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Quality Assurance/Quality Control Plan
Water Licence **NWB1JER0410**
Jericho Diamond Mine
Nunavut, Canada

Submitted to:

Tahera Diamond Corporation
Toronto, Ontario

Submitted by:

AMEC Earth & Environmental
A Division of AMEC Americas Ltd.
Burnaby, BC

April 2005

VE51295

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APPENDIX A: GENERAL AND AQUATIC EFFECTS MONITORING PLANS

EXECUTIVE SUMMARY

This quality assurance/quality control (QA/QC) plan was developed pursuant to Jericho Diamond Mine Water Licence **NWB1JER0410**, Part L, *Conditions Applying to General and Aquatic Effects Monitoring Plans*, Item 5 and Schedule L, Item 2 which set out the requirements for the QA/QC Plan. The Plan covers all field and laboratory QA/QC aspects of these monitoring programs. This QA/QC information was previously incorporated into the General Monitoring Plan and the Aquatic Effects Monitoring Plan submitted to NWB for approval.

This QA/QC plan covers environmental monitoring at the Jericho Mine site specified in the NWB Water Licence. The objective of the QA/QC Plan is to help ensure data collected, analyzed and evaluated under the monitoring plans is high quality and reliably reflects actual conditions it was meant to monitor.

Generally recognized QA/QC principles have been adopted throughout. As a general guide, the ISO-9000 standard has been followed.

1.0 INTRODUCTION

1.1 Background

The Jericho Diamond Mine (Jericho) is being developed by Tahera Diamond Corporation on behalf of its wholly owned subsidiary, Benachee Resources Inc. The mine site is located approximately 420 km north northeast of Yellowknife, NWT, in the West Kitikmeot region of Nunavut (Figure 1).

A copy of the recommendation to the Minister of DIAND for a Project Water Licence was received from Nunavut Water Board 22 December 2004 and sign off by the DIAND Minister 26 January 2005. A number of plans must be developed under the terms of the Water Licence and the quality assurance/quality control (QA/QC) plan is detailed in this document.

This quality assurance/quality control (QA/QC) plan was developed pursuant to Jericho Diamond Mine Water Licence **NWB1JER0410**, Part L, *Conditions Applying to General and Aquatic Effects Monitoring Plans*, Item 5 and Schedule L, Item 2 which set out the requirements for the QA/QC Plan. The Plan covers all field and laboratory QA/QC aspects of these monitoring programs. This QA/QC information was previously incorporated into the General Monitoring Plan and the Aquatic Effects Monitoring Plan submitted to NWB for approval.

1.2 Regulatory Requirements

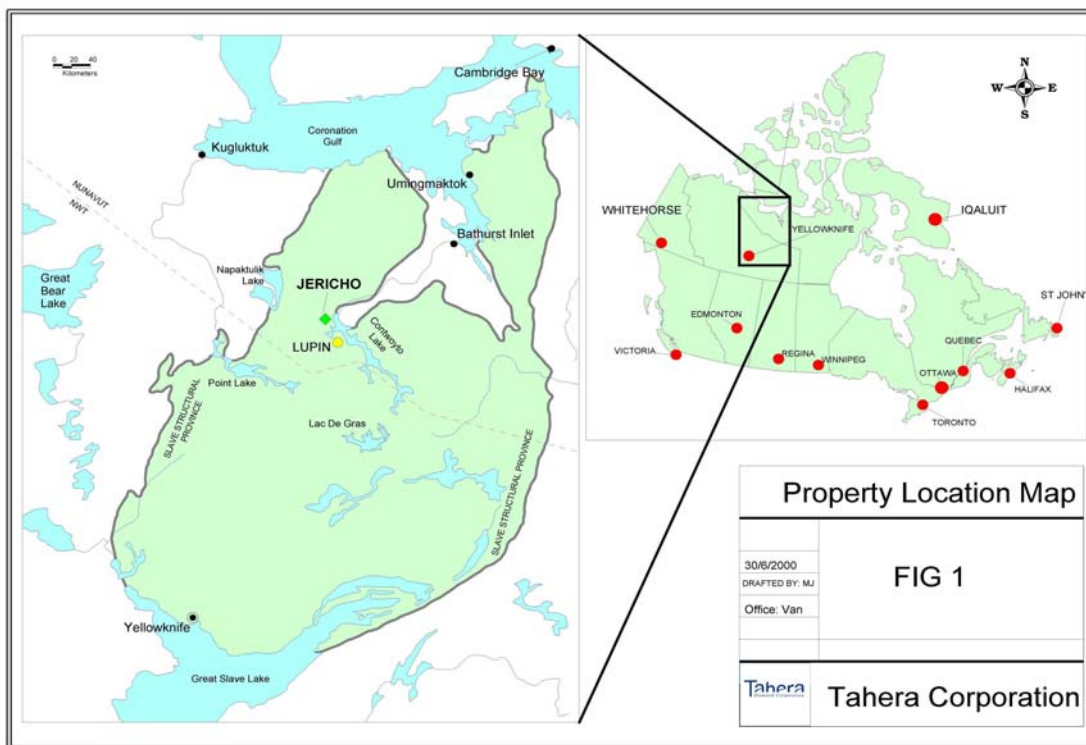
The Jericho Water Licence, Part L, Item 5 requires that a Quality Assurance/Quality Control Plan be submitted to an Analyst for approval within three months of the effective date of the licence. The plan is to include the following (pursuant to Schedule L, Item 2):

- a. consideration of the INAC *QA/QC Guidelines for Type 'A' Licenses*
- b. approval of the plan by an analyst;
- c. information on the analyst;
- d. introduction on Quality Assurance/Quality Control and its principles and how the Plan elements will be implemented on site;
- e. field sampling, locations, frequency, sample types, sample containers;
- f. logging of samples, sample handling, preservation, transportation requirements, information requirements, chain of custody;
- g. field measurements, calibration of field equipment;
- h. sampling and analysis, use of field blanks, replicate samples, spiked samples and split samples;
- i. laboratory analysis and information methods used for analysis;
- j. laboratory QC and reporting of data.

1.3 Analyst

An analyst had not been appointed at the time of writing of this report.

Figure 1 Property Location Map



1.4 INAC QA/QC Guidelines

The INAC QA/QC guidelines are targeted to water quality sampling for surveillance network programs (SNPs) for Class A water licenses. The guidelines cover field sampling, laboratory analysis and reporting. Topics discussed under field sampling include both methods and quality control. General guidelines are provided which are accepted practice and will be employed in Jericho sampling programs as detailed in the General Monitoring Plan (AMEC 2005). Laboratory accreditation and procedures are, again, those generally accepted by the industry and will be followed in Jericho sampling programs (AMEC 2005). Finally, reporting requirements again generally follow accepted standards and will be followed by Jericho environmental staff and consultants as detailed by AMEC (2005) and Mainstream Aquatics and AMEC (2005). Both the General and Aquatic Effects Monitoring Program Plans, previously submitted to NWB are attached in Appendix A for reference.

1.5 QA/QC Principles

An internationally recognized standard for quality assurance is ISO-9001. While it applies more to the manufacture of things, many of the general principles have a broader application. There are eight general principles in the ISO-9001 system (International Standards Organization 2000):

1. Customer focus.
2. Leadership.
3. Involvement of people.

4. Process approach.
5. System approach to management.
6. Continual improvement.
7. Factual approach to decision making.
8. Mutually beneficial supplier relationships.

Principles 1 and 8 do not apply to environmental monitoring on this project but the other six can be applied and are employed in this plan and in the monitoring plans the QA/QC plan applies to.

Tahera management is committed to quality assurance in monitoring programs for the Jericho Project as part of the company's submission for project approval. Quality assurance has been integrated into environmental monitoring programs by design. Each component of the QA process contributes to the overall QA/QC program. Continual improvement is a key focus of the QA/QC program and an integral part of the mine's adaptive management plan. Data gathered through monitoring will provide the factual basis required for this adaptive management approach to environmental control at the Jericho Mine.

Quality assurance and quality control are used to identify and implement methodologies which limit the introduction of error into data and procedures. A quality system is a management system that describes the elements necessary to plan, implement and assess the effectiveness of QA/QC activities. A quality assurance plan (QAP) is the critical planning document for any environmental data collection operation because it documents how QA/QC activities will be implemented during the life cycle of a project. The QAP is a blueprint for identifying how the quality system of the organization performing the work is reflected in a particular project and in associated technical goals.

This QAP incorporates existing data collection procedures by reference in most cases, i.e., the general and aquatic effects monitoring plans. These monitoring plans were developed to conform to the requirements of the mine Water Licence. As such, there was little latitude for site-specific adjustment of initial monitoring plans, although modification and continual improvement will be an integral part of the evaluation process.

Assessment of environmental data is used to evaluate whether the data meet the objectives of the survey and whether the data are sufficient to answer questions required to implement adaptive environmental management at the site, i.e., is there an effect caused by mining and is it significant?

Data verification is an integral part of quality control. Data verification ensures that the requirements stated in the QAP and monitoring plans are implemented as prescribed. Deficiencies or problems that occur during surveys will be documented.

Performance of equipment requires checking through calibration and monitoring. Calibration checks need to be recorded and reviewed to identify and remedy equipment problems.

1.6 Scope and Objective of the QA/QC Plan

This QA/QC plan covers environmental monitoring at the Jericho Mine site specified in the NWB Water Licence and detailed in the General Monitoring and Aquatic Effects Monitoring Program (AEMP) plans. The objective of the QA/QC Plan is to help ensure data collected, analyzed and

evaluated under the monitoring plans is focused on relevant variables, is of high quality and reliably reflects actual conditions it was meant to monitor.

Recognized QA/QC principles have been adopted throughout. As a general guide, INAC's guidelines for Type A Licences and the ISO-9000 standard (where applicable) have been followed.

2.0 GENERAL MONITORING

2.1 General Monitoring Activities

General environmental monitoring at the minesite has the following elements (AMEC 2005):

- site monitoring;
- flows and water chemistry;
- solids geochemistry;
- ground ice;
- thermal monitoring;
- site surveys and visual inspections;
- stream flows;
- receiving environment water quality monitoring.

Standard operating procedures will be adopted for all sampling as discussed in the General Monitoring Plan. Existing standard procedures demonstrated to work over several years and in a large number of organizations will be used where possible. Some site-specific modifications may be required. The General Monitoring Plan provides procedure outlines. Where required, more detailed instructions will be written and maintained by the mine environmental staff.

2.2 QA/QC Procedures

2.2.1 Site Water Quality

Standard QA/QC procedures for water sampling including collection of field, travel and method blanks and duplicate samples will be included in the program. Section 2.4 provides additional details on field and laboratory QA/QC.

2.2.2 Receiving Water Body Water Quality

2.2.2.1 Field

To check on the precision of the samplers, duplicate water samples will be submitted for testing for some of the samples taken. Sequential duplicate samples will be collected for 10% of the total number of samples per sampling session. A sequential duplicate requires that the collector fill two sampling sets (group of bottles from two different samples at the same depth). Since sampling will take place over three seasons, no spatial bias towards any specific site or temporal bias towards any season will be incorporated into the sampling program. The sampling program will submit blind duplicates for analysis, i.e., duplicate samples not labelled with the location.

To ensure that no contamination had reached the samples, during the process of sampling (field blanks) or introduced from the bottles or preservatives (trip blanks), will be incorporated into the sampling process. A travel/field blank is a set of bottles filled with demineralized-de-ionized water (supplied by the lab) and processed in the same manner as a collected water sample. These blanks will be carried for each sampling session. Trip blanks will have preservative

added in the field to bottles filled in the lab with demineralized-de-ionized water. All field blanks will be filled in the field with de-ionized-demineralized water to ensure that they undergo the same conditions and procedures as the water samples (i.e., collection, storage, and travel). A filter blank will be filled with field-filtered de-ionized-demineralized water.

The third level of quality control will be a check on the laboratory's precision and accuracy by preparing a split sample in the field. A split sample is a discrete water sample separated into two identical tests. The water sample is collected at one time and at a specific depth. In theory, the same results should be achieved when analyzed by the lab.

Field instrumentation (DO meter, pH meter, conductivity meter) will be calibrated prior to use. Mercury-in-glass thermometers (for water temperature) are normally very stable and do not need recalibration each time used. Any thermometers with broken columns will be discarded and not used for water temperature determinations.

2.2.2.2 Laboratory

Quality Assurance Management

Laboratory analytical reports contain pertinent information regarding the sample(s) submitted for analyses. This information includes the date the sample was collected and received by the lab, date of analysis, technician's initials, parameters, methodology, method reference, method detection limit and results. The report is reviewed by the lab QA/QC coordinator and lab manager for completeness and accuracy. All documentation associated with the analysis including raw data, chromatograms, calibration curves, calculations, etc. are kept in that file.

Quality Objectives

- To assure a Quality System that is documented and incorporates adequate review, audit and internal quality control.
- To assure personnel are adequately supervised and are proficient to carry out assigned activities.
- To assure test methods and related procedures are validated and incorporate adequate quality control.
- To assure all equipment, supplies and services are functioning properly and/or meet required specifications.
- To assure that facilities are adequate to carry out the testing activity.
- To assure sample management procedures that incorporate adequate procedures for the security, receipt, identification, checking, routing, storage and disposal of all samples.
- To assure data management procedures that incorporate adequate procedures for the security, recording, calculation, validation, authorization, transmittal, storage and disposal of all test data and related records.
- To assure workload management procedures that incorporate acceptable turnaround time and verification of resource availability prior to the acceptance of additional testing.

Sample Containers and Preservatives

The lab will utilize the list of recommended containers, preservation techniques and holding times published by USEPA to guide project managers and clients in making the correct choices for particular samples. All sample containers used by the chemistry laboratory will be purchased as pre-cleaned according to EPA protocol. Upon request, the chemistry laboratory supplies the necessary sampling containers with the required preservatives and sampling instructions. All samples submitted to the lab will be kept at 4°C until the time of analysis and they are analyzed within the maximum holding time.

Chain of Custody

It is necessary for each sample or group of samples to be accompanied by a chain-of-custody record from the time of sampling in order to trace possession. The record will contain the following information:

- Name of client.
- Project name or sampling address.
- Sample ID.
- Date and time of collection.
- Size of sample containers.
- Analysis required.
- Signature of all individuals involved in the chain of possession.
- Inclusive dates of possession.

Sample Hold Time

United States Environmental Agency and many other regulatory agencies have established holding times for most analytical parameters. Quality data requires that analyses be performed within the specified holding times. The assay laboratory will notify the project manager of any expired holding times prior to proceeding with the analysis.

Trip Blanks

Trip blanks are part of the field QA. Many types of blanks are available to the analyst including field, trip and laboratory reagent blanks. All sets of analyses are accompanied by at least reagent blank. The analysis of this blank is performed to identify potential sources of interferences from glassware, reagents and instrumentation. Blank corrections are not performed, but the blank values above the detection limit are noted and reported in the report.

Field Blanks

Field blanks are part of the field QA. The laboratory will provide support to field sampling crews by recommending and supplying quality Class 1 U.S.-EPA pre-cleaned containers, as well as the required preservatives, coolers and refrigerants. Field personnel will be reminded by the lab are to supply the appropriate number of field blanks and duplicates. Distilled and de ionized water for field and trip blanks will be provided upon request. Blank corrections are not performed, but the blank values above the detection limit are noted and reported in the report.

Surrogate Standards and Internal Standards

Surrogates are compounds not normally found in the environment but respond to analysis in a manner similar to the compound of interest. Surrogate spike recoveries are used to determine the accuracy of the analysis. The results from surrogate analyses are used in a manner similar to check samples including control charts of expected recoveries. Any analyses with values outside the action limits are re-analyzed and checks are made for calculation and preparation errors.

Instrument Calibrations

Instruments are calibrated prior to analyses using a series of high-purity standards that cover the working range of the instrument. Instrument responses are collated in an appropriate quality control sheet and this data is plotted regularly to monitor for inappropriate changes.

Calibration Check Standards & Drift Control Standards

When the instrument is not running continuously, a check calibration standard is analyzed at the end of an analytical run. A check calibration standard is a mid-range standard that is analyzed as an unknown. The calibration check standard is reviewed and its response is compared with the response for the beginning standards. If the response for the check calibration standard differs from the response for the beginning standards by more than 15 percent, corrective action must be taken.

Field Duplicates

Field duplicates are part of field QA. Field duplicates will be included by the field samplers at a rate of 10% of the number of samples.

Replicate analysis

Duplicate analysis is performed on every tenth sample submitted to the lab. Projects, with a large number of samples submitted as one lot, are automatically assigned replicates at a rate of 1 in 10 samples (10%). The results from replicate analyses are normally submitted as a separate set of reports.

Standard Reference Material (SRM) and Matrix Spikes

Standard reference materials (SRM's), if available, will be run concurrently with sample analyses. A QC report will accompany reports providing details of lab results versus the SRM certified value and advisory ranges.

Matrix spikes will be analyzed to determine the effect of the sample matrix on the analyte of interest. Spikes are usually performed on the same sample analyzed in duplicate when required. They are performed when the analyst suspects potential matrix interference or when specifically requested by the client.

Method Blanks

With every batch of samples, a method blank will be prepared with deionized water and/or extraction solvent and is analyzed to verify the absence of interferences or contaminants associated with storage, preparation and instrumental analyses.

Control Charts

Analysts will report the results from the SRM's onto control charts. The control charts are used to document the statistical control of the measurement process and to determine the limits of acceptable data. Control charts are prepared from surrogate standard values and spike values on an ongoing basis but entered daily. A minimum of 30 points are used in preparing each control chart. It is the responsibility of the appropriate analyst to prepare the control charts pertaining to his/her analyses and to refer to those charts regularly. Warning limits are set at +2 and -2 standard deviations from the mean and action limits are set at +3 and -3 deviations from the mean. The charts are reviewed regularly by the QA/QC Manager.

Inter-laboratory Comparisons

A Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. will be used for analyses. It should be noted that for continuity over what is expected to be a long term monitoring program, the same laboratory will be used year after year.

2.3 Water Levels

Water height recorders will be factory calibrated before installation. Readings from water height recorders will be periodically checked against surveyed water levels. A minimum of three (3) benchmarks will be established on bedrock near the water height recorder locations to allow water levels to be periodically surveyed in order to calibrate actual water levels with the recorders readings. As previously discussed, where staff gauges are installed checks will be against staff gauge readings and at least annually against bench marks.

2.4 Stream Flows

In-stream current meters are factory calibrated when new. They require periodic recalibration. This is accomplished in a towing tank. A number of facilities exist in Canada and calibration of the instruments used at Jericho would be undertaken at a minimum frequency of every two years during winter months when the flow meters are not employed.

Discharge measurements for streams will be made at the same location for all readings at a particular site. A staff gauge will be installed at each site where stream flows are required and the gauge surveyed in to three benchmarks. Staff gauges will be resurveyed against benchmarks annually after ice out to determine whether staff gauges have shifted or at other times when a shift in staff gauges is suspected. Standard procedures for stream gauging will be employed; methods may vary at different sites, depending on conditions. For measurements using the area and flow method, discharge transects will be repeated and only sequential measurements within 10% of each other accepted.

2.5 In-Pipe Totalizing Flow Meters

Several types of meters are available and appropriate meters will be chosen for the specific application at Jericho. All such meters are factory-calibrated and do not require re-calibration in normal use.

3.0 AQUATIC EFFECTS MONITORING PROGRAM

3.1 AEMP Activities

Activities included in the AEMP include (Mainstream Aquatics and AMEC 2005):

- water chemistry;
- sediment chemistry;
- dissolved oxygen;
- sediment deposition;
- aquatic biota:
 - o phytoplankton;
 - o zooplankton;
 - o benthic invertebrates; and
 - o fish:
 - metal contaminants;
 - community structure;
 - population structure;
 - population health.

3.2 QA/QC

3.2.1 Water and Sediment Quality

Water quality field and laboratory QA procedures are discussed in Section 2. Sediment QA procedures will be similar.

3.2.2 Dissolved Oxygen

Dissolved oxygen will be measured with a multi-probe. The multi-probe will be calibrated prior to shipment from the supplier and daily before use at the site.

3.2.3 Nonvertebrate Aquatic Biota

The following QA/QC procedures are used to ensure the integrity of the data.

1. Strict sampling protocols are adhered to ensure consistency in technique for each parameter.
2. Consistency of identifications for each indicator is achieved by using the same person.
3. Ten percent of samples are analyzed by other qualified persons to ensure the accuracy of identifications and counts.
4. Split samples collected from 5% of the samples are submitted as blinds.
5. For benthic invertebrates the residue of the sample is examined to determine sorting efficiency. If the residue contains a number of organisms that exceeds 10% of the entire sample, the sample is re-processed (ENVCAN 2002).
6. For benthic invertebrates subsampling error is evaluated by evaluating subsample precision and subsample accuracy. Subsample precision is calculated by determining the difference between two subsamples as a percent. Subsample accuracy is

determined by comparing the estimate of the subsample to that of the entire sample. Subsample precision and accuracy are deemed appropriate if < 20% (ENVCAN 2002)

7. Use of reference keys and/or reference collections to ensure standard taxonomic identifications.
8. All samples are archived for future reference.

3.2.4 Fish Tissues

Fish metal contaminants sampling will follow safeguards to prevent contamination as follows:

- Use of sterile stainless steel instruments.
- Tissue cups rinsed in 5% nitric acid solution.
- Covering the work area in plastic.

Analytical QA/CC procedures include:

1. Use of an accredited laboratory.
2. Running certified reference materials (NBS1566A oyster tissue, DORM2, and DOLT2)
3. Split samples from 5% of the replicates are submitted for analyses.

4.0 DATA VERIFICATION AND REPORTING

4.1 Data Verification

Activities performed during data collection will be assessed by mine environmental staff after each sampling campaign. Corrective actions undertaken will be reviewed for adequacy and appropriateness and documented in response to findings.

All data collected in the field and all data reports received from third parties, e.g., analytical laboratories, will be checked by Tahera mine environmental staff to ensure data are reasonable. All field notes will be archived for reference should questions arise concerning data recorded manually in the field. All original third party reports will be archived in the mine environmental database. Where digital entry and storage devices are used for any data capture, copies of electronic files will also be archived and catalogued in the mine environmental database maintained by environmental staff. A preliminary analysis will be carried out on all datasets by mine environmental staff to determine whether results indicated from the data are reasonable.

4.2 Reporting

All reports written by consultants will be subject to review by the consultant's organization prior to submission to Tahera. Tahera's environmental personnel will review final draft copies of reports prior to finalization for release, thus affording two levels of senior review and scrutiny before reports are made public.

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APPENDIX A
GENERAL AND AQUATIC EFFECTS MONITORING PLANS

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Water Licence **NWB1JER0410**
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VE51295

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EXECUTIVE SUMMARY

This general monitoring plan fulfills the requirements of Jericho Water Licence **NWB1JER410** Part L, Conditions Applying to General and Aquatic Effects Monitoring Plans, Section 1 which requires a general monitoring plan for the mine. The objective of the plan is to provide information on the extent of influence of mine operations on the water chemistry of site and receiving waters at the mine which will provide data for adaptive management strategies to improve mitigation where indicated. The plan covers pre-construction, construction and operation of the Jericho Diamond Mine.

Site monitoring will include all areas of the mine where seepage occurs or where surface water is collected and treated; both quality and quantity will be monitored. As well the amount of ore, wastes and overburden or till handled will be tracked. The frequency of monitoring will vary from daily to monthly, depending on the stream being monitored.

Receiving environment monitoring covered in this plan focuses on water chemistry. Control and potentially affected sites will be monitored on a monthly basis; three sites not directly affected by mine operations will be monitored annually. Controls include upstream and downstream and a separate drainage basin. Potentially affected sites will be close to the discharge and some distance away from the discharge (nearfield and farfield). Since the mine has the potential to affect both federally controlled and Inuit lands, sampling will occur on both.

A total of 18 receiving water quality sites, including the water intake and Processed Kimberlite Containment Area (PKCA) discharge, are included in the surveillance network program; eight of these sites were included in the baseline water quality monitoring program which commenced in 1995. At least 14 sampling locations are located on the Jericho Diamond Mine site exclusive of seeps. Twelve thermistor strings will be installed on dams and stockpiles to monitor temperature changes in these facilities.

A quality control program will be instituted for field and laboratory sampling and analyses. All instruments used in the field and laboratory will be calibrated as indicated by manufacturers or established protocols in the laboratory.

Triggers that will invoke adaptive management for the site would be significant changes in water chemistry of monitored water or significant changes in the thermal regime for dams and stockpiles. Exceedance of site specific water quality guidelines in the receiving environment or significant changes in aquatic biota noted from the aquatic effects monitoring program (discussed elsewhere) would also trigger adaptive management to improve mitigation and reduce concentrations of problematic water parameters where possible.

All data will be stored electronically and on paper. Reports will be prepared as required by the Water Licence, either monthly or annually.

1.0 INTRODUCTION

The Jericho Diamond Project is being developed by Tahera Diamond Corporation on behalf of its wholly owned subsidiary, Benachee Resources Inc. The mine site is located approximately 420 km north northeast of Yellowknife, NWT, in the West Kitikmeot region of Nunavut.

A copy of the recommendation to the Minister of DIAND for a Project Water Licence was received from Nunavut Water Board 22 December 2004 and sign off by the DIAND Minister 26 January 2005. A number of plans must be developed under the terms of the Water Licence and the general monitoring plan is detailed in this document.

This general monitoring plan fulfills the requirements of Jericho Water Licence NWB1JER410 Part L, Conditions Applying to General and Aquatic Effects Monitoring Plans, Section 1 which requires a monitoring plan for the mine as set out under Schedule L, Section 1. The following terms apply:

- a. Updated operation monitoring plan which reflects the requirements of the licence.
- b. Describe the assessment of Stream C3 by a hydrologist and, if required, erosion protection measures required. **Note:** this requirement will be addressed in an addendum report from the consultant hydrologist engaged prior to Long Lake dewatering as Stream C3 in winter is completely frozen and snow covered. Thus it is not possible at the time of writing of this plan to comply with this requirement.

The Jericho Water Licence **NWB1JER410** is attached as Appendix A.

2.0 OBJECTIVES AND SCOPE OF THE GENERAL MONITORING PLAN

2.1 Objectives

- To provide information on the extent of influence of mine operations on the water chemistry of site and receiving waters for the mine.
- To build on the water quality data base collected from 1995 through 2001 as part of baseline studies in support of the Jericho Diamond Project environmental impact statement.
- To allow feedback to the adaptive management plan which will be used to assess mitigation and management at the mine.
- To provide data to modify and improve mitigation where indicated.

2.2 Scope

The general monitoring plan covers site and receiving environment monitoring as set out in the Jericho Diamond Mine Water Licence. A separate plan was developed for aquatic effects monitoring and relevant parts of this plan are also included in the aquatic effects monitoring plan. The mining phases covered by this plan are:

- pre-construction;
- construction; and
- operation

as required by the Water Licence. Closure monitoring (including temporary, indefinite and permanent shutdown) is discussed in the Abandonment and Restoration Plan for the project and will be updated as required by the Water Licence in that plan.

2.3 Previous Water Quality Monitoring

Table 2-1 provides a listing of baseline water quality history.

Table 2-1: Baseline Water Quality Sampling History

Lake	Sample Site	Location Description	Sampling Dates
Cigar Lake	CL-01	control site	1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12
	CL-02		1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12 1997: 7 1998: 8 1999: 4, 7, 8, 9
Carat Lake	CL-03	project site	1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12 1997: 7 1998: 8
	CL-04		1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12 1997: 7 1998: 8
	CL-05		1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12 1997: 7 1999: 4, 7, 8, 9
Jericho Lake Outlet	CL-06	downstream of project	1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12 1998: 8 1999: 7, 8, 9
	CL-07		1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12
	CL-08		1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12
Kathawachaga Lake	CL-09	mouth of Jericho River	1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12
	CL-10	mouth of Burnside River	1995: 7, 8, 9, 11 1996: 4, 7, 8, 9, 12
Tailings Lake	CL-12		1997: 7
Seep Creek	CL-13		1997: 7
Key Lake	CL-14		1996: 4, 7, 8, 9, 12
Pocket Lake	CL-15		1996: 4, 7, 8, 9, 12
Lynne Lake	CL-16		1996: 4, 7, 8, 9, 12
Ash Lake	CL-17		1996: 4, 7, 8, 9, 12
Contwoyto Lake	CL-18	proposed dock facility	1996: 7, 8, 9, 12
	CL-19	halfway to Lupin	1996: 7, 8, 9, 12
	CL-20	3/4 to Lupin	1996: 7, 8, 9, 12
3 unnamed lakes	CL-21	near airstrip	1996: 6, 7, 8, 9
	CL-22		1996: 6, 7, 8, 9
	CL-23		1996: 6, 7, 8, 9
Long Lake	CL-25	potential tailings pond, near outlet	1999: 7, 8, 9
Key Lake outlet stream	CL-26		1999: 7, 8, 9
Lynne Lake outlet stream	CL-27		1999: 7, 8, 9
Lake C3	CL-28	upstream of Carat	1999: 8, 9
Lake C4	CL-31		2000: 8, 9

Table 2-2 provides a comparison between baseline station water quality sampling and the surveillance network program for mine operation.

Table 2-2: Baseline – Operational Monitoring Comparison

Baseline Monitoring Station	Location	Operations Monitoring Station
CL-02	Cigar Lake	JER-WQ11
CL-04	Carat Lake Central Basin	JER-WQ5
CL-06	Jericho Lake	JER-WQ8
CL-14	Key Lake	JER-WQ17
CL-16	Ash Lake	JER-WQ18
CL-17	Lynne Lake	JER-WQ16
CL-28	Lake C3	JER-WQ4
CL-31	Lake C4	JER-WQ14

Baseline water quality monitoring was discussed in detail in the Jericho Final EIS filed with the Nunavut Environmental Impact Review Board and the Nunavut Water Board. See Figure 1 for surveillance network program sampling sites.

3.0 OVERVIEW

3.1 Site Monitoring

The monitoring locations representing internal flows at the site (i.e. to the pit sump or PKCA) are intended to provide an early indication of how the systems are performing. This information will be used by the mine operator to make adaptive management decisions and projections of PKCA discharge water quality. Sampling of the PKCA inflows would be on a bi-weekly basis during the open water season (generally June to September) for the first two years of operations. The PKCA pond and any inflows that continue through the winter months (i.e. the supernatant and the treated sewage) would be monitored on a monthly basis.

3.1.1 Flows and Water Chemistry

Flows and water quality will be monitored at key locations in the site water management system to anticipate any significant deviations from the conditions assumed in the current water and load balance that could indicate the need for management to ensure that the PKCA discharges continue to meet discharge criteria. The site monitoring program will be complemented by monitoring of the waste rock, kimberlite, processed kimberlite solids, recovery plant rejects, monitoring of receiving water quality, and environmental effects monitoring. Details of those other programs are provided in the *Waste Rock, Kimberlite and Coarse PK Management Plan* (SRK 2004) and the *Aquatic Effects Monitoring Program* (Mainstream Aquatics 2004).

Key locations in the site water monitoring network are shown on Figure 2. These include:

- Temporary or permanent collection ditches or ponds A, B and C, which will be used as control structures to direct water to the pit sump or PKCA during operations
- The pit sump.
- The process plant supernatant.
- Treated sewage effluent.
- PKCA pond water.
- PKCA discharge water.
- Stream C3 during PKCA discharge for signs of erosion (periodically, as required).

During the first two years of operations, each of the above locations would be established as “routine monitoring stations” for measurement of flow and water quality. Sampling of the PKCA inflows would be on a monthly basis during the open water season (generally June to September). The PKCA pond and any inflows that continue through the winter months (i.e. the supernatant and the treated sewage) would continue to be monitored on a monthly basis during the winter. The PKCA discharge would be monitored on a weekly basis during the discharge period from June through September; flows will be continuously monitored.

The methods for estimating flow will depend on the final details of the water management facilities. Any pumped flows would be equipped with totalizer meters to record the total throughput of water occurring between sampling events. Ditch flows would be monitored using weirs, and piped flows directed by gravity would be measured using bucket and stopwatch methods.

An annual seepage survey would be completed along the down-gradient side of each of waste rock dump, ore stockpile, coarse PK stockpile, recovery plant stockpile and any sumps in the plant area to develop a better understanding of variations in source concentrations from different areas of site. This information may be used to optimize the water management

system. For example, seeps that meet discharge criteria may be managed separately from those that do not. Based on Ekati Diamond Mine™ seepage chemistry, this sampling will take place in July or August to coincide with maximum seepage concentrations. It should be noted that the provision of routine monitoring stations at each of the collection points ensures that seepage and runoff from the waste rock is monitored on a seasonal basis. Therefore an annual seepage survey is considered sufficient for characterizing variability in the source concentrations from different areas of the dumps and stockpiles.

3.1.2 Solids Geochemistry

Geochemical monitoring will be carried out to confirm the geochemical properties of the waste rock, low-grade kimberlite ore, fine PK, coarse PK and recovery plant rejects.

Waste rock and low-grade kimberlite ore samples will be collected as grab samples from the muck pile produced by blasting. In the first two years of the mine operation blasting will occur approximately once per day, with approximately one blast per two days in the next two years of mining. Characterization of the waste rock should include:

- Sample collection during every week for the first year of mining, and, assuming that the testing data indicates minimal variability in the geochemistry of the waste rock, the sample frequency would be reduced to every other week for the remaining years of mining.
- Sample collection from each rock type present in the blast (i.e. granite/granodiorite, pegmatite, diabase, waste kimberlite).
- Geological description of the sample by a geologist or engineer, and general geological observations of the blasted rock, such as presence and composition of any xenoliths, occurrence of sulphide minerals etc.
- Testing of paste pH, reaction with HCl, total sulphur, and uranium on every sample. (Uranium analyses may be discontinued after the first year of testing if uniformity can be demonstrated). Full ABA analyses and ICP-metals would be performed on every 10th sample.
- Testing of a duplicate sample every 10th sample.

3.1.3 Ground Ice

During collection of the waste rock samples, blasted rock and freshly blasted rock faces will be examined for presence of significant quantities of ground ice. If present, the quantity of ice will be estimated, and samples of the ice lenses will be collected and submitted for water quality analyses to characterize the quality of ice melt water that would report to the pit or waste rock dumps. The frequency of sampling would depend on the amount of ice encountered, and the water quality data from the first few samples. However, based on observations from the underground development and drilling, it is considered unlikely that significant amounts of ice will be encountered.

3.1.4 Thermal Monitoring

A number of thermistors will be installed in the waste rock dumps and the Coarse PK Stockpile, including:

- two locations in waste dump one;

- two locations in waste dump two; and
- two locations in the coarse PK stockpile.

Two thermistors per dam will also be installed in the frozen zone of each of the dams. Thermistor readings will be collected on a monthly basis for a period of two years, or until a clear pattern has been established. Thereafter the reading frequency will be quarterly.

3.1.5 Site Surveys and Visual Inspections

Three pairs of survey hubs will be established on each of the dams to monitor dam movements should they occur.

During the active development of each of the mine components, site staff will carry out daily inspections of these facilities (PKCA, including dams, all collection ponds, water control dikes, waste rock dumps and stockpiles), including slope stability, seepage and conformity to the development footprint. When activity ceases on an interim or seasonal basis, the inspection frequency will shift to monthly. Following completion of a component, inspections will continue on a semi-annual basis to closure.

Formal semi-annual inspections will also be carried out by site personnel, one of which will be conducted by an independent professional geotechnical or civil engineer.

Stream C3 will be inspected prior to discharge of the PKCA by a qualified hydrologist to determine the potential for erosion under discharge scenarios. Stream C3 will be inspected periodically as required during Long Lake pump out and PKCA discharge to determine whether bank or bed erosion is occurring. Should erosion be occurring, pumping/discharge will cease and rock armouring will be placed at the erosion site prior to commencement of pumping/discharge.

The water management facilities which specifically include the collector ditches and ponds below each dump or stockpile as well as various sumps will be monitored by site staff on a daily basis during freshet, weekly during summer and fall and once during the winter.

3.1.6 Stream Flows

An automated water level recorder equipped with a radio link will be installed near the outlet to Lake C3 prior to mine start up. Appendix B contains information on typical equipment that can be used for this application¹. The recorder will be fitted with a radio link to the control room of the diamond processing plant where data can be monitored in real time if required. The water level recorder will be operated whenever PKCA discharge is occurring. A minimum of three (3) benchmarks will be established on bedrock near the site to allow lake levels to be periodically surveyed in order to calibrate actual lake levels with the recorder's readings. A suitable location will be selected in the C3 outlet stream (Jericho River) to measure stream discharge. The stage discharge curve developed as part of baseline studies and reported in the Jericho Final EIS will be upgraded with additional information to improve the relationship between lake water level and lake outlet discharge. This relationship, coupled with continuous monitoring of lake levels when the Jericho River is flowing from Lake C3 (summer only as the River freezes completely in winter) will be used to determine Lake C3 discharge.

In order to provide data for operation of the Stream C1 diversion, this stream will also be gauged at the transition pool 2 (Figure 3) by means of a weir and a continuous height recorder

¹ No endorsement of the equipment shown is implied.

(pressure transducer) once the diversion becomes operational. Use of a calibrated weir at this location will allow direct conversion of water height records to discharge. Prior to construction of the diversion the baseline flow monitoring station will be used as this is the first point above the mouth suitable for water height and flow measurements (Figure 3).

A staff gauge will be installed near the mouth of Stream C3 (JER-WQ3) and will be monitored during Long Lake dewatering and PKCA discharge. Periodic discharge measurements will also be taken.

3.1.7 Receiving Environment Water Quality Monitoring

The objective of the water quality monitoring program will be to detect changes in water chemistry caused by mining activities. Discharges from the PKCA are predicted to be above CCME Aquatic Life Guidelines and for most parameters above background concentrations in the receiving environment. The site-specific water quality criteria developed for Jericho can be found in Appendix C. Fallout of suspended particulate from blasting could increase ammonia concentrations in water bodies within the mine site as well but the amount of suspended particulate that will enter water bodies from blasting is not expected to measurably affect suspended solids concentrations.

Monitoring stations will be established (a) at two control sites one within the Jericho River drainage basin and one in a separate basin), (b) near to the discharge location for PKCA and (d) in lakes on and adjacent to the mine site and (e) in lakes within the Jericho River at some distance from the mine.

During summer, water will be collected by submersing bottles 0.25 m below the surface in lakes and below the surface in streams, uncapping and allowing bottles to fill, recapping and then resurfacing. Raw water sample bottles will be rinsed three times; other sample bottles will not be rinsed.

During periods of ice cover (i.e., the April and December sampling periods), holes will be drilled through the ice cover by a gas powered ice auger for the collection of surface grab water samples. Samples will be collected approximately 0.5 m below the water surface exposed in the holes. Rinsing of sample containers with in-situ water will be impractical due to the cold weather; consequently, laboratory prepared sample containers will be used.

Dissolved metal samples will be filtered through a 0.45 µm nullipore filter and preserved with AA grade nitric acid. Total metals samples will also be preserved with AA grade nitric acid. Total organic carbon samples will be preserved with AA grade sulphuric acid. A 2-L sample of raw water will not be preserved. All samples will be kept cool during storage and air transported to the analytical laboratory.

Schedule 1 lists the monitoring stations and the frequency of monitoring. Detection limits to be used in laboratory analyses are listed in Table 3-1.

Table 3-1: Water Sample Laboratory Detection Limits

Water Quality Parameter	Detection Limits (mg/L or parameter units)	Water Quality Parameter	Detection Limits (mg/L or parameter units)
Physical Tests		Total & Dissolved Metals	
Conductivity (umhos/cm)	2	Cobalt (Co)	0.0001
Hardness CaCO ₃	0.05	Copper (Cu)	0.0001

Water Quality Parameter	Detection Limits (mg/L or parameter units)	Water Quality Parameter	Detection Limits (mg/L or parameter units)
pH	0.01	Iron (Fe)	0.03
Total Suspended Solids	3	Lead (Pb)	0.00005
Total Dissolved Solids	3	Lithium (Li)	0.001
Dissolved Anions		Magnesium (Mg)	0.05
Alkalinity-Total, bicarbonate CaCO ₃	1	Manganese (Mn)	0.00005
Chloride Cl	0.5	Mercury (Hg)	0.00005
Sulphate SO ₄	1	Molybdenum (Mo)	0.00005
Nutrients		Nickel (Ni)	0.0001
Nitrate (NO ₃)	0.005	Phosphorus (P)	0.3
Nitrite (NO ₂)	0.002	Potassium (K)	2
Ammonia (NH ₃)	0.005	Selenium (Se)	0.001
Total Dissolved Phosphorus	0.001	Silicon (Si)	0.05
Total Phosphorus	0.001	Silver (Ag)	0.00001
Total & Dissolved Metals		Sodium (Na)	2
Aluminum (Al)	0.001	Strontium (Sr)	0.0001
Antimony (Sb)	0.00005	Thallium (Tl)	0.00005
Arsenic (As)	0.0001	Tin (Sn)	0.0001
Barium (Ba)	0.00005	Titanium (Ti)	0.01
Beryllium (Be)	0.0005	Uranium (U)	0.001
Bismuth (Bi)	0.0005	Vanadium (Va)	0.001
Boron (B)	0.001	Zinc (Zn)	0.001
Cadmium (Cd)	0.00005	Organic Parameters	
Calcium (Ca)	0.05	Total Organic Carbon (TOC)	0.01
Chromium (Cr)	0.0005	Total Inorganic Carbon (TIC)	0.01

Parameters that will be measured in the field for each station are listed in Table 3-2.

Table 3-2: Field Water Quality Monitoring Parameters

Sampler's name	Field pH
Station number	Water temperature
Single or replicate sample	Dissolved oxygen (where appropriate)
Conductivity	Oxidation Reduction Potential (where appropriate)
Date and time	Water transparency (secci disk) (where appropriate)
Type and number of bottles filled	Any other field measurements, e.g. weather
Sample depth (for depth profiles)	Turbidity (dewatering only)

General water parameters (pH, dissolved anions, nutrients) will be analyzed in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (United States Environmental Protection Agency), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (British Columbia Ministry of the Environment), and/or

“Standard Methods for the Examination of Water and Wastewater” (American Public Health Association).

Total and dissolved metals and organic parameter samples will be analyzed in accordance with procedures described in “Standard Methods for the Examination of Water and Wastewater”, 18th Edition (American Public Health Association, 1992). Several methods will be employed for metals analysis, including Inductively Coupled Plasma-Mass Spectrophotometry (ICP-MS) and Atomic Absorption Spectrophotometry (AA) to obtain the required detection limit for each element. Organic parameters will be analyzed using a gas chromatograph - flame ionization detector (GC/FID). Mercury will be analyzed by cold vapour AA.

3.2 Monitoring Activities and Schedules

1. Pursuant to Water Licence Part E, Conditions Applying to Water Use, Section 1, a totalizing meter will be installed at the water intake line at Carat Lake and a log of water use kept for inspection at the Jericho Diamond Mine.
2. Pursuant to Water Licence Schedule L, Conditions Applying to General and Aquatic Effects Monitoring Plans, Section 4dvii, the level of Carat Lake will be monitored at the water intake.
3. Pursuant to Water Licence Part F, Conditions Applying to Water Management, Section 4c, a minimum of weekly inspection of water management structures will be carried out during the open water period. Inspection reports will be filed with the Mine Manager after each inspection and reports maintained for review by a Nunavut Water Board Inspector upon request.
4. Pursuant to Water Licence Part G, Conditions Applying to Waste Management, Section 1, totalizing meters will be installed on:
 - a. the main tailings discharge line from the diamond processing plant;
 - b. the discharge line from the sewage treatment plant;
 - c. the final discharge line from the PKCA;
 - d. any other internal pumped discharge lines that may from time to time be required as part of liquid waste management.

Logs of discharges will be kept for inspection at the Jericho Diamond Mine.

5. Pursuant to Water Licence Part G, Section 2d, a minimum of weekly inspection of waste management structures will be carried out throughout the mining operation period. Inspection reports will be filed with the Mine Manager after each inspection and reports maintained for review by a Nunavut Water Board Inspector upon request.
6. Pursuant to Water Licence Part G, Section 3, a minimum of weekly inspection of earthworks, retention structures, dams and diversion structures, stockpiles, dumps, berms and pit slopes will be carried out throughout the mining operation period. Inspection reports will be filed with the Mine Manager after each inspection and reports maintained for review by a Nunavut Water Board Inspector upon request.
7. Pursuant to Water Licence Part G, Sections 6a, 6b, 7a and 7b all discharges from the PKCA to Stream C3 at monitoring station JER-WQ2 will be analyzed for the parameters listed in Schedule 1. Upon directing discharge from the waste water treatment plant to the PKCA the following additional parameters will be monitored:

- a. Biochemical Oxygen Demand
- b. Oil and Grease
- c. Faecal Coliforms

Acute toxicity will also be monitored before discharge and monthly thereafter using rainbow trout and *Daphnia magna* according to Environmental Protection Series Biological Test Method EPS/1/RM/13 and EPS/1/RM/14, respectively.

8. Pursuant to Water Licence Part H, Conditions Applying to Waste Management Plans, Section 4 during the first year of operation, recovery plant rejects (coarse PK) will be collected once every two weeks. Samples will be submitted for testing of paste pH, reactivity with HCl, and total sulphur. Full ABA analyses, ICP-metals and uranium analyses would be performed on every 10th sample. At the end of the sampling period an analysis report will be prepared and submitted as an addendum to the Waste Rock Management Plan.
9. Pursuant to Water Licence Part K, Conditions Applying to General and Aquatic Effects Monitoring, Section 2, a continuous water height recorder will be installed in Lake C3 near its outlet during the first open water season of the construction period. The recorder will be fitted with a radio link to the control room of the diamond processing plant where data can be monitored in real time if required. The water height recorder will be operated whenever PKCA discharge is occurring. A minimum of three (3) benchmarks will be established on bedrock to allow lake levels to be periodically surveyed in order to calibrate actual lake levels with the recorders readings. A suitable location will be selected in the C3 outlet stream (Jericho River) to measure stream discharge. The stage discharge curve developed for the Final EIS will be upgraded with additional information to allow a relationship between lake water level and lake outlet discharge to be determined. This relationship, coupled with continuous monitoring of lake levels when the Jericho River is flowing from Lake C3 (summer only as the River freezes completely in winter) will be used to determine Lake C3 discharge.
10. Pursuant to Water Licence Part K, Section 4, water quality monitoring will be conducted according to the schedules set out in Schedule 1.
11. Pursuant to Water Licence Part K, Section 12, flows will be measured as per Schedule 1. In addition to flows listed in Schedule 1:
 - a. The volume of PKCA reclaim water will be monitored when water is being reclaimed.
 - b. The weight of solids in tonnes and volume of liquid fractions in m³ of each waste pumped to the PKCA.
 - c. The volume of sewage sludge removed from the Waste Water Treatment Plant.
12. Pursuant to Water Licence Part K, Section 13, the following quantities produced or stockpiled will be monitored and recorded on a monthly basis:
 - a. processed ore;
 - b. waste rock;
 - c. coarse PK;

d. till and overburden.

13. Pursuant to Water Licence Part L, Conditions Applying to General and Aquatic Effects Monitoring Plans, Section 9, an annual seepage survey will be conducted during summer months. A report will be submitted to NWB within 60 days of completion of the survey.
14. Pursuant to Water Licence Schedule L, Conditions Applying to General and Aquatic Effects Monitoring Plans, Section 1c, the conditions of Stream C3 channel will be monitored during PKCA release as will water levels and discharges near the mouth.
15. Pursuant to Water Licence Schedule L, Section 4 d iv, chronic toxicity tests will be conducted on water collected at the edge of the mixing zone in Lake C3 during the open water season when PKCA discharge is occurring. Environment Canada Biological Test Method EPS /1/RM/21 (1992) will be used.

3.3 Monitoring Summary

3.3.1 Site Water, Ore and Waste

Specific locations at each facility will have to be field fit. The following sites will be monitored:

- Temporary or permanent collection ditches or ponds A, B and C, which will be used as control structures to direct water to the pit sump or PKCA during operations.
- The pit sump.
- The process plant supernatant.
- Treated sewage effluent.
- PKCA pond water.
- PKCA discharge water.

A seepage survey will monitor all seepages from waste and water management structures on the site annually in the summer.

Quantities of ore, waste and till/overburden generated during mining will be recorded.

The following volumes will be monitored:

- Daily intake water volume at the main intake in Carat Lake.
- Volume of water from runoff collection ponds.
- Volume of water reclaimed from the PKCA when water recycling occurs.
- Daily volume of water discharged from the PKCA.
- Daily volume of mine water and seepage pumped from the open pit, ponds and other site water management facilities. (Note: operationally it may not be possible to separate runoff and mine water collected in site water management facilities.)
- Daily volume of treated sewage effluent discharged from the Waste Water Treatment Plant.
- The volume of sewage sludge removed from the Waste Water Treatment Plant.
- The weight of solids and volume of liquids pumped to the PKCA from the diamond processing plant.

3.3.2 Receiving Environment Water Quality and Quantity

All receiving environment water quality and flow monitoring is listed in Schedule 1.

Lake levels will be monitored continuously at the Carat Lake water intake and Lake C3 outlet by means of water level recorders.

The following flows will be monitored:

- Stream C3 near its mouth during PKCA discharge.
- Jericho River at the outlet of Lake C3 during periods of flow (spring-summer-fall).
- Stream C1 at pond 2 (lower energy dissipation pool) after construction of the C1 Diversion and prior to that at the baseline stream flow station upstream when the stream is flowing.

Acute toxicity tests using rainbow trout and *Daphnia magna* will be conducted monthly on PKCA discharge. Chronic toxicity testing will be conducted on *Ceriodaphnia dubia* monthly during the open water season from water collected at the edge of the 200 m mixing zone in Lake C3.

4.0 QA/QC

4.1 Site Water Quality

Standard QA/QC procedures for water sampling including collection of field, travel and method blanks and duplicate samples will be included in the program. Section 4.2 provides additional details on field and laboratory QA/QC.

4.2 Receiving Water Body Water Quality

4.2.1 Field

To check on the precision of the samplers, duplicate water samples will be submitted for testing for some of the samples taken. Sequential duplicate samples will be collected for 10% of the total number of samples per sampling session. A sequential duplicate requires that the collector fill two sampling sets (group of bottles from two different samples at the same depth). Since sampling will take place over three seasons, no spatial bias towards any specific site or temporal bias towards any season will be incorporated into the sampling program. The sampling program will submit blind duplicates for analysis, i.e., duplicate samples not labelled with the location.

To ensure that no contamination had reached the samples, during the process of sampling (field blanks) or introduced from the bottles or preservatives (trip blanks), will be incorporated into the sampling process. A travel/field blank is a set of bottles filled with demineralized-de-ionized water (supplied by the lab) and processed in the same manner as a collected water sample. These blanks will be carried for each sampling session. Trip blanks will have preservative added in the field to bottles filled in the lab with demineralized-de-ionized water. All field blanks will be filled in the field with de-ionized-demineralized water to ensure that they undergo the same conditions and procedures as the water samples (i.e., collection, storage, and travel). A filter blank will be filled with field-filtered de-ionized-demineralized water.

The third level of quality control will be a check on the laboratory's precision and accuracy by preparing a split sample in the field. A split sample is a discrete water sample separated into two identical tests. The water sample is collected at one time and at a specific depth. In theory, the same results should be achieved when analyzed by the lab.

Field instrumentation (DO meter, pH meter, conductivity meter) will be calibrated prior to use. Mercury-in-glass thermometers (for water temperature) are normally very stable and do not need recalibration each time used. Any thermometers with broken columns will be discarded and not used for water temperature determinations.

4.2.2 Laboratory

4.2.2.1 Quality Assurance Management

Laboratory analytical reports contain pertinent information regarding the sample(s) submitted for analyses. This information includes the date the sample was collected and received by the lab, date of analysis, technician's initials, parameters, methodology, method reference, method detection limit and results. The report is reviewed by the lab QA/QC coordinator and lab manager for completeness and accuracy. All documentation associated with the analysis including raw data, chromatograms, calibration curves, calculations, etc. are kept in that file.

4.2.2.2 Quality Objectives

- To assure a Quality System that is documented and incorporates adequate review, audit and internal quality control.

- To assure personnel are adequately supervised and are proficient to carry out assigned activities.
- To assure test methods and related procedures are validated and incorporate adequate quality control.
- To assure all equipment, supplies and services are functioning properly and/or meet required specifications.
- To assure that facilities are adequate to carry out the testing activity.
- To assure sample management procedures that incorporate adequate procedures for the security, receipt, identification, checking, routing, storage and disposal of all samples.
- To assure data management procedures that incorporate adequate procedures for the security, recording, calculation, validation, authorization, transmittal, storage and disposal of all test data and related records.
- To assure workload management procedures that incorporate acceptable turnaround time and verification of resource availability prior to the acceptance of additional testing.

4.2.2.3 Sample Containers and Preservatives

The lab will utilize the list of recommended containers, preservation techniques and holding times published by USEPA to guide project managers and clients in making the correct choices for particular samples. All sample containers used by the chemistry laboratory will be purchased as pre-cleaned according to EPA protocol. Upon request, the chemistry laboratory supplies the necessary sampling containers with the required preservatives and sampling instructions. All samples submitted to the lab will be kept at 4°C until the time of analysis and they are analyzed within the maximum holding time.

4.2.2.4 Chain of Custody

It is necessary for each sample or group of samples to be accompanied by a chain-of-custody record from the time of sampling in order to trace possession. The record will contain the following information:

- Name of client.
- Project name or sampling address.
- Sample ID.
- Date and time of collection.
- Size of sample containers.
- Analysis required.
- Signature of all individuals involved in the chain of possession.
- Inclusive dates of possession.

4.2.2.5 Sample Hold Time

United States Environmental Agency and many other regulatory agencies have established holding times for most analytical parameters. Quality data requires that analyses be performed within the specified holding times. The assay laboratory will notify the project manager of any expired holding times prior to proceeding with the analysis.

4.2.2.6 Trip Blanks

Trip blanks are part of the field QA. Many types of blanks are available to the analyst including field, trip and laboratory reagent blanks. All sets of analyses are accompanied by at least reagent blank. The analysis of this blank is performed to identify potential sources of

interferences from glassware, reagents and instrumentation. Blank corrections are not performed, but the blank values above the detection limit are noted and reported in the report.

4.2.2.7 Field Blanks

Field blanks are part of the field QA. The laboratory will provide support to field sampling crews by recommending and supplying quality Class 1 U.S.-EPA pre-cleaned containers, as well as the required preservatives, coolers and refrigerants. Field personnel will be reminded by the lab are to supply the appropriate number of field blanks and duplicates. Distilled and de ionized water for field and trip blanks will be provided upon request. Blank corrections are not performed, but the blank values above the detection limit are noted and reported in the report.

4.2.2.8 Surrogate Standards and Internal Standards

Surrogates are compounds not normally found in the environment but respond to analysis in a manner similar to the compound of interest. Surrogate spike recoveries are used to determine the accuracy of the analysis. The results from surrogate analyses are used in a manner similar to check samples including control charts of expected recoveries. Any analyses with values outside the action limits are re-analyzed and checks are made for calculation and preparation errors.

4.2.2.9 Instrument Calibrations

Instruments are calibrated prior to analyses using a series of high-purity standards that cover the working range of the instrument. Instrument responses are collated in an appropriate quality control sheet and this data is plotted regularly to monitor for inappropriate changes.

4.2.2.10 Calibration Check Standards & Drift Control Standards

When the instrument is not running continuously, a check calibration standard is analyzed at the end of an analytical run. A check calibration standard is a mid-range standard that is analyzed as an unknown. The calibration check standard is reviewed and its response is compared with the response for the beginning standards. If the response for the check calibration standard differs from the response for the beginning standards by more than 15 percent, corrective action must be taken.

4.2.2.11 Field Duplicates

Field duplicates are part of field QA. Field duplicates will be included by the field samplers at a rate of 10% of the number of samples.

4.2.2.12 Replicate analysis

Duplicate analysis is performed on every tenth sample submitted to the lab. Projects, with a large number of samples submitted as one lot, are automatically assigned replicates at a rate of 1 in 10 samples (10%). The results from replicate analyses are normally submitted as a separate set of reports.

4.2.2.13 Standard Reference Material (SRM) and Matrix Spikes

Standard reference materials (SRM's), if available, will be run concurrently with sample analyses. A QC report will accompany reports providing details of lab results versus the SRM certified value and advisory ranges.

Matrix spikes will be analyzed to determine the effect of the sample matrix on the analyte of interest. Spikes are usually performed on the same sample analyzed in duplicate when required. They are performed when the analyst suspects potential matrix interference or when specifically requested by the client.

4.2.2.14 Method Blanks

With every batch of samples, a method blank will be prepared with deionized water and/or extraction solvent and is analyzed to verify the absence of interferences or contaminants associated with storage, preparation and instrumental analyses.

4.2.2.15 Control Charts

Analysts will report the results from the SRM's onto control charts. The control charts are used to document the statistical control of the measurement process and to determine the limits of acceptable data. Control charts are prepared from surrogate standard values and spike values on an ongoing basis but entered daily. A minimum of 30 points are used in preparing each control chart. It is the responsibility of the appropriate analyst to prepare the control charts pertaining to his/her analyses and to refer to those charts regularly. Warning limits are set at +2 and -2 standard deviations from the mean and action limits are set at +3 and -3 deviations from the mean. The charts are reviewed regularly by the QA/QC Manager.

4.2.2.16 Inter-laboratory Comparisons

A Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc. will be used for analyses. It should be noted that for continuity over what is expected to be a long term monitoring program, the same laboratory will be used year after year.

4.3 Lake Levels

Water height recorders will be factory calibrated before installation. Readings from water height recorders will be periodically checked as previously discussed. A minimum of three (3) benchmarks will be established on bedrock near the water height recorder locations to allow water levels to be periodically surveyed in order to calibrate actual water levels with the recorders readings.

4.4 Stream Flows

In-stream current meters are factory calibrated when new. They require periodic recalibration. This is accomplished in a towing tank. A number of facilities exist in Canada and calibration of the instruments used at Jericho would be undertaken at a minimum frequency of every two years during winter months when the flow meters are not employed.

4.5 In-Pipe Totalizing Flow Meters

Several types of meters are available and appropriate meters will be chosen for the specific application at Jericho. All such meters are factory-calibrated and do not require re-calibration in normal use.

5.0 REPORTING AND DATA ANALYSIS

5.1 Data Analysis

All raw abiotic and biotic data collected as part of the monitoring plan will be stored into a common database. The determination of an effect, whether that be abiotic or biotic, will be identified through a rigorous data analysis exercise. All parametric data analysis will be accompanied by appropriate QA/QC to ensure the fundamental assumptions of the analysis of variance (ANOVA) are not violated. Transformation of the raw data may be necessary. Initially, the analysis of the data will focus on a geographic comparison between upstream distant controls, proximal stations and distal downstream locations. Eventually as data is accumulated during the construction phase, temporal trends will be evaluated and comparisons with baseline data would become important.

The monitoring program is designed for comparison among sampling stations, rather than water bodies or watersheds. Monitoring of the abiotic environment will occur at the same locations over time, thus should statistically be treated as a repeated measures analysis of variance. Variance of a given abiotic parameter will occur in space (among stations) and in time. In order to distinguish between these two potential sources of variance, the analysis of variance model, designed to test for spatial effects (among station variance), will consider each of these factors and the potential interaction between these two factors.

The analysis of the temporal trend will proceed through a stepwise process initiated by simple charting over time of the parameter concentrations at each station. To quantitatively investigate suspected temporal trends, the logical statistical tool is regression analysis. If a parameter of potential concern is indicating an increasing (or decreasing) trend a regression analysis will be conducted across time. To determine whether or not the trend differs from those at other stations, either up gradient or down gradient, a statistical test to investigate the differences in slopes will be performed (analysis of covariance).

5.1.1 Site Monitoring

Standard measures of central tendency (mean or median, standard deviation) will be calculated for each data set. Trend analyses will be performed annually on data exhibiting trends. The focus of site water chemistry monitoring is to determine the sources of potentially problematic parameters. The proposed statistical analyses will allow this determination.

Site thermal monitoring data will undergo the same statistical analyses for the same purpose.

Certain monitoring data (e.g. volume of water use, volume of water pumped from collection facilities, volume of recycled water) only require totalizing.

PKCA discharge volume will be compared to Lake C3 discharge to determine theoretical dilution factors for discharge water.

5.1.2 Receiving Environment

5.1.2.1 Stream C3 Discharge

Stream C3 discharge during Long Lake dewatering will be monitored periodically and compared to the natural hydrograph developed as part of baseline studies. The purpose will be to mirror as much as possible, the natural hydrograph of Stream C3 during pump out of Long Lake.

5.1.2.2 Jericho River Discharge from Lake C3

Development of a stage-discharge relationship from continuous measurement of lake water levels and periodic measurement of river discharge were previously discussed.

5.1.2.3 Stream C1 Discharge

Seasonal variation in the natural Stream C1 discharge will be determined by plotting the periodic discharge measurements made before installation of the weir. These data will be compared with the baseline data collected for the Jericho EIS to build on the database. Once the diversion is completed, the measuring point for Stream C1 discharge will be moved as previously discussed. Seasonal variation in discharge through the diversion will then be compared to the background data collected during baseline studies and during early mine operations to determine whether a significant drop in water discharge has occurred. Any contact water in the Stream C1 drainage basin that meets discharge criteria could be discharged to the stream pursuant to regulatory approval, thus increasing stream flows.

5.1.2.4 Carat Lake Water Level

Carat Lake level will be continuously monitored at the water intake. An estimate of the drawdown of the lake, if measurable, will be determined from the data. Since there are no background data on Carat Lake water level seasonal variations, the lake level records will be compared to lake bathymetry to determine the percentage of total lake water volume drawn off for mine use.

5.1.2.5 Water Chemistry

Water chemistry data analyses will include:

- Within sample variation at each site using measures of central tendency (range, mean or median, standard deviation).
- Spatial variability in parameters controlled by the project water licence.
- Spatial trends quantitative analysis: To test whether there is any difference among stations a repeated measures factorial analysis of variance (ANOVA) test will be performed with normalized data for parameters controlled by the project water licence for Stations within the Jericho River (Control, C3, Carat, Jericho Lakes and Jericho River downstream of Jericho Lake).
- Qualitative temporal trends will be evaluated using time series charts. Quantitative temporal trends, as required, will be investigated with regression analysis and determinations of differences among slopes (analysis of covariance).
- Quantitative temporal trends among sites on the Jericho drainage using ANOVA. Again, an increase in metals coupled with biological effects will trigger adaptive management.

5.2 Reporting

Reporting requirements of the Jericho Water Licence with respect to general monitoring activities are discussed in this section. The format of the Water Licence is again followed for ease of reference to the Licence.

1. Pursuant to Water Licence Part B, Section 6, all reports will be submitted as three paper copies and one electronic copy.

2. Pursuant to Water Licence Part F, Section 4c, inspection records of all water management engineered structures will be kept by the Mine Manager for inspection by a NWB Inspector.
3. Pursuant to Water Licence Part F, Section 4e, independent geotechnical engineer's reports will be submitted to the NWB within sixty days of completion of the inspection.
4. Pursuant to Water Licence Part G, Section 2d, inspection records of all waste management structures will be kept by the Mine Manager for inspection by a NWB Inspector.
5. Pursuant to Water Licence Part G, Section 2g, independent geotechnical engineer's report will be submitted to the NWB within sixty days of completion of the inspection.
6. Pursuant to Water Licence Part H, Section 4, a report identifying the characteristics of the recovery plant rejects and plans for management will be submitted after the first year of operation.
7. Pursuant to Water Licence Part L, Section 9, the annual seepage survey report will be submitted to the NWB within 60 days of the completion of the survey.
8. Pursuant to Water Licence Part L, Section 14, all data and information from surveys will be submitted to NWB in electronic and printed format including the results of the QA/QC program.
9. Pursuant to Water Licence Part M, Section 7, an annual report will be submitted by 31 March for the preceding year, including an updated estimate of the total mine closure restoration liability using the current version of RECLAIM, or equivalent.

Reporting of spills or other extra-ordinary events is not listed here, nor is any other occasional reporting requirements as set out in the Jericho Water Licence.

For ease of reference, reporting requirements of the Jericho Water Licence are summarized in Table 5-1.

Table 5-1: Jericho Water Licence Reporting Requirements Summary

Report	Water Licence Reference	Frequency	Due Date
Inspection reports, water management facilities	Part F, 4c	Weekly or more frequently	On file for review by NWB
Inspection reports, waste management facilities	Part G, 2d	Weekly or more frequently	On file for review by NWB

Report	Water Licence Reference	Frequency	Due Date
Independent geotechnical engineer's reports • PKCA dams • Ponds • Waste rock dumps • Stockpiles • Landfarm • Landfill • Fuel farm	Part F, 4e; Part G, 2g	Annual	Within 60 days of inspection
Recovery plant rejects characterization	Part H, 4	Once	1 year after operation begins
Seepage survey report	Part L, 9	Annual	Within 60 days of survey
Data and information from surveys	Part L, 14	As collected	To NWB as collected in paper and electronic form
Update of reclamation liabilities	Part M, 7	Annual	March 31 of the following year

6.0 TRIGGERS FOR ACTION

6.1 Site Monitoring

No water exceeding Water Licence criteria will be discharged to the environment. Contact water not meeting criteria will be pumped to the PKCA.

Geotechnical stability issues will be dealt with on a case by case basis with appropriate action to re-establish stability.

6.2 Receiving Environment Water Chemistry

In general exposure site exceedance of site-specific water quality guidelines outside of the initial dilution zone will be a trigger for action. Increases mirrored at control sites and reasonably ascribable to natural causes will not trigger remedial action. The management strategy will be to first isolate the probable cause(s). Should the probable cause be PKCA discharge, management strategies discussed in the Water Licence application include alternate treatment methods for PKCA supernatant water such as increased storage time, spray irrigation (when approved) and controlled phosphate addition to the PKCA. If the source is other than PKCA discharge, appropriate action will be instituted to eliminate or adequately control discharge from the source.

6.3 Toxicity Testing

Failure of acute toxicity tests will trigger cessation of discharge until acute toxicity tests again pass. Failure of chronic toxicity tests will trigger an investigation of water chemistry, Lake C3 outflows and any other parameters that are appropriate to determine the possible cause. Chronic toxicity tests are to be performed on a monthly basis and take 21 days to complete; thus a failed test would be routinely followed by another test, except at the end of the season when PKCA discharge ceases.

REFERENCES

American Public Health Association. 1992. Examination of Water and Wastewater", 18th Edition.

Mainstream Aquatics. 2004. Jericho Diamond Project. Aquatics Effects Monitoring Program.

