DOMINION DIAMOND

New Vision, New Focus, New Name

Ekati Diamond Mine

Aquatic Response Framework Version 1.1

DOMINION DIAMOND

November 20, 2014

Ms. Violet Camsell-Blondin
Chair
Wek'èezhìi Land and Water Board
#1, 4905-48th Street
Yellowknife, NT, CA X1A 2P6

Dear Ms. Camsell-Blondin

Re: EKATI Diamond Mine Aquatic Response Framework Version 1.1

Dear Ms. Camsell-Blondin:

Dominion Diamond Ekati Corporation (DDEC) is pleased to provide the attached *Aquatic Response Framework Version 1.1*, as required under Part J, Item 8 of W2012L2-0001. This framework is intended to be integrated into the approved Aquatic Effects Monitoring Program (AEMP) design while satisfying the requirements of the board outlined in Schedule 8, Item 1.q of W2012L2-0001 and the September 12th directive regarding the Development of Version 1.1 DDEC's *Aquatic Response Framework Version 1.1* was duly developed in accordance with the guidelines outlined by the WLWB's Response Framework Guideline document (2010).

The overall objective of the Response Framework is to link the results of the AEMP with actions necessary to ensure that project-related effects in the receiving environment remain within an acceptable range. In the proposed framework, the results of the AEMP will be incorporated into an "early warning" system with defined action levels that will allow DDEC to monitor and respond to any change in the receiving environment prior to significant environmental impact occurring.

As required in W2012L2-0001, the Response Framework includes:

1. Definitions, with rationale, for Significance Thresholds and tiered Action Levels applicable to biotic and abiotic parameters monitored in the aquatic Receiving Environment at Ekati; and
2. For each action level:

- A description of the rationale including, but not limited to, a consideration of the predictions and conclusions of the Environmental Assessment as well as AEMP results to date;
- A description of how exceedances of Action Levels will be assessed; and
- A general description of what types of actions may be taken if an Action Level is exceeded.

3. Guidelines for reporting any action level exceedances and submitting response plans that describe specific actions to be taken by DDEC in response to an action level exceedance in a timely and efficient manner.

Pending approval from the board, it is expected that the Response Framework will be integrated with the 2014 AEMP. DDEC trusts that you will find the framework to be clear and informative. Please contact Kate Mansfield, Environmental Advisor - Fisheries and Aquatics at Kathleen.Mansfield@ekati.ddcorp.ca or 867-880-2115 or the undersigned at Claudine.a.lee@ekati.ddcorp.ca or 867-880-2232 should you have any questions.

Yours sincerely,

Dominion Diamond Ekati Corporation

Claudine Lee
Superintendent – Environment Operations

References:

WLWB. 2010. *DRAFT: Guidelines for Adaptive Management- a Response Framework for Aquatic Effects Monitoring*. Prepared by the Wek'eezhii Land and Water Board.

EKATI DIAMOND MINE
AQUATIC RESPONSE FRAMEWORK
VERSION 1.1

November 2014
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Prepared for:

DOMINION DIAMOND

Dominion Diamond Ekati Corporation

Prepared by:

ERM

ERM Rescan
Yellowknife, Northwest Territories

Executive Summary

ERM

Executive Summary

The Aquatic Response Framework, Version 1.1 for the Ekati Diamond Mine was developed to satisfy the requirements of Water Licence W2012L2-0001 (WLWB 2014a), and the Directive for the Development of Version 1.1 [of the Ekati Diamond Mine Aquatic Response Framework] from the Wek'èezhìi Land and Water Board (WLWB 2014b). The Framework was written in consideration of the document titled *"Guidelines for Adaptive Management – a Response Framework for Aquatic Effects Monitoring DRAFT"* (WLWB 2010).

The overarching objective of the Aquatic Response Framework is to provide a tool to ensure the protection of the uses of the aquatic receiving environment at the Ekati Diamond Mine. Uses of the aquatic receiving environment include use by people and wildlife for drinking water and fishing, and use by fish and other aquatic life that live in the receiving waterbodies.

Within the Aquatic Response Framework, both abiotic (water quality) and biotic (plankton, benthos and fish) variables were selected for assessment against action levels. Variables were selected based on historically predicted impacts, observed current environmental effects and risks, and recent predictions of water quality trends. Action levels for each of the variables were set to allow for management action being initiated within an adequate timeframe to ensure that a significant adverse environmental impact does not occur.

The results of the Aquatic Effects Monitoring Program (AEMP) will be used in the Aquatic Response Framework for regular assessment against the defined action levels. Any exceedance of an action level will be reported to the WLWB on a regular basis and corresponding Response Plans will be developed (see Table 1) reviewed, updated and amended, as appropriate. The implementation, status and results of the management actions associated with each approved Response Plan will be presented in the annual AEMP Summary Report, or as otherwise approved by the WLWB. The Aquatic Response Framework will be updated annually in the AEMP Summary Report, and the Aquatic Response Framework document itself will be updated on a three year basis (with the AEMP re-evaluation). Updates may include changes to the variables lists, newly defined benchmarks or action levels, as well as any other proposed changes (e.g., changes relating to new information gleaned from the AEMP re-evaluation, etc.).

Table 1. Reporting Schedule for Action Level Exceedance and Subsequent Response Plans

Sampling Period	Type of Waterbody	Type of Variable	Notification of Action Level Exceedance	Submission of Response Plan (if required)
Under-ice (mid to late April)	Lake	Water quality	July 31	August 31
August	Lake	Water quality and biological variables	October 31 for water quality, March 31 for biological variables	November 30 for water quality, April 30 for biological variables

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AQUATIC RESPONSE FRAMEWORK
VERSION 1.1

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Glossary and Abbreviations

Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Action Level	A predetermined change, to a monitored variable or other qualitative or quantitative measure that requires the Licensee to take appropriate actions that may include, but that are not limited to: further investigations, changes to operations, or enhanced mitigation measures.
AEMP	Aquatic Effects Monitoring Program
Biological Benchmark	For the purposes of the Aquatic Response Framework, biological benchmarks are broad ecosystem and biological indicators. Where biological measures meet their benchmarks, the measure remains similar to reference or baseline conditions.
BHP Billiton	BHP Billiton Canada Inc.
CCME	Canadian Council of Ministers of the Environment
the Board	Wek'èezhìi Land and Water Board
CPUE	Catch-per-unit-effort
DDEC	Dominion Diamond Ekati Corporation
DO	Dissolved oxygen
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPT	Ephemeroptera, Plecoptera and Trichoptera
EQC	Effluent Quality Criteria
EROD	ethoxyresorufin-O-deethylase
KPSF	King Pond Settling Facility
LLCF	Long Lake Containment Facility
MAC	Maximum Acceptable Concentration
PDC	Panda Diversion Channel
PSD	Pigeon Stream Diversion
Response Framework	A systematic approach to responding when the results of a monitoring program indicate that an Action Level has been reached.
Response Plan	A part of the Response Framework that describes the specific actions to be taken by the Licensee in response to reaching or exceeding an Action Level.
Significance Threshold	A level of environmental change in any monitored variable which, if reached, would result in a significant adverse effect.

SNP	Surveillance Network Program
SSWQO	Site Specific Water Quality Objective
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
VEC	Valued Ecosystem Component
Water Quality Benchmark	For the purposes of Aquatic Response Framework, the term water quality benchmark encompasses water quality guidelines (e.g., CCME guidelines, provincial guidelines or guidelines from the published literature) and SSWQO for the Ekati Diamond Mine. Water quality that meets water quality benchmarks is safe for its identified uses.
WLWB	Wek'èezhìi Land and Water Board

1. Introduction

1. Introduction

1.1 BACKGROUND

The Wek'èezhìi Land and Water Board (WLWB) defines a Response Framework as "*a systematic approach to responding when the results of a monitoring program indicate that an action level has been reached*". The WLWB further defines an action level as "*a predetermined change, to a monitored parameter or other qualitative or quantitative measure, that requires the Licensee to take appropriate actions…*" (WLWB 2010). In a Response Framework, action levels are set to trigger management actions to provide environmental protection such that significant adverse impacts never occur.

Version 1.1 of Aquatic Response Framework for the Ekati Diamond Mine, as detailed in this report, was developed to satisfy the requirements of Water Licence W2012L2-0001 (WLWB 2014a), and the Directive for the Development of Version 1.1 [of the Ekati Diamond Mine Aquatic Response Framework] from the Wek'èezhìi Land and Water Board (WLWB 2014b). The Framework was written in consideration of the document titled *"Guidelines for Adaptive Management – a Response Framework for Aquatic Effects Monitoring DRAFT"* (WLWB 2010). The results of the Aquatic Effects Monitoring Program (AEMP) were used to inform the Aquatic Response Framework, which along with regular monitoring and evaluation of the AEMP, will be used to "*prevent or avoid adverse environmental effects*" (WLWB 2014a).

Part J, Item 8 of Water Licence W2012L2-0001 includes a requirement to submit a Response Framework prior to February 15, 2014 "*which shall be integrated with the approved AEMP Design and shall satisfy the requirements of Schedule 8, Item 1(q) to the Board for approval*". The requirements outlined in Schedule 8, Item 1(q) include:

"a. definitions, with rationale, for Significance Thresholds and tiered Action Levels applicable to biotic and abiotic parameters monitored in the aquatic Receiving Environment of the Project; and

b. for each Action Level:

i. a description of the rationale including, but not limited to, a consideration of the predictions and conclusions of the Environmental Assessment as well as AEMP results to date;

ii. a description of how exceedances of Action Levels will be assessed; and

iii. a general description."

If an action level is exceeded, DDEC is required to notify the WLWB within 60 days of when the exceedance was detected and a Response Plan must be submitted to the WLWB within 90 days of when the exceedance was detected, unless otherwise approved by the WLWB. The Response Plan must satisfy the requirements of Schedule 8, Item 4 of Water Licence W2012L2-0001 and will undergo review for approval by the WLWB. The specific requirements for the Response Plans are discussed further in Section 4 of this report.

1.2 OBJECTIVES

The overarching objective of the Aquatic Response Framework is to provide a tool to ensure the protection of the uses of the aquatic receiving environment at the Ekati Diamond Mine. Uses of the aquatic receiving environment include use by people and wildlife for drinking water and fishing, and use by fish and other aquatic life that live in the receiving waterbodies. This approach is commonly referred to as the "use protection approach" and is consistent with the approach under which the 1995 Environmental Impact Statement (EIS) was approved, and the draft Response Framework guidance document (WLWB 2010). The Aquatic Response Framework is one component of a suite of monitoring and reporting tools that are designed to provide environmental protection using the use protection approach at the Ekati Diamond Mine (see BHP Billiton 2012c).

Specifically, the Aquatic Response Framework will serve to provide an early-warning system with defined action levels that are initiated within an adequate timeframe to ensure that a significant adverse environmental impact does not occur. This will be accomplished by:

- Defining appropriate benchmarks and action levels such that mine-related environmental effects will be investigated, and if necessary, mitigated, prior to any significant environmental impact occurring;
- Clearly defining the process by which mine-related environmental effects will be assessed against defined action levels;
- Clearly defining the procedure for reporting exceedances of action levels to the WLWB, and defining the process by which the Response Framework itself will be reviewed and amended;
- Identifying the types of mitigation actions that may be implemented if action levels are exceeded; and
- Defining the procedures for submitting Response Plans to the WLWB, outlining the type of information that will be included in Response Plans, defining how the results of Response Plan actions will be reported, and defining the process for reviewing and amending the Response Plans.

1.3 REPORT CONTENTS

Section 1 - Provides the background and objectives as well as the concordance with Water Licence W2012L2-0001 requirements, the WLWB's draft Response Framework guidance document, and the WLWB Directive to Guide the Development of Version 1.1 of the Ekati Diamond Mine Aquatic Response Framework (see Section 1.4 below).

Section 2 - Provides a summary of historical predictions for the aquatic receiving environment at the Ekati Diamond Mine and puts those predictions in context with current mine effects, key environmental risks for water, and updated water quality predictions.

Section 3 - Provides the water quality and biological variables that will be assessed within the Aquatic Response Framework, the benchmarks and action levels that AEMP data will be assessed against, and definitions of significance thresholds for the Ekati Diamond Mine Aquatic Response Framework. The reporting process for the notification of exceedance of action levels to the WLWB, and the process for review and amendment of the Aquatic Response Framework itself are also provided.

Section 4 - Includes an overview of the content of a Response Plan, describes potential management response actions that may be appropriate if low, medium and high action levels are exceeded, describes the procedures for reporting on Response Plan actions, and the procedures for review and amendment of Response Plans.

1.4 CONCORDANCE WITH WLWB GUIDANCE AND W2012L2-0001 REQUIREMENTS

The Aquatic Response Framework was developed in consideration of the draft Response Framework guidance document published by the WLWB (WLWB 2010), the requirements listed in Schedule 8, Item 1(q) of Water Licence W2012L2-0001 (WLWB 2014a), and the WLWB's Directive to Guide the Development of Version 1.1 of the Ekati Diamond Mine Aquatic Response Framework (WLWB 2014b). Tables 1.4-1 and 1.4-2 provide the key requirements of the Aquatic Response Framework and the sections in this report that address each of the requirements.

Table 1.4-1. Concordance of the Aquatic Response Framework Version 1.1 with WLWB Guidance and W2012L2-0001 Requirements

Criterion	Source	Section in Aquatic Response Framework V1.1
Statement of Objectives	WLWB 2010	1.2
Environmental Interactions and Predictions of Change	WLWB 2010, WLWB 2014a	2
Identify Environmental Variables of Concern	WLWB 2010, WLWB 2014a	3.1.1 and 3.2.1
Define Significance Thresholds	WLWB 2010, WLWB 2014a	3.3.2
Overview of Existing Environmental Monitoring Programs	WLWB 2010	3.4.1
Assessment of Environmental Change	WLWB 2010, WLWB 2014a	3.1 and 3.2
Environmental Action Levels - abiotic and biotic	WLWB 2010, WLWB 2014a	3.1.3 and 3.2.3
Potential Management Responses	WLWB 2010, WLWB 2014a	4.2
Outline of Response Plan Contents	WLWB 2010, WLWB 2014a	4.1
Timelines for Review and Updating Response Plans	WLWB 2010, WLWB 2014a	4.3

Table 1.4-2. Concordance of the Aquatic Response Framework Version 1.1 with WLWB Directive

Criterion[a]	Topic	Section in Aquatic Response Framework V1.1	Page Number
1	Significance Thresholds	3.3.1	3-24
2	Significance Thresholds	3, 3.3.2	3-1, 3-25
3	Water Quality Parameter Selection	3.1.1	3-7
4	Water Quality Parameter Selection	3.1.3[c]	3-11
5	Plankton and Benthos Parameter Selection	3.2.1.1	3-13, 3-21, 3-23
6	Plankton and Benthos Parameter Selection	3.2.1.1	3-23
7	Fish Parameter Selection	3.2.1.2	3-17
8	Exclusion of Sediment as an Abiotic Component	3.1	3-1
9	Water Quality Action Levels	3.1.3	3-10
10	Water Quality Action Levels	3.1.3	3-12
11	Plankton and Benthos Action Levels	3.2.3.1	3-22
12	Plankton and Benthos Action Levels	3.2.3.1	3-22
13	Plankton and Benthos Action Levels	3.2.3.1	3-22
14	Fish Action Levels	3.2.3.2	3-23
15	Fish Action Levels	3.2.3.2	3-24

(continued)

Table 1.4-2. Concordance of the Aquatic Response Framework Version 1.1 with WLWB Directive (completed)

Criterion[a]	Topic	Section in Aquatic Response Framework V1.1	Page Number
16	Response Plans	4.2.1	4-2
17	Response Plans	4.2	4-1
18	Response Plans	4.3	4-1
19	Response Framework Reporting	3.4.2	3-28
20	Response Framework Reporting	3.4.2	3-28
NA[b]	Response Framework Reporting (April and August lake data only)	3.4.2	3-28
NA[b]	Response Framework Review and Amendment	3.4.3	3-28
NA[b]	Minor Formatting and Grammatical Changes	NA[d]	NA

Notes:
[a] *WLWB 2014b*
[b] *As indicated in the WLWB directive any additional changes made to the Aquatic Response Framework are to be identified.*
[c] *No changes were made to the original version, submitted on February 15, 2014.*
[d] *Some general formatting and grammatical changes have been made for document consistency.*

2. Predicted and Current Aquatic Environmental Impacts

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2.1 1995 EIS, 2000 EA AND 2012 EIR

The Ekati Diamond Mine began its operations in October 1998 following approval of the an eight volume Environmental Impact Statement (EIS) by the federal cabinet (BHP and Dia Met 1995a, 1995b). Baseline aquatic environment data were collected from 1993 to 1995 and continued through 1996 so that the baseline database would be current when monitoring started during construction in 1997. In 1996, the mine plan included five open pits: Panda, Koala, Fox and Leslie pits in the Koala Watershed, and Misery Pit in the King-Cujo Watershed. However, early in the mine life, Leslie Pit was removed from the plan. In April 2000 an Environmental Assessment (EA) Report was prepared by BHP and Dia Met as part of the approval process for the Sable, Pigeon, and Beartooth Expansion Project. Regulatory approval was received, incorporating three kimberlite pipes into operation: Beartooth in the Koala Watershed, Pigeon in the Pigeon Watershed, and Sable in the Horseshoe Watershed (BHP and Dia Met 2000).

