# APPENDIX 6.2.8-E

## Freshwater Toxicological Assessment of the Mannville Formation Water

# FRESHWATER TOXICOLOGICAL ASSESSMENT OF THE MANNVILLE FORMATION WATER

Submitted to:

**Shore Gold Inc.**

Saskatoon, Saskatchewan

Submitted by:


**AMEC Earth & Environment**

Saskatoon, Saskatchewan


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## TABLE OF CONTENTS



### TABLES



### APPENDICES

# 1.0 INTRODUCTION

Shore Gold Inc. (Shore Gold) submitted a draft Environmental Impact Statement (EIS) for the proposed Star-Orion South Diamond Project for regulatory review (Shore Gold, 2010). The EIS considered the release of a combined stream consisting of process water and Mannville Formation water to the Saskatchewan River through a diffuser pipe. In their comments on the EIS, the Federal Department of Fisheries and Oceans (DFO) and Environment Canada (EC) requested additional information regarding water quality effects of the proposed release, and an evaluation as to whether or not such action would be considered 'deleterious' under Section 34(1)(a) & (b) of the *Fisheries Act*.

Under the *Fisheries Act*, a deleterious substance is defined as:

> 34(1)(*a*) any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
>
> 34(1) (*b*) any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water,

As a result of the DFO and EC comments, Shore Gold modified the proposed development. The modified plans now have separated the process water from the Mannville Formation water that are produced by the dewatering system. The process water will not be discharged into Saskatchewan River, rather it will be discharged into the Processed Kimberlite Containment Facility (PKCF). Process water will also be taken from the PKCF so as to establish a closed loop type system. The Mannville Formation is still being considered for discharge to the Saskatchewan River using a diffuser.

A Toxicological Assessment was prepared in 2011 (Shore Gold, 2011) in response to the DFO and EC comments, and demonstrated that Mannville Formation water is not deleterious and could therefore be discharged into the Saskatchewan River.

This 2012 Toxicological Assessment updates the 2011 Toxicological Assessment. This 2012 Toxicological Assessment is submitted as part of the Revised EIS (Shore Gold, 2012). After presenting new information, this 2012 Toxicological Assessment again concludes that Mannville Formation water is not deleterious based on the weight of evidence, and considering uncertainties in the *Ceriodaphnia dubia* toxicity test which suggest that this test may not be appropriate for the natural conditions specific to the Saskatchewan River.

## 1.1 OBJECTIVES AND SCOPE OF WORK

The objective of this Toxicological Assessment is to evaluate the water quality of the Mannville Formation water and determine if it is non-deleterious. This Toxicological Assessment considered three lines of evidence:

1) A comparison of Mannville Formation water quality parameters to provincial and federal water quality guidelines and objectives,
2) Acute and chronic toxicity testing of the Mannville Formation water, and
3) A comparison of literature toxicity values to further evaluate effects to lake sturgeon, a protected species.

## 2.0 COMPARISON OF MANNVILLE FORMATION WATER CHEMISTRY TO PROVINCIAL AND FEDERAL WATER QUALITY OBJECTIVES AND GUIDELINES

A pump test of a prototype dewatering well was conducted as part of Shore Gold's preliminary mine development efforts from October 25, 2010 to November 14, 2010. During that period, nine Mannville Formation water samples were collected over a period of three weeks and sent to a laboratory for chemical analysis of total metals, chloride, and other water quality parameters including bicarbonate, hardness, specific conductivity, pH, etc. Manville Formation water chemistry data are summarized in Table 1 and presented in full in **Appendix A**. Note that Table 1 does not include the first sample (#10064). Sample #10064 was collected early on the morning of October 26 before well conditions had stabilized, and is not representative of Mannville Formation water chemistry.

Table 1 also compares water chemistry data to the following provincial and federal water quality objectives as described below:

- Mineral Industry Environmental Protection Regulations (MIEPR) (SERM, 1996)
- Metals Mining Effluent Regulation (MMER)(DFO, 2002)
- Saskatchewan Water Quality Objectives (SWQOs) (Saskatchewan Environment, 2006)
- CCME Chloride Water Quality Guidelines (WQG) (CCME, 2011)

AMEC recognizes that EC and DFO have indicated that the MMER do not apply to Shore Gold as the proposed facility is a diamond mine and the MMER apply only to metal mines. Since there are no diamond mining effluent regulations, the MMER are provided for comparison purposes.

## Table 1. Chemistry of Mannville Formation Water

| Group # | | Sask. Enviro. SWQO[1] | MIEPR[3] | MMER[4] | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample #** | | **FAL[2]** | **Authorized Conc.** | **Authorized Limits** | **#10065** | **#10066** | **#10067** | **#10068** | **#10071** | **#10072** | **#10073** | **#10074** |
| **Date** | | | | | **29-Oct-10** | **2-Nov-10** | **4-Nov-10** | **7-Nov-10** | **11-Nov-10** | **12-Nov-10** | **14-Nov-10** | **14-Nov-10** |
| **Analyte** | **Units** | | **Max. Monthly Mean** | **Max. Monthly Mean** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** |
| Aluminum | mg/L | 0.1 | | | | | | 0.005 | | 0.0021 | | 0.0024 |
| Antimony | mg/L | | | | | | | <0.002 | | <0.0002 | | <0.0002 |
| Arsenic | mg/L | 0.005 | 0.5 | 0.5 | | | | <0.001 | | 0.0003 | | 0.0002 |
| Barium | mg/L | | | | | | | 0.011 | | 0.010 | | 0.010 |
| Beryllium | mg/L | | | | | | | <0.001 | | <0.0001 | | <0.0001 |
| Bicarbonate | mg/L | | | | 476 | 477 | 477 | 474 | 474 | | 474 | |
| Boron | mg/L | | | | | | | 2.0 | | 2.0 | | 1.9 |
| Cadmium | mg/L | 0.0001 | | | | | | <0.0001 | | 0.00001 | | 0.00001 |
| Calcium | mg/L | | | | 136 | 133 | 133 | 136 | 134 | | 134 | |
| Carbonate | mg/L | | | | <1 | <1 | <1 | <1 | <1 | | <1 | |
| Chloride | mg/L | | | | 1600 | 1600 | 1560 | 1600 | 1700 | | 1700 | |
| Chromium | mg/L | 0.001[5] | | | | | | <0.005 | | <0.0005 | | <0.0005 |
| Cobalt | mg/L | | | | | | | <0.001 | | 0.0001 | | 0.0001 |
| Copper | mg/L | 0.004 | 0.3 | 0.3 | | | | **<u>0.005</u>** | | 0.0032 | | 0.0024 |
| Fluoride | mg/L | | | | 2.2 | 2.3 | 2.2 | 2.2 | 2.3 | | 2.5 | |
| Hydroxide | mg/L | | | | <1 | <1 | <1 | <1 | <1 | | <1 | |
| Iron | mg/L | 0.3 | | | | | | 0.29 | | 0.24 | | 0.23 |
| Lead | mg/L | 0.007 | 0.2 | 0.2 | | | | <0.001 | | 0.0005 | | 0.0003 |
| Magnesium | mg/L | | | | 46 | 45 | 45 | 46 | 45 | | 45 | |
| Manganese | mg/L | | | | | | | 0.092 | | 0.087 | | 0.086 |
| Molybdenum | mg/L | | | | | | | <0.001 | | 0.0002 | | 0.0001 |
| Nickel | mg/L | 0.15 | 0.5 | 0.5 | | | | <0.001 | | 0.0005 | | 0.0005 |
| Nitrate | mg/L | | | | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | | <0.04 | |
| P. Alkalinity | | | | | <1 | <1 | <1 | <1 | <1 | | <1 | |
| pH | pH units | | | | 7.82 | 7.82 | 7.88 | 7.79 | 7.74 | | 7.73 | |
| Phosphorus | mg/L | | | | | | | 0.06 | | 0.05 | | 0.05 |

| Group # | | Sask. Enviro. SWQO[1] | MIEPR[3] | MMER[4] | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT | OSPT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sample #** | | **FAL[2]** | **Authorized Conc.** | **Authorized Limits** | **#10065** | **#10066** | **#10067** | **#10068** | **#10071** | **#10072** | **#10073** | **#10074** |
| **Date** | | | | | **29-Oct-10** | **2-Nov-10** | **4-Nov-10** | **7-Nov-10** | **11-Nov-10** | **12-Nov-10** | **14-Nov-10** | **14-Nov-10** |
| **Analyte** | **Units** | | **Max. Monthly Mean** | **Max. Monthly Mean** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** | **Results** |
| Potassium | mg/L | | | | 57 | 58 | 58 | 57 | 56 | | 56 | |
| Selenium | mg/L | 0.001 | | | | | | <0.001 | | 0.0003 | | 0.0002 |
| Silver | mg/L | 0.0001 | | | | | | <0.0001 | | <0.00001 | | <0.00001 |
| Sodium | mg/L | | | | 1210 | 1270 | 1250 | 1210 | 1210 | | 1220 | |
| Specific conductivity | μS/cm | | | | 6530 | 6470 | 6530 | 6450 | 6160 | | 6180 | |
| Strontium | mg/L | | | | | | | 2.5 | | 2.50 | | 2.48 |
| Sulfate | mg/L | | | | 750 | 740 | 750 | 750 | 740 | | 740 | |
| Sum of ions | mg/L | | | | 4280 | 4320 | 4270 | 4270 | 4360 | | 4370 | |
| Thallium | mg/L | | | | | | | <0.002 | | <0.0002 | | <0.0002 |
| Tin | mg/L | | | | | | | <0.001 | | <0.0001 | | <0.0001 |
| Titanium | mg/L | | | | | | | <0.002 | | 0.0002 | | <0.0002 |
| Total alkalinity | mg/L | | | | 390 | 391 | 391 | 389 | 389 | | 389 | |
| Total dissolved solids | mg/L | | | | 3960 | 3970 | 3960 | 3950 | 3950 | | 3950 | |
| Total hardness | mg/L | | | | 528 | 517 | 517 | 528 | 519 | | 519 | |
| Uranium | mg/L | 0.015 | 2.5 | | | | | <0.001 | | <0.001 | | <0.0001 |
| Vanadium | mg/L | | | | | | | <0.001 | | 0.0002 | | 0.0002 |
| Zinc | mg/L | 0.03 | 0.5 | 0.5 | | | | 0.021 | | 0.014 | | 0.011 |

**Bold** and underlined values exceed Surface Water Quality Objectives

[1] Saskatchewan Environment. 2006. Surface water quality objectives. Interim Edition. EPB356. July.

[2] Protection of Freshwater Aquatic Life

[3] Saskatchewan Environment and Resource Management (SERM). 1996. The mineral industry environmental protection regulations. Chapter E-10.2 Reg 7. Concentrations presented are the Maximum Monthly Arithmetic Mean for the total amount of the metal of specified.

[4] Department of Fisheries and Oceans (DFO). 2002. Metal Mining Effluent Regulations. Registration SOR/2002-222. Ottawa, Ontario. Concentrations presented are the Maximum Authorized Monthly Mean Concentrations for the total amount of the metal specified.

[5] Value is for hexavalent chromium.

## 2.1 Comparison of Formation Water Chemistry to MIEPR and MMER Authorized Values

Under MIEPR Section 30, no liquid effluent is permitted to be discharged into the environment if the concentration of any pollutant in the effluent exceeds the authorized concentration listed in the Regulation. Similarly, under the federal MMER, discharges must meet authorized limits. Table 1 shows that concentrations of the Mannville Formation water analytes are less than MIEPR and MMER authorized values. Discharge of the Mannville Formation water to the Saskatchewan River would therefore not be deleterious under both of these quality objectives.

## 2.2 Comparison of Formation Water Chemistry to SWQOs

Saskatchewan Environment has published SWQOs for several metals/metalloids (Table 1). Concentrations of water quality parameters are below SWQOs except the November 7 copper measurement (0.005 mg/L) which is marginally above the SWQO (0.004 mg/L).

However, the existing SWQO overestimates copper toxicity. The SWQO for copper is based on the hardness-dependant CCME formula (CCME, 1987). The CCME standard in turn adopts the 1984 USEPA chronic ambient water quality criterion (USEPA, 1985), but also includes an “application factor” to account for unspecified uncertainties in the underlying toxicity dataset:

$$\text{Chronic WQG} = e^{(0.8545 * \ln(\text{hardness}) - 1.465)} * 0.2 \qquad \text{(Equation 1)}$$

where

Chronic WQG = CCME water quality guideline (ug/L)
Hardness = mg/L as $CaCO_3$
0.2 = conservative application factor (unitless)

Saskatchewan Environment uses Equation 1 to calculate a hardness-dependant SWQOs, but for only three ranges of hardness conditions (Saskatchewan Environment, 2006):

**Table 2. Copper SWQOs Based on Hardness**

| Hardness (mg/L as $CaCO_3$) | SWQO (mg/L) |
|---|---|
| < 120 | 0.002 |
| 120-180 | 0.003 |
| > 180 | 0.004 |

Source: CCME (1987), Saskatchewan Environment (2006)

However, hardness of the Mannville Formation (approximately 525 mg/L as $CaCO_3$), is well above the hardness used to set the highest range (180 mg/L as $CaCO_3$). Using Equation 1 and a Site-specific hardness value yields a Site-specific SWOQ of 0.009 mg/L. Mannville Formation water copper concentrations (0.005 mg/L) are well below a Site-specific hardness-adjusted SWQO even with the over-conservative “application factor.”

Based on these concentrations and SWQOs, discharge of the Mannville Formation water to the Saskatchewan River would not be deleterious with respect to metals.

### 2.3 CCME Chloride Guideline

CCME (2011) has developed a surface water quality guideline for chloride to protect freshwater aquatic life. The acute guideline is 640 mg/L and the chronic is 120 mg/L. As shown in Table 1, the average concentration of chloride in Mannville Formation water (approximately 1,600 mg/L as $CaCO_3$) is above both guidelines.

However, there is uncertainty associated with the guidelines. Though a number of studies that showed that chloride toxicity is counteracted by elevated hardness, CCME concluded that there were insufficient data available to develop a hardness relationship for chronic toxicity. CCME further recognizes the importance of the ameliorating effects of hardness by encouraging jurisdictions (*e.g.* Provinces) to develop site-specific hardness adjusted water quality criteria if they so choose. (CCME, 2011).

In addition, the chloride guidelines are based on generic environmental fate and behaviour and toxicity data. The guidelines are conservative values below which all forms of aquatic life, during all life stages and in all Canadian aquatic systems, should be protected. Because the chloride guidelines are not corrected for any toxicity modifying factors (*e.g.* hardness), they are generic values that do not take into account any site-specific factors. Since the chloride guidelines are mostly based on toxicity tests using laboratory organisms, the guideline may not be relevant for areas with a naturally elevated concentration of chloride and associated adapted ecological community (CCME, 2011).

Given the high hardness concentrations in the Mannville Formation water, and considering the ameliorating effects of hardness on toxicity, the CCME's chloride guidelines likely overestimate chloride toxicity at the Site.
Thus, a comparison of Mannville Formation water chloride concentration to the CCME guideline is inconclusive.

### 2.4 Summary of Water Quality Comparison

Based on a comparison of concentrations of water quality parameters obtained during a three-week pump test conducted in 2010 to MIEPR and MMER authorized values, and to SWQOs, discharge of the Mannville Formation water to the Saskatchewan River would not be deleterious. Effects of chloride are uncertain and therefore were assessed using Site-specific toxicity tests (see Sections 3.0) and comparing chloride (salinity) concentrations to literature toxicity values (see Section 4.0)

## 3.0 TOXICITY TESTING

Given the uncertainties associated with the chloride water quality guideline, additional samples of Mannville Formation water were collected and subjected to acute and chronic whole effluent toxicity tests to assess Site-specific effects as suggested by EC. This section discusses the acute (Section 3.1) and chronic (Section 3.2) test procedures and results, and summarizes overall toxicity test conclusions (Section 3.3). Laboratory reports are presented in Appendix B.

### 3.1 Acute Toxicity Tests

Acute toxicity of the Mannville Formation water was evaluated using *Daphnia magna* (Section 3.1.1) and rainbow trout (*Oncorhynchus mykiss*) (Section 3.1.2). Acute toxicity test conclusions are summarized in Section 3.1.3. Manville Formation water for acute toxicity testing was collected on June 4, 2011.

#### 3.1.1 Acute Toxicity of *Daphnia magna*

A static 48-hr test with *Daphnia magna* (a freshwater invertebrate) was performed following the Environment Canada (2000) method for effects on survival and immobility. Test organism were exposed to undiluted (100%) Mannville Formation water. The specific conductivity of test water ranged from 6,170 µS/cm to 6,520 µS/cm, similar to conditions reported during the 2010 pump test (Table 1). Exposure of *D. magna* to the undiluted Mannville Formation water resulted in 7% mortality, considerably less than guidance for an LC30 (*i.e.*, the undiluted sample must not result in more than a 30% mortality rate in the test population). Therefore, Manville Formation water is non-deleterious to freshwater invertebrates under acute exposure conditions, including exposure to chloride.

#### 3.1.2 Acute Toxicity of Rainbow Trout

A static 96-hr test with rainbow trout (*Oncorhynchus mykiss*) was performed following the Environment Canada (2007a) method for survival. Test organisms were exposed to undiluted (100% concentration) Manville Formation water. The specific conductivity of test water ranged from 6,460 µS/cm to 6,890 µS/cm for rainbow trout, similar to conditions during the 2010 pump test (Table 1). No mortality to rainbow trout was observed, indicating that the Mannville Formation water is non-deleterious to freshwater fish under acute exposure conditions, including exposure to chloride.

#### 3.1.3 Acute Toxicity – Conclusions

Toxicity tests conducted with *D. magna* and rainbow trout indicate that Mannville Formation water is non-deleterious under acute exposure conditions.

### 3.2 Chronic Toxicity Tests - 2011

The use of chronic toxicity tests to determine whether mining effluent is 'deleterious' has heretofore been unprecedented in Canada. The standard to determine 'deleterious' has, to this point, been based on meeting acute toxicity testing criteria. Nevertheless, Shore Gold, in response to requests from Environment Canada, has agreed to perform chronic toxicity tests with Mannville Formation water. Chronic toxicity of the Mannville Formation water was evaluated using fathead minnow (*Pimephales promelas*) (Section 3.2.1) and *Ceriodaphnia dubia* (Section 3.2.2). Section 3.2.2 also presents the uncertainties and limitations in using *Ceriodaphnia dubia* as a test organism to assess water quality from the Mannville Formation entering the Saskatchewan River. Chronic toxicity test conclusions are summarized in Section 3.2.3.

Two rounds of Mannville Formation water were collected for chronic toxicity testing: June 14, 2011, and July 20, 2011.

#### 3.2.1 Chronic Toxicity of Fathead Minnow

A static 7-day test with fathead minnow (*Pimephales promelas*) was performed following the Environment Canada (2008) method for effects on survival and growth. Test organisms were exposed to Mannville Formation water in serial dilutions of 1.6%, 3.2%, 6.3%, 13%, 25%, 50% and 100% (v/v). The LC25 and LC50 for the survival, and the IC25 and IC50 for growth were greater than 100% v/v for all dilutions from both the June 2011 and July 2011 sampling rounds (Appendix B). Therefore, Mannville Formation water is non-deleterious to fish under chronic exposure conditions, including exposure to chloride.

#### 3.2.2 Chronic Toxicity of *Ceriodaphnia dubia*

This section presents the Ceriodaphnia dubia toxicity test results (Section 3.2.2.1), as well as the uncertainties in applying this test under conditions naturally occurring in the Saskatchewan River (Section 3.2.2.2).

##### 3.2.2.1 Test Results

A static 7-day test with *Ceriodaphnia dubia* (a freshwater invertebrate) was performed following the Environment Canada (2007b) method for effects on survival and reproduction. Test organisms were reared in serial dilutions of the Mannville Formation water, *i.e.*, 1.6%, 3.1%, 6.3%, 13%, 25%, 50% and 100% (v/v). The undiluted samples resulted in mortality rates of 80% and 100%, and, therefore no reproductive success. EC has suggested that an LC30 (*i.e.*, the undiluted sample must not result in a more than 30% mortality rate in the test population) indicates the degree of chronic toxicity could be of concern, and warrants further evaluation. The toxicity data indicate that the LC30 condition is met at an approximately 50% dilution.

### 3.2.2.2 Discussion of *Ceriodaphnia dubia* Test Uncertainty

*Ceriodaphnia dubia* is a standard test organism used for assessments of effluents discharged into freshwater systems, and reproduction is the typical endpoint used to determine chronic toxicity (Environment Canada, 2007b; USEPA, 2002a). However, qualified toxicologists have questioned the use of *Ceriodaphnia dubia* as a reliable predictor of environmental effects under certain circumstances (Marshall, 1999; Chapman, 2000). Uncertainties and limitations using *Ceriodaphnia dubia* as a test organism to assess water quality from the Mannville Formation water entering the Saskatchewan River are presented below.

**Appropriateness of *Ceriodaphnia dubia* as a Test Species for the Mannville Formation**

The scientific community has raised concerns regarding the use of a test species that does not inhabit the receiving water under investigation (Chapman, 2000). *Ceriodaphnia dubia* inhabit shallow lakes (Wetzel, 1983). They rarely occur in rivers, and when they do, are restricted to shorelines with shallow and slow moving water. Considering the depth and flow of the Saskatchewan River, *Ceriodaphnia dubia* is not likely to be a receptor of ecological significance. Results from a test that evaluates effects to a species that is unlikely to inhabit the subject water body should be given a low weight of evidence, if any.

A more likely and more significant invertebrate receptor in the Saskatchewan River is *Daphnia magna*. Like *Ceriodaphnia dubia*, *Daphnia magna* is a planktonic species. However, *Daphnia magna* is naturally found in rivers, and also occurs in water bodies that are naturally high in dissolved ions, such as the Saskatchewan River. As previously discussed (Section 3.1.1), toxicity of Mannville Formation water to *Daphnia magna* was assessed and found not to meet the DFO's current definition of 'deleterious' due to a lack of observed toxicity in acute toxicity tests.

Fathead minnows, which were also used to assess chronic toxicity, are an appropriate test species because these fish have been observed in the Saskatchewan River (Saskatchewan Conservation Date Centre, 2012).

**Inaccuracy of the *Ceriodaphnia dubia* Sublethal Test**

The scientific community has raised concerns regarding the unusually high rate of false positives (*i.e.* Type I errors) associated with the *Ceriodaphnia dubia* reproduction endpoint. A false positive is a test result that falsely indicates toxicity. While all toxicity tests have an inherent rate of false positives, the rate of false positives in the *Ceriodaphnia dubia* test may be higher than initially understood when the test was designed. As demonstrated by a series of theoretical and empirical experiments discussed below, the test may not be as reliable for toxicity testing as previously thought.

Two theoretical studies (Dhaliwall *et al.*, 1995; Warren-Hicks & Parkhurst, 1995) suggest that false positives are two to three times higher than what USEPA expected when the test was first developed (Moore, Canton & Grimes, 2000).

Moore, Canton & Grimes (2000) conducted a laboratory experiment to empirically measure the rate of false positives. In this study, the researchers prepared synthetic moderately hard water, which is a formulation recommended for lab controls and culturing under the Environment Canada toxicity testing protocols. The researchers sent identical aliquots of this uncontaminated water to over a dozen different toxicity testing labs, obtaining a total of 14 blind tests that met stringent QA/QC standards. The tests were administered as standard whole effluent toxicity tests following USEPA's chronic method for *Ceriodaphnia dubia* using a standard 0.5 dilution series with six treatment concentrations ranging from 100% to 0%. Six of the 14 tests (43%) reported statistically significant reductions in reproduction (*i.e*. false positives). This experiment provides empirical evidence that the *Ceriodaphnia dubia* reproduction test is susceptible to an unacceptably high rate of false positives, and thus may not be reliable for toxicity testing.

DeGraeve *et al.* (1998) empirically determined that *Ceriodaphnia dubia* reproduction rates varied from 0 to 55-offspring per female among organisms exposed to uncontaminated, moderately hard water. Oris & Bailer (1993) and G.A. Chapman *et al.* (1995) reported similar reproduction rates in uncontaminated control chambers. In other words, an observed reproduction rate could fall below Environment Canada acceptability criteria (15 young per female) and generate a false positive result simply on the basis of natural variability, even absent contamination.

**Extrapolating Toxicity Demonstrated in the Laboratory to Actual Field Conditions**

The scientific community has long recognized the difficulties in accurately extrapolating results of toxicity tests conducted under laboratory conditions to predict effects under actual field conditions (Amman *et al*., 1999; Ankley 1997; Bailey *et al.* 1999; Barbour *et al*. 1996; Cairns, 1983; 1988; Chapman, 1995a,b; 2000; 2002; Clements & Kiffney, 1994; Diamond *et al.*, 2008; Ellis *et al*. 2002; Lapoint & Waller *et al*. 2000; Waller *et al*., 1996). The scientific literature makes a compelling case that whole effluent toxicity tests conducted with *Ceriodaphnia dubia* must be evaluated with caution when attempting to extrapolate to effects expected in the field, as explained below.

First, laboratory whole effluent toxicity tests with *Ceriodaphnia dubia* are performed under conditions that are different than actual field conditions:

- Whole effluent toxicity tests are conducted in a controlled laboratory setting in the absence of complex and dynamic environmental processes, such as sorption, precipitation, and dilution that have the potential to ameliorate exposure and toxicity in the Saskatchewan River (Chapman, 2000).
- In whole effluent toxicity tests, *Ceriodaphnia dubia* are trapped within the test chambers, artificially eliminating any possibility of chemical avoidance which commonly occurs in the natural environment. The artificial inability to avoid unfavorable conditions can result

in longer exposure durations, and therefore worse effects, than would normally occur in the field.

- Whole effluent toxicity tests do not account for ecological compensation and regulation mechanisms which can result in acclimation or adaption. Adaption occurs in the environment but not in whole effluent toxicity test chambers due to a relatively short exposure period resulting in potential overestimation of risk and effects (Chapman, 2000; Saro *et al*., 2012). In the field, populations of organisms can adapt to, or even evolve resistance to stressors (Chapman, 2000). This has been well documented for inorganic minerals in several organisms, especially bacteria, protists, plants, and invertebrates (including *Ceriodaphnia dubia*) which may pass through dozens of lifecycles on a monthly or yearly basis. Independent unpublished laboratory work (AMEC, 2012) has shown that in as little as 8 weeks, *Ceriodaphnia dubia* can adapt to withstand hardness and TDS conditions that are harsh by laboratory standards.

- Whole effluent toxicity tests using *Ceriodaphnia dubia* were not designed to assess effects to receiving water which are naturally high in minerals (Chapman, 2000). Aquatic habitats in Saskatchewan (including the Saskatchewan River and its tributaries) tend to naturally high in minerals (Rawson & Moore, 1944). Natural mineral concentrations are above concentration used in test dilution water and laboratory culture water. As a result, test conditions do not fairly reflect receiving water conditions to which organisms would actually be exposed, resulting in an over estimation of toxicity.

Second, the use of toxicity tests to predict effects in the field works only if that predictive power has been validated with monitoring or field studies (Chapman, 2000). However, as reported in the scientific literature, this link between the laboratory and field environments has not been sufficiently established, particularly with respect to *Ceriodaphnia dubia* survival and reproduction tests. The Water Environment Research Foundation pointed out that the predictions of whole effluent toxicity tests are rarely validated by actually assessing or measuring effects on the aquatic community (Chapman, 2000). In fact, several investigators have tried to correlate predicted effects in the lab to actual effects empirically measured in the field, with little success:

- Birge *et al.* (1989) found that whole effluent toxicity tests were good predictors of fish response, but were poor predictors of invertebrate response (Chapman, 2000).

- Diamond *et al*. (2008) compared whole effluent toxicity test results (*Ceriodaphnia dubia* and the fathead minnow *Pimphales promales*) with instream biological assessment data (macroinvertebrate surveys) for 250 dischargers across the United States. The researchers found good agreement between whole effluent toxicity test results and instream biological condition only when effluent comprised over 80% of stream flow, at least three toxicity tests had been run, more than one type of test had been conducted, and a test failure rate of greater than 25% had occurred. Effluents that comprised less than 20% of the stream flow had a low probability of being associated with impairment even if several test failures were observed in a 1-year period (Chapman, 2000; Diamond & Daley, 2000). Modeling of flow volumes conducted for the Project has shown that discharge of Mannville Formation water would mix to less than 1.5% in less than 40 meters from a given discharge point. Proposed Mannville discharge would be less than 1 % of the 7Q10 low flow (*i.e*., the lowest 7 day flow expected with a 10 year return period) in the Saskatchewan River. This demonstrates that the discharge constitutes far less than the 80% and 20% thresholds, and therefore the *Ceriodaphnia daphnia* whole effluent toxicity test is unlikely to reflect instream biological condition.

- Sarakinos & Rasmussen (1998) compared variations in benthic invertebrate community composition and total abundance (from 210 samples) against response thresholds from whole effluent toxicity tests, including *Ceriodaphnia dubia* survival and reproduction. The researchers concluded that standard whole effluent tests overestimated the effluent concentration that would elicit an ecological response in the receiving environment. The researchers could not correlate sublethal toxicity to actual biological effects in the field (MMEEMRT, 2007).

- Walker *et al.* (2005) examined chronic whole effluent toxicity test results and in-stream biological conditions collected over an 18 month period from six different sites, where effluent concentrations contributed to over 60% of stream flow. *Ceriodaphnia dubia* toxicity tests were administered quarterly. Overall, whole effluent toxicity test results were not significantly related to differences in biological condition upstream and downstream of a discharge.

- A mining consortium group consisting of regulatory and industry experts reviewed Environment Canada toxicity testing procedures and conducted a literature review with the goal of improving toxicity testing and reporting methodologies (MMEEMRT, 2007). After reviewing dozens of papers and test results, the panel concluded "There is presently inadequate data to demonstrate that sublethal toxicity tests are predictive of receiving-environment effects" including tests administered with *Ceriodaphnia dubia*.

- The few studies that have suggested a link between toxicity test results and field biological condition (Eagleson *et al*. 1990; USEPA 1991; Dickson *et al*. 1992, 1996) have been criticized for using outdated test methods with unspecified data quality. Other studies (*e.g.* Marcus & McDonald 1992) that demonstrated a link generally targeted sites had already been shown to have acute toxicity issues so chronic effects were already expected (Diamond *et al.*, 2008).

Overall, these studies indicate that toxic effects to *Ceriodaphnia dubia* demonstrated in the laboratory cannot be reliably extrapolated to field conditions, and that this test result is only one line of evidence that needs to be integrated with other chemical and biological information to make any meaningful assessment.

**Misuse of Whole Effluent Toxicity Tests to Predict Environmental Effects**

The scientific community has raised concerns regarding the misuse of whole effluent toxicity tests, including *Ceriodaphnia dubia* reproduction tests, to predict environmental effects under conditions for which the test was not developed.

Whole effluent toxicity testing was originally designed by USEPA as a simple, screening-level regulatory tool to understand toxicity of municipal and industrial effluent under low-flow conditions, and to provide a reasonably reliable means of identifying preventative measures (Federal Register 1995; Marshall, 1999; Chapman, 2000). No other environmental conditions other than low-flow events were intended to be assessed as a part of whole effluent toxicity tests (Federal Register 1995; Marshall, 1999). If whole effluent toxicity tests suggest adverse effects, then additional studies including chemical analyses and field assessment of biological conditions in the receiving body should also be considered in order to identify actual hazards (Marshall, 1999). Then, common sense could be used to address and mitigate persistent hazards (Chapman, 2000; Diamond *et al.*, 2008).

Applying whole effluent toxicity test procedures, including the *Ceriodaphnia dubia* reproduction test, beyond these design conditions constitutes a misuse of the test and risks generating questionable conclusions. Relying on a screening-level tool as an absolute pass/fail criterion is a misuse of the test.

**Weight of Evidence**

The scientific community also recognizes that whole effluent toxicity tests are only one piece of information in a weight-of-evidence approach applied to environmental decision making.

As such, the scientific community recognizes that whole effluent toxicity tests should not be used as inflexible guidance without consideration of site-specific conditions (*e.g.* naturally high mineral ion concentrations). There is concern in the scientific community (Chapman, 2000) when regulatory programs place an inordinate amount of reliance upon whole effluent toxicity tests, such as the *Canadian Fisheries Act*, which considers anything that has the potential to cause harm to the environment to be a toxicant.

With respect to the Mannville Formation water, the weight of evidence including acute toxicity tests (performed with rainbow trout and *Daphnia magna*), and chronic tests (performed with fathead minnows), do not rise to DFO's regulatory standards of 'deleterious' under Section 34(1)(a) or (b). The uncertainty associated with testing *Ceriodaphnia dubia* under conditions specific to the Mannville Formation water should not outweigh more robust lines of evidence.

**Uncertainty Conclusions**

The rationale behind using whole effluent toxicity data for environmental decision making assumes that the test is a good predictor of toxicity in the receiving environment, and therefore a good predictor of actual biological effects. Whole effluent toxicity tests may be appropriate for risk evaluations under the right circumstances. However, as demonstrated, this key assumption may not be accurate with respect to the Environment Canada chronic *Ceriodaphnia dubia* toxicity test and the chemical, hydrological, and ecological conditions in the receiving body (Saskatchewan River) and Mannville Formation water where dissolved mineral ions are naturally elevated.

Furthermore, extrapolating hazards identified using sublethal *Ceriodaphnia dubia* toxicity tests to effects in the natural environment can be problematic. Using toxicity test data to predict effects on natural communities requires extrapolation from laboratory exposures to field exposures, from surrogate test species to indigenous species, and from single-species responses to community level responses (Maltby, 2000). Based on the scientific literature, these uncertainties compound upon themselves, and result in a test that is very conservative and could significantly over predict the concentration that would elicit an ecologically significant response in the receiving water.

A single screening-level test should not alone be the basis for an absolute pass/fail decision. Other lines of evidence, including chemical and physical analyses, assessment of existing biological communities, and results from other appropriate toxicity tests, should be considered to assess potential effects from discharge of Mannville Formation water to the Saskatchewan River. The high uncertainty associated with using the *Ceriodaphnia dubia* as a test species, uncertainties in the *Ceriodaphnia dubia* test methodology (*e.g*. test inaccuracies, misuse of the test itself), inappropriateness of using *Ceriodaphnia dubia* in high hardness waters, and uncertainties associated with extrapolating sublethal laboratory results to field conditions suggest that the use of *Ceriodaphnia dubia* as a test species for Mannville Formation water should be re-evaluated. The toxicity tests already performed with fathead minnows, rainbow trout, and *Daphnia magna* are more relevant and appropriate test species, as they are naturally found in and adapted to waters with naturally elevated mineral concentrations, and as indicated above, better correlated with effects in the field. The over-all weight of evidence clearly indicates that Mannville Formation water is not deleterious.

Finally, most environmental effects may be reduced, even eliminated, by incorporating a diffuser for discharge to the receiving body and allowing for consideration of a mixing zone within the river (as is standard practice with other mines) combined with monitoring and field studies to confirm effects on field-based early-warning indicators and prior to effluent management (Black *et al.*, 1996; Lowell *et al.*, 2000; Suter *et al.*, 2002; Chapman and Anderson, 2005; MMEEMRT, 2007; D. Moore *et al.*, 2000).

### 3.2.3 Chronic Toxicity – Conclusions

Toxicity tests conducted with fathead minnows indicate that Mannville Formation water is non-deleterious under chronic exposure conditions. The high uncertainty associated with using the *Ceriodaphnia dubia* test methodology suggest that the use of the *Ceriodaphnia dubia* chronic toxicity test to evaluate whether Manville Formation water is ‘deleterious’ should be re-evaluated.

## 3.3 Chronic Toxicity Tests – 2012

Additional chronic toxicity testing was carried out in 2012 upon request by regulators to attempt to adjust for hardness effects. Two populations of *Ceriodaphnia dubia* were cultured in progressively harder water, with increases occurring after each successful brood. Target hardness levels in the first population were 200 mg/L as $CaCO_3$ to reflect the hardness in the discharge environment, and 500 mg/L as $CaCO_3$ (high hardness) with an ionic strength matching Mannville Formation water (Appendix C) in the second population. When the high hardness culture reached the target hardness of 500 mg/l and about 70% of the target ionic strength, a dilution series whole effluent toxicity test was performed to calibrate the culture process and revised testing methodology. At the same time, a test was performed following standard Environment Canada testing protocols.

Direct comparisons between the two tests are complicated by the customized test procedure used for the 500 mg/L testing. Rather than comparing test results on a dilution volume basis (*i.e.* a direct comparison survival or reproduction rates at a given dilution), results from these tests are more appropriately compared in terms of TDS. Results, and a brief discussion of the concentrations of TDS within each dilution, are presented in Appendix B.

At about 80% of the ion balance, acclimated populations were no longer stable; the acclimation process was discontinued and toxicity tests at the full ionic strength were not completed; and organisms successfully cultured in 200 mg/L hardness water were never tested.

The results of these acclimation exercises demonstrate that even if *Ceriodaphnia dubia* were to inhabit the Saskatchewan River, they are able to survive and reproduce at hardness levels consistent with Mannville Formation water, and an ionic strength 80% of the Mannville Formation water. These results thus provide another line of evidence that toxic effects of Mannville Formation water are likely to be ameliorated under actual field conditions.

### 3.4 Toxicity Testing – Conclusions

Acute toxicity tests conducted with *Daphnia magna* and rainbow trout, and chronic toxicity tests conducted with fathead minnow indicate that Mannville Formation water is non-deleterious. While *Ceriodaphnia dubia* did exhibit chronic effects, results were given a low weight due to numerous Site-specific uncertainties. Therefore, the weight of evidence from toxicity testing indicates that Manville formation water is not deleterious.

## 4.0 LAKE STURGEON

Lake sturgeon (*Acipenser fulvescens*) are known to inhabit the Saskatchewan River. This species was once considered a single unit and designated Not at Risk in April 1986. When the species was split into separate units in May 2005, the “Western populations” unit was designated Endangered. In November 2006, when the Western populations unit was split into five separate populations, the “Saskatchewan River populations” unit was designated Endangered (COSEWIC, 2000). Even though acute and chronic toxicity tests did not result in adverse effects to fish survival or growth, potential effects of Mannville Formation water on lake sturgeon were given additional consideration because of its endangered status.

Most sturgeon species are diadromous, i.e., they migrate between salt water and fresh water. Lake sturgeon are potamodromous i.e., live their life cycle entirely in freshwater (Allen et al., 2009). However, lake sturgeon do have some tolerance for brackish water (Ontario Ministry of Natural Resources, 2009).

LeBreton & Beamish (1998) investigated the ability of lake sturgeon to tolerate saline conditions by capturing juvenile lake sturgeon from the Moose River and slowly transferring them to increasingly saline conditions at a rate of 2‰ (parts per thousand) per day. Blood samples were collected from fish after a 48 hour acclimation period at intervals of 0‰, 10‰, 15‰, and 25‰ salinity concentrations for analysis of $Na^+$, $K^+$, $Cl^-$, $Ca^{2+}$ and osmolarity. Under freshwater conditions, lake sturgeon blood serum displayed comparable osmotic and ionic composition to other North American sturgeon. However, lake sturgeon were not capable of homeostasis above 15‰. Larger fish seemed to have a greater tolerance to higher salinities.

In another study (Suchy, 2009), three lake sturgeon exposed to 0 or 4 ‰ for 24 hours without an acclimation period had lower plasma osmolality levels (237.8 ± 3.1 mOsm) compared to lake sturgeon exposed to 12 ppt (322.7 ± 4.5 mOsm) for 24 hours (Suchy, 2009). Lake sturgeon exposed to an increase of 1 ‰ per day had a slight day to day variation in plasma osmolality levels from 1 to 6 ppt (231.06 ± 9.5 mOsm) but plasma osmolality steadily increased at levels above 7 ppt. There was no difference between the plasma osmolality levels of lake sturgeon exposed to the acclimated and non-acclimated trials below 12‰. No mortalities occurred below 16 ‰, and all three sturgeon died at 16 ‰.

Given that salinity (chloride) concentrations in Mannville Formation water (1,600 mg/L or 1.6 ‰) are 10 times below Suchy's (2009) acute effects concentration (16,000 mg/L or 16 ‰), Mannville Formation water would not be expected to be deleterious to lake sturgeon even absent the ameliorating effects of dilution through the proposed diffuser.

## 5.0 CONCLUSIONS

Based on a comparison of concentrations of water quality parameters obtained during a three-week pump test conducted in 2010 to MIEPR and MMER authorized values, and to SWQOs, discharge of the Mannville Formation water to the Saskatchewan River would not be deleterious. Effects of chloride were uncertain and therefore were assessed using Site-specific toxicity tests.

Acute toxicity tests conducted with *Daphnia magna* and rainbow trout indicate that Mannville Formation water is non-deleterious. The use of chronic toxicity tests to determine whether mining effluent is 'deleterious' has heretofore been unprecedented in Canada. Chronic toxicity tests conducted with fathead minnow indicated that Manville Formation water is non-toxic. While *Ceriodaphnia dubia* did exhibit some chronic effects, results were given a low weight due to numerous Site-specific uncertainties.

Furthermore, most environmental effects may be reduced, even eliminated, by incorporating a diffuser for discharge to the receiving body and allowing for consideration of a mixing zone within the river (as is standard practice with other mines) combined with monitoring and field studies to confirm effects on field-based early-warning indicators and prior to effluent management.

Lake sturgeon, which inhabit the Saskatchewan River, were given additional consideration because of their protected status. A review of the scientific literature and the results of the acute and chronic fish toxicity tests suggest that Mannville Formation water would not be deleterious to lake sturgeon even absent the ameliorating effects of dilution through the proposed diffuser.

Considering the results of the SWQO concentration comparisons, toxicity tests, and lake sturgeon evaluation, the weight of evidence indicates that Mannville Formation water should be considered non-deleterious.

## 6.0 CLOSURE

This report has been prepared for the exclusive use of Shore Gold Inc. The project was conducted using standard assessment practices and in accordance with verbal and written requests from the client. No further warranty, expressed or implied, is made. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AMEC Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. The limitations of this report are attached in Appendix E.

