,Turbidity,Conductivity,Color)
Mercury, Cold Vapour AA, Digestion Required
Ammonia
Total Kjeldahl Nitrogen, Digestion Required
Dissolved Inorganic Carbon, as Carbon(Autoanalyzer)
Dissolved Organic Carbon, as Carbon(Autoanalyzer)
Total Suspended Solids
Cyanide, Free
Cyanide, Total(UV-Visible)
Acid Digestion

Methodology:

1) Determination of alkalinity in water by automated colorimetry.
U.S. EPA Method No. 310.2

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

2) Analysis of anions in water by ion chromatography and/or by colorimetry.
U.S. EPA Method No. 300.0 or
U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.

3) Analysis of trace metals in water by inductively coupled plasma atomic emission spectrometry.
U.S. EPA Method No. 200.7

4) Analysis of silicon in water by ICPAES and conversion to silica.
Standard Methods(17th ed.) No. 4500-Si G

5) Analysis of trace metals in water by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 200.8(Modification)

6) Determination of theoretical RCAP parameters by calculation.
EPL Internal Reference Method

7) Analysis of water for pH(by electrode), conductivity(by measuring resistance in micro siemens/cm), turbidity(by nephelometry) and color(by UV Visible Spectrometry).
U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

8) Cold Vapour Atomic Absorption Analysis of water for mercury.
U.S. EPA Method No. 245.2
(Reference - Varian Method No. AA-51)

9) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

10) Analysis of total Kjeldahl Nitrogen in water by colourimetric determination in a continuous liquid flow.
ASTM Method No. D3590-84AFD
Refer - Method No. 1100106 Issue 122289

11) The determination of dissolved inorganic carbon by converting species to carbon dioxide and measuring the decrease in absorbance of a colour reagent.
MOE Method No. ROM - 102AC2.1
(Refer Method No. 1102106 Issue 122989)

12) Sample is filtered, followed by the colourimetric determination of dissolved organic carbon in a continuous liquid flow.
MOE Method No. ROM - 102AC2
Refer - Method No. 1102106 Issue 122989

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 15/96
MDS Ref#:	966865
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Methodology: (Cont'd)

13) The determination of Total Suspended Solids by weight.
U.S. EPA Method No. 160.2
14) Determination of free cyanide in water by UV-Visible Spectrophotometry.
15) Analysis of cyanide in water by Ultra Violet Spectophotometry.
U.S. EPA Method No. 335.2
16) Acid digestion of water for metal determination by Inductively Coupled Plasma Emission Spectrometry and/or flame or furnace Atomic Absorption Spectroscopy.
U.S. EPA Method No. 3020

Instrumentation:

1) Cobas Fara Centrifugal Analyzer
2) Dionex Ion Chromatograph, 4500i/4000i or Cobas Fara II Analyzer
3, 4) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
5) PE Sciex ELAN 6000 ICP-MS Spectrometer
6) Calculation from existing results; no instrumentation required.
7) Orion pH meter/Radiometer Conductometer/Turbidity meter/UV-Visible
8) Varian SpectrAA 400 Plus AA/VGA 76/MCA 90 Mercury Analyzer
9) Skalar Segmented Flow Analyzer, Model SA 20/40

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 2/96
Date Reported: October 15/96
MDS Ref#: 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239
Sampled By: Mike Zimmer

Certificate of Analysis

Instrumentation:

10,11,12) Technicon Autoanalyzer
13) Precision Mechanical Convention Oven/Sartorius Basic Balance
14,15) Hach UV - Visible Spectrophotometer, Model DR/3000
16) Thermolyne Hotplate/Hot Block

Sample Description: Water

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

Certified By
T. Munshaw, M.Sc.,C.Chem
Director, Laboratory Operations

Water Received Oct 31/96

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 8/96
Date Reported: October 16/96
MDS Ref#: 967005
MDS Quote#: 96-697-GS
Client PO#: 96239

Sampled By: Irene Uddelaad

invoice #26265

Certificate of Analysis

Analysis Performed:

Alkalinity
Anions(Cl,NO2,NO3,o-PO4 & SO4)
RCAP MS Package, 8 Element ICPAES Scan
Reactive Silica
RCAP MS Package, 22 Element ICP-MS Scan
RCAP Calculations
Manual Conventionals(pH,Turbidity,Conductivity,Color)
Mercury, Cold Vapour AA, Digestion Required
Ammonia
Dissolved Inorganic Carbon, as Carbon(Autoanalyzer)
Dissolved Organic Carbon, as Carbon(Autoanalyzer)

Methodology:

1) Determination of alkalinity in water by automated colorimetry.
U.S. EPA Method No. 310.2
2) Analysis of anions in water by ion chromatography and/or by colorimetry.
U.S. EPA Method No. 300.0 or
U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.

6850 Goreway Drive, Mississauga, Ontario, Canada L4V 1V1
Tel: 905•673•3255 Fax: 905•673•7399 Toll Free: 1•800•701•7092

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 8/96
Date Reported:	October 16/96
MDS Ref#:	967005
MDS Quote#:	96-697-GS
Client PO#:	96239
Sampled By:	Irene Uddelaad

Certificate of Analysis

Methodology: (Cont'd)

3) Analysis of trace metals in water by inductively coupled plasma atomic emission spectrometry.
U.S. EPA Method No. 200.7

4) Analysis of silicon in water by ICPAES and conversion to silica.
Standard Methods(17th ed.) No. 4500-Si G

5) Analysis of trace metals in water by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 200.8(Modification)

6) Determination of theoretical RCAP parameters by calculation.
EPL Internal Reference Method

7) Analysis of water for pH(by electrode), conductivity(by measuring resistance in micro siemens/cm), turbidity(by nephelometry) and color(by UV Visible Spectrometry).
U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3

8) Cold Vapour Atomic Absorption Analysis of water for mercury.
U.S. EPA Method No. 245.2
(Reference - Varian Method No. AA-51)

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 8/96
Date Reported:	October 16/96
MDS Ref#:	967005
MDS Quote#:	96-697-GS
Client PO#:	96239
Sampled By:	Irene Uddelaad

Certificate of Analysis

Methodology: (Cont'd)

9) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

10) The determination of dissolved inorganic carbon by converting species to carbon dioxide and measuring the decrease in absorbance of a colour reagent.
MOE Method No. ROM - 102AC2.1
(Refer Method No. 1102106 Issue 122989)

11) Sample is filtered, followed by the colourimetric determination of dissolved organic carbon in a continuous liquid flow.
MOE Method No. ROM - 102AC2
Refer - Method No. 1102106 Issue 122989

Instrumentation:

1) Cobas Fara Centrifugal Analyzer
2) Dionex Ion Chromatograph, 4500i/4000i or Cobas Fara II Analyzer
3, 4) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
5) PE Sciex ELAN 6000 ICP-MS Spectrometer
6) Calculation from existing results; no instrumentation required.
7) Orion pH meter/Radiometer Conductometer/Turbidity meter/UV-Visible
8) Varian SpectrAA 400 Plus AA/VGA 76/MCA 90 Mercury Analyzer
9) Skalar Segmented Flow Analyzer, Model SA 20/40

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 8/96
Date Reported: October 16/96
MDS Ref#: 967005
MDS Quote#: 96-697-GS
Client PO#: 96239

Sampled By: Irene Uddelaad

Certificate of Analysis

10,11) Technicon Autoanalyzer

Sample Description: Water

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

for Certified By
M. Hartwell, M.Sc.
Director, Laboratory Operations

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
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N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 6/96
Date Reported: October 23/96
MDS Ref#: 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping
Sampled By: Geoff Carnegie

Invoice # 26792

Certificate of Analysis

Analysis Performed:

Alkalinity
Ammonia
Anions(Cl,NO2,NO3,o-PO4 & SO4)
RCAP MS Package, 8 Element ICPAES Scan
Reactive Silica
RCAP MS Package, 22 Element ICP-MS Scan
RCAP Calculations
Manual Conventionals(pH,Turbidity,Conductivity,Color)
Mercury, Cold Vapour AA, Digestion Required
Ammonia
Total Kjeldahl Nitrogen, Digestion Required
Dissolved Inorganic Carbon, as Carbon(Autoanalyzer)
Dissolved Organic Carbon, as Carbon(Autoanalyzer)
Total Suspended Solids
Cyanide, Free
Cyanide, Total(UV-Visible)
Acid Digestion

Methodology:

1) Determination of alkalinity in water by automated colorimetry.
U.S. EPA Method No. 310.2

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 6/96
Date Reported:	October 23/96
MDS Ref#:	966957
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Client PO#:	CANMET
Client Ref#:	96239Onaping
Sampled By:	Geoff Carnegie

Certificate of Analysis

Methodology: (Cont'd)

2) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

3) Analysis of anions in water by ion chromatography and/or by colorimetry.
U.S. EPA Method No. 300.0 or
U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.

4) Analysis of trace metals in water by inductively coupled plasma atomic emission spectrometry.
U.S. EPA Method No. 200.7

5) Analysis of silicon in water by ICPAES and conversion to silica.
Standard Methods(17th ed.) No. 4500-Si G

6) Analysis of trace metals in water by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 200.8(Modification)

7) Determination of theoretical RCAP parameters by calculation.
EPL Internal Reference Method

Client: Ecological Services for Planning
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Certificate of Analysis

Methodology: (Cont'd)

8) Analysis of water for pH(by electrode), conductivity(by measuring resistance in micro siemens/cm), turbidity(by nephelometry) and color(by UV Visible Spectrometry).
U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3

9) Cold Vapour Atomic Absorption Analysis of water for mercury.
U.S. EPA Method No. 245.2
(Reference - Varian Method No. AA-51)

10) Analysis of ammonia in water by colourimetry in a continuous liquid flow.
ASTM Method No. D1426-79 C
Refer - Method No. 1100106 Issue 122289

11) Analysis of total Kjeldahl Nitrogen in water by colourimetric determination in a continuous liquid flow.
ASTM Method No. D3590-84AFD
Refer - Method No. 1100106 Issue 122289

12) The determination of dissolved inorganic carbon by converting species to carbon dioxide and measuring the decrease in absorbance of a colour reagent.
MOE Method No. ROM - 102AC2.1
(Refer Method No. 1102106 Issue 122989)

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

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Certificate of Analysis

Methodology: (Cont'd)

13) Sample is filtered, followed by the colourimetric determination of dissolved organic carbon in a continuous liquid flow.
MOE Method No. ROM - 102AC2
Refer - Method No. 1102106 Issue 122989

14) The determination of Total Suspended Solids by weight.
U.S. EPA Method No. 160.2

15) Determination of free cyanide in water by UV-Visible Spectrophotometry.

16) Analysis of cyanide in water by Ultra Violet Spectophotometry.
U.S. EPA Method No. 335.2

17) Acid digestion of water for metal determination by Inductively Coupled Plasma Emission Spectrometry and/or flame or furnace Atomic Absorption Spectroscopy.
U.S. EPA Method No. 3020

Instrumentation:

1, 2) Cobas Fara Centrifugal Analyzer
3) Dionex Ion Chromatograph, 4500i/4000i or Cobas Fara II Analyzer

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

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Date Submitted:	October 6/96
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Certificate of Analysis

Instrumentation: (Cont'd)

4, 5) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
6) PE Sciex ELAN 6000 ICP-MS Spectrometer
7) Calculation from existing results; no instrumentation required.
8) Orion pH meter/Radiometer Conductometer/Turbidity meter/UV-Visible
9) Varian SpectrAA 400 Plus AA/VGA 76/MCA 90 Mercury Analyzer
10) Skalar Segmented Flow Analyzer, Model SA 20/40
11,12,13) Technicon Autoanalyzer
14) Precision Mechanical Convention Oven/Sartorius Basic Balance
15,16) Hach UV - Visible Spectrophotometer, Model DR/3000
17) Thermolyne Hotplate/Hot Block

Sample Description: Water

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

Certified By
M. Hartwell, M.Sc.
Director, Laboratory Operations

APPENDIX C2

QA/QC

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 10/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Alkalinity(as CaCO3)	na	1	mg/L	nd(b)	2	yes	97	87	113	yes	na	na	na	na	na	yes
Chloride	na	1	mg/L	nd(b)	2	yes	110	90	113	yes	na	na	na	na	na	yes
Nitrate(as N)	ON-DIL	0.05	mg/L	nd(b)	0.1	yes	109	88	114	yes	0.32	0.30	0.18	0.42	yes	yes
Nitrite(as N)	na	0.01	mg/L	nd(b)	0.03	yes	89	80	116	yes	na	na	na	na	na	yes
Orthophosphate(as P)	ON-DIL	0.01	mg/L	nd(b)	0.03	yes	103	90	110	yes	0.94	1.0	0.6	1.4	yes	yes
Sulphate	na	2	mg/L	nd(b)	3	yes	102	90	113	yes	na	na	na	na	na	yes
Boron	ON-DIL	0.005	mg/L	nd(b)	0.02	yes	102	85	115	yes	0.975	1.00	0.60	1.40	yes	yes
Calcium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	101	85	115	yes	0.6	1.0	0.2	1.8	yes	yes
Iron	ON-DIL	0.02	mg/L	nd(b)	0.03	yes	100	85	115	yes	0.92	1.00	0.60	1.40	yes	yes
Magnesium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	108	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Phosphorus	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	92	85	115	yes	0.8	1.0	0.4	1.6	yes	yes
Potassium	ON-DIL	0.5	mg/L	nd(b)	1.0	yes	100	85	115	yes	4.7	5.0	1.0	8.0	yes	yes
Sodium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	100	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Zinc	ON-DIL	0.002	mg/L	0.003(b)	0.02	yes	101	85	115	yes	1.01	1.00	0.60	1.40	yes	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	96	80	120	yes	na	na	na	na	na	yes
Aluminum	ON-DIL	0.01	mg/L	nd(b)	0.03	yes	103	85	115	yes	0.07	0.100	0.050	0.140	yes	yes
Antimony	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.086	0.100	0.050	0.140	yes	yes
Arsenic	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	107	85	115	yes	0.082	0.100	0.050	0.140	yes	yes
Barium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	105	85	115	yes	0.089	0.100	0.050	0.140	yes	yes
Beryllium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	103	85	115	yes	0.060	0.100	0.050	0.140	yes	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ
(b) = Analyte results on REPORT of ANALYSIS have been background corrected for the process blank.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 10/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Analysis of Water

Client Ref#: 96239

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Bismuth	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.082	0.100	0.050	0.140	yes	yes
Cadmium	ON-DIL	0.0005	mg/L	nd(b)	0.0010	yes	104	85	115	yes	0.0859	0.100	0.050	0.140	yes	yes
Chromium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.087	0.100	0.050	0.140	yes	yes
Cobalt	ON-DIL	0.001	mg/L	nd(b)	0.002	yes	106	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Copper	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Lead	ON-DIL	0.0001	mg/L	nd(b)	0.002	yes	99	85	115	yes	0.0828	0.100	0.050	0.140	yes	yes
Manganese	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Molybdenum	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Nickel	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.083	0.100	0.050	0.140	yes	yes
Selenium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.076	0.100	0.050	0.140	yes	yes
Silver	ON-DIL	0.0003	mg/L	nd(b)	0.0006	yes	104	85	115	yes	0.0802	0.100	0.050	0.140	yes	yes
Strontium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	106	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Thallium	ON-DIL	0.0001	mg/L	nd(b)	0.0002	yes	103	85	115	yes	0.0887	0.100	0.050	0.140	yes	yes
Tin	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	0.081	0.100	0.050	0.140	yes	yes
Titanium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Uranium	ON-DIL	0.0001	mg/L	nd(b)	0.0002	yes	102	85	115	yes	0.0878	0.100	0.050	0.140	yes	yes
Vanadium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.083	0.100	0.050	0.140	yes	yes
Colour	na	5	TCU	nd(b)	10	yes	94	85	115	yes	na	na	na	na	na	yes
Conductivity - @25°C	na	1	us/cm	na(b)	na	na	96	91	109	yes	na	na	na	na	na	yes
pH	na	0.1	Units	na(b)	na	na	99	98	102	yes	na	na	na	na	na	yes

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na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 10/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Analysis of Water

Client Ref#: 96239

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Turbidity	na	0.1	NTU	nd(b)	0.5	yes	96	81	129	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	103	79	120	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	104	79	119	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	104	79	119	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	0.07	0.1	yes	95	77	122	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	nd	0.1	yes	96	77	122	yes	na	na	na	na	na	yes
Dissolved Inorganic Carbon(as C)	na	0.5	mg/L	nd	1.0	yes	na	na	na	na	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	102	80	116	yes	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	98	80	116	yes	na	na	na	na	na	yes
Total Suspended Solids	na	5	mg/L	nd	2	yes	99	82	118	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	92	77	127	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 10/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

NOTE THIS IS REPORTED ON NET BASIS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	INCO-EFFLUENT 96/10/01	INCO-EFFLUENT UFILT. 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UFILT. 96/10/01
Alkalinity(as CaCO3)	1	mg/L	16	-	7	7	-
Chloride	1	mg/L	112	-	1	1	-
Nitrate(as N)	0.05	mg/L	4.32	-	0.11	0.10	-
Nitrite(as N)	0.01	mg/L	0.23	-	nd	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	nd	-
Sulphate	2	mg/L	899	-	5	5	-
Boron	0.005	mg/L	0.044	-	nd	nd	-
Calcium	0.1	mg/L	341	-	3.8	3.7	-
Iron	0.02	mg/L	nd	-	0.29	0.30	-
Magnesium	0.1	mg/L	14.0	-	1.1	1.1	-
Phosphorus	0.1	mg/L	nd	-	nd	nd	-
Potassium	0.5	mg/L	33.1	-	0.8	0.5	-
Reactive Silica(SiO2)	0.5	mg/L	1.6	-	3.6	3.7	-
Sodium	0.1	mg/L	109	-	1.5	1.4	-
Zinc	0.002	mg/L	nd	-	0.005	0.005	-
Aluminum	0.01	mg/L	0.03	-	0.02	0.02	-
Antimony	0.002	mg/L	nd	-	nd	nd	-
Arsenic	0.002	mg/L	nd	-	nd	nd	-
Barium	0.005	mg/L	0.022	-	0.007	0.006	-
Beryllium	0.005	mg/L	nd	-	nd	nd	-
Bismuth	0.002	mg/L	nd	-	nd	nd	-
Cadmium	0.0005	mg/L	nd	-	nd	nd	-
Chromium	0.002	mg/L	0.004	-	0.002	0.002	-
Cobalt	0.001	mg/L	nd	-	nd	nd	-
Copper	0.002	mg/L	nd	-	nd	nd	-
Lead	0.0001	mg/L	nd	-	nd	nd	-
Manganese	0.002	mg/L	nd	-	0.003	0.003	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
\- = Not Requested
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 10/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	INCO-EFFLUENT 96/10/01	INCO-EFFLUENT UFILT. 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UFILT. 96/10/01
Molybdenum	0.002	mg/L	0.002	-	nd	nd	-
Nickel	0.002	mg/L	0.019	-	nd	nd	-
Selenium	0.002	mg/L	nd	-	nd	nd	-
Silver	0.0003	mg/L	nd	-	nd	nd	-
Strontium	0.005	mg/L	1.09	-	0.014	0.014	-
Thallium	0.0001	mg/L	nd	-	nd	nd	-
Tin	0.002	mg/L	nd	-	nd	nd	-
Titanium	0.002	mg/L	nd	-	nd	nd	-
Uranium	0.0001	mg/L	nd	-	nd	nd	-
Vanadium	0.002	mg/L	0.015	-	0.017	0.010	-
Anion Sum	na	meq/L	22.5	-	0.289	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	11	-	7	-	-
Carbonate(as CaCO3, calculated)	1	mg/L	4	-	nd	-	-
Cation Sum	na	meq/L	23.8	-	0.371	-	-
Colour	5	TCU	nd	-	37	36	-
Conductivity - @25°C	1	us/cm	1940	-	36	36	-
Hardness(as CaCO3)	0.1	mg/L	909	-	14.2	-	-
Ion Balance	0.01	%	2.86	-	12.4	-	-
Langelier Index at 20°C	na	na	1.73	-	-3.74	-	-
Langelier Index at 4°C	na	na	1.33	-	-4.14	-	-
pH	0.1	Units	9.6	-	6.3	6.2	-
Saturation pH at 20°C	na	units	7.82	-	9.99	-	-
Saturation pH at 4°C	na	units	8.22	-	10.4	-	-
Total Dissolved Solids(Calculated)	1	mg/L	1540	-	22	-	-
Turbidity	0.1	NTU	0.1	-	0.4	0.5	-
Mercury	0.1	ug/L	nd	nd	nd	-	nd
Ammonia(as N)	0.05	mg/L	0.49	-	nd	-	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
na = Not Applicable
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 10/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter Date Sampled >	LOQ	Units	INCO-EFFLUENT 96/10/01	INCO-EFFLUENT UFILT. 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UFILT. 96/10/01
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.89	-	3.05	-	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	3.5	-	2.1	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	2.6	-	5.9	-	-
Total Suspended Solids	5	mg/L	nd	-	nd	-	-
Cyanide, Free	0.002	mg/L	nd	-	nd	-	-
Cyanide, Total	0.005	mg/L	nd	-	nd	-	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 10/96
MDS Ref#:	966847
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Additional Comments:

NOTE:
Ion balance in excess of 5% due to the low ionic strength of the sample.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Alkalinity(as CaCO3)	na	1	mg/L	nd(b)	2	yes	97	87	113	yes	na	na	na	na	na	yes
Chloride	na	1	mg/L	nd(b)	2	yes	110	90	113	yes	na	na	na	na	na	yes
Nitrate(as N)	ON-DIL	0.05	mg/L	nd(b)	0.1	yes	109	88	114	yes	0.32	0.30	0.18	0.42	yes	yes
Nitrite(as N)	na	0.01	mg/L	nd(b)	0.03	yes	89	80	116	yes	na	na	na	na	na	yes
Orthophosphate(as P)	ON-DIL	0.01	mg/L	nd(b)	0.03	yes	103	90	110	yes	0.94	1.0	0.6	1.4	yes	yes
Sulphate	na	2	mg/L	nd(b)	3	yes	102	90	113	yes	na	na	na	na	na	yes
Boron	ON-DIL	0.005	mg/L	nd(b)	0.02	yes	102	85	115	yes	0.975	1.00	0.60	1.40	yes	yes
Calcium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	101	85	115	yes	0.6	1.0	0.2	1.8	yes	yes
Iron	ON-DIL	0.02	mg/L	nd(b)	0.03	yes	100	85	115	yes	0.92	1.00	0.60	1.40	yes	yes
Magnesium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	108	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Phosphorus	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	92	85	115	yes	0.8	1.0	0.4	1.6	yes	yes
Potassium	ON-DIL	0.5	mg/L	nd(b)	1.0	yes	100	85	115	yes	4.7	5.0	1.0	8.0	yes	yes
Sodium	ON-DIL	0.1	mg/L	nd(b)	0.2	yes	100	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Zinc	ON-DIL	0.002	mg/L	0.003(b)	0.02	yes	101	85	115	yes	1.01	1.00	0.60	1.40	yes	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	96	80	120	yes	na	na	na	na	na	yes
Aluminum	ON-DIL	0.01	mg/L	nd(b)	0.03	yes	103	85	115	yes	0.07	0.100	0.050	0.140	yes	yes
Antimony	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.086	0.100	0.050	0.140	yes	yes
Arsenic	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	107	85	115	yes	0.082	0.100	0.050	0.140	yes	yes
Barium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	105	85	115	yes	0.089	0.100	0.050	0.140	yes	yes
Beryllium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	103	85	115	yes	0.060	0.100	0.050	0.140	yes	yes

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MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Bismuth	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.082	0.100	0.050	0.140	yes	yes
Cadmium	ON-DIL	0.0005	mg/L	nd(b)	0.0010	yes	104	85	115	yes	0.0859	0.100	0.050	0.140	yes	yes
Chromium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.087	0.100	0.050	0.140	yes	yes
Cobalt	ON-DIL	0.001	mg/L	nd(b)	0.002	yes	106	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Copper	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Lead	ON-DIL	0.0001	mg/L	nd(b)	0.002	yes	99	85	115	yes	0.0828	0.100	0.050	0.140	yes	yes
Manganese	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Molybdenum	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.084	0.100	0.050	0.140	yes	yes
Nickel	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.083	0.100	0.050	0.140	yes	yes
Selenium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.076	0.100	0.050	0.140	yes	yes
Silver	ON-DIL	0.0003	mg/L	nd(b)	0.0006	yes	104	85	115	yes	0.0802	0.100	0.050	0.140	yes	yes
Strontium	ON-DIL	0.005	mg/L	nd(b)	0.01	yes	106	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Thallium	ON-DIL	0.0001	mg/L	nd(b)	0.0002	yes	103	85	115	yes	0.0887	0.100	0.050	0.140	yes	yes
Tin	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	0.081	0.100	0.050	0.140	yes	yes
Titanium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Uranium	ON-DIL	0.0001	mg/L	nd(b)	0.0002	yes	102	85	115	yes	0.0878	0.100	0.050	0.140	yes	yes
Vanadium	ON-DIL	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.083	0.100	0.050	0.140	yes	yes
Colour	na	5	TCU	nd(b)	10	yes	94	85	115	yes	na	na	na	na	na	yes
Conductivity - @25°C	na	1	us/cm	na(b)	na	na	96	91	109	yes	na	na	na	na	na	yes
pH	na	0.1	Units	na(b)	na	na	99	98	102	yes	na	na	na	na	na	yes

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MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966847
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Turbidity	na	0.1	NTU	nd(b)	0.5	yes	96	81	129	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	103	79	120	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	104	79	119	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	104	79	119	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	0.07	0.1	yes	95	77	122	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	nd	0.1	yes	96	77	122	yes	na	na	na	na	na	yes
Dissolved Inorganic Carbon(as C)	na	0.5	mg/L	nd	1.0	yes	na	na	na	na	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	102	80	116	yes	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	98	80	116	yes	na	na	na	na	na	yes
Total Suspended Solids	na	5	mg/L	nd	2	yes	99	82	118	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	92	77	127	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	INCO -EFFLUENT 96/10/01	INCO-EFFL. UNFILTERED 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UNFILTERED 96/10/01
Alkalinity(as CaCO3)	1	mg/L	16	-	7	7	-
Chloride	1	mg/L	112	-	1	1	-
Nitrate(as N)	0.05	mg/L	4.32	-	0.11	0.10	-
Nitrite(as N)	0.01	mg/L	0.23	-	nd	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	nd	-
Sulphate	2	mg/L	899	-	5	5	-
Boron	0.005	mg/L	0.044	0.056	nd	nd	0.006
Calcium	0.1	mg/L	341	345	3.8	3.7	3.6
Iron	0.02	mg/L	nd	nd	0.29	0.30	0.34
Magnesium	0.1	mg/L	14.0	15.6	1.1	1.1	1.1
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	33.1	37.5	0.8	0.5	3.1
Reactive Silica(SiO2)	0.5	mg/L	1.6	-	3.6	3.7	-
Sodium	0.1	mg/L	109	125	1.5	1.4	1.6
Zinc	0.002	mg/L	nd	0.059	0.005	0.005	0.006
Aluminum	0.01	mg/L	0.03	nd	0.02	0.02	0.03
Antimony	0.002	mg/L	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd
Barium	0.005	mg/L	0.022	0.022	0.007	0.006	0.006
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd
Cadmium	0.0005	mg/L	nd	nd	nd	nd	nd
Chromium	0.002	mg/L	0.004	0.004	0.002	0.002	nd
Cobalt	0.001	mg/L	nd	nd	nd	nd	nd
Copper	0.002	mg/L	nd	nd	nd	nd	nd
Lead	0.0001	mg/L	nd	0.0018	nd	nd	nd
Manganese	0.002	mg/L	nd	0.002	0.003	0.003	0.011

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	INCO -EFFLUENT 96/10/01	INCO-EFFL. UNFILTERED 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UNFILTERED 96/10/01
Molybdenum	0.002	mg/L	0.002	0.002	nd	nd	nd
Nickel	0.002	mg/L	0.019	0.027	nd	nd	nd
Selenium	0.002	mg/L	nd	nd	nd	nd	nd
Silver	0.0003	mg/L	nd	nd	nd	nd	nd
Strontium	0.005	mg/L	1.09	1.04	0.014	0.014	0.014
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	0.015	0.012	0.017	0.010	0.012
Anion Sum	na	meq/L	22.5	-	0.289	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	11	-	7	-	-
Carbonate(as CaCO3, calculated)	1	mg/L	4	-	nd	-	-
Cation Sum	na	meq/L	23.8	-	0.371	-	-
Colour	5	TCU	nd	-	37	36	-
Conductivity - @25°C	1	us/cm	1940	-	36	36	-
Hardness(as CaCO3)	0.1	mg/L	909	-	14.2	-	-
Ion Balance	0.01	%	2.86	-	12.4	-	-
Langelier Index at 20°C	na	na	1.73	-	-3.74	-	-
Langelier Index at 4°C	na	na	1.33	-	-4.14	-	-
pH	0.1	Units	9.6	-	6.3	6.2	-
Saturation pH at 20°C	na	units	7.82	-	9.99	-	-
Saturation pH at 4°C	na	units	8.22	-	10.4	-	-
Total Dissolved Solids(Calculated)	1	mg/L	1540	-	22	-	-
Turbidity	0.1	NTU	0.1	-	0.4	0.5	-
Mercury	0.1	ug/L	nd	nd	nd	-	nd
Ammonia(as N)	0.05	mg/L	0.49	-	nd	-	-

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966847
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter Date Sampled >	LOQ	Units	INCO -EFFLUENT 96/10/01	INCO-EFFL. UNFILTERED 96/10/01	ON-DIL 96/10/01	ON-DIL Replicate	ON-DIL UNFILTERED 96/10/01
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.89	-	3.05	-	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	3.5	-	2.1	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	2.6	-	5.9	-	-
Total Suspended Solids	5	mg/L	nd	-	nd	-	-
Cyanide, Free	0.002	mg/L	nd	-	nd	-	-
Cyanide, Total	0.005	mg/L	nd	-	nd	-	-

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Client:	Ecological Services for Planning 361 Southgate Drive Guelph, ONT, CANADA N1G 3M5	Date Submitted: Date Reported: MDS Ref#: MDS Quote#:	October 2/96 October 15/96 966847 96-697-GS
Fax:	519-836-2493	Client Ref#: Sampled By:	96239 Mike Zimmer
Attn:	Barbara Dowsley		

Certificate of Analysis

Additional Comments:

NOTE:
Ion balance in excess of 5% due to the low ionic strength of the sample.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Alkalinity(as CaCO3)	na	1	mg/L	nd(b)	2	yes	97	87	113	yes	na	na	na	na	na	yes
Chloride	na	1	mg/L	nd(b)	2	yes	110	90	113	yes	na	na	na	na	na	yes
Nitrate(as N)	M3-1	0.05	mg/L	nd(b)	0.1	yes	108	88	114	yes	0.32	0.30	0.18	0.42	yes	yes
Nitrite(as N)	na	0.01	mg/L	nd(b)	0.03	yes	86	80	116	yes	na	na	na	na	na	yes
Orthophosphate(as P)	na	0.01	mg/L	nd(b)	0.03	yes	100	90	110	yes	na	na	na	na	na	yes
Sulphate	na	2	mg/L	nd(b)	3	yes	102	90	113	yes	na	na	na	na	na	yes
Boron	M3-1	0.005	mg/L	nd(b)	0.02	yes	106	85	115	yes	1.05	1.00	0.60	1.40	yes	yes
Boron	M3-1 [total]	0.005	mg/L	nd(b)	0.02	yes	102	85	115	yes	0.998	1.00	0.60	1.40	yes	yes
Calcium	M3-1	0.1	mg/L	nd(b)	0.2	yes	102	85	115	yes	*	*	*	*	*	yes
Calcium	M3-1 [total]	0.1	mg/L	nd(b)	0.2	yes	101	85	115	yes	*	*	*	*	*	yes
Iron	M3-1	0.02	mg/L	nd(b)	0.03	yes	101	85	115	yes	1.03	1.00	0.60	1.40	yes	yes
Iron	M3-1 [total]	0.02	mg/L	nd(b)	0.03	yes	100	85	115	yes	0.97	1.00	0.60	1.40	yes	yes
Magnesium	M3-1	0.1	mg/L	nd(b)	0.2	yes	110	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Magnesium	M3-1 [total]	0.1	mg/L	nd(b)	0.2	yes	108	85	115	yes	*	*	*	*	*	yes
Phosphorus	M3-1	0.1	mg/L	nd(b)	0.2	yes	91	85	115	yes	0.9	1.0	0.4	1.6	yes	yes
Phosphorus	M3-1 [total]	0.1	mg/L	nd(b)	0.2	yes	92	85	115	yes	1.0	1.0	0.4	1.6	yes	yes
Potassium	M3-1	0.5	mg/L	nd(b)	1.0	yes	92	85	115	yes	5.2	5.0	1.0	8.0	yes	yes
Potassium	M3-1 [total]	0.5	mg/L	nd(b)	1.0	yes	100	85	115	yes	4.8	5.0	1.0	8.0	yes	yes
Sodium	M3-1	0.1	mg/L	nd(b)	0.2	yes	103	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Sodium	M3-1 [total]	0.1	mg/L	nd(b)	0.2	yes	100	85	115	yes	*	*	*	*	*	yes