The approach of the 1995 EIS and that continued for the 2000 EA was to identify Valued Ecosystem Components (VECs) for evaluating possible mine effects. However over time the number and names of the VECs were updated to eliminate overlap and redundancies (e.g., see Section in 4.2.1.1 in the Sable, Pigeon and Beartooth EA; BHP and Dia Met 2000). Updates to the VECs were evaluated and associated with the production of an Environmental Impact Report (EIR), produced every three years (beginning on April 30, 2000). The purpose of the EIR is to satisfy the requirements of the Environmental Agreement that was signed in 1997 between BHP Diamonds Inc. and the governments of Canada and the Northwest Territories. According to the requirements of the Environmental Agreement, the primary objective of the EIR is to compare predictions from the EIS and the actual performance of the Ekati Diamond Mine; however, beginning in 2012 the focus of the EIR shifted towards current environmental risks and the management actions appropriate to address these risks. The focus was shifted to improve regulatory satisfaction with the EIR. Particularly for assessment of project impacts on water, the AEMP has become more sophisticated with the accumulation of long-term datasets and advances in science and technology. Thus the results of the current AEMP and associated monitoring programs (e.g., Surveillance Network Program) as well as results of the recently developed water quality prediction model for the Koala Watershed (Rescan 2012h) informed the key aquatic environmental risks in the 2012 EIR (BHP Billiton 2012a).

Below a brief summary of the VECs and predictions made through the 1995 EIS and the 2000 EA is provided, along with a list of key environmental risks for water identified in the 2012 EIR. However for the same reasons as provided above (and as described in the 2012 EIR), the Aquatic Response Framework focusses on the current environmental predictions and risks for the aquatic environment as opposed to predictions made in the 1995 and 2000 environmental assessments.

2.1.1 1995 Environmental Impact Statement

The key conclusion of the 1995 EIS was that with appropriate mitigation and compensation, there would be no moderate or major environmental effects of the mine. Sixteen VECs were originally identified, of which ‘Water Quality’ and ‘Fish/Aquatic Habitat’ pertained to the aquatic environment.

The 1995 EIS predicted the following changes in water quality and aquatic life other than fish:

- loss of aquatic habitat due to lake dewatering;
- addition of stream habitat due to construction of the Panda Diversion Channel (PDC);
- modification of aquatic habitat by silt from construction of mine infrastructure with local negligible residual effects as a result of increase in total suspended solids (TSS);
- aluminum and nickel concentrations were expected to be elevated in discharged water but not surpass receiving water criteria;
- elevated concentrations of aluminum, ammonia, and TSS in seepage from the Panda/Koala Waste Rock Storage Area; and
- negligible effects with respect to changes in sediment quality.

The 1995 EIS predicted the following effects on fish habitat and fish:

- loss of fish habitat due to lake dewatering;
- addition of fish habitat due to construction of the PDC;
- changes in fish biology (sampling mortality) as a result of biological sampling; and
- exposure to hydrocarbons.

2.1.2 2000 Sable, Pigeon and Beartooth Environmental Assessment

The water environment VECs defined in the 2000 Sable, Pigeon and Beartooth EA (BHP and Dia Met 2000) included water quality and quantity, and fish/aquatic habitat. The majority of effects from the proposed development on water VECs were predicted to be negligible. However minor residual effects were predicted for water quality in relation to pit water discharges (sediment associated variables (e.g., TSS, phosphorus, and total aluminum) and nitrogen compounds) and the construction of the Pigeon Stream Diversion (sediment associated variables).

2.1.3 2012 Environmental Impact Report

The 2012 EIR identified key environmental risks for each of the VEC categories (air, land, water, and wildlife). For each category, current mitigation measures that should be continued to ensure that the operation has left a manageable footprint at the Ekati Diamond Mine were identified. If applicable, new management practices to address the risks were also identified (BHP Billiton 2012a). Key environmental risks were ranked in order of importance as identified by stakeholders and regulators during the EIR technical sessions, as well as by the Ekati Diamond Mine Environment Department Environment Superintendents. Of the 22 risks identified, '*the aquatic receiving environment downstream of the LLCF and KPSF*' was the top risk. For the water VEC category, nine key environmental risks were identified and ranked in order of importance:

1. the aquatic receiving environment downstream of the Long Lake Containment Facility (LLCF) and King Pond Settling Facility (KPSF);
2. fish biology;
3. low under-ice dissolved oxygen;
4. water quality of waste rock seepage;
5. water quality associated with Misery Pit "push-back";

6. water quality and quantity associated with Pigeon Pit development;
7. hydrocarbon contamination downstream of the LLCF and KPSF;
8. long-term performance of the PDC; and
9. Fay Bay water quality and aquatic life.

The Aquatic Response Framework was identified as a future management practice to address the top risks identified for water.

2.2 CURRENT ENVIRONMENTAL EFFECTS AND WATER QUALITY MODEL PREDICTIONS

As stated above, the key risks for water identified in the 2012 EIR were developed in consideration of the most recent AEMP results and the results of the 2012 water quality model predictions for the Koala Watershed. The results of the 2012 AEMP and 2012 water quality model predictions for the Koala Watershed are summarized below. In addition to informing the key risks, these results were used to help identify the water quality variables and biological variables for inclusion within the Aquatic Response Framework.

2.2.1 Summary of AEMP Results

The 2012 AEMP (Rescan 2013a) concluded that concentrations of 16 of the 27 evaluated water quality variables were greater than baseline or reference concentrations in lakes or streams in the Koala Watershed or Lac de Gras, likely due to mine activities. In the King-Cujo Watershed concentrations of nine water quality variables were found to be elevated downstream of the KPSF in comparison to reference lakes and streams. Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life were exceeded for several water quality variables in both reference and monitored lakes, suggesting the majority of observed exceedances were not related to mine activities. Only exceedances of the potassium site specific water quality objective (SSWQO) and CCME water quality guideline for nitrite-N were likely related to mine activities. In the case of potassium, the 2012 observed mean and fitted mean (when the minimal detectable difference or uncertainty was taken into account) exceeded the long-term SSWQO in Leslie and Moose lakes. In the case of nitrite-N, only the upper 95% confidence interval exceeded the CCME water quality guideline in Leslie Lake, while the observed and fitted means remained below the guideline.

There was some evidence of change in under-ice water temperatures downstream of the LLCF to Nema Lake and possibly in Grizzly Lake; however, open-water season temperature profiles were examined during the 2012 re-evaluation of the AEMP and no trends indicative of mine effects were observed (Rescan 2012b). Dissolved oxygen concentrations in Cujo Lake were low, similar to past years; however, it is not known whether this was a mine effect or simply a part of the natural conditions of the lake. Nonetheless, oxygen levels were increased through snow clearing on Cujo Lake in late winter to allow increased light penetration into the water for phytoplankton oxygen production.

In 2011, the most recent year in which sediment quality was monitored, some changes in molybdenum, antimony and strontium concentrations were observed in the sediments of the Koala Watershed. Changes in these variables were also observed in water quality. The CCME sediment quality guideline for arsenic was exceeded in both reference and monitored lakes, suggesting that the exceedances were not related to mine activities.

Although the results from the water and sediment quality analyses suggest little reason to expect adverse biological effects in the waterbodies downstream of the Ekati Diamond Mine, some changes were observed in the diversity and taxonomic composition of phytoplankton and zooplankton communities downstream of the LLCF. Altered taxonomic composition of lake benthos communities downstream of both the LLCF and KPSF were also observed. The cause of these changes was examined in further detail as part of the 2012 AEMP Re-evaluation and it was suggested that the observed changes in plankton community composition likely result from inter-specific differences in the competitive ability of different taxonomic groups under novel conditions, rather than elemental toxicity (Rescan 2012b). Specifically, the shifts in phytoplankton and zooplankton community composition appeared to be related to changes in nitrate-N and phosphorus in the water column and changing ratios of nitrogen to phosphorus. The shift in phytoplankton community composition and associated increase in nitrogen in lakes downstream of the LLCF has been recognized for some time and a number of adaptive management actions have been taken to reduce the amount of nitrate-N released into the receiving environment (see BHP Billiton 2012a).

The 2012 assessment of fish populations and fish biology indicated few changes thought to be related to the mine (mine effects). Observed changes that were likely mine effects included increases (over time or compared to reference lakes) in antimony, molybdenum and selenium concentrations in tissues of fish collected downstream of the LLCF, higher ethoxyresorufin-O-deethylase (EROD) activity in round whitefish from lakes closest to the LLCF compared to round whitefish from reference lakes, and a significant correlation for EROD activity in slimy sculpin with distance from the LLCF. In the King-Cujo Watershed, potential mine-related changes included increases over time in selenium and uranium concentrations in fish tissue or liver and a significant correlation with elevated EROD activity in slimy sculpin and distance from haul roads or the KPSF. The EROD results were considered to be unrelated to PCBs, dioxins and furans; therefore, the source of the contamination which may have led to elevated EROD responses in fish is currently being investigated. Mean selenium tissue concentrations were below BC (4.0 mg/kg dwt) and USEPA (7.91 mg/kg dwt) draft guidelines at all lakes for all fish species, except for lake trout collected from Leslie Lake. Mercury concentrations in fish were generally below the Health Canada guideline for fish tissue (0.5 mg/kg wwt), except for a few individuals of one or more species from Kodiak, Moose, Nema and Slipper lakes. There was little evidence of mine effects on monitored fish populations in either the Koala or King-Cujo watersheds despite some changes in lower trophic levels such as plankton and benthos. Round whitefish and lake trout are considered opportunistic feeders which in the absence of strong prey community-wide effects, may not exhibit strong biological changes, including any bioenergetics-related response variables. The mobile nature of these large-bodied fish populations may also serve to reduce any potential effects.

2.2.2 2012 Water Quality Model Predictions

A comprehensive update to the LLCF water quality prediction model was undertaken in 2012. The model was initially developed in 2004 and reported in Rescan (2006) and has since been developed incrementally for various objectives over the last several years. The model has contributed to identifying potential water quality concerns and to the evaluation of potential water management options, such as the option to discharge underground water to Beartooth Pit (reduce chloride concentrations in the LLCF) and to undertake fertilization work within Cell D of the LLCF (to lower nitrate concentrations in the LLCF). The most recent model update (Rescan 2012h) was submitted by BHP Billiton as part of the application for renewal of Water Licence W2009L2-0001 and the results fed directly into BHP Billiton’s rationale for the selection of appropriate Effluent Quality Criteria (EQC) variables for the renewed Water Licence (WLWB 2014a). The predictions also feed directly into DDEC’s selection of variables for the Aquatic Response Framework in Section 3.1.1 below.

The 2012 water quality prediction model is able to estimate future concentrations of 30 water quality variables for lakes downstream of the LLCF to Slipper Lake, at which point water flows into Lac de Gras. The model is calibrated against observed data from the Ekati Diamond Mine up to the end of 2010 and in some cases includes 2011 data, and is run for a base case future scenario to February 2020. The base case future scenario is the current processed kimberlite and water management strategy, including the use of Beartooth Pit for underground mine water and processed kimberlite (Rescan 2012h).

For most variables the model produces predictions for the historical period (2000 to the end of 2010) that match very well with observed concentrations in the LLCF, Leslie Lake, Moose Lake, Nema Lake and Slipper Lake. The model is able to predict the inter-annual variations in concentrations (i.e., model the rate of increase of concentrations over time) and it also provides good fits to the seasonal variations in water quality throughout the year. Further detail is available in the water quality modelling report (Rescan 2012h).

Table 2.2-1 provides a summary of the model results indicating the maximum concentrations predicted for each modelled water quality variable that has a defined water quality benchmark for the Ekati Diamond Mine (see Section 3.2.1 for further detail). The results indicate when the maximum predicted concentration of each variable is expected to occur and the percentage of the water quality benchmark that is predicted to be reached at that time. These results are used in Section 3.1.1 to aid in the selection of water quality variables appropriate for assessment in the Aquatic Response Framework.

Table 2.2-1. Model Predicted Maximum Concentrations and Percentages of Water Quality Benchmark Value for Downstream Lakes for Period January 2011 to February 2020

Variable	Leslie Lake		Moose Lake		Nema Lake		Slipper Lake	
	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark
Aluminum	0.143	143	0.15	150	0.113	113	0.0771	77
	Mar. 2014	*Mar. 2014*	*Jan. 2015*	*Jan. 2015*	*Jan. 2015*	*Jan. 2015*	*Apr. 2016*	*Apr. 2016*
Ammonia-N	0.0337	6	0.0349	6	0.0277	5	0.0212	4
	Jan. 2013	*Jan. 2020*	*Jan. 2013*	*Jan. 2013*	*Jan. 2011*	*Jan. 2011*	*Apr. 2011*	*Apr. 2011*
Antimony	0.00572	29	0.00592	30	0.00355	18	0.00185	9
	Feb. 2020	*Feb. 2020*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*
Arsenic	0.00359	72	0.00372	74	0.00216	43	0.00105	21
	Feb. 2020	*Feb. 2020*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*
Barium	0.0638	6	0.0671	7	0.0439	4	0.0239	2
	Mar. 2011	*Feb. 2020*	*Jan. 2011*	*Jan. 2011*	*Jan. 2011*	*Jan. 2011*	*Apr. 2011*	*Apr. 2011*
Boron	0.0575	4	0.0591	4	0.032	2	0.0136	<1
	Feb. 2020	*Feb. 2020*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*
Cadmium[1]	0.000293	420	0.000305	491	0.000184	429	0.0000948	464
	Feb. 2020	*Mar. 2014*	*Jan. 2020*	*Jul. 2014*	*Feb. 2020*	*Jan. 2015*	*Feb. 2020*	*Jan. 2015*
Chloride	383	99	392	101	212	55	85.8	28
	Mar. 2019	*Mar. 2019*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*	*Feb. 2020*
$Chromium_{(III)}$	0.000284	3	0.000552	6	0.000366	4	0.000218	2
	Mar. 2019	*Jan. 2019*	*Jan. 2020*	*Jan. 2020*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*
$Chromium_{(VI)}$	0.00101	101	0.000794	79	0.000526	53	0.000314	31
	Mar. 2019	*Jan. 2019*	*Jan. 2020*	*Jan. 2020*	*Jan. 2020*	*Jan. 2020*	*Feb. 2020*	*Feb. 2020*
Copper	0.00193	51	0.00209	70	0.00239	99	0.00196	98
	Feb-19	*Aug. 2014*	*Jan. 2019*	*May.2015*	*Jan. 2019*	*Dec. 2014*	*Apr. 2019*	*Apr. 2019*
Iron	0.0975	33	0.1	33	0.062	21	0.0341	11
	Mar. 2014	*Feb. 2014*	*Jan. 2014*	*Jan. 2014*	*Apr. 2015*	*Apr. 2015*	*Apr. 2015*	*Apr. 2015*
Lead	0.000134	2	0.00014	4	0.0000978	4	0.0000626	5
	Mar. 2011	*Aug. 2014*	*Jan. 2015*	*Jul. 2014*	*Jan. 2011*	*Sep. 2014*	*Apr. 2011*	*Dec. 2015*

(continued)

Table 2.2-1. Model Predicted Maximum Concentrations and Percentages of Water Quality Benchmark Value for Downstream Lakes for Period January 2011 to February 2020 (completed)