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# Appendix A

# Mannville Formation Water Chemistry Reports

RECEIVED NOV 3 0 2010

SRC Group: 2010-10684

# SRC ANALYTICAL

422 Downey Road
Saskatoon, Saskatchewan, S7N 4N1
(306) 933-6932 or 1-800-240-8808
Fax: (306) 933-7922

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson

Date Samples Received: Nov-12-2010    Client P.O.: 4671

---

Analysis has been reviewed by:

<original signed by>    <original signed by>

Jeff Zimmer
Inorganics Supervisor

Keith Gipman
ICP Supervisor

---

* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as
    * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
    * Environment Canada
    * US EPA
    * CANMET

* The results reported relate only to the test samples as provided by the client.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

# SRC ANALYTICAL

Nov 25, 2010

422 Downey Road
Saskatoon, Saskatchewan, Canada
S7N 4N1
(306) 933-6932 or 1-800-240-8808

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson



Date Samples Received: Nov-12-2010 Client P.O.: 4671

43866 10/26/2010 OSPT #10064 *WATER*
43867 11/07/2010 OSPT #10068 *WATER*

| Analyte | Units | 43866 | 43867 |
|---|---|---|---|
| **Inorganic Chemistry** | | | |
| Bicarbonate | mg/L | 473 | 474 |
| Carbonate | mg/L | <1 | <1 |
| Chloride | mg/L | 1600 | 1600 |
| Hydroxide | mg/L | <1 | <1 |
| P. alkalinity | mg/L | <1 | <1 |
| pH | pH units | 7.82 | 7.79 |
| Specific conductivity | uS/cm | 6420 | 6450 |
| Sum of ions | mg/L | 4240 | 4270 |
| Total alkalinity | mg/L | 388 | 389 |
| Total hardness | mg/L | 537 | 528 |
| Nitrate | mg/L | <0.04 | <0.04 |
| Fluoride | mg/L | 2.2 | 2.2 |
| Total dissolved solids | mg/L | 3960 | 3950 |
| **ICP** | | | |
| Calcium | mg/L | 138 | 136 |
| Magnesium | mg/L | 47 | 46 |
| Potassium | mg/L | 57 | 57 |
| Sodium | mg/L | 1190 | 1210 |
| Sulfate | mg/L | 740 | 750 |
| Phosphorus | mg/L | 0.06 | 0.06 |
| Aluminum | mg/L | 0.021 | 0.005 |
| Antimony | mg/L | <0.002 | <0.002 |
| Arsenic | ug/L | <1 | <1 |
| Barium | mg/L | 0.013 | 0.011 |
| Beryllium | mg/L | <0.001 | <0.001 |
| Boron | mg/L | 2.1 | 2.0 |
| Cadmium | mg/L | <0.0001 | <0.0001 |
| Chromium | mg/L | <0.005 | <0.005 |
| Cobalt | mg/L | 0.001 | <0.001 |
| Copper | mg/L | 0.010 | 0.005 |
| Iron | mg/L | 0.36 | 0.29 |
| Lead | mg/L | <0.001 | <0.001 |
| Manganese | mg/L | 0.099 | 0.092 |
| Molybdenum | mg/L | <0.001 | <0.001 |
| Nickel | mg/L | 0.002 | <0.001 |
| Selenium | mg/L | <0.001 | <0.001 |

# *SRC ANALYTICAL*



Kensington Resources



43866 (Cont.) 10/26/2010 OSPT #10064 *WATER*
43867 11/07/2010 OSPT #10068 *WATER*

| Analyte | Units | 43866 | 43867 |
|---|---|---|---|
| **ICP** | | | |
| Silver | mg/L | <0.0001 | <0.0001 |
| Strontium | mg/L | 2.6 | 2.5 |
| Thallium | mg/L | <0.002 | <0.002 |
| Tin | mg/L | <0.001 | <0.001 |
| Titanium | mg/L | <0.002 | <0.002 |
| Uranium | ug/L | <1 | <1 |
| Vanadium | mg/L | <0.001 | <0.001 |
| Zinc | mg/L | 0.16 | 0.021 |

"<": not detected at level stated above.

# SRC ANALYTICAL



Kensington Resources



| | | |
|---|---|---|
| 43868 | 10/29/2010 OSPT #10065 | *WATER* |
| 43869 | 11/02/2010 OSPT #10066 | *WATER* |
| 43870 | 11/04/2010 OSPT #10067 | *WATER* |

| Analyte | Units | 43868 | 43869 | 43870 |
|---|---|---|---|---|
| **Inorganic Chemistry** | | | | |
| Bicarbonate | mg/L | 476 | 477 | 477 |
| Carbonate | mg/L | <1 | <1 | <1 |
| Chloride | mg/L | 1600 | 1600 | 1560 |
| Hydroxide | mg/L | <1 | <1 | <1 |
| P. alkalinity | mg/L | <1 | <1 | <1 |
| pH | pH units | 7.82 | 7.82 | 7.88 |
| Specific conductivity | uS/cm | 6530 | 6470 | 6530 |
| Sum of ions | mg/L | 4280 | 4320 | 4270 |
| Total alkalinity | mg/L | 390 | 391 | 391 |
| Total hardness | mg/L | 528 | 517 | 517 |
| Nitrate | mg/L | <0.04 | <0.04 | <0.04 |
| Fluoride | mg/L | 2.2 | 2.3 | 2.2 |
| Total dissolved solids | mg/L | 3960 | 3970 | 3960 |
| **ICP** | | | | |
| Calcium | mg/L | 136 | 133 | 133 |
| Magnesium | mg/L | 46 | 45 | 45 |
| Potassium | mg/L | 57 | 58 | 58 |
| Sodium | mg/L | 1210 | 1270 | 1250 |
| Sulfate | mg/L | 750 | 740 | 750 |

"<": not detected at level stated above.

# SRC ANALYTICAL



Kensington Resources



43871 10/23/2010 MWS-01 #10069 *WATER*
43872 11/07/2010 MWS-01 #10070 *WATER*

| Analyte | Units | 43871 | 43872 |
|---|---|---|---|
| **Inorganic Chemistry** | | | |
| Bicarbonate | mg/L | 152 | 173 |
| Carbonate | mg/L | <1 | <1 |
| Chloride | mg/L | 238 | 219 |
| Hydroxide | mg/L | <1 | <1 |
| P. alkalinity | mg/L | <1 | <1 |
| pH | pH units | 8.21 | 8.26 |
| Specific conductivity | uS/cm | 1200 | 1130 |
| Sum of ions | mg/L | 757 | 720 |
| Total alkalinity | mg/L | 125 | 142 |
| Total hardness | mg/L | 43 | 52 |
| Ammonia as nitrogen | mg/L | 0.04 | 0.10 |
| Nitrite+Nitrate nitrogen | mg/L | <0.01 | 0.02 |
| Total Kjeldahl nitrogen | mg/L | 0.29 | 0.41 |
| Chemical oxygen demand | mg/L | 4 | 6 |
| Organic carbon | mg/L | 1.7 | 2.0 |
| Fluoride | mg/L | 0.47 | 0.39 |
| Total dissolved solids | mg/L | 712 | 666 |
| **ICP** | | | |
| Calcium | mg/L | 3.0 | 4.5 |
| Magnesium | mg/L | 8.6 | 9.9 |
| Potassium | mg/L | 6.2 | 6.0 |
| Sodium | mg/L | 239 | 218 |
| Sulfate | mg/L | 110 | 89 |
| Phosphorus | mg/L | 0.09 | 0.11 |
| Aluminum | mg/L | 1.94 | 2.27 |
| Antimony | mg/L | 0.0005 | 0.0003 |
| Arsenic | ug/L | 1.4 | 1.1 |
| Barium | mg/L | 0.065 | 0.067 |
| Beryllium | mg/L | <0.0001 | <0.0001 |
| Boron | mg/L | 1.4 | 0.95 |
| Cadmium | mg/L | 0.00004 | 0.00002 |
| Chromium | mg/L | 0.020 | 0.026 |
| Cobalt | mg/L | 0.0049 | 0.0067 |
| Copper | mg/L | 0.0036 | 0.0052 |
| Iron | mg/L | 2.92 | 3.45 |
| Lead | mg/L | 0.0011 | 0.0010 |
| Manganese | mg/L | 0.073 | 0.052 |
| Molybdenum | mg/L | 0.011 | 0.0070 |
| Nickel | mg/L | 0.072 | 0.105 |
| Selenium | mg/L | 0.0006 | 0.0006 |
| Silver | mg/L | <0.00001 | 0.00001 |
| Strontium | mg/L | 0.070 | 0.069 |
| Thallium | mg/L | <0.0002 | <0.0002 |
| Tin | mg/L | <0.0001 | 0.0001 |
| Titanium | mg/L | 0.053 | 0.048 |
| Uranium | ug/L | 1.8 | 1.3 |
| Vanadium | mg/L | 0.0087 | 0.0090 |

43871 (Cont.) 10/23/2010 MWS-01 #10069 *WATER*
43872 11/07/2010 MWS-01 #10070 *WATER*

| Analyte | Units | 43871 | 43872 |
|---|---|---|---|
| **ICP** | | | |
| Zinc | mg/L | 0.010 | 0.0084 |

"<": not detected at level stated above.

SRC Group: 2010-10684

# *SRC ANALYTICAL*

15 Innovation Blvd.
Saskatoon, Saskatchewan S7N 2X8
(306) 933-6932 1-800-240-8808

(Summary of charges: not an invoice)

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson

Nov-25-2010

Date Samples Received: Nov-12-2010 Client P.O.: 4671

SRC Sample Numbers: 43866 to 43872

| | | |
|---|---|---|
| 43866 | 26-Oct-10 | OSPT #10064 |
| 43867 | 07-Nov-10 | OSPT #10068 |
| 43868 | 29-Oct-10 | OSPT #10065 |
| 43869 | 02-Nov-10 | OSPT #10066 |
| 43870 | 04-Nov-10 | OSPT #10067 |
| 43871 | 23-Oct-10 | MWS-01 #10069 |
| 43872 | 07-Nov-10 | MWS-01 #10070 |

| No. of Det'ns | Analyte Description | Unit Charge | No. of Det'ns | Analyte Description | Unit Charge |
|---|---|---|---|---|---|
| 2 | Ammonia as nitrogen | $22.00 | 2 | Chemical oxygen demand | $50.00 |
| 2 | Organic carbon | $39.00 | 4 | Phosphorus | $13.00 |
| 2 | Total Kjeldahl nitrogen | $35.00 | | | |

Analyte Charge Subtotal = $344.00

5 General Chemical @ $105.00 each
2 General Chemistry (NO2+NO3) @ $105.00 each
4 ICP-MS scan (mg/L) @ $105.00 each

Packages Subtotal = $1155.00

2 Acid digestion (liquids) @ $15.00 each

Special Charges Subtotal = $30.00

Less 40% = ($611.60)

Summary of Charges (Before taxes) = $917.40

This summary of charges does not include the GST or HST. It will be added to the invoice if applicable. Payment is due upon the receipt of invoice. Late payment charges will be assessed after 30 days at a rate of 1.5% compounded monthly.

SRC Group: 2010-10864

# SRC ANALYTICAL

422 Downey Road
Saskatoon, Saskatchewan, S7N 4N1
(306) 933-6932 or 1-800-240-8808
Fax: (306) 933-7922

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson

Date Samples Received: Nov-18-2010 Client P.O.: 4671

---

Analysis has been reviewed by:

<original signed by>

Jeff Zimmer
Inorganics Supervisor

<original signed by>

Keith Gipman
ICP Supervisor

---

* Test methods and data are validated by the laboratory's Quality Assurance Program.

* Routine methods follow recognized procedures from sources such as
  * Standard Methods for the Examination of Water and Wastewater APHA AWWA WEF
  * Environment Canada
  * US EPA
  * CANMET

* The results reported relate only to the test samples as provided by the client.

* Samples will be kept for 30 days after the final report is sent. Please contact the lab if you have any special requirements.

* Additional information is available upon request.

# SRC ANALYTICAL

Nov 29, 2010

422 Downey Road
Saskatoon, Saskatchewan, Canada
S7N 4N1
(306) 933-6932 or 1-800-240-8808

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson



Date Samples Received: Nov-18-2010

Client P.O.: 4671

| | |
|---|---|
| 44342 | 11/11/2010 #10071 OSPT *WATER* |
| 44343 | 11/14/2010 #10073 OSPT *WATER* |

| Analyte | Units | 44342 | 44343 |
|---|---|---|---|
| **Inorganic Chemistry** | | | |
| Bicarbonate | mg/L | 474 | 474 |
| Carbonate | mg/L | <1 | <1 |
| Chloride | mg/L | 1700 | 1700 |
| Hydroxide | mg/L | <1 | <1 |
| P. alkalinity | mg/L | <1 | <1 |
| pH | pH units | 7.74 | 7.73 |
| Specific conductivity | uS/cm | 6160 | 6180 |
| Sum of ions | mg/L | 4360 | 4370 |
| Total alkalinity | mg/L | 389 | 389 |
| Total hardness | mg/L | 519 | 519 |
| Nitrate | mg/L | <0.04 | <0.04 |
| Fluoride | mg/L | 2.3 | 2.5 |
| Total dissolved solids | mg/L | 3950 | 3950 |
| **ICP** | | | |
| Calcium | mg/L | 134 | 134 |
| Magnesium | mg/L | 45 | 45 |
| Potassium | mg/L | 56 | 56 |
| Sodium | mg/L | 1210 | 1220 |
| Sulfate | mg/L | 740 | 740 |

"<": not detected at level stated above.

# SRC ANALYTICAL



Kensington Resources



44344 11/12/2010 #10072 OSPT *WATER*
44345 11/14/2010 #10074 OSPT *WATER*

| Analyte | Units | 44344 | 44345 |
|---|---|---|---|
| **ICP** | | | |
| Phosphorus | mg/L | 0.05 | 0.05 |
| Aluminum | mg/L | 0.0021 | 0.0024 |
| Antimony | mg/L | <0.0002 | <0.0002 |
| Arsenic | ug/L | 0.3 | 0.2 |
| Barium | mg/L | 0.010 | 0.010 |
| Beryllium | mg/L | <0.0001 | <0.0001 |
| Boron | mg/L | 2.0 | 1.9 |
| Cadmium | mg/L | 0.00001 | 0.00001 |
| Chromium | mg/L | <0.0005 | <0.0005 |
| Cobalt | mg/L | 0.0001 | 0.0001 |
| Copper | mg/L | 0.0032 | 0.0024 |
| Iron | mg/L | 0.24 | 0.23 |
| Lead | mg/L | 0.0005 | 0.0003 |
| Manganese | mg/L | 0.087 | 0.086 |
| Molybdenum | mg/L | 0.0002 | 0.0001 |
| Nickel | mg/L | 0.0005 | 0.0005 |
| Selenium | mg/L | 0.0003 | 0.0002 |
| Silver | mg/L | <0.00001 | <0.00001 |
| Strontium | mg/L | 2.50 | 2.48 |
| Thallium | mg/L | <0.0002 | <0.0002 |
| Tin | mg/L | <0.0001 | <0.0001 |
| Titanium | mg/L | 0.0002 | <0.0002 |
| Uranium | ug/L | <0.1 | <0.1 |
| Vanadium | mg/L | 0.0002 | 0.0002 |
| Zinc | mg/L | 0.014 | 0.011 |

"<": not detected at level stated above.

SRC Group: 2010-10864

# SRC ANALYTICAL

15 Innovation Blvd.
Saskatoon, Saskatchewan S7N 2X8
(306) 933-6932 1-800-240-8808

(Summary of charges: not an invoice)

Kensington Resources
300 - 224 4th Ave S
Box 1522
Saskatoon, Saskatchewan S7K 5M5
Attn: Jeff Pratt\Chad Wilkinson

Nov-29-2010

Date Samples Received: Nov-18-2010 Client P.O.: 4671

SRC Sample Numbers: 44342 to 44345

| | | |
|---|---|---|
| 44342 | 11-Nov-10 | #10071 OSPT |
| 44343 | 14-Nov-10 | #10073 OSPT |
| 44344 | 12-Nov-10 | #10072 OSPT |
| 44345 | 14-Nov-10 | #10074 OSPT |

| No. of Det'ns | Analyte Description | Unit Charge | No. of Det'ns | Analyte Description | Unit Charge |
|---|---|---|---|---|---|
| 2 | Phosphorus | $13.00 | | | |

Analyte Charge Subtotal = $26.00

| | | | |
|---|---|---|---|
| 2 | General Chemical | @ | $105.00 each |
| 2 | ICP-MS scan (mg/L) | @ | $105.00 each |

Packages Subtotal = $420.00

Less 40% = ($178.40)

Summary of Charges (Before taxes) = $267.60

This summary of charges does not include the GST or HST. It will be added to the invoice if applicable. Payment is due upon the receipt of invoice. Late payment charges will be assessed after 30 days at a rate of 1.5% compounded monthly.

# Appendix B

# Toxicity Testing Results

HydroQual Laboratories Ltd.

# Trout (single concentration) Test Report

| |
|---|
| Client: SHO108 |
| Reference: 11-0991-01-TRS |

## Result Summary

**Contents**



**Client:** Shore Gold Inc.; operation Saskatoon

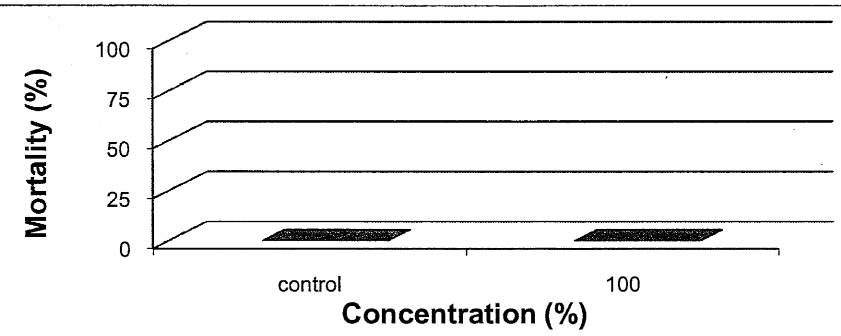
**Sample:** Mannville Water

**Collection:** collected on 2011/06/04 at 1500 by C. Wilkinson
**Receipt:** received on 2011/06/07 at 0845 by C. Quinteros
**Containers:** received 6 x 20 L pails at 17 °C, in good condition with no seals and no initials
**Description:** type: water, collection method: not given

**Test:** started on 2011/06/09 ; ended on 2011/06/13

**Result:**

| Sample | Client Code | Mortality (%) | Comment |
|---|---|---|---|
| control | lab control | 0 | |
| 100% | Mannville Water | 0 | not toxic as tested |




The test data and results are authorized and verified correct.

<original signed by> — Technical Lead

<original signed by> — Quality Coordinator






HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
Tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

## Test Conditions

| Client: SHO108 |
|---|
| Reference: 11-0991-01-TRS |

**Method:** Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout, 2000. Environment Canada, EPS 1/RM/13. Second Edition (amended 2007).

**Test type:** Trout 96-h Static Acute Test (WTR-ME-041)
**Species:** *Oncorhynchus mykiss*
**Organism source:** Lyndon Fish Hatcheries (Batch 20110518TR)
**Acclimation:** 22 days (must be $\geq$ 2 weeks)
**Stock mortality:** 0.10% (seven days preceding testing)

**Sample initial chemistry:** pH: 7.4; EC: 6380 (µS/cm @ 25°C); DO: 7.5 (mg/L); temperature: 19 °C
hardness (mg CaC03/L): 589; colour: colourless; odour: odourless
**Sample holding time:** 5 days (must be ≤ 5 days)
**Sample storage:** 4 ± 2°C in darkness

**Test vessel:** The test was conducted in 22 L plastic pails with polyethylene liners
**Test volume:** 20 Litres (depth of solution in each test vessel ≥15cm)
**Sample pre-treatment:** All test solutions and controls were pre-aerated for 30 minutes at 6.5 ±1 mL/min/L
Dissolved oxygen in full strength sample was 7.9 mg/L after pre-aeration
The sample was not filtered or pH adjusted prior to or during testing
**Loading density:** 0.166 g/Litre (must be ≤ 0.5 g/Litre)
**Control water:** Dechlorinated City of Calgary water acclimated to test conditions
**Test concentrations:** Undiluted sample plus a negative control
**Test replicates:** One replicate per treatment; 10 fish per replicate
**Feeding:** Fish are not fed 24 hours before test initiation and no feeding during test
**Measurements:** pH, conductivity, dissolved oxygen and temperature measured daily
**Aeration:** All treatments aerated at 6.5 ±1 mL/min/L by oil-free compressed air passed through airline tubes connected to disposable air stones
**Lighting:** Overhead full spectrum fluorescent lights; 100-500 lux at surface
**Photoperiod:** 16h light:8h dark
**Test temperature:** 15 ± 1°C

**Endpoint:** Mortality, % mortality at 96-h
**Test validity:** The control had 100% survival (must ≥ 90%)
The control had 0 percent (%) stressed behaviour (must ≤ 10%)
**Reference toxicant:** 96-h test with Phenol ($C_6H_50H$) initiated May 27, 2011; current results (96-h LC50 and 95% confidence limits) = 0.93 (0.84-1.00) log (mg/L Phenol)

Note: Outlined sections are protocol deviations explained on the comment page; v/v, volume per volume





HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
Tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

HydroQual Laboratories Ltd.

# Trout (single concentration) Test Report

## Test Data

| Client: SHO108 |
|---|
| Reference: 11-0991-01-TRS |

**Test Log:**

| Date | Day | Time | Technician | Comment/Observation |
|---|---|---|---|---|
| 2011/06/09 | 0 | 1030 | R. Bradley/N. Turner | test fish loaded at 1030 h |
| 2011/06/10 | 1 | 1030 | N. Turner/C. Velasco | all test fish appear normal |
| 2011/06/11 | 2 | 1015 | N. Turner/C. Velasco | all test fish appear normal |
| 2011/06/12 | 3 | 1130 | L. Henson/H. Stewart | all test fish appear normal |
| 2011/06/13 | 4 | 1045 | R. Bradley/C. Velasco/N. Turner | all test fish appear normal |

**Chemistry:**

| Conc. (%) | control | 100 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Day** | **pH (units)** | | | | | | | |
| 0 | 6.8 | 7.5 | | | | | | |
| 1 | 7.6 | 8.0 | | | | | | |
| 2 | 7.8 | 8.1 | | | | | | |
| 3 | 7.7 | 8.0 | | | | | | |
| 4 | 7.7 | 8.0 | | | | | | |
| | **Conductivity (µS/cm @ 25°C)** | | | | | | | |
| 0 | 410 | 6730 | | | | | | |
| 1 | 406 | 6890 | | | | | | |
| 2 | 401 | 6850 | | | | | | |
| 3 | 413 | 6510 | | | | | | |
| 4 | 393 | 6460 | | | | | | |
| | **Dissolved Oxygen (mg/L)** | | | | | | | |
| 0 | 8.2 | 7.9 | | | | | | |
| 1 | 8.3 | 8.4 | | | | | | |
| 2 | 8.3 | 8.3 | | | | | | |
| 3 | 9.0 | 9.0 | | | | | | |
| 4 | 8.5 | 8.6 | | | | | | |
| | **Temperature (°C)** | | | | | | | |
| 0 | 14 | 14 | | | | | | |
| 1 | 14 | 14 | | | | | | |
| 2 | 15 | 14 | | | | | | |
| 3 | 15 | 15 | | | | | | |
| 4 | 14 | 14 | | | | | | |

HydroQual Laboratories Ltd.

# Trout (single concentration) Test Report

## Test Data

| |
|---|
| Client: SHO108 |
| Reference: 11-0991-01-TRS |

**Number Alive (In brackets number stressed):**

| Conc. (%) | control | 100 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Day** | | | | | | | | |
| 0 | 10 | 10 | | | | | | |
| 1 | 10 | 10 | | | | | | |
| 2 | 10 | 10 | | | | | | |
| 3 | 10 | 10 | | | | | | |
| 4 | 10 | 10 | | | | | | |
| **Mortality (%)** | | | | | | | | |
| 4 | 0 | 0 | | | | | | |
| **Stressed (%)** | | | | | | | | |
| 4 | 0 | 0 | | | | | | |

**Biology Summary Tables:**

| Control Fish | Length (cm) | Wet Weight(g) |
|---|---|---|
| 1 | 3.4 | 0.3 |
| 2 | 3.6 | 0.4 |
| 3 | 4.0 | 0.5 |
| 4 | 3.8 | 0.4 |
| 5 | 3.6 | 0.4 |
| 6 | 3.5 | 0.4 |
| 7 | 3.2 | 0.3 |
| 8 | 3.1 | 0.3 |
| 9 | 3.1 | 0.2 |
| 10 | 3.4 | 0.3 |
| average | 3.5 | 0.3 |
| sd | 0.3 | 0.1 |
| cv(%) | 8.5 | 28.7 |

Notes: nd, not done; na, not applicable; sd, standard deviation; cv(%), coefficient of variation

| Sample | Group Wet Weight (g) |
|---|---|
| control | 3.3 |
| 100 | 4.0 |

## Comments/Statistics

| | |
|---|---|
| Client: SHO108 | |
| Reference: 11-0991-01-TRS | |

**Test Result Comments:**
None

**Data Analysis:**
None

**Protocol Deviations:**
None

# Warning Chart Trout

**Test Method:** Trout 96h Static Acute Test. (LC50, 5 treatments plus a control)
HydroQual Test Method: WTR-ME-042

**Reference:** Biological Test Method: Reference Method for Determining Acute Lethality of Effluents to Rainbow Trout, 1990. Environment Canada, EPS 1/RM/13. including May 1996 and December 2000 amendments.

**Test Organism:**

test species: *Oncorhyncus mykiss*
culture source: Lyndon Fish Hatcheries
temperature (°C): 15 ± 1
dissolved oxygen: 70-100% saturation
stock mortality (last 7d): 0.07%
batch number: 20110518TR

**Test Design:**

vol. of test vessel (L): 20
test volume depth: >15 cm
replicates per treatment: 1
fish per replicate: 10
loading (g fish/L): ≤0.5
temperature (°C): 15 ± 1
photoperiod: 16h light: 8h dark
light level (water surface): 100-500 lux (full-spectrum)
control/dilution water: dechlorinated tap water

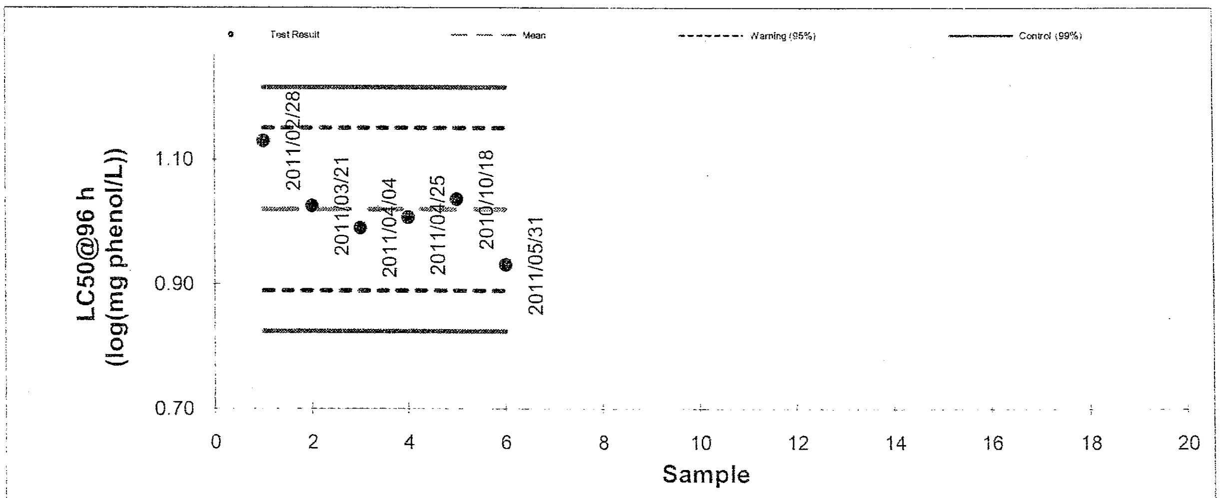
**Current Test**

toxicant phenol ($C_6H_5OH$)
started on 2011/05/27 ended on 2011/05/31
Result (LC50 @ 96h) 0.93 log (mg phenol/L); geometric mean
Confidence Limits (95%) lower 0.84 upper 1.00

**Historical Values**

| | | | | | |
|---|---|---|---|---|---|
| mean | 1.02 | sd | 0.07 | cv(%): | 6 |
| | lower | upper | | | |
| warning limits (±2 sd) | 0.89 | 1.15 | (95% confidence limits) | | |
| control limits (±3 sd) | 0.82 | 1.22 | (99% confidence limits) | | |

**notes: sd, standard deviation; cv, coefficient of variance**




The data and results are authorized and verified correct.

<original signed by>
Technical Lead

<original signed by>
Quality Coordinator

Our liability is limited to the cost of the test requested on the sample as received. No liability in whole or in part is assumed for the collection, handling or transport of the sample, application or interpretation of the test data or results in part or in whole.



HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

# HydroQual Laboratories Ltd.

# *Daphnia* (single concentration) Test Report

| Client: SHO108 |
|---|
| Reference: 11-0991-01-DAS |

## Result Summary

**Contents**



**Client:** Shore Gold Inc.; operation Saskatoon

**Sample:** Mannville Water

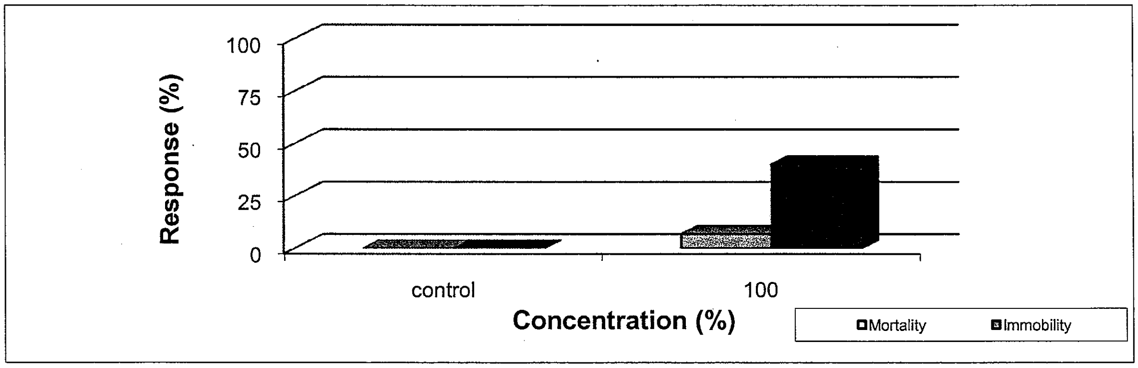
**Collection:** collected on 2011/06/04 at 1500 by C. Wilkinson
**Receipt:** received on 2011/06/07 at 0845 by C. Quinteros
**Containers:** received 6 x 20 L pails at 17 °C, in good condition with no seals and no initials
**Description:** type: water, collection method: not given

**Test:** started on 2011/06/07 ; ended on 2011/06/09

**Result:**

| Sample | Client Code | Average Mortality (%) | Average Immobility (%) | Comment |
|---|---|---|---|---|
| control | lab control | 0 | 0 | |
| 100 | Mannville Water | 7 | 40 | none |

Notes: sd, sample standard deviation; cv, coefficient of variation; nd, not done; na, not applicable;




The test data and results are authorized and verified correct

<original signed by>
Technical Lead

<original signed by>
Quality Coordinator





HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
Tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

## Test Conditions

| Client: SHO108 |
|---|
| Reference: 11-0991-01-DAS |

**Method:** Biological Test method: Reference Method for Determining Acute Lethality of Effluents to *Daphnia magna*, 2000. Environ. Can., EPS 1/RM/14. Second Edition.

**Test type:** *Daphnia* 48-h Static Acute Test (WTR-ME-015)
**Species:** *Daphnia magna*
**Age:** < 24 hours old
**Organism source:** in-house culture
**Stock mortality:** 21%
**Culture brood data:** 10 days to first brood
16 neonates per average brood

**Sample initial chemistry:** pH: 7.4; EC: 6380 (µS/cm @ 25°C); DO: 7.5 (mg/L); temperature: 19 °C
hardness (mg CaC03/L): 589; colour: colourless; odour: odourless
**Sample holding time:** 3 days (must be ≤ 5 days)
**Sample storage:** 4 ± 2°C in darkness

**Test vessel:** 385 mL plastic vessels
**Test volume:** 150 mL
**Sample pre-treatment:** The sample was not filtered or pH adjusted prior to or during testing
The sample was pre-aerated for 0 minutes (rate of 37.5 ± 12.5 mL/min.$L^{-1}$)
The hardness of the sample was not adjusted (mg $CaCO_3$/L) prior to or during testing
**Loading density:** One daphnid/15 mL (must ≤ 1 organism/15 mL)
**Control water:** Dechlorinated City of Calgary water acclimated to test conditions
The hardness of the control/dilution water was 173 mg $CaCO_3$/L
**Test concentrations:** Undiluted sample plus a negative control
**Test replicates:** Three replicates per treatment, 10 daphnids per replicate
**Feeding:** None
**Aeration:** None
**Measurements:** pH, conductivity, dissolved oxygen and temperature at test initiation and termination
**Lighting:** Cool white fluorescent lights; 400-800 lux at surface
**Photoperiod:** 16h light:8h dark
**Test temperature:** 20 ± 2°C

Note: Outlined sections are protocol deviations explained on the comment page

## Test Conditions

Client: SHO108
Reference: 11-0991-01-DAS

**Endpoint:** Mortality, % mortality at 48-h
Immobility, % immobility at 48-h

**Test validity:** The control had 100% survival (must ≥ 90%)
Control had 0% abnormal behaviour (must ≤ 10%), e.g. immobility

**Reference toxicant:** 48-h test with NaCl initiated June 13, 2011; current results
(48-h LC50 and 95% confidence limits) = 0.69 (0.65-0.72) log (g/L NaCl)

Note: Outlined sections are protocol deviations explained on the comment page

# Test Data

Client: SHO108
Reference: 11-0991-01-DAS

**Test Log:**

| Date | Day | Time | Technician | Comment/Observation |
|---|---|---|---|---|
| 2011/06/07 | 0 | 1400 | C. Velasco | test *Daphnia* appear normal |
| 2011/06/08 | 1 | 1410 | C. Velasco | test *Daphnia* appear normal |
| 2011/06/09 | 2 | 1355 | C. Velasco | test *Daphnia* appear normal |

**Chemistry:**

| Conc (%) | control | | | 100 | | |
|---|---|---|---|---|---|---|
| replicate | a | b | c | a | b | c |
| **Day** | **pH (units)** | | | | | |
| 0 | 8.0 | 8.0 | 8.0 | 7.6 | 7.6 | 7.6 |
| 2 | 7.8 | 7.8 | 7.8 | 7.5 | 7.5 | 7.5 |
| | **Conductivity (µS/cm @ 25°C)** | | | | | |
| 0 | 383 | 390 | 389 | 6170 | 6430 | 6520 |
| 2 | 400 | 405 | 407 | 6280 | 6370 | 6410 |
| | **Dissolved Oxygen (mg/L)** | | | | | |
| 0 | 8.0 | 7.9 | 7.9 | 7.4 | 7.4 | 7.3 |
| 2 | 7.8 | 7.8 | 7.8 | 7.2 | 7.2 | 7.1 |
| | **Temperature (°C)** | | | | | |
| 0 | 21 | 21 | 21 | 21 | 20 | 20 |
| 2 | 21 | 21 | 21 | 21 | 21 | 21 |

**Biology:**

| Conc (%) | control | | | 100 | | |
|---|---|---|---|---|---|---|
| replicate | a | b | c | a | b | c |
| **Day** | **Number Alive and Behavior (behavior is in brackets)** | | | | | |
| 1 | 10 | 10 | 10 | 10 (10F,2I) | 10 (10F,2I) | 10 (10F,2I) |
| 2 | 10 | 10 | 10 | 10 (3I) | 8 (3I) | 10 (4I) |
| | **Mortality (%)** | | | | | |
| 2 | 0 | 0 | 0 | 0 | 20 | 0 |
| | **Immobility (%)** | | | | | |
| 2 | 0 | 0 | 0 | 30 | 50 | 40 |

Notes: F, floating; I, immobile; B, stuck on bubble; D, caught in debris

## Comments/Statistics

| Client: SHO108 |
|---|
| Reference: 11-0991-01-DAS |

**Test Result Comments:**
None

**Data Analysis:**
None

**Protocol Deviations:**
None





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# Warning Chart
## *Daphnia*

## Quality Assurance Information

**Test Method:** *Daphnia* Static Acute Test (LC50, 5 treatments plus a control)
HydroQual Test Method: WTR-ME-016

**Reference:** Biological Test Method: Reference Method for Determining the Acute Lethality of Effluents to *Daphnia magna,* 1990. Environment Canada, EPS 1/RM/14. including May 1996 and December 2000 ammendments.

| **Test Organism:** | | **Test Design:** | |
|---|---|---|---|
| test species: | *Daphnia magna* | vol. of test vessel (mL): | 500 |
| culture source: | in-house | toxicant: | sodium chloride |
| original culture source: | Environment Canada | test volume (mL): | 150 |
| days to first brood: | 10 | replicates per treatment: | 1 |
| mean brood size: | 16 | neonates per replicate: | 10 |
| ephippia in stock culture: | no | volume per neonate (mL): | 15 |
| age of test organisms: | <24 hours old | samples preaerated: | no |
| culture mortality (%): | 7% | hardness adjustment: | no |
| dissolved oxygen: | 40-100% saturation | temperature (°C): | 20 |
| | | photoperiod: | 16h light:8h dark |
| | | light level (water surface): | 400-800 lux (cool white) |
| | | control/dilution water: | dechlorinated tap water |

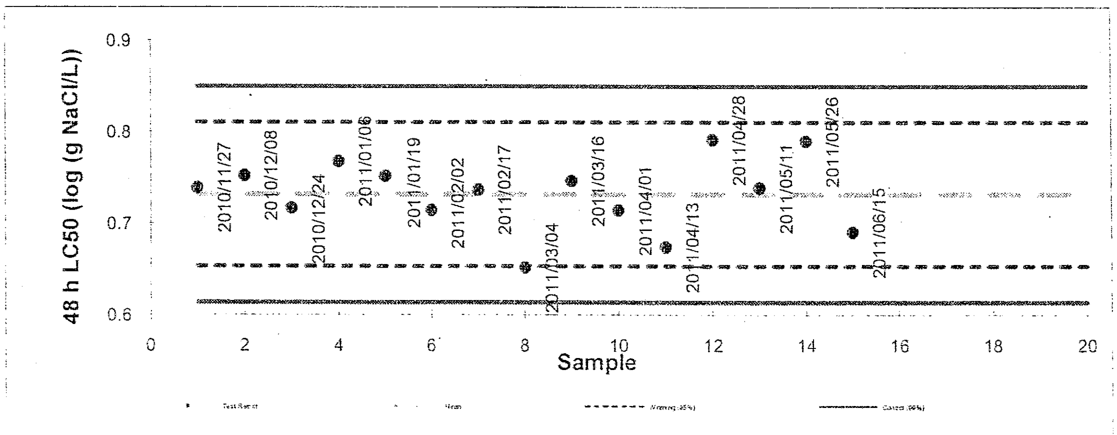
**Current Test**

| | | | | | |
|---|---|---|---|---|---|
| toxicant | Sodium chloride (NaCl) | | | | |
| started on | 2011/06/13 | ended on | 2011/06/15 | | |
| Result (LC50 @ 48h) | 0.69 | log (g NaCl/L); geometric mean | | | |
| Confidence Limits (95%) | lower | 0.65 | upper | 0.72 | |

**Historical Values**

| | | | | | |
|---|---|---|---|---|---|
| mean | 0.73 | sd | 0.04 | cv(%): | 5 |
| | lower | upper | | | |
| warning limits (±2 sd) | 0.65 | 0.81 | (95% confidence limits) | | |
| control limits (±3 sd) | 0.61 | 0.85 | (99% confidence limits) | | |

notes: sd, standard deviation; cv, coefficient of variance
Comments:




The data and results are authorized and verified correct.

<original signed by>

<original signed by>

Technical Lead

Quality Coordinator

HydroQual Laboratories Ltd.

# *Ceriodaphnia* (6-8d LC50/IC25) Test Report

**Reissued 2011/08/11**

| |
|---|
| Client: SHO108 |
| Reference: 11-1052-01-CDD |

## Result Summary

**Contents**



**Client:** Shore Gold Inc.; operation Saskatoon

**Sample:** 140-10-089

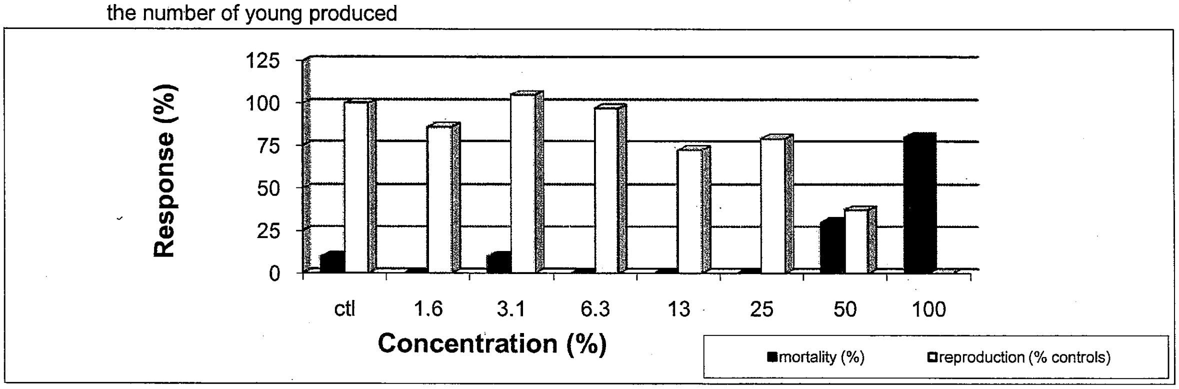
**Collection:** collected on 2011/06/14 at 1400 by not given
**Receipt:** received on 2011/06/16, 17 at 1035 by C. Quinteros
**Containers:** received 2 x 20 L pails at 15 °C, in good condition with no seals and no initials
**Description:** type: water, collection method: not given

**Test:** started on 2011/06/17 ; ended on 2011/06/24

**Result:**

| | Endpoint (7-day) | Value | Confidence Limits (95%) lower | upper | Units | Method Calculated |
|---|---|---|---|---|---|---|
| Acute: | LC25 | 47 | 32 | 61 | % | Linear Interpolation |
| (survival) | LC50 | 67 | 43 | >100 | % | Spearman-Karber |
| Chronic: | IC25 | 24 | 12 | 35 | % | Log-Gompertz |
| (fecundity) | IC50 | 42 | 30 | 57 | % | Log-Gompertz |

Notes: LCx & ICx, concentrations lethal or inhibitory to 'x' percent of the test population; fecundity, reproduction as the number of young produced




The test data and results are authorized and verified correct

<original signed by> <original signed by>

Technical Lead — Quality Coordinator

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling or transport of the sample, application or interpretation of the test data or results.



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Form: F060 v 3.2

## Test Conditions

Client: SHO108
Reference: 11-1052-01-CDD

**Method:** Biological Test method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia.* Environment Canada, EPS 1/RM/21, 2nd Edition, February 2007.