SRK Consulting. 2004. Technical Memorandum M. Waste Rock, Overburden, Low Grade Ore and Coarse Kimberlite Management Plan. Jericho Project, Nunavut.

SCHEDULE 1

Water Quality Monitoring Schedules

Table 1 – Water Quality Parameters

Test Group	Analytical Parameters	Measurement Units
Routine – R	Alkalinity, acidity, chloride, carbonate, bicarbonate, total hardness, hydroxide, sulphate, total suspended solids (TSS), total dissolved solids (TDS), total organic carbon (TOC), total inorganic carbon (TIC) pH (field and lab) ORP (field) Conductivity (field and lab) Temperature (field) Turbidity	mg/L pH units mV µS/cm °C NTU
Metals (Total – unfiltered) – MT and Metals (Dissolved – filtered) – MD	T- Aluminum T – Arsenic T- Cadmium T – Chromium T – Copper T – Lead T – Molybdenum T – Nickel T – Uranium T – Zinc D - Aluminum	mg/L
ICP-T, ICP-D; ICP Metals Scan (Total and dissolved) to include	Ca, Mg, Na, K, Al, As, Ba, B, Be, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, Sr, U, V, Zn	mg/L
Nutrients – N	Total Ammonia – N, Nitrate – N, Nitrite – N Total Phosphorus, orthophosphorus	mg N/L mg/L
Biological – B	Biochemical Oxygen Demand Fecal Coliform	mg/L CFU/100 mL
Potable Water – PW	Fecal Coliform ICP metals (Total and dissolved) TSS	CFU/100 mL mg/L mg/L
Dissolved Oxygen Profile – DO		

Table 2 – Receiving Environment Water Quality Monitoring Requirements¹

Station	Location	Phase	Test Group	Freq	Flow	Freq
JER-WQ1	Carat Lake – Freshwater Intake	Operation	PW	M2	m ³ /day	C
JER-WQ2	PKCA Discharge	Construction	Turbidity (correlated with TSS)	D	m ³ /day	D
		Operation	R, ICP-T, ICP-D, N B	W M2	m ³ /day	C
JER-WQ3	Stream C3 upstream of Lake C3	Pre-construction ^a	R, ICP-T, ICP-D, N	M2		
		Construction	R, ICP-T, ICP-D, N	M2		
		Operation	R, ICP-T, ICP-D, N	M2		
JER-WQ4	Lake C3 South Basin	Pre-construction	R, ICP-T, ICP-D, N DO	A1		
		Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ5	Lake C3 Outlet	Pre-construction			m ³	C ⁰
		Construction	R, ICP-T, ICP-D, N	M2	m ³	C
		Operation	R, ICP-T, ICP-D, N	M2	m ³	C
JER-WQ6	Carat Lake Centre Basin	Pre-construction	DO	A1		
		Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ7	Carat Lake Outlet	Construction	R, ICP-T, ICP-D, N	M2		
		Operation	R, ICP-T, ICP-D, N	M2		
JER-WQ8	Jericho Lake North Basin	Pre-construction	R, ICP-T, ICP-D, N, DO	A1		
		Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ9	Jericho River Downstream of Jericho Lake	Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ10	Control Lake	Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ11	Cigar Lake (2 nd Control Lake)	Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ12	Stream C1 Upstream of Carat Lake ^c	Construction	R, ICP-T, ICP-D, N	M2	m ³	CS
		Operation	R, ICP-T, ICP-D, N	M2	m ³	CS
JER-WQ13	Lake C1	Pre-construction	R, ICP-T, ICP-D, N, DO	A1		
		Construction	R, ICP-T, ICP-D, N	M1		
		Operation	R, ICP-T, ICP-D, N	M1		
JER-WQ14	Lake C4 ^d	Pre-construction	R, ICP-T, ICP-D, N, DO	A1		
		Construction	R, ICP-T, ICP-D, N	M2		
		Operation	R, ICP-T, ICP-D, N	M2		
JER-WQ15	Stream C4 upstream of Carat Lake	Construction	R, ICP-T, ICP-D, N	M2		
		Operation	R, ICP-T, ICP-D, N	M2		
JER-WQ16	Lynne Lake	Operation	R, ICP-T, ICP-D, N	A2		

¹ A1: Annual once in winter
A2: Annual once in summer

M1: Monthly; mid Apr, Jun, Jul, Aug, Sept, Dec
M2: Monthly; once during Jun, Jul, Aug, Sep

PW: Potable Water

W: Weekly

D: Daily

C: Continuous

CS: Continuous Seasonal

Station	Location	Phase	Test Group	Freq	Flow	Freq
JER-WQ17	Key lake	Operation	R, ICP-T, ICP-D, N	A2		
JER-WQ18	Ash Lake	Operation	R, ICP-T, ICP-D, N	A2		

Notes

- a Pre-construction will occur in the winter and Stream C3 does not flow in the winter as stated in the Jericho Final EIS. Sampling will be conducted as soon as flows commence the first spring during construction.
- b Jericho River at the outlet of Lake C3 does not flow in the winter and therefore cannot be measured, as stated in the Jericho Final EIS. Lake C3 water levels will not change throughout the winter period, although it will be possible to record water levels continuously throughout the winter.
- c The flow monitoring location for Stream C1 once the diversion is constructed (Year 3) is pool 2. Prior to construction the monitoring location will be upstream at the baseline monitoring site for the stream to provide continuity with background flow data. As well, the lower stream is braided and not suitable for flow measurement.
- d Lake C4 freezes completely to the bottom in winter, as stated in the Jericho Final EIS. Therefore no water can be collected during pre-construction or until the ice melts (typically in May or early June. Water cannot be collected on the M1 schedule since the lake is complete frozen in mid April and mid December. Water will be collected on the M2 schedule.

Locations are shown on Figure 1.

¹ A1: Annual once in winter
A2: Annual once in summer

M1: Monthly; mid Apr, Jun, Jul, Aug, Sept, Dec
M2: Monthly; once during Jun, Jul, Aug, Sep

PW: Potable Water

W: Weekly

D: Daily

C: Continuous

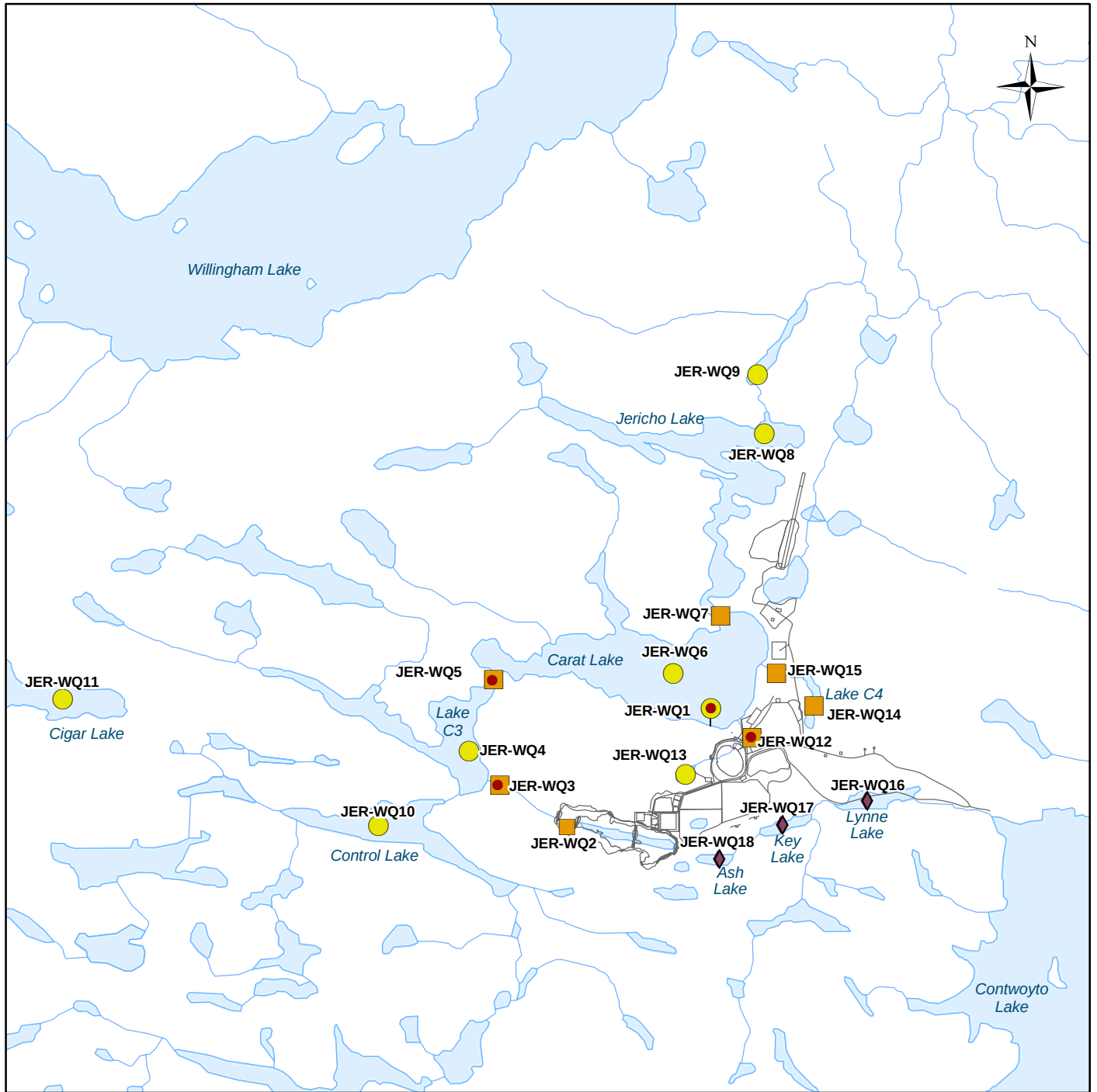
CS: Continuous Seasonal

Table 3 – Site Water Quality and Thermal Monitoring Stations²

Station	Location	Phase	Test Group	Freq	Flow	Freq
JER-SW1	Sewage Treatment Plant Effluent	Construction	R, ICP-T, ICP-D, N, B	M	m ³	C
		Operation	R, ICP-T, ICP-D, N, B	M	m ³	C
JER-SW2	Open Pit	Construction	R, ICP-T, ICP-D, N	M	m ³	C
		Operation	R, ICP-T, ICP-D, N	M	m ³	C
JER-SW3	Process Plant Supernatant	Construction	R, ICP-T, ICP-D, N	M	m ³	C
		Operation	R, ICP-T, ICP-D, N	M	m ³	C
JER-SW4	PKCA Pond Water	Construction	R, ICP-T, ICP-D, N	M		
		Operation	R, ICP-T, ICP-D, N	M		
JER-SW5	Temporary/permanent Collection Ditches	Construction	R, ICP-T, ICP-D, N	M3		
		Operation	R, ICP-T, ICP-D, N	M3		
JER-SW6	Collection Pond A	When in Use	R, ICP-T, ICP-D, N	M2	m ³	
JER-SW7	Collection Pond B	When in Use	R, ICP-T, ICP-D, N	M2	m ³	
JER-SW8	Collection Pond C	When in Use	R, ICP-T, ICP-D, N	M2	m ³	
JER-SW9	Rock Dump 1 Seepage	Operation	R, ICP-T, ICP-D, N	A3		
JER-SW10	Rock Dump 2 Seepage	Operation	R, ICP-T, ICP-D, N	A3		
JER-SW11	Coarse PK Stockpile	Operation	R, ICP-T, ICP-D, N	A3		
JER-SW12	Ore Stockpile	Operation	R, ICP-T, ICP-D, N	A3		
JER-SW13	Low Grade Ore Stockpile	Operation	R, ICP-T, ICP-D, N	A3		
JER-SW14	Recovery Plant Rejects	Operation	R, ICP-T, ICP-D, N	A3		
	West Dam Thermistor 1	Upon Installation	Temperature	M		
	West Dam Thermistor 2	Upon Installation	Temperature	M		
	East Dam Thermistor 1	Upon Installation	Temperature	M		
	East Dam Thermistor 2	Upon Installation	Temperature	M		
	Southeast Dam Thermistor 1	Upon Installation	Temperature	M		
	Southeast Dam Thermistor 2	Upon Installation	Temperature	M		
	Waste Dump 1 Thermistor 1	Upon Installation	Temperature	M		
	Waste Dump 1 Thermistor 2	Upon Installation	Temperature	M		
	Waste Dump 2 Thermistor 1	Upon Installation	Temperature	M		
	Waste Dump 2 Thermistor 2	Upon Installation	Temperature	M		
	Coarse PK Stockpile Thermistor 1	Upon Installation	Temperature	M		
	Coarse PK Stockpile Thermistor 2	Upon Installation	Temperature	M		

Approximate locations are shown on Figure 2.

² A3: Annual during seepage survey
M: Monthly
M1: Monthly; mid Apr, Jun, Jul, Aug, Sep, Dec
M2: Monthly once during Jun, Jul, Aug, Sep
M3: during periods of flow
W: Weekly D: Daily C: Continuous CS: Continuous Seasonal



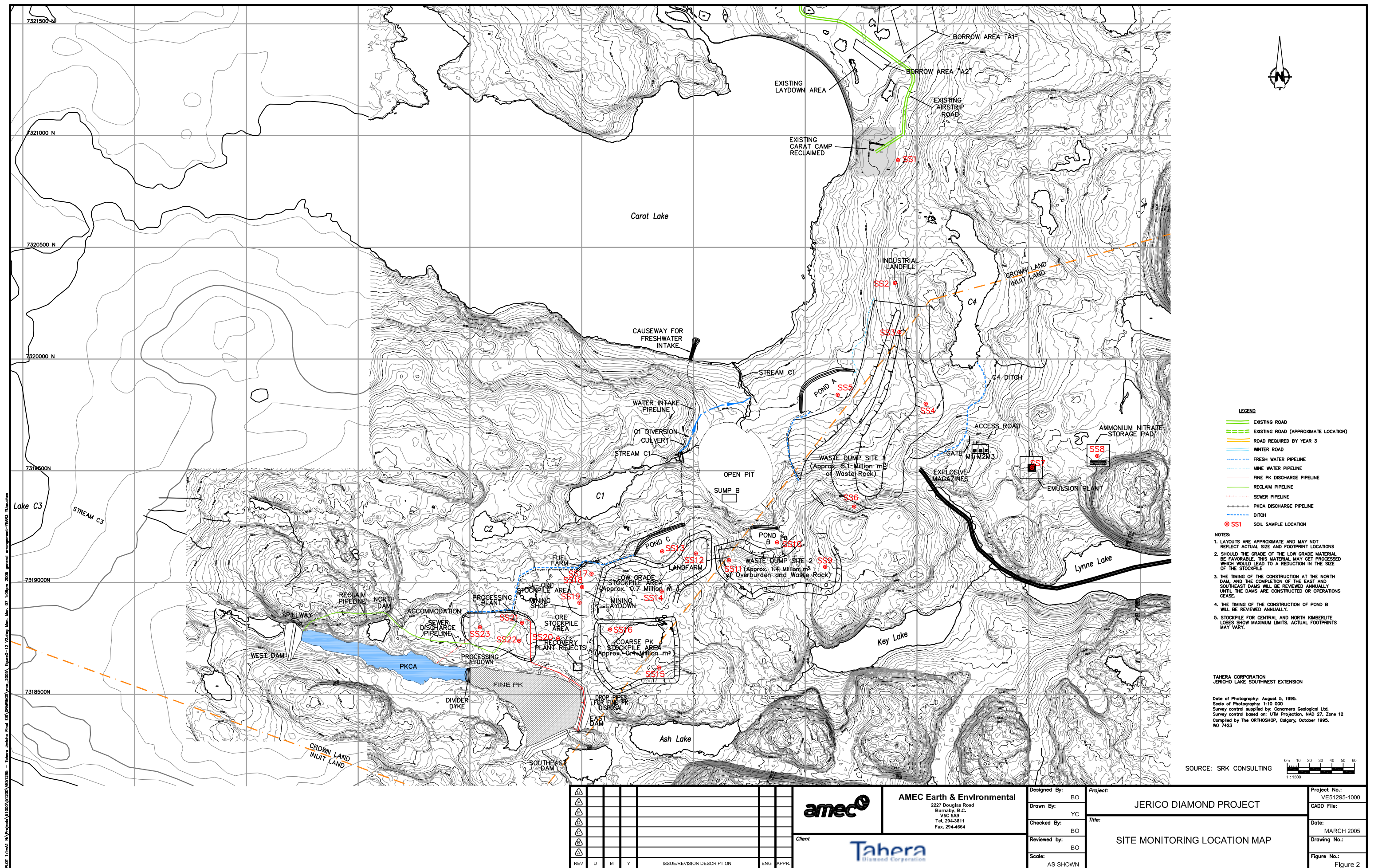
Legend

- Year Round Water Quality
- Summer Only Water Quality
- ◆ Once Per Summer
- Flow Monitoring - Open Water

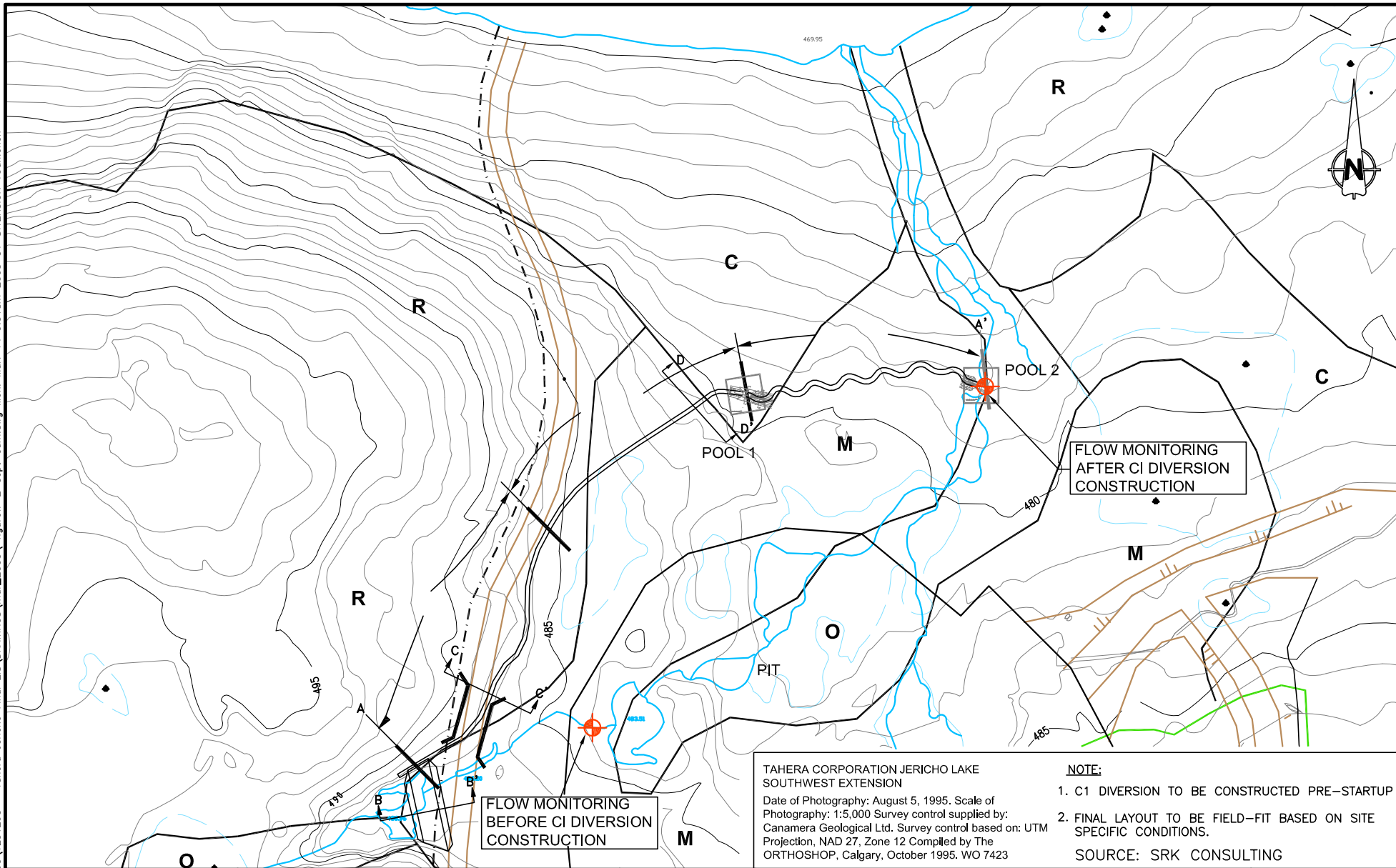
Scale: 1:75,000



CLIENT:		Tahera Diamond Corporation	
PROJECT:		Jericho Diamond Mine	
Receiving Environment Water Quality and Flow Monitoring Sites			
DATE:	March 18, 2005	ANALYST:	KKQ
JOB No:	VE51295-1000	QA/QC:	KKQ
GIS FILE:		PDF FILE:	Figure 1
Figure 1 Water Quality SitesV2.mxd		VE51295_Figure1.pdf	
PROJECTION:	UTM Zone 12	DATUM:	NAD27
		amec	



\\PLOT 1:1=D N:\Projects\51000\51200\VE51295 - Tahera Jericho Final EIS\DRAWINGS\mar_2005\figureW-2-sept-com.dwg Mon. Mar. 14 9:31am 2005 C1-DIVERSION Ylan.chen



TAHERA CORPORATION JERICHO LAKE
SOUTHWEST EXTENSION
Date of Photography: August 5, 1995. Scale of
Photography: 1:5,000 Survey control supplied by:
Canamera Geological Ltd. Survey control based on: UTM
Projection, NAD 27, Zone 12 Compiled by The
ORTHOSHOP, Calgary, October 1995. WO 7423

NOTE:
1. C1 DIVERSION TO BE CONSTRUCTED PRE-STARTUP
2. FINAL LAYOUT TO BE FIELD-FIT BASED ON SITE
SPECIFIC CONDITIONS.
SOURCE: SRK CONSULTING



AMEC Earth & Environmental

2227 Douglas Road
Burnaby, B.C.
V5C 5A9
Tel. 294-3811
Fax. 294-4664

Client



DWN BY: YC
CHK'D BY: BO
APP. BO
SCALE 1:3000

JERICHO DIAMOND MINE

**C1 DIVERSION
PLAN AND CROSS SECTION**

DATE: MAR. 2005
PROJECT NO: VE51295
REV. NO.: -
FIGURE No. Figure 3

**APPENDIX A
JERICHO DIAMOND MINE
WATER LICENCE
NWB1JER0410**



By Courier, Email and Regular Mail

Subject: License NWB1JER0410
Jericho Diamond Mine, Nunavut

c.c. G. Missal, Tahera Diamond Corporation
Distribution List
NWB Public Registry



NUNAVUT WATER BOARD WATER LICENCE

Pursuant to the Nunavut Waters and Nunavut Surface Rights Tribunal Act and the Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in right of Canada, the Nunavut Water Board, hereinafter referred to as the Board, hereby grants to

**BENACHEE RESOURCES INC., A WHOLLY OWED SUBSIDIARY OF
TAHERA DIAMOND CORPORATION**

(Licensee)

803-121 RICHMOND STREET WEST, TORONTO, ONTARIO M5H 2K1

(Mailing Address)

hereinafter called the Licensee, the right to alter, divert or otherwise use water or dispose of waste for a period subject to restrictions and conditions contained within this Licence:

Licence Number/Type: NWB1JER0410 Type "A"

Water Management Area: NUNAVUT 07

Location: KITIKMEOT REGION, NUNAVUT

Purpose: INDUSTRIAL WATER USE AND WASTE DISPOSAL

Description: MINING AND PROCESSING

Quantity of Water not to be Exceeded: 350,400 CUBIC METRES ANNUALLY

Date of Licence: DECEMBER 21, 2004

Expiry of Licence: DECEMBER 31, 2010

This License issued and recorded at Baker Lake, Nunavut includes and is subject to the annexed conditions.

ORIGINAL SIGNED BY

**Thomas Kudloo,
Nunavut Water Board
Chair**

**APPROVED BY: Minister of Indian and
Northern Affairs Canada**

EFFECTIVE DATE OF LICENCE: _____

PART A: SCOPE, DEFINITIONS AND ENFORCEMENT

1. SCOPE

- a. This Licence entitles Benachee Resources Incorporated (“BRI” and the “Licensee”), a wholly-owned subsidiary of Tahera Diamond Corporation, to use water and dispose of waste associated with the industrial undertakings in diamond mining of Kimberlite as outlined in the Mine Plan and summarized below.

BRI may conduct mining and associated activities at the Jericho Diamond Mine in the Kitikmeot Region of Nunavut, (65°59’50” N, 111°28’30 W) including:

- i. the extraction of overburden, waste rock and ore from the open pit and underground;
- ii. the development and operation of site facilities (including the airstrip);
- iii. the construction, handling, and storage of petroleum products and hazardous material;
- iv. the construction of dams, spillway, and embankment infrastructure needed for the operation of a Processed Kimberlite Containment Area;
- v. to divert a watercourse (Stream C1 and Stream C4) for on site water management;
- vi. the construction and maintenance of water/sediment control infrastructure;
- vii. the processing of Kimberlite, including the deposition of Processed Kimberlite;
- viii. the construction and operation of a Short-Term Landfill;
- ix. the construction and operation of a Landfill and Landfarm;
- x. the construction of site roads and lay down area;
- xi. the construction and operation of a Waste Water Treatment Plant for sewage;
- xii. the construction of storage pads;
- xiii. the quarrying of materials from specified locations;
- xiv. the construction and maintenance of a winter ice road;
- xv. the progressive reclamation of on site infrastructure; and,

- xvi. the use of water for processing, hydrostatic testing, winter road construction, and domestic purposes.
- b. This Licence is issued subject to the conditions contained herein with respect to the taking of water and the depositing of waste of any type in any waters or in any place under any conditions where such waste or any other waste that results from the deposits of such waste may enter any waters. Whenever new Regulations are made or existing Regulations are amended by the Governor in Council under the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*, or other statutes imposing more stringent conditions relating to the quantity or type of waste that may be so deposited or under which any such waste may be so deposited, this licence shall be deemed to be subject to such requirements.
- c. Compliance with the terms and conditions of this licence does not absolve the Licensee from responsibility for compliance with all applicable legislation, guidelines and directives.
- d. The Licensee shall notify the Board within sixty (60) days should the Licensee decide to enter into a Care and Maintenance Phase.

2. DEFINITIONS

Refer to Schedule A

3. ENFORCEMENT

- a. Failure to comply with this Licence will be a violation of the *Act*, subjecting the Licensee to the enforcement measures and the penalties provided for in the *Act*;
- b. All inspection and enforcement services regarding this Licence will be provided by Inspectors appointed under the *Act*; and
- c. For the purpose of enforcing this Licence and with respect to the use of water and deposit or discharge of waste by the licensee, Inspectors appointed under the *Act*, hold all powers, privileges and protections that are conferred upon them by the *Act* or by other applicable law.

PART B: GENERAL CONDITIONS

- 1. Water Use fees shall be paid annually in advance of any use in accordance with the Section 9 of the *Regulations*.
- 2. The Licensee shall file an Annual Report with the Board no later than March 31 or sixty (60) days following the anniversary, of the effective date of issuance of the licence in the year following the calendar year being reported. The Annual Report shall be developed in accordance with Schedule B Item 1.

3. The Licensee shall ensure a copy of this Licence is maintained at the site of operations at all times.
4. Any communication with respect to this Licence shall be made in writing to the attention of:

Chief Administrative Officer
Nunavut Water Board
P. O. Box 119
Gjoa Haven, NU X0B 1J0
Telephone: (867) 360-6338
Fax: (867) 360-6369
Email: licensing@nwb.nunavut.ca
5. Any notice made to an Inspector shall be made in writing to the attention of:

Water Resources Officer
Nunavut District, Nunavut Region
P.O. Box 100
Iqaluit, NU X0A 0H0
Telephone: (867) 975-4298
Fax: (867) 979-6445
6. The Licensee shall submit three (3) paper copies and one (1) electronic copy of all reports, studies, and plans to the Board unless otherwise requested by the Board. Reports or studies submitted to the Board by the Licensee shall include a detailed executive summary in Inuktitut and Inuinnaqtun.
7. This Licence is not assignable except as provided in Section 44 of the *Act*.

PART C: CONDITIONS APPLYING TO SECURITY

1. The Licensee shall within thirty (30) days of the effective date of the Licence, furnish and maintain a security in the amount of \$2.2 million dollars in the form and nature in accordance with the Regulation or that is satisfactory to the Minister.
2. The Licensee shall furnish and maintain such further or other amounts of security as may be required by the Board, and adjustment to the amount of security upon request of the Licensee with supporting evidence may be approved by the Board, based on annual estimates of current mine restoration liability in accordance with Part B, Item 2, Schedule B, Item 1(u) of this License.
3. The security shall be maintained until such time as it is fully or in part refunded by the Minister pursuant to Section 76(5) of the *Act*. This clause shall survive the expiry of this License or renewals thereof and until full and final restoration has been completed to the satisfaction of the Minister.

PART D: CONDITIONS APPLYING TO CONSTRUCTION

1. The Licensee shall submit to the Board for review, within thirty (30) days of the effective date of the licence, a detailed Mine Plan which outlines timing of construction for all infrastructure components. The Plan shall identify measures to be taken should implementation deviate from the proposal. The plan shall be developed in accordance with Schedule D, Item 1.
2. The Licensee shall submit to the Board for approval, design plans and drawings stamped by a Geotechnical Engineer, at least sixty (60) days prior to the construction of any dams, dykes or structures intended to contain, withhold, divert or retain Water or Waste. The Licensee shall ensure that such facilities are designed and constructed to engineering standards such that at a minimum they comply with the Dam Safety Guidelines.
3. All rock used in construction must meet the appropriate geochemical criteria as specified in the approved as per Schedule D Item 3.
4. The Licensee shall submit to the Board for review, a revised Borrow Management Plan at least sixty (60) days prior to the extraction of any borrow material. This plan shall be developed in accordance with Schedule D, Item 4.
5. The Licensee shall submit to the Board for approval, a detailed Design Plan at least sixty (60) days prior to the construction of the Processed Kimberlite Containment Area including drawings, stamped by a Geotechnical Engineer and/or Engineering Geologist. This plan shall be developed in accordance with Schedule D, Item 5.
6. The Licensee shall submit to the Board for approval, a detailed Landfill Design Plan at least sixty (60) days prior to the construction of the Landfill including drawings, stamped by an Engineer. The plan shall be developed in accordance with Schedule D, Item 6.
7. The Licensee shall submit to the Board for approval, a detailed Landfarm Design Plan at least sixty (60) days prior to the construction of the Landfarm including drawings, stamped by an Engineer. The plan shall be developed in accordance with Schedule D, Item 7.
8. The Licensee shall submit to the Board for approval, a detailed Waste Water Treatment Plant Design Plan at least sixty (60) days prior to the construction of the Waste Water Treatment Plant including drawings, stamped by an Engineer. The plan shall be developed in accordance with Schedule D, Item 8.
9. The Licensee shall, submit to the Board for approval, a detailed Design Plan at least sixty (60) days prior to the construction of the Site Water Management Facilities, including drawings stamped by an Engineer. The plan shall be development in accordance with Schedule D Item 9.
10. The Licensee shall submit to the Board for approval, a detailed Design Plan at least sixty (60) days prior to the construction of the Ore Stockpile, Coarse Processed Kimberlite, Recovery Rejects Stockpile, Waste Rock Dump No. 1 and Waste Rock Dump No. 2, the including drawings, stamped by a Geotechnical Engineer and/or Engineering Geologist.

This plan shall be developed in accordance with Schedule D, Item 10.

11. The Licensee shall, at least sixty (60) days prior to the construction of the Collection Ponds A, B, and C submit to the Board for approval the final detailed Design Plan stamped by a Geotechnical Engineer and/or Engineering Geologist. This report shall be developed in accordance with Schedule D, Item 11.
12. The Licensee shall, at least sixty (60) days prior to the construction of the Fuel Storage and Containment Facility, submit to the Board for approval the final detailed design plan stamped by a qualified Engineer. This report shall be developed in accordance with Schedule D, Item 12.
13. The Licensee shall, at least sixty (60) days prior to the dewatering of Long Lake, submit to the Board for approval, a Long Lake Dewatering Plan, certified by a Hydrologist. This report shall be developed in accordance with Schedule D, Item 13.
14. The Licensee shall, at least sixty (60) days prior to commencement operations, submit to the Board for review, an approved Explosives Management Plan. This report shall be developed in accordance with Schedule D, Item 14.
15. The Licensee shall, at least sixty (60) days prior to the construction of the Causeway, submit to the Board for approval the final detailed Causeway design plan stamped by a Geotechnical Engineer and/or Engineering Geologist. This report shall be developed in accordance with Schedule D, Item 15.
16. The Licensee shall, at least sixty (60) days prior to the construction of the C1 Diversion, submit to the Board for approval the final detailed design plan stamped by a Geotechnical Engineer and/or Engineering Geologist. This report shall be developed in accordance with Schedule D, Item 16.
17. The Licensee shall ensure that all containment and runoff control structures are constructed and maintained to prevent escape of wastes to the surface or ground water systems.
18. The Licensee shall, within ninety (90) days of completion of any structure designed to contain, withhold, divert or retain waters or wastes, submit to the Board for review, a construction report prepared by a qualified Engineer that shall include as-built drawings, documentation of field decisions that deviate from original plans and any data used to support these decisions.
19. The Licensee shall ensure that all construction of engineered structures will be supervised and field checked by an appropriately qualified and experienced Engineer in such a manner that the project specification can be enforced and, where required, the quality control measures can be followed. The licensee shall also ensure that the construction records of all engineered Structures are maintained and made available at the request of the Board and/or an Inspector.
20. All detailed design plans referred to in this Part shall consider Adaptive Management strategies.

PART E: CONDITIONS APPLYING TO WATER USE

1. The Licensee shall install meters to measure flow for all structures used to withdraw water to the satisfaction of an Inspector.
2. The Licensee is authorized to use water for domestic purposes, construction, hydrostatic testing, mining, processing and associated used for the Water Intake Facility or as approved by the Board.
3. The Licensee is authorized to use water for winter road construction from Lynne Lake and Contwoyto Lake or as otherwise approved by the Board.
4. The Licensee shall ensure that direct water use for Winter Road construction shall not be extracted from locations with the potential to generate adverse effects to fish habitat.
5. The total annual quantity of water used for all purposes and from all sources shall not exceed 350,400m³.
6. The Licensee shall ensure that the water intake is equipped with a screen with a mesh size sufficient such that no entrainment of fish can occur and that the chosen site is to the agreement of DFO.
7. The Licensee shall ensure that the rate of water withdrawal is such that fish do not become impinged on the screen.

PART F: CONDITIONS APPLYING TO WATER MANAGEMENT

1. The Licensee shall, at least four (4) months prior to commencement of production, submit to the Board for approval a detailed Site Water Management Plan. The final detailed report shall be stamped by an Engineer. This report shall be developed in accordance with Schedule F, Item 1.
2. In the event that the Site Water Management Plan described in Part F Item 1, and outlined in Schedule F Item 1, is not approved by the Board, the Licensee shall provide a revised version to the Board for review within thirty (30) of notification by the Board.
3. The Licensee shall implement the Site Water Management Plan as and when approved by the Board.
4. The Licensee shall operate and maintain the Site Water Management Facilities. C1 Diversion and C4 Ditch to engineering standards such that at a minimum, they comply, where applicable to the Dam Safety Guidelines, and in accordance with the following (where applicable):
 - a. The Licensee shall ensure that all containment and runoff control structures are constructed and maintained to prevent escape of wastes to the surface or ground water

systems.

- b. a minimum freeboard limit of one (1) metre (where applicable) shall be maintained at all times or as recommended by a Geotechnical Engineer and as approved by the Board;
- c. the Licensee shall carry out, at a minimum, weekly inspections, during periods of flow, and the records be kept for review upon request of an Inspector. Areas of deterioration and erosion shall be repaired immediately
- d. any runoff accumulated and/or seepage that does not meet the effluent quality criteria Part G, Item 6(a) shall be collected and directed to the PKCA and measures shall be employed to reduce seepage;
- e. an inspection shall be carried out annually in July by a Geotechnical Engineer. The engineer's report shall be submitted to the Board within sixty (60) days of the inspection, including a covering letter from the Licensee outlining an implementation plan addressing each of the Engineer's recommendations; and
- f. The Licensee shall perform more frequent inspection of the Site Water Management Facilities at the request of an Inspector.

PART G: CONDITIONS APPLYING TO WASTE MANAGEMENT

- 1. The Licensee shall install meters for all structures used to discharge wastes to the satisfaction of an Inspector.
- 2. The Licensee shall operate and maintain the Processed Kimberlite Containment Area to engineering standards such that:
 - a. a minimum freeboard limit of one (1) metre below the lowest point of either the zero degree isotherm for the perimeter dams or the emergency spillway, whichever is lower, shall be maintained at all times; or as recommended by a Geotechnical Engineer and as approved by the Board;
 - b. the minimum Freeboard limit of one (1) metre as defined in Part B shall be maintain at all times; or as recommended by a Geotechnical Engineer and as approved by the Board;
 - c. the Licensee shall collect and return seepage from the PKCA and corrective measures shall be implemented,
 - d. the Licensee shall carry out, at a minimum, weekly inspections including, but not limited to, dams, spillway, pipeline(s), and the records be kept for review upon request of an Inspector. Areas of deterioration and erosion shall be repaired immediately;
 - e. the Licensee shall make every effort to simulate natural water flows in Stream C3

during discharge.

- f. the solids fraction of all Processed Kimberlite shall be deposited and permanently contained within the PKCA;
 - g. an inspection shall be carried out annually in July by a Geotechnical Engineer. The engineer's report shall be submitted to the Board within sixty (60) days of the inspection, including a covering letter from the Licensee outlining an implementation plan addressing each of the Engineer's recommendations; and
 - h. The Licensee shall perform more frequent inspection of the PKCA at the request of an Inspector.
3. The Licensee shall carry out, at a minimum, weekly (regular) inspection, including, but not limited to, all major earthworks, retention structures, dams and diversion structures, stockpiles, dumps, berms as well as open pit slopes and the records shall be kept for review upon request of an Inspector. Areas of deterioration and erosion shall be repaired immediately.
 4. The Geotechnical Engineer inspection to be carried out annually as required by Part F, 4(e), Part G, Item 2 (g) may be carried out as one inspection and reported accordingly and shall include, not limited to: Landfill, Landfarm, Fuel Containment Facility, Collection Ponds (if applicable) and facilities provided in the Waste Rock Management Plan.
 5. The Licensee shall provide at least ten (10) days written notice to an Inspector and the Board prior to any planned discharges from the PKCA to Steam C3.
 6. The Licensee shall ensure that any discharges to Steam C3 meet the following Effluent quality requirements:
 - a. All discharges to Stream C3 by the licensee from the PKCA at monitoring Station Number JER-WQ2 shall meet the following effluent quality criteria:

Parameter	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total Aluminum – Al	1.5 mg/L	3.0 mg/L
Dissolved Aluminum – Al	1.0 mg/L	2.0 mg/L
Total Arsenic – As	0.05 mg/L	0.1 mg/L
Total Cadmium – Cd	0.0012 mg/L	0.0024 mg/L
Total Chromium – Cr	0.087 mg/L	0.17 mg/L
Total Copper – Cu	0.02 mg/L	0.04 mg/L
Total Lead – Pb	0.01 mg/L	0.02 mg/L
Total Molybdenum – Mo	0.73 mg/L	1.5 mg/L
Total Nickel – Ni	0.05 mg/L	0.1 mg/L
Uranium – U	0.5 mg/L	1.0 mg/L
Total Zinc – Zn	0.25 mg/L	0.50 mg/L
Total Ammonia – N	6 mg/L	12 mg/L

Parameter	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Nitrate – N	28 mg/L	56 mg/L
Nitrite – N	2.5 mg/L	5.0 mg/L
Phosphorus – P	0.2 mg/L	0.4 mg/L
Chloride – Cl	500 mg/L	1000 mg/L
Total Dissolved Solids – TDS	2000 mg/L	4000 mg/L
Total Suspended Solids –TSS*	15.0 mg/L	25.0 mg/L
pH	6 – 8.8	6 – 8.8

* Conditional on Part G, Item 4 (b) below

- i. Upon directing discharge from the WWTP to the PKCA, the main effluent discharge to Stream C3 shall meet the following additional effluent quality requirements:

Parameter	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Biological Oxygen Demand (5 day) - BOD ₅	15.0 mg/L	25.0 mg/L
Oil and Grease ⁽¹⁾	3.0 mg/L	5.0 mg/L
Faecal Coliforms	10 CFU/100 ml	20 CFU/100 ml

- b. All surface runoff during construction of any facilities designed to withhold, divert, or retain such runoff (except for within the PKCA) shall meet the following criteria:

Parameter	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total Suspended Solids –TSS	50.0 mg/L	100.0 mg/L

- c. All surface runoff during construction within the PKCA shall meet the criteria for TSS as required by Part G, Item 9 (a).
7. All discharges to Stream C3 by the Licensee from the PKCA at Station Number JER-WQ2 shall not be acutely toxic under the following tests to be conducted once prior to discharge and monthly thereafter until freeze up:
 - a. Acute lethality to Rainbow Trout, *Oncorhynchus mykiss* (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13); and
 - b. Acute lethality to the crustacean, *Daphnia magna* (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14).
 8. The Licensee shall ensure that the de-watering of Long Lake and or effluent discharge to Stream C3 is undertaken such that

- a. the discharge does not exceed the typical average freshet flows over the sustained discharge period for the de-watering and the discharge during operation should simulate the natural seasonal flows;
 - b. the discharge is supervised by a qualified hydrologist;
 - c. erosion control mitigation shall be implemented where necessary; and
 - d. if, erosion is evident, pumping shall cease immediately until mitigation is complete.
9. The Licensee shall not add flocculant directly to the PKCA.
10. During the first year of construction and operation, the Licensee shall dispose of and contain all solid waste at the Short Term Landfill or as otherwise approved by the Board.
11. Following commissioning and approval by the Board for the Landfill, the Licensee shall dispose of and contain all solid waste at the Landfill or as otherwise approved by the Board.
12. The Licensee shall implement measure to ensure leachate from the Landfill does not enter water.
13. The Licensee shall dispose of and contain all identified hydrocarbon-contaminated soils from spill in the Landfarm.
14. The Licensee shall dispose of and contain all identified hydrocarbon-contaminated snow and ice in a segregated sump in the Coarse Processed Kimberlite stockpile.
15. The Licensee shall dispose of and contain all identified hydrocarbon-contaminated rock in a segregated area of Waste Dump No.1.

PART H: CONDITIONS APPLYING TO WASTE MANAGEMENT PLANS

1. The Licensee shall, at least four (4) months prior to the first effluent discharge from the PKCA, submit to the Board for approval, the PKCA Management Plan. The final detailed report shall be stamped by an Engineer. This report shall be developed in accordance with Schedule H, Item 1.
2. The Licensee shall implement the PKCA Discharge Management Plan as and when approved by the Board.
3. The Licensee shall submit to the Board for approval within four (4) months of the effective date of this license a Waste Rock Management Plan, to address the management of all rock this is disturbed, moved, stored, or otherwise affected by mining-related activity on the property over the term of the project. This Plan shall be developed in accordance with Schedule H, Item 2.
4. The Licensee shall submit to the Board for review, after the first year of operation, a report identifying the characteristics of the recovery plant rejects, and the specifics of how they will be handled, including final location, and rationale for appropriate blending ratio. The report may be submitted as an addendum to the plan referred to in Part H, Item

- 3.
5. The Licensee shall, within one (1) year of the effective date of this License, submit to the Board for approval an Operation and Management Plan for the Waste Water Treatment Plant, the Landfill and the Landfarm. The plan(s) shall be developed in accordance with Schedule H, Item 3.
6. In the event that the Plans referred to in Part H, Item 1, Item 3, and Item 5, are not approved by the Board, the Licensee shall provide a revised versions to the Board for review within thirty (30) of notification by the Board.
7. The Licensee shall implement the Plan referred to in the Part as and when approved by the Board.

PART I: CONDITIONS APPLYING TO MODIFICATIONS

1. The Licensee may, without written consent from the Board, carry out Modifications to the Water Supply Facilities and Waste Disposal Facilities provided that such Modifications are consistent with the terms of this Licence and the following requirements are met:
 - a. the Licensee has notified the Board in writing of such proposed Modifications at least sixty (60) days prior to beginning the Modifications;
 - b. such Modifications do not place the Licensee in contravention of the Licence or the *Act*;
 - c. the Board has not, during the sixty (60) days following notification of the proposed Modifications, informed the Licensee that review of the proposal will require more than sixty (60) days; and
 - d. the Board has not rejected the proposed Modifications.
2. Modifications for which all of the conditions referred to in Part I, Item 1 have not been met can be carried out only with written approval from the Board.
3. The Licensee shall provide as-built plans and drawings of the Modifications referred to in this Licence within ninety (90) days of completion of the Modification. These plans and drawings shall be stamped by an Engineer.

PART J: CONDITIONS APPLYING TO CONTINGENCY PLANNING

1. The Licensee shall submit to the Board for approval within thirty (30) days of the effective of this Licence, a revised Contingency Plan prepared in accordance with the NWT Water Board's, "Guidelines for Contingency Planning, January 1987," or subsequent editions. This Plan shall be developed in accordance with Schedule J, Item 1.

2. In the event that the Plan referred to in Part J, Item 1, is not approved by the Board, the Licensee shall provide a revised versions to the Board for review within thirty (30) of notification by the Board.
3. The Licensee shall implement the Plan referred to in the Part as and when approved by the Board.
4. The Licensee shall review the Contingency Plan annually and revise as necessary to reflect changes in operation and technology. Any proposed changes to the plan shall be submitted to the Board for approval. Proposed changes may be submitted as addendum to the approved plan as part of the Annual report requirement Part B, Item 2.
5. If, during the period of this Licence, an unauthorized discharge of Waste and/or Effluent occurs, or if such a discharge is foreseeable, the Licensee shall:
 - a. Employ the Contingency Plan;
 - b. Report the incident immediately via the 24-Hour Spill Reporting Line (867) 920-8130; and
 - c. Submit to an Inspector a detailed written report on each occurrence no later than thirty (30) days after initially reporting to the Spill Reporting Line.
6. If, during the period of this Licence, the Licensee enters into a Care and Maintenance phase, the Licensee shall submit to the Board for approval an addendum to the Contingency Plan within thirty (30) days of providing notification to the Board. This shall be developed in accordance with Schedule I, Item 2.

PART K: CONDITIONS APPLYING TO GENERAL AND AQUATIC EFFECTS MONITORING

1. The Licensee shall install meters or such devices, or use such methods as approved by the Board for measuring the volumes of Water used and Effluent discharged. The meters and measuring devices or methods shall be operated and maintained to the satisfaction of an Inspector.
2. The Licensee shall install the appropriate hydrograph instrumentation to adequately monitor the Lake C3 water elevations in order to correlate the release of PKCA effluent to the otherwise naturally occurring hydrograph of Stream C3.
3. The Licensee shall maintain the necessary signs to identify the stations of the Monitoring Program to the satisfaction of an Inspector.
4. The Licensee shall, for the purposes of general monitoring, refer to Tables 1 – Water Quality Parameters and Table 2 – Receiving Environment Water Quality Monitoring Requirements, in Schedule K for the description of the locations to be monitored in the receiving environment and the required analytical parameters to be measured.

5. The Licensee shall, for the purposes of specific site water management monitoring, refer to Table 3 – Site Water Quality and Thermal Monitoring Requirements in Schedule K for the description of the locations to be monitored and the analytical parameters to be measured.
6. Additional monitoring may be requested by the Board or the Inspector.
7. The Licensee shall collect the samples referred to in this Part without delay. If at any time, the period specified for collecting samples was extended due to unforeseen circumstances due to safety concerns or access problems and render the collection of samples impracticable, the Licensee shall notify an Inspector of the circumstances.
8. The Licensee shall increase sampling frequency if results of such sampling indicate that the Effluent Quality Requirements provided in Part G have been exceeded, or as requested by the Board or directed by an Inspector.
9. All analyses shall be conducted as described in the most recent edition of “*Standard Methods for the Examination of Water and Wastewater*”, or by such other methods as approved by an Analyst.
10. All analyses shall be performed in a laboratory approved by the Analyst.
11. An annual inspection of the earthworks, as required by Part G, Item 4 shall be carried out annually during the summer by a Geotechnical Engineer. The Geotechnical Engineer’s report shall be submitted to the Board within sixty (60) days of the inspection, with a covering letter from the Licensee outlining an implementation plan to respond to the Engineer’s recommendations.
12. The Licensee shall measure and record all flow and volume measurements on a monthly basis in cubic metres (unless otherwise stated) for the following:
 - a. the daily volume of water obtained from Carat Lake for all purposes;
 - b. the volume of water obtained from runoff collection, ponds or any other source used for any purpose;
 - c. the volume of water reclaimed from the PKCA;
 - d. the volume of the solids in tonnes and liquid fractions in cubic metres of each waste pumped to the PKCA;
 - e. the daily volume of effluent discharged from the PKCA;
 - f. the daily volume of minewater and seepage pumped from the open pit, Ponds, or other Site Water Management facilities to the PKCA;
 - g. the daily volume of treated Sewage effluent discharged from the Waste Water Treatment Plant; and

- h. the volume of Sewage sludge removed from the Waste Water Treatment Plant.
- 13. The Licensee shall, on a monthly basis, measure and record the amounts in tonnes (unless otherwise stated) including the location of disposal for the following:
 - a. the quantity of ore processed; and
 - b. the quantity of waste rock, coarse processed Kimberlite, till and overburden.

PART L: CONDITIONS APPLYING TO GENERAL AND AQUATIC EFFECTS MONITORING PLANS

- 1. The Licensee shall within one (1) month of the effective date of this License, submit to the Board for approval a General Monitoring Plan. The plan shall be developed in accordance with Schedule L, Item 1.
- 2. In the event that the Plan referred to in Part L, Item 1, is not approved by the Board, the Licensee shall provide a revised versions to the Board for review within thirty (30) of notification by the Board.
- 3. The Licensee shall implement the Plan referred to in the Part L, Item 1 as and when approved by the Board.
- 4. The Licensee shall annually review the approved General Monitoring Plan and modify the Plan as necessary. Proposed modifications shall be submitted to the Board for approval.
- 5. The Licensee shall submit to an Analyst for approval within three (3) months of the effective date of this License, a Quality Assurance/Quality Control (QA/QC) Plan that includes field and laboratory procedures and requirements. This report shall be developed in accordance with Schedule L, Item 2.
- 6. The Licensee shall annually review the approved QA/QC Plan and modify the Plan as necessary. Proposed changes shall be submitted to an Analyst for approval.
- 7. In the event that the Plan referred to in Part L, Item 5, is not approved by the Board, the Licensee shall provide a revised version to the Analyst for review within thirty (30) of notification by the Board.
- 8. The Licensee shall implement the Plan referred to in the Part L, Item 5 as and when approved by the Analyst.
- 9. The Licensee shall conduct an Annual Seepage survey in July or August. The Licensee shall submit to the Board for review, sixty (60) days following completion of the survey, the results, analysis and recommendations. This report shall be developed in accordance with Schedule L, Item 3.
- 10. The Licensee shall within two (2) month of the effective date of this License, submit to the Board for approval an Aquatic Effects Monitoring Plan. The plan shall be developed

in accordance with Schedule L, Item 4.

11. In the event that the Plan referred to in Part L, Item 10, is not approved by the Board, the Licensee shall provide a revised versions to the Board for review within thirty (30) of notification by the Board.
12. The Licensee shall implement the Plan referred to in the Part L, Item 10 as and when approved by the Board.
13. The Licensee shall annually review the approved Aquatic Effects Monitoring Plan and modify the Plan as necessary. Proposed changes shall be submitted to the Board for approval.
14. The Licensee shall, within thirty (30) days following the month being reported, submit to the Board all data and information in an electronic and printed format acceptable to the Board required by Part K and Part L, including the results of the QA/QC program.

PART M CONDITIONS APPLYING TO CLOSURE AND RECLAMATION

1. The Licensee shall notify the Board in writing of its intent to enter into a Care and Maintenance Phase or to achieve Recognized Closed Mine status.
2. The Licensee shall submit to the Board for approval within nine (9) months of effective date of this Licence, a revised Interim Closure and Reclamation Plan in accordance with the NWT Water Board's, "Guidelines for Abandonment and Restoration Planning for Mines in the Northwest Territories," or subsequent editions. The plan shall be developed in accordance with Schedule M, Item 1.
3. In the event that the Plan referred to in Part M, Item 2, is not approved by the Board, the Licensee shall provide a revised version to the Board for review within thirty (30) of notification by the Board.
4. The Licensee shall implement the Plan referred to in the Part M, Item 2 as and when approved by the Board.
5. The Licensee shall submit to the Board for approval, at the time of licence renewal, a Proposed Final Closure and Reclamation Plan developed in accordance with Schedule M, Item 2.
6. The Licensee shall implement progressive revegetation program and revegetation shall commence on an area as soon as possible once they are no longer utilized by the project;
7. The Licensee shall submit to the Board for approval, annually by March 31st for the preceding year, an updated estimate of the total mine closure restoration liability using the current version of RECLAIM, its equivalent or other similar method approved by the Board. In accordance with principles of DIAND's "Mine Site Reclamation Policy for Nunavut" (2000)

SCHEDULES

The following schedules provide instructive detail to the conditions appearing in more general terms in the main body of the Licence and are spelled out in this format for greater clarity.

Schedule A - Definitions

In this Licence: NWB1JER0410

“**Act**” means the *Nunavut Waters and Nunavut Surface Rights Tribunal Act*;

“**Acid Rock Drainage (ARD)**” means the production of acidic leachate, seepage or drainage from underground workings, ore piles, waste rock, Processed Kimberlite, and overburden that can lead to the release of metals to groundwater or surface water during the life of the Project and after closure;

“**Acutely lethal effluent**” means effluent as defined in the *Metal Mining Effluent Regulations* SOR/2002-222 dated 6 June 2002;

“**Adaptive Management**” means a management plan that describes a way of managing risks associated with uncertainty and provides a flexible framework for the mitigation measures to be implemented and actions to be taken when specified thresholds are exceeded.

“**Aliquot**” means the amount comprising a known fraction of a whole and constituting a sample used for analysis;

“**Amendment**” means a change to any terms and condition of this Licence, through application to the NWB, requiring correction, addition or deletion of specific terms and conditions of the Licence;

“**Ammonium Nitrate Storage Area**” means the location designed to store Ammonium nitrate-Fuel oil (ANFO) explosives to be used for dry blasting as described in the document titled “Ammonium Nitrate and Explosives Management Plan” by AMEC Earth & Environmental dated August 2004 and illustrated in Drawing 1CT004.06-G12 dated July 2004;

“**Analyst**” means an Analyst designated by the Minister under Section 85 (1) of the *Act*;

“**Aquatic Effects Monitoring Plan (AEMP)**” means a monitoring program designed to determine the short-and long-term effects in the aquatic environment resulting from the Project, to evaluate the accuracy of impact predictions, to assess the effectiveness of planned impact mitigation measures and to identify additional impact mitigation measures to avert or reduce environmental effects;

“**Board**” means the Nunavut Water Board established under Article 13 the *Nunavut Land Claims Agreement* and under Section 14 of the *Act*;

“**Care and Maintenance**” in respect of a mine, means when the licensee ceases production or commercial operation for an undefined period of time;

(Schedule A - Definitions)

“Causeway” means the infrastructure in Carat Lake designed to access and support the freshwater Water Supply Facilities;

“Chief Administrative Officer” means the Executive Director of the Nunavut Water Board;

“Coarse PK Stockpile” means the engineered facility designed to permanently store coarse processed Kimberlite as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Collector Ditches” means containment structures that are designed to direct local runoff toward the open pit and/or towards the collection ponds as described in the document titled “Site Water Management” prepared by SRK Consulting, August 2004 and illustrated in Drawing Numbers: 1CT004.06-W-1 dated July 2004;

“Collection Ponds A, B, and C” means containment structures that may be designed to contain runoff and potential seepage from Waste Rock Dump sites, overburden stockpile, ore stockpile, coarse PK stockpile and plant site area as described in the document titled “Site Water Management” prepared by SRK Consulting, August 2004 and illustrated in Drawing Numbers: 1CT004.06-W-1 dated July 2004; 1CT004.06-W-4 dated July 2004; and 1CT004.06-W-5 dated July 2004;

“Commercial Operation” in respect of a mine, means an average rate of production is equal to or greater than 25 % of the design rated capacity of the mine over a period of 90 consecutive days;

“Construction” means any activities undertaken to construct or build any component of, or associated with, the development of the Jericho Diamond Project, as described in the Summary Document, Appendices and Addendum information submitted to the Board throughout the regulatory process;

“C1 Diversion” means the engineered structures designed to divert waters and includes the C1 Diversion Dyke/Dam as described in the document titled “Site Water Management” prepared by SRK Consulting, August 2004 and illustrated in Drawing Numbers: 1CT004.06-W-2 dated July 2004 and 1CT004.06-W-3 dated July 2004;

“C4 Ditch” means the clean water containment structure that is designed to collect overland flow from southeast of Waste Dump Site 1 to be discharged to Lake C4 as described in the document titled “Site Water Management” prepared by SRK Consulting, August 2004 and illustrated in Drawing Number: 1CT004.06-W-1 dated July 2004;

“Dam Safety Guidelines” means the *Canadian Dam Association (CDA) Dam Safety Guidelines (DSG)*, January 1999 or subsequent approved editions;

“Deleterious Substance” means a substance as defined in Section 34(1) of the *Fisheries Act*

“Deposit” means the placement of waste rock, Processed Kimberlite or other solids materials on land or in water;

(Schedule A - Definitions)

“Discharge” means the release of any water or waste to the receiving environment;

“Divider Dyke” means the embankment infrastructure within the PKCA dividing it into two sections to limit the extent to which fine PK solids move into the western half of the PKCA as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers 1CT004.06-P2 and 1CT004.06-P7 dated July 2004;

“Domestic Waste” means all solid waste generated from the accommodations, kitchen facilities and all other site facilities, excluding those industrial and hazardous wastes associated with the mining and processing of kimberlite;

“East Dam” means the embankment infrastructure utilizing a central frozen core as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-P5 and 1CT004.06-P7 dated July 2004;

“Effective Date of Licence” means the date on which the Minister of DIAND approves the Licence;

“Effluent” means the liquid discharge from all site water management facilities;

“Emulsion Plant” means the facility designed to manufacture on-site, emulsion explosives to be used for wet blasting as described in the document titled “Ammonium Nitrate and Explosives Management Plan” by AMEC Earth & Environmental dated August 2004 and illustrated in Drawing 1CT004.06-G10 dated July 2004;

“Engineer” means a professional engineer registered to practice in Nunavut in accordance with the *Engineering, Geological and Geophysical Act (Nunavut)* S.N.W.T. 1998, c.38, s.5;

“Engineering Geologist” means a professional geologist registered with the Association of Professional Engineers, Geologist and Geophysicists of Nunavut and whose principal field of specialization is the investigation and interpretation of geological conditions for civil engineering purposes;

“Fuel Storage and Containment Facility” means the facility designed for the bulk storage of fuel as illustrated in the Addendum to the submission to the NWB dated October 8, 2004 Drawing “Diesel Fuel Farm Preliminary Layout” dated July 10, 2004;

“Geotechnical Engineer” means a professional engineer registered with the Association of Professional Engineers, Geologist and Geophysicists of Nunavut and whose principal field of specialization with the engineering properties of earth materials in dealing with man-made structures and earthworks that will be built on a site. These can include shallow and deep foundations, retaining walls, dams, and embankments;

“Engineered Structure” means any facility, which was designed and approved by a Professional Engineer registered with the Association of Professional Engineers, Geologists and Geophysicists of Nunavut;

(Schedule A - Definitions)

“Environmental Assessment (EA)” means, for the purpose of this licence, the totality of the Nunavut Impact Review Board (NIRB) Public Registry as established under the authority of Article 12 of the NLCA, this includes everything that was submitted by Tahera Diamond Corporation or Tahera Corporation Limited to the NIRB, the scope of which is consistent with the Water License Application;

“Freeboard” means the vertical distance between the water level and the top of the containment element (i.e. a liner), within a dam or any other channel or pond used for containment of site runoff;

“Fresh Water Supply Facilities” means the infrastructure required for extraction, storage, treatment and distribution of water as described in the Final Environmental Impact Statement, Project Description dated January 2003 and illustrated in Drawing Numbers 1CT004.06-G10 and 1CT004.06-W6 dated July 2004;

“Frozen Core” means a permafrost core comprising frozen ice-saturated aggregate material and functioning as an impervious seepage barrier;

“Grab Sample” means an undiluted quantity of material collected at a particular time and place that may be representative of the total substance being sampled at the time and place it was collected;

“Greywater” means the component of effluent produced from domestic use (i.e. washing, bathing, food preparation and laundering), excluding sewage;

“Ground Ice” means ice that occupies fractures in rock and soil below the ground surface and may be present as ice inclusion in permafrost, soil or rock, as pore ice, lense ice or massive ice;

“Ground Water” means water that occupies pores and fractures in rock and soil below the ground surface in a liquid or frozen state;

“ICP Metal Scan” means, for the purpose of the License, elements detected in an inductively coupled plasma (ICP) mass spectrometer including, but not limited to, aluminum, barium, boron, cadmium, chromium, copper, iron, lead, manganese, molybdenum, nickel, selenium, strontium, uranium and zinc;

“Inspector” means an Inspector designated by the Minister under Section 85 (1) of the Act;

“Landfill” means a facility, designed to permanently contain inert solid waste materials, as described in the document titled “Landfill Management Plan” prepared by AMEC Earth & Environmental, August 2004 and illustrated in Drawing Number 1CT004.06-G10 dated July 2004 and in the Addendum Information Figure 1, dated May 31, 2004;

“Kimberlite” refers to the Jericho Kimberlite pipe with a length of ~300m, a width of up to 100m and a depth of at least 350m that was formed from multiple emplacement events comprising a precursor dyke (JDF2) and three diatreme intrusive stage consisting of a northern (JDF4N), central (JDF6) and southern lobe (JDF4s) as described in the FEIS Project Description

(Schedule A - Definitions)

prepared by Tahera Diamond Corporation, dated January 2003 and illustrated in Maps A and D in Appendix E-Maps dated June 2000

“Landfarm” means a lined, engineered area designed to contain and treat, using bioremediation, hydrocarbon impacted sediment and soil described in the document titled “Land Farm Management Plan” prepared by AMEC Earth & Environmental, August 2004 and illustrated in Figure 1, dated May 31, 2004 and Drawing Number 1CT004.06-G12 dated July 2004;

“Licence” means this Type “A” Water Licence NWB1JER0410, issued by the Nunavut Water Board in accordance with the *Act*, to Tahera Diamond Corporation (formerly Tahera Corporation Limited) for the Jericho Diamond Project;

“Licensee” means to whom Licence NWB1JER0410 is issued to or assigned;

“Low Grade Stockpile” means the engineered facility designed to store low grade ore pending future assessment of economic feasibility for processing as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Major Ions” means to include the following parameters: sulphate, nitrate, chloride, total magnesium, total sodium, total potassium and total calcium;

“Maximum Average Concentration” means the average concentration of any four consecutively collected samples taken from the identical sampling location and taken during any given timeframe;

“Metal Leaching” means the mobilization of metals into solution under neutral, acidic or alkaline conditions;

“Mine Plan” means the document which describes actual mining activities (i.e. open pit and underground drilling and blasting, Kimberlite extraction, ground water control, backfilling and other mining activities) including the sequencing of the development;

“Mine Water” means any water, including groundwater, that is pumped or flows out of any underground workings or open pit;

“Minister” means the Minister of Indian and Northern Affairs Canada;

“Modification” means an alteration to a physical work that introduces a new structure or eliminates an existing structure and does not alter the purpose or function of the work, but does not include an expansion;

“North Dam” means the embankment water retaining infrastructure utilizing a central frozen core backed by a geosynthetic clay liner as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers 1CT004.06-P4 and 1CT004.06-P7 dated July 2004;

(Schedule A - Definitions)

“Nunavut Land Claims Agreement” (NLCA) means the *“Agreement Between the Inuit of the Nunavut Settlement Area and Her Majesty the Queen in Right of Canada,”* including its preamble and schedules, and any amendments to that agreement made pursuant to it;

“Nutrients” means to include the following measurements: total ammonia-N, nitrate-N, nitrite-N, total phosphorus, orthophosphate, total carbon and total organic carbon;

“Open Pit” refers to the conventional open pit method of mining described in the Mine Plan included in the report “Waste Rock, Overburden, Low Grade ore and Coarse Kimberlite Management Plan” prepared by SRK Consulting, dated August 2004 and illustrated in Drawing Numbers 1CT004.06-G10 and 1CT004.06-M1, dated July 2004;

“Operations” means the entire set of site activities (excluding construction and commissioning activities) associated with mining, processing and recovery of diamonds at the Jericho Diamond Project, as described in the Water Licence Application Summary Document on October 19, 2004;

“Operator” means the person who operates, has control or custody of, or is in charge of a mine or recognized closed mine;

“Ore Stockpile” means the above-ground facility designated for the temporary storage of ore to be processed in the processing plant using conventional diamond extraction methods as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Overburden” means the material, excluding waste rock, that must be removed to gain access to the ore in the development of the Open Pit. Material is to be stored at Waste Dump No. 2 as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Perimeter Dykes” means the embankment infrastructure required at four shallow depressions located around the PKCA (i.e. two of the north side of the PKCA and two on the south side) as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-P2 and 1CT004.06-P7 dated July 2004;

“Physical Parameters” means to include the following measurements: alkalinity, turbidity, conductivity, pH and Hardness;

“Pit Water” means the water that seeps into and or is collected within the open pit;

“Processed Kimberlite” means material (solid/liquid), considered to have no current value, which is rejected from the process plant after the recoverable minerals have been extracted;

“Processed Kimberlite Containment Area (PKCA)” means the containment basin and the engineered structures that are designed to contain the Fine Processed Kimberlite as described in the document titled “Design of the Processed Kimberlite Containment Area Plan” prepared by

(Schedule A - Definitions)

SRK Consulting, August 2004 and illustrated in Drawing Numbers: 1CT004.06-G10 and 1CT004.06-P1, dated July 2004;

“Project” means the Jericho Diamond Project as outlined in the FEIS submitted by Tahera Diamond Corporation (formerly Tahera Corporation Limited) to the Nunavut Impact Review Board NIRB and supplemental information, and updated in the Submission to the NWB summary Document and Appendices and Addendum information, comprising an open pit and underground mine, surface processing facilities, surface waste containment, water collection and treatment facilities and other infrastructure;

“Reclamation” means the process of converting disturbed land back to its former or other productive use;

“Receiving Environment” means both the aquatic and terrestrial environments that receive any discharge resulting from the Project;

“Recovery Plant Rejects (RPR) Stockpile” means the engineered facility designed to permanently store RPR as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M4 dated July 2004;

“Recognized Closed Mine” means a recognized closed mine as defined by section (1) of the *Metal Mining Effluent Regulations* SOR/2002-222 dated 6 June 2002;

“Regulations” means the *Northwest Territories Water Regulations* SOR/93-303 8 June, 1993.