Variable	Leslie Lake		Moose Lake		Nema Lake		Slipper Lake	
	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark	Maximum Predicted (mg/L)	% of Benchmark
Manganese	0.0215 *Mar. 2011*	1 *Jan. 2014*	0.0227 *Jan. 2011*	1 *Jan. 2015*	0.0178 *Jan. 2011*	1 *Jan. 2015*	0.0118 *Apr. 2011*	1 *Apr. 2016*
Molybdenum	0.163 *Feb. 2020*	<1 *Feb. 2020*	0.168 *Jan. 2020*	<1 *Jan. 2020*	0.0885 *Feb. 2020*	<1 *Feb. 2020*	0.0354 *Feb. 2020*	<1 *Feb. 2020*
Nickel	0.00733 *Feb. 2020*	4 *Mar. 2015*	0.00762 *Jan. 2020*	6 *Jun. 2015*	0.00545 *Jan. 2020*	5 *Jul. 2015*	0.00311 *Apr. 2019*	5 *Feb. 2016*
Nitrate-N	9.22 *Feb. 2020*	56 *Feb. 2020*	9.50 *Jan. 2020*	35 *Jan. 2020*	5.09 *Feb. 2020*	41 *Apr. 2015*	2.08 *Feb. 2020*	36 *Jan. 2015*
Nitrite-N	0.0213 *Feb. 2020*	35 *Feb. 2020*	0.0211 *Feb. 2020*	35 *Feb. 2020*	0.0107 *Apr. 2011*	18 *Apr. 2011*	0.00578 *Apr. 2011*	10 *Apr. 2011*
Phosphate-P	0.00663 *Feb. 2012*	69 *Feb. 2012*	0.00721 *Jan. 2012*	94 *Jan. 2012*	0.00965 *Jan. 2013*	106 *Jan. 2013*	0.00929 *Aug. 2012*	92 *Apr. 2013*
Potassium	41.1 *Feb. 2020*	100 *Feb. 2020*	42.4 *Jan. 2020*	103 *Jan. 2020*	23.3 *Feb. 2020*	57 *Feb. 2020*	9.89 *Feb. 2020*	24 *Feb. 2020*
Selenium	0.00117 *Mar. 2015*	117 *Mar. 2015*	0.00120 *Jan. 2015*	120 *Jan. 2015*	0.000685 *Apr. 2015*	68 *Apr. 2015*	0.000327 *Apr. 2016*	33 *Apr. 2016*
Strontium	2.40 *Mar. 2019*	38 *Mar. 2019*	2.46 *Jan. 2020*	39 *Jan. 2020*	1.33 *Feb. 2020*	21 *Feb. 2020*	0.543 *Feb. 2020*	9 *Feb. 2020*
Sulphate	133 *Feb. 2020*	24 *Feb. 2020*	137 *Jan. 2020*	24 *Jan. 2020*	74.2 *Feb. 2020*	15 *Apr. 2015*	31.1 *Feb. 2020*	13 *Apr. 2015*
Uranium	0.000916 *Mar. 2019*	6 *Jan. 2019*	0.000944 *Jan. 2019*	6 *Jan. 2019*	0.000569 *Apr. 2019*	4 *Apr. 2019*	0.000278 *Apr. 2019*	2 *Apr. 2019*
Vanadium	0.00622 *Feb. 2020*	21 *Feb. 2020*	0.00640 *Jan. 2020*	21 *Jan. 2020*	0.00347 *Feb. 2020*	12 *Feb. 2020*	0.00148 *Feb. 2020*	5 *Feb. 2020*
Zinc	0.00318 *Feb. 2020*	11 *Feb. 2020*	0.00338 *Jan. 2020*	11 *Jan. 2020*	0.00350 *Jan. 2020*	12 *Jan. 2020*	0.00258 *Apr. 2011*	9 *Apr. 2011* [1]

Note:
[1] based on comparison to 1996 CCME guideline (CCME 1996). CCME (2014) guideline is currently used as benchmark (see Section 3.1.2).

3. Aquatic Response Framework

ERM

3. Aquatic Response Framework

This chapter describes the bulk of the Aquatic Response Framework, including the abiotic and biological variables selected for assessment, the applicable water quality and biological benchmarks, a description of the action levels and significance thresholds, and the associated cyclical monitoring and reporting process.

As described in Chapter 2, in the 1995 EIS and 2000 EA two VECs pertaining to the aquatic environment and Aquatic Response Framework were identified: Water Quality and Fish/Aquatic Habitat. The abiotic and biological components described below that were selected for inclusion within the Aquatic Response Framework are water quality, plankton and benthos, and fish. Water quality and fish clearly relate back to the identified VECs and also relate to the results of the 2012 EIR and the identified key environmental risks. Plankton and benthos have been incorporated because changes in these communities can be indicators of changes in water or sediment quality and also because these organisms may be used as indicators of fish habitat quality in terms of food availability.

3.1 ABIOTIC COMPONENT

Within the abiotic component, only water quality variables are proposed for assessment in the Aquatic Response Framework. Water quality variables are considered to be more appropriate than sediment quality variables for several reasons:

1. Water quality in the receiving environment is (appropriately) monitored more frequently than sediment quality. Sediment quality is monitored every three years whereas water quality is monitored multiple times annually. Thus, changes in the quality of water can be detected more quickly (on an annual or seasonal basis).
2. Few changes in sediment quality in the receiving environment at the Ekati Diamond Mine have been observed and generally, corresponding changes in water quality variables also exist. For example, the 2011 AEMP (the most recent sediment quality monitoring year), concluded only three mine-related changes in sediment quality in the Koala Watershed and no mine-related changes in the King-Cujo Watershed. For each of the sediment quality variables for which mine effects were detected in the Koala Watershed, water quality changes in these variables were also detected (Rescan 2012a).
3. Sediment quality constituents that have changed significantly to date (antimony, molybdenum and strontium; Rescan 2012a) are assessed in the Aquatic Response Framework as part of the water quality component.
4. Sediment quality was not identified as a VEC is the 1995 EIS or 2000 EA.
5. Sediment quality was not identified as a key environmental risk in the 2012 EIR.
6. Few relevant sediment quality guidelines are available.

Should an action level be triggered in the Aquatic Response Framework for water quality or biological variables, sediment quality may be incorporated into the Response Plan in a variety of ways. For example, it may be appropriate to: review the existing sediment quality data to determine if changes for that particular variable also exist for sediment quality, conduct sediment sampling in advance of the three year schedule, conduct a literature search for an appropriate sediment quality benchmark for a particular variable, or a number of other actions. In this way, sediment quality can be monitored and maintained to protect the uses of the aquatic receiving environment at the Ekati Diamond Mine.

3.1.1 Water Quality Variables

The selection of water quality variables to be included within the Aquatic Response Framework largely follows the methods presented in the initial draft of BHP Billiton's *Review of Protection Measures for the Aquatic Receiving Environment at the Ekati Mine* (BHP Billiton 2012c) presented to the WLWB as part of the application for renewal of Water Licence W2009L2-0001 (BHP Billiton 2012b); however it also includes predictions made in the 1995 EIS and 2000 EA, AEMP monitoring results up to and including 2012, relevant changes incorporated into W2012L2-0001 (for example changes to EQC), new information gleaned through the analysis in the 2012 AEMP Re-evaluation (Rescan 2012b) and commitments made in the approved 2013 to 2015 AEMP Plan (Rescan 2013b) (Figure 3.1-1). BHP Billiton (2012a) also incorporated EQC variables for the Sable development; however Sable EQC are not incorporated into the selection process for Aquatic Response Framework variables herein because there are no plans for the development of the Sable area in the near future. Since the 2012 EIR (BHP Billiton 2012a) assessment of environmental risks for water relied largely on the results of the AEMP and the predictions in the Koala Watershed water quality model, the key risks for water identified in the EIR are incorporated indirectly into the selection of water quality variables for the Aquatic Response Framework, through the direct incorporation of the AEMP results and water quality predictions.

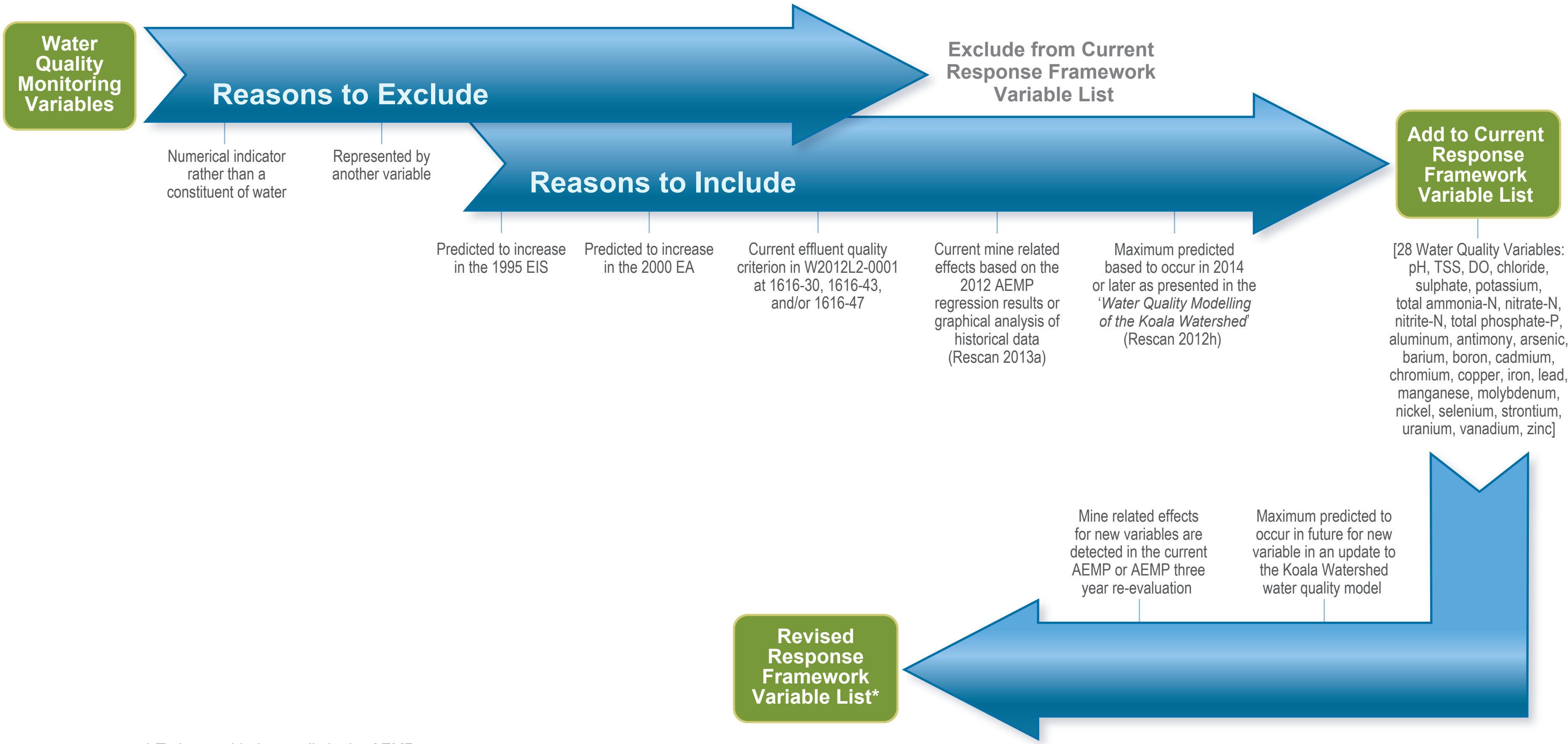
The selection process was developed using the list of variables monitored as part of the AEMP (in both the Koala and King-Cujo watersheds). This list also encompasses variables that have a current EQC at SNP stations 1616-30, 1616-43 and 1616-47 enforced in Water Licence W2012L2-0001, total petroleum hydrocarbons (TPH) being the one exception. TPH has an EQC and is monitored under the SNP but is not required to be monitored in the AEMP. Regardless, TPH was added to the list of candidate variables for potential inclusion in the Aquatic Response Framework. Thus in total, 48 variables or tests routinely conducted on the water of the receiving environment, in the containment facilities prior to and/or during release of water to the receiving environment, or at both locations, were considered.

Table 3.1-1 provides a summary of the decision steps followed for excluding or including each variable, flowing from left to right. If a variable is marked with a check (✓) in the first two columns (reasons for exclusion), then it was automatically excluded from the Aquatic Response Framework. If a variable received a check in any of the next five columns (reasons for inclusion) or was marked as having an unclear trend (*), then it was included in the Aquatic Response Framework unless otherwise described as below for silicon and TPH. Because only one reason to include or exclude a variable was required, once a check was received in one column no further assessment of the variable was completed and the variable was included or excluded from the list of Aquatic Response Framework variables, as appropriate. Dashes (-) were added to the remaining columns to indicate that the variable was not assessed further.

As per BHP Billiton (2012b; Section 3, Data Review), some variables are excluded from the Aquatic Response Framework simply because they are numerical indicators of water quality and not constituents of the water themselves (total alkalinity, hardness and ion balance), or because the variable is adequately and appropriately represented by another variable that is carried forward into the Aquatic Response Framework (total dissolved solids (TDS), bicarbonate, calcium, magnesium, sodium, orthophosphate, total kjeldahl nitrogen (TKN), total organic carbon (TOC) and turbidity) (Table 3.1-1). Specific rationale for those variables listed above which were excluded because they were deemed to be adequately represented by another variable is provided below:

Figure 3.1-1

Schematic of the Selection and Revision of the Aquatic Response Framework Water Quality Variables List



** To be provided annually in the AEMP report.*

Table 3.1-1. Selection of Aquatic Response Framework Water Quality Variables

Variable	Reasons for Exclusion		Reasons for Inclusion					Response Framework Variable
	Numerical Indicator Rather than a Constituent of Water →	Represented by Other Variable	→ Predicted to Increase in 1995 EIS →	Predicted to Increase in 2000 EA →	Current EQC[1] →	Current Mine-related Effect[2] →	Maximum Predicted to Occur in 2014 or Later[3]	
Alkalinity, Total	✓	-	-	-	-	-	-	No
Bicarbonate (HCO_3)	-	✓	-	-	-	-	-	No
Carbonate (CO_3)	-	✓	-	-	-	-	-	No
Hydroxide	-	✓	-	-	-	-	-	No
Hardness	✓	-	-	-	-	-	-	No
Ion Balance	✓	-	-	-	-	-	-	No
Total Dissolved Solids (calculated)	-	✓	-	-	-	-	-	No
Turbidity	-	✓	-	-	-	-	-	No
Total Kjeldahl Nitrogen	-	✓	-	-	-	-	-	No
Orthophosphate (PO_4)	-	✓	-	-	-	-	-	No
Total Organic Carbon	-	✓	-	-	-	-	-	No
Beryllium (Be)	-	-	-	-	-	-	-	No
Calcium (Ca)	-	✓	-	-	-	-	-	No
Cobalt (Co)	-	-	-	-	-	-	-	No
Magnesium (Mg)	-	✓	-	-	-	-	-	No
Mercury (Hg)	-	-	-	-	-	-	-	No
Silver (Ag)	-	-	-	-	-	-	-	No
Sodium (Na)	-	✓	-	-	-	-	-	No
Silicon (Si) - Total	-	-	-	-	-	*	-	No
Total Petroleum Hydrocarbons	-	-	-	-	✓	-	-	No
Dissolved Oxygen	-	-	-	-	-	*	-	Yes
pH	-	-	-	-	✓	-	-	Yes
Chloride (Cl)	-	-	-	-	✓	-	-	Yes
Potassium (K)	-	-	-	-	✓	-	-	Yes
Sulphate (SO_4)	-	-	-	-	✓	-	-	Yes

(continued)

Table 3.1-1. Selection of Aquatic Response Framework Water Quality Variables (completed)

Variable	Reasons for Exclusion		Reasons for Inclusion					Response Framework Variable
	Numerical Indicator Rather than a Constituent of Water ➔	Represented by Other Variable	➔ Predicted to Increase in 1995 EIS ➔	Predicted to Increase in 2000 EA ➔	Current EQC[1] ➔	Current Mine-related Effect[2] ➔	Maximum Predicted to Occur in 2014 or Later[3]	
Total Suspended Solids	-	-	✓	-	-	-	-	Yes
Total Ammonia-N	-	-	-	✓	-	-	-	Yes
Nitrate-N	-	-	-	✓	-	-	-	Yes
Nitrite-N	-	-	-	✓	-	-	-	Yes
Total Phosphate-P	-	-	-	✓	-	-	-	Yes
Aluminum (Al)	-	-	✓	-	-	-	-	Yes
Antimony (Sb)	-	-	-	-	✓	-	-	Yes
Arsenic (As)	-	-	-	-	✓	-	-	Yes
Barium (Ba)	-	-	-	-	-	✓	-	Yes
Boron (B)	-	-	-	-	-	✓	-	Yes
Cadmium (Cd)	-	-	-	-	-	-	✓	Yes
Chromium (Cr)	-	-	-	-	-	*	✓	Yes
Copper (Cu)	-	-	-	-	✓	-	-	Yes
Iron (Fe)	-	-	-	-	-	-	✓	Yes
Lead (Pb)	-	-	-	-	-	-	✓	Yes
Manganese (Mn)	-	-	-	-	-	-	✓	Yes
Molybdenum (Mo)	-	-	-	-	-	✓	-	Yes
Nickel (Ni)	-	-	✓	-	-	-	-	Yes
Selenium (Se)	-	-	-	-	✓	-	-	Yes
Strontium (Sr)	-	-	-	-	✓	-	-	Yes
Uranium (U)	-	-	-	-	-	✓		Yes
Vanadium (V)	-	-	-	-	-	-	✓	Yes
Zinc (Zn)	-	-	-	-	-	-	✓	Yes

Notes:
[1] EQC in W2012L2-0001 at 1616-30 and/or 1616-43 and/or 1616-47.
[2] based on 2012 AEMP regression results or graphical analysis of historical data.
[3] based on Table 2.2-1 data. Refers to maximum predicted concentration or maximum percentage of benchmark for any of the downstream AEMP lakes (Leslie, Moose, Nema or Slipper).
** unclear whether there is a mine-related effect.*

- TDS, bicarbonate, calcium, magnesium and sodium: several key individual constituents of TDS are analyzed in place of TDS and several other of its constituents. TDS at the Ekati Diamond Mine is made up of key ions: bicarbonate, calcium, chloride, magnesium, nitrate, potassium, sodium and sulphate. Chloride is the dominant anion and is also the ion of greatest environmental interest because of its potential toxicity at elevated concentrations. The dominant cation is sodium, which is also the cation paired with chloride and other anions such as sulphate in toxicity testing. Thus, regardless of being known to be of low risk of aquatic toxicity, sodium is inherently included in the testing and development of benchmarks. For the Aquatic Response Framework, key constituents of TDS are assessed as a measure of addressing the site-specific risks, these include chloride, nitrate, potassium and sulphate, these four ions and sodium represent over 80% of TDS in the receiving environment and are considered representative of TDS, bicarbonate, calcium and magnesium (BHP Billiton 2012b);
- Orthophosphate is represented by the inclusion of total phosphate-P;
- TKN is represented by the inclusion of ammonia-N, nitrate-N and nitrite-N. The three individual nitrogen compounds that comprise TKN have established individual toxicity risks and benchmarks, making their inclusion more appropriate;
- TOC is represented by dissolved oxygen because the risk that is represented by TOC is oxygen deficiency in the water; and
- Turbidity is represented by total suspended solids (TSS), as it is an alternate measure of the risk represented by TSS.