**Test type:** *Ceriodaphnia* Survival and Reproduction Static Renewal Test (WTR-ME-018)
**Species:** *Ceriodaphnia dubia*
**Age:** <24 hours old; all from same brood source within 12 hours of the same age.
**Organism source:** in-house cultures; cultures from a single brood organism to provide test organisms.
**Culture health:** Culture mortality was 3% (must be ≤ 20%).
**7-d prior to test initiation:** No ephippia were noted in the cultures at any time.
Average young produced per adult in the first three broods was 18 (must be ≥ 15)
Number of young produced by each brood organism in the last complete brood before use was 9 (must be ≥ 8).
**Organism observations:** No unusual behavior, appearance or treatment of test organisms was noted prior to or during the test. All first-generation mortality was recorded on the day it was observed.
**Sample initial chemistry:** pH: 7.5; EC: 6840 (µS/cm); DO: 7.1 (mg/L); temperature: 19 °C
hardness (mg CaC03/L): 578; colour: grey; odour: odourless
**Sample holding time:** 3 days (must be ≤ 3 days); The test was conducted with three subsamples, samples a, b, and c were for days 0 to 2, 3 to 5, and 6 to 8 respectively
**Sample storage:** 4 ± 2°C in darkness

**Test vessel:** The tests were conducted in 30 mL plastic vessels (2 cm depth).
**Test volume:** 15 mL of solution (1 cm depth); replenished daily.
**Control/dilution water:** The control and dilution water was a mixture of moderately hard reconstituted water and Bow River Water (50:50). Chemicals added to dilution water: 0.96 g NaHCO3, 0.60 g CaSO4, 0.60 g MgSO4, 0.04 g KCl per 20L.
**Test concentrations:** 7 effluent concentrations (1.6, 3.1, 6.3, 13, 25, 50, 100% (v/v) plus a negative control)
**Test replicates:** One neonate <24 hours old was loaded per test vessel;
10 replicates/concentration
**Feeding:** The test organisms were fed daily a mixture of fermented trout chow, yeast, alfalfa powder, and the green alga *Pseudokirchneriella subcapitata* (formerly *Selenastrum capricornutum* and *Raphidocelis subcapitata* ).
Food expiration date: 2011/06/26
**Measurements:** pH, conductivity, dissolved oxygen and temperature were measured daily.
**Sample pre-treatment:** The sample was not aerated, filtered or pH adjusted prior or during testing.
The dissolved oxygen concentration (mg/L) was: 6.8
The sample pH was: 7.7
**Lighting:** Overhead full spectrum fluorescent lights; 100-600 lux at surface
**Photoperiod:** 16h light:8h dark
**Test temperature:** 25 ± 1°C

Note: Outlined sections are protocol deviations explained on the comment page

## Test Conditions

| |
|---|
| Client: SHO108 |
| Reference: 11-1052-01-CDD |

**Endpoints:** Survival, 7-d LC50 (with 95% confidence limits)
Reproduction, 7-d IC25 (with 95% confidence limits)
Test endpoints were bracketed by at least 1 test concentration (except for <1.6% or >100 %)
No outliers were observed within the data set.

**Test completion:** 90% of the control organisms had ≥ 3 broods on day 7 (must be ≥ 60% within 8 days) Any neonates produced after third brood were not included in the mean young per adult calculation.

**Test validity:** The control had 90% survival (must ≥ 80%)
Number of young produced by each surviving control adult within the first three broods was 18 (must be ≥ 15).

**Reference toxicant:** 7-d test with NaCl initiated on June 20, 2011;
(must be within 14 days of test initiation)
current results: (7-d LC50 and 95% confidence limits) =
3.35 (3.19-3.52) log (mg/L NaCl)
current results: (7-d IC50 and 95% confidence limits) =
2.74 (2.56-2.95) log (mg/L NaCl)
The reference toxicant test was performed under the same conditions as those used during this test.

Note: Outlined sections are protocol deviations explained on the comment page





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## Test Data

Client: SHO108
Reference: 11-1052-01-CDD

**Test Log:**

| Date | Day | Time | Technicians | Temperature (ºC) Control | Temperature (ºC) Sample |
|---|---|---|---|---|---|
| 2011/06/17 | 0 | 1020 | E. Petho | 24 | 24 |
| 2011/06/18 | 1 | 1110 | E. Petho | 24 | 24 |
| 2011/06/19 | 2 | 1000 | E. Petho | 24 | 24 |
| 2011/06/20 | 3 | 1010 | R. Bradley | 24 | 24 |
| 2011/06/21 | 4 | 1020 | H. Stewart | 25 | 25 |
| 2011/06/22 | 5 | 0955 | R. Bradley | 24 | 24 |
| 2011/06/23 | 6 | 1045 | H. Stewart | 25 | 25 |
| 2011/06/24 | 7 | 0850 | R. Bradley | na | na |
| | | | | | |

**Chemistry Summary Tables:**

| | New Solutions | | | | | | | | Old Solutions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc. % | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
| **Average Values** | | | | | | | | | | | | | | | | |
| pH | 7.8 | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 | 7.8 | 7.7 | 7.8 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.3 | 8.2 |
| cond. | 388 | 504 | 612 | 820 | 1218 | 2021 | 3630 | 6607 | 410 | 535 | 644 | 864 | 1303 | 2253 | 3771 | 6613 |
| DO | 7.1 | 7.0 | 7.0 | 7.0 | 6.9 | 6.9 | 6.9 | 7.0 | 7.1 | 6.8 | 6.7 | 6.7 | 6.6 | 6.6 | 6.5 | 6.6 |
| temp. | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| **Coefficients of Variation (%)** | | | | | | | | | | | | | | | | |
| pH | 3 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| cond. | 2 | 1 | 2 | 2 | 3 | 6 | 3 | 2 | 2 | 5 | 5 | 5 | 5 | 4 | 4 | 3 |
| DO | 6 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| temp. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |





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# *Ceriodaphnia* (6-8d LC50/IC25) Test Report

**Reissued 2011/08/11**

## Test Data

Client: SHO108
Reference: 11-1052-01-CDD

**Biology (number of young produced):**

**Control**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 4 | 0 | 5 | 7 | |
| 2 | 0 | 0 | 0 | 3 | 8 | 0 | 8 | |
| 3 | 0 | 0 | 0 | 3 | 5 | 0 | 7 | |
| 4 | 0 | 0 | 0 | 5 | 10 | 0 | 12 | |
| 5 | 0 | 0 | 0 | 4 | 7 | 0 | 9 | |
| 6 | 0 | 0 | 0 | 2 | 0 | 5 | 8 | |
| 7 | 0 | **0** | X | X | X | X | X | |
| 8 | 0 | 0 | 0 | 2 | 10 | 0 | 9 | |
| 9 | 0 | 0 | 0 | 2 | 9 | 0 | 8 | |
| 10 | 0 | 0 | 0 | 0 | 8 | 2 | 2 | |

**13%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 0 | 4 | 6 | |
| 2 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | |
| 3 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | |
| 4 | 0 | 0 | 0 | 3 | 2 | 0 | 7 | |
| 5 | 0 | 0 | 0 | 3 | 6 | 0 | 7 | |
| 6 | 0 | 0 | 0 | 3 | 4 | 0 | 10 | |
| 7 | 0 | 0 | 0 | 2 | 0 | 5 | 10 | |
| 8 | 0 | 0 | 0 | 3 | 5 | 0 | 6 | |
| 9 | 0 | 0 | 0 | 3 | 2 | 0 | 8 | |
| 10 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | |

**1.6%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 6 | 0 | 9 | |
| 2 | 0 | 0 | 0 | 0 | 0 | 4 | 6 | |
| 3 | 0 | 0 | 0 | 4 | 6 | 0 | 9 | |
| 4 | 0 | 0 | 0 | 3 | 5 | 9 | - | |
| 5 | 0 | 0 | 0 | 3 | 4 | 0 | 4 | |
| 6 | 0 | 0 | 0 | 0 | 9 | 0 | 7 | |
| 7 | 0 | 0 | 0 | 2 | 0 | 5 | 11 | |
| 8 | 0 | 0 | 0 | 3 | 0 | 4 | 5 | |
| 9 | 0 | 0 | 0 | 0 | 5 | 6 | 0 | |
| 10 | 0 | 0 | 0 | 2 | 0 | 3 | 4 | |

**25%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 0 | 3 | 4 | |
| 2 | 0 | 0 | 0 | 0 | 4 | 7 | 0 | |
| 3 | 0 | 0 | 0 | 3 | 0 | 7 | 9 | |
| 4 | 0 | 0 | 0 | 0 | 0 | 5 | 9 | |
| 5 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | |
| 6 | 0 | 0 | 0 | 2 | 8 | 0 | 7 | |
| 7 | 0 | 0 | 0 | 3 | 0 | 7 | 7 | |
| 8 | 0 | 0 | 0 | 4 | 0 | 10 | 8 | |
| 9 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | |
| 10 | 0 | 0 | 0 | 0 | 0 | 5 | 6 | |

**3.1%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 0 | 4 | 6 | |
| 2 | 0 | 0 | 0 | 2 | 0 | 7 | 7 | |
| 3 | 0 | 0 | 0 | 2 | 0 | 8 | 7 | |
| 4 | 0 | 0 | 0 | 2 | 4 | 8 | - | |
| 5 | 0 | 0 | 0 | 3 | 7 | 0 | 7 | |
| 6 | 0 | 0 | 0 | 2 | 6 | 0 | 9 | |
| 7 | 0 | 0 | 0 | 3 | 0 | 5 | 8 | |
| 8 | 0 | 0 | 0 | 3 | 0 | 8 | 12 | |
| 9 | 0 | 0 | 0 | 5 | 0 | 8 | **12** | |
| 10 | 0 | 0 | 0 | 3 | 0 | 4 | 7 | |

**50%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 3 | 6 | |
| 2 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | |
| 3 | 0 | 0 | 0 | 2 | 0 | 2 | 5 | |
| 4 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | |
| 5 | 0 | 0 | 0 | 2 | 4 | **0** | X | |
| 6 | 0 | 0 | 0 | 2 | 2 | 0 | **0** | |
| 7 | 0 | 0 | 0 | 0 | 5 | 0 | 6 | |
| 8 | 0 | 0 | 0 | 2 | 5 | 0 | 3 | |
| 9 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | |
| 10 | 0 | 0 | 0 | 2 | **0** | X | X | |

Notes: #, young produced; 0, no young; X, dead; bold #, number of young the test organism had the day it died;
—, young produced after third brood





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Client: SHO108
Reference: 11-1052-01-CDD

## Test Data

**Biology (number of young produced):**

| Replicate | 6.3% Day 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 100% Day 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 2 | 2 | 0 | 6 | | 0 | 0 | 0 | **0** | X | X | X | |
| 2 | 0 | 0 | 0 | 0 | 6 | 4 | 6 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 3 | 4 | 0 | 7 | | 0 | 0 | 0 | 0 | 0 | **0** | X | |
| 4 | 0 | 0 | 0 | 4 | 7 | 0 | 9 | | 0 | 0 | 0 | 0 | 0 | 0 | **0** | |
| 5 | 0 | 0 | 0 | 3 | 8 | 0 | 8 | | 0 | 0 | 0 | 0 | 0 | **0** | X | |
| 6 | 0 | 0 | 0 | 2 | 4 | 0 | 7 | | 0 | 0 | 0 | 0 | **0** | X | X | |
| 7 | 0 | 0 | 0 | 3 | 0 | 8 | 10 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 8 | 0 | 0 | 0 | 3 | 0 | 8 | 9 | | 0 | 0 | 0 | **0** | X | X | X | |
| 9 | 0 | 0 | 0 | 3 | 6 | 0 | 5 | | 0 | **0** | X | X | X | X | X | |
| 10 | 0 | 0 | 0 | 3 | 2 | 7 | - | | 0 | **0** | X | X | X | X | X | |

Notes: #, young produced; 0, no young; X, dead; bold #, number of young the test organism had the day it died; —, young produced after third brood

**Biology Summary Tables:**

Number of Organism Alive

| Day \ Conc. % | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 8 |
| 3 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 8 |
| 4 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 6 |
| 5 | 9 | 10 | 10 | 10 | 10 | 10 | 9 | 5 |
| 6 | 9 | 10 | 10 | 10 | 10 | 10 | 8 | 3 |
| 7 | 9 | 10 | 9 | 10 | 10 | 10 | 7 | 2 |
| 8 | | | | | | | | |

Percent Mortality (%)

| | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| mean | 10 | 0 | 10 | 0 | 0 | 0 | 30 | 80 |

Total Young Produced by Each Adult

| Replicate | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 1 | 16 | 18 | 13 | 10 | 13 | 10 | 9 | 0 |
| 2 | 19 | 10 | 16 | 16 | 10 | 11 | 3 | 0 |
| 3 | 15 | 19 | 17 | 14 | 2 | 19 | 9 | 0 |
| 4 | 27 | 17 | 14 | 20 | 12 | 14 | 5 | 0 |
| 5 | 20 | 11 | 17 | 19 | 16 | 6 | 6 | 0 |
| 6 | 15 | 16 | 17 | 13 | 17 | 17 | 4 | 0 |
| 7 | 0 | 18 | 16 | 21 | 17 | 17 | 11 | 0 |
| 8 | 21 | 12 | 23 | 20 | 14 | 22 | 10 | 0 |
| 9 | 19 | 11 | 25 | 14 | 13 | 3 | 2 | 0 |
| 10 | 12 | 9 | 14 | 12 | 5 | 11 | 2 | 0 |

Daily Young Production

| Day | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 25 | 20 | 28 | 26 | 23 | 18 | 12 | 0 |
| 5 | 57 | 35 | 17 | 39 | 23 | 12 | 16 | 0 |
| 6 | 12 | 31 | 52 | 27 | 13 | 50 | 13 | 0 |
| 7 | 70 | 55 | 75 | 67 | 60 | 50 | 20 | 0 |
| 8 | | | | | | | | |
| Total | 164 | 141 | 172 | 159 | 119 | 130 | 61 | 0 |

Young Per Adult (within first three broods)

| | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| mean | 16 | 14 | 17 | 16 | 12 | 13 | 6 | 0 |
| sd | 7.09 | 3.84 | 3.88 | 3.87 | 5 | 5.93 | 3.41 | 0 |
| cv(%) | 43.2 | 27.3 | 22.6 | 24.3 | 42 | 45.6 | 56 | na |

Young Production as a Percent of Controls

| ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| 100 | 86 | 105 | 97 | 73 | 79 | 37 | 0 |

HydroQual Laboratories Ltd.

# *Ceriodaphnia* (6-8d LC50/IC25) Test Report

**Reissued 2011/08/11**

## Test Data

Client: SHO108
Reference: 11-1052-01-CDD

**Chemistry:**

### pH (units)

| Day | New ctl | New 1.6 | New 3.1 | New 6.3 | New 13 | New 25 | New 50 | New 100 | Old ctl | Old 1.6 | Old 3.1 | Old 6.3 | Old 13 | Old 25 | Old 50 | Old 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.9 | 7.9 | 7.8 | 7.7 | | | | | | | | |
| 1 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 7.9 | 7.8 | 8.0 | 8.0 | 8.1 | 8.1 | 8.1 | 8.2 | 8.3 | 8.2 |
| 2 | 7.8 | 8.0 | 8.0 | 8.0 | 8.0 | 7.9 | 7.8 | 7.7 | 7.8 | 8.0 | 8.1 | 8.1 | 8.2 | 8.2 | 8.4 | 8.2 |
| 3 | 7.8 | 7.8 | 7.8 | 7.9 | 7.9 | 7.9 | 7.8 | 7.7 | 7.8 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.4 | 8.2 |
| 4 | 7.7 | 7.9 | 7.9 | 7.9 | 7.9 | 7.8 | 7.8 | 7.7 | 7.9 | 7.9 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.2 |
| 5 | 7.3 | 7.8 | 7.8 | 7.9 | 7.9 | 7.9 | 7.8 | 7.7 | 7.5 | 8.0 | 8.0 | 8.1 | 8.1 | 8.2 | 8.3 | 8.3 |
| 6 | 7.7 | 7.9 | 7.9 | 8.0 | 7.9 | 8.0 | 7.8 | 7.7 | 7.9 | 8.0 | 8.0 | 8.0 | 8.0 | 8.1 | 8.3 | 8.2 |
| 7 | | | | | | | | | 8.0 | 7.8 | 7.9 | 8.0 | 8.0 | 8.1 | 8.4 | 8.3 |
| 8 | | | | | | | | | | | | | | | | |

### Conductivity (μS/cm)

| Day | New ctl | New 1.6 | New 3.1 | New 6.3 | New 13 | New 25 | New 50 | New 100 | Old ctl | Old 1.6 | Old 3.1 | Old 6.3 | Old 13 | Old 25 | Old 50 | Old 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 381 | 498 | 591 | 793 | 1186 | 1968 | 3550 | 6530 | | | | | | | | |
| 1 | 397 | 507 | 609 | 828 | 1219 | 1951 | 3580 | 6530 | 403 | 509 | 611 | 803 | 1221 | 2120 | 3590 | 6260 |
| 2 | 383 | 498 | 600 | 802 | 1167 | 1943 | 3530 | 6570 | 403 | 530 | 629 | 912 | 1290 | 2250 | 3740 | 6580 |
| 3 | 386 | 502 | 603 | 807 | 1193 | 1939 | 3540 | 6580 | 401 | 517 | 613 | 828 | 1247 | 2160 | 3590 | 6450 |
| 4 | 383 | 510 | 627 | 836 | 1244 | 2220 | 3650 | 6470 | 425 | 578 | 686 | 899 | 1307 | 2320 | 3770 | 6530 |
| 5 | 383 | 512 | 628 | 833 | 1233 | 1978 | 3770 | 6760 | 409 | 561 | 676 | 888 | 1386 | 2400 | 3990 | 6810 |
| 6 | 400 | 503 | 626 | 840 | 1283 | 2150 | 3790 | 6810 | 418 | 520 | 645 | 842 | 1302 | 2220 | 3830 | 6830 |
| 7 | | | | | | | | | 409 | 528 | 648 | 875 | 1366 | 2300 | 3890 | 6830 |
| 8 | | | | | | | | | | | | | | | | |

### Dissolved Oxygen (mg/L)

| Day | New ctl | New 1.6 | New 3.1 | New 6.3 | New 13 | New 25 | New 50 | New 100 | Old ctl | Old 1.6 | Old 3.1 | Old 6.3 | Old 13 | Old 25 | Old 50 | Old 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 7.2 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | | | | | | | | |
| 1 | 6.7 | 7.1 | 7.0 | 7.0 | 6.9 | 6.9 | 6.9 | 6.9 | 6.7 | 6.5 | 6.5 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 |
| 2 | 7.5 | 7.0 | 6.9 | 6.9 | 6.8 | 6.8 | 6.8 | 7.0 | 7.1 | 6.8 | 6.7 | 6.7 | 6.6 | 6.6 | 6.5 | 6.5 |
| 3 | 7.5 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.1 | 7.3 | 7.4 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | 6.7 | 6.7 |
| 4 | 7.5 | 7.1 | 7.0 | 7.0 | 6.9 | 6.9 | 6.9 | 6.9 | 7.1 | 6.9 | 6.7 | 6.6 | 6.6 | 6.5 | 6.5 | 6.5 |
| 5 | 6.7 | 7.3 | 7.3 | 7.3 | 7.2 | 7.2 | 7.2 | 7.2 | 7.3 | 6.9 | 6.8 | 6.8 | 6.8 | 6.8 | 6.7 | 6.7 |
| 6 | 6.7 | 6.9 | 6.7 | 6.7 | 6.7 | 6.7 | 6.6 | 6.7 | 6.7 | 6.5 | 6.4 | 6.4 | 6.4 | 6.3 | 6.3 | 6.3 |
| 7 | | | | | | | | | 7.3 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.7 | 6.8 |
| 8 | | | | | | | | | | | | | | | | |

### Temperature (°C)

| Day | New ctl | New 1.6 | New 3.1 | New 6.3 | New 13 | New 25 | New 50 | New 100 | Old ctl | Old 1.6 | Old 3.1 | Old 6.3 | Old 13 | Old 25 | Old 50 | Old 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | | | | | | | | |
| 1 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 2 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 3 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 4 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 6 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 7 | | | | | | | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 8 | | | | | | | | | | | | | | | | |





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## Comments/Statistics

Client: SHO108
Reference: 11-1052-01-CDD

**Test Result Comments:**
None

**Data Analysis:**
Endpoints for mortality were calculated using Linear Interpolation and Spearman-Karber models with CETIS v. 1.7.0 rev Q.

Endpoints for reproduction were calculated using a non-linear regression model (3P Log-Gompertz) with CETIS v. 1.7.0 rev Q.

**Protocol Deviations:**
None





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# Warning Chart
# *Ceriodaphnia*

**Test Method:** *Ceriodaphnia* Survival and Reproduction Test (7 treatments plus a control)
HydroQual Test Method: WTR-ME-019

**Reference:** Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*, 2007. Environment Canada, EPS 1/RM/21

**Test Organism:**

test species: *Ceriodaphnia dubia*
culture source: in-house
original culture source: Environment Canada
ephippia in stock culture: none
food type: YAT:Algae
frequency of feeding: daily
age of test organisms: <24 hours
culture mortality 7 days prior: 4%
culture fecundity 7 days prior within the first three broods: 18
young produced in previous brood: 9
culture condition prior to test initiation: normal
culture water: mixture of moderately hard reconstituted* water and Bow River Water (50:50)

**Test Design:**

test type: static renewal
toxicant: sodium chloride (NaCl)
test vessel: 30 mL plastic cup
test volume (mL): 15
replicates per treatment: 10
organisms per replicate: 1
feeding: daily
temperature (°C): 24-26
photoperiod: 16 hours light: 8 hours dark
light level (surface): 100-600 lux (full spectrum)
hardness adjustment: no

*Note: there are 2 subcultures within this culture source, separated by one week in age. The test is set with organisms from one subculture.
The number of young a culture has is monitored daily. If young are not used that day, they are discarded, therefore organisms in tests are <24h.

**Control/Dilution Water:**

source: mixture of moderately hard reconstituted* water and Bow River Water (50:50)
pH (units): 7.9
conductance (uS/cm): 383
dissolved oxygen (mg/L): 7.3
$NH_4^+$ (mg/L): <0.1
hardness (mg $CaCO_3$/L): 128
alkalinity (mg $CaCO_3$/L): 106
total residual chlorine (mg/L): <0.01

* Note: moderately hard reconstituted water prepared as per EPS 1/RM/21

**Comments:** There were no protocol deviations during the conduct of this test.

The data and results are authorized and verified correct.

<original signed by>

Technical Lead

<original signed by>

Quality Coordinator





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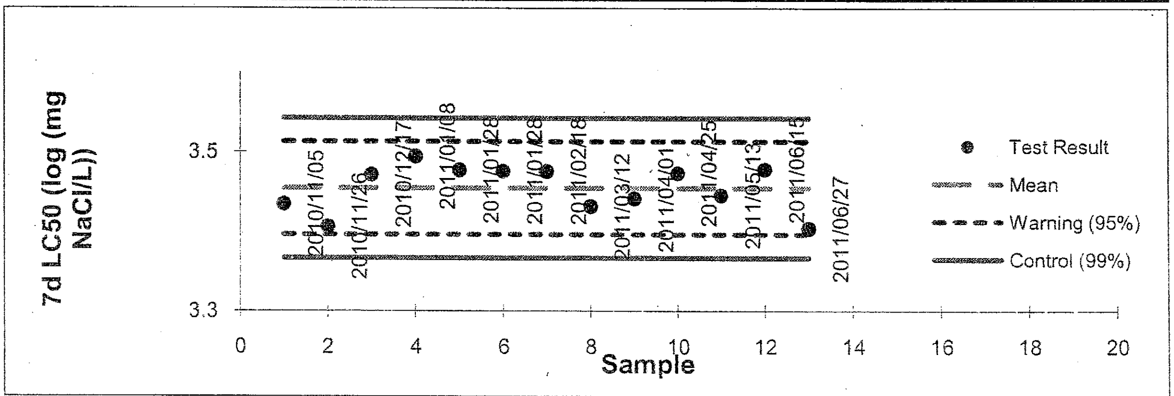
# Warning Chart *Ceriodaphnia*

## Mortality

**Current Test**

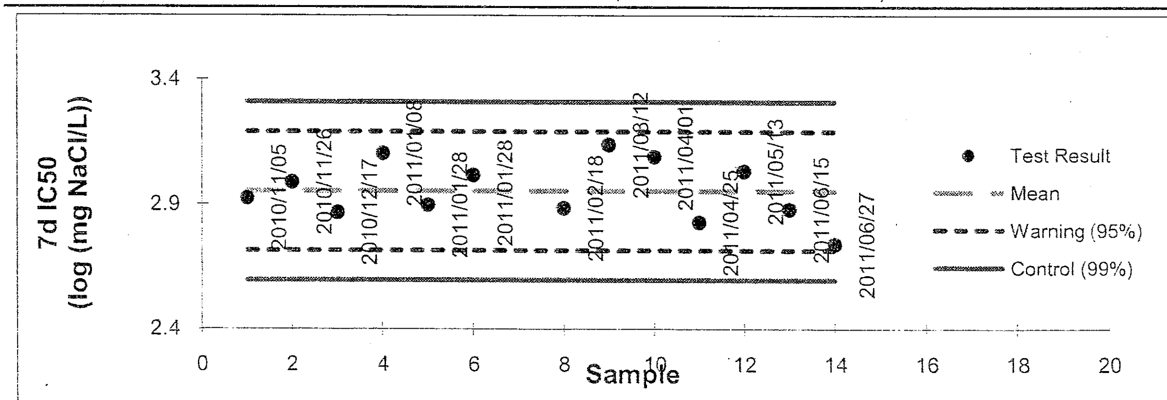
| | | | | | | |
|---|---|---|---|---|---|---|
| toxicant | Sodium chloride (NaCl) | | | | | |
| started on | 2011/06/20 | ended on | 2011/06/27 | | | |
| Result (7d LC50): | 3.35 | log (mg NaCl/L); geometric mean | | | | |
| Confidence Limits (95%) | lower | 3.19 | upper | 3.52 | | |
| **Historical Values** | | | | | | |
| mean | 3.40 | sd | 0.03 | cv(%): | 1 | |
| | lower | upper | | | | |
| warning limits (±2 sd) | 3.35 | 3.46 | (95% confidence limits) | | | |
| control limits (±3 sd) | 3.32 | 3.49 | (99% confidence limits) | | | |




## Reproduction

**Current Test**

| | | | | | | |
|---|---|---|---|---|---|---|
| toxicant | Sodium chloride (NaCl) | | | | | |
| started on | 2011/06/20 | ended on | 2011/06/27 | | | |
| Result (7d IC50) | 2.74 | log (mg NaCl/L); geometric mean | | | | |
| Confidence Limits (95%) | lower | 2.56 | upper | 2.95 | | |
| **Historical Values** | | | | | | |
| mean | 2.95 | sd | 0.12 | cv(%): | 4 | |
| | lower | upper | | | | |
| warning limits (±2 sd) | 2.71 | 3.19 | (95% confidence limits) | | | |
| control limits (±3 sd) | 2.60 | 3.31 | (99% confidence limits) | | | |



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*Ceriodaphnia* **Test Report**

# Quality Assurance Information

**Culture history for adults used in the test for reference QA122:**

**Number of young produced per brood adult:**
(Note: The third brood per adult may be on the day the test is set)

| row/replicate | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young | 4 | 6 | 7 | 5 | 3 | 5 | 4 | 3 | 5 | 8 | |
| number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

| | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young | 5 | 8 | 4 | 2 | 5 | 4 | 5 | 4 | 7 | 4 | |
| number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

| | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young | 11 | 10 | 4 | 8 | 12 | 9 | 8 | 9 | 7 | 4 | |
| number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

| | | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAY USED | number of young | 8 | 9 | 9 | 10 | 4 | 10 | 8 | 9 | 10 | 11 | |
| 2011/06/20 | number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |

| | | A2 | B2 | B4 | D4 | E3 | A1 | A2 | A5 | B2 | B5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| totals (# of young in first 3 broods) | number of young | 20 | 24 | 15 | 15 | 20 | 18 | 17 | 16 | 19 | 16 | |

| | |
|---|---|
| Number of young produced per organism in the last brood before use | 9 |
| Mean number of surviving young per adult over the first three broods | 18 |
| Culture mortality over the last seven days | 4 |





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# *Ceriodaphnia* (6-8d LC50/IC25) Test Report

Client: SHO108
Reference: 11-1290-01-CDD

## Result Summary

**Client:** Shore Gold Inc.; operation Saskatoon

**Sample:** 11497164019

**Collection:** collected on 2011/07/20 at not given by not given
**Receipt:** received on 2011/07/22 at 1030 by A. Lanuzo
**Containers:** received 2 x 20 L pails at 18 °C, in good condition with no seals and no initials
**Description:** type: water, collection method: not given

**Test:** started on 2011/07/22 ; ended on 2011/07/29

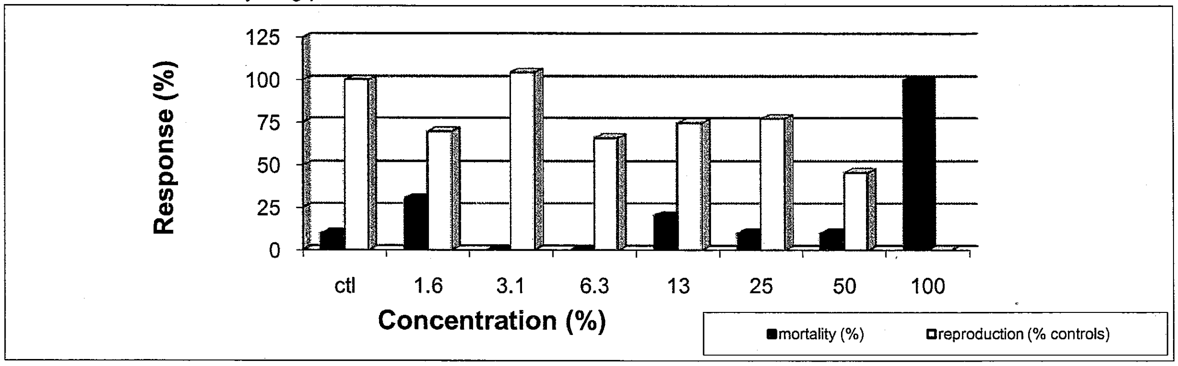
**Contents**



**Result:**

| | Endpoint (7-day) | Value | Confidence Limits (95%) lower | upper | Units | Method Calculated |
|---|---|---|---|---|---|---|
| Acute: | LC25 | 58 | 43 | 60 | % | Linear Interpolation |
| (survival) | LC50 | 65 | 57 | 76 | % | Spearman-Karber |
| Chronic: | IC25 | 5.6 | <1.6 | 31 | % | Linear Interpolation |
| (fecundity) | IC50 | 45 | 19 | 57 | % | Linear Interpolation |

Notes: LCx & ICx, concentrations lethal or inhibitory to 'x' percent of the test population; fecundity, reproduction as the number of young produced




The test data and results are authorized and verified correct.

<original signed by> <original signed by>

Technical Lead Quality Coordinator





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## Test Conditions

| |
|---|
| Client: SHO108 |
| Reference: 11-1290-01-CDD |

| | |
|---|---|
| **Method:** | Biological Test method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia.* Environment Canada, EPS 1/RM/21, 2nd Edition, February 2007. |
| **Test type:** | *Ceriodaphnia* Survival and Reproduction Static Renewal Test (WTR-ME-018) |
| **Species:** | *Ceriodaphnia dubia* |
| **Age:** | <24 hours old; all from same brood source within 12 hours of the same age. |
| **Organism source:** | in-house cultures; cultures from a single brood organism to provide test organisms. |
| **Culture health:** | Culture mortality was 0% (must be ≤ 20%). |
| **7-d prior to test initiation:** | No ephippia were noted in the cultures at any time.<br>Average young produced per adult in the first three broods was 21 (must be ≥ 15)<br>Number of young produced by each brood organism in the last complete brood before use was 9 (must be ≥ 8). |
| **Organism observations:** | No unusual behavior, appearance or treatment of test organisms was noted prior to or during the test. All first-generation mortality was recorded on the day it was observed. |
| **Sample initial chemistry:** | pH: 7.3; EC: 6760 (µS/cm); DO: 7.8 (mg/L); temperature: 20 °C<br>hardness (mg CaC03/L): 588; colour: light yellow; odour: odourless |
| **Sample holding time:** | 2 days (must be ≤ 3 days); The test was conducted with three subsamples, samples a, b, and c were for days 0 to 2, 3 to 5, and 6 to 8 respectively |
| **Sample storage:** | 4 ± 2°C in darkness |
| **Test vessel:** | The tests were conducted in 30 mL plastic vessels (2 cm depth). |
| **Test volume:** | 15 mL of solution (1 cm depth); replenished daily. |
| **Control/dilution water:** | The control and dilution water was a mixture of moderately hard reconstituted water and Bow River Water (50:50). Chemicals added to dilution water: 0.96 g NaHCO3, 0.60 g CaSO4, 0.60 g MgSO4, 0.04 g KCl per 20L. |
| **Test concentrations:** | 7 effluent concentrations (1.6, 3.1, 6.3, 13, 25, 50, 100% (v/v) plus a negative control) |
| **Test replicates:** | One neonate <24 hours old was loaded per test vessel;<br>10 replicates/concentration |
| **Feeding:** | The test organisms were fed daily a mixture of fermented trout chow, yeast, alfalfa powder, and the green alga *Pseudokirchneriella subcapitata* (formerly *Selenastrum capricornutum* and *Raphidocelis subcapitata*).<br>Food expiration date: 2011/07/30 |
| **Measurements:** | pH, conductivity, dissolved oxygen and temperature were measured daily. |
| **Sample pre-treatment:** | The sample was not aerated, filtered or pH adjusted prior or during testing.<br>The dissolved oxygen concentration (mg/L) was: 6.7<br>The sample pH was: 7.9 |
| **Lighting:** | Overhead full spectrum fluorescent lights; 100-600 lux at surface |
| **Photoperiod:** | 16h light:8h dark |
| **Test temperature:** | 25 ± 1°C |

Note: Outlined sections are protocol deviations explained on the comment page

## Test Conditions

Client: SHO108
Reference: 11-1290-01-CDD

**Endpoints:** Survival, 7-d LC50 (with 95% confidence limits)
Reproduction, 7-d IC25 (with 95% confidence limits)
Test endpoints were bracketed by at least 1 test concentration (except for <1.6% or >100 %)
No outliers were observed within the data set.

**Test completion:** 70% of the control organisms had ≥ 3 broods on day 7 (must be ≥ 60% within 8 days) Any neonates produced after third brood were not included in the mean young per adult calculation.

**Test validity:** The control had 90% survival (must ≥ 80%)
Number of young produced by each surviving control adult within the first three broods was 16 (must be ≥ 15).

**Reference toxicant:** 7-d test with NaCl initiated on July 8, 2011;
(must be within 14 days of test initiation)
current results: (7-d LC50 and 95% confidence limits) =
3.36 (3.26-3.46) log (mg/L NaCl)
current results: (7-d IC50 and 95% confidence limits) =
3.05 (2.94-3.14) log (mg/L NaCl)
The reference toxicant test was performed under the same conditions as those used during this test.

Note: Outlined sections are protocol deviations explained on the comment page

# Test Data

Client: SHO108
Reference: 11-1290-01-CDD

**Test Log:**

| Date | Day | Time | Technicians | Temperature (°C) Control | Sample |
|---|---|---|---|---|---|
| 2011/07/22 | 0 | 1210 | R. Bradley | 25 | 25 |
| 2011/07/23 | 1 | 0945 | E. Blais | 24 | 24 |
| 2011/07/24 | 2 | 1055 | E. Blais | 24 | 24 |
| 2011/07/25 | 3 | 0905 | E. Blais | 24 | 24 |
| 2011/07/26 | 4 | 0930 | R. Bradley | 25 | 25 |
| 2011/07/27 | 5 | 0905 | E. Blais | 24 | 24 |
| 2011/07/28 | 6 | 0900 | R. Bradley | 25 | 25 |
| 2011/07/29 | 7 | 0830 | R. Bradley | na | na |
| | | | | | |

**Chemistry Summary Tables:**

| | New Solutions | | | | | | | | Old Solutions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc. % | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
| **Average Values** | | | | | | | | | | | | | | | | |
| pH | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.1 | 8.0 | 7.9 | 8.0 | 8.0 | 8.0 | 8.0 | 8.1 | 8.2 | 8.2 | 8.2 |
| cond. | 423 | 522 | 632 | 853 | 1210 | 2062 | 3690 | 6750 | 426 | 578 | 686 | 856 | 1249 | 2186 | 3814 | 6797 |
| DO | 7.2 | 7.1 | 7.0 | 6.9 | 6.9 | 6.8 | 6.8 | 6.8 | 6.7 | 6.6 | 6.5 | 6.5 | 6.4 | 6.5 | 6.4 | 6.4 |
| temp. | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| **Coefficients of Variation (%)** | | | | | | | | | | | | | | | | |
| pH | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 5 | 4 | 3 | 3 | 3 | 2 | 3 | 2 |
| cond. | 9 | 3 | 8 | 3 | 4 | 5 | 1 | 1 | 7 | 10 | 7 | 4 | 3 | 6 | 3 | 5 |
| DO | 6 | 5 | 5 | 5 | 4 | 5 | 6 | 6 | 8 | 7 | 7 | 6 | 7 | 6 | 7 | 8 |
| temp. | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

## Test Data

Client: SHO108
Reference: 11-1290-01-CDD

**Biology (number of young produced):**

**Control**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 0 | 5 | 10 | |
| 2 | 0 | 0 | 0 | 3 | 6 | 0 | 10 | |
| 3 | 0 | 0 | 4 | 4 | 8 | - | - | |
| 4 | 0 | 0 | 0 | 0 | 6 | 7 | 4 | |
| 5 | 0 | 0 | 0 | 3 | 8 | 5 | - | |
| 6 | 0 | 0 | 0 | 4 | 6 | 0 | 0 | |
| 7 | 0 | 0 | 0 | 4 | 7 | 0 | 10 | |
| 8 | 0 | 0 | 3 | 6 | 7 | - | - | |
| 9 | 0 | 0 | 0 | 4 | 5 | 2 | - | |
| 10 | 0 | 0 | 0 | 4 | 0 | 0 | 10 | |

**13%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | **0** | X | X | X | X | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 4 | 8 | 0 | 6 | |
| 4 | 0 | 0 | 0 | 4 | 6 | 0 | 7 | |
| 5 | 0 | 0 | 0 | 3 | 7 | 10 | - | |
| 6 | 0 | 0 | 0 | 2 | 4 | 5 | - | |
| 7 | 0 | 0 | **0** | X | X | X | X | |
| 8 | 0 | 0 | 0 | 4 | 7 | 8 | - | |
| 9 | 0 | 0 | 0 | 5 | 6 | 0 | 9 | |
| 10 | 0 | 0 | 0 | 4 | 3 | 0 | 6 | |

**1.6%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 4 | 0 | 8 | 10 | |
| 2 | 0 | 0 | 0 | 2 | 0 | 4 | 12 | |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 4 | 0 | 0 | 0 | 2 | 4 | 0 | 8 | |
| 5 | 0 | 0 | 0 | 4 | 8 | 4 | - | |
| 6 | 0 | 0 | 0 | 2 | 6 | 0 | 10 | |
| 7 | 0 | 0 | 0 | 4 | 6 | **2** | X | |
| 8 | 0 | 0 | 0 | **3** | X | X | X | |
| 9 | 0 | 0 | 0 | 0 | **0** | X | X | |
| 10 | 0 | 0 | 0 | 2 | 0 | 5 | 0 | |

**25%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 2 | 0 | **0** | X | |
| 2 | 0 | 0 | 0 | 3 | 7 | 0 | 10 | |
| 3 | 0 | 0 | 0 | 4 | 7 | 0 | 10 | |
| 4 | 0 | 0 | 0 | 3 | 4 | 6 | - | |
| 5 | 0 | 0 | 0 | 3 | 6 | 7 | - | |
| 6 | 0 | 0 | 0 | 0 | 4 | 6 | 4 | |
| 7 | 0 | 0 | 0 | 3 | 7 | 0 | 6 | |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 9 | 0 | 0 | 0 | 2 | 4 | 0 | 8 | |
| 10 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | |

**3.1%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 5 | 0 | 8 | 14 | |
| 2 | 0 | 0 | 0 | 3 | 0 | 0 | 11 | |
| 3 | 0 | 0 | 0 | 2 | 6 | 0 | 9 | |
| 4 | 0 | 0 | 0 | 3 | 7 | 7 | - | |
| 5 | 0 | 0 | 0 | 4 | 8 | 9 | - | |
| 6 | 0 | 0 | 0 | 0 | 4 | 4 | 7 | |
| 7 | 0 | 0 | 0 | 0 | 7 | 8 | 0 | |
| 8 | 0 | 0 | 0 | 4 | 6 | 8 | - | |
| 9 | 0 | 0 | 0 | 2 | 9 | 0 | 10 | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

**50%**

| Replicate | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Day 6 | Day 7 | Day 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 3 | 0 | 3 | 0 | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 3 | 4 | 0 | 6 | |
| 4 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | |
| 5 | 0 | 0 | 0 | 4 | 4 | 0 | 5 | |
| 6 | 0 | 0 | 0 | 2 | 2 | 0 | 3 | |
| 7 | 0 | 0 | 0 | 2 | 0 | 4 | 2 | |
| 8 | 0 | **0** | X | X | X | X | X | |
| 9 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | |
| 10 | 0 | 0 | 0 | 5 | 0 | 3 | 6 | |

Notes: #, young produced; 0, no young; X, dead; bold #, number of young the test organism had the day it died;
—, young produced after third brood





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# *Ceriodaphnia* (6-8d LC50/IC25) Test Report

## Test Data

Client: SHO108
Reference: 11-1290-01-CDD

**Biology (number of young produced):**

6.3%

| Day / Replicate | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 3 | 0 | 0 | 0 | 3 | 8 | 8 | - | |
| 4 | 0 | 0 | 0 | 4 | 8 | 8 | - | |
| 5 | 0 | 0 | 0 | 4 | 7 | 8 | - | |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 7 | 0 | 0 | 0 | 4 | 7 | 7 | - | |
| 8 | 0 | 0 | 0 | 4 | 6 | 2 | - | |
| 9 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | |
| 10 | 0 | 0 | 0 | 2 | 5 | 7 | - | |

100%

| Day / Replicate | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | **0** | X | X | X | X | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | |
| 3 | 0 | **0** | X | X | X | X | X | |
| 4 | 0 | 0 | 0 | **0** | X | X | X | |
| 5 | 0 | **0** | X | X | X | X | X | |
| 6 | 0 | **0** | X | X | X | X | X | |
| 7 | 0 | **0** | X | X | X | X | X | |
| 8 | 0 | 0 | 0 | 0 | 0 | **0** | X | |
| 9 | 0 | 0 | 0 | 0 | 0 | **0** | X | |
| 10 | 0 | 0 | **0** | X | X | X | X | |

Notes: #, young produced; 0, no young; X, dead; bold #, number of young the test organism had the day it died;
—, young produced after third brood