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Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Zinc	M3-1	0.002	mg/L	0.003(b	0.02	yes	102	85	115	yes	1.04	1.00	0.60	1.40	yes	yes
Zinc	M3-1 [total]	0.002	mg/L	0.003(b	0.02	yes	101	85	115	yes	0.908	1.00	0.60	1.40	yes	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	96	80	120	yes	na	na	na	na	na	yes
Aluminum	M3-1	0.01	mg/L	nd(b)	0.03	yes	88	85	115	yes	*	*	*	*	*	yes
Aluminum	na	0.01	mg/L	nd(b)	0.03	yes	114	85	115	yes	na	na	na	na	na	yes
Antimony	M3-1	0.002	mg/L	nd(b)	0.004	yes	108	85	115	yes	0.135	0.100	0.050	0.140	yes	yes
Antimony	na	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	na	na	na	na	na	yes
Arsenic	M3-1	0.002	mg/L	nd(b)	0.004	yes	90	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Arsenic	na	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	na	na	na	na	na	yes
Barium	M3-1	0.005	mg/L	nd(b)	0.01	yes	113	85	115	yes	*	*	*	*	*	yes
Barium	na	0.005	mg/L	nd(b)	0.01	yes	104	85	115	yes	na	na	na	na	na	yes
Beryllium	M3-1	0.005	mg/L	nd(b)	0.01	yes	100	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Beryllium	na	0.005	mg/L	nd(b)	0.01	yes	107	85	115	yes	na	na	na	na	na	yes
Bismuth	M3-1	0.002	mg/L	nd(b)	0.004	yes	94	85	115	yes	0.099	0.100	0.050	0.140	yes	yes
Bismuth	na	0.002	mg/L	nd(b)	0.004	yes	98	85	115	yes	na	na	na	na	na	yes
Cadmium	M3-1	0.0005	mg/L	nd(b)	0.0010	yes	107	85	115	yes	0.1290	0.100	0.050	0.140	yes	yes
Cadmium	na	0.0005	mg/L	nd(b)	0.0010	yes	104	85	115	yes	na	na	na	na	na	yes
Chromium	M3-1	0.002	mg/L	nd(b)	0.004	yes	96	85	115	yes	0.098	0.100	0.050	0.140	yes	yes
Chromium	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Cobalt	M3-1	0.001	mg/L	nd(b)	0.002	yes	102	85	115	yes	*	*	*	*	*	yes

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Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
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Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Cobalt	na	0.001	mg/L	nd(b)	0.002	yes	105	85	115	yes	na	na	na	na	na	yes
Copper	M3-1	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	*	*	*	*	*	yes
Copper	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Lead	M3-1	0.0001	mg/L	nd(b)	0.002	yes	94	85	115	yes	0.1120	0.100	0.050	0.140	yes	yes
Lead	na	0.0001	mg/L	nd(b)	0.002	yes	100	85	115	yes	na	na	na	na	na	yes
Manganese	M3-1	0.002	mg/L	nd(b)	0.004	yes	94	85	115	yes	*	*	*	*	*	yes
Manganese	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Molybdenum	M3-1	0.002	mg/L	nd(b)	0.004	yes	94	85	115	yes	0.114	0.100	0.050	0.140	yes	yes
Molybdenum	na	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	na	na	na	na	na	yes
Nickel	M3-1	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	*	*	*	*	*	yes
Nickel	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Selenium	M3-1	0.002	mg/L	nd(b)	0.004	yes	90	85	115	yes	0.126	0.100	0.050	0.140	yes	yes
Selenium	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Silver	M3-1	0.0003	mg/L	nd(b)	0.0006	yes	114	85	115	yes	0.1310	0.100	0.050	0.140	yes	yes
Silver	na	0.0003	mg/L	nd(b)	0.0006	yes	96	85	115	yes	na	na	na	na	na	yes
Strontium	M3-1	0.005	mg/L	nd(b)	0.01	yes	90	85	115	yes	*	*	*	*	*	yes
Strontium	na	0.005	mg/L	nd(b)	0.01	yes	105	85	115	yes	na	na	na	na	na	yes
Thallium	M3-1	0.0001	mg/L	nd(b)	0.0002	yes	94	85	115	yes	0.1060	0.100	0.050	0.140	yes	yes
Thallium	na	0.0001	mg/L	nd(b)	0.0002	yes	100	85	115	yes	na	na	na	na	na	yes
Tin	M3-1	0.002	mg/L	nd(b)	0.004	yes	109	85	115	yes	0.130	0.100	0.050	0.140	yes	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Tin	na	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	na	na	na	na	na	yes
Titanium	M3-1	0.002	mg/L	nd(b)	0.004	yes	95	85	115	yes	0.107	0.100	0.050	0.140	yes	yes
Titanium	na	0.002	mg/L	nd(b)	0.004	yes	100	85	115	yes	na	na	na	na	na	yes
Uranium	M3-1	0.0001	mg/L	nd(b)	0.0002	yes	90	85	115	yes	0.1000	0.100	0.050	0.140	yes	yes
Uranium	na	0.0001	mg/L	nd(b)	0.0002	yes	101	85	115	yes	na	na	na	na	na	yes
Vanadium	M3-1	0.002	mg/L	nd(b)	0.004	yes	96	85	115	yes	0.138	0.100	0.050	0.140	yes	yes
Vanadium	na	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	na	na	na	na	na	yes
Colour	na	5	TCU	nd(b)	10	yes	100	85	115	yes	na	na	na	na	na	yes
Conductivity - @25°C	na	1	us/cm	na(b)	na	na	96	91	109	yes	na	na	na	na	na	yes
pH	na	0.1	Units	na(b)	na	na	99	98	102	yes	na	na	na	na	na	yes
Turbidity	na	0.1	NTU	nd(b)	0.5	yes	96	81	129	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	99	79	120	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	98	79	119	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	98	79	119	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	nd	0.1	yes	100	77	122	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	nd	0.1	yes	96	77	122	yes	na	na	na	na	na	yes
Dissolved Inorganic Carbon(as C)	na	0.5	mg/L	nd	1.0	yes	na	na	na	na	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	98	80	116	yes	na	na	na	na	na	yes
Total Suspended Solids	na	5	mg/L	nd	2	yes	99	82	118	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	92	77	127	yes	na	na	na	na	na	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
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ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 15/96
MDS Ref # : 966865
MDS Quote#: 96-697-GS

Client Ref#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	92	77	127	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	90	82	115	yes	na	na	na	na	na	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Filter Total

Parameter / Date Sampled >	LOQ	Units	Blank 96/09/30	Blank [total] 96/09/30	M3-1 96/09/30	M3-1 Replicate	M3-1 [total] 96/09/30	M3-1 [total] Replicate	M3-2 96/09/30	M3-2 [total] 96/09/30
Alkalinity(as CaCO3)	1	mg/L	nd	-	15	15	-	-	15	-
Chloride	1	mg/L	nd	-	148	148	-	-	145	-
Nitrate(as N)	0.05	mg/L	nd	-	0.48	0.48	-	-	0.49	-
Nitrite(as N)	0.01	mg/L	nd	-	nd	nd	-	-	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	nd	-	-	nd	-
Sulphate	2	mg/L	nd	-	586	586	-	-	588	-
Boron	0.005	mg/L	nd	nd	0.035	0.036	0.029	0.031	0.033	0.028
Calcium	0.1	mg/L	0.8	nd	277	270	279	285	270	281
Iron	0.02	mg/L	nd	nd	0.26	0.26	0.38	0.39	0.28	0.36
Magnesium	0.1	mg/L	0.1	nd	5.8	5.8	5.5	5.6	5.8	5.2
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	nd	nd	21.1	20.8	16.2	16.9	21.1	16.4
Reactive Silica(SiO2)	0.5	mg/L	nd	-	7.2	7.0	-	-	7.0	-
Sodium	0.1	mg/L	0.3	0.2	78.2	78.9	72.0	74.2	80.4	67.9
Zinc	0.002	mg/L	0.047	nd	0.033	0.034	0.022	0.023	0.039	0.020
Aluminum	0.01	mg/L	nd	nd	0.14	0.13	0.25	-	0.14	0.25
Antimony	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	Blank 96/09/30	Blank [total] 96/09/30	M3-1 96/09/30	M3-1 Replicate	M3-1 [total] 96/09/30	M3-1 [total] Replicate	M3-2 96/09/30	M3-2 [total] 96/09/30
Barium	0.005	mg/L	nd	nd	0.041	0.044	0.027	-	0.042	0.027
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Cadmium	0.0005	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Chromium	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Cobalt	0.001	mg/L	nd	nd	0.024	0.024	0.021	-	0.023	0.020
Copper	0.002	mg/L	0.048	nd	0.092	0.094	0.096	-	0.092	0.096
Lead	0.0001	mg/L	0.0003	nd	0.0007	0.0007	nd	-	0.0008	nd
Manganese	0.002	mg/L	nd	nd	0.138	0.132	0.126	-	0.131	0.125
Molybdenum	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Nickel	0.002	mg/L	0.003	0.002	0.885	0.886	0.749	-	0.869	0.748
Selenium	0.002	mg/L	nd	nd	0.003	0.003	nd	-	0.003	nd
Silver	0.0003	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Strontium	0.005	mg/L	nd	nd	0.654	0.621	0.615	-	0.641	0.613
Thallium	0.0001	mg/L	nd	nd	0.0003	0.0002	nd	-	0.0003	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	-	nd	nd
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	-	nd	nd

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	Blank 96/09/30	Blank [total] 96/09/30	M3-1 96/09/30	M3-1 Replicate	M3-1 [total] 96/09/30	M3-1 [total] Replicate	M3-2 96/09/30	M3-2 [total] 96/09/30
Vanadium	0.002	mg/L	nd	0.006	nd	0.002	0.008	-	0.003	0.008
Anion Sum	na	meq/L	0.000	-	16.7	16.7	-	-	16.6	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	nd	-	15	15	-	-	15	-
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	nd	-	-	nd	-
Cation Sum	na	meq/L	0.000	-	17.5	NCALC	-	-	18.2	-
Colour	5	TCU	nd	-	18	18	-	-	17	-
Conductivity - @25°C	1	us/cm	3	-	1540	1540	-	-	1520	-
Hardness(as CaCO3)	0.1	mg/L	nd	-	698	722	-	-	713	-
Ion Balance	0.01	%	na	-	2.41	NCALC	-	-	4.54	-
Langelier Index at 20°C	na	na	NCALC	-	-0.947	NCALC	-	-	-0.928	-
Langelier Index at 4°C	na	na	NCALC	-	-1.35	NCALC	-	-	-1.33	-
pH	0.1	Units	6.8	-	7.0	7.0	-	-	7.0	-
Saturation pH at 20°C	na	units	NCALC	-	7.93	NCALC	-	-	7.92	-
Saturation pH at 4°C	na	units	NCALC	-	8.33	NCALC	-	-	8.32	-
Total Dissolved Solids(Calculated)	1	mg/L	nd	-	1120	NCALC	-	-	1130	-
Turbidity	0.1	NTU	nd	-	1.3	1.3	-	-	1.3	-
Mercury	0.1	ug/L	nd	nd	0.1	-	nd	-	nd	nd
Ammonia(as N)	0.05	mg/L	nd	-	0.63	-	-	-	0.60	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
na = Not Applicable
NCALC = Not Calculated
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	Blank 96/09/30	Blank [total] 96/09/30	M3-1 96/09/30	M3-1 Replicate	M3-1 [total] 96/09/30	M3-1 [total] Replicate	M3-2 96/09/30	M3-2 [total] 96/09/30
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	-	0.77	-	-	-	0.78	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	0.8	-	3.8	-	-	-	3.7	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	nd	-	2.0	-	-	-	2.0	-
Total Suspended Solids	5	mg/L	-	-	nd	-	-	-	nd	-
Cyanide, Free	0.002	mg/L	nd	-	nd	-	-	-	nd	-
Cyanide, Total	0.005	mg/L	nd	-	nd	-	-	-	nd	-

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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	M3-3 96/09/30	M3-3 Replicate	M3-3 [total] 96/09/30					
Alkalinity(as CaCO3)	1	mg/L	15	-	-					
Chloride	1	mg/L	146	-	-					
Nitrate(as N)	0.05	mg/L	0.51	-	-					
Nitrite(as N)	0.01	mg/L	nd	-	-					
Orthophosphate(as P)	0.01	mg/L	nd	-	-					
Sulphate	2	mg/L	590	-	-					
Boron	0.005	mg/L	0.030	-	0.025					
Calcium	0.1	mg/L	270	-	273					
Iron	0.02	mg/L	0.26	-	0.36					
Magnesium	0.1	mg/L	5.8	-	5.1					
Phosphorus	0.1	mg/L	nd	-	nd					
Potassium	0.5	mg/L	22.1	-	11.5					
Reactive Silica(SiO2)	0.5	mg/L	7.0	-	-					
Sodium	0.1	mg/L	80.5	-	66.6					
Zinc	0.002	mg/L	0.040	-	0.021					
Aluminum	0.01	mg/L	0.13	-	0.25					
Antimony	0.002	mg/L	nd	-	nd					
Arsenic	0.002	mg/L	nd	-	nd					

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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Client Ref#: 96239

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	M3-3 96/09/30	M3-3 Replicate	M3-3 [total] 96/09/30					
Barium	0.005	mg/L	0.044	-	0.026					
Beryllium	0.005	mg/L	nd	-	nd					
Bismuth	0.002	mg/L	nd	-	nd					
Cadmium	0.0005	mg/L	nd	-	nd					
Chromium	0.002	mg/L	nd	-	nd					
Cobalt	0.001	mg/L	0.023	-	0.019					
Copper	0.002	mg/L	0.084	-	0.091					
Lead	0.0001	mg/L	0.0008	-	nd					
Manganese	0.002	mg/L	0.128	-	0.120					
Molybdenum	0.002	mg/L	nd	-	nd					
Nickel	0.002	mg/L	0.870	-	0.711					
Selenium	0.002	mg/L	0.003	-	nd					
Silver	0.0003	mg/L	nd	-	nd					
Strontium	0.005	mg/L	0.641	-	0.585					
Thallium	0.0001	mg/L	0.0003	-	nd					
Tin	0.002	mg/L	nd	-	nd					
Titanium	0.002	mg/L	nd	-	nd					
Uranium	0.0001	mg/L	nd	-	nd					

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Analysis of Water

Client Ref#: 96239

Parameter / Date Sampled >	LOQ	Units	M3-3 96/09/30	M3-3 Replicate	M3-3 [total] 96/09/30					
Vanadium	0.002	mg/L	0.003	-	0.008					
Anion Sum	na	meq/L	16.7	-	-					
Bicarbonate(as CaCO3, calculated)	1	mg/L	15	-	-					
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-					
Cation Sum	na	meq/L	18.3	-	-					
Colour	5	TCU	12	-	-					
Conductivity - @25°C	1	us/cm	1530	-	-					
Hardness(as CaCO3)	0.1	mg/L	736	-	-					
Ion Balance	0.01	%	4.48	-	-					
Langelier Index at 20°C	na	na	-0.913	-	-					
Langelier Index at 4°C	na	na	-1.31	-	-					
pH	0.1	Units	7.0	-	-					
Saturation pH at 20°C	na	units	7.90	-	-					
Saturation pH at 4°C	na	units	8.30	-	-					
Total Dissolved Solids(Calculated)	1	mg/L	1140	-	-					
Turbidity	0.1	NTU	1.3	-	-					
Mercury	0.1	ug/L	nd	-	nd					
Ammonia(as N)	0.05	mg/L	0.62	-	-					

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 15/96
MDS Ref # : 966865
MDS Quote #: 96-697-GS

Client Ref#: 96239

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	M3-3 96/09/30	M3-3 Replicate	M3-3 [total] 96/09/30					
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.73	-	-					
Dissolved Inorganic Carbon(as C)	0.5	mg/L	3.8	-	-					
Dissolved Organic Carbon(DOC)	0.5	mg/L	1.8	-	-					
Total Suspended Solids	5	mg/L	nd	-	-					
Cyanide, Free	0.002	mg/L	nd	-	-					
Cyanide, Total	0.005	mg/L	nd	-	-					

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
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Client: Ecological Services for
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 2/96
Date Reported:	October 15/96
MDS Ref#:	966865
MDS Quote#:	96-697-GS
Client Ref#:	96239
Sampled By:	Mike Zimmer

Certificate of Analysis

Additional Comments:

NOTE:
Ion balance not reported on samples with low ionic stength.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 16/96
MDS Ref # : 967005
MDS Quote#: 96-697-GS
Client PO#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Alkalinity(as CaCO3)	na	1	mg/L	nd(b)	2	yes	97	87	113	yes	na	na	na	na	na	yes
Chloride	na	1	mg/L	nd(b)	2	yes	111	90	113	yes	na	na	na	na	na	yes
Nitrate(as N)	FALC-EFFL	0.05	mg/L	nd(b)	0.1	yes	108	88	114	yes	0.31	0.30	0.18	0.42	yes	yes
Nitrite(as N)	na	0.01	mg/L	nd(b)	0.03	yes	83	80	116	yes	na	na	na	na	na	yes
Orthophosphate(as P)	FALC-EFFL	0.01	mg/L	nd(b)	0.03	yes	102	90	110	yes	0.80	1.0	0.6	1.4	yes	yes
Sulphate	na	2	mg/L	nd(b)	3	yes	103	90	113	yes	na	na	na	na	na	yes
Boron	FALC-EFFL Unfiltered	0.005	mg/L	nd(b)	0.02	yes	106	85	115	yes	1.03	1.00	0.60	1.40	yes	yes
Calcium	FALC-EFFL Unfiltered	0.1	mg/L	nd(b)	0.2	yes	106	85	115	yes	*	*	*	*	*	yes
Iron	FALC-EFFL Unfiltered	0.02	mg/L	nd(b)	0.03	yes	106	85	115	yes	1.02	1.00	0.60	1.40	yes	yes
Magnesium	FALC-EFFL Unfiltered	0.1	mg/L	nd(b)	0.2	yes	109	85	115	yes	1.0	1.0	0.2	1.6	yes	yes
Phosphorus	FALC-EFFL Unfiltered	0.1	mg/L	nd(b)	0.2	yes	97	85	115	yes	0.9	1.0	0.4	1.6	yes	yes
Potassium	FALC-EFFL Unfiltered	0.5	mg/L	nd(b)	1.0	yes	108	85	115	yes	3.9	5.0	1.0	8.0	yes	yes
Sodium	FALC-EFFL Unfiltered	0.1	mg/L	nd(b)	0.2	yes	104	85	115	yes	0.5	1.0	0.2	1.6	yes	yes
Zinc	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.02	yes	108	85	115	yes	1.07	1.00	0.60	1.40	yes	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	99	80	120	yes	na	na	na	na	na	yes
Aluminum	FALC-EFFL Unfiltered	0.01	mg/L	nd(b)	0.03	yes	88	85	115	yes	0.10	0.100	0.050	0.140	yes	yes
Antimony	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.102	0.100	0.050	0.140	yes	yes
Arsenic	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	91	85	115	yes	0.099	0.100	0.050	0.140	yes	yes
Barium	FALC-EFFL Unfiltered	0.005	mg/L	nd(b)	0.01	yes	108	85	115	yes	0.106	0.100	0.050	0.140	yes	yes
Beryllium	FALC-EFFL Unfiltered	0.005	mg/L	nd(b)	0.01	yes	95	85	115	yes	0.095	0.100	0.050	0.140	yes	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
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nd = parameter not detected
TR = trace level less than LOQ
(b) = Analyte results on REPORT of ANALYSIS have been background corrected for the process blank.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 16/96
MDS Ref # : 967005
MDS Quote#: 96-697-GS
Client PO#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Bismuth	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	100	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Cadmium	FALC-EFFL Unfiltered	0.0005	mg/L	nd(b)	0.0010	yes	102	85	115	yes	0.1020	0.100	0.050	0.140	yes	yes
Chromium	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Cobalt	FALC-EFFL Unfiltered	0.001	mg/L	nd(b)	0.002	yes	107	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Copper	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	112	85	115	yes	0.114	0.100	0.050	0.140	yes	yes
Lead	FALC-EFFL Unfiltered	0.0001	mg/L	0.0007(b)	0.002	yes	98	85	115	yes	0.1000	0.100	0.050	0.140	yes	yes
Manganese	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Molybdenum	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Nickel	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.099	0.100	0.050	0.140	yes	yes
Selenium	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	91	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Silver	FALC-EFFL Unfiltered	0.0003	mg/L	nd(b)	0.0006	yes	102	85	115	yes	0.0705	0.100	0.050	0.140	yes	yes
Strontium	FALC-EFFL Unfiltered	0.005	mg/L	nd(b)	0.01	yes	101	85	115	yes	0.096	0.100	0.050	0.140	yes	yes
Thallium	FALC-EFFL Unfiltered	0.0001	mg/L	nd(b)	0.0002	yes	99	85	115	yes	0.0993	0.100	0.050	0.140	yes	yes
Tin	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Titanium	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.102	0.100	0.050	0.140	yes	yes
Uranium	FALC-EFFL Unfiltered	0.0001	mg/L	nd(b)	0.0002	yes	99	85	115	yes	0.1020	0.100	0.050	0.140	yes	yes
Vanadium	FALC-EFFL Unfiltered	0.002	mg/L	nd(b)	0.004	yes	107	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Colour	na	5	TCU	na	na	na	106	85	115	yes	na	na	na	na	na	yes
Conductivity - @25°C	na	1	us/cm	na	na	na	96	91	109	yes	na	na	na	na	na	yes
pH	na	0.1	Units	na	na	na	100	98	102	yes	na	na	na	na	na	yes

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TR = trace level less than LOQ

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 16/96
MDS Ref # : 967005
MDS Quote#: 96-697-GS
Client PO#: 96239

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Turbidity	na	0.1	NTU	nd	0.5	yes	95	81	129	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	103	79	120	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	99	79	119	yes	na	na	na	na	na	yes
Dissolved Inorganic Carbon(as C)	na	0.5	mg/L	nd	1.0	yes	na	na	na	na	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	101	80	116	yes	na	na	na	na	na	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
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TR = trace level less than LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 16/96
MDS Ref # : 967005
MDS Quote #: 96-697-GS
Client PO#: 96239

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	FALC-EFFL 96/10/05	FALC-EFFL Replicate	FALC-EFFL Filtered 96/10/05	FALC-EFFL Unfiltered 96/10/05	FALC-EFFL Unfiltered Replicate
Alkalinity(as CaCO3)	1	mg/L	21	21	-	-	-
Chloride	1	mg/L	159	159	-	-	-
Nitrate(as N)	0.05	mg/L	0.50	0.50	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-
Sulphate	2	mg/L	651	651	-	-	-
Boron	0.005	mg/L	-	-	0.036	0.037	0.040
Calcium	0.1	mg/L	-	-	309	310	306
Iron	0.02	mg/L	-	-	0.04	0.06	0.04
Magnesium	0.1	mg/L	-	-	2.9	2.8	2.8
Phosphorus	0.1	mg/L	-	-	nd	nd	nd
Potassium	0.5	mg/L	-	-	20.0	22.4	20.2
Reactive Silica(SiO2)	0.5	mg/L	5.6	5.6	-	-	-
Sodium	0.1	mg/L	-	-	81.6	79.1	79.2
Zinc	0.002	mg/L	-	-	0.022	nd	nd
Aluminum	0.01	mg/L	-	-	0.06	0.05	0.05
Antimony	0.002	mg/L	-	-	nd	nd	nd
Arsenic	0.002	mg/L	-	-	nd	nd	nd
Barium	0.005	mg/L	-	-	0.033	0.032	0.033
Beryllium	0.005	mg/L	-	-	nd	nd	nd
Bismuth	0.002	mg/L	-	-	nd	nd	nd
Cadmium	0.0005	mg/L	-	-	nd	nd	nd
Chromium	0.002	mg/L	-	-	nd	nd	nd
Cobalt	0.001	mg/L	-	-	0.003	0.003	0.003
Copper	0.002	mg/L	-	-	0.016	0.013	0.013
Lead	0.0001	mg/L	-	-	nd	nd	nd
Manganese	0.002	mg/L	-	-	0.016	0.016	0.016

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
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nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 16/96
MDS Ref # : 967005
MDS Quote #: 96-697-GS
Client PO#: 96239

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	FALC-EFFL 96/10/05	FALC-EFFL Replicate	FALC-EFFL Filtered 96/10/05	FALC-EFFL Unfiltered 96/10/05	FALC-EFFL Unfiltered Replicate
Molybdenum	0.002	mg/L	-	-	nd	nd	nd
Nickel	0.002	mg/L	-	-	0.095	0.097	0.098
Selenium	0.002	mg/L	-	-	0.004	0.004	0.005
Silver	0.0003	mg/L	-	-	nd	nd	nd
Strontium	0.005	mg/L	-	-	0.858	0.858	0.858
Thallium	0.0001	mg/L	-	-	0.0003	0.0002	0.0003
Tin	0.002	mg/L	-	-	nd	nd	nd
Titanium	0.002	mg/L	-	-	nd	nd	nd
Uranium	0.0001	mg/L	-	-	nd	nd	nd
Vanadium	0.002	mg/L	-	-	nd	nd	nd
Anion Sum	na	meq/L	18.5	18.5	-	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	21	20	-	-	-
Carbonate(as CaCO3, calculated)	1	mg/L	nd	nd	-	-	-
Cation Sum	na	meq/L	19.8	19.5	-	-	-
Colour	5	TCU	nd	nd	-	-	-
Conductivity - @25°C	1	us/cm	1670	1670	-	-	-
Hardness(as CaCO3)	0.1	mg/L	786	776	-	-	-
Ion Balance	0.01	%	3.32	2.71	-	-	-
Langelier Index at 20°C	na	na	0.020	-0.010	-	-	-
Langelier Index at 4°C	na	na	-0.380	-0.400	-	-	-
pH	0.1	Units	7.8	7.8	-	-	-
Saturation pH at 20°C	na	units	7.79	7.80	-	-	-
Saturation pH at 4°C	na	units	8.19	8.20	-	-	-
Total Dissolved Solids(Calculated)	1	mg/L	1250	1240	-	-	-
Turbidity	0.1	NTU	0.2	0.1	-	-	-
Mercury	0.1	ug/L	nd	-	-	-	-
Ammonia(as N)	0.05	mg/L	0.79	-	-	-	-

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 16/96
MDS Ref # : 967005
MDS Quote #: 96-697-GS
Client PO#: 96239

Analysis of Water

Parameter Date Sampled >	LOQ	Units	FALC-EFFL 96/10/05	FALC-EFFL Replicate	FALC-EFFL Filtered 96/10/05	FALC-EFFL Unfiltered 96/10/05	FALC-EFFL Unfiltered Replicate
Dissolved Inorganic Carbon(as C)	0.5	mg/L	4.9	-	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	2.5	-	-	-	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 23/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Alkalinity(as CaCO3)	na	1	mg/L	nd(b)	2	yes	97	87	113	yes	na	na	na	na	na	yes
Ammonia(as N)	OR3-1	0.05	mg/L	nd(b)	0.10	yes	103	81	118	yes	0.93	1.00	0.60	1.40	yes	yes
Chloride	na	1	mg/L	nd(b)	2	yes	111	90	113	yes	na	na	na	na	na	yes
Nitrate(as N)	OR3-1	0.05	mg/L	nd(b)	0.1	yes	108	88	114	yes	0.32	0.30	0.18	0.42	yes	yes
Nitrite(as N)	na	0.01	mg/L	nd(b)	0.03	yes	83	80	116	yes	na	na	na	na	na	yes
Orthophosphate(as P)	OR3-1	0.01	mg/L	nd(b)	0.03	yes	102	90	110	yes	0.90	1.0	0.6	1.4	yes	yes
Sulphate	na	2	mg/L	nd(b)	3	yes	103	90	113	yes	na	na	na	na	na	yes
Boron	OR3-1	0.005	mg/L	nd(b)	0.02	yes	106	85	115	yes	1.14	1.00	0.60	1.40	yes	yes
Boron	OR3-2 [total]	0.005	mg/L	0.007(b)	0.02	yes	93	85	115	yes	0.847	1.00	0.60	1.40	yes	yes
Calcium	OR3-1	0.1	mg/L	nd(b)	0.2	yes	107	85	115	yes	0.4	1.0	0.2	1.8	yes	yes
Calcium	OR3-2 [total]	0.1	mg/L	nd(b)	0.2	yes	95	85	115	yes	1.0	1.0	0.2	1.8	yes	yes
Iron	OR3-1	0.02	mg/L	nd(b)	0.03	yes	101	85	115	yes	1.05	1.00	0.60	1.40	yes	yes
Iron	OR3-2 [total]	0.02	mg/L	nd(b)	0.03	yes	100	85	115	yes	0.90	1.00	0.60	1.40	yes	yes
Magnesium	OR3-1	0.1	mg/L	nd(b)	0.2	yes	97	85	115	yes	1.0	1.0	0.2	1.6	yes	yes
Magnesium	OR3-2 [total]	0.1	mg/L	nd(b)	0.2	yes	106	85	115	yes	1.0	1.0	0.2	1.6	yes	yes
Phosphorus	OR3-1	0.1	mg/L	nd(b)	0.2	yes	92	85	115	yes	0.9	1.0	0.4	1.6	yes	yes
Phosphorus	OR3-2 [total]	0.1	mg/L	nd(b)	0.2	yes	108	85	115	yes	1.0	1.0	0.4	1.6	yes	yes
Potassium	OR3-1	0.5	mg/L	nd(b)	1.0	yes	100	85	115	yes	5.1	5.0	1.0	8.0	yes	yes
Potassium	OR3-2 [total]	0.5	mg/L	nd(b)	1.0	yes	95	85	115	yes	3.3	5.0	1.0	8.0	yes	yes
Sodium	OR3-1	0.1	mg/L	nd(b)	0.2	yes	104	85	115	yes	0.9	1.0	0.2	1.6	yes	yes

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MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 23/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Sodium	OR3-2 [total]	0.1	mg/L	nd(b)	0.2	yes	105	85	115	yes	0.8	1.0	0.2	1.6	yes	yes
Zinc	OR3-1	0.002	mg/L	nd(b)	0.02	yes	101	85	115	yes	1.03	1.00	0.60	1.40	yes	yes
Zinc	OR3-2 [total]	0.002	mg/L	0.002(b)	0.02	yes	106	85	115	yes	0.951	1.00	0.60	1.40	yes	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	101	80	120	yes	na	na	na	na	na	yes
Reactive Silica(SiO2)	na	0.5	mg/L	nd(b)	1.0	yes	99	80	120	yes	na	na	na	na	na	yes
Aluminum	OR3-1	0.01	mg/L	nd(b)	0.03	yes	92	85	115	yes	0.11	0.100	0.050	0.140	yes	yes
Aluminum	OR3-2 [total]	0.01	mg/L	nd(b)	0.03	yes	105	85	115	yes	0.11	0.100	0.050	0.140	yes	yes
Antimony	OR3-1	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Antimony	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.107	0.100	0.050	0.140	yes	yes
Arsenic	OR3-1	0.002	mg/L	nd(b)	0.004	yes	96	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Arsenic	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	102	85	115	yes	0.107	0.100	0.050	0.140	yes	yes
Barium	OR3-1	0.005	mg/L	nd(b)	0.01	yes	107	85	115	yes	0.106	0.100	0.050	0.140	yes	yes
Barium	OR3-2 [total]	0.005	mg/L	nd(b)	0.01	yes	105	85	115	yes	0.106	0.100	0.050	0.140	yes	yes
Beryllium	OR3-1	0.005	mg/L	nd(b)	0.01	yes	97	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Beryllium	OR3-2 [total]	0.005	mg/L	nd(b)	0.01	yes	108	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Bismuth	OR3-1	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Bismuth	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.106	0.100	0.050	0.140	yes	yes
Cadmium	OR3-1	0.0005	mg/L	nd(b)	0.0010	yes	103	85	115	yes	0.1030	0.100	0.050	0.140	yes	yes
Cadmium	OR3-2 [total]	0.0005	mg/L	nd(b)	0.0010	yes	105	85	115	yes	0.1070	0.100	0.050	0.140	yes	yes
Chromium	OR3-1	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.101	0.100	0.050	0.140	yes	yes