Based on these initial screening criteria, a total of 35 water quality variables remain for potential inclusion within the Aquatic Response Framework (this is similar to the Pool 2, Parameters for Review, as defined in BHP Billiton 2012b; Table 3.1-1).

The last step in determining which variables are relevant for assessment within the Aquatic Response Framework is to include any of the remaining variables which met any of the four criteria below:

1. Variable was predicted to be affected by the mine in the 1995 EIS or 2000 EA;
2. Variable has a current EQC at either 1616-30, 1616-43 or 1616-47 in WL2012L2-0001;
3. Variable currently exhibits an increasing trend (or other potential mine-related trend) in the receiving environment based on the results of the 2012 AEMP. An increasing trend was deemed present based on the AEMP evaluation of effects methodology (Rescan 2013a; Section 2.2 Evaluation Methods of Part 1 Evaluation of Effects), or through visual examination of historical data graphed in Section 5 of Part 1 Evaluation of Effects (Rescan 2013a), for variables which were not evaluated and subjected to statistical tests; and
4. Variable is predicted to reach its maximum concentration or the maximum percentage of its benchmark at any point in the future (2014 or beyond) in any AEMP lake downstream of the LLCF based on the predictions of the 2012 Koala Watershed water quality model (Rescan 2012h); as summarized in Table 2.2-1.

Thus if any one or more of the above criteria were met, then the variable was included in the Aquatic Response Framework. Two exceptions to the aforementioned criteria were the exclusions of silicon and TPH. Silicon was considered to have met the criterion of exhibiting a current mine-related effect because the trend for silicon in the receiving environment is unclear, and to be conservative, unclear trends were considered for inclusion in the list of variables to be assessed in the Aquatic Response Framework. However, silicon is a nutrient for which there are no Canadian water quality guidelines;

therefore, small changes in silicon concentrations in the environment, if they were to exist, are not considered to be of potential concern thus silicon is not included in the Aquatic Response Framework. TPH met the criteria for inclusion because it has a current EQC but was excluded from the Aquatic Response Framework because concentrations measured in effluent at the Ekati Diamond Mine are generally below analytical detection and show no clear trends. Additionally there are no Canadian water quality guidelines for TPH and guidelines for individual components of TPH vary widely making the development of a site specific benchmark impractical (Rescan 2012h).

Based on the criteria for inclusion and exclusion described above, the final list of the 28 Aquatic Response Framework water quality variables includes:

- pH;
- TSS;
- Dissolved oxygen;
- Ions: chloride, sulphate, potassium;
- Nutrients: total ammonia-N, nitrate-N, nitrite-N, total phosphate-P;
- Total metals: aluminum, antimony, arsenic, barium, boron, cadmium, chromium, copper, iron, lead, manganese, molybdenum, nickel, selenium, strontium, uranium, vanadium, zinc.

The above list of Aquatic Response Framework water quality variables will be assessed for inclusion within the Aquatic Response Framework annually in the AEMP, within the Response Framework Reporting chapter of the AEMP Summary Report (also see Section 3.4.2). The assessment process will involve repeating the water quality variable selection process described above using up to date information. For example, if a mine-related effect for an evaluated water quality variable is concluded for the first time in the current year's AEMP, or if a potential mine effect is identified through graphical analysis of historical data for a non-evaluated variable, Table 3.1.1 will be adjusted to show that there is a current or potential mine effect and the variable will be added to the revised Aquatic Response variable list unless the aforementioned rationale for exclusion apply (Figure 3.1-1). The annual update to the variable list will also consider new water quality prediction information, if available (e.g., an update to the Koala Watershed water quality prediction model has been published within the AEMP reporting year; Figure 3.1-1).

3.1.2 Water Quality Benchmarks

Benchmarks for the 28 water quality variables assessed in the Aquatic Response Framework are defined in Table 3.1-2. Benchmarks for the Ekati Diamond Mine are typically designed for the protection of freshwater aquatic life, which is generally the most sensitive of the identified water uses in the Ekati Diamond Mine area. They include SSWQO, federal guidelines (CCME), provincial guidelines, or when appropriate, values from published literature. DDEC has adopted these potential sources in that stated order of preference. A water quality concentration below a SSWQO or guideline value is therefore considered to be a negligible risk to the environment. However, a water quality concentration above a guideline value is not necessarily indicative of an environmental impact, and instead may indicate that further study is necessary. For example, at the Ekati Diamond Mine, an SSWQO is often developed when a guideline value shows the need for further study and is based on sensitivities of species, or surrogates for those species, present at the mine site. Both the SSWQO and guideline values should continue to evolve over time based on new and relevant science.

Table 3.1-2. Summary of Long-Term Water Quality Benchmarks for the Ekati Diamond Mine

Aquatic Response Framework Variable	Benchmark (mg/L)	Source
pH	6.5-9.0	CCME 1987
TSS	Increase of 5 mg/L from background	CCME 1999d
Dissolved Oxygen‡	6.5 mg/L and 9.5 mg/L	CCME 1999a
Chloride	[116.63*ln(hardness)]-204.09 for hardness greater than 10 mg/L but less than or equal to 160 mg/L	Elphick et al. 2011
Sulphate	$e^{(0.9116[\ln(hardness)]+1.712}$ for hardness less than or equal to 160 mg/L	Rescan 2012f
Potassium	41	Rescan 2012e
Total ammonia-N	0.019 (un-ionized), total ammonia-N is temperature and pH dependent	CCME 2001
Nitrate-N	$e^{(0.9518[\ln(hardness)]-2.032}$ for hardness less than or equal to 160 mg/L, at hardness greater than 160 mg/L the guideline at hardness 160 mg/L applies, or 10 mg/L (Canadian drinking water MAC)	Rescan 2012d, Health Canada 1987
Nitrite-N	0.06	CCME 1987
Total phosphate-P	lake specific, lower of 0.01 or baseline + 50%	CCME 2004
Aluminum	0.1	CCME 1987
Antimony	0.02	Fletcher et al. 1996
Arsenic	0.005	CCME 1999a
Barium	1	Haywood and Drinnan 1983
Boron	1.5	CCME 2009
Cadmium	$10^{(0.83[\log10(hardness)]-2.46)}$/1000, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L	CCME 2014
Chromium	0.0089 (III), 0.001 (VI)	CCME 1999b
Copper	$0.2*e^{(0.8545[\ln(hardness)]-1.465)/1000}$, minimum 0.002 mg/L applicable to hardness 0-82 mg/L, maximum of 0.004 mg/L applicable to hardness greater than 180 mg/L	CCME 1987
Iron	0.3	CCME 1987
Lead	$e^{(1.273[\ln(hardness)]-4.705)/1000}$, minimum of 0.001 mg/L applicable to hardness 0-60 mg/L, maximum of 0.007 mg/L applicable to hardness greater than 180 mg/L	CCME 1987
Manganese	(4.4*hardness+605)/1000	BC MoE 2001
Molybdenum	19	Rescan 2012c
Nickel	$e^{(0.76[\ln(hardness)]+1.06)/1000}$, minimum of 0.025 mg/L applicable to hardness 0-60 mg/L, maximum of 0.15 mg/L at hardness greater than 180 mg/L	CCME 1987
Selenium	0.001	CCME 1987
Strontium	6.242	Golder 2011
Uranium	0.015	CCME 2011
Vanadium	0.03	Rescan 2012g
Zinc	0.03	CCME 1987

Note:
‡ *Or 90% of baseline concentrations where baseline concentrations are less than 110% of the CCME guideline.*

Human and wildlife use of water for drinking are protected through Canadian drinking water guidelines (Health Canada 2012) and CCME guidelines for livestock watering (CCME 2013). However, benchmarks identified for the Ekati Diamond Mine for the protection of aquatic life are more stringent than Canadian drinking water guidelines and CCME guidelines for livestock watering for all Aquatic Response Framework variables, with the exception of nitrate. Therefore, by using the SSWQO and freshwater guidelines for the protection of aquatic life, all current water uses downstream of the Ekati Diamond Mine to Lac de Gras are protected.

For nitrate, the Canadian drinking water guideline Maximum Acceptable Concentration (MAC) is 10 mg/L (as N). Because the Canadian drinking water guideline MAC for nitrate is lower than the SSWQO for the protection of aquatic life at some water hardness values, the guideline of 10 mg/L for nitrate-N is also included as a water quality benchmark in the Aquatic Response Framework (Table 3.1-2).

3.1.3 Water Quality Action Levels

An action level is defined as "*a predetermined change, to a monitored parameter or other qualitative or quantitative measure, that requires the Licensee to take appropriate actions that may include, but that are not limited to: further investigations, changes to operations, or enhanced mitigation measures*" (WLWB 2014a). Three action levels are proposed for the Aquatic Response Framework: low, medium and high. The action levels are designed to provide adequate time for appropriate response actions to be developed and implemented before a significant adverse environmental effect may occur.

Spatially, action-levels are triggered based on near-field water quality concentrations. Near-field sites are those closest downstream of mine discharge. This is consistent with the WLWB's draft Response Framework guidance document which states that for a chain of small lakes the near-field area is often the lake that receives the discharge (WLWB 2010). No near-field lakes are monitored downstream of discharge from Desperation Pond in the King-Cujo Watershed, Mossing Outflow is not currently included as a near-field site because there are no baseline data or historical data that can be used to determine if water quality in the stream is being affected by the mine. Mossing Outflow will be considered for addition during the next update of the Aquatic Response Framework in conjunction with the AEMP re-evaluation (see Section 3.4.3). At that time a short time series of recent data will be available to assist in determining whether an action level has been exceeded. Kodiak Lake and Fay Lake are also considered near-field for the purposes of the Aquatic Response Framework, under unique rationale (Table 3.1-3).

Table 3.1-3. Rationale for Near-Field Aquatic Response Framework Lake Sites

Koala Watershed		King-Cujo Watershed		Pigeon-Fay and Upper Exeter watersheds	
Leslie Lake Moose Lake	The first 2 lakes downstream of the LLCF, because of the placement of the AEMP station the AEMP data show similar water quality for these two lakes	Cujo Lake	The first lake downstream of the KPSF	Fay Lake	The first lake downstream of the Pigeon Stream Diversion
Kodiak Lake	Historical mine influences				

For water quality variables, only low action levels are predefined in the Aquatic Response Framework. The medium and high action levels will be defined if the low action level is exceeded. In some cases setting of a high action level may be deferred if sufficient rationale is provided (e.g., additional research is required). Medium and high action levels may be generic (encompass all water quality variables) or based on variable specific considerations. This methodology is considered appropriate for a number of reasons including the availability of a long time series of data for the Ekati Diamond Mine and the detailed and generally conservative water quality prediction model developed for the Koala Watershed. The potential need for variable-specific action levels depending on the rate at which the different variables are increasing, whether the variable is predicted to exceed its benchmark, and the ecological significance of increased concentrations are also important factors to consider when setting action levels.

A low action level for an Aquatic Response Framework water quality variable (with the exception of dissolved oxygen) is exceeded when all of the following conditions are met:

1. The average measured monthly concentration of the water quality variable at any near-field AEMP sampling location is greater than 50% of the water quality benchmark (Table 3.1-4);
2. The variable shows an increasing annual trend for all sampling events based on data collected within the same month for which condition (1) is met; and
3. The average measured monthly concentration of the water quality variable at any near-field AEMP sampling location is greater than the maximum observed reference lake concentration based on data collected within the same month for which condition one (1) is met.

Table 3.1-4. Fifty Percent of Long-Term Water Quality Benchmarks Used to Determine If Low Action Level Has Been Exceeded

Aquatic Response Framework Variable	50% of Long-Term Water Quality Benchmark (mg/L)
pH	8.7
TSS	Increase of 2.5 mg/L from background
Dissolved Oxygen[a]	6.5 or 90% of the baseline concentration when baseline concentrations are less than 110% of the guideline
Chloride[b]	([116.63*ln(hardness)]-204.09)/2 for hardness greater than 10 mg/L but less than or equal to 160 mg/L
Sulphate[b]	$(e^{(0.9116[\ln(hardness)]+1.712})/2$ for hardness less than or equal to 160 mg/L
Potassium	20.5
Total ammonia-N[c]	0.019 (un-ionized), temperature and pH dependent total ammonia-N guideline/2
Nitrate-N[b]	$(e^{(0.9518[\ln(hardness)]-2.032})/2$ for hardness less than or equal to 160 mg/L, at hardness greater than 160 mg/L the guideline at hardness 160 mg/L applies, or 5 mg/L (50% of Canadian drinking water MAC)
Nitrite-N	0.03
Total phosphate-P[d]	lake specific, lower of 0.01 or baseline + 25%
Aluminum	0.05
Antimony	0.01
Arsenic	0.0025
Barium	0.5
Boron	0.75
Cadmium[b]	$(10^{(0.83[\log10(hardness)]-2.46)}/1000)/2$, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L
Chromium	0.0045 (III), 0.0005 (VI)

(continued)

Table 3.1-4. Fifty Percent of Long-Term Water Quality Benchmarks Used to Determine If Low Action Level Has Been Exceeded (completed)

Aquatic Response Framework Variable	50% of Long-Term Water Quality Benchmark (mg/L)
Copper[b]	$(0.2*e^{(0.8545[\ln(hardness)]-1.465)/1000})/2$, minimum 0.001 mg/L applicable to hardness 0-82 mg/L, maximum of 0.002 mg/L applicable to hardness greater than 180 mg/L
Iron	0.15
Lead[b]	$(e^{(1.273[\ln(hardness)]-4.705)/1000})/2$, minimum of 0.0005 mg/L applicable to hardness 0-60 mg/L, maximum of 0.0035 mg/L applicable to hardness greater than 180 mg/L
Manganese[b]	((4.4*hardness+605)/1000)/2
Molybdenum	9.5
Nickel[b]	$(e^{(0.76[\ln(hardness)]+1.06)/1000})/2$, minimum of 0.0125 mg/L applicable to hardness 0-60 mg/L, maximum of 0.075 mg/L at hardness greater than 180 mg/L
Selenium	0.0005
Strontium	3.121
Uranium	0.0075
Vanadium	0.015
Zinc	0.015

Notes:
[a] For dissolved oxygen the benchmark of 6.5 mg/L is used to determine whether a low action level is reached, rather than 50% of the benchmark. If baseline concentrations are less than 110% of the 6.5 mg/L benchmark, then 90% of baseline concentrations are used as the benchmark.
[b] Hardness used in the equation is the monthly average hardness measured in the AEMP water samples collected from each station.
[c] For total ammonia-N, the monthly average pH and surface water temperatures are used to determine the appropriate guideline value. Because the CCME total ammonia-N guideline is set for every 5 degree difference in temperature and 0.5 unit difference in pH, the final benchmark is determined by rounding up (to the next 5 degree mark or 0.5 pH unit).
[d] For total phosphate-P, the benchmark is lake specific (lower of 0.01 mg/L or baseline plus 50%) because benchmarks set at 0.01 mg/L for some lakes are already more conservative than benchmarks set at baseline plus 50% for other lakes (allow for a smaller degree of change). Therefore, for total phosphate-P, 50% of the benchmark will only be calculated for those lakes that have benchmarks set at baseline plus 50%. Fifty percent of those benchmarks will be calculated as baseline plus 25%.

When determining whether the low action level has been exceeded, the average monthly concentration refers to the April and August sampling events for lakes. The sampling events and number of replicates collected are defined according to the current AEMP Plan (Rescan 2013b), and any approved changes to the AEMP sampling frequency or number of replicates collected would also change the number of samples or sampling events available for analysis within the Aquatic Response Framework.

