A Review of the Adequacy of Baseline Water Quality Data and Mitigation of Mining Impacts in the Vicinity of the New Prosperity Gold-Copper Mine Project, British Columbia

Prepared for:

Tsilhqot'in National Government
for the New Prosperity Panel Hearings
Williams Lake, July 2013

Prepared July 22, 2013, by:

D.D. MacDonald, A. Schein, and J.A. Sinclair
MacDonald Environmental Sciences Ltd. -
Pacific Environmental Research Centre
#24 - 4800 Island Highway North
Nanaimo, B.C. V9T 1W6

and

J. Stockner
UBC Fisheries Centre & Eco-Logic Ltd.
2614 Mathers Avenue
West Vancouver, B.C. V7V 2J4

Contents

List of Acronyms iii

1.0 Introduction 1

2.0 Evaluation of the Adequacy of Baseline Water Quality Data 3

2.1 Inadequacies of Baseline Water Quality Data for Streams and Rivers 3

2.2 Inadequacies of Baseline Water Quality Data for Lakes near the Mine Site 6

2.3 Inadequacies of Baseline Sediment Quality Data 8

2.4 Inadequacies of Water Quality Model and Predictions of Future Water Quality Conditions 10

2.5 Inadequacies of the Baseline Watershed Model 13

2.6 Inadequacies of Baseline Characterization of Dissolved Oxygen and Temperature 15

3.0 Adequacy of Evaluations of Water Quality During Mine Construction, Operations, and Closure 16

3.1 Inadequacies of the Approach Used to Select Water Quality Guidelines 16

3.2 Inadequacies of Selection of Water Quality Guidelines 17

3.3 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake 18

3.4 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Beece Creek and Taseko River 20

3.5 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Lower Fish Creek 21

3.6 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Wasp Lake, Little Onion Lake, and Big Onion Lake 21

3.7 Inadequacies of Water Quality Predictions - Selection of Locations 23

3.8 Inadequacies of Water Quality Predictions - Interpretation Using Toxicity Reference Values and/or Ecological Screening Values 23

3.9 Inadequacies of Water Quality Predictions - Interpretation Using Biotic Ligand Modelling 25

3.10 Inadequacies of Water Quality Predictions - Selection of Time Periods 26

3.11 Inadequacies of Water Quality Predictions - Evaluation of Effects of Chemical Mixtures 27

3.12 Inadequacies of Predictions of Mine-Related Effects on Hydrological Conditions 27

3.13 Inadequacies of Characterization of the Food Web 31

3.14 Inadequacies of Water Quality Predictions - Evaluation of Cumulative Within-Project Effects 34

3.15 Inadequacies of Determination of Significant Residual Effects 36

3.16 Inadequacies of Mitigation and Adaptive Management Plans 38

3.17 Inadequacies of Planned Water Quality and Aquatic Ecology Monitoring Program 41

4.0 Overall Conclusions 42

5.0 References Cited 46

Curriculum Vita:

Donald MacDonald
Allison Schein
Jesse Sinclair
John Stockner

List of Acronyms

-d	day
°C	degrees Celsius
µg/L	microgram per litre
µm	micrometre
AMP	adaptive management plan
ASTM	American Society for Testing and Materials
BACI	before-after-control-impact
BCEAO	British Columbia Environmental Assessment Office
BCMOE	British Columbia Ministry of Environment
BLM	biotic ligand model
CCME	Canadian Council of Ministers of the Environment
CEAA	Canadian Environmental Assessment Agency
COPC	chemical of potential concern
DFO	Fisheries and Oceans Canada
EA	environmental assessment
EIS	environmental impact statement
ESV	ecological screening value
ECx	effective concentration
ICx	inhibitory concentration
ISQG	interim sediment quality guideline
KPL	Knight Piésold Ltd.
L	litre
LC_{50}	lethal concentration affecting 50% of the population
LSA	local study area
m	metre
mm	millimetre
masl	metres above sea level
m^3/s	cubic metre per second
MESL-PERC	MacDonald Environmental Sciences Ltd.-Pacific Environmental Research Centre
mg	milligram
mm	millimetre
PAG	potentially acid generating
PAH	polycyclic aromatic hydrocarbon
PCA	principal component analysis
PEL	probable effect level
ppm	parts per million
PRS	project report specifications
RSA	regional study area
SEM-AVS	simultaneously extracted metals and acid volatile sulfide

SIR	Supplemental Information Request
SQG	sediment quality guideline
SRK	SRK Consulting
TECL	Triton Environmental Consultants Ltd.
TML	Taseko Mines Ltd.
TNG	Tsilhqot'in National Government
TRV	toxicity reference value
TSF	tailings storage facility
TSS	total suspended solids
USEPA	United States Environmental Protection Agency.
WQG	water quality guideline

1.0 Introduction

The New Prosperity Gold-Copper Mine project (which is located 125 km southwest of Williams Lake, B.C.) is subject to review under the *Canadian Environmental Assessment Act*. In a report released in 2010, a Federal Review Panel concluded that the original Prosperity Gold-Copper Mine project would have significant effects on fish and fish habitat, on navigation, on the current use of lands and resources by First Nations, on cultural heritage, and on certain potential or established Aboriginal rights or title, as well as other land and water uses in the region. In response to the results of the Federal Review Panel, the Proponent (Taseko Mines Ltd.; TML) revised the mine development plan and submitted a project description for the New Prosperity Mine to the Canadian Environmental Assessment Agency (CEAA) in 2011. In addition, TML submitted an Environmental Impact Statement (EIS) for the project to the CEAA in 2012 (TML 2012). The CEAA reviewed the submission relative to the EIS Guidelines (CEAA 2012) it had created, which provided TML with a list of information requirements for the EIS. The CEAA's Federal Review Panel then identified a number of deficiencies in the EIS and provided TML with a number of associated information requests to address these deficiencies in December 2012 (New Prosperity Gold-Copper Mine Project Federal Review Panel 2012).

MacDonald Environmental Sciences Ltd.-Pacific Environmental Research Centre (MESL-PERC) was retained by the Tsilhqot'in National Government (TNG) to review those components of the EIS for the New Prosperity Gold-Copper Mine project that related to water quality conditions in the vicinity of the mine. The key questions that were addressed in this review included:

- Are the available data and information adequate to determine baseline water quality conditions in the vicinity of the proposed mine site?
- Have baseline water quality conditions been adequately characterized in the documents that have been submitted to CEAA?
- Are the predictions of future water quality conditions in the vicinity of the proposed mine site scientifically defensible?
- Have the effects of the proposed changes in water quality conditions been adequately described and evaluated?

This report was prepared to provide the TNG with an evaluation of the EIS relative to the characterization of baseline conditions and the predictions of the effects of the project on water quality conditions in the vicinity of the mine. Below we detail the deficiencies in the EIS with respect to the following topics.

- Evaluation of the adequacy of baseline water quality data, including:
    - Inadequacies of Baseline Water Quality Data for Streams and Rivers;
    - Inadequacies of Baseline Water Quality Data for Lakes near the Mine Site;
    - Inadequacies of Baseline Sediment Quality Data;
    - Inadequacies of Water Quality Model and Predictions of Future Water Quality Conditions;
    - Inadequacies of the Baseline Watershed Model; and,
    - Inadequacies of Baseline Characterization of Dissolved Oxygen and Water Temperature.

- The adequacy of evaluations of water quality during mine construction, operations, and closure, including:
    - Inadequacies of the Approach Used to Select Water Quality Guidelines;
    - Inadequacies of Selection of Water Quality Guidelines;
    - Inadequacies of Water Quality Predictions - Interpretation Using Water Quality Guidelines: Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake;
    - Inadequacies of Water Quality Predictions - Interpretation Using Water Quality Guidelines: Beece Creek and Taseko River;
    - Inadequacies of Water Quality Predictions - Interpretation Using Water Quality Guidelines: Lower Fish Creek;
    - Inadequacies of Water Quality Predictions - Interpretation Using Water Quality Guidelines: Wasp Lake, Little Onion Lake, and Big Onion Lake;
    - Inadequacies of Water Quality Predictions - Selection of Locations;
    - Inadequacies of Water Quality Predictions - Interpretation Using Toxicity Reference Values/Ecological Screening Values;
    - Inadequacies of Water Quality Predictions - Interpretation Using Biotic Ligand Modelling;
    - Inadequacies of Water Quality Predictions - Selection of Time Periods;
    - Inadequacies of Water Quality Predictions - Evaluation of Effects of Chemical Mixtures;
    - Inadequacies of Predictions of Mine-Related Effects on Hydrological Conditions;
    - Inadequacies of Characterization of the Food Web;
    - Inadequacies of Water Quality Predictions - Evaluation of Cumulative Within-Project Effects;
    - Inadequacies of Determination of Significant Residual Effects;
    - Inadequacies of Mitigation and Adaptive Management Plans; and,

- Inadequacies of Planned Water Quality and Aquatic Ecology Monitoring Program.

2.0 Evaluation of the Adequacy of Baseline Water Quality Data

2.1 Inadequacies of Baseline Water Quality Data for Streams and Rivers

Baseline water quality conditions in the vicinity of the New Prosperity Mine site are described in Section 2.6.1.4 of the EIS (TML 2012). This section of the EIS refers to Appendix 5-2-A of the March 2009 EIS/Application for the Taseko Prosperity Gold-Copper Project for more detailed information on baseline water quality conditions (Water Quality and Aquatic Ecology; TML 2009). Sections 2.6.1.4 of the EIS and Appendix 5-2-A were reviewed to evaluate the description of baseline conditions in the vicinity of the proposed mine site.

Within the regional study area (RSA), water, sediment, and biological tissues have been sampled to evaluate baseline conditions in the vicinity of the New Prosperity Mine site. Data and information collected between 1992 and 1996 were characterized as pre-project report specifications (pre-PRS), obtained prior to obtaining regulatory input on the design of the baseline sampling program (e.g., input on sampling stations and methods). Post-PRS data were collected between 1997 and 2008 at specified sampling stations using methods that met regulatory requirements (as specified in the PRS; BCEAO 1998, as referred to in the EIS). Following the decision to adjust the location of the Tailings Storage Facility (TSF), the Proponent expanded the spatial scope of the baseline data collection program to include Fish Lake and its tributaries (i.e., in 2011 and 2012).

Baseline water quality data were collected at a total of 24 sampling stations on streams and rivers in the vicinity of the mine site, with a total of 1,167 surface water samples (total of 1,084 given in Table 2.6.1.4A-1 of TML [2012] is incorrect) collected at these sampling stations (i.e., lotic sampling stations). Eleven (11) of these sampling stations were selected because surface waters at that location had the potential to be affected by the project development. A total of 698 surface water samples were collected at these locations. The other 13 sampling stations were selected to support determination of reference conditions on a regional basis. A total of 469 surface water samples were collected at the reference stations (see Table 2.6.1.4A-1 of TML [2012] for more information).

Baseline water quality conditions in the stream systems located near the New Prosperity Mine site are described in Section 2.6.1.4 of TML (2012) and in Appendix 5-2-A of TML (2009). Most of the baseline surface water chemistry data for the stream systems in the Taseko River basin were collected prior to May, 1997 (i.e., prior to issuance of the PRS by the British Columbia Environmental Assessment Office [BCEAO]; See Table 2-2 of Appendix 5-2-A; TML 2009). As these earlier data were largely generated using less sensitive analytical methods (i.e., detection limits that were up to 200 times higher than those achieved for the post-PRS data), and had a number of quality assurance issues (i.e., extended holding times, absence of systematic collection of replicates and blanks), data collected prior to May, 1997 must be used with caution and may not be appropriate for determining baseline water quality conditions in receiving waters in the vicinity of the New Prosperity Mine site.

With such limitations on the use of the pre-PRS data, it is not apparent that the existing surface water chemistry data are sufficient to adequately characterize baseline conditions, including temporal and spatial variability in water quality conditions (i.e., data collected between May, 1997 and October, 2006 are limited and were collected only during 1997, 1998 and 2006). While TML (2012) indicated that additional data were collected at selected locations in 2008, 2011, and 2012, we were unable to locate the supplemental data in the EIS, other than for three tributaries to Fish Lake sampled in July 2011 and February 2012, and two tributaries sampled in October 2011 (eight samples; Appendix 2.7.2.4B-C).

Section 2.3.1.3 of Appendix 5-2-A from TML (2009) described the results of baseline monitoring of stream water quality. However, the analysis of temporal or spatial variability in water quality conditions is not robust (i.e., comparisons over time and between stations were only presented for selected water quality variables and stations; Figures 2-3 to 2-14 from Appendix 5-2-A, which show seasonal and inter-annual variations for selected variables, were not printed in the 2009 EIS available online [only their captions were given]). Hence, baseline water quality conditions in streams in the vicinity of the New Prosperity Mine site are only incompletely characterized.

The Proponent conducted principal component analysis (PCA) and discriminate analysis to assess water quality conditions. Results of the PCA indicated there are three groups of streams in the study area, including the Taseko River (higher levels of turbidity and metals; lower levels of hardness and major ions), Fish Creek (higher levels of nutrients and nickel), and all of the remaining streams. Accordingly, the other streams will not likely serve as appropriate reference streams for evaluating the effects of the mine on water quality conditions in Fish Creek or in the Taseko River. The impact assessment will need to focus on a before-after evaluation, rather than the more robust before-after-control-impact (BACI-type) design. This limitation emphasizes the importance of establishing baseline water quality conditions in Fish Creek and the Taseko River with a high level of confidence and statistical power. The existing water quality data for these water bodies do not provide a sufficient basis to evaluate long-term effects on water quality conditions.

Conclusions: The baseline water quality data for stream systems in the vicinity of the New Prosperity Mine site are inadequate to support accurate predictions of future water quality conditions. As a first step toward compiling an adequate baseline dataset, performance criteria for measurement data need to be established, including performance criteria for analytical precision, analytical accuracy, and analytical sensitivity (i.e., detection limits) for each analyte. Then, the existing data need to be evaluated to facilitate identification of usable data. Subsequently, usable data should be used to estimate baseline conditions for each location for relevant periods of the hydrograph (e.g., low, moderate, and high flow conditions), with results reported for total and dissolved concentrations when appropriate. As these things have not been done, there is no basis for concluding that an adequate amount of good quality data is available to characterize the baseline water quality conditions in streams and rivers. On the contrary, our evaluation of the available data indicates that the vast majority of the results were generated using inappropriate methods and insufficient quality assurance. Hence, these data are of limited value for defining baseline conditions.

The timing and quantity of sampling events were not sufficient to evaluate temporal variability in baseline data. At minimum, data for evaluating baseline conditions should include three full years of monitoring at the key sampling stations, including monthly sampling each year and two 5 samples-in-30 days sampling events in each year (i.e., during high flow and low flow). The number and location of sampling stations need to be adequate to apply a BACI-type design to evaluate project-related effects in each of the potentially-affected water courses and stream reaches. At each sampling station and sampling date, data must be collected on conventional water quality variables (e.g., dissolved oxygen, water hardness, alkalinity, etc.), major ions, dissolved organic carbon, nutrients, and metals (dissolved and total). As these things have not been done, an accurate description of the current baseline conditions is not available for the streams and rivers in the vicinity of the New Prosperity Mine site.

2.2 Inadequacies of Baseline Water Quality Data for Lakes near the Mine Site

Baseline water quality data were collected at a total of 13 lake sampling stations in the vicinity of the mine site. A total of 72 surface water samples were collected at the sampling stations (i.e., an average of 5.5 samples per station). Four (4) of these sampling stations were selected because surface waters at that location had the potential to be affected by the project development. A total of 47 surface water samples were collected at these locations. The other nine (9) sampling stations were selected to support determination of reference conditions on a regional basis. A total of 25 surface water samples were collected at the reference stations (See Table 2.6.1.4A-2 of TML 2012 for more information).

Baseline water quality conditions in the lakes located nearby the New Prosperity Mine site are described in Section 2.6.1.4 of TML (2012) and in Appendix 5-2-A of TML (2009). Most baseline surface water chemistry data for the lakes within the Taseko River basin were collected prior to May, 1997 (i.e., prior to issuance of the PRS by the BCEAO; 41 of 72 surface water samples from lakes; according to Table 2-6 and Appendix Table C3 of Appendix 5-2-A; TML 2009). As these earlier data were largely generated using less sensitive analytical methods (i.e., detection limits that were up to 200 times higher than those achieved for the post-PRS data) and had a number of quality assurance issues (i.e., extended holding times, absence of systematic collection of replicates and blanks), data collected prior to May, 1997 must be used with caution and may not be appropriate for determining baseline water quality conditions in receiving waters in the vicinity of the New Prosperity Mine site. The EIS does not do a good job of compiling and displaying data in its entirety. For example, Table 2.6.1.4A-2 and the text in TML (2012) state that there were 72 surface water samples collected from lakes, while Appendix Table C3 (Appendix 5-2-A; TML 2009) shows 80 samples that were collected from lakes.

The EIS (TML 2012) indicates that sampling in lakes has been extensive. However, collection of 72 surface water samples to characterize water quality conditions in 13 lakes is anything but extensive. With the limitations on the use of the pre-PRS data, it is not apparent that the existing surface water chemistry data are sufficient to adequately characterize baseline conditions, including temporal and spatial variability in water quality conditions (i.e., data collected between May, 1997 and October, 2006 are limited and were collected only during 1997, 1998 and 2006). During the period 1993 to 2006, sampling frequency ranged from 0 to 3 sampling dates/year for the 13 lakes that were included in the baseline sampling program, making evaluation of temporal variability in water quality conditions in each lake virtually impossible. TML (2012) indicated that additional data were collected at selected locations in 2008, 2011, and 2012, and at least some of these data are presented in Appendix 2.7.2.4B-C, but it is unclear whether they were used in the analysis of baseline conditions.

Section 2.3.2.3 of Appendix 5-2-A of TML (2009) described the results of baseline monitoring of water quality in lakes located nearby the proposed mine site. More specifically, this section of the Prosperity EIS compared measurements of conventional water quality variables (e.g., pH, turbidity), nutrients, and metals among the lakes that were sampled. In addition, the water chemistry data (conventionals, nutrients, and iron) for Fish Lake were compared for the epilimnetic, metalimnetic, and hypolimnetic zones. However, detailed analyses of the data to establish baseline levels of key water quality variables were not conducted. Importantly, the data for each lake were not segregated into open-water and under-ice periods prior to data analysis. No analysis of the earlier water chemistry data (i.e., 1993 - 2006) or more recent water chemistry data (2008 - 2012) was located in TML (2012), other than reference to Appendix 5-2-A from TML (2009) and in Appendices 2.7.2.4B-A and 2.7.2.4B-C. Hence, baseline water quality conditions in lakes in the vicinity of the New Prosperity Mine site are only incompletely characterized.

<u>Conclusions:</u> The baseline water quality data for lakes in the vicinity of the New Prosperity Mine site are inadequate to support accurate predictions of future water quality conditions. As a first step towards compiling an adequate baseline dataset, performance criteria for measurement data need to be established, including performance criteria for analytical precision, analytical accuracy, and analytical sensitivity (i.e., detection limits) for each analyte. Existing data then need to be evaluated to facilitate identification of usable data. Usable data should be used to estimate baseline conditions for each location for relevant periods of the year (e.g., open-water and under-ice), with results reported for total and dissolved concentrations when appropriate. As these things have not been done, there is no basis for concluding that an adequate amount of data is available to characterize the baseline water quality conditions in lakes. On the contrary, our evaluation of the available data indicates that the majority of the results were generated using inappropriate methods and insufficient quality assurance. Hence, these data are of limited value for defining baseline conditions.

The timing and quantity of sampling events were not sufficient to evaluate temporal variability in baseline data. At minimum, the dataset for evaluating baseline conditions should include three full years of monitoring at the key sampling stations, including monthly sampling during open water each year, quarterly sampling under ice, and two 5-samples-in-30 days sampling events in each year (i.e., during open-water and under-ice). The number and location of sampling stations need to be adequate to apply a BACI-type design to evaluate project-related effects in each of the potentially-affected lakes. At each sampling station and sampling date, data must be collected on conventional water quality variables (e.g., dissolved oxygen, water hardness, alkalinity, etc.), major ions, dissolved organic carbon, nutrients, and metals (dissolved and total). As these things have not been done, an accurate description of the current baseline conditions is not available for lakes in the vicinity of the New Prosperity Mine site.

2.3 Inadequacies of Baseline Sediment Quality Data

A total of 249 sediment samples have been collected to evaluate baseline sediment quality conditions in streams and rivers located in the vicinity of the New Prosperity Mine site (see Table 2.6.1.4A-1 of TML 2012). Of these, it appears that 139 sediment samples were collected from nine sampling stations located in areas with the potential to be directly affected by the project. Another 110 sediment samples were collected at the nine selected reference stations. All of the lotic sediment chemistry data were collected between 1994 and 2006.

A total of 73 sediment samples were collected to evaluate baseline sediment quality conditions in lakes located in the vicinity of the New Prosperity Mine site (see Table 2.6.1.4A-2 of TML 2012). Of these, it appears that 38 sediment samples were collected from four (4) sampling stations located in areas with the potential to be directly affected by the project (i.e., Fish Lake, Little Fish Lake, Big Onion Lake, and Wasp Lake). Another 35 sediment samples were collected at the seven (7) selected reference stations. All lake sediment chemistry data were collected between 1995 and 1998.

Prior to analysis, the sediment samples that were collected from both stream and lake stations were sieved to <0.63 μm. The variables that were measured in the sediment samples obtained in the vicinity of the mine site included grain size, percent moisture, total organic carbon, and total metals.

The baseline sediment sampling program included many of the elements required to establish baseline conditions in the vicinity of the proposed mine site and to determine if such baseline conditions were sufficient to support aquatic life. However, there were a number of issues that limit the application of the data for establishing baseline sediment quality conditions. For example, simultaneously extracted metals and acid volatile sulfides (SEM-AVS), key indicators of the bioavailability of sediment-associated metals (USEPA 2005), were not measured in stream or lake sediment samples. Furthermore, petroleum hydrocarbons and other organic contaminants were not measured in any of the sediment samples collected in the vicinity of the proposed mine site.

Another problem with the sediment sampling program is that the sediment samples were sieved to <63 μm before analysis. This is a problem for a few reasons. First, guidance on methods for collection, storage, and manipulation of sediments for chemical and toxicological analysis states that sieving of the sediments prior to analysis is not recommended because the sieving process can alter the physicochemical characteristics of the sediment (USEPA 2001; ASTM 2013). If the intent of the sieving is to remove indigenous organisms or debris, the guidance also states that a 2.00 mm sieve is generally adequate to discriminate between sediment and other materials. It is not recommended to sieve sediments to <63 µm because the changes in metal chemistry may be significant (USEPA 2001; ASTM 2013). While procedures such as normalizing the sediment concentration to the <63 µm fraction may be useful in certain circumstances, generally sediment chemistry should be reported on a dry weight basis (MacDonald and Ingersoll 2003). In general, analytical methods for measuring the concentration of chemicals of potential concern (COPCs) in sediments specify analysis of the <2.00 mm fraction (e.g., USEPA method 3050b). Finally, sediment quality guidelines (SQGs) that have been promulgated by the Canadian Council of Ministers of the Environment (CCME) generally refer to the total concentration of the substance in surficial sediments on a dry weight basis, except where noted (CCME 1995). Importantly, all of the data used to generate the CCME SQGs reported concentrations of contaminants for the whole sediment or <2.00 mm fraction. Because the concentrations of metals in sediment samples are higher in the <63 µm fraction than they are in the <2.00 mm fraction (i.e., because the metals tend to associate most strongly with the clay fraction), the EIS (TML 2012) concludes, likely erroneously, that the concentrations of antimony, arsenic, chromium, iron, manganese, and nickel frequently exceed SQGs under baseline conditions. Accordingly, baseline sediment quality conditions have not been adequately characterized.

A variety of contaminants could be released into receiving waters due to activities conducted in the vicinity of the proposed New Prosperity Mine site, including nutrients, organic carbon, metals, petroleum hydrocarbons, and other substances. Many of these substances tend to form associations with particulate matter upon release to water and ultimately become associated with bed sediments in rivers, lakes, and streams. It is essential that baseline levels of these substances be established for those water bodies that may be affected by mining-related activities and those that will serve as reference areas.

Conclusions: The existing sediment chemistry data do not provide an adequate basis for establishing baseline conditions in the rivers, lakes, and streams located in the vicinity of the proposed mine site. Sediment sampling should have targeted the <2.00 mm fraction in all sediment samples and should have included the following analytes:

- Grain size;
- Percent moisture;
- Total organic carbon;

- Total metals (Using hydrofluoric acid, concentrated nitric acid, or aqua regia digestion);
- Mercury;
- Simultaneously extracted metals;
- Acid volatile sulfides;
- Parent and alkylated polycyclic aromatic hydrocarbons (PAHs); and,
- Total petroleum hydrocarbons.

The baseline sediment quality data are needed to support the effects assessment, with subsequent aquatic effects monitoring designed to confirm or refute predictions based on a BACI-type design. As appropriate baseline sediment chemistry data have not been collected, the Panel does not have an accurate characterization of baseline sediment quality conditions. In addition, it is not possible to accurately evaluate the potential effects of the project on sediment quality conditions.

2.4 Inadequacies of Water Quality Model and Predictions of Future Water Quality Conditions

According to TML (2012), two water quality models were used to predict how water quality conditions in the vicinity of the proposed New Prosperity Mine site could change as a result of mine construction, operation, and closure. Water quality conditions during the post-closure period were also predicted using the models. A mass balance model was used to predict water quality in Fish Lake, Fish Lake Tributary 1, Fish Creek Reach 8, the proposed TSF Lake, and Pit Lake. Subsequently, a detailed mixing point model (using a mass balance calculation approach) was used to predict future water quality conditions for the water bodies located outside and downstream of the delineated maximum disturbance area (i.e., for Wasp Lake, Big Onion Lake, Little Onion Lake, Beece Creek, Taseko River at Beece Creek, Lower Fish Creek, and the Taseko River at Fish Creek). In the description of the water quality modelling, TML (2012) refers to three appendices to the EIS, including:

- Appendix 2.7.2.4B-G (Knight Piésold Ltd.; KPL 2012a);
- Appendix 2.7.2.1-I (SRK Consulting; SRK 2012); and,
- Appendix 2.7.2.4B-F (Triton Environmental Consultants Ltd.; TECL 2012a).

According to Appendix 2.7.2.4B-G, KPL (2012a) created the water quality model to predict changes in surface water quality downstream of the project in Wasp Lake, Little Onion Lake, Big Onion Lake, Beece Creek, Lower Fish Creek, and Taseko River. Predictions of future water quality for these water bodies were developed using a simple mass balance approach that relies on baseline surface and groundwater quality data, predicted water quality for source areas, and flow rates and/or volume of the various water bodies. The sources of input variables are identified in KPL (2012a), as are model assumptions. For each water body, the minimum, mean (with standard deviation and covariance), and maximum concentrations of each of the selected water quality variables were estimated for each month, starting at the beginning of operations and ending in Year 100. We were unable to determine how the distributions of concentrations were calculated and what they consisted of (e.g., daily predictions). This information is needed to evaluate the estimates of contaminant concentrations and associated variability in the model (i.e., minimum, maximum, mean, standard deviation).

Water quality predictions are also presented in Appendix 2.7.2.1-I (Water Quality Prediction Results). More specifically, this appendix presents the predictions of water quality conditions, for 100 years, that appear to have been developed by SRK Consulting (SRK 2012) for the following water bodies:

- Tailing Storage Facility Pond;
- Tributary 1;
- Upper Fish Creek;
- Fish Lake;
- Open Pit;
- Ore Stock Pile;
- Non-PAG Stockpile;
- Crusher Pad;
- Plant Site;
- Mine Site Roads;
- Main Embankment Seepage Pond 1;
- Main Embankment Seepage Pond 2;
- West Embankment Seepage Pond; and,
- South Embankment Seepage Pond.

All results presented in this appendix are graphical representations of the predictions of concentrations of contaminants in the water associated with each facility. All results were approved by someone with the initials “DBM,” but the authors of the document were not identified. In addition, no tabulated results are provided. Furthermore, no descriptions are provided of the methods that were used, underlying assumptions, source terms, or uncertainty in the results. As a result, it is difficult to determine the level of confidence that can be placed in the predictions (i.e., are they correct ± 10%, 100%, 1000%, or something else). This represents a major shortcoming of the water quality modelling effort. As no authors of the documentation were identified, it was not possible to seek further information directly from the source of the predictions.

Water quality predictions are also presented in Appendix 2.7.2.4B-F, a report that was prepared by Triton Environmental Consultants Ltd. (TECL 2012a) on behalf of TML. Although the report is entitled Water Quality Modelling, it is not clear if TECL (2012a) conducted the water quality modelling or if they relied on the predictions that were developed by SRK Consulting (SRK 2012) and/or Knight Piésold Ltd. (KPL 2012a). Section 1.0 of TECL (2012a) indicates that a stochastic model was used to predict water quality nearby the mine site. However, no methods were described in the report. In the *Responses to the Technical Information Requests* dated July 17, 2013 (TML 2013), TML stated that Triton (TECL 2012a) relied on the water quality predictions in SRK (2012) and KPL (2012a).

Section 2.7 of the EIS (TML 2012; Pages 705 - 717) describes water quality models, but it is not clear that TML (2012) presents the same models or model results that were presented in KPL (2012a), SRK (2012), or TECL (2012a). While KPL (2012a), SRK (2012), and TECL (2012a) are referred to in Section 2.7 of TML (2012), it is not clear who developed each of the water quality predictions presented in TML (2012) or if those individuals were qualified to do the work. This limitation represents a major shortcoming of the EIS.

Conclusions: Predictions of changes in water quality associated with the construction, operation, and closure of the proposed New Prosperity Mine are an essential component of the overall environmental assessment. Failure to clearly document methods used to develop the predictions, or to identify the professionals who conducted the work, makes it difficult to evaluate the water quality conditions and determine the level of confidence that can be placed in them. The EIS should have included a detailed conceptual site model that described potential sources and releases of COPCs, the environmental fate of the COPCs, and the key exposure pathways for ecological receptors and humans using aquatic resources in the vicinity of the mine site. Furthermore, the models that were used to predict future water quality conditions should have been better identified and described, including a list of water quality variables evaluated (and associated rationale for selection), the input parameters for the model(s) (including uncertainty in the estimates of such parameters), the corrections that were applied, and the underlying assumptions. Critically, the uncertainty associated with the water quality models and associated predictions should have been explicitly described and discussed to provide the reader with an understanding of the level of confidence that can be placed in the modelling results. As the uncertainty associated with the water quality models was not described, the Panel cannot put a high level of confidence in the water quality predictions.

2.5 Inadequacies of the Baseline Watershed Model

The baseline hydrological characteristics of the Fish Lake watershed are described in Section 2.6.1.2 (Atmospheric Environment) and Section 2.6.1.4 (Water Quality and Quantity) of the EIS (TML 2012). In the description of the baseline hydrological conditions, TML (2012) refers to the following appendices:

- Appendix 4-4-D of the March, 2009 EIS/Application for the Taseko Prosperity Gold-Copper Project [Hydrometeorlogy Report; Knight Piésold Ltd. (KPL) 2007];
- Appendix 4-4-E of the March, 2009 EIS/Application for the Taseko Prosperity Gold-Copper Project (Meteorological Site Installation and Maintenance Report; KPL 2008);
- Appendix 2.6.1.4B-A (Baseline Watershed Model; KPL 2012b);
- Appendix 2.6.1.4D-A (Baseline Groundwater Hydrology Assessment; BGC Engineering Inc. 2012a);
- Appendix 2.7.2.4A-C (Numerical Hydrogeologic Analysis; BGC Engineering Inc. 2012b); and,
- Appendix 2.7.2.4A-D (Climate Change Assessment; KPL 2012c).