**Biology Summary Tables:**

Number of Organism Alive

| Day / Conc. % | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 1 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| 2 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 6 |
| 3 | 10 | 10 | 10 | 10 | 8 | 10 | 9 | 4 |
| 4 | 10 | 9 | 10 | 10 | 8 | 10 | 9 | 3 |
| 5 | 10 | 8 | 10 | 10 | 8 | 10 | 9 | 3 |
| 6 | 10 | 7 | 10 | 10 | 8 | 9 | 9 | 1 |
| 7 | 9 | 7 | 10 | 10 | 8 | 9 | 9 | 0 |
| 8 | | | | | | | | |

Percent Mortality (%)

| | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| mean | 10 | 30 | 0 | 0 | 20 | 10 | 10 | 100 |

Total Young Produced by Each Adult

| Replicate | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 1 | 18 | 22 | 27 | 0 | 0 | 2 | 6 | 0 |
| 2 | 19 | 18 | 14 | 0 | 0 | 20 | 0 | 0 |
| 3 | 16 | 0 | 17 | 19 | 18 | 21 | 13 | 0 |
| 4 | 17 | 14 | 17 | 20 | 17 | 13 | 4 | 0 |
| 5 | 16 | 16 | 21 | 19 | 20 | 16 | 13 | 0 |
| 6 | 10 | 18 | 15 | 0 | 11 | 14 | 7 | 0 |
| 7 | 21 | 12 | 15 | 18 | 0 | 16 | 8 | 0 |
| 8 | 16 | 3 | 18 | 12 | 19 | 0 | 0 | 0 |
| 9 | 11 | 0 | 21 | 2 | 20 | 14 | 7 | 0 |
| 10 | 14 | 7 | 0 | 14 | 13 | 6 | 14 | 0 |

Daily Young Production

| Day | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 35 | 23 | 23 | 23 | 26 | 22 | 21 | 0 |
| 5 | 53 | 24 | 47 | 41 | 41 | 39 | 10 | 0 |
| 6 | 19 | 23 | 44 | 40 | 23 | 23 | 16 | 0 |
| 7 | 44 | 40 | 51 | 0 | 28 | 38 | 25 | 0 |
| 8 | | | | | | | | |
| Total | 158 | 110 | 165 | 104 | 118 | 122 | 72 | 0 |

Young Per Adult (within first three broods)

| | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| mean | 16 | 11 | 17 | 10 | 12 | 12 | 7 | 0 |
| sd | 3.39 | 8 | 6.96 | 8.87 | 8.64 | 7.19 | 5.05 | 0 |
| cv(%) | 21.5 | 72.7 | 42.2 | 85.3 | 73.2 | 59 | 70.2 | na |

Young Production as a Percent of Controls

| ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|
| 100 | 70 | 104 | 66 | 75 | 77 | 46 | 0 |

# Test Data

Client: SHO108
Reference: 11-1290-01-CDD

**Chemistry:**

| | New Solutions | | | | | | | | Old Solutions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc. % | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 | ctl | 1.6 | 3.1 | 6.3 | 13 | 25 | 50 | 100 |
| Day | pH (units) | | | | | | | | pH (units) | | | | | | | |
| 0 | 8.4 | 8.5 | 8.5 | 8.4 | 8.4 | 8.3 | 8.2 | 7.9 | | | | | | | | |
| 1 | 8.3 | 8.3 | 8.3 | 8.2 | 8.2 | 8.1 | 8.0 | 7.9 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.3 | 8.4 | 8.3 |
| 2 | 8.2 | 8.1 | 8.1 | 8.1 | 8.1 | 8.0 | 8.0 | 8.0 | 8.0 | 7.9 | 7.9 | 7.8 | 7.9 | 8.0 | 8.0 | 7.9 |
| 3 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.1 | 8.0 | 8.2 | 8.2 | 8.3 | 8.2 | 8.3 | 8.4 | 8.5 | 8.4 |
| 4 | 7.9 | 8.0 | 8.0 | 8.1 | 8.0 | 8.1 | 8.0 | 7.7 | 8.1 | 8.1 | 8.1 | 8.1 | 8.2 | 8.2 | 8.3 | 8.2 |
| 5 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.1 | 8.0 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.3 | 8.4 |
| 6 | 8.2 | 8.1 | 8.0 | 8.0 | 8.0 | 8.0 | 7.9 | 7.8 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.2 | 8.3 | 8.3 |
| 7 | | | | | | | | | 7.1 | 7.3 | 7.5 | 7.6 | 7.7 | 7.8 | 7.9 | 8.0 |
| 8 | | | | | | | | | | | | | | | | |
| | Conductivity (µS/cm) | | | | | | | | Conductivity (µS/cm) | | | | | | | |
| 0 | 420 | 509 | 534 | 836 | 1254 | 2060 | 3720 | 6820 | | | | | | | | |
| 1 | 417 | 514 | 670 | 884 | 1203 | 2110 | 3710 | 6830 | 408 | 535 | 645 | 855 | 1277 | 2130 | 3780 | 6710 |
| 2 | 410 | 511 | 631 | 879 | 1241 | 2110 | 3710 | 6880 | 403 | 523 | 630 | 870 | 1301 | 2210 | 3690 | 6810 |
| 3 | 394 | 528 | 659 | 860 | 1140 | 1875 | 3610 | 6680 | 404 | 554 | 683 | 800 | 1241 | 2130 | 3850 | 7100 |
| 4 | 409 | 504 | 606 | 831 | 1222 | 2070 | 3660 | 6710 | 458 | 662 | 706 | 820 | 1188 | 1980 | 3950 | 6660 |
| 5 | 405 | 550 | 687 | 836 | 1166 | 2220 | 3720 | 6640 | 470 | 558 | 663 | 860 | 1240 | 2220 | 3830 | 7390 |
| 6 | 509 | 538 | 639 | 845 | 1242 | 1987 | 3700 | 6690 | 401 | 649 | 770 | 900 | 1218 | 2360 | 3960 | 6310 |
| 7 | | | | | | | | | 438 | 565 | 704 | 884 | 1277 | 2270 | 3640 | 6600 |
| 8 | | | | | | | | | | | | | | | | |
| | Dissolved Oxygen (mg/L) | | | | | | | | Dissolved Oxygen (mg/L) | | | | | | | |
| 0 | 6.9 | 6.9 | 6.8 | 6.8 | 6.7 | 6.7 | 6.7 | 6.7 | | | | | | | | |
| 1 | 7..6 | 7.2 | 7.1 | 6.7 | 6.6 | 6.5 | 6.5 | 6.5 | 6.4 | 6.4 | 6.1 | 6.1 | 6.0 | 6.1 | 6.0 | 5.9 |
| 2 | 7.5 | 7.4 | 7.1 | 7.1 | 6.9 | 6.9 | 6.8 | 6.6 | 6.6 | 6.6 | 6.5 | 6.3 | 6.1 | 6.1 | 6.0 | 6.0 |
| 3 | 6.9 | 6.7 | 6.5 | 6.5 | 6.5 | 6.3 | 6.3 | 6.3 | 6.1 | 6.0 | 6.0 | 6.0 | 6.0 | 6.0 | 5.9 | 5.9 |
| 4 | 6.8 | 6.7 | 6.8 | 6.8 | 6.8 | 6.9 | 6.8 | 6.9 | 6.3 | 6.3 | 6.3 | 6.4 | 6.4 | 6.4 | 6.3 | 6.4 |
| 5 | 7.8 | 7.7 | 7.6 | 7.4 | 7.3 | 7.3 | 7.3 | 7.3 | 7.4 | 7.2 | 7.1 | 7.0 | 7.0 | 7.0 | 6.8 | 6.8 |
| 6 | 7.3 | 7.2 | 7.2 | 7.2 | 7.2 | 7.2 | 7.3 | 7.4 | 7.4 | 7.1 | 7.0 | 7.0 | 6.9 | 6.8 | 6.8 | 7.3 |
| 7 | | | | | | | | | 6.9 | 6.8 | 6.8 | 6.8 | 6.7 | 6.8 | 6.8 | 6.8 |
| 8 | | | | | | | | | | | | | | | | |
| | Temperature (°C) | | | | | | | | Temperature (°C) | | | | | | | |
| 0 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | | | | | | | | |
| 1 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 2 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 3 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 4 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 6 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 7 | | | | | | | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 8 | | | | | | | | | | | | | | | | |

## Comments/Statistics

| Client: SHO108 |
|---|
| Reference: 11-1290-01-CDD |

**Test Result Comments:**
One organism died in the Control test concentration (replicate 9) on day 7.

**Data Analysis:**
Regression analysis was attempted on the data, but the assumptions of normality and equal variance were not met. Therefore, endpoints for mortality and reproduction were calculated using Spearman-Karber and Linear Interpolation models using CETIS v. 1.7.0 rev Q.

**Protocol Deviations:**
None

## Quality Assurance Information

**Culture history for adults used in the test for reference 11-1290**

**Number of young produced per brood adult:**
(Note: The third brood per adult may be on the day the test is set)

| row/replicate | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young<br>number of adults | | | | | | | | | | | |

| | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young | 5 | 5 | 7 | 6 | 5 | 6 | 5 | 6 | 4 | 4 | 4 |
| number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| number of young | 4 | 11 | 8 | 8 | 8 | 7 | 5 | 7 | 8 | 4 | 7 |
| number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAY USED | number of young | 10 | 8 | 9 | 10 | 8 | 8 | 9 | 9 | 10 | 8 | 10 |
| 2011/07/22 | number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

| | | A7 | A9 | C8 | C9 | D6 | D8 | D9 | C8 | C9 | D6 | E6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| totals (# of young in first 3 broods) | number of young | 19 | 24 | 24 | 24 | 21 | 21 | 19 | 22 | 22 | 16 | 21 |

| | |
|---|---|
| Number of young produced per organism in the last brood before use | 9 |
| Mean number of surviving young per adult over the first three broods | 21 |
| Culture mortality over the last seven days | 0 |

HydroQual Laboratories Ltd.

# Warning Chart *Ceriodaphnia*

**Test Method:** *Ceriodaphnia* Survival and Reproduction Test (7 treatments plus a control)
HydroQual Test Method: WTR-ME-019
**Reference:** Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*, 2007. Environment Canada, EPS 1/RM/21

**Test Organism:**

test species: *Ceriodaphnia dubia*
culture source: in-house
original culture source: Environment Canada
ephippia in stock culture: none
food type: YAT:Algae
frequency of feeding: daily
age of test organisms: <24 hours
culture mortality 7 days prior: 8%
culture fecundity 7 days prior within the first three broods: 19
young produced in previous brood: 9
culture condition prior to test initiation: normal
culture water: mixture of moderately hard reconstituted* water and Bow River Water (50:50)

**Test Design:**

test type: static renewal
toxicant: sodium chloride (NaCl)
test vessel: 30 mL plastic cup
test volume (mL): 15
replicates per treatment: 10
organisms per replicate: 1
feeding: daily
temperature (°C): 24-26
photoperiod: 16 hours light: 8 hours dark
light level (surface): 100-600 lux (full spectrum)
hardness adjustment: no

*Note: there are 2 subcultures within this culture source, separated by one week in age. The test is set with organisms from one subculture. The number of young a culture has is monitored daily. If young are not used that day, they are discarded, therefore organisms in tests are <24h.

**Control/Dilution Water:**

source: mixture of moderately hard reconstituted* water and Bow River Water (50:50)
pH (units): 8.0
conductance (uS/cm): 361
dissolved oxygen (mg/L): 7.2
$NH_4^+$ (mg/L): <0.1
hardness (mg $CaCO_3$/L): 123
alkalinity (mg $CaCO_3$/L): 111
total residual chlorine (mg/L): <0.01

* Note: moderately hard reconstituted water prepared as per EPS 1/RM/21

**Comments:** There were no protocol deviations during the conduct of this test.

The data and results are authorized and verified correct.

<original signed by> <original signed by>

Technical Lead Quality Coordinator




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HydroQual Laboratories Ltd.

# Warning Chart
# *Ceriodaphnia*

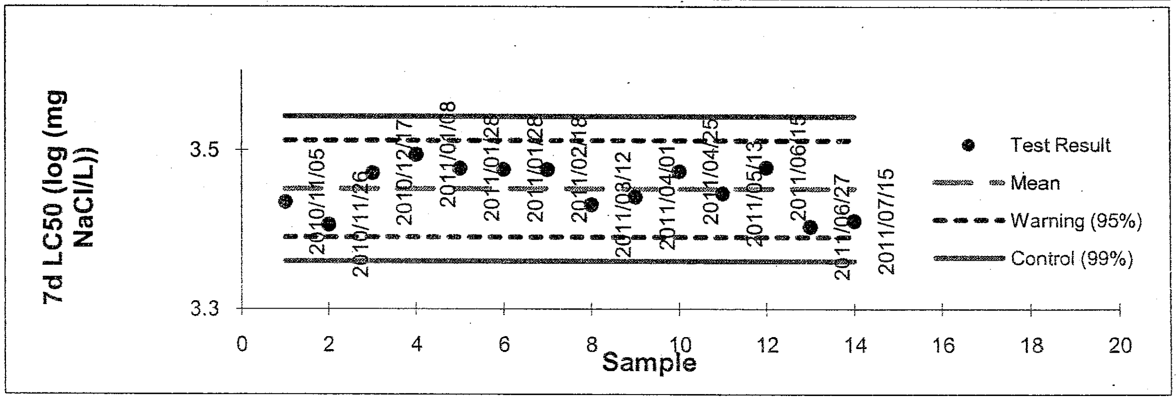
## Mortality

**Current Test**

| | | | | |
|---|---|---|---|---|
| toxicant | Sodium chloride (NaCl) | | | |
| started on | 2011/07/08 | ended on | 2011/07/15 | |
| Result (7d LC50): | 3.36 | log (mg NaCl/L); geometric mean | | |
| Confidence Limits (95%) | lower | 3.26 | upper | 3.46 |

**Historical Values**

| | | | | | |
|---|---|---|---|---|---|
| mean | 3.40 | sd | 0.03 | cv(%): | 1 |
| | lower | upper | | | |
| warning limits (±2 sd) | 3.34 | 3.46 | (95% confidence limits) | | |
| control limits (±3 sd) | 3.31 | 3.49 | (99% confidence limits) | | |



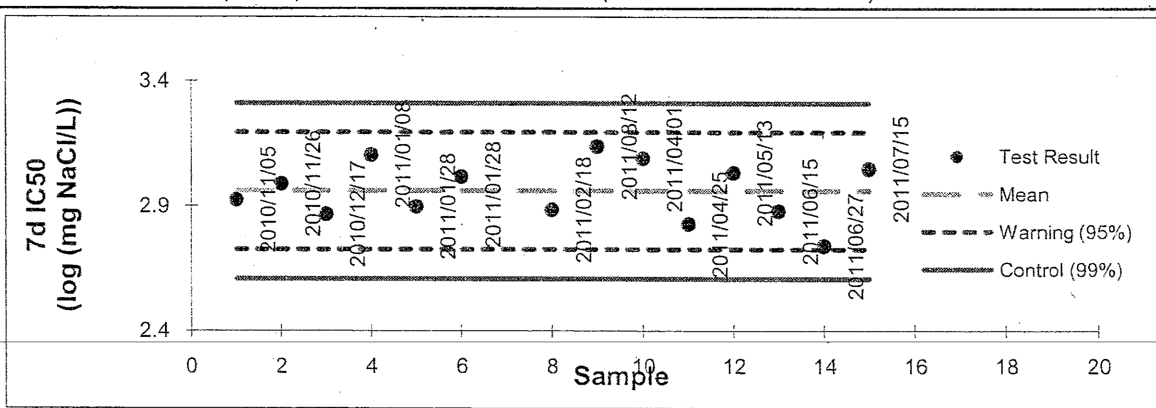

## Reproduction

**Current Test**

| | | | | |
|---|---|---|---|---|
| toxicant | Sodium chloride (NaCl) | | | |
| started on | 2011/07/08 | ended on | 2011/07/15 | |
| Result (7d IC50) | 3.05 | log (mg NaCl/L); geometric mean | | |
| Confidence Limits (95%) | lower | 2.94 | upper | 3.14 |

**Historical Values**

| | | | | | |
|---|---|---|---|---|---|
| mean | 2.96 | sd | 0.12 | cv(%): | 4 |
| | lower | upper | | | |
| warning limits (±2 sd) | 2.73 | 3.19 | (95% confidence limits) | | |
| control limits (±3 sd) | 2.61 | 3.31 | (99% confidence limits) | | |



## Quality Assurance Information

**Culture history for adults used in the test for reference QA139:**

**Number of young produced per brood adult:**
(Note: The third brood per adult may be on the day the test is set)

| | row/replicate | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | number of young | | | | | | | | | | | |
| | number of adults | | | | | | | | | | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| | number of young | | | | | | | | | | | |
| | number of adults | | | | | | | | | | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| | number of young | | | | | | | | | | | |
| | number of adults | | | | | | | | | | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| | number of young | | | | | | | | | | | |
| | number of adults | | | | | | | | | | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| | number of young | 2 | 5 | 4 | 5 | 2 | 5 | 3 | 2 | 5 | | |
| | number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| | number of young | 4 | 5 | 5 | 5 | 9 | 6 | 6 | 6 | 7 | | |
| | number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| DAY USED | number of young | 9 | 9 | 8 | 8 | 8 | 9 | 10 | 11 | 13 | | |
| 2011/07/08 | number of adults | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| | | C7 | C8 | E8 | E10 | C9 | B10 | C7 | D6 | E9 | | |
| totals (# of young in first 3 broods) | number of young | 15 | 19 | 17 | 18 | 19 | 19 | 19 | 19 | 25 | | |

| | |
|---|---|
| Number of young produced per organism in the last brood before use | 9 |
| Mean number of surviving young per adult over the first three broods | 19 |
| Culture mortality over the last seven days | 8 |





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# HydroQual Laboratories Ltd.

# Fathead minnow (7-d LC50/IC25) Test Report

| |
|---|
| Client: SHO108 |
| Reference: 11-1290-01-FMD |

## Result Summary

**Client:** Shore Gold Inc.; operation Saskatoon

**Sample:** 11497164019

**Collection:** collected on 2011/07/20 at not given by not given
**Receipt:** received on 2011/07/22 at 1030 by A. Lanuzo
**Containers:** received 2 x 20 L pails at 18 °C, in good condition with no seals and no initials
**Description:** type: water, collection method: not given

**Test:** started on 2011/07/22 ; ended on 2011/07/29

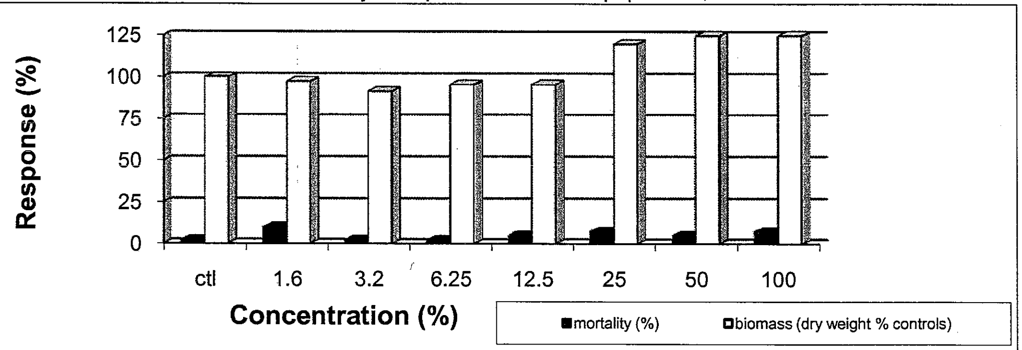
**Contents**



**Result:**

| | Endpoint (7-day) | Value | Confidence Limits (95%) lower | upper | Units | Method Calculated |
|---|---|---|---|---|---|---|
| Acute: | LC25 | >100 | | | % | could not be calculated |
| (survival) | LC50 | >100 | | | % | could not be calculated |
| Chronic: | IC25 | >100 | | | % | could not be calculated |
| (growth) | IC50 | >100 | | | % | could not be calculated |

Notes: LCx & ICx, concentrations lethal or inhibitory to 'x' percent of the test population;




The test data and results are authorized and verified correct.

<original signed by> <original signed by>

Technical Lead Quality Coordinator

## Test Conditions

| Client: SHO108 |
|---|
| Reference: 11-1290-01-FMD |

**Method:** Biological Test Method: Test of Larval Growth and Survival Using Fathead minnows, 1992. Environment Canada, EPS 1/RM/22. (amended September 2008)

**Test type:** Fathead Minnow 7-d Survival and Growth Static Renewal Test (WTR-ME-052)
**Species:** *Pimephales promelas*
**Age:** ≤ 24 hour post hatch
**Organism source:** Aquatox Inc., Hot Springs, Arkansas (Batch 20110722FM)
**Culture conditions:** temperature, 25 °C; dissolved oxygen, 95-100 % saturation
**Shipped:** 2011/07/21
**Breeding Stock Mortality:** < 1 % during the week prior to test initiation
**Organisms upon receipt:** mortality, < 1 %; temperature, 26 °C: dissolved oxygen, 11.7 mg/L
No acclimation was necessary. Test organisms maintained at 25 ± 1°C until loaded
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition, with inflated swim bladders and normal feeding behaviour.
**Organism observation:** No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.
Normal feeding behaviour was noted during the test.
**Sample initial chemistry:** pH: 7.3; EC: 6760 (µS/cm); DO: 7.8 (mg/L); temperature: 20 °C
hardness (mg CaC03/L): 588; colour: light yellow; odour: odourless
**Sample holding time:** 2 days (must be ≤ 3 days); The test was conducted with three subsamples, samples a, b, and c were for days 0 to 2, 3 to 5, and 6 to 8 respectively
**Sample storage:** 4 ± 2°C in darkness
**Test vessel:** Tests were conducted in 500 mL plastic vessels
**Test volume:** 250 mL of solution (depth of 6.5 cm), replenished daily
**Control/dilution water:** The control and dilution water was dechlorinated City of Calgary water acclimated to the test conditions; no chemicals were added to the dilution/control water
A second control was not set up for this test. However, duplicate controls are run in the reference toxicant for each batch of fish.
**Test concentrations:** 7 effluent concentrations (1.6, 3.2, 6.3, 13, 25, 50, 100% (v/v) plus a negative control)
**Test replicates:** Ten fish ≤ 24 hours old were loaded per test vessel; 4 replicates/conc.
**Feeding:** The test organisms were fed twice daily newly-hatched brine shrimp nauplii
The fish are not fed during the final 12 hours of the test
**Measurements:** pH, conductivity, dissolved oxygen and temperature were measured daily
**Sample pre-treatment:** The sample was not aerated, pH or hardness adjusted prior to or during testing.
No sample filtration, settling, or decanting occurred prior to or during testing
The dissolved oxygen concentration (mg/L) was: 6.8
The sample pH was: 7.8
**Lighting:** Overhead full spectrum fluorescent lights; ≤ 500 lux at surface
**Photoperiod:** 16h light:8h dark
**Test temperature:** 25 ± 1°C

Note: Outlined sections are protocol deviations explained on the comment page





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| |
|---|
| Client: SHO108 |
| Reference: 11-1290-01-FMD |

## Test Conditions

**Endpoint:** Survival, 7-d LC50 (with 95% confidence limits)
Biomass, 7-d IC25 (with 95% confidence limits)
Test endpoints were bracketed by at least 1 test concentration (except for <1.6% or >100 %)
No outliers were observed within the data set

**Test validity:** Control had 97% survival (must ≥ 80%)
Control had 0% abnormal behaviour (must < 20%), e.g.atypical swimming, loss of equilibrium
The average dry weight of the control fish was 0.54 (must ≥ 0.25 mg)

**Reference toxicant:** 7-d test with NaCl initiated July 22, 2011;
current results: (7-d LC50 and 95% confidence limits) = 3.14 (3.00-3.27) log (mg/L NaCl)
current results: (7-d IC25 and 95% confidence limits) = 2.70 (2.64-2.75) log (mg/L NaCl)
The reference toxicant test was performed under the same conditions as those used during this test.

Note: Outlined sections are protocol deviations explained on the comment page

## Test Data

| Client: SHO108 |
|---|
| Reference: 11-1290-01-FMD |

**Test Log:**

| Date | Day | Time | Technicians | Temperature Before Use(°C) Control | Sample |
|---|---|---|---|---|---|
| 2011/07/22 | 0 | 1200 | E. Petho / H. Stewart | 25 | 25 |
| 2011/07/23 | 1 | 1015 | E. Blais | 24 | 24 |
| 2011/07/24 | 2 | 1150 | E. Blais | 24 | 24 |
| 2011/07/25 | 3 | 1054 | N. Grebneva | 24 | 24 |
| 2011/07/26 | 4 | 1030 | R. Bradley | 25 | 25 |
| 2011/07/27 | 5 | 1430 | N. Turner | 25 | 25 |
| 2011/07/28 | 6 | 1035 | H. Caro-Riano | 25 | 25 |
| 2011/07/29 | 7 | 1030 | C. Velasco | na | na |

**Combined Mortality and Atypical Swimming Behavior (%):**

| Day | ctl | 1.6 | 3.2 | 6.3 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|
| 0 | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 1 | 0% | 0% | 0% | 3% | 0% | 0% | 0% | 0% |
| 2 | 3% | 3% | 3% | 3% | 0% | 0% | 3% | 0% |
| 3 | 3% | 3% | 3% | 3% | 3% | 5% | 3% | 3% |
| 4 | 3% | 3% | 3% | 3% | 3% | 8% | 5% | 3% |
| 5 | 3% | 8% | 3% | 3% | 5% | 8% | 5% | 3% |
| 6 | 3% | 10% | 3% | 3% | 5% | 8% | 5% | 3% |
| 7 | 3% | 10% | 3% | 3% | 5% | 8% | 5% | 8% |

**Chemistry Summary Tables:**

| | New Solutions | | | | | | | | Old Solutions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Conc. (%) | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
| **Average Values** | | | | | | | | | | | | | | | | |
| pH | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.1 | 8.0 | 7.9 | 8.1 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.1 | 8.0 |
| cond. | 368 | 445 | 547 | 743 | 1150 | 1959 | 3673 | 6786 | 393 | 456 | 567 | 754 | 1150 | 1923 | 3663 | 6717 |
| DO | 7.0 | 7.0 | 7.0 | 7.0 | 7.0 | 6.9 | 6.9 | 7.0 | 6.4 | 6.2 | 6.0 | 5.9 | 5.9 | 5.9 | 5.9 | 5.9 |
| temp | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| **Coefficients of Variation (%)** | | | | | | | | | | | | | | | | |
| pH | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| cond. | 8 | 3 | 3 | 3 | 3 | 6 | 2 | 2 | 10 | 2 | 7 | 2 | 3 | 4 | 1 | 1 |
| DO | 6 | 5 | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 4 |
| temp | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

## Test Data

Client: SHO108
Reference: 11-1290-01-FMD

**Biology (number alive):** / **Biology (% mortality):**

| Conc. (%) | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Day 1

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 |

Day 2

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 |

Day 3

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 10 | 9 | 10 | 9 | 0 | 0 | 0 | 10 | 0 | 10 | 0 | 10 |

Day 4

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 |
| b | 9 | 9 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 10 | 9 | 10 | 9 | 0 | 0 | 0 | 10 | 0 | 10 | 0 | 10 |

Day 5

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 10 | 0 | 0 | 0 | 0 | 0 | 10 | 10 | 0 |
| b | 9 | 7 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 30 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 9 | 0 | 0 | 0 | 10 | 10 | 10 | 0 | 10 |

Day 6

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 9 | 10 | 10 | 10 | 9 | 9 | 10 | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 0 |
| b | 9 | 7 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 30 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 9 | 0 | 0 | 0 | 10 | 10 | 10 | 0 | 10 |

Day 7

| Replicate | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 10 | 9 | 10 | 10 | 10 | 9 | 9 | 10 | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 0 |
| b | 9 | 7 | 10 | 10 | 10 | 10 | 9 | 10 | 10 | 30 | 0 | 0 | 0 | 0 | 10 | 0 |
| c | 10 | 10 | 9 | 10 | 9 | 9 | 10 | 10 | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 |
| d | 10 | 10 | 10 | 9 | 9 | 9 | 10 | 7 | 0 | 0 | 0 | 10 | 10 | 10 | 0 | 30 |

# Fathead minnow (7-d LC50/IC25) Test Report

Client: SHO108
Reference: 11-1290-01-FMD

Biology (number displaying atypical swimming): | Biology (% atypical swimming behavior):

| Conc. (%) | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 | ctl | 1.6 | 3.2 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replicate | Day 1 | | | | | | | | Day 1 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 2 | | | | | | | | Day 2 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 3 | | | | | | | | Day 3 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 4 | | | | | | | | Day 4 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 5 | | | | | | | | Day 5 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 6 | | | | | | | | Day 6 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Day 7 | | | | | | | | Day 7 | | | | | | | |
| a | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| b | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| c | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |





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## Test Data

Client: SHO108
Reference: 11-1290-01-FMD

### Unpreserved Dry Weights (mg)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5.0 | 5.7 | 5.2 | 5.4 | 5.2 | 6.0 | 7.6 | 7.5 |
| 5.2 | 4.5 | 5.1 | 4.5 | 5.3 | 6.7 | 6.9 | 7.9 |
| 5.7 | 5.7 | 4.4 | 5.1 | 5.0 | 7.0 | 7.9 | 6.7 |
| 5.7 | 5.2 | 5.1 | 5.5 | 5.2 | 6.2 | 7.5 | 6.5 |

**Biology Summary Tables:**

| | Mortality (%) | | | | | | | | Biomass Data (mg per fish) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| a | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 0 | 0.50 | 0.57 | 0.52 | 0.54 | 0.52 | 0.60 | 0.76 | 0.75 |
| b | 10 | 30 | 0 | 0 | 0 | 0 | 10 | 0 | 0.52 | 0.45 | 0.51 | 0.45 | 0.53 | 0.67 | 0.69 | 0.79 |
| c | 0 | 0 | 10 | 0 | 10 | 10 | 0 | 0 | 0.57 | 0.57 | 0.44 | 0.51 | 0.50 | 0.70 | 0.79 | 0.67 |
| d | 0 | 0 | 0 | 10 | 10 | 10 | 0 | 30 | 0.57 | 0.52 | 0.51 | 0.55 | 0.52 | 0.62 | 0.75 | 0.65 |
| mean | 3 | 10 | 3 | 3 | 5 | 8 | 5 | 8 | 0.54 | 0.53 | 0.49 | 0.52 | 0.52 | 0.65 | 0.75 | 0.71 |
| sd | 5 | 14 | 5 | 5 | 6 | 5 | 6 | 15 | 0.04 | 0.06 | 0.04 | 0.04 | 0.01 | 0.05 | 0.04 | 0.07 |
| cv(%) | 200 | 141 | 200 | 200 | 115 | 67 | 115 | 200 | 7 | 11 | 7 | 9 | 3 | 8 | 6 | 9 |

| Average Dry Weight of Surviving Control Fish: | 0.54 | Biomass as a Percent of Controls | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 100 | 97 | 91 | 96 | 96 | 120 | 138 | 132 |

## Test Data

Client: SHO108
Reference: 11-1290-01-FMD

**Chemistry:**

| Conc. (%) | New Solutions ctl | 1.6 | 3 | 6.25 | 12.5 | 25 | 50 | 100 | Old Solutions ctl | 1.6 | 3 | 6.25 | 12.5 | 25 | 50 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Day** | **pH (units)** | | | | | | | | **pH (units)** | | | | | | | |
| 0 | 8.2 | 8.2 | 8.3 | 8.3 | 8.2 | 8.1 | 8.0 | 7.8 | | | | | | | | |
| 1 | 8.4 | 8.4 | 8.4 | 8.4 | 8.3 | 8.2 | 8.1 | 7.9 | 8.4 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.2 |
| 2 | 8.1 | 8.1 | 8.0 | 7.9 | 8.0 | 8.0 | 8.0 | 7.9 | 8.1 | 8.0 | 8.0 | 7.9 | 7.9 | 7.9 | 7.8 | 7.9 |
| 3 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.0 | 7.9 | 7.8 | 7.7 | 7.8 | 7.8 | 7.8 | 7.9 | 7.9 | 8.0 | 8.0 |
| 4 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.0 | 7.9 | 7.8 | 8.0 | 7.9 | 7.8 | 7.8 | 7.9 | 7.9 | 7.9 | 7.9 |
| 5 | 8.3 | 8.3 | 8.3 | 8.3 | 8.3 | 8.2 | 8.1 | 8.0 | 8.1 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.1 | 8.1 |
| 6 | 8.2 | 8.3 | 8.4 | 8.4 | 8.3 | 8.3 | 8.2 | 8.0 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.2 | 8.1 |
| 7 | | | | | | | | | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.1 | 8.0 |
| 8 | | | | | | | | | | | | | | | | |
| | **Conductivity (µS/cm)** | | | | | | | | **Conductivity (µS/cm)** | | | | | | | |
| 0 | 395 | 444 | 541 | 744 | 1153 | 1940 | 3690 | 6670 | | | | | | | | |
| 1 | 406 | 469 | 555 | 756 | 1160 | 1979 | 3700 | 6870 | 404 | 464 | 540 | 732 | 1140 | 1906 | 3600 | 6580 |
| 2 | 398 | 453 | 567 | 749 | 1163 | 1981 | 3730 | 6910 | 399 | 451 | 563 | 743 | 1169 | 1941 | 3710 | 6830 |
| 3 | 360 | 430 | 534 | 742 | 1157 | 1906 | 3670 | 6630 | 357 | 444 | 543 | 748 | 1118 | 1851 | 3640 | 6640 |
| 4 | 340 | 426 | 522 | 705 | 1102 | 1871 | 3560 | 6780 | 348 | 441 | 552 | 771 | 1197 | 1970 | 3670 | 6740 |
| 5 | 347 | 456 | 572 | 778 | 1207 | 2200 | 3770 | 6830 | 472 | 461 | 546 | 734 | 1118 | 1870 | 3670 | 6710 |
| 6 | 333 | 440 | 537 | 725 | 1111 | 1839 | 3590 | 6810 | 383 | 466 | 572 | 773 | 1198 | 2080 | 3740 | 6800 |
| 7 | | | | | | | | | 388 | 467 | 655 | 774 | 1108 | 1842 | 3610 | 6720 |
| 8 | | | | | | | | | | | | | | | | |
| | **Dissolved Oxygen (mg/L)** | | | | | | | | **Dissolved Oxygen (mg/L)** | | | | | | | |
| 0 | 6.8 | 6.7 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | 6.8 | | | | | | | | |
| 1 | 6.5 | 6.5 | 6.5 | 6.5 | 6.5 | 6.4 | 6.4 | 6.4 | 6.4 | 6.4 | 6.0 | 5.8 | 6.1 | 6.0 | 6.0 | 6.0 |
| 2 | 6.6 | 6.6 | 6.6 | 6.6 | 6.5 | 6.5 | 6.4 | 6.3 | 6.1 | 6.1 | 6.1 | 5.9 | 5.9 | 5.9 | 6.0 | 5.9 |
| 3 | 7.5 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 7.4 | 6.4 | 6.1 | 5.9 | 5.9 | 6.0 | 5.8 | 6.0 | 6.1 |
| 4 | 7.2 | 7.1 | 7.1 | 7.0 | 7.0 | 7.0 | 7.0 | 7.1 | 5.6 | 5.6 | 5.6 | 5.6 | 5.5 | 5.6 | 5.6 | 5.6 |
| 5 | 7.4 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 | 6.5 | 6.1 | 5.8 | 5.7 | 5.6 | 5.5 | 5.5 | 5.6 |
| 6 | 7.3 | 7.2 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 7.5 | 6.7 | 6.2 | 6.1 | 6.1 | 5.9 | 5.9 | 5.8 | 5.8 |
| 7 | | | | | | | | | 7.0 | 7.0 | 6.6 | 6.5 | 6.4 | 6.4 | 6.3 | 6.2 |
| 8 | | | | | | | | | | | | | | | | |
| | **Temperature (°C)** | | | | | | | | **Temperature (°C)** | | | | | | | |
| 0 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | | | | | | | | |
| 1 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 2 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 3 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 | 24 |
| 4 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 5 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 6 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 7 | | | | | | | | | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| 8 | | | | | | | | | | | | | | | | |

## Comments/Statistics

Client: SHO108
Reference: 11-1290-01-FMD

**Test Result Comments:**
None

**Data Analysis:**
Endpoints for mortality could not be calculated. No effect occurred.

Endpoints for biomass could not be calculated. No effect occurred.

**Protocol Deviations:**
None

HydroQual Laboratories Ltd.

# Warning Chart
# Fathead minnow

**Test Method:** 7 days Fathead minnow Survival and Growth Test (7 treatments plus a control)
HydroQual Test Method: WTR-ME-046

**Reference:** Biological Test Method: Test of Larval Growth and Survival Using Fathead minnows, 1992. Environment Canada, EPS 1/RM/22. (amended September 2008)

**Test Organism:**

test species: *Pimephales promelas*
culture source: Aquatox (Arkansas, USA)
temp of breeding aquaria: 23 - 26 °C
food type: frozen brine shrimp
frequency of feeding: daily
breeding colony mortality: <1% (last 7 days)
age of test organisms: <24 hours
condition prior to test initiation: normal
batch number: 20110722FM

**Test Design:**

test type: static renewal
toxicant: sodium chloride
test vessel: polypropelyene cups, 11 x 9 cm
volume of test vessel (ml): 500
test volume (ml): 250
depth of test solution: >3 cm
replicates per treatment: 4 replicates
organisms per replicate: 10
feeding: twice daily
temperature (°C): 24-26
photoperiod: 16 hours light: 8 hours dark
light level (surface): 100-500 lux (full spectrum)

**Control/Dilution Water:**

source: dechlorinated City of Calgary tap water
no chemicals were added to the dilution water
pH (units): 7.0
conductance (µS/cm): 382
dissolved oxygen (mg/L): 6.4
$NH_4^+$ (mg/L): <0.1
hardness (mg $CaCO_3$/L): 166
alkalinity (mg $CaCO_3$/L): 159
total residual chlorine (mg/L): <0.01

**Comments:**

The data and results are authorized and verified correct.

<original signed by>
Technical Lead

<original signed by>
Quality Coordinator





HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

# HydroQual Laboratories Ltd.

# Warning Chart Fathead minnow

## Mortality

### Current Test

toxicant Sodium Chloride (NaCl)

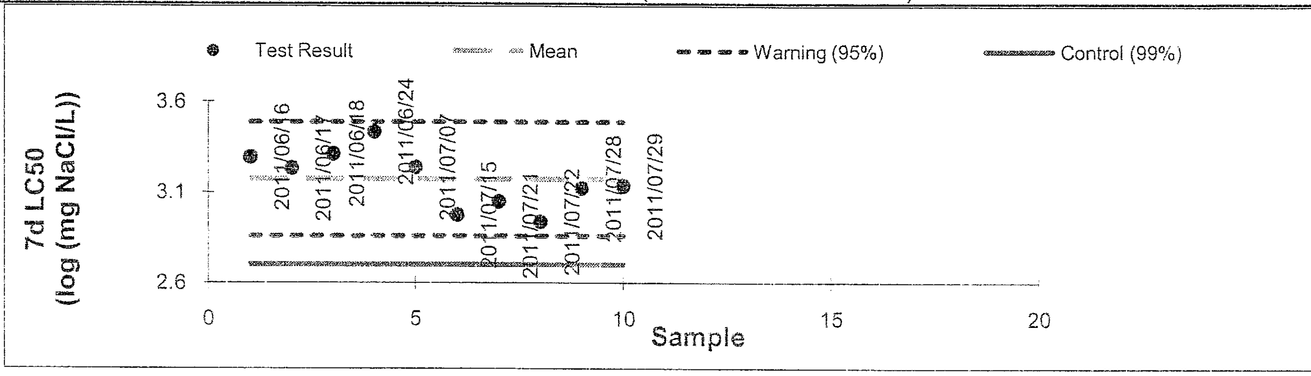
started on 2011/07/22 ended on 2011/07/29

Result (7 d LC50): 3.14 log (mg NaCl/L); geometric mean

Confidence Limits (95%) lower 3.00 upper 3.27

### Historical Values

| | | | | | |
|---|---|---|---|---|---|
| mean | 3.17 | sd | 0.16 | cv(%): | 5 |
| | lower | upper | | | |
| warning limits (±2 sd) | 2.86 | 3.49 | (95% confidence limits) | | |
| control limits (±3 sd) | 2.70 | 3.65 | (99% confidence limits) | | |




## Biomass

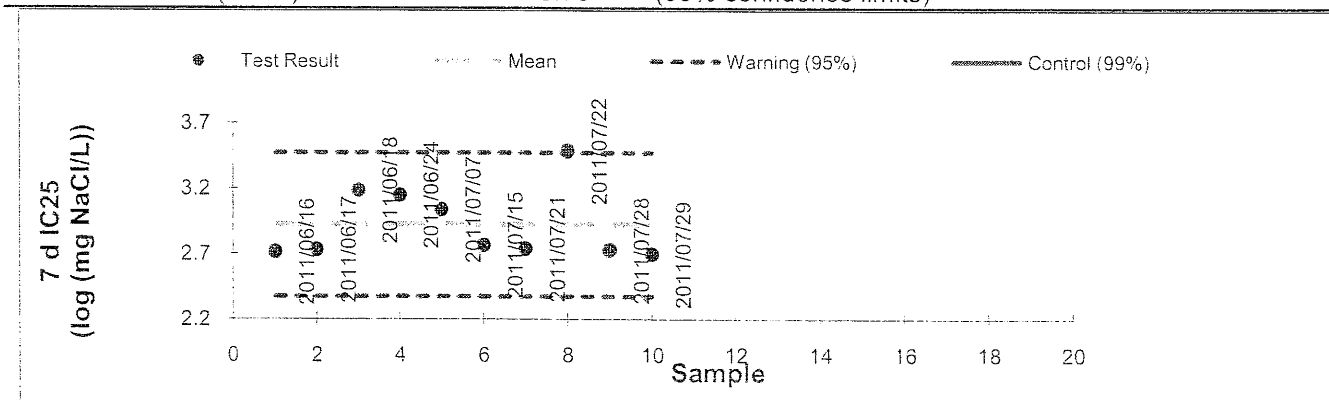
started on 2011/07/22 ended on 2011/07/29

Result (7 d IC25): 2.70 log (mg NaCl/L); geometric mean

Confidence Limits (95%) lower 2.64 upper 2.75

### Historical Values

| | | | | | |
|---|---|---|---|---|---|
| mean | 2.92 | sd | 0.27 | cv(%): | 9 |
| | lower | upper | | | |
| warning limits (±2 sd) | 2.38 | 3.47 | (95% confidence limits) | | |
| control limits (±3 sd) | 2.10 | 3.75 | (99% confidence limits) | | |




notes: sd, standard deviation; cv, coefficient of variance; N/A, could not be calculated





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# Appendix C

# Acclimation of *Ceriodaphnia dubia* to High Hardness Conditions

# Evaluation of pre-acclimation on the sensitivity of *Ceriodaphnia dubia* to high hardness and Total Dissolved Solids

**Final Report**

Report date: August 3, 2012

Submitted to:

**AMEC**
Saskatoon, SK

8664 Commerce Court
Burnaby, BC
V5A 4N7

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF APPENDICES

## 1.0 INTRODUCTION

Nautilus Environmental conducted culturing of test organisms and toxicity testing to evaluate the effect of pre-acclimation of *Ceriodaphnia dubia* to culture waters containing elevated hardness and total dissolved solids (TDS) on the sensitivity of this species to a sample containing high TDS, using a three brood (6 – 8 day) survival and reproduction test.