The average of replicate samples collected at each near-field AEMP station will be compared to 50% of the benchmark value (Table 3.1-4). For hardness dependent benchmarks, the benchmark is initially calculated using the hardness in the water sample, and divided by two to determine 50% of the benchmark. For nitrate, 50% of the lower of the hardness dependent SSWQO or drinking water benchmark will be used when determining whether a low action level has been exceeded. Because pH is on the log scale, 50% of the benchmark range of 6.5 to 9 was calculated as half of the hydroxide ion concentration (OH^-) for a pH of 9.0, which is equivalent to a pH value of 8.7. The 50% of benchmark was only calculated for pH 9 and not pH 6.5 because lakes in the Ekati Diamond Mine area are known to naturally have low pH and the trend in the receiving environment is towards increased pH as opposed to more acidic conditions (Rescan 2013a). For total ammonia-N, the monthly average pH and surface water temperatures are used to determine the appropriate benchmark value. Because the CCME guideline for total ammonia-N is set for every 5 degree difference in temperature and 0.5 unit difference in pH, the final benchmark is determined by rounding up (to the next 5 degree temperature mark or 0.5 pH unit). For total phosphate-P, the benchmark is lake specific (lower of 0.01 mg/L or baseline plus 50%) because benchmarks set at 0.01 mg/L for some lakes are already more conservative than benchmarks set at baseline plus 50% for other lakes (allow for a smaller degree of change). Therefore, for total phosphate-P, 50% of the benchmark will only be calculated for those lakes that have benchmarks set at baseline plus 50%. Fifty percent of those benchmarks will be calculated as baseline plus 25%.

When determining whether low action level condition two (2) is met, an increasing trend may be determined either through graphical analysis and best professional judgement of historical and current AEMP data, or based on AEMP regression methodologies if appropriate data are available (Rescan 2013a). The data examined for an increasing trend will include all AEMP data collected in the month of interest for all sampling events at the near-field AEMP station in question.

For low action level condition three (3), the maximum observed reference lake concentration is the highest monthly average observed at any reference lake from baseline through to the current monitoring year. The concentrations of water quality variables in monitored lakes are compared to the maximum observed reference lake concentrations as opposed to comparisons to trends observed in reference lakes because the changes observed in water quality variables over time are generally non-linear and therefore comparing the slopes of trends in monitored lakes to the slope of trends in reference lakes would be difficult without significant additional analyses or a heavy reliance on professional judgement to determine whether one trend may be steeper than another.

The three conditions that define whether a low action level for water quality will be exceeded work in concert to identify an early warning indicator of change at near-field sites that could lead to effects on drinking water quality or toxicity to aquatic biological communities (condition one), identify change at near-field sites (condition 2), and determine whether concentrations of a variable are outside the range of baseline (condition 2) and reference conditions (condition 3) and are therefore likely representative of a mine effect.

For dissolved oxygen (DO), the low action level applies to under-ice DO only. The low action level is set for the under-ice season as opposed to open water season concentrations because under-ice concentrations often represent the '*worst-case scenario*.' DO concentrations are generally lowest during the winter because ice cover restricts oxygen diffusion into the water column from the atmosphere, and because of aerobic microbial activity in the sediment. The amount of sunlight penetrating into the water column is also limited by snow and ice cover, thus restricting phytoplankton growth and the production of DO by photosynthesis.

With respect to DO, the CCME guideline of 6.5 mg/L is considered the appropriate benchmark for the winter season at the Ekati Diamond Mine for a number of reasons. First, DO concentrations are naturally depleted under-ice in Arctic lakes and the available baseline data as well as data for the reference lakes indicate that setting an action level using the guideline of 9.5 mg/L would often result in exceedances in both reference and near-field lakes based on natural conditions. Second, the guideline of 6.5 mg/L is more applicable to the biota living in the water column under-ice in lakes. The guideline of 9.5 mg/L is the "early life stage" guideline which was established to protect salmonid larvae in redds (CCME 1999c) and is therefore more applicable to DO concentrations at the lake bottom. CCME (1999c) also acknowledges that DO concentrations can naturally fluctuate below the guideline and states that in cases where DO is naturally less than 110% of the guideline, "the minimum acceptable concentrations is 90% of the natural concentrations".

Therefore, a low action level for winter DO concentrations is exceeded when either of the following conditions is met:

1. The average DO concentration at any near-field AEMP lake is less than 6.5 mg/L and at least 10% less than observed during any baseline year; or
2. The average DO concentration at any near-field AEMP lake is less than 90% of the average DO concentration observed during any baseline year for lakes where the baseline average DO concentration in any year is less than 7.15 mg/L (110% of the 6.5 mg/L guideline).

The average DO concentrations referred to in conditions one (1) and two (2) are calculated as a whole-lake volume-weighted average. Whole-lake volume-weighted average DO concentrations are calculated using observed DO data obtained from AEMP under-ice DO and temperature profiles along with the depth-volume curves for each lake obtained by applying GIS techniques to the bathymetric data. The measured DO concentrations will be weighted by the volume of water within each 1 m-depth strata of the lake to obtain the average volume-weighted whole lake DO concentration. If multiple DO measurements are collected within a 1 m-depth stratum, the average for each 1 m-depth stratum will be calculated and used to obtain the whole-lake volume-weighted average.

3.2 BIOLOGICAL COMPONENT

3.2.1 Biological Variables

3.2.1.1 Phytoplankton, Zooplankton and Benthos

The selection of phytoplankton, zooplankton and benthos variables to be included within the Aquatic Response Framework follows a similar methodology as for water quality variables in that it includes predictions made in the 1995 EIS and 2000 EA, and AEMP monitoring results up to and including 2012, information from the analysis in the 2012 AEMP Re-evaluation (Rescan 2012b), and commitments made in the approved 2013 to 2015 AEMP Plan (Rescan 2013b).

The selection process was developed using the full list of biological variables monitored in lakes as part of the AEMP. Biological variables were divided into two distinct groups, the “general” and the “community” to distinguish between the types of benchmarks and action levels that are set in Sections 3.2.2 and 3.2.3 (Table 3.2-1; Figure 3.2-1). General biological variables are those that were considered appropriate for high level measures of change in biological communities (i.e., biomass and total density) and are calculated on an annual basis as part of the AEMP. General variables are assigned numerical benchmarks for the purposes of the Aquatic Response Framework. Community variables (i.e., community composition and diversity) are also calculated on an annual basis in the AEMP but are considered more complex and are therefore assigned narrative benchmarks. Changes in community composition in the AEMP are assessed through analysis of diversity indices and also through the examination of total and relative densities of major taxonomic groups. Diversity indices are complex because they are calculations that consider both species richness and species abundance, and the same diversity value may represent very different community compositions. Changes in the total or relative densities of major taxonomic groups can vary in their ecological significance for a variety of reasons such as the importance of the group as a food resource for fish or other invertebrates, or the known tolerance of the group to disturbance. Table 3.2-1 provides a summary of the decision steps followed for excluding or including each variable, flowing from left to right. If a variable is marked with a check (✓) in any of the four reasons for inclusion columns, then it was included in the Aquatic Response Framework. Once a check was received in one column no further assessment of the variable was completed and the variable was included in the list of Aquatic Response Framework plankton and benthos variables, as appropriate. Dashes (-) were added to the remaining columns to indicate that the variable was not further assessed.

Table 3.2-1. Selection of Aquatic Response Framework Plankton and Benthos Variables

Biological Variable	Variable Group	Reasons for Inclusion: Predicted to Change in 1995 EIS		Predicted to Change in 2000 EA		Current Mine-related Effect?[1]		Included as High Level Measure of Change for Each Biological Community	Response Framework Variable
Phytoplankton Biomass (as chlorophyll *a*)	General	-		✓[2]		-		-	Yes
Phytoplankton Density	General	-		-		-		✓	Yes
Phytoplankton Diversity/Community Composition	Community	-		-		✓		-	Yes
Zooplankton Biomass	General	-		-		-		✓	Yes
Zooplankton Density	General	-		-		-		✓	Yes
Zooplankton Diversity/Community Composition	Community	-		-		✓		-	Yes
Lake Benthos Density	General	-		-		-		✓	Yes
Lake Benthos Dipteran Diversity/ Community Composition	Community	-		-		✓		-	Yes

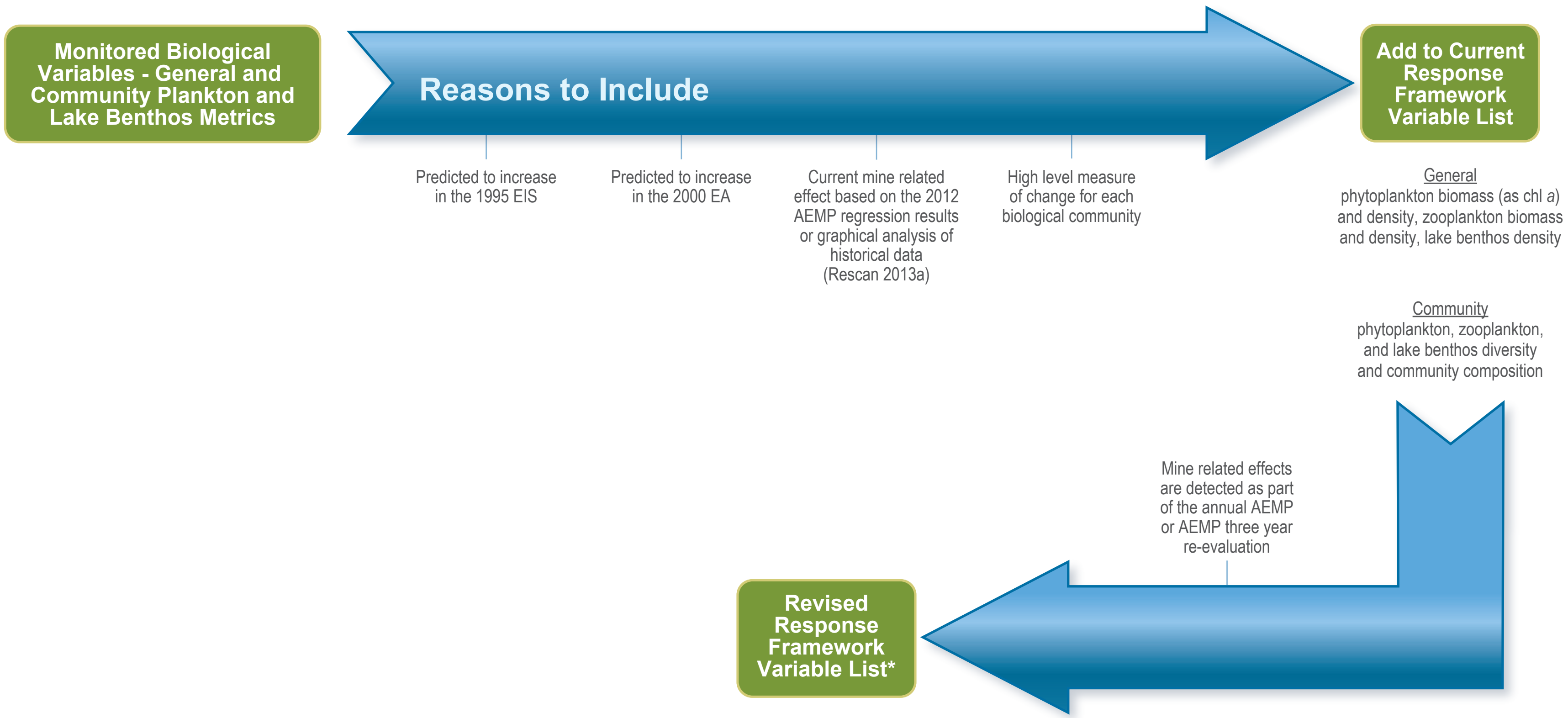
Notes:
[1] Based on conclusions from 2012 AEMP.
[2] Slightly elevated phytoplankton biomass was predicted to be possible but unlikely in Fay Lake downstream of the Pigeon Stream Diversion (PSD).

Therefore, the variables included in the Aquatic Response Framework plankton and benthos variables list are:

- General
  - Phytoplankton biomass (as chlorophyll *a*);
  - Phytoplankton density;
  - Zooplankton biomass;
  - Zooplankton density;
  - Lake benthos density; and
- Community
  - Phytoplankton diversity/community composition;
  - Zooplankton diversity/community composition; and
  - Lake benthos diversity/community composition.

Figure 3.2-1

Schematic of the Selection and Revision of the Aquatic Response Framework Plankton and Benthos Variable List



** To be provided annually in the AEMP report.*

The list of Aquatic Response Framework plankton and benthos variables will be assessed for inclusion within the Aquatic Response Framework annually in the AEMP report. The results of the assessment will be reported within the Response Framework Reporting chapter of the AEMP Summary Report (also see Section 3.4.2). The assessment process will involve repeating the plankton and benthos selection process described above using up to date information. For example, if a mine-related effect for a biological variable is concluded for the first time in the current years AEMP, Table 3.2.1 will be adjusted to show that there is a current or potential mine effect and the variable will be added to the revised Aquatic Response variable list (Figure 3.2-1). Stream benthos will also be included in this assessment process.

3.2.1.2 Fish

The selection of fish variables to be included within the Aquatic Response Framework follows similar methodology as for other biological variables. Predictions made in the 1995 EIS and 2000 EA are included, as are AEMP monitoring results up to and including 2012, and commitments made in the approved 2013 to 2015 AEMP Plan (Rescan 2013b). Fish habitat was identified during the initial EA process as a VEC and is assessed as part of the abiotic (water quality) variables including DO as well as through the assessment of plankton and benthos which represent food availability. The 2012 EIR identified fish biology as a key environmental risk at the Ekati Diamond Mine (BHP Billiton 2012a).

The selection process was developed using the full list of variables monitored as part of the 2012 AEMP. Table 3.2-2 provides a summary of the decision steps followed for including each variable, flowing from left to right. If a variable is marked with a check (✓) in any of the columns then it was included in the Aquatic Response Framework, unless excluded under a unique rationale, as explained below for catch-per-unit-effort (CPUE). Because only one reason to include a variable was required, once a check was received in one column no further assessment of the variable was completed and the variable was included in the list of Aquatic Response Framework variables. Dashes (-) were added to the remaining columns to indicate that the variable was not further assessed.

Table 3.2-2. Selection of Response Framework Fish Variables

Fish Variable	Predicted to Change in 1995 EIS	➔	Predicted to Change in 2000 EA	➔	Current Mine-related Effect?[2]	Response Framework Variables
CPUE	✓		-		-	No[3]
Length	-		-		-	No
Weight	-		-		-	No
Condition	-		-		-	No
Age	-		-		-	No
Growth in length	-		-		-	No
Maturity	-		-		-	No
Sex ratio	-		-		-	No
Number of eggs (LKTR/RDWH)	-		-		-	No
GSI	-		-		-	No
LSI	-		-		-	No
Diet	-		-		-	No
Tissue metal concentrations	-		-		antimony, molybdenum, selenium, and uranium	antimony, molybdenum, selenium, and uranium

(continued)

Table 3.2-2. Selection of Response Framework Fish Variables (completed)

Fish Variable	Predicted to Change in 1995 EIS	➔	Predicted to Change in 2000 EA	➔	Current Mine-related Effect?[2]	Response Framework Variables
Palatability (chlorinated phenols)[1]	-		-		-	No
Hydrocarbon exposure (EROD; RDWH/SLSC)	✓		-		-	Yes
DELT (LKTR/RDWH)	-		-		-	No
Parasite loading (SLSC)	-		-		-	No

Notes:
CPUE = catch-per-unit-effort; Condition = weight-length regression; GSI = gonadosomatic index; LSI = liver somatic index; EROD = ethoxyresorufin-O-deethylase, DELT = deformities, erosions, lesions, tumours; LKTR = lake trout; RDWH = round whitefish; SLSC = slimy sculpin.
[1] Related to human consumption concerns including palatability.
[2] Based on 2012 AEMP statistical results or graphical analysis of historical data.
[3] Changes in CPUE have been detected for lake trout likely as a result of sampling mortality.

CPUE is excluded from variables assessed in the Aquatic Response Framework because predicted and historical effects are thought to be related to sampling mortality as opposed to effects directly related to mine operations. Additionally, steps have already been taken to reduce the number of large-bodied fish sacrificed for AEMP sampling.