Therefore, these sections of the EIS and the listed appendices were reviewed to evaluate the description of baseline conditions in the vicinity of the proposed mine site.

Baseline hydrological conditions in the vicinity of the New Prosperity Mine site were characterized using a baseline watershed model (KPL 2012b). The baseline watershed model relied on site-specific meteorological data (rainfall and air temperature; no snow data) collected between October 2006 and September 2010, hydrometric data collected within the Fish Creek watershed in 2007, and meteorological and hydrometric data collected at the Williams Lake A regional climate station (KPL 2012b). The baseline model was developed using the observed correlations between the site-specific and regional dataset for both precipitation and air temperature. Using this model, monthly precipitation and air temperature in the vicinity of the New Prosperity Mine site were estimated for the period of 1979 to 2009 (these estimates of precipitation and air temperature were considered to represent the baseline dataset for the site). Precipitation and air temperature in the Fish Creek watershed were predicted at all elevations using the estimated site-specific dataset and a winter orographic precipitation rate of 10% per 1000 m and a temperature lapse rate of 5.8°C per 1000 m. Potential evapotranspiration was estimated using the Thornthwaite method, calculated using the average monthly temperature estimated from the model. Actual evapotranspiration rates for soil were estimated using a soil water balance model; actual evapotranspiration for Fish Lake was assumed to match the potential evapotranspiration rate. Other elements that would be considered important components of a water balance model (e.g., groundwater recharge, water available for runoff, groundwater flow between catchments, and surface water storage) were also included in the baseline watershed model.

The baseline watershed model was calibrated to (i.e., optimized to reflect) measured streamflow in 2006 and 2007 at three hydrometric stations in the following areas:

- H4d: Lower Fish Creek near the Taseko River confluence;
- H17b: upstream of Fish Lake on Upper Fish Creek; and,
- H6b: downstream of Fish Lake on Lower Fish Creek.

The calibrated model was used to estimate monthly flow estimates for the period of 1979 to 2009 for each sub-catchment of the watershed. The estimated flows predicted at three hydrometric stations reasonably matched the measured streamflow (from 2007) during most months of the year. However, the model did a poor job of predicting streamflow in the month of September, 2007. It was stated that the objective of the model was not to reproduce the measured streamflow, but instead to provide reasonable estimates of expected conditions. The watershed model also describes the flow conditions in the Fish Lake watershed to be highly variable as a result of watershed characteristics. However, the model does not account for extreme low-flow and high-flow events that are important in determining water quality.

Conclusions: The baseline watershed model was developed based on the observed correlations in climate data (i.e., precipitation and temperature) between the regional climate station (Williams Lake A) and the site meteorological station (M1). However, the methods and results of the statistical analyses performed to determine the conversion factors (precipitation factors: 0.93 to 1.02, calibrated to site-specific flows; temperature adjustment: -2.18°C) are not presented and, therefore, the robustness of the method cannot be evaluated. Additionally, the streamflow data used to calibrate the model are inadequate. These data were collected in 2006 and 2007 at only three hydrometric stations. There has been no evaluation of extreme low-flow or extreme high-flow conditions (i.e., characterization of frequency and/or magnitude), even though the EIS Guidelines (CEAA 2012) specifically require inclusion of "the entire range of the water quality and quantity data in addition to mean values, because identification of extreme events that have serious environmental consequences may not be captured from the dataset when using only mean values." Furthermore, there has been no direct evaluation of the inter-annual variability in streamflow. Additional data from a minimum of three years would be needed to evaluate the variability in streamflow across multiple years. No evaluation of the inter-annual variability in the relationship between site-specific precipitation and streamflow or sensitivity analyses of the relationship between the regional and site-specific climate data were presented. Without the methods and results of the statistical analyses being presented and a sensitivity analysis being performed to determine the extreme (i.e., 5th and 95th percentile) monthly flows for the baseline watershed model, one cannot put a high degree of confidence in the accuracy of this model.

The characterization of the site-specific baseline precipitation is based on the collection of rainfall data only (i.e., does not include snow as precipitation). This limitation in methodology substantially increases the uncertainty of the baseline characterization and subsequent development of the water balance for the proposed site. The characterization of hydrological conditions in the Fish Creek watershed is inadequate and incomplete because it did not include the measurement of precipitation as snow.

The characterization of the unit area run-off for the Fish Creek watershed is extrapolated from data collected from three hydrometric stations (H17b, Upper Fish Creek; H6b, Lower Fish Creek downstream of the ore body; and, H4c, Fish Creek at the Taseko River). Areas that have not been sampled, but are important components of rainbow trout habitat (i.e., Fish Lake Tributary 1), should have been directly characterized to ensure that an accurate description of habitat size and quality was included to support the assessment of project-related effects and was considered in the development of the mitigation and compensation plan.

2.6 Inadequacies of Baseline Characterization of Dissolved Oxygen and Temperature

Fish Lake, which supports a healthy population of rainbow trout, is a dimictic lake, stratifying in both the summer and winter. It is stated in the description of the existing environment that dissolved oxygen concentrations were low in the winter; however, few data were collected to characterize baseline conditions. One temperature and dissolved oxygen profile was taken in Fish Lake on August 26, 1994. Measured water temperature was 16°C at the surface and 7.3°C at the bottom (11 m), with a weak thermocline at 6 m. Dissolved oxygen decreased from 99% saturation at the surface to 64% saturation at the bottom, with the largest drop occurring between 2 and 4 m depth (Hallam Knight Piesold Ltd. 1995). A dissolved oxygen and temperature profile was taken in Little Fish Lake on August 28, 1994. The temperature decreased from 16°C at the surface to 10°C at the bottom (5 m), with no thermocline. There was 97% saturation of dissolved oxygen at the surface and 71% saturation at the bottom (Hallam Knight Piesold Ltd. 1995). More recent data were collected in 2011 and 2012 in Fish Lake (TECL 2012b), with depth, temperature, and dissolved oxygen profiles collected in April, July, October, and February. In April, the concentration of dissolved oxygen under ice decreased to <5 ppm (33.5% saturation) at depths greater than 2.5 m. In July, the concentration of dissolved oxygen at a different station remained above 5 ppm until a depth of 6 m. Profiles developed at two stations in Fish Lake in October of 2011 show dissolved oxygen concentrations ranging from 7.66 ppm to 10.57 ppm throughout the water column. Dissolved oxygen profiles taken in February of 2012 under ice at the same two stations show dissolved oxygen concentrations falling below 5 ppm at a depth of 4 m (TECL 2012b).

Conclusions: The description of the existing environment does not include adequate characterization of the water temperature and dissolved oxygen concentrations in key aquatic habitats (i.e., Fish Lake, Upper Fish Creek, and Fish Lake Tributary 1). One cannot evaluate temporal variability with samples taken in different months in only one year. An adequate description of the existing aquatic habitat would include an evaluation of habitat quality in regards to water temperature and dissolved oxygen in key spawning areas during spawning, early life-stage development, and juvenile rearing, and in adult rearing areas throughout the year for salmonids (specifically rainbow trout). At minimum, three years of baseline data are required to characterize baseline conditions. Therefore, it is concluded that the existing baseline data are inadequate.

3.0 Adequacy of Evaluations of Water Quality during Mine Construction, Operations, and Closure

3.1 Inadequacies of the Approach Used to Select Water Quality Guidelines

The EIS Guidelines (CEAA 2012) state that the EIS must include a “prediction of the quality, over time, of water in all water bodies that could be impacted.” The results of the water quality predictions are presented in Section 2.7 of the EIS (TML 2012; Pages 717 - 746), with future water quality conditions predicted for four water bodies within the mine site (i.e., Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake) and six water bodies located downstream of the mine (i.e., Lower Fish Creek [2 stations], Taseko River [3 stations], Beece Creek, Big Onion Lake, Little Onion Lake, and Wasp Lake). The water quality predictions were compared to B.C. approved and working WQGs, CCME WQGs, and/or toxicity reference values (TRVs) from the literature.

Conclusions: It is important to compare predicted water quality in the vicinity of the proposed New Prosperity Mine site to the most applicable WQGs that are available. The EIS was not explicit about how the WQGs were selected for use in the environmental assessment. More specifically, a hierarchical approach should have been used to select the WQGs for each water quality variable, as follows:

- Approved B.C. WQGs;
- Working B.C. WQGs;
- CCME WQGs;
- WQGs from other Canadian jurisdictions; and,
- WQGs from other sources.

As this was not done, the comparisons made to different types of WQGs in the EIS are unreliable and not very useful. In addition, as explained further in Section 3.8, TRVs from the literature should not be considered to be equivalent to WQGs and should not be used in place of WQGs in the assessment.

3.2 Inadequacies of Selection of Water Quality Guidelines

As indicated above, predicted water quality conditions in the vicinity of the proposed New Prosperity Mine site were evaluated using numerical WQGs. In general, it appears that the approved and working WQGs for British Columbia were used preferentially in the EIS (TML 2012). However, it appears that WQGs for certain COPCs were not compiled and used in the assessment. More specifically, WQGs for the following substances were not located in the EIS in the section that was comparing predicted COPC concentrations with WQGs (the B.C. approved or working WQGs for these substances are included in parentheses):

- Nitrate (maximum = 32.8 mg/L; 30-day [-d] average = 3 mg/L);
- Nitrite (only maximum WQG presented, but not compared to predictions; 30-d average = 0.02 mg/L);
- Total Phosphorus (maximum = 5 to 15 µg/L);
- Chlorophyll *a* (maximum = 100 mg/m^2 for streams);
- Lead (WQGs compiled, but not compared to predictions; maximum = 0.063 mg/L; 30-d average = 0.0058 mg/L, at hardness of 82 mg/L);
- Thallium (Compared to predictions in one instance, but WQGs not compiled; maximum = 0.0017 mg/L; 30-d average = 0.0008 mg/L); and,
- Zinc (WQGs compiled, but not always compared to predictions; maximum = 0.033 mg/L; 30-d average = 0.0075 mg/L, at hardness of 82 mg/L).

In addition, chloride, total suspended solids (TSS), and turbidity were not addressed in detail in the EIS, even though these substances could be altered by mining-related activities. Chloride concentrations in Fish Lake are discussed only in the context of lake stratification (Section 2.7.2.4 in TML 2012), even though the chloride concentration is necessary for calculating the WQG for nitrite and should be included in water quality predictions for the different phases of mine life. In Section 2.7 (TML 2012), it was simply stated that the Proponent will attempt to minimize the introduction of sediment into local water bodies during construction by implementing a surface sediment and erosion control plan. TML (2012) says that monitoring will occur during construction to ensure TSS and turbidity stay below B.C. WQGs, but they do not say what will happen if these WQGs are exceeded.

Conclusions: British Columbia WQGs and related WQGs provide reliable tools for evaluating the potential effects of water quality changes on designated water uses in the vicinity of the proposed mine site. Failure to apply WQGs for certain COPCs or both maximum and 30-d average WQGs for certain COPCs represents a potentially significant limitation of the EIS. That is, effects of water quality changes on designated water uses are likely to be underestimated if certain COPCs are not considered or if all of the WQGs for certain COPCs are not considered. As predicted concentrations of all relevant COPCs have not been compared to WQGs for all water bodies in the vicinity of the mine, the data are inadequate to determine whether the proposed mine will have adverse effects on water quality. Furthermore, a plan needs to be in place for water treatment if monitoring finds that WQGs are exceeded at some point during mine operations, closure, or post-closure. Taseko provides some details about an adaptive management plan (AMP) in the Response to Supplemental Information Request 15/19/25/49a, but they are not satisfactory because of the following statement: “The proposed AMP included in this response is intended as an initial outline and concept. The final adaptive management plan and its associated threshold levels will be determined at the time of permitting and adjusted through-out its implementation.” This statement suggests that the threshold levels presented in the Response to Supplemental Information Request 15/19/25/49a could change at the permitting stage; it is impossible to assess the merits of the AMP when key components will change at a later date.

3.3 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake

Table 2.7.2.4B-14 of the EIS (TML 2012) presents the comparison of predicted water quality for Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake (Year 48 - 100 only) to the WQGs for the protection of aquatic life. The water quality predictions include minimum, average, and maximum values for selected COPCs for five time periods (Years 1-16, Years 17-20, Years 21-30, Years 31-47, and Years 48-100). Based on the information provided, it is not clear if the Tributary 1 identified is Tributary 1 to Fish

Lake or Tributary 1 to Upper Fish Creek. In the *Responses to the Technical Information Requests* (TML 2013), Taseko clarified that this is Tributary 1 to Fish Lake. Application of numerical WQGs typically requires an understanding of baseline water quality conditions for the water bodies under consideration (i.e., information on pH, temperature, water hardness, and/or form of the COPC is often required to calculate the WQGs that apply to a specific water body). In some cases, the WQGs for each of the three of the four water bodies under consideration are presented in Table 2.7.2.4B-14 (i.e., with the exception of Pit Lake), which were calculated using estimates of water hardness or pH under baseline conditions. In the case of fluoride, the WQG was incorrectly expressed as a greater than value (i.e., >1.25 vs. 1.25 mg/L). For iron, WQGs are presented for total and dissolved iron, but it is not clear which WQGs were used in the analysis. For mercury, two WQGs were presented: one assuming that methylmercury represents 0.5% of total mercury and one assuming that methylmercury represents 8% of the total mercury in the receiving water bodies. However, it was not clear which guideline was used in the evaluation of baseline water quality data or predictions of future water quality conditions. The level of methylmercury in each water body should have been measured during the characterization of baseline water quality conditions, so that the appropriate B.C. WQG could have been selected to facilitate reliable assessments of water quality conditions. Furthermore, this table does not include comparisons of water quality predictions to the selected WQGs for nitrate, nitrite, ammonia, phosphorus, or lead. For thallium and zinc, the comparisons to WQGs are incomplete because the WQGs for these substances were not fully compiled and applied. These limitations make it difficult to reliably document actual or predicted exceedances of WQGs for certain COPCs in various receiving water bodies. While the EIS shows that predicted water quality conditions for aluminum, arsenic, cadmium, iron, mercury, silver, sulphate, thallium, and vanadium will exceed WQGs during one or more stages of mine life (i.e., operations, closure, and/or post closure), the information needed to characterize or quantify the potential risks to aquatic life as a result of exceeding these WQGs is not provided.

Conclusions: Table 2.7.2.4B-14 of the EIS (TML 2012) presents essential information for evaluating the potential effects on aquatic organisms associated with changes in water quality conditions resulting from construction, operation, and closure of the proposed New Prosperity Mine. It is essential that reviewers of the EIS be able to compare the predictions of future water quality conditions to the WQGs for the protection of aquatic life. Such comparisons are also required to evaluate monitoring data collected at all stages of mine life. However, the way the data are displayed in the table makes them hard to interpret because the relevant water quality parameters (e.g., hardness, which is required for calculating certain WQGs) are not displayed for each water body. In addition, the table is missing the predicted concentrations of a number of relevant COPCs (e.g., lead, nitrate, nitrite) for comparison to WQGs. Therefore, this table does not give an adequate description of the predicted water quality in Fish Lake, Upper Fish Creek, Tributary 1, and Pit Lake at various stages of mine life, nor of the potential effects of such water quality alterations on aquatic life.

3.4 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Beece Creek and Taseko River

Table 2.7.2.4B-18 of the EIS (TML 2012) presents the comparison of predicted water quality for Beece Creek and three locations on the Taseko River (i.e., labeled Taseko 1, 2, and 3) to the WQGs for the protection of aquatic life. The water quality predictions include minimum, average, and maximum values for selected COPCs (i.e., aluminum, cadmium, copper, and iron) for five time periods. Application of numerical WQGs typically requires an understanding of baseline water quality conditions for the water bodies under consideration (i.e., information on pH, temperature, water hardness, and/or form of the COPC is often required to calculate the WQGs that apply to a specific water body). For cadmium, WQGs are presented that apply to two water hardness measures; however, it is not clear which WQG applies to which site. A range of WQGs is presented for copper, but it is not clear which WQG applies to which sampling station. Importantly, this table does not include comparisons of water quality predictions to the appropriate WQGs for numerous COPCs at the site. Furthermore, the three locations on the Taseko River for which water quality predictions were developed are not clearly identified in the table. These limitations make it difficult to evaluate the exceedances of WQGs for certain COPCs in various receiving water bodies.

Conclusions: Table 2.7.2.4B-18 of the EIS (TML 2012) presents essential information for evaluating the potential effects on aquatic organisms associated with changes in water quality conditions resulting from construction, operation, and closure of the proposed New Prosperity Mine. It is essential that reviewers of the EIS be able to compare the predictions of future water quality conditions to the WQGs for the protection of aquatic life. Such comparisons are also required to evaluate monitoring data collected at all stages of mine life. However, the way the data are displayed in the table makes them hard to interpret because the relevant water quality parameters (e.g., hardness) are not displayed for each water body. In addition, the table is missing the predicted concentrations of a number of relevant COPCs (e.g., lead, nitrate, nitrite, zinc) for comparison to WQGs. Therefore, this table does not give an adequate description of the predicted water quality in Beece Creek and Taseko River (at three unspecified locations) at various stages of mine life, nor of the potential effects of such water quality alterations on aquatic life.

3.5 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Lower Fish Creek

Table 2.7.2.4B-19 of the EIS (TML 2012) presents the comparison of predicted water quality for two locations on Lower Fish Creek (i.e., labeled Fish Creek 1 and 2) to the WQGs for the protection of aquatic life. The water quality predictions include minimum, average, and maximum values for selected COPCs for Years 48-100 (once the pit is allowed to spill over and flow into Lower Fish Creek). No results are presented for any of the time periods between Year 1 and Year 47 because no contact water from the Project is anticipated to enter Lower Fish Creek until Year 48, when the open pit is predicted to be full and to start discharging into Lower Fish Creek (TML 2013). Application of numerical WQGs typically requires an understanding of baseline water quality conditions for the water bodies under consideration (i.e., information on pH, temperature, water hardness, and/or form of the COPC is often required to calculate the WQGs that apply to a specific water body); however, the input values for these ancillary water quality variables are not identified in Table 2.7.3.4B-19. Furthermore, the two locations on Lower Fish Creek for which water quality predictions were developed are not clearly identified in the table. These limitations make it difficult to evaluate the exceedances of WQGs for certain COPCs in Lower Fish Creek.

Conclusions: Table 2.7.2.4B-19 of the EIS (TML 2012) presents essential information for evaluating the potential effects on aquatic organisms associated with changes in water quality conditions resulting from construction, operation, and closure of the proposed New Prosperity Mine. It is essential that reviewers of the EIS be able to compare the predictions of future water quality conditions to the WQGs for the protection of aquatic life. Such comparisons are also required to evaluate monitoring data collected at all stages of mine life. However, the way the data are displayed in the table makes them hard to interpret because the relevant water quality parameters (e.g., hardness) are not displayed for Lower Fish Creek. In addition, the table is missing the predicted concentrations of a number of relevant COPCs (e.g., lead, nitrate, nitrite, zinc) for comparison to WQGs. Therefore, this table does not give an adequate description of the predicted water quality in Lower Fish Creek (at two unspecified locations) during post-closure, nor of the potential effects of such water quality alterations on aquatic life.

3.6 Inadequacies of Water Quality Predictions - Interpretation Using WQGs: Wasp Lake, Little Onion Lake, and Big Onion Lake

Table 2.7.2.4B-20 of the EIS (TML 2012) presents the comparison of predicted water quality for Wasp Lake, Little Onion Lake, and Big Onion Lake to the WQGs for the protection of aquatic life. The water quality predictions include minimum, average, and maximum values for selected COPCs for five time periods (Years 1-16, Years 17-20, Years 21-30, Years 31-47, and Years 48-100). Application of numerical WQGs typically requires an understanding of baseline water quality conditions for the water bodies under consideration (i.e., information on pH, temperature, water hardness, and/or form of the COPC is often required to calculate the WQGs that apply to a specific water body). However, water body-specific WQGs are not presented in Table 2.7.2.4B-20. For cadmium, two WQGs were calculated, but these WQGs were not specifically identified as relevant for any water body. For copper, a range of WQG values are presented, making it impossible to determine what value or values apply to which water body. For fluoride, a calculated LC_{50} (lethal concentration affecting 50% of the population) is presented rather than the B.C. WQG, which is inconsistent with the intent of the comparison to WQGs. For iron, WQGs are presented for total and dissolved iron, but it is not clear which WQGs were used in the analysis. For mercury, two WQGs were presented: one assuming that methylmercury represents 0.5% of total mercury and one assuming that methylmercury represents 8% of the total mercury in the receiving water bodies. However, it was not clear which guideline was used in the evaluation of baseline water quality data or predictions of future water quality conditions. The level of methylmercury in each water body should have been measured during the characterization of baseline water quality conditions, so that the appropriate B.C. WQG could have been selected to facilitate reliable assessments of water quality conditions. Furthermore, this table does not include comparisons of water quality predictions to the selected WQGs for antimony, boron, cobalt, lead, lithium, thallium, vanadium, zinc, nitrate, nitrite, ammonia, or phosphorus. These limitations make it difficult to evaluate the exceedances of WQGs for certain COPCs in various receiving water bodies.

Conclusions: Table 2.7.2.4B-20 of the EIS (TML 2012) presents essential information for evaluating the potential effects on aquatic organisms associated with changes in water quality conditions resulting from construction, operation, and closure of the proposed New Prosperity Mine. It is essential that reviewers of the EIS be able to compare the predictions of water quality conditions to the WQGs for the protection of aquatic life. Such comparisons are also required to evaluate monitoring data collected at all stages of mine life. However, the way the data are displayed in the table makes them hard to interpret because the relevant water quality parameters (e.g., hardness) are not displayed for each water body. In addition, the table is missing the predicted concentrations of a number of relevant COPCs (e.g., lead, nitrate, nitrite, zinc) for comparison to WQGs. Therefore, this table does not give a useful description of the predicted water quality in Wasp Lake, Little Onion Lake, and Big Onion Lake at various stages of mine life, nor of the potential effects of such water quality alterations on aquatic life.

3.7 Inadequacies of Water Quality Predictions - Selection of Locations

In Tables 2.7.2.4B-14, 2.7.2.4B-18, 2.7.2.4B-19, and 2.7.2.4B-20, predictions of future water quality conditions were presented for various locations in the vicinity of the proposed New Prosperity Mine site. Three of these locations are on the Taseko River, two are on Lower Fish Creek, and one is on Fish Lake; however, the information provided is insufficient to determine if these locations correspond to one or more of the sampling stations included in the baseline water quality monitoring program. Importantly, it is not clear that the water quality predictions cover all of the locations (or stream reaches) that could be adversely affected by discharges from the mine site or mine-related facilities. In addition, the Big Onion Lake outlet was identified as potentially impacted by mining-related activities, but was not included in the water quality predictions. Therefore, it is not clear that the potential effects of mining-related activities on water quality conditions have been adequately evaluated.

Conclusions: Table 2-1 of Appendix 5-2-A of TML (2009) identifies the lake and stream stations that were selected for inclusion in the baseline monitoring program, including the rationale for their selection (i.e., Site Type: Control, Reference, or Impact). However, as it is not clear whether predictions of future water quality have been made at these same baseline stations, one cannot make a proper evaluation of how the proposed mine will affect water quality in numerous nearby water bodies.

3.8 Inadequacies of Water Quality Predictions - Interpretation Using Toxicity Reference Values and/or Ecological Screening Values

Section 2.7 of TML (2012) provides comparisons of the future concentrations of COPCs in receiving waters to selected published toxicity data, TRVs, and/or ESVs. According to the information provided in Section 2.7, this comparison was conducted because the guideline values typically reflect a factor of safety and are not always reflective of mitigating factors outside of water hardness. This section appears to indicate that the WQGs are not applicable for evaluating the potential effects of mining-related activities on the designated uses of receiving waters in the vicinity of the New Prosperity Mine site. That is, this section appears to be focused on deriving site-specific water quality objectives that would provide a basis for establishing toxicity thresholds for the selected COPCs.

In British Columbia, procedures for deriving site-specific water quality objectives have been developed (i.e., MacDonald 1997; BCMOE 2013a) and may be used to establish benchmarks for use in this type of water quality assessment. However, it is not clear that the approved procedures have been used to select the toxicity data, TRVs, or ESVs used in the assessment. On the contrary, it appears that a limited number of values have been handpicked from a variety of sources. It is not clear that these hand-picked values reflect the range of toxicity thresholds that have been generated for the selected COPCs. It is also not clear that the authors of Section 2.7 understand the purpose of the uncertainty factor that is applied to support the WQG-derivation process. According to BCMOE (2012), an uncertainty factor is applied to the most appropriate effective concentration/inhibitory concentration (ECx/ICx) representing a low effects threshold (i.e., to derive a WQG) to account for:

- Laboratory to field differences;
- Single to multiple contaminants;
- Toxicity of metabolites;
- Intra-species and inter-species differences;
- Indirect effects;
- Whole life-cycle vs. partial life-cycle;
- Delayed effects;
- Other stressors; and,
- Impacts of climate change.

It is not appropriate to predict adverse effects associated with changes in water quality conditions using a limited number of hand-picked values from selected sources. Evaluation of the effects of water quality alterations on fish and aquatic life requires a robust evaluation of toxicity data that were compiled to support the WQG-derivation process. As TML (2012) did not provide a robust evaluation of the available aquatic toxicity data for any of the COPCs under consideration, the comparison of predicted exceedances of WQGs to published toxicity data should not be relied upon to support the environmental assessment of the proposed New Prosperity Mine.

Conclusions: The toxicity data, TRVs, and ESVs compiled in Section 2.7 of the EIS should not be used to evaluate the potential effects of water quality alterations on aquatic organisms using habitats in the vicinity of the mine site. However, the adverse effects associated with exceedances of WQGs could have been evaluated by conducting a comprehensive compilation of toxicity data for the amphibians, fish, invertebrates, aquatic plants, and microorganisms that occur or ought to occur in the vicinity of the mine site (including the data used to support WQG derivation and data generated thereafter). Such data would have provided a basis for estimating the nature, severity, and spatial extent of effects on aquatic organisms associated with changes in water quality conditions in the vicinity of the mine site. Such an evaluation needs to consider the uncertainty in the available toxicity data and in the predicted water quality conditions. As these things were not done in the EIS, the comparisons of future water quality conditions to TRVs and ESVs are inappropriate and should not be relied upon to evaluate project-related effects.

3.9 Inadequacies of Water Quality Predictions - Interpretation Using Biotic Ligand Modelling

Section 2.7 of TML (2012) presents an assessment of predicted water quality in receiving waters in the vicinity of the proposed New Prosperity Mine site using biotic ligand models (BLMs). The BLMs generate LC_{50} values for copper, silver, and cadmium by considering the levels of selected water quality variables that have the potential to influence the bioavailability and, hence, the toxicity of metals in water, including:

- Temperature;
- pH;
- Dissolved organic carbon;
- Dissolved inorganic carbon;
- Humic acid content;
- Calcium;
- Magnesium;
- Alkalinity;
- Nitrate;
- Sodium;
- Potassium;
- Sulphate;
- Chloride; and,
- Sulfide.

The BLMs that were used in the assessment are not described and nor are the underlying assumptions. In addition, the source of the BLMs is not properly cited in Section 2.7 or in Appendix 2.7.2.4B-E. Hence, it is not possible for a reviewer of the EIS to determine if the BLMs that were used to predict effect concentrations for these metals are valid. It is important to note that BLMs have never been approved for use in developing WQGs in British Columbia. In addition, the CCME has not approved the use of BLMs for deriving Canadian WQGs. However, the U.S. Environmental Protection Agency has developed water quality criteria for copper using the BLM (USEPA 2007), though it has not approved water quality criteria using the BLM for any other metal. Importantly, no documentation was provided by TML (2012) that demonstrates that the BLMs used in the EIS provide a reliable basis for predicting toxicity to fish or other aquatic organisms.

<u>Conclusions:</u> As the source of the BLMs used by TML (2012) in the EIS is not identified and the BLMs used by TML (2012) are not described, none of the BLMs developed by TML (2012) should be used to predict the effects of water quality changes on aquatic organisms utilizing habitats in the vicinity of the proposed New Prosperity Mine site. More specifically, any conclusions indicating that predicted concentrations of copper, silver, or cadmium are below BLM-based LC_{50}s for selected aquatic species should not be used to evaluate the potential effects of water quality changes on aquatic organisms. If BLMs are to be used in the EIS, only BLMs that have been approved by B.C. Ministry of Environment (BCMOE) for use in British Columbia, by the CCME for use in Canada, or by USEPA for use in water quality criteria derivation should be used in the assessment. In all cases, the associated BLMs must be fully described and the underlying assumptions must be fully documented.

3.10 Inadequacies of Water Quality Predictions - Selection of Time Periods

Predictions of future water quality conditions described in Section 2.7 of TML (2012) present minimum, average, and maximum values for selected COPCs for up to five periods of time. However, it is not clear that such predictions provide all of the relevant information needed to evaluate the effects of mining-related activities on the quality of receiving waters located proximal to the mine site. Numerical WQGs are typically expressed as maximum and 30-d average concentrations. Therefore, evaluation of the effects of water quality changes also requires information on the magnitude and frequency of exceedance of the maximum WQG for each COPC at each location. In addition, information is also required on the magnitude and frequency of exceedance of the 30-d average WQGs for each COPC at each location. For certain locations (e.g., Big Onion Lake), it is apparent that water quality conditions are likely to continue to degrade over time, even beyond Year 100. Therefore, further information is required to evaluate water quality changes over the time frame relevant for assessing mine-related impacts.

<u>Conclusions:</u> Predictions of water quality conditions for each location are inadequate because they did not provide the information needed to evaluate the magnitude and frequency of exceedance of the maximum and 30-d average WQGs for each COPC. In addition, the predictions of water quality conditions are incomplete because they did not extend beyond the current 100-year period for all locations that could be adversely affected by plumes of contaminated groundwater (i.e., Upper Fish Creek, Tributary 1 to Fish Lake, Tributary 1 to Fish Creek, Fish Lake, Wasp Lake, etc.).

3.11 Inadequacies of Water Quality Predictions - Evaluation of Effects of Chemical Mixtures

The assessment of the effects on fish and aquatic life associated with changes in water quality conditions in the vicinity of the New Prosperity Mine site was conducted on a substance-by-substance basis. However, many COPCs are known to exert additive or synergistic effects on aquatic organisms when they occur together as complex mixtures. For example, divalent metals have been shown to exert roughly additive effects on fish and aquatic life (USEPA 2005). In addition, it is well known that the toxicity of many water quality variables, such as ammonia and metals, is increased when dissolved oxygen levels decrease (Lloyd 1961). Therefore, the substance-by-substance analysis of water quality effects conducted by TML (2012) virtually certainly underestimates the toxicity of COPCs to fish and other aquatic organisms.

Conclusions: The analysis of the effects of water quality changes on aquatic organisms is insufficient because it did not consider the effects of mixtures of contaminants. More specifically, the joint toxicity of TSS, the toxic compounds of nitrogen, major ions, and metals was not considered in the assessment. A proper analysis would select a chemical mixture model for conducting this evaluation, and would clearly identify and describe the model, including the rationale for its selection (i.e., demonstrated reliability). Because dissolved oxygen levels in Fish Lake are likely to be affected by mining-related activities, such an evaluation also needs to consider the interactive effects of exposure to mixtures of COPCs under depressed dissolved oxygen conditions.