This report describes the results of the acclimation and toxicity tests and the relationships of elevated TDS and toxicity. The results presented herein relate only to the composition of the samples tested. Copies of raw laboratory data sheets and statistical analysis for each test species are provided in Appendix A. Analytical chemistry data are presented in Appendix B.

## 2.0 METHODS

### 2.1 Pre-acclimation

*C. dubia* were pre-acclimated for multiple generations under three sets of conditions:

1) Usual laboratory culture water, which is comprised of Perrier water diluted to ~25% with deionized water, with a hardness of 80 to 100 mg/L as $CaCO_3$.
2) Water prepared to a hardness of 200 mg/L as $CaCO_3$, with an ionic balance (i.e., ratios of major ions) comparable to that anticipated in the sample. This water was comprised of Perrier water diluted to 20% with deionized water, and with various salts added (see Table 1 for details);
3) Water prepared to a hardness of 500 mg/L as $CaCO_3$, with a similar concentration of calcium, magnesium, and bicarbonate as anticipated in the site water, and containing approximately 50% of the anticipated sulphate and potassium, 30% of the anticipated sodium, and 25% of the anticipated chloride. This water was prepared by addition of various salts to a 80% solution of Perier water diluted with deionized water (Table 1).

Acclimation was conducted over a series of generations in which the ionic strength was gradually increased.

**Table 1.** Nominal concentrations (mg/L) of major salts, and ions used to prepare culture waters in comparison to the anticipated sample.

| Constituent Added | Laboratory water | 200 mg/L hardness | 500 mg/L hardness | Anticipated sample (500 mg/L hardness) |
|---|---|---|---|---|
| Perrier water | 25%(v/v) | 20%(v/v) | 80%(v/v) | |
| **Salts added** | | | | |
| NaCl | - | 951.0 | 559.0 | |
| KCl | - | 41.5 | 51.0 | |
| $CaSO_4.2H_2O$ | - | 97.4 | 50.0 | |
| $MgSO_4$ | - | 82.0 | 198.0 | |
| $Na_2SO_4$ | - | 238.0 | 213.0 | |
| $NaHCO_3$ | - | 143.5 | 192.0 | |
| **Ions** | | | | |
| $Na^+$ | 2.3 | 492 | 349 | 1188 |
| $Mg^{2+}$ | 0.9 | 17 | 43 | 43 |
| $K^+$ | 0.1 | 22 | 27 | 55 |
| $Ca^{2+}$ | 36.8 | 52 | 129 | 129 |
| $Cl^-$ | 5.2 | 601 | 380 | 1520 |
| $SO_4^{2-}$ | 8.2 | 287 | 356 | 712 |
| $HCO_3^-$ | 97.5 | 182 | 451 | 451 |
| **Total** | **151** | **1654** | **1736** | **4098** |

## 2.2 Toxicity tests

Toxicity tests were conducted using the three-brood (6 to 8 day) survival and reproduction test using *C. dubia*, according to Environment Canada (2007) guidelines, with the exception that 20 replicates were used in the test rather than 10. Increased replication was employed in order to increase the statistical power of the test. Test methods for the toxicity tests are summarized in Table 2.

Toxicity tests were only conducted using organisms that had been pre-acclimated under usual laboratory conditions (80 – 100 mg/L hardness) and high hardness (~500 mg/L) conditions. The culture of organisms that had been pre-acclimated to water with ~200 mg/L hardness did not meet the health requirements to initiate the test within the holding time for the sample, although that culture had been performing well prior to arrival of the sample, and continued to perform well in the weeks subsequent to the sample delivery. Tests used the culture water that had been used to acclimate the test organisms for preparing dilutions of the sample.

The sample, identified as PTW1, was collected by AMEC on June 11, 2012, and delivered to the Nautilus Environmental laboratory by Purolator on June 13. The sample was 1.8°C and in good condition upon receipt. The toxicity tests were initiated on the day of receipt (June 13).

A reference toxicant test was conducted concurrently with the tests using sodium chloride as the toxicant and using organisms that had been cultured under usual laboratory conditions. The results from this test were compared with data from historical tests conducted in the laboratory to evaluate whether the sensitivity of the test organisms was appropriate, and within the range of mean plus or minus two standard deviations of the previous twenty test results.

**Table 2.** Summary of test conditions for the *Ceriodaphnia dubia* survival and reproduction test.

| | |
|---|---|
| Test organism | *Ceriodaphnia dubia* |
| Test organism source | In-house culture, pre-acclimated to specific hardnesses |
| Test organism age | < 24-h old neonates produced within 12 hr |
| Test type | Static-renewal |
| Test duration | 7 ± 1 day |
| Test chamber | 20-mL test tube |
| Test solution volume | 15 mL |
| Test concentrations (% sample) | Seven concentrations, plus laboratory control (Phase 1)<br>Five concentrations, plus laboratory control (Phase 2) |
| Number of replicates | 20 |
| Test solution renewal | Daily |
| Test temperature | 25 ± 1°C |
| Number of organisms/chamber | 1 |
| Feeding | Daily, with *Pseudokirchneriella subcapitata* and YCT |
| Light intensity | 100 to 600 lux |
| Photoperiod | 16 hours light/8 hours dark |
| Aeration | None |
| Test protocol | Environment Canada (2007), EPS 1/RM/21 |
| Test endpoints | Survival and reproduction |
| Test acceptability criterion for controls | ≥80% survival; ≥15 young per surviving control female; ≥60% of controls producing three or more broods |

Statistical analyses were based on the percentage dilution of the samples. The corresponding TDS was calculated on the basis of extrapolation of measured concentrations of major ions (i.e., Ca, Mg, Na, K, Cl, $SO_4$ and $HCO_3$), which were summed to provide a measure of TDS.

The data were analyzed using trimmed Spearman-Karber to produce LC50 estimates and linear interpolation of log-transformed concentration data for reproductive endpoints. Statistical analyses for all the tests were performed using CETIS (Tidepool Scientific Software, 2011).

### 2.3 Additional Acclimation

Following completion of the toxicity tests, the pre-acclimation process in the high hardness (500 mg/L) culture was continued with the goal of reaching approximately 4,000 mg TDS/L and the same ion balance of ions as the anticipated sample. Reproduction was observed at a TDS as high as a nominal concentration of 2,490 mg/L when the culture were terminated.

### 2.4 Quality Assurance/Quality Control (QA/QC)

Nautilus follows a comprehensive QA/QC program to ensure that all data generated are of high quality and are scientifically defensible. To meet these objectives, quality control procedures include the following:

- Negative controls to ensure that appropriate testing performance criteria are met;
- Positive controls to assess the health and sensitivity of the test organisms;
- Use of appropriate species, life stage and test methods to meet the study objectives;
- Appropriate number of replicates to allow the proper statistical analyses;
- Calibration and proper maintenance of instruments to ensure accurate measurements;
- Proper documentation and recordkeeping to allow traceability of performance;
- Adequate supervision and training of staff to ensure that methods are followed;
- Proper handling and storage of samples to ensure sample integrity;
- Procedures in place to address issues that may arise during testing and ensure the implementation of appropriate corrective actions; and
- Rigorous review of data by a Registered Professional Biologist to ensure they are of good quality and are scientifically defensible prior to release to the client.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Pre-acclimation

*C. dubia* were successfully acclimated to each of the three water types. The 200 and 500 mg/L hardness waters contained nominal concentrations of 1654 and 1736 mg/L TDS, indicating that this species was able to survive and reproduce normally under these conditions.

The results of the pre-acclimation indicated that *C. dubia* cultures could perform successfully in culture water containing hardness of 500 mg/L and nominal TDS corresponding to approximately 40% to 60% of the anticipated sample (i.e., TDS of 1,654 to 2,490 mg/L), but could not tolerate TDS exceeding 4,000 mg/L.

It should be noted that it was difficult to maintain target concentrations of $CaCO_3$ in the high hardness culturing solution This culture water, which was also used for dilutions, contained 1,508 mg/L at the start of the test and 1,347 mg/L TDS at the end of the test. The measured concentrations of major ions were similar to the target values with the exception of $Ca^{2+}$ and $HCO_3^-$, which were both lower than the target value, indicating that these ions had partially precipitated out as $CaCO_3$; this would have been exacerbated by the relatively high temperature of the test (i.e., 25°C), since this salt exhibits lower solubility with increasing temperature.

### 3.2 Toxicity tests

The results of the toxicity tests conducted using organisms that had been cultured in usual laboratory water (80 - 100 mg/L hardness water) and 500 mg/L hardness water are shown in Tables 3 and 4. The IC25 for reproduction of *C. dubia* was 27.6% for the organisms cultured in the usual laboratory water and 16.4% for the high hardness acclimated organisms. Thus, on a percent sample basis, the *C. dubia* that had been pre-acclimated to high hardness conditions exhibited a higher degree of sensitivity to the sample than the regular cultures.

However, when presented on the basis of TDS in the test solutions (based on the sum of measured ions), the high hardness acclimated organisms were less sensitive to TDS than the organisms from the normal culture. The IC25 of 27.6% in the usual laboratory water corresponded to a TDS of 1,253 mg/L, whereas the IC25 of 16.4% using 500 mg/L hardness water for dilution corresponded to a TDS of 1,889 mg/L. Thus, the high hardness acclimated organisms demonstrated a 25% reduction in reproduction at a concentration of TDS (1,889 mg/L) that was 50% higher than did the organisms from the usual culture water (1,252 mg/L).

The apparent contradiction between the high hardness test exhibiting higher sensitivity on a percent sample basis, but a lower sensitivity on the basis of TDS, stems from the fact that the water used for the high hardness culture, as well as for dilution water in the test with those organisms, had much higher TDS itself (~1,428 mg/L) than the usual laboratory water (~169 mg/L). Thus, diluting the sample with high hardness water resulted in a smaller reduction in TDS than diluting with usual laboratory dilution water.

The results from these tests demonstrate that *C. dubia* do indeed acclimate to changes in ionic conditions, resulting in higher tolerance to TDS. The IC25 of 1,889 mg/L and the NOEC of 1,781 mg/L TDS corresponds well with the results from pre-acclimation, and collectively suggest that a threshold for effects on this species was approximately 1,889 mg/L following acclimation. The acclimation studies that were continued after the toxicity testing suggest that further acclimation may be possible.

**Table 3.** Toxicity test results for the 7-day *Ceriodaphnia dubia* survival and reproduction test in usual laboratory water. Reproduction data are presented as mean ± SD.

| % sample | Measured (Sum of Ions mg/L) | Survival (%) | Reproduction (No. of Young/Female) |
|---|---|---|---|
| Control | 169 | 100 | 16.0 ± 6.7 |
| 1.6 | 237 | 100 | 14.9 ± 6.5 |
| 3.1 | 301 | 90 | 15.1 ± 9.6 |
| 6.2 | 426 | 100 | 21.2 ± 7.4 |
| 12.5 | 666 | 100 | 21.8 ± 8.3 |
| 25 | 1199 | 95 | 14.8 ± 8.8 |
| 50 | 2254 | 75 | 4.8 ± 4.9 * |
| 75 | 3400 | 0 | 0 * |
| 100 | 4459 | 0 | 0 * |
| **Test endpoint (% sample)** | | | |
| | LC50 (95% CL) | 48.1 (41.1 – 56.4)% | -- |
| | IC25 (95% CL) | -- | 27.6 (20.4 – 32.4)%<br>1,253 mg/L |
| | IC50 (95% CL) | -- | 37.6 (31.8 – 43.7)% |
| | NOEC | | 25% |
| | LOEC | | 50% |

LC = Lethal Concentration; IC = Inhibition Concentration; SD = Standard Deviation; CL = Confidence Limits; * Significantly different from control.

**Table 4.** Toxicity test results for the 7-day *Ceriodaphnia dubia* survival and reproduction test in high hardness (500 mg/L) water. Reproduction data are presented as mean ± SD.

| % sample | Measured (Sum of Ions mg/L) | Survival (%) | Reproduction (No. of Young/Female) |
|---|---|---|---|
| Control | 1428 | 100 | 15.9 ± 6.3 |
| 1.6 | 1471 | 100 | 17.8 ± 6.5 |
| 3.1 | 1507 | 100 | 16.1 ± 7.5 |
| 6.2 | 1494 | 90 | 17.8 ± 9.6 |
| 12.5 | 1781 | 90 | 15.4 ± 8.4 |
| 25 | 2129 | 85 | 7.7 ± 5.3 * |
| 50 | 2862 | 50 | 2.0 ± 2.4 * |
| 75 | 3467 | 10 | 0 * |
| 100 | 4459 | 0 | 0 * |
| **Test endpoint (% sample)** | | | |
| | LC50 (95% CL) | 37.8 (30.5 – 47.0)% | -- |
| | IC25 (95% CL) | -- | 16.4 (11.0 – 18.6)%<br>1,889 mg/L |
| | IC50 (95% CL) | -- | 23.5 (19.4 – 27.8)% |
| | NOEC | | 12.5% |
| | LOEC | | 25% |

LC = Lethal Concentration; IC = Inhibition Concentration; SD = Standard Deviation; CL = Confidence Limits; * Significantly different from control.

## 4.0 QUALITY ASSURANCE/QUALITY CONTROL

All the tests reported herein met the acceptability criteria for test validity specified in the respective protocols, and water quality parameters measured during the toxicity tests were within acceptable ranges.

The concurrent reference toxicant test conducted during this testing program fell within the laboratory's acceptable historical range of values (i.e., mean ± 2 SD) (Table 5).

**Table 5.** Reference toxicant test results for *Ceriodaphnia dubia*.

| | Result (with 95% CL) | Acceptable range | CV (%) | Test Date |
|---|---|---|---|---|
| Survival (LC50) | 1.6 (1.0 – 2.1) | 1.5 – 2.3 | 10 | 13 June 2012 |
| Reproduction (IC50) | 1.4 (1.1 – 2.0) | 0.9 – 1.7 | 18 | 13 June 2012 |

## 5.0 REFERENCES


Environment Canada. 2007. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series. Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Tidepool Scientific Software. 2011. CETIS comprehensive environmental toxicity information system, version 1.8.0. Tidepool Scientific Software, McKinleyville, CA. 222 pp.

# APPENDIX A – Toxicity Test Data

# *Ceriodaphnia dubia* Summary Sheet

Client: AMEC
Work Order No.: 12285

Start Date/Time: June 14/12 @1530h
Set up by: KB

**Sample Information:**

Sample ID: PTW-1 (with 20% Perrier dilution water)
Sample Date: June 11/12
Date Received: June 13/12
Sample Volume: 16 X 2L

**Test Validity Criteria:**

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

**WQ Ranges:**

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6 to 8.5

**Test Organism Information:**

Broodstock No.: ~~060412~~ KB 060712
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: KB ~~15 30~~ KB 26
Mortality (%) in previous 7 d: KB ~~15~~ 13
Individual female # used ≥8 young on test day: ~~2,3,4,6,10,12,18,24,29,30,34,8,11~~ KB
5,8,12,13,14,19,23,25,26,28,33,34,35,37

**NaCl Reference Toxicant Results:**

Reference Toxicant ID: Cd82
Stock Solution ID: 12NaO1
Date Initiated: June13/12

7-d LC50 (95% CL): 1.6 (1.0 - 2.1) g/L NaCl
7-d IC50 (95% CL): 1.4 (1.1 - 2.0) g/L NaCl

7-d LC50 Reference Toxicant Mean and Historical Range: 1.9 (1.5-2.3) g/L NaCl CV (%): 10
7-d IC50 Reference Toxicant Mean and Historical Range: 1.2 (0.9-1.7) g/L NaCl CV (%): 18

Test Results:

| | Survival | Reproduction |
|---|---|---|
| LC50 %(v/v) (95% CL) | 48.1 (41.1 - 56.4) | |
| IC25 %(v/v) (95% CL) | | 27.6 (20.4 - 32.4) |
| IC50 %(v/v) (95% CL) | | 37.6 (31.8 - 43.7) |

Reviewed by: JGL

Date reviewed: July 23/12

# CETIS Analytical Report

Report Date: 03 Jul-12 12:41 (p 1 of 2)
Test Code: 12285a | 19-4965-0754

**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 04-3671-4682 | **Endpoint:** | 7d Survival Rate | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:40 | **Analysis:** | Untrimmed Spearman-Kärber | **Official Results:** | Yes |
| **Batch ID:** | 15-9127-9678 | **Test Type:** | Reproduction-Survival (7d) | **Analyst:** | Krysta Banack |
| **Start Date:** | 14 Jun-12 15:30 | **Protocol:** | EC/EPS 1/RM/21 | **Diluent:** | 20% Perrier Water |
| **Ending Date:** | 21 Jun-12 13:45 | **Species:** | Ceriodaphnia dubia | **Brine:** | |
| **Duration:** | 6d 22h | **Source:** | In-House Culture | **Age:** | <24h |
| **Sample ID:** | 14-9508-3321 | **Code:** | 591D2939 | **Client:** | AMEC |
| **Sample Date:** | 11 Jun-12 16:15 | **Material:** | Water Sample | **Project:** | |
| **Receive Date:** | 13 Jun-12 09:30 | **Source:** | AMEC | | |
| **Sample Age:** | 71h | **Station:** | PTW-1 | | |

### Spearman-Kärber Estimates

| Threshold Option | Threshold | Trim | Mu | Sigma | EC50 | 95% LCL | 95% UCL |
|---|---|---|---|---|---|---|---|
| Control Threshold | 0 | 0.00% | 1.682 | 0.03435 | 48.14 | 41.09 | 56.39 |

### 7d Survival Rate Summary

Calculated Variate(A/B)

| C-% | Control Type | Count | Mean | Min | Max | Std Err | Std Dev | CV% | %Effect | A | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 1.6 | | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 3.1 | | 20 | 0.9 | 0 | 1 | 0.06882 | 0.3078 | 34.2% | 10.0% | 18 | 20 |
| 6.3 | | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 13 | | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 25 | | 20 | 0.95 | 0 | 1 | 0.05 | 0.2236 | 23.54% | 5.0% | 19 | 20 |
| 50 | | 20 | 0.75 | 0 | 1 | 0.09934 | 0.4443 | 59.23% | 25.0% | 15 | 20 |
| 75 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% | 0 | 20 |
| 100 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% | 0 | 20 |

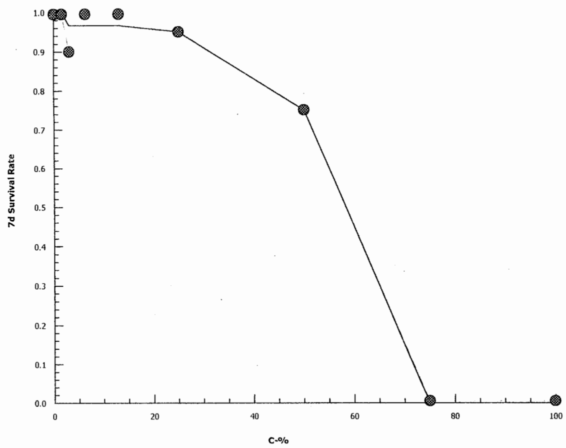
### 7d Survival Rate Detail

| C-% | Control Type | Rep 1 | Rep 2 | Rep 3 | Rep 4 | Rep 5 | Rep 6 | Rep 7 | Rep 8 | Rep 9 | Rep 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1.6 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3.1 | | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6.3 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 25 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 50 | | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 |
| | | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 75 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 04-3671-4682 | **Endpoint:** | 7d Survival Rate | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:40 | **Analysis:** | Untrimmed Spearman-Kärber | **Official Results:** | Yes |

## Graphics



# CETIS Analytical Report



**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 10-0775-7044 | **Endpoint:** | Reproduction | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:41 | **Analysis:** | Linear Interpolation (ICPIN) | **Official Results:** | Yes |

| | | | | | |
|---|---|---|---|---|---|
| **Batch ID:** | 15-9127-9678 | **Test Type:** | Reproduction-Survival (7d) | **Analyst:** | Krysta Banack |
| **Start Date:** | 14 Jun-12 15:30 | **Protocol:** | EC/EPS 1/RM/21 | **Diluent:** | 20% Perrier Water |
| **Ending Date:** | 21 Jun-12 13:45 | **Species:** | Ceriodaphnia dubia | **Brine:** | |
| **Duration:** | 6d 22h | **Source:** | In-House Culture | **Age:** | <24h |

| | | | | | |
|---|---|---|---|---|---|
| **Sample ID:** | 14-9508-3321 | **Code:** | 591D2939 | **Client:** | AMEC |
| **Sample Date:** | 11 Jun-12 16:15 | **Material:** | Water Sample | **Project:** | |
| **Receive Date:** | 13 Jun-12 09:30 | **Source:** | AMEC | | |
| **Sample Age:** | 71h | **Station:** | PTW-1 | | |

**Linear Interpolation Options**

| X Transform | Y Transform | Seed | Resamples | Exp 95% CL | Method |
|---|---|---|---|---|---|
| Log(X+1) | Linear | 525678 | 200 | Yes | Two-Point Interpolation |

**Point Estimates**

| Level | % | 95% LCL | 95% UCL | TU | 95% LCL | 95% UCL |
|---|---|---|---|---|---|---|
| IC5 | 15.82 | 13.52 | 26.25 | 6.32 | 3.809 | 7.394 |
| IC10 | 19.21 | 15.12 | 27.59 | 5.205 | 3.624 | 6.612 |
| IC15 | 23.29 | 16.82 | 29.04 | 4.294 | 3.443 | 5.946 |
| IC20 | 25.99 | 18.49 | 30.71 | 3.847 | 3.256 | 5.407 |
| IC25 | 27.65 | 20.39 | 32.37 | 3.616 | 3.089 | 4.905 |
| IC40 | 33.27 | 27.19 | 38.3 | 3.006 | 2.611 | 3.677 |
| IC50 | 37.61 | 31.8 | 43.7 | 2.659 | 2.288 | 3.145 |

**Reproduction Summary** — **Calculated Variate**

| C-% | Control Type | Count | Mean | Min | Max | Std Err | Std Dev | CV% | %Effect |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 20 | 16.05 | 4 | 34 | 1.493 | 6.677 | 41.6% | 0.0% |
| 1.6 | | 20 | 14.9 | 4 | 24 | 1.451 | 6.488 | 43.54% | 7.17% |
| 3.1 | | 20 | 15.1 | 0 | 30 | 2.143 | 9.586 | 63.48% | 5.92% |
| 6.3 | | 20 | 21.15 | 7 | 34 | 1.65 | 7.379 | 34.89% | -31.78% |
| 13 | | 20 | 21.8 | 3 | 33 | 1.849 | 8.269 | 37.93% | -35.83% |
| 25 | | 20 | 14.8 | 0 | 23 | 1.96 | 8.764 | 59.21% | 7.79% |
| 50 | | 20 | 4.75 | 0 | 17 | 1.088 | 4.865 | 102.4% | 70.4% |
| 75 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% |
| 100 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% |



Analyst:________ QA: JBh July 23/12

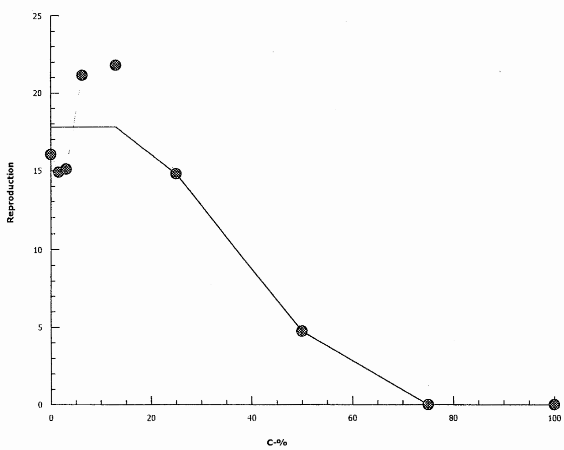
**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 10-0775-7044 | **Endpoint:** | Reproduction | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:41 | **Analysis:** | Linear Interpolation (ICPIN) | **Official Results:** | Yes |

### Reproduction Detail

| C-% | Control Type | Rep 1 | Rep 2 | Rep 3 | Rep 4 | Rep 5 | Rep 6 | Rep 7 | Rep 8 | Rep 9 | Rep 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 19 | 12 | 13 | 16 | 13 | 20 | 21 | 9 | 16 | 16 |
| | | 22 | 12 | 4 | 11 | 14 | 34 | 24 | 18 | 7 | 20 |
| 1.6 | | 19 | 24 | 17 | 5 | 11 | 20 | 5 | 4 | 6 | 18 |
| | | 11 | 19 | 23 | 13 | 12 | 16 | 11 | 22 | 21 | 21 |
| 3.1 | | 29 | 30 | 26 | 0 | 11 | 5 | 19 | 2 | 7 | 16 |
| | | 11 | 11 | 0 | 21 | 18 | 22 | 21 | 23 | 24 | 6 |
| 6.3 | | 30 | 15 | 18 | 31 | 18 | 21 | 12 | 7 | 21 | 14 |
| | | 34 | 29 | 27 | 15 | 27 | 22 | 21 | 19 | 13 | 29 |
| 13 | | 27 | 20 | 20 | 27 | 27 | 4 | 23 | 3 | 27 | 10 |
| | | 25 | 29 | 18 | 19 | 33 | 20 | 27 | 18 | 29 | 30 |
| 25 | | 22 | 23 | 23 | 20 | 22 | 18 | 2 | 21 | 0 | 14 |
| | | 17 | 22 | 0 | 19 | 18 | 23 | 3 | 2 | 7 | 20 |
| 50 | | 6 | 0 | 7 | 0 | 7 | 5 | 4 | 2 | 5 | 0 |
| | | 0 | 0 | 1 | 13 | 17 | 8 | 11 | 2 | 0 | 7 |
| 75 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Graphics



# Chronic Freshwater Toxicity Test
## Initial and Final Water Quality Measurements

**Client:** AMEC
**Sample ID:** PTW-1 with 20% Perrier
**Work Order #:** 12285

**Start Date & Time:** June 14/12 @ 1530h
**Stop Date & Time:** June 21/12 @ 1345h
**Test Species:** *Ceriodaphnia dubia*

| % (v/v) Concentration Control | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.0 | 7.7 | 8.1 | 7.4 | 8.0 | 7.0 | 8.0 | 6.5 | 8.1 | 6.9 | 8.1 | 7.0 | 8.4 | 6.6 |
| pH | 8.0 | 7.9 | 8.0 | 7.8 | 8.2 | 7.8 | 8.1 | 7.7 | 8.1 | 7.8 | 8.2 | 7.7 | 8.2 | 7.6 |
| Cond. (µS/cm) | 215 | 216 | | 216 | | 218 | | 219 | | 221 | | 219 | | 222 |
| Initials | KLB | ~ | | ^ | | ^ | | KLB | | JW | | JW | | KLB |

| Concentration 1.6 | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.0 | 7.6 | 8.1 | 7.4 | 8.0 | 6.9 | 8.0 | 6.7 | 8.0 | 6.9 | 7.9 | 7.0 | 8.0 | 6.4 |
| pH | 8.0 | 8.0 | 8.0 | 7.9 | 8.2 | 7.9 | 8.1 | 7.8 | 8.0 | 7.8 | 8.2 | 7.7 | 8.01 | 7.6 |
| Cond. (µS/cm) | 328 | 331 | | 315 | | 321 | | 343 | | 333 | | 352 ~~467~~ JW JW | | 347 |
| Initials | KLB | ~ | | ^ | | ^ | | KJL | | JW | | JW | | KLB |

| Concentration 3.1 | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.1 | 7.7 | 8.1 | 7.4 | 8.0 | 6.8 | 8.0 | 6.8 | 8.0 | 6.9 | 7.9 | 6.8 | 8.1 | 6.3 |
| pH | 8.0 | 7.9 | 7.9 | 7.9 | 8.2 | 7.9 | 8.1 | 7.8 | 8.0 | 7.8 | 8.2 | 7.7 | 8.0 | 7.7 |
| Cond. (µS/cm) | 443 | 439 | | 429 | | 428 | | 470 | | 448 | | 467 | | 458 |
| Initials | KLB | ~ | | ^ | | ^ | | KJL | | JW | | JW | | KLB |

| Concentration 6.3 | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.5 | 8.1 | 7.3 | 8.0 | 6.8 | 8.0 | 6.9 | 7.8 | 7.1 | 7.9 | 6.8 | 8.1 | 6.4 |
| pH | 8.0 | 7.8 | 7.9 | 7.9 | 8.2 | 7.9 | 8.1 | 7.8 | 8.0 | 7.9 | 8.2 | 7.7 | 8.0 | 7.7 |
| Cond. (µS/cm) | 671 | 659 | | 658 | | 641 | | 711 | | 689 | | 698 | | 691 |
| Initials | KLB | ~ | | ^ | | ^ | | KJL | | JW | | JW | | KLB |

| | Control | 100% (v/v) | | |
|---|---|---|---|---|
| Hardness* | 100 | 580 | | |
| Alkalinity* | 84 | 364 | | |

* mg/L as CaCO3

**Analysts:** KLB, AWR, JW, KJL
**Reviewed by:** JOL
**Date reviewed:** July 23/12

WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5

**Sample Description:** slightly yellow ~~yellowish~~ - ppt present

**Comments:** **Broodboard Used:** 060712

# Chronic Freshwater Toxicity Test
# Initial and Final Water Quality Measurements

**Client:** AMEC
**Sample ID:** PTW-1 with 20% Perrier
**Work Order #:** 12285

**Start Date & Time:** June 14/12 @ 1530h
**Stop Date & Time:** June 21/12 @ 1345h
**Test Species:** *Ceriodaphnia dubia*

| % (v/v) Concentration 13 | Days 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.7 | 8.2 | 7.3 | 8.1 | 6.8 | 8.0 | 6.9 | 7.9 | 7.2 | 7.9 | 7.1 | 8.1 | 6.2 |
| pH | 7.9 | 7.9 | 7.9 | 7.9 | 8.0 | 8.0 | 8.1 | 7.9 | 8.0 | 7.9 | 8.1 | 7.8 | 8.0 | 7.7 |
| Cond. (µS/cm) | 1095 | 1055 | | 1043 | | 1100 | | 1174 | | 1143 | | 1128 | | 1090 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | KCB |

| Concentration 25 | Days 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.6 | 8.2 | 7.3 | 8.1 | 6.8 | 8.0 | 6.9 | 7.8 | 7.3 | 7.8 | 7.1 | 8.1 | 6.5 |
| pH | 7.8 | 8.0 | 7.8 | 8.0 | 7.9 | 8.0 | 8.0 | 8.1 | 7.9 | 8.1 | 8.1 | 8.0 | 7.9 | 7.9 |
| Cond. (µS/cm) | 1967 | 2000 | | 2170 | | 2150 | | 2010 | | 2050 | | 2030 | | ~~10~~ 1957 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | KCB |

| Concentration 50 | Days 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.5 | 8.2 | 7.4 | 8.1 | 6.9 | 8.0 | 7.0 | 7.9 | 7.4 | 7.8 | 7.4 | 8.1 | 6.8 |
| pH | 7.7 | 7.9 | 7.8 | 8.0 | 7.8 | 8.1 | 7.9 | 8.0 | 7.8 | 8.1 | 8.0 | 8.0 | 7.8 | 7.9 |
| Cond. (µS/cm) | 3690 | 3580 | | 3573 | | 3710 | | 3350 | | 3760 | | 3780 | | 3660 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | KCB |

| Concentration 75 | Days 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | | | | | | | |
| DO (mg/L) | 8.2 | 7.4 | 8.2 | 7.3 | 8.1 | 6.8 | 8.0 | | | | | | | |
| pH | 7.6 | 7.8 | 7.7 | 7.9 | 7.7 | 8.1 | 7.8 | | | | | | | |
| Cond. (µS/cm) | 5340 | 5100 | | 5050 | | 5010 | | | | | | | | |
| Initials | KCB | ~ | | ~ | | ~ | | | | | | | | |

| | Control | 100% (v/v) | | |
|---|---|---|---|---|
| Hardness* | 100 | 580 | | |
| Alkalinity* | 84 | 366 | | |

* mg/L as CaCO3

**Analysts:** KCB, AWD, JW, KJL

**Reviewed by:** JOM

**Date reviewed:** July 23/12

**WQ Ranges:** T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5

**Sample Description:** slightly yellow, ppt present

**Comments:** **Broodboard Used:** 060712

# Chronic Freshwater Toxicity Test
# Initial and Final Water Quality Measurements

Client: AMEC
Sample ID: PTW-1 with 20% Perrier
Work Order #: 12285

Start Date & Time: June 14/12 @ 1530h
Stop Date & Time: June 21/12 @ 1345h
Test Species: *Ceriodaphnia dubia*

| % (v/v) Concentration | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| 100 | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | 24.0 | | | | | | | | | | | | | |
| DO (mg/L) | 8.2 | | | | | | | | | | | | | |
| pH | 7.6 | | | | | | | | | | | | | |
| Cond. (µS/cm) | 6940 | | | | | | | | | | | | | |
| Initials | KEB | | | | | | | | | | | | | |

| Concentration | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| Concentration | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| Concentration | Days | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | final |
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| | Control | 100% (UW) | | |
|---|---|---|---|---|
| Hardness* | 100 | 580 | | |
| Alkalinity* | 84 | 366 | | |

* mg/L as CaCO3
WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5
Sample Description: slightly yellow, ppt present

Analysts: KEB, AWD, JW, KJL
Reviewed by: JOK
Date reviewed: July 23/12

Comments: Broodboard Used: 060712

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** PTW-1 **with 20% Perrier Dilution Water**
**Work Order:** 12285

**Start Date & Time:** June 14/12 @ 1530h
**Stop Date & Time:** June 21/12 @ 1345h
**Set up by:** KB

% (v/v)

| Days | Concentration: Control | | | | | | | | | | | | | | | | | | | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | |
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | 3 | 2 | 3 | 3 | 3 | ✓ | 4 | ✓ | ✓ | 2 | 5 | 2 | ✓ | X✓ JW | X – JW | 5 | 5 | ✓ | ✓ | 2 | KB |
| 5 | 8 | 6 | 4 | 6 | 7 | 5 | 7 | 4 | 8 | 6 | – | 6 | – | 5 | 6 | 11 | – | 2 | – | 6 | JW |
| 6 | 8 | 4 | 6 | 7 | – | 10 | 10 | 5 | 8 | 8 | 11 | – | – | 6 | – | – | 11 | 9 | 4 | – | JW |
| 7 | ✓ | ✓ | ✓ | ✓ | 3 | 5 | ✓ | ✓ | ✓ | 9 | 6 | 4 | 4 | ✓ | 8 | 18 | 8 | 7 | 3 | 12 | KB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 19 | 12 | 13 | 16 | 13 | 20 | 21 | 9 | 16 | 16 | 22 | 12 | 4 | 11 | 14 | 34 | 24 | 18 | 7 | 20 | KB |

| Days | Concentration: 1.6 | | | | | | | | | | | | | | | | | | | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | |
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | ✓ | 2 | 3 | ✓ | ✓ | 4 | ✓ | ✓ | ✓ | ✓ | 2 | 4 | 5 | 3 | 4 | 3 | 2 | 4 | 5 | ✓ | KB |
| 5 | 4 | – | – | 3 | – | – | – | – | – KB | 6 | 4 | – | – | 6 | 5 | – JW | 5 | – | – | 6 | JW |
| 6 | 7 | 8 | 6 | 2 | 3 | 8 | 2 | – | ✓ | 3 | 5 | 7 | 10 | 4 | 3 | 6 | – | 10 | 9 | 10 | JW |
| 7 | 8 | 14 | 8 | ✓ | 8 | 8 | 3 | 4 | 6 | 9 | ✓ | 8 | 8 | ✓ | ✓ | 7 | 4 | 8 | 7 | 5 | KB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 19 | 24 | 17 | 5 | 11 | 20 | 5 | 4 | 6 | 18 | 11 | 19 | 23 | 13 | 12 | 16 | 11 | 22 | 21 | 21 | KB |

| Days | Concentration: 3.1 | | | | | | | | | | | | | | | | | | | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | |
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | 5 | 5 | 3 | X | 3 | ✓ | ✓ | ✓ | ✓ | 2 | 3 | 2 | X | 3 | 2 | 4 | 2 | 2 | 2 | 12 JW | KB |
| 5 | – | – | – | \| | 5 | 2 | 4 | – | 3 | 6 | – | 6 | \| | 6 | 7 | 8 | 7 | 7 | 8 | – | JW |
| 6 | 10 | 10 | 10 | \| | 3 | 3 | 7 | 2 JW | – | 8 | 8 | 3 | \| | 12 | 9 | 10 | 12 | 14 | 14 | 4 | JW |
| 7 | 14 | 15 | 13 | \| | ✓ | ✓ | 8 | ✓ | 4 | 6 | ✓ | 9 | \| | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | KB |
| 8 | | | | \| | | | | | | | | | \| | | | | | | | | |
| Total | 29 | 30 | 26 | 0* | 11 | 5 | 19 | 2 | 7 | 16 | 11 | 11 | 0* | 21 | 18 | 22 | 21 | 23 | 24 | 6 | KB |

Notes: X = mortality.

**Sample Description:** slightly yellow, ppt present
**Comments:** used 20% Perrier dilution water

**Reviewed by:** JOL

**Date reviewed:** July 23/12

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** ETW-1 with 20% Perrier Dilution Water
**Work Order:** 12285

**Start Date & Time:** June 14/12 @ 1530h
**Stop Date & Time:** June 21/12 @ 1345h
**Set up by:** KB

% (v/v)

**Concentration: 6.3**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 4 | 4 | 2 | ~~✗~~ KB ✓ | ✓ | 2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 3 | 4 | 2 | ~~x~~ JW | 4 | 3 | 4 | ✓ | 5 | KB |
| 5 | – | 3 | ~~8 6~~ KB 7 | 5 | 5 | 4 | 4 KB | 2 | 4 | 6 | 7 | – | – | 4 | 6 | 8 | 8 | 6 | – | – | JW |
| 6 | 11 | 10 | 11 | 11 | 11 | 10 | ~~7~~ 8 | 5 | 8 | 8 | 12 | 11 | 10 | 9 | 9 | 10 | 10 | 9 | 4 | 11 | JW |
| 7 | 15 | 16 | ✓ | 15 | ✓ | 7 | ✓ | ✓ | 9 | ✓ | 15 | 15 | 13 | ✓ | 12 | ✓ | ✓ | ✓ | 9 | 13 | KB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 30 | 15 | 18 | 31 | 18 | 21 | 12 | 7 | 21 | 14 | 34 | 29 | 27 | 15 | 27 | 22 | 21 | 19 | 13 | 29 | KB |

**Concentration: 13**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 4 | 5 | ✓ | 3 | ✓ | 5 | ✓ | 4 | ✓ | 5 | ✓ | 3 | 4 | 3 | 3 | ✓ | 4 | 4 | ✓ | 4 | 5 | KB |
| 5 | ✓ | 3 | 6 | 4 | ✓ | ✓ | ✓ | ✓ | ✓ | 2 | ✓ | ✓ | 5 | 5 | 8 | 6 | ✓ | 6 | ✓ | ✓ | KB |
| 6 | 9 | 7 | 11 | 9 | 8 | ✓ | 7 | 3 | 8 | 8 | 10 | 9 | 10 | 11 | 10 | ✓ | 10 | 12 | 9 | 10 | KJL |
| 7 | 13 | 10 | ✓ | 14 | 14 | 4 | 12 | ✓ | 14 | ✓ | 12 | 16 | ✓ | 13 | 15 | 10 | 13 | ✓ | 16 | 15 | KB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 27 | 20 | 20 | 27 | 27 | 4 | 23 | 3 | 27 | 10 | ~~13~~ 25 KB | ~~13~~ 29 KB | 18 | 19 | 33 | 20 | 27 | 18 | 29 | 30 | KB |

**Concentration: 25**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | n |
| 4 | 3 | 4 | 4 | ✓ | 3 | 4 | ✓ | ✓ | ✓ | ✓ | 3 | 3 | ✓ | 2 | 3 | 5 | ✓ KB | ✓ | ✓ | ✓ | KB |
| 5 | ✓ | ✓ | ✓ | 4 | ✓ | ✓ | ✓ | 3 | X | 7 | 6 | ✓ | ✓ | 6 | 5 | ✓ | ~~2~~ 3 | ✓ | 2 | 4 | KB |
| 6 | 9 | 8 | 9 | 7 | 7 | 6 | ✓ | 8 | \| | 7 | 8 | 7 | ✓ | 11 | 10 | 7 | ✓ | 2 | 5 | 7 | KJL |
| 7 | 10 | 11 KB | 10 | 9 | 12 | 8 | 2 | 10 | \| | ✓ | 12 | 12 | ✓ | 11 | ✓ | 11 | ✓ | ✓ | ✓ | 9 | KB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 22 | 23 | 23 | 20 | 22 | 18 | 2 | 21 | 0ˣ | 14 | 17 | 22 | 0 | 19 | 18 | 23 | 3 | 3 | 7 | 20 | KB |

Notes: X = mortality.

**Sample Description:** slightly yellow, ppt present
**Comments:** used 20% Perrier dilution water

**Reviewed by:** JBu

**Date reviewed:** July 23/12

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** PTW-1 with 20% Perrier Dilution Water
**Work Order:** 12285

**Start Date & Time:** June14/12@ 1530h
**Stop Date & Time:** June21/12 @1345h
**Set up by:** KLB

% (v/v)

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Concentration: 50** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | — | — | — | — | — | — | — | — | ^ |
| 2 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | — | — | — | — | — | — | — | — | ^ |
| 3 | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | X | | X | ✓ | — | — | — | — | — | — | — | ^ |
| 4 | ✓ | X | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | KLB |
| 5 | ✓ | | 2 | | ✓ | 1 | ✓ | ✓ | ✓ | | | | ✓ | 3 | 4 | ✓ | 2 | ✓ | ✓ | 3 | KLB |
| 6 | 2 | | 5 | | 2 | ✓ | ✓ | ✓ | ✓ | | | | 1 | 4 | 5 | 3 | 4 | ✓ | ✓ | 4 | KJL |
| 7 | 4 | | ✓ | | 5 | 4 | 4 | 2 | 5 | | | | ✓ | 6 | 8 | 5 | 5 | 2 | ✓ | ✓ | KLB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 6 | 0X | 7 | 0X | 7 | 5 | 4 | 2 | 5 | 0X | 0X | 0X | 1 | 13 | 17 | 8 | 11 | 2 | 0 | 7 | KLB |
| **Concentration: 75** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | X | ✓ | ✓ | X | ✓ | ✓ | ^ |
| 2 | X | X | X | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | | X | X | X | | X | X | | X | X | ^ |
| 3 | | | | X | X | X | | X | X | X | | | | | | | | | | | ^ |
| 4 | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | KLB |
| **Concentration: 100** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | ^ |
| 2 | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | KLB |

Notes: X = mortality.