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MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 23/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Chromium	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.105	0.100	0.050	0.140	yes	yes
Cobalt	OR3-1	0.001	mg/L	nd(b)	0.002	yes	105	85	115	yes	0.101	0.100	0.050	0.140	yes	yes
Cobalt	OR3-2 [total]	0.001	mg/L	nd(b)	0.002	yes	102	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Copper	OR3-1	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.101	0.100	0.050	0.140	yes	yes
Copper	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.102	0.100	0.050	0.140	yes	yes
Lead	OR3-1	0.0001	mg/L	nd(b)	0.002	yes	101	85	115	yes	0.1040	0.100	0.050	0.140	yes	yes
Lead	OR3-2 [total]	0.0001	mg/L	nd(b)	0.002	yes	103	85	115	yes	0.1060	0.100	0.050	0.140	yes	yes
Manganese	OR3-1	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Manganese	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	102	85	115	yes	0.108	0.100	0.050	0.140	yes	yes
Molybdenum	OR3-1	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Molybdenum	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.106	0.100	0.050	0.140	yes	yes
Nickel	OR3-1	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.098	0.100	0.050	0.140	yes	yes
Nickel	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	99	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Selenium	OR3-1	0.002	mg/L	nd(b)	0.004	yes	98	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Selenium	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.105	0.100	0.050	0.140	yes	yes
Silver	OR3-1	0.0003	mg/L	nd(b)	0.0006	yes	90	85	115	yes	0.1080	0.100	0.050	0.140	yes	yes
Silver	OR3-2 [total]	0.0003	mg/L	nd(b)	0.0006	yes	107	85	115	yes	0.1110	0.100	0.050	0.140	yes	yes
Strontium	OR3-1	0.005	mg/L	nd(b)	0.01	yes	104	85	115	yes	0.105	0.100	0.050	0.140	yes	yes
Strontium	OR3-2 [total]	0.005	mg/L	nd(b)	0.01	yes	107	85	115	yes	0.110	0.100	0.050	0.140	yes	yes
Thallium	OR3-1	0.0001	mg/L	nd(b)	0.0002	yes	100	85	115	yes	0.1020	0.100	0.050	0.140	yes	yes

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MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 23/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Thallium	OR3-2 [total]	0.0001	mg/L	nd(b)	0.0002	yes	102	85	115	yes	0.1040	0.100	0.050	0.140	yes	yes
Tin	OR3-1	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.102	0.100	0.050	0.140	yes	yes
Tin	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.107	0.100	0.050	0.140	yes	yes
Titanium	OR3-1	0.002	mg/L	nd(b)	0.004	yes	101	85	115	yes	0.101	0.100	0.050	0.140	yes	yes
Titanium	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	102	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Uranium	OR3-1	0.0001	mg/L	nd(b)	0.0002	yes	103	85	115	yes	0.1070	0.100	0.050	0.140	yes	yes
Uranium	OR3-2 [total]	0.0001	mg/L	nd(b)	0.0002	yes	104	85	115	yes	0.1080	0.100	0.050	0.140	yes	yes
Vanadium	OR3-1	0.002	mg/L	nd(b)	0.004	yes	104	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Vanadium	OR3-2 [total]	0.002	mg/L	nd(b)	0.004	yes	102	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Colour	na	5	TCU	nd(b)	10	yes	106	85	115	yes	na	na	na	na	na	yes
Conductivity - @25°C	na	1	us/cm	na(b)	na	na	96	91	109	yes	na	na	na	na	na	yes
pH	na	0.1	Units	na(b)	na	na	100	98	102	yes	na	na	na	na	na	yes
Turbidity	na	0.1	NTU	nd(b)	0.5	yes	95	81	129	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	103	79	120	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	103	79	120	yes	na	na	na	na	na	yes
Mercury	na	0.1	ug/L	nd	0.2	yes	95	79	120	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	98	79	119	yes	na	na	na	na	na	yes
Ammonia(as N)	na	0.05	mg/L	nd	0.1	yes	98	79	119	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	na	na	na	102	77	122	yes	na	na	na	na	na	yes
Total Kjeldahl Nitrogen(as N)	na	0.05	mg/L	nd	0.1	yes	93	77	122	yes	na	na	na	na	na	yes

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Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 23/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Dissolved Inorganic Carbon(as C)	na	0.5	mg/L	nd	1.0	yes	na	na	na	na	na	na	na	na	na	yes
Dissolved Organic Carbon(DOC)	na	0.5	mg/L	nd	1.0	yes	101	80	116	yes	na	na	na	na	na	yes
Total Suspended Solids	na	5	mg/L	nd	2	yes	93	82	118	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	96	77	127	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	96	77	127	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	96	77	127	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	96	77	127	yes	na	na	na	na	na	yes
Cyanide, Free	na	0.002	mg/L	nd	0.004	yes	96	77	127	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	89	82	115	yes	na	na	na	na	na	yes
Cyanide, Total	na	0.005	mg/L	nd	0.010	yes	89	82	115	yes	na	na	na	na	na	yes

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	FALC-EFFL 96/10/01	FALC-EFFL Replicate	FALC-EFFL [total] 96/10/01	OR1-1 96/10/03	OR1-1 [total] 96/10/03
Alkalinity(as CaCO3)	1	mg/L	18	-	-	6	-
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Chloride	1	mg/L	170	-	-	1	-
Nitrate(as N)	0.05	mg/L	0.54	-	-	0.13	-
Nitrite(as N)	0.01	mg/L	nd	-	-	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-	-	nd	-
Sulphate	2	mg/L	642	-	-	6	-
Boron	0.005	mg/L	0.033	-	0.023	0.005	nd
Calcium	0.1	mg/L	259	-	231	3.7	2.9
Iron	0.02	mg/L	0.05	-	0.14	0.26	0.22
Magnesium	0.1	mg/L	2.4	-	2.6	0.7	1.0
Phosphorus	0.1	mg/L	nd	-	nd	nd	nd
Potassium	0.5	mg/L	18.6	-	12.8	nd	0.8
Reactive Silica(SiO2)	0.5	mg/L	4.8	-	5.2	3.6	3.6
Sodium	0.1	mg/L	75.6	-	52.5	1.8	3.2
Zinc	0.002	mg/L	0.167	-	0.005	0.045	0.003
Aluminum	0.01	mg/L	0.06	-	0.10	0.03	0.04
Antimony	0.002	mg/L	nd	-	nd	nd	nd
Arsenic	0.002	mg/L	nd	-	nd	nd	nd
Barium	0.005	mg/L	0.029	-	0.028	0.007	0.007
Beryllium	0.005	mg/L	nd	-	nd	nd	nd
Bismuth	0.002	mg/L	nd	-	nd	nd	nd
Cadmium	0.0005	mg/L	nd	-	nd	nd	nd
Chromium	0.002	mg/L	nd	-	nd	nd	nd
Cobalt	0.001	mg/L	0.003	-	0.004	nd	nd
Copper	0.002	mg/L	nd	-	0.020	nd	nd
Lead	0.0001	mg/L	0.0001	-	nd	nd	0.0060

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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	FALC-EFFL 96/10/01	FALC-EFFL Replicate	FALC-EFFL [total] 96/10/01	OR1-1 96/10/03	OR1-1 [total] 96/10/03
Manganese	0.002	mg/L	0.018	-	0.023	0.004	0.015
Molybdenum	0.002	mg/L	nd	-	nd	nd	nd
Nickel	0.002	mg/L	0.107	-	0.102	nd	nd
Selenium	0.002	mg/L	0.005	-	0.004	nd	nd
Silver	0.0003	mg/L	nd	-	nd	nd	nd
Strontium	0.005	mg/L	0.785	-	0.759	0.015	0.014
Thallium	0.0001	mg/L	nd	-	0.0003	nd	nd
Tin	0.002	mg/L	nd	-	nd	nd	nd
Titanium	0.002	mg/L	nd	-	nd	nd	nd
Uranium	0.0001	mg/L	nd	-	nd	nd	nd
Vanadium	0.002	mg/L	nd	-	nd	nd	nd
Anion Sum	na	meq/L	18.5	-	-	0.275	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	18	-	-	6	-
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	nd	-
Cation Sum	na	meq/L	16.9	-	-	0.329	-
Colour	5	TCU	6	-	-	36	-
Conductivity - @25°C	1	us/cm	1640	-	-	35	-
Hardness(as CaCO3)	0.1	mg/L	657	-	-	12.3	-
Ion Balance	0.01	%	4.50	-	-	8.97	-
Langelier Index at 20°C	na	na	-0.965	-	-	-3.72	-
Langelier Index at 4°C	na	na	-1.37	-	-	-4.12	-
pH	0.1	Units	6.9	-	-	6.4	-
Saturation pH at 20°C	na	units	7.87	-	-	10.1	-
Saturation pH at 4°C	na	units	8.27	-	-	10.5	-
Total Dissolved Solids(Calculated)	1	mg/L	1190	-	-	21	-
Turbidity	0.1	NTU	0.2	-	-	0.3	-
Mercury	0.1	ug/L	nd	-	-	nd	nd

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Report of Analysis

Client : Ecological Services for Planning
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Report Date: October 23/96
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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	FALC-EFFL 96/10/01	FALC-EFFL Replicate	FALC-EFFL [total] 96/10/01	OR1-1 96/10/03	OR1-1 [total] 96/10/03
Ammonia(as N)	0.05	mg/L	0.77	-	-	0.06	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.82	-	-	nd	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	-	-	-	1.6	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	5.8	-
Total Suspended Solids	5	mg/L	5	-	-	nd	-
Cyanide, Free	0.002	mg/L	nd	-	-	nd	-
Cyanide, Total	0.005	mg/L	nd	-	-	nd	-

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-2 96/10/03	OR1-2 [total] 96/10/03	OR1-3 96/10/03	OR1-3 [total] 96/10/03	OR1-4 96/10/04
Alkalinity(as CaCO3)	1	mg/L	5	-	5	-	6
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Chloride	1	mg/L	1	-	1	-	2
Nitrate(as N)	0.05	mg/L	0.19	-	0.09	-	0.06
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	nd
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	-	nd
Sulphate	2	mg/L	6	-	6	-	6
Boron	0.005	mg/L	nd	0.005	nd	nd	nd
Calcium	0.1	mg/L	3.9	2.9	3.7	2.8	3.7
Iron	0.02	mg/L	0.25	0.22	0.25	0.22	0.23
Magnesium	0.1	mg/L	0.8	1.0	0.7	1.0	0.7
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	nd	2.0	nd	2.1	nd
Reactive Silica(SiO2)	0.5	mg/L	3.6	3.7	3.6	3.6	3.6
Sodium	0.1	mg/L	1.9	3.2	1.8	3.2	1.8
Zinc	0.002	mg/L	0.044	0.002	0.082	nd	0.027
Aluminum	0.01	mg/L	0.03	0.04	0.03	0.04	0.03
Antimony	0.002	mg/L	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd
Barium	0.005	mg/L	0.007	0.008	0.007	0.007	0.007
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd
Cadmium	0.0005	mg/L	nd	nd	nd	nd	nd
Chromium	0.002	mg/L	nd	nd	nd	nd	nd
Cobalt	0.001-	mg/L	nd	nd	nd	nd	nd
Copper	0.002	mg/L	nd	nd	nd	nd	nd
Lead	0.0001	mg/L	nd	nd	nd	0.0003	nd

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Report of Analysis

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-2 96/10/03	OR1-2 [total] 96/10/03	OR1-3 96/10/03	OR1-3 [total] 96/10/03	OR1-4 96/10/04
Manganese	0.002	mg/L	0.004	0.014	0.004	0.015	0.003
Molybdenum	0.002	mg/L	nd	nd	nd	nd	nd
Nickel	0.002	mg/L	nd	nd	nd	nd	nd
Selenium	0.002	mg/L	nd	nd	nd	nd	nd
Silver	0.0003	mg/L	nd	nd	nd	nd	nd
Strontium	0.005	mg/L	0.015	0.015	0.016	0.015	0.015
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd
Anion Sum	na	meq/L	0.271	-	0.269	-	0.286
Bicarbonate(as CaCO3, calculated)	1	mg/L	5	-	5	-	6
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	nd
Cation Sum	na	meq/L	0.346	-	0.327	-	0.327
Colour	5	TCU	37	-	34	-	33
Conductivity - @25°C	1	us/cm	35	-	35	-	38
Hardness(as CaCO3)	0.1	mg/L	12.8	-	12.3	-	12.2
Ion Balance	0.01	%	12.0	-	9.87	-	6.77
Langelier Index at 20°C	na	na	-3.78	-	-3.82	-	-3.76
Langelier Index at 4°C	na	na	-4.18	-	-4.22	-	-4.16
pH	0.1	Units	6.3	-	6.3	-	6.3
Saturation pH at 20°C	na	units	10.1	-	10.1	-	10.1
Saturation pH at 4°C	na	units	10.5	-	10.5	-	10.5
Total Dissolved Solids(Calculated)	1	mg/L	21	-	20	-	21
Turbidity	0.1	NTU	0.3	-	0.3	-	0.3
Mercury	0.1	ug/L	nd	0.1	0.1	nd	nd

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Report of Analysis

Client : Ecological Services for Planning
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Report Date: October 23/96
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Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-2 96/10/03	OR1-2 [total] 96/10/03	OR1-3 96/10/03	OR1-3 [total] 96/10/03	OR1-4 96/10/04
Ammonia(as N)	0.05	mg/L	0.10	-	0.06	-	0.05
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.09	-	nd	-	0.09
Dissolved Inorganic Carbon(as C)	0.5	mg/L	1.8	-	1.8	-	1.8
Dissolved Organic Carbon(DOC)	0.5	mg/L	5.6	-	5.9	-	5.5
Total Suspended Solids	5	mg/L	nd	-	nd	-	nd
Cyanide, Free	0.002	mg/L	nd	-	nd	-	nd
Cyanide, Total	0.005	mg/L	0.016	-	nd	-	nd

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-4 [total] 96/10/04	OR1-5 96/10/04	OR1-5 Replicate	OR1-5 [total] 96/10/04	OR1-6 96/10/03
Alkalinity(as CaCO3)	1	mg/L	-	5	-	-	3
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Chloride	1	mg/L	-	1	-	-	1
Nitrate(as N)	0.05	mg/L	-	0.14	-	-	0.58
Nitrite(as N)	0.01	mg/L	-	nd	-	-	nd
Orthophosphate(as P)	0.01	mg/L	-	nd	-	-	nd
Sulphate	2	mg/L	-	6	-	-	6
Boron	0.005	mg/L	0.009	nd	-	nd	0.005
Calcium	0.1	mg/L	3.0	3.8	-	3.0	3.6
Iron	0.02	mg/L	0.22	0.22	-	0.22	0.24
Magnesium	0.1	mg/L	1.0	0.7	-	1.0	0.7
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd
Potassium	0.5	mg/L	1.4	nd	-	2.4	nd
Reactive Silica(SiO2)	0.5	mg/L	3.6	3.6	-	3.8	3.6
Sodium	0.1	mg/L	3.2	1.8	-	3.1	1.8
Zinc	0.002	mg/L	nd	0.024	-	nd	0.015
Aluminum	0.01	mg/L	0.04	0.04	-	0.04	0.03
Antimony	0.002	mg/L	nd	nd	-	nd	nd
Arsenic	0.002	mg/L	nd	nd	-	nd	nd
Barium	0.005	mg/L	0.007	0.008	-	0.007	0.007
Beryllium	0.005	mg/L	nd	nd	-	nd	nd
Bismuth	0.002	mg/L	nd	nd	-	nd	nd
Cadmium	0.0005	mg/L	nd	nd	-	nd	nd
Chromium	0.002	mg/L	nd	nd	-	nd	nd
Cobalt	0.001	mg/L	nd	nd	-	nd	nd
Copper	0.002	mg/L	nd	0.003	-	nd	nd
Lead	0.0001	mg/L	nd	nd	-	nd	0.0002

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-4 [total] 96/10/04	OR1-5 96/10/04	OR1-5 Replicate	OR1-5 [total] 96/10/04	OR1-6 96/10/03
Manganese	0.002	mg/L	0.013	0.004	-	0.013	0.005
Molybdenum	0.002	mg/L	nd	nd	-	nd	nd
Nickel	0.002	mg/L	nd	nd	-	nd	nd
Selenium	0.002	mg/L	nd	nd	-	nd	nd
Silver	0.0003	mg/L	nd	nd	-	nd	nd
Strontium	0.005	mg/L	0.015	0.015	-	0.015	0.015
Thallium	0.0001	mg/L	nd	nd	-	nd	nd
Tin	0.002	mg/L	nd	nd	-	nd	nd
Titanium	0.002	mg/L	nd	nd	-	nd	nd
Uranium	0.0001	mg/L	nd	nd	-	nd	nd
Vanadium	0.002	mg/L	nd	nd	-	nd	nd
Anion Sum	na	meq/L	-	0.265	-	-	0.269
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	5	-	-	3
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	-	nd
Cation Sum	na	meq/L	-	0.333	-	-	0.321
Colour	5	TCU	-	35	-	-	35
Conductivity - @25°C	1	us/cm	-	35	-	-	37
Hardness(as CaCO3)	0.1	mg/L	-	12.4	-	-	12.0
Ion Balance	0.01	%	-	11.4	-	-	8.78
Langelier Index at 20°C	na	na	-	-3.84	-	-	-4.21
Langelier Index at 4°C	na	na	-	-4.24	-	-	-4.61
pH	0.1	Units	-	6.3	-	-	6.2
Saturation pH at 20°C	na	units	-	10.1	-	-	10.4
Saturation pH at 4°C	na	units	-	10.5	-	-	10.8
Total Dissolved Solids(Calculated)	1	mg/L	-	21	-	-	22
Turbidity	0.1	NTU	-	0.4	-	-	0.3
Mercury	0.1	ug/L	nd	nd	-	nd	nd

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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR1-4 [total] 96/10/04	OR1-5 96/10/04	OR1-5 Replicate	OR1-5 [total] 96/10/04	OR1-6 96/10/03
Ammonia(as N)	0.05	mg/L	-	0.06	-	-	0.06
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.23	-	-	0.08
Dissolved Inorganic Carbon(as C)	0.5	mg/L	-	1.6	-	-	1.7
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	6.0	-	-	5.2
Total Suspended Solids	5	mg/L	-	nd	-	-	nd
Cyanide, Free	0.002	mg/L	-	nd	-	-	nd
Cyanide, Total	0.005	mg/L	-	nd	-	-	nd

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Report of Analysis

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MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter	LOQ	Units	OR1-6 Replicate	OR1-6 [total] 96/10/03	OR3-1 96/10/02	OR3-1 Replicate	OR3-1 [total] 96/10/02
Alkalinity(as CaCO3)	1	mg/L	-	-	6	7	-
Ammonia(as N)	0.05	mg/L	-	-	0.13	0.12	-
Chloride	1	mg/L	-	-	9	9	-
Nitrate(as N)	0.05	mg/L	-	-	0.10	0.10	-
Nitrite(as N)	0.01	mg/L	-	-	nd	nd	-
Orthophosphate(as P)	0.01	mg/L	-	-	nd	nd	-
Sulphate	2	mg/L	-	-	35	35	-
Boron	0.005	mg/L	-	nd	nd	nd	0.011
Calcium	0.1	mg/L	-	3.0	16.5	16.4	13.7
Iron	0.02	mg/L	-	0.21	0.29	0.29	0.28
Magnesium	0.1	mg/L	-	1.1	1.4	1.4	1.3
Phosphorus	0.1	mg/L	-	nd	nd	nd	nd
Potassium	0.5	mg/L	-	2.5	nd	nd	3.7
Reactive Silica(SiO2)	0.5	mg/L	-	3.7	4.4	4.4	4.2
Sodium	0.1	mg/L	-	3.1	5.9	5.9	5.7
Zinc	0.002	mg/L	-	0.009	0.059	0.057	0.006
Aluminum	0.01	mg/L	-	0.04	0.06	0.05	0.08
Antimony	0.002	mg/L	-	nd	nd	nd	nd
Arsenic	0.002	mg/L	-	nd	nd	nd	nd
Barium	0.005	mg/L	-	0.007	0.009	0.009	0.010
Beryllium	0.005	mg/L	-	nd	nd	nd	nd
Bismuth	0.002	mg/L	-	nd	nd	nd	nd
Cadmium	0.0005	mg/L	-	nd	nd	nd	nd
Chromium	0.002	mg/L	-	nd	nd	nd	nd
Cobalt	0.001	mg/L	-	nd	0.001	0.001	0.002
Copper	0.002	mg/L	-	nd	0.007	0.007	0.008
Lead	0.0001	mg/L	-	nd	nd	nd	0.0006

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Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter	LOQ	Units	OR1-6 Replicate	OR1-6 [total] 96/10/03	OR3-1 96/10/02	OR3-1 Replicate	OR3-1 [total] 96/10/02
Manganese	0.002	mg/L	-	0.013	0.033	0.034	0.049
Molybdenum	0.002	mg/L	-	nd	nd	nd	nd
Nickel	0.002	mg/L	-	nd	0.060	0.059	0.061
Selenium	0.002	mg/L	-	nd	nd	nd	0.002
Silver	0.0003	mg/L	-	nd	nd	nd	nd
Strontium	0.005	mg/L	-	0.015	0.053	0.053	0.054
Thallium	0.0001	mg/L	-	nd	nd	nd	nd
Tin	0.002	mg/L	-	nd	nd	nd	nd
Titanium	0.002	mg/L	-	nd	nd	nd	nd
Uranium	0.0001	mg/L	-	nd	nd	nd	nd
Vanadium	0.002	mg/L	-	nd	nd	nd	nd
Anion Sum	na	meq/L	-	-	1.11	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	-	6	-	-
Carbonate(as CaCO3, calculated)	1	mg/L	-	-	nd	-	-
Cation Sum	na	meq/L	-	-	1.21	-	-
Colour	5	TCU	-	-	42	41	-
Conductivity - @25°C	1	us/cm	-	-	138	138	-
Hardness(as CaCO3)	0.1	mg/L	-	-	46.9	-	-
Ion Balance	0.01	%	-	-	4.25	-	-
Langelier Index at 20°C	na	na	-	-	-1.87	-	-
Langelier Index at 4°C	na	na	-	-	-2.27	-	-
pH	0.1	Units	-	-	7.6	7.6	-
Saturation pH at 20°C	na	units	-	-	9.44	-	-
Saturation pH at 4°C	na	units	-	-	9.84	-	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	77	-	-
Turbidity	0.1	NTU	-	-	0.5	0.5	-
Mercury	0.1	ug/L	-	nd	nd	-	nd

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Analysis of Water

Parameter	LOQ	Units	OR1-6 Replicate	OR1-6 [total] 96/10/03	OR3-1 96/10/02	OR3-1 Replicate	OR3-1 [total] 96/10/02
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	-	0.17	-	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	-	-	2.1	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	5.3	-	-
Total Suspended Solids	5	mg/L	-	-	nd	-	-
Cyanide, Free	0.002	mg/L	-	-	nd	-	-
Cyanide, Total	0.005	mg/L	-	-	nd	-	-

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-2 96/10/02	OR3-2 Replicate	OR3-2 [total] 96/10/02	OR3-2 [total] Replicate	OR3-3 96/10/02
Alkalinity(as CaCO3)	1	mg/L	7	-	-	-	7
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Chloride	1	mg/L	9	-	-	-	10
Nitrate(as N)	0.05	mg/L	0.22	-	-	-	0.98
Nitrite(as N)	0.01	mg/L	nd	-	-	-	nd
Orthophosphate(as P)	0.01	mg/L	nd	-	-	-	nd
Sulphate	2	mg/L	35	-	-	-	35
Boron	0.005	mg/L	0.008	-	0.005	0.011	nd
Calcium	0.1	mg/L	16.4	-	13.5	14.0	16.6
Iron	0.02	mg/L	0.26	-	0.27	0.27	0.33
Magnesium	0.1	mg/L	1.4	-	1.6	1.7	1.4
Phosphorus	0.1	mg/L	nd	-	nd	nd	nd
Potassium	0.5	mg/L	nd	-	2.5	2.5	nd
Reactive Silica(SiO2)	0.5	mg/L	4.4	-	4.3	4.3	4.3
Sodium	0.1	mg/L	5.8	-	5.8	6.0	5.8
Zinc	0.002	mg/L	0.031	-	0.005	0.006	0.044
Aluminum	0.01	mg/L	0.06	-	0.08	0.07	0.06
Antimony	0.002	mg/L	nd	-	nd	nd	nd
Arsenic	0.002	mg/L	nd	-	nd	nd	nd
Barium	0.005	mg/L	0.011	-	0.009	0.009	0.010
Beryllium	0.005	mg/L	nd	-	nd	nd	nd
Bismuth	0.002	mg/L	nd	-	nd	nd	nd
Cadmium	0.0005	mg/L	nd	-	nd	nd	nd
Chromium	0.002	mg/L	nd	-	nd	nd	nd
Cobalt	0.001	mg/L	0.001	-	0.002	0.002	0.001
Copper	0.002	mg/L	0.007	-	0.008	0.008	0.007
Lead	0.0001	mg/L	nd	-	nd	nd	nd

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Report of Analysis

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Report Date: October 23/96
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Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-2 96/10/02	OR3-2 Replicate	OR3-2 [total] 96/10/02	OR3-2 [total] Replicate	OR3-3 96/10/02
Manganese	0.002	mg/L	0.032	-	0.048	0.049	0.033
Molybdenum	0.002	mg/L	nd	-	nd	nd	nd
Nickel	0.002	mg/L	0.056	-	0.058	0.059	0.060
Selenium	0.002	mg/L	nd	-	nd	nd	nd
Silver	0.0003	mg/L	nd	-	nd	nd	nd
Strontium	0.005	mg/L	0.051	-	0.052	0.053	0.053
Thallium	0.0001	mg/L	nd	-	nd	nd	nd
Tin	0.002	mg/L	nd	-	nd	nd	nd
Titanium	0.002	mg/L	0.003	-	nd	nd	nd
Uranium	0.0001	mg/L	nd	-	nd	nd	nd
Vanadium	0.002	mg/L	nd	-	nd	nd	nd
Anion Sum	na	meq/L	1.13	-	-	-	1.21
Bicarbonate(as CaCO3, calculated)	1	mg/L	7	-	-	-	7
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	nd
Cation Sum	na	meq/L	1.26	-	-	-	1.21
Colour	5	TCU	44	-	-	-	40
Conductivity - @25°C	1	us/cm	126	-	-	-	129
Hardness(as CaCO3)	0.1	mg/L	46.8	-	-	-	46.9
Ion Balance	0.01	%	5.41	-	-	-	0.07
Langelier Index at 20°C	na	na	-2.09	-	-	-	-2.12
Langelier Index at 4°C	na	na	-2.49	-	-	-	-2.52
pH	0.1	Units	7.3	-	-	-	7.3
Saturation pH at 20°C	na	units	9.39	-	-	-	9.37
Saturation pH at 4°C	na	units	9.79	-	-	-	9.77
Total Dissolved Solids(Calculated)	1	mg/L	78	-	-	-	81
Turbidity	0.1	NTU	0.5	-	-	-	0.4
Mercury	0.1	ug/L	nd	-	nd	-	nd

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-2 96/10/02	OR3-2 Replicate	OR3-2 [total] 96/10/02	OR3-2 [total] Replicate	OR3-3 96/10/02
Ammonia(as N)	0.05	mg/L	0.81	-	-	-	0.24
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.51	-	-	-	0.63
Dissolved Inorganic Carbon(as C)	0.5	mg/L	1.9	-	-	-	1.7
Dissolved Organic Carbon(DOC)	0.5	mg/L	5.9	-	-	-	5.3
Total Suspended Solids	5	mg/L	nd	-	-	-	nd
Cyanide, Free	0.002	mg/L	nd	-	-	-	nd
Cyanide, Total	0.005	mg/L	nd	-	-	-	nd

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Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-3 [total] 96/10/02	OR3-4 96/10/02	OR3-4 [total] 96/10/02	OR3-5 96/10/02	OR3-5 [total] 96/10/02
Alkalinity(as CaCO3)	1	mg/L	-	7	-	6	-
Ammonia(as N)	0.05	mg/L	-	-	-	-	-
Chloride	1	mg/L	-	9	-	9	-
Nitrate(as N)	0.05	mg/L	-	0.25	-	0.31	-
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-
Sulphate	2	mg/L	-	38	-	35	-
Boron	0.005	mg/L	nd	0.009	nd	nd	nd
Calcium	0.1	mg/L	13.8	15.8	13.2	16.1	13.3
Iron	0.02	mg/L	0.26	0.28	0.26	0.28	0.26
Magnesium	0.1	mg/L	1.6	1.4	1.6	1.4	1.6
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	1.5	nd	1.6	nd	2.5
Reactive Silica(SiO2)	0.5	mg/L	4.2	4.3	4.1	4.3	4.2
Sodium	0.1	mg/L	5.8	5.8	5.8	5.9	5.8
Zinc	0.002	mg/L	0.003	0.014	0.005	0.015	0.008
Aluminum	0.01	mg/L	0.07	0.05	0.07	0.05	0.09
Antimony	0.002	mg/L	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd
Barium	0.005	mg/L	0.009	0.009	0.009	0.009	0.009
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd
Cadmium	0.0005	mg/L	nd	nd	nd	nd	nd
Chromium	0.002	mg/L	nd	nd	nd	nd	nd
Cobalt	0.001	mg/L	0.002	0.001	0.002	0.001	0.002
Copper	0.002	mg/L	0.008	0.009	0.008	0.007	0.011
Lead	0.0001	mg/L	nd	nd	nd	nd	nd

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Report of Analysis

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Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-3 [total] 96/10/02	OR3-4 96/10/02	OR3-4 [total] 96/10/02	OR3-5 96/10/02	OR3-5 [total] 96/10/02
Manganese	0.002	mg/L	0.047	0.035	0.049	0.033	0.048
Molybdenum	0.002	mg/L	nd	nd	nd	nd	nd
Nickel	0.002	mg/L	0.058	0.060	0.059	0.060	0.059
Selenium	0.002	mg/L	nd	nd	nd	nd	nd
Silver	0.0003	mg/L	nd	nd	nd	nd	nd
Strontium	0.005	mg/L	0.052	0.054	0.052	0.052	0.053
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd
Anion Sum	na	meq/L	-	1.20	-	1.14	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	7	-	6	-
Carbonate(as CaCO3, calculated)	1	mg/L	-	nd	-	nd	-
Cation Sum	na	meq/L	-	1.16	-	1.18	-
Colour	5	TCU	-	40	-	40	-
Conductivity - @25°C	1	us/cm	-	129	-	129	-
Hardness(as CaCO3)	0.1	mg/L	-	44.9	-	45.9	-
Ion Balance	0.01	%	-	1.66	-	1.83	-
Langelier Index at 20°C	na	na	-	-2.21	-	-2.29	-
Langelier Index at 4°C	na	na	-	-2.61	-	-2.69	-
pH	0.1	Units	-	7.2	-	7.1	-
Saturation pH at 20°C	na	units	-	9.41	-	9.43	-
Saturation pH at 4°C	na	units	-	9.81	-	9.83	-
Total Dissolved Solids(Calculated)	1	mg/L	-	80	-	77	-
Turbidity	0.1	NTU	-	0.4	-	0.4	-
Mercury	0.1	ug/L	0.1	nd	nd	nd	nd

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Report of Analysis

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Analysis of Water

Parameter Date Sampled >	LOQ	Units	OR3-3 [total] 96/10/02	OR3-4 96/10/02	OR3-4 [total] 96/10/02	OR3-5 96/10/02	OR3-5 [total] 96/10/02
Ammonia(as N)	0.05	mg/L	-	0.20	-	0.10	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.10	-	0.10	-
Dissolved Inorganic Carbon(as C)	0.5	mg/L	-	1.6	-	1.9	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	4.9	-	5.4	-
Total Suspended Solids	5	mg/L	-	nd	-	nd	-
Cyanide, Free	0.002	mg/L	-	nd	-	nd	-
Cyanide, Total	0.005	mg/L	-	nd	-	nd	-

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-6 96/10/02	OR3-6 [total] 96/10/02	OR3-6 REP 96/10/02	OR3-6 REP [total] 96/10/02	
Alkalinity(as CaCO3)	1	mg/L	6	-	7	-	
Ammonia(as N)	0.05	mg/L	-	-	0.13	-	
Chloride	1	mg/L	9	-	9	-	
Nitrate(as N)	0.05	mg/L	0.15	-	0.42	-	
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	-	
Sulphate	2	mg/L	35	-	35	-	
Boron	0.005	mg/L	nd	nd	nd	nd	
Calcium	0.1	mg/L	15.8	13.4	15.7	13.3	
Iron	0.02	mg/L	0.29	0.27	0.28	0.27	
Magnesium	0.1	mg/L	1.3	1.6	1.3	1.5	
Phosphorus	0.1	mg/L	nd	nd	nd	nd	
Potassium	0.5	mg/L	nd	2.8	nd	2.0	
Reactive Silica(SiO2)	0.5	mg/L	4.2	4.3	4.2	4.2	
Sodium	0.1	mg/L	10.8	5.9	5.8	5.9	
Zinc	0.002	mg/L	0.008	0.004	0.010	0.002	
Aluminum	0.01	mg/L	0.05	0.08	0.06	0.08	
Antimony	0.002	mg/L	nd	nd	nd	nd	
Arsenic	0.002	mg/L	nd	nd	nd	nd	
Barium	0.005	mg/L	0.009	0.009	0.009	0.008	
Beryllium	0.005	mg/L	nd	nd	nd	nd	
Bismuth	0.002	mg/L	nd	nd	nd	nd	
Cadmium	0.0005	mg/L	nd	nd	nd	nd	
Chromium	0.002	mg/L	nd	nd	nd	nd	
Cobalt	0.001	mg/L	0.001	0.002	0.001	0.002	
Copper	0.002	mg/L	0.007	0.008	0.009	0.009	
Lead	0.0001	mg/L	nd	nd	nd	nd	

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
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MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-6 96/10/02	OR3-6 [total] 96/10/02	OR3-6 REP 96/10/02	OR3-6 REP [total] 96/10/02	
Manganese	0.002	mg/L	0.034	0.047	0.032	0.047	
Molybdenum	0.002	mg/L	nd	nd	nd	nd	
Nickel	0.002	mg/L	0.060	0.060	0.061	0.057	
Selenium	0.002	mg/L	nd	nd	nd	nd	
Silver	0.0003	mg/L	nd	nd	nd	nd	
Strontium	0.005	mg/L	0.054	0.052	0.053	0.052	
Thallium	0.0001	mg/L	nd	nd	nd	nd	
Tin	0.002	mg/L	nd	nd	nd	nd	
Titanium	0.002	mg/L	nd	nd	nd	nd	
Uranium	0.0001	mg/L	nd	nd	nd	nd	
Vanadium	0.002	mg/L	nd	nd	nd	nd	
Anion Sum	na	meq/L	1.13	-	1.16	-	
Bicarbonate(as CaCO3, calculated)	1	mg/L	6	-	7	-	
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	nd	-	
Cation Sum	na	meq/L	1.37	-	1.16	-	
Colour	5	TCU	40	-	42	-	
Conductivity - @25°C	1	us/cm	137	-	130	-	
Hardness(as CaCO3)	0.1	mg/L	44.9	-	44.7	-	
Ion Balance	0.01	%	9.83	-	0.18	-	
Langelier Index at 20°C	na	na	-2.33	-	-2.38	-	
Langelier Index at 4°C	na	na	-2.73	-	-2.78	-	
pH	0.1	Units	7.1	-	7.0	-	
Saturation pH at 20°C	na	units	9.43	-	9.42	-	
Saturation pH at 4°C	na	units	9.83	-	9.82	-	
Total Dissolved Solids(Calculated)	1	mg/L	81	-	78	-	
Turbidity	0.1	NTU	0.4	-	0.4	-	
Mercury	0.1	ug/L	nd	0.2	nd	nd	

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
na = Not Applicable
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 23/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Water

Parameter / Date Sampled >	LOQ	Units	OR3-6 96/10/02	OR3-6 [total] 96/10/02	OR3-6 REP 96/10/02	OR3-6 REP [total] 96/10/02	
Ammonia(as N)	0.05	mg/L	0.13	-	-	-	
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.11	-	0.28	-	
Dissolved Inorganic Carbon(as C)	0.5	mg/L	1.2	-	2.0	-	
Dissolved Organic Carbon(DOC)	0.5	mg/L	5.7	-	5.2	-	
Total Suspended Solids	5	mg/L	nd	-	-	-	
Cyanide, Free	0.002	mg/L	nd	-	nd	-	
Cyanide, Total	0.005	mg/L	nd	-	nd	-	

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
- = Not Requested
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

Client:	Ecological Services for Planning 361 Southgate Drive Guelph, ONT, CANADA N1G 3M5	Date Submitted:	October 6/96
		Date Reported:	October 23/96
		MDS Ref#:	966957
		MDS Quote#:	96-697-GS
		Client PO#:	CANMET
Fax:	519-836-2493	Client Ref#:	96239Onaping
		Sampled By:	Geoff Carnegie
Attn:	Barbara Dowsley		

Certificate of Analysis

Additional Comments:

NOTE:
Ion balance in excess of %5 mostly due to the low ionic strength of the sample.