3.12 Inadequacies of Predictions of Mine-Related Effects on Hydrological Conditions

The predictions of mine-related effects on the hydrological conditions are described in Section 2.7.2.4 (Water Quality and Quantity) of the EIS (TML 2012). In the description of the potential impacts on water quantity and quality conditions, TML (2012) refers to the following appendices:

- Appendix 2.6.1.4B-A (Baseline Watershed Model; KPL 2012b);
- Appendix 2.7.2.4A-A (Lake Level Fluctuation Predictions for Fish Lake; KPL 2012d);
- Appendix 2.7.2.4A-B (Water Management Report; KPL 2012e); and,
- Appendix 2.7.2.4A-C (Numerical Hydrogeologic Analysis; BGC Engineering Inc. 2012b).

Therefore, these sections of the EIS and the listed appendices were reviewed to evaluate the description of predicted effects on the hydrological conditions and the influence on water quality in the vicinity of the proposed mine site. The review of the predicted effects on hydrological conditions in the study area also included:

- Review of the water management plan; and,
- Assessment of the effects on hydrological conditions and physical characteristics of water quality.

Based on the probabilistic water balance model developed by KPL (2012e), the annual flow volumes in the Fish Creek watershed are expected to change as a result of the mine development. Generally, the flow volume in the lower Fish Creek watershed (i.e., downstream of Fish Lake) is expected to decrease substantially. In fact, the construction of the open pit will eliminate the flow of water from Fish Lake to Middle and Lower Fish Creek during mining and pit in-filling. While some non-contact water will be diverted around the open pit mine, the rainbow trout spawning habitat in this portion of Fish Creek will be eliminated. It is predicted by the Proponent that the flow volume to Fish Lake will generally increase based on the recirculation of water to the Fish Lake inlets. However, it is also stated that a portion of the recirculated water will need to be diverted to maintain coverage of the potentially acid generating (PAG) rock in the TSF.

The estimated mean annual flow volume for Lower Fish Creek is expected to decrease by 76% during the operations and closure phases, but is predicted to return to baseline conditions during the post-closure phase. The estimated annual flow volume in Upper Fish Creek at the inlet to Fish Lake is expected to increase during the operations and closure phases by 28% under average conditions; a 31% increase in flow is predicted during the post-closure phase (Table 2.7.2.4A-7 of EIS). However, these estimates do not agree with the predictions in the water balance model (KPL 2012e). Furthermore, while these predictions are accompanied by estimates in the variability of low and high streamflow (i.e., 5^{th} percentile and 95^{th} percentile flows), these estimates were derived from probability distributions created from the water balance model using baseline conditions from a single year (i.e., measured streamflow in 2007) and precipitation data from Williams Lake. Therefore, these predictions may not capture inter-annual variability in streamflow or extreme low-flow or high-flow conditions.

Upper Fish Creek includes habitat that is used by rainbow trout for spawning and juvenile rearing. While the estimated annual flow in Upper Fish Creek is predicted to increase during operations, closure, and post-closure phases, estimated monthly flow volumes are lower during critical spawning times (i.e., May and June) than they are under baseline flow conditions. Under baseline conditions, the mean estimated flow during the critical spawning time ranges from 0.254 m^3/s in May to 0.792 m^3/s in June. During the operations phase, the estimated mean monthly flow ranges from 0.194 m^3/s in May to 0.458 m^3/s in June. During post-closure, the estimated mean monthly flow ranges from 0.205 m^3/s in May to 0.483 m^3/s in June (TML 2012). The estimated flow to support spawning rainbow trout was determined to be 0.450 m^3/s in Upper Fish Creek (TECL 2012c) and, thus, flow would barely be adequate during the operations, closure, and post-closure phases. Importantly, flow would be inadequate during years with less than average precipitation. Furthermore, in TECL (2012c), it was stated that at peak discharge in April and June, 0.41 m^3/s and 0.32 m^3/s of flow volume would be provided to Upper Fish Creek Reach 8 and Fish Lake Tributary 1, respectively, by the recirculation system, which is inconsistent with the flow volume information (stated above and presented in Table 2.7.2.4A-11) from TML (2012). During other portions of the year, TECL (2012c) stated that sustained discharges of 0.16 and 0.13 m^3/s in Upper Fish Creek Reach 8 and Fish Lake Tributary 1, respectively, are needed to ensure adequate wintering and rearing habitat for juvenile rainbow trout. Based on the predictions provided in Table 2.7.2.4A-11, this flow volume would not be achieved in Upper Fish Creek during operations, closure, and post-closure, even under the 95th percentile wet scenario.

The water levels at Fish Lake under baseline conditions were modeled using the Fish Lake level fluctuation model (KPL 2012d). The model has estimated that the natural water level of the lake fluctuates between -0.2 and 0.6 m of the outlet elevation of 1,457 metres above sea level (masl). The water balance model has predicted that during operations, closure, and post-closure the variation in water level of Fish Lake would be limited to 0.8 m. The minimum and maximum water levels would be similar to those under baseline conditions.

During the operations phase of the mine life, the recirculation system will provide 60% and 50% of the water to Fish Lake Tributary 1 and Upper Fish Creek, respectively. During post-closure, the contribution of the recirculation system to flows in Fish Lake Tributary 1 will decrease to 46% of the flow, while the contribution in Upper Fish Creek will increase to 69% of the flow (KPL 2012e). It was stated that this will have an effect on water temperature in these tributaries, as they will shift to reflect ambient temperatures in Fish Lake. The results of the model predict that winter water temperatures would increase, while summer temperatures would decrease. However, it was stated that the changes would be less than 6°C (TECL 2012c).

TECL (2012c) presented water temperature scenarios for Upper Fish Creek following the development of the project. These scenarios are presented in Table 11 of TECL (2012c). The B.C. WQGs for temperature (BCMOE 2013b) for rainbow trout during incubation periods are between 9.0 and 13°C. During the life of the project, it is predicted that mean water temperature during typical incubation periods (June through

July) would range from 10.7 to 14.57°C. While these predictions are outside of the range for compliance with B.C. WQGs, they are within the calculated range under baseline conditions presented in the report.

TECL (2012c) also presented an analysis of predicted dissolved oxygen concentrations in the inlet streams that would be influenced by the recirculation of Fish Lake water through the inlet streams. Based on the analysis, and assuming no equilibration with the atmosphere as it moves through the pipeline, the concentration of dissolved oxygen at the end of the pipeline would be below B.C. WQGs during the winter (i.e., as low as 4 mg/L) and during the summer stratification period (i.e., between 6 and 7 mg/L).

The effects of reduced flow volume to Fish Lake on the trophic status of Fish Lake was evaluated by TECL (2012d). Fish Lake is described as a meso-eutrophic lake under baseline conditions (TECL 2012d). The effects assessment included the prediction of trophic status, total phosphorus concentrations, orthophosphate, algal biomass (based on chlorophyll *a*), and transparency using the BATHTUB model (TECL 2012d). Using the model, it was predicted that total phosphorus concentrations in the epilimnion would remain relatively constant during June and July, but would increase to make the lake eutrophic during all other months. Furthermore, it was predicted that the hypolimnetic waters would become hyper-eutrophic throughout the year. This predicted shift in trophic status has implications on the water quality of Fish Lake and may lead to increases in the incidences of algal blooms, changes in the composition of algal communities, increases in biological oxygen demand, and subsequent fish kills.

All of the modelling was done based on the assumption that phosphorus is the limiting nutrient in Fish Lake. However, Fisheries and Oceans Canada (DFO 2012) indicated that Fish Lake is likely nitrogen-limited at certain times of year (i.e., during part of the summer and fall). Some of the evidence DFO (2012) presented to support a combination of phosphorus and nitrogen limitation in Fish Lake, based on information from TML (2009), is that N-fixing cyanobacteria become abundant in Fish Lake in the summer and fall. In addition, the total nitrogen to total phosphorus ratio (expressed on a molar basis) suggests nitrogen-limitation at some times of the year and phosphorus-limitation at others. As Taseko's own data (TML 2009) suggest that nitrogen is sometimes the limiting nutrient in Fish Lake, it is inappropriate for their models to be based on phosphorus-limitation alone. Therefore, it is unclear whether the predictions of trophic status changes in the EIS (TML 2012) are accurate.

Conclusions: The management of water at the proposed mine site is a critical component of the project, especially for mitigating effects. Fish Lake and the tributaries to Fish Lake provide critical habitat for all life-stages of rainbow trout. To supplement flows in the tributaries to Fish Lake to ensure that flows and the water level of Fish Lake are maintained at pre-mine conditions, the recirculation system will need to provide water to the tributaries at an annual average rate of 0.184 m^3/s at the start of operations. This water will be directed to the inlets to Fish Lake and contribute 60% of the average annual flow in Fish Lake Tributary 1 and 50% of the average annual flow in Upper Fish Creek at the start of operations (KPL 2012e). During the post-closure phase of the mine life, the recirculation system will provide 46% of the flow in Fish Lake Tributary 1 and 69% of the average annual flow in Upper Fish Creek (KPL 2012e). During the rainbow trout spawning period, the recirculation system will need to provide water at a rate of 0.735 m^3/s (TECL 2012c) to ensure adequate flow for spawning and incubation of rainbow trout. Therefore, the recirculation system will play a vital role in the maintenance of habitat quality in Fish Lake through the operation, closure, and post-closure of the New Prosperity Mine. While the Proponent has developed a contingency plan for providing power to the site (i.e., back-up diesel generators), the fault tolerance of the recirculation system has not been thoroughly evaluated. The EIS did not include a sensitivity analysis evaluating the performance of the recirculation system under various realistic scenarios (e.g., low-flow and high-flow conditions, power-outages, high-sediment load, algal blooms, pump failure). This is a large deficiency because it leaves the Panel with uncertainty as to whether adequate flows can be delivered to Fish Lake tributaries and Fish Lake throughout the year.

Based on the information provided, it is apparent that the effects of the mine development will include a shift in the trophic status of Fish Lake from meso-eutrophic to eutrophic or hyper-eutrophic. However, the accuracy of the predicted effects associated with this change is uncertain because nitrogen-limitation in Fish Lake at certain times of year was never addressed. An integrative analysis of the predicted effects of changes to water temperature, dissolved oxygen concentration, and nutrient loading and/or retention should have been developed to evaluate the potential for adverse effects on rainbow trout and associated habitat quality in Fish Lake. As it stands, not enough information is available to conclude that the re-circulation system will work well enough at all times to support the needs of rainbow trout during all stages of their life cycle.

3.13 Inadequacies of Characterization of the Food Web

Minimal sampling of the base of the food web in Fish Lake was done as part of the baseline characterization. Phytoplankton samples were collected in 1994 (August), 1995 (July), 1997 (August), and 2006 (May, July, and October). Chlorophyll *a* concentration provides a measure of the standing crop of phytoplankton and, thus, was used as an indicator of primary production. The chlorophyll *a* concentration in Fish Lake ranged from 0.70 to 5.03 µg/L (TML 2012). It is not possible to evaluate temporal variability due to the limitations on data collected within each year and the lack of consistency in sampling timing among years. For months that were sampled in two years, the chlorophyll *a* concentration was quite different between years (e.g., 0.70 µg/L in August 1994 compared to 2.90 µg/L in August 1997 at a depth of 0.25 m; TML 2012). Therefore, the baseline levels of primary production (as chlorophyll *a* concentration) in Fish Lake are uncertain. Details regarding the taxonomic groups of phytoplankton collected are provided in tables in Appendix G to Appendix 5-2-A of the 2009 EIS. The summary of these data provided in the main 2012 EIS indicates that the phytoplankton community in Fish Lake was composed mainly of small flagellates (cryptophytes *Chroomonas acuta* and *Cryptomonas* sp.) in May and July, and was dominated by blue-green algae (e.g., *Aphanizomenon flos-aquae* and *Lyngyba limnetica*) in August and October (TML 2012). The presence of these species indicates that algal productivity is likely limited by nitrogen levels during August and October.

Zooplankton samples were collected in 1993, 1997 (August or September), and 2006 (August). As the methods used to collect these samples varied over the three years, the resultant data may not be directly comparable. According to Table 2.6.1.4A-16 (page 261), the zooplankton community in Fish Lake was dominated by rotifers in 1997 and by rotifers and cladocerans in 2006. This table also shows that the density and taxon richness were about two times higher in 2006 than 1997 (TML 2012). However, later (page 263) the text says that protozoa made up 81% of the zooplankton in Fish Lake and rotifers only made up 8%. While Table 2.6.1.4A-16 does say that numbers of protozoa were excluded, it does not provide the full set of information when it does not mention that protozoa made up 81% of the taxa in 1997. Rotifers were hardly the "predominant taxa" when it is later noted they made up 8% of the zooplankton. Appendix 5-2-A in TML 2009 also notes that 81% of the zooplankton in Fish Lake were protozoa in 1997 and that 40% of the zooplankton were rotifers in 2006; there were no protozoa recorded in 2006. In 1997, Fish Lake samples had a mean density of 124 organisms/L, while in 2006 they had a mean density of 3,500 organisms/L (TML 2012). It is very confusing to read this after seeing densities of 23 and 51 organisms/L in 1997 and 2006, respectively, in Table 2.6.1.4A-16. While the difference in density in 1997 could be explained by the fact that protozoa were excluded from Table 2.6.1.4A-16, as no protozoa were found in 2006 it is unclear how the density could go from 51 organisms/L in Table 2.6.1.4A-16 to 3,500 organisms/L in the text. This discrepancy is just one example of how the EIS (TML 2012) can be confusing and difficult to understand. As the zooplankton composition and density were very different in 1997 and 2006, the baseline zooplankton community to be compared to future communities if the mine were built is uncertain. This is a deficiency of the EIS because zooplankton provide an important food source for the rainbow trout in Fish Lake.

Although Table 2.7.2.4B-5 in Section 2.7 says that community composition will be a measurable parameter in streams and lakes to assess predicted changes to the benthic and planktonic communities, only total phytoplankton biomass (as chlorophyll *a*), not phytoplankton community composition, is predicted for different project phases. Figures 2.7.2.4B-3 to 2.7.2.4B6 show that chlorophyll *a* concentration is predicted to increase from baseline conditions during all phases of the mine life. There is a brief mention of the possibility of blue-green algae overtaking Fish Lake with increased phosphorus concentrations, but there is no quantitative assessment of predicted phytoplankton community composition as Table 2.7.2.4B-5 implies. Therefore, the evaluation of potential changes to the phytoplankton and zooplankton communities is incomplete.

The benthic invertebrate community in Fish Lake was sampled in 1993 and 1997. In 1993, 14 taxa were identified (which included midge [*Chironomus* sp.], copepods [Cyclopoida], clams [*Pisidium* sp.], worms [Oligochaeta], roundworms [Nemotoda], and seed shrimp [Ostracoda]), with a mean total abundance of 15,153 organisms/m^2 (TML 2012). In 1997, only 1 taxon was identified in Fish Lake (midge, *Chironomus* sp.), with a density of 71/m^2 (TML 2012). The much lower values in 1997 were attributed to differences in sampling and enumeration techniques. The 1993 values were considered to overestimate benthic invertebrate diversity and density because they included limnetic taxa such as copepods (Copepoda) and water fleas (Cladocera), while the 1997 values were considered to underestimate the density and diversity of benthic invertebrates because a larger mesh size was used to sieve the sediments before analysis (Appendix 5-2-A in TML 2009; TML 2012). Therefore, accurate estimates of the structure and abundance of benthic communities under baseline conditions are not available. In addition, specific predictions on how the benthic invertebrate community in Fish Lake might change over the course of mine life were not provided in the EIS.

Conclusions: The base of the food chain in Fish Lake has been inadequately characterized in the EIS. As the temporal variability of phytoplankton and zooplankton appears to be so high, it is impossible to obtain a reliable picture of their composition and abundance from the small number of samples collected for the EIS. It is important to document the current composition of zooplankton in Fish Lake because these species support the rainbow trout population. Minor changes in water chemistry can change the phytoplankton community, so changes to nutrient inputs and water chemistry caused by the proposed mine could shift the phytoplankton community from mainly edible species to mainly inedible species. If the phytoplankton community becomes dominated by inedible species, the zooplankton that normally feed on them will decrease in number, and this will lead to a decrease in food for the rainbow trout. Therefore, it is essential to have a detailed understanding of the composition and abundance of phytoplankton, zooplankton, and benthic macroinvertebrate communities under baseline conditions and of the effects of mine development on these organisms. These potential changes to the functionality of the Fish Lake ecosystem should have been addressed in a more thorough manner in the EIS.

3.14 Inadequacies of Water Quality Predictions - Evaluation of Cumulative Within-Project Effects

There are major problems with how the EIS (TML 2012) has addressed cumulative effects. First, the definition of "cumulative effects" in Section 2.7 of the EIS states that "Cumulative environmental effects are changes to the biophysical or human environment that are caused by an action associated with the Project under review, in combination with other past, present and future projects and activities." This means the EIS only considers effects of the project in combination with the effects of other projects as cumulative effects; it does not consider the different effects of the New Prosperity Mine Project in a combined manner (i.e., project-related cumulative effects). For example, predicted changes to water temperature, water quality, water levels, and rainbow trout numbers in Fish Lake were all assessed separately and considered to have no significant effects after compensation measures were applied. However, all these things actually interact together and should be considered in a cumulative manner, even if that is not the definition of "cumulative effects" under the Canadian Environmental Assessment Act. A list of 22 projects and activities was compiled in Section 2.7.1.4 of the EIS that was considered in the cumulative effects assessment. In all cases relating to water quality and water quantity, it was concluded that there would be no cumulative effects because there were no other nearby projects that would add to these types of effects from the New Prosperity Project.

According to the information provided in Section 2.7 of TML (2012), mining-related activities are predicted to result in increased loadings of nitrogen and phosphorus to receiving water systems. Such increases in nutrient loadings are likely to alter the trophic status of affected lakes and streams (i.e., increase primary productivity, including both phytoplankton and periphyton production). While such increases in primary productivity can, potentially, be beneficial in terms of increasing the amount of food available to invertebrates and, ultimately, fish, they can also result in changes to the communities of organisms that occur within the receiving waters. In some cases, the new communities may include species that represent less desirable food organisms for fish. For example, a change in nutrient inputs could cause a shift from mainly edible phytoplankton (e.g., diatoms) to inedible phytoplankton (e.g., *Ceratium* spp. of dinoflagellates). Decreasing the amount of food available to invertebrates would reduce their population, which in turn would decrease the amount of food available for the rainbow trout in the lake, eventually reducing the fish population as well. In other cases, the increased nutrient loadings can result in blooms of noxious or toxic algae (e.g., blue-green algae) that can adversely affect fish directly. Blue-green algae (i.e., cyanobacteria) can fix nitrogen from the atmosphere and, therefore, can quickly dominate the lake if nitrogen becomes a limiting nutrient. Not only can blue-green algae out-compete edible phytoplankton, but the toxins they release can directly harm fish and invertebrates. Algal blooms can also result in reduced levels of dissolved oxygen in the water column at night, causing indirect stress on fish and other aquatic organisms. Importantly, increases in primary productivity can result in elevated biological oxygen demand in receiving waters during and after die-off periods. This is extremely important in the winter, when under-ice dissolved oxygen levels can drop to levels that are toxic to fish and other organisms. However, the combined effects of such water quality changes and trophic status alterations were not evaluated by TML (2012). This represents a major limitation of the EIS. Because the combined effects of water quality changes and other stressors (e.g., water temperature, streamflow, eutrophication, alteration of spawning habitat) were not evaluated, the cumulative effects of the proposed project have not been fully evaluated in the EIS (TML 2012).

In addition, the loss of wetlands and their water purification functions were not considered when evaluating the predicted levels of nutrients and metals in Fish Lake during the proposed mine operations, closure, and post-closure. The EIS (TML 2012) states that there are 2,071 ha of wetlands in the RSA and 627 ha of wetlands in the local study area (LSA) under baseline conditions. TML (2012) predicts that 407 ha of wetlands will be lost during the maximum disturbance of the mine, and 311 ha will remain lost during post-closure. This means that 50 to 65% of the wetlands in the LSA will be temporarily or permanently lost. While wetlands and their functions are discussed from page 1003 to page 1016 of the EIS (TML 2012), this analysis does not describe the potential impacts on water quality in Fish Lake. This is a problem because wetlands play an important role in storing nutrients such as nitrogen and phosphorus (Mitsch *et al.* 2000; Verhoeven *et al.* 2006). Wetlands can also filter contaminants from the water passing through them (Weis and Weis 2004). Therefore, the loss of wetlands upstream of Fish Lake could increase the levels of nutrients and metals in Fish Lake compared to predictions.

<u>Conclusions:</u> The combined effects of changes in water quality conditions and alterations in the primary productivity of lakes was not critically evaluated, and thus an accurate prediction of what will happen to the rainbow trout in Fish Lake is not available in the EIS. Specifically, dissolved oxygen levels should have been modeled for all lakes during all months of the year during construction, operation, closure, and post-closure. Then, the effects of depressed dissolved oxygen levels on fish and other aquatic organisms should have been evaluated. Subsequently, the combined effects of exposure to mixtures of contaminants, low dissolved oxygen levels, eutrophication, degraded sediment quality conditions, and other stressors should have been evaluated. The fact that procedures for conducting an assessment of the within-project cumulative effects are not described is a major deficiency of the EIS because all the individual potential impacts of the Project will act together to increase the overall effect on the aquatic ecosystem in the Fish Lake watershed. The interactions of multiple stressors caused by the mine development will likely cause Fish Lake to die within ten years (Stockner and Brandt 2013).

3.15 Inadequacies of Determination of Significant Residual Effects

Section 2.7 of the EIS (TML 2012) presents results on the residual effects of the project on receiving waters located in the vicinity of the proposed New Prosperity Mine site. According to TML (2012), determination of the significance of potential project residual effects on water quality relied on:

- Baseline site-specific data compared with applicable guidelines;
- Water quality predictions compared with applicable guidelines;
- Productivity models; and/or,
- Professional judgment, applying the precautionary principle or approach.

For Fish Lake, continuous moderate to high effects were predicted to occur in the long-term due to releases of nutrients, metals, and sulphate into the lake. Similar effects were predicted for the tributaries to Fish Lake. For Pit Lake, releases of metals and sulphate were predicted to have continuous permanent effects that would last into the far future or permanently. Effects in adjacent rivers, streams, and lakes were predicted to be continuous with a moderate to high magnitude over the long-term. In all cases, however, the effects of changes in water quality conditions were considered to be reversible and not significant. A moderate level of confidence was placed on all of these predictions of effects.

The assessment of residual effects that was described in the EIS (Tables 2.7.2.4B-31, 2.7.2.4B-31A, 2.7.2.4B-32, 2.7.2.4B-33, and 2.7.2.4B-34) does not provide a reliable basis for documenting the adverse effects of the project, determining their significance and reversibility, or predicting residual effects on water quality or the aquatic organisms that utilize habitats in the vicinity of the proposed mine site. The assessment of residual effects is considered to be unreliable because:

- Baseline water quality conditions have not been adequately documented. As such, the reliability of the water quality models that rely upon baseline water quality data is uncertain, particularly for the lakes in the vicinity of the proposed mine site;

- The water quality models that were used to predict future water quality conditions were incompletely documented. As a result, the confidence that can be placed on the model outputs is uncertain;
- The predictions of future water quality conditions were not consistent for all of the water bodies considered (i.e., only a subset of contaminants were considered for many of the water bodies; the potential effects of fuel spills were not evaluated for any water body). As a result, the assessment of future water quality conditions is incomplete and the associated effects of water quality changes on water uses are underestimated;
- The predictions of future water quality conditions did not provide a basis for estimating 30-d average concentrations of contaminants. Hence, it was not possible to evaluate exceedances of long-term WQGs;
- Water quality guidelines were not compiled for a number of contaminants (e.g., nitrate and phosphorus) and not completely compiled for other contaminants (e.g., thallium and nitrite). Therefore, it was not possible to predict the potential effects associated with exposure of aquatic organisms to certain COPCs;
- Predictions of future water quality conditions were not developed for all of the water bodies that could be affected by mining-related activities (e.g., Upper Groundhog Creek, Big Onion Lake tributary). Therefore, the spatial extent of water quality impairments has not been fully documented;
- The effects of water quality alterations on aquatic organisms were evaluated with a number of tools that were not demonstrated to be appropriate or reliable (i.e., selected toxicity data, TRVs, ESVs, BLMs). Reliance on such potentially inappropriate and unreliable tools renders the effects assessment uncertain;
- The predictions of future water quality conditions covered a period of only 100 years. As water quality conditions in certain water bodies (e.g., Big Onion Lake) are expected to continue to degrade even beyond Year 100, the temporal extent of water quality changes has not been fully documented;
- The effects of mixtures of contaminants on fish and other aquatic organisms were not evaluated. Therefore, water quality effects associated with discharges of contaminants from the proposed mine site and mining-related activities have been underestimated; and,
- An assessment of the cumulative within-project effects on water quality and associated water uses has not been undertaken (i.e., effects on water quality combined with effects of dissolved oxygen depression under ice and other project-related stressors). Because contaminants are more toxic to aquatic organisms in the presence of other stressors, the effects of contaminant releases and associated water quality effects have not been fully evaluated.

Owing to these substantial shortcomings of the predictions of future water quality conditions and associated effects on aquatic organisms, the magnitude, frequency and duration, and spatial extent of predicted effects described in the EIS are incorrect and understated. Importantly, little or no information is provided in the EIS on the effectiveness or adequacy of the proposed and potential mitigation options for addressing project-related effects. Without such information, it is impossible to conclude that project-related effects will be reversible and not significant.

Conclusions: The effects assessment that is presented in the EIS is incomplete and unreliable. Therefore, the Panel cannot meaningfully assess the impacts of all project-related effects.

3.16 Inadequacies of Mitigation and Adaptive Management Plans

Section 2.7 of TML (2012) described the proposed mitigation measures and compensation measures that could be used to address project-related effects on water quality. Most or all of the mitigation measures involve collection of contact water and pumping it to the TSF, with water released from the TSF when water quality meets yet-to-be-determined water quality objectives. If water quality monitoring indicates that water quality predictions are correct, then active water treatment is proposed to be implemented. No residual adverse effects are anticipated by the proponent following implementation of the proposed AMP.

While the EIS indicates that the effects assessment represents the worst-case scenario, it is virtually certain that the magnitude, frequency and duration, and spatial extent of predicted effects on water quality have been substantially understated for water bodies located proximal to the proposed mine site. The EIS concludes that mitigation, monitoring, and adaptive management will ensure that no residual effects will occur. However, failure to document the effectiveness of mitigation measures, to describe the potential water treatment methods, and to evaluate their efficacy renders uncertain the validity of this conclusion. Moreover, limitations in the proposed monitoring program are likely to render ineffective the AMP.

In response to Supplemental Information Request (SIR) #15/19/25/49a and in the *Responses to the Technical Information Requests* (TML 2013), TML stated that the AMP they were providing was just an initial outline and concept. The final AMP and its action threshold levels would be determined at permitting time and adjusted as necessary during its implementation. The AMP uses key indicators to assess the health of Fish Lake. The Primary Key Indicators (total phosphorus, algal biomass as chlorophyll *a*, Secchi depth, and dissolved oxygen) look at trophic status of the lake, while the Secondary Key Indicators look at water quality (aluminum, cadmium, iron, selenium, silver, and sulphate) and sediment quality (arsenic, chromium, copper, mercury, and nickel). For each Key Indicator, three threshold levels are identified (indication, alert, and action), which will trigger increases in monitoring frequency and/or implementation of mitigation techniques. The threshold levels are defined as follows (SIR #15/19/25/49a):

- Indication: Increase the monitoring frequency in order to verify the data and watch for accelerated changes;
- Alert: Continue with increased monitoring frequency. Watch for accelerated changes. Evaluate the effectiveness of the existing mitigation and increase the frequency or intensity of this mitigation if applicable. Initiate the choice and design of appropriate further mitigation techniques;
- Action: Implement appropriate new mitigation and continue to monitor the effectiveness of the new mitigation technique.

In Table 15/19/25/49A-1 of the response to SIR #15/19/25/49a, TML lays out the threshold levels for Primary and Secondary Key Indicators. These thresholds are compared to B.C. maximum WQGs for water-based indicators and to B.C. probable effects levels (PELs) for sediment quality variables. The action threshold level for Primary Key Indicators is 50% greater or less than baseline (depending on the indicator). A 50% difference from baseline is a large difference to occur before implementing new mitigation measures. For example, if Fish Lake had 50% less oxygen than baseline, it would likely be having detrimental effects on the fish and other organisms in the lake already. Another problem with the threshold levels is that the response to SIR #15/19/25/49a presents B.C. WQGs for Primary Key Indicators in Table 15/19/25/49A-1 that do not correspond with the B.C. WQGs on the BCMOE website; it is unclear where the values in Table 15/19/25/49A-1 come from. In addition, TML gives four years to implement mitigation in order to counter predicted adverse concentrations of Key Indicators, anticipating this will be enough time to design, permit, construct, and commission mitigation techniques before B.C. WQGs are exceeded. This means TML will be relying heavily on the trend lines that predict the speed at which concentrations of Key Indicators are increasing. If a concentration increases faster than predicted, the mitigation response might not be ready in time. An Operational Policy Statement about adaptive management measures under the *Canadian Environmental Assessment Act* (CEAA 2009) states “Commitment to adaptive management is not a substitute for committing to specific mitigation measures in the EA [Environmental Assessment] prior to the course of action decision.” It is not appropriate for Taseko to leave final mitigation plans to the permitting stage, particularly because water quality issues are expected in association with project-related activities.

The proposed mitigation technique for the Primary Key Indicators is Hypolimnetic Oxygenation, where pure oxygen is pumped from a storage facility on shore to the hypolimnion of the lake through a series of diffusers on the bottom of the lake (TML response to SIR #15/19/25/49b). This technique is newer than the hypolimnetic aeration technique (injecting air into the lake) that has been used more frequently, but TML believes it would be more effective. TML predicts that it would take six months to one year for the levels of Primary Key Indicators to improve after treatment with Hypolimnetic Oxygenation is initiated. However, such predictions are uncertain at best given the uncertain efficacy of this procedure in Fish Lake. In addition, significant adverse effects on rainbow trout and/or other receptors can occur within this time frame.

In response to SIR #15/19/25/49b, TML provided the report # 2013-04-232-Rev1 (BioteQ 2013), which describes the water quality mitigation plan proposed by BioteQ Environmental Technologies Inc. It is only intended to be implemented if secondary key indicators reach action threshold levels. The proposed treatment processes include membrane Nano-Filtration, sulphide/lime precipitation, and Ion Exchange. This report indicates that it would take 1.5 years to treat the entire volume of water in Fish Lake for heavy metals removal (BioteQ 2013). It is not clear whether this takes into account the fact that water removed from the lake for treatment will always contain some water that has already been treated, due to mixing of water in the lake. Importantly, the costs and efficacy of the proposed water treatment methods have not been established, leading to uncertainties about the feasibility of the AMP to address key water quality issues, either from a technical or economic perspective.