“Seepage” means any water that drains through or escapes from any structure designed to contain, withhold, divert or retain water or waste. Seepage also includes any flows that have emerged from the toe, or as a result of runoff from overburden storage areas, waste rock storage facilities, coarse kimberlite reject areas and ore stockpile areas;

“Sewage” means all toilet wastes and greywater;

“Site Water Management Facilities” means the sumps, ponds, ditches and associated piping and pumps used for collection and handling of surface runoff, minewater and seepage as described in the document titled “Site Water Management” by SRK Consulting dated August 2004 and illustrated in Drawing Number 1CT004.06-W1 dated July 2004;

“Short Term Landfill” means the facility, designed to contain inert Solid waste materials during Year 1 of operations located in the area of Waste Dump Site No. 1 as described in the “Landfill Management Plan” prepared by AMEC Earth & Environmental, and illustrated on Drawing Number 1CT004.06-G10, dated July 2004;

“Southeast Dam” means the embankment infrastructure utilizing a central frozen core as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-P6 and 1CT004.06-P7 dated July 2004;

(Schedule A - Definitions)

“Spillway” means an engineered structure to facilitate the emergency release of water or waste from a facility. The spillway elevation is the elevation at which water or waste begins to flow through the spillway structure as illustrated in Drawing Numbers 1CT004.06-011 and 1CT004.06-P8, dated July 2004;

“Surface Drainage” means all surface waters resulting from the flow over, through or out of an operations area and is collected by means of engineered structures considered under the site Water Management Facilities as described in the document titled “Site Water Management” by SRK Consulting dated August 2004 and illustrated in Drawing Number 1CT004.06-W1 dated July 2004;

“Traditional Knowledge” means the practical knowledge that has been gathered through the experience of living in close contact with nature and has been passed along or communicated orally, and handed down from generation to generation;

“Talik” means a layer or body of *unfrozen* ground occurring in a permafrost area due to a local anomaly in thermal, hydrological, hydrogeological or hydrochemical condition;

“Total Metals” means to include at a minimum: arsenic, aluminum, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, mercury, manganese, molybdenum, nickel, selenium, strontium, uranium, vanadium and zinc. Total metals shall be analyzed on an un-filtered sample;

“Uncontrolled Surface Runoff” means the runoff that is not controlled by site Water Management Facilities as described in the document titled “Site Water Management” by SRK Consulting dated August 2004 and illustrated in Drawing Number 1CT004.06-W1 dated July 2004;

“Use” means use as defined in section 4 of the Act;

“Waste” means waste as defined in section 4 of the Act;

“Waste Dump No. 1” means the engineered facility designed for the disposal of waste rock as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Waste Dump No. 2” means the engineered facility designed for the disposal of overburden with a waste rock buttress as described in the document titled “Waste Rock, Low Grade Ore and Coarse Processed Kimberlite Management Plan” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers: 1CT004.06-M1 and 1CT004.06-M3 dated July 2004;

“Waste Rock” means all unprocessed rock materials that are or were produced as a result of mining operations and having no current economical value;

“Waste Water” means the water generated by site activities or originates on-site that requires treatment or any other water management activity;

(Schedule A - Definitions)

“Waste Water Treatment Plant (WWTP)” means the engineered system designed for the containment and treatment of sewage during the construction and operation phase of the project as described in the report “Wastewater Treatment Plant Operation Plan” dated May 2004 as illustrated in Drawing No. A1-K17296-7868;

“Water” means water as defined in section 4 of the *Act*;

“Water Licence Application” for the purposes of this License includes to totality of the NWB and NIRB Public Registries as establishes as a result of the filing of the application dated September 11, 2000;

“West Dam” means the embankment water retaining infrastructure utilizing a central frozen core backed by a geosynthetic clay lined as described in document titled “Design of PKCA” by SRK Consulting dated August 2004 and illustrated in Drawing Numbers 1CT004.06-P3 and 1CT004.06-P7 dated July 2004;

Schedule B - General Conditions

1. The Annual Report referred to in Part B Item 2 shall include, but not necessarily be limited to the following:
 - a. the monthly and annual quantities in cubic metres of water obtained from Carat Lake;
 - b. the monthly and annual quantities in cubic metres of recycled water identifying both the source and use;
 - c. the monthly and annual quantities of solids in tonnes and liquid fractions in cubic metres of each waste stream discharged to the Processed Kimberlite Containment Area;
 - d. the monthly and annual quantities in cubic metres of any discharges from the Processed Kimberlite Containment Area;
 - e. the monthly and annual quantities in cubic metres of mine water and dyke seepage pumped from all facilities to the Processed Kimberlite Containment Area;
 - f. the monthly and annual quantities in cubic metres of treated effluent discharged from the Waste Water Treatment Facility;
 - g. the monthly and annual quantities in cubic metres of Sewage solids removed from the Waste Water Treatment Facility;
 - h. the annual quantities in cubic metres of overburden, waste rock, ore stockpiled, ore processed stored;
 - i. a summary report which includes all data and information generated under the Monitoring Program in an electronic and printed format acceptable to the Board;
 - j. a summary of construction activities conducted and an update Mine Plan;
 - k. a summary of any modification and/or major maintenance work and/or demolition work carried out and any associated structures;
 - l. a summary of all work carried out under the Managements Plans in accordance with this licence;
 - m. a progress report and revisions (if applicable) to any studies requested by the Board that relate to waste management, water use or reclamation and a brief description of any future studies planned by the Licensee including, an executive summary in terms understandable to the general public, translated into Inuktitut and Inuinnaqtun;
 - n. a report identifying whether recycle will be implemented at the PKCA for the remaining years of operation, and if not, providing a detailed rationale for why recycle is not considered a valid management practice at this site for that time.
 - o. the results of the Aquatic Effects Monitoring Program in accordance with Part L including QA/QC measures;
 - p. any revisions to the approved Contingency Plan;
 - q. a list and description including volumes, Spill report Line identification number of all un-authorized discharges, spills and summaries of follow-up action taken;
 - r. an outline of any spill training exercises carried out by the Licensee;
 - s. any revisions to the approved Closure and Reclamation Plan;
 - t. a summary of any closure and reclamation work undertaken and an outline of any work anticipated for the next year, including any changes to implementation and scheduling;
 - u. an updated estimate of the total current mine restoration liability based upon the

(Schedule B – General Conditions)

- results of mine reclamation research, monitoring during mine construction and development and any modification to the mine plan;
- v. a summary report describing public consultation and participation with local organizations and the residents of the nearby communities, including a schedule of upcoming community events/information sessions;
 - w. a summary of actions taken to address concerns or deficiencies listed in the inspection reports and/or compliance reports filed by an Inspector;
 - x. any other details on water use or waste disposal requested by the Board by November 1st of the year being reported.

Schedule C - Conditions Applying to Security

No schedule required

Schedule D - Conditions Applying to Construction

1. The Mine Plan referred to in Part D item 1 of the licence, shall include, but not necessarily be limited to the following:
 - a. Schedule of commissioning of all facilities and infrastructure;
 - b. Proposed schedule for mine development (open pit, and underground);
 - c. Plan for dealing with pit water;
 - d. Monitoring to be done during construction/development;
 - e. Adaptive Management strategy for construction phase;
 - f. Stability assessment planning.
2. The detailed design plans and drawings for water retention structures referred to in Part D Item 2 shall include any facilities and infrastructure not captured under conditions applying to construction.
3. The rock used for construction referred to in Part D, Item 3 of the Licence, shall meet the following geochemical criteria:
 - a. Non acid generating;
 - b. Provide a complete characterization of the rock properties (including thermal) of both in-situ and placed materials within the appropriate detailed design report for which material is to be use and confirm the material will to meet performance objectives or alternative shall be outlined; and
 - c. Should any material be found unacceptable as a construction material the Licensee shall confirm in the plan referred to in Part H, Item 1, procedures to be followed upon identification of any unacceptable materials, that includes reporting, removal, replacement, specifications for in-situ remediation and/or replacement of material;
4. The Borrow Management Plan referred to in Part D Item 4 of the Licence, shall be revised to include an outline the environmental management measures for at least the following:
 - a. Implementation plan for use of the resource;
 - b. Drainage and erosion control;
 - c. Contingency options for dealing with massive ice;
 - d. Air quality management;
 - e. Wildlife management;
 - f. Treatment and or disposal of meltwater
 - g. Overview of reclamation measures; including
 - h. Operational and post closure monitoring.
5. The detailed design report for the PKCA referred to in Part D, Item 5 of the Licence, shall include but not necessarily limited to the following:
 - a. Detailed construction implementation schedule for the PKCA infrastructure;

(Schedule D – Conditions Applying to Construction)

- b. Consideration of industry standard “Dam Safety Guidelines” (Canadian Dam Association, 1999)
 - c. Key design and performance parameters for PKCA components including, the spillway, West Dam, North Dam, Perimeter Dykes, East Dam, Southeast Dam, and the Divider Dyke.
 - d. Contingency components (i.e. the North Dam) can be submitted as part of this detailed design or may require separate submission of detailed design.
 - e. The PKCA shall be designed and constructed to prevent discharge to the groundwater system.
 - f. There shall be no accumulation of water against the containment dam structures of the PKCA until such time as the results of the thermal monitoring program has demonstrated the integrity of all frozen core dams;
 - g. Representative cross sections showing the various stages of dam raises when geothermal modeling and short term slope stability analyses are to be conducted;
 - h. The results of revised geothermal modeling throughout the intermediate and final stages of construction; and
 - i. Additional site assessments: delineation including of ice-rich features; follow-up test pit and/or bore hole investigations data; and geophysical surveys.
6. The detailed design plan for the Landfill referred to in Part D, Item 6 of the Licence, shall include but not necessarily limited to the following:
- a. Consideration for the “Guidelines for the Planning, Design, Operation and Management, of Modified Solid Waste Sites in NWT” (Ferguson, Simek, Clark, April 2003).
 - b. Detailed Implementation schedule;
 - c. A plan on how the landfill will be incorporated into the reclamation of Waste Rock Dump No.1;
 - d. Design criteria and Material specifications;
 - e. Estimates of cover thickness to ensure encapsulation in permafrost;
 - f. Consideration of global warming effects;
 - g. Overview Operation and Maintenance needs;
 - h. Runoff and seepage control measures; and
 - i. Monitoring requirements during construction.
7. The detailed design report for the Landfarm referred to in Part D, Item 7 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed Implementation Schedule;
 - b. Site baseline information (local features, site drainage patterns, location within Waste Rock Dump No. 2);
 - c. Comprehensive design details, including the dimensions, materials of construction and installation/construction procedures of all landfarm facility components are required such as: retaining structures, liner properties, monitoring equipment);
 - d. Measure for runoff, leachate or seepage control;
 - e. Environmental monitoring equipment;
 - f. Overview of Operation and Maintenance needs; and
 - g. Operational monitoring to assess treatment efficiency;

(Schedule D – Conditions Applying to Construction)

- h. Proposed soil quality remedial objective to be achieved; and
 - i. Closure and reclamation summary;
8. The detailed design report for the Waste Water Treatment Plant referred to in Part D, Item 8 of the Licence, shall include but not necessarily be limited to the following:
- a. Implementation schedule;
 - b. Design criteria/parameters;
 - c. Overview System components;
 - d. Site investigation and Alignment;
 - e. Treatment efficiency expectations; and
 - f. Site monitoring to be done during construction;
9. The detailed design report for the Site Water Management Facilities referred to in Part D, Item 9 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed Implementation schedule for construction of all facilities;
 - b. Design Criteria and parameters;
 - c. The report shall include design criteria for C4 Ditch; and
 - d. The effect of roads on surface drainage;
 - e. Monitoring requirements for each facility during construction; and
 - f. Overview of general operation and maintenance requirements.
10. The detailed design report for the Ore Stockpile, Coarse Processed Kimberlite, Recovery Rejects Stockpile, Waste Rock Dump No. 1 and Waste Rock Dump No. 2, referred to in Part D, Item 10 of the Licence, shall include but not necessarily limited to the following:
- a. Detailed Implementation for construction of each facility;
 - b. Plans in this part may be submitted individually depending upon the overall implementation strategy for construction;
 - c. Design Criteria and parameters for each stockpile and/or dump;
 - d. Design plan for the waste rock buttress or justification as to why it was not constructed;
 - e. Operational volumes of materials projected for each pile;
 - f. The Licensee shall ensure maintenance of a 200m buffer between the toe waste rock dump site 1 and Carat Lake;
 - g. Stability assessment based on projected volumes; and
 - h. Monitoring to be done during construction.
11. The detailed design report for the Collection Ponds A, B, and C referred to in Part D, Item 11 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed Implementation for construction of each facility;
 - b. Plans in this part may be submitted individually depending upon the overall implementation strategy for construction;
 - c. Design Criteria and parameters for each Pond; and
 - d. Monitoring to be done during construction.
12. The detailed design report for the Fuel Storage and Containment Facility referred to in

(Schedule D – Conditions Applying to Construction)

Part D, Item 12 of the Licence, shall include but not necessarily be limited to the following:

- a. Detailed Implementation schedule for construction of the facility;
 - b. Design Criteria and parameters;
 - c. Hydrostatic testing procedures for new tanks (water source and wash water disposal location);
 - d. Primary and secondary containment measures;
 - e. Monitoring to be done during construction.
13. The detailed design report for the Dewatering of the PKCA referred to in Part D, Item 13 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed Implementation schedule for construction of the facility;
 - b. Design Criteria and parameters for the program to ensure minimize effects to the receiving environment Stream C3;
 - c. Overview of fish salvage plan taking into account community interests; and
 - d. Monitoring to be done during construction.
14. The Explosives Management Plan referred to in Part D, Item 14 of the Licence, shall include but not necessarily be limited to the following:
- a. Consideration for the “Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters (Wright & Hopky, 1998)
 - b. In conjunction with DFO, the Licensee shall incorporate mitigation measures into the blasting plan ensure impacts to fish and fish eggs are minimized;
 - c. Measures to control runoff from storage areas;
15. The detailed design report for the construction of the Causeway referred to in Part D, Item 15 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed implementation schedule for construction;
 - b. Design criteria and parameters;
 - c. Mitigation measures to reduce TSS and control sedimentation;
 - d. Construction sampling monitoring of waste rock used for causeway construction;
 - e. The Licensee should ensure the Causeway is constructed to minimize disturbance and maximize development of fish habitat including benthic substrate.
 - f. Monitoring to be done during construction.
16. The detailed design report for the construction of the Stream C1 diversion and associated dam structure referred to in Part D, Item 16 of the Licence, shall include but not necessarily be limited to the following:
- a. Detailed implementation schedule for construction;
 - b. Design criteria and parameters;
 - c. The report shall discuss options adjusting the design of the two channel diversion energy dissipation pools to become a narrow, longer pool configuration and why this is to be considered or not;

(Schedule D – Conditions Applying to Construction)

- d. Consideration for the use of the pools and temporary cofferdams;
- e. Measure to be employed to control sediment;
- f. Stabilization along the banks of the channel considers the use of vegetation;
- g. Final design plan for culverts including specific location of installation; and
- h. Monitoring proposed during construction;

Schedule E – Conditions Applying to Water Use

No schedule required.

Schedule F - Conditions applying to Water Management

1. The detailed Site Water Management Plan referred to in Part F, Item 1 of the Licence, shall include but not necessarily be limited to the following:
 - a. measures that will be undertaken to minimize the amount of raw water required from Carat Lake, that includes consideration of alternative water sources;
 - b. the projected amount of water to be obtained from Carat Lake in the upcoming year;
 - c. assess drawdown on Carat Lake based on water use
 - d. a summary of plans for managing water to be stores in the PKCA and for management of all other waters in the project area;
 - e. an overall water balance for the project, including the specific water balance for the PKCA updated with current information respecting:
 - i. on-site precipitation, evaporation and runoff;
 - ii. volumes for recycled/reclaimed water and raw water utilized during the previous year;
 - iii. ground water inflows to the pit; and
 - iv. volumes of runoff redirected to the PKCA form water management facilities (i.e. ponds, ditches, diversions).

Schedule G - Conditions Applying to Waste Management

No schedule required.

Schedule H - Conditions Applying to Waste Management Plans

1. The PKCA Management Plan referred in Part H, Item 1 of the Licence, shall include but not necessarily limited to the following:
 - a. consider operational guidelines provided in “A Guide to the Management of Tailings Facilities (Mining Association of Canada, 1998)” and the “Dam Safety Guidelines (CDA, 1999)”
 - b. the use flocculant in the treatment process and controls for its use;
 - c. detail how effluent discharge rates will be managed to ensure a minimum 10:1 dilution at the edge of the mixing zone in Lake C3. This plan shall not rely on estimating receiving environment outflow rates from changes in Carat Lake level unless monitoring data is provided that shows that the procedure will work as a means of calibrating effluent discharge rates.
 - d. stage-volume curves and water, solids and ice balance calculations showing life expectancy of the PKCA Facility; and
 - e. any operational and/or structural modifications which may be implemented that will affect the management of the PKCA Facility and associate wastewater operations.
2. The detailed Waste Rock Management Plan referred to in Part H, Item 3 of the Licence, shall include but not necessarily limited to the following:
 - a. the Plan shall be developed in accordance with the Department of Indian Affairs and Northern Development’s (DIAND) “Guidelines for Acid Rock Drainage Protection in the North, September 1993” or subsequent editions.
 - b. this Plan shall describe decision criteria and operating procedures of how all rock will be placed and managed during construction, mining and post closure.
 - c. an annual schedule for ore stockpiling, processed kimberlite generation and waste rock production by rock type, tonnage, and destination over the term of the project including sources and volumes of each rock type;
 - d. a description of operational procedures that will be used to segregate and manage the rock that is identified for construction;
 - e. a description of the sampling design and analytical methods that will be used to support the operational classification of all rock types;
 - f. a description of the methods that will be used to construct till storage, ore stockpiling, Processed Kimberlite, and waste rock facilities such that generation of acidic drainage and/or metal leaching is limited;
3. The detailed Operation and Management Plan for the Waste Water Treatment Plant, Landfill and Landfarm referred to in Part H, Item 5 of the Licence, shall include but not necessarily be limited to the following:
 - a. consideration for the “Guidelines for the Preparation on an Operation and maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories”, (Diep Duong and Ron Kent, 1996) (where applicable);

(Schedule H – Conditions Applying to Waste Management Plans)

b. For the Landfarm:

- i. The procedures to determine if soils may be accepted including (soil characterization, treat ability, and ampling)
- ii. Procedures to be used during active land farming including (cell development, soil thickness, method of aeration, oversize material management, surface water management); and
- iii. Surface and groundwater monitoring program including QA/QC measures.

Schedule I - Conditions Applying to Modifications

No schedule required.

Schedule J - Conditions Applying to Contingency Planning

1. The detailed Contingency Plan referred to in Part J Item 1 of the Licence, shall include but not necessarily be limited to the following:
 - a. The Plan shall comply with the Dam Safety Guidelines, address the construction and development phases;
 - b. Integration of the hazardous waste management plan as provided with the “Application for Water Licence Appendix F” into the spill contingency plan;
 - c. Introduction, scope of plan, when the plan is active, description of project and site;
 - d. Name, address and title of person in charge;
 - e. Name, job title and 24 hour number of person responsible; on site;
 - f. Chain of command and organizational chart;
 - g. Location, size and capacity of facility; Map showing all potential spill locations and materials storage;
 - h. Types and amounts of materials stored on site;
 - i. Current Materials Safety Data Sheets for all hazardous materials/petroleum products on site
 - j. Analysis of potential spills, fate and effects identified;
 - k. Site map, showing sensitive areas and potential for contamination;
 - l. Steps taken to report, contain, clean up and respond;
 - m. Response Team identification giving lines of authority and responsibility;
 - n. Reporting and communication procedures;
 - o. Site contact list with names, titles, phone and pager numbers;
 - p. Off-site contact list including all relative regional contacts; DIO, DIAND Water Resources Inspector, EC, DFO, GNU DOE, special assistance contacts;
 - q. How plan is activated;
 - r. Description of training provided to employees/designated responders; including the initial training and active response training;
 - s. Response Action Plans and countermeasures (ie fuel storage and transfer protocols, explosives transfers) in the event of a spill; this would include potential spills from the PKCA, process pipelines, material storage areas (fuels, chemicals, explosives)
 - t. Clean-up and disposal practices; hazardous waste transportation and removal;
 - u. Inventory and location of response equipment and supplies;
 - v. Copy of NWT Spill Report Form;
 - w. Date plan was prepared;
2. The detailed Contingency Plan during Care and Maintenance referred to in Part I, Item 6 of the Licence, shall include but not necessarily be limited to the following:
 - a. Any changes to the operations resulting from the move to Care and Maintenance;
 - b. Any changes in the personnel on site;
 - c. Response Team identification and responsibility;
 - d. Any changes to the availability of response equipment; and
 - e. Any changes with respect to access at the site and access to the site from the nearest location for assistance.

Schedule K - Conditions Applying to General and Aquatic Effects Monitoring

Table 1 - Water Quality Parameters

Test Group	Analytical Parameters	Measurement Units
Routine - R	Alkalinity, acidity, chloride, carbonate, bicarbonate, total hardness, hydroxide, sulphate, total suspended solids (TSS), total dissolved solids (TDS) total organic carbon (TOC), total inorganic (TIC) pH (field and lab) ORP (field) Conductivity (field and lab) Temperature (field) Turbidity	mg/L pH units mV uS/cm °C NTU
Metals (Total – Unfiltered) - MT and, Metals (Dissolved – Filtered) MD	T-Aluminum, T-Arsenic T-Cadmium, T-Chromium T-Copper, T-Lead T-Molybdenum, T-Nickel T-Uranium, T-Zinc Aluminum	mg/L
ICP-T, ICP-D; ICP Metals Scan (Total and Dissolved) 24 or 32 metal scan or equivalent that shall include at a minimum	Ca, Mg, Na, K, Al, As, Ba, B, Be, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, Sr, U, V, Zn	Mg/L
Nutrients – N	Ammonia-N, Nitrate-N, Nitrite-N Total Phosphorus, Orthophosphate	mg N/L mg/L
Biological –B	Biochemical Oxygen Demand Fecal Coliform	mg/L CFU/100mL (colony forming units)
Potable Water - PW	Fecal Coliform ICP Metals (Total and dissolved) Total Suspended Solids –TSS	CFU/100mL mg/L mg/L
Dissolved Oxygen Profile - DO		

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 2 - Receiving Environment Water Quality Monitoring Requirements¹

Station	Location	Phase	Test Group Water Chemistry (refer to Table 1)	Frequency	Flow Measurement	Frequency	
JER-WQ1	Carat Lake-Freshwater Intake	Pre-construction					
		Construction					
		Operation	PW	M2	M ³ /day	C	
JER-WQ2	PKCA Discharge	Pre-construction					
		Construction	Turbidity (correlate with TSS)	D	M ³ /day	D	
		Operation	R, ICP-T, ICP-D, N B	W M2	M ³ /day	C	
JER-WQ3	Stream C3 upstream of Lake C3	Pre-construction	R, ICP-T, ICP-D, N	M2			
		Construction	R, ICP-T, ICP-D, N	M2			
		Operation	R, ICP-T, ICP-D, N	M2			
JER-WQ4	Lake C3 South Basin	Pre-construction	R, ICP-T, ICP-D, N, DO	A1			
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ5	Lake C3 Outlet	Pre-construction			M ³	C	
		Construction	R, ICP-T, ICP-D, N	M2	M ³	C	
		Operation	R, ICP-T, ICP-D, N	M2	M ³	C	
JER-WQ6	Carat Lake Centre Basin	Pre-construction	DO	A1			
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N				
JER-WQ7	Carat Lake Outlet	Pre-construction					

¹Notes: A1=Annual Once in Winter
A2=Annual once in summer

M1=Montly; Mid-Apr, Jun, Jul, Aug, Sept, and Mid-Dec at a minimum 3 weeks apart
M2=Monthly; once during Jun, Jul, Aug, Sep at a minimum 3 weeks apart

W=Weekly D=Daily C=Continuous CS=Continuous Seasonal

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 2 - Receiving Environment Water Quality Monitoring Requirements¹

Station	Location	Phase	Test Group Water Chemistry (refer to Table 1)	Frequency	Flow Measurement	Frequency	
		Construction	R, ICP-T, ICP-D, N	M2			
		Operation	R, ICP-T, ICP-D, N	M2			
JER-WQ8	Jericho Lake North Basin	Pre-construction	R, ICP-T, ICP-D, N, DO	A1			
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ9	Jericho River Downstream of Jericho Lake	Pre-construction					
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ10	Control Lake	Pre-construction					
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ11	Cigar Lake (2 nd Control)	Pre-construction					
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ12	Stream C1 Upstream of Carat Lake	Pre-construction					
		Construction	R, ICP-T, ICP-D, N	M2	Yes	CS	
		Operation	R, ICP-T, ICP-D, N	M2	Yes	CS	
JER-WQ13	Lake C1	Pre-construction	R, ICP-T, ICP-D, N, DO	A1			
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ14	Lake C4	Pre-construction	R, ICP-T, ICP-D, N, DO	A1			
		Construction	R, ICP-T, ICP-D, N	M1			
		Operation	R, ICP-T, ICP-D, N	M1			
JER-WQ15	Stream C4 upstream of Carat Lake	Pre-construction					
		Construction	R, ICP-T, ICP-D, N	M2			
		Operation	R, ICP-T, ICP-D, N	M2			
JER-WQ16	Lynne Lake	Pre-construction					

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 2 - Receiving Environment Water Quality Monitoring Requirements¹

Station	Location	Phase	Test Group Water Chemistry (refer to Table 1)	Frequency	Flow Measurement	Frequency	
		Construction					
		Operation	R, ICP-T, ICP-D, N	A2			
JER-WQ17	Key Lake	Pre-construction					
		Construction					
		Operation	R, ICP-T, ICP-D, N	A2			
JER-WQ18	Ash Lake	Pre-construction					
		Construction					
		Operation	R, ICP-T, ICP-D, N	A2			

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 3 - Site Water Quality and Thermal Monitoring Stations²

Station	Location	Phase	Test Group Water Chemistry	Frequency	Flow Measurement	Frequency	
JER-SW1	Sewage Treatment Plant Effluent	Pre-construction	R, ICP-T, ICP-D, N, B	M	M ³	C	
		Construction					
		Operation					
JER-SW2	Open Pit	Pre-construction	R, ICP-T, ICP-D, N	M2	M ³	C	
		Construction					
		Operation					
JER-SW3	Process Plant Supernatant	Pre-construction	R, ICP-T, ICP-D, N	M	M ³	C	
		Construction					
		Operation					
JER-SW4	Processed Kimberlite Containment Area Pond Water	Pre-construction	R, ICP-T, ICP-D, N	M			
		Construction					
		Operation					
JER-SW5	Temporary/permanent Collection Ditches	Pre-construction	R, ICP-T, ICP-D, N	M3			
		Construction					
		Operation					
JER-SW6	Collection Pond A	When in use	R, ICP-T, ICP-D, N	M2			
JER-SW7	Collection Pond B	When in use	R, ICP-T, ICP-D, N	M2			
JER-SW8	Collection Pond C	When in use	R, ICP-T, ICP-D, N	M2			

² Notes: A3=Annual during seepage survey
M=Monthly
M1=Monthly; Mid-Apr, Jun, Jul, Aug, Sept, and Mid-Dec at a minimum 3 weeks apart
M2=Monthly once during Jun, Jul, Aug, Sep at a minimum 3 weeks apart
M3=during periods of flow
W=Weekly D=Daily C=Continuous CS=Continuous Seasonal

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 3 - Site Water Quality and Thermal Monitoring Stations²

Station	Location	Phase	Test Group Water Chemistry	Frequency	Flow Measurement	Frequency	
JER-SW9	Rock Dump 1 Seepage	Operation	R, ICP-T, ICP-D, N	A3			
JER-SW10	Rock Dump 2 Seepage	Operation	R, ICP-T, ICP-D, N	A3			
JER-SW11	Coarse PK Stockpile	Operation	R, ICP-T, ICP-D, N	A3			
JER-SW12	Ore Stockpile	Operation	R, ICP-T, ICP-D, N	A3			
JER-SW13	Low Grade Ore Stockpile	Operation	R, ICP-T, ICP-D, N	A3			
JER-SW14	Recovery Plant Rejects	Operation	R, ICP-T, ICP-D, N	A3			
	West Dam Thermistor 1	Upon Installation	Temperature	M			
	West Dam Thermistor 2	Upon Installation	Temperature	M			
	East Dam Thermistor 1	Upon Installation	Temperature	M			
	East Dam Thermistor 2	Upon Installation	Temperature	M			
	Southeast Dam Thermistor 1	Upon Installation	Temperature	M			
	Southeast Dam Thermistor 2	Upon Installation	Temperature	M			
	Waste Dump 1 Thermistor 1	Upon Installation	Temperature	M			

(Schedule K – Conditions Applying to General and Aquatic Effects Monitoring)

Table 3 - Site Water Quality and Thermal Monitoring Stations²

Station	Location	Phase	Test Group Water Chemistry	Frequency	Flow Measurement	Frequency	
	Waste Dump 1 Thermistor 2	Upon Installation	Temperature	M			
	Waste Dump 2 Thermistor 1	Upon Installation	Temperature	M			
	Waste Dump 2 Thermistor 2	Upon Installation	Temperature	M			
	Coarse PK Stockpile Thermistor 1	Upon Installation	Temperature	M			
	Coarse PK Stockpile Thermistor 2	Upon Installation	Temperature	M			

Schedule L - Conditions Applying to General and Aquatic Effects Monitoring Plans

1. The General Monitoring Plan, referred to in Part L, Item 1 of the Licence, shall include but not necessarily be limited to, the following:
 - a. updated operation monitoring plan which reflects the requirements of this licence.
 - b. describe the assessment of Stream C3 by a hydrologist and, if required, erosion protection measures should be in place prior to dewatering or discharge from the PKCA.
 - c. the Licensee shall monitor the condition of channels occupied by flow released from PKCA; and record water levels and discharges near outlet of Stream C3 at Lake C3.
2. The detailed QA/QC plan referred to in Part L, Item 5 of the Licence shall include but not necessarily be limited to the following:
 - a. consideration of the INAC “QA/QC Guidelines for Type “A” Licenses”;
 - b. approval of the plan by an analyst;
 - c. information on the analyst;
 - d. introduction on Quality Assurance/Quality Control and its principles and how the Plan elements will be implemented on site;
 - e. field sampling, locations, frequency, sample types, sample containers;
 - f. logging of samples, sample handling, preservation, transportation requirements, information requirements, chain of custody;
 - g. field measurements, calibration of field equipment;
 - h. sampling and analysis, use of field blanks, replicate samples, spiked samples and split samples;
 - i. laboratory analysis and information methods used for analysis;
 - j. laboratory QC and reporting of data;
3. The detailed Annual Seepage Survey in July or August referred to in Part L, Item 9 shall include but not necessarily be limited to the following:
 - a. to include routine monitoring of all surface storage facilities identified in Table 3;
 - b. to include the explosives storage and emulsion plant areas;
 - c. to include seepage chemistry results from any sumps in the plant area;
 - d. an annual seepage survey from the toe of the recovery plant rejects stockpile should be submitted to the Nunavut Water Board, along with the annual seepage survey results for all other waste and low grade ore stockpile; and
 - e. to include any seepage at the base of the West Dam and all other dams around the perimeter of the PKCA.
4. Aquatic Effects Monitoring Plan referred to in Part L, Item 10 of the Licence, shall include but not necessarily be limited to the following:
 - a. Clearly identifiable objectives;
 - b. A description of the area to be monitored including maps showing all sampling and

(Schedule L – Conditions Applying to General and Aquatic Effects Monitoring Plans)

control sites as well as the overall area of influence of the Project;

- c. A description of the sampling program that will be conducted throughout the term of the license to achieve the objectives of the AEMP including the variables, sample media, monitoring protocols and Quality Assurance/Quality Control (QA/QC) protocols;
- d. Specifically, the AEMP shall include, but not necessarily be limited to, the following:
 - i. Water quality;
 - ii. Sediment quality;
 - iii. Fish and fish habitat;
 - iv. Testing done at least once per month during discharge, on samples taken at the edge of the Lake C3 mixing zone, just before freeze up, using *Ceriodaphnia dubia*;
 - v. Surface and shallow groundwater regimes;
 - vi. Fish migration routes;
 - vii. Water levels in Carat Lake with relation to water usage, lake recharge;
 - viii. Structure, abundance and biomass of phytoplankton, zooplankton, benthic macro invertebrates and fish communities;
 - ix. Contaminant levels in fish and procedures that will minimize impacts to fish populations;
 - x. Establishment of control sites;
 - xi. Procedures to assess the accuracy of the Licensee's impact predictions and effectiveness of mitigation measures;
 - xii. Statistical design criteria, including a description of sampling frequencies for each parameter that ensures both accurate characterization of short-term variability and the collection of sufficient data to establish long-term trends;
 - xiii. a description of procedures to analyze and interpret data collected;
 - xiv. a description of evaluation criteria for the AEMP and approaches to revise and refine the Program;
 - xv. description of how the results of the AEMP will be incorporated in the overall Adaptive Management strategies employed by the Licensee. This description shall include details related to any new monitoring requirements for the evaluation of the effects to the Receiving Environment, the management of the risk to the Receiving Environment and any mitigation/treatment methods that will be implemented;
 - xvi. description of the QA/QC protocols. QA/QC protocols must ensure that any future changes in monitoring protocols will be calibrated to initial monitoring protocols and data sets so that continuity, consistency, validity, and applicability of monitoring results will be maintained;
 - xvii. a description of the measures that will be taken to identify and address any information deficiencies; and
 - xviii. how the AEMP will minimize the impacts of the Project

Schedule M - Conditions Applying to Closure and Reclamation

1. The Interim Closure and Reclamation Plan referred to in Part M, Item 2 of the Licence, shall include but not necessarily be limited to the following:
 - a. The combined use of a Inuksuit built by Elders, berms, and signs to warn people and animals about the unfilled open pit. The edge of the Pit Lake shall be contoured and controlled-blasted on a shallow 5:1 angle into the lake for a 10 meter distance so as not pose a hazard to people or wildlife;
 - b. Maintenance of the diversion channel, as a permanent structure beyond closure should water quality dictate. This issue shall be further addressed during operation and resolve the issue prior to closure, when water quality concerns and the options available to re-instate the flows in the channel are better understood;
 - c. The implementation of revegetation through the abandonment and restoration planning;
 - d. to conduct re-vegetation research on the kimberlite to determine if the post-closure conditions can be improved.
 - e. details of the proposed methodology for recovering the stockpiled overburden materials for reclamation purposes;
 - f. address how meltwater from the stockpile is managed to prevent release of suspended sediment;
 - g. revisions based on all monitoring data collected to that time,
 - h. an updated prediction of pit fill rate and effluent discharge quality after closure;
 - i. a plan to remove and dispose all chemicals and regulated materials in a manner that meets all current regulations.
 - j. An evaluation of alternative closure and reclamation measures for each project component, including the rationale for selection of the preferred measures, to include, but not be limited to all site facilities/infrastructure as defined in this licence.
 - k. detailed description, including maps and other visual representations, of the pre-disturbance conditions for each site, accompanied by a detailed description of the proposed final landscape, with emphasis on the restoration of surface drainage over the restored units;
 - l. a comprehensive assessment of materials suitability, including geochemical and physical characterization, and schedule of availability for restoration needs, with attention to top-dressing materials, including maps where appropriate, showing sources and stockpile locations of all reclamation construction materials;
 - m. an assessment of the long-term physical stability of project components;
 - n. an assessment and description of any required post-closure treatment for drainage water that is not acceptable for discharge from any of the reclaimed mine components including a description for handling and disposing of post-closure treatment facility sludges;
 - o. monitoring programs to assess reclamation performance and environmental conditions including, but not limited to, monitoring locations for surface water and groundwater, parameters, schedules and overall timeframes;
 - p. contingency measures for all reclamation components including action thresholds that are linked to the monitoring programs;
 - q. a description of the proposed means for providing long-term maintenance of each

(Schedule M – Conditions Applying to Closure and Reclamation)

- reclaimed project component, including the water collection and distribution systems, retaining structures and spillways;
- r. an evaluation of the potential to re-vegetate disturbed sites that includes the identification of criteria to be used to determine technical feasibility and alternative restoration options;
 - s. a description of how Waste Rock Dumps and the PKCA could use a geomorphic approach to simulate surrounding landscape conditions, rather than the highly engineered closure designs;
 - t. an identification of the research needs for reclamation;
 - u. a description of how progressive reclamation will be employed and monitored throughout the life of the mine, plus reclamation scheduling and coordination of activities with the overall sequence of the project; details of restoration scheduling and procedures for coordinating restoration activities within the overall mining sequence and materials balance;
2. The Proposed Final Closure and Reclamation Plan referred to in Part M, Item 5 of the Licence, shall include, but not necessarily be limited to the following:
- a. An update of all information presented in the Interim Closure and Reclamation Plan based on data collected and proposed closure concepts;
 - b. A Human Health and Ecological Risk Assessment;
 - c. The setting soil quality remediation objectives along CCME guidelines;
 - d. All results of landfarming;
 - e. All results of revegetation trials;
 - f. Multi-stage Environmental Site Assessment plans; and
 - g. A revised closure and reclamation cost estimate.

APPENDIX B
TYPICAL WATER LEVEL
RECORDER AND RADIO LINK EQUIPMENT

CR10X Measurement and Control System

A Rugged Instrument with Research-Grade Performance

The CR10X is a rugged measurement and control system that delivers accurate, reliable measurements in a variety of applications. Designed for both research and day-to-day monitoring operations, the CR10X combines the ability to measure virtually any sensor with the control capability to respond to specific site conditions (e.g., open flood gates, turn fans off/on). From simple to complex, Campbell Scientific data acquisition systems are at work on every continent, at sea, and in space.

Measurement Example — Weather Station

Measurements: The CR10X measures wind speed and direction, air temperature, relative humidity, precipitation, barometric pressure, soil moisture and temperature, and solar radiation. Scan rates are programmable from 1/64 second to 2.5 hours.

Data Processing: Output intervals for raw or processed data are user-specified. Typically, hourly and daily summaries (e.g., maxima, minima, averages, histograms) are stored. Conditional outputs, such as rainfall intensity, can also be processed and stored.

Data Storage: The non-volatile Flash memory and lithium-backed SRAM store up to 62,000 data points—equating to more than three months of data when typical hourly and daily outputs are stored from a typical meteorological application. An optional memory expansion allows the CR10X to store more than one million data points—or about 12 years' worth of meteorological data.

Data Retrieval: Data can be transferred to a computer using telephones (including cellular or voice-synthesized), radio telemetry, short-haul modems, satellite transmitters, multtidrop modems, Ethernet, or storage modules.

12-Volt Power: The low-power design allows the CR10X to operate up to one year on a 7 Ahr, unregulated 12 Vdc source, depending on scan rate, number of sensors, data retrieval method, and external temperature.



Measurement and Control Example — Head Gates



Measurements: The CR10X measures water level upstream, downstream, and in a diversion ditch.

Data Storage/Processing/Retrieval: Data are recorded over time, showing trends. The CR10X calculates flow and summarizes the data as averages, maxima, or totals. A PC, PDA or keyboard display can show both real-time and summarized data.

Equipment Control: The CR10X controls multiple headgates based on measured conditions, flow, or time. The control capabilities of the CR10X allow levels to be maintained, even in the absence of a manager. The gates can also be controlled remotely by the water master if conditions change.

Alarms: If high or low water levels are detected, the CR10X can initiate on-site alarms, data or voice-synthesized warning calls, or activate pagers.

Applications

The measurement precision, flexibility, long-term reliability, and economical price of the CR10X make it ideal for scientific, commercial, and industrial applications.

Meteorology

The CR10X is used in long-term climatological monitoring, meteorological research, and routine weather measurement applications. Sensors the CR10X can measure include:

- cup, propeller, and sonic anemometers
- tipping bucket and weighing rain gages
- wind vanes
- evaporation pans and lysimeters
- pyranometers
- ultrasonic distance sensors
- thermistors, thermocouples, and RTDs
- capacitance and strain gage barometric pressure sensors
- RH sensors
- cooled mirror hygrometers



Weather station at Denali National Park, Alaska, monitors meteorological and soil conditions.

The CR10X can output data in your choice of units (e.g., wind speed in miles per hour, meters per second, or knots). Standard CR10X outputs include wind vector averaging, sigma, theta, histograms, saturation vapor pressure, and vapor pressure from wet/dry bulb temperatures.

Air Quality

The CR10X can monitor and control gas analyzers, particle samplers, and visibility sensors. The CR10X can also automatically control calibration sequences and compute conditional averages that exclude invalid data (e.g., data recorded during power failures or calibration intervals).



Network of approximately 20 stations continuously monitors air quality, northern Oquirrh Mountains, Utah.

Agriculture and Agricultural Research

The versatility of the CR10X allows measurement of agricultural processes and equipment in applications such as:

- plant water research
- canopy energy balance
- machinery performance
- plant pathology
- crop management decisions
- food processing/storage
- frost prediction
- irrigation scheduling
- integrated pest management



Typical agricultural research sites integrate meteorological, soil, and crop measurements.

Soil Moisture

The CR10X is compatible with the following soil moisture measurement technologies:

- **Soil moisture blocks** are inexpensive sensors that estimate soil water potential.
- **Matric water potential sensors** also estimate soil water potential but are more durable than soil moisture blocks.
- **Time-Domain Reflectometry Systems (TDR)** use a reflectometer controlled by a CR10X to accurately measure soil water content. Multiplexers allow sequential measurement of a large number of probes by one reflectometer, reducing cost per measurement.
- **Self-contained water content reflectometers** are sensors that emit and measure a TDR pulse.
- **Tensiometers** measure the soil pore pressure of irrigated soils and calculate soil moisture.

Industry

Vehicle Testing

The CR10X performs well in cold/hot temperature, high altitude, off-highway, and cross-country tests. It can measure temperature, fuel flow, velocity, acceleration, engine RPM, force, displacement, and electrical system load. The CR10X is often interfaced to a dashboard-mounted heads up display for luminescent data display in real time.

HVAC Systems

The CR10X optimizes HVAC performance by monitoring and controlling pumps, fans, and starter motors.

Process Control

Both product and assembly line status can be monitored simultaneously, providing on-line quality control while minimizing production down-time.

Water Resources

The CR10X is well-suited to remote, unattended monitoring of hydrologic conditions. Many hydrologic sensors, including SDI-12 sensors, interface directly to the CR10X.

Typical hydrologic measurements:

- **Water level** is monitored with incremental shaft encoders, double bubblers, ultrasonic level transducers, resistance tapes, or strain gage or vibrating wire pressure transducers. Some shaft encoders require a QD1 Interface. Vibrating wire transducers require an AVW1, AVW4, or AVW100 Interface.
- **Well draw-down tests** use a pressure transducer measured at logarithmic intervals or at a rate based on incremental changes in water level.
- **Ionic conductivity** measurements use one of the switched excitation ports from the CR10X.
- **Samplers** are controlled by the CR10X as a function of time, water quality, or water level.
- **Alarm and pump actuation** are controlled through digital I/O ports that operate external relay drivers.



Datalogger measures water level using a shaft encoder, then calculates flow. The data are telemetered, via radio, to the water master for further processing, review, and archive. Stilling well at diversionary dam, Emery County, Utah.

Mining, Earth Science, and Geotechnical

The small size, low power requirements, and wide operating temperature range of the CR10X make it a good choice for these remote, typically harsh applications. Multiple CR10Xs can be accessed via telemetry allowing monitoring and review of measurements across an entire study area. Vibrating wire sensors, strain gages, load cells, pressure transducers, linear and string potentiometers, GPS receivers, and frequency output devices are regularly used in these systems.

Historical Preservation



Weather measurements on the Sphinx provided input for its preservation, Cairo, Egypt.

The CR10X's small size, versatility, and expandability allow it to simultaneously monitor environmental variables that could be detrimental to works of art (e.g., relative humidity, solar radiation, air temperature, water table level, gas concentrations). By using multiplexers or SDMs, these parameters (and others) can be monitored at a number of locations in a building or across a structure. This enables comprehensive monitoring, management, remediation efforts, and documentation.

Other Applications

- Avalanche control, snow science, and Arctic research
- Highway and pavement studies
- Sporting events
- Space research



Our dataloggers measured the effects of gravity on a test structure aboard a NASA low-gravity flight.

System Description

The CR10X consists of a Measurement and Control Module and a detachable Wiring Panel. The Mean Time Between Failures (MTBF) for the CR10X is over 180 years. Standard operating range is -25° to $+50^{\circ}\text{C}$; an optional extended range of -55° to $+85^{\circ}\text{C}$ is available.

6 Differential (12 single-ended)

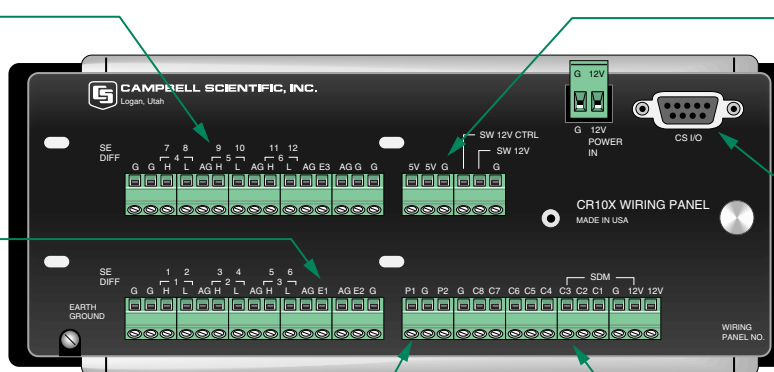
Analog Inputs for measuring voltage levels on five software selectable voltage ranges.

3 Switched Excitation Channels

for precision excitation of sensors or short-term actuation of external devices. Excitation is programmable over a ± 2500 mV range.

2 Pulse Counting Channels

for switch closures, high frequency pulses, or low level ac measurement.



Power and Ground Connections for 12 V external batteries or peripherals or for 5 V peripherals. Switched 12 V terminal is controlled by any digital output.

9-Pin CS I/O Port for connection of data storage, retrieval, and telecommunications peripherals.

8 Digital Inputs/Outputs for output control, sensing status, and reading SDM peripherals or SDI-12 sensors.

Measurement and Control Module

The module measures sensors, drives direct communications and telecommunications, reduces data, controls external devices, and stores data and programs in on-board, non-volatile storage. The electronics are RF shielded and glitch protected by the sealed, stainless steel canister. A battery-backed clock assures accurate timekeeping. The module can simultaneously provide measurement and communication functions.

The CR10X contains a comprehensive set of processing, math, and program control instructions to build a datalogger program. The maximum rate the CR10X can execute its program is 64 times per second. (The maximum rate a single input can be measured is 750 samples per second.) Data and programs are stored either in non-volatile Flash memory or battery-backed SRAM. The standard memory stores 62,000 data points. Optional versions store up to one million data points.

Datalogger Operating Systems

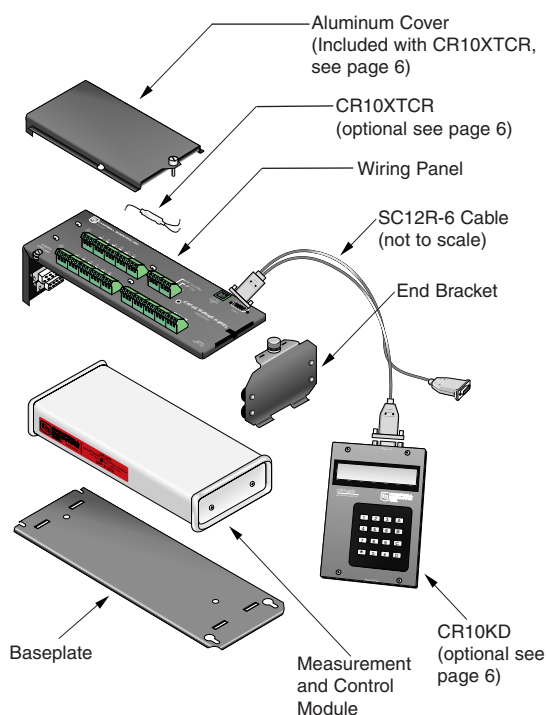
Options for the CR10X Operating System (OS) include array-based, table, Pakbus, Modbus, and ALERT. The array-based OS stores arrays of data at specified intervals or when a measured condition has been met. Two final storage areas are provided for storing the arrays. Table OS groups similar data in separate tables. Pakbus OS enables the CR10X to communicate with CR200-series dataloggers that are in the same network. Pakbus OS stores data in the same format as the table OS. The Modbus OS allows the CR10X to interface with SCADA or MMI software, and ALERT OS allows the CR10X to be used in an ALERT system. Operating System is specified at time of CR10X purchase but can be changed easily if application needs change.

SC12 and SC12R-6 Cables

The SC12 is a two-foot cable that connects communication devices to the CR10X's 9-pin serial port. The SC12 is shipped with most of our communication devices, including our phone modems, satellite transmitters, and keyboard display. The SC12R-6 is a six-foot cable that is purchased separately.

Wiring Panel

The Wiring Panel includes screw terminals for sensor connections and a 9-pin CS I/O port. An end bracket attaches the Wiring Panel to the Control Module and to an enclosure-mounted or free-standing baseplate. The Control Module easily disconnects from the Wiring Panel allowing field replacement without rewiring the sensors. Gas tubes on the wiring panel provide rugged electrostatic discharge protection.



Peripherals

Typical field-based CR10X systems include a data retrieval option, power supply, and environmental enclosure. Peripherals that expand the CR10X's measurement and control capabilities are also available.

Data Storage and Retrieval Options

To determine the best option for your application, consider the accessibility of your site, availability of services (e.g., cellular phone or satellite coverage), quantity of data to collect, and desired time between data-collection sessions.

Telephone Networks use landlines, or cellular CDMA transceivers for communications between the datalogger and PC. Our voice-synthesized modem allows a CR10X to "speak" to you or transmit data to a computer.

Radio Frequency (RF) Communications are supported via UHF, VHF, spread spectrum, or meteor burst radios.

Direct Links use either an SC32B Interface or an SC-USB Interface to provide an optically isolated connection between the CR10X and a laptop or desktop computer. The SC32B connects to a computer RS-232 port and the SC-USB connects to a USB port.

PDAs can set the CR10X's clock, monitor real-time data, retrieve data, graph data, and transfer CR10X programs. PDAs with a Palm™ OS require PConnect software (purchased separately). These PDAs communicate with the CR10X via a direct serial connection, spread spectrum radio, or the SC-IRDA infrared wireless interface. PDAs with a Windows® CE OS require PConnectCE software (purchased separately). These PDAs communicate with the CR10X via a direct serial connection or spread spectrum radio.

Short Haul Modems provide local communications between the CR10X and a PC with an RS-232 serial port.

Multidrop Interface links a central computer to one or more dataloggers over a distance of 4000 ft.

Satellite Transmitters transmit data via the GOES, or Argos, satellite systems. Campbell Scientific's SAT HDR GOES transmitter has been certified by NESDIS for High Data Rates (HDR).

Ethernet Communications Peripherals allow the CR10X to communicate over a local network or the Internet.

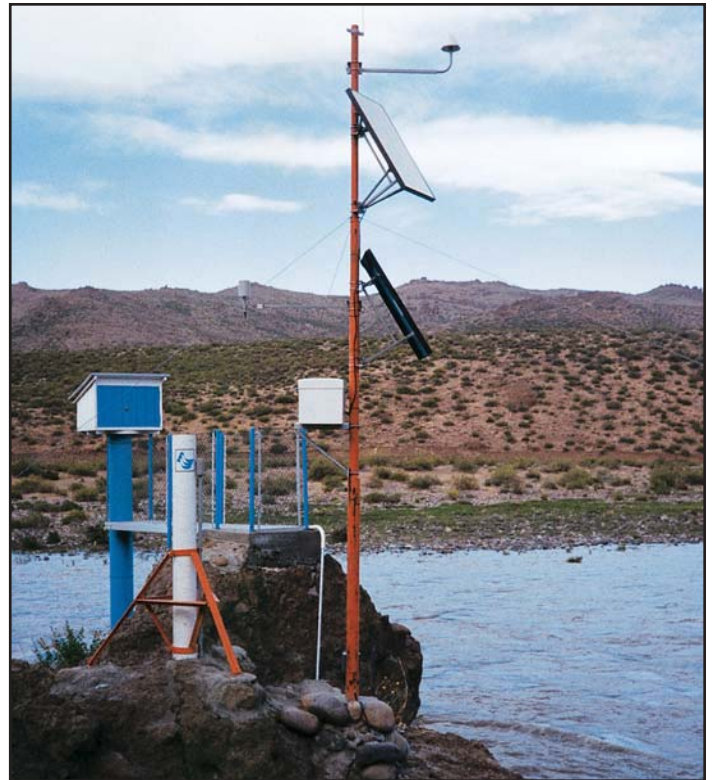
Storage Modules reliably store data and datalogger programs. This allows you to transport programs between the datalogger and PC or use the storage modules to serve as an independent backup of the datalogger data. The storage modules are not compatible with the Table and Pakbus datalogger operating systems.

CR10KD Keyboard Display programs the CR10X, manually initiates data transfer, and displays data. One CR10KD can be carried from station to station in a CR10X network.

Other Displays such as the DataView Display Unit and the DSP4 Heads Up Display can be used with the CR10X. DataView provides a two-line, 32-character LCD that displays one real-time value, a description, and units. The DSP4 Heads Up Display is typically used in vehicle testing applications.

Thermocouple Reference Thermistor

Campbell Scientific offers the CR10XTCR which provides a tem-



A satellite transmitter provides telecommunications for remote Argentine stations where phone lines are impractical.

perature reference for thermocouple measurements. It requires one single-ended analog input channel. A cover that reduces temperature gradients along the input terminals is included.

Channel Expandability

The already formidable measurement and control capabilities can be expanded using CSI multiplexers and Synchronous Devices for Measurement (SDMs). SDMs are addressable peripherals that expand digital I/O ports, plus interval channels analog output ports, and datalogger measurement capabilities. Up to 16 SDMs can be connected to three CR10X control ports.

Multiplexers increase the number of sensors that can be measured by a CR10X by sequentially connecting each sensor to the datalogger. Several multiplexers can be connected to, and controlled by, a single CR10X.

Enclosures

A CR10X housed in a weather-resistant enclosure can collect data under extremely harsh conditions. The enclosure protects the CR10X from dust, water, sunlight, or pollutants. Typically a 12" x 14" or 16" x 18" enclosure is used. They are NEMA 4X enclosures modified for cable entry. The enclosures attach to a flat surface, 1.00" to 1.25" IPS pipe, or vertical mast or leg of a tripod or tower. These white fiberglass-reinforced polyester enclosures are UV-stabilized and reflect solar radiation, reducing temperature gradients inside the housing. An internal mounting plate is prepunched for easy system configuration and exchange of equipment in the field. A lockable hasp adds security.

Power Supplies

Any 12 Vdc source can power the CR10X; a PS100 or BPALK is typically used. The PS100 includes one 7 Ahr rechargeable battery, charged with ac power (requires the optional wall charger) or a solar panel. The BPALK consists of eight non-rechargeable D-cell alkaline batteries with a 7.5 Ahr rating at 20°C. An external AA-cell pack that supplies power while the D-cells are replaced is included.

The BP12 and BP24 battery packs are also available. The BP12 and BP24 have nominal ratings of 12 and 24 Ahrs, respectively. The batteries should be connected to a charging regulator and a charging source. For information about analyzing your system's power requirements, see our Power Supply product literature or Application Note 5-F. Both can be obtained from www.campbellsci.com



Systems that include high current drain peripherals such as satellite transmitters or are located where it's inconvenient to replace batteries might require batteries with larger Ahr capacities than our PS100 or BPALK. Campbell Scientific offers the BP12 and BP24 battery packs for these systems.

Software Packages

Campbell Scientific software supports datalogger programming, communications between the datalogger and PC, and data display. Brief descriptions follow; for more information, see our literature or Web site.

Starter Software

Our Starter Software can be downloaded at no charge from www.campbellsci.com/resource.html. Our Resource CD also provides this software as well as PDF versions of our literature and manuals.

SCWin Program Builder creates datalogger programs requiring only sensor measurement and data output. It supports 120 sensors and multiplexers.

PC200W Starter Software allows you to transfer a program to, or retrieve data from, a CR10X via a direct communications link.

Datalogger Support Software

The LoggerNet 2.X-series is our full-featured software package that supports:

- direct connection and telecommunications links
- combinations of communication options (e.g., phone-to-RF)
- manual and scheduled data collection
- programming for most commercially available sensors as well as devices such as SDMs, multiplexers, and relays
- storage module communication
- multitab data displays that can include alarms, sliders, graphs, toggles, tables and/or gauges

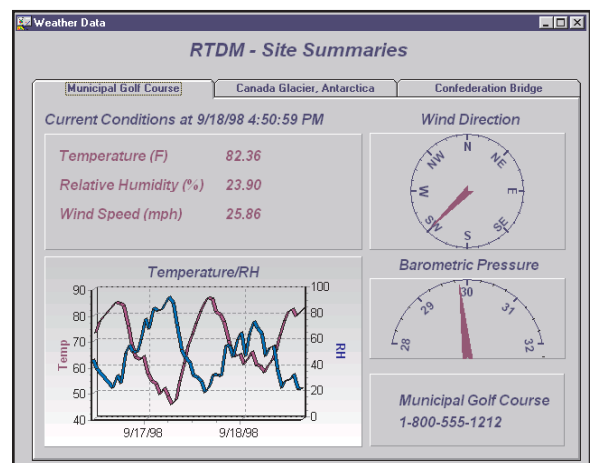
Campbell Scientific offers several programs that are intended to be used with our LoggerNet software. All of these programs require a licensed copy of LoggerNet running on a PC. The programs are:

- **Baler** stores LoggerNet data into new files so that the data can be imported to a data base or third-party analysis program
- **RTMC Web Server** converts real-time data displays into HTML files
- **RTMCRT** allows remote PCs to display and print real-time data

- **LoggerNetData** allows users at remote PCs to post-process LoggerNet data, generate reports, and display LoggerNet data
- **CSI OPC server** allows third-party OPC compatible graphic packages to view our datalogger data
- **LoggerNet-SDK** allows software developers to create and freely distribute custom applications that communicate with our dataloggers

Real-Time Data Monitor (RTDM)

RTDM allows experienced users to create custom graphic screens. RTDM supports automatic generation of JPEG output for Internet display. Developer and display-only versions are also available.



RTDM is powerful, versatile software that can display real-time or archived data in bar, lines, area, or point charts. Automatic generation of JPEG outputs facilitates displaying information on Internet pages.

CR10X Specifications

Electrical specifications are valid over a -25° to +50°C range unless otherwise specified; non-condensing environment required. To maintain electrical specifications, Campbell Scientific recommends recalibrating dataloggers every two years.

PROGRAM EXECUTION RATE

Program is synchronized with real-time up to 64 Hz. One channel can be measured at this rate with uninterrupted data transfer. Burst measurements up to 750 Hz are possible over short intervals.

ANALOG INPUTS

NUMBER OF CHANNELS: 6 differential or 12 single-ended, individually configured. Channel expansion provided by AM16/32 or AM416 Relay Multiplexers and AM25T Thermocouple Multiplexers.

ACCURACY: $\pm 0.1\%$ of FSR (-25° to 50°C);
 $\pm 0.05\%$ of FSR (0° to 40°C);
e.g., $\pm 0.1\%$ FSR = ± 5.0 mV for ± 2500 mV range

RANGE AND RESOLUTION:

Full Scale Input Range (mV)	Resolution (μ V)	
	Differential	Single-Ended
± 2500	333	666
± 250	33.3	66.6
± 25	3.33	6.66
± 7.5	1.00	2.00
± 2.5	0.33	0.66

INPUT SAMPLE RATES: Includes the measurement time and conversion to engineering units. The fast and slow measurements integrate the signal for 0.25 and 2.72 ms, respectively. Differential measurements incorporate two integrations with reversed input polarities to reduce thermal offset and common mode errors.

Fast single-ended voltage:	2.6 ms
Fast differential voltage:	4.2 ms
Slow single-ended voltage:	5.1 ms
Slow differential voltage:	9.2 ms
Differential with 60 Hz rejection:	25.9 ms
Fast differential thermocouple:	8.6 ms

INPUT NOISE VOLTAGE (for ± 2.5 mV range):
Fast differential: 0.82 μ V rms
Slow differential: 0.25 μ V rms
Differential with 60 Hz rejection: 0.18 μ V rms

COMMON MODE RANGE: ± 2.5 V

DC COMMON MODE REJECTION: >140 dB

NORMAL MODE REJECTION: 70 dB (60 Hz with slow differential measurement)

INPUT CURRENT: ± 9 nA maximum

INPUT RESISTANCE: 20 Gohms typical

ANALOG OUTPUTS

DESCRIPTION: 3 switched, active only during measurement, one at a time.

RANGE: ± 2.5 V

RESOLUTION: 0.67 mV

ACCURACY: ± 5 mV; ± 2.5 mV (0° to 40°C)

CURRENT SOURCING: 25 mA

CURRENT SINKING: 25 mA

FREQUENCY SWEEP FUNCTION: The switched outputs provide a programmable swept frequency, 0 to 2.5 V square wave for exciting vibrating wire transducers.

RESISTANCE MEASUREMENTS

MEASUREMENT TYPES: The CR10X provides ratiometric bridge measurements of 4- and 6-wire full bridge, and 2-, 3-, and 4-wire half bridges. Precise dual polarity excitation using any of the switched outputs eliminates dc errors. Conductivity measurements use a dual polarity 0.75 ms excitation to minimize polarization errors.

ACCURACY: $\pm 0.02\%$ of FSR plus bridge resistor error.

PERIOD AVERAGING MEASUREMENTS

The average period for a single cycle is determined by measuring the duration of a specified number of cycles. Any of the 12 single-ended analog input channels can be used. Signal attenuation and ac coupling are typically required.

INPUT FREQUENCY RANGE:

Signal peak-to-peak ¹ Min.	Max.	Min. Pulse w.	Max Freq. ²
500 mV	5.0 V	2.5 μ s	200 kHz
10 mV	2.0 V	10 μ s	50 kHz
5 mV	2.0 V	62 μ s	8 kHz
2 mV	2.0 V	100 μ s	5 kHz

¹Signals centered around datalogger ground

²Assuming 50% duty cycle

RESOLUTION: 35 ns divided by the number of cycles measured

ACCURACY: $\pm 0.01\%$ of reading (number of cycles 100)
 $\pm 0.03\%$ of reading (number of cycles <100)

TIME REQUIRED FOR MEASUREMENT: Signal period times the number of cycles measured plus 1.5 cycles + 2 ms

PULSE COUNTERS

NUMBER OF PULSE COUNTER CHANNELS: 2 eight-bit or 1 sixteen-bit; software selectable as switch closure, high frequency pulse, and low level ac.

MAXIMUM COUNT RATE: 16 kHz, eight-bit counter; 400 kHz, sixteen-bit counter. Channels are scanned at 8 or 64 Hz (software selectable).

SWITCH CLOSURE MODE

Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Maximum Bounce Time: 1 ms open without being counted

HIGH FREQUENCY PULSE MODE

Minimum Pulse Width: 1.2 μ s
Maximum Input Frequency: 400 kHz
Voltage Thresholds: Count upon transition from below 1.5 V to above 3.5 V at low frequencies. Larger input transitions are required at high frequencies because of input filter with 1.2 μ s time constant. Signals up to 400 kHz will be counted if centered around ± 2.5 V with deviations ± 2.5 V for 1.2 μ s.
Maximum Input Voltage: ± 20 V

LOW LEVEL AC MODE

(Typical of magnetic pulse flow transducers or other low voltage, sine wave outputs.)

Input Hysteresis: 14 mV

Maximum ac Input Voltage: ± 20 V

Minimum ac Input Voltage:

(Sine wave mV RMS)	Range (Hz)
20	1.0 to 1000
200	0.5 to 10,000
1000	0.3 to 16,000

DIGITAL I/O PORTS

8 ports, software selectable as binary inputs or control outputs. 3 ports can be configured to count switch closures up to 40 Hz.

OUTPUT VOLTAGES (no load): high 5.0 V ± 0.1 V;
low < 0.1 V

OUTPUT RESISTANCE: 500 ohms

INPUT STATE: high 3.0 to 5.5 V; low -0.5 to 0.8 V

INPUT RESISTANCE: 100 kohms

SDI-12 INTERFACE STANDARD

Digital I/O Ports C1-C8 support SDI-12 asynchronous communication; up to ten SDI-12 sensors can be connected to each port. Meets SDI-12 Standard version 1.2 for datalogger and sensor modes.

CR10XTCR THERMOCOUPLE REFERENCE

POLYNOMIAL LINEARIZATION ERROR: Typically $\pm 0.5^\circ\text{C}$ (-35° to +50°C), $\pm 0.1^\circ\text{C}$ (-24° to +45°C).

INTERCHANGEABILITY ERROR: Typically $\pm 0.2^\circ\text{C}$ (0° to +60°C) increasing to $\pm 0.4^\circ\text{C}$ (at -35°C).

CE COMPLIANCE (as of 09/01)

STANDARD(S) TO WHICH CONFORMITY IS DECLARED:

EN55022: 1995 and EN61326: 1998

EMI and ESD PROTECTION

IMMUNITY: Meets or exceeds following standards:
ESD: per IEC 1000-4-2; ± 8 kV air, ± 4 kV contact discharge

RF: per IEC 1000-4-3; 3 V/m, 80-1000 MHz

EFT: per IEC 1000-4-4; 1 kV power, 500 V I/O

Surge: per IEC 1000-4-5; 1 kV power and I/O

Conducted: per IEC 1000-4-6; 3 V 150 kHz-80 MHz

Emissions and immunity performance criteria available on request.