**Sample Description:** slightly yellow, ppt present
**Comments:** used 20% Perrier dilution water

**Reviewed by:** JCh
**Date reviewed:** July 23/12

# *Ceriodaphnia dubia* Summary Sheet

Client: AMEC
Work Order No.: 12285

Start Date/Time: June 14/12 @ 1500h
Set up by: KLB

**Sample Information:**

Sample ID: PTW-1 (with 80% Perrier + Salts dilution water)
Sample Date: June 11/12
Date Received: June 13/12
Sample Volume: 16 X 2L

**Test Validity Criteria:**

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

**WQ Ranges:**

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6 to 8.5

**Test Organism Information:**

Broodstock No.: 060112 (80% Perrier + Salts)
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 30
Mortality (%) in previous 7 d: 15
Individual female # used ≥8 young on test day: 2,3,4,6,10,12,18,24,29,30,34,8,11

**NaCl Reference Toxicant Results:**

Reference Toxicant ID: cd82
Stock Solution ID: 12NaCl
Date Initiated: June 13/12

7-d LC50 (95% CL): 1.6 (1.0-2.1) g/L NaCL
7-d IC50 (95% CL): 1.4 (1.1-2.0) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 1.9 (1.5-2.3) g/L NaCL CV (%): ~~11~~ 10 JOH
7-d IC50 Reference Toxicant Mean and Historical Range: 1.2 (0.9-1.7) g/L NaCL CV (%): 18

Test Results:

| | Survival | Reproduction |
|---|---|---|
| LC50 %(v/v) (95% CL) | 37.8 (30.5-47.0) | |
| IC25 %(v/v) (95% CL) | | ~~8~~ KLB 16.4 (11.0-18.6) |
| IC50 %(v/v) (95% CL) | | 23.5 (19.4-27.8) |

Reviewed by: JOH

Date reviewed: July 23/12

# CETIS Analytical Report



**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 04-6401-5106 | **Endpoint:** | 7d Survival Rate | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:53 | **Analysis:** | Untrimmed Spearman-Kärber | **Official Results:** | Yes |
| **Batch ID:** | 10-2926-1046 | **Test Type:** | Reproduction-Survival (7d) | **Analyst:** | Krysta Banack |
| **Start Date:** | 14 Jun-12 15:00 | **Protocol:** | EC/EPS 1/RM/21 | **Diluent:** | 80% Perrier + Salts |
| **Ending Date:** | 21 Jun-12 16:30 | **Species:** | Ceriodaphnia dubia | **Brine:** | |
| **Duration:** | 7d 2h | **Source:** | In-House Culture | **Age:** | <24h |
| **Sample ID:** | 14-9508-3321 | **Code:** | 591D2939 | **Client:** | AMEC |
| **Sample Date:** | 11 Jun-12 16:15 | **Material:** | Water Sample | **Project:** | |
| **Receive Date:** | 13 Jun-12 09:30 | **Source:** | AMEC | | |
| **Sample Age:** | 71h | **Station:** | PTW-1 | | |

## Spearman-Kärber Estimates

| Threshold Option | Threshold | Trim | Mu | Sigma | EC50 | 95% LCL | 95% UCL |
|---|---|---|---|---|---|---|---|
| Control Threshold | 0 | 0.00% | 1.578 | 0.04688 | 37.83 | 30.48 | 46.95 |

## 7d Survival Rate Summary

Calculated Variate(A/B)

| C-% | Control Type | Count | Mean | Min | Max | Std Err | Std Dev | CV% | %Effect | A | B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 1.6 | | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 3.1 | | 20 | 1 | 1 | 1 | 0 | 0 | 0.0% | 0.0% | 20 | 20 |
| 6.3 | | 20 | 0.9 | 0 | 1 | 0.06882 | 0.3078 | 34.2% | 10.0% | 18 | 20 |
| 13 | | 20 | 0.9 | 0 | 1 | 0.06882 | 0.3078 | 34.2% | 10.0% | 18 | 20 |
| 25 | | 20 | 0.85 | 0 | 1 | 0.08192 | 0.3663 | 43.1% | 15.0% | 17 | 20 |
| 50 | | 20 | 0.5 | 0 | 1 | 0.1147 | 0.513 | 102.6% | 50.0% | 10 | 20 |
| 75 | | 20 | 0.1 | 0 | 1 | 0.06882 | 0.3078 | 307.8% | 90.0% | 2 | 20 |
| 100 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% | 0 | 20 |

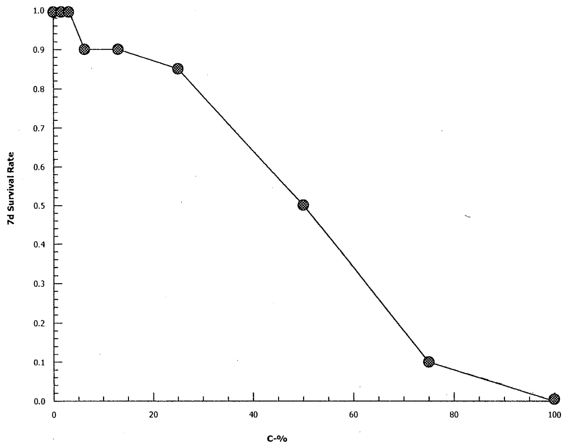
## 7d Survival Rate Detail

| C-% | Control Type | Rep 1 | Rep 2 | Rep 3 | Rep 4 | Rep 5 | Rep 6 | Rep 7 | Rep 8 | Rep 9 | Rep 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1.6 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3.1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6.3 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 13 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 25 | | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| | | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 50 | | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 |
| | | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| 75 | | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 100 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 04-6401-5106 | **Endpoint:** | 7d Survival Rate | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 12:53 | **Analysis:** | Untrimmed Spearman-Kärber | **Official Results:** | Yes |

### Graphics



**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

| | | | | | |
|---|---|---|---|---|---|
| **Analysis ID:** | 18-4744-4775 | **Endpoint:** | Reproduction | **CETIS Version:** | CETISv1.8.4 |
| **Analyzed:** | 03 Jul-12 13:51 | **Analysis:** | Linear Interpolation (ICPIN) | **Official Results:** | Yes |

| | | | | | |
|---|---|---|---|---|---|
| **Batch ID:** | 10-2926-1046 | **Test Type:** | Reproduction-Survival (7d) | **Analyst:** | Krysta Banack |
| **Start Date:** | 14 Jun-12 15:00 | **Protocol:** | EC/EPS 1/RM/21 | **Diluent:** | 80% Perrier + Salts |
| **Ending Date:** | 21 Jun-12 16:30 | **Species:** | Ceriodaphnia dubia | **Brine:** | |
| **Duration:** | 7d 2h | **Source:** | In-House Culture | **Age:** | <24h |

| | | | | | |
|---|---|---|---|---|---|
| **Sample ID:** | 14-9508-3321 | **Code:** | 591D2939 | **Client:** | AMEC |
| **Sample Date:** | 11 Jun-12 16:15 | **Material:** | Water Sample | **Project:** | |
| **Receive Date:** | 13 Jun-12 09:30 | **Source:** | AMEC | | |
| **Sample Age:** | 71h | **Station:** | PTW-1 | | |

**Linear Interpolation Options**

| X Transform | Y Transform | Seed | Resamples | Exp 95% CL | Method |
|---|---|---|---|---|---|
| Log(X+1) | Linear | 2145217 | 200 | Yes | Two-Point Interpolation |

**Point Estimates**

| Level | % | 95% LCL | 95% UCL | TU | 95% LCL | 95% UCL |
|---|---|---|---|---|---|---|
| IC5 | 9.506 | 0.8095 | 13.94 | 10.52 | 7.176 | 123.5 |
| IC10 | 13.2 | 2.397 | 14.93 | 7.574 | 6.696 | 41.71 |
| IC15 | 14.2 | 3.263 | 16 | 7.041 | 6.251 | 30.65 |
| IC20 | 15.27 | 8.932 | 17.2 | 6.548 | 5.814 | 11.2 |
| IC25 | 16.42 | 11.04 | 18.56 | 6.092 | 5.387 | 9.058 |
| IC40 | 20.36 | 16.08 | 23.87 | 4.913 | 4.19 | 6.22 |
| IC50 | 23.47 | 19.43 | 27.79 | 4.261 | 3.599 | 5.147 |

**Reproduction Summary** — **Calculated Variate**

| C-% | Control Type | Count | Mean | Min | Max | Std Err | Std Dev | CV% | %Effect |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 20 | 15.9 | 2 | 29 | 1.414 | 6.324 | 39.77% | 0.0% |
| 1.6 | | 20 | 17.85 | 6 | 27 | 1.448 | 6.475 | 36.27% | -12.26% |
| 3.1 | | 20 | 16.1 | 3 | 28 | 1.67 | 7.469 | 46.39% | -1.26% |
| 6.3 | | 20 | 17.8 | 0 | 28 | 2.145 | 9.595 | 53.9% | -11.95% |
| 13 | | 20 | 15.4 | 0 | 26 | 1.891 | 8.457 | 54.91% | 3.15% |
| 25 | | 20 | 7.7 | 0 | 18 | 1.183 | 5.292 | 68.73% | 51.57% |
| 50 | | 20 | 1.95 | 0 | 7 | 0.5255 | 2.35 | 120.5% | 87.74% |
| 75 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% |
| 100 | | 20 | 0 | 0 | 0 | 0 | 0 | | 100.0% |

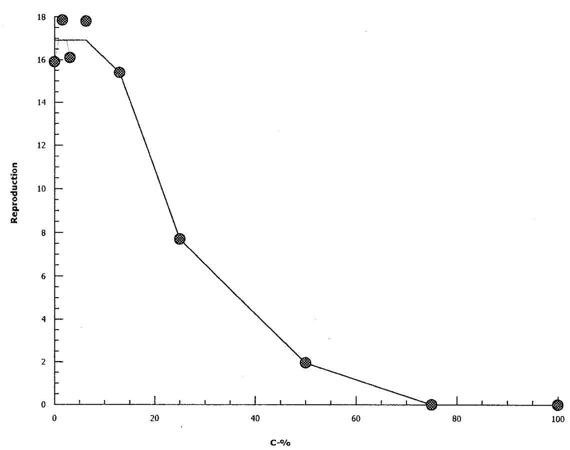
**Ceriodaphnia 7-d Survival and Reproduction Test** — **Nautilus Environmental**

**Analysis ID:** 18-4744-4775 **Endpoint:** Reproduction **CETIS Version:** CETISv1.8.4
**Analyzed:** 03 Jul-12 13:51 **Analysis:** Linear Interpolation (ICPIN) **Official Results:** Yes

### Reproduction Detail

| C-% | Control Type | Rep 1 | Rep 2 | Rep 3 | Rep 4 | Rep 5 | Rep 6 | Rep 7 | Rep 8 | Rep 9 | Rep 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Negative Control | 29 | 18 | 9 | 22 | 26 | 18 | 16 | 9 | 16 | 7 |
| | | 17 | 13 | 13 | 20 | 18 | 2 | 21 | 14 | 14 | 16 |
| 1.6 | | 23 | 27 | 24 | 22 | 26 | 25 | 15 | 15 | 11 | 18 |
| | | 10 | 21 | 26 | 18 | 10 | 6 | 15 | 17 | 8 | 20 |
| 3.1 | | 17 | 26 | 17 | 16 | 27 | 27 | 28 | 7 | 10 | 14 |
| | | 6 | 3 | 17 | 15 | 17 | 6 | 13 | 21 | 22 | 13 |
| 6.3 | | 25 | 26 | 24 | 28 | 18 | 28 | 26 | 13 | 23 | 26 |
| | | 3 | 11 | 25 | 21 | 22 | 0 | 17 | 0 | 17 | 3 |
| 13 | | 26 | 20 | 22 | 18 | 21 | 25 | 19 | 9 | 9 | 25 |
| | | 4 | 8 | 21 | 21 | 14 | 0 | 11 | 10 | 0 | 25 |
| 25 | | 0 | 10 | 9 | 0 | 3 | 7 | 9 | 5 | 0 | 7 |
| | | 14 | 8 | 18 | 10 | 17 | 0 | 11 | 9 | 10 | 7 |
| 50 | | 4 | 5 | 0 | 0 | 3 | 2 | 3 | 0 | 2 | 0 |
| | | 0 | 7 | 0 | 5 | 6 | 0 | 0 | 0 | 0 | 2 |
| 75 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 100 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

### Graphics



# Chronic Freshwater Toxicity Test
# Initial and Final Water Quality Measurements

**Client:** AMEC
**Sample ID:** PTW-1 with 80% Perrier + Salts
**Work Order #:** 12285

**Start Date & Time:** June 14/12 @ 1500h
**Stop Date & Time:** June 21/12 @ 1630h
**Test Species:** *Ceriodaphnia dubia*

| % (v/v) Concentration Control | Day 0 init. | Day 1 old | Day 1 new | Day 2 old | Day 2 new | Day 3 old | Day 3 new | Day 4 old | Day 4 new | Day 5 old | Day 5 new | Day 6 old | Day 6 new | Day 7 ~~old~~ final JW | Day 7 new JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 8.9 | 8.0 | 7.3 | 8.0 | 6.9 | 8.0 | 6.3 | 8.1 | 6.4 | 7.7 | 7.0 | 8.4 | 6.7 | 8.0 |
| pH | 8.3 | 8.1 | 8.2 | 8.2 | 8.3 | 8.1 | 8.3 | 8.0 | 8.3 | 8.0 | 8.4 | 7.8 | 8.3 | 7.9 | 8.3 |
| Cond. (µS/cm) | 2370 | 2330 | | 2290 | | 2270 | | 2290 | | JW ~~2370~~ 3960 | | 2290 | | 2180 ~~2350~~ JW | |
| Initials | KCB | ^ | | ~ | | ^ | | KJL | | JW | | JW | | JW | |

| Concentration 1.6 | Day 0 init. | Day 1 old | Day 1 new | Day 2 old | Day 2 new | Day 3 old | Day 3 new | Day 4 old | Day 4 new | Day 5 old | Day 5 new | Day 6 old | Day 6 new | Day 7 ~~old~~ final JW | Day 7 new JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.1 | 8.1 | 7.3 | 8.0 | 6.9 | 8.0 | 6.4 | 8.0 | 6.5 | 8.1 | 7.0 | 8.2 | 6.7 | 8.1 |
| pH | 8.3 | 8.1 | 8.2 | 8.2 | 8.3 | 8.2 | 8.3 | 8.0 | 8.2 | 8.0 | 8.3 | 7.9 | 8.2 | 7.8 | 8.1 |
| Cond. (µS/cm) | 2440 | 2420 | | 2410 | | 2365 | | 2370 | | 2370 | | 2360 | | JW ~~2350~~ 2280 | |
| Initials | KCB | ^ | | ~ | | ^ | | KJL | | JW | | JW | | JW | |

| Concentration 3.1 | Day 0 init. | Day 1 old | Day 1 new | Day 2 old | Day 2 new | Day 3 old | Day 3 new | Day 4 old | Day 4 new | Day 5 old | Day 5 new | Day 6 old | Day 6 new | Day 7 ~~old~~ final JW | Day 7 new JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.2 | 8.1 | 7.2 | 8.0 | 6.9 | 8.0 | 6.4 | 8.0 | 6.5 | 8.2 | 7.0 | 8.3 | 6.6 | 8.0 |
| pH | 8.3 | 8.1 | 8.1 | 8.2 | 8.3 | 8.2 | 8.3 | 8.0 | 8.2 | 8.0 | 8.3 | 7.9 | 8.2 | 8.0 | 8.1 |
| Cond. (µS/cm) | 2520 | 2590 | | 2500 | | 2435 | | 2430 | | 2450 | | 2430 | | JW ~~2430~~ 2340 | |
| Initials | KCB | ^ | | ^ | | ~ | | KJL | | JW | | JW | | JW | |

| Concentration 6.3 | Day 0 init. | Day 1 old | Day 1 new | Day 2 old | Day 2 new | Day 3 old | Day 3 new | Day 4 old | Day 4 new | Day 5 old | Day 5 new | Day 6 old | Day 6 new | Day 7 ~~old~~ final JW | Day 7 new JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.6 | 24.0 | 24.6 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.3 | 8.1 | 7.3 | 8.0 | 7.0 | 8.0 | 6.2 | 8.0 | 6.4 | 8.1 | 6.9 | 8.3 | 6.6 | 7.9 |
| pH | 8.2 | 8.1 | 8.1 | 8.2 | 8.3 | 8.2 | 8.3 | 8.1 | 8.2 | 8.0 | 8.3 | 8.0 | 8.2 | 8.0 | 8.1 |
| Cond. (µS/cm) | 2660 | 2610 | | 2710 | | 2585 | | 2590 | | 2600 | | 2580 | | JW ~~2570~~ 2510 | |
| Initials | KCB | ~ | | ~ | | ^ | | KJL | | JW | | JW | | JW | |

| | Control | 100% (v/v) | | |
|---|---|---|---|---|
| Hardness* | 510 | 580 | | |
| Alkalinity* | 392 | 366 | | |

* mg/L as CaCO3

**Analysts:** KCB, JW, AWD, KJL
**Reviewed by:** JGU
**Date reviewed:** July 23/12

WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5

**Sample Description:** Sample PTW-1 w/ 80% Perrier + Salts dilution H2O, slightly yellow, ppt present

**Comments:** Broodboard Used: BB 060112 (80% Perrier + Salts)

# Chronic Freshwater Toxicity Test
# Initial and Final Water Quality Measurements

**Client:** AMEC
**Sample ID:** PTW-1 with 80% Perrier + Salts
**Work Order #:** 12285

**Start Date & Time:** June 14/12 @ 1500h
**Stop Date & Time:** June 21/12 @ 1630h
**Test Species:** *Ceriodaphnia dubia*

| % (v/v) Concentration 13 | Days | | | | | | | | | | | | | | JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | ~~old~~ JW final | new |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.2 | 8.1 | 7.3 | 8.0 | 6.9 | 8.0 | 6.4 | 8.0 | 6.4 | 8.1 | 6.9 | 8.3 | 6.9 | 8.0 |
| pH | 8.2 | 8.1 | 8.0 | 8.2 | 8.2 | 8.2 | 8.3 | 8.1 | 8.0 | 8.1 | 8.3 | 8.0 | 8.2 | 8.0 | 8.0 |
| Cond. (µS/cm) | 2980 | 2870 | | 3010 | | 2910 | | 2890 | | 2920 | | 2900 | | ~~2880~~ | 2780 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | JW | |

| Concentration 25 | Days | | | | | | | | | | | | | | JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | ~~old~~ JW final | new |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.3 | 8.1 | 7.2 | 8.0 | 6.8 | 7.9 | 6.7 | 8.0 | 6.5 | 8.0 | 7.1 | 8.2 | 6.9 | 8.0 |
| pH | 8.0 | 8.0 | 8.0 | 8.1 | 8.1 | 8.1 | 8.3 | 8.1 | 8.0 | 8.1 | 8.2 | 8.1 | 8.2 | 8.1 | 8.0 |
| Cond. (µS/cm) | 3570 | 3450 | | 3445 | | 3560 | | 3380 | | 3530 | | 3500 | | JW ~~3500~~ | 3390 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | JW | |

| Concentration 50 | Days | | | | | | | | | | | | | | JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | ~~old~~ JW final | new |
| Temperature (°C) | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.3 | 8.1 | 7.3 | 8.1 | 7.0 | 7.9 | 7.0 | 8.0 | 6.8 | 8.0 | 7.3 | 8.0 | 7.2 | 8.0 |
| pH | 7.8 | 8.0 | 7.9 | 8.1 | 8.0 | 8.1 | 8.3 | 8.1 | 7.9 | 8.1 | 8.0 | 8.1 | 8.1 | 8.2 | 7.8 |
| Cond. (µS/cm) | 4690 | 4400 | | 4290 | | 4320 | | 4560 | | 4710 | | 4680 | | JW ~~4670~~ | 4490 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | JW | |

| Concentration 75 | Days | | | | | | | | | | | | | | JW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | |
| | init. | old | new | old | new | old | new | old | new | old | new | old | new | ~~old~~ JW final | new |
| Temperature (°C) | 24.0 | 24.3 | 24.0 | 24.6 | 24.0 | 24.0 | 24.0 | 24.5 | 24.0 | 25.0 | 24.0 | 24.0 | 24.0 | 25.0 | 24.0 |
| DO (mg/L) | 8.2 | 7.3 | 8.1 | 7.3 | 8.0 | 6.9 | 7.9 | 7.1 | 8.0 | 6.8 | 7.9 | 7.2 | 8.0 | 7.4 | 8.0 |
| pH | 7.7 | 7.9 | 7.8 | 8.1 | 8.0 | 8.1 | 8.2 | 8.1 | 7.8 | 8.1 | 7.9 | 8.0 | 8.1 | 8.1 | 7.7 |
| Cond. (µS/cm) | 5820 | 5295 | | 5625 | | 5482 | | 5720 | | 5740 | | 5830 | | JW ~~5820~~ | 5370 |
| Initials | KCB | ~ | | ~ | | ~ | | KJL | | JW | | JW | | JW | |

| | Control | 100% (v/v) | | |
|---|---|---|---|---|
| Hardness* | 510 | 580 | | |
| Alkalinity* | 392 | 366 | | |

* mg/L as CaCO3

**Analysts:** KCB, JW, AWP, KJL
**Reviewed by:** JGU
**Date reviewed:** July 23/12

**WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5**

**Sample Description:** Sample PTW-1 w/ 80% Perrier + Salts dilution water, slightly yellow, ppt present

**Comments:** **Broodboard Used:** 060112 (80% Perrier + Salts)

# Chronic Freshwater Toxicity Test
# Initial and Final Water Quality Measurements

**Client:** AMEC
**Sample ID:** PTw-1 with 80% Perrier + Salts
**Work Order #:** 12285

**Start Date & Time:** June 14/12 @ 1500h
**Stop Date & Time:** June 21/12 @ 1630h
**Test Species:** *Ceriodaphnia dubia*

| % (v/v) Concentration 100 | Days 0 init. | 1 old | 1 new | 2 old | 2 new | 3 old | 3 new | 4 old | 4 new | 5 old | 5 new | 6 old | 6 new | 7 final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | 24.0 | | | | | | | | | | | | | |
| DO (mg/L) | 8.2 | | | | | | | | | | | | | |
| pH | 7.6 | | | | | | | | | | | | | |
| Cond. (µS/cm) | 6940 | | | | | | | | | | | | | |
| Initials | KLB | | | | | | | | | | | | | |

| Concentration | Days 0 init. | 1 old | 1 new | 2 old | 2 new | 3 old | 3 new | 4 old | 4 new | 5 old | 5 new | 6 old | 6 new | 7 final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| Concentration | Days 0 init. | 1 old | 1 new | 2 old | 2 new | 3 old | 3 new | 4 old | 4 new | 5 old | 5 new | 6 old | 6 new | 7 final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| Concentration | Days 0 init. | 1 old | 1 new | 2 old | 2 new | 3 old | 3 new | 4 old | 4 new | 5 old | 5 new | 6 old | 6 new | 7 final |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature (°C) | | | | | | | | | | | | | | |
| DO (mg/L) | | | | | | | | | | | | | | |
| pH | | | | | | | | | | | | | | |
| Cond. (µS/cm) | | | | | | | | | | | | | | |
| Initials | | | | | | | | | | | | | | |

| | Control | 100% (v/v) | | |
|---|---|---|---|---|
| Hardness* | 510 | 580 | | |
| Alkalinity* | 392 | 366 | | |

* mg/L as CaCO3

**Analysts:** KLB, JW, AWD, KJL
**Reviewed by:** JGL
**Date reviewed:** July 23/12

**WQ Ranges: T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 (mg/L) ; pH = 6 to 8.5**

**Sample Description:** PTw-1 w/ 80% Perrier + Salts dilution water, slightly yellow, ppt present

**Comments:** **Broodboard Used:** 060112 (80% Perrier + salts)

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** P7w-1 with 80% Perrier + Salts Dilution Water
**Work Order:** 12285

**Start Date & Time:** June 14/12 @ 1500h
**Stop Date & Time:** June 21/12 @ 1630h
**Set up by:** KLB

% (v/v)

**Concentration: Control**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | 8 | 3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 2 | 2 | ✓ | ✓ | ✓ | 4 | 4 | ✓ | 3 | ✓ | RJW | ✓ | KLB |
| 5 JW | ~~8~~ 7 | 5 | 2 | 3 | 4 | 5 | 4 | - | 6 | 5 | 3 | 3 | - | 6 | - | - | - | 6 | 6 | - | JW |
| 6 | - | ~~3~~ ✓ (JW) | 5 | 7 | 10 | 9 | 7 | 5 | 8 | - | 7 | ~~3~~ 5 | 4 | 10 | 7 | - | 6 | 8 | 8 | 5 | KJL |
| 7 | 14 | ~~8~~ 10 (JW) | 2 | 12 | 12 | 4 | 5 | 4 | ✓ | ✓ | 7 | 5 | 9 | ✓ | 7 | 2 | 12 | - | - | 11 | KLB |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 29 | ~~16~~ 18 | 9 | 22 | 26 | 18 | 16 | 9 | 16 | 7 | 17 | 13 | 13 | 20 | 18 | 2 | 21 | 14 | 14 | 16 | KLB |

**Concentration: 1.6**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ~ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 3 | ✓ | ✓ | 2 | ✓ | 4 | 4 | 4 | ✓ | ✓ | ✓ | ✓ | ✓ | 2 | KLB |
| 5 | 4 | 5 | 3 | 4 | 5 | 6 | 5 | - | - | 6 | ✓ | - | - (JW) | 6 | - | - | 5 | 5 | - | - | JW |
| 6 | 7 | 10 | 8 | 8 | 10 | 7 | ✓ | 6 | 4 | 10 | 3 | 8 | 9 | 8 (JW) | 5 | 6 | 10 | 12 | 2 | 10 | KJL |
| 7 | 12 | 12 | 13 | 10 | 11 | 12 | 7 | 9 | 7 | - | 7 | 9 | 13 | - | 5 | - | - | - | 6 | 8 | JW |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 23 | 27 | 24 | 22 | 26 | 25 | 15 | 15 | 11 | 18 | 10 | 21 | 26 | 18 | 10 | 6 | 15 | 17 | 8 | 20 | KLB |

**Concentration: 3.1**

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | ✓ | | | | | | | | | | | | | | | | | | | | ~ |
| 3 | ✓ | | | | | | | | | | | | | | | | | | | | ^ |
| 4 | 3 | ✓ | 2 | 2 | ✓ | ✓ | 3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | 2 | ✓ | ✓ | ✓ | ✓ | ✓ | KLB |
| 5 | 6 | 4 | 6 | 5 | 5 | 4 | - | 3 | - | 6 | 3 | - | - | - | 6 | - | 4 | - | 4 | 4 | JW |
| 6 | - | 9 | 9 | 9 | 9 | 10 | 11 | 4 | 4 | 8 | 3 | - | 6 | 5 | 9 | 6 | 9 | 8 | 8 | 9 | KJL |
| 7 | 8 | ~~10~~ 13 (JW) | - | - | 13 | 13 | 14 | - | 6 | - | - | 3 | 11 | 10 | - | - | ~~10~~ (JW) | 13 | 10 | - | JW |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 17 | 26 | 17 | 16 | 27 | 27 | 28 | 7 | 10 | 14 | 6 | 3 | 17 | 15 | 17 | 6 | 13 | 21 | 22 | 13 | KLB |

Notes: X = mortality.

**Sample Description:** slightly yellow, ppt present
**Comments:** used 80% Perrier + Salts dilution water

**Reviewed by:** JOh

**Date reviewed:** July 23/12

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** PTW 1 with 80% Perrier + Salts Dilution Water
**Work Order:** 12285

**Start Date & Time:** June 14/12@ 1500h
**Stop Date & Time:** June 21/12 @ 1630h
**Set up by:** KUB

% (v/v)

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Concentration: 6.3** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | X | ✓ | ✓ | m |
| 2 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | \| | ✓ | ✓ | ~ |
| 3 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | \| | ✓ | ✓ | ~ |
| 4 | 5 | 5 | 5 | 5 | 3 | ✓ | 4 | ✓ | 4 | 13 | ✓ | ✓ | 4 | 5 | 3 | X | 3 | \| | 3 | ✓ | KUB |
| 5 | ✓ | ✓ | ✓ | ✓ | 6 | 5 | ✓ | ~~7~~ | ✓ | ✓ | ✓ | 4 | ✓ | ✓ | ✓ | \| | ✓ | \| | 6 | 3 | JW |
| 6 | 8 | 9 | 7 | 8 | ✓ | 8 | 8 | 6 | 8 | 8 | 3 | 7 | 8 | 5 | 9 | \| | 5 | \| | 8 | ✓ | JW |
| 7 | 12 | 12 | 12 | 15 | 9 | 15 | 14 | ✓ | 11 | 15 | ~~13~~ JW | ~~11~~ JW | 13 | 11 | 10 | \| | 9 | \| | ✓ | ✓ | JW |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 25 | 26 | 24 | 28 | 18 | 28 | 26 | 13 | 23 | 26 | 3 | 11 | 25 | 21 | 22 | 0x | 17 | 0x | 17 | 3 | KUB |

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Concentration: 13** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | m |
| 2 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | A |
| 3 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | ~ |
| 4 | 5 | 3 | 4 | ✓ | ✓ | ✓ | ~~6~~ 3 KUB | ✓ | ✓ | 4 | ✓ | ✓ | 3 | ✓ | 2 | ✓ | ✓ | ✓ | ✓ | ✓ | KUB |
| 5 | ✓ | ✓ | ✓ | 4 | 3 | 4 | ✓ | ✓ | 3 | ✓ | ✓ | 2 | ✓ | 6 | 5 | ✓ | 4 | 3 | ✓ | 4 | KUB |
| 6 | 10 | 8 | 8 | 4 | 7 | 8 | 7 | 4 | 6 | 8 | ✓ | 6 | 8 | 8 | ✓ | X JW | ✓ | ✓ | X | 10 | JW |
| 7 | 11 | 9 | 10 | 10 | 11 | 13 | 9 | 5 | ✓ | 13 | 4 JW | ✓ | 10 | 7 | 7 | \| | 7 | 7 | \| | 11 | JW |
| 8 | | | | | | | | | | | | | | | | | | | | | |
| Total | 26 | 20 | 22 | 18 | 21 | 25 | ~~16~~ 19 KUB | 9 | 9 | 25 | 4 | 8 | 21 | 21 | 14 | 0x | 11 | 10 | 0x | 25 | KUB |

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Concentration: 25** | | | | | | | | | | | | | | | | | | | | | |
| 1 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | ~ |
| 2 | ✓ | ✓ | X KUB | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | ✓ | ~ |
| 3 | ✓ | — | — | — | — | — | — | — | — | — | — | — | — | — | — | \| | ✓ | ✓ | ✓ | ✓ | ~ |
| 4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ~~✓~~ KUB | X | ✓ KUB | ✓ | ✓ | ✓ | ✓ | ✓ | \| | ✓ | ✓ | ✓ | ✓ | KUB |
| 5 | ✓ | 4 | 3 | ✓ | ✓ | ✓ | 3 | ✓ KUB | \| | ~~2~~ 3 | 4 | 3 | 4 | 4 | 3 | \| | ✓ | ✓ | 4 | 2 | KUB |
| 6 | ✓ | 6 | 6 | ✓ | 3 | 7 | 6 | ✓ | \| | 4 | 4 | 5 | 6 | 6 | 7 | \| | 4 | 2 | 6 | 5 | JW |
| 7 | ✓ | ✓ | ✓ | X | ✓ | ✓ | ✓ | 5 | \| | ✓ | 6 | ✓ | 8 | ✓ | 7 | \| | 7 | 7 | ✓ | ✓ | JW |
| 8 | | | | \| | | | | | | | | | | | | | | | | | |
| Total | 0 | 10 | 9 | 0x | 3 | 7 | 9 | 5 | 0x | 7 | 14 | 8 | 18 | 10 | 17 | 0x | 11 | 9 | 10 | 7 | KUB |

~~① Neonate lost during transfer~~ KUB

Notes: X = mortality.

JW ~~① missing~~

**Sample Description:** slightly yellow, ppt present
**Comments:** used 80% Perrier + salts dilution water

**Reviewed by:** JGh

**Date reviewed:** July 23/12

# Chronic Freshwater Toxicity Test
## *C. dubia* Reproduction Data

**Client:** AMEC
**Sample ID:** PTW-1 with 80% Perrier + Salts Dilution Water
**Work Order:** 12285

**Start Date & Time:** June 14/12@ 1500h
**Stop Date & Time:** June 21/12 @ 1650h
**Set up by:** KCB

% (v/v)

Concentration: 50

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ✓ | | X | ✓ | | | | X | / | / | | | | | | | | | | | | ^ |
| 2 | ✓ | / | X | / | / | / | / | | / | / | X | / | / | / | / | / | X | ✓ | / | / | | ^ |
| 3 | ✓ | / | | ✓ | / | / | / | | / | ✓ | | / | X | ✓ | / | / | | X | / | / | | ^ |
| 4 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | | | X | ✓ | | KCB |
| 5 | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | X | | ✓ | | 2 | ✓ | X | | | | ✓ | | KCB |
| 6 | ✓ | 3X | | X | ✓ | 2 | ✓ | | 2 | | | 2 | | ✓ | X | | | | | ✓ | | JW |
| 7 | 4 | 5 | | | 3 | / | 3 | | / | | | 5 | | 3 | 6 | | | | | 2 | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | |
| Total | 4 | 5 | 0X | 0X | 3 | 2 | 3 | 0X | 2 | 0X | 0X | 7 | 0X | 5 | 6 | 0X | 0X | 0X | 0X | 2 | | KCB |

Concentration: 75

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | / | X | / | ✓ | / | / | X | / | / | X | / | X | / | / | X | X | / | / | / | | ^ |
| 2 | | ✓ | | X | X | X | X | | X | ✓ | | / | | X | X | | | X | ✓ | X | | ^ |
| 3 | | ✓ | | | | | | | | X | | X | | | | | | | ✓ | | | ^ |
| 4 | | ✓ | | | | | | | | | | | | | | | | | ✓ | | | KCB |
| 5 | | ✓ | | | | | | | | | | | | | | | | | ✓ | | | KCB |
| 6 | | ✓ | | | | | | | | | | | | | | | | | ✓ | | | JW |
| 7 | | / | | | | | | | | | | | | | | | | | ✓ | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | |
| Total | 0X | 0 | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0 | 0X | | KCB |

Concentration: 100

| Days | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | | Init |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | X | | | | | | | | | | | | | | | | | | | | | ^ |
| 2 | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | |
| Total | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | 0X | | KCB |

Notes: X = mortality.

**Sample Description:** slightly yellow, ppt present
**Comments:** used 80% Perrier + salts dilution water

**Reviewed by:** JGL

**Date reviewed:** July 23/12

Client: AMEC

W.O.#: 12285

# Hardness and Alkalinity Datasheet

| | Alkalinity | | | | | | Hardness | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample ID | Sample Date | Sample Volume (mL) | (mL) 0.02N HCL/$H_2SO_4$ used to pH 4.5 | (mL) of 0.02N HCL/$H_2SO_4$ used to pH 4.2 | Total Alkalinity (mg/LCaCO$_3$) | | Sample Volume (mL) | Volume of 0.01M EDTA Used (mL) | Total Hardness (mg/L $CaCO_3$) | Technician |
| PTW-1 | June 14/12 | 50 | 18.5 | 18.7 | 366 | | 10 (1) | 5.8 | 580 | KLB |
| 20% Perrier | ↓ | 50 | ~~[illegible]~~ 4.3 | 4.4 | 84 | | 50 | 5.0 | 100 | KLB |
| 80% Perrier + Salts | ↓ | 50 | 20.1 | 20.6 | 392 | | 50 | 25.5 | 510 | KLB |
| | | | | | | | | | | |
| | | | | | | | | | | |
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Notes: (1) Diluted to 100mL w/ DI

Reviewed by: JCh

Date Reviewed: July 20/12

Version 1.0 Issued June 26, 2006

Nautilus Environmental

Nautilus Environmental

**BRITISH COLUMBIA**
8664 Commerce Court
Burnaby British Columbia Canada V5A 4N7
Phone 604.420.8773
Fax 604.357.1361

# Chain of Custody

0641

Date June 12, 2012 Page 1 of 1

Sample Collection by: Darren Lefebvre

**Report to:**
Company Amec Environment & Infrastructure
Address 4015 Miller Avenue
City Saskatoon Prov. SK PC S7T 0E3
Contact Ian Judd-Henrey / Tony Radolakis
Phone No. (306) 975-3607

**Invoice to:**
Company Amec Environment / Infrastructure
Address 4015 Miller Avenue
City Saskatoon Prov. SK PC S7T 0E3
Contact Ian Judd-Henrey
Phone No. (306) 975-3607

ANALYSIS REQUIRED

| SAMPLE ID | DATE | TIME | MATRIX | CONTAINER TYPE | NUMBER OF CONTAINERS | COMMENTS | 3 sets of chronic | C. Daphnia | Acute toxicity | testing | (CONFIRM TESTS | WITH TONY | RODOLAKIS | OF AMEC) | | | RECEIPT TEMPERATURE (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PTW 1 | June 11, 2012 | 4:15PM | Water | 2L Poly | 16 | | ✓ | ✓ | ✓ | ✓ | | | | | | | 1.8 |

12285

**PROJECT INFORMATION**
CLIENT: Shore Gold
P.O. NO.: SX0373306
SHIPPED VIA: Purolator

**SAMPLE RECEIPT**
TOTAL NO. OF CONTAINERS
REC'D GOOD CONDITION

**RELINQUISHED BY (CLIENT)**
(Signature) Darren Lefebvre (Time) 2:30pm
(Printed Name) [signature] (Date) 12 June 2012
(Company) Amec Environment & Infrastructure

**RELINQUISHED BY (COURIER)**
(Signature) (Time)
(Printed Name) (Date)
(Company)

**RECEIVED BY (COURIER)**
(Signature) (Time)
(Printed Name) (Date)
(Company)

**RECEIVED BY (LABORATORY)**
[signature]
(Signature) Jacob Frank (Time)
(Printed Name) June 13/12 @ 0930 (Date)

**SPECIAL INSTRUCTIONS/COMMENTS:**
Tony Radolakis: phone: 1-978-392-5365
email: tony.radolakis@amec.com
*please confirm sample analysis and send results to Ian and Tony

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

DISTRIBUTION: WHITE - Nautilus Environmental, COLOR - Originator

# APPENDIX B – Analytical Chemistry Data

Usual test conditions (80 - 100 mg/L hardness); test initiation

NAUTILUS ENVIRONMENTAL
ATTN: Krysta Banack
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 25-JUL-12
Report Date: 01-AUG-12 17:11 (MT)
Version: FINAL

Client Phone: 604-420-8773

# Certificate of Analysis

**Lab Work Order #:** **L1184327**

Project P.O. #: NOT SUBMITTED

Job Reference:

C of C Numbers:

Legal Site Desc:

<original signed by>

Can Dang
Senior Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Grouping | Analyte | L1184327-1 | L1184327-2 | L1184327-3 | L1184327-4 | L1184327-5 |
|---|---|---|---|---|---|---|
| | **Description** | CHEM | CHEM | CHEM | CHEM | CHEM |
| | **Sampled Date** | 14-JUL-12 | 14-JUL-12 | 14-JUL-12 | 14-JUL-12 | 14-JUL-12 |
| | **Sampled Time** | | | | | |
| | **Client ID** | 20% PERRIER CONTROL | 20% PERRIER 1.6% | 20% PERRIER 3.1% | 20% PERRIER 6.3% | 20% PERRIER 13% |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 89.7 | 95.4 | 98.7 | 111 | 128 |
| | Chloride (Cl) (mg/L) | 5.87 | 29.7 | 53.1 | 100 | 202 |
| | Sulfate (SO4) (mg/L) | 10.1 | 21.8 | 33.5 | 56.9 | 107 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Boron (B)-Total (mg/L) | <0.10 | <0.10 | <0.10 | 0.16 | 0.28 |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Calcium (Ca)-Total (mg/L) | 38.9 | 40.2 | 45.3 | 45.1 | 49.8 |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Iron (Fe)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Lithium (Li)-Total (mg/L) | <0.010 | <0.010 | <0.010 | 0.017 | 0.032 |
| | Magnesium (Mg)-Total (mg/L) | 1.42 | 2.21 | 3.23 | 4.50 | 7.37 |
| | Manganese (Mn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | 0.0068 | 0.0129 |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 |
| | Potassium (K)-Total (mg/L) | <2.0 | <2.0 | <2.0 | 3.4 | 6.2 |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Silicon (Si)-Total (mg/L) | 1.18 | 1.22 | 1.36 | 1.31 | 1.41 |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Sodium (Na)-Total (mg/L) | 2.7 | 21.4 | 43.7 | 77.0 | 147 |
| | Strontium (Sr)-Total (mg/L) | 0.177 | 0.215 | 0.278 | 0.328 | 0.468 |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | 0.0466 | 0.177 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | Sample ID | L1184327-6 | L1184327-7 | L1184327-8 | L1184327-9 |
|---|---|---|---|---|---|
| | Description | CHEM | CHEM | CHEM | CHEM |
| | Sampled Date | 14-JUL-12 | 14-JUL-12 | 14-JUL-12 | 14-JUL-12 |
| | Sampled Time | | | | |
| | Client ID | 20% PERRIER 25% | 20% PERRIER 50% | 20% PERRIER 75% | 20% PERRIER 100% |
| **Grouping** | **Analyte** | | | | |
| **WATER** | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 164 | 239 | 268 | 380 |
| | Chloride (Cl) (mg/L) | 405 | 822 | 1230 | 1600 |
| | Sulfate (SO4) (mg/L) | 208 | 416 | 619 | 802 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | <0.010 DLA | <0.010 DLA |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Boron (B)-Total (mg/L) | 0.59 | 1.16 | 1.75 | 2.27 |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Calcium (Ca)-Total (mg/L) | 68.3 | 96.9 | 111 | 149 |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | 0.027 |
| | Iron (Fe)-Total (mg/L) | <0.030 | 0.036 | <0.060 DLA | 1.05 |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | <0.10 DLA | <0.10 DLA |
| | Lithium (Li)-Total (mg/L) | 0.069 | 0.138 | 0.214 | 0.271 |
| | Magnesium (Mg)-Total (mg/L) | 14.7 | 27.6 | 41.8 | 52.8 |
| | Manganese (Mn)-Total (mg/L) | 0.0284 | 0.0559 | 0.010 | 0.081 |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | <0.060 DLA | <0.060 DLA |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | <0.10 DLA | <0.10 DLA |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | <0.60 DLA | <0.60 DLA |
| | Potassium (K)-Total (mg/L) | 13.3 | 26.8 | 40.8 | 51.9 |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Silicon (Si)-Total (mg/L) | 1.84 | 2.48 | 3.19 | 3.80 |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Sodium (Na)-Total (mg/L) | 322 | 650 | 1030 | 1340 |
| | Strontium (Sr)-Total (mg/L) | 0.843 | 1.49 | 2.20 | 2.80 |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | <0.40 DLA | <0.40 DLA |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | <0.060 DLA | <0.060 DLA |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | <0.020 DLA | <0.020 DLA |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | <0.060 DLA | <0.060 DLA |
| | Zinc (Zn)-Total (mg/L) | 0.0743 | 0.102 | 0.074 | 0.129 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# Reference Information