November 8, 1996

In house QA/QC of our lab supplies used in the field.

Client I.D.#	Description
Q1	Store bought "Equality" distilled water
Q2	5% Nitric Acid solution made with original Nitric acid in the lab and the store bought "Equality" distilled water.
Q3	Milli 9 Water (Millipore "Milli 9" system-deionized water feed) University of Waterloo
Q4	One filter moistened with the above 5% Nitric Acid as done in the field and then removed with forceps (as should have been done in the field) and placed in Whirl pak bag
Q5	Two filters moistened with the above 5% nitric acid as done in the field and removed with gloves and placed in Whirl pak bag
Q6	Glove dipped in Milli 9 distilled water from the University of Waterloo

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Date Reported: November 21/96
MDS Ref # : 968374
MDS Quote#: CANMET Investig

Analysis of Water

Client Ref#: 96239-QA/QC

				Process Blank			Process % Recovery				Matrix Spike					Overall QC
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	Acceptable
Boron	Q5 FILTRAT E	0.005	mg/L	nd(b)	0.02	yes	98	85	115	yes	0.980	1.00	0.60	1.40	yes	yes
Calcium	Q5 FILTRAT E	0.1	mg/L	nd(b)	0.2	yes	99	85	115	yes	1.0	1.0	0.2	1.8	yes	yes
Iron	Q5 FILTRAT E	0.02	mg/L	nd(b)	0.03	yes	96	85	115	yes	1.00	1.00	0.60	1.40	yes	yes
Magnesium	Q5 FILTRAT E	0.1	mg/L	nd(b)	0.2	yes	102	85	115	yes	1.0	1.0	0.2	1.6	yes	yes
Phosphorus	Q5 FILTRAT E	0.1	mg/L	nd(b)	0.2	yes	94	85	115	yes	0.8	1.0	0.4	1.6	yes	yes
Potassium	Q5 FILTRAT E	0.5	mg/L	nd(b)	1.0	yes	106	85	115	yes	4.5	5.0	1.0	8.0	yes	yes
Sodium	Q5 FILTRAT E	0.1	mg/L	0.1(b)	0.2	yes	91	85	115	yes	0.9	1.0	0.2	1.6	yes	yes
Zinc	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.02	yes	97	85	115	yes	1.02	1.00	0.60	1.40	yes	yes
Aluminum	Q5 FILTRAT E	0.01	mg/L	nd(b)	0.03	yes	91	85	115	yes	0.12	0.100	0.050	0.140	yes	yes
Antimony	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	102	85	115	yes	0.101	0.100	0.050	0.140	yes	yes
Arsenic	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	109	85	115	yes	0.091	0.100	0.050	0.140	yes	yes
Barium	Q5 FILTRAT E	0.005	mg/L	nd(b)	0.01	yes	99	85	115	yes	0.110	0.100	0.050	0.140	yes	yes
Beryllium	Q5 FILTRAT E	0.005	mg/L	nd(b)	0.01	yes	104	85	115	yes	0.112	0.100	0.050	0.140	yes	yes
Bismuth	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	100	85	115	yes	0.101	0.100	0.050	0.140	yes	yes
Cadmium	Q5 FILTRAT E	0.0005	mg/L	nd(b)	0.0010	yes	106	85	115	yes	0.0985	0.100	0.050	0.140	yes	yes
Chromium	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	94	85	115	yes	0.054	0.100	0.050	0.140	yes	yes
Cobalt	Q5 FILTRAT E	0.001	mg/L	nd(b)	0.002	yes	104	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Copper	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.104	0.100	0.050	0.140	yes	yes
Lead	Q5 FILTRAT E	0.0001	mg/L	nd(b)	0.002	yes	91	85	115	yes	0.0902	0.100	0.050	0.140	yes	yes
Manganese	Q5 FILTRAT E	0.002	mg/L	nd(b)	0.004	yes	107	85	115	yes	0.099	0.100	0.050	0.140	yes	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ
(b) = Analyte results on REPORT of ANALYSIS have been background corrected for the process blank.

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Date Reported: November 21/96
MDS Ref # : 968374
MDS Quote#: CANMET Investig

Client Ref#: 96239-QA/QC

Analysis of Water

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Molybdenum	Q5 FILTRATE	0.002	mg/L	nd(b)	0.004	yes	109	85	115	yes	0.096	0.100	0.050	0.140	yes	yes
Nickel	Q5 FILTRATE	0.002	mg/L	nd(b)	0.004	yes	103	85	115	yes	0.100	0.100	0.050	0.140	yes	yes
Selenium	Q5 FILTRATE	0.002	mg/L	0.004(b	0.004	yes	111	85	115	yes	0.085	0.100	0.050	0.140	yes	yes
Silver	Q5 FILTRATE	0.0003	mg/L	nd(b)	0.0006	yes	94	85	115	yes	0.0672	0.100	0.050	0.140	yes	yes
Strontium	Q5 FILTRATE	0.005	mg/L	nd(b)	0.01	yes	112	85	115	yes	0.090	0.100	0.050	0.140	yes	yes
Thallium	Q5 FILTRATE	0.0001	mg/L	0.0002(	0.0002	yes	101	85	115	yes	0.1010	0.100	0.050	0.140	yes	yes
Tin	Q5 FILTRATE	0.002	mg/L	nd(b)	0.004	yes	100	85	115	yes	0.099	0.100	0.050	0.140	yes	yes
Titanium	Q5 FILTRATE	0.002	mg/L	nd(b)	0.004	yes	105	85	115	yes	0.103	0.100	0.050	0.140	yes	yes
Uranium	Q5 FILTRATE	0.0001	mg/L	nd(b)	0.0002	yes	102	85	115	yes	0.0993	0.100	0.050	0.140	yes	yes
Vanadium	Q5 FILTRATE	0.002	mg/L	nd(b)	0.004	yes	106	85	115	yes	0.104	0.100	0.050	0.140	yes	yes

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
* = Unavailable due to dilution required for analysis
na = Not Applicable
ns = Insufficient Sample Submitted
nd = parameter not detected
TR = trace level less than LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Report Date: November 21/96
MDS Ref # : 968374
MDS Quote #: CANMET Investig

Analysis of Water

Client Ref#: 96239-QA/QC

Parameter / Date Sampled >	LOQ	Units	Q1 96/11/08	Q2 96/11/08	Q3 96/11/08	Q4 FILTRATE	Q5 FILTRATE
Boron	0.005	mg/L	nd	nd	0.005	nd	nd
Calcium	0.1	mg/L	1.4	0.4	2.1	3.4	3.6
Iron	0.02	mg/L	nd	nd	nd	0.21	0.21
Magnesium	0.1	mg/L	nd	nd	nd	0.5	0.5
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd
Potassium	0.5	mg/L	nd	nd	nd	1.1	nd
Sodium	0.1	mg/L	nd	nd	nd	1.3	1.3
Zinc	0.002	mg/L	0.018	0.019	0.042	0.021	0.035
Aluminum	0.01	mg/L	nd	nd	nd	0.08	0.08
Antimony	0.002	mg/L	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	0.008	0.008
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd
Cadmium	0.0005	mg/L	nd	nd	nd	nd	nd
Chromium	0.002	mg/L	nd	nd	nd	nd	nd
Cobalt	0.001	mg/L	nd	nd	nd	nd	nd
Copper	0.002	mg/L	0.101	0.098	nd	0.036	0.025
Lead	0.0001	mg/L	nd	nd	nd	nd	nd
Manganese	0.002	mg/L	nd	nd	nd	0.004	0.004
Molybdenum	0.002	mg/L	nd	nd	nd	nd	nd
Nickel	0.002	mg/L	0.019	0.018	nd	nd	nd
Selenium	0.002	mg/L	nd	nd	nd	nd	nd
Silver	0.0003	mg/L	nd	nd	nd	nd	nd
Strontium	0.005	mg/L	nd	nd	nd	0.015	0.016
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Report Date: November 21/96
MDS Ref # : 968374
MDS Quote #: CANMET Investig

Analysis of Water

Client Ref#: 96239-QA/QC

Parameter / Date Sampled >	LOQ	Units	Q1 96/11/08	Q2 96/11/08	Q3 96/11/08	Q4 FILTRATE	Q5 FILTRATE
Titanium	0.002	mg/L	nd	nd	nd	nd	nd
Uranium	0.0001	mg/L	nd	nd	nd	0.0005	0.0005
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

Report of Analysis

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Report Date: November 21/96
MDS Ref # : 968374
MDS Quote #: CANMET Investig

Analysis of Water

Client Ref#: 96239-QA/QC

Parameter	LOQ	Units	Q5 FILTRATE Replicate	Q6 96/11/08			
Boron	0.005	mg/L	nd	nd			
Calcium	0.1	mg/L	3.5	8.0			
Iron	0.02	mg/L	0.21	nd			
Magnesium	0.1	mg/L	0.5	0.5			
Phosphorus	0.1	mg/L	nd	nd			
Potassium	0.5	mg/L	1.2	1.7			
Sodium	0.1	mg/L	1.3	1.0			
Zinc	0.002	mg/L	0.033	0.410			
Aluminum	0.01	mg/L	0.07	nd			
Antimony	0.002	mg/L	nd	nd			
Arsenic	0.002	mg/L	nd	nd			
Barium	0.005	mg/L	0.008	nd			
Beryllium	0.005	mg/L	nd	nd			
Bismuth	0.002	mg/L	nd	nd			
Cadmium	0.0005	mg/L	nd	nd			
Chromium	0.002	mg/L	nd	nd			
Cobalt	0.001	mg/L	nd	nd			
Copper	0.002	mg/L	0.024	nd			
Lead	0.0001	mg/L	nd	nd			
Manganese	0.002	mg/L	0.003	nd			
Molybdenum	0.002	mg/L	nd	nd			
Nickel	0.002	mg/L	nd	nd			
Selenium	0.002	mg/L	nd	nd			
Silver	0.0003	mg/L	nd	nd			
Strontium	0.005	mg/L	0.015	0.007			
Thallium	0.0001	mg/L	nd	nd			
Tin	0.002	mg/L	nd	nd			

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Chris Wren, PhD.

Report Date: November 21/96
MDS Ref # : 968374
MDS Quote #: CANMET Investig

Analysis of Water

Client Ref#: 96239-QA/QC

Parameter	LOQ	Units	Q5 FILTRATE Replicate	Q6 96/11/08			
Titanium	0.002	mg/L	nd	0.003			
Uranium	0.0001	mg/L	0.0004	nd			
Vanadium	0.002	mg/L	nd	nd			

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

MDS
Environmental Services Limited

November 21, 1996

Mr. Chris Wren
Ecological Services for Planning
361 Southgate Drive
Guelph, Ontario
N1G 3M5

Dear Chris:

Attached is the data for the water and filter samples for QC checks on the Canmet project. As agreed, there is no charge for these tests. A few comments on the data:

1.0 The samples were analyzed using cleaned and proofed glassware. All glassware was pre-cleaned (as it was for the original Canmet projects from ESP, EVS, and Jacques Whitford) and the final pure water rinse solutions were analyzed as our lab blanks (reported in the "Certificate of Quality Control" as "Process Blank").

2.0 The water used by MDSE was Type 1 ASTM 18 megaohm water, which is the cleanest available water we have been able to source.

3.0 All samples were analyzed by ICP-MS and ICP-ES. The results for boron to zinc (the first eight elements) are reported from the ICP-ES data. The remainder are from ICP-MS. The data are very comparable for both ES and MS for all samples, all parameters.

4.0 The filters were wet on arrival at MDSE; we assume this means they had been pre-washed/rinsed.

5.0 The filters were analyzed as follows:

- 50 ml of pure water was put through each filter.
- The filtrate (50 ml) was analyzed by ICP-MS and ICP-ES.
- The data reported is for the water. To obtain the mass loading on the filters, multiply the result by 50 ml. For example, for Q4, the Ca level is 3.4 mg/L, therefore there were 50 ml x 3.4 mg/L = 170.0 mg of Ca removed by 50 ml of water from the filter.

6.0 Sample Q5 had two filters; we used one for the sample and the other as a replicate.

6870 Goreway Drive, Mississauga, Ontario, Canada L4V 1P1
Tel: 905•673•3255 Fax: 905•673•7399 Toll Free: 1•800•701•7092

7.0 The filters contain some metals residues. The pattern of Ca, Mg, Ba, Sr, Na, and K, and of Fe, Al, Zn, Cu, and Mn is consistent with the background of metals in glass fibre filters.

8.0 The filter data show some variation, which is also consistent with our experience with most available filter media.

9.0 The water samples show some metals that one would not expect in a high quality grade of lab water. The presence of Cu and Ni is unusual.

10.0 All of these samples were analyzed by both ICP-ES and ICP-MS. The positive results for the metals are corroborated and confirmed.

Chris, I hope these comments are helpful, and that the data helps you interpret the earlier results. If I can assist in any way, please let me know.

Yours very truly,

J.N. Bishop
Vice President
New Business Development

JNB/no

6696 Gorreway Drive, Mississauga, Ontario, Canada L4V 1P1
Tel: 905•672•2255 Fax: 905•673•7399 Toll Free: 1•800•701•7092

APPENDIX C3

Results

Legend of codes and symbols for water and sediment quality data	
LOQ	Limit of Quantification
+	Guideline for the protection of freshwater aquatic life (where available)
*	Interim Ontario Provincial Water Quality Objective
**	ammonia concentration at pH 7.5 and 20°C
nd	not detected at LOQ (n.b. for statistics, nd converted to ½ LOQ)
na	not applicable/not available
-	not requested
TKN	Total Kjeldahl Nitrogen
DIC	Dissolved Inorganic Carbon
DOC	Dissolved Organic Carbon
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
NCALC	Not Calculated

Table C3-1 : General Water Chemistry of Sample Stations in Moose Creek Onaping/Levack Mine Sites

Parameter	LOQ	M3 - 1	M3 -1 Lab Replicate	M3 -2	M3 -3	Travel Blank
Nitrate	0.05	0.48	0.48	0.49	0.51	nd
Nitrite	0.01	nd	nd	nd	nd	nd
Ammonia	0.05	0.63	-	0.6	0.62	nd
TKN	0.05	0.77	-	0.78	0.73	nd
Phosphorus	0.1	nd	nd	nd	nd	nd
Orthophosphate	0.01	nd	nd	nd	nd	nd
Alkalinity	1	15	15	15	15	nd
Chloride	1	148	148	145	146	nd
Sulphate	2	586	586	588	590	nd
Bicarbonate	1	15	15	15	15	nd
Carbonate	1	nd	nd	nd	nd	nd
Colour (TCU)	5	18	18	17	12	nd
Conductivity (us/cm)	1	1540	1540	1520	1530	3
Hardness	0.1	698	722	713	736	nd
Turbidity	0.1	1.3	1.3	1.3	1.3	nd
Anion Sum (meq/L)	na	16.7	16.7	16.6	16.7	0
Cation Sum (meq/L)	na	17.5	NCALC	18.2	18.3	0
Ion Balance	0.01	2.41	NCALC	4.54	4.48	na
pH (units)	0.1	7.0	7.0	7.0	7.0	6.8
DIC	0.5	3.8	-	3.7	3.8	0.8
DOC	0.5	2.0	-	2.0	1.8	nd
TDS	1	1120	NCALC	1130	1140	nd
TSS	5	nd	-	nd	nd	-

Table C3-2 : Metal Concentrations in Moose Creek Onaping/Levack Mine Site											
		Dissolved Metals					Total Metals				
Metal (mg/L)	LOQ	M3 -1	M3 -1 Lab Replicate	M3-2	M3 -3	Travel Blank	M3 -1	M3 - 1 Lab Replicate	M3 -2	M3 - 3	Travel Blank
Aluminum	0.01	0.14	0.13	0.14	0.13	nd	0.25	-	0.25	0.25	nd
Antimony	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	0.041	0.044	0.042	0.044	nd	0.027	-	0.027	0.026	nd
Beryllium	0.005	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Bismuth	0.002	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Boron	0.005	0.035	0.036	0.033	0.030	nd	0.029	0.031	0.028	0.025	nd
Cadmium	0.0005	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Calcium	0.1	227	270	270	270	0.8	279	285	281	273	nd
Chromium	0.002	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Cobalt	0.001	0.024	0.024	0.023	0.023	nd	0.021	-	0.020	0.019	nd
Copper	0.002	0.092	0.094	0.092	0.084	0.048	0.096	-	0.096	0.091	nd
Iron	0.02	0.26	0.26	0.28	0.26	nd	0.38	0.39	0.36	0.36	nd
Lead	0.0001	0.0007	0.0007	0.0008	0.0008	0.0003	nd	-	nd	nd	nd
Magnesium	0.1	5.8	5.8	5.8	5.8	0.1	5.5	5.6	5.2	5.1	nd
Manganese	0.002	0.138	0.132	0.131	0.128	nd	0.126	-	0.125	0.12	nd
Mercury (ug/L)	0.1	0.1	-	nd	nd	nd	nd	-	nd	nd	nd
Molybdenum	0.002	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Nickel	0.002	0.885	0.886	0.749	0.870	0.003	0.749	-	0.748	0.711	0.002
Potassium	0.5	21.1	20.8	21.1	22.1	nd	16.2	16.9	16.4	11.5	nd
Reactive Silica	0.5	7.2	7.0	7.0	7.0	nd	-	-	-	-	-
Selenium	0.002	0.003	0.003	0.003	0.003	nd	nd	-	nd	nd	nd
Silver	0.0003	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Sodium	0.1	78.2	78.9	80.4	80.5	0.3	72.0	74.2	67.9	66.6	0.2
Strontium	0.005	0.654	0.621	0.641	0.641	nd	0.615	-	0.613	0.585	nd
Thallium	0.0001	0.0003	0.0002	0.0003	0.0003	nd	nd	-	nd	nd	nd
Tin	0.002	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Titanium	0.002	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Uranium	0.0001	nd	nd	nd	nd	nd	nd	-	nd	nd	nd
Vanadium	0.002	nd	0.002	0.003	0.003	nd	0.008	-	0.008	0.008	0.006
Zinc	0.002	0.033	0.034	0.039	0.040	0.047	0.022	0.023	0.020	0.021	nd
Total Cyanide	0.005	nd	-	nd	nd	nd	-	-	-	-	-
Free Cyanide	0.002	nd	-	nd	nd	nd	-	-	-	-	-

Table C3-3 : General Water Chemistry Analysis of Samples Collected from Reference and Exposure Areas at the Onaping/Levack Mine site

Parameter	LOQ	Reference Stations						Exposure Stations							
		OR1-1	OR1-2	OR1-3	OR1-4	OR1-5	OR1-6	OR3-1	OR3-1 Lab Replicate	OR3-2	OR3-3	OR3-4	OR3-5	OR3-6	OR3-6 Field Replicate
Nitrate	0.05	0.13	0.19	0.09	0.06	0.14	0.58	0.1	0.1	0.22	0.98	0.25	0.031	0.15	0.42
Nitrite	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Ammonia	0.05	-	-	-	-	-	-	0.13	0.12	-	-	-	-	-	0.13
TKN	0.05	nd	0.09	nd	0.09	0.23	0.08	0.17	-	0.51	0.63	0.1	0.1	0.11	0.28
Phosphorus	0.1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Orthophosphate	0.01	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Total Phosphorus	0.004														
Alkalinity	1	6	5	5	6	5	3	6	7	7	7	7	6	6	7
Chloride	1	1	1	1	2	1	1	9	9	9	10	9	9	9	9
Sulphate	2	6	6	6	6	6	6	35	35	35	35	38	35	35	35
Bicarbonate	1	6	5	5	6	5	3	6	-	7	7	7	6	6	7
Carbonate	1	nd	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	nd
Colour (TCU)	5	36	37	34	33	35	35	42	41	44	40	40	40	40	42
Conductivity (us/cm)	1	35	35	35	38	35	37	138	138	126	129	129	129	137	130
Hardness	0.1	12.3	12.8	12.3	12.2	12.4	12	46.9	-	46.8	46.9	44.9	45.9	44.9	44.7
Turbidity	0.1	0.3	0.3	0.3	0.3	0.4	0.3	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Anion Sum (meq/L)	na	0.275	0.271	0.269	0.286	0.265	0.269	1.11	-	1.13	1.21	1.2	1.14	1.13	1.16
Cation Sum (meq/L)	na	0.329	0.346	0.327	0.327	0.333	0.321	1.21	-	1.26	1.21	1.16	1.18	1.37	1.16
Ion Balance	0.01	8.97	12	9.87	6.77	11.4	8.78	4.25	-	5.41	0.07	1.66	1.83	9.83	0.18
pH (units)	0.1	6.4	6.3	6.3	6.3	6.3	6.2	7.6	7.6	7.3	7.3	7.2	7.1	7.1	7
DIC	0.5	1.6	1.8	1.8	1.8	1.6	1.7	2.1	-	1.9	1.7	1.6	1.9	1.2	2
DOC	0.5	5.8	5.6	5.9	5.5	6	5.2	5.3	-	5.9	5.3	4.9	5.4	5.7	5.2
TDS	1	21	21	20	21	21	22	77	-	78	81	80	77	81	78
TSS	5	nd	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	-

Table C3-4 : Total Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

		Reference Stations						Exposure stations							
Metal (mg/L)	LOQ	OR1-1	OR1-2	OR1-3	OR1-4	OR1-5	OR1-6	OR3-1	OR3-2	OR3-2 Lab Replicate	OR3-3	OR3-4	OR3-5	OR3-6	OR3-6 Field Replicate
Aluminum	0.01	0.04	0.04	0.04	0.04	0.04	0.04	0.08	0.08	0.07	0.07	0.07	0.09	0.08	0.08
Antimony	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	0.007	0.008	0.007	0.007	0.007	0.007	0.01	0.009	0.009	0.009	0.009	0.009	0.009	0.008
Beryllium	0.005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Bismuth	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	nd	0.005	nd	0.009	nd	nd	0.011	0.005	0.011	nd	nd	nd	nd	nd
Cadmium	0.0005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	2.9	2.9	2.8	3	3	3	13.7	13.5	14	13.8	13.2	13.3	13.4	13.3
Chromium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cobalt	0.001	nd	nd	nd	nd	nd	nd	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Copper	0.002	nd	nd	nd	nd	nd	nd	0.008	0.008	0.008	0.008	0.008	0.011	0.008	0.009
Iron	0.02	0.22	0.22	0.22	0.22	0.22	0.21	0.28	0.27	0.27	0.26	0.26	0.26	0.27	0.27
Lead	0.0001	0.006	nd	0.0003	nd	nd	nd	0.0006	nd	nd	nd	nd	nd	nd	nd
Magnesium	0.1	1	1	1	1	1	1.1	1.3	1.6	1.7	1.6	1.6	1.6	1.6	1.5
Manganese	0.002	0.015	0.014	0.015	0.013	0.013	0.013	0.049	0.048	0.049	0.047	0.049	0.048	0.047	0.047
Mercury (ug/L)	0.1	nd	0.1	nd	nd	nd	nd	nd	nd	-	0.1	nd	nd	0.2	nd
Molybdenum	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Nickel	0.002	nd	nd	nd	nd	nd	nd	0.061	0.058	0.059	0.058	0.059	0.059	0.06	0.057
Potassium	0.5	0.8	2	2.1	1.4	2.4	2.5	3.7	2.5	2.5	1.5	1.6	2.5	2.8	2
Reactive Silica	0.5	3.6	3.7	3.6	3.6	3.8	3.7	4.2	4.3	4.3	4.2	4.1	4.2	4.3	4.2
Silver	0.0003	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Selenium	0.002	nd	nd	nd	nd	nd	nd	0.002	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	3.2	3.2	3.2	3.2	3.1	3.1	5.7	5.8	6	5.8	5.8	5.8	5.9	5.9
Strontium	0.005	0.014	0.015	0.015	0.015	0.015	0.015	0.054	0.052	0.053	0.052	0.052	0.053	0.052	0.052
Thallium	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Uranium	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.002	0.003	0.002	nd	nd	nd	0.009	0.006			0.003	0.005	0.008	0.004	0.002
Total Cyanide	0.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Free Cyanide	0.002	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C3-5 : Dissolved Metals (mg/L) in Water Chemistry Samples Collected from Reference and Exposure Areas at Onaping/Levack Mine Site

		Reference Stations						Exposure Stations							
Metal (mg/L)	LOQ	OR1-1	OR1-2	OR1-3	OR1-4	OR1-5	OR1-6	OR3-1	OR3-1 Lab Replicate	OR3-2	OR3-3	OR3-4	OR3-5	OR3-6	OR3-6 Field Replicate
Aluminum	0.01	0.03	0.03	0.03	0.03	0.04	0.03	0.06	0.05	0.06	0.06	0.05	0.05	0.05	0.06
Antimony	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.005	0.007	0.007	0.007	0.007	0.008	0.007	0.009	0.009	0.011	0.01	0.009	0.009	0.009	0.009
Beryllium	0.005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Bismuth	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	0.005	nd	nd	nd	nd	0.005	nd	nd	0.008	nd	0.009	nd	nd	nd
Cadmium	0.0005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	3.7	3.9	3.7	3.7	nd	nd	16.5	16.4	16.4	16.6	15.8	16.1	15.8	15.7
Chromium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cobalt	0.001	nd	nd	nd	nd	nd	nd	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	0.002	nd	nd	nd	nd	0.003	nd	0.007	0.007	0.007	0.007	0.009	0.007	0.007	0.009
Iron	0.02	0.26	0.25	0.25	0.23	0.22	0.24	0.29	0.29	0.26	0.33	0.28	0.28	0.29	0.28
Lead	0.0001	nd	nd	nd	nd	nd	0.0002	nd	nd	nd	nd	nd	nd	nd	nd
Magnesium	0.1	0.7	0.8	0.7	0.7	0.7	0.7	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3
Manganese	0.002	0.004	0.004	0.004	0.003	0.004	0.005	0.033	0.034	0.032	0.033	0.035	0.033	0.034	0.032
Mercury (ug/L)	0.1	nd	nd	0.1	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	nd
Molybdenum	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Nickel	0.002	nd	nd	nd	nd	nd	nd	0.06	0.059	0.056	0.06	0.06	0.06	0.06	0.061
Potassium	0.5	nd	nd	nd	nd	nd	nd	nd	nd			nd	nd	nd	nd
Reactive Silica	0.5	3.6	3.6	3.6	3.6	3.6	3.6	4.4	4.4			4.3	4.3	4.2	4.2
Selenium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.0003	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	1.8	1.9	1.8	1.8	1.8	1.8	5.9	5.9			5.8	5.9	10.8	5.8
Strontium	0.005	0.015	0.015	0.016	0.015	0.015	0.015	0.053	0.053	0.051	0.053	0.054	0.052	0.054	0.053
Thallium	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	0.003	nd	nd	nd	nd	nd
Uranium	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	0.002	0.045	0.044	0.082	0.027	0.024	0.015	0.059	0.057			0.014	0.015	0.008	0.01
Total Cyanide	0.002	nd	0.016	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	nd
Free Cyanide	0.002	nd	nd	nd	nd	nd	nd	nd	-	nd	nd	nd	nd	nd	nd

Table C3-6 : Field Measurements Taken at Reference and Exposure Stations

Onaping/Levack Mine Sites

Measurement	Reference Stations						Exposure Stations					
	OR1-1	OR1-2	OR1-3	OR1-4	OR1-5	OR1-6	OR3-1	OR3-2	OR3-3	OR3-4	OR3-5	OR3-6
pH (units)	7.8	7.6	7.6	7.7	7.5	7.5	7.9	7.8	7.8	7.8	7.8	7.8
Conductivity (us/cm)	36	36	36	35	36	35	150	154	145	147	146	152
Air Temperature (°C)	9	5	4	9	12	10.5	16	16	10	8.5	6	6
Water Temperature (°C)	11	11	10	9	9	10	13	13	13	13	13	13
Dissolved Oxygen (mg/L)	11.2	11.1	11.1	11.8	11.6	11.7	10.1	10.3	10.3	10.3	10.1	10.4
Depth (m)	2.8	2.4	2.3	1.52	1.78	1.79	1.7	3.2	1.8	1.6	2.1	2.4
Velocity (m/s)	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
Substrate Type	r,c,s,o	r,c,s,o,	r,c,s,o	r,c,s,o	r,c,s,o	r,c,s,o	r,c,m,s	r,c,m,s	r,c,m,s	r,c,m,s	r,c,m,s	r,c,m,s

Measurement	Water Samples Collected at M3		
	M3 - 1	M3 - 2	M3- 3
pH (units)	8	7.9	8
Conductivity (us/cm)	1487	1433	1795
Air Temperature (°C)	13	13	13
Water Temperature (°C)	11	11	11
Dissolved Oxygen (mg/L)	10.4	10.5	10.4
Depth (m)	0.3	0.4	0.85
Velocity (m/s)	0.3	0.2	0.1
Substrate Type	c,g	fs over s	fs/cm

r = rock
c = cobble
m = muck
s = sand
o = organic
g = gravel
fs = fine sediment
cm = clayey muck

APPENDIX D

Sediment Chemistry

APPENDIX D1

Detailed Methods

MDS
Environmental Services Limited

Received Nov 4/96

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 6/96
Date Reported: October 17/96
MDS Ref#: 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping
Sampled By: Geoff Carnegie

Invoice # 26742

Certificate of Analysis

Analysis Performed:

Boron(hot water soluble) by ICP
ICP-MS, Contaminated Sites Guidelines
Loss on Ignition
Mercury, Cold Vapour AA, Digestion Required
Moisture Content

Methodology:

1) Analysis of hot water soluble boron in soil by performing a hot aqueous extraction prior to the analysis using ICPAES.
U.S. EPA Method No. 6010
Canadian Council Min.Environ. Criteria
2) Analysis of trace metals in soil by Inductively Coupled Plasma Mass Spectrophotometry.
U.S. EPA Method No. 6020(Modification)
3) The determination of the loss on ignition of organic matter by heating to constant weight @420°C.
McKeague Methods of Soil Analysis # 3.81
4) Analysis of mercury in soil by Cold Vapour Atomic Absorption.
U.S. EPA Method No. 7471
(Reference - Varian Method No. AA-51)

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted:	October 6/96
Date Reported:	October 17/96
MDS Ref#:	966957
MDS Quote#:	96-697-GS
Client PO#:	CANMET
Client Ref#:	96239Onaping
Sampled By:	Geoff Carnegie

Certificate of Analysis

Methodology: (Cont'd)

5) Determination of the moisture content of soil by weight.
ASTM Method No. D2216-80

Instrumentation:

1) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer
2) PE Sciex ELAN 6000 ICP-MS Spectrometer
3) Precision Mechanical Convention Oven/Neytech Furnace
4) Varian SpectrAA 400 Plus AA/Vapour Accessory VGA 76
5) Precision Mechanical Convention Oven/Sartorius Basic Balance

Sample Description: Soil

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

Certified By
M. Hartwell, M.Sc.
Director, Laboratory Operations

MDS
Environmental Services Limited

Received Nov-4/96

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 6/96
Date Reported: October 15/96
MDS Ref#: 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping
Sampled By: Geoff Carnegie

INVOICE #26742

Certificate of Analysis

Analysis Performed: 20 Element ICP Scan(18 Scan + Ti and P)
ICP Alkaline Scan(Ca,Mg,Na,K,Sr), Digestion Required

Methodology:
1) Analysis of trace metals on a swab by Inductively Coupled Plasma Spectrophotometry, following an acidic extraction.
MDS Internal Method No. 96-MET-1
(Reference - NIOSH Method No. 7300)
2) Analysis of alkaline metals in a swab by Inductively Coupled Plasma Spectrophotometry.
U.S. EPA Method No. 6010
(Ministry of Environment ELSCAN)

Instrumentation: 1, 2) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer

Sample Description: Swab

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

Certified By
for T. Munshaw, M.Sc.,C.Chem
Director, Laboratory Operations

MDS
Environmental Services Limited

Client: Ecological Services for Planning
361 Southgate Drive
Guelph, ONT, CANADA
N1G 3M5

Fax: 519-836-2493

Attn: Barbara Dowsley

Date Submitted: October 17/96
Date Reported: October 21/96
MDS Ref#: 967327
MDS Quote#: 96-697-gs
Client PO#: 96239

invoice #26392

NB Asked

Certificate of Analysis

Analysis Performed: 20 Element ICP Scan(18 Scan + Ti and P)
ICP Alkaline Scan(Ca,Mg,Na,K,Sr), Digestion Required

Methodology:
1) Analysis of trace metals on a swab by Inductively Coupled Plasma Spectrophotometry, following an acidic extraction.
MDS Internal Method No. 96-MET-1
(Reference - NIOSH Method No. 7300)
2) Analysis of alkaline metals in a swab by Inductively Coupled Plasma Spectrophotometry.
U.S. EPA Method No. 6010
(Ministry of Environment ELSCAN)

Instrumentation: 1, 2) Thermo Jarrell Ash ICAP 61E Plasma Spectrophotometer

Sample Description: Swab

QA/QC: Refer to CERTIFICATE OF QUALITY CONTROL report.