Conclusions: The mitigation measures and AMP are inadequate because they do not incorporate a complete evaluation of effects on water quality and associated water uses. In addition, the concept of waiting until the permitting stage to finalize the AMP is not appropriate. Furthermore, active long-term water treatment is currently identified as a key element of the AMP, which is not desirable. Rather, active treatment of contact water must be incorporated as an integral element of the project design, with sufficient capacity to treat all water released to the environment. It is also not appropriate to only compare the concentrations of Key Secondary Indicators to maximum B.C. WQGs and sediment PELs when developing the threshold levels. The concentrations should also be compared to 30-d average WQGs and interim sediment quality guidelines (ISQGs) to ensure the protection of aquatic life from chronic effects. Moreover, the water treatment system is not described in sufficient detail or with sufficient supporting documentation to demonstrate its effectiveness. It must be assumed that the water treatment system will need to be operated in perpetuity to ensure the quality of water that is released into Fish Lake and its tributaries. TML indicated that it is not aware of a similar recirculation process to the one proposed here being implemented in other lakes (TML response to SIR

#15/19/25/49d), so there is no existing evidence that this recirculation system will work and maintain Fish Lake as a functioning aquatic ecosystem. Likewise, we are not aware of any such recirculation system being constructed and operated at this scale for an indefinite period of time. Therefore, there is no basis for evaluating its long-term reliability or performance.

3.17 Inadequacies of Planned Water Quality and Aquatic Ecology Monitoring Program

An overview of the planned water quality and aquatic ecology monitoring program for the proposed New Prosperity Mine project is presented in Table 2.7.2.4B-44 of the EIS (TML 2012). This overview indicates that water quality, phytoplankton, and zooplankton monitoring will generally be conducted on a monthly basis at four locations in Fish Lake, in Fish Creek at the inlet to Fish Lake, in Fish Lake Tributary 1, at the Fish Lake outlet, at two locations on Lower Fish Creek, and at two locations on the Taseko River. Sediment and benthic macroinvertebrate community sampling would be conducted annually at six locations, including Fish Lake, Fish Creek at the inlet to Fish Lake, Fish Lake Tributary 1, two locations on Lower Fish Creek (upstream and downstream of the ore body), and the Taseko River downstream of Fish Creek. Spawning surveys, fish morphometry, and fish tissue chemistry would be conducted annually at up to five locations, including Fish Lake, Fish Creek at the inlet to Fish Lake, Fish Lake Tributary 1, and two locations on the Taseko River (upstream and downstream of Fish Creek).

While the details of the planned monitoring program are not provided, it is likely that this program will not provide the data needed to evaluate the accuracy of impact predictions or to inform the AMP at the site. More specifically, the proposed water quality monitoring does not identify the variables that will be measured, which makes evaluation of its adequacy difficult. In addition, monthly sampling will not provide an adequate basis for determining the maximum concentrations of contaminants in water, nor will it provide a basis for evaluating compliance with 30-d average WQGs.

Annual sampling is likely adequate for assessing sediment quality and benthic macroinvertebrate community structure. However, collection of a single sample at each location will not provide the information needed to detect changes from baseline conditions or to evaluate impacts. Rather, the variability in the baseline data needs to be evaluated and the results of that evaluation used to determine the number of samples that need to be collected each year to detect changes/effects of a specific size (e.g., 20%) with a reasonable level of confidence (e.g., 90-95%). Sediment toxicity testing also needs to be included in the planned monitoring program to provide a basis for evaluating the effects of changes in sediment quality on the benthic community. As these things were not done in the EIS, the sediment sampling component of the monitoring program is inadequate.

The monitoring planned to evaluate effects on fish is also inadequate. In addition to enumerating the number of spawners, spawning success and recruitment of juvenile fish into the population also need to be evaluated. Recruitment data are critically required to evaluate the effectiveness of the mitigation measures and compensation measures identified to address potential effects on rainbow trout populations. Further details are required on the tissue chemistry and morphometric monitoring to evaluate their adequacy.

Conclusions: As planned and described, the water quality and aquatic ecology monitoring program is inadequate for evaluating project-related effects or informing the AMP. Therefore, the monitoring program is not appropriate for evaluating compliance with WQGs and SQGs. The monitoring program is not sufficiently robust to detect effects of a specific magnitude with a specific level of confidence. Furthermore, there is no mention of how the monitoring program will be paid for, even though the EIS Guidelines (CEAA 2012) specify that sources of funding for the monitoring program should be included in the EIS.

4.0 Overall Conclusions

The intent of this review was to address the following four questions:

1. Are the available data and information adequate to determine baseline water quality conditions?
2. Have baseline water quality conditions been adequately characterized in the documentation provided in the EIS?
3. Have the predictions of future water quality conditions been developed in an appropriate manner?
4. Have the effects of the predicted changes in water quality conditions been adequately described and evaluated?

Based on the results of this review, it is concluded that the existing water quality data are insufficient to document baseline conditions in the vicinity of the site. Most of the baseline data for streams and lakes were collected before 1997, when the Project Report Specifications defined appropriate methods for data collection and analysis. Hence, much of the data generated to define baseline conditions are of uncertain quality and at least some of these data are unusable. Samples collected before 1997 were analyzed using inadequate quality assurance methods and less sensitive detection limits; detection limits were up to 200 times higher than those for samples from 1997 onwards. Furthermore, there was not enough sampling done to evaluate spatial and temporal variability in water quality or to compare measured concentrations to long-term average WQGs. Compliance with the long-term B.C. WQGs requires data from five samples collected within 30 days. Water samples were not collected at this frequency during the baseline water quality characterization program. In addition, there was no measurement of dissolved oxygen and temperature in spawning areas during spawning times.

The sediment data collected were also insufficient to characterize baseline conditions for several reasons. First, sediment samples were sieved to <63 µm, while B.C. and CCME WQGs are based on toxicity test data that used the <2.00 mm fraction of sediment. As metals bind more to clays than to larger sediment particles, there are higher concentrations of metals in the <63 µm fraction than in the <2.00 mm fraction or a whole-sediment sample. Therefore, Taseko's conclusion that certain metals exceed SQGs under baseline conditions is likely incorrect when one considers the <2.00 mm sediment fraction. In addition, SEM and AVS were not measured in any sediment samples from the site and these data are needed to accurately characterize the potential for toxicity from some metals to benthic invertebrates (i.e., divalent metals, such as cadmium, copper, lead, nickel, silver, and zinc).

The mass balance model that was used to predict water quality conditions was not adequately described. The description of the methods for this model that was used to predict monthly concentrations of water quality variables was severely lacking because the underlying assumptions, model inputs, and source terms were not fully explained. In addition, as the uncertainty associated with the water quality model was not described, the Panel cannot put a high level of confidence in the water quality predictions.

There were problems with the hydrological model as well. For example, the statistical analyses used to develop the model and the associated results were not presented. Furthermore, the streamflow data used to calibrate the hydrological model were obtained in 2006 and 2007 only. This does not provide enough data to evaluate temporal variability in streamflows or characterize extreme high-flow and low-flow events. Consequently, a high level of confidence cannot be placed in the model results.

Another problem with the water quality evaluation is that predictions of future water quality conditions were not consistently compared to B.C. WQGs. Instead, predicted COPC concentrations were compared to B.C. and CCME WQGs, as well as TRVs from the literature. TRVs are not equivalent to WQGs and should not be used in place of WQGs. Furthermore, the predicted concentrations of some COPCs were not compared to WQGs at all, while the concentrations of other COPCs were only compared to WQGs at certain locations. For hardness-dependent WQGs, it was unclear what hardness was used to calculate the WQGs and what sites that hardness corresponded to. In addition, adequate information was not available to completely compare the predicted water quality results to WQGs (i.e., instantaneous maxima and long-term averages). Finally, the additive or synergistic effects of contaminant mixtures on aquatic organisms were not assessed. This incomplete evaluation of predicted concentrations of COPCs does not provide an accurate picture of how the mine will affect the water quality of various water bodies in the area.

The Proponent generally intends to leave many important things for a later date. For example, TML plans to implement mitigation techniques only if monitoring shows water quality conditions are getting worse and approaching certain thresholds. However, water treatment should be considered an essential component of the project and planned for from the beginning. Furthermore, the details of the water quality and aquatic ecology monitoring program have yet to be fully worked out and described. These things should not be left to the permitting stage. It is important to know whether the monitoring program will provide the data needed to evaluate the accuracy of impact predictions or to inform the AMP at the site, especially as adaptive management is a key component of the approach to mitigating adverse effects of the mine. As it currently stands, the proposed monitoring program is inadequate and will not provide the necessary information for evaluating the effects of the mine. For example, monthly water quality sampling will not provide a basis for evaluating compliance with 30-d average WQGs.

One overarching problem with the EIS for the proposed New Prosperity Mine is that within-project cumulative effects are not addressed at all. For example, mining operations are predicted to cause increased loadings of nitrogen and phosphorus into Fish Lake. Increased nutrient loadings can cause changes to the amount and types of phytoplankton growing in the lake. A shift to less desirable phytoplankton in the lake can result in fewer zooplankton available for the rainbow trout to feed on. Blooms of blue-green algae can also release toxins and result in decreased dissolved oxygen concentrations in the water. Combined with increased water temperature (which is likely when water is constantly recirculated into the lake), decreased dissolved oxygen and decreased food availability would represent important stressors on the rainbow trout. Add these stressors to those caused by increased concentrations of metals and conditions are likely to be even worse than predicted. However, there was no analysis of how all these factors, combined, would affect the rainbow trout in Fish Lake. This is a major deficiency of the EIS, and a major risk of the project. According to the precautionary principle, the Proponent must prove that the project will not cause significant adverse effects on the environment. However, as the interactions of all the single stressors combined have not been evaluated, there is not enough information to conclude there will be no significant adverse effects associated with the development of the mine. On the contrary, it is likely that all the combined stressors will cause Fish Lake to die within a decade (Stockner and Brandt 2013). As it currently stands, the proposed monitoring program is inadequate and will not provide the necessary information for evaluating the effects of the mine or, importantly, provide the information to mine managers to respond in an effective and timely manner to upset conditions.

In conclusion, the results of this evaluation of the information included in the EIS show that the information is insufficient to support the assertion that the proposed New Prosperity Mine project will not result in significant adverse environmental effects. In addition, the results of this evaluation indicate that the proposed project represents a significant threat to the environment and to those people who rely on those resources present within the Fish Lake ecosystem. Importantly, the Proponent has not met the burden of proof demonstrating that the New Prosperity Mine will not cause significant adverse environmental effects; there is no demonstration of the technical viability of the proposed project. The information uncertainties are so pervasive throughout the sections of the EIS that we reviewed, that we believe there would be a significant risk of failure if this project was to be approved on the basis of the available information. In such a situation, the precautionary principle should be applied in considering the project's overall acceptability.

5.0 References Cited

ASTM (American Society for Testing and Materials2013. Standard guide for collection, storage, characterization, and manipulation of sediments for toxicological testing. Designation: E 1391-03. *In:* ASTM 2009 Annual Book of Standards Volume 11.05. West Conshohocken, Pennsylvania.

BCMOE (British Columbia Ministry of Environment). 2012. Derivation of water quality guidelines to protect aquatic life in British Columbia. Water Protection and Sustainability Branch, Environmental Sustainability and Strategic Policy Division, Ministry of Environment. Victoria, British Columbia. 34 p.

BCMOE (British Columbia Ministry of Environment). 2013a. Guidance for the Derivation and Application of Water Quality Objectives in British Columbia. Water Protection and Sustainability Branch. Ministry of Environment. Victoria, British Columbia.

BCMOE (British Columbia Ministry of Environment). 2013b. B.C. Water Quality Guidelines for Temperature. Overview Report. Developed in 2001. Environmental Protection Division. Ministry of Environment. Accessed April 2013 at http://www.env.gov.bc.ca/wat/wq/BCguidelines/temptech/temperature.html#tab2

BGC Engineering Inc. 2012a. New Prosperity Gold-Copper Project, Baseline Groundwater Hydrology Assessment. Project No.: 0499-002. August 17, 2012. Prepared for Taseko Mines Limited C/O Knight Piésold Limited by BGC Engineering Inc. Appendix 2.6.1.4D-A in TML 2012.

BGC Engineering Inc. 2012b. New Prosperity Gold-Copper Project, Numerical Hydrogeologic Analysis. Project No.: 0499-002-50. August 17, 2012. Prepared for Taseko Mines Limited C/O Knight Piésold Limited by BGC Engineering Inc. Appendix 2.7.2.4A-C in TML 2012.

BioteQ. 2013. Report #2013-04-232-Rev1: Taseko Mines Limited - New Prosperity Copper Mine; Fish Lake Water Quality Mitigation Plan. Prepared by BioteQ Environmental Technologies Inc. Prepared for Taseko Mines Ltd. May 28, 2013.

Canadian Council of Ministers of the Environment (CCME). 1995. Protocol for the derivation of Canadian sediment quality guidelines for the protection of aquatic life. CCME EPC-98E. Ottawa, Ontario.

CEAA (Canadian Environmental Assessment Agency). 2009. Operational Policy Statement: Adaptive Management Measures under the *Canadian Environmental Assessment Act.* Catalogue No.: 978-1-100-12062-1. ISBN: En106-83/2009E-PDF Accessed July 2013 at http://www.ceaa-acee.gc.ca/default.asp?lang=En&n=50139251-1

CEAA (Canadian Environmental Assessment Agency). 2012. Guidelines for the Preparation of an Environmental Impact Statement pursuant to the *Canadian Environmental Assessment Act* for the New Prosperity Gold-Copper Mine Project. March 2012.

DFO (Fisheries and Oceans Canada). 2012. Sufficiency review of lake productivity information contained in the Environmental Impact Statement for the New Prosperity Gold-Copper Mine Project. DFO Canadian Science Advisory Secretariat Science Response. 2012/040.

Hallam Knight Piesold Ltd. 1995. Aquatic Resources of Fish Lake, Fish Creek and Related Fish Habitat Compensation Sites. Prepared for Taseko Mines Limited by Hallam Knight Piesold Ltd. February 1995. Appendix 5-3-E in TML 2009.

KPL (Knight Piésold Limited). 2007. Taseko Mines Limited Prosperity Gold-Copper Project, Hydrometeorology Report. REF. NO. VA101-00266/01-2. Rev B, December 3, 2007. Prepared for Taseko Mines Limited by Knight Piésold Limited. Appendix 4-4-D in TML 2009.

KPL (Knight Piésold Limited). 2008. Taseko Mines Limited Prosperity Gold-Copper Project, Meteorological Site Installation and Maintenance Report. REF. NO. VA101-00266/01-8. Rev A, January 25, 2008. Prepared for Taseko Mines Limited by Knight Piésold Limited. Appendix 4-4-E in TML 2009.

KPL (Knight Piésold Limited). 2012a. Taseko Mines Limited New Prosperity Gold-Copper Project, Water Quality Model. REF. NO. VA101-266/25-1. Rev 0. August 30, 2012. Prepared for Taseko Mines Limited by Knight Piésold Limited. Appendix 2.7.2.4B-G in TML 2012.

KPL (Knight Piésold Limited). 2012b. Baseline Watershed Model for New Prosperity Project. File No.: VA101-266/25-A.01. Cont. No.: VA12-00832. Prepared for Taseko Mines Limited by Knight Piésold Limited. August 10, 2012. Appendix 2.6.1.4B-A in TML 2012.

KPL (Knight Piésold Limited). 2012c. New Prosperity Project – Climate Change Assessment. File No.: VA101-266/25-A.01. Cont. No.: VA12-01495. Prepared for Taseko Mines Limited by Knight Piésold Limited. August 14, 2012. Appendix 2.7.2.4A-D in TML 2012.

KPL (Knight Piésold Limited). 2012d. Lake Level Fluctuation Predictions for Fish Lake. File No.: VA101-266/25-A.01. Cont. No.: VA12-00743. Prepared for Taseko Mines Limited by Knight Piésold Limited. July 31, 2012. Appendix 2.7.2.4A-A in TML 2012.

KPL (Knight Piésold Limited). 2012e. Taseko Mines Limited New Prosperity Gold-Copper Project, Water Management Report. REF. NO. VA101-266/27-2. Rev 0. August 30, 2012. Prepared for Taseko Mines Limited by Knight Piésold Limited. Appendix 2.7.2.4A-B in TML 2012.

Lloyd, R. 1961. Effect of dissolved oxygen concentrations on the toxicity of several poisons to rainbow trout (*Salmo gairdnerii* Richardson). Journal of Experimental Biology 38: 447-455.

MacDonald, D.D. 1997. Methods for deriving site-specific water quality objectives in British Columbia and Yukon. Prepared for B.C. Ministry of Environment, Lands and Parks, Victoria, British Columbia and Environment Canada, Whitehorse, Yukon.

MacDonald and Ingersoll. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia - Volume III: Interpretation of the results of sediment quality investigations. Prepared for: Pollution Prevention and Remediation Branch, British Columbia Ministry of Water, Land, and Air Protection.

Mitsch, W.J., A.J. Horne and R.W. Nairn. 2000. Nitrogen and phosphorus retention in wetlands - ecological approaches to solving excess nutrient problems. Ecological Engineering 14: 1-7.

New Prosperity Gold-Copper Mine Project Federal Review Panel. 2012. Information Requests from the Federal Review Panel to Taseko Mines Ltd. Regarding the Environmental Impact Statement for the New Prosperity Gold-Copper Mine Project, British Columbia. December 10, 2012.

SRK (SRK Consulting). 2012. Water Quality Prediction Results. Prepared for Taseko Mines Limited by SRK Consulting. July 2012. Appendix 2.7.2.1-I in TML 2012.

Stockner, J. and D. Brandt. 2013. A Fish Lake testimony. Comments on the proposed New Prosperity Mine. Prepared for Tsilhqot'in National Government for the New Prosperity Panel Hearings, Williams Lake, July 2013.

TECL (Triton Environmental Consultants Ltd). 2012a. Water Quality Modelling. Prepared for Taseko Mines Limited by Triton Environmental Consultants Ltd. Appendix 2.7.2.4B-F in TML 2012.

TECL (Triton Environmental Consultants Ltd). 2012b. Fish Lake Limnology - 2011/2012. Prepared for Taseko Mines Limited by Triton Environmental Consultants Ltd. Appendix 2.7.2.4B-C in TML 2012.

TECL (Triton Environmental Consultants Ltd). 2012c. Fish Lake Mitigation Flow. Prepared for Taseko Mines Limited by Triton Environmental Consultants Ltd. Appendix 2.7.2.4B-D in TML 2012.

TECL (Triton Environmental Consultants Ltd). 2012d. Effects of Reduced Inflow on Fish Lake Trophic Status using the Mass Balance Approach. Prepared for Taseko Mines Limited by Triton Environmental Consultants Ltd. September 2012. Appendix 2.7.2.4B-A in TML 2012.

TML (Taseko Mines Limited). 2009. Taseko Prosperity Gold-Copper Project. Environmental Impact Statement/Application. British Columbia, Canada. Submitted March 2009.

TML (Taseko Mines Limited). 2012. Environmental Impact Statement for the Proposed New Prosperity Gold-Copper Mine Project. British Columbia, Canada. Submitted September 2012.

TML (Taseko Mines Limited). 2013. Responses to the Technical Information Requests from Taseko Mines Ltd. To the Federal Review Panel Regarding the Environmental Impact Statement for the New Prosperity Gold-Copper Mine Project, British Columbia. July 17, 2013.

USEPA (United States Environmental Protection Agency). 2001. Methods for collection, storage and manipulation of sediments for chemical and toxicological analyses: Technical manual. EPA-823-B-01-002. Office of Water. Washington, District of Columbia.

USEPA (United States Environmental Protection Agency). 2005. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: metal mixtures (cadmium, copper, lead, nickel, silver, zinc). EPA-600-R-02-011. Office of Research and Development. Washington, District of Columbia.

USEPA (United States Environmental Protection Agency). 2007. Aquatic Life Ambient Freshwater Quality Criteria – Copper. 2007 Revision. EPA-822-R-07-001. Office of Water, Office of Science and Technology. Washington, District of Columbia.

Verhoeven, J.T.A., B. Arheimer, C. Yin and M.M. Hefting. 2006. Regional and global concerns over wetlands and water quality. Trends in Ecology and Evolution 21(2): 96-103.

Weis, J.S. and P. Weis. 2004. Metal uptake, transport and release by wetland plants: implications for phytoremediation and restoration. Environment International 30(5): 685-700.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

EDUCATION:

Bachelor of Science, Zoology
(Fisheries Biology; Environmental Physiology, Comparative Biochemistry)
University of British Columbia, 1982

SPECIALIZATION:

Principal of MacDonald Environmental Sciences Limited, which was established to provide scientific consulting services in the fields of fisheries and aquatic resource management, stream ecology, environmental quality guidelines and policy development, environmental risk and hazard assessment, and information and technology transfer.

Specialist in environmental toxicology and chemistry, ecosystem-based resource management, water quality/water use interactions, and sediment quality assessment.

PROFESSIONAL MEMBERSHIPS:

American Fisheries Society
- President Western Division; Past-President, Canadian Aquatic Resources Section; Nominations Committee; Chair, Wetlands Conservation Committee; Newsletter Committee; Membership Committee.

Aquaculture Association of Canada
Association of Professional Biologists of British Columbia
Canadian Association on Water Pollution Research and Control
International Association on Water Pollution Research and Control
Society of Environmental Toxicology and Chemistry

OTHER PROFESSIONAL ACTIVITIES:

1986-1988	Newsletter Editor, North Pacific International Chapter, American Fisheries Society
1987-1989	Chair, Membership Committee, North Pacific International Chapter, American Fisheries Society
1992-1994	Chair, Wetlands Conservation Committee, Canadian Aquatic Resources Section, American Fisheries Society
1990-1994	Vice-President, President-Elect, President, and Past-President, Canadian Aquatic Resources Section, American Fisheries Society
1995-Present	Canadian Director and Chair, Board of Directors, Sustainable Fisheries Foundation
1997-2001	Vice-President, President-Elect, President, and Past-President, Western Division, American Fisheries Society
2000-2001	Member, Membership Committee, American Fisheries Society
2003-2006	Award of Excellence Committee, American Fisheries Society
2005-2006	Member, Science Advisory Board for Contaminated Sites in British Columbia
2006-Present	Board or Directors, Mid-Island Science, Technology & Innovation Council (MISTIC)

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

PROFESSIONAL CERTIFICATIONS:

Fisheries Professional-Certified (American Fisheries Society)
Registered Professional Biologist (College of Applied Biology - British Columbia)

EXPERIENCE:

AQUATIC BIOLOGIST - *February 1989 to Present*
MacDonald Environmental Sciences Limited, #24 - 4800 Island Highway North, Nanaimo, B.C. V9T 1W6 Independent consulting on environmental impact assessment, natural resource damage assessment, ecological risk assessment, fisheries and aquatic resource management, environmental quality, stream ecology, computer data management, and information and technology transfer. Projects include the development of water quality guidelines, sediment quality guidelines, tissue residue guidelines, environmental quality monitoring programs, fisheries co-management programs, ecosystem-based management, ecological risk assessments, natural resource damage assessments, and the assessment of environmental quality.

WATER QUALITY OBJECTIVES OFFICER - *September 1984 to February 1989*
Water Quality Branch, Inland Waters, Environment Canada, 502 - 1001 West Pender Street, Vancouver, B.C. V6E 2M9 Compilation, management and statistical analysis of existing and new information generated to support the formulation of water quality objectives in waters of significant federal interest; generation of water quality criteria information through toxicological, water quality, and other studies; design and implementation of monitoring programs to assess compliance with water quality objectives; preparation of reports and other publications on information developed to formulate water quality objectives; organization of workshops and information exchange sessions on water quality guidelines and objectives; provision of information and advice to technical committees established to resolve the International Joint Commission reference on the Flathead River. Supervisor: Dr. D. Valiela, Head Water Quality Objectives Division

TECHNICAL PLANNING COORDINATOR - *November 1983 to September 1984*
Water Quality Branch, Inland Waters, Environment Canada. 502 - 1001 West Pender Street, Vancouver, B.C. V6E 2M9 Planning and development of regional water quality programs, including long- and short-term logistics and budgetary requirements and inter-project coordination; planning, organization, expedition, and supervision of special field studies and sampling projects for water quality analysis; pollution surveillance and sediment sampling; planning and implementation on national water quality monitoring programs to assess national trends and conditions. Supervisor: Dr. W.E. Erlebach, Chief Water Quality Branch

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

PUBLICATIONS AND TECHNICAL REPORTS:

Journal/Book Publications

MacDonald D.D., D. Moore D, C.G. Ingersoll, D.E. Smorong, R.S. Carr, R. Gouguet, D. Charters, D. Wilson, T. Harris, J. Rauscher, S. Roddy, and J. Meyer. 2011. Baseline ecological risk assessment of the Calcasieu Estuary, Louisiana: 1. Overview and problem formulation. Archives of Environmental Contamination and Toxicology 61:1-13.

MacDonald D.D., C.G. Ingersoll, D.E. Smorong, J.A. Sinclair, R.A. Lindskoog, N. Wang, C. Severn, R. Gouguet, J. Meyer, and J. Field. 2011. Baseline ecological risk assessment of the Calcasieu Estuary, Louisiana: 2. An evaluation of the predictive ability of effects-based sediment quality guidelines. Archives of Environmental Contamination and Toxicology 61:14-28.

MacDonald D.D., C.B. Ingersoll, N. Kemble, D.E. Smorong, J.A. Sinclair, R.A. Lindskoog, C. Gaston, D. Sanger, S. Carr, J. Biedenbach, R. Gouguet, J. Kern, A. Shortelle, J. Field, and J. Meyer. 2011. Baseline ecological risk assessment of the Calcasieu Estuary, Louisiana: 3. An evaluation of the risks to benthic invertebrates associated with exposure to contaminated sediments. Archives of Environmental Contamination and Toxicology 61:29-58.

MacDonald D.D and C.G. Ingersoll. 2010. Tools for assessing contaminated sediments in freshwater, estuarine, and marine ecosystems. *In:* Sedimentology of Aqueous Systems, 1st edition, C. Poleto, S. Charlesworth editors. Blackwell Publishing. Boston Massachusetts.

Clark, M.J.R., D.D. MacDonald, P.H. Whitfield, and M.P. Wong. 2010. Designing monitoring programs for water quality based on experience in Canada. Part II - Monitoring Tools - Problem Characterization and Data Quality Objectives. Trends in Analytical Chemistry 29(5):385-398.

MacDonald, D.D., M.J.R. Clark, P.H. Whitfield, and M.P. Wong. 2009. Using water sampling for decision making for status and trends: Part III - Ecosystem Based Management and Water Quality Objectives - Problem Characterization and Data Quality Objectives. In Review.

MacDonald, D.D. M.J.R. Clark, P.H. Whitfield, and M.P. Wong. 2009. Designing monitoring programs for water quality based on experience in Canada I. Theory and framework. Trends in Analytical Chemistry 28(2):204-213.

Ingersoll, C.G., N.E. Kemble, J.L. Kunz,, W.G. Brumbaugh, D.D. MacDonald, and D. Smorong. 2009. Toxicity of sediment cores collected from the Ashtabula River in Northeastern Ohio, USA, to the amphipod *Hyalella azteca*. Archives of Environmental Contamination and Toxicology 57(2):315-329.

Bay, S.M., W. Berry, P. Chapman, R. Fairey, T. Gries, E. Long, D. MacDonald, and S. Weisberg. 2007. Evaluating consistency of best professional judgment in the application of a multiple lines of evidence sediment quality triad. Integrated Environmental Assessment and Management 3(4):491-497.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Long E.R., C.G. Ingersoll, and D.D. MacDonald. 2006. Calculation and uses of mean sediment quality guidelines: A critical review. Environmental Science and Technology 40(6)1726-1736.

Ingersoll, C.G., S.M. Bay, J.L. Crane, L.J. Field, T.H. Gries, J.L. Hyland, E.R. Long, D.D. MacDonald, and T.P. O'Connor. 2005. Ability of sediment quality guidelines to estimate effects or no effects of sediment-associated contaminants in laboratory toxicity tests or in benthic community assessments. *In:* Wenning RJ, Batley G, Ingersoll CG, editors. Use of sediment quality guidelines (SQGs) and related tools for the assessment of contaminated sediments. 497-556. SETAC Press. Pensacola Florida.

MacDonald, D.D., R.S. Carr, D. Eckenrod, H. Greening, S. Grabe, C.G. Ingersoll, S. Janicki, R.A. Lindskoog, E.R. Long, R. Pribble, G. Sloane, and D.E. Smorong. 2004. Development, evaluation and application of sediment quality targets for assessing and managing contaminated sediments in Tampa Bay, Florida. Archives of Environmental Contamination and Toxicology 46(2):147-161.

Knudsen, E.E., D.D. MacDonald, and Y.K. Muirhead, editors. 2004. Sustainable management of North American fisheries. American Fisheries Society, Symposium 43, Bethesda, Maryland.

Carr, R.S., J.M. Biedenbach, and D.D. MacDonald. 2003. Comparison of sediment quality guideline values derived using sea urchin porewater toxicity test data with existing guidelines. *In:* Porewater Toxicity Testing: Biological, Chemical, and Ecological Considerations R.S. Carr and M. Nipper (Eds). SETAC Press. Pensacola, Florida.

Crane, J.L. and D.D. MacDonald. 2003. Applications of numerical sediment quality targets for assessing sediment quality conditions in a U.S. Great Lakes Area of Concern. Environmental Management 32(1):128-140.

Nipper, M. R.S. Carr, W.J. Adams, W.J. Berry, G.A. Burton Jr., K.T. Ho. D.D. MacDonald, R. Scroggins, and P.V. Winger. 2003. Recommendations for research related to biological, chemical, and ecological aspects of sediment pore water: The way forward. *In:* Porewater Toxicity Testing: Biological, Chemical, and Ecological Considerations R.S. Carr and M. Nipper (Eds). SETAC Press. Pensacola, Florida.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, D.W. Sparks, J.R. Smith, T.P, Simon, and M.A. Hanacek. 2002. Assessment of injury to fish and wildlife resources in the Grand Calumet River and Indiana Harbor area of concern. Archives of Environmental Contamination and Toxicology 43:130-140.

MacDonald, D.D., M.A. Hanacek and L. Genn. 2002. Salmon, society and politics: The potential for ecosystem-based management of pacific salmon. *In:* Sustaining North American Salmon: Perspectives Across Regions and Disciplines. American Fisheries Society.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, D.W. Sparks, J.R. Smith, T.P, Simon, and M.A. Hanacek. 2002. An assessment of injury to sediments and sediment-dwelling organisms in the Grand Calumet River and Indiana Harbor area of concern. Archives of Environmental Contamination and Toxicology 43:141-155.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, C.G. Severn, T.A. Berger, and L.J. Field. 2002. Evaluation of numerical sediment quality targets for the St. Louis River area of concern. Archives of Environmental Contamination and Toxicology 43:1-10.

Ingersoll, C.G., D.D. MacDonald, W.G. Brumbaugh, B.T. Johnson, N.E. Kemble, J.L. Kunz, T.W. May, N. Wang, J.R. Smith, D.W. Sparks, and S.D. Ireland. 2002. Toxicity assessment of sediments from the Grand Calumet River and Indiana Harbor Canal in northwestern Indiana. Archives of Environmental Contamination and Toxicology 43:156-167.

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D. Smorong, and R. Lindskoog. 2002. Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environmental Toxicology and Chemistry 21(9):1993-2005.

Ingersoll C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R.A. Lindskoog, C.G. Severn, and D.E. Smorong. 2001. Predictions of sediment toxicity using consensus-based freshwater sediment quality guidelines. Archives of Environmental Contamination and Toxicology. Archives of Environmental Contamination and Toxicology 41:8-21.

MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology 39:20-31.

MacDonald, D.D., C.R. Steward, and E.E. Knudsen. 2000. One Northwest Community - People, Salmon, Rivers, and the Sea: Towards Sustainable Fisheries. *In:* E.E. Knudsen, C.R. Steward, D.D. MacDonald, J.E. Williams, and D.W. Reiser (Eds.). Sustainable Fisheries Management: Pacific Salmon. CRC Press. Boca Raton, Florida.

MacDonald, D.D., L.M. DiPinto, J. Field, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls (PCBs). Environmental Toxicology and Chemistry 19:1403-1413.

Kemble, N.E., D.G. Hardesty, C.G. Ingersoll, B.T. Johnson, F.J. Dwyer, and D.D. MacDonald. 2000. An evaluation of the toxicity of contaminated sediments from Waukegan Harbor, Illinois following remediation. Archives of Environmental Contamination and Toxicology 39:452-461.

Knudsen, E.E., D.D. MacDonald, C.R. Steward. 2000. Setting the Stage for a Sustainable Pacific Salmon Fisheries Strategy. *In:* E.E. Knudsen, C.R. Steward, D.D. MacDonald, J.E. Williams, and D.W. Reiser (Eds.). Sustainable Fisheries Management: Pacific Salmon. CRC Press. Boca Raton, Florida.

Knudsen, E.E., C.R. Steward, D.D. MacDonald, J.E. Williams, and D.W. Reiser (Eds.). 2000. Sustainable Fisheries Management: Pacific Salmon. CRC Press. Boca Raton, Florida.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Long, E.R., D.D. MacDonald, C.G. Severn, and C.B. Hong. 2000. Short Communication. Classifying probabilities of acute toxicity in marine sediments with empirically derived sediment quality guidelines. Environmental Toxicology and Chemistry 19(10):2598-2601.

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Severn, and C.G. Ingersoll. 1999. Evaluating sediment chemistry and toxicity data using logistic regression modelling. Environmental Toxicology and Chemistry 18(6):1311-1322.

Milburn, D., D.D. MacDonald, T.D. Prowse, and J.M. Culp. 1999. Ecosystem Maintenance Indicators for the Slave River Delta, Northwest Territories, Canada. *In*: Y.A. Pykh, D.E. Hyatt, and R.J.M. Lenz (Eds.). Environmental Indices: Systems Analysis Approach. ISBN 0 9534944 0 3. EOLSS Publishers Co. Ltd. Oxford, United Kingdom.

MacDonald, D.D., M.G. Ikonomou, A.-L. Rantalainen, I.H. Rogers, D. Sutherland, J. Van Oostdam. 1998. Contaminants in white sturgeon (*Acipenser transmontanus*) from the Upper Fraser River, British Columbia. Environmental Toxicology and Chemistry 16(3):479-490.

Long, E.R. and D.D. MacDonald. 1998. Recommended uses of empirically derived, sediment quality guidelines for marine and estuarine ecosystems. Human and Ecological Risk Assessment 4(5):1019-1039.

Long, E.R., D.D. MacDonald, J.C. Cubbage, and C.G. Ingersoll. 1998. Predicting the toxicity of sediment-associated trace metals with SEM:AVS concentrations and dry weight-normalized concentrations - A critical comparison. Environmental Toxicology and Chemistry 17(5):972-974.

Long, E.R., L.J. Field, and D.D. MacDonald. 1998. Predicting toxicity in marine sediments with numerical sediment quality guidelines. Environmental Toxicology and Chemistry 17(4):714-727.

Ingersoll, C.G., G.T. Ankley, R. Baudo, G.A. Burton, W. Lick. S.N. Luoma, D.D. MacDonald, T.B. Reynoldson, K.R. Solomon, R.C. Swartz, and W.J. Warren-Hicks. 1997. Workgroup summary report on uncertainty evaluation of measurement endpoints used in sediment ecological risk assessment. *In:* C.G. Ingersoll, T. Dillon, and G.R. Biddinger (Eds.). Ecological Risk Assessment of Contaminated Sediments. Pensacola Florida: SETAC Press p. 297-352.

Solomon, K.R., G.T. Ankley, R. Baudo, G.A. Burton, C.G. Ingersoll, W. Lick, S. Luoma, D.D. MacDonald, T.B. Reynoldson, R.C. Swartz, W.J. Warren-Hicks. 1997. Work group summary report on methodological uncertainty in sediment ecological risk assessment. *In:* C.G. Ingersoll, T. Dillon, and R.G. Biddinger (Eds). Ecological Risk Assessment of Contaminated Sediment. Pensacola Florida: SETAC Press. p. 271-296.

Zarbock, H., J. Schulten, E. Long, and D.D. MacDonald. 1997. Sediment contamination in Tampa Bay: Sources, risks, and management. Tampa Bay BASIS3 Proceedings.

MacDonald, D.D., R.S. Carr, F.D. Calder, E.R. Long, and C.G. Ingersoll. 1996. Development and evaluation of sediment quality guidelines for Florida coastal waters. Ecotoxicology 5:253-278.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.L. Gaudet. 1996. The development and implementation of Canadian sediment quality guidelines. *In:* M. Munawar and G. Dave (Eds.). Development and Progress in Sediment Quality Assessment: Rationale, Challenges, Techniques and Strategies. Ecovision World Monograph Series. SPB Academic Publishing. Amsterdam. The Netherlands.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. Journal of Great Lakes Research 22(3):624-638.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Journal of Environmental Management 19(1):81-97.

Porter, E.L., R.A. Kent, D.E. Andersen, K.A. Keenleyside, D. Milne, P. Cureton, S.L. Smith, K.G. Drouillard, and D.D. MacDonald. 1995. Development of proposed Canadian Environmental Quality Guidelines for cadmium. Journal of Geochemical Exploration 52:205-219.

Outridge, P.M. and D.D. MacDonald. 1994. An evaluation of the ecological hazards associated with cadmium in the Canadian environment. Environmental Reviews 2:91-107.

Powles, H. and D. MacDonald. 1994. Development of a Canadian office for the American Fisheries Society. Fisheries 19(2):30-31.

Caux, P.-Y., R.A. Kent, G.T. Fan, C. Grande, and D.D. MacDonald. 1994. Aldicarb. *In:* P.Y. Caux and R.A. Kent (Eds.). Canadian Water Quality Guidelines for Pesticides and Industrial Substances. Canadian Association on Water Quality. Monograph Series No. 4:1-62.

Caux, P.-Y., R.A. Kent, G.T. Fan, C. Grande, and D.D. MacDonald. 1994. Bromoxynil. *In:* P.Y. Caux and R.A. Kent (Eds.). Canadian Water Quality Guidelines for Pesticides and Industrial Substances. Canadian Association on Water Quality. Monograph Series No. 4:63-112

Caux, P.-Y., R.A. Kent, G.T. Fan, C. Grande, and D.D. MacDonald. 1994. Dimethoate. *In:* P.Y. Caux and R.A. Kent (Eds.). Canadian Water Quality Guidelines for Pesticides and Industrial Substances. Canadian Association on Water Quality. Monograph Series No. 4:113-164.

Caux, P.-Y., R.A. Kent, G.T. Fan, and D.D. MacDonald. 1994. Protocols for deriving Canadian water quality guidelines for the protection of agricultural water uses. Regulatory Toxicology and Pharmacology 20:223-247.

Caux, P.-Y., R.A. Kent, M. Tache, C. Grande, G.T. Fan, and D.D. MacDonald. 1994. Environmental fate and effects of dicamba: A Canadian perspective. Reviews of Environmental Contamination and Toxicology 133:1-58.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. and C.P. Newcombe. 1993. Effects of suspended sediments in aquatic ecosystems: A clarification of the stress index model. North American Journal of Fisheries Management 13(4):873-876.

Marshall, T.R. and D.D. MacDonald. 1992. Expanding the role of the American Fisheries Society in Canada: The issues, recent initiatives, and future strategies. Fisheries 17(4):28-31.

Newcombe, C.P. and D.D. MacDonald. 1991. Factors affecting the impacts of suspended sediments on aquatic ecosystems: Concentration and duration of exposure. North American Journal of Fisheries Management 11:72-82.

MacDonald, D.D. and T.R. Marshall. 1990. Canadian members of the AFS: Do we really belong? Fisheries 11(4):63-67.

MacDonald, D.D., D. Valiela, and S.J. Brown. 1988. Temporal variability of phosphorus levels in the Flathead River at the International Border Station. Water Pollution Research Journal of Canada 23(4):556-567.

MacDonald, D.D. and L.E. McDonald. 1987. The influence of surface coal-mining on potential salmonid spawning habitat in the Fording River, B.C. Water Pollution Research Journal of Canada 22(4):584-595.

Mommsen, T.P., J. Ballantyne, D.D. MacDonald, J. Gosline and P.W. Hochachka. 1981. Analogues of red and white muscle in squid mantle. Proceedings of the National Academy of Sciences USA 78(5):3274-3278.

Technical Reports

Carter, R., M.E. Wainwright, D.D. MacDonald, J.A. Sinclair, A. Schein, H.J. Prencipe, M.L. Haines, W. Lorentz, D. Tillitt, and D.K. Nicks. 2013. Field Sampling Plan for Evaluation of Exposure of Avian Receptors to Bioaccumulative Contaminants. Prepared for United States Fish and Wildlife Service. Birmingham, Alabama.

MacDonald, D.D., C.G. Ingersoll, M.E. Wainwright, A. Schein, C.E. Orazio, W.G. Brumbaugh, H.J. Prencipe, J.A. Sinclair, M.L. Haines. 2013. Quality Assurance Protection Plan (QAPP) for Evaluation of the Toxicity of Upper Columbia River Sediments to Freshwater Mussels. Prepared for United States Department of the Interior (USDOI) Project Manager. Spokane, Washington.

MacDonald, D.D., J. Sinclair, and M. Coady. 2012. An Evaluation of the Reference Envelope Approach Applied in the Baseline Ecological Risk Assessment for the Portland Harbor Site. Prepared for: Office of Environmental Assessment, U.S. Environmental Protection Agency. Seattle, Washington. Prepared by: MacDonald Environmental Sciences Ltd., Nanaimo, BC in association with CDM Smith, Bellevue, WA.

MacDonald, D.D., A. Schein, and J. Sinclair. 2012. Overview of Water Quality Issues and Concerns Related to the Avanti Kitsault Mine Project. Prepared for Nisga'a Lisims Government, New Aiyansh, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D., J.A. Sinclair, A. Schein, H.J. Prencipe, M.E. Wainwright, M.R. Coady, M.L. Haines, C.G. Ingersoll, N.E. Kemble, J.L. Kunz, J.A. Steevens, G.R. Lotufo, and D. Farrar. 2012. Preliminary Assessment and Quantification of Natural Resource Injuries Associated with Discharges of Oil or Releases of Other Hazardous Substances in the Vicinity of the Piles Creek Site, Linden, New Jersey. Volume 1 - Technical Report. Prepared for Office of Response and Restoration National Oceanic and Atmospheric Administration and New Jersey Field Office, U.S. Fish and Wildlife Service. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, United States Geological Survey, Columbia, Missouri, and United States Army Corps of Engineers (ERDC), Vicksburg, Missouri.

MacDonald, D.D. and J.A. Sinclair. 2012. Identification and evaluation of toxicity tests to support the development of site-specific water quality objectives for Buttle Lake, Vancouver Island, British Columbia. Prepared for B.C. Ministry of the Environment. Nanaimo, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Sinclair, J.A., M.A. Crawford, D.D. MacDonald, and H.J. Prencipe. 2012. Preliminary risk assessment of Long Lake in the Quinsam River Watershed, Vancouver Island. Technical Report. Prepared for Ministry of Environment. Province of British Columbia. Nanaimo, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Ingersoll1, C.G., J.A. Steevens, J.A., and D.D. MacDonald. 2012. Evaluation of toxicity to the amphipod, *Hyalella azteca*, and to the midge, *Chironomus dilutus*, and bioaccumulation by the oligochaete, *Lumbriculus variegatus*, with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by: U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; MacDonald Environmental Sciences Ltd., Nanaimo, BC

Ingersoll, C.G., W.G. Brumbaugh, J. A., Steevens, G.R. Lotufo, D.D. MacDonald, and J.A. Sinclair. 2012. Sediment aample collection, handling, preparation, and characterization. Chapter 2 . *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca,* and to the midge, *Chironomus dilutus,* and bioaccumulation by the oligochaete, *Lumbriculus variegatus,* with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; MacDonald Environmental Sciences Ltd., Nanaimo, BC

Steevens, J.A.,G.R. Lotufo, N.E. Kemble, C.G. Ingersoll, J.K. Stanley, J.D. Farrar, J.A. Sinclair, D.D. MacDonald. 2012. Evaluation of bioaccumulation in the oligochaete, *Lumbriculus variegatus*, exposed to sediments from the Anniston PCB Site. Chapter 3. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca,* and to the midge, *Chironomus dilutus*, and bioaccumulation by the oligochaete, *Lumbriculus variegatus,* with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; U.S. Geological Survey, Columbia, MO; 3MacDonald Environmental Sciences Ltd., Nanaimo, BC.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Stanley, J.K., N.E. Kemble, J.D. Farrar, C.G. Ingersoll, D.D. MacDonald, J.A. Steevens, J.A. Sinclair. 2012. Toxicity testing with the amphipod, *Hyalella azteca*, and with the midge *Chironomus dilutus*. Chapter 4. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca*, and to the midge, *Chironomus dilutus*, and bioaccumulation by the oligochaete, *Lumbriculus variegatus*, with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; MacDonald Environmental Sciences Ltd., Nanaimo, BC.

MacDonald, D.D., C.G. Ingersoll, J.A. Sinclair, J.A. Steevens, J.K. Stanley, J.D. Farrar, N.E. Kemble, J.L. Kunz, W.G. Brumbaugh, and M.R. Coady. 2012. Evaluation of relations between sediment toxicity and sediment chemistry at the Anniston PCB Site. Chapter 5. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca*, and to the midge, *Chironomus dilutus*, and bioaccumulation by the oligochaete, *Lumbriculus variegatus*, with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, BC; U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS.

MacDonald, D.D., J. Sinclair, M.A. Crawford, H. Prencipe, and M. Coady. 2012. Evaluation and interpretation of the sediment chemistry and sediment toxicity data for the Upper Columbia River. Prepared for Washington Department of Ecology Toxic Cleanup Program. Through Science Applications International Corporation. Bothell, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia.

MacDonald, D.D. 2011. Approach to the Compilation of Toxicity Thresholds and Selection of Toxicity Tests for the Hanford Natural Resources Damage Assessment. Summary Report for Workshop Convened March 15, 2011 in Richland, WA MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia, in association with Industrial Economics, Inc., Cambridge, Massachusetts. Prepared for: Hanford Natural Resource Trustee Council, U.S. Fish and Wildlife Service, Spokane, Washington.

MacDonald, D.D., J.A. Sinclair, M. Crawford, H. Prencipe, C. Lewis, and M. Donlan. 2011. Preliminary Summary of Whole-Sediment Chemistry, Fish-Tissue Chemistry, and Invertebrate-Tissue Chemistry Data Obtained during the 2010 Sediment and Biota Sampling Program for Piles Creek and South Branch Creek, Linden, New Jersey. Prepared for Office of Response and Restoration, National Oceanic and Atmospheric Administration and Division of Environmental Contaminants, U.S. Fish and Wildlife Service. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, and Industrial Economics Inc., Columbia, Missouri.

MacDonald, D.D., J. Sinclair, M. Crawford, H. Prencipe and M. Meneghetti. 2011. Potential effects of contaminants on Fraser River sockeye salmon. MacDonald Environmental Sciences Ltd. Cohen Commission Tech. Rep. 2. In prep. Vancouver, British Columbia www.cohencommission.ca

MacDonald, D.D., C.G. Ingersoll, J. Sinclair, M. Crawford, H. Prencipe, M. Coady, N.E. Kemble, A. Jones, M. Curry, C. Lewis, J. Steevens, and K. Nolan. 2011. Preliminary evaluation of the effects on benthic invertebrates associated with exposure to

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

PCB-contaminated sediments in the Upper Hudson River, New York. Prepared for National Oceanic and Atmospheric Administration. Silver Spring, Maryland. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia.

MacDonald, D.D., G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume I: Overview of the Recommended Decision Framework. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume II: Description of the Rapid (Tier 1) Assessment Process. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume III: Description of Detailed (Tier 2) Assessment Process. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., G.L. Linder, C.G. Ingersoll, and S.E. Finger. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume IV: Monitoring Requirements for Evaluating the Ecological Effects Associated with Placement of Candidate Materials on Units of the National Wildlife Refuge System. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., C.G. Ingersoll, M. Crawford, H. Prencipe, J.M. Besser, W.G. Brumbaugh, N. Kemble, T.W. May, C.D. Ivey, M. Meneghetti, J. Sinclair, and M. O'Hare. 2010. Advanced screening-level ecological risk assessment (SLERA) for aquatic habitats within the Tri-State Mining District, Oklahoma, Kansas, and Missouri. Draft Final Technical Report. Submitted to United States Environmental Protection Agency (USEPA). Region 6, Dallas, Texas, Region 7, Kansas City, Kansas, and US Fish and Wildlife Service, Columbia, Missouri. Submitted by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. United States Geological Survey, Columbia, Missouri. CH2M Hill, Dallas, Texas

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D., P. Landrum, J. Sanderson, C. Lafontaine, M. Crawford, H. Prencipe, M. Meneghetti, M.L. Haines, A. Czarnecki, D. Smorong, O. Forest, and J. Smejkal. 2010. Status and Trends of Environmental Quality Conditions in the Transboundary Reach of the Slave River, NWT. Draft Report. Prepared for Indian and Northern Affairs Canada. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences, Nanaimo, British Columbia. Landrum and Associates, Ann Arbor, Michigan. Indian and Northern Affairs Canada, Yellowknife, Northwest Territories.

MacDonald, D.D. 2009. Development of a sediment remediation footprint to address risks to benthic invertebrates and fish in the vicinity of the shipyards site in San Diego Bay, California. MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Prepared for: Clean Bay Campaign Environmental Health Coalition. National City, California.

MacDonald, D.D. and M. Stelljes. 2009. Pilot Sediment Investigation for the Detailed Quantitative Ecological Risk Assessment of Esquimalt Harbour: Evaluation of Candidate Reference Areas and Candidate Toxicity Tests. Prepared for Public Works and Government Services Canada. Prepared by MacDonald Environmental Sciences Ltd, Nanaimo, British Columbia and SLR Consulting, Victoria, British Columbia.

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, J.M. Besser, W.G. Brumbaugh, N. Kemble, T.W. May, C.D. Ivey, S. Irving, and M. O'Hare. 2009. Development and evaluation of sediment and pore-water toxicity thresholds to support sediment quality assessments in the Tri-State Mining District (TSMD), Missouri, Oklahoma, and Kansas. Draft Final Technical Report. Volume I: Text. Submitted to United States Environmental Protection Agency (USEPA). Region 6, Dallas, Texas, Region 7, Kansas City, Kansas, and US Fish and Wildlife Service, Columbia, Missouri. Submitted by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. United States Geological Survey, Columbia, Missouri. CH2M Hill, Dallas, Texas.

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, J.M. Besser, W.G. Brumbaugh, N. Kemble, T.W. May, C.D. Ivey, S. Irving, and M. O'Hare. 2009. Development and evaluation of sediment and pore-water toxicity thresholds to support sediment quality assessments in the Tri-State Mining District (TSMD), Missouri, Oklahoma, and Kansas. Draft Final Technical Report. Volume II: Appendices 1 through 4. Submitted to United States Environmental Protection Agency (USEPA). Region 6, Dallas, Texas, Region 7, Kansas City, Kansas, and US Fish and Wildlife Service, Columbia, Missouri. Submitted by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. United States Geological Survey, Columbia, Missouri, and CH2M Hill, Dallas, Texas.

MacDonald, D.D., J. Steevens, W. Lorentz, P. Tuttle, and S. Thoms. 2009. Preliminary evaluation of the effects of wet and dry sieving on the concentrations and homolog distribution of PCBs in Choccolocco Creek samples. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., C.G. Ingersoll, A. Jones, D.E. Smorong, M. Curry, and K. Lanahan. 2009. Work Plan for the pilot study on the effects of PCB-contaminated sediments on benthic invertebrates in the Upper Hudson River, New York. Prepared for National Oceanic and Atmospheric Administration. Silver Spring, Maryland. Prepared by: MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Industrial Economics Inc. Cambridge, Massachusetts.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 1- Recommended procedures for identifying issues and concerns associated with development projects. Prepared for Indian and Northern Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Zajdlik and Associates, Rockwood, Ontario.

MacDonald, D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 2 - Recommended procedures for developing the problem formulation to support the design of aquatic effects monitoring identifying issues and concerns associated with development projects. Prepared for Indian and Northern Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Zajdlik and Associates, Rockwood, Ontario.

MacDonald, D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 3 - Recommended procedures for developing data quality objectives and a conceptual study design. Prepared for Indian and Northern Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Zajdlik and Associates, Rockwood, Ontario.

MacDonald, D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 5 - Recommended procedures for documenting and verifying conceptual and detailed designs of aquatic effects monitoring programs. Prepared for Indian and Northern Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Zajdlik and Associates, Rockwood, Ontario.

MacDonald, D.D., B. Zajdlik, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 6 - Recommended procedures for evaluating, compiling, interpreting, and reporting data collected under aquatic effects monitoring programs. Prepared for Indian and Northern Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Zajdlik and Associates, Rockwood, Ontario.

Stelljes, M., D.D. MacDonald, D.E. Smorong, M. McLeay, S. Reimer, and J. Smejkal. 2009. Preliminary problem formulation for the detailed quantitative ecological risk assessment of Esquimalt Harbour, BC. March 2009 version. Prepared for Public Works and Government Services Canada. Prepared by SLR Consulting, Victoria, British Columbia and MacDonald Environmental Sciences Ltd, Nanaimo, British Columbia

Zajdlik, B. D.D. MacDonald, and INAC Water Resources. 2009. Guidelines for designing and implementing aquatic effects monitoring programs for development projects in the Northwest Territories: Volume 4 - Recommended procedures for developing detailed designs of aquatic effects monitoring programs. Prepared for Indian and Northern

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Affairs Canada. Water Resources Division. Yellowknife, Northwest Territories. Prepared by Zajdlik and Associates, Rockwood, Ontario and MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia.

MacDonald, D.D. and P.F. Landrum. 2008. An Evaluation of the Approach for Assessing Risks to the Benthic Invertebrate Community at the Portland Harbor Superfund Site. Preliminary Draft. Prepared for United States Environmental Protection Agency, Region 10, Seattle, Washington 9 and Parametrix, Inc. Albany, Oregon. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and Landrum and Associates, Ann Arbor, Michigan..

MacDonald, D.D. and D.E. Smorong. 2008. An assessment of injury to natural resources and associated damages to surface water and biological resources in the vicinity of the Cornell-Dubilier Electronics, Inc. Superfund Site, South Plainfield, N.J. Prepared for United States Department of Justice. Washington, District of Columbia. Prepared by MacDonald Environmental Sciences Ltd, Nanaimo, British Columbia in association with Industrial Economics Inc., Cambridge, Massachusetts.

MacDonald, D.D., B. Zajdlik, K. Racher, M. Culhane, and J. Arsenault. 2008. Guidelines for Designing and Implementing Aquatic Effects Monitoring Program for Development Projects in the Northwest Territories: Overview Report. Prepared for Indian and Northern Affairs Canada. Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia and Zajdlik & Associates Inc. Rockwood, Ontario.

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, N. Kemble, C.D. Ivey, T. Baker, and M. Curry. 2008. Preliminary evaluation of the toxicity of field-collected sediments from the Calcasieu Estuary, Louisiana. Technical Report. Prepared for: National Oceanic and Atmospheric Administration, Assessment and Restoration Division. Baton Rouge, Louisiana.

MacDonald, D.D., R. Gale, W. Brumbaugh, C.G. Ingersoll, D.E. Smorong, S. Hamilton, and Y. Muirhead. 2008. Guidelines on the selection of analytical detection limits for generating water chemistry, sediment chemistry, and tissue residue data for use in aquatic risk assessments. Prepared for Office of Environmental Policy and Compliance. Department of the Interior. Washington, District of Columbia and Emergency Response Team. United States Environmental Protection Agency. Edison, New Jersey. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., D.E. Smorong, J.J. Jackson, and Y.K. Muirhead. 2008. Ecological and human health risk assessment of aquatic habitats in the vicinity of the Weston Foods (Canada) Inc. Site in Quathiaski Cove, Quadra Island. Technical Report. Prepared for Weston Foods (Canada) Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., D.E. Smorong, J.J. Jackson, J. Rao, N. Shah, and S. Reimer. 2008. Overview of the assessment activities and remedial measures conducted to support an application for certificate of compliance for the Weston Foods Inc. waterlot site, Quathiaski Cove, Quadra Island, B.C. Prepared for Weston Foods (Canada) Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Levelton Consultants Ltd. Surrey, British Columbia and SEACOR Environmental. Victoria, British Columbia

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, J.M. Besser, W.G. Brumbaugh, N. Kemble, T.W. May, S. Irving, and M. O'Hare. 2008. Evaluation of the matching sediment chemistry and sediment toxicity in the Tri-State Mining District (TSMD), Missouri, Oklahoma, and Kansas. Preliminary Draft. Prepared for United States Environmental Protection Agency Region 6, and Region 7 and United States Fish and Wildlife Service, Columbia, Missouri. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. United States Geological Survey. Columbia, Missouri and CH2M Hill. Dallas, Texas.

Canton, S.P., A. Fairbrother, A.D. Lemly, H.M. Ohlendorf, L.E. McDonald, and D.D. MacDonald. 2008. Experts Workshop on the evaluation and management of selenium in the Elk Valley, British Columbia. Submitted to: British Columbia Ministry of the Environment. Environmental Protection Division, Kootenay and Okanagan Regions.

Ingersoll C.G., D.D. MacDonald, J.M. Besser, W.G. Brumbaugh, C.D. Ivey, N.E. Kemble, J.L. Kunz, T.W. May, N. Wang, and D.E. Smorong. 2008. Sediment chemistry, toxicity, and bioaccumulation data report for the US Environmental Protection Agency - Department of the Interior sampling of metal-contaminated sediment in the Tri-state Mining District in Missouri, Oklahoma, and Kansas. Prepared by USGS, Columbia Missouri and MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia for the USEPA Kansas City, Missouri; USEPA, Dallas, Texas, and USFWS, Columbia, Missouri.

MacDonald, D.D. and D.E. Smorong. 2007. Response to Comments on: Receiving Environmental Monitoring Program (REMP) for the Capital Regional District (CRD) Core Area Liquid Waste Management Plan (LWMP) for the Macaulay Point and Clover Point Outfalls. Submitted to British Columbia Ministry of Environment, Nanaimo, British Columbia and British Columbia Ministry of Environment, Victoria, British Columbia.

MacDonald, D.D., D.E. Smorong, and J.J. Jackson. 2007. Evaluation of residual risks to ecological receptors associated with exposure to toxic and bioaccumulative contaminants of concern following the implementation of various sediment restoration options in the Indiana Harbor Area of Concern, Indiana. Version 1. Prepared for United States Fish and Wildlife Service. Bloomington, Indiana and Indiana Department of Environment Management. Indianapolis, Indiana. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., D.E. Smorong, J.J. Jackson, Y.K. Muirhead, J.G. Stefanoff, B.E. Sample, H.M. Ohlendorf, and Frank Dillon. 2007. Screening Level ecological risk assessment (SLERA) of the Upper Columbia River Site, Washington. Preliminary problem formulation Version 1.0 (Draft - April, 2007). Prepared for CH2M Hill Spokane, Washington. Prepared by MacDonald Environmental Sciences Ltd. CH2M Hill.

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, J.J. Jackson, Y.K. Muirhead, and S. Irving. 2007. Advanced screening level ecological risk assessment (SLERA) of aquatic habitats in the Tri-State Mining District in Missouri, Kansas, and Oklahoma - Preliminary problem formulation. Version 2.0. Prepared for United States Environmental

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Protection Agency. Region 6. Dallas, Texas and Region 7. Kansas City, Kansas. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. United States Geological Survey. Columbia, Missouri and CH2M Hill. Dallas, Texas.

MacDonald, D.D., D.E. Smorong, C.G. Ingersoll, J.J. Jackson, Y.K. Muirhead, and S. Irving. 2007. Candidate assessment endpoints, risk questions, and measurement endpoints for a baseline ecological risk assessment. Version 1.0. Prepared for United States Environmental Protection Agency. Region 6. Dallas, Texas and Region 7. Kansas City, Kansas. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. United States Geological Survey. Columbia, Missouri and CH2M Hill. Dallas, Texas.

MacDonald, D. D., D.E. Smorong, D.G. Pehrman, C.G. Ingersoll, J. J. Jackson, Y.K. Muirhead, S. Irving, and C. McCarthy. 2007. Conceptual field sampling design - 2007 sediment sampling program of the Tri-State Mining District. Prepared for United States Environmental Protection Agency. Region 6. Dallas, Texas and Region 7. Kansas City, Kansas. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Black & Veatch Special Projects Corp. Laurel Springs, New Jersey. United States Geological Survey. Columbia, Missouri and CH2M Hill. Dallas, Texas.

MacDonald, D.D., D.E. Smorong, J.J. Jackson, Y.K. Muirhead, and C.G. Ingersoll. 2007. Receiving Environmental Monitoring Program (REMP) for the Capital Regional District (CRD) Core Area Liquid Waste Management Plan (LWMP) for the Macaulay Point and Clover Point Outfalls. Submitted to British Columbia Ministry of Environment. Nanaimo, British Columbia and British Columbia Ministry of Environment. Victoria, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri.

MacDonald, Donald D., Christopher G. Ingersoll, Aswea D. Porter, Yvonne K. Muirhead, Scott T. Black, and C.G. Miller. 2007. Approach to the development of delisting targets for the Presque Isle Bay Area of Concern, Pennsylvania. Technical Report - Prepared April 2005, revised May 2007. Prepared for: Pennsylvania Sea Grant. Penn State University. Erie, Pennsylvania, and Pennsylvania Department of Environmental Protection. Meadville, Pennsylvania.

MacDonald, Donald D., D.E. Smorong, C.G. Ingersoll, and J.J. Jackson, 2007. An assessment of recovery-period sediment quality conditions in Presque Isle Bay Area of Concern, Pennsylvania. Technical Report - Preliminary Draft. PIB-SQCRP-0707-V2. Prepared for: Pennsylvania Sea Grant. Penn State University. Erie, Pennsylvania, and Pennsylvania Department of Environmental Protection. Meadville, Pennsylvania. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., A.D. Porter, C. Miller, and S. Black. 2007. Field sampling plan for the 2005 sediment quality evaluation of Presque Isle Bay, Pennsylvania. Prepared August 2005, revised May 2007. Prepared for Pennsylvania Sea Grant. Penn State University. Erie, Pennsylvania and Pennsylvania Department of Environmental Protection. Meadville, Pennsylvania. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MESL (MacDonald Environmental Sciences Ltd.) and CH2M Hill. 2007. Ecological risk assessment workshop for the Tri-State Mining District - Kansas, Missouri, and

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Oklahoma - Workshop summary report. Prepared for United States Environmental Protection Agency. Region 6. Dallas, Texas and Region 7. Kansas City, Kansas. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia, and CH2M Hill. Dallas, Texas.