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Sulfate (SO4) | MS-B | L1184327-1, -2, -3, -4, -5, -6, -7, -8, -9 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLA | Detection Limit Adjusted For required dilution |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ALK-COL-VA** | Water | Alkalinity by Colourimetric (Automated) | EPA 310.2 |

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **MET-TOT-ICP-VA** | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| VA | ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Nautilus Environmental

**Chain of Custody (electronic)**

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

L1184327

Date: July 25/12 Page 1 of 1

| Sample Collection By: | Report to: | Invoice to: |
|---|---|---|
| Company | Nautilus Environmental | Nautilus Environmental |
| Address | 8664 Commerce Court | 8664 Commerce Court |
| City/Prov/Postal Code | Burnaby, BC, V5A 4N7 | Burnaby, BC, V5A 4N7 |
| Contact | Krysta Banack | Krysta Banack |
| Phone | 604- 420- 8773 | 604- 420- 8773 |
| Email | krysta@nautilusenvironmental.com | krysta@nautilusenvironmental.com |

ANALYSIS REQUIRED

| | SAMPLE ID | DATE | TIME | MATRIX | CONTAINER TYPE | # OF CONTAINERS | COMMENTS | Total Metals ICPOES | Sulfate | Chloride | Alkalinity | | | | | | | | Receipt Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20% Perrier Control | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 2 | 20% Perrier 1.6% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 3 | 20% Perrier 3.1% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 4 | 20% Perrier 6.3% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 5 | 20% Perrier ~~12.5%~~ 13% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 6 | 20% Perrier 25% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 7 | 20% Perrier 50% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 8 | 20% Perrier 75% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 9 | 20% Perrier 100% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | |

| PROJECT INFORMATION | SAMPLE RECEIPT | | RELIQUINSHED BY (CLIENT) | RELIQUINSHED BY (COURIER) |
|---|---|---|---|---|
| Client: | Total # Containers: | | Signature: [signature] | Signature: |
| P.O. No.: | Good Condition? | | Print: Krysta Banack | Print: |
| Shipped Via: | Matches Schedule? | | Company: Nautilus Environmental | Company: |
| | | | Time/Date: July 25/12 @ 17:00h | Time/Date: |

SPECIAL INSTRUCTIONS/COMMENTS:

Attn: Can Dang

| RECEIVED BY (COURIER) | RECEIVED BY (LABORATORY) |
|---|---|
| Signature: | Signature: [signature] |
| Print: | Print: 9.2 °C |
| Company: | Company: |
| Time/Date: | Time/Date: 17:30 July 25 |

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

NAUTILUS ENVIRONMENTAL
ATTN: Krysta Banack
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 25-JUL-12
Report Date: 01-AUG-12 14:17 (MT)
Version: FINAL

Client Phone: 604-420-8773

# Certificate of Analysis

**Lab Work Order #: L1184324**

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

<original signed by>

Can Dang
Senior Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| Grouping | Analyte | L1184324-1 | L1184324-2 | L1184324-3 | L1184324-4 | L1184324-5 |
|---|---|---|---|---|---|---|
| | Description | CHEM | CHEM | CHEM | CHEM | CHEM |
| | Sampled Date | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 |
| | Sampled Time | | | | | |
| | Client ID | 20% PERRIER CONTROL | 20% PERRIER 1.6% | 20% PERRIER 3.1% | 20% PERRIER 6.3% | 20% PERRIER 13% |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 89.1 | 96.0 | 102 | 110 | 127 |
| | Chloride (Cl) (mg/L) | 6.14 | 32.4 | 55.0 | 106 | 191 |
| | Sulfate (SO4) (mg/L) | 9.78 | 22.7 | 34.0 | 58.1 | 97.3 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Boron (B)-Total (mg/L) | <0.10 | <0.10 | <0.10 | 0.17 | 0.28 |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Calcium (Ca)-Total (mg/L) | 38.6 | 40.1 | 41.7 | 43.9 | 50.3 |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Iron (Fe)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Lithium (Li)-Total (mg/L) | <0.010 | <0.010 | <0.010 | 0.017 | 0.032 |
| | Magnesium (Mg)-Total (mg/L) | 1.46 | 2.35 | 3.06 | 4.59 | 7.57 |
| | Manganese (Mn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0091 |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 |
| | Potassium (K)-Total (mg/L) | <2.0 | <2.0 | <2.0 | 3.5 | 6.4 |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Silicon (Si)-Total (mg/L) | 1.24 | 1.25 | 1.27 | 1.28 | 1.49 |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Sodium (Na)-Total (mg/L) | 3.4 | 24.9 | 41.9 | 79.1 | 148 |
| | Strontium (Sr)-Total (mg/L) | 0.177 | 0.222 | 0.255 | 0.323 | 0.472 |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0178 |

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | Sample ID | L1184324-6 | L1184324-7 | | | |
|---|---|---|---|---|---|---|
| | Description | CHEM | CHEM | | | |
| | Sampled Date | 21-JUN-12 | 21-JUN-12 | | | |
| | Sampled Time | | | | | |
| | Client ID | 20% PERRIER 25% | 20% PERRIER 50% | | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 167 | 227 | | | |
| | Chloride (Cl) (mg/L) | 383 | 779 | | | |
| | Sulfate (SO4) (mg/L) | 195 | 392 | | | |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | | | |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Boron (B)-Total (mg/L) | 0.55 | 1.13 | | | |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Calcium (Ca)-Total (mg/L) | 64.2 | 86.5 | | | |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Iron (Fe)-Total (mg/L) | 0.034 | 0.073 | | | |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | | | |
| | Lithium (Li)-Total (mg/L) | 0.065 | 0.128 | | | |
| | Magnesium (Mg)-Total (mg/L) | 13.7 | 26.3 | | | |
| | Manganese (Mn)-Total (mg/L) | 0.0228 | 0.0218 | | | |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | | | |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | | | |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | | | |
| | Potassium (K)-Total (mg/L) | 12.4 | 25.0 | | | |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Silicon (Si)-Total (mg/L) | 1.81 | 2.43 | | | |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Sodium (Na)-Total (mg/L) | 294 | 591 | | | |
| | Strontium (Sr)-Total (mg/L) | 0.765 | 1.35 | | | |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | | | |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | | | |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | | | |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | | | |
| | Zinc (Zn)-Total (mg/L) | 0.0144 | 0.0088 | | | |

# Reference Information

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ALK-COL-VA** | Water | Alkalinity by Colourimetric (Automated) | EPA 310.2 |

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

| | | | |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **MET-TOT-ICP-VA** | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| VA | ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Nautilus Environmental

**Chain of Custody (electronic)**

[X] ~~British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7~~ L1184324

Date: July 25/12 Page 1 of 1

**Sample Collection By:**

| | Report to: | Invoice to: |
|---|---|---|
| Company | Nautilus Environmental | Nautilus Environmental |
| Address | 8664 Commerce Court | ~~8664 Commerce Court~~ |
| City/Prov/Postal Code | Burnaby, BC, V5A 4N7 | Burnaby, BC, V5A 4N7 |
| Contact | Krysta Banack | Krysta Banack |
| Phone | 604- 420- 8773 | 604- 420- 8773 |
| Email | krysta@nautilusenvironmental.com | krysta@nautilusenvironmental.com |

ANALYSES REQUIRED

| | SAMPLE ID | DATE | TIME | MATRIX | CONTAINER TYPE | # OF CONTAINERS | COMMENTS | Total Metals ICPOES | Sulfate | Chloride | Alkalinity | | | | | | | | Receipt Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 20% Perrier Control | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 2 | 20% Perrier 1.6% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 3 | 20% Perrier 3.1% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 4 | 20% Perrier 6.3% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 5 | 20% Perrier 13% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 6 | 20% Perrier 25% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 7 | 20% Perrier 50% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | |

| PROJECT INFORMATION | SAMPLE RECEIPT | |
|---|---|---|
| Client: | Total # Containers: | |
| P.O. No.: | Good Condition? | |
| Shipped Via: | Matches Schedule? | |

SPECIAL INSTRUCTIONS/COMMENTS:

Attn: Can Dang

| RELIQUINSHED BY (CLIENT) | RELIQUINSHED BY (COURIER) |
|---|---|
| Signature: [signature] | Signature: |
| Print: Krysta Banack | Print: |
| Company: Nautilus Environmental | Company: |
| Time/Date: July 25/12 @ 17oo h | Time/Date: |

| RECEIVED BY (COURIER) | RECEIVED BY (LABORATORY) |
|---|---|
| Signature: | Signature: [signature] July 25 |
| Print: | Print: 9.2°C |
| Company: | Company: |
| Time/Date: | Time/Date: ~~17:40 PM~~ 17:30PM |

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

500 mg/L hardness; test initiation

NAUTILUS ENVIRONMENTAL
ATTN: Krysta Banack
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 25-JUL-12
Report Date: 03-AUG-12 15:23 (MT)
Version: FINAL

Client Phone: 604-420-8773

# Certificate of Analysis

**Lab Work Order #:** **L1184326**
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

<original signed by>

Can Dang
Senior Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1184326-1 | L1184326-2 | L1184326-3 | L1184326-4 | L1184326-5 |
|---|---|---|---|---|---|---|
| | **Description** | CHEM | CHEM | CHEM | CHEM | CHEM |
| | **Sampled Date** | 14-JUN-12 | 14-JUN-12 | 14-JUN-12 | 14-JUN-12 | 14-JUN-12 |
| | **Sampled Time** | | | | | |
| | **Client ID** | 80% PERRIER + SALT CONTROL | 80% PERRIER + SALT 1.6% | 80% PERRIER + SALT 3.1% | 80% PERRIER + SALT 6.3% | 80% PERRIER + SALT 13% |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 222 | 223 | 227 | 235 | 239 |
| | Chloride (Cl) (mg/L) | 391 | 414 | 429 | 460 | 544 |
| | Sulfate (SO4) (mg/L) | 373 | 385 | 385 | 395 | 426 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Boron (B)-Total (mg/L) | <0.10 | <0.10 | 0.10 | 0.17 | 0.31 |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Calcium (Ca)-Total (mg/L) | 61.9 | 58.4 | 61.6 | 67.1 | 68.7 |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Iron (Fe)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | 0.034 |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Lithium (Li)-Total (mg/L) | <0.010 | <0.010 | 0.010 | 0.020 | 0.036 |
| | Magnesium (Mg)-Total (mg/L) | 44.1 | 40.7 | 42.2 | 43.8 | 43.7 |
| | Manganese (Mn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 |
| | Potassium (K)-Total (mg/L) | 28.1 | 25.9 | 27.1 | 29.1 | 30.2 |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Silicon (Si)-Total (mg/L) | 3.95 | 3.61 | 3.72 | 3.87 | 3.80 |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Sodium (Na)-Total (mg/L) | 339 | 322 | 344 | 386 | 436 |
| | Strontium (Sr)-Total (mg/L) | 0.225 | 0.236 | 0.289 | 0.384 | 0.529 |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Sample ID** | L1184326-6 | L1184326-7 | L1184326-8 | | |
| | **Description** | CHEM | CHEM | CHEM | | |
| | **Sampled Date** | 14-JUN-12 | 14-JUN-12 | 14-JUN-12 | | |
| | **Sampled Time** | | | | | |
| | **Client ID** | 80% PERRIER + SALT 25% | 80% PERRIER + SALT 50% | 80% PERRIER + SALT 75% | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 265 | 268 | 297 | | |
| | Chloride (Cl) (mg/L) | 699 | 1020 | 1300 | | |
| | Sulfate (SO4) (mg/L) | 483 | 605 | 704 | | |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | DLA <0.010 | | |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Boron (B)-Total (mg/L) | 0.59 | 1.12 | 1.70 | | |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Calcium (Ca)-Total (mg/L) | 82.6 | 89.0 | 116 | | |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Iron (Fe)-Total (mg/L) | 0.073 | 0.089 | 0.223 | | |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | DLA <0.10 | | |
| | Lithium (Li)-Total (mg/L) | 0.071 | 0.134 | 0.206 | | |
| | Magnesium (Mg)-Total (mg/L) | 45.9 | 47.8 | 51.4 | | |
| | Manganese (Mn)-Total (mg/L) | 0.0086 | <0.0050 | 0.010 | | |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | DLA <0.060 | | |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | DLA <0.10 | | |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | DLA <0.60 | | |
| | Potassium (K)-Total (mg/L) | 34.0 | 39.6 | 46.6 | | |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Silicon (Si)-Total (mg/L) | 3.85 | 3.75 | 3.86 | | |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Sodium (Na)-Total (mg/L) | 558 | 823 | 1090 | | |
| | Strontium (Sr)-Total (mg/L) | 0.844 | 1.36 | 2.11 | | |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | DLA <0.40 | | |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | DLA <0.060 | | |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | DLA <0.020 | | |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | DLA <0.060 | | |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | DLA <0.010 | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# Reference Information

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Sulfate (SO4) | MS-B | L1184326-1, -2, -3, -4, -5, -6, -7, -8 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLA | Detection Limit Adjusted For required dilution |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ALK-COL-VA** | Water | Alkalinity by Colourimetric (Automated) | EPA 310.2 |

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

| | | | |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| | | | |
|---|---|---|---|
| **MET-TOT-ICP-VA** | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| VA | ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**
*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Nautilus Environmental

of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

L1184326

Date: July 25/12 Page 1 of 1

| Sample Collection By: | Report to: | Invoice to: |
|---|---|---|
| Company | Nautilus Environmental | Nautilus Environmental |
| Address | 8664 Commerce Court | 8664 Commerce Court |
| City/Prov/Postal Code | Burnaby, BC, V5A 4N7 | Burnaby, BC, V5A 4N7 |
| Contact | Krysta Banack | Krysta Banack |
| Phone | 604- 420- 8773 | 604- 420- 8773 |
| Email | krysta@nautilusenvironmental.com | krysta@nautilusenvironmental.com |

ANALYSES REQUIRED

| | SAMPLE ID | DATE | TIME | MATRIX | CONTAINER TYPE | # OF CONTAINERS | COMMENTS | Total Metals ICPOES | Sulfate | Chloride | Alkalinity | | | | | | | | Receipt Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 80% Perrier +Salt Control | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 2 | 80% Perrier +Salt 1.6% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 3 | 80% Perrier +Salt 3.1% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 4 | 80% Perrier +Salt 6.3% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 5 | 80% Perrier +Salt 13% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 6 | 80% Perrier +Salt 25% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 7 | 80% Perrier +Salt 50% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 8 | 80% Perrier +Salt 75% | June 14/12 | - | Chem | 250 mL | 1 | Day 0 Subsample | X | X | X | X | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | |

| PROJECT INFORMATION | SAMPLE RECEIPT | | RELIQUINSHED BY (CLIENT) | RELIQUINSHED BY (COURIER) |
|---|---|---|---|---|
| Client: | Total # Containers: | | Signature: KBanack | Signature: |
| P.O. No.: | Good Condition? | | Print: Krysta Banack | Print: |
| Shipped Via: | Matches Schedule? | | Company: Nautilus Environmental | Company: |
| | | | Time/Date: July 25/12 @ 1700h | Time/Date: |

| SPECIAL INSTRUCTIONS/COMMENTS: | RECEIVED BY (COURIER) | RECEIVED BY (LABORATORY) |
|---|---|---|
| | Signature: | Signature: CW |
| Attn: Can Dang | Print: | Print: ~9.2°C |
| | Company: | Company: |
| | Time/Date: | Time/Date: 17:30 Jul 25 |

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

500 mg/L hardness test; test termination

NAUTILUS ENVIRONMENTAL
ATTN: Krysta Banack
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 25-JUL-12
Report Date: 02-AUG-12 11:08 (MT)
Version: FINAL

Client Phone: 604-420-8773

# Certificate of Analysis

**Lab Work Order #: L1184325**

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

<original signed by>

Can Dang
Senior Account Manager

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | Sample ID | L1184325-1 | L1184325-2 | L1184325-3 | L1184325-4 | L1184325-5 |
|---|---|---|---|---|---|---|
| | Description | CHEM | CHEM | CHEM | CHEM | CHEM |
| | Sampled Date | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 |
| | Sampled Time | | | | | |
| | Client ID | 80% PERRIER + SALT CONTROL | 80% PERRIER + SALT 1.6% | 80% PERRIER + SALT 3.1% | 80% PERRIER + SALT 6.3% | 80% PERRIER + SALT 13% |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 139 | 147 | 150 | 154 | 170 |
| | Chloride (Cl) (mg/L) | 387 | 410 | 428 | 465 | 540 |
| | Sulfate (SO4) (mg/L) | 367 | 378 | 389 | 399 | 423 |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | <0.0050 |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Boron (B)-Total (mg/L) | <0.10 | <0.10 | 0.10 | 0.17 | 0.31 |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Calcium (Ca)-Total (mg/L) | 28.4 | 31.5 | 32.2 | 35.0 | 42.7 |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Iron (Fe)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Lithium (Li)-Total (mg/L) | <0.010 | <0.010 | 0.012 | 0.018 | 0.036 |
| | Magnesium (Mg)-Total (mg/L) | 40.7 | 42.8 | 41.2 | 41.4 | 43.8 |
| | Manganese (Mn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | 0.0057 | 0.0112 |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | <0.050 | <0.050 | <0.050 |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | <0.30 | <0.30 | <0.30 |
| | Potassium (K)-Total (mg/L) | 34.4 | 28.8 | 27.0 | 27.2 | 29.7 |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Silicon (Si)-Total (mg/L) | 3.69 | 3.84 | 3.76 | 3.72 | 3.81 |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Sodium (Na)-Total (mg/L) | 320 | 344 | 348 | 369 | 435 |
| | Strontium (Sr)-Total (mg/L) | 0.0906 | 0.142 | 0.161 | 0.230 | 0.390 |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | <0.20 | <0.20 | <0.20 |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | <0.030 | <0.030 | <0.030 |
| | Zinc (Zn)-Total (mg/L) | <0.0050 | <0.0050 | <0.0050 | <0.0050 | 0.0053 |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# ALS ENVIRONMENTAL ANALYTICAL REPORT

| | **Sample ID** | L1184325-6 | L1184325-7 | L1184325-8 | | |
|---|---|---|---|---|---|---|
| | **Description** | CHEM | CHEM | CHEM | | |
| | **Sampled Date** | 21-JUN-12 | 21-JUN-12 | 21-JUN-12 | | |
| | **Sampled Time** | | | | | |
| | **Client ID** | 80% PERRIER + SALT 25% | 80% PERRIER + SALT 50% | 80% PERRIER + SALT 75% | | |
| **Grouping** | **Analyte** | | | | | |
| **WATER** | | | | | | |
| **Anions and Nutrients** | Alkalinity, Total (as CaCO3) (mg/L) | 197 | 243 | 259 | | |
| | Chloride (Cl) (mg/L) | 684 | 938 | 1210 | | |
| | Sulfate (SO4) (mg/L) | 474 | 551 | 655 | | |
| **Total Metals** | Aluminum (Al)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Antimony (Sb)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Arsenic (As)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Barium (Ba)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Beryllium (Be)-Total (mg/L) | <0.0050 | <0.0050 | DLIV <0.010 | | |
| | Bismuth (Bi)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Boron (B)-Total (mg/L) | 0.55 | 1.09 | 1.53 | | |
| | Cadmium (Cd)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Calcium (Ca)-Total (mg/L) | 53.6 | 79.0 | 90.6 | | |
| | Chromium (Cr)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Cobalt (Co)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Copper (Cu)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Iron (Fe)-Total (mg/L) | <0.030 | 0.065 | DLIV <0.060 | | |
| | Lead (Pb)-Total (mg/L) | <0.050 | <0.050 | DLIV <0.10 | | |
| | Lithium (Li)-Total (mg/L) | 0.063 | 0.133 | 0.184 | | |
| | Magnesium (Mg)-Total (mg/L) | 42.2 | 46.2 | 46.4 | | |
| | Manganese (Mn)-Total (mg/L) | 0.0191 | 0.0233 | DLIV <0.010 | | |
| | Molybdenum (Mo)-Total (mg/L) | <0.030 | <0.030 | DLIV <0.060 | | |
| | Nickel (Ni)-Total (mg/L) | <0.050 | <0.050 | DLIV <0.10 | | |
| | Phosphorus (P)-Total (mg/L) | <0.30 | <0.30 | DLIV <0.60 | | |
| | Potassium (K)-Total (mg/L) | 30.6 | 38.5 | 41.7 | | |
| | Selenium (Se)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Silicon (Si)-Total (mg/L) | 3.57 | 3.68 | 3.47 | | |
| | Silver (Ag)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Sodium (Na)-Total (mg/L) | 507 | 801 | 904 | | |
| | Strontium (Sr)-Total (mg/L) | 0.647 | 1.28 | 1.74 | | |
| | Thallium (Tl)-Total (mg/L) | <0.20 | <0.20 | DLIV <0.40 | | |
| | Tin (Sn)-Total (mg/L) | <0.030 | <0.030 | DLIV <0.060 | | |
| | Titanium (Ti)-Total (mg/L) | <0.010 | <0.010 | DLIV <0.020 | | |
| | Vanadium (V)-Total (mg/L) | <0.030 | <0.030 | DLIV <0.060 | | |
| | Zinc (Zn)-Total (mg/L) | 0.0059 | 0.0063 | DLIV <0.010 | | |

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

# Reference Information

**QC Samples with Qualifiers & Comments:**

| QC Type Description | Parameter | Qualifier | Applies to Sample Number(s) |
|---|---|---|---|
| Matrix Spike | Sulfate (SO4) | MS-B | L1184325-1, -2, -3, -4, -5, -6, -7, -8 |

**Qualifiers for Individual Parameters Listed:**

| Qualifier | Description |
|---|---|
| DLIV | Detection Limit Adjusted: Lower Initial Volume |
| MS-B | Matrix Spike recovery could not be accurately calculated due to high analyte background in sample. |

## Test Method References:

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ALK-COL-VA** | Water | Alkalinity by Colourimetric (Automated) | EPA 310.2 |

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-CL-IC-VA** | Water | Chloride by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **ANIONS-SO4-IC-VA** | Water | Sulfate by Ion Chromatography | APHA 4110 B. |

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

| ALS Test Code | Matrix | Test Description | Method Reference** |
|---|---|---|---|
| **MET-TOT-ICP-VA** | Water | Total Metals in Water by ICPOES | EPA SW-846 3005A/6010B |

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

*The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:*

| Laboratory Definition Code | Laboratory Location |
|---|---|
| VA | ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA |

**Chain of Custody Numbers:**

**GLOSSARY OF REPORT TERMS**

*Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.*
*mg/kg - milligrams per kilogram based on dry weight of sample.*
*mg/kg wwt - milligrams per kilogram based on wet weight of sample.*
*mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.*
*mg/L - milligrams per litre.*
*< - Less than.*
*D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).*
*N/A - Result not available. Refer to qualifier code and definition for explanation.*

*Test results reported relate only to the samples as received by the laboratory.*
*UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.*
*Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.*

# Nautilus Environmental

## Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

L1184325

*L1184325-COFC*

Date: July 25/12 Page 1 of 1

| | Report to: | Invoice to: |
|---|---|---|
| Sample Collection By: | | |
| Company | Nautilus Environmental | Nautilus Environmental |
| Address | 8664 Commerce Court | 8664 Commerce Court |
| City/Prov/Postal Code | Burnaby, BC, V5A 4N7 | Burnaby, BC, V5A 4N7 |
| Contact | Krysta Banack | Krysta Banack |
| Phone | 604- 420- 8773 | 604- 420- 8773 |
| Email | krysta@nautilusenvironmental.com | krysta@nautilusenvironmental.com |

ANALYSES REQUIRED

| | SAMPLE ID | DATE | TIME | MATRIX | CONTAINER TYPE | # OF CONTAINERS | COMMENTS | Total Metals ICPOES | Sulfate | Chloride | Alkalinity | Receipt Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 80% Perrier +Salt Control | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 2 | 80% Perrier +Salt 1.6% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 3 | 80% Perrier +Salt 3.1% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 4 | 80% Perrier +Salt 6.3% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 5 | 80% Perrier +Salt 13% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 6 | 80% Perrier +Salt 25% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 7 | 80% Perrier +Salt 50% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 8 | 80% Perrier +Salt 75% | June 21/12 | - | Chem | 250 mL | 1 | Day 7 Subsample old | X | X | X | X | |
| 9 | | | | | | | ↑ very little sample, analyze if possible | | | | | |
| 10 | | | | | | | | | | | | |

| PROJECT INFORMATION | SAMPLE RECEIPT | | RELIQUINSHED BY (CLIENT) | RELIQUINSHED BY (COURIER) |
|---|---|---|---|---|
| Client: | Total # Containers: | | Signature: KBanack | Signature: |
| P.O. No.: | Good Condition? | | Print: Krysta Banack | Print: |
| Shipped Via: | Matches Schedule? | | Company: Nautilus Environmental | Company: |
| | | | Time/Date: July 25/12 @ 1700h | Time/Date: |

| SPECIAL INSTRUCTIONS/COMMENTS: | RECEIVED BY (COURIER) | RECEIVED BY (LABORATORY) |
|---|---|---|
| Attn: Can Dang | Signature: | Signature: [signature] July 25 |
| | Print: | Print: 9.2°C |
| | Company: | Company: |
| | Time/Date: | Time/Date: 17.30 PM |

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

# Appendix D

# Saskatchewan River Dispersion Modeling Reports

# SASKATCHEWAN RIVER HYDROTECHNICAL AND DISPERSION MODELING STUDY STAR DIAMOND PROJECT – 2010

Submitted to:

**Shore Gold Inc.**
Saskatoon, Saskatchewan

Submitted by:

**AMEC Earth & Environmental**
Edmonton, Alberta

December 2010

SX0373305

## EXECUTIVE SUMMARY

This report presents the results of a hydrotechnical and dispersion modeling study undertaken on the Saskatchewan River, east of Prince Albert, Saskatchewan, near the proposed **Shore Gold Inc.** *Star Diamond Project*. Operation of the mine will require some facilities to discharge brackish groundwater into the Saskatchewan River near the Duke or FALC Ravines. A hydrotechnical and dispersion modeling study was required to assess the local river hydraulics and quantify chloride concentrations in the receiving waterway in support of the Environmental Impact Study (EIS) and feasibility study for the *Star Diamond Project*. This report is presented in two parts as described below.

### *PART 1 – HYDROTECHNICAL MODELING STUDY*

Part 1 of this report discusses the hydrotechnical modeling study, which includes a detailed two-dimensional bathymetric survey of an 8 km reach of river near the proposed effluent discharge location and hydrodynamic modeling using River2D and HEC-RAS applications. Bathymetric survey data and findings from the hydrotechnical study were used as a foundation for two-dimensional dispersion modeling of chloride concentrations in the Saskatchewan River that corresponds to the proposed effluent discharge.

Some key findings of the hydrotechnical modeling study are that:

- the Saskatchewan River near the proposed effluent discharge location has a steeper upper reach, with characteristically higher velocities and shallower depths, and a more mild-sloping lower reach that is wider, deeper, and has lower velocities;
- flow through the reach is relatively uniform across the channel under most conditions, and there are no islands or mid-channel features to divide the flow and promote transverse mixing;
- some degree of backwater effect from the downstream hydropower reservoir was evident at the time of survey, which increased depths and water levels throughout the study reach;
- based on available sediment data and methodologies for assessing probable bed form type and size, the predominant bed material is expected to be sand with a median grain size of 0.28 mm and bed forms are anticipated to be dunes of 0.5 to 1 m in height in the vicinity of the outlet structure; however, direct observations and sampling of bed material during a low-flow period are recommended for the detailed design phase of an outfall or diffuser structure at this site; and,
- there appear to be no available observations documenting the river ice regime in the study area, but the channel geometry, hydraulic characteristics, and conceptual modeling of ice jams suggest that ice action should be considered during the detailed design phase; to better understand how ice activity might impact the detailed design of an outfall or diffuser, observations should be made along the study reach in the winter and/or immediately after break-up.

***PART 2 – DISPERSION MODELING STUDY***

Part 2 of this report discusses the results of a dispersion modeling study using AQUASEA, undertaken to assist **Shore Gold Inc.** with subsequent design of a river outfall or diffuser located on the Saskatchewan River and permitting for the *Star Diamond Project*. Bathymetric survey data and findings from the hydrotechnical study were used as a foundation for a two-dimensional dispersion modeling study which addresses the prediction of chloride concentrations in the Saskatchewan River that are expected to result from the discharge of groundwater to the river.

A 70 m long outfall and a 40 m long outfall were considered separately in the dispersion modeling study. Some key findings of the study are that:

- during low flows, the predicted maximum chloride concentration at a point 500 m downstream of the 70 m outfall, was 90 mg/L near the river bank for an effluent discharge rate of 199 000 $m^3$/d and an effluent chloride concentration of 1725 mg/L. For this scenario, the plume centreline is located approximately 25 m from the river bank at this location where the maximum chloride concentration is 99 mg/L and the plume width is 95 m;

- for the 40 m outfall, the plume generated was closer to the river bank with two to three times higher river concentrations within 500 m downstream of the outfall. Concentrations predicted approach those predicted for the 70 m outfall further downstream;

- for the low-flow condition, the river bank chloride concentration at the end of the study reach (6000 m downstream) was reduced to 33 mg/L (approximately 2% of initial chloride concentration); and,

- under average-flow conditions the plume was narrower with lower chloride concentrations.

## TABLE OF CONTENTS

**PAGE**

**PART 1 – HYDROTECHNICAL MODELING STUDY**

## TABLE OF CONTENTS

PAGE



## PART 2 – DISPERSION MODELING STUDY

# LIST OF TABLES

**PAGE**

## PART 1 – HYDROTECHNICAL MODELING STUDY



## PART 2 – DISPERSION MODELING STUDY

## LIST OF FIGURES

**PAGE**

### PART 1 – HYDROTECHNICAL MODELING STUDY

## LIST OF FIGURES



## PART 2 – DISPERSION MODELING STUDY



## APPENDICES

# PART 1

# HYDROTECHNICAL MODELING STUDY

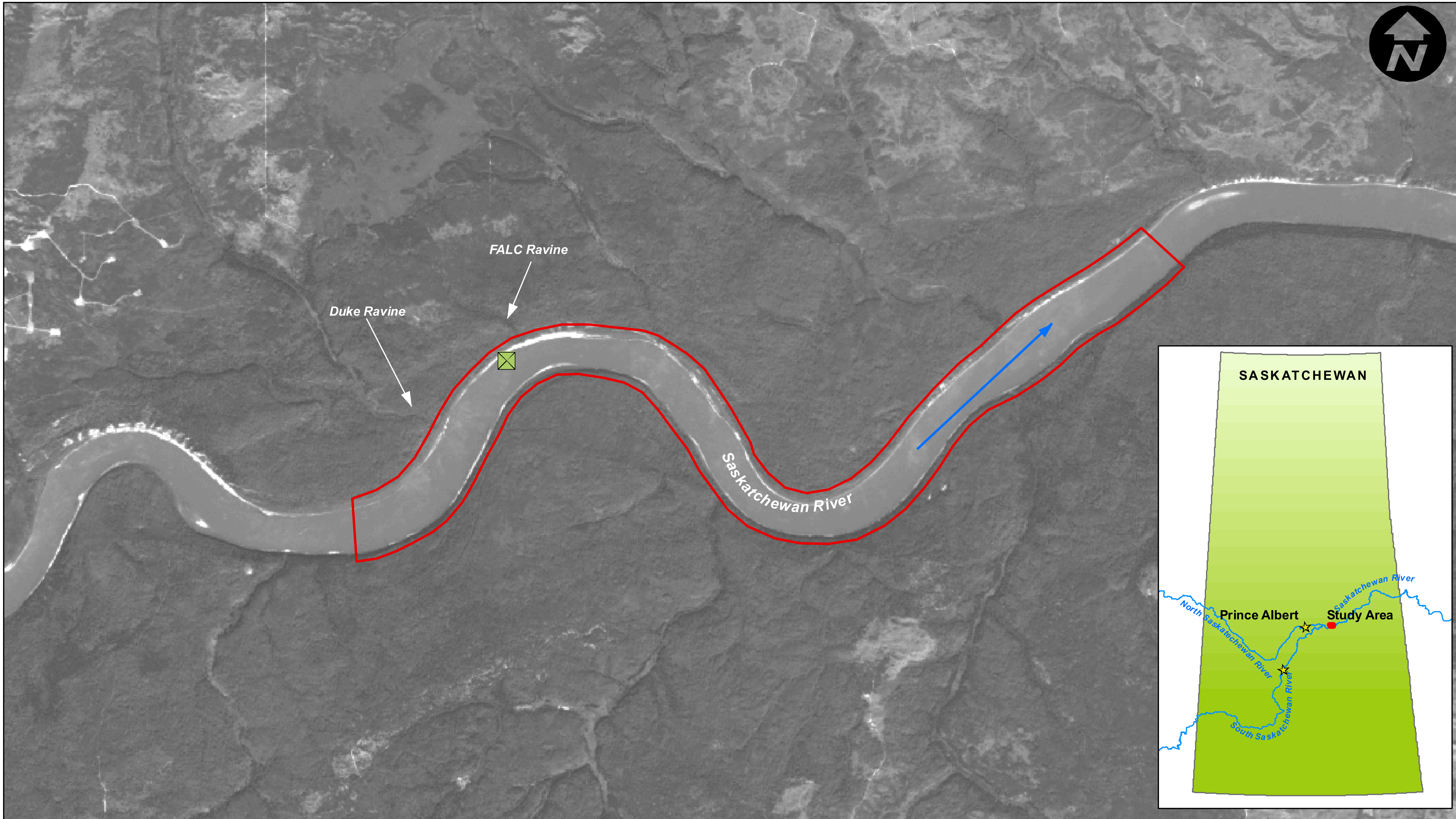
## 1.0 INTRODUCTION

AMEC Earth & Environmental (AMEC) was retained by **Shore Gold Inc.** to conduct a preliminary modeling study for a proposed river outfall or diffuser structure on the Saskatchewan River for the *Star Diamond Project*. Effluent that must be discharged from a proposed diamond mining operation is expected to be brackish. The goal of this study was to evaluate effluent mixing in the Saskatchewan River from a proposed outfall or diffuser and to build a reliable and detailed hydraulic model that can be used to evaluate the characteristics of the river under a wide range of flow scenarios that are important to a more detailed design of the structure. The proposed outfall or diffuser structure site is located along the Saskatchewan River, approximately 600 m downstream of the mouth of Duke Ravine and approximately 40 km downstream of the confluence of the North Saskatchewan and South Saskatchewan rivers. **Figure 1.1** provides an overview of the study area, including the boundary of the study site and the approximate location of the diffuser site.

Baseline bathymetry data in the study area was collected by CanNorth in August 2008. This data consisted of depth-based mapping extending approximately 0.5 km upstream and 1.5 km downstream of the proposed outfall location. To demonstrate to regulators that an adequate reach of the river is being considered, a detailed bathymetric survey and discharge measurements extending 1.0 km upstream and 6.5 km downstream of the proposed outfall location were carried out in late June 2010 by AMEC, with field support provided by CanNorth.

Using the information obtained from the field program, a reliable two-dimensional hydrodynamic model was constructed, calibrated, and used to provide necessary information that aided effluent dispersion modeling. River hydrology analyses were carried out in order to supply the model with relevant flow scenarios; including low flows where mixing is least efficient and high flows in which the diffuser must be adequately designed to withstand. Bed sediment material was analysed for the purpose of predicting the type and size of bed forms in the channel. One-dimensional ice jam modeling was carried out in order to explore the potential effects that an ice jam may have at the proposed outfall or diffuser site.

This hydrotechnical modeling study focuses on details of the field program, river hydrology, river hydraulics, sediment characteristics and river ice jam considerations with respect to the design of the outfall structure. In addition, recommendations for various aspects of a detailed final design for the proposed outfall structure are made. Instream mixing and details of effluent dispersion are covered in Part 2 of this report.




Study Area Boundary
Outfall/Diffuser (Approximate)

0 500 1,000 2,000 3,000 metres

Background Data from GeoBase®

| | | |
|---|---|---|
| CLIENT: Shore Gold Inc. | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | FIGURE 1.1 |
| DWN BY: RBA / CHK'D BY: RBA | Study Area Map | amec |

Map Path: L:\Water\PROJECT\EW...

## 2.0 DESCRIPTION OF STUDY REACH

The 7.5 km long reach of the Saskatchewan River chosen for the study, extending 1.0 km upstream and 6.5 km downstream of the proposed outfall location, is shown in **Figure 1.1**. This site is located approximately 40 km downstream of the confluence of the North Saskatchewan and the South Saskatchewan Rivers. The Saskatchewan River at Nipawin, which is located approximately 60 km downstream of the study area, has an effective drainage area of 287 000 km$^2$, as reported by the Water Survey of Canada. The streamflow in the North Saskatchewan River is regulated by the Bighorn and Brazeau Dams located in Alberta and the flow in the South Saskatchewan River is regulated by the Gardiner Dam located in Saskatchewan. Downstream of the site, there are two reservoirs for hydroelectric power generation: the Francois Finlay Dam at Nipawin which is located 60 km downstream and the E.B. Campbell Dam at Tobin Lake, which is located 130 km downstream of the site. There are a number of small creeks within the reach, entering the river on both sides of the channel.

In the study reach, the Saskatchewan River flows east through the south region of Fort à la Corne forest. This reach includes two sections: a steep upper reach resulting in shallower depths and a more mildly-sloping lower reach with deeper wide sections. There are two large meanders in the upper part of the reach before entering a relatively straight downstream portion. The river is entrenched in its valley, with little floodplain on either side of the channel and very steep banks in certain areas. Throughout the study site, the flow is relatively uniform across the channel and there are no islands that divide the flow. The reach is relatively remote with the closest access point located approximately 20 km downstream near a bridge along Highway 6 at Wapiti Valley.

**Figure 2.1** shows a photograph of the area of the proposed outfall structure. This area is located 600 m downstream of the mouth of Duke Ravine and 300 m upstream of the mouth of FALC Ravine on the left bank of the Saskatchewan River. The coordinates of this area are: 53°13’26” N, 104°42’27” W and it can be found on NTS map sheet number 073H02.

**Figure 2.1 Photograph of Outfall/Diffuser Site**

# 3.0 FIELD PROGRAM

## 3.1 Introduction

In order to construct computer models capable of simulating river hydraulics and mixing, a comprehensive field program providing adequate river geometry and calibration data was required. Such a program was undertaken for the 8 km long study reach over the period of 24 through 28 June 2010. During this time, the field crew completed a detailed bathymetric survey, water level surveys, and discharge measurements. Throughout the survey, horizontal and vertical positioning was achieved using survey-grade Trimble® R6/R8 GNSS RTK-GPS receivers.

All survey data was recorded in the UTM NAD83 coordinate system (Zone 13) with elevations as geoid heights referenced to the HT2.0 datum. Coordinates stated in this report are converted to NAD27, which is being used in other work on the Star Diamond Project. Local survey control points were established within the reach (see **Figure 3.1**) and tied into provincial benchmarks. These control points consisted of iron bars which were driven into the ground to a depth sufficient to resist frost movements so as to provide a semi-permanent control that can be referenced during future programs. Positional accuracy of survey points for the bank and bathymetry surveys is better than ±1 cm in the horizontal and ±2 cm in the vertical directions.

## 3.2 Bathymetric Surveys

The bathymetric survey comprised two parts: a bank survey for the above-water portion of the channel and a channel bed survey for the portion below the water. A feature-based survey was conducted, complete with appropriate annotation, that captured the details of the topography of the channel such as top of bank, bottom of bank, edge of water and channel bed. The bank survey was carried out using the RTK-GPS system, consisting of a base station communicating by radio with several mobile ‘rover’ units. The spacing between bank feature points was approximately 50 m. In total, 1800 ground points were surveyed.

The channel bed survey was conducted from a boat with an OHMEX SonarLite 2000 depth sounder and RTK-GPS attached. The transducer was attached to a bracket on the boat, and placed at a depth approximately 0.2 m below the water level. The RTK-GPS antenna was then positioned a known distance directly above this transducer, allowing for the bed elevation to be determined at each point. In total, 22 000 discrete bed points were measured and recorded over the reach. **Figure 3.2** displays all of the surveyed bathymetry points.

## 3.3 Water Level Surveys

In addition to the control points set up for the bathymetry survey, temporary benchmarks with less permanence were established along the reach to facilitate open water surveying. These points were spaced approximately 700 m apart and included points at the upstream and downstream limits of the survey (see **Figure 3.1**, Temporary Benchmarks 20 through 30). A rod and level were used to survey water levels relative to these control points in order to obtain a detailed water surface profile. **Table 3.1** presents a summary of the water levels obtained on 28 June 2010.