CPU AND INTERFACE

PROCESSOR: Hitachi 6303

PROGRAM STORAGE: Up to 16 kbytes for active program; additional 16 kbytes for alternate programs. Operating system stored in 128 kbytes Flash memory.

DATA STORAGE: 128 kbytes SRAM standard (approximately 60,000 data values). Additional 2 Mbytes Flash available as an option.

OPTIONAL KEYBOARD DISPLAY: 8-digit LCD (0.5" digits)

PERIPHERAL INTERFACE: 9 pin D-type connector for keyboard display, storage module, modem, printer, card storage module, and RS-232 adapter.

BAUD RATES: Selectable at 300, 1200, 9600 and 76,800 bps for synchronous devices. ASCII communication protocol is one start bit, one stop bit, eight data bits (no parity).

CLOCK ACCURACY: ± 1 minute per month

SYSTEM POWER REQUIREMENTS

VOLTAGE: 9.6 to 16 Vdc

TYPICAL CURRENT DRAIN: 1.3 mA quiescent, 13 mA during processing, and 46 mA during analog measurement.

BATTERIES: Any 12 V battery can be connected as a primary power source. Several power supply options are available from Campbell Scientific. The Model CR2430 lithium battery for clock and SRAM backup has a capacity of 270 mAh.

PHYSICAL SPECIFICATIONS

SIZE: 7.8" x 3.5" x 1.5" - Measurement & Control Module; 9" x 3.5" x 2.9" - with CR10WP Wiring Panel. Additional clearance required for serial cable and sensor leads.

WEIGHT: 2 lbs

WARRANTY

Three years against defects in materials and workmanship.

We recommend that you confirm system configuration and critical specifications with Campbell Scientific before purchase.



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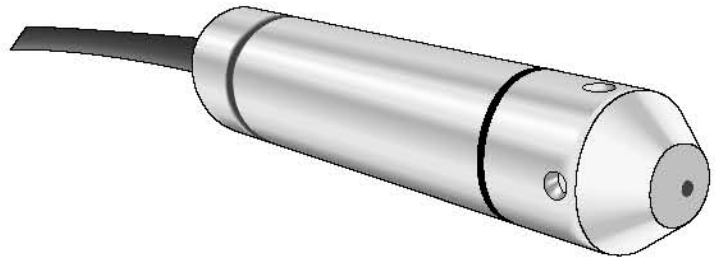
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Printed March 2004

Submersible Pressure Transducers

Models Keller169-L and Keller173-L

These submersible pressure transducers, manufactured by Pressure Systems, measure surface water, ground water, or hostile fluid levels. They are piezoresistive sensors that incorporate an isolated stainless steel diaphragm into a stainless steel package. The sensor assembly is housed in welded 316 SS or titanium case that includes a diaphragm shield for protection against debris.



Each transducer is shipped with a calibration sheet. The sheet specifies I/O conditions, as well as actual data reflecting the unit's static accuracy and thermal characteristics. Each vented transducer is also shipped with a desiccant tube to extract water vapor from air entering the vent tube.

These units are designed for installation in a Class 1, Division 1, Groups A, B, C and D; Class II, Division 1, Groups E, F and G; and Class III Division 1 hazardous location when connected to an approved electrical barrier.

Features

- High static accuracy and repeatability
- Small, rugged package
- User-specified pressure ranges available
- Welded 316 stainless steel construction
- Computer tested, calibrated and serialized
- Unique cable seal system
- Fully temperature compensated
- Compatible with Campbell Scientific's CR510, CR10(X), CR23X, CR7, CR5000 and CR9000 dataloggers

Ordering Information

When ordering a transducer, specify the desired psi range, choose either a polyurethane-jacketed or Tefzel-jacketed cable and specify the lead length, in feet, after the L.

Keller169_L	Four-wire pressure transducer with an accuracy of $\pm 0.25\%$ FSO. Compatible with the PST3/8 system and connects directly to a multiplexer. Requires an L7977 resistor assembly to connect with a datalogger.
Keller173_L	Four-wire pressure transducer with an accuracy of $\pm 0.1\%$ FSO. Compatible with the PST3/8 system and connects directly to a multiplexer. Requires an L7977 resistor assembly to connect to a datalogger.
L7977	100 Ohm Shunt Resistor Assembly for the Keller169-L or Keller173-L
L14421	Optional titanium housing for the Keller169-L or Keller173-L
L13462	Optional $\frac{1}{4}$ " NPT Pressure Cap
L7421	Optional Split Mesh Grip

Manufacturer's Specifications (Pressure Systems)

Performance

User Specified Pressure Ranges:	0-2 through 0-300 psig (Keller169-L, Keller173-L)
Static Accuracy:*	$\pm 0.25\%$ FSO BFSL (Keller169-L) $\pm 0.1\%$ FSO BFSL (Keller173-L)
Thermal Error:**	0.022% FSO $^{\circ}\text{C}^{-1}$ worst case
Proof Pressure:	1.5 x rated pressure
Burst Pressure:	2.0 x rated pressure
Resolution:	Infinitesimal

* Static accuracy includes the combined errors due to nonlinearity, hysteresis and nonrepeatability on a Best Fit Straight Line (BFSL) basis, at 25°C, per ISA S51.1.

**Thermal error is the maximum allowable deviation from the Best Fit Straight Line due to a change in temperature, per ISA S51.1.

Environmental

Compensated temperature range:	0° to 27°C
Operating temperature range:	-20° to 60°C

Physical

Weight:	4 oz., 113 g (not including cable)
Cable:	Polyurethane-jacketed or Tefzel-jacketed, shielded cable with polyethylene vent tube and Kevlar tension members. Pull strength is 200 lbs. Conductors are 22 awg. Approximate weight is 0.04 lb, (18 g) per foot. Polyurethane-jacketed cables contain water-block tape to prevent moisture intrusion through small cuts in the cable from reaching the transducer.
Dimensions:	
Transducer:	4.5" (11.4 cm) length, 1.0" (2.5 cm) diameter
Cable:	0.28" (0.71 cm) diameter
Output:	30 to 65 mV full scale at 0.5 mA excitation, ratiometric (Keller169-L, Keller173-L)



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Spread Spectrum Radio Modems

Models RF400, RF410, RF415

Spread spectrum radios spread the normally narrowband information signal over a relatively wide band of frequencies. This allows the communications to be more immune to noise and interference from RF sources such as pagers, cellular phones and multipath.¹ The RF400-series modems reduce susceptibility to RF interference from other spread spectrum devices by providing user-selectable frequency hopping patterns.

The RF400-series spread spectrum radio modems support point-to-point and point-to-multipoint datalogger communications. They can serve as a field modem/radio while connected to the datalogger or as a base station modem/radio when connected to a computer. The RF400-series modems can also be used for general purpose wireless data communications.



Features

- Individual FCC license not required²
- Transmission distance of one to 10 miles using inexpensive omnidirectional antennas (shown), several times that using higher gain directional antennas (please note that line-of-sight obstructions and RF interference will affect transmission distance)
- Low power consumption
- 9-pin CS I/O port that connects directly to the datalogger (no additional interface required)
- 9-pin RS-232 port that connects directly to a computer serial port or other RS-232 device
- 25-channel frequency-hopping radio
- Built-in simplified and advanced setup menus for configuring port modes, network/radio addresses, hop table, and power saving modes
- Setup that allows different addresses for multiple dataloggers in a point-to-multipoint network (call about repeater capability)
- Settings stored in non-volatile memory

1. The operating frequency band of these radio modems may be shared with other non-licensed services such as cordless telephones and with licensed services including emergency, broadcast, and air-traffic control.
2. RF400-series modems, like all FCC Part 15 devices, are not allowed to cause harmful interference to licensed radio communications and must accept any interference that they receive. Most Campbell Scientific users operate in open or remote locations where interference is unlikely. If there is a problem, interference can be reduced using methods such as moving the device, reorienting or using a different type of antenna, or adding RF shielding. We recommend the use of licensed UHF or VHF narrowband frequencies for critical communication links.



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Specifications

Operating Frequency:	910 to 918 MHz RF400, 920 to 928 MHz RF410, 2.450 to 2.460 GHz RF415
Type:	Frequency Hopping Spread Spectrum (FHSS) Transceiver
I/O Data Rate:	9600 bps
Channel Capacity:	65,000 Network Identifiers share 25 hop channels
Frequency Hopping Patterns:	Six different selectable patterns
Frequency Control:	Direct FM
Receiver Sensitivity:	-110 dBm (-104 dBm RF415) at 10^{-4} bit error rate (Campbell Scientific protocols will issue retries wherever a bit error occurs)
Interference Rejection:	70 dB at pager and cellular phone frequencies
Transmitter Power Output:	100 mW nominal (RF400, RF410) 60 mW nominal (RF415)
Antenna Connector:	Reverse polarity SMA
FCC ID:	OUR9XTREAM (RF400, RF410) OUR-24XSTREAM (RF415)
Operating Temperature Range:	-25° to +50°C standard, -55° to +85°C extended
Dimensions:	4.75 x 2.75 x 1.3 inches (12.1 cm x 7.0 cm x 3.3 cm)
Power:	9 to 16 Vdc
Average Current Drain:	<1 mA stand-by (assuming power-saving options used), 24 mA while receiving, <75 mA while transmitting (RF400, RF410) 36 mA while receiving, 75 mA while transmitting (RF415)
LEDs:	Power on, TX, RX, diagnostics
CS I/O Connector:	9-pin "D" Male for all needed communications lines. Newer loggers provide power to the radio on this connector. Older loggers may require optional power cable #14291*
RS-232 Connector:	9-pin "D" Female for TX, RX, CTS, ground RS-232 levels
Power Connector:	Barrel connector, center positive 12 V for use in base station configuration or with older dataloggers (newer loggers provide power to the radio on the CS I/O connector)
Compatible Devices:	21X(L), CR10(X)*, CR200-series, CR23X, CR510, CR7, CR5000, CR500, RAD Modem, and COM200/COM210 (with A100/PS100 at a nondatalogger site)

**Older wiring panels (CR10 silver or CR10 black with gray terminal strips) will require optional power cable L14291.*

RF415 antennas

2.4 GHz, Indoor Omnidirectional

- L16005 0 dBd, ½ wave whip articulating. RPSMA connector connects directly to radio; no antenna cable needed.



The L16005 antenna has an articulating knuckle joint that can be oriented vertically or at right angles.

2.4 GHz, Outdoor Yagi

- L16755 13 dBd with mounts. Has Type N female connector; requires an antenna cable to connect to radio.



For the L16755 Yagi antenna, the primary and secondary elements are enclosed in a white cylinder.

Antenna Cables and Surge Protectors for Outdoor Antennas

Recommended for cable lengths <10 ft

- COAX RPSMA-L Low-loss RG58 antenna cable with reverse polarity, SMA connector and type N male connector. Specify length, in feet, after L.

Recommended for cable lengths >10 ft and/or use with lightning protection

- RG8 NM/NM-L Low-loss RG8 antenna cable with type N male to type N male connectors (requires L14462 or L16982). Specify length, in feet, after L.

- L14462 Antenna surge protector kit for 900 MHz radios. Includes one COAX RPSMA-L1.5. Requires RG8 NM/NM-L cable.

- L16982 Antenna surge protector kit for 2.4 GHz radios. Includes one COAX RPSMA-L1.5. Requires RG8 NM/NM-L cable.



The purchase of an antenna cable (COAX RPSMA-L shown) is required for our outdoor antennas.

Additional accessories

- L14162 Mounting bracket kit
L14291 Optional power cable



The surge protectors help protect the radios from electrical transients conducted through the antenna cable.

APPENDIX C
SITE-SPECIFIC WATER QUALITY OBJECTIVES

Technical Memorandum N

**Estimates of Receiving Water Quality
for the Jericho Project, Nunavut**

**Report Prepared for
Tahera Corporation**

Report Prepared by



August 2004

Technical Memorandum N

Estimates of Receiving Water Quality for the Jericho Project, Nunavut

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1 Introduction

This report provides revised estimates of receiving water quality for the Jericho Project in Nunavut, as requested during the NIRB hearings in January 2004. These estimates supercede those presented in the “*Jericho Final EIS*” (Tahera 2003), supplemental memorandum “*Water Quality Impacts from Jericho Mine Drainages*”(AMEC 2003), and the errata “*Ammonia Discharges from PKCA*” issued during the final EIS hearings (AMEC 2004b).

The revised receiving water quality estimates were derived using additional dilution modelling to estimate the potential build-up of TDS, specific TDS components, nutrients and metals in Lake C3 and Carat Lake during mining and into the post-closure period. Minor changes in the discharge flow and water quality estimates resulting from minor revisions to the layout of the mine site facilities and water management plans are incorporated, and post-closure water quality estimates are provided.

The revised receiving water quality estimates are compared to the available CCME guidelines for receiving water quality and potential impacts to freshwater aquatic life and human health are discussed. A review of the potential environmental effects of TDS is also provided.

This report is organized as follows:

- Section 2 summarizes information on the discharge flows and concentrations from the updated water and load balance presented in the accompanying report “*Site Water Management* (SRK 2004a), and presents earlier estimates of receiving water flows for both average and low flow conditions.
- Section 3 presents the methods and results of dilution modelling completed by Lorax Environmental, that was used to calculate the available dilution capacity in the receiving environment;
- Section 4 presents final estimates of receiving water quality, and a discussion of potential impacts to the receiving environment;
- Section 5 presents a summary and conclusions; and
- Section 6 lists references to other work.

SRK would like to acknowledge significant contributions to this work made by Don Dunbar of Lorax Environmental (Princeton Ocean and CORMIX modelling), Bruce Ott of AMEC (impact assessment, review), and James Elphick of AMEC (Review of ecological effects of TDS).

2 Background Information

2.1 Discharge Flows and Concentrations

2.1.1 Operations

The updated water and load balance provided in the accompanying report “*Site Water Management*” (SRK 2004a) was used to estimate discharge flows and concentrations from the Processed Kimberlite Containment Area (PKCA) during operations. It should be noted that these differ slightly from the results presented in “*Technical Memorandum F – Water and Load Balance*” (SRK 2003a) of the supplemental EIS, due to minor changes to the layout of the waste rock dumps and water management plans. In addition, as requested by technical reviewers, specific components of the TDS are also included in the estimates. However, the total loading from the site, and therefore potential impacts to the receiving environment resulting from these changes, are lower than predicted in the EIS. Further discussion of the revised water and load balance, including the derivation of source concentrations for the TDS components, is provided in SRK 2004a.

Monthly discharge flows for average and low flow conditions used in the dilution modelling are presented in Table 1. It should be noted that these flows are approximately 5% higher than the final values presented in “*Site Water Management*” (SRK 2004a) due to adjustments made to the contributory catchment areas after the dilution modelling work had been initiated. The annual and monthly release volumes presented in SRK 2004a are considered final. Therefore, actual dilution is expected to be slightly higher and actual receiving water concentrations slightly lower than indicated in this report. Annual discharges from the site are expected to be approximately 510,000 m³ for an average year, or 366,000 m³ for a low flow year. The flows would be paced with receiving water flows to maximize dilutions in the receiving environment, as shown in Table 1.

Discharge concentrations are presented in Table 2. These reflect maximum concentrations expected in the PKCA discharges over the life of the mine. As illustrated in Figure 1, concentrations will increase over the first few years of the mine life, and will fluctuate seasonally due to seasonal inputs. For simplicity, the calculations used to estimate the changes in PKCA discharge concentrations over time assumed that the waste rock dumps and ore stockpiles would be fully in place starting in Year 1, and that seepage and runoff would reach peak concentrations in the first year of operations. In reality, the build-up of concentrations in the PKCA will be more gradual due to staged construction and wetting-up of these facilities over the first few years of the mine life. Therefore, it is expected that the initial concentrations will be substantially lower than the values presented in Table 2, and that the build-up of concentrations in the PKCA discharges will be more gradual than indicated in Figure 1.

Under base-case operating assumptions, water meeting the discharge criteria for the site will be released directly from the PKCA via Stream C3 to Lake C3 starting in the first year of operations. However, if necessary, the PKCA has sufficient capacity to store water for one to two years of

operations, which will allow additional time in the PKCA for settling, attenuation and mixing with other inflows, all of which would result in improved water quality. The provision for storage would also allow sufficient time to develop the spray irrigation system, currently proposed as a contingency plan for water treatment. Flows from the PKCA, assuming storage during the first year of operations and release of all excess flows during second year, are presented in Table 3.

2.1.2 Post-Closure

Immediately following operations, flows from the waste rock dumps, coarse processed kimberlite (coarse PK) stockpile and low-grade stockpile will be directed to the open pit. Discharges from the PKCA will be reduced to a nominal level reflecting local runoff to the PKCA (Table 4). As noted in the preceeding section, the flows differ slightly from the values presented in “*Site Water Management*” (SRK 2004a) due to some minor adjustments in areas. The values in SRK 2004a are considered final, and the changes have a negligible effect the dilution modelling results.

The current closure plans for the PKCA call for placement of a cover of approximately 0.5 m of coarse PK on top of the fine PK, and possibly placement of soil or overburden to promote revegetation. As freezing of the underlying fine PK progresses, interaction between local runoff and materials in the PKCA will be dominated by the coarse PK layer, and discharge water quality will reflect interaction with this relatively thin layer of coarse PK and soil. Post-closure source concentrations for this cover were not estimated in the previous work (SRK 2003c). However, the general approach and basis for the estimates is similar:

1. Source concentrations for the coarse PK stockpile were compared to source concentration estimates for “disturbed ground”:
 - if the concentrations for “disturbed ground” were higher than the concentrations for “unadjusted coarse PK stockpile concentrations”, the “unadjusted coarse PK concentrations” were used to represent post closure runoff quality from the PKCA.
 - if the concentrations from “disturbed ground” were lower than the “unadjusted coarse PK stockpile concentrations”, the coarse PK stockpile concentrations were divided by 10 to account for the differences in thickness between the stockpile and the PKCA cover, and:
 - if the values from “disturbed ground” were higher than the “adjusted coarse PK stockpile concentrations”, the “disturbed ground concentrations” were used.
 - if the values from “disturbed ground” were lower than the “adjusted coarse PK stockpile concentrations”, the “adjusted coarse PK stockpile concentrations were used.
2. In the case of iron and aluminum, concentrations were further adjusted by applying dissolved concentrations for these parameters. These were considered more representative of post-closure conditions, where suspended sediments are unlikely to be an issue.

The resulting post-closure concentrations for the PKCA are summarized in Table 5.

The closure plan assumes that all discharges from the waste rock dumps and stockpiles will be directed to the open pit following cessation of mining operations. Flows in Stream C1 will be maintained to a level that is sufficient to support fish habitat. Calculations from the water and load balance indicate that it will take 15 to 20 years for the pit to fill. This will allow sufficient time for flushing and removal of any blasting residues from the active layers of the pile. Freeze back of the dumps is also expected to occur in the first few years following deposition, which will reduce the exposed surface area and “lock-up” porewater, and therefore available loading from the rock. These processes are accounted for in the post-closure estimates of waste rock and pit lake water quality presented in Appendix B of the Abandonment and Restoration Plan (SRK 2004b, in AMEC 2004c). The post-closure water quality estimates indicate that concentrations of some metals could exceed CCME guidelines for freshwater aquatic life or CCME/Health Canada guidelines for drinking water in the pit lake.

Monitoring of seepage and runoff during operations and the post closure filling period will be needed to refine the estimates of long term water quality. If the updated estimates indicate the pit water will meet CCME guidelines for freshwater aquatic life or can be demonstrated to have negligible impacts on aquatic life, the diversion will be breached, the upper part of Stream C1 will be allowed to flow into the pit, and the pit will be allowed to spill into the original Stream C1 channel. If the revised estimates indicate the pit will not meet CCME guidelines, but could be discharged without significant impacts at the shore of Carat Lake, the diversion will be maintained, and water will be discharged via a constructed channel to the northeast of Stream C1 (see accompanying Drawing G-14). In the unlikely event that the pit water quality would be unacceptable for discharge, contingency measures such as in-pit biological treatment could be used to reduce concentrations to levels acceptable for discharge (“*Jericho Post Closure Pit Lake Water Treatment*” (SRK 2004c), in AMEC 2004c).

Stream C1 flows and pit discharge rates were estimated from the water and load balance. The timing of the peak flows from the pit was delayed by two weeks relative to that in Stream C1 to reflect storage in the waste dumps and open pit during the initial part of freshet. Final flow estimates are presented in Table 6. Current estimates of post-closure concentrations in the pit discharges are presented in Table 7.

2.2 Receiving Water Flows

Monthly estimates of average and 10 year low flows were made for:

- Jericho River immediately upstream of Lake C3,
- lateral inflows to Lake C3, and
- lateral inflows to Carat Lake.

The combination of all three synthesized records represents the outflow from Carat Lake. The receiving water flows were estimated using a technique known as Regional Analysis, which is a means of inferring the flows of an un-gauged stream using the measured flow records of streams in the region. The steps undertaken to estimate average flows in the Jericho River are described in *Technical Memorandum C: Supplemental Climate and Hydrology* (SRK 2003b). The analysis for estimating low flow conditions differs slightly, and is presented in Attachment N1 of this report. Average monthly and 10 year low flow estimates are provided in Table 8. Figure 2 shows two hydrographs for this location, one representing the flows during a 10-year drought and the other during average meteorological conditions.

For the dilution modelling, it was desirable to break the monthly flows into increments of one week. This was achieved by apportioning the monthly flows according to the average weekly hydrographs of regional stream-flow gauging stations. Table 9 summarizes the estimated weekly flows.

2.3 Lake Volumes

The volumes of Lake C3 and Carat Lake were estimated based on bathymetries prepared as part of the baseline studies (*“Jericho Final EIS, Appendix B.1.1 – Baseline Summary Report, Section 13.2”*, Tahera 2003). Lake C3 has a volume of approximately 4,740,000 m³ and Carat Lake has a volume of approximately 27,200,000 m³.

3 Dilution Modelling

3.1 Methods

3.1.1 Box Model

A simple spreadsheet based mixing model of the Lake C3/Carat lake system was set-up to model monthly variations in whole-lake concentrations in Lake C3 and Carat Lake from the start of construction to 5 years after the pit lake begins to spill into Carat Lake. The advantage of this type of model is that it can be used to rapidly simulate changes in concentration over time resulting from build-up of loading in the two lake system. However, because it assumes complete mixing of the discharges, it does not adequately simulate spatial variations in concentration at a given time-step resulting from time dependent mixing processes. Therefore, the output from this model was used as a starting condition for additional modelling using the Princeton Ocean Model (Section 3.1.2) to simulate spatial variations in the lakes.

The basic steps in the spreadsheet based model are:

1. Calculate the start-of-month inventory of load within each lake (lake volume x starting concentration).
2. Calculate the incremental loading from the discharge and/or the upstream environment (sum of concentration x flow for each inflow sources).
3. Calculate the end-of-month inventory by adding the incremental loading to the start-of-month inventory.
4. Calculate the overall concentration in each lake by dividing the end-of-month inventory by the total volume of water in the lake plus any inflows to the lake.
5. Calculate the load leaving the system by multiplying the concentration from above by the outflow.
6. Calculate the new starting inventory of load within the lake by subtracting the previous month's load out from the previous month's end-of-month inventory.
7. Repeat steps 2 through 6 for each subsequent month of simulation.

For convenience, discharge concentrations were assigned a nominal value of 1 mg/L, while background concentrations were assigned a value approaching 0 (0.0001 mg/L). This allowed calculation of a dilution factor ($D = C_o/C_t$), where C_o was the initial discharge concentration of 1, and C_t was the modelled concentration in the receiving water at time t . This approach is consistent with

the approach used in previous dilution modelling on this project (“*Jericho Final EIS, Appendix D.1.2, Numerical Simulation of the Dilution of Polishing Pond Effluent in Lake C3*”, Tahera 2003, “*Numerical Simulation of the Dilution of Polishing Pond Effluent in Lake C3 and Carat Lake*”, Greisman 2003), and eliminates the need for separate dilution calculations for each parameter. However, as discussed in Section 4.1, a correction is needed to account for parameter specific background loading in the receiving environment.

The spreadsheet model was used to simulate a number of different scenarios of discharge and receiving water flows, including:

- *Scenario 1*: Release of average discharge flows into average flows in the receiving environment throughout operations (base case).
- *Scenario 2*: As above, with low flows in both discharges and receiving environment at years 2010 and 2013 (i.e. after build-up has occurred in the system).
- *Scenario 3*: Release of stored flows from two average years (one year of storage) into average flows in the receiving environment. *Scenario 3a* assumes the release of stored flows would be in the second year of operations, *Scenario 3b* assumes the release of stored flows would be in the fourth year of operation.

Discharge and receiving water flows for each of the above conditions were as presented in Sections 2.1 and 2.2.

3.1.2 Princeton Ocean Model

The results of the box model were used to calculate the increase and reduction of whole lake concentrations in Lake C3 and Carat Lake over the life of mine and into post closure. The Princeton Ocean Model (POM) was used to show how these concentrations could be distributed in the lakes after any build-up of concentration over time has occurred. The modelling was completed by Lorax Environmental, with the effluent and receiving water flow inputs provided by SRK.

The model is suitable for calculating time-varying physical properties in a variety of water bodies, and simulates all of the physical processes that affect circulation and mixing, including:

- Horizontal and vertical currents
- Vertical stratification by temperature and/or salinity
- Vertical and horizontal turbulent mixing
- Vertical fluctuations in surface elevation
- Freshwater discharges
- Surface wind stress and heat fluxes

The Princeton Ocean Model was used for earlier simulations of average and low flow conditions in the receiving environment (*"Jericho Final EIS, Appendix D.1.2"*, Tahera 2003, *"Numerical Simulation of the Dilution of Polishing Pond Effluent in Lake C3 and Carat Lake"*, Greisman 2003). Details on the model configuration and fixed environmental variables such as bathymetry, duration of ice cover, wind direction and speed, etc. were the same as in the earlier modelling work. Minor changes to the model configuration to reduce run times are documented in Attachment N2. Due to the long simulation times required for this model, the box model was used to generate starting concentrations that reflected any build-up of concentrations in the lakes from previous years of discharge.

Based on the results of the box model, two operational discharge scenarios and one post-closure discharge scenario were selected for modelling:

- *Scenario 4:* Release of average discharge flows into average flows in the receiving environment, with starting concentrations from the box model Scenario 1 outputs. The original 40 x 40 metre grid used in the December 2003 simulations (*"Numerical Simulation of the Dilution of Polishing Pond Effluent in Lake C3 and Carat Lake"*, Greisman 2003) was used for these runs, except the model domain was restricted to Lake C3. This scenario reflects expected conditions during operations.
- *Scenario 5:* Release of stored flows from two average years (one year of storage) into average flows in the receiving environment, with starting concentrations from the box model. The model grid was as above. This scenario reflects the probable maximum ratio of discharge to receiving water flows in this system.
- *Scenario 6:* Post-closure release of discharge from the shore of Carat Lake via an open channel, with average flow conditions in the discharge and receiving environment. In this run, the model grid was restricted to Carat Lake, and inflows from Lake C3 (via the Jericho River) were conservatively assigned dilutions of 60. This scenario represents one of the post-closure discharge scenarios explained in Section 2.1.2, and was used in conjunction with plume modelling to estimate the amount of dilution that could be expected with shoreline discharge of the pit outflow to Carat Lake. Final decisions regarding the post closure discharge scenario can only be made once site data is available to refine the water quality estimates.

Discharge and receiving water flows for each of the above scenarios were as presented in Sections 2.1 and 2.2.

3.1.3 CORMIX Plume Model

A plume model "CORMIX" was used to assess mixing in the near-shore environment as an alternative approach for the post-closure modelling of the discharges from the pit lake to Carat Lake. The modeling was completed by Lorax Environmental, with input assumptions provided by SRK.

The CORMIX model is a steady-state, three-dimensional model, designed to simulate the near-field concentration of positively or negatively buoyant plumes resulting from surface or subsurface effluent discharge. It is suited to water bodies that can be represented by relatively simple, idealized geometries such as a linear shoreline and constant bottom gradient. It is not well suited to rapidly changing conditions or complex shoreline or bottom morphology. However, it has the advantage of being sanctioned by the U.S. EPA, and has been verified against a large body of measurements. The intention of the plume model was to generate a broader understanding of the potential range of outcomes in this mixing problem, which provides a more robust means of evaluating the closure alternatives.

CORMIX differs significantly from POM in that the latter solves a set of mathematical equations representing the governing physical processes on a three-dimensional computational grid. Small-scale processes are not resolved. CORMIX, on the other hand, uses parameterizations of the physical processes governing several classes of effluent discharge and mixing, and provides a more detailed picture of the near-field dilution zone. CORMIX consists of three separate modules: CORMIX 1 and 2 for simulating subsurface discharge, and CORMIX 3 for simulating surface discharge of effluent. In this study CORMIX 3 was used for all simulations.

CORMIX uses a simplified geometry to represent the receiving environment, as follows:

- The section of shoreline within the modelled region is straight.
- The receiving environment is effectively infinite in extent.
- The bottom slope is constant.
- The ambient current and wind, when specified, are spatially homogeneous and constant with time.

Four scenarios were evaluated including:

- June discharge flows, no wind (assuming ice cover is present) (Jun 16)
- June discharge flows, wind present (after break-up) (Jun 19)
- August discharge flows, no wind (Aug 01a)
- August discharge flows, wind present (Aug 01b)

Specific input parameters used for each of these scenarios are summarized in Table 10.

3.2 Results and Discussion

3.2.1 Operations

Box Model

The results of the box model are summarized in Figure 3 and Table 11.

Results for the base case simulation of average discharge flows into average receiving water flows (Scenario 1) indicate that minimum whole lake dilutions in Lake C3 (50) would be established within one season of discharge and minimum dilutions in Carat Lake (58) would be established within three seasons of discharge.

Results for the low flow simulations (Scenario 2) indicate minimum whole lake dilutions could be slightly lower in Lake C3 (41) and Carat Lake (53) during low flow years due to the relatively higher proportion of discharge flows resulting from the processing operations.

Results from the simulation of stored discharges into average receiving water flows during the first year of operations (Scenario 3a) indicate a minimum whole lake dilution of 27 in Lake C3, and a minimum whole lake dilution of 53 in Carat Lake. If these releases occur during year 4 of operations (Scenario 3b), the minimum whole lake dilution would be 27 in Lake C3 and 49 in Carat Lake.

In general, Carat Lake is less sensitive to a single year of stored release or low flow conditions than Lake C3 due to its larger volume.

Princeton Ocean Model

The results of the Princeton Ocean Model are provided in Attachment N3, with a summary for key locations in the system provided in Figures 4 and 5.

Results for the scenario with average discharge flows into average flows in the receiving environment and starting conditions from the box model (Scenario 4, Figure 4), indicate that minimum dilutions of approximately 20 could occur within 200 metres of the mouth of Stream C3 during the brief period when ice would still be present on the lake (assumed to be June 18th in the modelling), and would increase to approximately 40 by mid-July. At the outlet of Lake C3, minimal dilutions would be on the order of 30 for a short period immediately after the wind begins to mix the lake (on June 19th), and would also increase to approximately 40 by mid-July. Concentrations in Carat Lake are expected to be within the range predicted by the box model due to complete mixing in the section of the Jericho River that is between the two lakes. In general, the simulations indicate there would be rapid mixing in Lake C3, as would be expected from the relatively small volume of the lake, high flows from the Jericho River, and the comparatively small amount of effluent.

Results for the scenario with release of stored flows from one year of accumulation in the PKCA, and one year of normal inflows into average flows in the receiving environment (Scenario 5, Figure 5), indicated that minimum dilutions of approximately 10 could occur within 200 metres of the mouth of Stream C3 during the brief period immediately prior to break-up of the ice (assumed to be June 18th in the modelling). Dilutions would then increase rapidly to approximately 20 by the beginning of July. At the outlet of Lake C3, minimal dilutions would be on the order of 20 for a short period immediately after the wind begins to mix the lake (on June 19th), would increase to approximately 27 by mid-July.

The Princeton Ocean model concentrations are thought to be lower than those predicted by the Box model for two reasons: 1) Flows into the west arm of Lake C3 do not mix with the effluent, and therefore do not contribute to the dilution; and, 2) A large amount of un-impacted water from the Jericho River may pass through the main part of Lake C3 before the ice is off the lake and wind driven mixing begins to take effect. Once mixing occurs, the resident contaminant load begins to mix with the Jericho River water, but it takes a few weeks to reach steady state mixing. The Princeton Ocean model results are considered conservative because observations by field staff (*pers. comm.* Rick Pattenden) indicate that the ice cover in Lake C3 breaks-up more rapidly than on Carat Lake, therefore wind driven mixing is likely to start at least one week sooner. This should result in a significantly smaller effluent plume and therefore higher dilutions when the wind driven mixing begins.

3.2.2 Post Closure

Box Model

Results of the box model (Table 11, Figure 3) indicate that following operations, the whole lake dilution will increase to approximately 200 in both lakes during the period in which the pit is filling and will then decrease to approximately 60 in Carat Lake once the pit starts to spill.

For the purposes of estimating post-closure concentrations at the outlet of Carat Lake, the box model approach is considered reasonable. However, concentrations near the point of discharge will depend on largely on shoreline mixing processes. These are complex and difficult to predict given the presence of lake ice through to early June, variability in wind conditions, local bathymetry, and uncertainties in timing of flows from the site.

Observations of ice conditions made during the baseline studies (*pers. comm.*, Bruce Ott), indicate that a shore lead typically forms in Carat Lake between Stream C1 and the Stream C4. This is expected to allow more rapid dispersion of the discharges along the shoreline, and thereby enhance mixing during the very short period when there are discharges, but ice is still present on the lake. Further studies, such as tracer studies, are likely needed to quantify mixing during this period. Results from the Princeton Ocean Model and the CORMIX Plume model discussed below also provide some further insight into the available near shore dilution.

Princeton Ocean Model

The Princeton Ocean Modelling was used to simulate the 2 dimensional mixing in the lake from the start of discharge in early June (prior to break-up of the lake ice), through to the end of June, when wind is expected to be the dominant influence on mixing. Although the simulations include the period of ice cover (by assuming no wind is present), it is not possible to include the potential effects of the ice lead discussed above. Therefore results from the Princeton model are likely to provide conservative estimates of mixing during the period of ice cover.

Results for the scenario with post-closure release of discharge from the shore of Carat Lake via an open channel (Scenario 6) are presented in Attachment N4 and summarized in Figure 6. The results indicate that the dilution prior to ice break-up could be as low as 3 at a distance of up to 300 metres

from the channel mouth for an approximately two week period in early June. As soon as the ice breaks-up, the plume will disperse rapidly, dilutions 40 metres from the channel mouth will fluctuate between 5 and 20, and dilutions 80 metres from the channel mouth will fluctuate between 10 and 45. At the outlet of Carat Lake, the apparent dilution would be on the order of 43. However, this is an artefact of conservatively setting the dilution of the Lake C3 inflows to 60. Actual dilutions are expected to remain close to the whole lake average concentrations of 60 predicted by the box model.

CORMIX Plume Model

The CORMIX Plume model was used to simulate mixing processes in the near shore environment, but does not accurately represent the influence of other inflows to the lake. Therefore, it may also provide conservative estimates of mixing during the post-closure period.

Results for the plume model, reflecting post-closure discharges from an open channel, are provided in Figure 7. The results indicate that, during periods of peak discharge in mid-June (i.e. prior to ice break-up), a dilution of approximately 8 could be expected at a distance of 50 metres from the channel, and a dilution of approximately 10 could be expected within a distance of 100 metres. The dilution during a period of relatively low flow (i.e. August), would be greater than 20 within 50 metres of the channel, and would increase during windy periods.

The results for the two models suggest that a reasonable degree of mixing (i.e. dilutions between 5 to 10 at a distance of 40 metres from the channel, 10 to 45 at a distance of 80 metres from the channel, and approximately 60 at the outlet of Carat Lake) can be sustained through most of the year. However, localized accumulation of the discharge, and dilutions between 3 and 8 may occur for an approximately 2 week period prior to break-up of the ice for a distance of up to 300 metres from the channel mouth. Due to the limitations of modelling dilution at this fine scale, further studies are recommended to quantify the assimilative capacity of Carat Lake if monitoring data indicate that post-closure water quality is likely to exceed applicable guidelines for receiving water quality.

4 Receiving Water Quality Estimates

4.1 Methods

Receiving water concentrations at a number of locations in the receiving environment were estimated by dividing the PKCA discharge concentrations (Section 2.1 and 2.2) by the dilution estimates (Section 3), and adding measured background concentrations in the Jericho River system (“*Jericho Final EIS, Appendix B.1.1, Baseline Summary Report, Section 6.4 and Table 6.3*”, Tahera 2003) to this value, i.e.:

$$C_R = \frac{C_D}{D} + C_B$$

Where:

C_D = Estimated Discharge Concentrations (as summarized in Section 2)

D = Dilution Factor (from Section 3)

C_B = Background Concentrations

C_R = Estimated Receiving Water Concentrations

The addition of the background concentrations corrects for background loadings irrespective of variations in the ratios of discharge and background flows.

The results are compared to CCME guidelines for freshwater aquatic life and Health Canada drinking water guidelines, as discussed in the following section. These estimates supercede those presented in the “*Jericho Final EIS*” (Tahera 2003), supplemental memorandum “*Water Quality Impacts from Jericho Mine Drainages*”(AMEC 2003), and the errata “*Ammonia Discharges from PKCA*” issued during the final EIS hearings (AMEC 2004b).

The one exception to this approach was for pH. The PKCA discharge is expected to have a relatively consistent pH of 8.1, resulting from equilibration with calcite, a naturally occurring mineral in the kimberlite. To estimate the pH in the receiving environment, PHREEQ, a geochemical equilibrium model, was used to estimate the receiving water pH at different mixing ratios. The results indicate receiving water pH’s would be in the range of 6.72 to 6.97, which are only marginally higher than the baseline Jericho River pH of 6.63. Therefore, we anticipate that there will be no impacts to the receiving environment resulting from slightly alkaline pH’s in the discharges.

Location	Mixing Ratio*	Receiving Water pH
Outlet of Lake C3.	50	6.97
Minimum dilutions at edge of Mixing Zone	10	6.72

* ratio of receiving water to discharge flows in Lake C3. The dilution modelling indicates dilutions on the order of 45 under typical conditions, and local minimum ratios on the order of 10 under worst case assumptions of discharge.

4.2 Results and Discussion

4.2.1 Water Quality Impacts on Lake C3 and Carat Lake from PKCA Discharges during Operations

Typical Operating Conditions (Average Discharge Flows)

Expected dilutions and receiving water quality estimates for three key locations in the Lake C3/Carat Lake system during normal operations (i.e. dilution modelling Scenarios 1 and 4) are provided in Tables 12 and 13. For consistency with the EIS, summaries of predicted aluminum, copper, cadmium and uranium concentrations are provided in the following tables, and values that exceed the criteria are shown in bold.

The receiving water quality estimates based on **average source concentration estimates** (Table 12) indicated potential exceedances of CCME guidelines are predicted only for cadmium as follows:

Parameter	Stream C3 outlet + 200 m (mg/L)	Lake C3 Outlet (mg/L)	Carat Lake (mg/L)	CCME Guideline (mg/L)	Background Concentrations (mg/L)
Aluminum	0.077	0.063	0.061	0.1	0.052
Cadmium*	0.000091	0.000068	0.000064	0.000017	<0.00005
Copper	0.0030	0.0024	0.0023	0.002 to 0.004	0.002
Uranium	0.0063	0.0029	0.0023	0.02	0.0002

Notes: * Assumes background concentrations are at the detection limit of <0.00005. Actual concentrations could be significantly lower.

Predicted cadmium concentrations are only marginally above the background concentration of <0.00005 mg/L. However, because the background concentration is at the analytical detection limit, and is approximately three times higher than the CCME guideline, it is not possible to determine whether CCME guidelines for cadmium are currently exceeded or whether they can be met in this system. It should be noted that the CCME guideline for this parameter is an interim guideline, based on applying a ten times safety factor to the lowest measured effects level for the most sensitive aquatic organism (i.e. 0.00017 mg/L). A review of toxicity data for cadmium completed as part of this project (Attachment O1 of “*Technical Memorandum O: Proposed Discharge Limits for the Jericho Project, Nunavut*” (SRK 2004) indicated that aquatic effects would be unlikely to occur at concentrations of 0.000091 mg/L at a hardness of approximately 50, which is the expected hardness at a dilution of 20. All of the estimated concentrations are below this value.

The background concentration for copper is approximately 0.002 mg/L, which is at the CCME guideline for waters with low alkalinity. The predicted copper concentrations would be only marginally above this value during mining operations. A review of toxicity data for copper completed as part of this project (Attachment O1 of “*Technical Memorandum O: Proposed Discharge Limits for the Jericho Project, Nunavut*” (SRK 2004) indicated that aquatic effects would be unlikely to occur at concentrations of 0.004 mg/L.

Predicted aluminum and uranium concentrations are below the CCME guidelines.

The receiving water quality estimates based on **maximum source concentration estimates** (Table 13) indicated potential exceedances of CCME guidelines are predicted only for cadmium and uranium as follows:

Parameter	Stream C3 outlet + 200 m (mg/L)	Lake C3 Outlet (mg/L)	Carat Lake (mg/L)	CCME Guideline (mg/L)	Background Concentrations (mg/L)
Aluminum	0.097	0.072	0.068	0.1	0.052
Cadmium*	0.00011	0.000075	0.000069	0.000017	<0.00005
Copper	0.0030	0.0025	0.0024	0.002 to 0.004	0.002
Uranium	0.034	0.015	0.012	0.02	0.0002

Notes: * Assumes background concentrations are at the detection limit of <0.00005. Actual concentrations could be significantly lower.

Concentrations of cadmium are predicted to be slightly higher than in the preceding scenario due to higher discharge concentrations. Uranium concentrations at the edge of the mixing zone could slightly exceed the CCME guideline for drinking water supplies in which there is ongoing and sustained use of the water by humans. However, the concentrations are well below levels where occasional use of this water would result in impacts to human health. Therefore, no impacts are predicted. Aluminum and copper would remain below the CCME guidelines. These concentrations represent probable maximum concentrations in the discharge and were estimated using several conservative assumptions.

As indicated in Tables 12 and 13, TDS concentrations are expected to be 65 mg/L and 93 mg/L at a distance of 200 metres from the stream outlet, for average and maximum source concentrations respectively. Concentrations of individual TDS components (i.e. Ca, Mg, Na, K, SO₄, and Cl) are well below criteria for chloride and sulphate that have been proposed in other jurisdictions. A discussion of the potential impacts of TDS on the receiving environment presented in Attachment N5 indicates that there would be little potential for toxicological effects at TDS concentrations below 400 mg/L.

Contingency Release of Stored flows from the PKCA

Expected dilutions and receiving water quality estimates at various locations in the Lake C3/Carat Lake system for the release of one year stored flow (i.e two years worth of discharges) into average receiving water flows (i.e. dilution modelling Scenarios 2 and 5) are provided in Tables 14 and 15.

The receiving water quality estimates based on **average source concentration estimates** (Table 14) indicate potential exceedances of CCME guidelines are predicted for aluminum and copper at the edge of the mixing zone, and cadmium in all three locations as follows:

Parameter	Stream C3 outlet + 200 m (mg/L)	Lake C3 Outlet (mg/L)	Carat Lake (mg/L)	CCME Guideline (mg/L)	Background Concentrations (mg/L)
Aluminum	0.10	0.072	0.062	0.1	0.052
Cadmium*	0.00013	0.000083	0.000066	0.000017	<0.00005
Copper	0.0040	0.0028	0.0024	0.002 to 0.004	0.002
Uranium	0.012	0.0051	0.0026	0.02	0.0002

Notes: * Assumes background concentrations are at the detection limit of <0.00005. Actual concentrations could be significantly lower.

The receiving water quality estimates based on **maximum source concentration estimates** (Table 15) indicate potential exceedances of CCME guidelines are predicted for aluminum, cadmium, copper and uranium at the edge of the mixing zone, uranium throughout Lake C3, and cadmium in all three locations, as follows:

Parameter	Stream C3 outlet + 200 m (mg/L)	Lake C3 Outlet (mg/L)	Carat Lake (mg/L)	CCME Guideline (mg/L)	Background Concentrations (mg/L)
Aluminum	0.14	0.088	0.070	0.1	0.052
Cadmium*	0.00016	0.000095	0.000072	0.000017	<0.00005
Copper	0.004	0.0028	0.0024	0.002 to 0.004	0.002
Uranium	0.069	0.028	0.014	0.02	0.0002

Notes: * Assumes background concentrations are at the detection limit of <0.00005. Actual concentrations could be significantly lower.

As indicated in Tables 14 and 15, TDS concentrations are expected to be 118 mg/L and 174 mg/L at a distance of 200 metres from the stream outlet, for average and maximum source concentrations respectively. As discussed in the above section, concentrations of individual TDS components would be well below the applicable guidelines and toxicity thresholds, indicating little potential for toxicological or environmental effects.

4.2.2 Post-Closure Discharges from the PKCA to Lake C3

After closure, discharges from the PKCA will be limited to direct precipitation and local runoff to the PKCA. Therefore flows from the PKCA will be approximately six times less than during operations, and overall dilution in Lake C3 will be approximately 170. As indicated in Section 2.1.2, post-closure concentrations from the PKCA will also be significantly less than during operations. Therefore, impacts to Lake C3 and Carat Lake are expected to be negligible after closure of the facility.

4.2.3 Post-Closure Discharges from the Open Pit to Carat Lake

As discussed in Section 3.2.2, after break-up of the ice, discharges from the shoreline are expected to disperse and mix rapidly, reaching a minimum of five times dilution within 40 metres of the outfall, a minimum of ten times dilution within 80 metres of the outfall, and a minimum of sixty times dilution at the Jericho River outlet of Carat Lake. Estimates for the two week period prior to

break-up indicate that locally lower dilutions could occur, but these are highly dependent on fine-scale mixing processes that cannot be accurately simulated in any of the available models. Tracer studies during operations can be used to quantify the near shore mixing processes well in advance of the pit reaching its spill point, should refined estimates of post-closure water quality indicate that the discharges from the pit lake would not meet receiving water quality.

Post-closure receiving water quality estimates at these locations are provided in Table 16. Although copper concentrations are predicted to approach the upper CCME guideline, cadmium is the only parameter predicted to exceed the CCME guideline as follows:

Parameter	40 m from Channel (mg/L)	80 m from Channel (mg/L)	Outlet of Carat Lake (mg/L)	CCME Guideline (mg/L)	Background Concentrations (mg/L)
Aluminum	0.083	0.067	0.055	0.1	0.052
Cadmium*	0.00011	0.000081	0.000055	0.000017	<0.00005
Copper	0.0039	0.0029	0.0022	0.002 to 0.004	0.002
Uranium	0.013	0.0065	0.0013	0.02	0.0002

Notes: * Assumes background concentrations are at the detection limit of <0.00005. Actual concentrations could be significantly lower.

Predicted TDS concentrations were 85 and 48 mg/L at 40 and 80 metres distance respectively. As in the previous estimates, these are well below the available guidelines and toxicity thresholds defined for any individual TDS component, and are not expected to result in adverse effects to the aquatic ecosystem.

5 Summary and Conclusions

Dilution modelling was used to estimate receiving water concentrations for TDS, major ions, metals and nutrients during mining operations and through the first 25 years of closure. The results indicate that, under typical operating conditions, concentrations of all parameters except cadmium are close to background, or within CCME guidelines. Cadmium is the only parameter which may exceed the CCME guidelines for freshwater aquatic life beyond a 200 metre mixing zone from the outlet of Stream C3. However, the predicted cadmium concentrations based on assuming background cadmium concentrations are at the detection limit of 0.00005 mg/L, are only slightly higher than the detection limit for cadmium, and are below the lowest effects level reported in the CCME guidelines fact sheet. Local exceedances of aluminum, copper and uranium may occur near the edge of the mixing zone under worst case discharge conditions, or if effluent concentrations approach the probable maximum values estimated for this site.

After closure, discharges from the PKCA will be limited to direct precipitation and local runoff to the PKCA. Therefore flows from the PKCA will be much lower and dilution in Lake C3 will be substantially higher. Post-closure concentrations from the PKCA will also be significantly lower than during operations. Therefore, impacts to Lake C3 and Carat Lake will be minimal after closure of the facility.

After closure, discharges from the waste dumps and stockpiles will be directed to the open pit. Post-closure discharges from the pit would only occur after the pit reaches its spill point. Depending on the quality of the pit water, the discharge may be returned to the original Stream C1 channel, or directed via a constructed channel directly to Carat Lake. Modelling of the constructed channel discharge indicates that the available dilution after break-up of the ice would be on the order of five to ten times at distances of 40 to 80 metres from the channel outlet. With the exception of cadmium, all parameters would meet CCME guidelines for freshwater aquatic life and human health beyond this mixing zone. In the case of cadmium, the predicted concentrations are below the lowest effects levels reported in the CCME (1999) guidelines. The available dilution prior to break-up of the ice depends on the development of the ice-free lead along the shoreline and fine scale mixing processes that cannot be accurately quantified by the available models. Should refined estimates of post-closure water quality indicate that discharges from the pit lake would not meet receiving water quality guidelines, a tracer study could be conducted to quantify the available dilution.

6 References

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Table 1
Discharge Flows During Operations

Month	Average Flows in Jericho River above Lake C3		Monthly Percent Flows Jericho River		Average Discharge Flows from PKCA	
	Average Year	10 Year Low Flow	Average Year	10 Year Low Flow	Average Year	10 Year Low Flow
	m3/mo	m3/mo	%	%	m3	
May	607,611	51	2.6%	0.0%	13,330	1
Jun	13,367,450	8,473,163	57.5%	64.5%	293,252	236,052
Jul	3,711,356	2,691,305	16.0%	20.5%	81,419	74,976
Aug	2,118,429	853,425	9.1%	6.5%	46,474	23,775
Sep	2,939,525	938,619	12.6%	7.1%	64,487	26,149
Oct	509,080	185,900	2.2%	1.4%	11,168	5,179
Nov	0	0	0.0%	0.0%	0	0
TOTAL	23,253,451	13,142,463	100.0%	100.0%	510,129	366,133

- Notes: 1. See Table 9 for Source of Jericho River Flows
2. Discharge Flows from PKCA were estimated using the site water and load balance (SRK 2004a), and were distributed in proportion to the monthly Jericho River Flows
3. In the Princeton Ocean Model, discharge flows from May were added to the June flows, and flows from October were added to the September flows to reduce run times to a four month period.

Table 2
Maximum Discharge Concentrations from the PKCA during Operations

Parameter	Estimated Discharge Concentration (mg/L)	
	Average Source Conc.	Maximum Source Conc.
Nutrients		
NH4-N	1.8	2.9
NO2-N	0.16	0.23
NO3-N	5.0	7.4
P	0.087	0.087
Physical		
TDS	1074	1635
TSS	6.3	7.4
Major Ions		
Alk	42	70
Ca	101	202
Cl	487	647
K	36	64
Mg	175	206
Na	21	36
SO4	184	380
Dissolved Metals		
DAI	0.12	0.21
DFe	0.26	0.64
Total Metals		
TAI	0.49	0.90
TAs	0.0013	0.0021
TCd	0.0008	0.0011
TCr	0.0047	0.0099
TCu	0.020	0.021
TFe	0.63	1.0
TMo	0.075	0.14
TNi	0.042	0.062
TPb	0.0038	0.0040
TU	0.12	0.68
TZn	0.015	0.034

Notes:

- 1) Data extracted from the water and load balance (SRK and Clearwater 2004)
- 2) 2013 used as representing typical seasonal maximums in concentration
- 3) Maximum concentrations typically occur in August/September in PKCA & Settling Pond, minimum concentrations in April/May, See Figure 1 For seasonal patterns
- 4) Source parameter concentrations provided by SRK (April 15, 2004)
- 5) All concentrations in mg/L

Table 3
Discharge Flows assuming 1 year storage and release of excess flows the following year

Month	Average Flows in Jericho River above Lake C3		Release of Stored Flows from PKCA m3
	m3/mo	monthly %	
May	607,611	2.6%	25,071
Jun	13,367,450	57.5%	551,570
Jul	3,711,356	16.0%	153,138
Aug	2,118,429	9.1%	87,411
Sep	2,939,525	12.6%	121,291
Oct	509,080	2.2%	21,006
Nov	0	0.0%	0
TOTAL	23,253,451	100.0%	959,487

NOTES

- 1) Releases from PKCA shown above are assumed to occur during the second year of operation and consist of cumulative net excess runoff and process flows from the first two years of operation assuming average precipitation conditions.
- 2) Monthly release volumes in June & July maximized based on available excess water in the system.
- 3) All flow rates & flow volumes for the Jericho River system are for estimated average conditions

Table 4
Post Closure Flows from the PKCA

Month	Post-Closure Flows from PKCA m3/mo
May	0
Jun	52,512
Jul	8,247
Aug	13,144
Sep	6,467
Oct	0
TOTAL	80,370

Table 5
Post-Closure Water Quality from the PKCA

Parameter mg/L, or specified	Runoff Disturbed Areas	Coarse Kimberlite Stockpile	Adjusted Coarse Kimberlite Stockpile	Estimated Post- Closure Water Quality from PKCA
pH	na	na	na	8.2
Ammonia - N (unionized) (calculated)*				0.014
Ammonia - N (total)	0.007	3.30	0.33	0.33
Nitrate - as N	0.041	8.3	0.83	0.83
Nitrite - as N	0.001	0.24	0.024	0.024
Phosphorus - P	0.01	0.01	0.00	0.01
Total Dissolved Solids	180	4395	440	440
Total Suspended Solids	3	10	1	3
Sulphate - SO ₄	13	717	72	72
Alkalinity (mg CaCO ₃ eq/L)	31	100	10	31
Chloride	29	2379	238	238
Calcium	29	155	16	29
Magnesium	6	861	86	86
Sodium	4.0	37	4	4
Potassium	2.0	146	15	15
Total Metals				
Aluminum - Al	0.085	0.019	0.002	0.019
Arsenic - As	0.00075	0.0037	0.0004	0.00075
Cadmium - Cd	0.00005	0.0042	0.0004	0.0004
Chromium - Cr	0.0005	0.012	0.001	0.0012
Copper - Cu	0.0056	0.0031	0.0003	0.0031
Iron - Fe	0.18	0.21	0.02	0.18
Lead - Pb	0.0185	0.0012	0.0001	0.0012
Molybdenum - Mo	0.0026	0.72	0.07	0.072
Nickel - Ni	0.0034	0.17	0.02	0.017
Uranium - U	0.28	0.080	0.008	0.080
Zinc - Zn	0.012	0.027	0.003	0.012

Notes: Source concentrations for "Disturbed Areas" and the "Coarse PK Stockpile" are from Technical Memorandum I (SRK 2003c)

Table 6
Post Closure Flows from the Pit Lake and Stream C1

Month	Pond A	Pond B	Pond C	Pit Pond	Total Flows from Pit Lake	Stream C1 Diversion Upstream of Pit Lake	Stream C1 Diversion with Pit Flows Returned to Original Channel
Jan	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0
May	5,071	1,950	4,762	1,305	13,088	8,487	21575
Jun	65,334	25,261	60,480	21,497	172,572	122,771	295343
Jul	23,282	8,926	22,058	3,170	57,436	35,977	93413
Aug	22,299	8,586	20,887	5,315	57,087	38,203	95290
Sep	10,682	4,116	9,986	2,833	27,617	18,607	46224
Oct	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0
Total	126,668	48,839	118,173	34,120	327,800	224,045	551,845

Notes: 1) Monthly flow volumes from Table W2 in Site Water Management Report (SRK 2004a)

2) Monthly net runoff flows (m3) for Ponds A, B, C, Pit Pond, C1 Diversion correspond to to period when the pit is full & overflowing/spilling to Carat Lake (starting approx year 2029).

Table 7
Post-Closure Estimates of Pit Water Quality

Parameter	1) Discharge from Pit Lake without Stream C1	2) Long-term Discharge from Pit Lake with Stream C1 redirected to pit.	CCME Aquatic Life Guidelines	Health Canada Guidelines	Carat Lake Baseline Data
TDS	372	231	na	500	11
TSS	2	2	na	na	1.4
Alk	16	14	na	na	4.7
Ca	38	24	na	na	2.3
Cl	161	96	na	250	3.4
K	13	8	na	na	2.0
Mg	62	37	na	na	0.8
Na	8	5	na	na	2.0
SO4	70	42	na	500	1.2
TAI*	0.15	0.13	0.1	0.1	0.052
TAs	0.0005	0.0004	0.005	0.025	0.00016
TCd	0.0003	0.0002	0.000017	0.005	0.00005
TCr	0.0017	0.0012	0.0089	0.05	0.0025
TCu	0.009	0.007	0.002	1.0	0.0020
TFe*	0.20	0.24	0.3	0.3	0.025
TMo	0.032	0.019	0.073	na	0.00005
TNi	0.015	0.009	0.025	na	0.0005
TPb	0.0020	0.0013	0.001	0.01	0.00005
TU	0.063	0.038	na	0.02	0.00020
TZn	0.006	0.004	0.03	5	0.0020

Notes:

Assumptions and Calculations are provided in SRK memo "Post-Closure Pit Water Quality" (prepared May 6, 2004, Kelly Sexsmith), provided as an appendix to the Abandonment and Reclamation Plan (AMEC, 2004)

1. Assumes all sources of water entering the pit have reached post-closure water quality by the start of filling
2. Reflects mixed water quality in the pit in the long term, once steady-state mixing has been reached (approximately 30 years after pit is filled)

Table 8
Estimated Flows for Jericho River During 10 Year Drought and Average Meteorological Conditions

Month	Monthly Average Discharge (m ³ /s)							
	Jericho River above Lake C3		Lateral inflows to Lake C3		Lateral inflows to Carat Lake		Jericho River at outlet of Carat Lake	
	10-Year Drought	Average Conditions	10-Year Drought	Average Conditions	10-Year Drought	Average Conditions	10-Year Drought	Average Conditions
Jan	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0
May	0	0.23	0	0.029	0	0.034	0	0.29
Jun	3.2	5.1	0.41	0.65	0.47	0.74	4.1	6.5
Jul	1.0	1.4	0.13	0.18	0.15	0.20	1.3	1.8
Aug	0.32	0.80	0.041	0.10	0.047	0.12	0.41	1.0
Sep	0.36	1.1	0.045	0.14	0.052	0.16	0.45	1.4
Oct	0.071	0.19	0.009	0.025	0.010	0.028	0.090	0.25
Nov	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0
Average	0.41	0.73	0.053	0.093	0.060	0.11	0.53	0.93

Note: These flows exclude releases from the PKCA and runoff from the areas controlled by the collection ponds and the PKCA.

Table 9**Estimated Weekly Hydrograph for Average and 10 Year Low Flow Conditions (excludes releases from PKCA and flows from areas controlled by collection ponds and PKCA)**

Start Date of Week	Weekly Average Flow (m ³ /h) - Average Conditions				Weekly Average Flow (m ³ /h) - 10 Year Low Flow Conditions			
	Jericho River above Lake C3	Lateral inflows to Lake C3	Lateral inflows to Carat Lake	Jericho River at outlet of Carat Lake	Jericho River above Lake C3	Lateral inflows to Lake C3	Lateral inflows to Carat Lake	Jericho River at outlet of Carat Lake
May 18	13	2	2	16	0	0	0	0
May 25	3635	463	529	4627	0	0	0	0
Jun 01	9355	1191	1361	11906	6400	815	931	8145
Jun 08	29506	3755	4292	37553	12791	1628	1861	16280
Jun 15	23672	3013	3443	30128	14833	1888	2157	18878
Jun 22	13236	1685	1925	16846	13488	1717	1962	17166
Jun 29	7426	945	1080	9452	6867	874	999	8740
Jul 06	6672	849	970	8492	4150	528	604	5282
Jul 13	3868	492	563	4923	3045	387	443	3875
Jul 20	4675	595	680	5950	2568	327	374	3268
Jul 27	3032	386	441	3859	2251	287	327	2865
Aug 03	2088	266	304	2658	1321	168	192	1682
Aug 10	2091	266	304	2661	1113	142	162	1417
Aug 17	2200	280	320	2799	1009	128	147	1284
Aug 24	4945	629	719	6293	999	127	145	1272
Aug 31	5562	708	809	7079	1264	161	184	1608
Sep 07	4944	629	719	6292	1649	210	240	2099
Sep 14	3136	399	456	3991	1437	183	209	1829
Sep 21	2832	360	412	3605	1084	138	158	1380
Sep 28	2707	345	394	3446	707	90	103	900
Oct 05	880	112	128	1119	360	46	52	459
Oct 12	726	92	106	924	196	25	28	249
Oct 19	237	30	34	302	121	15	18	154
Oct 26	61	8	9	78	19	2	3	24
Nov 02	0	0	0	0	0	0	0	0
Nov 09	0	0	0	0	0	0	0	0

Table 10
Input Parameters for CORMIX3 Plume Model

Parameter		June 16	June 19	Aug 1a	Aug 1b
Ambient					
Average Depth of Discharge Zone	m	3.5	3.5	3.5	3.5
Current	m/s	0.001	0.05	0.03	0.03
Wind	m/s	0	4	0	3.5
Effluent					
Flow rate	m3/s	0.28	0.28	0.034	0.034
Conc.	mg/l	100	100	100	100
Discharge					
Bottom slope	%	5	5	5	5
Depth at point of discharge	m	0.5	0.5	0.5	0.5
Channel width	m	3	3	3	3
Channel depth	m	0.3	0.3	0.3	0.3
Mixing Zone					
Region of interest	m	250	250	250	250

Table 11
Summary of Box Model Results

Scenario	Discharge Flows	Receiving Flows	Years to Steady State		Dilution Factors							
			Lake C3	Carat Lake	Operations				Post-closure - Pit Filling		Post-Closure - Long-term	
					Lake C3*		Carat Lake		Lake C3	Carat Lake	Lake C3	Carat Lake
					Minimum	Minimum	Minimum	Monthly	Monthly	Monthly	Monthly	Monthly
					Winter	Monthly	Winter	Minimum	Minimum	Minimum	Minimum	Minimum
1	Average	Average	1	3	56	50	58	58	168	199	168	60
2	Periodic Low	Periodic Low	1	3	43	41	54	53	168	199	168	60
3a	Stored Release (yr2)	Average	1	3	30	27	54	53	168	199	168	60
3b	Stored Release (yr4)	Average	1	3	30	27	49	49	168	199	168	60

Notes: * The duration of minimum dilutions from periodic low flow years or from stored release would be limited to one year in Lake C3.