Results: Refer to REPORT of ANALYSIS attached.

Certified By
Brad Newman
Service Manager

for Certified By
M. Hartwell, M.Sc.
Director, Laboratory Operations

APPENDIX D2

QA/QC

MDS Environmental Services Limited.

Certificate of Quality Control

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Date Reported: October 17/96
MDS Ref # : 966957
MDS Quote#: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Soil, expressed on a dry weight basis

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Boron(Hot water soluble)	na	0.2	mg/kg	nd(b)	2.0	yes	98	80	120	yes	na	na	na	na	na	yes
Antimony	OR3-EXP 01	2.0	mg/kg	nd(b)	4.0	yes	101	80	120	yes	12.4	12.5	7.5	17.5	yes	yes
Arsenic	OR3-EXP 01	2.0	mg/kg	nd(b)	4.0	yes	97	80	120	yes	12.0	12.5	7.5	17.5	yes	yes
Barium	OR3-EXP 01	0.5	mg/kg	nd(b)	1.0	yes	106	80	120	yes	13.5	12.5	7.5	17.5	yes	yes
Beryllium	OR3-EXP 01	0.5	mg/kg	nd(b)	1.0	yes	110	80	120	yes	13.2	12.5	7.5	17.5	yes	yes
Cadmium	OR3-EXP 01	0.1	mg/kg	nd(b)	1.0	yes	101	80	120	yes	12.4	12.5	7.5	17.5	yes	yes
Chromium	OR3-EXP 01	0.5	mg/kg	nd(b)	1.0	yes	105	80	120	yes	12.6	12.5	7.5	17.5	yes	yes
Cobalt	OR3-EXP 01	0.8	mg/kg	nd(b)	1.6	yes	103	80	120	yes	13.0	12.5	7.5	17.5	yes	yes
Copper	OR3-EXP 01	0.5	mg/kg	nd(b)	1.0	yes	101	80	120	yes	16.1	12.5	7.5	17.5	yes	yes
Lead	OR3-EXP 01	2.5	mg/kg	nd(b)	5.0	yes	102	80	120	yes	12.6	12.5	7.5	17.5	yes	yes
Molybdenum	OR3-EXP 01	1.0	mg/kg	nd(b)	2.0	yes	100	80	120	yes	12.5	12.5	7.5	17.5	yes	yes
Nickel	OR3-EXP 01	1.5	mg/kg	nd(b)	3.0	yes	101	80	120	yes	*	*	*	*	*	yes
Selenium	OR3-EXP 01	1.0	mg/kg	nd(b)	2.0	yes	90	80	120	yes	11.2	12.5	7.5	17.5	yes	yes
Silver	OR3-EXP 01	0.15	mg/kg	nd(b)	1.0	yes	105	80	120	yes	12.6	12.5	7.5	17.5	yes	yes
Thallium	OR3-EXP 01	0.1	mg/kg	nd(b)	1.0	yes	103	80	120	yes	12.8	12.5	7.5	17.5	yes	yes
Vanadium	OR3-EXP 01	0.5	mg/kg	nd(b)	1.0	yes	105	80	120	yes	12.6	12.5	7.5	17.5	yes	yes
Zinc	OR3-EXP 01	0.8	mg/kg	1.6(b)	1.6	yes	107	80	120	yes	12.2	12.5	7.5	17.5	yes	yes
Mercury	na	0.01	mg/kg	0.01	0.02	yes	101	80	123	yes	na	na	na	na	na	yes

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(b) = Analyte results on REPORT of ANALYSIS have been background corrected for the process blank.

MDS Environmental Services Limited.

Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 17/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Soil, expressed on a dry weight basis

Parameter / Date Sampled >	LOQ	Units	OR1-REF 01 96/10/03	OR1-REF 02 96/10/03	OR1-REF 02 Replicate	OR1-REF 04 96/10/04	OR3-EXP 01 96/10/02
Boron(Hot water soluble)	0.2	mg/kg	nd	nd	-	nd	nd
Antimony	2.0	mg/kg	nd	nd	-	nd	nd
Arsenic	2.0	mg/kg	nd	nd	-	nd	nd
Barium	0.5	mg/kg	19.5	19.1	-	29.0	36.1
Beryllium	0.5	mg/kg	nd	nd	-	nd	nd
Cadmium	0.1	mg/kg	nd	nd	-	0.3	0.3
Chromium	0.5	mg/kg	23.4	18.4	-	17.8	36.9
Cobalt	0.8	mg/kg	7.2	6.6	-	9.3	61.3
Copper	0.5	mg/kg	8.9	14.9	-	13.0	232
Lead	2.5	mg/kg	5.0	5.2	-	8.8	15.1
Molybdenum	1.0	mg/kg	nd	nd	-	nd	nd
Nickel	1.5	mg/kg	17.7	14.8	-	18.1	805
Selenium	1.0	mg/kg	nd	nd	-	nd	nd
Silver	0.15	mg/kg	1.99	1.35	-	2.48	0.61
Thallium	0.1	mg/kg	nd	nd	-	nd	nd
Vanadium	0.5	mg/kg	23.6	24.3	-	21.7	33.9
Zinc	0.8	mg/kg	39.3	35.3	-	56.7	98.8
Loss on Ignition	0.01	%	0.73	0.38	-	2.92	3.18
Mercury	0.01	mg/kg	0.02	0.02	-	0.02	0.02
Moisture Content	0.01	%	19.2	18.6	-	47.1	67.9

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Report of Analysis

Client : Ecological Services for Planning
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Report Date: October 17/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Soil, expressed on a dry weight basis

Parameter	LOQ	Units	OR3-EXP 01 Replicate	OR3-EXP 03 96/10/02	OR3-EXP 06 96/10/02	OR3-EXP 06 REP 96/10/02	
Boron(Hot water soluble)	0.2	mg/kg	nd	nd	nd	nd	
Antimony	2.0	mg/kg	nd	nd	nd	nd	
Arsenic	2.0	mg/kg	nd	nd	nd	nd	
Barium	0.5	mg/kg	34.3	29.3	16.5	15.6	
Beryllium	0.5	mg/kg	nd	nd	nd	nd	
Cadmium	0.1	mg/kg	0.2	0.1	nd	nd	
Chromium	0.5	mg/kg	35.0	21.0	18.8	18.0	
Cobalt	0.8	mg/kg	54.4	43.4	14.8	14.5	
Copper	0.5	mg/kg	206	142	65.7	50.7	
Lead	2.5	mg/kg	15.1	8.6	5.2	4.9	
Molybdenum	1.0	mg/kg	nd	nd	nd	nd	
Nickel	1.5	mg/kg	699	198	121	126	
Selenium	1.0	mg/kg	nd	nd	nd	nd	
Silver	0.15	mg/kg	0.90	0.49	0.85	1.62	
Thallium	0.1	mg/kg	nd	nd	nd	nd	
Vanadium	0.5	mg/kg	32.8	20.9	17.6	17.2	
Zinc	0.8	mg/kg	90.2	58.2	37.6	33.9	
Loss on Ignition	0.01	%	2.59	2.71	0.70	0.70	
Mercury	0.01	mg/kg	-	0.05	0.01	0.01	
Moisture Content	0.01	%	66.6	50.8	26.7	25.6	

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Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Swab

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Aluminum	na	1.0	ug/totl	2.2(b)	4.0	yes	88	80	120	yes	na	na	na	na	na	yes
Barium	na	0.1	ug/totl	nd(b)	0.3	yes	94	80	120	yes	na	na	na	na	na	yes
Beryllium	na	0.3	ug/totl	nd(b)	0.6	yes	97	80	120	yes	na	na	na	na	na	yes
Bismuth	na	2.5	ug/totl	nd(b)	5.0	yes	96	80	120	yes	na	na	na	na	na	yes
Boron	na	0.5	ug/totl	nd(b)	1.5	yes	96	80	120	yes	na	na	na	na	na	yes
Cadmium	na	0.2	ug/totl	nd(b)	0.4	yes	100	80	120	yes	na	na	na	na	na	yes
Chromium	na	0.3	ug/totl	nd(b)	0.6	yes	97	80	120	yes	na	na	na	na	na	yes
Cobalt	na	0.3	ug/totl	nd(b)	0.6	yes	98	80	120	yes	na	na	na	na	na	yes
Copper	na	0.2	ug/totl	nd(b)	0.4	yes	95	80	120	yes	na	na	na	na	na	yes
Iron	na	0.3	ug/totl	nd(b)	0.9	yes	89	80	120	yes	na	na	na	na	na	yes
Lead	na	1.3	ug/totl	nd(b)	2.6	yes	96	80	120	yes	na	na	na	na	na	yes
Manganese	na	0.3	ug/totl	nd(b)	0.6	yes	95	80	120	yes	na	na	na	na	na	yes
Molybdenum	na	0.5	ug/totl	nd(b)	1.0	yes	99	80	120	yes	na	na	na	na	na	yes
Nickel	na	0.5	ug/totl	nd(b)	1.0	yes	96	80	120	yes	na	na	na	na	na	yes
Phosphorus	na	3.0	ug/totl	nd(b)	9.0	yes	91	70	130	yes	na	na	na	na	na	yes
Silver	na	0.2	ug/totl	nd(b)	0.4	yes	99	80	120	yes	na	na	na	na	na	yes
Tin	na	2.5	ug/totl	nd(b)	5.0	yes	100	80	120	yes	na	na	na	na	na	yes
Titanium	na	2.5	ug/totl	nd(b)	5.0	yes	96	80	120	yes	na	na	na	na	na	yes
Vanadium	na	0.5	ug/totl	nd(b)	1.0	yes	98	80	120	yes	na	na	na	na	na	yes
Zinc	na	0.3	ug/totl	0.6(b)	0.9	yes	96	80	120	yes	na	na	na	na	na	yes

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Analysis of Swab

Date Reported: October 15/96
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				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Calcium	na	0.5	ug/swb	nd(b)	2.0	yes	85	80	120	yes	na	na	na	na	na	yes
Magnesium	na	1.0	ug/swb	nd(b)	4.0	yes	89	80	120	yes	na	na	na	na	na	yes
Potassium	na	20	ug/swb	nd(b)	80.0	yes	83	80	120	yes	na	na	na	na	na	yes
Sodium	na	0.5	ug/swb	nd(b)	2.0	yes	96	80	120	yes	na	na	na	na	na	yes
Strontium	na	0.3	ug/swb	nd(b)	1.2	yes	100	80	120	yes	na	na	na	na	na	yes

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Report of Analysis

Client : Ecological Services for Planning
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Report Date: October 15/96
MDS Ref # : 966957
MDS Quote #: 96-697-GS
Client PO#: CANMET
Client Ref#: 96239Onaping

Analysis of Swab

Parameter / Date Sampled >	LOQ	Units	OR1-REF 02 96/10/03	OR1-REF 03 96/10/03	OR1-REF 05 96/10/03	OR3-EXP 02 96/10/02	OR3-EXP 02 Replicate
Aluminum	1.0	ug/tot	9.2	16.2	4.9	8.1	8.2
Barium	0.1	ug/tot	0.1	0.2	0.1	0.2	0.2
Beryllium	0.3	ug/tot	nd	nd	nd	nd	nd
Bismuth	2.5	ug/tot	nd	nd	nd	nd	nd
Boron	0.5	ug/tot	0.8	nd	2.2	1.2	1.0
Cadmium	0.2	ug/tot	nd	nd	nd	nd	nd
Calcium	0.5	ug/swb	48.9	34.6	46.8	3380	3430
Chromium	0.3	ug/tot	nd	nd	nd	nd	nd
Cobalt	0.3	ug/tot	nd	nd	nd	nd	nd
Copper	0.2	ug/tot	0.6	0.6	0.4	0.9	0.8
Iron	0.3	ug/tot	17.8	26.8	9.8	11.6	11.3
Lead	1.3	ug/tot	1.4	nd	nd	nd	nd
Magnesium	1.0	ug/swb	9.0	10.0	4.3	30.6	30.9
Manganese	0.3	ug/tot	0.6	1.0	0.3	1.1	1.1
Molybdenum	0.5	ug/tot	nd	nd	nd	nd	nd
Nickel	0.5	ug/tot	nd	nd	nd	nd	nd
Phosphorus	3.0	ug/tot	nd	nd	nd	6.2	7.5
Potassium	20	ug/swb	nd	nd	nd	nd	nd
Silver	0.2	ug/tot	nd	nd	nd	nd	nd
Sodium	0.5	ug/swb	34.0	25.5	34.0	32.0	33.4
Strontium	0.3	ug/swb	nd	nd	nd	1.5	1.5
Tin	2.5	ug/tot	nd	nd	nd	nd	nd
Titanium	2.5	ug/tot	nd	nd	nd	nd	nd
Vanadium	0.5	ug/tot	nd	nd	nd	nd	nd
Zinc	0.3	ug/tot	2.3	4.6	5.2	72.3	73.3

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Analysis of Swab

Parameter / Date Sampled >	LOQ	Units	OR3-EXP 04 96/10/02	OR3-EXP 05 96/10/02			
Aluminum	1.0	ug/tot	6.5	11.2			
Barium	0.1	ug/tot	0.1	0.2			
Beryllium	0.3	ug/tot	nd	nd			
Bismuth	2.5	ug/tot	nd	nd			
Boron	0.5	ug/tot	nd	nd			
Cadmium	0.2	ug/tot	nd	nd			
Calcium	0.5	ug/swb	44.2	2300			
Chromium	0.3	ug/tot	nd	nd			
Cobalt	0.3	ug/tot	nd	nd			
Copper	0.2	ug/tot	0.8	0.5			
Iron	0.3	ug/tot	11.3	13.6			
Lead	1.3	ug/tot	nd	nd			
Magnesium	1.0	ug/swb	4.9	26.9			
Manganese	0.3	ug/tot	0.6	0.8			
Molybdenum	0.5	ug/tot	nd	nd			
Nickel	0.5	ug/tot	nd	nd			
Phosphorus	3.0	ug/tot	nd	nd			
Potassium	20	ug/swb	nd	nd			
Silver	0.2	ug/tot	nd	nd			
Sodium	0.5	ug/swb	26.8	28.8			
Strontium	0.3	ug/swb	nd	1.1			
Tin	2.5	ug/tot	nd	nd			
Titanium	2.5	ug/tot	nd	nd			
Vanadium	0.5	ug/tot	nd	nd			
Zinc	0.3	ug/tot	2.4	51.8			

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Certificate of Quality Control

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Contact: Barbara Dowsley

Date Reported: October 21/96
MDS Ref # : 967327
MDS Quote#: 96-697-gs
Client PO#: 96239

Analysis of Swab

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Aluminum	na	1.0	ug/totl	nd(b)	4.0	yes	102	80	120	yes	na	na	na	na	na	yes
Barium	na	0.1	ug/totl	nd(b)	0.3	yes	102	80	120	yes	na	na	na	na	na	yes
Beryllium	na	0.3	ug/totl	nd(b)	0.6	yes	103	80	120	yes	na	na	na	na	na	yes
Bismuth	na	2.5	ug/totl	nd(b)	5.0	yes	101	80	120	yes	na	na	na	na	na	yes
Boron	na	0.5	ug/totl	nd(b)	1.5	yes	103	80	120	yes	na	na	na	na	na	yes
Cadmium	na	0.2	ug/totl	nd(b)	0.4	yes	103	80	120	yes	na	na	na	na	na	yes
Chromium	na	0.3	ug/totl	nd(b)	0.6	yes	105	80	120	yes	na	na	na	na	na	yes
Cobalt	na	0.3	ug/totl	nd(b)	0.6	yes	106	80	120	yes	na	na	na	na	na	yes
Copper	na	0.2	ug/totl	nd(b)	0.4	yes	102	80	120	yes	na	na	na	na	na	yes
Iron	na	0.3	ug/totl	nd(b)	0.9	yes	101	80	120	yes	na	na	na	na	na	yes
Lead	na	1.3	ug/totl	nd(b)	2.6	yes	103	80	120	yes	na	na	na	na	na	yes
Manganese	na	0.3	ug/totl	nd(b)	0.6	yes	102	80	120	yes	na	na	na	na	na	yes
Molybdenum	na	0.5	ug/totl	nd(b)	1.0	yes	103	80	120	yes	na	na	na	na	na	yes
Nickel	na	0.5	ug/totl	nd(b)	1.0	yes	102	80	120	yes	na	na	na	na	na	yes
Phosphorus	na	3.0	ug/totl	nd(b)	9.0	yes	95	70	130	yes	na	na	na	na	na	yes
Silver	na	0.2	ug/totl	nd(b)	0.4	yes	99	80	120	yes	na	na	na	na	na	yes
Tin	na	2.5	ug/totl	nd(b)	5.0	yes	108	80	120	yes	na	na	na	na	na	yes
Titanium	na	2.5	ug/totl	nd(b)	5.0	yes	105	80	120	yes	na	na	na	na	na	yes
Vanadium	na	0.5	ug/totl	nd(b)	1.0	yes	101	80	120	yes	na	na	na	na	na	yes
Zinc	na	0.3	ug/totl	nd(b)	0.9	yes	102	80	120	yes	na	na	na	na	na	yes

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Date Reported: October 21/96
MDS Ref # : 967327
MDS Quote#: 96-697-gs
Client PO#: 96239

Analysis of Swab

				Process Blank			Process % Recovery				Matrix Spike					Overall
Parameter	SAMPLE ID (spike)	LOQ	Units	Result	Upper Limit	Accept	Result	Lower Limit	Upper Limit	Accept	Result	Target	Lower Limit	Upper Limit	Accept	QC Acceptable
Calcium	na	0.5	ug/swb	nd(b)	2.0	yes	101	80	120	yes	na	na	na	na	na	yes
Magnesium	na	1.0	ug/swb	nd(b)	4.0	yes	104	80	120	yes	na	na	na	na	na	yes
Potassium	na	20	ug/swb	nd(b)	80.0	yes	103	80	120	yes	na	na	na	na	na	yes
Sodium	na	0.5	ug/swb	nd(b)	2.0	yes	107	80	120	yes	na	na	na	na	na	yes
Strontium	na	0.3	ug/swb	nd(b)	1.2	yes	105	80	120	yes	na	na	na	na	na	yes

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Report of Analysis

Client : Ecological Services for Planning
Contact: Barbara Dowsley

Report Date: October 21/96
MDS Ref # : 967327
MDS Quote #: 96-697-gs
Client PO#: 96239

Analysis of Swab

Parameter	LOQ	Units	Swab Blank -1	Swab Blank -1 **Replicate**	Swab Blank -2		
Aluminum	1.0	ug/tot	2.5	2.6	2.5		
Barium	0.1	ug/tot	0.2	0.4	0.2		
Beryllium	0.3	ug/tot	nd	nd	nd		
Bismuth	2.5	ug/tot	nd	nd	nd		
Boron	0.5	ug/tot	2.2	2.4	0.9		
Cadmium	0.2	ug/tot	nd	nd	nd		
Calcium	0.5	ug/swb	2.1	2.2	2.2		
Chromium	0.3	ug/tot	nd	nd	nd		
Cobalt	0.3	ug/tot	nd	nd	nd		
Copper	0.2	ug/tot	0.6	0.5	0.4		
Iron	0.3	ug/tot	8.0	8.1	6.6		
Lead	1.3	ug/tot	nd	nd	nd		
Magnesium	1.0	ug/swb	nd	nd	nd		
Manganese	0.3	ug/tot	nd	nd	nd		
Molybdenum	0.5	ug/tot	nd	nd	nd		
Nickel	0.5	ug/tot	1.0	0.9	nd		
Phosphorus	3.0	ug/tot	nd	nd	nd		
Potassium	20	ug/swb	39	36	36		
Silver	0.2	ug/tot	nd	nd	nd		
Sodium	0.5	ug/swb	69.9	72.1	72.4		
Strontium	0.3	ug/swb	nd	nd	nd		
Tin	2.5	ug/tot	nd	nd	nd		
Titanium	2.5	ug/tot	nd	nd	nd		
Vanadium	0.5	ug/tot	nd	nd	nd		
Zinc	0.3	ug/tot	1.0	1.2	1.1		

LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence.
nd = parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

APPENDIX D3

Results

Table D3-1 : Metals (mg/kg) in Sediment Chemistry Samples Collected from Reference and Exposure Areas, Onaping/Levack Mines

Metal (mg/kg)	LOQ	Reference Stations			Exposure Stations				
		OR 1 - 1	OR - 2	OR1 - 4	OR 3 - 1	OR 3 - 1 Lab Replicate	OR 3 - 3	OR 3 - 6	OR 3 - 6 Field Replicate
Antimony	2.0	nd	nd	nd	nd	nd	nd	nd	nd
Arsenic	2.0	nd	nd	nd	nd	nd	nd	nd	nd
Barium	0.5	19.5	19.1	29.0	36.1	34.3	29.3	16.5	15.6
Beryllium	0.5	nd	nd	nd	nd	nd	nd	nd	nd
Boron	0.2	nd	nd	nd	nd	nd	nd	nd	nd
Cadmium	0.1	nd	nd	0.3	0.3	0.2	0.1	nd	nd
Chromium	0.5	23.4	18.4	17.8	36.9	35.0	21.0	18.8	18.0
Cobalt	0.8	7.2	6.6	9.3	61.3	54.4	43.4	14.8	14.5
Copper	0.5	8.9	14.9	13.0	232.0	206.0	142.0	65.7	50.7
Lead	2.5	5.0	5.2	8.8	15.1	15.1	8.6	5.2	4.9
Mercury	0.01	0.02	0.02	0.02	0.02	-	0.05	0.01	0.01
Molybdenum	1.0	nd	nd	nd	nd	nd	nd	nd	nd
Nickel	1.5	17.7	14.8	18.1	805.0	699.0	198.0	121.0	126.0
Selenium	1.0	nd	nd	nd	nd	nd	nd	nd	nd
Silver	0.15	1.99	1.35	2.48	0.61	0.90	0.49	0.85	1.62
Thallium	0.1	nd	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.5	23.6	24.3	21.7	33.9	32.8	20.9	17.6	17.2
Zinc	0.8	39.3	35.3	56.7	98.8	90.2	58.2	37.6	33.9
Total Carbon (%)		0.16	<0.01	2.53	19.27	-	2.77	0.35	0.24
Total Inorganic Carbon (%)		<0.01	<0.01	<0.01	<0.01	-	<0.01	<0.01	<0.01
Total Organic Carbon (%)		0.16	<0.01	2.53	19.27	-	2.77	0.35	0.24
Loss on Ignition (%)	0.1	0.73	0.38	2.92	3.18	2.59	2.71	0.7	0.7
Moisture Content (%)	0.01	19.2	18.6	47.1	67.9	66.6	50.8	26.7	25.6
Particle Size Distribution									
% Gravel		13.8	25.9	0.3	42.9	-	<0.1	<0.1	<0.1
% Sand		83.5	73.2	84.4	25.2	-	81.9	96.8	96.9
% Silt		1.7	0.5	8.6	13.5	-	11.7	1.8	1.8
% Clay		1.0	0.4	6.8	18.4	-	6.4	1.4	1.4

Table D3-2 Metals (mg/kg) in Sediment Chemistry Samples Collected from Reference and Exposure Areas; lab values and normalized for percent fines, Onaping/Levack Mines

Metal (mg/kg)	LOQ	Reference Stations						Exposure Stations					
		OR 1 - 1		OR - 2		OR1 - 4		OR 3 - 1		OR 3 - 3		OR 3 - 6	
		LAB	NORMAL.	LAB	NORMAL.	LAB	NORMAL.	LAB	NORMAL.	LAB	NORMAL.	LAB	NORMAL.
Barium	0.5	19.5	722.2	19.1	2122.2	29.0	188.3	36.1	113.2	29.3	161.9	16.5	515.6
Cadmium	0.1	**nd**	1.85	**nd**	5.56	0.3	1.95	0.3	0.94	0.1	0.55	**nd**	1.56
Chromium	0.5	23.4	866.7	18.4	2044.4	17.8	115.6	36.9	115.7	21.0	116.0	18.8	587.5
Cobalt	0.8	7.2	266.7	6.6	733.3	9.3	60.4	61.3	192.2	43.4	239.8	14.8	462.5
Copper	0.5	8.9	329.6	14.9	1655.6	13.0	84.4	232.0	727.3	142.0	784.5	65.7	2053.1
Lead	2.5	5.0	185.2	5.2	577.8	8.8	57.1	15.1	47.3	8.6	47.5	5.2	162.5
Mercury	0.01	0.02	0.74	0.02	2.22	0.02	0.13	0.02	0.06	0.05	0.28	0.01	0.31
Nickel	1.5	17.7	655.6	14.8	1644.4	18.1	117.5	805.0	2523.5	198.0	1093.9	121.0	3781.3
Silver	0.15	1.99	73.70	1.35	150.00	2.48	16.10	0.61	1.91	0.49	2.71	0.85	26.56
Vanadium	0.5	23.6	874.1	24.3	2700.0	21.7	140.9	33.9	106.3	20.9	115.5	17.6	550.0
Zinc	0.8	39.3	1455.6	35.3	3922.2	56.7	368.2	98.8	309.7	58.2	321.5	37.6	1175.0
FINES (as proportion)		**0.027**		**0.009**		**0.154**		**0.319**		**0.181**		**0.032**	

TSL/ASSAYERS Laboratories
1270 WEBSTER DRIVE, UNIT 3 MISSISSAUGA, ONTARIO L4W-1A4
PHONE #: (905)602-8236 FAX #: (905)206-0513

Received Nov 4/96

LECO SUITE

MDS ENVIRONMENTAL SERVICES
ATTN: N. BOULTON
PROJ: 966957

Ecological Services for Planning
361 Southgate Drive
Guelph ON N1G 3M5
ATTENTION: Barbara Dowsley

REPORT No. : **M8156**
Page No. : 1 of 1
File No. : M8156
Date : OCT-11-1996

SAMPLE #	TC %	TIC %	TOC %
S09C82344 OR3-EXP01	19.27	<0.01	19.27
S09C82346 OR3-EXP03	2.77	<0.01	2.77
S09C82349 OR3-EXP06	0.35	<0.01	0.35
S09C82350 OR3-EXP06R	0.24	<0.01	0.24
S09C82351 OR1-REF01	0.16	<0.01	0.16
S09C82352 OR1-REF02	<0.01	<0.01	<0.01
S09C82354 OR1-REF04	2.53	<0.01	2.53

TC TOTAL CARBON COMBUSTION METHOD
TIC CARBONATE CARBON ACIDIFICATION METHOD
TOC ACID INSOLUBLE CARBON TC-TIC

TSL/96

SIGNED :

TSL/ASSAYERS Laboratories
1270 WEBSTER DRIVE, UNIT 3 MISSISSAUGA,ONTARIO L4W-1A4
PHONE #: (905)602-8236 FAX #: (905)206-0513

LECO SUITE

MDS ENVIRONMENTAL SERVICES
ATTN: N. BOULTON
PROJ: 966957

Ecological Services for Planning
361 Southgate Drive
Guelph ON N1G 3M5
ATTENTION: Barbara Dowsley

REPORT No. : **M8156**
Page No. : 1 of 1
File No. : M8156
Date : OCT-11-1996

SAMPLE #	TC %	TIC %	TOC %
S09C82344 OR3-EXP01	19.27	<0.01	19.27
S09C82346 OR3-EXP03	2.77	<0.01	2.77
S09C82349 OR3-EXP06	0.35	<0.01	0.35
S09C82350 OR3-EXP06R	0.24	<0.01	0.24
S09C82351 OR1-REF01	0.16	<0.01	0.16
S09C82352 OR1-REF02	<0.01	<0.01	<0.01
S09C82354 OR1-REF04	2.53	<0.01	2.53

TC TOTAL CARBON COMBUSTION METHOD
TIC CARBONATE CARBON ACIDIFICATION METHOD
TOC ACID INSOLUBLE CARBON TC-TIC

T3L/96

SIGNED :

MDS Environmental Services Limited

WRKMET ANALYTICAL WORK SHEET - **Metal/Conventional Analysis**

TESTCODE:	TOC-SBC-SO
SAMPLE TYPE:	SO

DATE:	96/10/11		
RUN #:	40531		
WC :	SUB	STAT:	SUB

TEST CODE SOP ID: Total Organic Carbon - Subcontracting

N 966957 Ecological Rev (96/10/11): All due dates for ICP metals changed to /18. MDL's to 1/10th CCME.Rev.10/10: soils defined as instructed by Client via

MDS LAB SAMPLE #	CLIENT SAMPLE ID	Date Received	Process By date	Due Date	Process Date	Analysis Date	Sample Wt/Vol	Final Ext Vol	Add. Dil.	Result		%H2O	Fact.
1-Q1 40531_1													
2-Q2 40531_1													
3-966957 Q3 -82344		1996/10/06											
4-966957 SO 9C 82344	OR3-EXP 01	1996/10/06	1996/11/03	96/10/17									
5-966957 Q4 -82344		1996/10/06											
6-966957 SO 9C 82346	OR3-EXP 03	1996/10/06	1996/11/03	96/10/17									
7-966957 SO 9C 82349	OR3-EXP 06	1996/10/06	1996/11/03	96/10/17									
8-966957 SO 9C 82350	OR3-EXP 06 REP	1996/10/06	1996/11/03	96/10/17									
9-966957 SO 9C 82351	OR1-REF 01	1996/10/06	1996/11/03	96/10/17									
10-966957 SO 9C 82352	OR1-REF 02	1996/10/06	1996/11/03	96/10/17									
11-966957 SO 9C 82354	OR1-REF 04	1996/10/06	1996/11/03	96/10/17									

SURROGATE:	CONC:	UNITS:	VOLUME ADDED:
FORTIFICATION STANDARD:	CONC:	UNITS:	VOLUME ADDED:
INTERNAL STANDARD:	CONC:	UNITS:	VOLUME ADDED:
CALIBRATION STANDARD 1:	CONC:	UNITS:	VOLUME ADDED:
CALIBRATION STANDARD 2:	CONC:	UNITS:	VOLUME ADDED:
CALIBRATION STANDARD 3:	CONC:	UNITS:	VOLUME ADDED:
CALIBRATION STANDARD 4:	CONC:	UNITS:	VOLUME ADDED:
CALIBRATION STANDARD 5:	CONC:	UNITS:	VOLUME ADDED:

SAMPLE CALCULATION:

PROCESSED BY:	DATE:
ANALYZED BY:	DATE:

MDS
Environmental Services Limited

FAX TRANSMITTAL

TO: Barbara Pauley, Ecological Services

FAX NO: 519-836-2493

DATE: Oct 11 '96

No. of pages including transmittal cover page 2

Original to follow by mail: Yes ____ No ____

MESSAGE: The following is your total organic analysis for your ref # 962390 naping.