Obert, E., L. Boughton, D. Smorong, and D. MacDonald. 2007. Quality Assurance Project Plan (QAPP): Development of delisting targets and associated sediment quality monitoring program for the Presque Isle Bay Area of Concern. Grant Number GL-96556701-0. Revision 3, prepared January 2005, revised May 2007. Prepared by Pennsylvania Sea Grant. Penn State University. Erie, Pennsylvania and Pennsylvania Department of Environmental Protection. Meadville, Pennsylvania. In association with MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Sustainable Fisheries Foundation. 2007. Workshop to support the development of guidance on the assessment of contaminated sediments in British Columbia: Workshop Summary Report. Prepared for the British Columbia Ministry of Environment. Victoria, British Columbia. Prepared by the Sustainable Fisheries Foundation. Nanaimo, British Columbia.

MacDonald, D.D. 2006. Toward the development of northern water standards: Review and evaluation of approaches for managing water use in Northern Canada. Discussion Paper. Prepared for Indian and Northern Affairs Canada. Gatineau, Quebec and Yellowknife, Northwest Territories. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D. and D.E. Smorong. 2006. An evaluation of sediment quality conditions in the vicinity of the Macaulay Point and Clover Point outfalls. Submitted to Environmental Management Branch. British Columbia Ministry of Environment, Victoria, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D. and D.E. Smorong. 2006. Review and evaluation of the seawater and seafloor triggers established under the Capital Regional District's core area liquid waste management plan. Submitted to British Columbia Ministry of Environment. Nanaimo, British Columbia and British Columbia Ministry of Environment. Victoria, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., C.G. Ingersoll, and D.E. Smorong. 2006. An assessment of injury to natural resources and associated damages to surface water and biological resources In the vicinity of the Bloomington PCB Sites. Technical Report. Prepared for United States Department of Interior. Washington, District of Columbia and United States Department of Justice. Washington, District of Columbia. Prepared by MacDonald Environmental Sciences Limited. Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri. In association with Industrial Economics Inc. Cambridge, Massachusetts.

MacDonald, D.D., D.E. Smorong, and C.G. Ingersoll. 2006. Approach for assessing and quantifying injuries to physical resources (surface water and bed sediments) and biological resources (sediment-dwelling organisms and benthic fish) in intertidal and shallow sub-tidal habitats of the Calcasieu Estuary associated with the June, 2006 slop

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

oil spill at the Citgo Facility in Lake Charles, Louisiana. Prepared for National Oceanic and Atmospheric Administration (NOAA). Baton Rouge, Louisiana and Louisiana Oil Spill Coordinator's Office. Baton Rouge, Louisiana. Prepared by MacDonald Environmental Sciences Limited. Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri.

MacDonald, D.D., C.G. Ingersoll, M. Donlan, C.H. Peterson, D.E. Smorong, A.D. Porter, Y.K. Muirhead, S.T. Black, C.G. Miller. 2006. Preliminary estimate of damages Technical Appendix 1: Potential injury to bed sediments and biological resources (sediment injury) and associated benthic service losses in the Passaic River - Newark Bay Complex. Prepared for Damage Assessment Center. National Oceanic and Atmospheric Administration. Silver Spring, Maryland. Site Remediation Program. New Jersey Department of Environmental Protection. Trenton, New Jersey and Environmental Contaminants and Private Lands. United States Fish and Wildlife Service - New Jersey Field Office. Pleasantville, New Jersey.

MacDonald, D.D., D.E. Smorong, A.D. Porter, Y.K. Muirhead, C.G. Ingersoll. 2006. Preliminary estimate of damages Technical Appendix 2: Preliminary identification of contaminants of concern in the Passaic River - Newark Bay Complex. National Oceanic and Atmospheric Administration. Silver Spring, Maryland, New Jersey Department of Environmental Protection. Trenton, New Jersey and United States Fish and Wildlife Service. Pleasantville, New Jersey. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri. In association with Industrial Economics Inc. Cambridge, Massachusetts.

MacDonald, D.D., D.E. Smorong, J.J. Jackson, and Y.K. Muirhead. 2006. Supplemental evaluation of sediment quality conditions in the vicinity of the Macaulay Point and Clover Point Outfalls. Submitted to British Columbia Ministry of Environment. Victoria, British Columbia and British Columbia Ministry of Environment, Nanaimo, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia

MacDonald, D.D., A. Jones, J. Michel, T. Baker, C.G. Ingersoll, D.E. Smorong, and J. Jackson. 2006. Field sampling plan for the 2006 sediment and biota sampling program of the Calcasieu Estuary, Louisiana. Prepared for National Oceanic and Atmospheric Administration. Damage Assessment Center. Baton Rouge, Louisiana and Louisiana Oil Spill Coordinator's Office. Office of the Governor. Baton Rouge, Louisiana. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Industrial Economics Inc. Cambridge, Massachusetts. Research Planning, Inc. Columbia, South Carolina. NOAA. Baton Rouge, Louisiana and United States Geological Survey. Columbia, Missouri.

MacDonald, D.D., A. Jones, D.E. Smorong, J. Jackson, C.G. Ingersoll, and T. Baker. 2006. Quality assurance project plan (QAPP) for the 2006 sediment and biota sampling program of the Calcasieu Estuary, Louisiana. Revision: 2.0. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Industrial Economics Inc. Cambridge, Massachusetts. United States Geological Survey. Columbia, Missouri and National Oceanic and Atmospheric Administration. Baton Rouge, Louisiana

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, and J. Jackson. 2006. Sediment and biota sampling program for the 2006 Citgo Oil Spill of the Calcasieu Estuary, Louisiana.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Procedures for selecting sediment samples for toxicity testing. Prepared for National Oceanic and Atmospheric Administration (NOAA). Baton Rouge, Louisiana and Louisiana Oil Spill Coordinator's Office. Baton Rouge, Louisiana. Prepared by MacDonald Environmental Sciences Limited. Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri.

MESL, USGS, and Tetra-Tech (MacDonald Environmental Sciences Ltd., United States Geological Survey, and Tetra Tech EC, Inc.). 2006. Appendix B.1: Evaluation of the adequacy of benthic preliminary restoration goals for protecting aquatic-dependent wildlife in the West Branch of the Grand Calumet River. Technical Appendix. *In:* Restoration alternatives development report. West Branch of the Grand Calumet River, Hammond, Indiana. Prepared by Tetra Tech EC, Inc. Prepared for United States Fish and Wildlife Service. Bloomington, Indiana and Indiana Department of Environmental Management. Indianapolis, Indiana.

MESL (MacDonald Environmental Sciences Ltd.) and Cantox (Cantox Environmental, Inc.). 2006. Identification of assessment and measurement endpoints to support the development of preliminary remediation goals for the Anniston PCB site, Anniston, Alabama. Prepared for: United States Environmental Protection Agency. Edison, New Jersey. Prepared by MESL. Nanaimo, British Columbia and Cantox. Ottawa, Ontario.

Smorong, D.E., D.D. MacDonald, Y.K. Muirhead, and J.J. Jackson. 2006. Data package for the 2006 sediment and biota field sampling program of the Calcasieu Estuary, Louisiana. Prepared for National Oceanic and Atmospheric Administration. Damage Assessment Center. Baton Rouge, Louisiana and Louisiana Oil Spill Coordinator's Office. Office of the Governor. Baton Rouge, Louisiana. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia

Wong, M., P. Whitfield, and D. MacDona1d. 2006. Discussion paper on water quality sampling: guidance on the use of sampling for decision making - Status and trends. Submitted to Working Group on Water Quality Sampling. International Organization for Standardization. Geneva, Switzerland.

MacDonald, D. D. 2005. Field sampling plan for advanced screening study of Quathiaski Cove Site, Quadra Island. Prepared for Weston Foods (Canada) Inc. Surrey, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia

MacDonald, D.D. 2005. Quality assurance project plan for the advanced screening study of the Quathiaski Cove Site, Quadra Island, British Columbia. Prepared for Weston Foods (Canada) Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D. 2005. Health and safety plan for the 2006 supplemental characterization program of the Quathiaski Cove Site, Quadra Island, BC. Prepared for Weston Foods (Canada) Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D. and C.G. Ingersoll. 2005. Baseline ecological risk assessment for the Quathiaski Cove Site, Quadra Island, B.C. Baseline Problem Formulation. Prepared for

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Weston Foods Inc. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey. Columbia, Missouri.

MacDonald, D.D., D.E. Smorong, and C.G. Ingersoll. 2005. Field sampling plan for the 2006 supplemental characterization of the Quathiaski Cove Site, Quadra Island. Prepared for Weston Foods Inc. c/o Zuliani & Company Consultants Ltd. Surrey, British Columbia.

MacDonald, D.D., D.E. Smorong, and C.G. Ingersoll. 2005. Quality assurance project plan for the 2006 supplemental characterization program of the Quathiaski Cove Site, Quadra Island, BC. Prepared for Weston Foods Inc. c/o Zuliani & Company Consultants Ltd. Surrey, British Columbia.

MacDonald, D.D., A.D. Porter, Y.K. Muirhead, S.T. Black, and C.G. Miller. 2005. Screening level ecological risk assessment for the Quathiaski Cove Site, Quadra Island, British Columbia. Technical Report. Prepared for Weston Foods Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D., R. Gale, W. Brumbaugh, C.G. Ingersoll, D.E. Smorong, S. Hamilton, and Y.K. Muirhead. 2005. Guidance on the selection of analytical detection limits for generating water chemistry, sediment chemistry, and tissue residue data for use in aquatic risk assessments. Prepared for Office of Environmental Policy and Compliance. Natural Resources Trust and Response Team. Department of the Interior. Washington, District of Columbia and Emergency Response Team. United States Environmental Protection Agency. Edison, New Jersey.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, L. Fisher, C. Huntington, and G. Braun. 2005. Development and evaluation of risk-based preliminary remediation goals for selected sediment-associated contaminants of concern in the West Branch of the Grand Calumet River. Prepared for: United States Fish and Wildlife Service. Bloomington, Indiana.

MacDonald, D.D., C.G. Ingersoll, A.D. Porter, S.B Black, C. Miller, Y.K. Muirhead. 2005. Development and evaluation of preliminary remediation goals for aquatic receptors in the Indiana Harbor Area of Concern. Technical Report. Prepared for: United States Fish and Wildlife Service. Bloomington, Indiana and Indiana Department of Environmental Management. Indianapolis, Indiana.

MacDonald, D.D., M. Donlan, A. Jones, C. Sommerfield, and C. Miller. 2005. Field sampling plan for the 2005 sediment quality evaluation of Delaware River estuary. Revision 2.0. Prepared for: J. Hoff. Damage Assessment Center. National Oceanic and Atmospheric Administration. Silver Spring, Maryland. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Industrial Economics, Inc. Cambridge, Massachusetts and College of Marine Sciences. University of Delaware - Penny Hall. Lewes, Delaware.

MacDonald Environmental Sciences Ltd. 2005. Advanced screening study of the Weston Foods Inc. Site in Quathiaski Cove, Quadra Island. Preliminary Problem Formulation. Prepared for Weston Foods Inc. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Donlan, M.C., G. Douglas, and D.D. MacDonald. 2005. An evaluation of the composition, and potential environmental fate and toxicity of heavy Venezuelan crude oil released into the Delaware River during the *M/T ATHOS I* oil spill. Prepared for the Aquatic Technical Work Group for ATHOS I Spill. Prepared by Industrial Economics Inc., Cambridge, Massachusetts; New Fields Environmental Forensics Practice LLC, Rockland, Massachusetts; and, MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia

Greenberg, M., D. MacDonald, D. Moore, and S. Thoms. 2005. Emergency Response Team review of screening level ecological risk assessment (SLERA) and problem formulation for Operable Unit 4 of the Anniston PCB site. Submitted to the United States Environmental Protection Agency. Atlanta, Georgia.

Obert, E., L. Boughton, and D. MacDonald. 2005. Quality Assurance Project Plan (QAPP): Sediment quality monitoring program for the Presque Isle Bay Area of Concern. Grant Number GL-96556701-0. Revision 3. Prepared by Pennsylvania Sea Grant. Penn State University. Erie, Pennsylvania and Pennsylvania Department of Environmental Protection. Meadville, Pennsylvania. In association with MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Tetra Tech EC Inc. 2005. Technical Memorandum - Development of remedial action objectives to support the evaluation of restoration alternatives for the West Branch of the Grand Calumet River, Indiana. Prepared for United States Fish and Wildlife Service. Bloomington, Indiana.

MacDonald, D.D. 2004. Evaluation of the proposed discharge limits for the De Beers Canada Mining Incorporated (DCMI) Snap Lake Project. Prepared for Water Resources Division. Indian and Northern Affairs Canada. Yellowknife, Northwest Territories.

MacDonald, D.D. and C.G. Ingersoll. 2004. An assessment of sediment injury in the Calcasieu Estuary, Louisiana. Volume I. Technical Report. In association with Industrial Economics Inc. Cambridge, Massachusetts. Prepared for Damage Assessment Center, National Oceanic and Atmospheric Administration. Seattle, Washington.

MacDonald, D.D. and C.G. Ingersoll. 2004. An assessment of sediment injury in the Calcasieu Estuary, Louisiana. Volume II-VII. Appendices. In association with Industrial Economics Inc. Cambridge, Massachusetts. Prepared for Damage Assessment Center, National Oceanic and Atmospheric Administration. Seattle, Washington.

MacDonald, D.D. and D.R.J. Moore. 2004. Considerations for developing problem formulations for ecological risk assessments conducted at contaminated sites under CERCLA. A discussion paper. Prepared for Environmental Response Team. United States Environmental Protection Agency. Edison, New Jersey.

MacDonald, D.D. and D.R.J. Moore. 2004. Review of the quality assurance project plan for the Anniston PCB site. Prepared for Environmental Response Team. United States Environmental Protection Agency. Edison, New Jersey.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. and D.R.J. Moore. 2004. Review of the quality assurance project plan for the Anniston PCB site. Prepared for Environmental Response Team. United States Environmental Protection Agency. Edison, New Jersey.

MacDonald, D.D. and D.R.J. Moore. 2004. Review of the OU-1/OU-2 field sampling plan for the Anniston PCB site. Prepared for Environmental Response Team. United States Environmental Protection Agency. Edison, New Jersey.

MacDonald, D.D. and D.R.J. Moore. 2004. Review of the remedial investigation/feasability study (RI/FS)OU-1/OU-2 field sampling plan for the Anniston PCB site. Prepared for Environmental Response Team. United States Environmental Protection Agency. Edison, New Jersey.

MacDonald, D.D. and D.E. Smorong. 2004. An evaluation of the Colomac Site remediation plan and supporting documentation. Prepared for Indian and Northern Affairs Canada. Yellowknife, Northwest Territories.

MacDonald, D.D. and D.E. Smorong. 2004. An evaluation of candidate effluent quality criteria for the Colomac Site, NT. Prepared for Contaminated Sites Office. Indian and Northern Affairs Canada. Yellowknife, Northwest Territories

MacDonald, D.D. C.G. Ingersoll, D.E. Smorong, L. Fisher, C. Huntington, and G. Braun. 2004. Development and evaluation of risk-based preliminary remediation goals for selected sediment-associated contaminants of concern in the West Branch of the Grand Calumet River. Draft report. Contract No. GS-10F-0208J. Prepared for United States Fish and Wildlife Service. Bloomington, Indiana.

MacDonald, D.D., D.A Levy, A. Czarnecki, G. Low, and N. Richea. 2004. State of the aquatic knowledge of Great Bear Watershed. Prepared for Water Resources Division. Indian and Northern Affairs Canada. Yellowknife, Northwest Territories.

MESL (MacDonald Environmental Sciences Ltd.) and Cantox (Cantox Environmental, Inc.). 2004. Anniston PCB site remedial investigation/feasibility study (RI/FS): Ecological risk assessment (ERA). Prepared for: United States Environmental Protection Agency. Edison, New Jersey. Prepared by MESL, Nanaimo, British Columbia and Cantox, Ottawa, Ontario.

Crane, J.L. D.D. MacDonald, D.E. Smorong, L.J. Fisher, S.L. Hamilton, and C.A. Huntington. 2004. Phase II GIS-based sediment quality database for the St. Louis River Area of Concern (AOC): Comparison of surficial sediment contamination in the St. Louis River AOC with other areas of concern in the Great Lakes Basin and other areas located elsewhere in the United States. Prepared for Minnesota Pollution Control Agency. St. Paul, Minnesota.

Macfarlane, M.W., D.D. MacDonald, and C.G. Ingersoll. 2004. Criteria for contaminated sites: Criteria for managing contaminated sediment in British Columbia. Technical Appendix. Environmental Management Branch. Environmental Protection Division. British Columbia Ministry of Water, Land and Air Protection. Victoria, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Smorong, D.E., Clara L. Mackenzie, Judy L. Crane, Donald D. MacDonald, Leanne J. Fisher, and Chad A. Huntington. 2004. Phase II GIS-based Sediment quality database for the St. Louis River Area of Concern (AOC). Technical documentation. Prepared for Minnesota Pollution Control Agency. St. Paul, Minnesota.

British Columbia Ministry of Water, Land and Air Protection. 2004. Director's criteria for contaminated sites: Criteria for managing contaminated sediment in British Columbia. Environmental Management Branch. Environmental Protection Division. Victoria, British Columbia.

USEPA (United States Environmental Protection Agency. 2004. Predicting amphipod toxicity from sediment chemistry. EPA/600/R-04/030. National Center for Environmental Assessment. Washington, District of Columbia

MacDonald, D.D. 2003. An evaluation of the application for amendment of water licence N7L2-1645 that was submitted to the Mackenzie Valley Land and Water Board by Diavik Diamond Mines Inc. Prepared for Dogrib Treaty 11 Council, Yellowknife, Northwest Territories and T.D. Pearse Resource Consulting, Mayne Island, British Columbia.

MacDonald, D.D. and C.G. Ingersoll. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia. Volume I: An ecosystem-based framework for assessing and managing contaminated sediments. Prepared for Pollution Prevention and Remediation Branch. British Columbia Ministry of Water, Land, and Air Protection. Victoria, British Columbia

MacDonald, D.D. and C.G. Ingersoll. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia. Volume II: Design and implementation of sediment quality investigations in freshwater ecosystems. Prepared for Pollution Prevention and Remediation Branch. British Columbia Ministry of Water, Land, and Air Protection. Victoria, British Columbia.

MacDonald, D.D. and C.G. Ingersoll. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia. Volume IV - Supplemental guidance on the design and implementation of detailed site assessments in marine and estuarine ecosystems. Prepared for Pollution Prevention and Remediation Branch. British Columbia Ministry of Water, Land, and Air Protection. Victoria, British Columbia

MacDonald, D.D. and D.A. Levy. 2003. Toward the development of a cumulative effects monitoring program for the lower Columbia River. Prepared for the British Columbia Ministry of Water, Land and Air Protection. Nelson, British Columbia. An initiative of the Columbia River Integrated Environmental Monitoring.

MacDonald, D.D., C.G. Ingersoll, and D.R.J. Moore. 2003. Response to comments on the Calcasieu Estuary baseline ecological risk assessment. Prepared for United States Environmental Protection Agency. Region 6. Dallas, Texas.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D., R.L. Breton, K. Edelmann, M.S. Goldberg, C.G. Ingersoll, R.A. Lindskoog, D.B. MacDonald, D.R.J. Moore, A.V. Pawlitz, D.E. Smorong, and R.P. Thompson. 2003. Development and evaluation of preliminary remediation goals for selected contaminants of concern at the Calcasieu Estuary cooperative site, Lake Charles, Louisiana. Prepared for United States Environmental Protection Agency, Region 6. Dallas, Texas.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, G. Sloane and T. Biernacki. 2003. Development and evaluation of numerical sediment quality assessment guidelines for Florida inland waters. Prepared for Florida Department of Environmental Management. Tallahassee, Florida.

MacDonald, D.D., C.G. Ingersoll, D.E. Smorong, and R.A. Lindskoog. 2003. Development and application of sediment quality criteria for managing contaminated sediments in British Columbia. Environmental Protection Division. Ministry of Water, Land, and Air Protection. Victoria, British Columbia.

MacDonald, D.D., D.E. Smorong, L.J. Fisher, and C.A. Huntington. 2003. Comparison of levels of contamination in the St. Louis River Area of Concern with other areas of concern in the Great Lakes Basin and other areas located elsewhere in North America. Prepared for Minnesota Pollution Control Agency. St. Paul, Minnesota.

MacDonald, D.D., D.E. Smorong, R.A. Lindskoog, and C.G. Ingersoll. 2003. An assessment of injury to human uses of fishery resources in the Grand Calumet River and Indiana Harbor Canal, the Grand Calumet River Lagoons, and Indiana Harbor and the nearshore areas of Lake Michigan. Volume I - Technical Report. Prepared for United States Fish and Wildlife Service. Bloomington, Indiana. In Association with Industrial Economics, Incorporated. Cambridge, Massachusetts.

Ingersoll C.G. and D.D. MacDonald. 2003. A guidance manual to support the assessment of contaminated sediments in freshwater, estuarine, and marine ecosystems in British Columbia. Volume III: Interpretation of the results of sediment quality investigations. Prepared for Pollution Prevention and Remediation Branch. British Columbia Ministry of Water, Land, and Air Protection. Victoria, British Columbia.

Nagpal, N.K, D.A. Levy, and D.D. MacDonald. 2003. Ambient water quality guidelines for chloride: Overview. Water Management Branch. British Columbia Ministry of Water, Land, and Air Protection. Victoria, British Columbia.

Smorong, D.E., R.A. Lindskoog, and D.D. MacDonald. 2003. Development of a data archiving system for the Coppermine River Basin cumulative effects monitoring program: User's manual. Prepared for Indian and Northern Affairs Canada. Yellowknife, Northwest Territories.

Smorong, D.E., C.L. Mackenzie, J.L. Crane, and D.D. MacDonald. 2003. GIS-based sediment quality database for the St. Louis River Area of Concern (AOC): Technical documentation. Environmental Outcomes Division. Minnesota Pollution Control Agency. St. Paul, Minnesota.

MacDonald, D.D. and C.G. Ingersoll. 2002. Development and evaluation of sediment quality standards for the waters of the Colville Indian Reservation, including the Lake

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Roosevelt and Okanogan River Basins. Prepared for the Confederated Tribes of the Colville Reservation. Nesplem, Washington. Under Contract to Environment International Ltd. Seattle, Washington.

MacDonald, D.D. and C.G. Ingersoll. 2002. A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems. Volume I: An ecosystem-based framework for assessing and managing contaminated sediments. EPA-905-B02-001-A. Prepared for the Great Lakes National Program Office. United States Environmental Protection Agency. Chicago, Illinois. Under contract to Sustainable Fisheries Foundation. Snohomish, Washington.

MacDonald, D.D. and C.G. Ingersoll. 2002. A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems. Volume II: Design and implementation of sediment quality investigations. EPA-905-B02-001-B. Prepared for the Great Lakes National Program Office. United States Environmental Protection Agency. Chicago, Illinois. Under contract to Sustainable Fisheries Foundation. Snohomish, Washington.

MacDonald, D.D., D.E. Smorong, D.A. Levy, L. Swain, P.Y. Caux, and J.B. Kemper. 2002. Guidance on the site-specific application of water quality guidelines in Canada: Procedures for deriving numerical water quality objectives. Prepared for Canadian Council of Ministers of the Environment, Winnipeg, Manitoba and Environment Canada, Ottawa, Canada.

MacDonald, D.D., C.G. Ingersoll, D.R.J. Moore, M. Bonnell, R.L. Breton, R.A. Lindskoog, D.B. MacDonald, Y.K. Muirhead, A.V. Pawlitz, D.E. Sims, D.E. Smorong, R.S. Teed, R.P. Thompson, and N. Wang. 2002. Calcasieu Estuary remedial investigation/feasability study (RI/FS): Baseline ecological risk assessment (BERA). Technical report plus appendices. Contract No. 68-W5-0022. Prepared for CDM Federal Programs Corporation and United States Environmental Protection Agency. Dallas, Texas.

MESL (MacDonald Environmental Sciences Ltd.). 2002. Procedures for deriving site-specific water quality objectives for ammonia. Prepared for Water Quality Guidelines and Assessment Section. National Guidelines and Standards Office. Environmental Quality Branch. Environment Canada. Hull, Quebec. Prepared by MESL. Nanaimo, British Columbia.

Crane, J.L., D.E. Smorong, D.A. Pillard, and D.D. MacDonald. 2002. Sediment remediation scoping project in Minnesota Slip, Duluth Harbor. EPA-905-R-02-002. Submitted to Great Lakes National Program Office, G-17J. United States Environmental Protection Agency. Chicago, Illinois.

Ingersoll C.G. and D.D. MacDonald. 2002. A guidance manual to support the assessment of contaminated sediments in freshwater ecosystems. Volume III: Interpretation of the results of sediment quality investigations. EPA-905-B02-001-C. Prepared for the Great Lakes National Program Office. United States Environmental Protection Agency. Chicago, Illinois. Under contract to Sustainable Fisheries Foundation. Snohomish, Washington.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. and C.G. Ingersoll. 2001. A review of the toxic effects of sediment-associated polycyclic aromatic hydrocarbons (PAHs), with special reference to the 8335 Meadow Avenue site in Burnaby, British Columbia. Prepared for Legal Services Branch. B.C. Ministry of the Attorney General. Vancouver, British Columbia.

MacDonald, D.D., D.E. Smorong, and R.A. Lindskoog. 2001. Development and evaluation of numerical sediment quality criteria for sediment contaminated sites in British Columbia: A retrospective. Prepared for B.C. Ministry of Environment, Lands, and Parks. Victoria, British Columbia.

MacDonald, D.D., J.L. Crane, and D.E. Smorong. 2001. Development of a GIS-based sediment quality database for the St. Louis River area of concern: summary of the results of stakeholder meetings. Prepared for Minnesota Pollution Control Agency. St. Paul, Minnesota.

MacDonald, D.D., D.R. Moore, A. Pawlisz, D.E. Smorong, R.L. Breton, D.B. MacDonald, R. Thompson, R.A. Lindskoog and M.A. Hanacek. 2001. Calcasieu estuary remedial investigation/feasibility study (RI/FS): Baseline ecological risk assessment (BERA). Volume I. Baseline problem formulation. Prepared for: CDM Federal Programs Corporation. Dallas, Texas.

MacDonald, D.D., D.R. Moore, A. Pawlisz, D.E. Smorong, R.L. Breton, D.B. MacDonald, R. Thompson, R.A. Lindskoog and M.A. Hanacek. 2001. Calcasieu estuary remedial investigation/feasibility study (RI/FS): Baseline ecological risk assessment (BERA). Volume 2. Baseline problem formulation: Appendices. Prepared for: CDM Federal Programs Corporation. Dallas, Texas.

MESL (MacDonald Environmental Sciences Ltd.). 2001. *Hyalella azteca* sediment toxicity tests, solid phase Microtox toxicity tests, metals analyses of whole sediments of the Calcasieu Estuary, Louisiana. Prepared for United States Environmental Protection Agency. Dallas Texas.

Ingersoll, C.G. and D.D. MacDonald. 2001. Response to the Golder Associates (2001) and Patrick (2001) responses to the MacDonald and Ingersoll (1999) critical evaluation of Golder methods used for the aquatic risk assessment for the 8335 Meadow Avenue site, Burnaby, B.C. Prepared for Legal Services Branch. B.C. Ministry of the Attorney General. Vancouver, British Columbia.

MacDonald, D.D. 2000. Interests and needs related to the development of freshwater sediment quality guidelines for the State of Florida: Workshop summary report. Prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

MacDonald, D.D. and C.G. Ingersoll. 2000. An assessment of sediment injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the nearshore areas of Lake Michigan B Volume I. Report prepared for the U.S. Fish and Wildlife Service, Bloomington, Indiana.

MacDonald, D.D. and C.G. Ingersoll. 2000. An assessment of sediment injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the nearshore areas of Lake Michigan B Volume II: Tables. Report prepared for the U.S. Fish and Wildlife Service, Bloomington, Indiana.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. and C.G. Ingersoll. 2000. An assessment of sediment injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the nearshore areas of Lake Michigan B Volume III: Figures. Report prepared for the U.S. Fish and Wildlife Service, Bloomington, Indiana.

MacDonald, D.D. and C.G. Ingersoll. 2000. An assessment of sediment injury in the Grand Calumet River, Indiana Harbor Canal, Indiana Harbor, and the nearshore areas of Lake Michigan B Volume IV: Appendices. Report prepared for the U.S. Fish and Wildlife Service, Bloomington, Indiana.

MacDonald, D.D., C.G. Ingersoll, D. Moore, and R.S. Carr. 2000. Calcasieu Estuary remedial investigation/feasibility study (RI/FS): Baseline Ecological Risk Assessment workshop. Workshop summary report. Report prepared for CDM Federal Programs Corporation. Dallas, Texas.

Crane, J.L., D.D. MacDonald, C.G. Ingersoll, D.E. Smorong, R.A. Lindskoog, C.G. Severn, T.A. Berger, L.J. Field. 2000. Development of a framework for evaluating numerical sediment quality targets and sediment contamination in the St. Louis Area of Concern. EPA 905-R-00-008. Great Lakes National Program Office. Chicago, Illinois.

Ingersoll C.G., D.D. MacDonald, N. Wang, J.L. Crane, L.J. Field, P.S. Haverland, N.E. Kemble, R.A. Lindskoog, C.G. Severn, D.E. Smorong. 2000. Prediction of sediment toxicity using consensus-based freshwater sediment quality guidelines. EPA 905/R-00/007. Chicago, Illinois.

MacDonald, D.D. 1999. Tampa Bay Sediment Quality Workshop: Establishing impact levels and setting sediment quality targets - Workshop Summary Report. Prepared for the Tampa Bay National Estuary Program. St. Petersburg, Florida.

MacDonald, D.D. 1999. Approaches to assessing cumulative environmental effects in Northern River ecosystems. Prepared for Aquatic Ecosystem Impacts Branch. National Water Research Institute. Saskatoon, Saskatchewan. 65 pp.

MacDonald, D.D. and C.G. Ingersoll. 1999. A critical review of the aquatic risk assessment prepared by Golder Associates for the 8335 Meadow Avenue site in Burnaby, B.C. Prepared for the Ministry of Environment, Lands, and Parks. Victoria, British Columbia.

MacDonald, D.D. and M. Macfarlane. 1999. Criteria for managing contaminated sediment in British Columbia. Prepared pursuant to Section 26(a) of the Waste Management Act. Prepared for Ministry of Environment, Lands, and Parks. Victoria, British Columbia.

MacDonald, D.D., T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J. MacDonald, S.L. Smith, and P. Shaw. 1999. A compendium of environmental quality benchmarks for priority substances in the Georgia Basin. Volume I. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Prepared for Environment Canada. North Vancouver, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D., T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J. MacDonald, S.L. Smith, and P. Shaw. 1999. A compendium of environmental quality benchmarks for priority substances in the Georgia Basin. Volume II - Water Quality Benchmarks. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Prepared for Environment Canada. North Vancouver, British Columbia.

MacDonald, D.D., T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J. MacDonald, S.L. Smith, and P. Shaw. 1999. A compendium of environmental quality benchmarks for priority substances in the Georgia Basin. Volume III - Sediment Quality Benchmarks. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Prepared for Environment Canada. North Vancouver, British Columbia.