Table 12
Receiving Water Quality Estimates - Average Source Concentrations, Average Receiving Water Flows

Parameter mg/L, or specified	Polishing Pond	Carat Lake	Receiving Water Quality Estimates			Guidelines		
	Avg Source Conc.	Background Conc.	Stream C3 Out + 200 m 20	Lake C3 Outlet 45	Carat Lake Water Intake 58	CCME Fresh Water Aquatic Life min max	Note	CCME/Health Canada Drinking 2003
Aluminum - Al	0.49	0.052	0.077	0.063	0.061	0.005 0.1	a	0.1
Ammonia - N (unionized) (calculated)*	0.075	0.000	0.004	0.0017	0.0013	0.016	*	
Ammonia - N (total)	1.8	0.009	0.10	0.050	0.041	0.59 60	b	
Arsenic - As	0.0013	0.00016	0.0002	0.0002	0.0002	0.005		0.025
Barium - Ba						na		1
Boron - B						na		5
Cadmium - Cd	0.0008	0.00005	0.000091	0.000068	0.000064	0.000017		0.005
Calcium - Ca	101	2.4	7.4	4.6	4.1	na		na
Chloride - Cl	487	3.4	28	14	12	na		250
Chromium - Cr	0.0047	0.0002	0.0004	0.0003	0.0003	0.0089		0.05
Copper - Cu	0.020	0.0020	0.0030	0.0024	0.0023	0.002 0.004	c	1
Iron - Fe	0.63	0.025	0.056	0.039	0.036	0.3		0.3
Lead - Pb	0.0038	0.00005	0.00024	0.00013	0.00012	0.001 0.007	d	0.01
Magnesium - Mg	175	0.84	9.6	4.7	3.8	na		na
Manganese - Mn						na		0.05
Mercury - Hg						0.00001		0.001
Molybdenum - Mo	0.075	0.00005	0.0038	0.0017	0.0013	0.073		
Nickel - Ni	0.042	0.0005	0.0026	0.0014	0.0012	0.025 0.15	e	
Nitrate - as N	5.0	0.18	0.43	0.29	0.27	4.0		10
Nitrite - as N	0.16	0.001	0.009	0.0047	0.0038	0.06		1
pH	8.2	6.63	6.8	6.80	6.8	6.5 9	f	
Phosphorus - P	0.087	0.0077	0.012	0.010	0.009	na		
Potassium - K	36	2	3.80	2.80	2.62	na		na
Selenium - Se						0.001		0.01
Silver - Ag						0.0001		
Sodium - Na	21	2	3	2	2	na		200
Sulphate - SO ₄	184	1.2	10	5	4	na		500
Sulphide (as H ₂ S)						na		0.05
Thallium - Tl						0.0008		
Total Dissolved Solids	1074	11	65	35	30	na		500
Total Suspended Solids	6.3	1.4	2	2	2	5	25 g	
Uranium - U	0.12	0.0002	0.0063	0.0029	0.0023	na		0.02
Zinc - Zn	0.015	0.002	0.003	0.002	0.002	0.03		5

Notes: Bolded guidelines were the applicable criteria

Blue highlighting indicates >5x dilution required to meet criteria

* Polishing Pond concentration is calculated at temperature of 15oC and estimated pH of 8.2. Actual receiving water pH's and temperatures will generally be much lower, resulting in a shift in equilibrium to less un-ionized ammonia (units are in N equivalents)

a - Guidelines indicate value of 0.1 is appropriate where the pH is greater than 6.5

b - Range reflects pH's from 6.5 to 8 and temperatures of 0 to 15 C. Actual range is pH 6.1 to 7.73, with mean values of 6.85 in Lake C3 and 6.74 in Carat Lake

c - Guidelines indicate lower value of 0.002 is appropriate where the hardness is less than 120 mg CaCO₃ eq/L

d - Guidelines indicate lower value of 0.001 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

e - Guidelines indicate lower value of 0.025 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

f - The pH must be within this range

g - The total suspended sediments must not exceed background levels by more than 5 mg/L on average, nor 25 mg/L from background levels on a short-term exposure (24 hours)

Table 13
Receiving Water Quality Estimates - Maximum Source Concentrations, Average Receiving Water Flows

Parameter mg/L, or specified	Polishing Pond	Carat Lake	Receiving Water Quality Estimates			Guidelines			
	Max. Source Conc.	Background Conc.	Stream C3 Out + 200 m 20	Lake C3 Outlet 45	Carat Lake Water Intake 58	CCME Fresh Water Aquatic Life		Note	CCME/Health Canada Drinking 2003
Aluminum - Al	0.90	0.052	0.097	0.072	0.068	0.005	0.1	a	0.1
Ammonia - N (unionized) (calculated)*		0.000	0.000	0.000	0.000	0.016		*	
Ammonia - N (total)	2.9	0.009	0.16	0.074	0.060	0.59	60	b	
Arsenic - As	0.0021	0.00016	0.0003	0.0002	0.0002	0.005			0.025
Barium - Ba						na			1
Boron - B						na			5
Cadmium - Cd	0.0011	0.00005	0.00011	0.000075	0.000069	0.000017			0.005
Calcium - Ca	202	2.4	12.5	6.9	5.9	na			na
Chloride - Cl	647	3.4	36	18	15	na			250
Chromium - Cr	0.0099	0.0025	0.0030	0.0027	0.0027	0.0089			0.05
Copper - Cu	0.021	0.0020	0.0030	0.0025	0.0024	0.002	0.004	c	1
Iron - Fe	1.0	0.025	0.08	0.048	0.043	0.3			0.3
Lead - Pb	0.0040	0.00005	0.00025	0.00014	0.00012	0.001	0.007	d	0.01
Magnesium - Mg	206	0.84	11.1	5.4	4.4	na			na
Manganese - Mn						na			0.05
Mercury - Hg						0.00001			0.001
Molybdenum - Mo	0.14	0.00005	0.007	0.0031	0.0024	0.073			
Nickel - Ni	0.062	0.0005	0.0036	0.0019	0.0016	0.025	0.15	e	
Nitrate - as N	7.4	0.18	0.55	0.35	0.31	4.0			10
Nitrite - as N	0.23	0.001	0.012	0.0060	0.0049	0.06			1
pH	8.2	6.63	6.8	6.8	6.8	6.5	9	f	
Phosphorus - P	0.087	0.0077	0.01	0.01	0.01	na			
Potassium - K	64	2	5.2	3.4	3.1	na			na
Selenium - Se						0.001			0.01
Silver - Ag						0.0001			
Sodium - Na	36	2	4	3	3	na			200
Sulphate - SO ₄	380	1.2	20	10	8	na			500
Sulphide (as H ₂ S)						na			0.05
Thallium - Tl						0.0008			
Total Dissolved Solids	1635	11	93	47	39	na			500
Total Suspended Solids	7.4	1.4	2	2	2	5	25	g	
Uranium - U	0.68	0.0002	0.034	0.015	0.012	na			0.02
Zinc - Zn	0.034	0.002	0.004	0.003	0.003	0.03			5

Notes: Bolded guidelines were the basis for the calculated dilutions

* Polishing Pond concentration is calculated at temperature of 15oC and estimated pH of 8.2. Actual receiving water pH's and temperatures will generally be much lower, resulting in a shift in equilibrium to less un-ionized ammonia, values are given in N

a - Guidelines indicate value of 0.1 is appropriate where the pH is greater than 6.5

b - Range reflects pH's from 6.5 to 8 and temperatures of 0 to 15 C. Actual range is pH 6.1 to 7.73, with mean values of 6.85 in Lake C3 and 6.74 in Carat Lake

c - Guidelines indicate lower value of 0.002 is appropriate where the hardness is less than 120 mg CaCO₃ eq/L

d - Guidelines indicate lower value of 0.001 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

e - Guidelines indicate lower value of 0.025 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

f - The pH must be within this range

g - The total suspended sediments must not exceed background levels by more than 5 mg/L on average, nor 25 mg/L from background levels on a short-term exposure (24 hours)

Table 14
Receiving Water Quality Estimates - Average Source Concentrations, Release of Stored Flows

Parameter mg/L, or specified	Polishing Pond	Carat Lake	Receiving Water Quality Estimates			Guidelines		
	Avg Source Conc.	Background Conc.	Stream C3 Out + 200 m 10	Lake C3 Outlet 25	Carat Lake Water Intake 50	CCME Fresh Water Aquatic Life min max	Note	CCME/Health Canada Drinking 2003
Aluminum - Al	0.49	0.052	0.10	0.072	0.062	0.005 0.1	a	0.1
Ammonia - N (unionized) (calculated)*	0.075	0.000	0.008	0.0030	0.0015	0.016	*	
Ammonia - N (total)	1.8	0.009	0.19	0.083	0.046	0.59 60	b	
Arsenic - As	0.0013	0.00016	0.0003	0.0002	0.0002	0.005		0.025
Barium - Ba						na		1
Boron - B						na		5
Cadmium - Cd	0.0008	0.00005	0.00013	0.00008	0.00007	0.000017		0.005
Calcium - Ca	101	2.4	12	6.4	4.4	na		na
Chloride - Cl	487	3.4	52	23	13	na		250
Chromium - Cr	0.0047	0.0025	0.0030	0.0027	0.0026	0.0089		0.05
Copper - Cu	0.020	0.0020	0.0040	0.0028	0.0024	0.002 0.004	c	1
Iron - Fe	0.63	0.025	0.088	0.050	0.038	0.3		0.3
Lead - Pb	0.0038	0.00005	0.00043	0.00020	0.00013	0.001 0.007	d	0.01
Magnesium - Mg	175	0.84	18	7.8	4.3	na		na
Manganese - Mn						na		0.05
Mercury - Hg						0.00001		0.001
Molybdenum - Mo	0.075	0.00005	0.0075	0.0030	0.0015	0.073		
Nickel - Ni	0.042	0.0005	0.0047	0.0022	0.0013	0.025 0.15	e	
Nitrate - as N	5.0	0.18	0.68	0.38	0.28	4.0		10
Nitrite - as N	0.16	0.001	0.017	0.0076	0.0043	0.06		1
pH	8.2	6.63	6.8	6.8	6.8	6.5 9	f	
Phosphorus - P	0.087	0.0077	0.02	0.01	0.01	na		
Potassium - K	36	2	5.6	3.4	2.7	na		na
Selenium - Se						0.001		0.01
Silver - Ag						0.0001		
Sodium - Na	21	2	4	3	2	na		200
Sulphate - SO ₄	184	1.2	20	9	5	na		500
Sulphide (as H ₂ S)						na		0.05
Thallium - Tl						0.0008		
Total Dissolved Solids	1074	11	118	54	32	na		500
Total Suspended Solids	6.3	1.4	2	2	2	5	25 g	
Uranium - U	0.12	0.0002	0.012	0.005	0.003	na		0.02
Zinc - Zn	0.015	0.002	0.004	0.003	0.002	0.03		5

Notes: Bolded guidelines were the basis for the calculated dilutions

Blue highlighting indicates >5 x dilution required to meet criteria

* Polishing Pond concentration is calculated at temperature of 15oC and estimated pH of 8.2. Actual receiving water pH's and temperatures will generally be much lower, resulting in a shift in equilibrium to less un-ionized ammonia, values are given in N

a - Guidelines indicate value of 0.1 is appropriate where the pH is greater than 6.5

b - Range reflects pH's from 6.5 to 8 and temperatures of 0 to 15 C. Actual range is pH 6.1 to 7.73, with mean values of 6.85 in Lake C3 and 6.74 in Carat Lake

c - Guidelines indicate lower value of 0.002 is appropriate where the hardness is less than 120 mg CaCO₃ eq/L

d - Guidelines indicate lower value of 0.001 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

e - Guidelines indicate lower value of 0.025 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

f - The pH must be within this range

g - The total suspended sediments must not exceed background levels by more than 5 mg/L on average, nor 25 mg/L from background levels on a short-term exposure (24 hours)

Table 15
Receiving Water Quality Estimates - Maximum Source Concentrations, Release of Stored Flows

Parameter mg/L, or specified	Polishing Pond	Carat Lake	Receiving Water Quality Estimates			Guidelines			
	Max. Source Conc.	Background Conc.	Stream C3 Out + 200 m	Lake C3 Outlet	Carat Lake Water Intake	CCME Fresh Water Aquatic Life		CCME/Health Canada Drinking	
			10	25	50	min	max	Note	2003
Aluminum - Al	0.90	0.052	0.14	0.088	0.070	0.005	0.1	a	0.1
Ammonia - N (unionized) (calculated)*		0.000	0.000	0.000	0.000	0.016		*	
Ammonia - N (total)	2.9	0.009	0.30	0.127	0.068	0.59	60	b	
Arsenic - As	0.0021	0.00016	0.0004	0.0002	0.0002	0.005			0.025
Barium - Ba						na			1
Boron - B						na			5
Cadmium - Cd	0.0011	0.00005	0.00016	0.00009	0.00007	0.000017			0.005
Calcium - Ca	202	2.4	23	10.5	6.4	na			na
Chloride - Cl	647	3.4	68	29	16	na			250
Chromium - Cr	0.0099	0.0025	0.0035	0.0029	0.0027	0.0089			0.05
Copper - Cu	0.021	0.0020	0.0041	0.0028	0.0024	0.002	0.004	c	1
Iron - Fe	1.0	0.025	0.13	0.067	0.046	0.3			0.3
Lead - Pb	0.0040	0.00005	0.00045	0.00021	0.00013	0.001	0.007	d	0.01
Magnesium - Mg	206	0.84	21.4	9.1	5.0	na			na
Manganese - Mn						na			0.05
Mercury - Hg						0.00001			0.001
Molybdenum - Mo	0.14	0.00005	0.014	0.0055	0.0028	0.073			
Nickel - Ni	0.062	0.0005	0.0067	0.0030	0.0017	0.025	0.15	e	
Nitrate - as N	7.4	0.18	0.92	0.48	0.33	4.0			10
Nitrite - as N	0.23	0.001	0.024	0.0101	0.0055	0.06			1
pH	8.2	6.63	6.8	6.8	6.8	6.5	9	f	
Phosphorus - P	0.087	0.0077	0.02	0.01	0.01	na			
Potassium - K	64	2	8.4	4.5	3.3	na			na
Selenium - Se						0.001			0.01
Silver - Ag						0.0001			
Sodium - Na	36	2	6	3	3	na			200
Sulphate - SO ₄	380	1.2	39	16	9	na			500
Sulphide (as H ₂ S)						na			0.05
Thallium - Tl						0.0008			
Total Dissolved Solids	1635	11	174	76	44	na			500
Total Suspended Solids	7.4	1.4	2	2	2	5	25	g	
Uranium - U	0.68	0.0002	0.068	0.028	0.014	na			0.02
Zinc - Zn	0.034	0.002	0.005	0.003	0.003	0.03			5

Notes: Bolded guidelines were the basis for the calculated dilutions

Blue highlighting indicates >5 x dilution required to meet criteria

* Polishing Pond concentration is calculated at temperature of 15°C and estimated pH of 8.2. Actual receiving water pH's and temperatures will generally be much lower, resulting in a shift in equilibrium to less un-ionized ammonia, values are given in N

a - Guidelines indicate value of 0.1 is appropriate where the pH is greater than 6.5

b - Range reflects pH's from 6.5 to 8 and temperatures of 0 to 15 C. Actual range is pH 6.1 to 7.73, with mean values of 6.85 in Lake C3 and 6.74 in Carat Lake

c - Guidelines indicate lower value of 0.002 is appropriate where the hardness is less than 120 mg CaCO₃ eq/L

d - Guidelines indicate lower value of 0.001 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

e - Guidelines indicate lower value of 0.025 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

f - The pH must be within this range

g - The total suspended sediments must not exceed background levels by more than 5 mg/L on average, nor 25 mg/L from background levels on a short-term exposure (24 hours)

Table 16
Receiving Water Quality Estimates - Post Closure Estimates of Receiving Water Quality in Carat Lake

Parameter mg/L, or specified	Pit Lake Post-Closure Estimates	Carat Lake Background Conc.	Receiving Water Quality Estimates			Guidelines			
			40 m from Channel	80 m from Channel	Outlet of Carat Lake	CCME Fresh Water Aquatic Life		Note	CCME/Health Canada Drinking Water 2003
			5	10	60	min	max		
Aluminum - Al	0.15	0.052	0.08	0.067	0.055	0.005	0.1	a	0.1
Ammonia - N (unionized) (calculated)*						0.016		*	
Ammonia - N (total)		0.009				0.59	60	b	
Arsenic - As	0.0005	0.00016	0.0003	0.0002	0.0002	0.005			0.025
Barium - Ba						na			1
Boron - B						na			5
Cadmium - Cd	0.00031	0.00005	0.00011	0.00008	0.00006	0.000017			0.005
Calcium - Ca		2.4				na			na
Chloride - Cl	161	3.36	36	19	6	na			250
Chromium - Cr	0.0017	0.0025	0.0028	0.0027	0.0025	0.0089			0.05
Copper - Cu	0.0094	0.0020	0.0039	0.0029	0.0022	0.002	0.004	c	1
Iron - Fe	0.20	0.025	0.06	0.045	0.028	0.3			0.3
Lead - Pb	0.0020	0.00005	0.00046	0.00025	0.00008	0.001	0.007	d	0.01
Magnesium - Mg		0.84				na			na
Manganese - Mn						na			0.05
Mercury - Hg						0.00001			0.001
Molybdenum - Mo	0.032	0.00005	0.006	0.0032	0.0006	0.073			
Nickel - Ni	0.015	0.0005	0.0036	0.0020	0.0008	0.025	0.15	e	
Nitrate - as N		0.18				4.0			10
Nitrite - as N		0.001				0.06			1
pH		6.63				6.5	9	f	
Phosphorus - P		0.0077				na			
Potassium - K		2				na			na
Selenium - Se						0.001			0.01
Silver - Ag						0.0001			
Sodium - Na	8.0	2	4	3	2	na			200
Sulphate - SO ₄	70	1.2	15	8	2	na			500
Sulphide (as H ₂ S)						na			0.05
Thallium - Tl						0.0008			
Total Dissolved Solids	372	11	85	48	17	na			500
Total Suspended Solids	2.0	1.4	2	2	1	5	25	g	
Uranium - U	0.063	0.0002	0.013	0.007	0.001	na			0.02
Zinc - Zn	0.006	0.002	0.003	0.003	0.002	0.03			5

Notes: Bolded guidelines were the basis for the calculated dilutions

Blue highlighting indicates >5 x dilution required to meet criteria

* Polishing Pond concentration is calculated at temperature of 15oC and estimated pH of 8.2. Actual receiving water pH's and temperatures will generally be much lower, resulting in a shift in equilibrium to less un-ionized ammonia, values are given in N

a - Guidelines indicate value of 0.1 is appropriate where the pH is greater than 6.5

b - Range reflects pH's from 6.5 to 8 and temperatures of 0 to 15 C. Actual range is pH 6.1 to 7.73, with mean values of 6.85 in Lake C3 and 6.74 in Carat Lake

c - Guidelines indicate lower value of 0.002 is appropriate where the hardness is less than 120 mg CaCO₃ eq/L

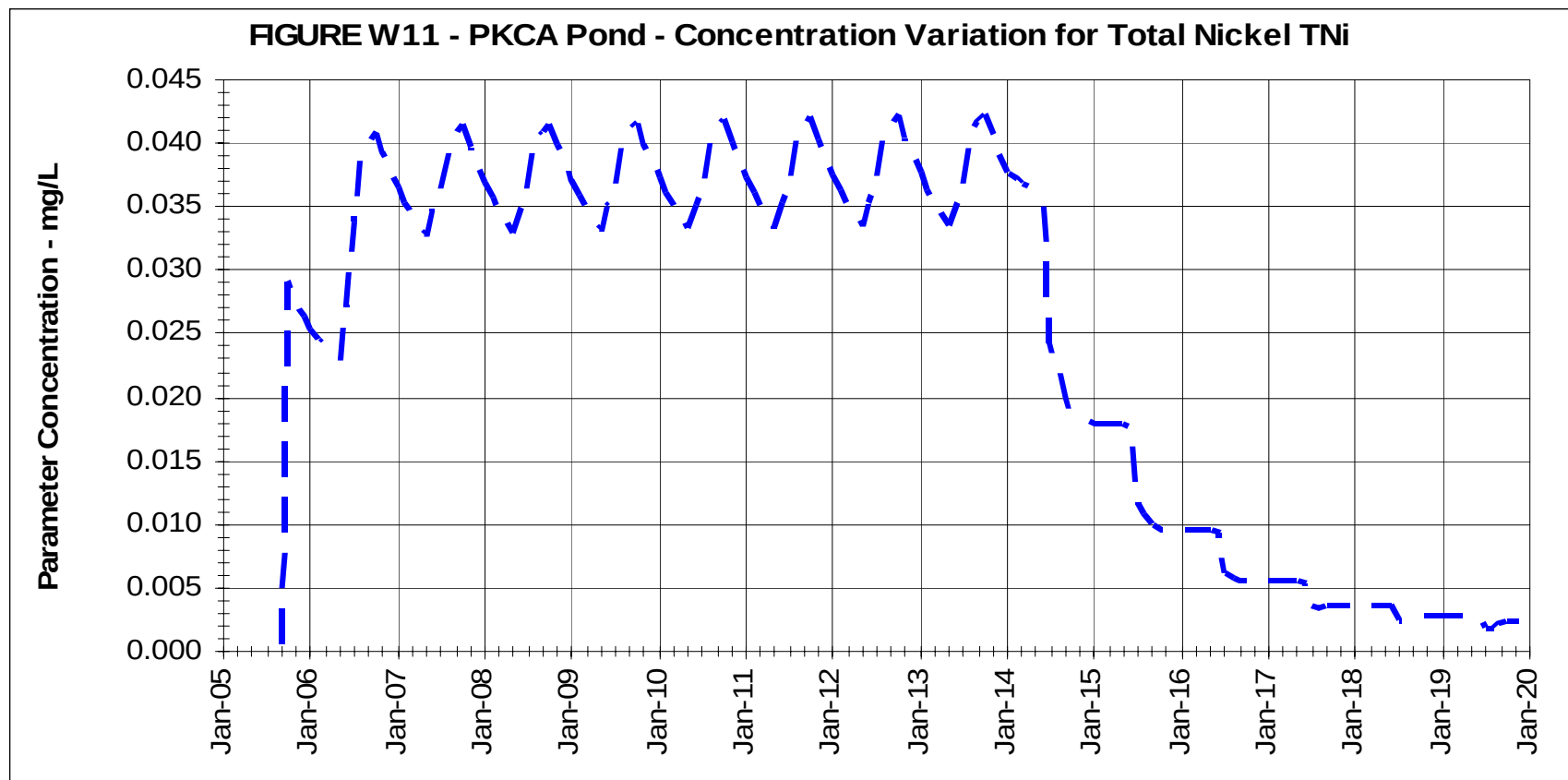
d - Guidelines indicate lower value of 0.001 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

e - Guidelines indicate lower value of 0.025 is appropriate where the hardness is less than 60 mg CaCO₃ eq/L

f - The pH must be within this range

g - The total suspended sediments must not exceed background levels by more than 5 mg/L on average, nor 25 mg/L from background levels on a short-term exposure (24 hours)

FIGURES



Jericho Project
Water Licence Application

**Typical Concentration Profile for the PKCA
during Operations**

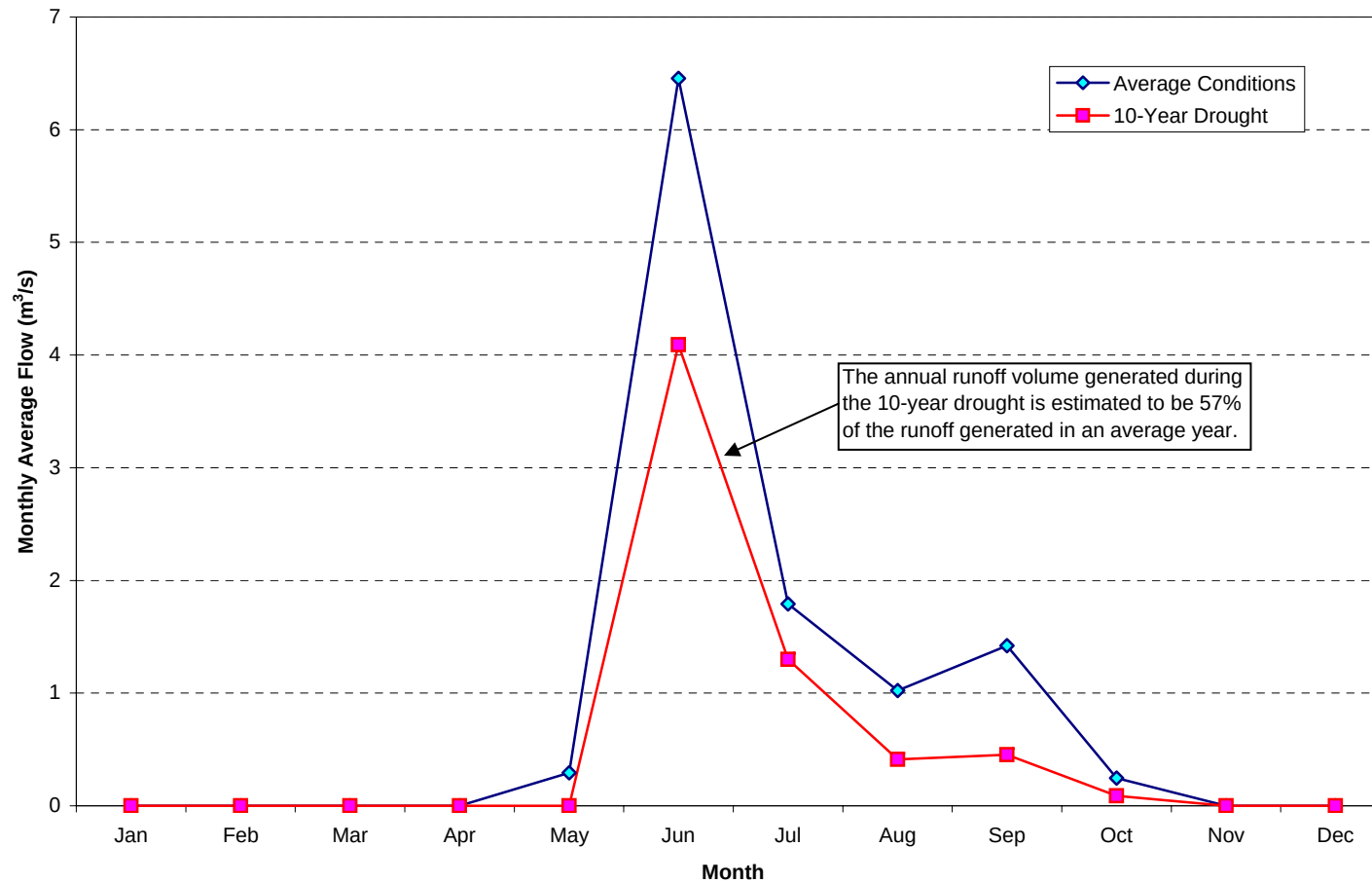
PROJECT
1CT004.06

DATE
July 2004

APPROVED

FIGURE
1

Jericho River at outlet of Carat Lake (excluding releases from PKCA)



Jericho Project
Water Licence Application

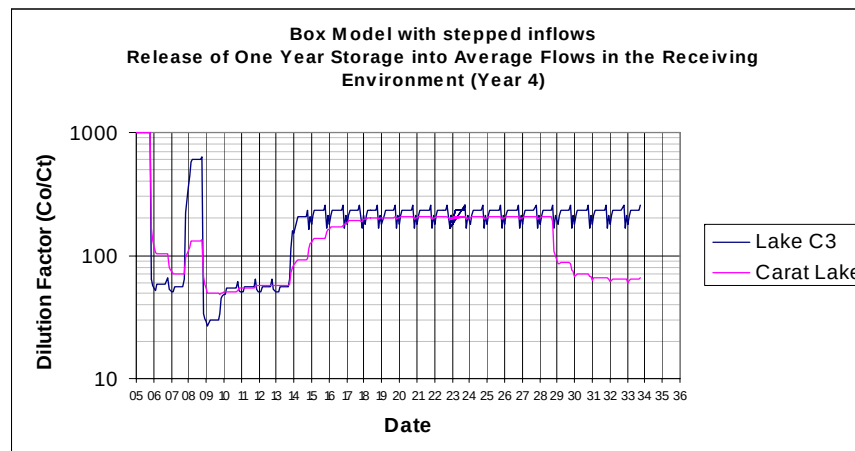
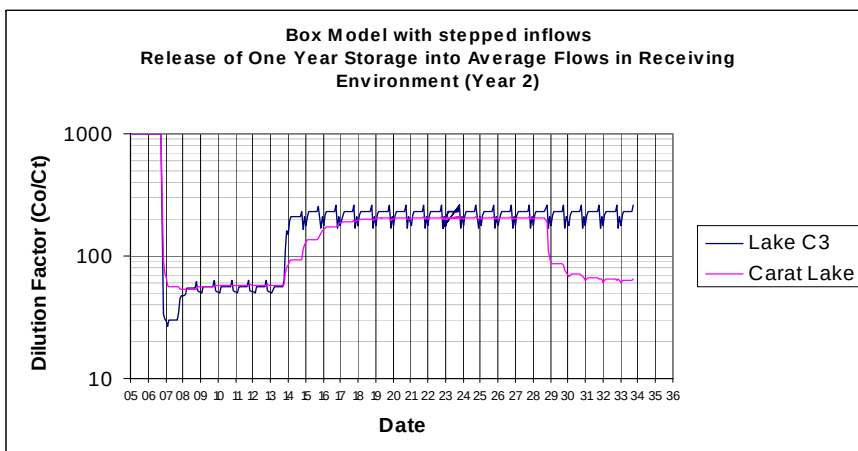
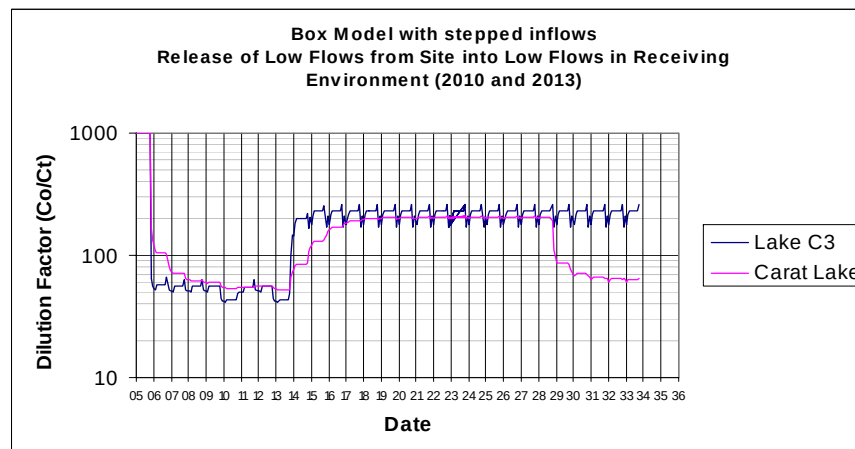
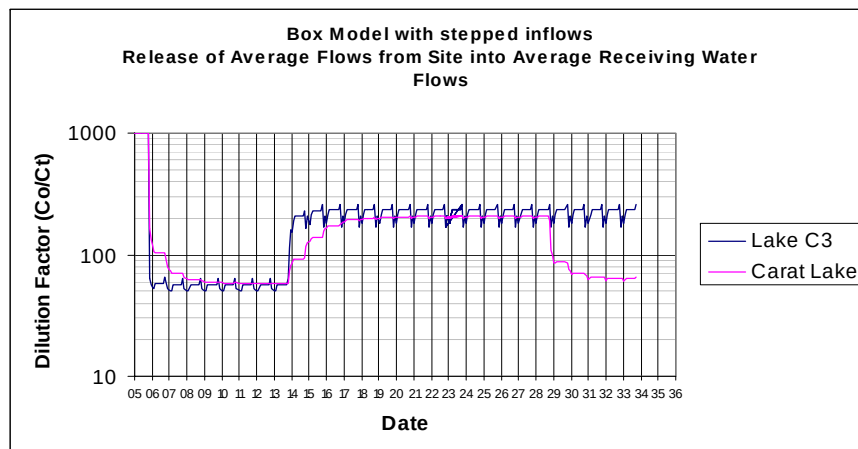
**Hydrograph of Jericho River at outlet of
Carat Lake (exclu. releases from PKCA)**

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1CT004.06

DATE
July 2004

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FIGURE
2



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**Box Model Results
(Scenarios 1 through 3)**

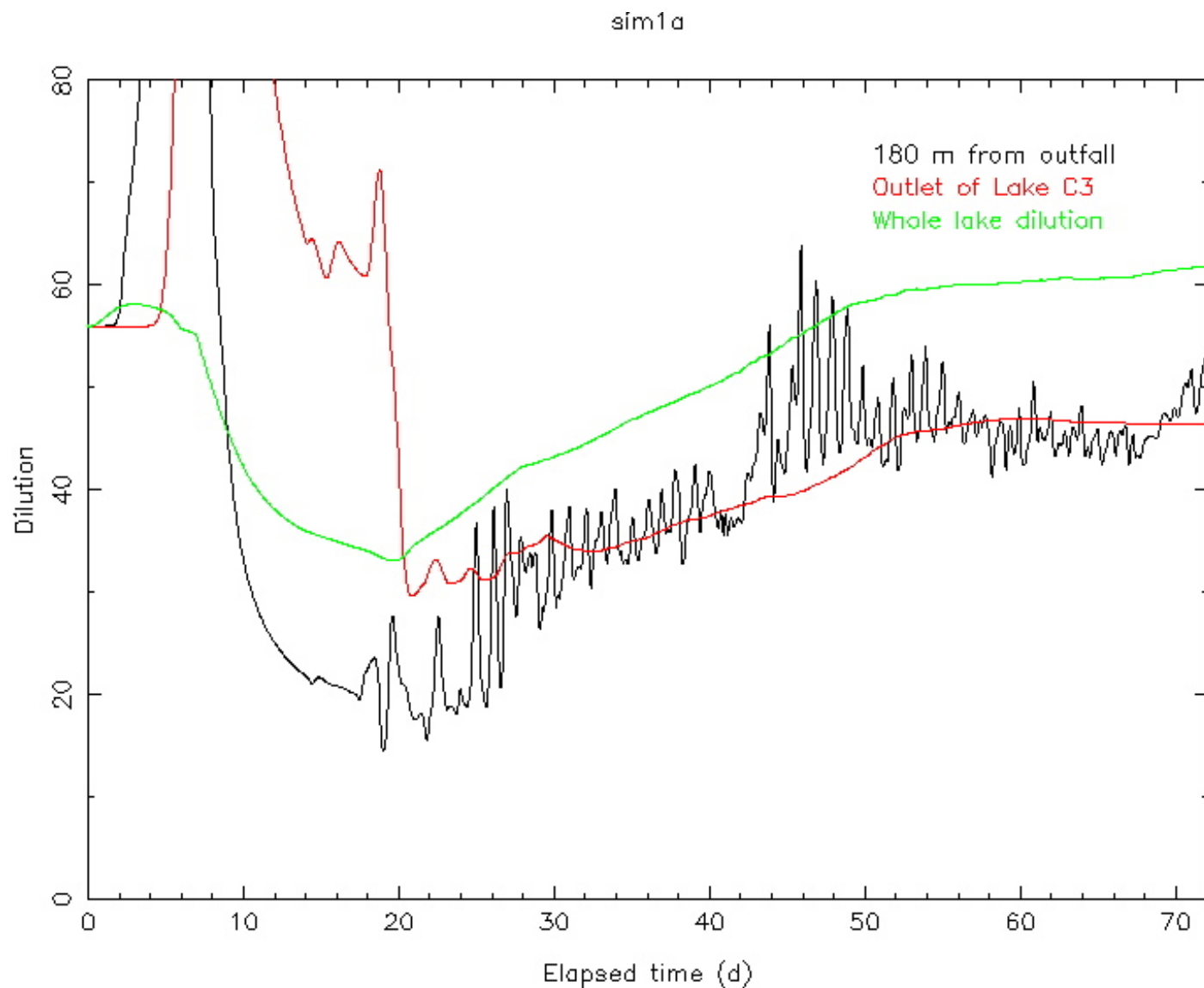
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FIGURE

3



SRK Consulting
Engineers and Scientists

Tahera
Diamond Corporation

Jericho Project
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**Summary of Princeton Ocean Model
Results for Scenario 4**

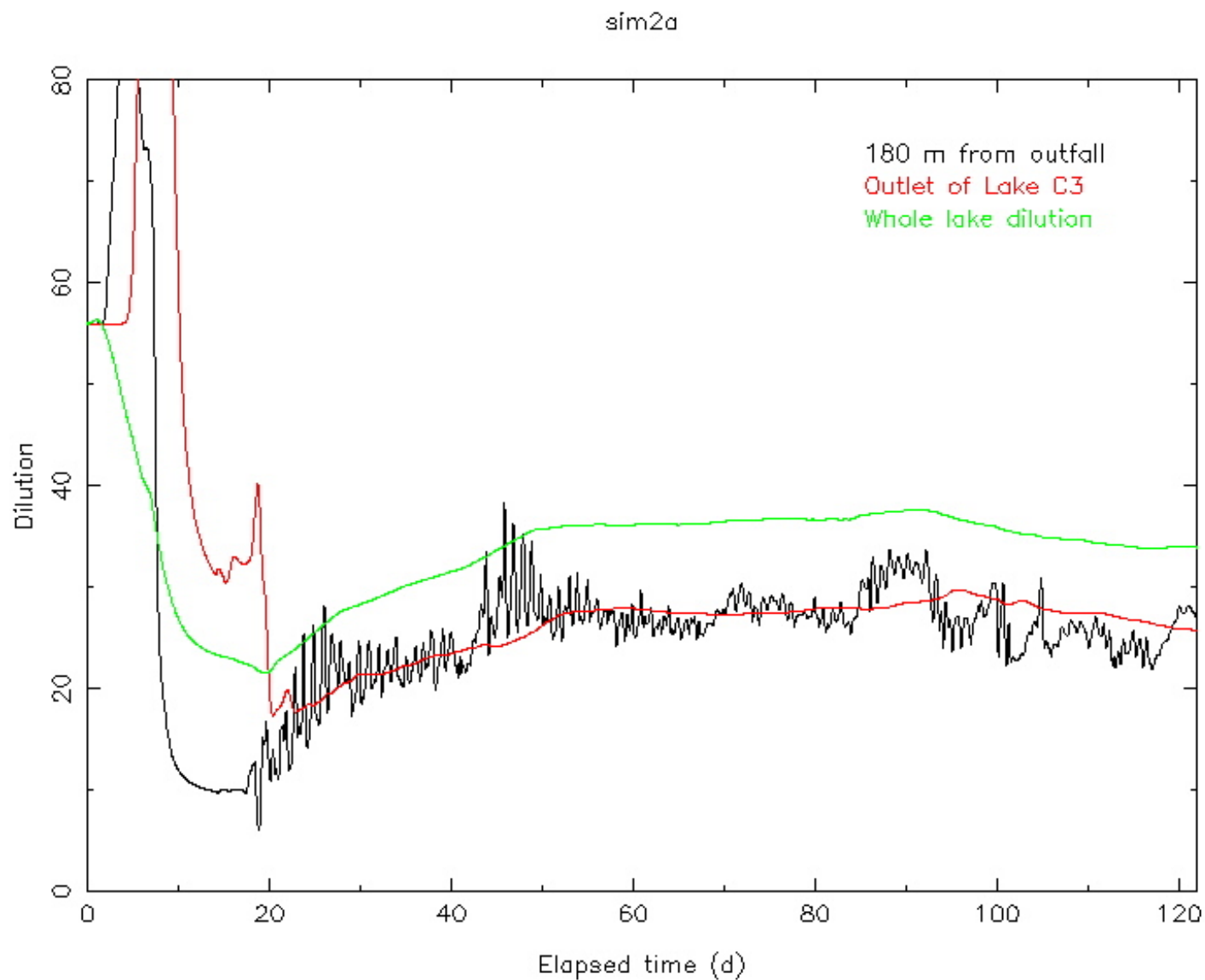
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FIGURE:

4



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Summary of Princeton Ocean Model Results for Scenario 5

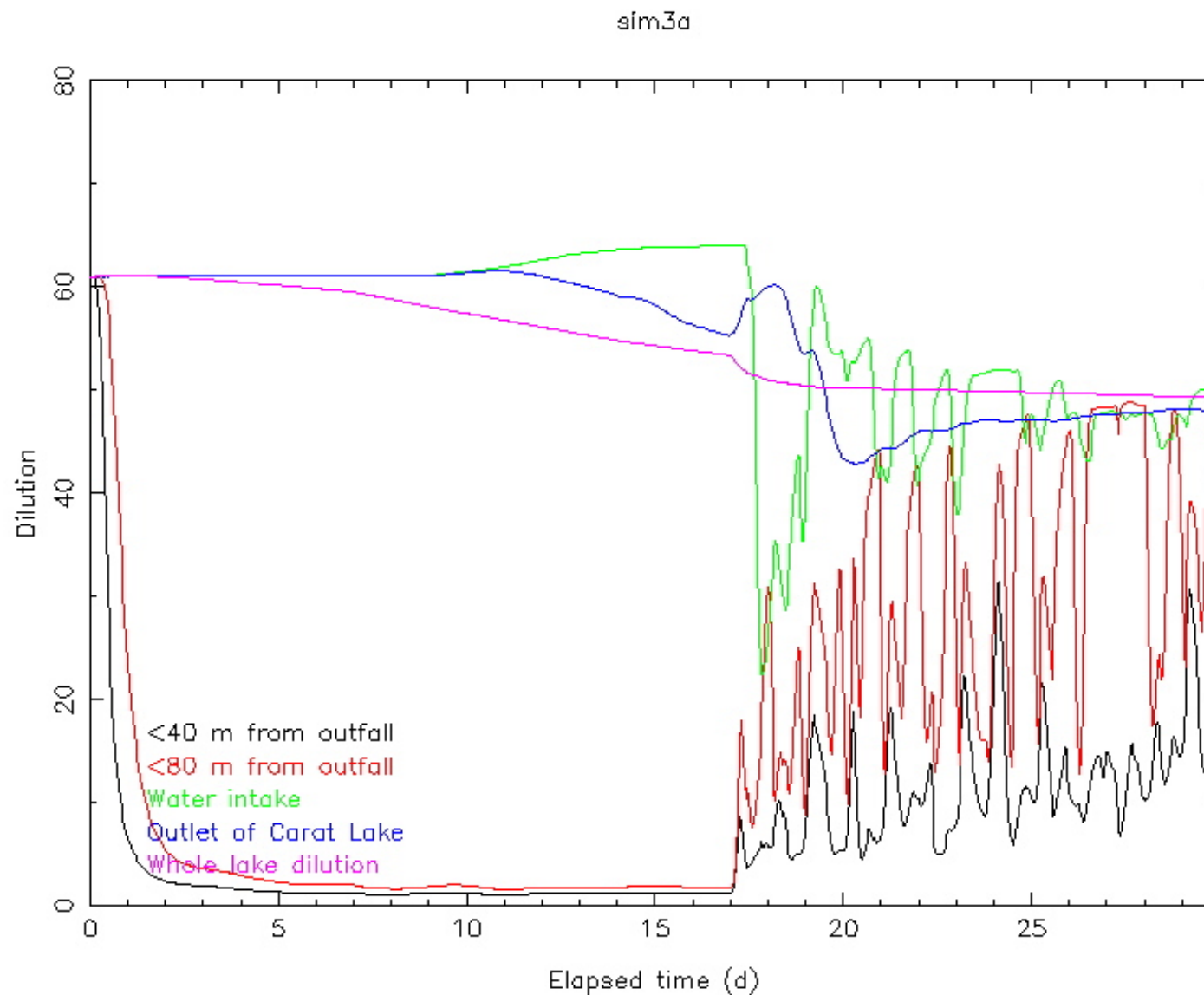
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DATE:
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5



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Summary of Princeton Ocean Model Results for Scenario 6

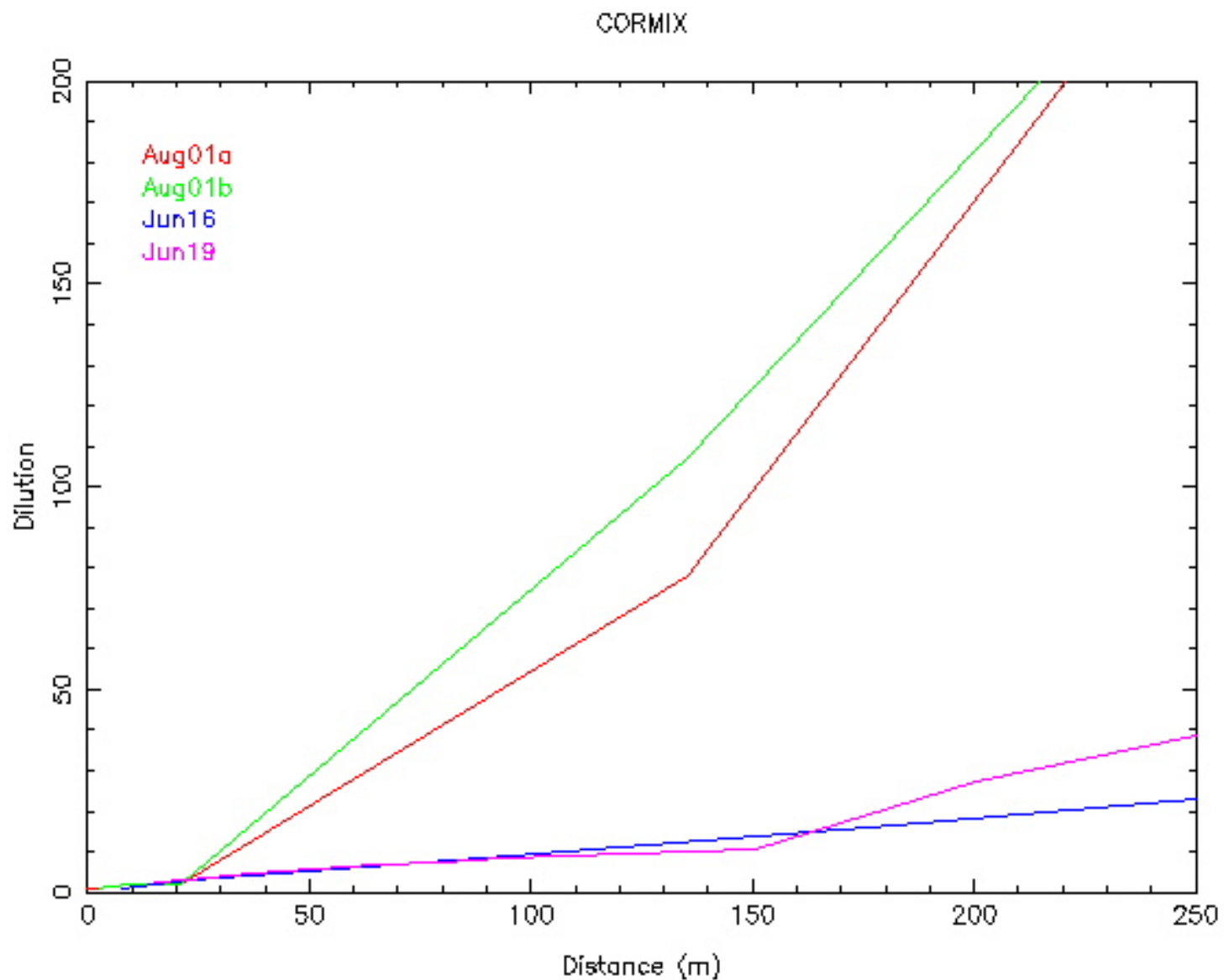
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DATE:
July 2004

APPROVED:

FIGURE:

6



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Summary of CORMIX Model Results

PROJECT:
1CT004.06

DATE:
July 2004

APPROVED:

FIGURE:

7

ATTACHMENT N1
Estimation of 10 Year Drought Hydrograph for Jericho River

Estimation of 10-Year Drought Hydrograph for Jericho River

Introduction

A water quality model was developed by SRK to estimate potential impacts of the proposed Jericho Diamond Project on the water quality of the receiving environment. One of the primary inputs to the model was a synthesized monthly record of flows for the Jericho River. The synthesized record spanned a period of several years and contained flows representing a mix of average and drought conditions. The average conditions were estimated using a technique outlined in the document entitled “Technical Memorandum C: Supplemental Climate and Hydrology” (SRK, 2003). To estimate drought conditions for the Jericho River, it was necessary to conduct an additional hydrological study that investigated the low-flow regime of arctic streams. This memorandum documents this new study.

The drought flows for Jericho River were estimated using a technique known as Regional Analysis. In essence, this technique provides a means of inferring the low flow regime of an ungauged location from the streamflow records of measured streams in the region. The development of the Regional Analysis involved four steps, as outlined below.

Step 1: Data Assembly

The first step entailed data gathering. The network of streamflow gauging stations operated by the Water Survey of Canada (WSC) was searched to find suitable data for developing the Regional Analysis. The emphasis of the search was to identify stations that: i) had long periods of record; ii) were in reasonably close proximity to the mine site; iii) were located north of the treeline; iv) measured flows from a wide range of catchment areas; and v) were sited on streams with zero flow during the winter months (i.e., the catchments drained by the streams were devoid of large lakes that could maintain a baseflow during the prolonged freezing conditions). Table 1 provides details of the six stations that were identified in the search.

To facilitate development of the low-flow analysis, a total of nine annual series were extracted from each streamflow record. The first series comprised the annual average flow for each complete year of record (or, at least, for each year in which the gauge was operational over the open water season). The remaining series focussed on monthly average flows for a specific month of the year. Individual series were extracted for the months of May through December. It was not necessary to extract series for the winter months, January to April, since flow in this period is almost always zero. The lengths of the series of annual average flows ranged from 8 to 27 years. The lengths of the series of monthly average flows were at least as long as, and often longer than, the corresponding series of annual values (i.e., an incomplete year would not provide an annual average value but would provide data for several of the calendar months). On completion of this

step of the analysis, a total of 54 annual series had been extracted (6 stations x 9 annual series per station).

Step 2: Statistical Analysis

This step was aimed at estimating extreme low flows at the six WSC stations. Initially, the focus was on estimating annual low flows for a range of return periods. For each station, the series of annual average flows was fitted to a theoretical frequency distribution (Gumbell III) to provide estimates of the 2-, 5-, 10- and 20-year return period annual low flows. All fittings were done using Version 2.0 of the LFA program (Environment Canada, 1994).

Table 1 presents the estimated annual droughts at the six regional stations determined by the frequency analyses. The catchment areas controlled by these stations range over four orders of magnitude from 15 km² to 16900 km². To facilitate comparison of the flows from these widely differing catchment areas, the flow rates in Table 1 have been expressed as normalized values in units of L/s/km² (i.e., the absolute flow rate has been divided by the contributing catchment area).

Examination of Table 1 indicates that the normalized flow rates do not vary much from station to station. For example, the 10-year low annual flows range from 3.4 to 5.7 L/s/km². If the station with the smallest catchment area is excluded (Akkutuak Creek), then the range narrows to 3.4 to 4.6 L/s/km². This narrow range exists despite the very large difference in catchment areas controlled by the WSC stations.

The objective of this study was to estimate the 10-year drought flows for the Jericho River on a monthly time step. Accordingly, the study could not end at assessing the average annual flow during a 10-year drought. The study had to also provide a way of apportioning the annual volume of water amongst the twelve months of the year. Although described in greater detail later, the adopted method of dividing the annual volume into monthly components required an understanding of how flows are distributed within each of the months. This understanding was obtained by fitting a theoretical frequency distribution to the annual series of monthly average flows to estimate a range of low flow events. The fitting of the distributions was facilitated using a suite of hydrological programs developed by the U.S. Geological Survey, known as IOWDM, SWSTAT and ANNIE (Lumb et al., 1990). This same suite of programs was also used in Step 1 to extract the annual series of monthly values.

Table 2 summarizes the flow patterns at the six WSC stations on a month by month basis. All statistics in this table represent the average flow over the entire month. The frequency analyses described above provided the estimates of monthly average low flows for return periods of 3-, 5- and 10-year return periods. Also shown on this table, are the average, extreme maximum and extreme minimum monthly average flows observed at the WSC stations. The information contained in Table 2 is graphically displayed in Figures 1 and 2. The average and extreme minimum flows observed at the stations provided a check on the frequency analyses. Because the streamflow records were

generally greater than 10 years in length, one would expect the 3-, 5- and 10-year low events to all fall between the average and extreme minimum flows. This turns out to be the case at all six WSC stations.

Step 3: Define 10-Year Drought at WSC Stations

A wide range of climatological conditions can lead to an annual runoff volume equal to the 10-year drought. For instance, an average spring freshet hydrograph can be followed by an extremely dry summer. Alternatively, a small freshet might be followed by a moderately wet summer. Given this, a sensible method was sought to define the monthly hydrograph of the 10-year drought. As inferred in Step 2, the adopted method involved using the frequency analyses for the individual months of the year. The basic premise was that the flow for all twelve months should have the same return period. So, for example, if all months experienced their 5-year low flow, the total volume for the twelve months may add up to equal a 10-year annual drought. Before applying this method, it was known that the return period for the individual months must be something less than 10 years. If every month of the year was to individually experience its 10-year event, the resulting annual event would be very extreme indeed, probably exceeding the 100-year annual event.

Figures 1 and 2 show how the 10-year low annual runoff volume for each WSC station was distributed amongst the twelve months of the year (bold line on plots). For four of the WSC stations, the 10-year event could be generated if each month of the year experienced its 3-year low event. For Atitok Creek, a sequence of 5-year monthly low events was required to generate an annual volume equal to the 10-year drought. For Ellice River, a sequence of 4-year events was required.

Step 4: Estimate 10-Year Drought for Jericho River

The final step in the analysis was to transpose the 10-year drought hydrographs at the WSC stations to the mine site. Figure 3 shows the graph used to facilitate the transposition. This graph shows the defined 10-year hydrographs for the six WSC stations superimposed on one another. Using the same convention as in Step 3, all flows are expressed as discharges per unit area with units of $L/s/km^2$.

The following observations were made about the hydrographs in Figure 3:

- The monthly flows for four of the hydrographs (Akkutuak, Qinguq, Kendall and Ellice) match one another very closely in the period July to November, and this is despite the very large difference in the catchments that generated these flows.
- The monthly average flows are zero, or very nearly so, for all stations from November to May.

- The flows of Atitok Creek are considerably lower than experienced at the other five WSC stations in July and August. The catchment of Atitok Creek has a significantly greater relief and a significantly smaller proportion of lakes than the catchment of Jericho River. Accordingly, the data from Atitok Creek are probably not representative of the conditions in the Jericho River. The greater relief and lower number of lakes would lead the catchment of Atitok Creek to have greater drainage efficiency than that of Jericho River.
- The Gordon River exhibits a slower recession than the remaining five WSC stations, which suggests greater lake storage in this river's catchment than experienced in the catchments of the other stations.
- The flows in June exhibit an inverse relationship with drainage area. The smaller the drainage area, the greater is the unit monthly average flow.

The above observations suggest that, except for the month of June, the normalized low flow rate is generally independent of drainage area. The relief of a catchment and the relative amount of lake storage cause variations in the flow response during dry conditions. Given these observations, the 10-year drought hydrograph for Jericho River was estimated to equal the median flow of all six stations. By using a median, this had the effect of discarding the two stations that are likely unrepresentative of conditions on Jericho River, namely Atitok Creek (with its high relief and low proportion of lakes) and Gordon River (with its slower recession relative to the other WSC stations). A higher flow would have been adopted for the month of June if the inverse relationship between flow and drainage area was used as basis for prediction of conditions on Jericho River, rather than the median. To be conservative, the lower estimate provided by the median was selected. The adopted 10-year drought hydrograph for the Jericho River is shown as a bold line superimposed on the rest of the WSC hydrographs presented in Figure 3.

The estimated long-term average annual runoff generated by the Jericho River is 210 mm, expressed as an equivalent depth of water spread uniformly over the contributing catchment. The runoff generated by the estimated 10-year drought hydrograph works out to 119 mm, or 57% of the runoff generated in an average year.

References

Environment Canada, 1994. Low Flow Frequency Analysis Package, Version 2.0. Climate/Water Information Branch, Atmospheric Environment Service.

Lumb, A.M., Kittle, J.L. Jr., and Flynn, K.M., 1990. Users manual for ANNIE, a computer program for interactive hydrologic analyses and data management: U.S. Geological Survey Water-Resources Investigations Report 89-4080.

Steffen Robertson and Kirsten (Canada) Inc., 2003. Technical Memorandum C: Supplemental Climate and Hydrology, Jericho Project, Nunavut. Report prepared for Tahera Corporation.

Table 1 Estimated Annual Low Flows at Regional WSC Streamflow Gauging Stations

WSC Streamflow Gauging Station		Drainage Area (km ²)	Sample Size (years)	Annual Average Low Flow (L/s/km ²) for the following Return Periods:				Observed Minimum Annual Flow (L/s/km ²)
ID No.	Name			2-Year	5-Year	10-Year	20-Year	
06MA004	Akkutuak Creek near Baker Lake	15	11	7.9	6.4	5.7	5.2	5.4
10PC002	Atitok Creek near Dismal Lakes	217	8	6.2	4.3	3.5	2.9	3.4
06MA002	Qinguq Creek near Baker Lake	432	22	5.4	4.1	3.6	3.4	3.3
10QC002	Gordon River near the mouth	1530	16	6.1	5.1	4.6	4.4	4.0
10PC001	Kendall River near outlet of Dismal Lakes	2790	12	5.3	4.5	4.1	3.8	3.5
10QD001	Ellice River near the mouth	16900	27	4.8	3.8	3.4	3.1	2.8

Table 2 Monthly Statistics for Regional WSC Streamflow Gauging Stations

WSC Station	Item	Monthly Average Flow (L/s/km ²)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Akkutuak Creek near Baker Lake	Extreme maximum	0	0	0	0	13.9	81.3	49.1	19.6	25.3	4.7	0	0
	Average	0	0	0	0	2.5	54.3	15.1	8.6	11.9	2.1	0	0
	3-year low	0	0	0	0	0	47.0	8.5	2.5	4.8	0	0	0
	5-year low	0	0	0	0	0	41.8	6.6	0.8	2.1	0	0	0
	10-year low	0	0	0	0	0	36.6	5.1	0.2	0.7	0	0	0
	Extreme minimum	0	0	0	0	0	31.9	4.3	0	0.1	0	0	0
Atitok Creek near Dismal Lakes	Extreme maximum	0	0	0	0	16.0	85.7	10.0	9.8	34.8	15.0	0.5	0
	Average	0	0	0	0	2.2	53.5	3.8	3.7	9.6	2.4	0.1	0
	3-year low	0	0	0	0	0	42.6	2.2	1.4	2.7	0.3	0	0
	5-year low	0	0	0	0	0	35.8	1.6	0.9	1.6	0.2	0	0
	10-year low	0	0	0	0	0	29.5	1.1	0.5	0.8	0.1	0	0
	Extreme minimum	0	0	0	0	0	25.9	0.7	0.5	0.6	0.1	0	0
Qinguq Creek near Baker Lake	Extreme maximum	0	0	0	0	18.6	86.3	28.2	22.3	39.6	7.4	0.4	0
	Average	0	0	0	0	1.6	39.1	13.0	5.8	8.2	1.3	0	0
	3-year low	0	0	0	0	0	29.1	9.1	2.7	3.2	0.4	0	0
	5-year low	0	0	0	0	0	24.3	6.8	1.9	1.9	0.1	0	0
	10-year low	0	0	0	0	0	20.0	4.8	1.3	1.0	0	0	0
	Extreme minimum	0	0	0	0	0	14.9	2.7	0.8	0.3	0	0	0
Gordon River near the mouth	Extreme maximum	0	0	0	0	17.3	56.1	32.7	19.9	20.9	8.2	1.3	0.1
	Average	0	0	0	0	1.6	31.2	18.4	9.2	9.5	4.0	0.6	0
	3-year low	0	0	0	0	0	24.7	14.2	6.7	6.6	2.7	0.4	0
	5-year low	0	0	0	0	0	19.7	11.8	5.8	5.1	2.1	0.2	0
	10-year low	0	0	0	0	0	14.8	9.5	5.1	3.7	1.5	0.1	0
	Extreme minimum	0	0	0	0	0	8.6	8.0	4.9	2.4	1.1	0	0
Kendall River near outlet of Dismal Lakes	Extreme maximum	0	0	0	0	8.5	49.1	23.9	16.8	17.1	7.0	2.2	0.4
	Average	0	0	0	0	1.1	34.2	13.5	5.8	5.8	2.5	0.4	0
	3-year low	0	0	0	0	0	30.4	11.0	4.4	3.0	0.9	0	0
	5-year low	0	0	0	0	0	27.8	9.4	3.9	2.2	0.5	0	0
	10-year low	0	0	0	0	0	25.2	8.0	3.5	1.5	0.3	0	0
	Extreme minimum	0	0	0	0	0	23.8	6.6	2.8	1.1	0.1	0	0
Ellice River near the mouth	Extreme maximum	0.1	0	0	0	8.2	45.4	35.4	14.9	23.0	5.6	1.2	0.2
	Average	0	0	0	0	0.4	29.8	14.9	5.3	6.6	2.2	0.3	0
	3-year low	0	0	0	0	0	26.7	10.5	3.6	3.8	1.2	0.1	0
	5-year low	0	0	0	0	0	21.5	8.5	2.9	2.8	0.9	0.1	0
	10-year low	0	0	0	0	0	15.9	6.7	2.4	2.0	0.6	0	0
	Extreme minimum	0	0	0	0	0	5.7	4.6	1.7	1.5	0.4	0	0

Table 3 Synthesized 10-Year Drought Hydrographs for Regional WSC Streamflow Gauging Stations

WSC Streamflow Gauging Station		Drainage Area (km ²)	Monthly Average Flow for Synthesized 10-Year Drought Hydrograph (L/s/km ²)												Annual 10-Year Low Flow	
ID No.	Name		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	(L/s/km ²)	(mm)
06MA004	Akkutuak Creek near Baker Lake	15	0	0	0	0	0	51.4	9.3	2.7	5.2	0	0	0	5.7	179
10PC002	Atitok Creek near Dismal Lakes	217	0	0	0	0	0.01	36.1	1.9	1.2	2.3	0.3	0	0	3.4	109
06MA002	Qinguq Creek near Baker Lake	432	0	0	0	0	0	28.5	8.9	2.7	3.1	0.4	0	0	3.6	114
10QC002	Gordon River near the mouth	1530	0	0	0	0	0.02	24.9	14.3	6.7	6.7	2.8	0.4	0	4.6	147
10PC001	Kendall River near outlet of Dismal Lakes	2790	0	0	0	0	0	30.0	10.8	4.3	2.9	0.9	0	0	4.1	128
10QD001	Ellice River near the mouth	16900	0	0	0	0	0	23.7	9.3	3.2	3.3	1.1	0.1	0	3.4	107
Estimated drought flows for Jericho River			0	0	0	0	0	29.2	9.3	2.9	3.2	0.6	0	0	3.8	119

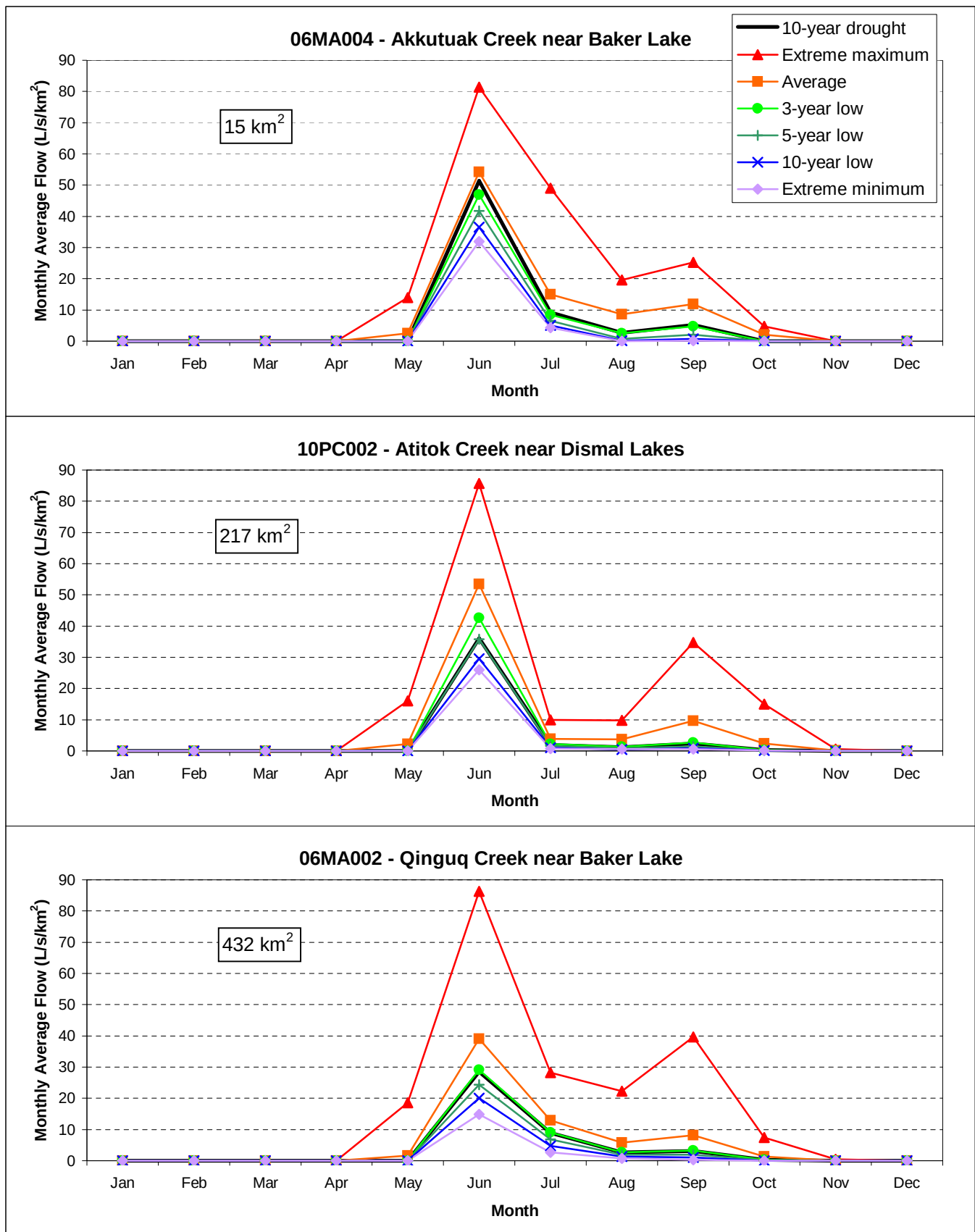


Figure 1: Synthesized 10-Year Drought Hydrographs for Akkutuuak, Atitok and Qinguq Creeks

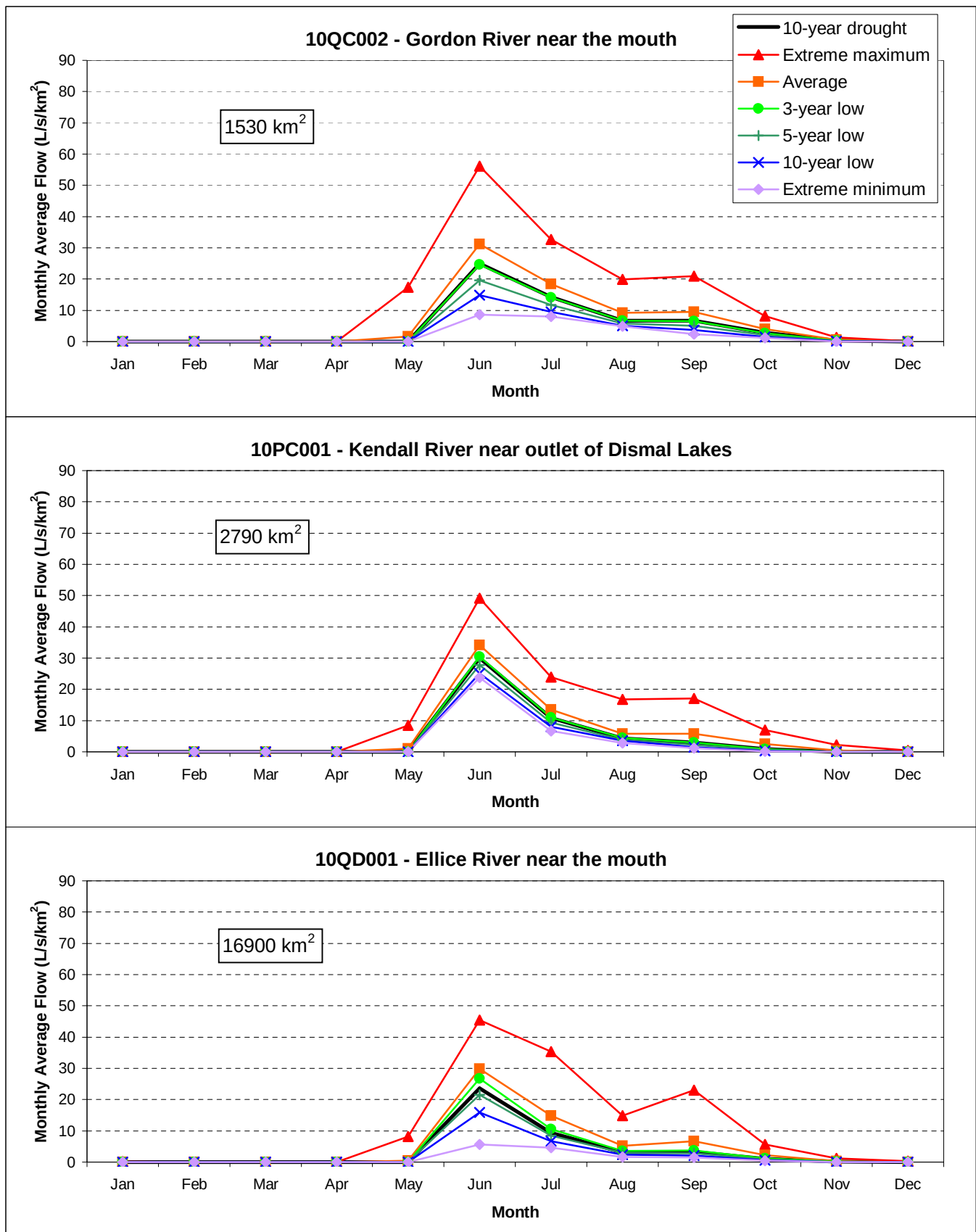


Figure 2: Synthesized 10-Year Drought Hydrographs for Gordon, Kendall and Ellice Rivers

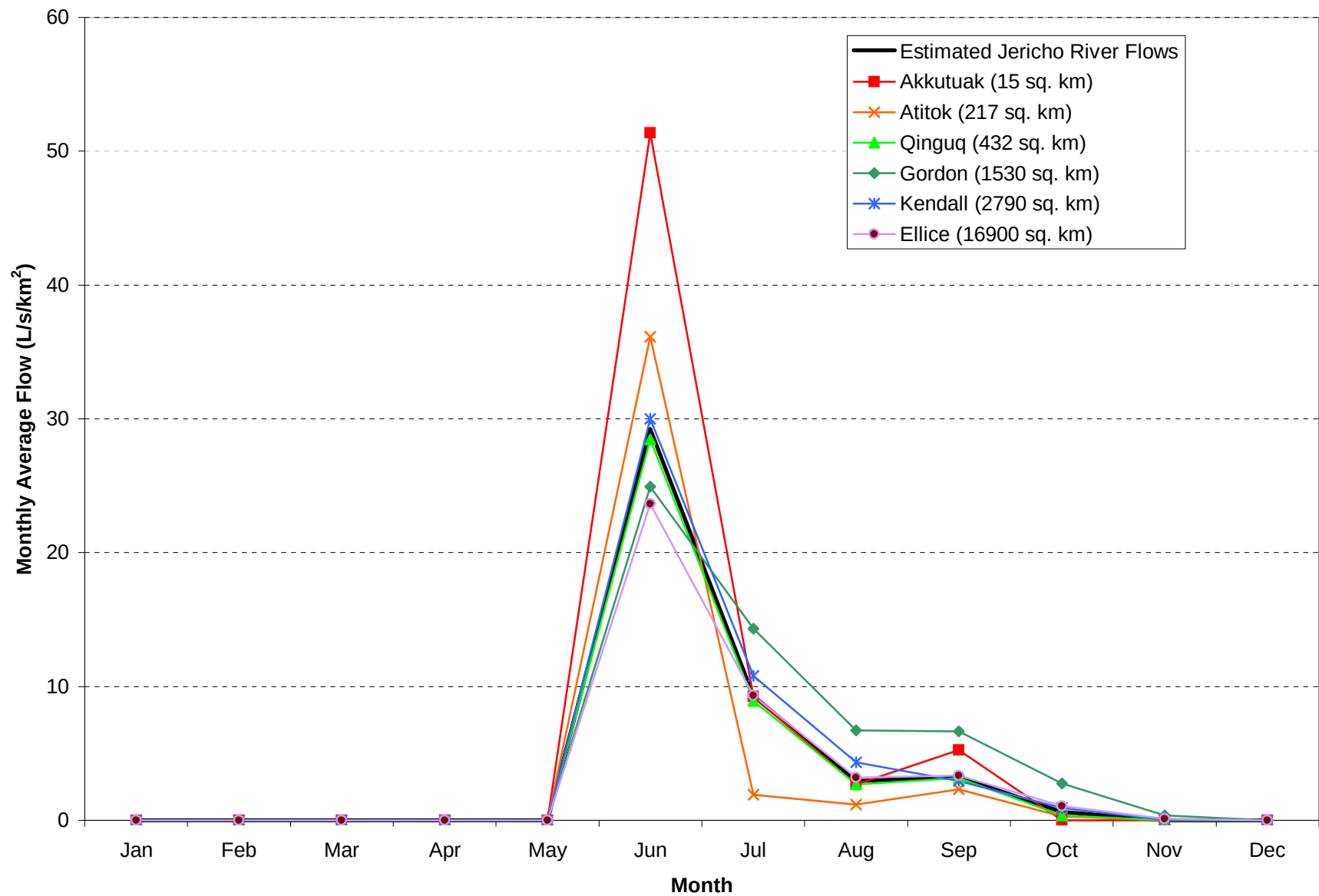


Figure 3: Synthesized 10-Year Drought Hydrographs for Jericho River and Regional WSC Stations

ATTACHMENT N2
Jericho Effluent Modeling (Lorax 2004)

MEMORANDUM

To: Kelly Sexsmith
From: Don Dunbar, Lorax
Subject: Jericho Effluent Modeling
Project:
Date: 2004/8/11
Copies:

Dilution model results for the Jericho Project in Nunavut are provided in the attached files.