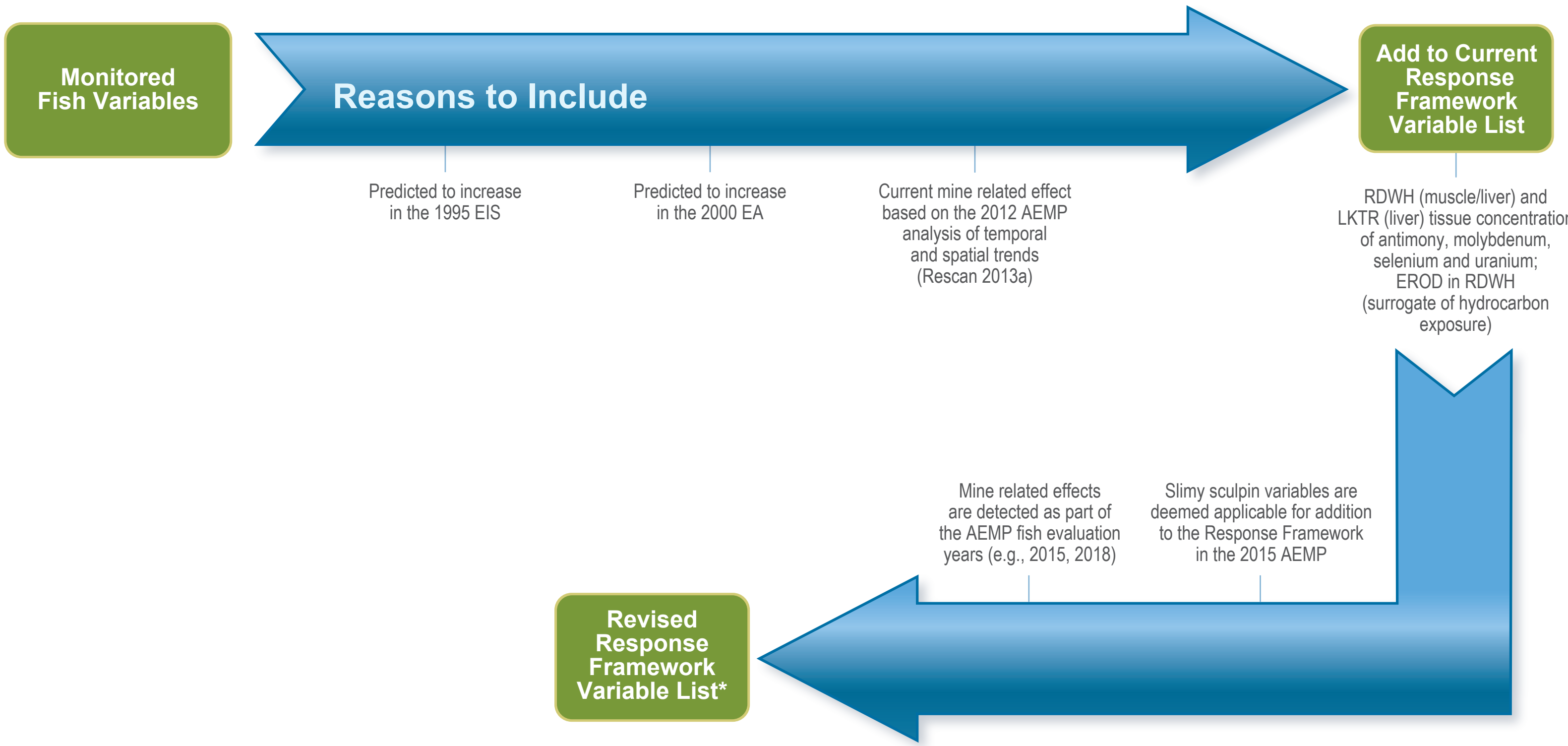
Thus, the variables for inclusion in the Aquatic Response Framework fish variables:

- concentrations of antimony, molybdenum, selenium and uranium in the muscle and liver of round whitefish and lake trout (muscle only); and
- EROD activity in round whitefish as a surrogate measure of hydrocarbon exposure.

Revisions to the Aquatic Response Framework fish variable list will occur when new AEMP data become available (i.e., the next AEMP fish sampling year is 2015 for slimy sculpin and 2018 for large bodied fish; Figure 3.2-2). The results of the assessment will be reported within the Response Framework Reporting chapter of the AEMP Summary Report using the same process as identified for water, plankton and benthos variables. The applicability of including fish variables for slimy sculpin will also be assessed. The fish sampling program as part of the AEMP has recently undergone modifications to address recommendations by the WLWB (Rescan 2011). A key change was the inclusion of slimy sculpin sampling every 3 years, beginning in 2012, for use as a sentinel species. The results from the most recent AEMP fish sampling in 2012 indicated that slimy sculpin have many of the characteristics of a good sentinel species (e.g., small home range, short life span and fast maturation, etc.) and in that way should be providing information on the presence or absence of environmental stressors in their local environments. However, the changes in tissue metals observed in slimy sculpin in 2012 are not indicative of the changes observed in round whitefish and lake trout (Rescan 2013a). Slimy sculpin were added to the AEMP to provide an early warning indicator of changes that may be occurring in the large-bodied fish species (lake trout and round whitefish) that hold recreational and cultural value to humans. To some degree, and for some variables such as tissue metals, the extent to which slimy sculpin function effectively as sentinel species is yet to be determined, and therefore applicability of slimy sculpin within the Aquatic Response Framework will be reviewed in the 2015 AEMP report. This review will be included in the 2015 AEMP report because the 2015 fish data will not be available for reporting by the next AEMP re-evaluation due date of December 15, 2015. Due to the lack of baseline data for slimy sculpin it may take several sampling seasons before the sentinel and large-bodied species system is fully developed, functional and understood; alternatively it may be determined that slimy sculpin are unsuitable for serving as an appropriate early warning indicator species for changes observed in large-bodied fish species.

Figure 3.2-2

Schematic of the Selection and Revision of the Aquatic Response Framework Fish Variable List



Notes: EROD = ethoxyresorufin-O-deethylase,
LKTR = lake trout,
RDWH = round whitefish.

** To be provided following fish sampling years in the AEMP report.*

3.2.2 Biological Benchmarks

3.2.2.1 Phytoplankton, Zooplankton and Benthos

Phytoplankton, zooplankton and benthos benchmarks were developed in two ways. General variables including biomass and total density of phytoplankton, zooplankton and benthos were considered simplified variables and were given numerical benchmarks. Community variables deemed to be “complex” such as community composition and diversity of phytoplankton, zooplankton and benthos were given narrative benchmarks. Both numerical and narrative benchmarks are described below.

<u>Biological General Variables (Biomass and Total Density)</u>

Phytoplankton, zooplankton and benthos biomass and total density benchmarks were developed by identifying reasonable normal ranges based on reference and baseline conditions. The benchmarks are based on modeled distributions of baseline and reference lake observations and the probability of observations occurring within the lower and upper extremes of these modeled distributions. A p value of 0.05 for both the upper and lower quantiles of the best fit distribution were used to calculate the benchmark for each variable (e.g., phytoplankton density or zooplankton biomass). Benchmarks are set as a range, meaning that if an observation (e.g., average 2013 phytoplankton density) is less than the lower benchmark or greater than the upper benchmark, the benchmark is exceeded.

For lakes, the data used to fit to the distributions included:

- reference lake observations prior to 2012 for Nanuq, Counts and Vulture lakes;
- baseline observations prior to 1998 for Leslie, Moose, Nema and Slipper lakes, and sites S2 and S3 in Lac de Gras; and
- baseline observations prior to 2001 in Cujo Lake and site LdS1 in Lac du Sauvage.

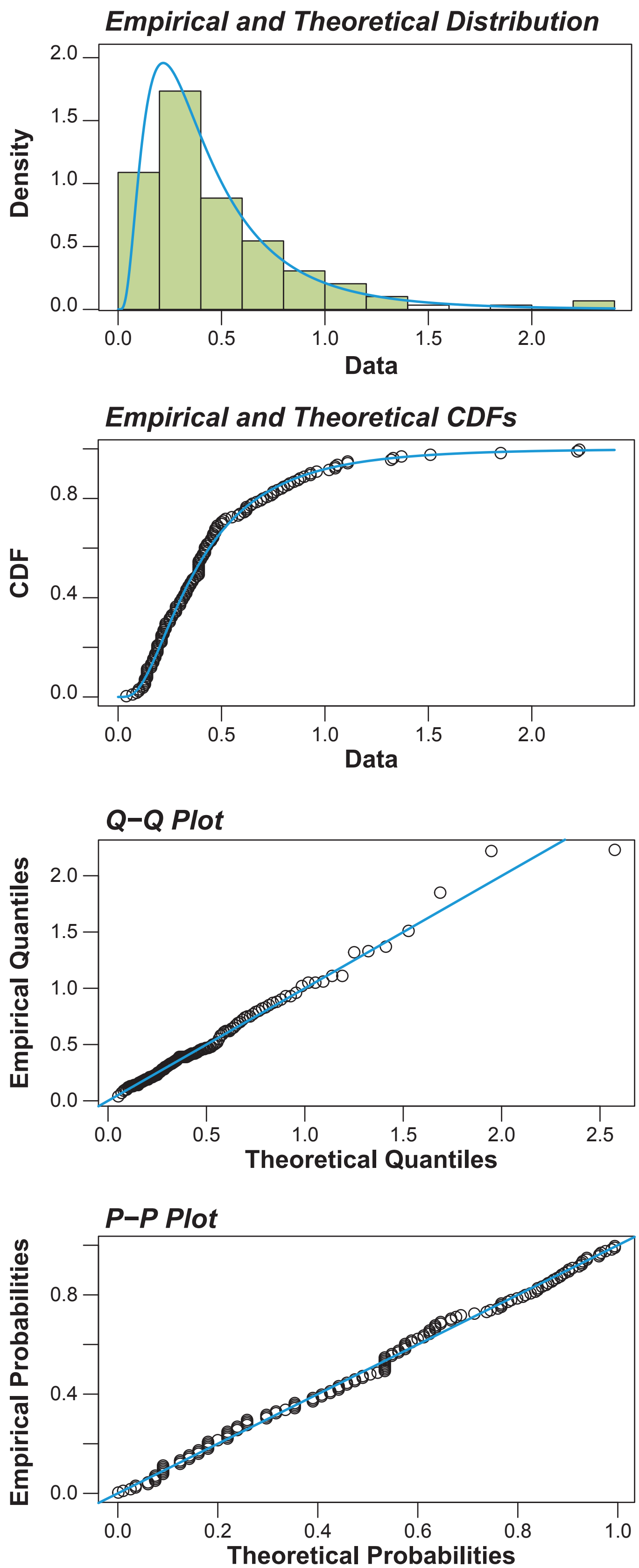
Kodiak Lake data were excluded because of the history of effects in the lake related to historical mine influences. Only observations prior to 2012 were included for the reference lakes because observations from the three most recent years (2012 to 2014) are considered when determining whether an action level is exceeded for a biological variable (see Section 3.2.3.1). Therefore, the data from 2012 to 2014 cannot also be included in the dataset used to determine the benchmark. This is important because if the recent observations from both a reference lake and a monitored lake are consistently below or above the lower or upper quantiles defined as the benchmark, then the variable may not be changing because of the mine (e.g., the variable may be changing due to a broad climatic pattern affecting all lakes similarly) and it may not be appropriate for an action level to be triggered.

The distribution of observed (empirical) data for each variable were plotted and compared to several common theoretical distributions (e.g. normal, lognormal, etc.) to determine which best described the observed data. A comparison of the fit of the theoretical distributions to the observed data was conducted visually using goodness of fit plots (Figure 3.2-3) and using summary statistics such as the Akaike information criterion and Bayesian information criteria (also known as Schwarz criterion; AIC and BIC). The AIC and BIC are measures of the quality of the statistical model for the given data and provide a means for model selection. The best fitting distribution for each variable was chosen based on best professional judgement of goodness of fit and a comparison of AIC and BIC values among the candidate distributions. Figure 3.2-3 shows an example of the goodness of fit plots. The distribution of empirical data is presented as bars in the top left panel and the lognormal distribution is represented by the curved line. In the other three panels, the distribution of the empirical data is represented by the circles; the closer the circles fit to the solid lines, the better the fit of the observed data to the theoretical distribution. In this example, the phytoplankton biomass data fit very closely to the lognormal distribution and the lognormal distribution was chosen as the best fit model.

Figure 3.2-3

Example of Empirical and Theoretical Distribution Fit, Phytoplankton Biomass

Best Fit Distribution-Lognormal



Once the best fitting distribution was selected, the quantiles at ($p = 0.05$) were calculated for the upper and lower tails. The calculated quantiles at $p = 0.05$ represent a one in 20 probability that an observation (e.g. 2014 phytoplankton biomass in Leslie Lake) would be less than the benchmark by chance alone, or a one in 20 chance that an observation would be above the benchmark by chance alone. These quantiles represent the upper and lower ends of the range for the benchmark for each biological variable being assessed. A p value of 0.05 for each quantile was chosen to balance conservatism while also retaining meaningful data. When a higher p value was chosen for a particular variable (e.g., phytoplankton biomass), both near-field and reference lake data were more frequently outside of the benchmark range. In these cases, choosing a higher p value may actually decrease the likelihood of exceeding an action level because the reference lakes are more likely to fall above or below the quantile in a given year or in several consecutive years (see more on biological action levels in Section 3.2.3.1).

In the same way that water quality benchmarks may be updated based on new science, the biological benchmarks should also be periodically updated to incorporate baseline data for new development areas (e.g., Pigeon) and more recent reference data. For the Aquatic Response Framework, biological benchmarks will be updated every three years in conjunction with the AEMP Re-evaluation unless earlier updates are deemed necessary to incorporate the Pigeon or other developments.

Table 3.2-3 provides the benchmark numbers for phytoplankton, zooplankton and lake benthos. A more detailed summary of the statistical methodologies used to derive these benchmarks is provided in Appendix 1.

Table 3.2-3. Numerical Benchmarks for General Phytoplankton, Zooplankton and Benthos Variables

Biological Variable	Units	Lower Benchmark ($p = 0.05$)	Upper Benchmark ($p = 0.05$)
Phytoplankton biomass (as chlorophyll *a*)	µg/L	0.09	1.2
Total phytoplankton density	cells/mL	179	2,164
Zooplankton biomass (as dry weight)	mg dry weight/m^3	15	248
Total zooplankton density	organisms/m^3	7,172	117,469
Lake benthos density	organisms/m^2	168	11,872

Biological Community Variables (Community Composition and Diversity)

The benchmark for community composition and diversity of phytoplankton, zooplankton and lake benthos is: a mine effect is not observed using the methodology applied in the AEMP – Part 1 Evaluation of Effects (see Sections 2.2.5 and 2.2.6 in ERM Rescan 2014).

Graphical analysis and best professional judgement are the primary methods used to determine whether there are mine effects on the diversity and community composition of plankton and benthos communities in the AEMP. Essentially, data for the current year must appear different from all baseline data to be considered an effect or a potential effect. If similar trends are observed in reference and monitored lakes than any changes are concluded to be a result of external factors or natural variation rather than mine effects.

3.2.2.2 Fish

The benchmark for fish muscle and liver metal variables (antimony, molybdenum, selenium and uranium) and EROD activity is: a mine effect is not observed using the statistical methodology applied in the AEMP – Part 1 Evaluation of Effects (see Section 2.2.6 in Rescan 2013a).

The benchmark applies to lake trout (muscle only) and round whitefish only (muscle and liver metals, EROD). EROD activity is not assessed in lake trout because it requires lethal sampling. The next sampling year for large-bodied fish as part of the AEMP is 2018. The benchmark for fish muscle and liver metals and EROD analyses does not rely on fish tissue guidelines at this time. None of the metals variables currently included in the Aquatic Response Framework for fish tissue have associated guidelines, except for selenium. If applicable, when the low action level has been exceeded (see Section 3.2.3.2) additional benchmarks based on guideline values may be derived for fish muscle and/or liver, or existing federal, provincial, or other guidelines may be used as benchmarks for the Ekati Diamond Mine.

3.2.3 Biological Action Levels

3.2.3.1 Phytoplankton, Zooplankton and Benthos

Similar to water quality variables, three action levels are proposed for the Aquatic Response Framework phytoplankton, zooplankton and benthos variables: low, medium and high. As described in Section 3.2.2 for biological benchmarks, action levels for phytoplankton, zooplankton and benthos were developed in two ways.

For biological variables, only low action levels have been predefined. The medium and high action levels will be developed as part of the Response Plan once the low action level is exceeded. As described for water quality, setting of high action levels may be deferred if clear and appropriate rationale is provided (e.g., additional research is required). Medium and high action levels may be generic (encompass all biological variables) or based on variable specific considerations. Additionally, two types of low action levels have been defined, which relate to the two types of defined benchmarks (general and community).

Spatially, action-levels are triggered based on biological variables at near-field sites as defined in Tables 3.1-1 and 3.1-2 for water quality variables. Action levels for general and community phytoplankton, zooplankton and benthos variables are described below.

<u>General Biological Variables (Biomass and Total Density)</u>

A low action level for phytoplankton, zooplankton or benthos biomass or total density variables is exceeded when both of the following conditions are met:

1. Based on AEMP methods for determining mine effects for phytoplankton, zooplankton and benthos biomass or total density, a statistically significant difference from a slope of zero and reference conditions in at least two reference lakes, or a statistically significant Before-After-Impact-Control (BACI) interaction is concluded for a near-field lake site; and
2. Using the biological benchmarks based on upper and lower quantiles (p = 0.05) of the fitted distributions, the average of the biological variable being assessed is less than the lower benchmark or greater than the upper benchmark for the current AEMP year and the previous two years at any near-field site (see benchmarks in Table 3.2-3).