MacDonald, D.D., T. Berger, K. Wood, J. Brown, T. Johnsen, M.L. Haines, K. Brydges, M.J. MacDonald, S.L. Smith, and P. Shaw. 1999. A compendium of environmental quality benchmarks for priority substances in the Georgia Basin. Volume IV - Tissue Residue Benchmarks. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia. Prepared for Environment Canada. North Vancouver, British Columbia.

MacDonald, D.D. R.A. Lindskoog, D.E. Smorong, and M.L. Haines. 1999. Development and evaluation of sediment quality values for the protection of marine ecosystems in Perth's Coastal Waters. Prepared for Western Australia Department of Environmental Protection. Perth, Western Australia

MacDonald, D.D., K.E. Wood, T. Johnsen, J.L. Brown, and P.K. Gregory. 1999. An overview of ambient environmental conditions in the Coppermine River watershed: Preliminary draft. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia Prepared for Indian and Northern Affairs Canada, Yellowknife, Western Arctic. In association with the Steering Committee on Cumulative Effects Assessment in the Coppermine River Basin.

Brown, J., S. Mann, T.F. Johnsen, M.L. Haines, and D.D. MacDonald. 1999. An annotated bibliography on cumulative effects assessment in Northern River ecosystems. Prepared for Aquatic Ecosystem Impacts Branch. National Water Research Institute. Saskatoon, Saskatchewan. 71 pp.

Ingersoll, C.G., and D.D. MacDonald. 1999. An assessment of sediment injury in the West Branch of the Grand Calumet River. Volume I. Prepared for Environmental Enforcement Section. Environment and Natural Resources Division. U.S. Department of Justice. Washington, District of Columbia. 161 pp.

Ingersoll, C.G., and D.D. MacDonald. 1999. An assessment of sediment injury in the West Branch of the Grand Calumet River. Volume II - Appendices. Prepared for Environmental Enforcement Section. Environment and Natural Resources Division. U.S. Department of Justice. Washington, District of Columbia. 159 pp.

Ingersoll, C.G. and D.D. MacDonald. 1999. United States v. Sanitary District of Hammond: Rebuttal of opinions provided in the reports prepared by Dr. J.E. Alleman and Dr. R.E. Roper. Report prepared for the Environmental Enforcement Section, Environment and Natural Resources Division. United States Department of Justice. Washington, District of Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Kemble, N.E., D.G. Hardesty, C.G. Ingersoll, B.T. Johnson, F.J. Dwyer, and D. MacDonald. 1999. Evaluation of the toxicity and bioaccumulation of contaminants in sediment samples from Waukegan Harbor, Illinois. Prepared for: Great Lakes National Program Office. United States Environmental Protection Agency. Chicago, Illinois. Prepared by: Biological Resource Division. United States Geological Survey. Columbia, Missouri.

Moore, D., S. Teed and D. MacDonald. 1999. Risk-based framework for Canada-wide standards. Proceedings of a Workshop in Calgary, Alberta; February 23-24, 1999. Prepared for Canadian Council of Ministers of the Environment. Winnipeg, Manitoba.

United States Environmental Protection Agency. 1999. Evaluation of the toxicity and bioaccumulation of contaminants in sediment samples from Waukegan Harbor, Illinois. EPA 905/R-99/009. Chicago, Illinois.

MacDonald, D.D. 1998. Criteria for managing contaminated sediment in British Columbia. Prepared pursuant to Section 26(1) of the Waste Management Act. Prepared for Ministry of Environment, Lands and Parks. Victoria, British Columbia.

MacDonald, D.D. 1998. Applications of sediment quality guidelines in the remediation of sediment contaminated sites in British Columbia. Prepared for Ministry of Environment, Lands and Parks. Victoria, British Columbia.

MacDonald, D.D. and Industrial Economics Inc. 1998. Development and evaluation of consensus-based sediment effect concentrations for PCBs in the Lower Hudson River and Estuary. Prepared for National Oceanic and Atmospheric Administration. Silver Spring, Maryland.

MacDonald, D.D., D.Q. Tao, and T. Berger. 1998. Water quality assessment and recommended objectives for the Salmon River. Summary Report. Prepared for Environment Canada's Fraser River Action Plan. Vancouver, British Columbia. DOE-FRAP 97-43

Gwanikar, S., S. Cross, D. MacDonald, D.Q. Tao, and T. Berger. 1998. Water quality assessment and recommended objectives for the Salmon River: Technical Appendix. (Volume I) Prepared for Environment Canada's Fraser River Action Plan. DOE-FRAP 97-42.

Gwanikar, S., S. Cross, D. MacDonald, D.Q. Tao, and T. Berger. 1998. Water quality assessment and recommended objectives for the Salmon River: Technical Appendix. (Volume II) Prepared for Environment Canada's Fraser River Action Plan. DOE-FRAP 97-42.

Mann, S., M.L. Haines, T.F. Johnsen, and D.D. MacDonald. 1998. An annotated bibliography on cumulative effects assessment and monitoring for the Coppermine River Basin project. Prepared for Water Resources Division. Indian and Northern Affairs Canada. Yellowknife, Northwest Territories. 212 pp.

Sustainable Fisheries Foundation. 1998. Toward ecosystem-based management in the Upper Columbia River Basin: Workshop summary report. Toward ecosystem-based

#24-4800 Island Hwy N + Nanaimo, British Columbia V9T 1W6 + Phone: 250-729-9623 + Fax: 250-729-9628 + E-mail: mesl@shaw.ca

management in the Upper Columbia River Basin: An International Conference and Workshop. Castlegar, British Columbia. April 27-30, 1998.

MacDonald, D.D. 1997. Water quality assessment and objectives: Methods for deriving site-specific water quality objectives in British Columbia and Yukon. Prepared for B.C. Ministry of Environment, Lands and Parks. Victoria, British Columbia.

MacDonald, D.D. 1997. Sediment injury in the Southern California Bight: Review of the toxic effects of DDTs and PCBs in sediments. Prepared for National Oceanic and Atmospheric Administration. United States Department of Commerce. Long Beach, California.

MacDonald, D.D. 1997. Sediment injury in the Southern California Bight: Review of the toxic effects of DDTs and PCBs in sediments. Volume II: Appendix 4, 5, and 6. Prepared for National Oceanic and Atmospheric Administration. United States Department of Commerce. Long Beach, California.

MacDonald, D.D. 1997. Tampa Bay sediment quality workshop: Setting targets and defining management strategies - Final Summary Report. Prepared for the Tampa Bay National Estuary Program. St. Petersburg, Florida.

MacDonald, D.D. 1997. Controlling arsenic releases to the environment in the Northwest Territories: Executive Summary. Prepared for Environment Canada, Yellowknife, Northwest Territories.

MacDonald, D.D. 1997. A review and critical evaluation of the applicability of existing sediment effect concentrations of PCBs to the Lower Hudson River and Estuary. Submitted to Industrial Economics Inc. Cambridge, Massachusetts.

MacDonald, D.D., J. Stavinga, and L. Hunter. 1997. Workshop on controlling arsenic releases into the environment in the Northwest Territories: Workshop report. Prepared for Environment Canada. Yellowknife, Northwest Territories.

MacDonald Environmental Sciences Ltd. 1997. Lower Columbia River from Birchbank to the International Boundary: Water Quality and Quantity Assessment and Objectives Technical Report. Prepared for Environment Canada, Vancouver, British Columbia and the British Columbia Ministry of Environment, Lands and Parks, Victoria, British Columbia.

Caux, P.-Y, D. MacDonald, D.R. Moore, and H.J. Singleton. 1997. Ambient water quality criteria for turbidity, suspended and benthic sediments in British Columbia. Technical Appendix. Prepared for Ministry of Environment Lands and Parks. Prepared by Cadmus Group. Ottawa, Ontario.

Gwanikar, S., S. Cross, D. MacDonald, and J.R. Brown. 1997. Salmon River Watershed: Water quality assessment and objectives. Technical Report. Prepared for Environment Canada. Prepared by Aquametrix Research Ltd. Sydney, British Columbia. 78 pp.

Milburn, D., D.D. MacDonald, T.D. Prowse, and J.M. Culp. 1997. Ecosystem maintenance indicators for the Slave River delta, Northwest Territories, Canada. Presented at

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

INDEX-97. An International Conference on Environmental Indices Systems Analysis Approach. St. Petersburg, Russia. July 7-11, 1997.

Stavinga, J.M. and MacDonald Environmental Sciences Ltd. 1997. Creating and celebrating our watershed's future. Selecting indicators for a sustainable watershed future. Workshop summary report. 1997. Prepared for Environment Canada, Vancouver, British Columbia and the Salmon River Watershed Roundtable, Salmon Arm, British Columbia.

MacDonald, D.D. 1996. Workshop on small diameter core diamond drilling from ice. Summary Report. Prepared for NWT Chamber of Mines, Fisheries and Oceans Canada, and Environment Canada. Yellowknife, Northwest Territories.

MacDonald, D.D. 1996. Peel River Watershed Advisory Committee workshop on land and water management. Workshop Summary Report. Prepared for Peel River Watershed Advisory Committee c/o First Nation of Na-cho Nyak Dun. Mayo, Yukon.

MacDonald, D.D. 1996. A discussion paper on the management of renewable resources by Indigenous peoples of British Columbia. Prepared for E.V. Christensen Consulting Ltd. Prepared by MacDonald Environmental Sciences Ltd. Ladysmith, British Columbia. 23 pp. + apps.

MacDonald, D.D. and C.R. Steward (Eds). 1996. Towards Sustainable Fisheries: Building a Cooperative Strategy for Balancing the Conservation and Use of Westcoast Salmon and Steelhead Populations. Sustainable Fisheries Foundation. Ladysmith, British Columbia.

MacDonald, D.D., N. Barnett, and J.R. Brown. 1996. Water quality assessment and objectives for the lower Columbia River: Birchbank to the international boundary. Prepared for Environment Canada and B.C. Ministry of Environment, Lands, and Parks. Vancouver, British Columbia.

MacDonald, D.D., J. Brodie, and L.M. Broughton. 1996. Review and evaluation of the draft water licence for the BHP Diamond Mine. Submitted to North West Territories Water Board. Prepared by MacDonald Environmental Sciences Ltd. Ladysmith, British Columbia.

MacDonald, D.D., J.R. Brown, N. Barnett, and M.L. Haines. 1996. Canadian sediment quality guidelines for toxaphene. Prepared for Guidelines Division. Environment Canada. Ottawa, Canada.

MacDonald, D.D., L. Pourlak, P. Tan, and M.L. Haines. 1996. Canadian tissue residue guidelines for DDTs. Prepared for Guidelines Division. Environment Canada. Ottawa, Canada.

MacDonald, D. P. Tan, N. Barnett, L. Pourlak, and M.L. Haines 1996. Canadian tissue residue guidelines for toxaphene. Prepared for Guidelines Division. Environment Canada. Ottawa, Canada.

MacDonald Environmental Sciences Ltd. 1996. Canadian sediment quality guidelines for DDTs. Prepared for Guidelines Division. Environment Canada. Ottawa, Canada.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald Environmental Sciences Ltd. 1996. Canadian tissue residue guidelines for polychlorinated biphenyls. Prepared for Guidelines Division. Environment Canada. Ottawa, Canada.

MacDonald Environmental Sciences Ltd. 1996. Guidelines for small core diameter drilling from ice in the Northwest Territories. Prepared for Environmental Protection. Environment Canada. Yellowknife, Northwest Territories.

MacDonald, D.D. 1995. Science advisory group on sediment assessment in Tampa Bay: Summary report. Technical Publication #06-95. Tampa Bay National Estuary Program. St. Petersburg, Florida.

MacDonald, D.D. 1995. Contaminated Sites Soil Task Group Workshop on the development and implementation of soil quality standards for contaminated sites: Summary Report. Prepared for the B.C. Ministry of Environment, Lands, and Parks. Victoria, British Columbia.

MacDonald, D.D. 1995. Canadian sediment quality guidelines for polychlorinated biphenyls: Draft. Prepared for the Guidelines Division. Environment Canada. Ottawa, Canada.

MacDonald, D.D. and C.R. Steward. 1995. Development of a sustainable fisheries strategy for west coast salmon and steelhead populations. Native Issues Monthly III(7):23-25.

Field, L.J., D.D. MacDonald, and C.G. Severn. 1996. Use of a sediment toxicity database for evaluating matching sediment chemistry and toxicity data. HAZMAT Report 97-1. Seattle: Hazardous Materials Response and Assessment Division. National Oceanic and Atmospheric Administration. 28 pp.

Louie, W.H., E. Hardisty, and D.D. MacDonald. 1995. Acquisition of traditional environmental knowledge in the Lower Liard River Basin. Prepared for Water Resources Division. Indian and Northern Affairs. Ottawa, Canada.

Oliver, G.G. and D.D. MacDonald. 1995. Technical review of the Columbia Power Corporation's application for an Energy Project Certificate for the Keenleyside Powerplant Project. Submitted to Fisheries and Oceans Canada. Vancouver, British Columbia. Submitted by Interior Reforestation Co. Ltd. Cranbrook, British Columbia and MacDonald Environmental Sciences Ltd. Ladysmith, British Columbia. 57 pp. + apps.

Sobolewski, A., D.D. MacDonald, and W.H. Louie. 1995. A review of the environmental effects of diamond mining. Prepared for the Assessment and Monitoring Division. Environment Canada. Yellowknife, Northwest Territories.

MacDonald Environmental Sciences Ltd. 1995. Development of ecosystem maintenance indicators for the Slave, Liard, and Peel Rivers. Supporting Documentation for Experts Workshop. Prepared for Water Resources Division. Indian and Northern Affairs. Ottawa, Canada.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald Environmental Sciences Ltd. 1995. Expert's workshop on the development of ecosystem maintenance indicators for the Transboundary river systems with the Mackenzie River basin. Workshop summary report. Prepared for Water Resources Division. Indian and Northern Affairs. Ottawa, Canada.

MacDonald, D.D. 1994. A review of environmental quality criteria and guidelines for priority substances in the Fraser River. Prepared for Environment Canada. Pacific and Yukon Region. West Vancouver, British Columbia. 55 pp.

MacDonald, D.D. 1994. A discussion paper on the development of ecosystem maintenance indicators for the transboundary river systems within the Mackenzie River Basin: Slave, Liard, and Peel rivers. Report prepared for Water Resources Division. Indian and Northern Affairs Canada. Ottawa, Canada. 84 pp.

MacDonald, D.D. 1994. Approach to the assessment of sediment quality in Florida coastal waters. Volume 1: Development and evaluation of sediment quality assessment guidelines. Report prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

MacDonald, D.D. 1994. Approach to the assessment of sediment quality in Florida coastal waters. Volume 2: Applications of the sediment quality assessment guidelines. Report prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

MacDonald, D.D. 1994. Canadian sediment quality guidelines for polycyclic aromatic hydrocarbons. Prepared for Evaluation and Interpretation Branch. Environment Canada. Ottawa, Canada. 195 pp.

MacDonald, D.D. and D. Sutherland. 1994. Contaminants in white sturgeon in the Upper Fraser River, British Columbia. A preliminary evaluation of the potential for adverse effects on human health. Prepared for Fisheries and Oceans Canada. Prince George, British Columbia.

MacDonald, D.D., B.L. Charlish, M.L. Haines, and K. Brydges. 1994. Approach to the assessment of sediment quality in Florida coastal waters. Volume 3: Supporting documentation - Biological effects database for sediments. Report prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

MacDonald, D.D., B.L. Charlish, M.L. Haines, and K. Brydges. 1994. Approach to the assessment of sediment quality in Florida coastal waters. Volume 4: Supporting documentation - Regional biological effects database for sediments. Report prepared for Florida Department of Environmental Protection. Tallahassee, Florida.

Zeeman, A.J. and D.D. MacDonald. 1994. An evaluation of the relationship between lowest observed effect levels and no observed levels in aquatic toxicity tests. Prepared for Environment Canada. Hull, Quebec. 40 pp.

Christensen, E.V., D.D. MacDonald, and P. Quaw. 1994. A discussion paper on First Nations environmental assessment. Prepared for Dene Nation. Yellowknife, Northwest Territories. 43 pp.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Haines, M.L., K. Brydges, M.J. MacDonald, S.L. Smith, D.D. MacDonald. 1994. A review of environmental quality criteria and guidelines for priority substances in the Fraser River. Supporting Documentation. Prepared for Environment Canada. Pacific and Yukon Region. West Vancouver, British Columbia. 222 pp.

MacDonald, D.D. 1993. Canadian environmental quality guidelines for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo furans. Report prepared for EcoHealth Branch, Environment Canada. Ottawa Canada. 212 pp.

MacDonald, D.D. 1993. A discussion paper on the development and use of safety, application, and uncertainty factors in the derivation of water quality guidelines for aquatic life. Technical Report. Report prepared for EcoHealth Branch, Environment Canada. Ottawa Canada. 18 pp.

MacDonald, D.D. and M.L. Haines. 1993. A discussion paper on the development and use of safety, application, and uncertainty factors in the derivation of water quality guidelines for aquatic life. Supporting Documentation. Report prepared for EcoHealth Branch, Environment Canada. Ottawa Canada. 244 pp.

MacDonald, D.D. and A. Sobolewski. 1993. Recommended procedures for developing site-specific environmental quality remediation objectives for contaminated sites. Report prepared for EcoHealth Branch, Environment Canada. Ottawa Canada. 85 pp.

MacDonald, D.D., A. White, B. Charlish, M.L. Haines, and T. Wong. 1993. Compilation of toxicological information on sediment-associated contaminants and the development of freshwater sediment quality guidelines. Report prepared for EcoHealth Branch, Environment Canada. Ottawa Canada. 24 pp + Supporting Documentation.

Smith, S.L. and D.D. MacDonald. 1993. A protocol for the derivation of sediment quality guidelines for the protection of aquatic life. *In:* Canadian Sediment Quality Guidelines. Report prepared for the Task Group on Water Quality Guidelines. Canadian Council of Ministers of the Environment. Ottawa, Canada.

Smith, S.L. and D.D. MacDonald. 1993. Framework for the Implementation of sediment quality guidelines. *In:* Canadian Sediment Quality Guidelines. Report prepared for the Task Group on Water Quality Guidelines. Canadian Council of Ministers of the Environment. Ottawa, Canada.

MacDonald Environmental Sciences Ltd. 1993. Development of a First Nations fisheries management model - Phase II: Strategic planning in stock assessment and stewardship. Report prepared for Coast Salish Fisheries Working Group. Vancouver, British Columbia. 132 pp.

MacDonald Environmental Sciences Ltd. 1993. Development of a First Nations fisheries management model - Phase III: Formulation and implementation of a joint fisheries management strategy. Report prepared for Coast Salish Fisheries Working Group. Vancouver, British Columbia.

MacDonald Environmental Sciences Ltd. 1993. Proceedings of the Coast Salish Fisheries Working Group Harvest Monitoring Workshop. Report prepared for Coast Salish Fisheries Working Group. Vancouver, British Columbia. 69 pp.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. 1992. Development of an approach to the assessment of sediment quality in Florida coastal waters. Report prepared for the Florida Department of Environmental Regulation. Tallahassee, Florida.

MacDonald, D.D. 1992. Canadian interim sediment quality guidelines for arsenic, cadmium, chromium, copper, lead, mercury, silver, and zinc. Report prepared for EcoHealth Branch. Environment Canada. Hull, Quebec. 81 pp.

MacDonald, D.D. and S.L. Walker. 1992. A discussion paper on the derivation and use of Canadian tissue residue guidelines for the protection of aquatic life and wildlife. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada.

MacDonald, D.D., K. Brydges, and M.L. Haines. 1992. Development of an approach to the assessment of sediment quality in Florida coastal waters: Supporting documentation. Report prepared for the Florida Department of Environmental Regulation. Tallahassee, Florida.

MacDonald, D.D., P.M. Outridge, and I.D. Cuthbert. 1992. Canadian soil quality criteria for contaminated sites: Cadmium. Report prepared for the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. 76 pp.

MacDonald, D.D., I.D. Cuthbert, and P.M. Outridge. 1992. Sampling and analytical methods for monitoring and assessing the impacts of glycols in the Canadian environment. Report prepared for Environment Canada and Transport Canada. Ottawa, Canada. 27 pp.

MacDonald, D.D., I.D. Cuthbert, and P.M. Outridge. 1992. Canadian environmental quality guidelines for three glycols used in aircraft de-icing/anti-icing fluids. Report prepared for Environment Canada and Transport Canada. Ottawa, Canada. 140 pp.

MacDonald, D.D., S.L. Smith, M.P. Wong, and P. Mudroch. 1992. The development of Canadian marine environmental quality guidelines. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada.

MacDonald, D.D., I.D. Cuthbert, P.M. Outridge, and R.T. Ruthman. 1992. Canadian water quality guidelines for the protection of aquatic life for ethylene glycol, diethylene glycol, and propylene glycol. Report prepared for Environment Canada and Transport Canada. Ottawa, Canada. 70 pp.

Haines, M.L. and D.D. MacDonald. 1992. A guide to conducting on-line literature searches in support of CEPA-PSL assessments and Canadian EQGs development: Experience with two organic chemicals: DCM and TCE. Environment Canada. Ottawa, Ontario. 8 pp.

Isaac, T.D. and D.D. MacDonald. 1992. Willow River adult chinook salmon enumeration/carcass recovery program: 1992. Report prepared by Lheit-Lit'en Nation. Prince George, British Columbia.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Long, E.R. and D.D. MacDonald. 1992. National Status and Trends Program approach. *In:* Sediment Classification Methods Compendium. Sediment Oversight Technical Committee. United States Environmental Protection Agency. Washington, District of Columbia.

Outridge, P.O., D.D. MacDonald, and I.D. Cuthbert. 1992. Background supporting document for cadmium. Canadian Environmental Protection Act. Priority Substances List. Report prepared for EcoHealth Branch, Environment Canada. Ottawa, Canada. 202 pp.

MacDonald Environmental Sciences Ltd. 1992. Development of a First Nations fisheries management model - Phase I: Derivation of a generic model. Report prepared for Coast Salish Fisheries Working Group. Vancouver, British Columbia. 80 pp.

MacDonald Environmental Sciences Ltd. 1992. An assessment of ambient environmental conditions in the Liard River Basin, Northwest Territories. Report prepared for Water Resources Division. Indian and Northern Affairs Canada. Yellowknife, Northwest Territories. 89 pp.

MacDonald, D.D. 1991. Canadian water quality guidelines for polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo furans. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada.

MacDonald, D.D. 1991. Canadian water quality guidelines for dimethoate. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 66 pp.

MacDonald, D.D. 1991. Canadian water quality guidelines for aldicarb. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 68 pp.

MacDonald, D.D. 1991. Canadian water quality guidelines for MCPA. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 64 pp.

MacDonald, D.D., L.E. Fidler, S.B. Miller, B.J. Moore, V.A. Wong, and S. Walker. 1991. Canadian water quality guidelines for polycyclic aromatic hydrocarbons. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 215 pp.

MacDonald, D.D. 1990. A discussion paper on the development of ecosystem guidelines for the Slave River, Northwest Territories. Report prepared for Indian and Northern Affairs Canada. Yellowknife, Northwest Territories. 63 pp.

MacDonald, D.D. 1990. Canadian water quality guidelines for bromoxynil. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 68 pp.

MacDonald, D.D. 1990. Canadian water quality guidelines for dicamba. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 81 pp.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacDonald, D.D. 1990. Protocols for the derivation of water quality guidelines for the protection of agricultural water uses. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 36 pp.

MacDonald, D.D. 1990. A discussion paper on the derivation and use of action levels for pesticides in groundwater: Technical appendix. Report prepared for Environment Canada. Ottawa, Canada. 54 pp.

MacDonald, D.D. and J.E. Fairfield. 1990. A discussion paper on the derivation and use of action levels for pesticides in groundwater. Report prepared for Environment Canada. Ottawa, Canada. 45 pp.

MacDonald, D.D. and S.L. Smith. 1990. An approach to monitoring ambient environmental quality in the Slave River basin, Northwest Territories: Toward a consensus. Report prepared for Indian and Northern Affairs Canada. Yellowknife, NWT. 64 pp.

MacDonald, D.D. and S.L. Smith. 1990. A strategic approach to monitoring ambient environmental quality conditions in the Slave River basin, NWT. Report prepared for Indian and Northern Affairs Canada. Yellowknife, NWT. 60 pp.

MacDonald, D.D. and S.L. Smith. 1990. A strategic approach to the development and implementation of environmental quality guidelines and objectives in the territorial portion of the Slave River basin. Report prepared for Indian and Northern Affairs Canada. Yellowknife, NWT. 146 pp.

Fidler, L.E., B.J. Moore, and D.D. MacDonald. 1990. A review of the status of prophylaxis, pretreatment, and therapy of intoxications due to botulinal neurotoxins, staphylococcal enterotoxins and ricin in humans. Report prepared for National Defence Canada. Ralston, Alberta. 92 pp.

Fidler, L.E., B.J. Moore, and D.D. MacDonald. 1990. A survey of research groups in Canada and the United States capable of conducting research on botulinal neurotoxins, staphylococcal enterotoxins and ricin in humans. Report prepared for National Defence Canada. Ralston, Alberta. 34 pp + appendices.

Roch, M., D.D. MacDonald, C. Hilliar and W.E. McLean. 1990. Copper toxicity bioassays conducted at the Puntledge River salmon hatchery to assess the effects of acid mine drainage from Mt. Washington. Report prepared for the Steelhead Society. Campbell River, British Columbia.

Kistritz, R.U. and D.D. MacDonald. 1990. Procedure for deriving water quality guidelines for nutrients, algae and aquatic vascular plants in Canadian stream ecosystems. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada.

Sigma Engineering Limited. 1990. Keenleyside powerplant project: Assessment of water quality and use. Report prepared for BC Hydro and Power Authority. Vancouver, British Columbia. 119 pp + appendices.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Sigma Engineering Limited. 1990. Columbia River integrated environmental sampling program. Report prepared for BC Ministry of Environment, Cominco Metals, Celgar Pulp, and BC Power and Hydro Authority. Vancouver, British Columbia. 47 pp + appendices.

MacDonald, D.D. 1989. An assessment of ambient water quality conditions in the Slave River basin, NWT. Report prepared for Indian and Northern Affairs Canada. Yellowknife, NWT. 94 pp.

MacDonald, D.D. 1989. Proceedings of the Canada-British Columbia workshop on water quality guidelines and objectives: Focus on the Fraser. Water Quality Branch, Environment Canada. Vancouver, B.C. 151 pp.

MacDonald, D.D. 1989. Canadian water quality guidelines for dinoseb. Report prepared for the Canadian Council of Resource and Environment Ministers. Ottawa, Canada. 74 pp.

MacDonald, D.D. 1989. Development, implementation and use of site-specific water quality objectives: A conceptual model. Proceedings of the CCREM Workshop on the Development and Use of Water Quality Objectives. Environment Canada. Ottawa, Canada.

MacDonald, D.D. and R. Bocking. 1989. Rosette Creek: Assessment of potential impacts of bridge construction on sockeye salmon. Report prepared for the Carrier Sekani Tribal Council. MacDonald Environmental Sciences Ltd. and LGL Ltd. Vancouver, British Columbia. 28 pp.

MacDonald, D.D., W.T. Willingham, L.P. Parrish, G.J. Rodreguez, J.M. Lazorchak, and J.W. Love. 1989. Using *in situ* bioassays as a basis for the development of water quality guidelines: A case study of the Arkansas River. Proceedings of the CCREM Workshop on the Development and Use of Water Quality Objectives. Environment Canada. Ottawa, Canada.

Mah, F.T.S., D.D. MacDonald, S.W. Sheehan, T.N. Tuominen, and D. Valiela. 1989. Dioxins and furans in sediments and fish from the vicinity of ten inland pulp mills in British Columbia. Water Quality Branch. Environment Canada. Vancouver, B.C. 77 pp.

MacDonald, D.D. and D. Valiela. 1988. Site-specific water quality guidelines for fish and aquatic life: Deposited sediments. Water Quality Branch, Environment Canada. 84 pp. + appendices.

MacDonald, D.D., L.E. Fidler and D. Valiela. 1987. Site-specific water quality criteria for fish and aquatic life in the Canadian portion of the Flathead River basin: Nitrate, nitrite and ammonia. Water Quality Branch, Environment Canada, Vancouver, B.C. 119 + appendices.

Kistritz, R., D.D. MacDonald and D. Valiela. 1987. Provisional water quality objectives for selected variables in the Canadian portion of the Flathead River. Water Quality Branch, Environment Canada, Vancouver, B.C. 53 pp.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

MacKinlay, D.D., D.D. MacDonald, M.K. Johnson and R.F. Fielden. 1987. Culture of chinook salmon (*Oncorhynchus tshawytscha*) in iron-rich groundwater: Stuart pilot hatchery experiences. Canadian Manuscript Report of Fisheries and Aquatic Sciences 1944. 45 pp.

Water Quality and Quantity Committee. 1987. Water Quality and Quantity Committee Technical Report. Report to the Flathead River International Study Board (International Joint Commission). 192 pp.

Water Quality Criteria Task Force. 1987. Ambient water quality criteria for selected variables in the Canadian portion of the Flathead River. Report to the Flathead River International Study Board (International Joint Commission). 76 pp.

MacDonald, D.D. (ed.) 1985. Proceedings of the Flathead River Basin Bull Trout Biology and Population Dynamics Modelling Information Exchange. Fisheries Branch. Ministry of Environment. 104 pp.

MacDonald, D.D. and L.E. Fidler. 1985. Flathead River bull trout - Approaches to modelling dynamic populations. *In:* D.D. MacDonald (ed.). Proceedings of the Flathead River Basin Bull Trout Biology and Population Dynamics Modelling Information Exchange. Fisheries Branch, B.C. Ministry of Environment. 104 pp.

MacDonald, D.D. 1983. Blackwater/Cottonwood juvenile salmonid studies, 1981-82. Internal Report. Enhancement Services Branch. Fisheries and Oceans Canada. 16 pp + appendices.

MacDonald, D.D. and D.D. MacKinlay. 1983. Stuart pilot operations, 1982-83. Internal Report. Enhancement Services Branch. Fisheries and Oceans Canada. 61 pp + appendices.

MacDonald, D.D. and B.G. Shepherd. 1983. Developmental timing of British Columbia salmon and steelhead trout. Enhancement Services Branch, Fisheries and Oceans Canada, Vancouver, B.C. 17 pp.

MacDonald, D.D. and B.G. Shepherd. 1983. A review of the Kitimat River watershed. Enhancement Services Branch, Fisheries and Oceans Canada, Vancouver, B.C. 166 pp.

MacDonald, D.D. 1982. A review of the effects of temperature on the developmental timing of East Coast Pacific anadromous salmonids. Internal Report. Enhancement Services Branch. Fisheries and Oceans Canada.

MacDonald, D.D. 1981. On the existence of, and salmonid interaction with, naturally occurring supersaturation. Internal Report. Enhancement Services Branch. Fisheries and Oceans Canada. 11 pp + appendices.

MacDonald, D.D. and B.G. Shepherd. 1980. Proceedings of the Aeration workshop. Enhancement Services Branch, Fisheries and Oceans Canada. 23 pp.

Helm, R.K., D.D. MacDonald, B. Sinclair, G. Stuart, A. Chalmers and B.G. Shepherd. 1980. A review of the Quesnel River watershed. Enhancement Services Branch, Fisheries and Oceans Canada. 72 pp. + appendices.