Don Dunbar of Lorax Environmental Services Ltd. performed all of the three-dimensional numerical model simulations of effluent dilution as well as the CORMIX near-field dilution simulations. Dr. Dunbar used input data provided by SRK to initialize both models. Model results were subsequently provided to SRK by Lorax.

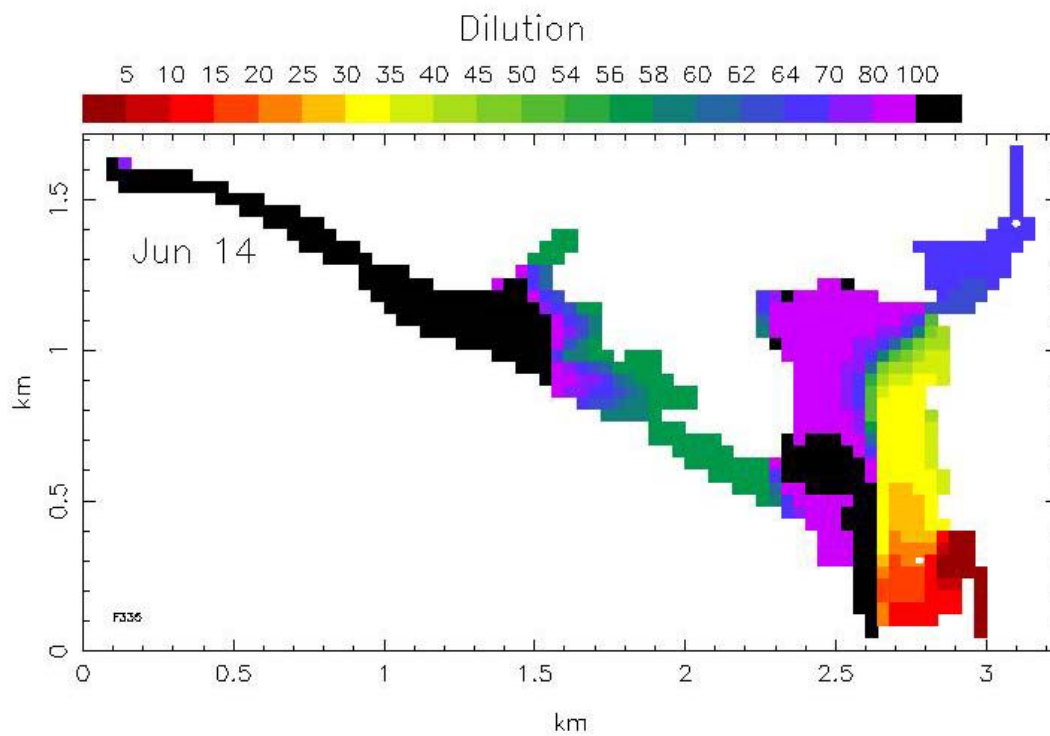
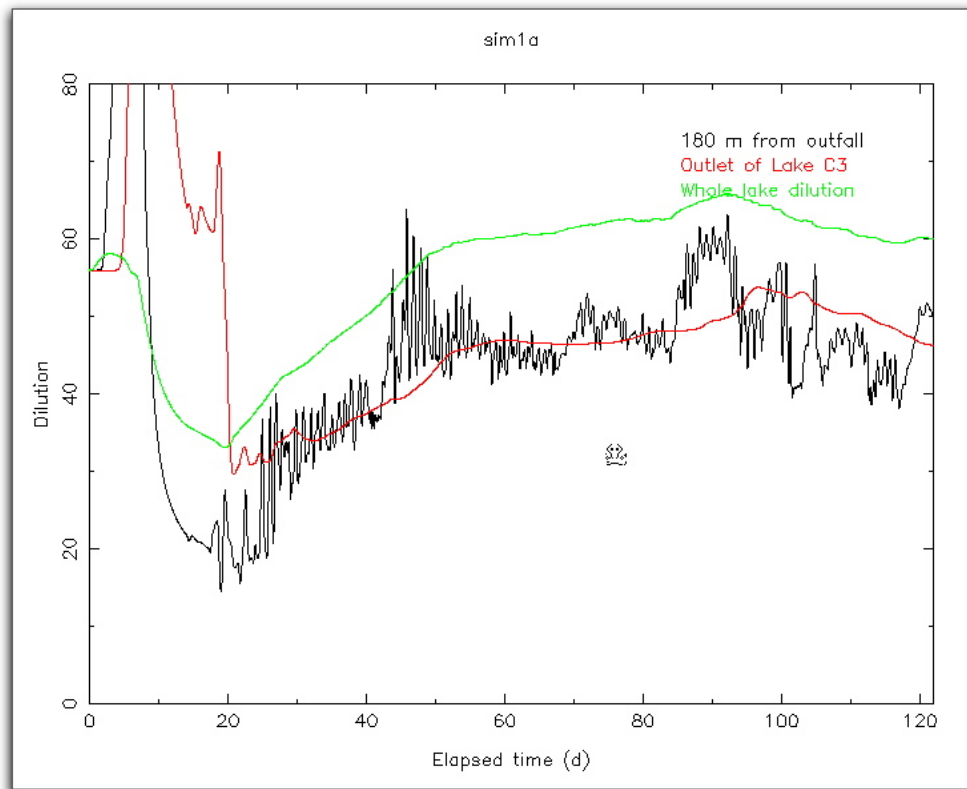
All model assumptions and inputs for the present set of POM simulations are the same as those used previously, except for the following:

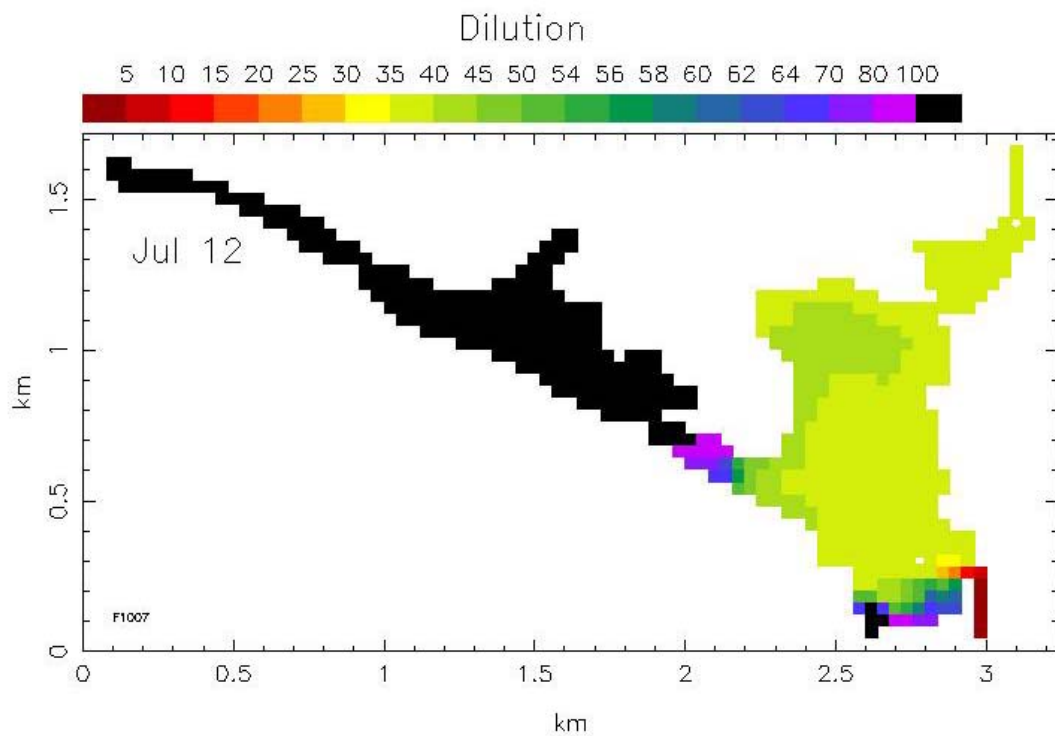
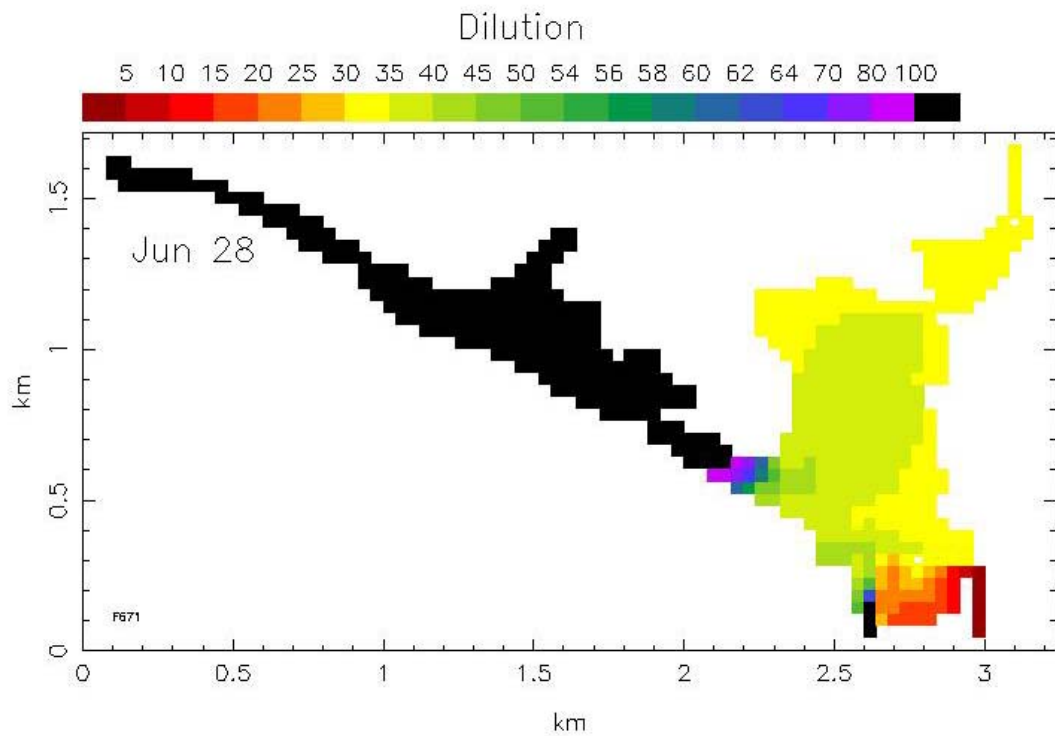
1. Jericho R. and effluent inflows have been adjusted to reflect changes in the water management plans. These flows were provided by SRK, and are documented in the accompanying report by SRK.
2. The vertical thermal structure has been removed and a constant temperature used.
3. Shoreline inflow of freshwater to both C3 and Carat Lakes has been concentrated into a few areas in the simulations, rather than being distributed evenly along the shore.
4. POM grid cell size has been decreased from 60 m to 40 m to increase the model resolution.
5. The number of vertical layers in the models was reduced from 21 to 11 to decrease execution time.

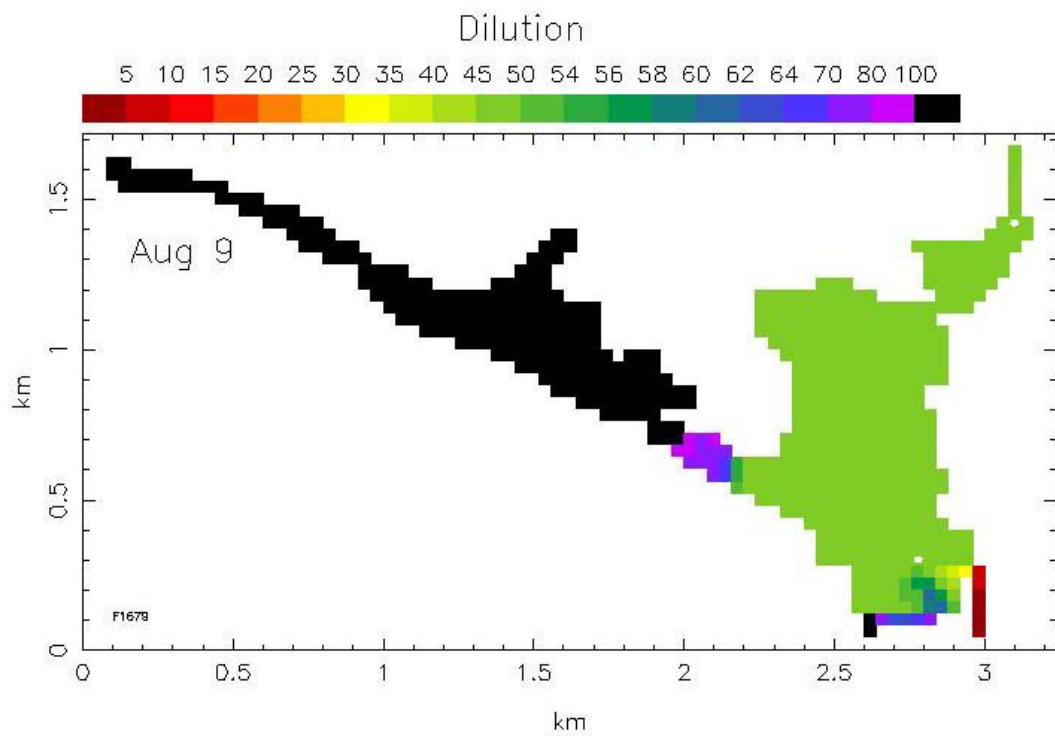
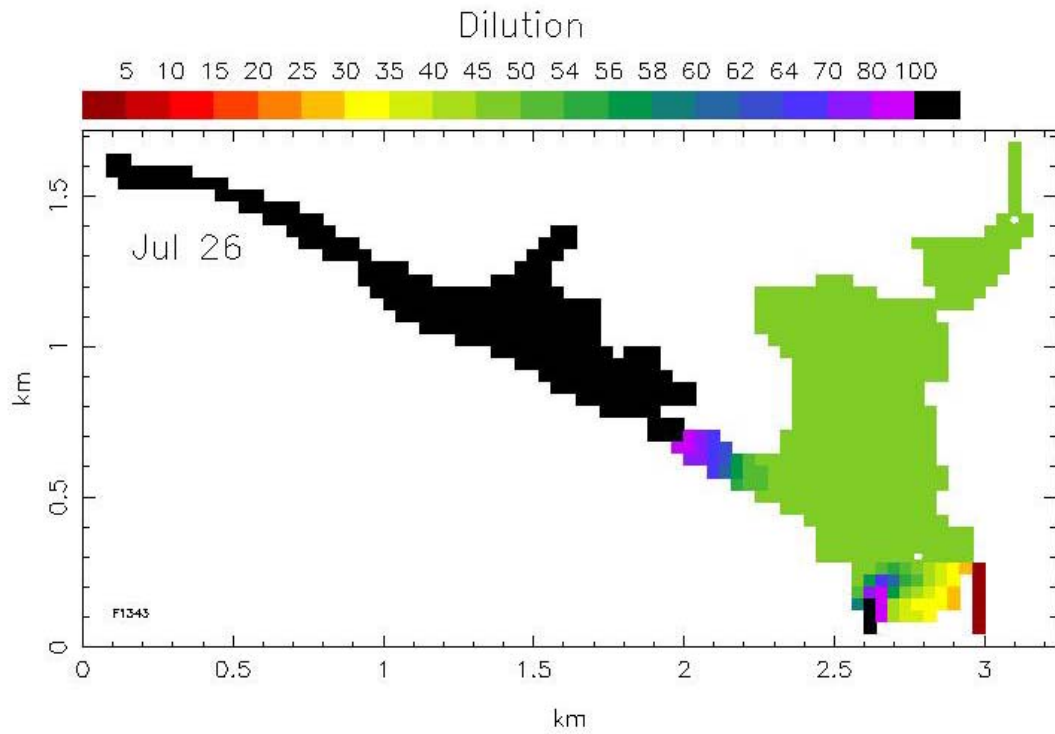
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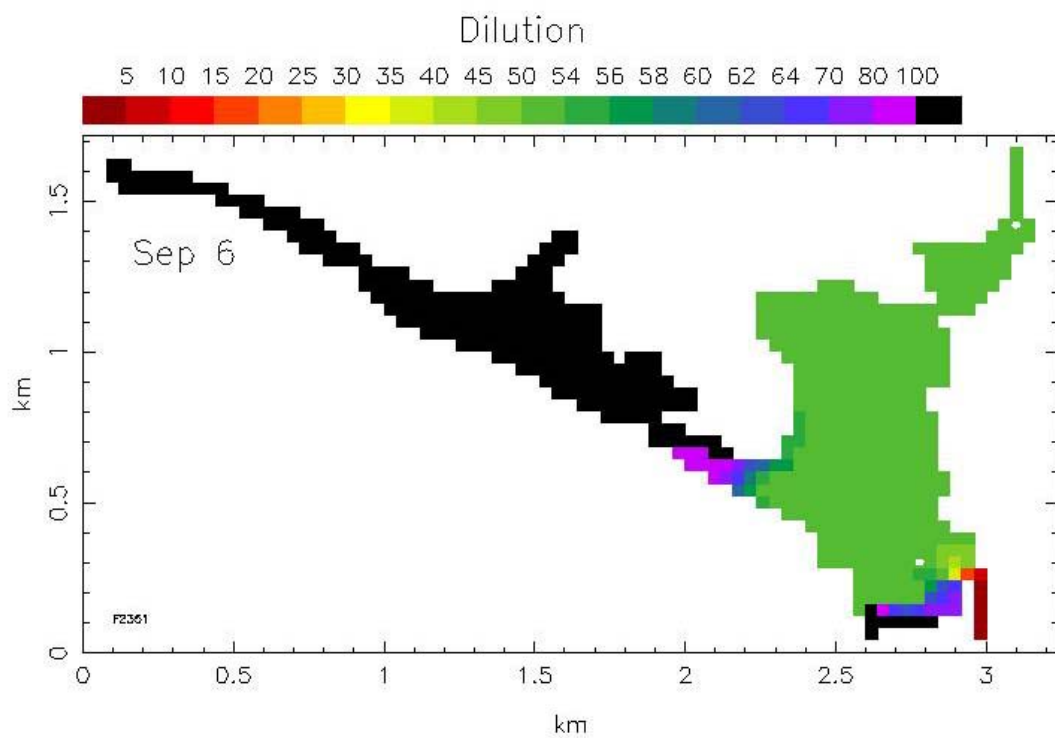
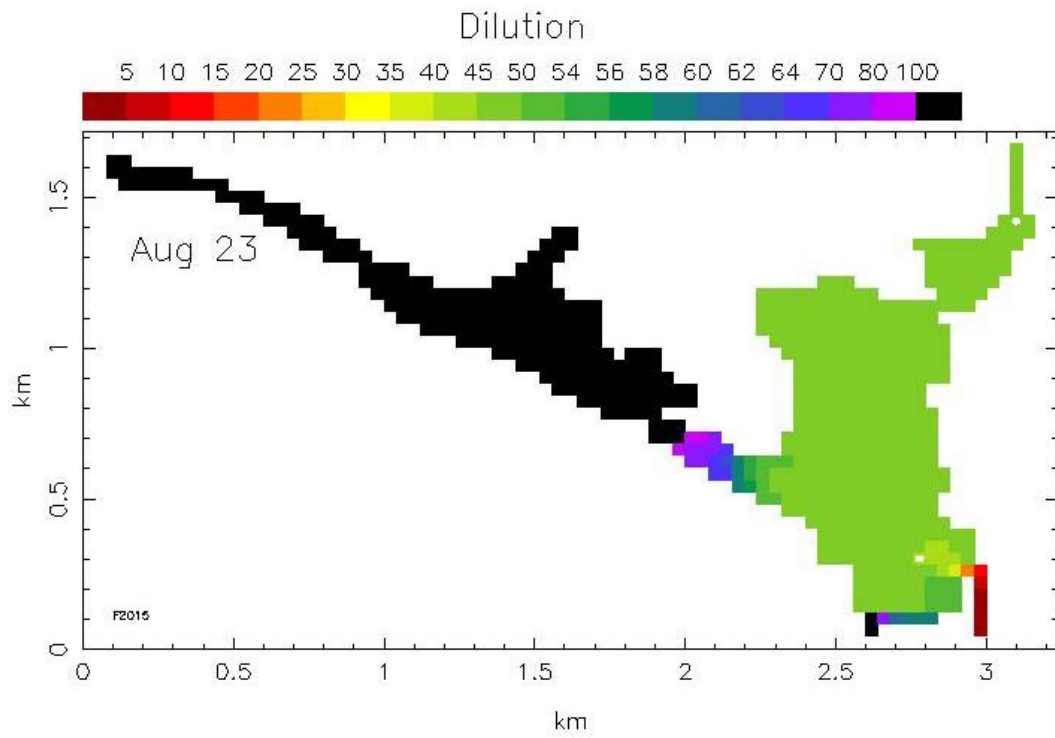
**Dilution Modelling Results – Discharges from the PKCA during Operations
(results provided by Lorax)**

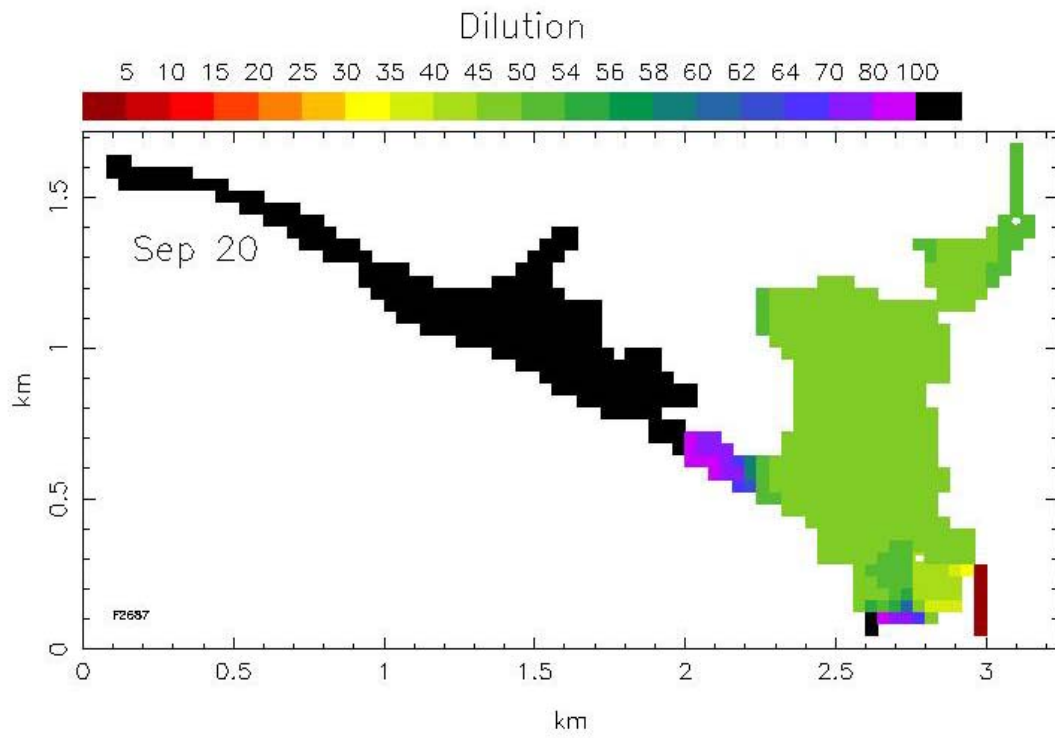
ATTACHMENT N3A
Expected Discharge Conditions



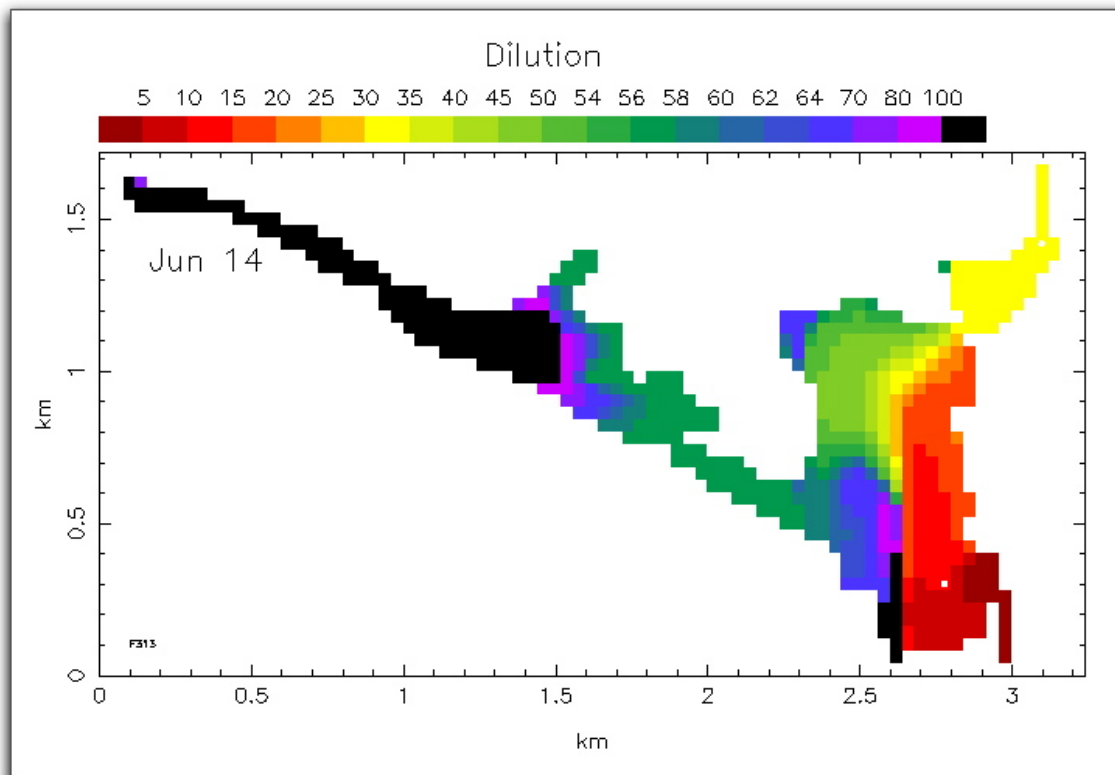
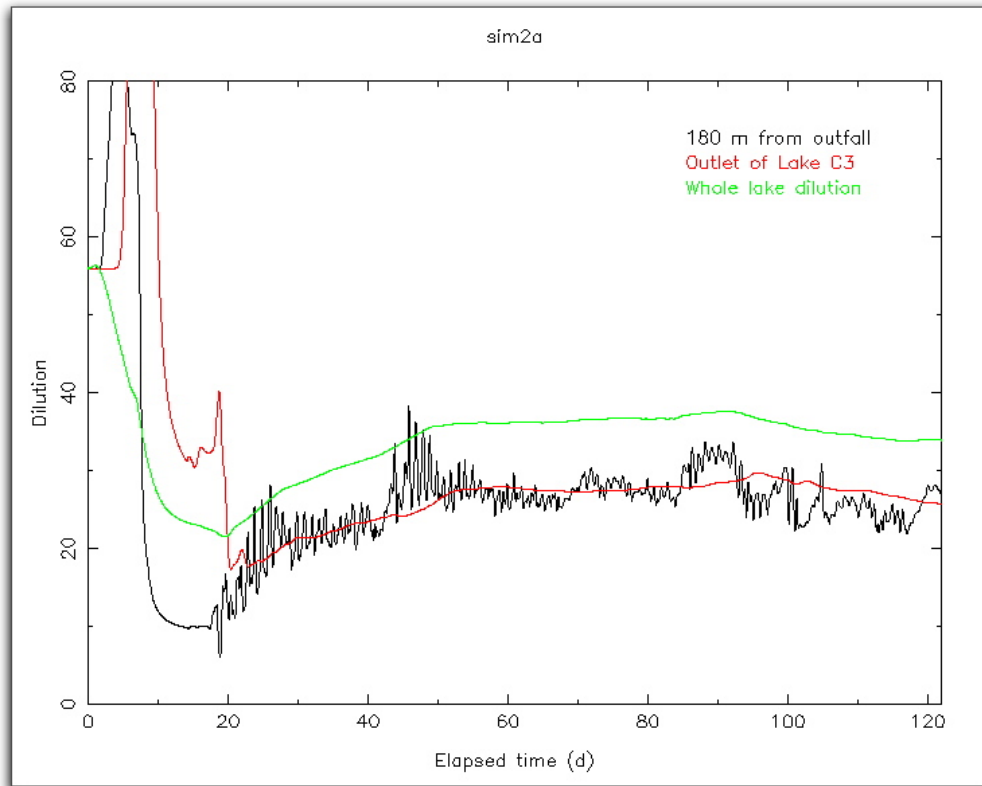


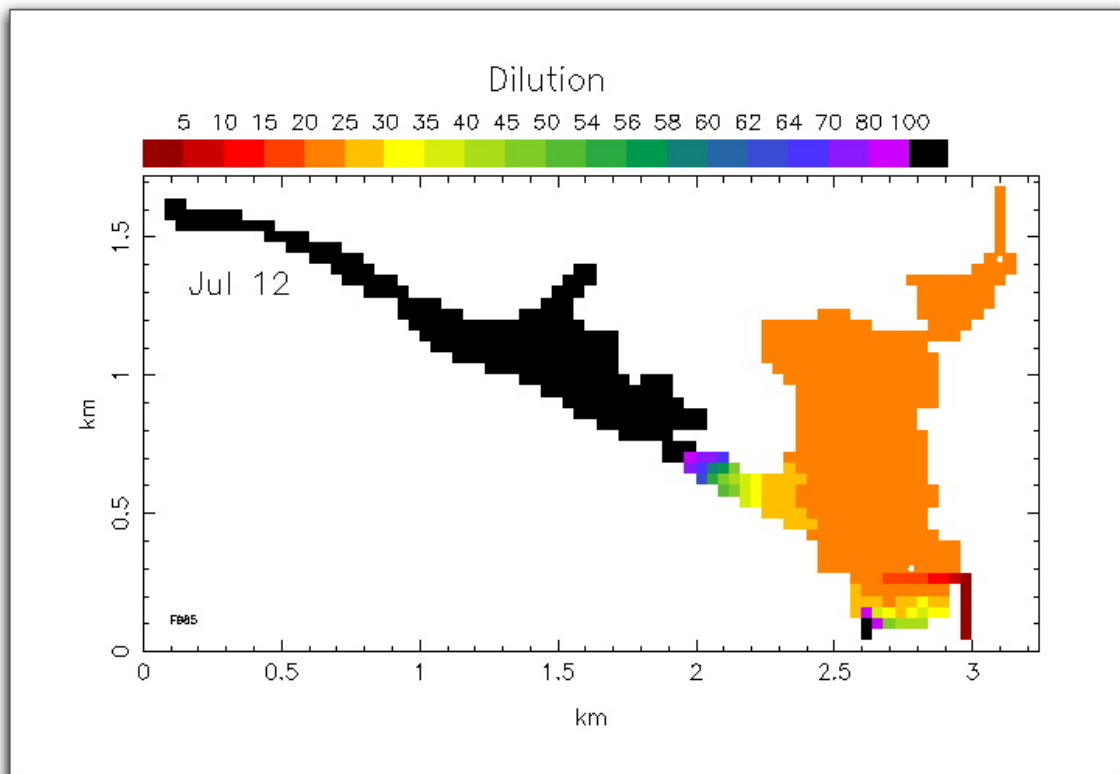
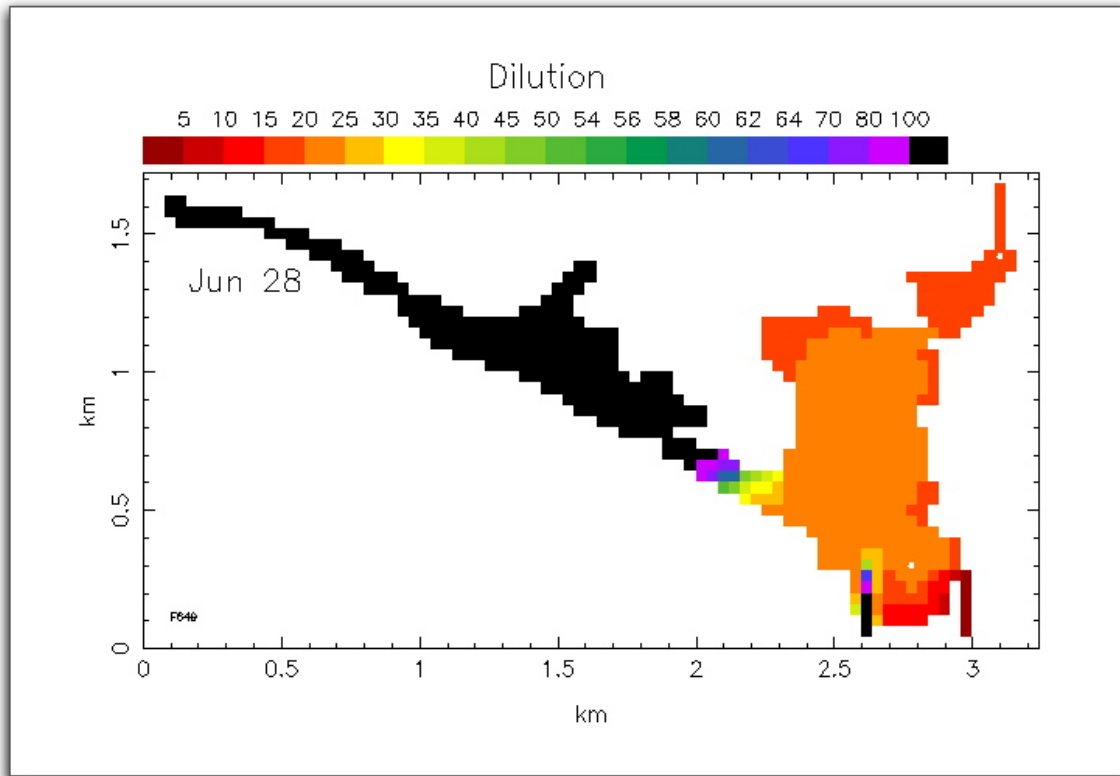


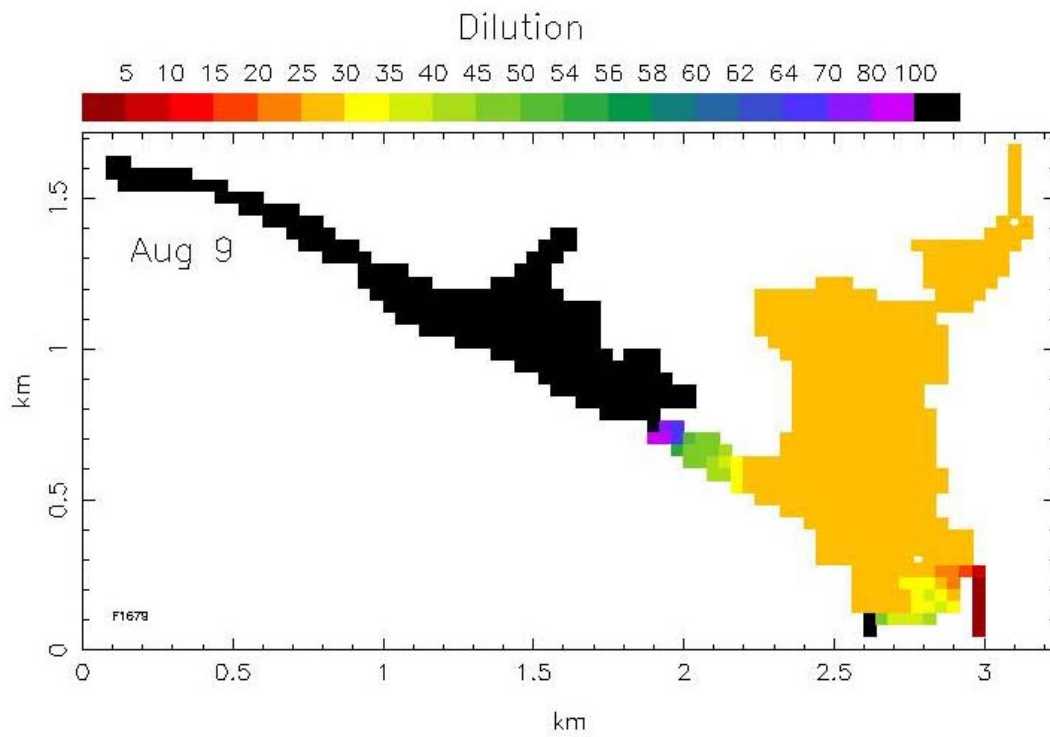
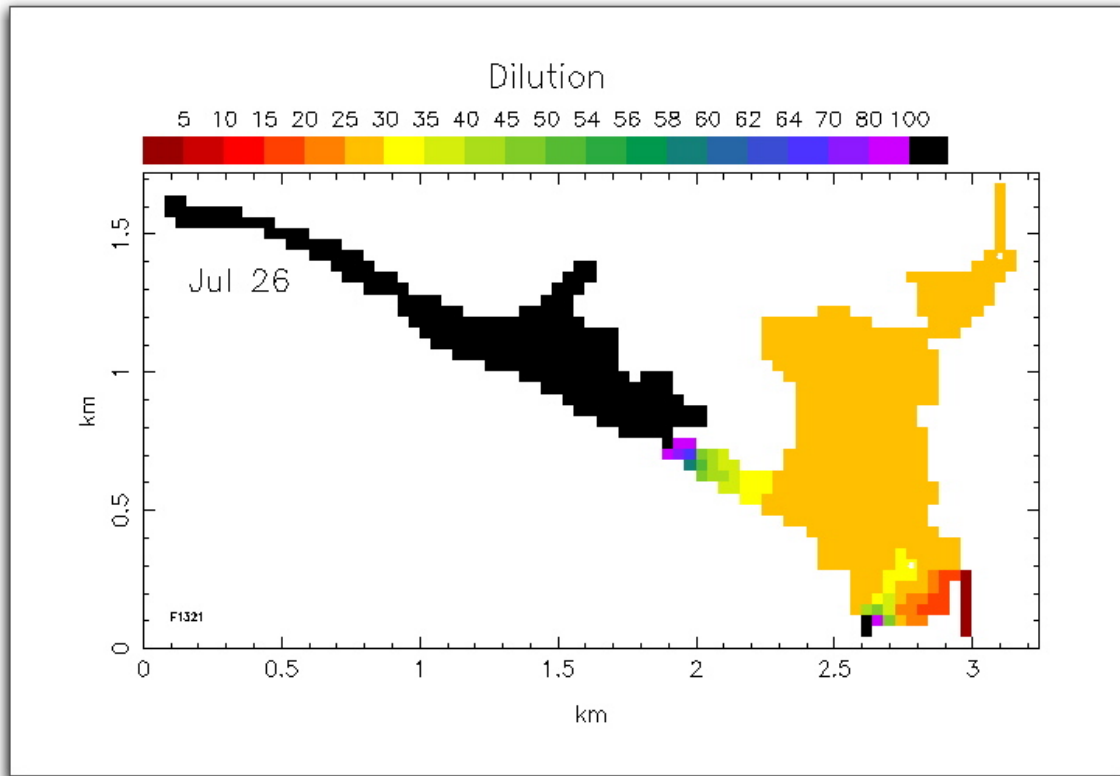


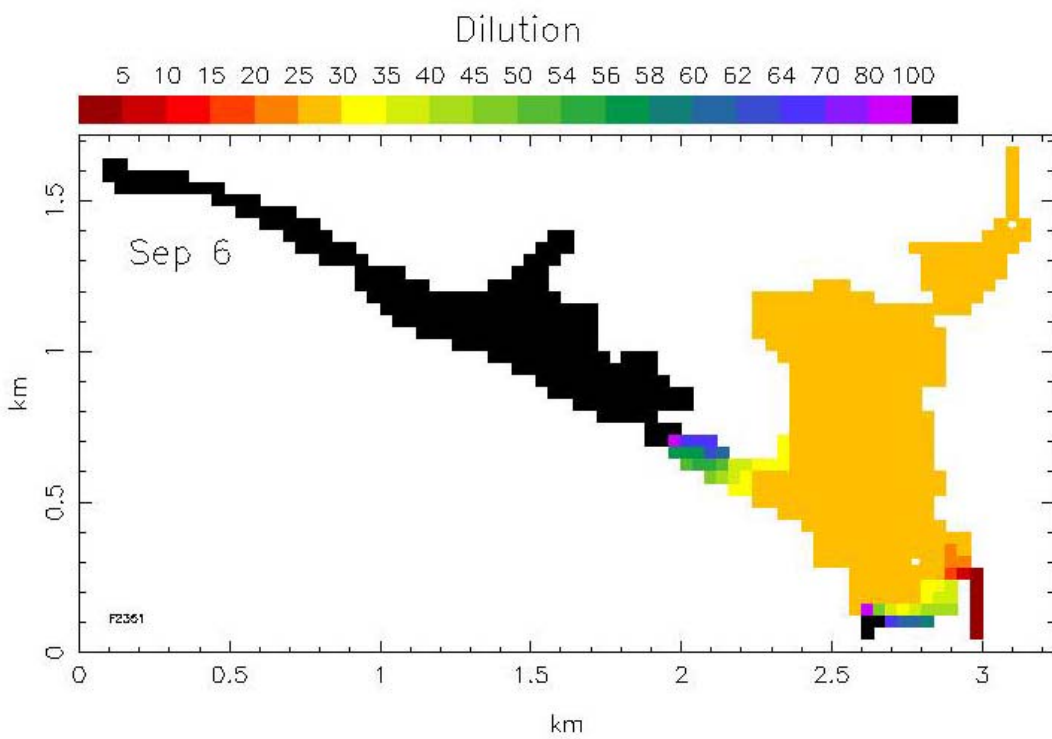
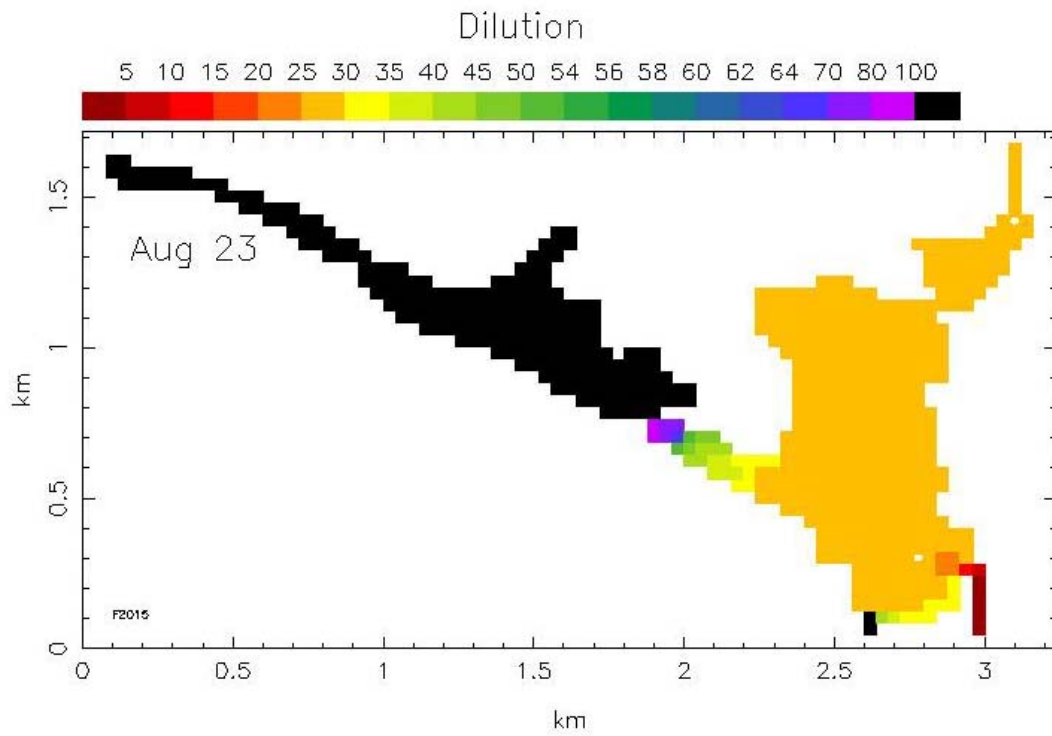


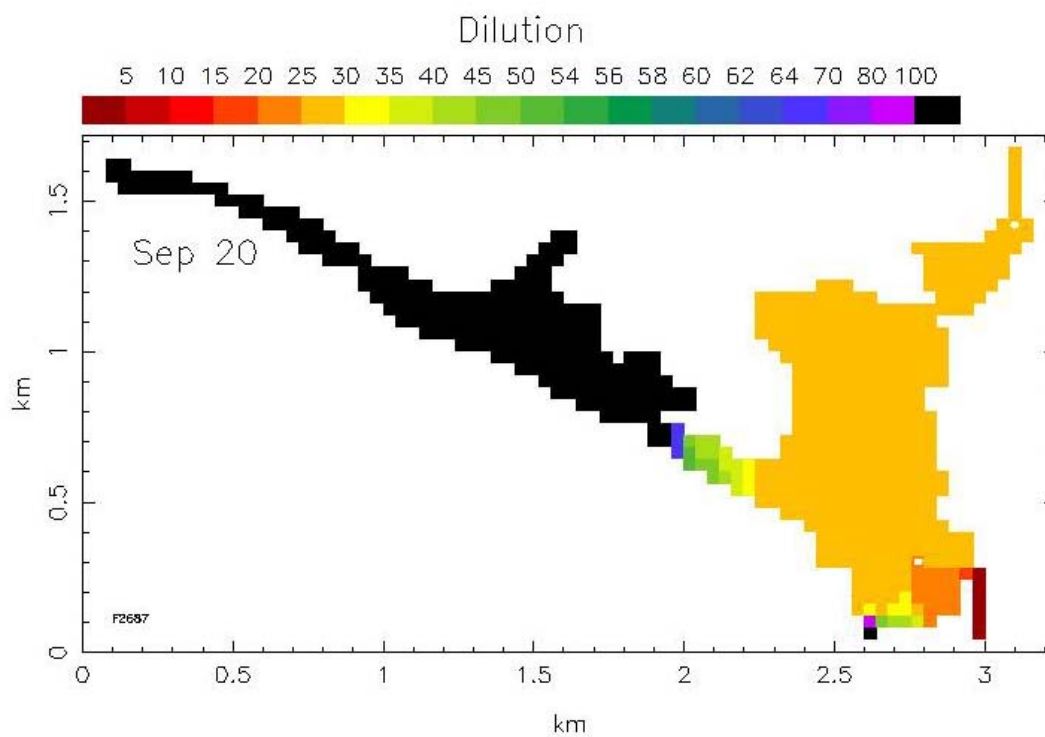
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Contingency Release of Stored Flows





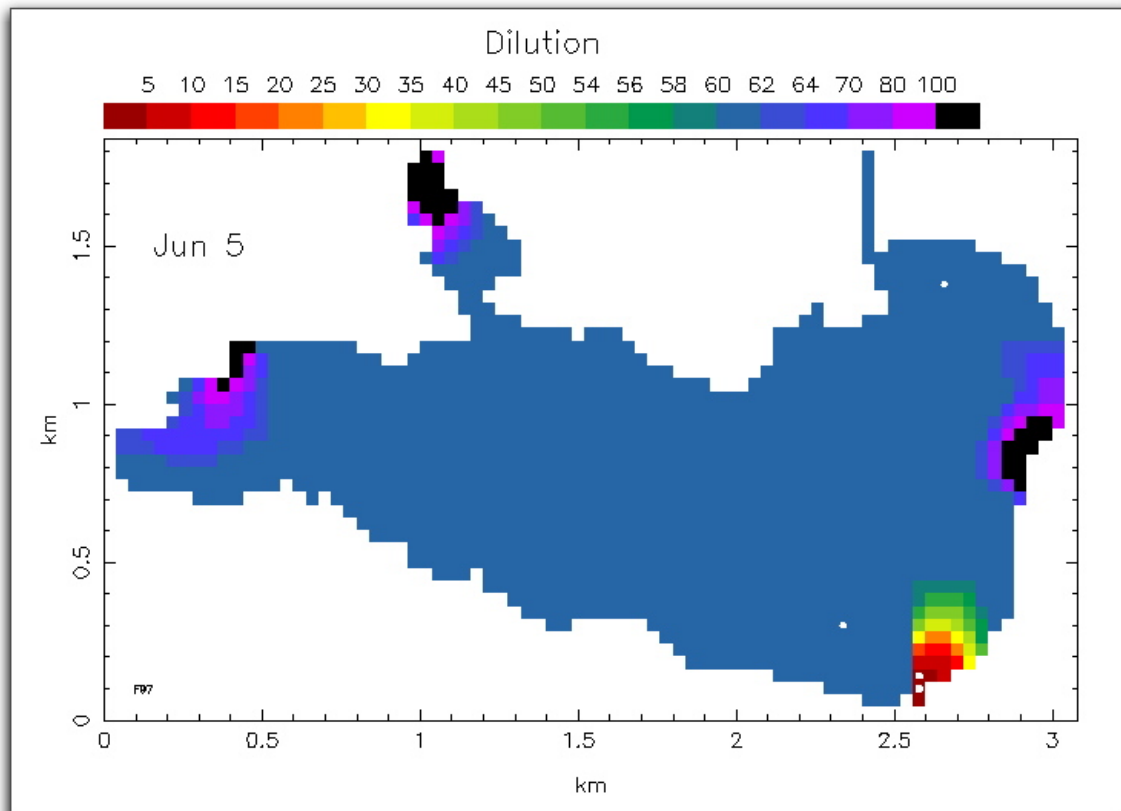
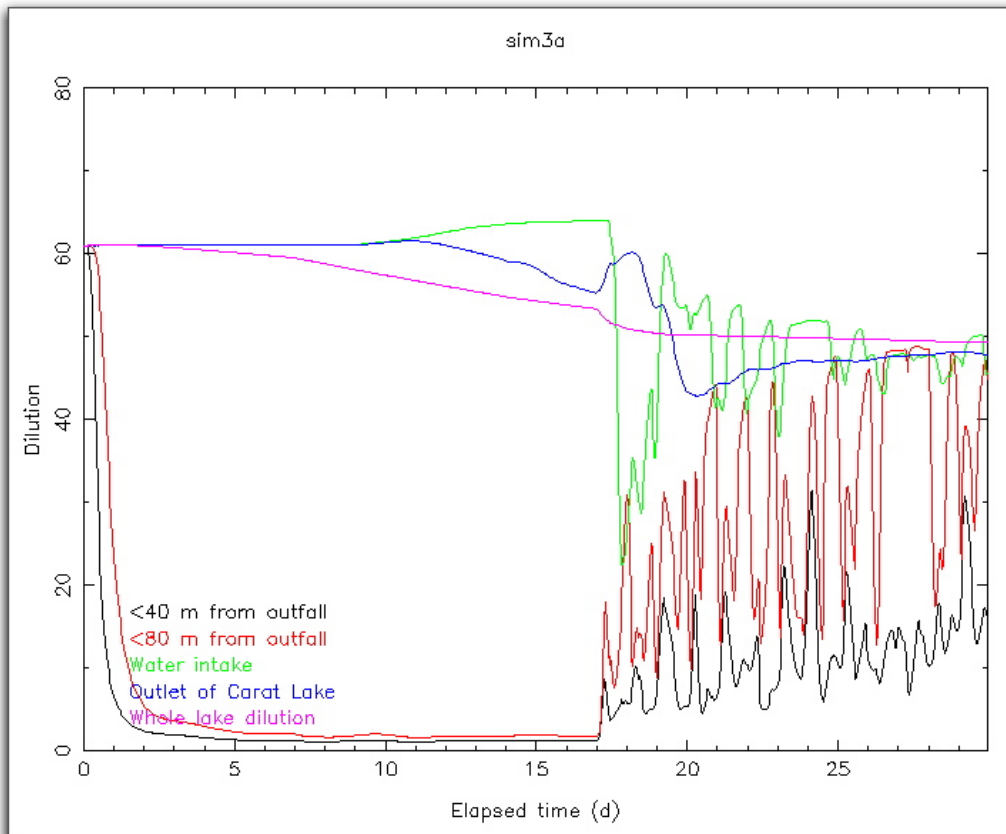


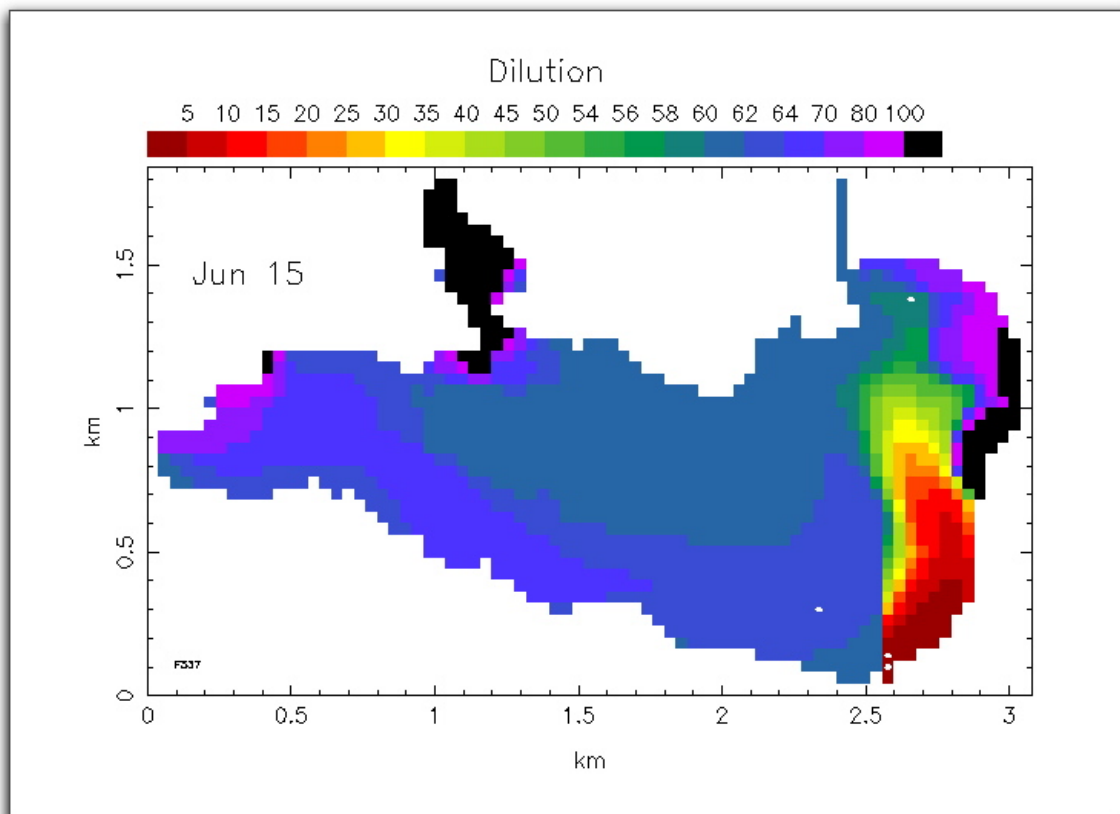
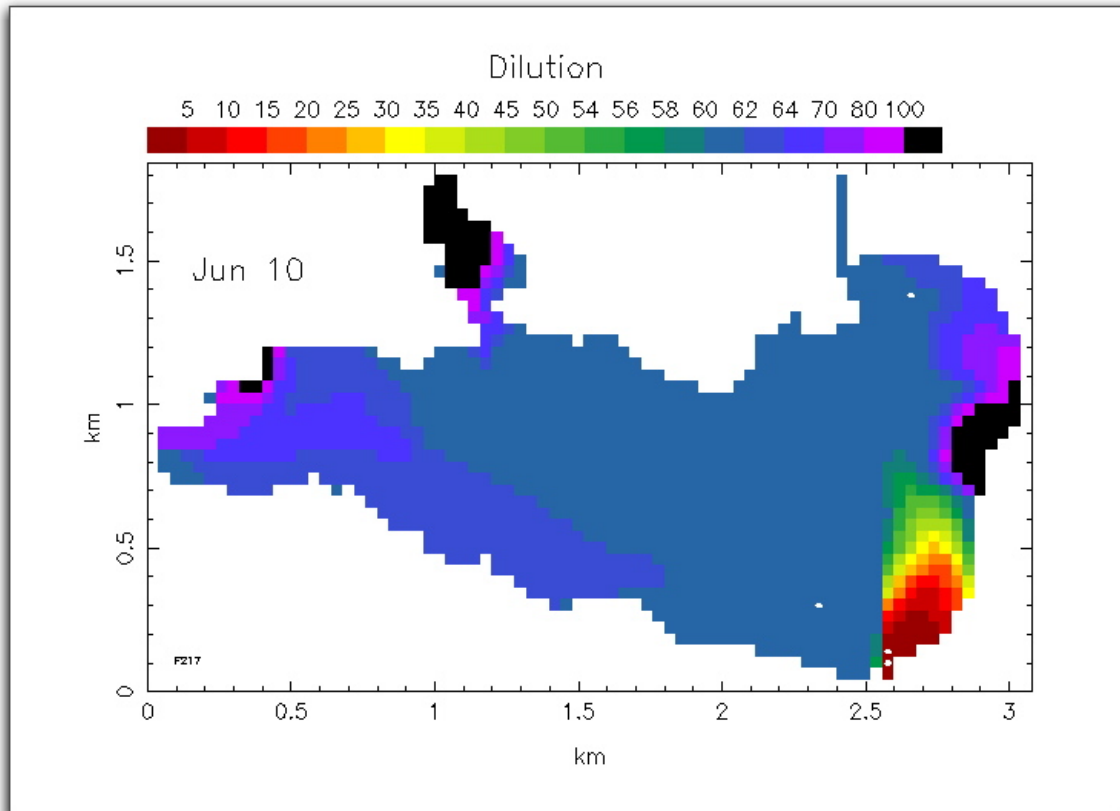


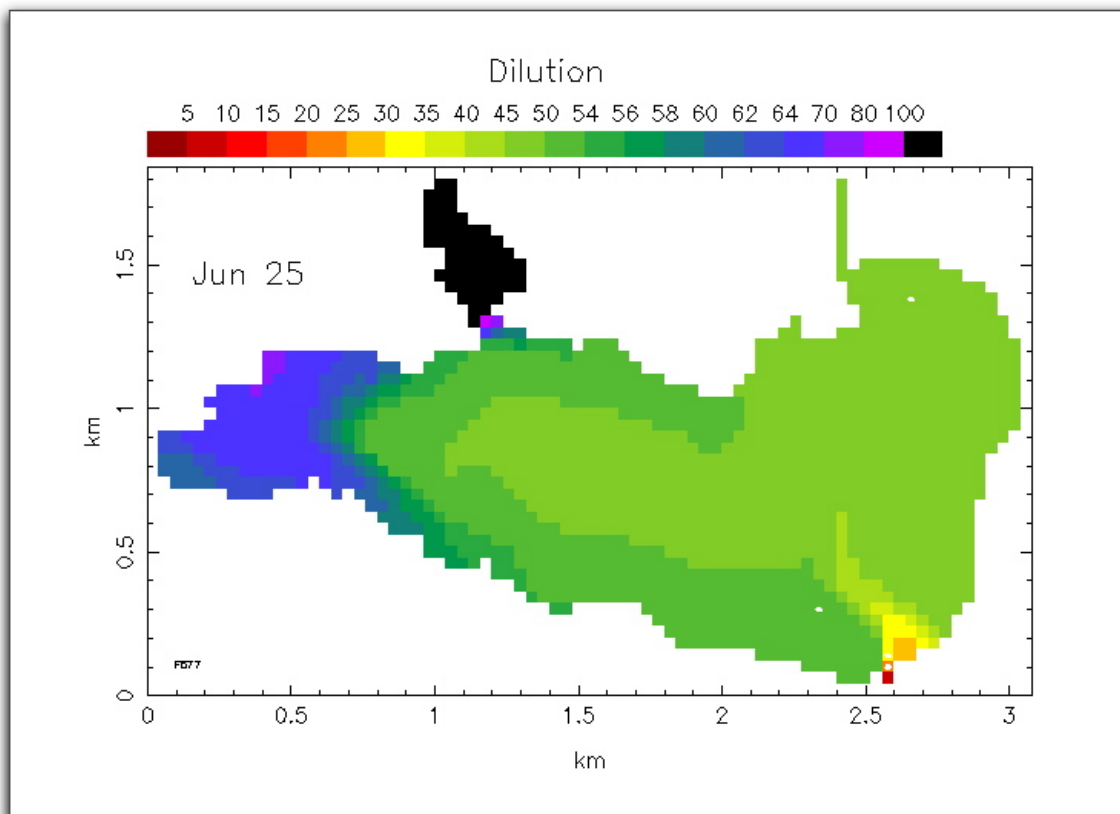
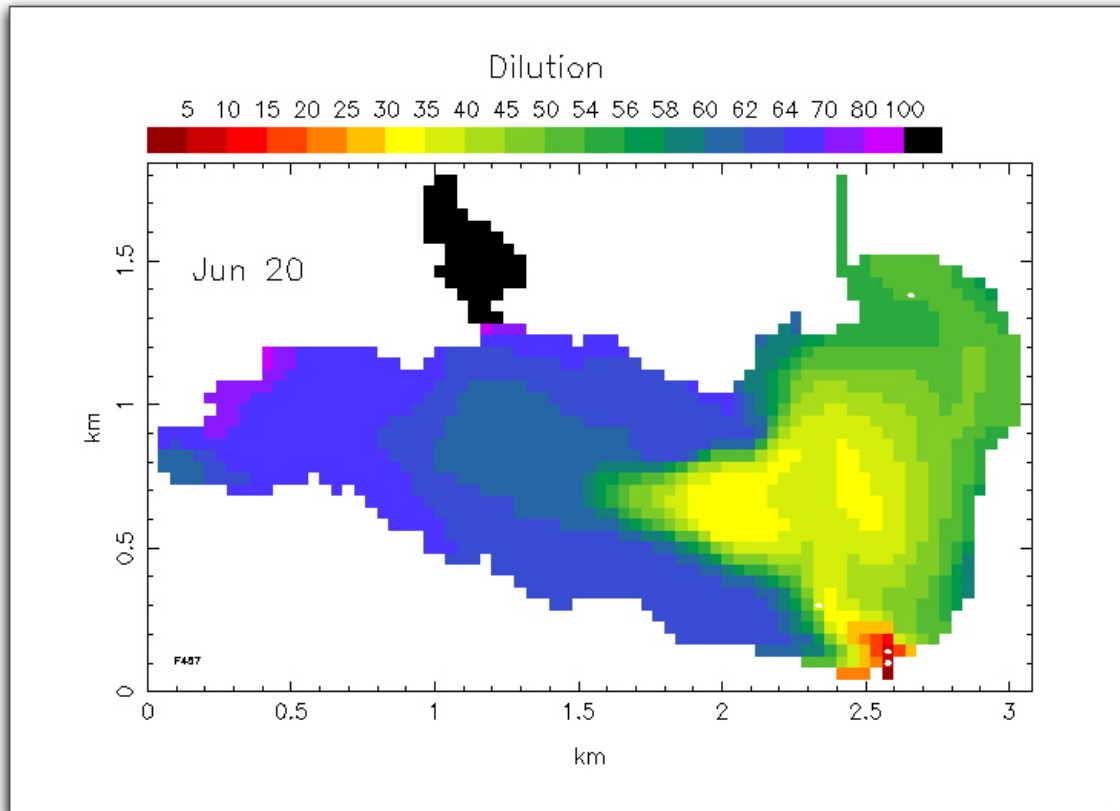


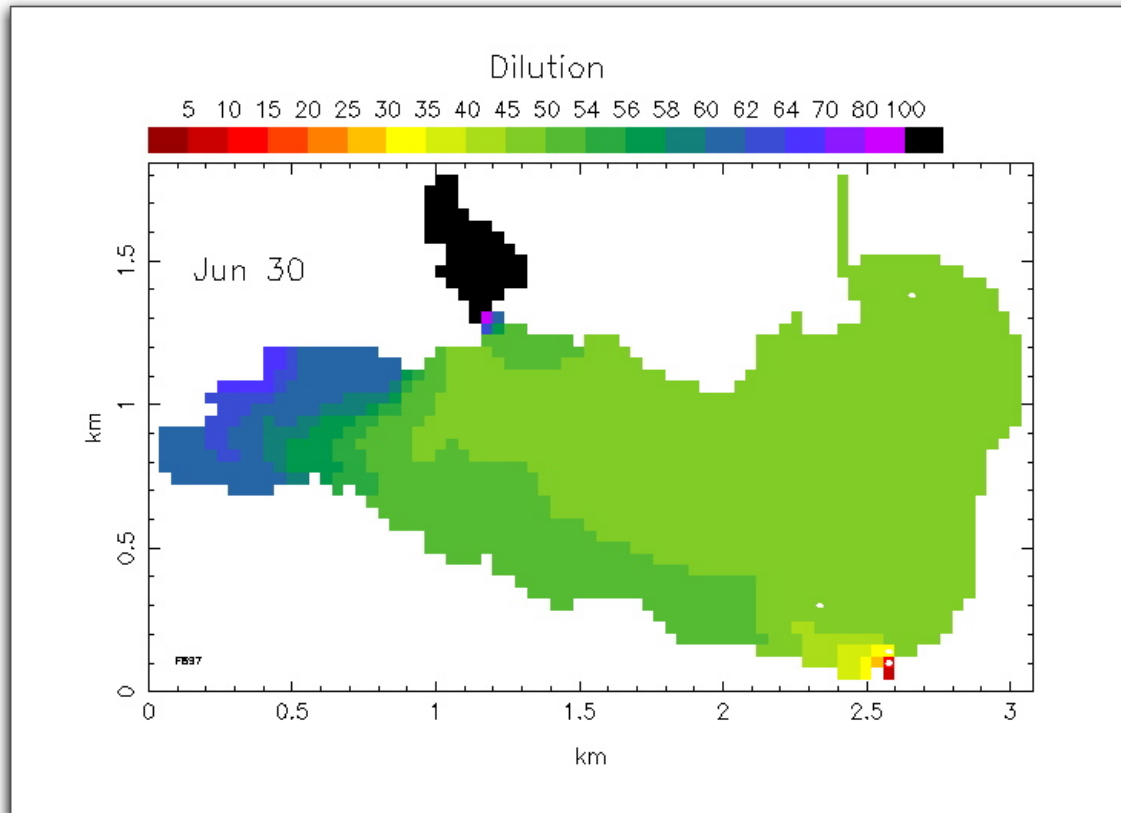
ATTACHMENT N4

**Dilution Modelling Results – Post Closure Discharge, Shoreline of Carat Lake
(Results provided by Lorax)**









ATTACHMENT N5

**Review of Total Dissolved Solids in Proposed Discharge
from the Jericho Diamond Project, Nunavut (AMEC 2004)**

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**Review of Total Dissolved Solids in Proposed Discharge
from the Jericho Diamond Project**

**West Kitikmeot
Nunavut**

Submitted to:

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Toronto, Ontario

Submitted by:

**AMEC Earth & Environmental,
a division of AMEC Americas Limited**

Burnaby, BC

June 2004

AMEC File: VE51295

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IMPORTANT NOTICE

This report was prepared exclusively for Tahera Corporation by AMEC Earth & Environmental Limited. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Tahera Corporation only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

1.0 INTRODUCTION

Tahera Corporation is in the process of applying for a water license to discharge water from the proposed Jericho Diamond Mine. Discharge from the mine will contain elevated concentrations of total dissolved solids (TDS) relative to the receiving environment and, consequently, this review was conducted to evaluate whether the concentrations that are likely to be observed in the receiving environment are of toxicological significance.