FROM: _____

MDS Environmental Services Ltd.
6850 Goreway Drive
Mississauga, Ontario
L4V 1P1

Fax #: 905-673-7399

Phone #: 905-673-3255
1-800-701-7092

If you experience difficulty with this transmission, please call (905) 673-3255, ext. 352.

××× TRANSMISSION REPORT ×××

OCT-11-96 15:39 ID:

START TIME	OCT-11-96 15:38
TELEPHONE NUMBER	15198362493
NAME(ID NUMBER)	5198362493
TRANSMISSION MODE	EMMR
RESOLUTION	STD
PAGES TRANSMITTED	002
MAILBOX	OFF
SECURITY	OFF
INFORMATION CODE	OK
REDIALING TIMES	01
MACHINE ENGAGED	00'36
JOB NUMBER	750

THIS TRANSMISSION IS COMPLETED.

LAST SUCCESSFUL PAGE 002

MDS ENVIRONMENTAL SERVICES LIMITED

Received Nov 4/96

Sample : 96-H032428
Client ID : SO 8C 82331
Project : 966957

ID #OR3-EXP01

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	57.1	% Finer	0.1	Grav.
PHI 0 (1 mm)	46.9	% Finer	0.1	Grav.
PHI +1 (1/2 mm)	41.0	% Finer	0.1	Grav
PHI +2 (1/4 mm)	38.2	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	35.0	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	31.9	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	24.8	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	21.9	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	19.0	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	18.4	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	16.7	% Finer	0.1	Grav.
Gravel	42.9	%	0.1	Wentworth
Sand	25.2	%	0.1	Wentworth
Silt	13.5	%	0.1	Wentworth
Clay	18.4	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

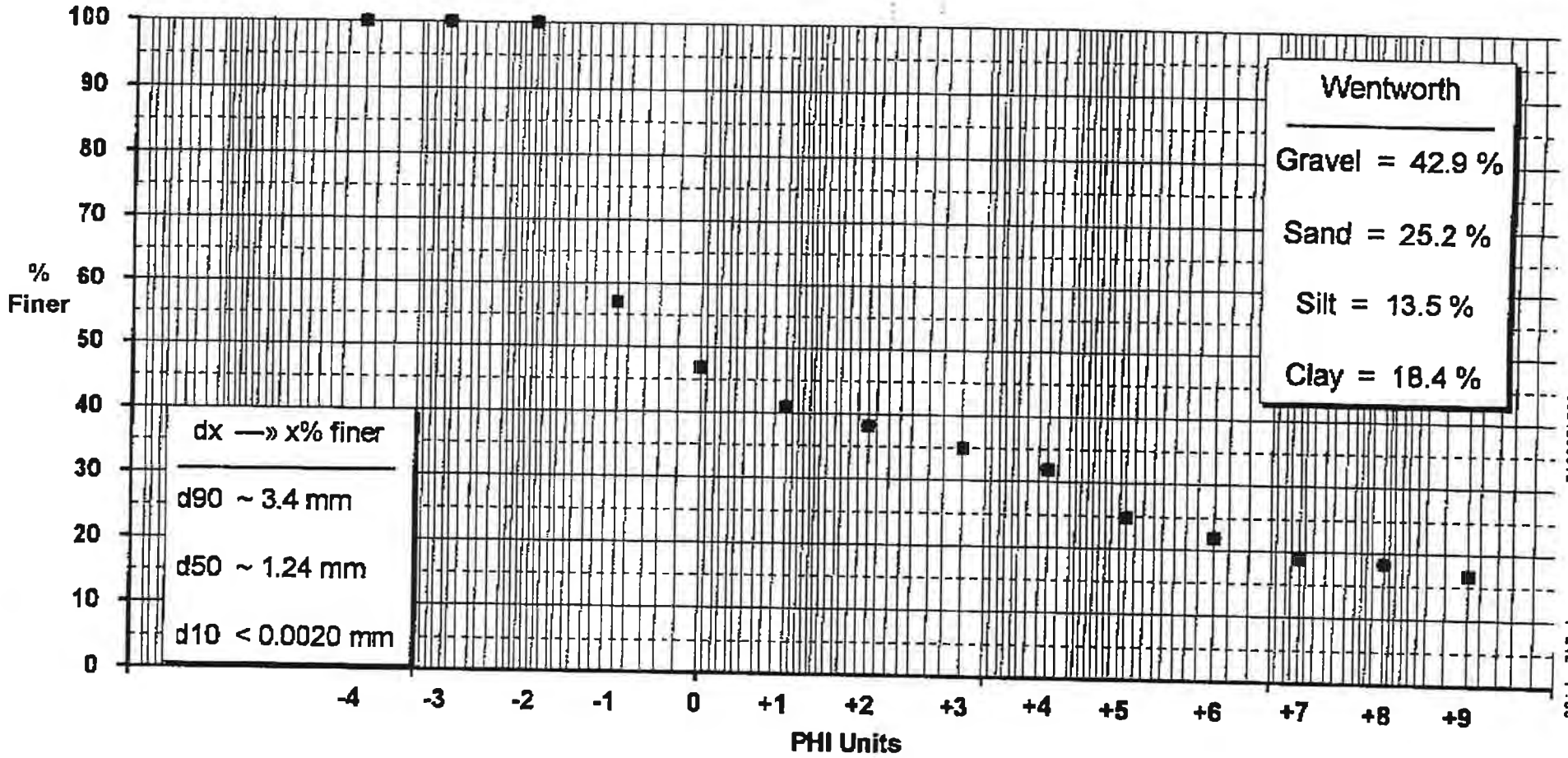
Inorganics Manager
Jerry Arenovich

SO 8C 82331

OR3-EXP-01

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032428



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : 96-H032429
Client ID : SO 8C 82333
Project : 966957

ID # OR3-EXP-03

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	100.	% Finer	0.1	Grav.
PHI 0 (1 mm)	99.6	% Finer	0.1	Grav
PHI +1 (1/2 mm)	98.7	% Finer	0.1	Grav.
PHI +2 (1/4 mm)	89.9	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	42.5	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	18.1	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	12.8	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	9.5	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	6.8	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	6.4	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	5.6	% Finer	0.1	Grav.
Gravel	< 0.1	%	0.1	Wentworth
Sand	81.9	%	0.1	Wentworth
Silt	11.7	%	0.1	Wentworth
Clay	6.4	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

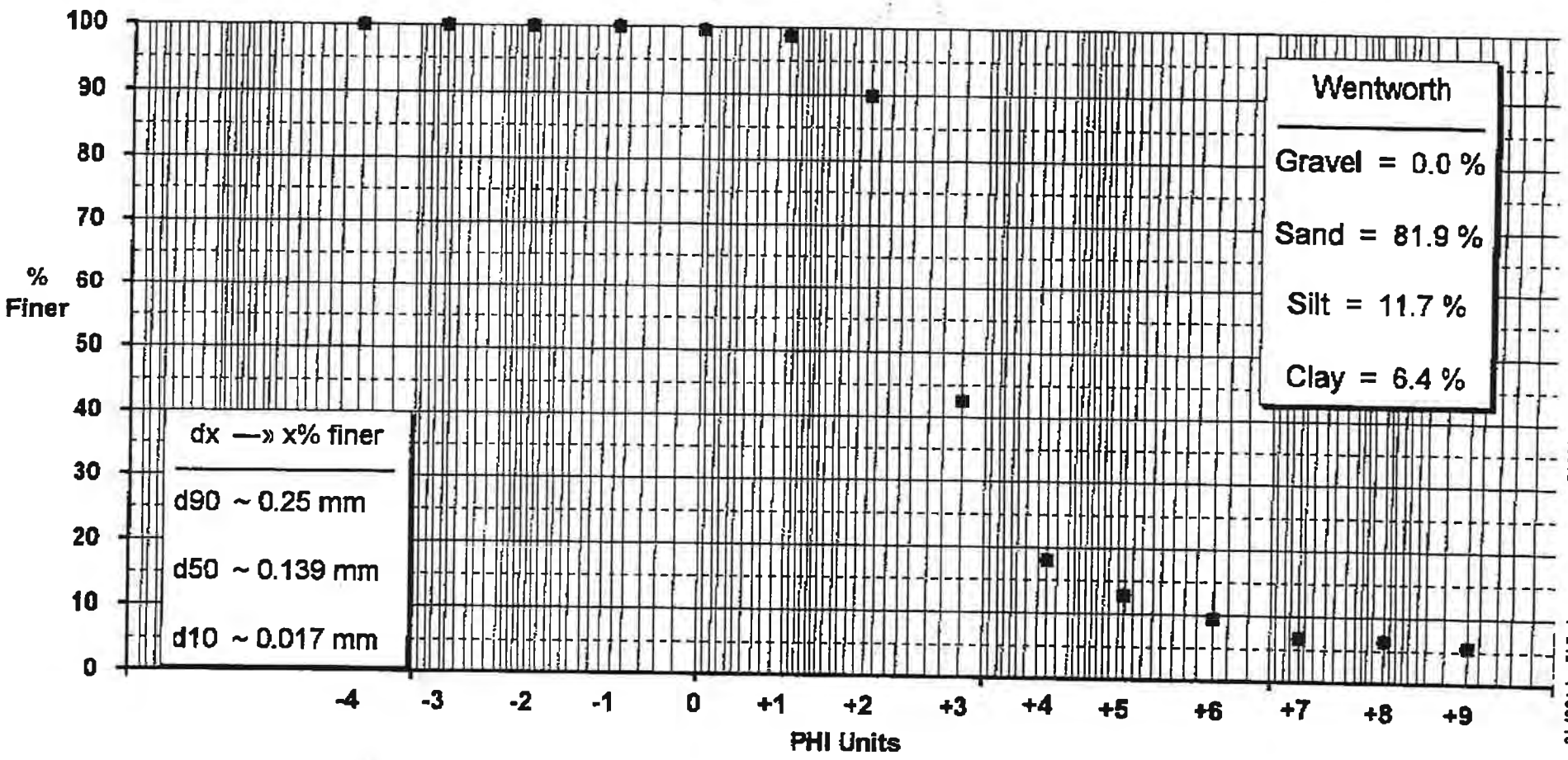
Inorganics Manager
Jerry Arenovich

SO 8C 82333

ID # OR3-Exp 03

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032429



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : 96-H032430
Client ID : SO 8C 82336
Project : 966957

ID # OR3-EXP 06

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	100.	% Finer	0.1	Grav.
PHI 0 (1 mm)	100.	% Finer	0.1	Grav.
PHI +1 (1/2 mm)	99.5	% Finer	0.1	Grav
PHI +2 (1/4 mm)	78.0	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	15.3	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	3.2	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	2.2	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	1.8	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	1.5	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	1.4	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	1.2	% Finer	0.1	Grav.
Gravel	< 0.1	%	0.1	Wentworth
Sand	96.8	%	0.1	Wentworth
Silt	1.8	%	0.1	Wentworth
Clay	1.4	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

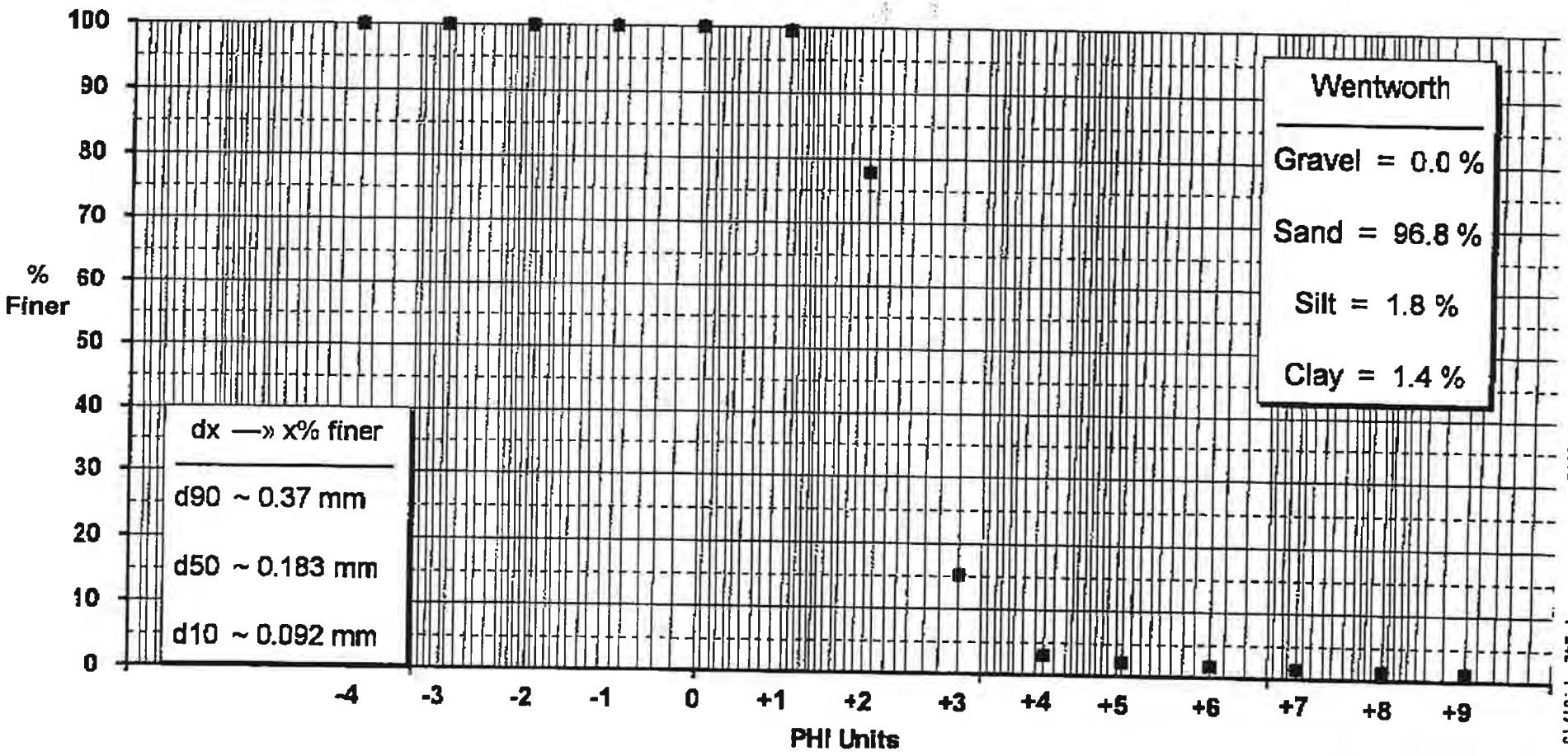
Inorganics Manager
Jerry Arenovich

SO 8C 82336

ID # OR3-EXP06

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032430



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : **96-H032431**
Client ID : SO 8C 82337
Project : 966957

ID # OR3-EXP 06 [redacted].

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	100.	% Finer	0.1	Grav.
PHI 0 (1 mm)	99.9	% Finer	0.1	Grav
PHI +1 (1/2 mm)	99.4	% Finer	0.1	Grav.
PHI +2 (1/4 mm)	77.8	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	15.3	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	3.1	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	2.2	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	1.7	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	1.4	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	1.4	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	1.2	% Finer	0.1	Grav.
Gravel	< 0.1	%	0.1	Wentworth
Sand	96.9	%	0.1	Wentworth
Silt	1.8	%	0.1	Wentworth
Clay	1.4	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 21, 1996
Date Reported: Oct 21, 1996

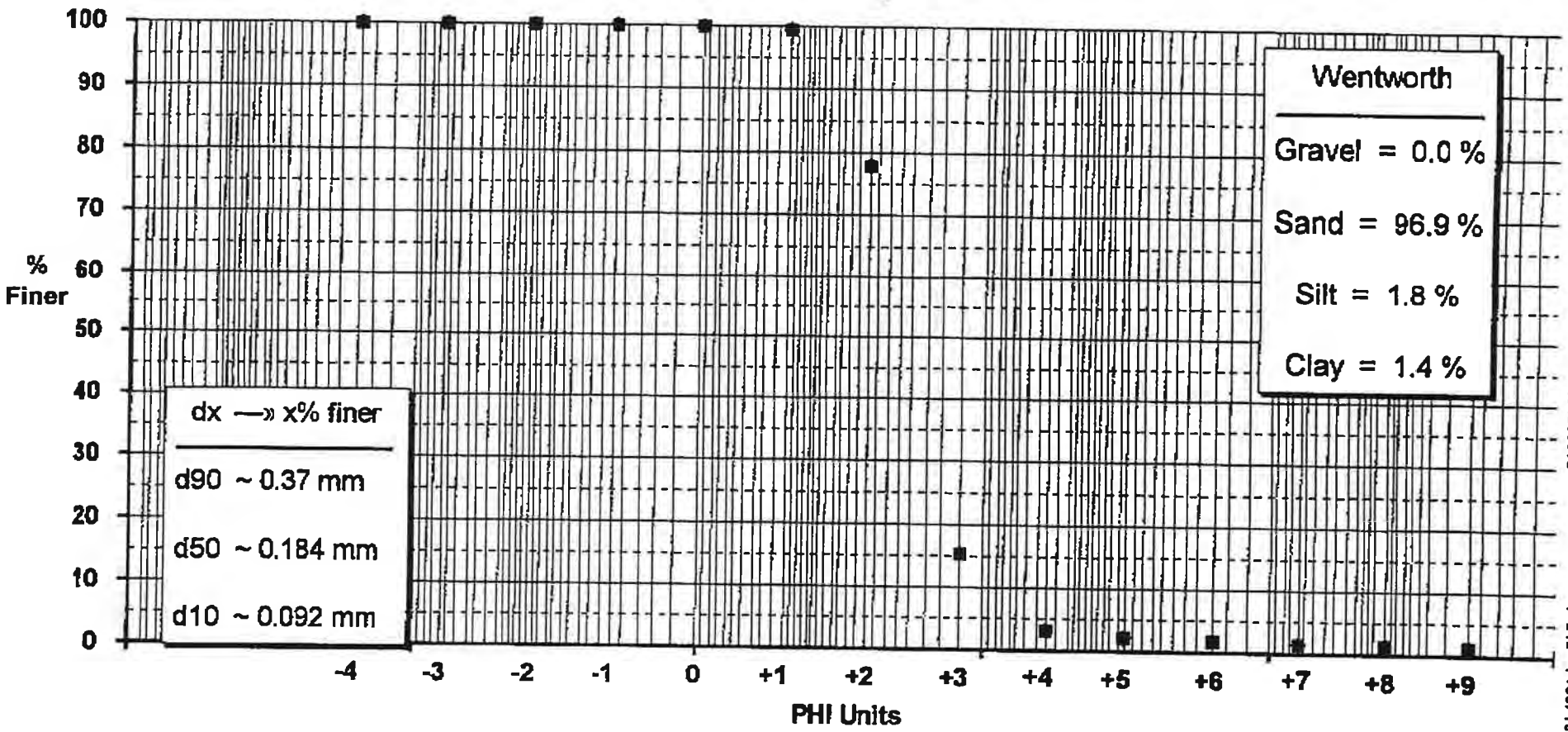
Inorganics Manager
Jerry Arenovich

SO 8C 82337

ID# OR3-EXP06

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032431



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : 96-H032432
Client ID : SO 8C 82338
Project : 966957

ID # ORI-REF01

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	86.2	% Finer	0.1	Grav.
PHI 0 (1 mm)	76.6	% Finer	0.1	Grav
PHI +1 (1/2 mm)	54.0	% Finer	0.1	Grav.
PHI +2 (1/4 mm)	20.8	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	6.5	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	2.7	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	1.9	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	1.5	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	1.1	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	1.0	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	0.9	% Finer	0.1	Grav.
Gravel	13.8	%	0.1	Wentworth
Sand	83.5	%	0.1	Wentworth
Silt	1.7	%	0.1	Wentworth
Clay	1.0	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

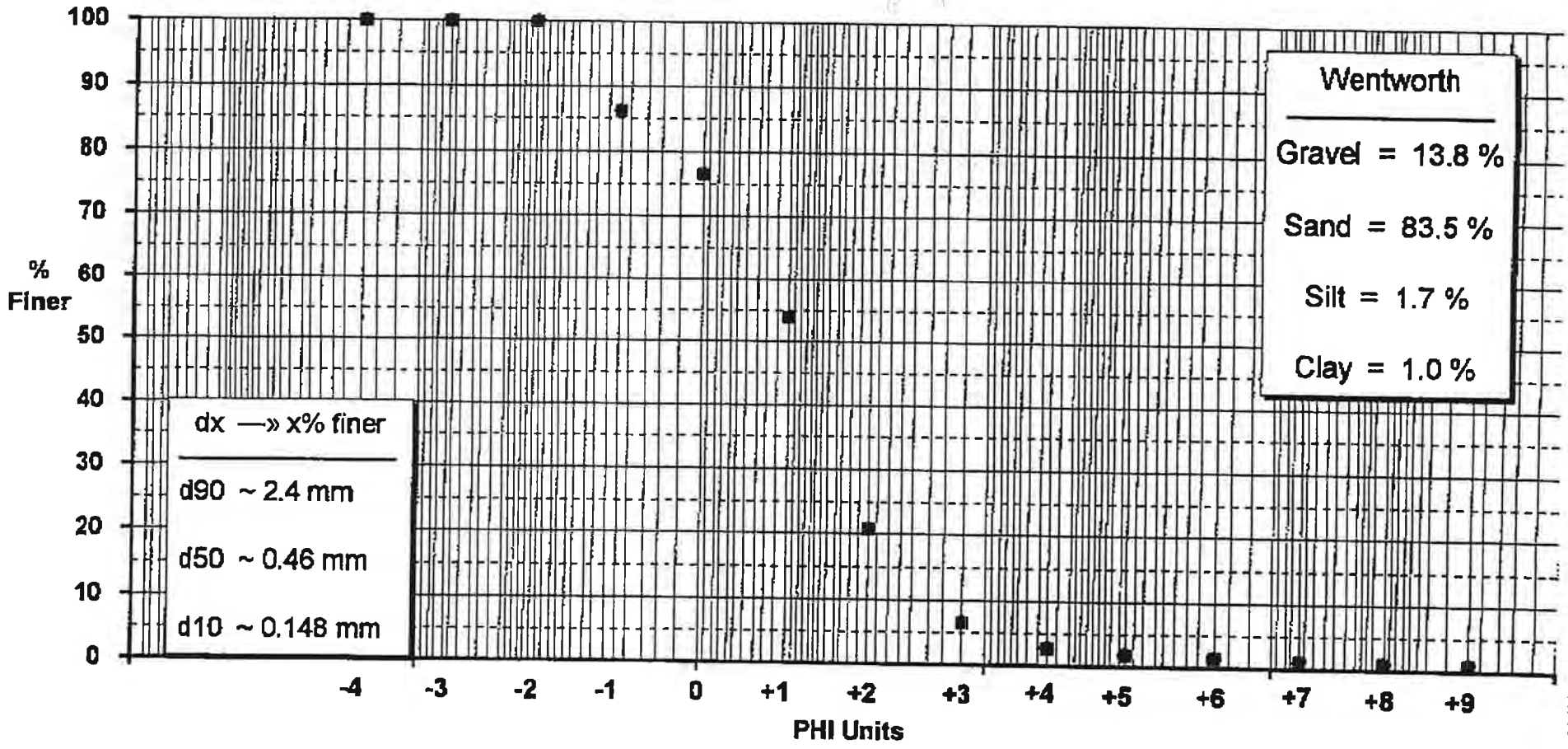
Inorganics Manager
Jerry Arenovich

SO 8C 82338

ORI-REF 01

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032432



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : 96-H032433
Client ID : SO 8C 82339
Project : 966957

ID # ORI-REF02.

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	74.1	% Finer	0.1	Grav.
PHI 0 (1 mm)	47.2	% Finer	0.1	Grav.
PHI +1 (1/2 mm)	15.2	% Finer	0.1	Grav
PHI +2 (1/4 mm)	2.3	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	1.1	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	0.9	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	0.7	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	0.6	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	0.5	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	0.4	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	0.4	% Finer	0.1	Grav.
Gravel	25.9	%	0.1	Wentworth
Sand	73.2	%	0.1	Wentworth
Silt	0.5	%	0.1	Wentworth
Clay	0.4	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

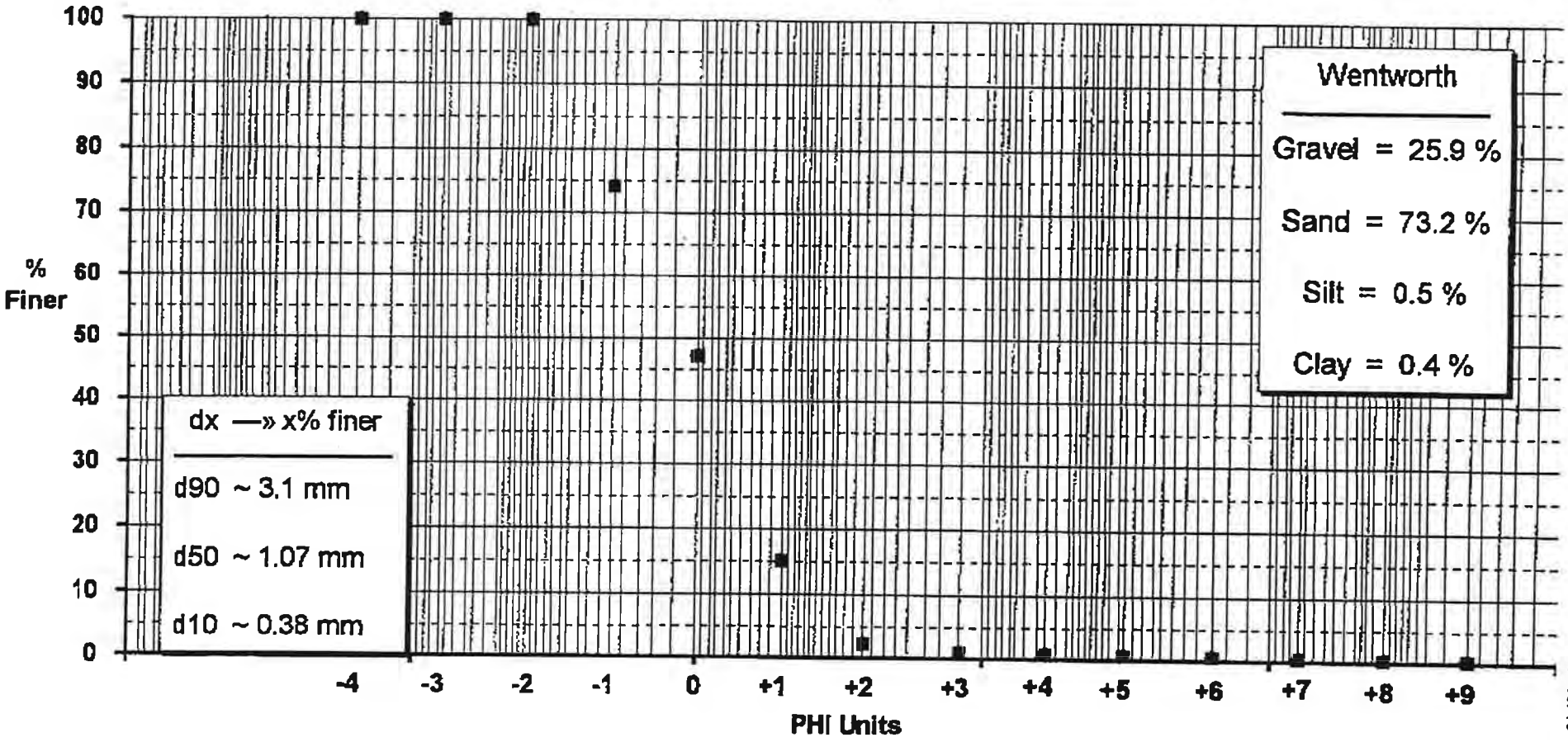
Inorganics Manager
Jerry Arenovich

SO 8C 82339

ID # ORI-REF 02

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032433



MDS ENVIRONMENTAL SERVICES LIMITED

Sample : 96-H032434
Client ID : SO 8C 82341
Project : 966957

ID# ORI-REF 04

Inorganic Analytes	Value	Units	MDL	Method
12.5 mm	100.	% Finer	0.1	Grav.
9.5 mm	100.	% Finer	0.1	Grav.
4.75 mm	100.	% Finer	0.1	Grav.
PHI -1 (2 mm)	99.7	% Finer	0.1	Grav.
PHI 0 (1 mm)	99.2	% Finer	0.1	Grav
PHI +1 (1/2 mm)	98.3	% Finer	0.1	Grav.
PHI +2 (1/4 mm)	90.8	% Finer	0.1	Grav.
PHI +3 (1/8 mm)	43.7	% Finer	0.1	Grav.
PHI +4 (1/16 mm)	15.4	% Finer	0.1	Grav.
PHI +5 (1/32 mm)	11.4	% Finer	0.1	Grav.
PHI +6 (1/64 mm)	8.7	% Finer	0.1	Grav.
PHI +7 (1/128 mm)	7.2	% Finer	0.1	Grav.
PHI +8 (1/256 mm)	6.8	% Finer	0.1	Grav.
PHI +9 (1/512 mm)	5.3	% Finer	0.1	Grav.
Gravel	0.3	%	0.1	Wentworth
Sand	84.4	%	0.1	Wentworth
Silt	8.6	%	0.1	Wentworth
Clay	6.8	%	0.1	Wentworth

Note : Results are expressed on a dry weight basis.