When determining whether a low action level for phytoplankton, zooplankton or benthos biomass or total density variable is exceeded the AEMP methods referenced in condition one (1) above refer to the regression methods outlined in the 2013 to 2015 AEMP Plan Section 3.2.2.1 (Rescan 2013b) and BACI methods that will be applied to the Pigeon-Fay and Upper Exeter watersheds beginning with the 2014 AEMP. As indicated in the AEMP methods (Section 3.2.2.1 of Rescan 2013b) the trend for a variable in monitored lakes is first compared to a slope of zero and if a statistically significant difference is found (i.e., there has been a change in the variable over time) then the slope in the monitored lake is compared to the slope for each of the reference lakes to assist in distinguishing natural variation from potential mine effects. A significant difference between the trend observed in a monitored lake and two or more reference lakes is considered indicative of a potential mine effect. In BACI analysis, potential mine effects are identified as significant interactions that are referred to as BACI interaction terms. A significant BACI interaction term indicates a significant difference in a variable at one lake location from the Before (baseline years) to the After (current year) period when compared with another lake. If the change from Before to After periods is the same for a reference site compared to a monitored site, then BACI analysis will not detect a significant interaction and no mine effect with be indicated. However, if a change is detected from the Before to After periods that is different in a reference site compared to a monitored site, then BACI analysis will detect a significant interaction and a potential mine effect will be indicated. The second condition, condition (2) for exceeding a low action level for general biological variables is added due to the inherent variability in biological data. For example, it is difficult to conclude that a one time difference from reference conditions is indicative of a mine effect as opposed to natural variation whereas a sustained difference from reference and baseline conditions is stronger evidence that a mine effect may be occurring.

<u>Community Biological Variables (Community Composition and Diversity)</u>

A low action level for phytoplankton, zooplankton or benthos community composition or diversity variables is exceeded when all of the following conditions are met:

1. Based on AEMP methods for determining mine effects for phytoplankton, zooplankton and benthos diversity and community composition (i.e., graphical analysis and best professional judgement), a mine effect is detected or suspected at a near-field lake;
2. The mine effect detected or suspected in condition one (1) is based on three years of data including the current AEMP year and the previous two years at any near-field site; and
3. Uncertainty exists around the meaning, significance or implication of the change triggering condition one (1) and more information is required.

3.2.3.2 Fish

As above, three action levels are proposed for fish variables: low, medium and high. Spatially, action-levels are triggered based on fish variables at near-field sites as defined in Tables 3.1-1 and 3.1-2 for water quality variables.

For fish variables, only low action levels are predefined. The medium and high action levels will be developed once the low action level is exceeded. As described for water quality, plankton, and benthos, setting of high action levels may be deferred if clear and appropriate rationale is provided (e.g., additional research is required). Medium and high action levels may be generic (encompass all fish variables) or based on variable specific considerations.

A low action level for fish variables is exceeded when the following condition is met:

1. Based on AEMP methods for determining mine effects for metals in fish muscle or liver and EROD activity, a mine effect is concluded for a near-field lake for lake trout or round whitefish muscle or liver metals or EROD activity.

As outlined in Section 2.2.6 of the 2012 AEMP (Rescan 2013a) AEMP methods for detecting a mine effect on fish variables is completed by progressively testing three hypotheses:

1. Do individual lakes show evidence of change over time (i.e., is there a temporal trend within lakes)?
2. Do temporal trends differ among lakes (i.e., are monitored lakes different from reference lakes)?
3. Is there a spatial relationship to differences among lakes (i.e., is the distance to mining activity associated with any variation in fish biology)?

3.3 SIGNIFICANCE THRESHOLDS

3.3.1 Background

The WLWB's draft Response Framework guidance document indicates that a Response Framework should be linked with the environmental assessment (EA) for the project (e.g., the Ekati Diamond Mine) because the EA documents the magnitude of environmental change that is considered significantly adverse and therefore unacceptable. However, the WLWB also acknowledges that in some cases the EA process does not provide a clear definition of significant adverse effects for a project and states that in this case any ambiguity in the definition of significance that remains after the EA must be resolved through the regulatory process (i.e., in the Response Framework; WLWB 2010).

The 1995 EIS for the Ekati Diamond Mine broadly defined negligible, minor, moderate and major impact significance ratings for residual effects for physical (e.g., water quality) and biological (e.g., fish) components (BHP and Dia Met 1995a). Residual effects for water quality and fish related VECs were predicted to be negligible to minor, and, based on the project's approval, were deemed acceptable. Thus for the purpose of the Aquatic Response Framework, a significance threshold for the aquatic receiving environment could be considered analogous to what was defined as a major residual effect in the 1995 EIS. However, the 1995 EIS ratings for an impact significance of 'major' for residual effects for physical and biological variables were linked to large geographical areas (i.e., South Arctic Ecozone) and times scales of several generations or decades that are not necessarily appropriate for the purposes of the Aquatic Response Framework. Therefore, an alternative approach to defining significance thresholds for the Ekati Diamond Mine Aquatic Response Framework is provided below.

The environmental protection measures at the Ekati Diamond Mine are focussed on protection of the uses of the receiving environment, which is in alignment with the WLWB's Water and Effluent Quality Management Policy (MVLWB 2011). The historical, current, and future uses of the aquatic environment around the Ekati Diamond Mine include drinking and fishing by people and wildlife, and a living environment for fish and other aquatic life in most of the waterbodies. Therefore definitions of significance thresholds related to these uses were derived for the purposes of the Aquatic Response Framework (see Section 3.3.2). The benchmarks and EQC being used to manage the day-to-day operations of the mine are based on much smaller levels of environmental change, well below significance thresholds, and are designed to be protective of the receiving environment. Additionally, by setting action levels well in advance of when benchmarks may be reached, the action levels function as an 'early-warning system' to ensure protection of the uses of the aquatic receiving environment at the Ekati Diamond Mine. The EQC and Aquatic Response Framework are also only two of many tools that provide environmental protection at the Ekati Diamond Mine (see further detail in BHP Billiton (2012c).

3.3.2 Thresholds

In W2012L2-0001 a significance threshold is defined '*as a level of environmental change in any monitored variable which, if reached, would result in a significant adverse effect.*' Narrative significance thresholds that are linked to the use protection approach and each component of the Aquatic Response Framework (i.e., water quality, plankton and benthos, and fish) are presented below. The significance thresholds also relate to the VECs identified for the aquatic environment in the 1995 EIS and 2000 EA for the Ekati Diamond Mine (see Sections 2.1.1 and 2.1.2) and to the current key risks for the aquatic environment identified in the 2012 EIR (see Section 2.1.3). The three significance thresholds identified for the purposes of the Ekati Diamond Mine Aquatic Response Framework are defined in Table 3.3-1.

Table 3.3-1. Aquatic Response Framework Significance Thresholds

Aquatic Response Framework Component	Significance Threshold	Section Describing Variables, Benchmarks and Action Levels Related to Each Component
Water Quality	The water quality of the Koala, King-Cujo or Pigeon-Fay and Upper Exeter watersheds is unsafe to drink for wildlife and/or humans.	3.1.1, 3.1.2, 3.1.3
Plankton and Benthos	The plankton and/or benthos communities of the Koala, King-Cujo or Pigeon-Fay and Upper Exeter watersheds have changed in such a way that sufficient food for fish is no longer available.	3.2.1.1, 3.2.2.1, 3.2.3.1
Fish	The fish of the Koala, King-Cujo or Pigeon-Fay and Upper Exeter watersheds are unsafe to eat or the population of an ecologically, recreationally or culturally important fish species is negatively affected.	3.2.1.2, 3.2.2.2, 3.2.3.2

The three significance thresholds defined in Table 3.3-1 are linked on a spatial scale to the watersheds in which there are current mine activities. The significance thresholds apply to waterbodies that are examined for mine effects in the AEMP (i.e., downstream waterbodies or select waterbodies in the immediate vicinity of the mine, not waterbodies that have been dewatered or are approved for dewatering or waterbodies designated for use by the mine (e.g., the LLCF, KPSF, Desperation Pond) and are relevant at the Koala, King-Cujo or Pigeon-Fay and Upper Exeter watershed scales (as opposed to lake specific watershed scales). For example, within the Koala Watershed several lakes (e.g., Leslie, Moose, Nema, and Slipper) are monitored and the significance threshold applies to these lakes collectively rather than individually (i.e., the threshold would not be exceeded on a lake by lake basis). Lac de Gras and Lac du Sauvage are not included for three reasons. First, the significance thresholds at the defined spatial scale are more conservative than would be the case if Lac de Gras and Lac du Sauvage were included. The significance thresholds can therefore be considered protective against significant adverse effects related to the Ekati Diamond Mine in these larger and further downstream waterbodies. Second, the Ekati Diamond Mine AEMP does not monitor or evaluate whole-lake mine effects in Lac de Gras and Lac du Sauvage, and the existing monitoring information does not indicate the need to do so. Third, because there is a potential for cumulative effects in Lac de Gras, DDEC cannot tie its significance thresholds for the Aquatic Response Framework to this waterbody since it does not have control over the level of impact that may be present due to other influences.

Although the actions levels for water quality (Section 3.1.3) rely in part on comparison to benchmarks for both freshwater aquatic life and drinking water guidelines, the significance threshold for water quality considers drinking water quality for humans and wildlife because the effects of changing water quality on the aquatic biological community are captured within the significance thresholds for plankton, benthos, and fish where the biological responses to potential water quality stressors are assessed.

If necessary, the mechanisms by which it may be determined whether a significance threshold has been reached or is likely to be reached will be outlined within a Response Plan to be submitted to the WLWB for approval. These methods would be determined within a Response Plan following exceedance of a medium or high action level.

3.4 CYCLICAL MONITORING AND REPORTING PROCESS

3.4.1 Overview of AEMP

The environmental monitoring data collected through the AEMP will feed into the Aquatic Response Framework for assessment against action levels. The AEMP program was last reviewed and revised in 2012 (Rescan 2012b) and following that review the 2013 to 2015 AEMP Plan was created (Rescan 2013b) and approved by the WLWB. The plan was based on an in depth analysis of fifteen years of monitoring data and included input from various regulatory bodies (Rescan 2012b). The lake sampling plan is summarized in Tables 3.4-1 and 3.4-2, details on additional special studies can be found in Rescan (2013b). The plan includes details for AEMP sampling within the 2013 to 2015 AEMP period to be carried out in the Pigeon-Fay and Upper Exeter watersheds once the Pigeon Stream Diversion (PSD) was connected to the natural Pigeon Stream. AEMP monitoring for the Pigeon AEMP began during the under-ice season of 2014 coincident with the PSD being connected to the natural Pigeon Stream. Any approved changes made to the AEMP prior to updating of the Aquatic Response Framework will also be incorporated into the data fed into the Aquatic Response Framework, where appropriate. Table 3.4-1 provides the lake sampling locations and environmental components sampled as part of the AEMP at each lake location. Table 3.4-2 provides the lake sampling frequency and number of samples (n) collected at each location. A map indicating AEMP lake sampling locations and types of sampling completed at each station sampled is provided in Figure 3.4-1. Although 1616-30, 1616-43 and 1616-47 data are included in the AEMP plan, they are included for comparative purposes only and are not included in the discussion of evaluation of effects because they are not located in the receiving environment. Data from these three stations will not be assessed against action levels in the Aquatic Response Framework and water quality at these stations will not trigger the need for Response Plans.

Table 3.4-1. AEMP Lake Sampling Scheme, 2013 to 2015

Location	Water Quality	Limnology	Phytoplankton	Zooplankton	Benthos	Sediment Quality[1]	Fish[2]
Reference							
Nanuq	x	x	x	x	x	x	x
Counts	x	x	x	x	x	x	x
Vulture	x	x	x	x	x	x	x
Koala Watershed							
Grizzly	x	x	-	-	-	-	-
Kodiak	x	x	x	x	x	x	x
Leslie	x	x	x	x	x	x	x
Moose	x	x	x	x	x	x	x
Nema	x	x	x	x	x	x	x
Slipper	x	x	x	x	x	x	x
S2	x	x	x	x	x	x	-
S3	x	x	x	x	-	-	-
King-Cujo Watershed							
Cujo	x	x	x	x	x	x	x
LdS2	x	x	-	-	-	-	-
LdS1	x	x	x	x	x	x	-

(continued)

Table 3.4-1. AEMP Lake Sampling Scheme, 2013 to 2015 (completed)

Location	Water Quality	Limnology	Phytoplankton	Zooplankton	Benthos	Sediment Quality[1]	Fish[2]
Pigeon-Fay and Upper Exeter watersheds							
Fay Bay	x	x	x	-	-	x	-
Upper Exeter Lake	x	x	x	-	-	x	-

Notes:
[1] Sediment quality will be monitored in 2014 (every 3 years post-baseline) and in the first year of monitoring in the Pigeon-Fay and Upper Exeter watersheds.
[2] Slimy sculpin will be monitored in 2015 (every 3 years).

Table 3.4-2. AEMP Lake Sampling Frequency and Replication, 2013 to 2015

Monitoring Component	Annual Frequency	Seasonal Frequency	Replication and Depths at each Lake per Sampling Event
Water quality	each year	April	n=2 @ mid water column depth n=2 @ 2 m from bottom
	each year	August	n=3 @ 1 m n=3 @ mid water column depth n=3 @ 2 m from bottom (Leslie Lake only)
	each year	July and September	n=2 @ 1 m (Pigeon-Fay and Upper Exeter watersheds only) n=2 @ mid water column depth (Pigeon-Fay and Upper Exeter watersheds only)
Limnology	each year	April	n=1 profile
	each year	August	n=1 profile
	each year	July and September	n=1 profile (Pigeon-Fay and Upper Exeter watersheds only)
Phytoplankton	each year	August	n=3 @ 1 m
Zooplankton[1]	each year	August	n=3 vertical hauls
Benthos[1]	each year	August	n=3 at mid-depth (5-10 m)
Sediment Quality	every 3 years	August	n=3 at mid-depth (5-10 m)
Fish[1]	every 3 years	August	n=30 for lethal sampling

Note:
[1] Reference lakes and lakes of the Koala and King-Cujo watersheds only.

3.4.2 Response Framework Reporting

The requirement of Part J, Item 10 of Water Licence W2012L2-0001 states that "*if any Action Level defined in the approved Response Framework is exceeded, the Licensee shall notify the Board within 60 days of when the exceedance is detected; and within 90 days of when the exceedance is detected, the Licensee must submit a Response Plan that satisfies the requirements of Schedule 8, Item 4 to the Board for approval.*"

Table 3.4-3 outlines the proposed Aquatic Response Framework reporting schedule for each AEMP sampling period and type of variable. A schedule with set reporting dates has been proposed, which was developed to meet or exceed the 60 day reporting requirement; however, depending on exact sampling dates, there may be times when the proposed dates marginally exceed the 60 or 90 day timeframe requirement. Nonetheless, the schedule is intended to make the reporting process user friendly (simplified) for both DDEC and the WLWB, and is intended to supersede the 60 day requirement defined in Water Licence W2012L2-0001. Following each April and August AEMP sampling period, DDEC will submit a notification letter to the WLWB according to the proposed schedule (Table 3.4-3) indicating to the WLWB whether or not an action level has been exceeded. Assessment of whether an action level has been exceeded will be based on final versions of the laboratory data files only. Only April and August AEMP lake results will be assessed against action levels in order to streamline the Response Framework reporting process, because April water quality data are generally considered '*worst-case scenario*' and therefore most water quality variables are often likely to first exceed action levels during the under-ice season, and because open water season AEMP reporting focuses on August results due to its relation to the biological data which are also collected in August.