TDS reflects the sum of materials that are dissolved in a solution. These materials are primarily comprised of four cations (calcium, magnesium, sodium and potassium) and three anions (sulphate, chloride, and bicarbonate/carbonate), all of which are important in biological structures and functions. A significant number of other trace materials can also contribute to TDS; however, for the sake of this assessment, we will only be considering the major ions.

Toxicity associated with elevated concentrations of TDS generally results from one of three mechanisms:

- The overall ionic strength associated with the combination of ions comprising the TDS can result in toxicity as a result of the inability of organisms to osmoregulate.
- Adverse effects can occur as a result of one or more of the ions which make-up TDS reaching toxicologically significant concentrations.
- An imbalance in the ratio between particular ions can result in toxicity because of disruption of biological mechanisms.

Toxicity test data for cationic components of TDS are always derived from tests with solutions containing an associated anionic component, and vice versa. These ions are present as salts, such as calcium carbonate, calcium sulphate, potassium chloride, etc, which are introduced into the test solutions. Consequently, the degree to which one or other of the co-ions comprising each salt, or any interactions associated with their combined presence, is responsible for toxicity is not entirely known.

Ions which comprise TDS each exhibit a differing degree of toxicological effect. A study on acute toxicity to larval fathead minnows and two species of cladocerans demonstrated that the order of relative ion toxicity is $K^+ > HCO_3^- \approx Mg^{2+} > Cl^- > SO_4^{2-}$. Sodium and calcium ions were generally unrelated to toxicity; toxicity associated with salts containing these two cations was generally caused by the corresponding anions (Mount et al., 1997).

2.0 EFFLUENT DESCRIPTION

Water from mining operations will be contained in the PKCA pond and will be discharged each year while weather conditions permit. Discharge from the PKCA is expected to contain elevated concentrations of TDS. In particular, under average precipitation conditions, average and maximum TDS concentrations are projected to be 1074 and 1635 mg/L, respectively (SRK, 2004). The projected composition of TDS in the effluent under these scenarios is provided in Table 1.

The anionic composition of the effluent is dominated by chloride, which comprises 40 to 45% of the total TDS by weight. Sulphate also contributes substantially to the total TDS (17 to 23%). Cationic components of the effluent collectively contribute approximately 30% of the TDS.

Table 1. Projected average and maximum contributions of major ions to TDS in water in the PKCA under conditions of average rainfall (from SRK, 2004).

	Average concentration (mg/L)	Maximum concentration (mg/L)	Average Composition (%)	Maximum Composition (%)
Calcium	101	202	9%	12%
Magnesium	175	206	16%	13%
Sodium	21	36	2%	2%
Potassium	36	64	3%	4%
Alkalinity	42	70	4%	4%
Chloride	487	647	45%	40%
Sulphate	184	380	17%	23%
TDS	1074	1635	--	--

3.0 RECEIVING ENVIRONMENT DESCRIPTION

Effluent from the PKCA will be discharged through a small stream into Lake C3, which subsequently drains into Carat Lake. These lakes are oligotrophic and very low in TDS (typically less than 20 mg/L). Dilution rates provided by Lake C3 and Carat Lake are estimated to be 50- and 58-fold, although higher concentrations of effluent would be expected to occur proximate to the discharge point.

The biological community in the lakes that will receive input from the mine is limited by the low productivity of the lakes. Periphyton and phytoplankton are dominated by Bacillariophyta (diatoms), Cyanophyta (cyanobacteria), Chrysophyta (golden-brown algae) and Chlorophyta (green algae). Zooplankton are comprised of cladocerans (52 to 86% of biomass), copepods and rotifers, and benthic invertebrates are predominantly comprised of benthic copepods and chironomid larvae. Smaller numbers of hydracarina, nematodes, oligochaetes, ostracods,

pelecypods and turbellarians are also observed. Fish populations present in Lake C3 and Carat Lake are comprised mainly of lake trout, round whitefish and Arctic char (data from a 1999 survey [RL&L, 2000]).

4.0 POTENTIAL FOR TOXICOLOGICAL EFFECTS ASSOCIATED WITH TDS

Evaluations of TDS with respect to potential for toxicological effects are complicated by the fact that they generally rely on laboratory data from toxicity tests with individual ion pairs (i.e., salts). Data from each of these tests must be considered in the context of the possibility that the toxicity was caused by one or other of the pair of ions, or some combination of the two. Furthermore, extrapolation of these effects data to mixtures of all seven of the major ions is complicated by the potential for interaction of the ions with one another. In some cases, the combined presence of multiple ions can reduce the toxicity of individual ions (Mount et al, 1997); however, the combined presence of multiple ions increases the overall ionic strength of the water, and may result in toxicity in cases where the individual ions would not have, if tested alone.

4.1 Anionic contributors to TDS

Sulphate

There are currently no Canadian or USEPA guidelines for the protection of aquatic life for sulphate; however, the BC Ministry of Water Land and Air Protection has established a water quality criterion for this parameter of 100 mg/L (BCMELP, 2000). This guideline is primarily based on sensitivity data for *Hyalella azteca*, a freshwater amphipod, and aquatic mosses.

The BC criteria document for sulphate contains a significant amount of toxicity data that are not published elsewhere; these data were generated in support of the guideline derivation. A subset of these results which are of particular relevance to Jericho have been summarized in Table 2. Although amphipods such as *H. azteca* would not be expected to occur in these lakes, the data for this species have also been included in Table 2 because of the reliance of the guideline on data from this species.

Adverse effects on the cladocerans *Ceriodaphnia dubia* and *Daphnia magna*, the chironomid *Chironomus tentans*, the salmonid *Oncorhynchus mykiss* and the unicellular alga *Selenastrum capricornutum* occurred at substantially higher concentrations than the maximum sulphate concentrations projected in the PKCA of 380 mg/L (i.e., not allowing for any dilution by lakes downstream of the discharge point). Concentrations of sulphate in the PKCA are expected to exceed the lowest effect value presented for *H. azteca*; however, it should be noted that the sensitivity of this species to sulphate is highly hardness dependant, and the toxicity of sulfate is more than an order of magnitude lower at a hardness of 100 mg/L than it is at a hardness of 25 mg/L. Moreover, elevated sulphate concentrations in discharges from the Jericho mine will co-occur with higher hardnesses: for example, at a sulphate concentration of 205 mg/L (the LC50

for *H. azteca* in 25 mg/L hardness water), we would anticipate that the discharge would have a hardness of more than 700 mg/L. Thus, even if *Hyalella* were present, we would not anticipate observing adverse effects on survival, and it would appear that the BC criterion for this parameter is overly protective in this instance.

The only other adverse effect data reported in the BC criteria document that were reported at concentrations below the maximum sulphate concentration predicted in the PKCA under average precipitation conditions (380 mg/L) were for larval striped bass (*Morone saxatilis*) which exhibited a 96-hr LC50 of 250 mg/L SO₄; this species does not occur in the receiving environment at the Jericho mine. In addition, evidence has been reported of adverse effects on aquatic mosses, in particular *Fontinalis antipyretica*, at concentrations of sulphate as low as 100 mg/L (Frahm, 1975, cited by BCMELP, 2000); however, these tests were apparently conducted using potassium sulphate rather than sodium sulphate, and it is likely that any observed effect was related to the potassium co-ion rather than to sulphate.

Thus, on the basis of a “worst case” analysis, it would appear that adverse effects associated with elevated concentrations of sulphate would not be likely to occur, even within the PKCA. Furthermore, given the 50-fold dilution available in Lake C3, projected sulphate concentrations in the receiving environment should be well under any known thresholds for toxicity.

Table 2. Effects concentrations for sulphate for selected data generated as part of derivation of the BC criteria for this parameter.

	Species	Endpoint	Hardness (mg/L)	Effect concentration (mg/L SO ₄)
Cladoceran	<i>C. dubia</i> <i>D. magna</i>	7-d reproduction IC25	100	1267
		21-day reproduction IC25	100	883
		48 hr survival LC50	25	537
		48 hr survival LC50	100	6281
Amphipod	<i>H. azteca</i>	96-hr survival LC50	25	205
		96-hr survival LC50	100	3711
		96-hr survival LC50	250	6787
Chironomid	<i>C. tentans</i>	96-hr survival LC50	25	6667
Salmonid	<i>O. mykiss</i>	96-hr survival LC50	25	5000
		7-day embryo EC25	100	1280
Alga	<i>S. capricornutum</i>	72-hr IC25	NR	2210

NR = Not reported

Chloride

The USEPA has established an ambient water quality criterion for chloride of 230 mg/L (USEPA, 1988). This value is based on laboratory toxicity tests using sodium chloride (NaCl). Chlorides of other co-ions (e.g., potassium, magnesium) are expected to exhibit a greater degree of toxicity; however, mixtures of ions are expected to exhibit lower overall toxicity than solutions of individual salts. Invertebrates were generally more sensitive to chloride than vertebrates, and *Daphnia* (a cladoceran) was the most sensitive genus evaluated.

There is currently no Canadian water quality guideline for chloride; however, Environment Canada have produced a report on use of road de-icing salts in which an HC₅ (the concentration that would be expected to protect 95% of the potentially exposed taxonomic groups) value of 212.6 mg/L chloride was reported (Environment Canada, 2001).

The BC water quality criterion for chloride is 150 mg/L (BCMWLAP, 2003). This was derived based on dividing data for the most sensitive species for which data were available (*C. dubia*) by a safety factor of five. The AMEC toxicity laboratory in Fife, Washington, uses sodium chloride as a reference toxicant in chronic tests with this cladocerans species. Based on the last twenty tests, a 50% reduction in reproductive output of *C. dubia* was observed at 1083 ± 329 mg/L NaCl (657 ± 200 mg/L Cl⁻). Bailey et al. (2000) reported results for reference toxicant tests for the same species using potassium chloride (KCl) of 192 ± 23 mg/L (92 ± 11 mg/L Cl⁻). The higher toxicity observed with the use of KCl, rather than NaCl, suggests that toxicity in the KCl tests was related primarily to the presence of potassium rather than chloride.

A risk assessment has recently been conducted for the Ekati mine in which a site-specific species sensitivity distribution was calculated for chloride for organisms that occur in the receiving environment (EVS, 2004). This approach involved calculating a threshold value designed to protect 95 percent of the species by extrapolation of the distribution of toxicity data for taxonomic groups (or reasonable surrogates) that occur in the community. It should be noted that this derivation relied largely on acute toxicity data, and used the acute to chronic ratio published in the EPA criteria document for this parameter to determine the chronic HC₅ from the acute HC₅. The acute and chronic values were 1369 and 180 mg/L chloride, respectively.

Cladocerans, in particular, *C. dubia*, are the most sensitive taxonomic group for which data are available. A substantial amount of data from the AMEC toxicity laboratory for *C. dubia* (n=20) indicates that the IC₅₀ occurs at or above 257 mg/L chloride (i.e., two standard deviations less than the mean response) in 97.5% of the tests. Thus, the EPA and BC criteria values (230 and 150 mg/L, respectively), and the site-specific species sensitivity distribution conducted for Ekati (180 mg/L) appear to be protective of effects to this species.

Based on the site-specific value for chloride of 180 mg/L prepared for Ekati, concentrations in the PKCA (up to 650 mg/L) exceed effects levels for chloride by nearly 4-fold. However, these

concentrations will be rapidly diluted to levels well below toxicity thresholds once the discharge reaches Lake C3.

Alkalinity (bicarbonate/carbonate)

The alkalinity in the water associated with discharge from the PKCA is relatively low even under worst-case scenarios and well-within the range tolerated by freshwater organisms. Consequently, no adverse effects associated with alkalinity would be anticipated.

4.2 Cationic contributors to TDS

Data used for assessment of chloride toxicity have generally been obtained from tests using sodium chloride. The effect concentrations associated with the USEPA and BC water quality criteria for chloride (230 and 150 mg/L chloride, respectively) and the chronic value from the risk assessment conducted for Ekati for this parameter (180 mg/L chloride) correspond to sodium concentrations of 149, 97 and 115 mg/L, respectively. These values exceed the maximum sodium concentration in the PKCA, indicating that no toxicological effects would be associated with the concentrations of sodium in the discharge.

As described in the section above with regard to chloride, laboratory reference toxicant tests with potassium chloride (Bailey et al., 2000) were more sensitive than data for sodium chloride (AMEC laboratory, unpublished data) by a factor of seven when presented on the basis of chloride. This suggests that potassium is primarily responsible for toxicity in *C. dubia* tests with KCl; the 50% effect concentration in these tests calculated on the basis of potassium was 100 ± 12 mg/L.

The US EPA Ecotox database was reviewed for other toxicity data associated with exposure to potassium chloride. The lowest reported 50% effect value was 61 mg/L, which was obtained from a 21-d survival and reproduction test using *D. magna* (Biesinger and Christensen, 1972). Concentrations of potassium in the PKCA (36 – 64 mg/L) will approach this most sensitive value under worst-case conditions.

Biesinger and Christensen (1972) also reported 21-d EC50 estimates for calcium (220 mg/L Ca^{2+}) and magnesium (125 mg/L Mg^{2+}) for *D. magna*, which were also the most sensitive values reported in the US EPA Ecotox database for their corresponding chloride salts. Concentrations of calcium in the PKCA (101 – 202 mg/L) will approach this effect level for calcium; concentrations of magnesium in the PKCA (175 – 206 mg/L) will exceed the value for magnesium by a maximum factor of 1.6.

Collectively, these data indicate that cladocerans, such as *D. magna* and *C. dubia*, are among the most sensitive species to elevated concentrations of major cations, and that the concentrations of major cations in the PKCA may approach or exceed those associated with adverse effects under worst-case conditions. However, even under worst-case concentrations,

a two- to three-fold dilution of the cationic components of TDS present in the PKCA should be sufficient to remove the risk of adverse toxicological effects in the receiving environment.

4.3 Ion ratios

The ratios of cations present in the discharge are somewhat unusual. In natural waters, calcium concentrations typically exceed magnesium, and sodium typically exceeds potassium. However, the reverse is true in the case of this discharge. Calcium to magnesium ratios in natural waters typically range from 1.6:1 to 8:1 (Naddy et al., 2002) on a mass-balance basis. Conversely, in this discharge the ratios will range from approximately 1:1 to 1:2. Potassium is generally present at low concentrations in surface waters and generally well below the concentration of sodium (Stumm and Morgan, 1981), whereas in the discharge from the PKCA, potassium concentrations exceed sodium by up to a factor of two.

It should be noted that the fact that ratios between specific ions are somewhat different than most natural waterbodies does not imply that adverse effects would result. For example, at the EC50 for KCl reported by Biesinger and Christensen (1972) for *D. magna*, the sodium to potassium ratio was 1:60. Thus, this species was able to survive and reproduce normally in waters with potassium concentrations exceeding sodium by a considerable margin.

In general, the ratios of calcium to magnesium and sodium to potassium do not exceed a factor of two and, therefore, it would be unlikely that adverse toxicological responses would occur as a result.

4.4 Other effects

The lake systems associated with the Jericho Diamond mining project are very low in productivity, largely as a result of cold temperatures and low concentrations of nutrients. Consequently, the types of species that can occur in these lakes and their abundances are limited. Increasing the concentration of dissolved solids may result in improved production of some species, which may result in a change in the balance of species that are present; however, these effects are not associated with toxicology but, rather, ecology. While data are available on the response of oligotrophic systems to nutrient enrichment, there is limited information that can be used to reliably predict changes to community structure that are likely to result in response to an increase in TDS. Regardless, the concentrations of TDS predicted in the receiving environment, while different from those currently present in these lakes, are well within those associated with water bodies supporting healthy aquatic ecosystems.

5.0 DIFFERENCES IN CLADOCERAN POPULATIONS OBSERVED IN THE LONG LAKE CONTAINMENT FACILITY, EKATI MINE

A study conducted at the Ekati mine in 2003 demonstrated that cladoceran populations tended to increase with distance from the discharge (Rescan, 2004). In particular, larger populations of cladocerans were observed in Cell E relative to Cell D within the Long Lake Containment Facility. Because cladocerans are relatively sensitive to elevated concentrations of TDS, it is worthwhile evaluating whether this difference could have been related to elevated concentrations of TDS.

Samples from Cell D collected in the summer of 2003 had mean values of approximately 40 mg/L sulphate and 123 mg/L TDS. While these values were higher than those observed in Cell E (approximately 25 mg/L sulphate and 65 mg/L TDS), they are well within the range of tolerance of cladocerans for these parameters. In fact, standardized laboratory reconstituted water for culturing *C. dubia* and *D. magna* is typically prepared to moderately hard standards of 80 – 100 mg/L as CaCO₃, and involves addition of more than 200 mg/L of various salts, incorporating more than 80 mg/L of sulphate (USEPA, 2002). Thus, standardized culture water for two sensitive cladoceran species contains higher concentrations of sulphate and overall TDS than that observed in Cell D in the Long Lake Containment Facility. Thus, it appears highly unlikely that differences in cladoceran populations observed between Cell D and Cell E in the 2003 monitoring program at Ekati were a result of toxicological responses to sulphate or TDS.

It should be noted that the differences in community composition observed between Cell D and Cell E in Long Lake at Ekati were only measured on one occasion in 2003. Thus, the differences observed on that occasion may be related to the patchiness or temporal variability inherent in zooplankton populations. Alternatively, they could also be related to the presence of a trace contaminant associated with the discharge or an ecological shift in the balance of the populations associated with nutrient enrichment.

6.0 SUMMARY

From the available toxicity data for TDS and the projected dilution rates available in Lake C3 and Carat Lake, it appears highly unlikely that TDS associated with discharge from the PKCA pond will result in toxicological effects on organisms in the receiving lakes. Conservatively, a three-fold dilution of the effluent under average discharge conditions and a four-fold dilution under worst-case discharge conditions should provide sufficient dilution to remove the risk of any toxicological effects associated with the major ions contributing to TDS, and result in a TDS values of approximately 400 mg/L.

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JERICO DIAMOND PROJECT AQUATIC BIOTA AEMP -2004-

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March 2005



Citation: Mainstream Aquatics Ltd. and AMEC Earth and Environmental Inc. 2005. Jericho Diamond Project Aquatic Effects Monitoring Program - 2004. Prepared for Tahera Diamond Corporation. Report No. 04006AF: 46 p.

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1.0 INTRODUCTION

1.1 BACKGROUND

The Jericho Diamond Project was initiated in 1995 based on the discovery of a kimberlite pipe adjacent to the southern shore of an unnamed lake (locally known as Carat Lake). The Jericho Diamond Project has undergone environmental review by the Nunavut Impact Review Board (NIRB), which recommended that the Project be approved, subject to several terms and conditions. NIRB issued a Project Certificate on 20 July 2004 after receiving approval from the Minister of Indian and Northern Affairs. The conditions include development and implementation of a comprehensive environmental monitoring program, part of which includes an Aquatic Effects Monitoring Program (AEMP). The Nunavut Water Board (NWB) issued Water License NWBJER0410 on 22 December 2004 pursuant to DIAND ministerial approval which was received on 26 January 2005. NWB adopted the NIRB recommendations regarding the AEMP. This document presents the results of the aquatic biota component of the 2004 Jericho AEMP. A detailed discussion of the rationale and design of the Jericho AEMP is presented in Mainstream and AMEC (2005).

1.2 PURPOSE AND OBJECTIVES

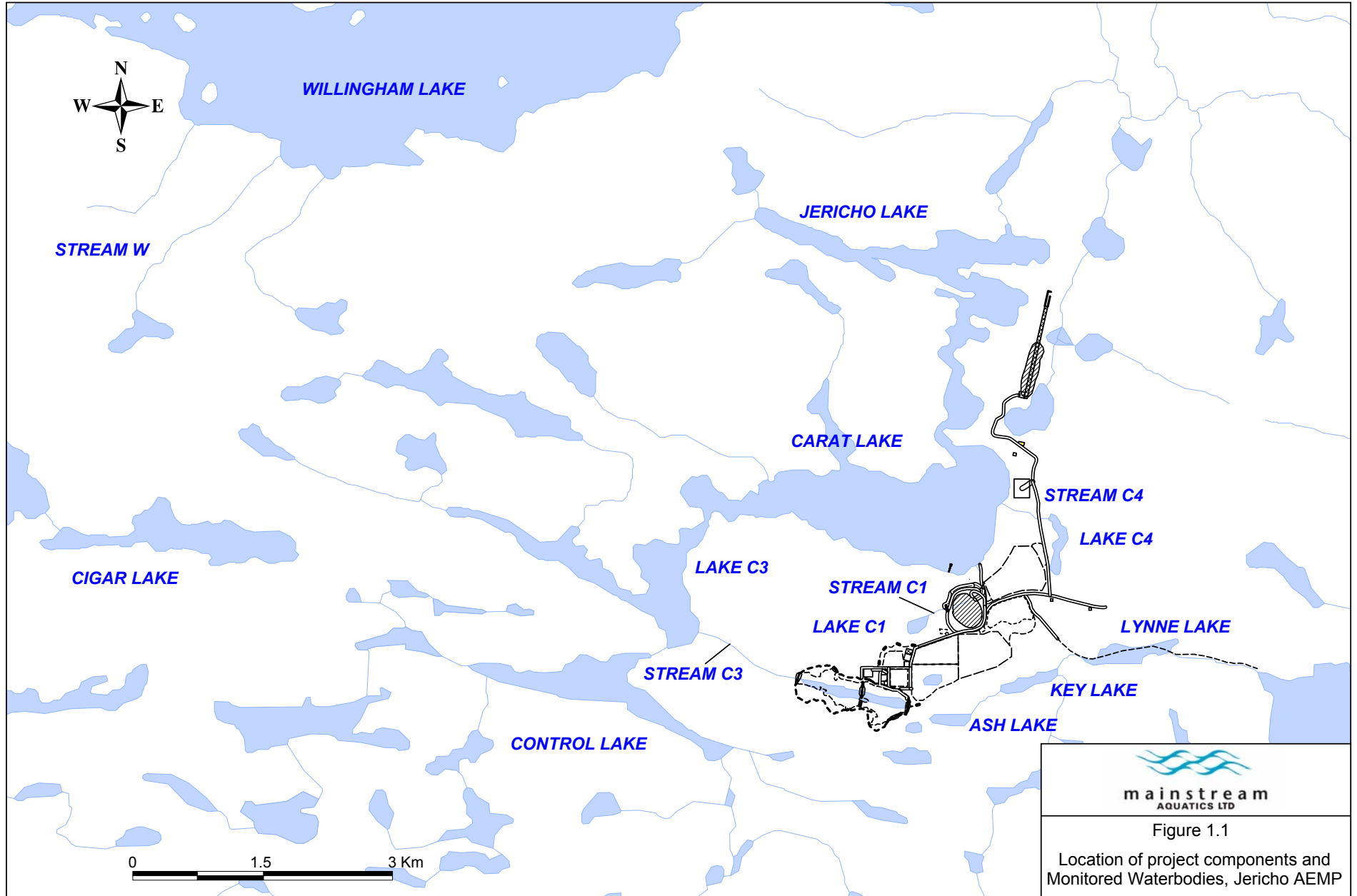
The purpose of an AEMP is to monitor the potential effects of the Jericho Diamond Project on the aquatic environment. The goals of the program are to:

- Protect the health and integrity of the aquatic environment.
- Confirm impact predictions.
- Ascertain whether mitigation measures are effective.
- Adjust mitigation where appropriate.

The objective of the 2004 aquatic biota component of the Jericho AEMP was to collect baseline data that describe selected components of the aquatic environment.

1.3 STUDY AREA

The ore bearing deposit and mine infrastructure will be located immediately south of Carat Lake (Figure 1.1). Potential contaminant sources that could affect aquatic biota, the mode of transport, and the receiving waterbodies are listed in Table 1.1. The modes of transport are licensed discharge, surface runoff, and airborne dust. In general the constituents of concern to the aquatic biota are nutrients, contaminants, and sediments.



Licensed discharge from the Processed Kimberlite Containment Area will be released into Lake C3 via Stream C3. Surface runoff and airborne contaminants have the potential to enter lakes and streams depending on the source.

Table 1.1 Discharge sources, potential mode of entry, and receiving waterbodies by Project phase, Jericho Diamond Project.

Phase	Source	Mode ^a	Receiving Waterbodies
Construction	- Processed Kimberlite Containment Area^b - Stream C1 diversion - Drainage ditch to Lake C4 - Permanent - Waste rock dump	- Discharge - Runoff - Runoff - Runoff - Airborne	- Stream C3 and Lake C3 - Stream C1 and Carat Lake - Lake C4, Stream C4, Carat Lake - Stream C4 and Carat Lake - Lynne Lake
Operation ^c	- Discharge from PKCA - Stream C1 Diversion - Drainage ditch to Lake C4 - Waste rock dump	- Discharge - Runoff - Runoff - Airborne	- Stream C3 and Lake C3 - Stream C1 and Carat Lake - Stream C4, Lake C4 and Carat Lake - Lynne Lake
Post-closure	- Discharge from reclaimed PKCA - Mine site runoff - Mine pit water discharge	- Runoff - Runoff - Runoff	- Stream C3 and Lake C3 - Lake C1, Stream C1, and Carat Lake - Stream C1 and Carat Lake

^a Discharge - licensed discharge into receiving waterbodies; Runoff - unanticipated discharge; Airborne - dust.

^b PKCA – Processed Kimberlite Containment Area

^c Mine site runoff will be collected and directed to the PKCA for release.

Receiving waterbodies are placed into two groups based on location and flow direction. The Jericho River group is part of the Jericho River system, which flows in a northerly direction to the Kathawachaga River system situated approximately 15 km downstream of the Project. The Lynne Lake group consists of a series of small waterbodies and ephemeral watercourses situated immediately east and north of the Project, which drain into Contwoyto Lake.

Waterbodies monitored for aquatic biota include Lake C3, Carat Lake, and Jericho Lake. Two control lakes are incorporated in the AEMP to provide data from nonaffected waterbodies. These include Control Lake located immediately upstream of Lake C3 and Cigar Lake located outside the watershed, 10 km west of the Project. A control stream was added to the aquatic biota AEMP to allow collection of slimy sculpin for metal tissue contaminants. Stream W, which flows into Willingham Lake is located 5 km north of Cigar Lake.

2.0 DESIGN

2.1 STATION LOCATIONS AND INDICATORS

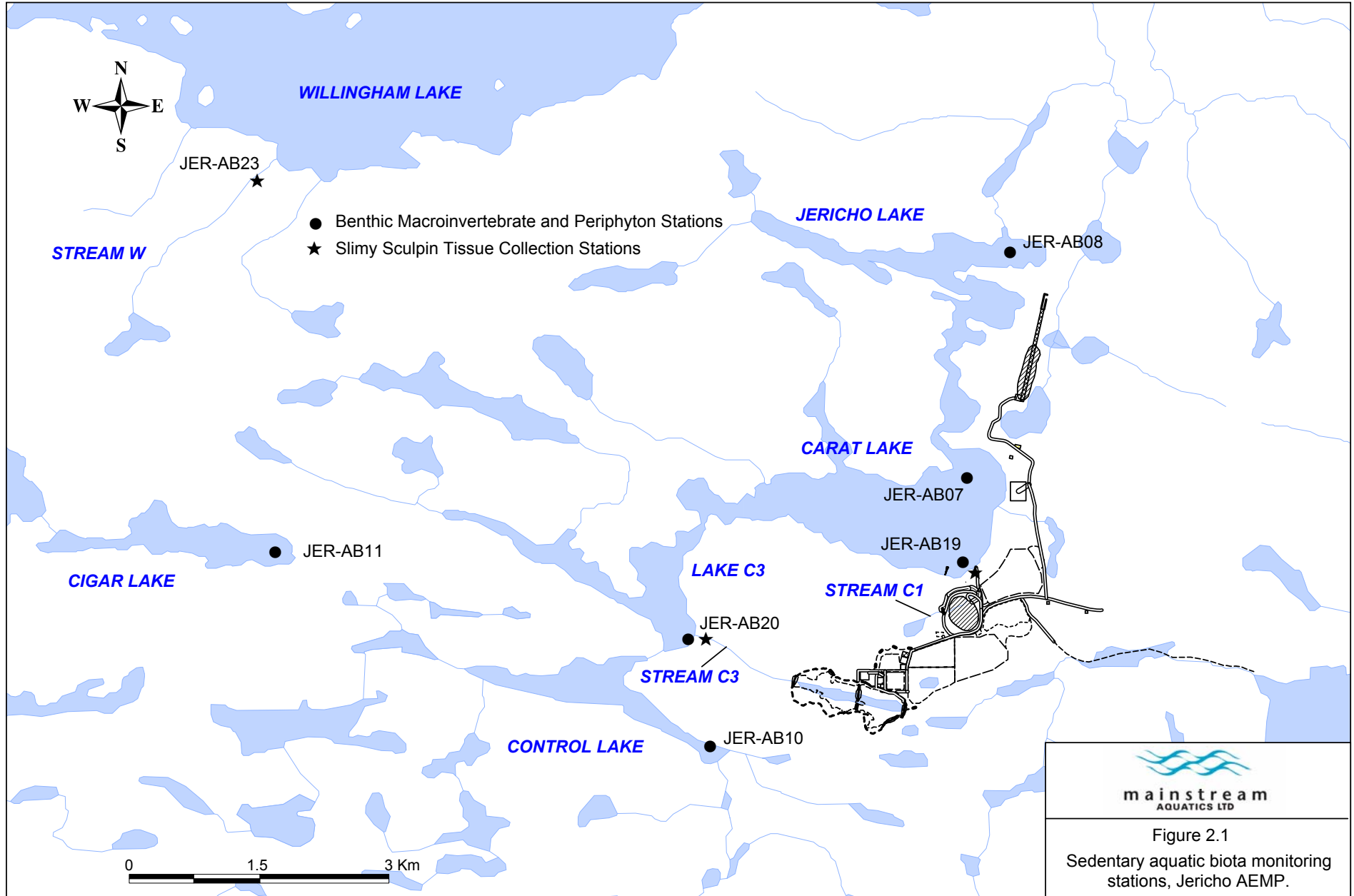
Station locations and the aquatic biota indicators monitored in 2004 are listed in Table 2.1 and Figures 2.1 and 2.2. Station location is based on the type of indicator monitored. Sedentary indicators are periphyton, benthic invertebrates, and slimy sculpin. Sedentary indicator stations are as follows:

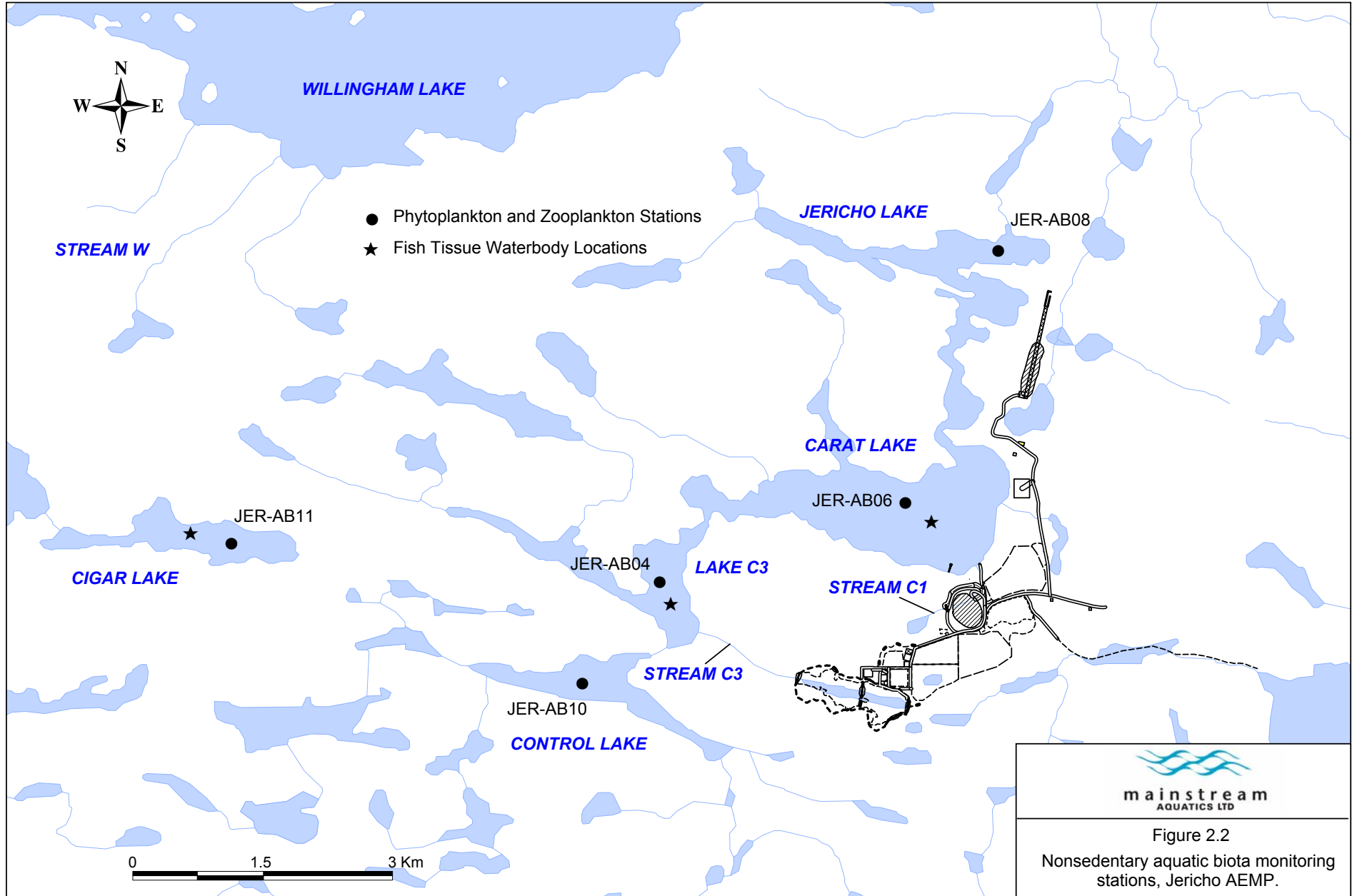
- 1) Adjacent to source (near field)
 - a) Stream C3 outlet in Lake C3 (JER-AB20)
 - b) Stream C1 outlet in Carat Lake (JER-AB19)
- 2) Downstream and outside the immediate zone of potential effect (far field)
 - a) Outlet to Carat Lake (JER-AB07)
 - b) Jericho Lake (JER-AB08)
- 3) Outside the zone of any potential effect (control)
 - a) Cigar Lake (JER-AB11)
 - b) Control Lake (JER-AB10)
 - c) Stream W (JER-AB23).

Nonsedentary indicators are phytoplankton, zooplankton, lake trout, and round whitefish. Nonsedentary indicator stations are as follows:

- 1) Waterbody adjacent to source (near field)
 - a) Lake C3 (JER-AB04)
 - b) Carat Lake (JER-AB06)
- 2) Waterbody outside the immediate zone of potential effect (far field)
 - a) Jericho Lake (JER-AB08)
- 3) Waterbody outside the zone of any potential effect (control)
 - a) Cigar Lake (JER-AB11)
 - b) Control Lake (JER-AB10)

Monitoring sediment deposition and dissolved oxygen profiles are part of the Jericho AEMP (Mainstream and AMEC 2005). These two components were monitored in 2004. Stations are listed in Table 2.1 and illustrated in Figures 2.3 and 2.4.





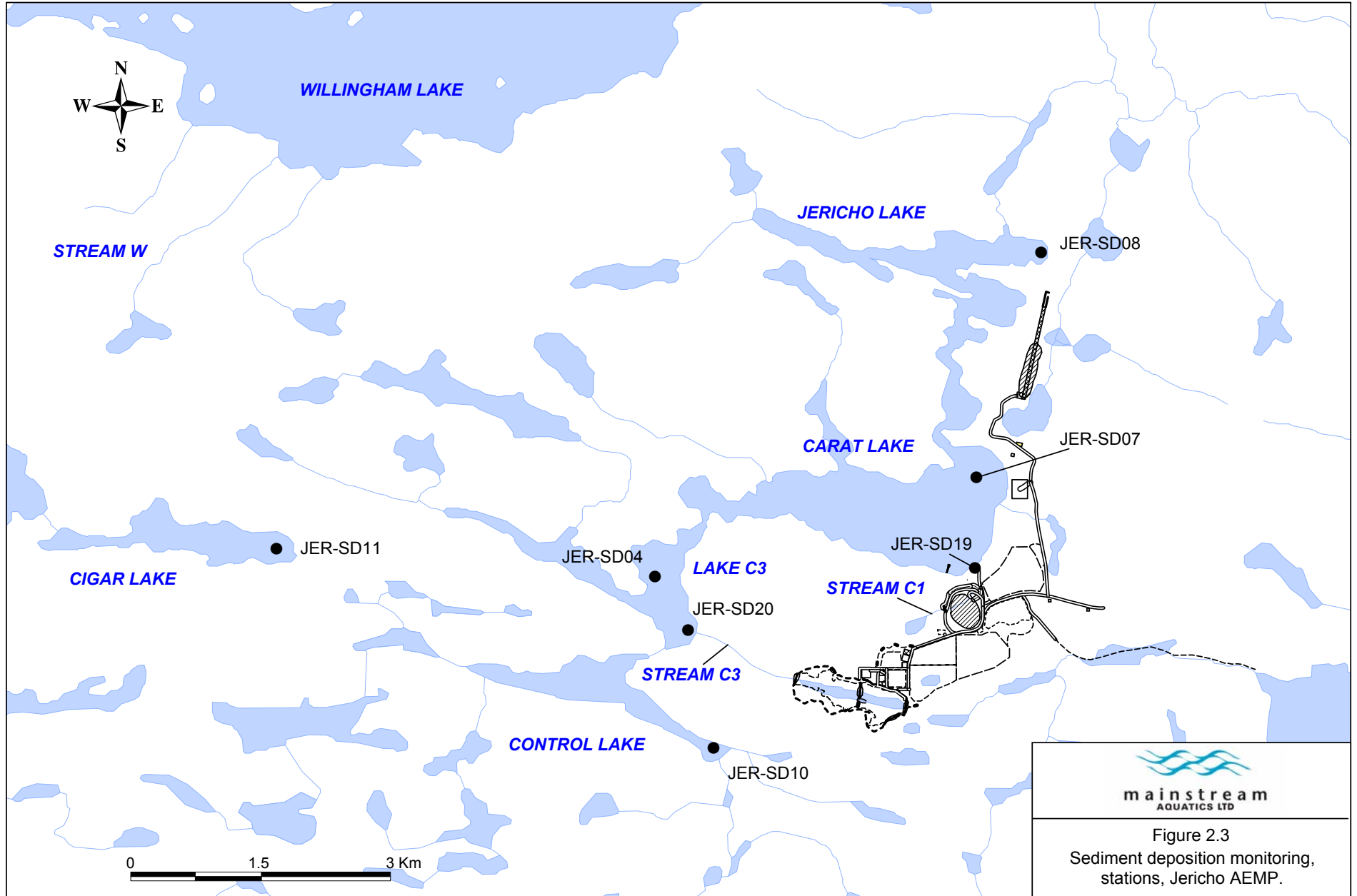


Figure 2.3
Sediment deposition monitoring,
stations, Jericho AEMP.

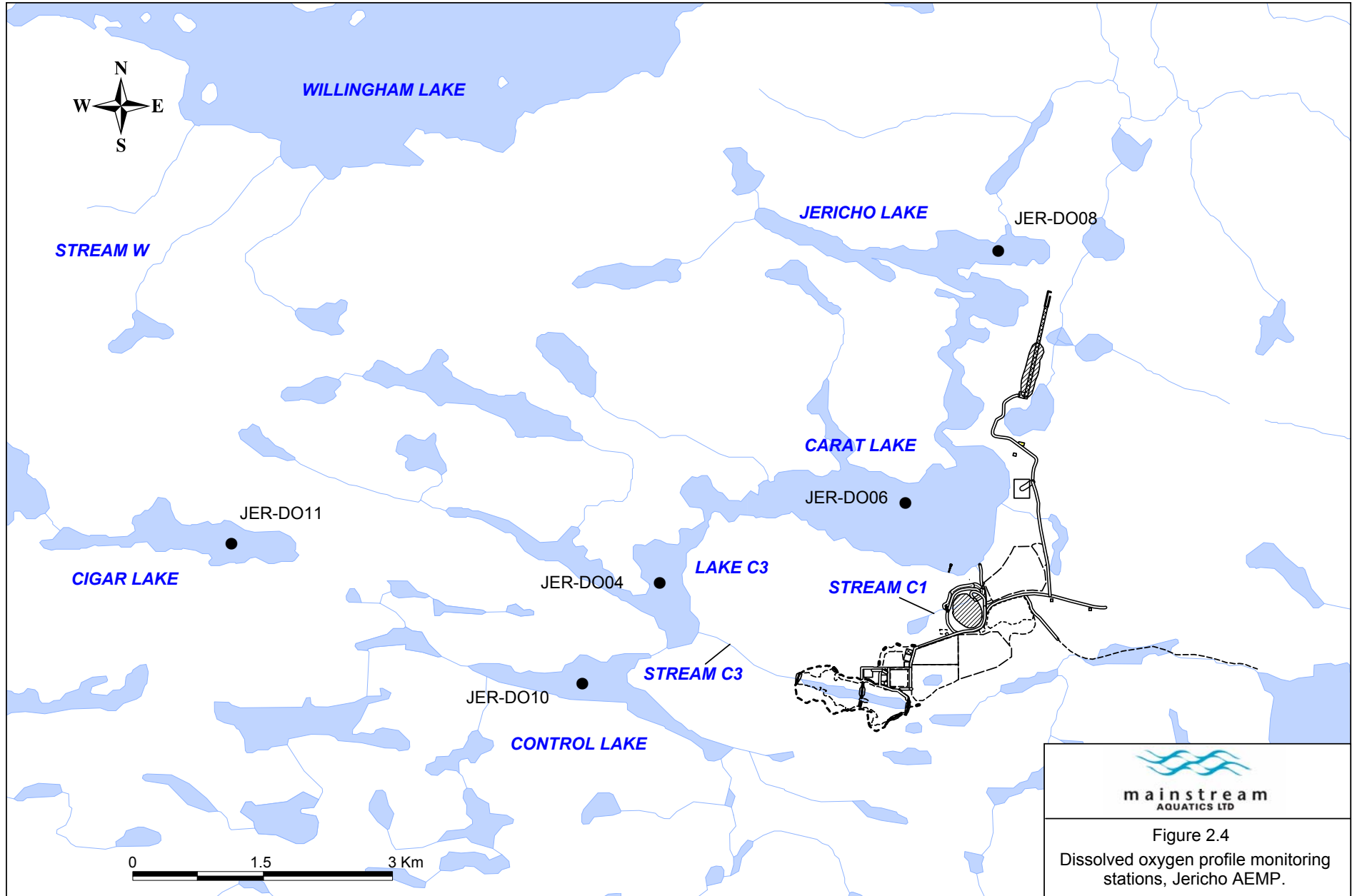


Table 2.1 Station type, waterbody and location, and indicators monitored in 2004, Jericho AEMP.

Station	Waterbody and Location	Indicators						Sediment Deposition	Dissolved Oxygen
		Non-sedentary			Sedentary				
		Phytoplankton	Zooplankton	Lake trout/ Round whitefish	Periphyton	Benthic Invertebrates	Slimy sculpin		
JER-AB10	Control Lake	✓	✓		✓	✓		✓	✓
JER-AB11	Cigar Lake	✓	✓	✓	✓	✓		✓	✓
JER-AB23	Stream W at Willingham Lake						✓		
JER-AB04	Lake C3	✓	✓	✓					✓
JER-AB06	Carat Lake	✓	✓	✓					✓
JER-AB07	Carat Lake outlet				✓	✓		✓	
JER-AB08	Jericho Lake	✓	✓		✓	✓		✓	✓
JER-AB19	Carat Lake at Stream C1				✓	✓	✓	✓	
JER-AB20	Lake C3 at Stream C3				✓	✓	✓	✓	

2.2 PARAMETERS

For each indicator monitored parameters are listed in Tables 2.2 and 2.3.

Table 2.2 Monitored indicators and parameters in 2004, Jericho AEMP.

Indicator	Parameter
Phytoplankton	Taxa richness; taxa diversity; density; biovolume; biomass index (Chl. <i>a</i>)
Periphyton ^a	
Zooplankton	Taxa richness; taxa diversity; density; biomass
Benthic invertebrates	Taxa richness; taxa diversity; density
Sediment deposition	Sediment weight ^b
Fish	Metal contaminants - muscle and liver (lake trout and round whitefish) - whole body (slimy sculpin)

^a Based on conditions specified in Schedule L in NWBJER0410 analyses of periphyton was omitted from the 2004 aquatic biota Jericho AEMP.

^b To be measured in 2005.

Table 2.3 Detection limits for fish tissue metal contaminants in 2004, Jericho AEMP.

Metal	Abbreviation	Detection Limit (µg/g)	Metal	Abbreviation	Detection Limit (µg/g)
Aluminum	Al	0.2	Manganese	Mn	0.2
Antimony	Sb	0.01	Mercury	Hg	0.01
Arsenic	As	0.1	Molybdenum	Mo	0.02
Barium	Ba	0.05	Nickel	Ni	0.02
Beryllium	Be	0.005	Selenium	Se	0.1
Bismuth	Bi	0.02	Silver	Ag	0.005
Cadmium	Cd	0.0005	Strontium	Sr	0.5
Chromium	Cr	0.02	Tin	Sn	0.5
Cobalt	Co	0.005	Titanium	Ti	0.25
Copper	Cu	0.5	Uranium	U	0.025
Iron	Fe	0.5	Vanadium	V	0.05
Lead	Pb	0.05	Zinc	Zn	0.5
Lithium	Li	0.05	Moisture		0.1%

2.3 SAMPLE TIMING AND REPLICATES

The timing of sample collection and number of replicates are listed in Table 2.4.

Table 2.4 Sampling timing and replication for aquatic biota in 2004, Jericho AEMP.

Indicator	Sample Timing	No. Replicates
Phytoplankton	19 to 22 August	7
Zooplankton	20 to 22 August	7
Periphyton	27 to 29 August	7
Benthic macroinvertebrates	20 to 23 July	7
Sediment deposition (trap deployment)	27 to 30 August	1
Dissolved oxygen	19 to 22 August	1
Fish tissue metal contaminants	24 August to 1 September	10 per species

3.0 METHODS

3.1 DISSOLVED OXYGEN

Dissolved oxygen concentration (± 0.1 mg/L) and water temperature (± 0.1 C°) were measured in the field using an Oxyguard Handy Beta dissolved oxygen-temperature meter. Depth profile measurements were collected at 1.0 m intervals. Water transparency was measured using a standard 20 cm diameter Secchi disk to the nearest 0.1 m.

3.2 PHYTOPLANKTON

3.2.1 Field

Phytoplankton was collected following procedures described in Findlay and Kling (2003). Samples were collected from the water column within the euphotic zone, which was assumed to be a water depth equal to two times the Secchi depth. In lakes that were shallower than two times the Secchi depth, samples encompassed the entire water column to 1 m above the lake bottom to avoid contamination with sediment.

Each replicate consisted of a composite of five samples from the euphotic zone collected using an integrated sampler. The integrated sampler consisted of a weighted 3 cm diameter polyethylene tube. The tube was gently lowered vertically into the water column and the top capped off before being lifted out of the water and drained into a bucket. The composite sample in the bucket was thoroughly mixed and a 970 ml volume subsample collected as a replicate. The process was repeated for each replicate.

Each replicate was placed in pre-labeled 1000 ml container and preserved with a combination acid-Lugol's solution (0.5% by volume) and a formaldehyde acetic acid solution (2% by volume). All replicates were stored in the dark.

Replicates destined specifically for chlorophyll *a* analysis were collected separately. A pre-determined 300 ml volume of subsample from the mixed composite sample was filtered onto Whatman GF/C filter paper, covered with anhydrous MgCO₃, and frozen.

Equipment was thoroughly rinsed before and after sampling at each station to prevent contamination. All samples were labeled with the station and replicate identifier, time, date, depth, volume sampled, preservative amount, and name of the collector.

3.2.2 Laboratory

Phytoplankton samples were processed by a qualified phytoplankton taxonomist using procedures outlined in Lund et al. (1958). Prior to analyses, samples were gently inverted, and a 10 to 100 ml subsample was dispensed into sedimentation chambers (Lund et al. 1958). Subsample volume was dependant on the ability to count a minimum of 200 phytoplankton cells or units (colonies, chains or filaments). Samples were processed after a 24 h sedimentation period. A species list was developed by scanning the entire basal area of the chamber with an inverted microscope (Wild™ M-40). Diatom identification was accomplished by concentrating a subsample onto a coverslip, clearing utilizing a muffle furnace and then mounting in Styrax. These were then examined under a compound microscope. Taxonomic keys used for identification included Prescott (1970), Taft and Taft (1971), and Webber (1971).

To calculate cell density (cells/ml), individual cells were enumerated within a specified area of the sedimentation chamber. This was accomplished by counting the number of cells along horizontal transects placed across the specified area. One or more transects were processed until the minimum number of 200 cells or units were counted. To calculate the cell density, the number of cells within the specified area was extrapolated to the subsample, and then to the entire sample.

Cell biovolume ($\mu\text{m}^3/\text{m}^3$) was calculated by first measuring the physical dimensions (length, width, and depth) of 10 to 30 cells of each species in the sample. Representative cell biovolume were then generated by calculating individual cell volumes for all cells measured (utilizing the nearest geometric shape(s)) and averaging these to produce an estimated cell biovolume for each species. The cell biovolume estimate for the subsample was then extrapolated to the entire sample (Note: averaging cell dimensions rather than individual cell volume estimates to produce a representative cell volume can seriously underestimate the representative cell volume used). Species that were encountered during the qualitative assessment, but not enumerated (i.e., very low numbers, nonviable, or located outside the enumeration transects) were recorded as present and included in the total taxa present for that sample.

Chlorophyll *a* analysis was conducted using the spectrophotometric-acetone extraction method described by Moss (1967a, 1967b). This method corrects for the presence of phaeophytin *a*, which may be present in decaying algal cells. This is achieved by acidification of the sample after initial measurement and referencing results to predetermined calibration curves.

3.3 ZOOPLANKTON

3.3.1 Field

Zooplankton was collected following the general procedures described in Paterson (2003). Each zooplankton sample consisted of a composite of five vertical hauls, each of which included two times the euphotic zone (i.e., four times the Secchi depth). In lakes that were shallower than four times the Secchi depth, hauls encompassed the entire water column to 1 m above the lake bottom to avoid contamination with sediment. Zooplankton were collected with a Wisconsin plankton net constructed with Nitex® mesh (net mouth diameter 130 mm; 0.064 x 0.064 mm mesh). For each haul, the net was lowered to the desired depth and then retrieved at a constant rate of 1.0 m/s. Samples were preserved immediately in 5% formaldehyde and stored in labeled 500 ml polyethylene bottles. All samples were labeled with a site identifier, time, date, depth, and name of the collector. Equipment was thoroughly rinsed before and after sampling at each site to prevent contamination.

3.3.2 Laboratory

Macrozooplankton (cladocerans and copepods) were enumerated from three 1 to 15 ml sub-samples using an automatic pipette with a dissecting microscope at magnifications of 12-50x. Subsampling was performed on samples that contained large numbers of specimens. All samples were subsampled using an automatic pipette for rotifer and copepod nauplii enumeration. Rotifers and copepod nauplii were enumerated by counting either six fields (one field = 0.02625 cm²) or the entire counting chamber (4.907 cm²) using a Zeiss Axiovert 40 CFL (inverted) microscope at magnifications of 200-400x. Subsamples for rotifers and nauplii were allowed to settle for 24 hours before counting. Subsample volumes depended largely on the amount of sediment in the sample. Subsamples were continually removed from the original sample until approximately 200 mature or identifiable rotifer organisms were processed. Once the numbers of organisms within each sample were established, these values were converted to densities per cubic metre. This was accomplished by dividing the number of organisms encountered in a sample by the total volume filtered (i.e., net mouth area * depth of haul * number of hauls).

Macrozooplankton were identified using keys from Brooks (1957), Edmondson (1959), Chengalath (1971), Grothe and Grothe (1977), Pennak (1978), and Clifford (1991). Microzooplankton were identified using keys from Chengalath (1971), Grothe & Grothe (1977), Stemberger (1979), Clifford (1991) and Thorp & Covich (1991).

Zooplankton biomass of major taxonomic groups was calculated based on animal lengths determined directly using a microscope with a micrometer in the ocular. Generally, lengths were measured for the first 30 individuals of each species or genus observed in each sample. Where less than 30 individuals occurred, the number measured equaled the average number counted over all sub-samples. The larger zooplankton were measured in the compound microscope at low power (40X). Smaller zooplankton, such as rotifers, were measured using an eyepiece graticule and corrected for magnification. Using length measurements from individual organisms, weights were calculated from published length-weight regressions; general equations for taxa were used where length-weight equations were not available for specific species (Table 3.1). For each sample, mean individual weights for each species were calculated by averaging estimated weights. Total biomass for each group (species or developmental stage) was calculated as the product of its density and estimated mean individual weight.

Table 3.1 Length-weight regressions used in calculating zooplankton weights.

Organism	Equation (ug=microgram)	Reference
Copepods (N I-adults)	$\ln W(\text{ug}) = 1.9526 + 2.399 \ln L(\text{mm})$	Bottrell et al. 1976
<i>Daphnia</i> spp.	$\ln W(\text{ug}) = 1.6 + 2.84 \ln L(\text{mm})$	Bottrell et al. 1976
<i>Ceriodaphnia</i> spp.	$\ln W(\text{ug}) = 2.8713 + 3.079 \ln L(\text{mm})$	Bottrell et al. 1976
<i>Scapholeberis</i> spp.	$\ln W(\text{ug}) = 2.5623 + 3.338 \ln L(\text{mm})$	Downing & Rigler 1984
<i>Chydorus sphaericus</i>	$\ln W(\text{ug}) = 4.543 + 3.6360 \ln L(\text{mm})$	Downing & Rigler 1984
Other Cladocerans	$\ln W(\text{ug}) = 1.7512 + 2.653 \ln L(\text{mm})$	Bottrell et al. 1976
Rotifers	$\ln W(\text{ug}) = -10.3815 + 1.574 \ln L(\text{mm})$	Stemberger & Gilbert. 1987

3.4 PERIPHYTON

3.4.1 Field

The periphyton community was monitored during a 38-day period between 20 July and 27 August using artificial substrates placed on the lake bottom immediately following ice-out in July.

The artificial substrates consisted of plastic flower pots (40 mm radius x 65 mm long) having a total surface area of 165.1 cm². Prior to placement, the surface of each pot was roughened and the pot filled with rock substrates to add weight. Seven pots were placed on the lake bottom at depths between 2.5 and 3.1 m with 1.5 m interval between each pot. The pots were secured to a float line at the water surface connected to two buoys and anchors.

At the end of the sampling period, the pots were retrieved and processed. If a pot was not in an upright position (i.e., pot that had tipped over), the area available for periphyton growth was calculated by subtracting the portion of the pot that was submerged in the lake sediment from the total surface area.

Periphyton was removed from each artificial substrate using a tooth brush and the material rinsed with 250 ml of deionized water into a 500 ml polyethylene bottle. Samples used for algal identification and enumeration were preserved with a combination acid-Lugol's solution (1% by volume) and a formaldehyde acetic acid solution (2% by volume). All replicates were stored in the dark. Before preservation the sample was thoroughly mixed and a 20 ml subsample collected for chlorophyll *a* analysis. The subsample was filtered onto Whatman GF/C filter paper, covered with anhydrous MgCO_3 , and frozen.

3.4.2 Laboratory

Periphyton samples were stored in the event that analyses are required in the future.

3.5 BENTHIC MACROINVERTEBRATES

3.5.1 Field

Benthic macroinvertebrates were sampled following general procedures described in Rosenberg *et al.* (2003) immediately following ice-out in July. Sampling during the early open water period is deemed appropriate for two reasons. First, it is logistically more feasible to sample during open water compared to winter when ice limits access to sites. Two, collections made during the open water period before emergence (transformation of larvae/pupae into adults), provides good representation of the benthic macroinvertebrate community.

All sites were located in water depths between 3.6 to 5.2 m. An ekman grab sampler (aperture area equal to 0.023 m^2) was used to collect seven replicates at each station. To address the issue of high within-site variation caused by clumped benthic macroinvertebrate distribution, and to increase the probability of encountering rare taxa, each replicate consisted of a composite of three ekman grabs.

The quality of the sample was examined (i.e., jaws were closed and the grab was full) before it was processed. If deemed of poor quality, the sample was rejected and the procedure repeated. Each replicate

was sieved through a 0.243 µm mesh net to remove excess sediments, placed in labelled polyethylene sample bags, and preserved in 10% formalin.

3.5.2 Laboratory

Samples were divided into two components for processing: elutriated and sediment. Invertebrates were collected by repeatedly rinsing and elutriation of the sample until invertebrates were no longer observed. The entire elutriated and sediment components of the sample were then processed.

Invertebrates were sorted by major taxonomic group and identified to the lowest practical taxonomic level (genus where possible) using a dissecting microscope (6-42x magnification). Chironomids were identified to family or tribe. Keys used for identification included Wiggins (1977), and Clifford (1991).

Once processing was complete samples were preserved in 70% ethanol.

3.6 SEDIMENT DEPOSITION

Methodology and analysis procedures will generally follow those described in DDMI (2003).

3.6.1 Field

The design of the traps was similar to those described in the CRC Handbook of Techniques for Aquatic Sediments Sampling (Mudroch and MacKnight 1991). Traps consisted of collection bottles located in PVC tubes suspended 1 m above the lake bottom and 2.5 m below the water surface (Figure 3.1). Traps were located at sites with water depths between 6.0 and 6.5 m.

3.6.2 Laboratory

Sediment deposition traps were deployed in August and will be left in place for one year before retrieval.

3.7 FISH

3.7.1 Field

Capture Methods

Variable-mesh standard gill nets sets were used to sample open water lake habitats. Each standard experimental gill net set was comprised of 15.2 x 1.8 m panels of 2.5, 3.8, 6.4, 8.9, 11.4, and 14.0 cm

mesh sizes (stretched measure). Set times were kept short (less than 2 h) to minimize capture mortality; occasionally overnight sets were employed if fish tissue quotas were not met. Shoreline areas and streams were sampled using a Smith Root Type XII high output backpack electrofisher.

All captured fish were measured for fork length (± 1 mm) and weight (± 2 g). Ageing structures and gonad weight also were collected for fish destined for tissue analyses.

Tissues Collection

Muscle and liver tissues were used to monitor tissue metal contaminants in lake trout and round whitefish, while whole fish were used for slimy sculpin.

Dorsal musculature (50 to 100 g) and livers (excluding the gall bladder) were dissected from each fish and sealed in 120 ml sterile, acid-washed specimen containers. All tissue samples were immediately frozen and kept frozen until the time of laboratory analyses.

Tissue sampling protocols followed procedures described by USAEPA (2000). Appropriate measures were taken to prevent contamination. All dissections occurred on a washable plastic surface. High-quality, corrosion-resistant stainless steel sample processing equipment was used including sterile knives with plastic handles. Utensils and containers were cleaned thoroughly with a detergent solution, rinsed with 5% HNO₃, followed by an immediate rinse with distilled water. All dissecting equipment, sample containers, sample wrapping and wash equipment were shipped and stored in clean waterproof containers.

Data recorded for each fish included fork length (to the nearest 1 mm), weight (to the nearest 2 g), sex, maturity, and gonad weight. An appropriate ageing structure was also collected (otoliths) from all captured tissue fish.

3.7.2 Laboratory

Tissues

Analyses of metal concentrations in fish tissues were conducted by Norwest Labs (Surrey, British Columbia). The following is a description of the methods and instrumentation that were used.

Tissue samples preparation was based on CFIA requirements. Samples were prepared for analyses by first homogenizing the tissue in plastic cups using a “Virtis” shearer equipped with stainless steel blades. Prior

to homogenization of each sample, the apparatus was cleaned with 18 MΩ deionized water. Approximately 1 g of homogenized tissue was then weighed into a precleaned (triple nitric acid) teflon digestion vessel. High purity “Seastar” nitric acid (4 ml) was added and the vessel was capped before being heated at 150°C. The resulting solution was made up to a volume of 25 ml with 18 ml deionized water for subsequent analyses.

The digested sample was then analyzed by ICP and ICPMS. The instrument methods are based on EPA 6010B and 6020. The minerals Ca, Mg, Na, K, Fe, P, and Si were reported from the ICP and the other metals were analyzed by ICPMS. The mercury was analyzed by cold vapor atomic absorption, based on EPA 7470.

Moisture content was measured using 1 g of homogenized tissue. The sample was weighed into a preweighed and tared 10 ml glass beaker. The beaker and sample were then dried overnight at 105°C. After cooling to room temperature, the beaker and sample were transferred to a desiccator for 2 h, after which, the beaker with the sample was re-weighed to obtain the loss in moisture.

All results were reported as micrograms per gram on a ‘wet weight’ basis.

Ageing

Fish ageing followed the protocol outlined in Mackay et al. (1990). Otoliths, stored dry in labelled envelopes, were first lightly ground and polished with emery cloth (400 grit) to allow sufficient light transmission. Then a binocular dissecting microscope, equipped with a transmitted light source, was used to obtain an age from each structure. Two independent readers aged each structure. When discrepancies in the assigned age occurred, the two readers conferred to arrive at a consensus.

3.8 QUALITY ASSURANCE

3.8.1 Nonvertebrate Aquatic Biota

The following QA/QC procedures were used for nonvertebrate data.