Report To:
Valerie Geldart
MDS Laboratories - Toronto
6850 Goreway Drive
Mississauga, ON, L4V 1P1

Date Received: Oct 11, 1996
Date Reported: Oct 21, 1996

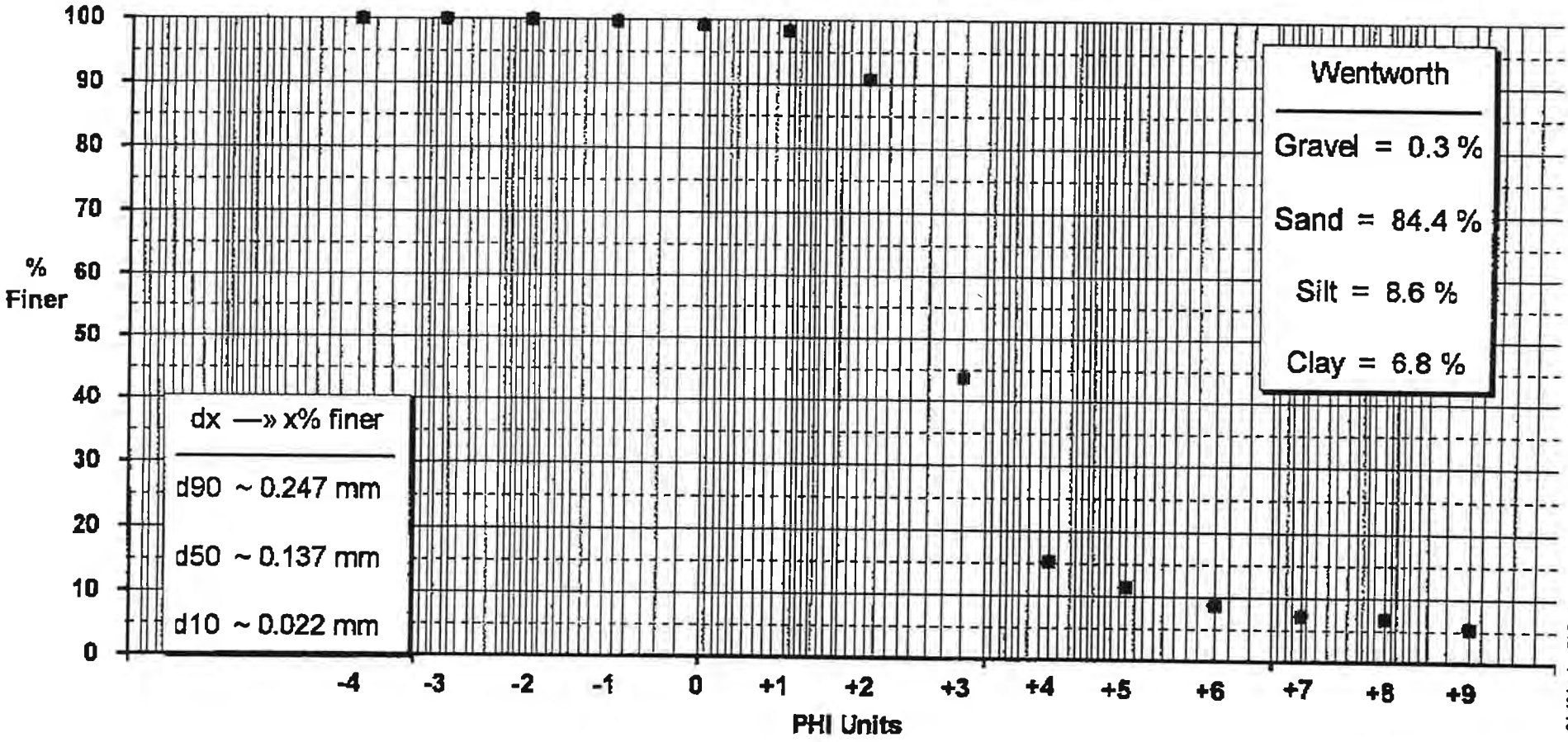
Inorganics Manager
Jerry Arenovich

SO 8C 82341

ID # DRI-REF 04

MDS
Environmental Services Ltd.

MDS Sample ID: 96-H032434



APPENDIX E

Benthic Invertebrate Community Structure

APPENDIX E1

Detailed Methods

SAMPLE PROCESSING

All benthos samples were processed and analyzed by Zaranko Environmental Assessment Series (ZEAS), Guelph, ON.

Upon arrival, samples were immediately logged and inspected to ensure adequate preservation to a minimum level of 10% buffered formalin and correct labeling. No problems with preservative or labeling were identified. All benthic samples were sorted with the use of a stereomicroscope. A magnification of 10X was used for macrobenthos (invertebrates > 500 µm) and 20X for meiobenthos (invertebrate size from 200 to 500 µm). To expedite sorting, prior to processing, all samples were stained with a protein dye that is absorbed by aquatic organisms but not by organic material such as detritus and algae. The stain has proven to be extremely effective in increasing sorting accuracy and efficiency.

Prior to sorting, samples were washed free of formalin in a 250 µm sieve. Benthic invertebrates and associated debris were elutriated from any sand and gravel in the sample. Elutriation techniques effectively removed almost all organisms. The remaining sand and gravel fraction was closely inspected for the odd heavier organism such as Pelecypoda, Gastropoda, and Trichoptera with stone cases that may not have all been washed from this fraction. After elutriation, the remaining debris and benthic invertebrates were washed through a series of two sieves, 500µm and 250 µm respectively.

SUBSAMPLING

Benthic samples were sorted entirely (both 500 and 250 µm) except in the instance of large amounts of organic matter and high densities of organisms. Benthic samples containing large amount of organic matter or high densities of organisms can often take days to sort entirely. Thus sorting the whole sample may not be cost effective. In addition, with large quantities of organic matter there comes a point when additional sorting does not yield further ecological information. As such, the following subsampling techniques were employed.

Sample material was distributed evenly on the 500 µm and 250 µm sieves. One half of the material was removed and set aside while the remaining half was distributed evenly on each sieve and again divided in two. A minimum subsample volume of 25% was the criteria set for this study. The same fraction was sorted from the 500 µm and the 250 µm sieve. On average, each sample took between five and six hours to sort in which an average of 300 organisms were removed from the associated debris.

Benthic invertebrates were enumerated and sorted into major taxonomic groups, (i.e., order and family), placed in glass vials and represerved in 70% ethanol for more detailed taxonomic analysis by senior staff. Each vial was labeled with the survey name, date, station, and replicate number. For QA/QC evaluation, sorted sediments and debris were represerved and will be retained for up to a

period of six months following the submission of the final report. For those samples that were subsampled, sorted and unsorted fractions were represerved separately.

DETAILED IDENTIFICATION

All invertebrates were identified to the lowest practical level, usually genus, with the exception of bivalves (*Sphaerium*), and oligochaetes which were identified to species. Nematodes were identified to phylum, water mites and harpacticoids to order, and ostracods to class.

Chironomids and oligochaetes were mounted on glass slides in a clearing media prior to identification using a compound microscope. In samples with large numbers of oligochaetes, a random sample of no less than 20% of the picked individuals, up to a maximum of 50, were mounted on slides for identification. Similarly, in samples with a large number of chironomids, individuals that could be identified using a dissecting scope, (e.g., *Cryptochironomus, Chironomus, Monodiamesa, Procladius, Heterotrissocladius*), were enumerated and removed from the sample. The remaining individuals were sorted into sub-families and tribes. A random sample of no less than 20% of the individuals from each group were mounted on slides for identification, up to a maximum of 50 individuals.

VOUCHER COLLECTION

The standard operating procedures for ZEAS's Benthic Ecology Laboratory requires the compilation of a voucher collection for all benthic invertebrate projects. Representative specimens for each taxon are placed in labeled glass vials. Mounted chironomids and oligochaetes remain on the initial slides and representatives of each taxon are circled with a permanent marker. A voucher collection is one way of ensuring continuity in taxonomic identifications if different taxonomists process future samples. The voucher collection is either maintained in our files indefinitely or returned to the client. ZEAS also maintains a master reference collection of all taxa which have been identified by the lab.

QUALITY ASSURANCE AND QUALITY CONTROL MEASURES

ZEAS incorporates the following QA/QC procedures for all benthic studies to ensure reliability of data:

- all samples were stained to facilitate accurate sorting;
- the most updated and widely used taxonomic keys are referenced;
- 10% of all sorted samples were resorted by a second taxonomist to ensure 95% recovery of all invertebrates;
- a voucher collection was compiled and will be kept indefinitely or returned to the client;
- both sorted and unsorted sample fractions were represerved in 10 % formalin and will be maintained for six months after submission of the final report;
- all tabulated benthic data were cross checked against bench sheets by a second person to ensure there have been no data entry errors or incorrect spelling of scientific nomenclature;
- subsampling error was calculated for 10% of the samples requiring subsampling.

REPORTING BENTHIC MACROINVERTEBRATE DATA

Following identification and enumeration, a detailed taxa list was prepared for each station summarizing the total organism density and total number of taxa. The taxa list was prepared using Excel 5.0.

APPENDIX E2

QA/QC

TABLE 1: CALCULATION OF SUBSAMPLING ERROR FOR BENTHIC INVERTEBRATE SAMPLES FROM LEVACK/ ONAPING, INCO, AND FALCONBRIDGE (1996).

Station	Number of Animals in Fraction 1	Number of Animals in Fraction 2	Standard Deviation	Coefficient of Variation
REF-OR1-01	153	175	15.56	9.5%
EXP-OR3-06	195	203	5.66	2.8%

* large organisms that were picked from the whole sample were excluded in the calculation.

TABLE 2: PERCENTAGE RECOVERY OF BENTHIC INVERTEBRATES FROM SAMPLES FOR LEVACK/ONAPING, INCO, AND FALCONBRIDGE (1996).

Station	Number of Animals Recovered	Number of Animals in Re-sort	Percent Recovery
REF-OR1-04	123	7	95%
EXP-SURBER-03	396	11	97%

TABLE 3: SAMPLE FRACTION SORTED FOR LEVACK/ONAPING, INCO, AND FALCONBRIDGE (1996).

Station	Fraction Sorted
REF-SURBER-01	WHOLE
REF-SURBER-02	WHOLE
REF-SURBER-03	WHOLE
REF-OR1-01	WHOLE[a]
REF-OR1-02	WHOLE
REF-OR1-04	WHOLE
EXP-SURBER-01	1/2
EXP-SURBER-02	WHOLE
EXP-SURBER-03	WHOLE
EXP-OR3-01	1/4
EXP-OR3-03	1/4
EXP-OR3-06	1/2[b]

[a] two halves were sorted for subsampling error calculations

[b] Two quarters were sorted for subsampling error calculations

APPENDIX E3

Results

BENTHIC INVERTEBRATE DATA FOR LEVACK/ONAPING MINE SITE (1996)

Station	REF-SURBER			REF-OR1			EXP-SURBER			EXP-OR3		
Replicate	1	2	3	1	2	4	1	2	3	1	3	6
P. Coelenterata												
Hydra	-	-	-	-	-	-	-	-	-	-	8	-
P. Nematoda	5	2	12	75	6	40	10	4	11	108	284	26
P. Platyhelminthes												
Cl. Turbellaria												
F. Tricladida	-	-	-	3	-	-	2	-	-	-	-	-
P. Nemertea												
Prostoma	34	21	7	38	12	2	-	3	3	-	108	-
P. Annelida												
Cl. Oligochaeta												
F. Enchytraeidae	-	-	10	1	-	1	2	-	2	4	-	-
F. Naididae												
Nais communis	-	-	-	-	-	-	30	2	3	-	-	-
Nais simplex	-	-	-	-	-	-	10	9	2	-	19	-
Nais variabilis	-	-	-	-	-	-	-	2	2	-	397	-
F. Tubificidae												
Limnodrilus udekemianus	-	-	-	-	-	2	-	-	-	-	38	-
immatures with hair chaetae	-	-	-	-	-	6	-	-	-	4	-	-
immatures without hair chaetae	-	-	-	-	-	-	-	-	-	8	38	10
F. Lumbriculidae												
Lumbriculus variegatus	-	-	-	-	-	1	-	-	-	-	-	4
F. Sparganophilidae												
Sparganophilus	-	-	-	-	-	3	-	-	-	-	4	-
Cl. Hirudinae												
F. Glossiphoniidae												
Placobdella papillifera	-	-	-	-	-	-	2	-	-	-	-	-
P. Arthropoda												
Cl. Arachnida												
O. Hydracarina	3	-	-	7	1	9	8	1	-	-	60	6
Cl. Maxillopoda												
O. Harpacticoida	-	-	-	-	1	1	-	-	-	-	-	4
Cl. Ostracoda	-	-	-	16	-	20	-	-	-	44	36	10
Cl. Entognatha												
O. Collembola	-	-	-	1	-	-	-	-	-	4	4	-
Cl. Insecta												
O. Coleoptera												
F. Elmidae	-	-	-	-	-	-	4	-	-	-	-	-
Dubiraphia vittata	-	-	-	-	-	-	-	-	-	-	4	-
Optioservus fastiditus	1	1	1	-	-	-	-	-	1	-	-	-
Optioservus	-	-	-	-	-	-	18	2	4	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	4	-
Stenelmis	-	-	-	-	-	-	12	2	-	-	-	-
O. Ephemeroptera												
F. Baetidae												
Acerpenna pygmaeus	-	-	-	-	-	-	-	-	2	-	-	-
Baetis	-	-	-	-	-	-	-	6	1	-	-	-
F. Caenidae												
Caenis	-	-	-	-	-	-	-	-	-	48	12	-
F. Ephemerellidae												
Ephemerella	-	-	-	-	1	-	24	6	2	-	-	-
F. Heptageniidae												
Epeorus	1	-	-	-	-	-	8	1	-	-	-	-
Heptagenia	5	-	1	-	-	-	18	14	27	-	-	-
Stenonema vicarium	1	1	-	-	-	-	-	-	3	-	-	-
Stenonema	2	-	-	-	-	-	10	-	-	-	-	-
F. Oligoneuriidae												
Isonychia	13	-	-	-	-	-	2	1	1	-	-	-
O. Lepidoptera												

BENTHIC INVERTEBRATE DATA FOR LEVACK/ONAPING MINE SITE (1996)

Station	REF-SURBER			REF-OR1			EXP-SURBER			EXP-OR3		
Replicate	1	2	3	1	2	4	1	2	3	1	3	6
F. Pyralidae	-	-	-	-	-	-	-	1	-	-	-	-
O. Megaloptera												
F. Sialidae												
Sialis	-	-	-	-	-	-	-	-	-	1	-	-
F. Corydalidae												
Nigronia	-	1	-	-	-	-	-	-	-	-	-	-
O. Odonata												
F. Gomphidae												
immature	3	-	-	-	-	-	6	-	1	-	-	-
Stylurus	-	-	-	-	-	-	-	-	-	-	-	1
O. Plecoptera												
immature	-	1	-	2	-	-	-	3	-	-	-	-
F. Capnilidae												
Paracapnia	-	-	-	-	-	-	-	-	1	-	-	-
F. Chloroperlidae												
immature	1	-	-	-	-	-	2	-	-	-	-	-
F. Perlidae												
Acroneuria	5	1	-	-	-	-	2	-	10	-	-	-
F. Perlodidae												
?Hydroperla	-	-	-	-	-	-	-	1	-	-	-	-
Isoperla	-	-	-	-	-	-	16	6	-	-	-	-
F. Pteronarcyidae												
Pteronarcys	-	-	-	-	-	-	-	1	-	-	-	-
F. Taeniopterygidae												
Taeniopteryx	11	-	12	-	-	-	12	2	3	-	-	-
O. Trichoptera												
Trichoptera pupae	-	-	-	-	-	-	-	-	-	-	4	-
F. Brachycentridae												
Micrasema	-	-	-	-	-	-	2	-	1	-	-	2
F. Dipseudopsidae												
Phylocentropus	-	-	-	-	-	-	-	-	-	7	-	1
F. Glossosomatidae												
Glossosoma	-	-	-	-	-	-	36	1	-	-	-	-
F. Helicopsychidae												
Helicopsyche	-	-	-	-	-	-	-	-	1	-	-	-
F. Hydropsychidae												
Cheumatopsyche	2	-	-	-	-	-	2	1	4	-	-	-
Hydropsyche betteni	-	-	3	-	-	-	-	1	-	-	-	-
Hydropsyche bronta	-	-	3	-	-	-	-	-	-	-	-	-
Hydropsyche dicantha	-	-	-	-	-	-	-	9	2	-	-	-
Hydropsyche morosa	2	-	-	-	-	-	38	6	1	-	-	-
Hydropsyche slossonae	1	1	-	-	-	-	-	-	-	-	-	-
Hydropsyche sparna	-	-	-	-	-	-	4	10	-	-	-	-
Hydropsyche	-	-	-	-	-	-	50	2	-	-	-	-
F. Hydroptilidae												
Hydroptila	-	-	-	-	-	-	78	10	19	-	-	-
Leucotrichia	-	-	-	-	-	-	-	-	1	-	-	-
Oxyethira	3	1	1	-	-	-	-	2	1	4	52	2
F. Lepidostomatidae												
Lepidostoma	-	-	-	-	-	-	42	9	13	-	-	-
F. Leptoceridae												
Ceraclea	-	-	-	-	-	-	2	-	2	-	-	-
Oecetis	1	-	-	1	1	-	6	4	8	-	4	-
Triaenodes	-	-	1	-	-	-	-	1	-	-	-	-
F. Limnephilidae	-	2	-	-	-	1	-	-	-	-	-	-
Pycnopsyche	2	-	1	-	-	-	-	-	-	-	-	-
F. Molannidae												
Molanna	-	-	-	-	-	-	-	-	-	1	-	-

BENTHIC INVERTEBRATE DATA FOR LEVACK/ONAPING MINE SITE (1996)

Station	REF-SURBER			REF-OR1			EXP-SURBER			EXP-OR3		
Replicate	1	2	3	1	2	4	1	2	3	1	3	6
F. Philopotamidae												
Chimarra	23	6	15	-	-	-	100	154	38	-	-	-
F. Polycentropodidae												
Neureclipsis	-	-	-	-	-	-	-	1	2	-	-	-
Nyctiophylax	-	-	-	-	-	-	6	-	1	-	-	-
Polycentropus	-	-	-	-	-	-	-	-	-	4	8	-
F. Psychomyiidae												
Psychomyia	-	-	-	-	-	-	-	-	3	-	-	-
F. Rhyacophilidae												
Rhyacophila	1	-	2	-	-	-	-	-	-	-	-	-
O. Diptera												
F. Athericidae												
Atherix	-	-	-	-	-	-	16	4	2	-	-	-
F. Ceratopogonidae	3	3	2	52	6	7	4	5	1	40	32	78
F. Chironomidae												
indeterminate	-	-	-	-	-	-	-	-	-	4	-	-
Chironomid pupae	-	-	-	-	-	-	2	1	2	-	-	-
S.F. Chironominae												
Cladopelma	-	-	-	-	-	-	-	-	-	24	-	-
Cladotanytarsus	-	-	-	-	-	-	-	-	-	-	-	4
Constempellina	2	-	-	-	-	-	-	-	-	-	-	-
Cryptochironomus	-	-	-	-	-	-	-	-	-	4	32	18
Demicryptochironomus	-	-	-	-	-	-	-	1	-	-	-	4
Dicrotendipes	-	-	-	-	-	-	-	-	-	24	-	22
Micropsectra	1	-	1	-	-	1	-	5	8	-	4	-
Microtendipes	2	2	3	-	-	-	2	7	19	-	-	-
Nilothauma	-	-	-	-	-	-	-	-	1	-	-	-
Pagastiella	-	-	-	40	7	4	-	-	-	60	40	35
Parachironomus	-	-	-	1	-	-	-	-	-	-	8	-
Paracladopelma	-	-	-	-	-	-	-	-	-	-	-	18
Paralauterborniella	-	-	-	-	-	-	-	-	-	12	-	-
Paratanytarsus	-	-	-	5	-	-	-	-	-	-	8	-
Paratendipes	-	-	-	8	-	-	-	-	-	-	-	-
Phaenopsectra	-	1	-	-	-	1	-	-	-	-	4	-
Polypedilum	-	1	-	13	-	13	-	-	-	60	8	310
Rheotanytarsus	12	-	-	-	-	-	20	3	7	-	-	-
Robackia	1	-	-	-	2	-	-	1	1	-	-	-
Stenochironomus	-	-	-	-	-	-	-	-	-	8	-	-
Stictochironomus	-	-	-	-	-	-	-	-	-	20	8	74
Tanytarsus	2	-	1	13	16	-	44	12	100	128	404	22
Xenochironomus	-	-	-	-	-	-	-	-	-	-	12	-
S.F. Orthocladiinae												
indeterminate	-	-	-	1	-	-	-	-	-	-	-	-
Cricotopus	-	-	-	-	-	-	14	3	15	28	44	18
Eukiefferiella	-	-	-	-	-	-	-	1	-	-	-	-
Lopescladius	-	2	-	-	-	-	2	-	-	-	-	-
Nanocladius	1	-	-	16	-	-	-	-	-	-	8	-
Orthocladius	-	-	-	-	-	-	2	3	-	-	-	-
Parakiefferiella	-	-	-	8	-	-	-	-	-	8	24	18
Parametriocnemus	-	-	-	-	-	-	2	1	-	-	-	-
Psectrocladius	-	-	-	-	-	-	-	-	2	-	16	4
Pseudorthocladius	-	-	11	-	-	-	-	-	-	-	-	-
Pseudosmittia	-	-	-	-	-	-	2	-	-	-	-	-
Rheocricotopus	-	-	-	-	-	-	-	3	8	-	-	-
Rheosmittia	1	-	-	-	-	-	-	-	-	-	-	-
Thienemanniella	-	-	-	-	-	-	2	-	-	-	-	-
Tvetenia	-	-	-	-	-	-	20	12	4	-	-	-
Xylotopus	-	-	-	-	-	-	-	-	-	8	-	-

BENTHIC INVERTEBRATE DATA FOR LEVACK/ONAPING MINE SITE (1996)

Station	REF-SURBER			REF-OR1			EXP-SURBER			EXP-OR3		
Replicate	1	2	3	1	2	4	1	2	3	1	3	6
S.F. Tanypodinae												
indeterminate	-	-	-	2	-	-	4	-	-	-	-	-
Ablabesmyia	-	-	-	1	1	-	-	-	-	148	8	4
Helopelopia	-	-	-	-	-	-	2	3	14	-	-	-
Labrudinia	-	-	-	-	-	-	2	-	-	-	32	-
?Larsia	-	-	1	-	-	-	-	-	-	-	-	13
Nilotanypus	-	-	-	-	-	-	-	1	-	-	-	-
Procladius	-	-	-	2	-	2	-	-	-	80	8	57
Rheopelopia	-	-	-	-	-	-	12	-	4	-	-	-
Thienemannimyia complex	-	-	-	-	-	-	2	1	3	-	-	-
F. Empididae												
Chelifera	-	-	-	-	-	-	-	2	-	-	-	-
Hemerodromia	-	-	-	-	-	-	28	2	9	-	-	2
F. Tipulidae												
Antocha	-	-	2	-	-	-	26	-	20	-	-	-
P. Mollusca												
Cl. Gastropoda												
F. Hydrobiidae												
Amnicola limosa	-	-	-	12	-	3	-	-	-	-	-	-
F. Physidae												
Physella	1	-	-	-	-	-	-	-	-	-	-	-
Cl. Pelecypoda												
F. Sphaeriidae												
Pisidium	13	-	-	10	3	6	-	-	-	-	8	26
Sphaerium striatinum	2	-	-	-	-	-	-	-	-	-	-	-
TOTAL NUMBER OF ORGANISMS	161	47	90	328	57	123	772	349	396	893	1792	793
TOTAL NUMBER OF TAXA	33	16	20	24	12	19	51	52	50	28	37	28

APPENDIX F

Fisheries

APPENDIX F1

Detailed Methods

Fish Habitat Assessment Methodology for DNRE/DFO Table

GENERAL INFORMATION
This methodology is to be used for information when completing the DNRE/DFO Table- New Brunswick Stream Survey and Habitat Assessment. The information provided from the survey will help to determine the streams potential for fish production, as well as identify problem areas which may in turn affect the quality of the river/stream.

SIDE 1/PAGE 1

TABLE HEADING	
River:	- the name of the river or stream being surveyed
Start Point:	- 500 m upstream of the proposed crossing
End Point:	- 500 m downstream of the proposed crossing
Drainage Code:	
Stream/River No.:	
Personnel:	- fill in each surveyors initials
Date:	- fill in date on which survey is performed
GIS Map No.:	- if known, fill in the Forest Inventory Map number pertaining to area on river/stream being surveyed
Stream Order No.:	

TABLE	
Rules for filling out the table: • for something assessed, but not observed put (0) • for something not assessed put (--) • specify orientations as: R = right L = left M = middle	
Column 1 **"Reach No."**	• reach number one starts 500 m upstream of the proposed crossing and continues downstream, terminating at the proposed crossing. • reach number two starts at the proposed crossing and continues downstream 500 m.
Column 2 "Unit No."	Each distinctive stream type encountered during the stream survey is denoted as a discrete unit and numbered consecutively, starting with one, from the start point to the end point of each reach surveyed.

Fish Habitat Assessment Methodology (continued)

<table>
<tr><td>Column 3
"Stream Type"</td><td>Identify and record stream type by number from the "Stream Type" table below. Definitions are presented in the attached Glossary.</td></tr>
<tr><td colspan="2">
STREAM TYPE
<table>
<tr><th colspan="2">FASTWATER</th><th colspan="2">POOLS</th></tr>
<tr><td>1. Fall
2. Cascade
3. Riffle (Gr/Rb)
4. Riffle (R/B)
5. Riffle (Sand)</td><td>6. Sheet (ledge)
7. Chute
8. Run
9. Rapid</td><td>10. Midchannel
11. Convergence
12. Lateral
13.Beaver
14.Trench
15. Plunge
16.
17. Bogan</td><td>18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater</td></tr>
</table>
</td></tr>
<tr><td>Column 4
"Channel Type"</td><td>Two or more stream types may occupy the width of a river/stream. In such cases the location of the stream type must be denoted as R, L or M.

Right and left are with respect to the right and left sides of the surveyor, as the surveyor is moving from upstream to downstream.

Main Channel: used when the stream identified encompasses the entire width of the river.

Side Channel: used when an island divides the river into two or more channels. One channel would be identified as the Main (1) and the other as a Side channel (2).
- specify if the side channel is to the left (L) or the right (R) of the Main Channel.

Split: used when there are two or more stream types encompassing the entire width of the river/stream use R, L to divide right and left sides.

Bogan: used when there is a backdrop of water due to an incoming tributary. Substrate normally consists of sands and fines
- specify if the bogan is on the left (L) or on the right (R).

(e.g., The survey for reach one has just begun. The river or stream has three stream types encompassing the entire width of the river or stream. To the left is a riffle (stream type 3, 4 or 5, depending on substrate composition); In the middle is a pool (stream type 14 to 24, depending on pool characteristics); To the right is a run (stream type 8). The riffle would be unit 1, the pool would be unit 2 and the run would be unit 3. The channel type of unit 1 would be written as 3L. The number designates the riffle as a split, with the unit being on the left side of the stream (L). The channel type for unit 2 would be written as 3M, and that for unit 3 would be 3R.)</td></tr>
<tr><td>Column 5
"Length (m)"</td><td>Length of the stream type being measured (i.e. the length of the unit)</td></tr>
</table>

Fish Habitat Assessment Methodology (continued)

Column 6 **"Average Width (m)"**	**Wet Width:** -The width of the river/stream system, in metres, from the edge of the existing water line of one bank to the edge of the existing water line of the opposite bank. Measurement is based on low water. The wet width is measured throughout the unit and the average is calculated. **Bank Channel Width:** -The channel width of river/stream system in, metres, based on the high water mark from one bank to the opposite bank. The channel width is measured throughout the unit and an average is calculated.
Column 7 **"Substrate (%)"**	Based on the chart below, use the criteria to identify the percent (%) of each substrate within the stream type. The total of all substrate types must equal 100%

SUBSTRATE AND CRITERIA

1. Bedrock, Ledge		
2. Boulder	=	> 461 mm
3. Rock	=	180 - 460 mm
4. Rubble	=	54 - 179 mm
5. Gravel	=	2.6 - 53 mm
6. Sand	=	0.06 - 2.5 mm
7. Fines	=	0.0005 - 0.05 mm

Column 8 **"Average Depth - Wet Width (m)"**	The wet depth is measured in metres from the stream bed to the water surface. Measure wet depth throughout each stream type, within the boundaries of the left and right bank waterlines (as determined during the measurement of the average wet width). An average is calculated from the measured wet depths.
Column 9 **"0-50% Undercut Bank"**	The bank overhang above the water edge for each stream type, based on low water. The left and right sides each represent 50% of the total stream type. Identify the percent of the length of each side (left and right) that is undercut. *(i.e., if a stream type is 10 m long and 5 m of the left side has an undercut and 4 m of the right side has an undercut bank then 25% (5m / 10m x 50%) of the left hand bank is undercut and 20% (4m / 10m x 50%) of the right hand bank is undercut.)*

Fish Habitat Assessment Methodology (continued)

Column 10 **"0-50% Overhanging Bank Vegetation"**	Vegetation at or near the water surface. The left and right sides each represent 50% of the total stream type. Identify the percent of the area of both the left side and the right side of the stream type influenced by overhanging vegetation. *(i.e., if a stream type is 10 m long and 5 m of the left side is influenced by overhanging vegetation and 2 m of the right side is influenced by overhanging vegetation then 25 % (5m / 10m x 50%) of the left hand bank has overhanging vegetation and 10% (2m / 10m x 50%) of the right hand bank has overhanging vegetation.)*
Column 11 **"Large Woody Debris in Stream (m)"**	The additive length of in-stream woody debris for each stream type. Only consider woody debris that is 10 cm in diameter or greater.

Fish Habitat Assessment Methodology (continued)

Column 12 **"Flows"**	**Type:** - determined from the "Flow Type " table presented below: **Flow Type:** 1. Survey Stream 2. Spring 3. Tributary 4. Spring Seep **Flow (cms):** to determine flow, first fill out the Water Flow Measurement Table on side 2 of the form: Unit no.- is the unit number for which the flow is being determined (from Side 1). Stream type - is the stream type for which the flow is being determined (from Side 1). Wet width (m) (W) - record corresponding data from Side 1 Depth (m) (D) - the wet depth is taken at ¼, ½ and ¾ of the distance across the wet width, and measured from the stream bed to the water surface - the average of the depth is calculated (depth sum divided by 4) Coefficient (A) - 0.9 (smooth) is used when stream bed is mud, sand, bedrock - 0.8 (rough) is used for all other stream bed types Length (m) (L) - the distance over which an object is floated (not less than 3m), and should be done over an homogenous area Float Time (seconds) (T) - time it takes for a floatable object (*i.e.*, a dry stick, a whiffle ball) to travel the designated length - taken at ¼, ½ and ¾ of the distance across the wet width - the average is calculated (float time sum divided by three) Comments - using the " Checklist of Land use and Attributes" on Side 1, record the number(s) which will best describe the location and/or problems affecting it. If no codes apply then write any observations that can accurately describe the area or location where the flow was measured. Flow is calculated using the equation at the bottom of side 2: W x D x A x L/T. Time: the time at which the flow is measured **Temperature:** the ambient and water temperatures, measured in degrees Celsius, at the time the flow is measured

Fish Habitat Assessment Methodology (continued)

Column 13 **"% Substrate Embeddedness"**	The percent of sands or fine material surrounding larger substrate (gravel through boulder). Record the number, from the chart below, which best represents the embeddedness of the large substrate in the streambed **Embeddedness Criteria** 1. ≤ 20% 2. 20% - 35% 3. 35% - 50% 4. ≥ 50%
Column 14 **"Comments"**	Using the "Checklist of Land Use Attributes", record the number(s) which will best describe the stream type location and/or problems affecting it.
SIDE 2/PAGE 2	
Column 1 **"Reach No."**	As in Side 1
Column 2 **"Site (50 m interval)"**	
Column 3 **"% Site"**	**Riffle/Run** - determine what percentage of each reach is riffle (gravel/rubble or rock/boulder or sand), and what percent of each reach is run. **Pools** - determine what percentage of each reach surveyed was pool habitat
Column 4 "Shade (%)"	Determine the percent of the stream type (from Side 1) which is shaded. This value will be based on the amount of the stream type which would be shaded by the sun between 10 am and 2 pm.
Column 5 **"Stream Banks"**	**Vegetation (%):** - percent of bare ground, grasses, shrubs and trees of both the left and right side from the channel bank and 15 m back (the shrubs category includes alders and willows). The total amount of stream bank vegetation should equal 100%. **Erosion (%):** - the left and right sides each represent 50% of the total stream type. - identify the percent of the length of each side that is stable, bare stable, eroding (bare stable refers to a bank that is stable but that has no vegetation on it). *(e.g., if a stream type is 10 m long and 5 m of the left bank is eroded and the remaining 5 m is stable with vegetation, and 10 m of the right bank is stable with no vegetation then the left bank is 25% (5m / 10m x 50%) stable, 0% bare stable and 25% (5m / 10m x 50%) eroding, and the right bank is 50% (10m / 10m x 50%) bare stable.)*

Fish Habitat Assessment Methodology (continued)

Column 6 **"O_2 (mg/l)"**	- the level of dissolved oxygen (mg/L) for each reach, measured in the field with a calibrated, YSI Dissolved Oxygen Meter (or equivalent)
Column 7 **"ph"**	- the pH for each reach, measured with a calibrated, field pH meter - measured in a laboratory from a grab sample taken at the time of the survey
Calcium and alkalinity are two parameters that need to be tested in the laboratory. There is no space for these criterion, however, these values are necessary in order to complete Table E2, DNRE/DFO - New Brunswick Stream Survey and Habitat Assessment. Only one grab sample is required from each reach to complete the analysis for pH, alkalinity and calcium,	
Column 8 **"Depth"**	**Wet:** the wet depth is taken, for each stream type, at ¼, ½ and ¾ of the distance across the wet width, and measured from the stream bed to the water surface, in metres. **Channel:** the channel depth is taken, for each stream type, at ¼, ½ and ¾ of the distance across the channel width. The depth is measured in metres from the stream bed to the upper limit of the channel width.
Column 9 **"Pool Rating"**	**Number:** assign an appropriate number from the criteria column of the "Pool Rating " table from the bottom of Side 1 to each pool encountered. **Letter:**
Column 10 **"Pool Tail"**	The lower or downstream end of the pool. **Embeddedness:** the percent of sands or fine material surrounding larger substrate (gravel through boulder). - record the number from the column chart, presented below, which best represents the embeddedness of the large substrate in the pool tail <u>Embeddedness Criteria</u> 1 ≤ 20% 2 20% - 35% 3 35% - 50% 4 ≥ 50% **Mean Substrate Size:** - the mean size of the substrate within the pool tail column **% Fine:** - how much of the substrate is fine material (diameter 0.0005 - 0.05 mm, from "Substrate" table, Side 1)
Column 11 "% Turbulence "	

River: Onaping River - REFERENCE (OR1) Start Point: OR1-1

Personnel: M. Zimmer Date: Oct 3 96

STREAM SURVEY and HABITAT ASSESSMENT

End Point: OR1-6 GIS Map No.