Table 3.4-3. Reporting Schedule for Action Level Exceedance and Subsequent Response Plans

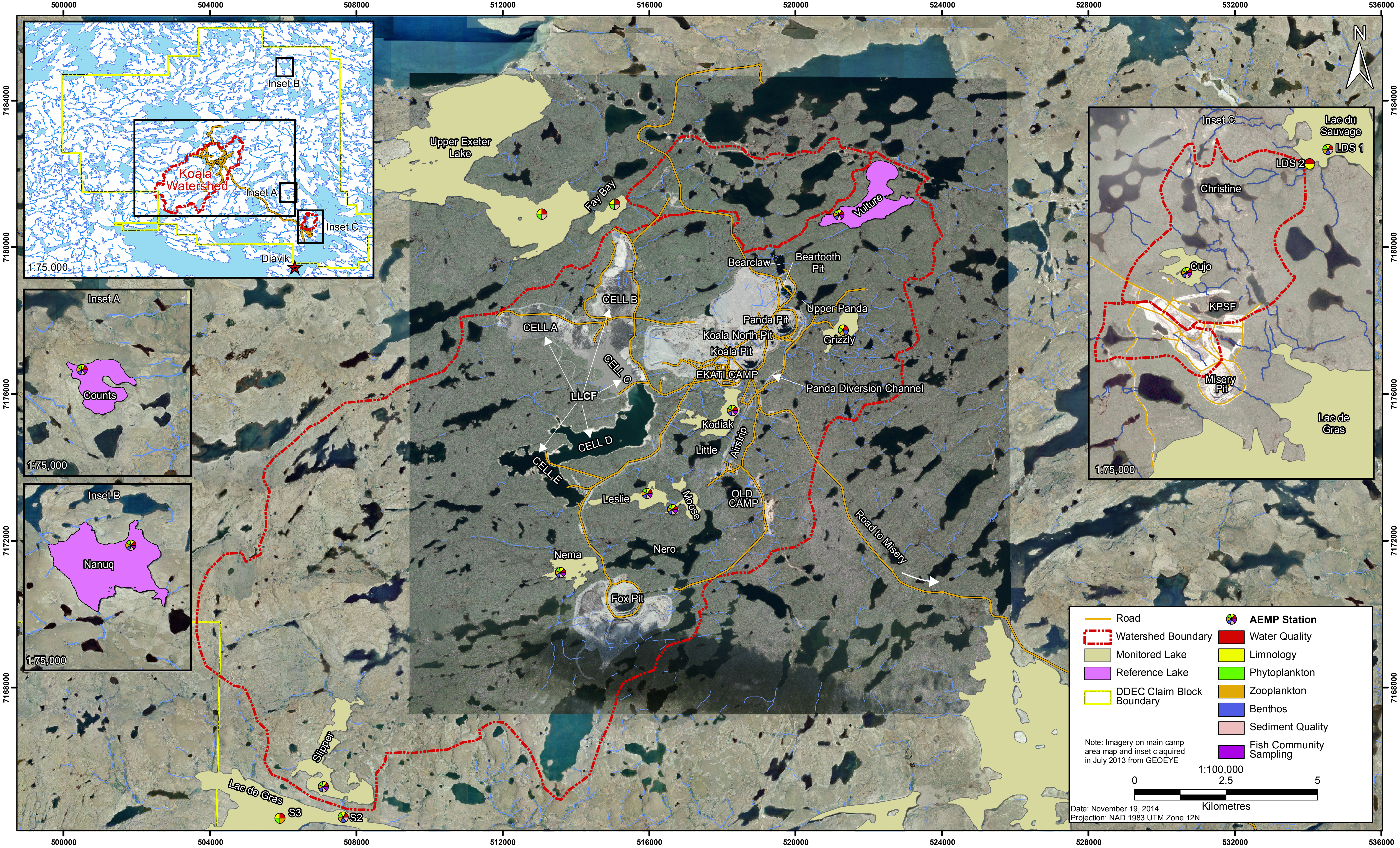
Sampling Period	Type of Waterbody	Type of Variable	Notification of Action Level Exceedance	Submission of Response Plan (if required)
Under-ice (mid to late April)	Lake	Water quality	July 31	August 31
August	Lake	Water quality and biological variables	October 31 for water quality, March 31 for biological variables	November 30 for water quality, April 30 for biological variables

The analysis of biological data (collected only once in August) has a lengthy turnaround time (counting and identifying the phytoplankton, zooplankton and benthic species), thus the report on assessment against action levels for biological variables will be provided in the Summary Report of the AEMP, due March 31 on an annual basis. A summary of the current years AEMP water quality data assessed against action levels will also be provided in the AEMP Summary Report along with a summary of any pre-existing action level exceedances, an assessment of whether additional water or biological variables should be included, or variables that have been resolved according to the requirements outlined in individual variable Response Plans.

3.4.3 Response Framework Review and Amendment

The Aquatic Response Framework will be updated on an annual basis, new components (variables, benchmarks and action levels) will be tracked in the AEMP Summary Report. The Aquatic Response Framework document itself will be updated on a three year basis (with the AEMP Re-evaluation) to include the variables that have been added during the three year period, newly defined benchmarks or action levels, as well as any other proposed changes (e.g. changes relating to new information gleaned from the AEMP re-evaluation, etc.).

Figure 3.4-1
AEMP Lake Sampling Locations



4. Response Plans

ERM

4. Response Plans

4.1 OVERVIEW

Response Plans will be submitted to the WLWB for approval according to the schedule provided in Table 3.4-3. Response Plans will be submitted on an individual variable basis, unless there is good rationale to group variables into a single Response Plan (e.g., they are related or have a common source). Each Response Plan will be written to satisfy the requirements of Schedule 8, Item 4 of W2012L2-0001, which states:

"*The AEMP Response Plan referred to in Part J, Item 10(b) shall contain the following information for each parameter that has exceeded an Action Level:*

a. A description of the parameter, its relation to Significance Thresholds, and the ecological implication of the Action Level exceedance;

b. A summary of how the Action Level exceedance was determined and confirmed;

c. A description of likely causes of the Action Level exceedance and potential mitigation options if appropriate;

d. A description of actions to be taken by the Licensee in response to the Action Level exceedance including:

  i. a justification of the selected action which may include a cost/benefit analysis;

  ii. a description of timelines to implement the proposed actions;

  iii. a projection of the environmental response to the planned actions, if appropriate;

  iv. a monitoring plan for tracking the response to the actions, if appropriate; and

  v. a schedule to report on the effectiveness of actions and to revise the AEMP Response Plan as required.

e. Any other information that is necessary to assess the response to an Action Level exceedance or that has been requested by the Board."

Response Plans will also include recommended methods or rationale for determining how the proposed actions in the Response Plan may be considered complete and the obligations under the Response Plan fulfilled indicating that a Response Plan is no longer required. Rationale may include specific rationale for achieving the completion of individual actions within a Response Plan and/or rationale for determining when a Response Plan is no longer required (e.g., because the variable is no longer exceeding an action level).

4.2 POTENTIAL MANAGEMENT RESPONSE ACTIONS

This section outlines potential management response actions that may be appropriate if an action level is exceeded; however, the potential actions described herein are not an all-inclusive list. The list is designed to show the types of actions that may be appropriate depending on the action level exceeded (low, medium or high) and the level of environmental risk. Management actions to be completed in response to the exceedance of an action level will be defined on a case by case basis depending on the water quality variable or biological variable for which an action level has been exceeded and the implications of exceeding the action level.

The primary response action associated with triggering any action level will be the submission of the Response Plan to the WLWB for approval. As described in Section 4.1, each Response Plan will be written to satisfy the requirements of Schedule 8, Item 4 of W2012L2-0001 outline the methods used to determine that the action level was exceeded, describe the variable, its relation to the Significance Thresholds, and the ecological implications of the action level exceedance, describe the likely cause of the action level exceedance, and describe planned actions including justification and timelines. Other information will be included as necessary. Examples of possible planned actions are described below.

4.2.1 Low Level Actions

A specific response action associated with triggering a low action level will be to set medium and high action levels. In some cases setting the high action level may be deferred if specific and appropriate rationale is provided (e.g., additional research is required). Additional management response actions upon exceeding a low action level will be largely investigative. Other actions that may be appropriate when exceeding a low action level may include but are not limited to:

- an investigation to verify the source(s) of observed change;
- an estimation of whether a water quality variable is expected to exceed its benchmark, and when. Depending on the variable and watershed, this may be accomplished by different means, but may include updates to water quality models to provide increased confidence in the water quality predictions as the number of years of monitoring data available increases;
- the planning or initiation of an issue-specific information collection program, ecological risk assessment, or study to define the magnitude, spatial extend and reversibility of the effect;
- a review of the water quality benchmark or development or update of an SSWQO as new and relevant science becomes available; or
- the identification of possible mitigation options.

4.2.2 Medium and High Level Actions

High action levels have not been predefined; therefore, if a medium action level is exceeded a high action level will be defined (if not previously defined upon exceeding a low action level). Additional management response actions upon exceeding medium or high action levels may involve greater intervention and may be based on options identified during investigations when the low action level was exceeded. Other actions that may be appropriate when exceeding a medium or high action level may include but are not limited to:

- an investigation to verify the source(s) of change measured;
- a more in-depth investigation of mitigation options which may include experimentation or small-scale tests;
- the initiation of an issue-specific information collection program, ecological risk assessment, or a study to define the magnitude, spatial extend and reversibility of the effect;
- a review of the water quality benchmark or development or update of an SSWQO as new and relevant science becomes available;
- selecting, planning for, and implementing a mitigation option such as modification of management plans (e.g., wastewater and processed kimberlite management plan), modification of water management practices (e.g., pumping rates and timing), or design and construction of mitigation structures or facilities; or
- an assessment of the effectiveness of implemented mitigation options as part of the Response Plans for the specific variable in question.

4.3 RESPONSE PLAN REVIEW AND AMENDMENT

The implementation, status and results of the management actions associated with each approved Response Plan will be presented in the annual AEMP Summary Report, or as otherwise approved by the WLWB. The Response Plan for a specific water quality or biological variable will be amended each time a new action level is exceeded, as per the schedule in Table 3.4-3. An amendment or update may also be required, if appropriate, requesting completion of a Response Plan that is no longer necessary because the water quality or biological variable no longer exceeds an action level based on the requirements outlined in the Response Plan.

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Appendix 1

Detailed Methods for Determining Phytoplankton, Zooplankton and Benthos Biomass and Total Density Benchmarks

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Appendix 1. Detailed Methods for Determining Phytoplankton, Zooplankton and Benthos Biomass and Total Density Benchmarks

Benchmarks for phytoplankton, zooplankton, and lake benthos variables are based on modeled distributions of baseline and reference lake observations and the probability of observations within the lower and upper extremes of the modeled distributions for baseline and reference data. A *p* value of 0.05 for both the upper and lower quantiles of the best fit distribution was used to determine the benchmark values for each variable. Benchmarks are set as a range, meaning that if an observation (e.g., average 2013 phytoplankton density) is less than the lower benchmark or greater than the upper benchmark, the benchmark is exceeded.

The data used to fit to the distributions included:

- reference lake observations prior to 2012 for Nanuq, Counts and Vulture lakes;
- baseline observations prior to 1998 for Leslie, Moose, Nema and Slipper lakes, and sites S2 and S3 in Lac de Gras; and
- baseline observations prior to 2001 in Cujo Lake and site LdS1 in Lac du Sauvage.

Kodiak Lake data were excluded because of the history of effects in the lake related to historical mine influences. Only observations prior to 2012 were included for the reference lakes because observations from the three most recent years (2012 to 2014) are considered when determining whether an action level has been exceeded for a biological variable (see Section 3.2.3.1). Therefore, the data from 2012 to 2014 cannot also be included in the data used to determine the benchmark.

Probability distributions were fit to the selected reference and baseline data using the R fitdistrplus package (R version 2.15.2; fitdistrplus version 1.0-1) (R Development Core Team 2009). The **plotdist** function was used to plot the empirical distribution for each variable. Distributions were plotted as continuous variables (Figure 1 – top).

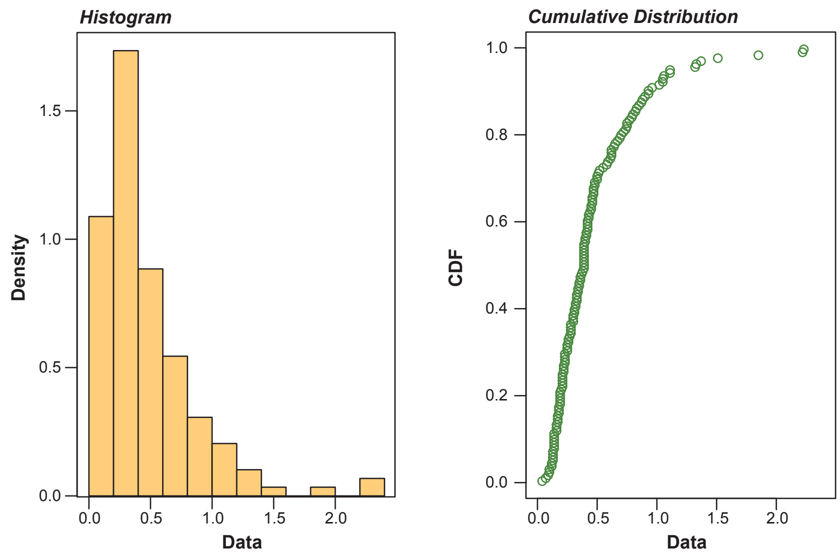
Descriptive statistics were used to help choose the best theoretical distribution to describe an empirical distribution by using the function **descdist** which provides calculations of descriptive statistics (i.e., minimum, maximum, median, mean, sample standard deviation) and estimations of skewness and Pearson's kurtosis values for the empirical distribution. **Descdist** also creates a skewness-kurtosis plot (Cullen and Frey graph) which displays skewness and kurtosis values for common distributions (lognormal, weibull, normal, uniform, logistical, exponential, gamma and beta) and can be used as a tool to help choose the appropriate candidate distributions to fit to the dataset. To take into account the uncertainty of the estimated values of skewness and kurtosis, data were bootstrapped 1000 times and these bootstrapped skewness and kurtosis values are those that are reported on the skewness-kurtosis plot (Figure 1 – middle).

The function **fitdist** was then used to fit candidate distributions to the dataset. Four goodness of fit plots are provided (Figure 1 - bottom) as well as summary statistics such as parameter estimates with estimated standard errors computed from the estimate of the Hessian matrix at the maximum likelihood solution, correlation matrix between parameter estimates, the log-likelihood, the Akaike information criterion and Bayesian information criteria (also known as Schwarz criterion) (AIC and BIC). Goodness of fit plots were visually assessed and the best fitting distribution was chosen based on professional judgement and a comparison of AIC and BIC values among the candidate distributions.

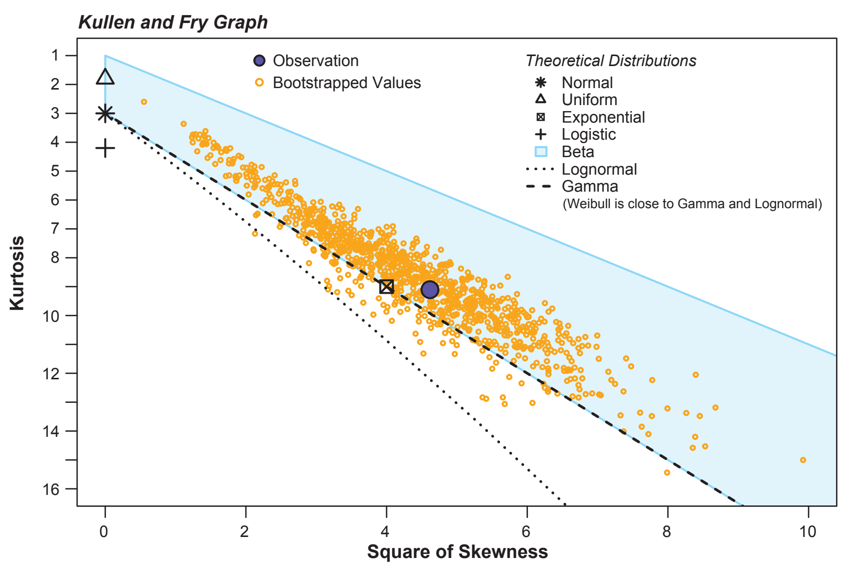
Figure 1

Example of Empirical and Theoretical Distribution Fit, Phytoplankton Biomass

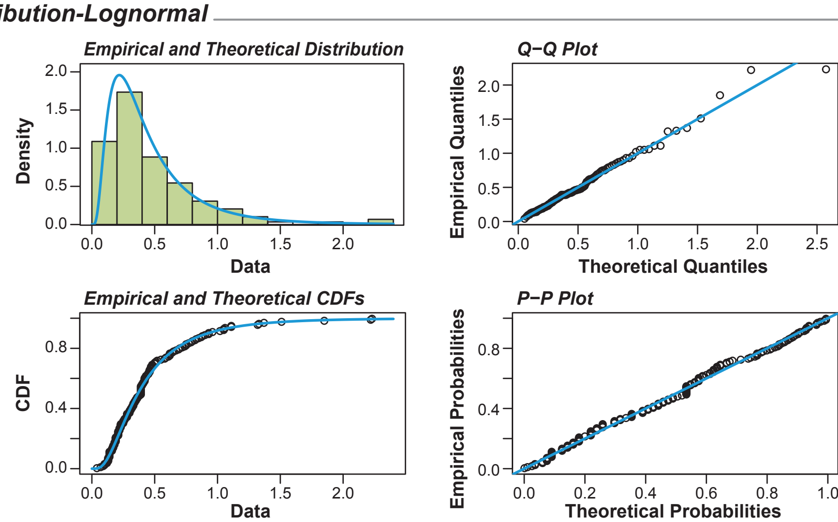
Empirical Distribution



Skewness-Kurtosis Plot



Best Fit Distribution-Lognormal



Once the best fitting distribution was selected, the quantiles at (p = 0.05) were calculated for the upper and lower tails. These quantiles represent the upper and lower ends of the range for the benchmark for each biological variable being assessed.

Table 3.2-3 in Section 3.2 of the main body of the Aquatic Response Framework report provides the benchmark numbers for phytoplankton, zooplankton and lake benthos.