1. Strict sampling protocols were adhered to ensure consistency in technique for each parameter.
2. Consistency of identifications for each indicator was achieved by using the same person.
3. Ten percent of samples were analyzed by other qualified persons to ensure the accuracy of identifications and counts.
4. Split samples collected from 5% of the samples were submitted as blinds.

5. For benthic invertebrates the residue of the sample was examined to determine sorting efficiency. If the residue contained a number of organisms that exceeded 10% of the entire sample, the sample was re-processed.
6. All samples were archived for future reference.

3.8.2 Fish Tissues

Fish metal contaminants sampling utilized safeguards to prevent contamination as follows:

1. Use of sterile stainless steel instruments.
2. Tissue cups rinsed in 5% nitric acid solution.
3. Covering the work area in plastic.

Analytical QA/CC procedures included:

1. Use of an accredited laboratory.
2. Running certified reference materials (NBS1566A oyster tissue, DORM2, and DOLT2)
3. Split samples from 5% of the replicates were submitted for analyses.

3.8.3 Analyses

Sample precision was examined for each indicator and parameter by measuring the percent difference between the sample estimate and the quality control estimate. The accuracy and consistency of taxa identification was examined by comparing the number of unique taxa identified in the sample versus the quality control.

3.9 DATA ANALYSES

Data analyses involved generating summary metrics (mean, standard deviation, minimum, maximum) for each parameter listed in Table 2.1. This was followed by evaluation of spatial differences among stations using univariate parametric statistical tests. Prior to summaries and statistical analyses the data for each parameter were examined to ensure appropriateness for evaluation

The first step was to present the data graphically to examine gross differences among stations, to examine the distribution pattern, and to identify outliers. An individual data point was defined as an outlier if its absolute value exceeded the absolute value of the next closest data point in the entire data by a magnitude of three. Once an outlier was identified, subsequent tests were completed with and without the outlier data point.

Data were then examined to establish whether assumptions were met for parametric statistical analyses using standard procedures as follows:

1. Homogeneity of variance (Levene's test)
2. Normal distribution (G test)
3. Independence (Runs Test)

If one or more assumptions for parametric tests were violated the data were transformed to an appropriate nonlinear scale. If the assumption for homogeneous variance was not met after transformation the parametric test statistic was adjusted (i.e., *Welch* statistic used in place of *F* statistic).

Spatial difference among stations was examined using Oneway Analysis of Variance (ANOVA). If a significant difference among stations was identified a post hoc mean comparisons tests was used to identify the station(s) responsible for the difference. The Tukey's b test was employed if sample variances were homogeneous; if not the Games-Howell test was used.

A different approach was used for metal concentrations in fish tissues. First, the number of data points below the analytical detection limit was summarized. If the number below detection was >5 no further analyses were undertaken. This approach was deemed appropriate because sample sizes available for metal concentration analyses (i.e., $10 - 6 = 4$) typically do not have sufficient power to identify a statistical difference if one exists assuming a size effect of 2 standard deviations (ENVCAN 2002). Samples of selected metals that met the criteria for a minimum sample size, but that contained data below analytical detection limits were adjusted. Data points below detection were assigned a value of $\frac{1}{2}$ the analytical detection limit.

Second, data were examined to ascertain whether there was a relationship between metal concentration and fish length using Pearson's Correlation Coefficient. If a consistent significant trend was established a Oneway Analysis of Covariance (ANCOVA) was used to examine station effects with fish length as the covariate. If not ANOVA was used.

Prior to evaluating for differences among stations with ANCOVA, sample slopes were tested for homogeneity. If slopes were significantly different data were transformed and/or outliers removed in order to meet this assumption. If a significant difference among stations occurred the adjusted station means were examined using the Bonferroni multiple comparisons test to identify the station(s) responsible for the difference.

Statistical significance was accepted at $P \leq 0.05$. All tests followed descriptions presented in Sokal and Rohlf (1981).

4.0 RESULTS

4.1 DISSOLVED OXYGEN

Dissolved oxygen and temperature profiles were measured at five stations between 19 and 22 August 2004 (Figure 4.1). Dissolved oxygen concentrations at all stations approximated 11.0 mg/L regardless of depth. Water temperatures in most lakes ranged from 7.5°C to 9.0°C. At the time of measurements only one waterbody was stratified: Control Lake. The thermocline occurred at 18 m depth. Although the maximum water depths exceeded 18 m in Cigar Lake and Carat Lake, the dissolved oxygen and temperature profiles at those stations demonstrated no thermocline. Based on these data, Control Lake was the only waterbody that was stratified.

4.2 SEDIMENT DEPOSITION

Sediment deposition traps were deployed in August 2004 and will remain in place until August 2005. Therefore, there are no results for this monitoring component.

4.3 PHYTOPLANKTON

Summary information are presented in Table 4.1 and Figure 4.2.

Taxa Richness

In general, taxa richness was similar among most waterbodies with the mean number of taxa ranging from 48 to 70. The one exception was Control Lake. The mean number of taxa of 26.5 in this waterbody was significantly less than the mean number of taxa in each of the other four waterbodies.

Taxa Diversity

Taxa diversity also was generally similar among most waterbodies. The mean Simpson's D value ranged from 0.647 to 0.750. The one exception was Carat Lake. The mean Simpson's D value of 0.510 for phytoplankton sampled from this waterbody was significantly less than mean values recorded at the remaining four waterbodies.

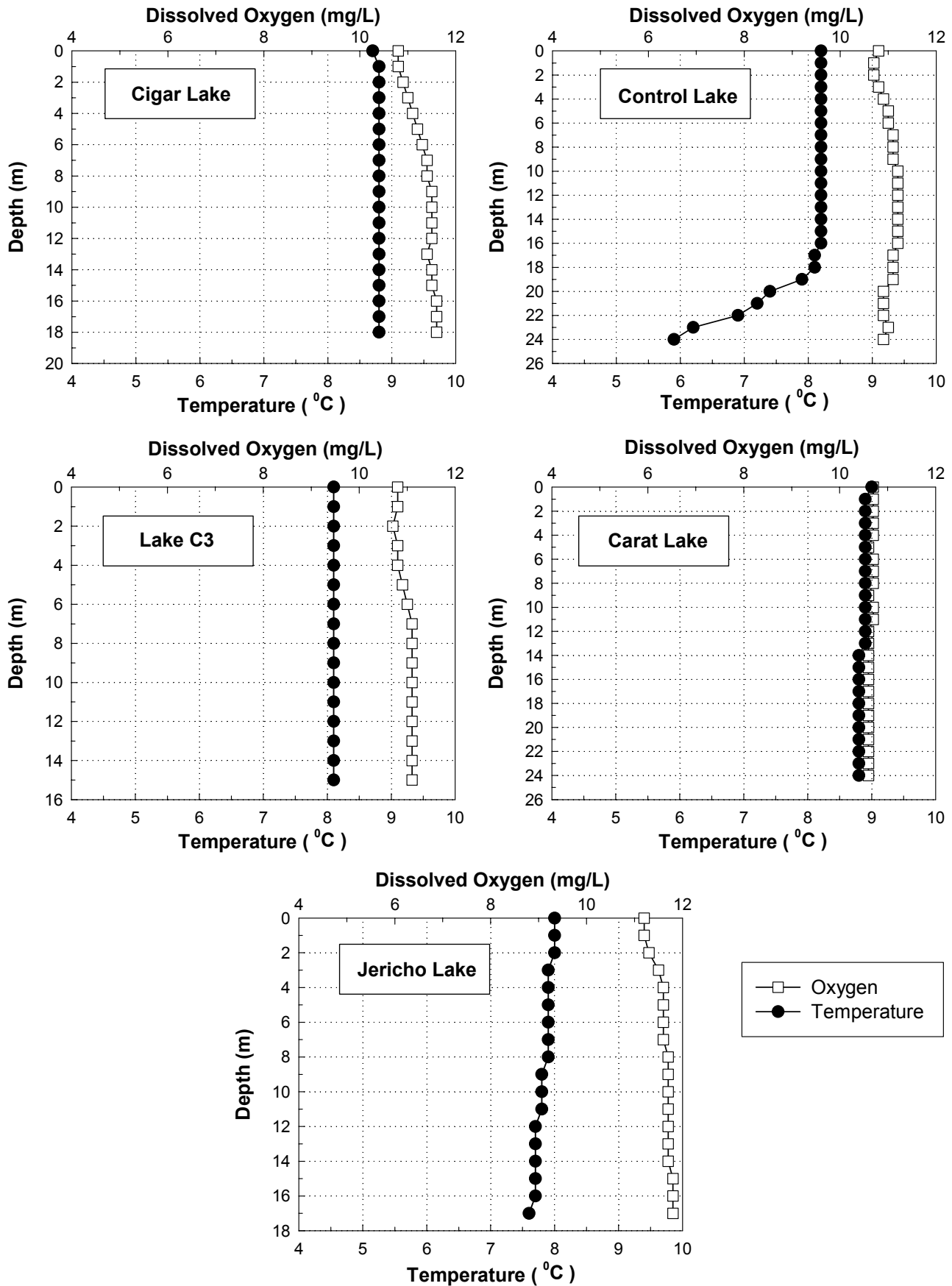


Figure 4.1 Dissolved oxygen and temperature profiles at stations monitored between 19 and 22 August 2004, Jericho AEMP.

Table 4.1 Phytoplankton parameter summary metrics at stations monitored in 2004, Jericho AEMP.

Parameter	Lake	Station	Sample Size	Mean	Standard Deviation	Minimum	Maximum	Significance ^a
Richness ^b (No. taxa)	Cigar	JER-AB11	7	55.1	1.1	48	64	B
	Control	JER-AB10	7	26.5	1.3	16	39	A
	C3	JER-AB04	7	62.4	1.1	55	70	B
	Carat	JER-AB06	7	61.6	1.1	55	67	B
	Jericho	JER-AB08	7	64.5	1.1	58	70	B
								$P = 0.000$
Diversity (Simpson's D)	Cigar	JER-AB11	7	0.731	0.113	0.58	0.89	B
	Control	JER-AB10	7	0.717	0.081	0.61	0.85	B
	C3	JER-AB04	7	0.750	0.070	0.69	0.89	B
	Carat	JER-AB06	7	0.510	0.049	0.45	0.60	A
	Jericho	JER-AB08	7	0.647	0.100	0.45	0.74	B
								$P = 0.000$
Total Density ^b (cells/ml)	Cigar	JER-AB11	7	1866.5	1.3	1110	2503	A
	Control	JER-AB10	7	3199.2	1.5	1995	5289	AB
	C3	JER-AB04	7	2676.0	1.2	2038	3324	A
	Carat	JER-AB06	7	4317.5	1.1	3842	4739	B
	Jericho	JER-AB08	7	3643.1	1.2	2592	4366	B
								$P = 0.000$
Total Biovolume ^b ($\mu\text{m}^3/\text{ml}$)	Cigar	JER-AB11	7	506,154.5	1.2	383,487	656,663	D
	Control	JER-AB10	7	408,306.2	1.2	277,306	519,036	CD
	C3	JER-AB04	7	336,287.1	1.3	242,709	514,115	BC
	Carat	JER-AB06	7	225,975.1	1.2	194,069	307,252	A
	Jericho	JER-AB08	7	296,681.4	1.3	204,482	432,354	AB
								$P = 0.000$
Chlorophyll a^c (mg/m^3)	Cigar	JER-AB11	7	0.38	0.14	0.26	0.66	A
	Control	JER-AB10	7	0.70	0.21	0.35	1.05	B
	C3	JER-AB04	7	0.67	0.18	0.37	0.92	B
	Carat	JER-AB06	7	0.63	0.17	0.34	0.89	AB
	Jericho	JER-AB08	7	0.54	0.15	0.35	0.69	AB
								$P = 0.014$

^a See Section 3.8 for description of statistical methods.

^b Represents back-transformed log scale data.

^c Represents back-transformed square root scale data.

Total Density

Total density varied among waterbodies. Mean values ranged from a low of 1866.5 cells/ml to 4317.5 cells/ml. Total densities in Cigar Lake and Lake C3 were significantly less than mean total densities in Carat Lake and Jericho Lake.

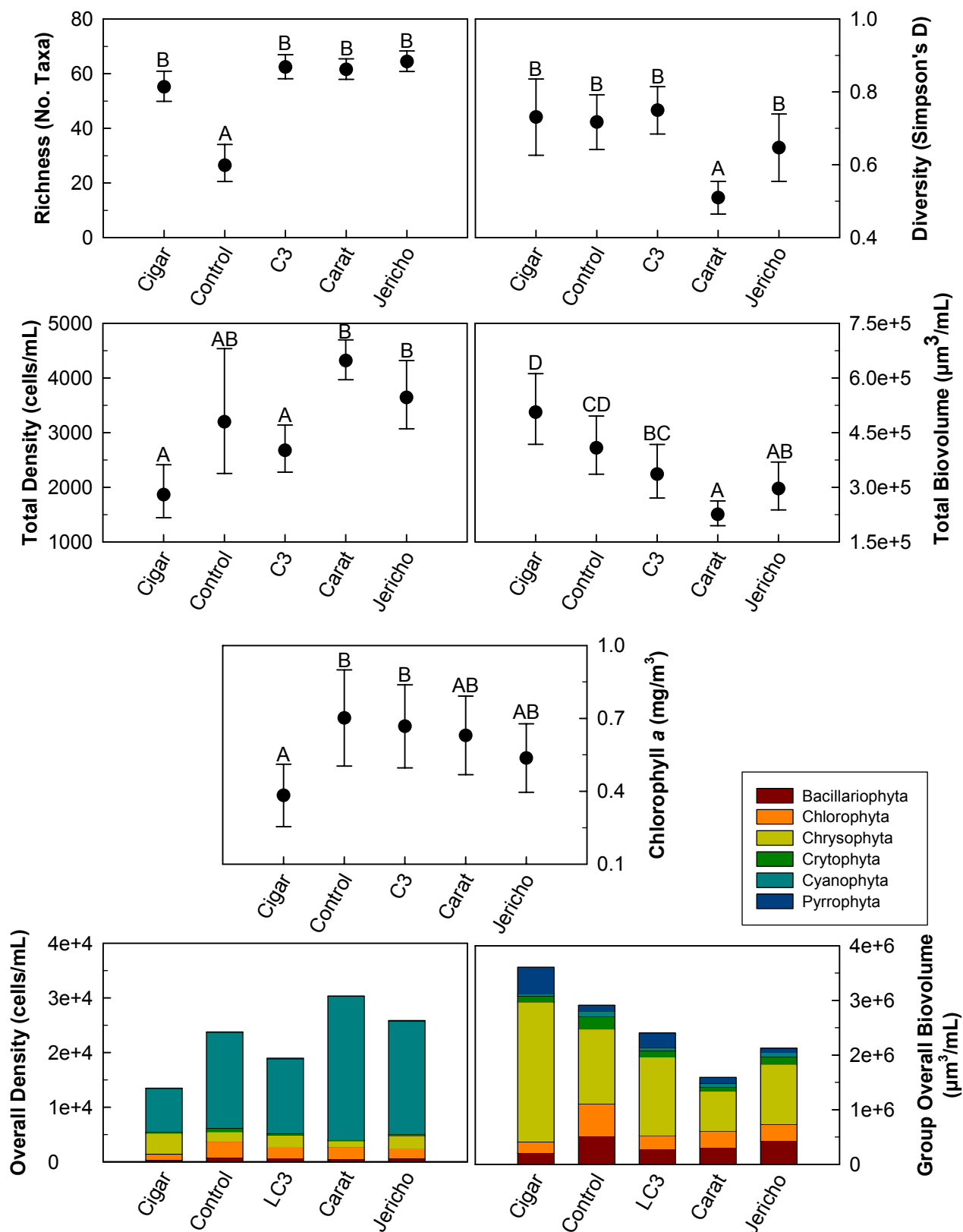


Figure 4.2 Phytoplankton parameter summary metrics ($\bar{x} \pm 95\%$ CI) monitored in 2004, Jericho AEMP (Letter designates statistical differences; see section 3.8 for methods).

Total Biovolume

Total biovolume varied among waterbodies. In general, there was a trend towards lower total biovolume from upstream to downstream. The highest mean value was recorded in Cigar Lake (506,154.5 $\mu\text{m}^3/\text{ml}$) and the lowest was recorded in Carat Lake (225,975.1 $\mu\text{m}^3/\text{ml}$). This pattern resulted in four significant groupings along this spatial gradient.

Chlorophyll *a*

Chlorophyll *a* varied among waterbodies. Mean values ranged from 0.38 mg/m^3 in Cigar Lake to 0.70 mg/m^3 in Control Lake. Based on these data chlorophyll *a* in Cigar Lake was significantly less than in Control Lake and Lake C3.

Major Taxa

The phytoplankton data (density and biovolume) were summarized by major taxonomic group and presented in Figure 4.2. In terms of density, the dominant group in all waterbodies was Cyanophyta. Chlorophyta was the dominant group in all waterbodies based on biovolume.

Quality Control

Four samples sent to an outside taxonomist and two split samples were evaluated for quality control (Table 4.2). Average percent difference exceeded 20% for most parameters for samples submitted to an external reviewer. Differences recorded using split samples were slightly better with average values ranging from 17.5% for taxa richness to 33.2% total density. There were large differences in the number of unique taxa identified in the quality control versus the processed samples (i.e., taxa recorded in one sample but not in the other). Differences were documented in the split samples but they were not as large. The reasons for the large number of unique taxa included differences in identification at the species (11 taxa) and the genus (2 taxa) levels and the presence of a large number of rare taxa.

Table 4.2 Percent difference in phytoplankton summary metrics and numbers of unique taxa between processed and quality control samples, Jericho AEMP.

Type	Station	Percent Difference					Unique Taxa (No.)	
		Replicate	Total Density	Total Biovolume	Richness	Diversity	Sample	QAQC
External	JER-AB10	CN0101	50.6	-15.4	10.3	-36.1	27	23
	JER-AB04	C30101	-2.1	-4.3	60.0	-10.4	70	29
	JER-AB06	CA0101	58.1	-34.0	58.7	-78.3	52	20
	JER-AB08	JE0101	67.9	-16.9	48.3	-22.9	48	19
		Average	48.9	-15.8	50.0	-32.3	49.3	22.8
Split	JER-AB10	CN0104	73.7	45.1	20.5	-25.8	21	13
	JER-AB08	JE0101	-10.8	-2.3	15.5	58.6	34	25
		Average	33.2	32.5	17.5	17.6	27.5	19.0

4.4 ZOOPLANKTON

Summary information are presented in Table 4.3 and Figure 4.3.

Taxa Richness

Zooplankton taxa richness varied among waterbodies. Mean number of taxa ranged from 10.1 in Cigar Lake to 12.4 in Control Lake. There were two distinct groupings based on significant differences in mean values as follows: Cigar Lake and Carat Lake (lowest) and Control Lake (highest).

Taxa Diversity

Taxa diversity was generally similar among most waterbodies. The mean Simpson's D value in most waterbodies ranged from 0.703 to 0.776. The one exception was Cigar Lake. The mean Simpson's D value of 0.596 was significantly less than mean values recorded for the remaining four waterbodies.

Total Density

Total density of zooplankton was similar among waterbodies. Mean values ranged from a low of 15,338.8 organisms/m³ to 22,647.5 organisms/m³. There were no significant differences in mean total density.

Total Biomass

Total biomass was generally similar among most waterbodies. Mean values ranged from 32,230.7 µg/m³ to 56,560.7 µg/m³. The single exception was Cigar Lake. The mean total biomass was significantly less than mean values recorded at all other waterbodies.

Cladocera Density

Unlike total density, there were differences in cladocera density among waterbodies. Mean values ranged from 80.8 organisms/m³ in Lake C3 to 415.9 organisms/m³ in Carat Lake. The difference between the mean values of these two waterbodies was significant.

Table 4.3 Zooplankton parameter summary metrics at stations monitored in 2004, Jericho AEMP.

Parameter	Lake	Station	Sample Size	Mean	Standard Deviation	Minimum	Maximum	Significance ^a
Richness (No. taxa)	Cigar	JER-AB11	7	10.1	1.2	8	11	A
	Control	JER-AB10	7	12.4	1.7	10	15	B
	C3	JER-AB04	7	11.9	1.1	11	14	AB
	Carat	JER-AB06	7	10.3	0.8	9	11	A
	Jericho	JER-AB08	7	11.1	1.1	10	13	AB
								$P = 0.005$
Diversity (Simpson's D)	Cigar	JER-AB11	7	0.596	0.049	0.55	0.68	A
	Control	JER-AB10	7	0.703	0.053	0.64	0.76	B
	C3	JER-AB04	7	0.736	0.035	0.69	0.78	B
	Carat	JER-AB06	7	0.776	0.020	0.75	0.80	B
	Jericho	JER-AB08	7	0.750	0.019	0.72	0.77	B
								$P = 0.000$
Total Density ^b (No./m ³)	Cigar	JER-AB11	7	18,432.2	1.1	16,151	23,735	-
	Control	JER-AB10	7	22,647.5	1.5	10,840	38,019	-
	C3	JER-AB04	7	19,697.3	1.2	13,506	24,262	-
	Carat	JER-AB06	7	15,338.8	1.1	12,069	16,927	-
	Jericho	JER-AB08	7	21,260.4	1.3	12,157	27,271	-
								$P = 0.052$
Total Biomass ^b (µg/m ³)	Cigar	JER-AB11	7	32,230.7	1.2	26,828	44,093	A
	Control	JER-AB10	7	42,656.7	1.4	24,421	65,043	B
	C3	JER-AB04	7	56,560.7	1.2	45,081	72,391	B
	Carat	JER-AB06	7	47,378.8	1.1	40,460	54,665	B
	Jericho	JER-AB08	7	50,957.7	1.2	32,582	62,370	B
								$P = 0.000$
Cladocera Density ^b (No./m ³)	Cigar	JER-AB11	7	174.8	1.6	76	281	AB
	Control	JER-AB10	7	168.7	1.3	116	256	AB
	C3	JER-AB04	7	80.8	1.5	39	122	A
	Carat	JER-AB06	7	415.9	1.3	277	646	B
	Jericho	JER-AB08	7	191.1	1.4	114	289	AB
								$P = 0.000$
Cladocera Biomass ^b (µg/m ³)	Cigar	JER-AB11	7	26.9	8.7	13	40	A
	Control	JER-AB10	7	54.7	7.8	45	66	BC
	C3	JER-AB04	7	43.6	7.3	34	52	B
	Carat	JER-AB06	7	66.2	7.9	55	79	C
	Jericho	JER-AB08	7	60.2	11.2	46	77	BC
								$P = 0.000$

^a See Section 3.8 for description of statistical methods.^b Represents back-transformed log scale data.

Cladocera Biomass

Cladocera biomass also varied among monitored waterbodies. Mean values ranged from 26.9 µg/m³ to 66.2 µg/m³. There were three groups based on significant differences in mean cladocera biomass. These were Cigar Lake, Lake C3, and Carat Lake. This pattern suggested a spatial gradient from upstream to downstream.

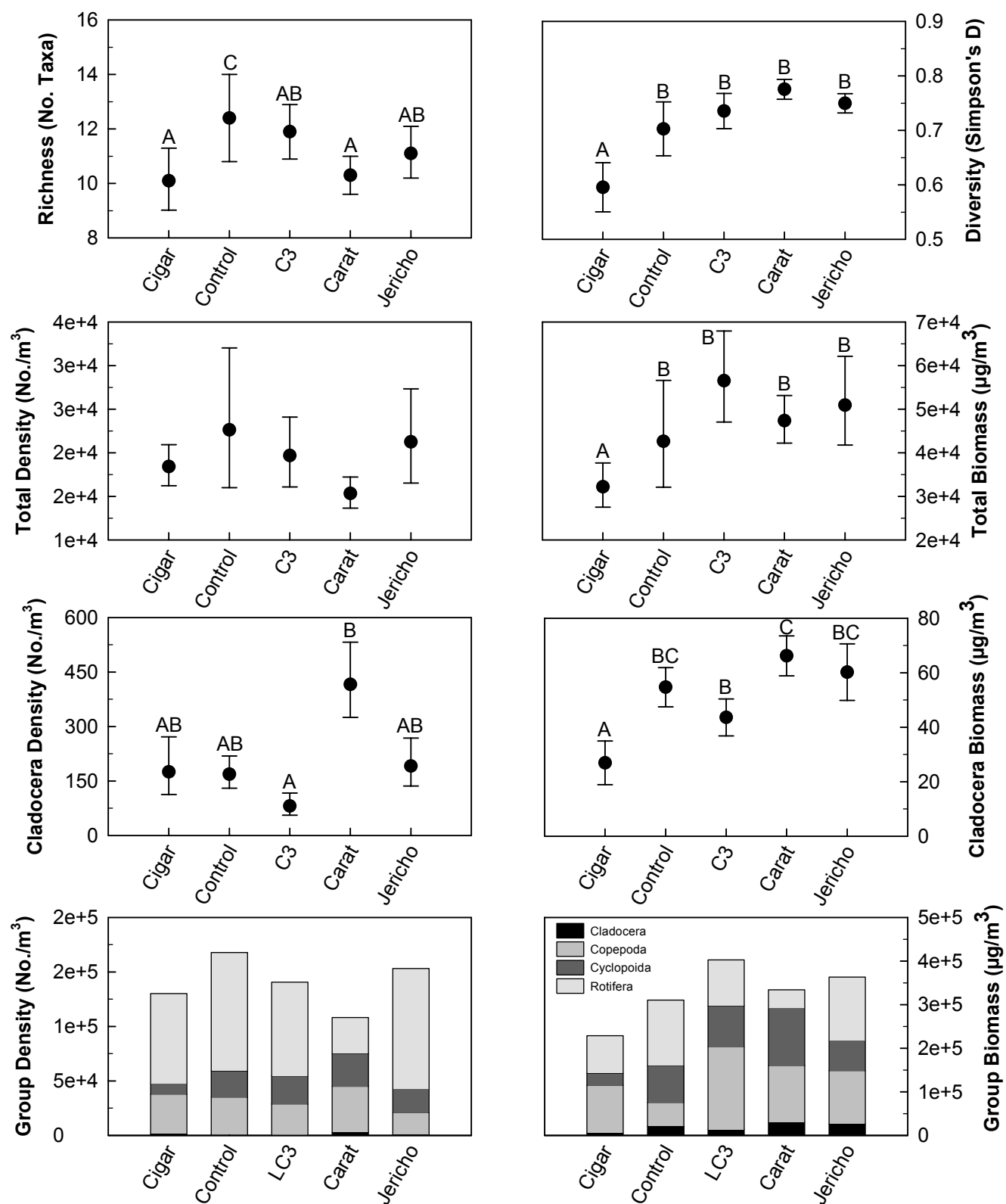


Figure 4.3 Zooplankton parameter summary metrics ($\bar{x} \pm 95\% \text{ CI}$) monitored in 2004, Jericho AEMP (Letter designates statistical differences; see section 3.8 for methods).

Major Taxa

The zooplankton data (density and biomass) were summarized by major taxonomic group and presented in Figure 4.3. In terms of density, the dominant group in all waterbodies was Rotifera, followed by Copepoda. Biomass was evenly distributed among groups. In general, Copepoda, Cyclopoida, and Rotifera dominated.

Quality Control

Four samples sent to an outside taxonomist and two split samples were evaluated for quality control (Table 4.4). Average percent difference ranged from 16.8% for total density to -6.9% for species richness for samples submitted to an external reviewer. Differences recorded using split samples were similar. There were small differences in the number of unique taxa identified in the quality control versus the processed samples (i.e., taxa recorded in one sample but not in the other). Values ranged from 1 to 3. The reasons for the unique taxa numbers included differences in identification of a single taxa in each of the external samples and the presence of rare taxa.

Table 4.4 Percent difference in zooplankton summary metrics and numbers of unique taxa between processed and quality control samples, Jericho AEMP.

Type	Station	Percent Difference					Unique Taxa (No.)	
		Replicate	Total Density	Total Biomass	Richness	Diversity	Sample	QAQC
External	JER-AB11	CI0101	12.5		-15.4	0.0	1	3
	JER-AB04	C30101	28.1		0.0	5.7	3	3
	JER-AB06	CA0101	-19.2		-7.1	-7.7	1	2
	JER-AB08	JE0101	34.0		-6.7	6.9	1	2
		Average	16.8	-	-6.9	1.5	1.5	2.5
Split	JER-AB10	CN0104	-12.6	4.9	25.0	-7.4	0	3
	JER-AB08	JE0104	-14.9	5.4	-30.0	3.9	3	0
		Average	-13.6	5.2	0.0	-1.4	-1.4	-1.4

4.5 BENTHIC MACROINVERTEBRATES

Summary information are presented in Table 4.5 and Figure 4.4.

Taxa Richness

Taxa richness was similar among stations. Mean number of taxa ranged from 11.8 at near and far field stations in Carat Lake to 14.2 at the Control Lake station. There were no significant differences among benthic macroinvertebrate stations monitored in 2004.

Table 4.5 Benthic macroinvertebrate parameter summary metrics at stations in 2004, Jericho AEMP.

Parameter	Lake	Station	Sample Size	Mean	Standard Deviation	Minimum	Maximum	Significance ^a
Richness (No. taxa)	Cigar	JER-AB11	5	14.0	2.6	10	17	-
	Control	JER-AB10	5	14.2	0.8	13	15	-
	C3	JER-AB20	5	13.4	1.1	12	15	-
	Carat (near)	JER-AB19	5	11.8	1.6	10	14	-
	Carat (far)	JER-AB07	5	11.8	1.9	9	14	-
	Jericho	JER-AB08	5	13.2	2.7	11	17	-
								$P = 0.240$
Diversity (Simpson's D)	Cigar	JER-AB11	5	0.709	0.102	0.58	0.86	A
	Control	JER-AB10	5	0.824	0.024	0.79	0.86	B
	C3	JER-AB20	5	0.821	0.045	0.76	0.87	B
	Carat (near)	JER-AB19	5	0.764	0.024	0.73	0.80	AB
	Carat (far)	JER-AB07	5	0.816	0.029	0.79	0.86	B
	Jericho	JER-AB08	5	0.821	0.037	0.76	0.85	B
								$P = 0.008$
Total Density ^b (No./m ²)	Cigar	JER-AB11	5	10,494.4	1.9	3638	19,870	B
	Control	JER-AB10	5	5487.1	1.3	4290	7942	AB
	C3	JER-AB20	5	5007.8	1.2	3580	5957	AB
	Carat (near)	JER-AB19	5	3033.4	1.6	1565	5812	A
	Carat (far)	JER-AB07	5	4346.2	1.4	3203	7652	A
	Jericho	JER-AB08	5	6487.0	1.8	3783	14362	AB
								$P = 0.006$
Chironomid Density ^b (No./m ²)	Cigar	JER-AB11	5	6925.7	1.8	2884	12812	B
	Control	JER-AB10	5	2635.1	1.3	2203	3609	A
	C3	JER-AB20	5	1513.3	1.3	1000	2058	A
	Carat (near)	JER-AB19	5	1713.9	1.7	942	3768	A
	Carat (far)	JER-AB07	5	1746.3	1.4	1159	2899	A
	Jericho	JER-AB08	5	1884.8	1.7	841	3420	A
								$P = 0.000$
Oligochaete Density ^b (No./m ²)	Cigar	JER-AB11	5	118.7	16.7	1	1304	-
	Control	JER-AB10	5	266.0	1.4	188	406	-
	C3	JER-AB20	5	221.4	2.6	44	478	-
	Carat (near)	JER-AB19	5	69.8	2.6	15	188	-
	Carat (far)	JER-AB07	5	129.6	2.4	44	290	-
	Jericho	JER-AB08	5	25.4	7.2	1	116	-
								$P = 0.226$

^a See Section 3.8 for description of statistical methods.^b Represents back-transformed log scale data.

Taxa Diversity

Taxa diversity was generally similar among most waterbodies. Mean Simpson's D values ranged from 0.764 to 0.824. The one exception was Cigar Lake. The mean Simpson's D value of 0.709 was significantly less than mean values recorded for the remaining four waterbodies. The Cigar Lake station exhibited higher range of replicate values compared to other stations, which may have influenced the mean value at this station.

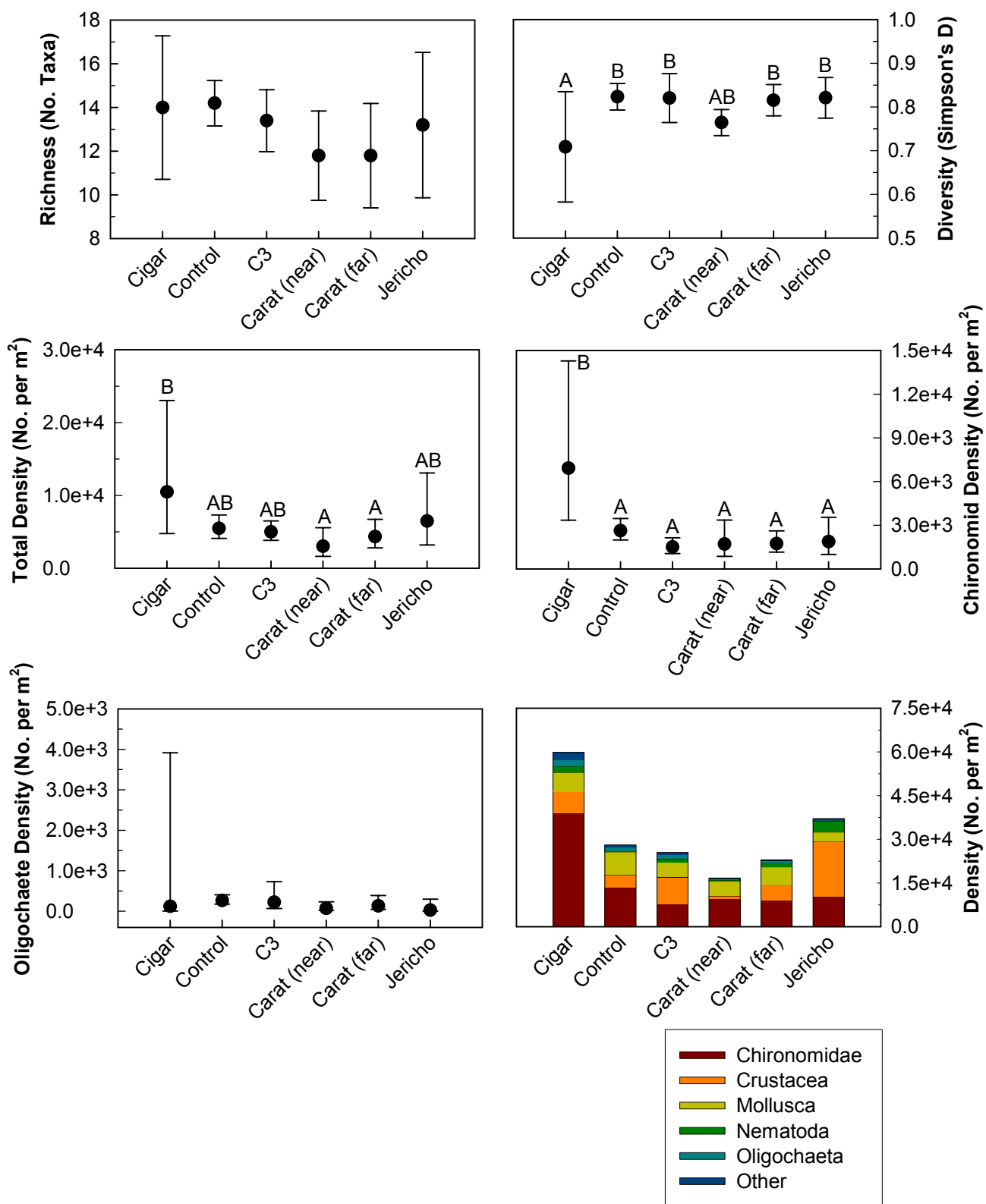


Figure 4.4 Benthic macroinvertebrate parameter summary metrics ($\bar{x} \pm 95\%$ CI) monitored in 2004, Jericho AEMP (Letter designates statistical differences; see section 3.8 for methods).

Total Density

Total density of benthic macroinvertebrates varied among waterbodies. Mean values ranged from a low of 4346.2 organisms/m² at the Carat Lake near field station to 10,494.2 organisms/m² at the Cigar Lake station. Differences among the mean values were significant. Carat Lake near and far field stations were significantly less than the Cigar Lake station. The Carat Lake stations did not differ significantly from stations at Control Lake, Lake C3 and Jericho Lake. It should be noted that the Cigar Lake site exhibited high within station variation compared to other stations, which may explain the significant difference.

Chironomid Density

A similar pattern was recorded for chironomid density. The mean value recorded at the Cigar Lake station (6925.7 organisms/m²) was approximately 2.5 times higher than the next closest mean value at the Control station (2635.1 organisms/m²). The difference was significant.

Oligochaete Density

Oligochaete densities were similar among the monitored stations. No significant differences were recorded. As per total density and chironomid density, oligochaete density replicates at the Cigar Lake station exhibited greater within station variation when compared to other stations.

Major Taxa

Major taxonomic groups varied among monitored stations (Figure 4.4). Chironomids were the numerically dominant taxa at all stations except Jericho Lake, where Crustacea (cladocera and copepoda) were the major group. Crustacea were important at most except Carat Lake near field. These data suggest that the importance of major taxonomic groups was not consistent among stations.

Quality Control

Four samples sent to an outside taxonomist and were evaluated for quality control (Table 4.6). Average percent differences were small for the summary metrics. Average values ranged from 4.6% for total density to -3.7% for species richness for samples submitted to an external reviewer. There were small differences in the number of unique taxa identified in the quality control versus the processed samples (i.e., taxa recorded in one sample but not in the other). Values ranged from 0 to 4. The reasons for the differences did not involve misidentification of taxa, but instead were due to the presence of rare taxa.

Table 4.6 Percent difference in benthic macroinvertebrates summary metrics and numbers of unique taxa between processed and quality control samples, Jericho AEMP.

Type	Station	Percent Difference				Unique Taxa (No.)	
		Replicate	Total Density	Richness	Diversity	Sample	QAQC
External	JER-AB10	CN0102	6.1	-20.0	1.2	3	1
	JER-AB20	C30102	2.4	-15.4	0.0	2	1
	JER-AB19	CA0202	5.7	23.1	3.9	0	3
	JER-AB07	CA0102	3.4	0.0	2.5	2	4
		Average	4.6	-3.7	1.9	1.8	2.3

4.6 FISH TISSUE

Summary information are presented in Table 4.7 to Table 4.9

There was a wide range in fork length of lake trout and round whitefish collected for tissues (Table 4.7). The length of lake trout ranged from 218 mm to 1009 mm and the length of round whitefish ranged from 312 mm to 445. This wide range was reflected in the age distribution of samples collected from both species. Slimy sculpin collected for tissue analyses exhibited a wide range in total length. Values ranged from 49 mm to 115 mm.

Table 4.7 Summary of biological characteristics of fish collected for tissue metal contaminants in 2004, Jericho AEMP.

Species	Lake	Sample Size	Length (mm) ^a				Age			
			Mean	Standard Deviation	Min.	Max.	Mean	Standard Deviation	Min.	Max.
Lake trout	Cigar Lake	10	409.8	33.5	352	474	15.1	3.3	10	19
	Lake C3	10	484.8	161.3	218	754	18.5	6.7	9	29
	Carat Lake	10	486.9	188.3	359	1009	16.3	9.7	11	45
Round whitefish	Cigar Lake	10	380.8	50.3	312	445	12.0	5.1	7	24
	Lake C3	10	363.1	25.7	315	395	10.2	1.6	8	13
	Carat Lake	10	389.2	24.2	346	435	9.9	1.3	8	12
Slimy sculpin	Stream W	14	83.2	16.9	58	115	-	-	-	-
	Stream C3	18	67.8	6.6	55	82	-	-	-	-
	Stream C1	19	66.2	11.1	49	84	-	-	-	-

^a Fork length for lake trout and round whitefish; total length for slimy sculpin.

The concentrations of most metal contaminants in fish tissues were below analytical detection limits (Table 4.8). Five metals meet the criteria for minimum sample size ($n \geq 5$ above detection limit) to allow statistical comparisons of the monitored lakes as follows:

- aluminum - slimy sculpin (whole fish)
- cadmium - lake trout and round whitefish (liver); slimy sculpin (whole fish)
- copper - lake trout and round whitefish (liver); slimy sculpin (whole fish)
- mercury - lake trout and round whitefish (liver and muscle); slimy sculpin (whole fish)
- zinc - lake trout and round whitefish (liver and muscle); slimy sculpin (whole fish)

Table 4.8 Number of fish tissue samples below analytical detection limits in 2004, Jericho AEMP.

Species	Tissue	Lake	Number below detection limit										
			Al (0.2) ^a	As (0.1)	Cd (0.005)	Cr (0.25)	Cu (0.5)	Hg (0.01)	Mo (0.5)	Ni (0.05)	Pb (0.05)	U (0.025)	Zn (0.05)
Lake trout	Liver	Cigar Lake	6	5	0	10	0	0	10	10	10	10	0
		Lake C3	8	6	0	10	0	0	10	9	10	10	0
		Carat Lake	5	6	0	9	0	0	10	8	10	10	0
	Muscle	Cigar Lake	8	10	10	10	10	0	10	10	10	10	0
		Lake C3	10	10	10	10	10	0	10	10	10	10	0
		Carat Lake	10	10	9	10	10	0	10	10	7	10	0
Round whitefish	Liver	Cigar Lake	9	8	0	10	0	0	10	10	10	10	0
		Lake C3	6	6	0	10	0	0	10	10	10	10	0
		Carat Lake	4	10	0	10	0	0	10	10	10	10	0
	Muscle	Cigar Lake	10	10	10	10	10	3	10	10	10	10	0
		Lake C3	9	10	10	8	10	0	10	8	10	10	0
		Carat Lake	8	10	10	9	8	0	10	9	9	10	0
Slimy sculpin	Whole	Stream W	1 ^b	10	0	10	0	0	10	10	10	10	0
		Stream C3	2	10	0	10	0	0	10	10	10	10	0
		Stream C1	3	10	0	10	0	0	10	10	10	10	0

^a Analytical detection limit.^b Highlighted cells represent samples used for analyses of metal concentrations.

Summary metrics for the five metals are presented in Table 4.9.

Metal concentrations were compared to fork length of lake trout and round whitefish to establish if there were correlations (Table 4.10). Mercury concentrations were significantly correlated with fish length for both liver and muscle tissue of lake trout. Positive correlations between mercury concentration and length also were recorded for round whitefish muscle tissue and correlations were significant in two of three samples. No consistent trends between metal concentration and fish length were recorded for other metals.

Based on the results for mercury fork length was assigned as a covariate in subsequent statistical analyses for lake trout and round whitefish muscle tissue and lake trout liver tissue. Composite samples for slimy sculpin precluded comparisons of fish length to metal concentrations for this species.

Table 4.9 Metal concentrations in fish tissue summary metrics in 2004, Jericho AEMP.

Species	Tissue	Lake	Parameter	Metal Concentrations (µg/g based on wet weight) ^a				
				Al (0.2) ^a	Cd (0.005)	Cu (0.5)	Hg (0.01)	Zn (0.05)
Lake trout	Liver (n = 10)	Cigar Lake	Mean ± SD ^b		0.281±1.632	12.8±1.8	0.15 ^c	37.53±1.15
			Range		0.136-0.732	6.4-35.7	0.06-0.37	29.61-45.81
		Lake C3	Mean ± SD		0.153±2.317	9.9±2.1	0.14 ^c	34.01±1.30
			Range		0.027-0.508	1.8-28.7	0.07-0.57	22.55-48.13
		Carat Lake	Mean ± SD		0.190±1.716	9.0±1.6	0.26	34.40±1.17
			Range		0.097-0.542	5.7-27.1	0.09-0.56	28.58-44.69
	Muscle (n = 10)	Cigar Lake	Mean ± SD				0.10 ^c	4.87±1.20
			Range				0.05-0.18	3.99-6.95
		Lake C3	Mean ± SD				0.11 ^c	3.72±1.14
Round whitefish	Liver (n = 10)	Cigar Lake	Mean ± SD		0.120±2.167	2.0±1.3	0.05±1.48	25.72±1.13
			Range		0.035-0.386	1.3-2.7	0.03-0.09	20.87-31.04
		Lake C3	Mean ± SD		0.069±1.594	1.9±1.2	0.05±1.36	25.55±1.05
			Range		0.021-0.116	1.5-2.8	0.03-0.08	23.05-27.81
		Carat Lake	Mean ± SD		0.096±1.574	1.7±1.2	0.04±1.51	24.87±1.08
			Range		0.036-0.177	1.3-2.1	0.03-0.11	21.81-28.24
	Muscle (n = 10)	Cigar Lake	Mean ± SD				0.02 ^c	4.16±1.11
			Range				0.02-0.04	3.56-5.14
		Lake C3	Mean ± SD				0.04 ^c	3.92±1.09
Slimy sculpin	Whole (n = 10)	Stream W	Mean ± SD	8.57±2.36	0.027±1.368	0.9±1.1	0.08±1.41	29.90±1.20
			Range	1.25-21.46	0.016-0.048	0.8-1.2	0.05-0.15	22.66-40.30
		Stream C3	Mean ± SD	4.02±1.99	0.031-1.154	0.9±1.1	0.06±1.23	36.56±1.12
			Range	1.25-8.33	0.024-0.039	0.8-1.1	0.04-0.08	30.78-44.68
		Stream C1	Mean ± SD	4.61±2.64	0.043±1.791	0.9±1.1	0.04±1.51	35.00±1.29
			Range	1.25-15.03	0.011-0.093	0.8-1.0	0.03-0.08	23.24-51.14

^a Represents back-transformed log scale data.^b Standard deviation.^c Adjusted mean based on ANCOVA with fork length as covariate; see Section 3.8 for description of methods.

Table 4.10 Correlations between metal concentrations in tissues and fish length in 2004, Jericho AEMP.

Species	Tissue	Lake	Pearson Correlation Coefficient				
			Al	Cd	Cu	Hg	Zn
Lake trout	Liver	Cigar Lake		+0.061	+0.515	+0.750*	+0.121
		Lake C3		-0.584	-0.345	+0.691*	-0.733*
		Carat Lake		+0.387	+0.898*	+0.987*	-0.259
	Muscle	Cigar Lake				+0.819*	-0.142
		Lake C3				+0.834*	-0.254
		Carat Lake				+0.984*	-0.014
Round whitefish	Liver	Cigar Lake		+0.867*	-0.199	+0.845*	-0.342
		Lake C3		+0.369	-0.755*	+0.168	-0.575
		Carat Lake		+0.299	-0.045	+0.620	+0.210
	Muscle	Cigar Lake				+0.963*	+0.245
		Lake C3				+0.694*	+0.169
		Carat Lake				+0.289	-0.343

^a * Denotes statistical significance.

Mean metal concentrations for the selected metals are presented in Table 4.11 and illustrated in Figures 4.5 to 4.7. For most comparisons, metal concentrations were not significantly different between waterbodies. No significant differences were recorded for aluminum and copper. Cadmium concentration in slimy sculpin whole fish tissue was higher in Stream C1 (0.043 µg/g) compared to Stream W (0.027 µg/g). Zinc concentration in lake trout muscle tissues was significantly higher in Cigar Lake (4.87 µg/g) compared to Lake C3 and Carat Lake (≤ 4.03 µg/g). Zinc concentration in slimy sculpin whole fish tissue in Stream C3 approached but was not significantly different from zinc concentrations in whole fish samples collected from slimy sculpin in the other streams.

In general, there were waterbody differences in mean mercury concentration. Wet weight concentrations in muscle tissues ranged from 0.57 µg/g in lake trout to 0.02 µg/g in round whitefish (Table 4.9). Mean concentrations were significantly higher in tissues collected from Carat Lake compared to Cigar Lake and Lake C3 (lake trout muscle and liver) and were significantly higher in Carat Lake compared to Cigar Lake (round whitefish muscle). Mean mercury concentration in slimy sculpin whole fish sample was significantly higher in Stream W compared to Stream C1.

Table 4.11 Statistical comparisons of mean metal concentrations in fish tissues in 2004, Jericho AEMP.

Species	Tissue	Lake	Mean Metal Concentration (µg/g wet weight) ^a				
			Al	Cd	Cu	Hg	Zn
Lake trout	Liver	Cigar Lake		0.281	12.8	0.15 A	37.53
		Lake C3		0.153	9.9	0.14 A	34.01
		Carat Lake		0.190	9.0	0.26 B	34.40
	Significance ^b			<i>P</i> = 0.120	<i>P</i> = 0.401	<i>P</i> = 0.027 ^c	<i>P</i> = 0.470
	Muscle	Cigar Lake			0.10 A	4.87 B	
		Lake C3			0.11 A	3.72 A	
Carat Lake				0.20 B	4.03 A		
Significance ^b					<i>P</i> = 0.000 ^c	<i>P</i> = 0.001	
Round whitefish	Liver	Cigar Lake		0.120	2.0	0.05	25.72
		Lake C3		0.069	1.9	0.05	25.55
		Carat Lake		0.096	1.7	0.04	24.87
	Significance ^b			<i>P</i> = 0.122	<i>P</i> = 0.162	<i>P</i> = 0.519	<i>P</i> = 0.661
	Muscle	Cigar Lake			0.02 A	4.16	
		Lake C3			0.04 B	3.92	
Carat Lake				0.06 B	4.05		
Significance ^b					<i>P</i> = 0.000 ^c	<i>P</i> = 0.331	
Slimy sculpin	Whole fish	Stream W	8.6	0.027 A	0.9	0.08 B	29.90
		Stream C3	4.0	0.031 AB	0.9	0.06 AB	36.56
		Stream C1	4.6	0.043 B	0.9	0.04 A	35.00
		Significance ^b		<i>P</i> = 0.122	<i>P</i> = 0.043	<i>P</i> = 0.579	<i>P</i> = 0.002

^a Represents back-transformed log scale data.

^b Unless stated otherwise all tests based on ANOVA; different letters designate significant difference based on post-hoc means test; see Section 3.8 for description of methods.

^c Based on ANCOVA with fork length as covariate; different letters designate significant difference based on post-hoc means test; see Section 3.8 for description of methods.

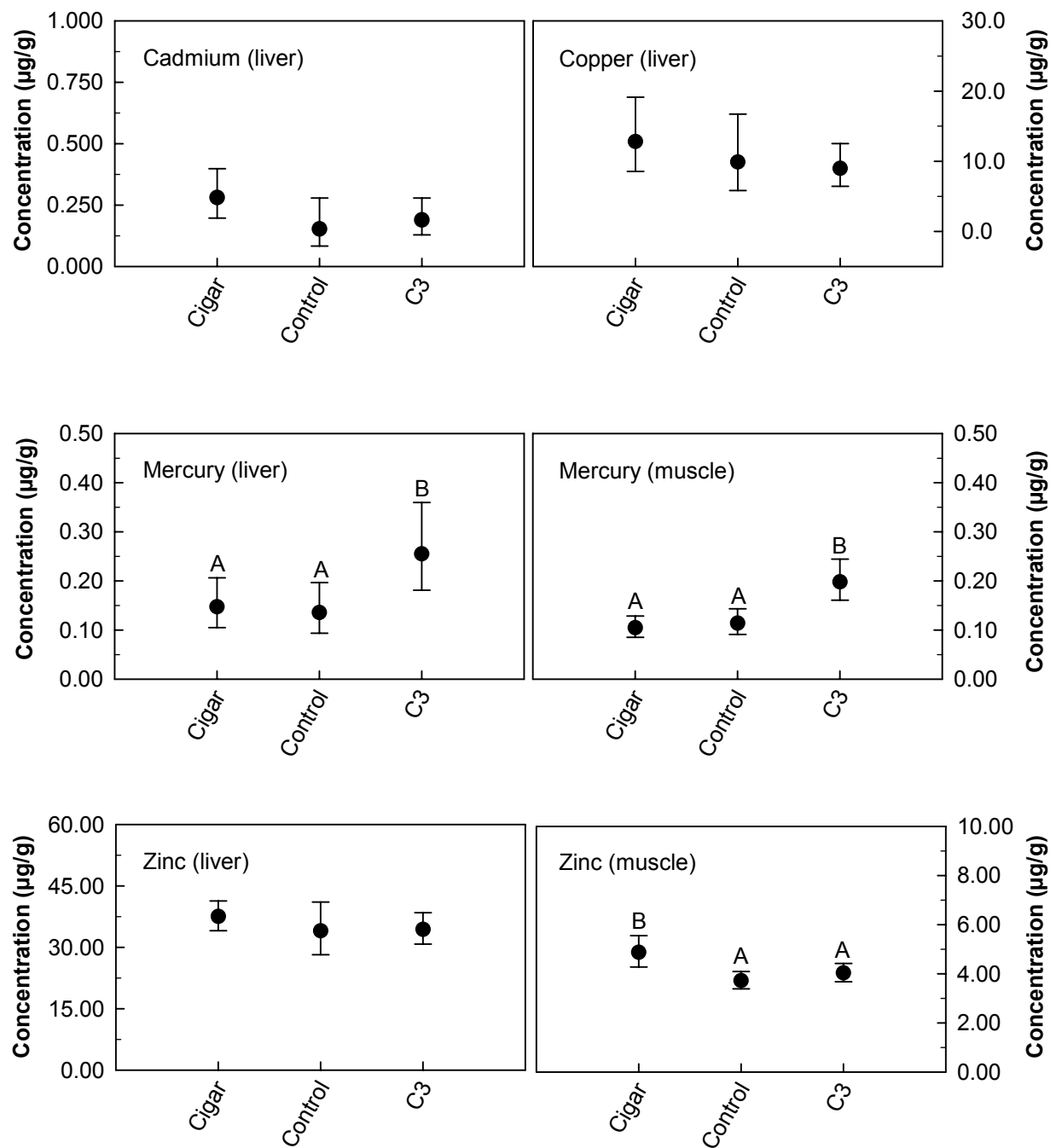


Figure 4.5 Selected metal contaminants in lake trout tissues summary metrics ($\bar{x} \pm 95\%$ CI) monitored in 2004, Jericho AEMP.

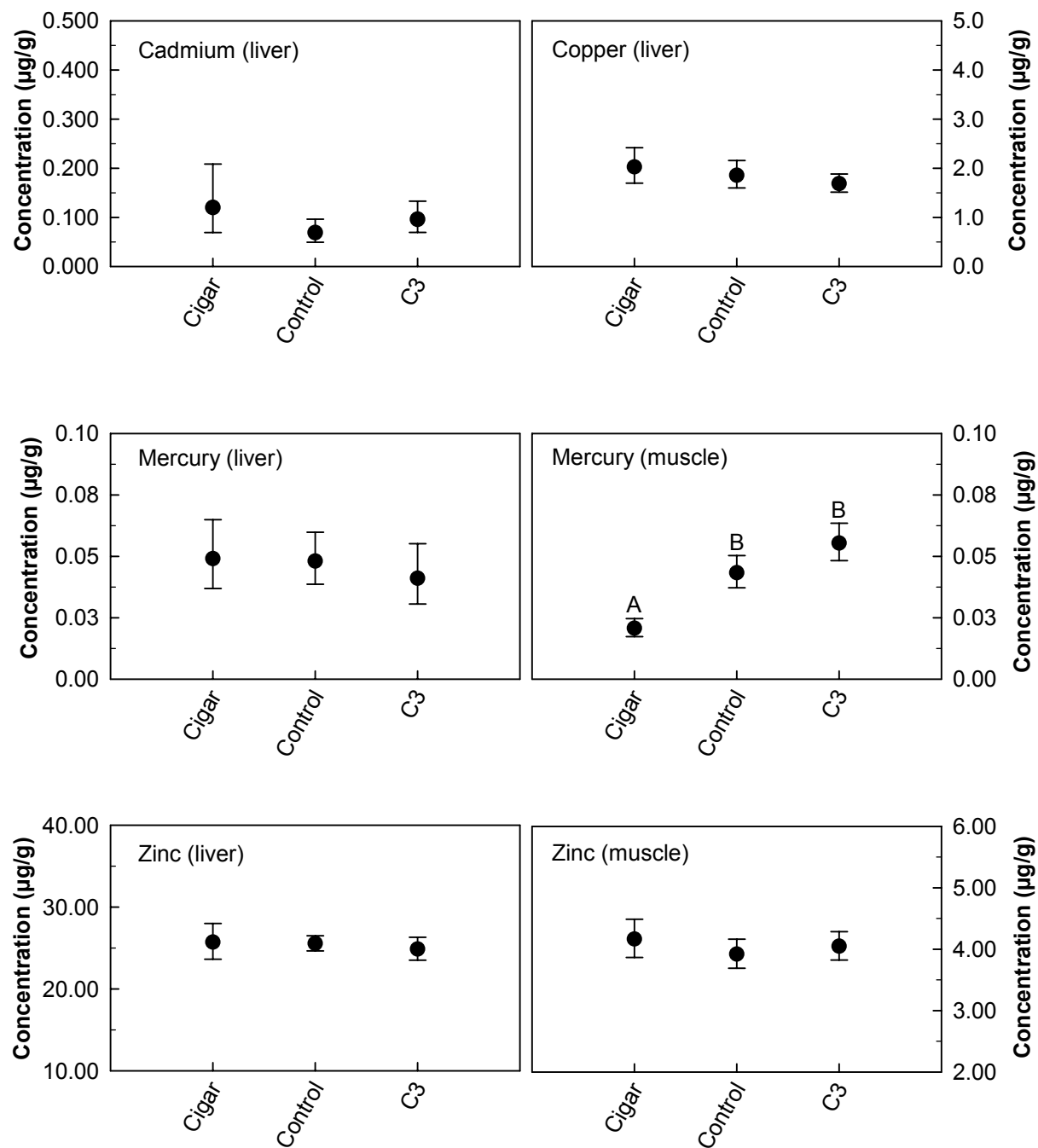


Figure 4.6 Selected metal contaminants in round whitefish tissues summary metrics ($\bar{x} \pm 95\%$ CI) monitored in 2004, Jericho AEMP.

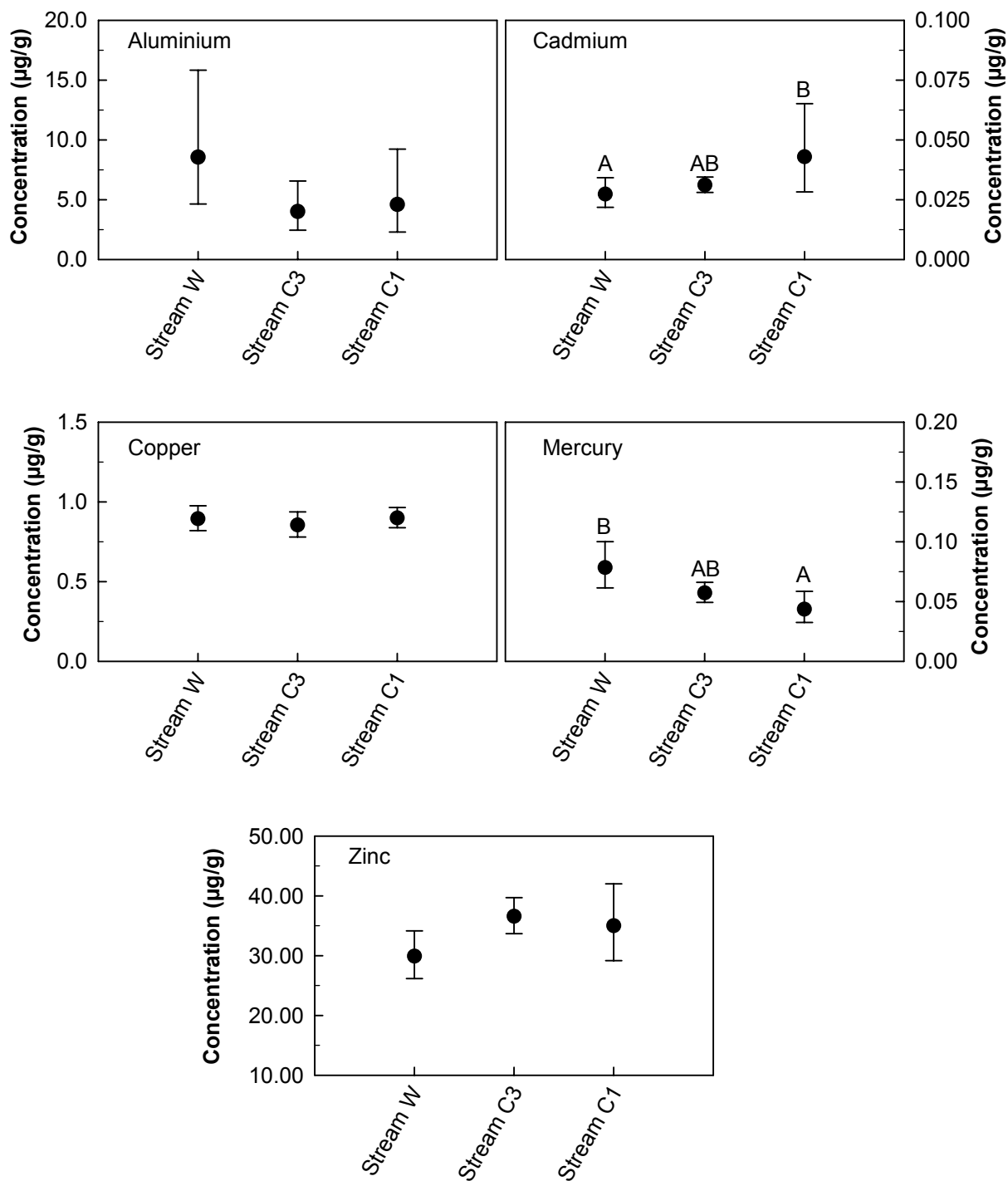


Figure 4.7 Selected metal contaminants in slimy sculpin tissues summary metrics ($\bar{x} \pm 95\%$ CI) monitored in 2004, Jericho AEMP.

Quality Control

Three lake trout muscle tissue samples were submitted as split samples for quality control analyses. Table 4.12 presents a summary of comparisons between the duplicate samples for metal contaminants that were above analytical detection limits. Absolute mean differences in metal concentrations varied from 0.1% (manganese) to 10.6% (selenium). Maximum percent differences were recorded for mercury (23.0%) and selenium (-26.8%). Mean percent difference for all remaining metals did not exceed 6.1%.

Table 4.12 Percent difference in selected metal concentrations between processed and quality control samples, Jericho AEMP.

Metal	Percent Difference			
	Mean	Number	Minimum	Maximum
Hg	3.8	3	-7.5	23.0
K	-0.6	3	-1.1	-0.3
Mg	-2.0	3	-2.6	-1.6
Mn	-0.1	3	-0.8	0.4
Na	1.2	3	-4.0	7.1
P	-1.1	3	-3.8	3.7
Se	-10.6	2	-26.8	5.6
Si	-0.1	3	-0.8	0.4
Sn	-1.4	3	-5.8	6.6
Ti	-0.2	2	-1.6	1.2
Va	-4.6	1		
Wet	-0.9	3	-2.6	0.1
Zn	6.1	3	-3.0	18.8
Average	-0.8	35	-26.8	23.0

5.0 SUMMARY

Indicators monitored in 2004 by the aquatic biota Jericho AEMP included dissolved oxygen profiles in summer, sediment deposition, phytoplankton, zooplankton, periphyton, benthic macroinvertebrates and metal concentrations in fish tissues. Data for some indicators were not presented either because they were omitted from the program based on conditions specified in Schedule L NWBJER0410 (periphyton) or data will not be available until 2005 (sediment deposition).

5.1 INDICATORS AND PARAMETERS

The dissolved oxygen results suggested that most waterbodies were not stratified at the time of measurement. Only one waterbody was stratified: Control Lake.

Multiple parameters were measured for aquatic biota indicators phytoplankton, zooplankton, and benthic invertebrates. For each of the parameters categories measured in phytoplankton and zooplankton significant (10 comparisons) or near significant (1 comparison) differences were recorded among stations. However, there was no apparent spatial trend among the parameters either for phytoplankton or zooplankton. The results indicated that the baseline phytoplankton and zooplankton communities in monitored lakes are variable.

Significant differences were recorded for three of five comparisons of benthic macroinvertebrate parameters. The spatial difference among waterbodies was primarily related to the Cigar Lake station, which contained higher density and lower diversity of macroinvertebrates. The result for Cigar Lake may be due in part to the large within site variation.

A large portion of metal concentration in fish tissue sample was below analytical detection limits for the respective metals. Of eleven metals of interest, five contained sufficient data for statistical analyses for one or more species and tissue type. These were aluminium (slimy sculpin whole fish), cadmium and copper (lake trout and round whitefish liver; slimy sculpin whole fish), and mercury and zinc (lake trout and round whitefish muscle and liver; slimy sculpin whole fish). Metal concentrations in fish tissues were not significantly different among waterbodies for the majority of comparisons. This included all comparisons for aluminium and copper. For cadmium, the mean concentration in slimy sculpin whole fish tissue was significantly higher in Stream W compared to Streams C1 and C3. For zinc, the mean

concentration in lake trout muscle tissue was significantly higher in Cigar Lake compared to Lake C3 and Carat Lake.

Unlike other metals mercury concentrations in tissues of all three species were significantly different among waterbodies. For lake trout muscle and liver, samples collected from Carat Lake were significantly higher than Cigar Lake and Lake C3. The same pattern was recorded for round whitefish muscle tissue. These results suggested that Carat Lake fish contain higher concentrations of mercury compared to other waterbodies. These results should be interpreted with caution because fish have the potential to move between Carat Lake and Lake C3. For slimy sculpin muscle tissue, mercury concentrations were significantly higher in Stream W compared to Stream C1.

5.2 QUALITY CONTROL

Quality control assessments suggested different levels of sample precision depending on the aquatic biota indicator and parameter. Phytoplankton estimate precision rarely was below 20%, which is the suggested threshold for acceptable precision (ENVCAN 2002). This result likely reflects the standard phytoplankton laboratory sampling methodology that relies heavily on subsampling. The majority of parameters for the two remaining indicators were below the 20% threshold. Overall, benthic macroinvertebrate estimates exhibited a higher level of precision than zooplankton estimates. The accuracy of taxa identification followed the same pattern. Based on the number of unique taxa, accuracy was deemed poor for phytoplankton, but good for zooplankton and benthic macroinvertebrates. The results for phytoplankton reflect the large number of taxa at the species and subspecies level and differences in the taxonomist expertise.

Quality control evaluations of metal concentrations in fish tissue suggested that the analytical precision of the laboratory was good. Percent difference between duplicate samples for the majority of metals was $\leq 6.1\%$.

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