Drainage Code □□-□□□□ Stream/River No. Stream Order No.

REACH NO.	UNIT NO.	STREAM TYPE	CHANNEL TYPE	LENGTH (m)	AVE WIDTH (m) WET	AVE WIDTH (m) BANK CHANNEL	SUBSTRATE (%) BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES	AVE DEPTH - WET WIDTH (cm)	0-50% UNDERCUT BANK L	0-50% UNDERCUT BANK R	0-50% OVER-HANGING BANK VEGETATION L	0-50% OVER-HANGING BANK VEGETATION R	LARGE WOODY DEBRIS BY STREAM (m)	FLOWS TYPE	FLOWS FLOW (cms)	FLOWS TIME	FLOWS TEMP °C W	FLOWS TEMP °C A	EMBEDDEDNESS (CRITERIA) 1: ≤ 20% 2: 20% - 25% 3: 25% - 50% 4: ≥ 50%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
OR1	1	10,18	3	10	34	36	0	2	30	35	18	15	21	1.76	0	0	50	50	0	1	~9.5	14:30	11.0	5.0	3	2, 35,36	
OR1	2	10,18	3	10	34	36	0	2	30	35	18	15	21	1.63	0	0	50	50	3	1	~9.5	14:40	11.0	5.0	3	2, 35,36	
OR1	3	10	1	10	32	34	0	2	30	35	18	15	21	1.43	0	0	50	50	3	1	~9.5	14:50	11.0	5.0	3	2, 35,36	
OR1	4	10	1	10	32	34	0	2	30	35	18	15	21	1.17	0	0	50	50	0	1	~9.5	15:00	11.0	5.0	3	2, 35,36	
OR1	5	10	1	10	30	32	0	2	30	35	18	15	21	1.26	0	0	50	50	3	1	~9.5	15:10	11.0	5.0	3	2, 35,36	
OR1	6	10	1	10	30	32	0	2	30	35	18	15	21	1.43	0	0	50	50	0	1	~9.5	15:20	11.0	5.0	3	2, 35,36	

\+ = Sampling site

* widths estimated

FASTWATER

1. Fall
2. Cascade
3. Riffle (GravD)
4. Riffle (RvD)
5. Riffle (Sand)
6. Sheet Bedgel
7. Chute
8. Run
9. Rapid

STREAM TYPE

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

CHANNEL TYPE

1. Main (if measurement refers to main area of river)
2. Side Channel (water diverted by islands)
3. Split (if river is split into various different stream types)
4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock, Ledge
2. Boulder = > 481 mm
3. Rock = 180 - 480 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE RATTEN
Pool Depth ≥ 1.5 m 1 - Instream Cover ≥ 30% 2 - Instream Cover < 30%	a - ≥ 30% b - ≥ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover 5 - 30% 4 - Instream Cover > 30%	a - ≥ 50% b - < 50%

COMMENTS

1. ACTIVE BEAVER DAM
2. INACTIVE BEAVER DAM
3. WOODY DEBRIS OBSTRUCTION
4. MAN-MADE DAM OBSTRUCTION
5. ROCK DAM (SWIMMING POOL)
6. BRAIDED STREAM CHANNELS
7. OBSTRUCTION IN STREAM
8. ROAD FORD

POLLUTION CAUSED BY:

9. FOOD PROCESSING INDUSTRY
10. FOREST INDUSTRY
11. CAMPSITES OR RESIDENTIAL
12. MINING
13. LITTER
14. OIL
15. AGRICULTURE WASTE
16. HEALTH HAZARD
17. CLEAR CUT TO STREAM EDGE
18. SELECTIVE CUT
19. BUFFER STRIP PRESENT
20. CATTLE CROSSING
21. EROSION FROM AGRICULTURE
22. SUSPENDED SILT NOTED
23. UNUSUAL STREAM SCOURING
24. LARGE BEDLOAD DEPOSIT
25. BANK EROSION - MODERATE
26. BANK EROSION - EXCESSIVE
27. STREAM DREDGING/BULLDOZING
28. GRAVEL REMOVAL
29. CHANNELIZATION (RIPRAP, ETC.)
30. STREAM DIVERSION
31. WATER WITHDRAWAL
32. REGULATED STREAM FLOW
33. CAMP/COTTAGE PRESENT
34. RESIDENTIAL AREA
35. ACCESS - ATV'S
36. ACCESS - TRAILS
37. ACCESS - SNOWMOBILE
38. ACCESS - [illegible]
39. [illegible]
40. [illegible]
41. BOAT LAUNCH
42. ORGANIC LITTER
43. AQUATIC PLANTS ABUNDANT
44. GOOD SPAWNING
45. GOOD NURSERY

* Stream surveys should be undertaken only during summer base (low) flow conditions. Also, minimum size of stream type is 4m² for larger streams.

1. Chute: water depth equal to or greater than channel width
2. Riffle: GrvRb - is a riffle flowing over a gravel and/or rubble bottom
   RvB - is a riffle flowing over & through large substrates (eg. rock and for boulders), some of which protrudes the surface
3. Side channels - treat as a separate stream type

4. Undercut Bank - % of bank overhang (above water edge for stream type. Specify left (L) or right (R)
5. Over-hanging Bank Vegetation - % of vegetation overhang for stream type. Specify L or R
6. Visual Embeddedness - % of sands or fines surrounding the larger substrates, up to 100%
7. Woody Debris - total width should be > 10 cm in diameter

A = 0.8 for rough bottom

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O2 (mg/l)	pH	DEPTH						POOL CRITERIA (CRITERIA ON OTHER SIDE)		POOL EVAL.			% TURBULENCE
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE/ RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: < 20% 2: 20% - 35% 3: 35% - 50% 4: > 50%	MEAN SUBSTRATE SIZE (cm)	% FINE	
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.2	7.8	1.00	--	2.80	--	1.00	--	2		3	4	10	
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.1	7.6	1.50	--	2.40	--	1.00	--	2		3	4	10	
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.1	7.6	1.00	--	2.30	--	1.00	--	2		--	--	10	
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.8*	7.7*	1.00	--	1.52	--	1.00	--	2		--	--	10	
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.6*	7.5*	1.00	--	1.78	--	1.00	--	2		--	--	10	
REF ORI		0	100	3	0	0	80	20	50	0	0	50	0	0	11.7*	7.5*	1.00	--	1.79	--	1.50	--	2		--	--	10	
															*Oct 4/96													

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.3 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS/ LOCATION
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W ___ (m) x D ___ (m) x A ___ x L ___ (m) / T ___ (sec) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom

CRITERIA:

River: Onaping River - EXPOSURE (OR3)

Personnel: M.Zimmer

Start Point: OR3-1

Date: Oct 3/96

End Point: OR3-6

GIS Map No.: /

Drainage Code □□/□□ □□

Stream/River No. /

Stream Order No. /

STREAM SURVEY and HABITAT ASSESSMENT

1 of 1

REACH NO.	UNIT NO. *	STREAM TYPE	CHANNEL TYPE	LENGTH (m) *	AVE WIDTH (m) * WET	AVE WIDTH (m) * BANK CHANNEL	SUBSTRATE (%) * BED-ROCK	BOULDER	ROCK	RUBBLE	GRAVEL	SAND	FINES	AVE DEPTH - WET WIDTH (cm) *	0-50% UNDERCUT BANK * L	0-50% UNDERCUT BANK * R	0-50% OVER-HANGING BANK VEGETATION * L	0-50% OVER-HANGING BANK VEGETATION * R	LARGE WOODY DEBRIS IN STREAM (m) *	FLOWS * TYPE	FLOW (cms)	TIME	TEMP °C W	TEMP °C A	EMBEDDEDNESS (CRITERIA) 1: ≤ 20% 2: 20% - 35% 3: 35% - 80% 4: > 80%	COMMENTS	CHECKLIST OF LAND USE ATTRIBUTES (COMMENTS)
OR3	1	18	2	3	30	--	0	5	30	45	5	5	10	170	0	0	0	50	0	1	~10.5	10:00	11.0	5.0	3	2, 12, 37	
OR3	2	18	2	3	30	--	0	5	35	50	<1	5	5	320	0	0	0	50	0	1	~10.5	10:05	11.0	5.0	3	2, 12, 37	
OR3	3	18	2	3	30	--	0	5	35	50	<1	5	5	180	0	0	0	50	0	1	~10.5	10:10	11.0	5.0	3	2, 12, 37	
OR3	4	18	2	3	30	--	0	5	35	50	<1	5	5	160	0	0	0	50	0	1	~10.5	10:15	11.0	5.0	3	2, 12, 37	
OR3	5	18	2	3	30	--	0	5	35	50	<1	5	5	210	0	0	0	50	0	1	~10.5	10:20	11.0	5.0	3	2, 12, 37	
OR3	6	18	2	3	30	--	0	5	35	50	<1	5	5	240	0	0	0	50	0	1	~10.5	10:25	11.0	5.0	3	2, 12, 37	
					*width to island																						
	*	= sampling site																									

1. ACTIVE BEAVER DAM
2. INACTIVE BEAVER DAM
3. WOODY DEBRIS OBSTRUCTION
4. MAN-MADE DAM OBSTRUCTION
5. ROCK DAM (SWIMMING POOL)
6. BRAIDED STREAM CHANNELS
7. OBSTRUCTION IN STREAM
8. ROAD FORD

POLLUTION CAUSED BY:

9. FOOD PROCESSING INDUSTRY
10. FOREST INDUSTRY
11. CAMPSITES OR RESIDENTIAL
12. MINING
13. LITTER
14. OIL
15. AGRICULTURE WASTE
16. HEALTH HAZARD
17. CLEAR CUT TO STREAM EDGE
18. SELECTIVE CUT
19. BUFFER STRIP PRESENT
20. CATTLE CROSSING
21. EROSION FROM AGRICULTURE
22. SUSPENDED SILT NOTED
23. UNUSUAL STREAM SCOURING
24. LARGE BEDLOAD DEPOSIT
25. BANK EROSION - MODERATE
26. BANK EROSION - EXCESSIVE
27. STREAM DREDGING/BULLDOZING
28. GRAVEL REMOVAL
29. CHANNELIZATION (RIPRAP, ETC.)
30. STREAM DIVERSION
31. WATER WITHDRAWAL
32. REGULATED STREAM FLOW
33. CAMP/COTTAGE PRESENT
34. RESIDENTIAL AREA
35. ACCESS - ATV'S
36. ACCESS - TRAILS
37. ACCESS - TRUCK/CAR
38. ACCESS - BOAT
39. ROAD CROSSING (BRIDGE)
40. ROAD CROSSING (CULVERT)
41. BOAT LAUNCHING
42. ORGANIC LITTER
43. AQUATIC PLANTS ABUNDANT
44. GOOD SPAWNING
45. GOOD NURSERY

STREAM TYPE

FASTWATER

1. Fall
2. Cascade
3. Riffle (GR/RB)
4. Riffle (R/B)
5. Riffle (Sand)
6. Sheet Bedge)
7. Chute
8. Run
9. Rapid

POOLS

10. Midchannel
11. Convergence
12. Lateral
13. Beaver
14. Trench
15. Plunge
16.
17. Bogan
18. Eddy
19. Gabion
20. Log Structure
21. Road Crossing
22. Wood Debris
23. Man-Made Dam
24. Natural Deadwater

Note: Stream surveys should be undertaken only during summer base flow) flow conditions. Also, minimum size of stream type is 4m² for larger streams.

CHANNEL TYPE

1. Main (If measurement refers to main area of river)
2. Side Channel (water diverted by islands)
3. Split (If river is split into various different stream types)
4. Bogan

* - Specify Left (L), Right (R) or Middle (M)

SUBSTRATE

1. Bedrock, Ledge
2. Boulder = > 481 mm
3. Rock = 180 - 480 mm
4. Rubble = 54 - 179 mm
5. Gravel = 2.6 - 53 mm
6. Sand = 0.06 - 2.5 mm
7. Fines = 0.0005 - 0.05 mm

FLOW TYPE

1. Survey Stream
2. Spring
3. Brook/River Trib
4. Spring Seep

POOL RATING (reverse side)

CRITERIA (NO.)	% OF POOLS IN SITE (LETTER)
Pool Depth ≥ 1.5 m 1 - Instream Cover ≥ 30% 2 - Instream Cover < 30%	a - ≥ 30% b - ≥ 10% to 30% c - < 10%
Pool Depth .5 to 1.5m 3 - Instream Cover ≥ 30% 4 - Instream Cover > 30%	a - ≥ 50% b - < 50%

1. Chute: water depth equal to or greater than channel width
2. Riffle: GR/RB - is a riffle flowing over a gravel and/or rubble bottom
   R/B - is a riffle flowing over & through large substrates (eg. rock and /or boulder), some of which protrudes the surface
3. Side channels - treat as a separate stream type
4. Undercut Bank - % of bank overhang (above water edge for stream type. Specify left (L) or right (R)
5. Over-hanging Bank Vegetation - % of vegetation overhang for stream type. Specify L or R
6. Visual Embeddedness - % of sands or fines surrounding the larger substrates, up to 100%
7. Woody Debris - total width should be > 10 cm in diameter

A = 0.8 for rough bottom

REACH NO.	SITE (50m - interval)	% SITE		SHADE (%)	STREAM BANKS										O₂ (mg/l)	pH	DEPTH						POOL RATING (CRITERIA ON OTHER SIDE)		POOL TAIL			
					VEGETATION (%)				EROSION (%)								1/4 (m)		1/2 (m)		3/4 (m)							
		RIFFLE/ RUN	POOLS		BARE GROUND	GRASSES	SHRUBS	TREES	LEFT BANK (0-50%)			RIGHT BANK (0-50%)					WET	CHANNEL	WET	CHANNEL	WET	CHANNEL	NO.	LETTER	EMBEDDEDNESS (CRITERIA) 1: ≤ 20% 2: 20% - 35% 3: 35% - 80% 4: ≥ 80%	MEAN SUBSTRATE SIZE (cm)	% FINE	% TURBULENCE
									STABLE	BARE STABLE	ERODING	STABLE	BARE STABLE	ERODING														
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.1	7.9	--	--	1.70	--	--	--	2		3	4	--	
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.3	7.8	--	--	3.20	--	--	--	2		3	4	--	
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.3	7.8	--	--	1.80	--	--	--	2		3	4	--	
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.3	7.8	--	--	1.60	--	--	--	2		3	4	--	
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.1	7.8	--	--	2.10	--	--	--	2		3	4	--	
EXP OR3		0	100	2	0	20	70	10	50	0	0	50	0	0	10.1	7.8	--	--	2.40	--	--	--	2		3	4	--	
															- Measured on Oct 2/96													

NOTE: * For selected site study, these columns (reverse side) should be done for a habitat assessment

WATER FLOW MEASUREMENT

REACH NO.	CORRESPONDING LOCATION		STREAM TYPE	WET WIDTH (m)	DEPTH (cm)			AVERAGE DEPTH SUM / 4		COEFFICIENT (0.9 - smooth) (0.8 - rough)	LENGTH (3m)	FLOAT TIME (sec)				COMMENTS (LOCATION)
	UNIT NO.	SITE (50 - interval)			1/4 way	1/2 way	3/4 way	CENTIMETERS (cm)	METERS (m)			1/4 way	1/2 way	3/4 way	AVERAGE	

Formula (CMS) = W ____ (m) x D ____ (m) x A ____ x L ____ (m) / T ____ (sec) Where: W = width, D = depth, L = length, A is a coefficient for the stream bottom

CRITERIA:

APPENDIX F2

Population Survey

CANMET
Fish Collection Record

REFERENCE

Station: GN1 Date: Oct 3/96 Time: 13:00 Air Temp: 9.0 Water Temp: 11.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 4.5hr Conditions: cool, partly cloudy calm Crew: M. Piché G. Carnegie

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
white sucker	01-R	336	471.2	1.2	0.6	7.2	d.spine Pect. Ray/ scales	Gill wt = 7.9 -otolith not found carcass wt: 418.6

Notes:

CANMET
Fish Collection Record

REFERENCE

Station: GN2 Date: Oct 4/96 Time: 14:00 Air Temp: 11.0 Water Temp: 9.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 23hr overnight Conditions: Sunny, cool, calm Crew: M. Piché M. Lamoureux, G. Carnegi

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
white sucker	02-R	158	47.0	0.2	0.2	0.1	Scales D. spine Pect. ray Otolith	Gill wt: 1.4g carcass wt: 39.7g excellent condition
brook trout	01-R	359	710.0	12.4 ♂	4.3	5.5	otolith scales D. spine pect. ray	Gill wt - 12.0g carcass wt - 620g
northern pike	01-R	362	343.6	5.0 ♀	2.4	5.6	scales D. spine pect ray cleithrum	Gill wt: 9.3g carcass wt: 278.5 Excellent condition
northern pike	02-R	434	710.0	11.0 ♀	5.2	9.6	scales D. spine Pect. Ray cleithrum	Gill wt: 13.3g carcass wt: 472.5g stomach full of fluid, EXC
northern pike	03-R	473	950.0	12.5 ♀	5.7	10.1	scales D. spine pect. ray cleithrum	Gill wt: 13.5g; carcass: stomach full of fluid Exc. cond.
northern pike	04-R	429	700.0	8.1 ♀	4.2	14.5	scales D. Spine pect Ray cleithrum	Gill wt: 13.5g; carcass: 585- Excellent condition
northern pike	05-R	403	620.0	11.6 ♀	3.3	10.2	scales D. Spine pect. Ray cleithrum	Gill wt: 9.6g; carcass - 57[illegible] Excellent condition
northern pike	06-R	458	860.0	9.0 ♀	3.7	10.9	scales D. spine pect. Ray cleithrum	Gill wt - 14.7g; carcass 74 Black spot over length fish

Notes:

CANMET
Fish Collection Record

REFERENCE

Station: GN3 Date: Oct 4/96 Time: 1430 Air Temp: 12C Water Temp: 9.0

Gear Type: 5m 2.5" Duration: 23hr Conditions: Sunny, cool, calm Crew: M. Piché, M. Zimmer, G. Carnegie

Species	Fish #	Fork Length (mm) ± 2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
northern pike	07-R	368	410.0	5.9 ♀	2.3	9.4	scales. D. spine P. ray cleithrum	Fill wt - 81.5; carcass: 315g EXCELLENT COND.
northern pike	08-R	316	205.5	1.1 ♂	1.1	2.6	scales D. spine P. ray cleithrum	Fill wt - 4.0; carcass: 181g EXCELLENT COND.

Notes: northern pike 08-R had a central mudminnow and a frog in its stomach.

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CANMET
Fish Collection Record

Station: REFERENCE Date: Oct 1/96 → Oct 5 Time: 13:15 Air Temp: 12.0 Water Temp: 11.0

Gear Type: BIG minnow (2) TRAPS Duration: 94.75 (1 each) Conditions: Variable Crew: M. Ziminer, M. Piche

Species	Fish #	Fork Length (mm) ± 2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
NO	CATCH							

Notes: BMTs checked periodically. moved on oct 4

CANMET
Fish Collection Record

Station: REFERENCE DR1 Date: Oct 4/96 Time: 13:00 Air Temp: 9.0 Water Temp: 9.0

Gear Type: Small Minnow Traps (4 total) Duration: 23hr (each) Conditions: cool, clear, calm Crew: M. Zimmer, M. Piché, C. Carnegie

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
Pearl dace	01-R	72	5.8					no external anomalies

Notes: kept whole then frozen

CANMET
Fish Collection Record

EXPOSURE

Station: GN 1 Date: Oct 2/96 Time: 1210 Air Temp: 16.0 Water Temp: 13.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 3hrs Conditions: cool, p.cloudy, light wind Crew: M. Piché G. Carnegie

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
Rainbow Trout	01-E	335	398	♀ Not dissected; not likely to be			sentinel species	Yellow grub in Abdominal muscle tissue & Kidney

Notes: max depth 3.7 m at end of 2 net series

CANMET
Fish Collection Record

EXPOSURE

Station: GN3 Date: Oct 2/96 Time: 15:25 Air Temp: 8.5 Water Temp: 13.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 3 hrs Conditions: cool, cloudy, windy Crew: M. Piché G. Carnegie

Species	Fish #	Fork Length (mm) ± 2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
Yellow Perch	01-E	179	71	4.5 ♂	N/A	1.0	0. spine pect. ray scales otolith	some black spot on caudal fin, some yellow, marks on gonads

Notes:

CANMET
Fish Collection Record

EXPOSURE

Station: GN 5 Date: Oct 3/96 Time: 10:30 Air Temp: 10.0 Water Temp: 12.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 8 hr Conditions: Sunny, cool, calm Crew: M. Zimmer L. Trudel

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
NO CATCH								

Notes:

CANMET
Fish Collection Record

Station: EXPOSURE Date: Oct 2-3 Time: 12:00 Air Temp: 10.0 Water Temp: 11.0

Gear Type: Minnow Traps (4) Duration: 74hrs Conditions: variable Crew: G. Carnegie, Minimer, L. Trudel

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
NO		CATCH						

Notes: Minnow traps were set within pool habitat around ORS. They were checked for fish and bait at 10:45 oct 3 and lifted at 18:30.

CANMET
Fish Collection Record

REFERENCE

Station: GN1 Date: Oct 3/96 Time: 13:00 Air Temp: 9.0 Water Temp: 11.0

Gear Type: 15m 1.5" 15m 2.5" Duration: 4.5hr Conditions: cool, partly cloudy calm Crew: M. Piché G. Carnegie

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
white sucker	01-R	336	471.2	1.2	0.6	7.2	d.spine Pect. Ray scales	Gill wt = 7.9 -otolith not found carcass wt: 418.6

Notes:

CANMET
Fish Collection Record

REFERENCE

Station: GN3 Date: Oct 4/96 Time: 1430 Air Temp: 12.0 Water Temp: 9.0

Gear Type: 15m 2.5" Duration: 23hr Conditions: Sunny, cool, calm Crew: M. Piché, M. 21mm, G. Carnegie

Species	Fish #	Fork Length (mm) ±2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
northern pike	07-R	368	410.0	5.9 ♀	2.3	9.4	scales D. Spine P. ray cleithrum	Gill wt - 8.5; carcass: 31.5; EXCELLENT COND.
northern pike	08-R	316	205.5	1.1 ♂	1.1	2.6	scales D. spine P. ray cleithrum	Gill wt - 4.0; carcass: 1[illegible]; EXCELLENT COND.

Notes: northern pike 08-R had a central mudminnow and a frog in its stomach.

CANMET
Fish Collection Record

Station: REFERENCE 021 Date: Oct 4/96 Time: 13:00 Air Temp: 9.0 Water Temp: 9.0

Gear Type: Small Minnow Traps (4 total) Duration: 23hr (each) Conditions: cool, clear, calm Crew: M. Zimmer, M. Piché, C. Carnegie

Species	Fish #	Fork Length (mm) ± 2mm	Fresh Weight (g)	Gonad Weight (g)	Kidney Weight (g)	Liver Weight (g)	Scale Ray Otolith Operc	Condition/Comments (external/internal)
Pearl dace	01-R	72	5.8	—	—	—	—	no external anomalies
—	—	—	—	—	—	—	—	—

Notes: kept whole then frozen

APPENDIX F3

Tissue Processing Methods and Results

Revised Protocol for Metallothionein Analyses on fish collected during the field trip for the preliminary survey

(Version: August 29, 1996)

Part of the biological monitoring component of AETE program consists of metallothionein analyses of tissues from large fish, e.g., trout, pike, suckers. This protocol presents the on-site sampling requirements. If the contractor is not familiar with conducting preparation of fish, advice in the dissection and handling of tissues should be obtained from the Freshwater Institute.

Sample size and sampling effort

1. Liver, kidney, gill filaments, and skeletal muscle should be dissected from the 8 to 10 (eigth to ten) individual, living fish from each of the two large species from a reference site and an exposed site. The two most abundant large fish species common to the sampling sites are targetted.

2. The largest specimens from each species should be selected.

3. When possible 4 males and 4 females from the same species should be collected. No additionnal sampling effort should be given to meet the above sex requirement for the Phase I of the field study.

4. A minimum number of 8 fish from the same species is required with a reasonable level of effort for sampling. The sampling gear and method should not be destructive: gill nets should be frequently tended to avoid overfishing and sacrifice fewer fish.

5. The tissues from the same fish can be split into two to serve for metallothionein and metal analyses.

6. These tissues should be immediatly placed in marked individual polyethylene ("Whirlpak") bags, frozen on dry ice, and submitted for metallothionein analyses.

7. When fish capture is performed using a seine net, 8 small fish (e.g. young-of-the-year of each species or Forage species) should be collected per site, as well. In this case no dissection is required (abdominal contents will be removed at the laboratory). Whole fish are placed in marked individual polyethylene ("Whirlpak") bags and frozen on dry ice.

Other information required

For the large fish, information should be obtained on fish sex, body length (±1 mm), body weight (±1.0 g), liver and gonadal weights (±0.1 g) and collection should be made of appropriate aging structures (scales, fin rays, operculum, cleithrum or otoliths, depending upon species). All fish should also be checked for external and internal anomalies (a useful guide can be found in Goede and Barton; Amer. Fish. Soc. Sympos. 8:93-108, 1990; other analogous methods can be used). These data should be analysed to provide information on average (with variability) parameters,

growth (size at age), the relationship between body length and weight, and the relationships between body size and liver weight, gonad weight and fecundity. All analyses should be conducted separately for each sex.

On-site sampling requirements

1. For metallothionein analyses, it is essential to obtain tissue samples from fish that are alive after collection and immediately before tissue removal.

2. A sample numbering system must be designed and used to facilitate tracking of all tissue sub-samples taken from the same fish. All tissue samples must be appropriately labelled.

3. After capture, the following measurements should be obtained on each large fish: total body weight (g), gutted carcass weight [g] after removal of viscera), gonad weight (g), liver weight (g), fork length (cm), sex; and appropriate structure(s) for determining fish age should be removed.

4. Sampling of fish tissues should begin immediately after the whole body measurements have been made. Fish should be euthanised via concussion, cervical dislocation or with an overdose of anesthesic.

5. Gill, liver and kidney from the same fish should be divided into a part used for metallothionein analyses and another part used for metal analyses. Work must progress quickly on the euthanised fish with tissue.

6. Dissection and preserving procedures

   a) Gills: Remove the gill arches and attached filaments by severing the dorsal and ventral cartilaginous attachment of the arches to the surrounding oral cavity. Place the gill arches in a polyethylene bag ("Whirlpak"), label and freeze on dry ice. Gill arches are to be removed from the fish and frozen as soon after death as possible.

   b) Open the fish ventrally to expose the abdominal contents by using scissors to cut from the anus to the base of the pectoral fins. Care should be taken not to cut into internal organs when opening the fish.

   c) Liver: Remove the liver using care not to rupture the gall bladder. Remove the gall bladder from liver using care to prevent bile leakage from contacting the liver. Weigh and record weight of liver to the nearest 0.1 g, if possible. Place the part of the liver in a "Whirlpak", label and freeze on dry ice.

   d) Kidney:Remove the kidneys by making lengthwise incisions along each edge of the tissue and then detach using the "spoon" end of a stainless steel weighing spatula by applying firm, but gentle, pressure against the upper abdominal cavity wall (i.e., against the dorsal aorta). In this procedure, the kidney is scraped away

from the dorsal aorta and all associated connective tissue. The kidney is then to be placed in a "Whirlpak", labelled and frozen on dry ice. The kidney is to be removed from the fish and frozen as soon after death as possible.

Samples for metallothionein (on dry ice) should be sent to:

Dr. J.F. Klaverkamp
Freshwater Institute
501 University Crescent
Winnipeg, Manitoba
R3T 2N6
Phone: (204) 983-5003
Fax: (204) 984-6587

(pome)

ESG

Description	Sample ID	Zn µg/g	Cu µg/g	Cd µg/g	MT µg/g	MT µmoles/g	Σ[Mx] µmoles/g
ECOLOGICAL SERVICES GROUP							
SOUTH PORCUPINE RIVER							
VISCERA							
REFERENCE	PDR-A	30	5.6	0.03	69.7	0.0093	0.551
REFERENCE	PDR-B	33	9.8	0.02	55.1	0.0073	0.663
REFERENCE	PDR-3	48	11.6	0.02	41.1	0.0055	0.914
REFERENCE	PDR-4	25	12.2	0.02	182.2	0.0243	0.581
REFERENCE	PDR-5	53	24.3	0.02	61.8	0.0082	1.200
REFERENCE	PDR-6	37	34.9	0.01	181.0	0.0241	1.121
REFERENCE	RDR-A	38	4.3	0.02	51.0	0.0068	0.647
REFERENCE	RDR-B	46	14.4	0.02	169.0	0.0225	0.934
REFERENCE	RDR-2	23	7.2	0.01	98.6	0.0131	0.468
REFERENCE	RDR-6	30	10.8	0.01	377.8	0.0504	0.636
REFERENCE	RDR-7	46	33.2	0.02	339.3	0.0452	1.230
EXP	PDE-A	29	103.0	0.03	70.4	0.0094	2.069
EXP	PDE-3	29	64.8	0.02	199.2	0.0266	1.458
EXP	PDE-4	25	140.2	0.03	66.8	0.0089	2.585
EXP	PDE-5	31	90.4	0.03	102.0	0.0136	1.898
EXP	PDE-6	27	56.5	0.02	72.1	0.0096	1.302
EXP	PDE-7	22	60.5	0.02	161.0	0.0215	1.285
EXP	PDE-8	26	133.5	0.04	116.7	0.0156	2.502
EXP	RDE-A	37	44.1	0.02	282.0	0.0376	1.264
EXP	RDE-B	43	26.1	0.02	250.9	0.0335	1.067
EXP	RDE-C	37	70.0	0.02	188.3	0.0251	1.665
EXP	RDE-6	36	96.6	0.04	123.8	0.0165	2.064
EXP	RDE-7	34	43.6	0.03	245.8	0.0328	1.209
WS REF LIVER	01-RL	14	10.2	1.00	102.5	0.0137	0.390
WS EXP LIVER	01-EL	32	12.7	0.05	207.2	0.0276	0.690
WS EXP LIVER	03-EL	17	20.2	0.08	752.6	0.1003	0.577
WS EXP KIDNEY	EXP-AK	36	4.2	0.74	405.6	0.0541	0.623
WS REF KIDNEY	REF-AK	34	7.4	3.12	114.5	0.0153	0.661
WS EXP GILL	01-EG	17	7.2	0.07	79.4	0.0106	0.377
WS EXP GILL	03-EG	11	9.1	0.07	20.0	0.0027	0.316
WS REF GILL	01-RG	13	0.8	0.11	29.6	0.0039	0.219
WS REF GILL	02-RG	13	3.5	0.18	27.3	0.0036	0.249

Summary

Description	Sample ID	$\bar{x}$ MT µg/g	S.E.	n	$\bar{x}$ Σ[Mx] µmol/g	S.E.
Jacque Whitford						
Gaspe site reference	BTR	183.7	37.9	5	1.14	0.14
Gaspe site exposure	BTE	383.1	72.3	8	2.24	0.16
Gaspe site reference	SALR	73.0	13.8	8	3.63	0.35
Gaspe site exposure	SALE	117.7	13.3	8	4.64	0.27
Heath Steele exposure	LCA	81.5	4.59	3	3.95	0.50
Heath Steele reference site 1	LCRA	159.6	16.8	2	3.51	0.55
Heath Steele reference site 2	LCMR	50.3	13.5	3	4.01	0.23
Heath Steele exposure	SALE	64.4	8.77	3	4.47	0.05
Heath Steele reference	SALMR	39.7	2.21	6	5.85	0.99
Heath Steele reference	BTR	128.2	15.7	5	3.75	0.60
ECOLOGICAL SERVICES GROUP						
SOUTH PORCUPINE RIVER						
VISCERA						
Pearl Dace reference site	PDR	98.5	26.6	6	0.84	0.11
Pearl Dace exposure site	PDE	112.6	19.2	7	1.87	0.21
Redbelly Dace reference site	RDR	207.1	64.9	5	0.78	0.13
Redbelly Dace exposure site	RDE	218.2	28.0	5	1.45	0.18
EVS ENVIRONMENT CONSULT.						
SULLIVAN MINE						
Sculpin reference site	SURCC	136.4	13.9	13	2.28	0.40
Sculpin exposure site	SUECC	135.0	13.3	11	2.93	0.40