#24-4800 ISLAND HWY N + NANAIMO, BRITISH COLUMBIA V9T 1W6 + PHONE: 250-729-9623 + FAX: 250-729-9628 + E-MAIL: MESL@SHAW.CA

Helm, R.K., D.D. MacDonald, B. Sinclair, D. Chan, T. Hetherington, A. Chalmers and B.G. Shepherd. 1980. A review of the Nechako River watershed. Enhancement Services Branch, Fisheries and Oceans Canada. 90 pp. + appendices.

ALLISON SCHEIN

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9625 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

SUMMARY OF QUALIFICATIONS

- Fish handling, identification & dissection.
- Beach seining, electrofishing, plankton towing & trailering/operating a motor boat.
- Monitoring estuarine water quality & water chemistry.
- Freshwater benthic macroinvertebrate identification.
- Familiar with multivariate (PRIMER) & univariate (Systat, SigmaPlot) statistics.
- Oral & written communication skills developed during my M.Sc. by giving presentations to ~ 70 people & writing papers.

EDUCATION

Canadian Rivers Institute at University of Prince Edward Island & University of New Brunswick **2009**
Master of Science, Biology (Aquatic Ecology)

Queen's University, Kingston, Ontario **2007**
Bachelor of Science (Honours), Biology, with Distinction

PROFESSIONAL CERTIFICATIONS

Biologist in Training (College of Applied Biology - British Columbia)

WORK HISTORY

Biologist/Quality Assurance Officer, MacDonald Environmental Sciences Ltd.
Nanaimo, British Columbia Feb. 2012 – Present

- Compiling water, sediment, soil, and tissue benchmarks.
- Data evaluation and analysis.
- Report preparation.

Port Sampling Technician, Pacific Salmon Commission Aug. – Oct. 2011
Vancouver, British Columbia

- Sampled salmon on troll fishing & gillnet boats & at fish plants.
- Prepared sampling supplies.

ALLISON SCHEIN

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9625 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

Aquatic Science Technician, Fisheries & Oceans Canada Dec. 2010 – Apr. 2011
West Vancouver, British Columbia

- Sorted & counted marine invertebrate samples.
- Organized & analyzed data (used ImageJ, Excel, PRIMER).

Volunteer at Burapha University, Thailand May 2010
Bang Saen, Thailand

- Assisted biology Ph.D. students with their fish research (field & lab).
- Went electrofishing, sorted invertebrates from river samples & counted eggs.

Laboratory Technician, University of New Brunswick Sept. – Dec. 2009
Fredericton, New Brunswick

- Identified freshwater benthic macroinvertebrates & processed them for stable isotope analysis.
- Organized & entered data into Excel.

M.Sc. Candidate, University of Prince Edward Island 2007 – 09
Charlottetown, PEI

- Coordinated & managed four-person team in the field.
- Independently processed samples for stable isotope analysis.
- Teaching Assistant for 4th year Environmental Biology course.

Instructor, Let's Talk Science Program (Volunteer) 2007 – 09
Fredericton, New Brunswick

- Led "hands-on" science activities with elementary & high school students in & around Fredericton, New Brunswick.

Honour's Thesis Candidate, Queen's University 2006 – 07
Kingston, Ontario

- Ran aquatic toxicity bioassays looking at effects of diesel oil on rainbow trout.

Research Assistant, UBC Biochemistry Lab Summer 2006
Vancouver, British Columbia

- Helped Ph.D. candidate with her immunohistochemistry research.
- Made & ran gels, made & stained slides & did PCR.

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9625 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

AWARDS AND CERTIFICATIONS

- Best student oral presentation, ACCESS 2009 conference, PEI ($200).
- NSERC Alexander Graham Bell Canada Graduate Scholarship ($17 500).
- NSERC Postgraduate Scholarship ($17 300).
- Principal's Scholarship from Queen's University ($8000).
- Youth Volunteer of the Year Award 2007, Providence Manor, Kingston, ON
- Valid BC Driver's Licence & Pleasure Craft Operator Card.
- SSI Advanced Adventurer SCUBA diving certification.
- Standard First Aid – CPR Level C with AED.

PUBLICATIONS

Carter, R., M.E. Wainwright, D.D. MacDonald, J.A. Sinclair, A. Schein, H.J. Prencipe, M.L. Haines, W. Lorentz, D. Tillitt, and D.K. Nicks. 2013. Field Sampling Plan for Evaluation of Exposure of Avian Receptors to Bioaccumulative Contaminants. Prepared for United States Fish and Wildlife Service. Birmingham, Alabama.

MacDonald, D.D., C.G. Ingersoll, M.E. Wainwright, A. Schein, C.E. Orazio, W.G. Brumbaugh, H.J. Prencipe, J.A. Sinclair, M.L. Haines. 2013. Quality Assurance Protection Plan (QAPP) for Evaluation of the Toxicity of Upper Columbia River Sediments to Freshwater Mussels. Prepared for United States Department of the Interior (USDOI) Project Manager. Spokane, Washington.

MacDonald, D.D., A. Schein, and J. Sinclair. 2012. Overview of Water Quality Issues and Concerns Related to the Avanti Kitsault Mine Project. Prepared for Nisga'a Lisims Government, New Aiyansh, British Columbia.

Schein, A., D.D. MacDonald, J. Sinclair, and H. Prencipe. 2012. Re-Evaluation of Baseline Water Quality Data Collected During 2009-2012 in the Vicinity of the Avanti Kitsault Mine. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. Prepared for Nisga'a Lisims Government, New Aiyansh, British Columbia.

Wainwright, M.E., M.R. Coady, A. Schein, and H.J. Prencipe. 2012. 2012 Water Quality Monitoring Report for Enos Lake, Nanoose Bay. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. Prepared for Pottinger Gaherty Environmental Consultants Ltd., Vancouver, British Columbia.

MacDonald, D.D., J. Sinclair, A. Schein, and M.L. Haines. 2012. Approaches to the

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9625 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

Development of Water Quality Objectives for Receiving Environments in the Vicinity of the BHP Billiton Diamonds, Inc. Ekati Diamond Mine, Northwest Territories. Prepared for Water Resources Division, Aboriginal Affairs and Northern Development Canada. Yellowknife, NWT.

MacDonald, D.D., J.A. Sinclair, A. Schein, H.J. Prencipe, M.E. Wainwright, M.R. Coady, M.L. Haines, C.G. Ingersoll, N.E. Kemble, J.L. Kunz, J.A. Steevens, G.R. Lotufo, and D. Farrar. 2012. Preliminary Assessment and Quantification of Natural Resource Injuries Associated with Discharges of Oil or Releases of Other Hazardous Substances in the Vicinity of the Piles Creek Site, Linden, New Jersey. Volume 1 - Technical Report. Prepared for Office of Response and Restoration National Oceanic and Atmospheric Administration and New Jersey Field Office, U.S. Fish and Wildlife Service. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, United States Geological Survey, Columbia, Missouri, and United States Army Corps of Engineers (ERDC), Vicksburg, Missouri.

MESL/IEc. 2012. Development of toxicity thresholds for water, sediment, soil, and biota tissues for application at the Hanford Site, Washington. Prepared for the Hanford Natural Resource Trustee Council. Nanaimo, B.C.

Schein, A., S.C. Courtenay, C.S. Crane, K.L. Teather, and M.R. van den Heuvel. 2012. The role of submerged aquatic vegetation in structuring the nearshore fish community within an estuary of the southern Gulf of St. Lawrence. Estuaries and Coasts 35: 799-810.

Schein, A., J.A. Scott, L. Mos, and P.V. Hodson. 2009. Oil dispersion increases the apparent bioavailability and toxicity of diesel to rainbow trout (*Oncorhynchus mykiss*). Environmental Toxicology and Chemistry 28: 595-602.

JESSE A. SINCLAIR

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

SUMMARY OF QUALIFICATIONS

Extensive experience in identifying and conducting appropriate statistical analyses through my Master's research and work as a Biologist with MacDonald Environmental Sciences Ltd. and the BC Ministry of Environment; I am proficient with the R programming language for statistical computing and graphics.

Participated in sediment and biological sampling programs to support Natural Resource Damage assessments and Ecological Risk Assessments.

Participated in hydoracoustic and gill netting surveys on the Sooke Lake and Coquitlam reservoirs; sampling consisted of identifying, measuring, weighing, sexing and collecting muscle tissue, stomach contents and scales of freshwater fishes.

Accumulated 34 days at sea participating in juvenile salmon surveys in the Bering Sea. I collaborated with NOAA, collecting phytoplankton, zooplankton and marine and anadromous fishes; sampling consisted of identifying, measuring, weighing, sexing and collecting muscle tissue, stomach contents and scales of selected fishes.

Experience using relational databases such as Microsoft Access, PostGreSQL and Oracle to import and extract biological and limnological data as well as creating queries to collate data and run analyses. I have designed and maintained multiple databases to support environmental assessments during my Master's research and work experience.

Worked with stakeholders (i.e., municipal government) during my experience in the Water and Aquatic Sciences Research Program at the University of Victoria and Natural Resource Trustees during my experience with MacDonald Environmental Sciences Ltd..

EDUCATION

University of Victoria Victoria, BC
M.Sc., Biology, 2010, Water and Aquatic Sciences Research Program

University of Saskatchewan Saskatoon, SK
B.Sc. with distinction, Biology, 2004, Minor in Geographic Information Systems

Carlton Comprehensive High School Prince Albert, SK
High School Diploma, 1997

JESSE A. SINCLAIR

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

PROFESSIONAL CERTIFICATIONS

Registered Professional Biologist (College of Applied Biology - British Columbia)

WORK HISTORY

Senior Biologist *February 2010 - Present*
MacDonald Environmental Sciences Ltd., Nanaimo, BC

- Develop and maintain relational databases to support the development of Natural Resource Damage Assessments and Ecological Risk Assessments.
- Participate in the compilation and statistical analysis of environmental data to support the development of Natural Resource Damage Assessments and Ecological Risk Assessments.
- Participate in the design of sampling programs and the subsequent collection of sediment and biota samples to support the development of Natural Resource Damage Assessments and Ecological Risk Assessments.
- Successfully created a package of statistical analysis tools, which has streamlined various aspects of analyses routinely performed at MESL, including: the analysis of environmental data needed to support the development of Natural Resource Damage Assessments, the development of concentration-response models to derive toxicity thresholds, and the calculation of preliminary estimates of damage of trust resources.

Scientific and Technical Officer - Water Protection *April 2009 - February 2010*
Health Protection Branch, Population and Public Health Division
BC Ministry of Healthy Living & Sport, Victoria, BC

- Analyzed and developed spatial information products to address source water protection issues, using ArcGIS.
- Identified key topic areas regarding water quality issues for human health in British Columbia and developed the Water Protection work plan to address the data requirements for priority issues
- Participated in creating a source area risk assessment tool to identify watersheds at risk in British Columbia.
- Reviewed water quality objectives reports, developed to assess water quality in Community Watersheds on Vancouver Island.

JESSE A. SINCLAIR

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

Water Quality Biologist *July 2008 - March 2009*
Information Branch, Water Stewardship Division
BC Ministry of Environment, Victoria, BC

- Improved and modernized the acquisition of continuous water quality data in the province by successfully installing and using satellite telemetry to acquire real-time water quality data from remote locations, configuring and downloading data from data loggers and calibrating and maintaining multi-parameter water quality probes.
- Reviewed and edited water quality assessment and objectives development reports for community watersheds across the province, including the compilation and analysis of water quality data pertaining to designated uses of the watersheds (drinking water, aquatic life, wildlife, recreation and irrigation). Used BC water quality and Health Canada guidelines for drinking water to assess water quality.
- Worked with colleagues in an inter-branch setting to assess and offer recommendations to improve data storage and processing of water quality and quantity data.
- Contributed to the Water Quality Objectives Attainment Summary Report; the project involved compiling and analyzing water quality data for select watersheds across the province; summary reports for various watersheds were written.

Field Technician *January 2008 - June 2008*
Water and Aquatic Sciences Research Program *April 2005 - September 2005*
University of Victoria, Victoria, BC

- Collected limnological data (physical and biological components) in both mesocosm and field settings.
- Supervised a Co-op student during their work term, training the student in collection and analysis of limnological data.
- Performed statistical analyses of field experiments and presented results to the municipal government.
- Prepared and analyzed water chemistry samples (organic carbon, nitrogen and phosphorus).
- Assisted in hydro-acoustic and gill netting fish surveys; identifying, measuring, weighing and bio-sampling salmonids in a freshwater environment.

Teaching Assistant (BIOL 330: Ecological Methods) *January 2007 - April 2007*
University of Victoria, Victoria, BC

- Instructed the lab component for 3rd and 4th year biology and environmental science students on design of ecological experiments, sampling design, and statistical analysis.

- Lab material focussed on the analysis of data sets using SPSS 14 and Microsoft Excel and writing scientific reports.
- Guided students through a term research project of their design.

VOLUNTEER EXPERIENCE

Bering-Aleutian Salmon International Survey 2006/2007
University of Victoria / NOAA Bering Sea

- Participated in multi-week trawl surveys in the Bering Sea collecting information on juvenile salmonids
- Identified, measured and weighed juvenile and adult salmonid and other fish species.
- Sampled juvenile and adult salmonids (collected muscle tissue, scales and stomach contents).

Volunteer Firefighter 2003/2004 (Seasonal)
Prince Albert National Park & Waskesiu Lake, SK

COMPUTER SKILLS

Statistical Software: R, SPSS, SigmaPlot
Operating Systems: Mac OS X, Microsoft Windows, GNU/Linux, UNIX
Office Software: Microsoft Word, Microsoft Excel, Microsoft Access, Microsoft Project, Microsoft Outlook
GIS Software: ArcGIS platform (ArcMap, ArcCatalog)

PUBLICATIONS

Carter, R., M.E. Wainwright, D.D. MacDonald, J.A. Sinclair, A. Schein, H.J. Prencipe, M.L. Haines, W. Lorentz, D. Tillitt, and D.K. Nicks. 2013. Field Sampling Plan for Evaluation of Exposure of Avian Receptors to Bioaccumulative Contaminants. Prepared for United States Fish and Wildlife Service. Birmingham, Alabama.

MacDonald, D.D., C.G. Ingersoll, M.E. Wainwright, A. Schein, C.E. Orazio, W.G. Brumbaugh, H.J. Prencipe, J.A. Sinclair, M.L. Haines. 2013. Quality Assurance Protection Plan (QAPP) for Evaluation of the Toxicity of Upper Columbia River Sediments to Freshwater Mussels. Prepared for United States Department of the

#24-4800 Island Hwy N • Nanaimo, British Columbia V9T 1W6 • Phone: 250-729-9623 • Fax: 250-729-9628 • E-mail: mesl@shaw.ca

Interior (USDOI) Project Manager. Spokane, Washington.

MacDonald, D.D., A. Schein, and J. Sinclair. 2012. Overview of Water Quality Issues and Concerns Related to the Avanti Kitsault Mine Project. Prepared for Nisga'a Lisims Government, New Aiyansh, British Columbia.

MacDonald, D.D., J. Sinclair, and M. Coady. 2012. An Evaluation of the Reference Envelope Approach Applied in the Baseline Ecological Risk Assessment for the Portland Harbor Site. Prepared for: Office of Environmental Assessment, U.S. Environmental Protection Agency. Seattle, Washington. Prepared by: MacDonald Environmental Sciences Ltd., Nanaimo, BC in association with CDM Smith, Bellevue, WA.

Sinclair, J.A., M.A. Crawford, D.D. MacDonald, and H.J. Prencipe. 2012. Preliminary Risk Assessment of Long Lake in the Quinsam River Watershed, Vancouver Island. Prepared for: Ministry of Environment, Nanaimo, British Columbia. Prepared by: MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

MacDonald, D.D. and J.A. Sinclair. 2012. Identification and evaluation of toxicity tests to support the development of site-specific water quality objectives for Buttle Lake, Vancouver Island, British Columbia. Prepared for B.C. Ministry of the Environment. Nanaimo, British Columbia. Prepared by MacDonald Environmental Sciences Ltd. Nanaimo, British Columbia.

Ingersoll, C.G., W.G. Brumbaugh, J. A., Steevens, G.R. Lotufo, D.D. MacDonald, and J.A. Sinclair. 2012. Sediment sample collection, handling, preparation, and characterization. Chapter 2 . *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca,* and to the midge, *Chironomus dilutus,* and bioaccumulation by the oligochaete, *Lumbriculus variegatus,* with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; MacDonald Environmental Sciences Ltd., Nanaimo, BC.

Steevens, J.A.,G.R. Lotufo, N.E. Kemble, C.G. Ingersoll, J.K. Stanley, J.D. Farrar, J.A. Sinclair, D.D. MacDonald. 2012. Evaluation of bioaccumulation in the oligochaete, *Lumbriculus variegatus*, exposed to sediments from the Anniston PCB Site. Chapter 3. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca,* and to the midge, *Chironomus dilutus,* and bioaccumulation by the oligochaete, *Lumbriculus variegatus*, with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; U.S. Geological Survey, Columbia, MO; 3MacDonald Environmental Sciences Ltd., Nanaimo, BC.

Stanley, J.K., N.E. Kemble, J.D. Farrar, C.G. Ingersoll, D.D. MacDonald, J.A. Steevens, J.A.

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

Sinclair. 2012. Toxicity testing with the amphipod, *Hyalella azteca*, and with the midge *Chironomus dilutus.* Chapter 4. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca*, and to the midge, *Chironomus dilutus,* and bioaccumulation by the oligochaete, *Lumbriculus variegatus,* with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS; U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; MacDonald Environmental Sciences Ltd., Nanaimo, BC.

MacDonald, D.D., C.G. Ingersoll, J.A. Sinclair, J.A. Steevens, J.K. Stanley, J.D. Farrar, N.E. Kemble, J.L. Kunz, W.G. Brumbaugh, and M.R. Coady. 2012. Evaluation of relations between sediment toxicity and sediment chemistry at the Anniston PCB Site. Chapter 5. *In:* Evaluation of toxicity to the amphipod, *Hyalella azteca*, and to the midge, *Chironomus dilutus,* and bioaccumulation by the oligochaete, *Lumbriculus variegatus*, with exposure to PCB-contaminated sediments from Anniston Alabama. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, BC; U.S. Geological Survey, Columbia Environmental Research Center, Columbia, MO; U.S. Army Corps of Engineer, Engineer Research and Development Center, Vicksburg, MS.

MacDonald, D.D., J.A. Sinclair, A. Schein, H.J. Prencipe, M.E. Wainwright, M.R. Coady, M.L. Haines, C.G. Ingersoll, N.E. Kemble, J.L. Kunz, J.A. Steevens, G.R. Lotufo, and D. Farrar. 2012. Preliminary Assessment and Quantification of Natural Resource Injuries Associated with Discharges of Oil or Releases of Other Hazardous Substances in the Vicinity of the Piles Creek Site, Linden, New Jersey. Volume 1 - Technical Report. Prepared for Office of Response and Restoration National Oceanic and Atmospheric Administration and New Jersey Field Office, U.S. Fish and Wildlife Service. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, United States Geological Survey, Columbia, Missouri, and United States Army Corps of Engineers (ERDC), Vicksburg, Missouri.

MacDonald, D.D., J. Sinclair, M.A. Crawford, C.G. Ingersoll, H. Prencipe, S. Cox, and M. Coady. 2012. Evaluation and interpretation of the 2005 sediment chemistry and sediment toxicity data for the Upper Columbia River Site. Prepared for Washington Department of Ecology Toxic Cleanup Program. Through Science Applications International Corporation. Bothell, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri and Tacoma, Washington.

MacDonald, D.D., J.A. Sinclair, M. Crawford, H. Prencipe, C. Lewis, and M. Donlan. 2011. Preliminary Summary of Whole-Sediment Chemistry, Fish-Tissue Chemistry, and Invertebrate-Tissue Chemistry Data Obtained during the 2010 Sediment and Biota Sampling Program for Piles Creek and South Branch Creek, Linden, New Jersey. Prepared for Office of Response and Restoration, National Oceanic and Atmospheric Administration and Division of Environmental Contaminants, U.S. Fish and Wildlife Service. Prepared by

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia, and Industrial Economics Inc., Columbia, Missouri.

MacDonald D.D., C.G. Ingersoll, D.E. Smorong, J.A. Sinclair, R.A. Lindskoog, N. Wang, C. Severn, R. Gouguet, J. Meyer, and J. Field. 2011. Baseline ecological risk assessment of the Calcasieu Estuary, Louisiana: 2. An evaluation of the predictive ability of effects-based sediment quality guidelines. Archives of Environmental Contamination and Toxicology 61:14-28.

MacDonald D.D., C.B. Ingersoll, N. Kemble, D.E. Smorong, J.A. Sinclair, R.A. Lindskoog, C. Gaston, D. Sanger, S. Carr, J. Biedenbach, R. Gouguet, J. Kern, A. Shortelle, J. Field, and J. Meyer. 2011. Baseline Ecological Risk Assessment of the Calcasieu Estuary, Louisiana: 3. An Evaluation of the Risks to Benthic Invertebrates Associated with Exposure to Contaminated Sediments. Archives of Environmental Contamination and Toxicology 61:29-58.

MacDonald, D.D., J. Sinclair, M. Crawford, H. Prencipe and M. Meneghetti. 2011. Potential effects of contaminants on Fraser River sockeye salmon. MacDonald Environmental Sciences Ltd. Cohen Commission Tech. Rep. 2. In prep. Vancouver, B.C. www.cohencommission.ca

MacDonald, D.D., C.G. Ingersoll, J.A. Sinclair, M. Crawford, H. Prencipe, M. Coady, N.E. Kemble, A. Jones, M. Curry, C. Lewis, J. Steevens, and K. Nolan. 2011. Preliminary evaluation of the effects on benthic invertebrates associated with exposure to PCB-contaminated sediments in the Upper Hudson River, New York. Prepared for: National Oceanic and Atmospheric Administration, Silver Spring, Maryland. Prepared by: MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. United States Geological Survey, Columbia, Missouri. Industrial Economics, Inc., Cambridge, Massachusetts. United States Army Corps of Engineers, Vicksburg, Mississippi. Watershed Assessment Associates, LLC, Schenectady, New York.

MacDonald, G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume I: Overview of the Recommended Decision Framework. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and

#24-4800 ISLAND HWY N • NANAIMO, BRITISH COLUMBIA V9T 1W6 • PHONE: 250-729-9623 • FAX: 250-729-9628 • E-MAIL: MESL@SHAW.CA

Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume II: Description of the Rapid (Tier 1) Assessment Process. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, G.L. Linder, C.G. Ingersoll, S.E. Finger, M.A. Crawford, H.J. Prencipe, J.A. Sinclair, M.B. Meneghetti, and J.E. Hinck. 2010. Handbook for Assessing Risks to Fish and Wildlife Associated with the Potential Use of Water, Treated Wastewater, Stormwater, Sediment, Soil, Biosolids, or Other Materials on Units of the National Wildlife Refuge System. Volume III: Description of Detailed (Tier 2) Assessment Process. Prepared for U.S. Fish and Wildlife Service. Vancouver, Washington. Prepared by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia and United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., A. Jones, C.G. Ingersoll, J.A. Sinclair, H. Prencipe, and M. Meneghetti. 2010. Sampling and analysis plan for the 2010 sediment and biota sampling program for Piles Creek and South Branch Creek, Linden, New Jersey. Prepared for: National Oceanic and Atmospheric Administration. Silver Spring, Maryland. Prepared by: MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. Industrial Economics Inc., Cambridge, Massachusetts. United States Geological Survey, Columbia, Missouri.

MacDonald, D.D., C.G. Ingersoll, M. Crawford, H. Prencipe, J.M. Besser, W.G. Brumbaugh, N. Kemble, T.W. May, C.D. Ivey, M. Meneghetti, J. Sinclair, and M. O'Hare. 2010. Advanced screening-level ecological risk assessment (SLERA) for aquatic habitats within the Tri-State Mining District, Oklahoma, Kansas, and Missouri. Draft Final Technical Report. Submitted to United States Environmental Protection Agency (USEPA). Region 6, Dallas, Texas, Region 7, Kansas City, Kansas, and US Fish and Wildlife Service, Columbia, Missouri. Submitted by MacDonald Environmental Sciences Ltd., Nanaimo, British Columbia. United States Geological Survey, Columbia, Missouri. CH2M Hill, Dallas, Texas

PRESENTATIONS

Effects of Wetland Inundation on Hydrologically Connected Aquatic Ecosystems
Society of Canadian Limnologists Annual Meeting, 2007 Montréal, QC

Resume - John Stockner - Limnologist

Professional Experience -

- 1968-1972 - Research Scientist, Dept. Fisheries & Oceans, Freshwater Institute, Winnipeg, Man., Canada
- 1972-1982 - Research Scientist, Dept. Fisheries & Oceans, W. Van. Lab. W. Vancouver, BC, Canada
- 1982-1984 - Assoc. Director, Fisheries Research Branch, Dept. Fisheries & Oceans, W. Vancouver, BC.
- 1984-1997 - Senior Res. Scientist, Dept. Fisheries & Oceans, W. Van Lab, W. Vancouver, BC.
- 1997-1998 - Professor of Limnology, Director, Institute of Limnology, Uppsala Univ., Sweden.
- 1998-2007 – A. Professor, Institute of Resources & Environment, Univ. of BC,
- 1993-present – A. Professor, Fisheries Centre, Univ. of B.C., Vancouver, BC.

` Vancouver, BC.

- 1998-present - Principal Limnologist/Oceanographer, Eco-Logic Ltd., West Vancouver, BC

Education -

1958-1962 BA (Biology, Chemistry) Augustana College, Rock Island, Illinois, USA

1962-1967 PhD (Zoology, Limnology & Oceanography) University of Washington, Seattle, Washington, USA

1967-1968 National Science Foundation Postdoctoral Fellow (Plankton ecology), Freshwater Biological Association, Ambleside, Cumbria, England

Recognition -

1989-1997 Appointed Senior Scientist, Dept. Fisheries & Oceans, Pacific Region, West Vancouver, BC.

1993 - Distinguished Service Medal in Aquatic Science, American Society of Limnology & Oceanography

1994 - Deputy Minister's Commendation Award - '*Outstanding contributions to Aquatic Sciences in Canada*' Ottawa

1997-1998 Appointed - Professor of Limnology & Director, Institute of Limnology, Uppsala University, Sweden (50 staff members).

2004 – Outstanding Achievement Award, Augustana College Alumni Association.

Expertise -

- Sept. - Oct. 1980 Visiting Scholar, National Institute of Environmental Research, Pretoria, South Africa
- Nov. - Oct. 1980 Visiting Professor, Dept. of Zoology, University of Rhodesia, Salisbury, Rhodesia
- Sept. - Nov. 1982 Visiting Professor, Dept. of Biological Sciences, Tsukuba University, Japan
- Sept. -Dec. 1990 Visiting Professor, Dept. of Zoology, University of Otago, Dunedin, New Zealand
- Sept. - Nov. 1993 Visiting Professor, Institute. Zoology & Limnology, Univ. of Innsbruck, Austria
- Aug. - Dec. 1995 Visiting Professor, National Institute of Environmental Studies, Tsukuba, Japan
- Sept. - Nov. 1996 Visiting Professor, Italian Institute of Hydrobiology, Verbania-Pallanza, Italy

Consultant to - BC Min. Environment, BC Hydro, DeBeers Inc., US-EPA, US Army Corp of Engineers, States of Idaho, Washington, Oregon, Alaska, Can. Dept. Fish & Oceans, etc.

Publications - 3 books (senior editor/author), 12 book chapters and 190 peer-reviewed papers (9 most relevant to current lake production research - below)

Stockner, J.G. 1987. Lake fertilization: The enrichment cycle and lake sockeye salmon (*Oncorhynchus nerka)* production, p. 198-215. In: H.D. Smith, L. Margolis and C.C. Wood (eds.). Sockeye salmon (*Oncorhynchus nerka*) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96, 486 p.

Stockner, J.G. and K.G. Porter. 1988. Microbial food w ebs in freshw ater planktonic ecosystems, p. 71-84. In: S.R. Carpenter (ed.) Complex interactions in lake communities. Springer-Verlag,

New York, N.Y., 283 p.
Henderson, M, J.G. Stockner, and D.A. Levy. 1992. Probable consequences of climate change on freshwater aspects of the production of Adams River sockeye salmon (*Oncorhynchus nerka*), Geo. Journal 28: 51-59.
Stockner, J.G., and E.A. MacIsaac. 1996. The British Columbia Lake fertilization program: overview after two decades of salmon enhancement. Reg. Rivers. 12: 344-356.
Stockner, J.G. 1998. Global warming, picocyanobacteria and fisheries decline: is there a connection? Atti del 12° Congresso dell'AIOL, Vol II - Genova AIOL 1998, Piccazzo (ed.): p. 29-37.
Stockner, J.G., E. Ryden, P Hyenstrand. 2000. Cultural Oligotrophication: Causes and consequences to fisheries resources. Fisheries, 25: 7-14.
Stockner, J.G., C. Callieri, G. Cronberg. 2000. Picoplankton and other non-bloom forming cyanobacteria in lakes. P. 195-231. In: B.A. Whitton and M. Potts (eds.) The Ecology of Cyanobacteria: their diversity in time and space. Kluwer Academic Publications, Netherlands, 669 p.
Stockner, J.G. and K. I. Ashley. 2001. Salmon Nutrients: closing the circle. P. 1-17. In: J. G. Stockner (ed.) Nutrients in salmonid ecosystems: sustaining production and biodiversity. AFS symposium series No. 34, Bethesda, Maryland, 286p.
Stockner, J.G., A. Langston, D. Sebastian, and G. Wilson. 2005. The limnology of Williston Reservoir: British Columbia's largest lacustrine Ecosystem. Water Qual. Res. J. Canada, 40: 28-50.

Statement of Qualifications.

Dr. Stockner's research interests focus on pelagic and littoral nutrient dynamics, food web interactions and carbon flows in aquatic ecosystems, notably lakes and reservoirs. He is well known for his work on British Columbia's large lacustrine ecosystems where he has extensively studied the carbon flow and C production by phytoplankton, nutrient fluxes, sediment -P retention, relating these findings to estimates of carbon 'productive capacities' of both pelagic and littoral habitats, using isotopic (^{15}N, ^{14}C) and paleolimnological techniques. His work relating carbon (C) and phosphorus (P) budgets to fisheries stock production and management, and innovative 'nutrient prescription' technology (lake and stream fertilization) as a restorative technique for salmonid enhancement has brought him international recognition as one of the world's leading authorities in the field. He is a skilled phytoplankton taxonomist, studying diatom taxonomy with Drs. Patrick and Reimer (Academy of Natural Sciences, Philadelphia) and with Dr. JWG Lund FRS (Freshwater Biological Association, Ambleside, England). He has an extensive database on freshwater phytoplankton and periphyton and an extensive library of limnological and paleolimnological papers. His pioneering works in paleolimnology as a tool to detect trophic changes and assess historic levels of 'paleo' C production using fossil diatoms and cladocerans continues to be applied to on-going studies in Pacific Northwest lakes and reservoirs. His work on microbial food-webs as 'drivers' of C metabolism in oligotrophic lakes has resulted in 3 edited books and recognition as one of the world's authorities on picoplankton and microbial food-webs in microbial ecology, notably the role of photosynthetic pico-cyanobacteria, their distribution, production, and role in whole-system C production. Recently his work has included dynamics of periphyton communities in the Upper Columbia Basin and in the NW Territories, utilizing key species as indicators of N or P limitation.