**Table 3.1**
**Water Surface Profile of the Study Reach Obtained on 28 June 2010**

| Benchmark Name | River Station (m) | Elevation (m) |
|---|---|---|
| 1 | 255 | 353.165 |
| 30 | 622 | 352.776 |
| 29 | 1583 | 352.023 |
| 28 | 2201 | 351.731 |
| 27 | 2941 | 351.43 |
| 26 | 3670 | 351.146 |
| 25 | 4468 | 350.835 |
| 24 | 5543 | 350.630 |
| 23 | 6262 | 350.599 |
| 22 | 6943 | 350.488 |
| 21 | 7626 | 350.397 |
| 20 | 8386 | 350.243 |

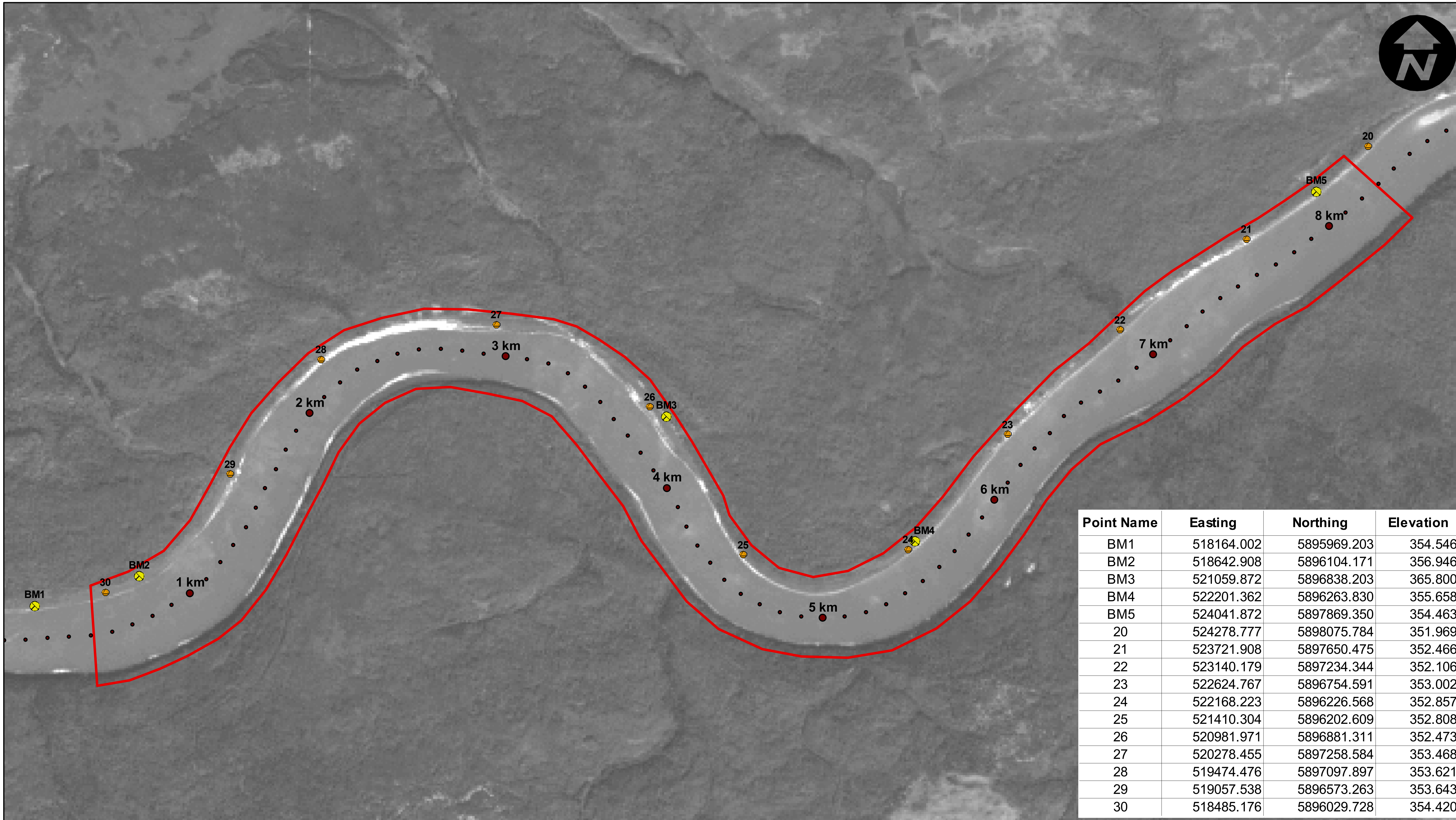
### 3.4 Discharge Measurements

A SonTek 3 MHz Acoustic Doppler Current Profiler (ADCP) (see **Figure 3.3**) was used to measure detailed depth-integrated velocity profile data and the total discharge across several sections in the reach. These sections include the upstream and downstream limits of the survey in order to provide estimates on inflow and outflow discharge. Additional velocity measurements were obtained in the vicinity of the proposed outfall structure to facilitate model validation. These three sites can be seen in **Figure 3.2**. The ADCP sensor was mounted in a trimaran and then deployed from the front of a boat. An RTK-GPS rover was attached to the system in order to aid bottom tracking and deal with moving bed conditions that were anticipated during the time of the survey. The distance from the endpoints to the edge of water was measured in each case and input into the ADCP software so that the entire section was accounted for when measuring the discharge. A minimum of 4 passes were made across each section. Instrument and quality control monitoring was done via computer from within the boat and the bottom tracking output was used to help guide the boat operator in a straight path between the endpoints.

At the first site (Section A-A), located near the upstream boundary of the survey, 5 passes were conducted on 24 June 2010. The resulting discharges ranged from 996 to 1182 $m^3$/s, with the average value of these measurements being 1118 $m^3$/s. There were some difficulties experienced in obtaining measurements at the site as bottom tracking and signal return was intermittent in some parts of the section due to sediment loads. Using the real-time data available from Water Survey of Canada for the North Saskatchewan River at Prince Albert and the South Saskatchewan River at Saskatoon, it is estimated that the discharge at the site on 24 June 2010 was approximately 1017 $m^3$/s. Taking into account the additional discharge from smaller tributaries downstream of the monitoring stations, the true discharge at the site is

expected to be higher. The ADCP average measurement value of 1118 $m^3/s$ is indeed higher, but still within 10% of the estimated value of 1017 $m^3/s$.
Four passes were conducted on 24 June 2010 at the second site (Section B-B) which is located in the vicinity of the proposed outfall structure. The resulting discharges ranged from 1071 to 1192 $m^3/s$, with the average value of these measurements being 1122 $m^3/s$. Again, there were some difficulties in taking measurements due to sediment movement along the bottom of the channel. However, there is confidence in the measurements taken as the values at this site and the previous site were very similar and are within 10% of the estimated discharge value using data from the North Saskatchewan River at Prince Albert and the South Saskatchewan River at Saskatoon.

On 28 June 2010, 8 passes were conducted near the downstream boundary of the survey (Section C-C). The resulting discharges ranged from 1097 to 1236 $m^3/s$, with the average value of these measurements being 1168 $m^3/s$. The mean velocities at this site were lower than at the two sites previously measured, which resulted in less sediment movement along the channel bottom and improved signal return. Using the available real-time data, it is estimated that the discharge at the site on 28 June 2010 was approximately 1079 $m^3/s$. Again, the ADCP average measurement value is slightly higher, as expected, but also within 10% of the estimated data. **Appendix A** provides detailed records for each of the velocity and discharge measurements obtained across the section.




| Point Name | Easting | Northing | Elevation |
|---|---|---|---|
| BM1 | 518164.002 | 5895969.203 | 354.546 |
| BM2 | 518642.908 | 5896104.171 | 356.946 |
| BM3 | 521059.872 | 5896838.203 | 365.800 |
| BM4 | 522201.362 | 5896263.830 | 355.658 |
| BM5 | 524041.872 | 5897869.350 | 354.463 |
| 20 | 524278.777 | 5898075.784 | 351.969 |
| 21 | 523721.908 | 5897650.475 | 352.466 |
| 22 | 523140.179 | 5897234.344 | 352.106 |
| 23 | 522624.767 | 5896754.591 | 353.002 |
| 24 | 522168.223 | 5896226.568 | 352.857 |
| 25 | 521410.304 | 5896202.609 | 352.808 |
| 26 | 520981.971 | 5896881.311 | 352.473 |
| 27 | 520278.455 | 5897258.584 | 353.468 |
| 28 | 519474.476 | 5897097.897 | 353.621 |
| 29 | 519057.538 | 5896573.263 | 353.643 |
| 30 | 518485.176 | 5896029.728 | 354.420 |

Study Area Boundary

Centreline River Station

Control Point

Temporary Bench Mark

0 500 1,000 2,000 metres

Background Data from GeoBase®
Horizontal Datum: NAD27 (13N)

CLIENT: Shore Gold Inc.

AMEC Project No.: SX0373305

DWN BY: RBA CHK'D BY: RBA

SHORE GOLD RIVER SURVEY

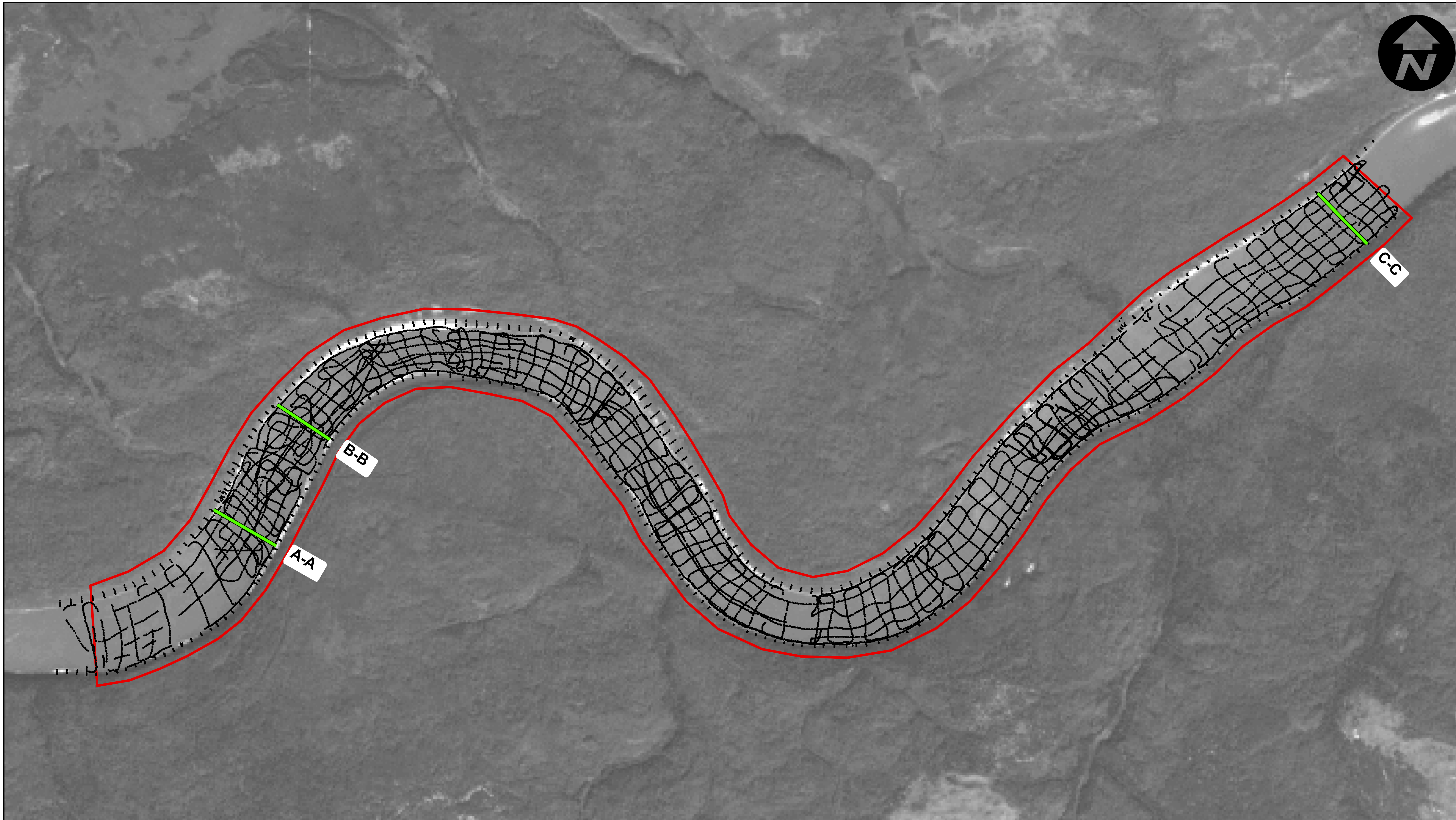
Benchmark and Control Point Locations

November 2010

FIGURE 3.1

amec

Map Path: L:\Water\PROJECT\EW...




| | | | | |
|---|---|---|---|---|
| Study Area Boundary<br>Discharge Measurement Transect<br>Bathymetry Point | Background Data from GeoBase®<br>0 500 1,000 2,000 metres | CLIENT: Shore Gold Inc.<br>AMEC Project No.: SX0373305<br>DWN BY: RBA CHK'D BY: RBA | SHORE GOLD RIVER SURVEY<br>Bank and Depth Sounding Survey Point Locations | November 2010<br>FIGURE 3.2<br>amec |

Map Path: L:\Water\PROJECT\EW...

**Figure 3.3 Photograph of Acoustic Doppler Current Profiler**

# 4.0 HYDROLOGY

## 4.1 Introduction

Hydrological analyses of recorded river discharges upstream and downstream of the site were undertaken to estimate river discharge parameters in support of dispersion modeling at the proposed effluent discharge location in the Saskatchewan River. The proposed outfall or diffuser structure is located approximately 40 km downstream of the confluence of the North Saskatchewan and the South Saskatchewan Rivers (see **Figure 1.1**). The flow in these rivers is regulated by hydroelectric dams upstream of the site. There are also two reservoirs for hydroelectric power generation located approximately 60 km and 130 km downstream of the site. Data from the closest Water Survey of Canada (WSC) hydrometric stations were used to assemble a suitable streamflow record for the proposed site. Analyses were conducted on the hydrological data to provide representative flows at the study site for river hydraulics and diffuser design modeling.

Using a synthetic streamflow record, average-flow conditions were determined and presented in the form of mean annual discharge and mean monthly discharges. Monthly flow duration curves were also created to determine the probability that various discharges would be equalled or exceeded. When considering mixing in a channel, of particular importance are the periods of low flow, as such cases represent times when water available for dispersion and mixing will be the lowest. To address this critical period, the 1-in-10-year average 7-day low flow, or 7Q10, was determined for both the annual (January–December) and the open water (May–October) cases. In addition, a flood frequency analysis was conducted in order to establish the peak discharges that may be experienced.

An ice data analysis was also undertaken to address critical design parameters affecting the proposed outfall structure that involve winter ice-covered conditions. The analysis was conducted using archived historic ice thickness information data from the WSC. This information was applied in a two-dimensional depth-averaged hydrodynamic model with a continuous intact ice cover in order to evaluate flow and velocity patterns and to a one-dimensional river ice jam model to provide estimates of velocities under potential ice jam conditions. These analyses are described in Sections 5.0 and 7.0, respectively.

## 4.2 Methodology

The WSC operates and maintains a hydrometric network that measures and records river water levels and flows. Surface water flow data are available at the locations shown in **Table 4.1**. Of these gauges, only three are currently active: North Saskatchewan River at Prince Albert (05GG001); South Saskatchewan River at Saskatoon (05HG001); and, Saskatchewan River below Lake Tobin (05KD003). The latter is the closest active WSC gauge to the site along the Saskatchewan River (located approximately 130 km downstream). However, data from this gauge are not representative of discharges at the site since the gauge is affected by the E.B. Campbell Hydroelectric Station. There are no active WSC gauges located along this reach that can be directly used to represent hydrological conditions at the site.

**Table 4.1**
**List of Water Survey of Canada Hydrometric Gauges Near the Study Site**

| WSC Station | Name | Period of Record | Drainage Area (km$^2$) | Comments |
|---|---|---|---|---|
| 05GG001 | North Saskatchewan River at Prince Albert | 1910 to 2009 | 131 000 | Upstream of confluence; regulated since 1962 |
| 05HG001 | South Saskatchewan River at Saskatoon | 1911 to 2009 | 141 000 | Upstream of confluence; regulated since 1968 |
| 05HH001 | South Saskatchewan River at St. Louis | 1958 to 1997 | 148 000 | Upstream of confluence; regulated since 1968 |
| 05KD001 | Saskatchewan River at Nipawin | 1945 to 1948; 1951 to 1962 | 287 000 | Downstream of confluence; regulated since 1968 |
| 05KD003 | Saskatchewan River below Lake Tobin | 1962 to 2009 | 289 000 | Downstream of confluence; regulated since 1963 |

To construct a streamflow record for the site, mean daily discharges for the two closest upstream gauges along both the North Saskatchewan River (05GG001 at Prince Albert) and South Saskatchewan River (05HG001 at Saskatoon) were added. These gauges are located approximately 100 km and 260 km upstream of the site, respectively. No gauged or major ungauged tributaries flow into the river between the upstream gauge sites and the study site. Due to the relatively small increase in contributing area between these gauges and the site, no adjustment was made to account for the small incremental increase in discharge downstream of the gauges; this provides slightly conservatively (approximately 5%) low estimates for discharge at the site. The lag time between the upstream gauges and the site was estimated for 2 cases, representing “long” and “short” travel times. Assuming a high average channel velocity, it was determined that the travel time from Prince Albert to the proposed site was 1 day and the travel time from Saskatoon to the proposed site was 2 days. Using a lower average channel velocity to better represent the low-flow period, a travel time of 2 days was used from Prince Albert to the proposed site and a travel time of 6 days was used from Saskatoon to the proposed site. These scenarios are presented in **Table 4.2**. Analysing the data using both sets of travel times allowed both the critical high- and low-flow scenarios to be simulated. These lag times were incorporated in the determination of mean daily discharge at the proposed site. As discussed below, both sets of travel times yielded similar computed river discharge parameter estimates at the proposed outfall site, which indicated that the results were not sensitive to the lag time.

**Table 4.2**
**Estimated Travel Time from WSC Gauged Sites to Study Site**

| Scenario | Travel Time (days) | |
|---|---|---|
| | Prince Albert to Study Site | Saskatoon to Study Site |
| Short Travel Time | 1 | 2 |
| Long Travel Time | 2 | 6 |

The effects of regulation were taken into account when building the dataset for the proposed site. There are several large dams that influence the flow patterns of the North Saskatchewan and South Saskatchewan Rivers. The Brazeau Dam, affecting the North Saskatchewan River, was built in 1962 and has an effective drainage area of 5660 $km^2$. The Bighorn Dam, also affecting the North Saskatchewan River, was created in the early 1970s and has an effective drainage area of 3890 $km^2$. The flows from these two dams represent a small percentage of the flow of the North Saskatchewan River at Prince Albert, which has a drainage area of 131 000 $km^2$, and thus are not likely to dramatically influence the flow patterns at the proposed site. The Gardiner Dam, affecting the South Saskatchewan River, was operational in 1968. It has an effective drainage area of 136 000 $km^2$, which is a large proportion of the effective drainage area of the South Saskatchewan River near Saskatoon of 141 000 $km^2$. Since regulation from this dam would have a great impact on the flow patterns at the proposed site, it was most appropriate to start the dataset in 1969, after the creation of the dam.

The effects of missing data were also considered in the creation of a dataset for the proposed site. From 1987 through 1991, winter flows were not monitored at the gauge located at South Saskatchewan River at Saskatoon (05HG001). Since excluding such a large period of flow would falsely alter any statistics conducted using daily discharge values, the entire flow record for these years were deleted from the mean daily discharge dataset. When analysing mean monthly data, the values for each month are considered independently of the rest of the year. Thus, for such analysis, it was suitable to incorporate the remaining available monthly data for the years 1987 through 1991.

## 4.3 Design Discharge Determination

### 4.3.1 Mean Annual Discharge

The mean annual discharge at the proposed site was calculated using mean daily data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001) for the combined periods of 1969–1986 and 1992–2009. This average was calculated for two annual periods. The first was based on a water year from November 1 to October 31. Using this method allowed for the water data to be split during a relatively steady flow period immediately prior to freeze-up during which discharge does not change significantly. The mean annual discharge was also calculated using a water year from July 1 to June 30. Using this method, the flows were split in the middle of the wet season in order to capture one low-flow period per water year. The value for the mean annual discharge using both methods of water year selection, as well as both sets of travel times, was determined to be 439 $m^3/s$.

### 4.3.2 Mean Monthly Discharge

The mean monthly discharge at the proposed site was calculated using mean monthly data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001) throughout the period of 1969–2009. Within that data set, some of the winter months for the years 1987 through 1991 were excluded due to lack of recorded data at the gauge. The results of this analysis are shown in **Figure 4.1**, which indicates that higher mean flows are experienced from April through August. Due to regulation by hydroelectric dams located upstream of the site, it can be seen that mean flows do not vary dramatically from the summer to the winter months. Monthly flow duration curves created using the mean monthly flow data are illustrated in **Figure 4.2**. These graphs show the probability that a given discharge will be equalled or exceeded in each month. **Figure 4.2** indicates that high flows are most likely to occur during the months April through August and that low flows commonly occur during November to March. Individual monthly flow duration curves are contained in **Appendix B**.

### 4.3.3 Low Flows

The design low-flow values are represented by a calculated consecutive 7-day low average discharge with a 10-year average recurrence interval, or 7Q10. The 7Q10 value was determined for both the open water and the annual case using mean daily data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001) for the combined periods of 1969–1986 and 1992–2009. For the open water case, this value was calculated using the open water period from May 1 to October 31. The open water 7Q10, calculated using both sets of travel times, was determined to be 188 $m^3/s$. For the annual case, this value was first calculated using a water year from November 1 to October 31 and also using a water year from July 1 to June 30, as in the case of the mean annual flow. The values of the annual 7Q10 using each method and incorporating both sets of travel times were determined to be 168 $m^3/s$ and 170 $m^3/s$, respectively. Thus, 169 $m^3/s$ was taken as the design value for the annual 7Q10. These results are summarized in **Table 4.3**.

**Table 4.3**
**Calculated 7Q10 Values for the Open Water and Annual Case**

| 7Q10 Values | Discharge ($m^3/s$) |
|---|---|
| **Open Water Design Value** | **188** |
| Nov 1 to Oct 31 annual value | 168 |
| July 1 to June 30 annual value | 170 |
| **Annual Design Value** | **169** |

### 4.3.4 Flood Frequency Estimates

Flood frequency analyses were conducted for the proposed site using mean daily data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001) throughout the periods of 1969–2009. Information from the period between 1987 and 1991 was re-introduced in this case, as missing data in the winter months do not affect the peak flow analysis. Maximum mean daily discharges were used for the analysis since it was found that the ratios of instantaneous peak values to maximum mean daily discharges at Saskatchewan River at Nipawin (05KD001), North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001) were near unity. The Log Pearson Type III distribution was found to best fit the collected data. The results of the analysis are summarized in **Table 4.4**. Note that the discharge measured at the time of the field program in late June 2010 corresponds closely with the 1:2-year flood discharge.

**Table 4.4**
**Flood Frequency Analysis for the Proposed Site Using a Log Pearson Type-III Distribution**

| Return Period (years) | Discharge ($m^3$/s) |
|---|---|
| 100 | 4770 |
| 50 | 3980 |
| 20 | 3080 |
| 10 | 2470 |
| 5 | 1930 |
| 3 | 1550 |
| 2 | 1250 |

## 4.4 Ice Data

No ice thickness data were available at the study site. However, in addition to measurements of river water levels and flows, the WSC also records ice thickness measurement data near certain hydrometric stations. Data were available for the North Saskatchewan River at Prince Albert (05GG001) in Saskatchewan and the Saskatchewan River at the Pas (05KJ001) in Manitoba. Data from the North Saskatchewan River at Prince Albert were chosen as representative and analysed since the station is closest to the study site and it lies along similar latitude.

Eleven years of ice thickness data were available from the WSC station at North Saskatchewan River at Prince Albert (05GG001), from 2000 to 2010. This data is shown in **Figure 4.3**. This figure shows ice thickness measurement values from the bottom of the ice to the top of the phreatic water surface. This thickness varies from the actual ice thickness, depending on the density of the ice and the depth of snow on top of the ice. Information on ice density and snow depths are not available; however, these reported thicknesses are considered to be within approximately 10% of the actual ice thickness.

Upon studying the ice thickness data presented, 70 cm was chosen as a representative value for a fully-developed, competent ice cover.

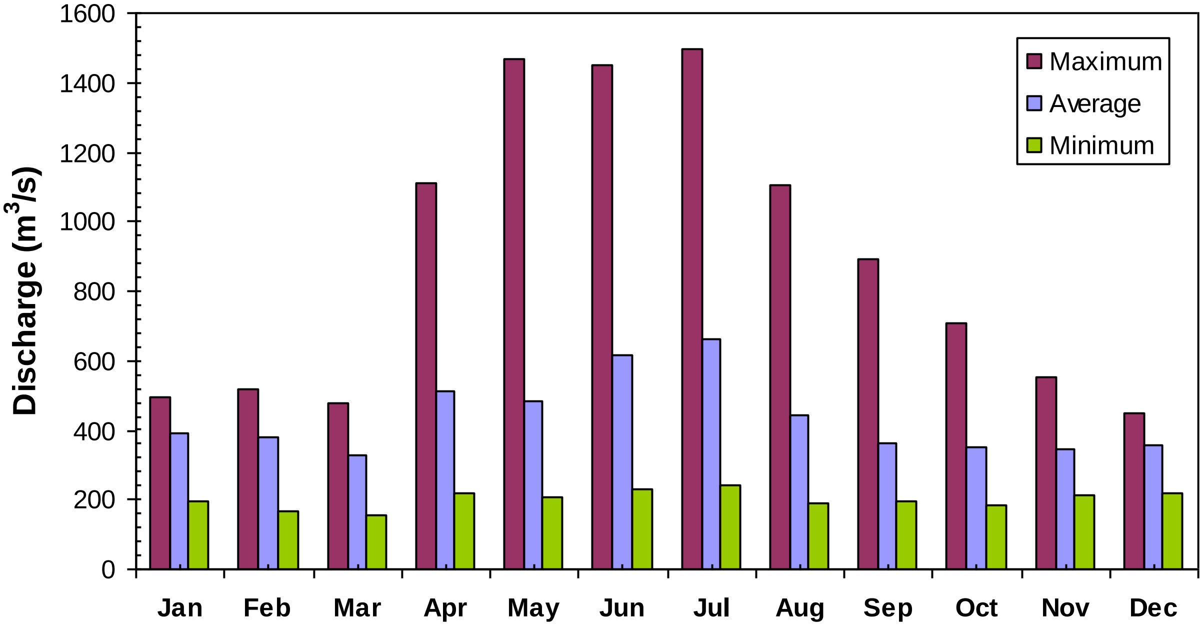



**Figure 4.1 Mean Monthly Flows for the Proposed Site Based on Data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009**

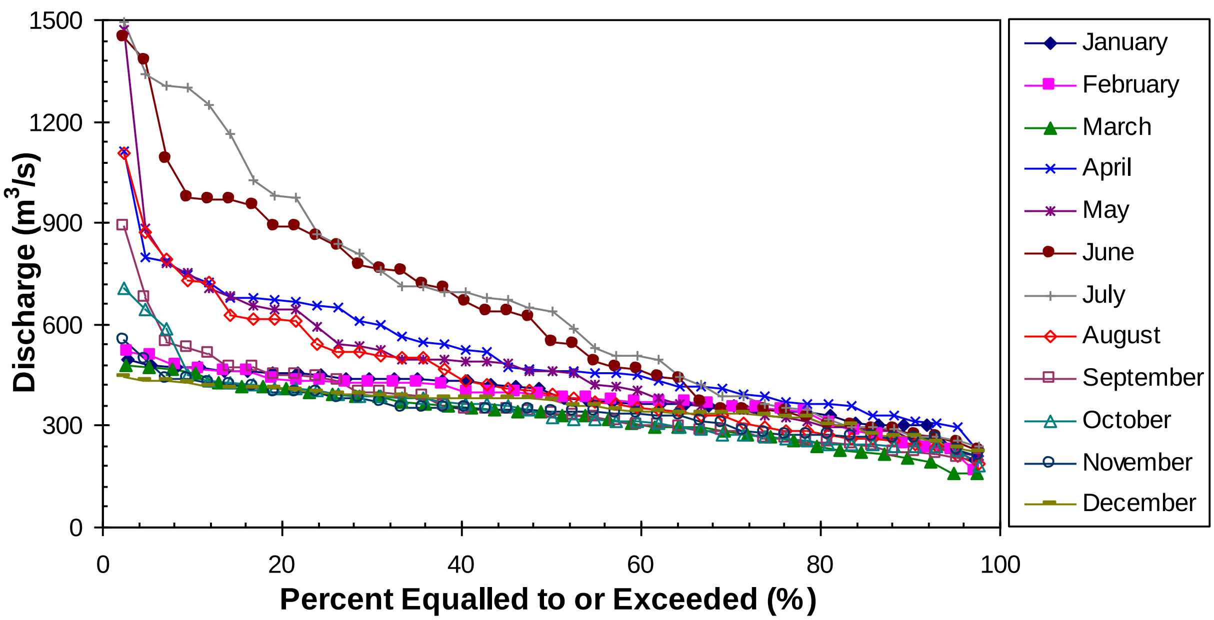



**Figure 4.2 Monthly Flow Duration Curves for the Proposed Site Based on Data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–1986; 1992–2009**

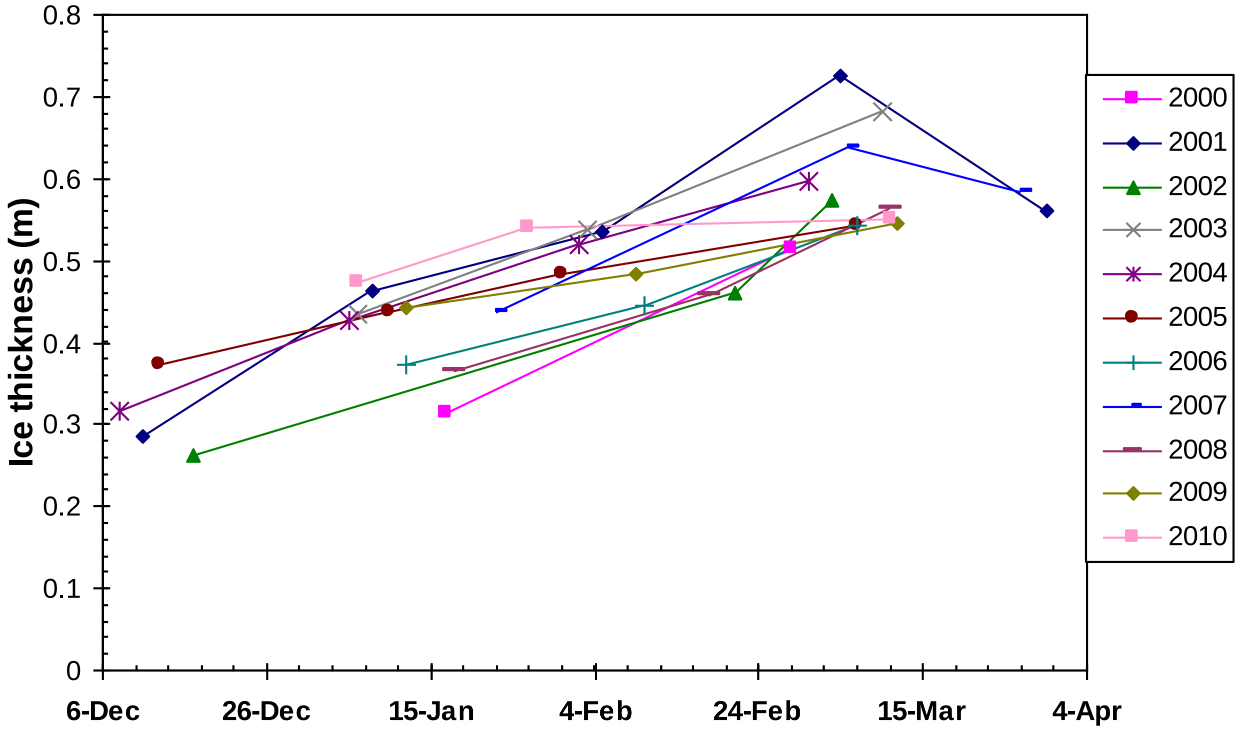



**Figure 4.3 Summary of Ice Thickness Measurements on the North Saskatchewan River at Prince Albert (05GG001)**

# 5.0 RIVER HYDRAULIC MODELING

## 5.1 Introduction

The use of a two-dimensional hydrodynamic model was necessary to assess flow patterns and to provide hydraulic information that is essential for sediment analysis and dispersion modeling. In order to address critical design conditions affecting the proposed outfall structure involving low river discharge and ice-covered conditions in winter, it was necessary that this model be capable of simulating ice-covered hydraulics. The University of Alberta's *River2D* suite of software, which uses a finite element scheme to solve depth-averaged hydrodynamic equations for both open water and continuous intact ice cover conditions, was selected for this study.

Using the data collected during the bathymetric survey, a two-dimensional model was constructed, calibrated to the conditions at the time of the field survey, and used to simulate depth and velocity throughout the study reach during design low- and high-flow conditions. The results of modeling provide an illustration of the water surface elevation, flow depth, velocity magnitude, shear bed velocity magnitude, and cumulative discharge over a range of flow conditions.

## 5.2 Model Construction

The model geometry bed file and computational mesh were constructed using the detailed bathymetric data that was collected during the field program carried out in June 2010. The bed geometry file was created, covering a reach approximately 7.5 km long in the vicinity of the proposed effluent discharge location. Break lines were inserted in the longitudinal direction to link common river features (e.g., top of bank, bottom of bank, edge of water, channel bed) and allow for correct interpolation of field data points. **Figure 5.1** displays all of the break lines added to the model (as dotted lines). An outer boundary was created around the data points, with delineated upstream and downstream boundaries.

A computational mesh was created using a constant node spacing of 15 m. The Triangulated Irregular Network (TIN) methodology was used to distribute data points, or nodes, and arrange them in a network of non-overlapping triangles (Steffler and Blackburn, 2002). **Figure 5.2** displays a detail of the mesh created in the vicinity of the proposed outfall structure. Special care was taken to distribute a sufficient number of nodes throughout the model, such that the low-flow scenarios would not have issues with the wet-dry transition of elements. The resulting bed geometry, displayed as colour contour elevation information, is shown in **Figure 5.3**. From this figure, it is evident that there is a relatively large change in elevation over the upstream half of the reach, while the downstream half of the reach is flatter. It can also be seen that at the channel bends the river becomes narrower and deeper.

## 5.3 Model Calibration

In order to be able to apply the model to various flow scenarios, it must first be adequately calibrated. Through the knowledge of the water surface elevation at the downstream boundary and a corresponding discharge at the upstream boundary, channel roughness is calibrated to achieve modeled values corresponding to the observed water surface elevation. For the purpose of this study, a calibration was performed using the data collected on 28 June 2010. This data consists of an inflow discharge of 1168 $m^3$/s and a water surface profile which includes the downstream boundary condition.

### 5.3.1 Calibration Results

In *River2D*, channel roughness is represented by a roughness height, $k_s$. This parameter theoretically represents the median diameter of an equivalent "particle" fixed to the bed that resists movement due to water flowing above. Several constant values of $k_s$ were tested during model calibration, as well as a variation with two different $k_s$ values used together. It was evident that two distinct reaches existed throughout the study site: a steeper upper reach and a wider, more mildly-sloping lower reach. The results of the water surface profile generated by each run are displayed in **Figure 5.4**. It can be seen that the profile which best represents the observed data is one with a value of $k_s = 0.25$ m used for the upstream half of the reach and $k_s = 0.15$ m used for the downstream half. **Figure 5.5** shows the simulated water surface elevation (in metres) along the entire study reach.

### 5.3.2 Velocity Comparisons

Observed depths and velocities were available for comparison at each of the three discharge measurement cross sections. In order to make an adequate comparison, the depth and velocity data collected by the ADCP was orthogonally projected onto the modeled cross section. The scalar projection of the ADCP velocity was also determined.

**Figure 5.6** presents all of the observed and simulated distributions of depth and velocity at Section A-A, located as shown on **Figure 3.2**. This cross section, which is located near the upstream boundary of the reach, is in a steep area of the reach where relatively high mean velocities were experienced at the time of survey. From the velocity graph, it can be seen that there was a section where the ADCP had difficulty in measuring velocity. However, the overall correlation between the depth and velocity data collected with the ADCP and the output from the model was good.

**Figure 5.7** shows all of the observed and simulated distributions of depth and velocity at Section B-B, located near the proposed effluent discharge site. This cross section also exists in a steep area where relatively high mean velocities were experienced at the time of survey. Very good correlation was found when comparing the depth and velocity data observed to the output from the model.

All of the observed and simulated distributions of depth and velocity at Section C-C, located near the downstream boundary, are shown in **Figure 5.8**. This cross section exists in a more mildly sloping, lower velocity area, as compared with the first two cross sections. Again, very good correlation was found when comparing the observed data to the output from the model. The results of the comparisons of modeled and observed velocities and depths at the three sites indicated that the calibration was successful and provides some validation for the modeling results. **Figure 5.9** shows the simulated velocity magnitude throughout the entire study reach for the calibration discharge of 1168 $m^3/s$. As can be seen in the figure, depth-averaged velocities are highest (1.6 m/s) at the upstream end of the reach and decrease towards 1 m/s at the downstream end of the reach. This is a result of the steeper bed slope that exists in the upstream part of the reach (see **Figure 5.3**). **Figure 5.10** displays the bed shear velocity magnitude throughout the reach for the calibration discharge. Again, values of bed shear velocity decrease in the downstream direction along the reach (from approximately 0.14 to 0.07 m/s). **Figure 5.11** presents the flow depth throughout the channel for the calibration discharge. Average values of depth tend to increase towards the downstream end of the channel (ranging from 2.2 to 3.8 m/s), with the deepest areas located at the channel bends. **Figure 5.12** exhibits the cumulative discharge, sometimes referred to as stream function, along the channel for the calibration flow. It can be seen that the flow is very evenly distributed throughout the channel.

### 5.3.3 Boundary Conditions

A depth-unit discharge relationship downstream boundary condition was used for all the scenarios modeled using *River2D*. This approach allowed for some consideration of the backwater effects at the time of the field program due to the reservoir located downstream of the study site. Based on experience, this type of boundary condition tends to result both in a more stable model than a fixed outflow boundary elevation and in a more natural shape to the water surface at the outflow boundary. This boundary condition takes the form of the following equation:

$$q = Kh^m$$

where $q$ = unit discharge
$h$ = flow depth
$K, m$ = constants

By modifying the value for K from the default of unity to a value of 0.43 and using the default value of 1.666 for the exponent *m*, a good match between the shape of the observed and simulated water surfaces was obtained. These values were used to describe the downstream boundary condition for the simulation of low- and high-flow scenarios. In the case of a continuous intact ice cover, the value of K was decreased to reflect the additional wetted perimeter and roughness introduced by the presence of the ice cover. These values are summarized in **Table 5.1**.

**Table 5.1**
**Modeling Constants for the Open Water and Annual Case**

| | Default Value | Calibrated Open Channel Flow | Ice-covered Flow |
|---|---|---|---|
| **K** | 1.00 | 0.43 | 0.27 |
| **m** | 1.666 | 1.666 | 1.666 |

### 5.4 Model Simulation Results

Model simulations were carried out for four different flow scenarios. Open water low-flow modeling was conducted on an open water 7Q10 value of 188 $m^3/s$, as determined through low-flow analysis. Annual low-flow modeling with a 0.7 m thick continuous intact ice cover was conducted for a 7Q10 value of 169 $m^3/s$, as determined through low-flow analysis. Model results for the mean annual-flow conditions of 439 $m^3/s$ were considered. A high-flow scenario model was run using a 1:100-year flow value of 4770 $m^3/s$, as determined through flood frequency analysis. These values were chosen to represent a broad range of conditions that may be experienced throughout the reach. Assessments of the water surface elevations, velocity magnitude, shear velocity magnitude, flow depth and cumulative discharge across the channel were made at the proposed outfall site for each flow scenario, with special consideration placed on the velocity and flow depth as parameters most relevant to design. **Figures 5.13 through 5.32** show the various modeled results under each flow scenario. These results were compared with the calibration flow of 1168 $m^3/s$, where relevant.

#### 5.4.1 Water Surface Elevation

**Figures 5.13 through 5.16** display the simulated water surface elevations throughout the study reach. **Table 5.2** presents the modeled water surface elevations at the upstream and downstream boundary for each flow scenario. For the low-flow ice-covered scenario, the water surface elevation represents the top of the phreatic water surface assuming that the specific density of ice is 0.92. Due to the channel geometry, the slope of the water surface flattens significantly in the downstream half of the reach under each flow scenario.

**Table 5.2**
**Modeled Water Surface Elevations at the Upstream and Downstream Boundary**

| Scenario (Discharge) | Upstream Water Surface Elevation (m) | Downstream Water Surface Elevation (m) |
|---|---|---|
| Open Water Low Flow (188 $m^3/s$) | 351.59 | 347.66 |
| Annual Low Flow (169 $m^3/s$) | 352.35 | 348.66 |
| Mean Annual Flow (439 $m^3/s$) | 352.02 | 348.53 |
| High Flow (4770 $m^3/s$) | 357.15 | 354.95 |

#### 5.4.2 Flow Depth

**Figures 5.17 through 5.20** present the simulated flow depth throughout the study reach under each of the flow conditions. The figures show that flow depths generally increase in the downstream direction. Again, this is due to the change in slope of the channel and the backwater effects from the reservoirs located downstream of the study site. Flow depths are lowest under low-flow scenarios. Under open water low-flow conditions, the site of the proposed outfall structure is located in an area where the flow transitions from a shallow to a deep section, with depths ranging from 0.9 to 2.0 m along the section. Under ice-covered annual low-flow conditions, depths near the proposed outfall site range from 1.1 to 2.2 m along the section. It can be seen that there is a slight increase in flow depth from the open water to the ice-covered case. This is due to the increased resistance in the channel from the roughness of the bottom of the ice cover. The open water low-flow case should be considered in the placement of the outfall or diffuser structure during detailed design. **Table 5.3** displays the flow depth at the proposed outfall structure site as well as at the upstream and downstream boundary for each flow scenario.

**Table 5.3**
**Modeled Flow Depth at the Site and Upstream and Downstream boundary**

| Scenario (Discharge) | Proposed Site Flow Depth Range (m) | Upstream Average Flow Depth (m) | Downstream Average Flow Depth (m) |
|---|---|---|---|
| Open Water Low Flow (188 $m^3/s$) | 0.9 to 2.0 | 0.8 | 1.3 |
| Annual Low Flow (169 $m^3/s$) | 1.1 to 2.2 | 0.9 | 1.6 |
| Mean Annual Flow (439 $m^3/s$) | 1.7 to 2.8 | 1.2 | 2.1 |
| High Flow (4770 $m^3/s$) | 7.9 to 9.0 | 6.1 | 8.4 |

### 5.4.3 Velocity Magnitude

**Figures 5.21 through 5.24** show the simulated velocity magnitude throughout the study reach under each of the flow conditions. From the figures, it can be seen that there are higher average velocities at the upstream half of the reach as compared to the downstream portion. This is due to the change in slope of the channel and the backwater effects from the reservoirs located downstream of the study site. For the low-flow scenarios, the highest velocities exist in the regions located just upstream of each of the main bends in the channel. For the mean annual-flow scenario, the increases in velocities experienced in the areas just upstream of the main channel bends are less pronounced than at the low-flow scenario and there is more of a consistent gradual decrease in velocity throughout the reach. For the high-flow scenario, the greatest velocities are experienced inside the main channel bends, with values reaching 3 m/s. The high-flow scenario represents the critical case in terms of velocities experienced at the site and must be considered in the final design. **Table 5.4** reports the velocity magnitude at the proposed outfall structure site as well as at the upstream and downstream boundary for each flow scenario. It can be seen that the modeled velocities at the site are very similar to the velocities at the upstream boundary of the reach.

**Table 5.4**
**Modeled Velocity Magnitude at the Site and Upstream and Downstream Boundary**

| Scenario (Discharge) | Proposed Site Velocity (m/s) | Upstream Average Velocity (m/s) | Downstream Average Velocity (m/s) |
|---|---|---|---|
| Open Water Low Flow (188 $m^3/s$) | 0.8 | 0.8 | 0.5 |
| Annual Low Flow (169 $m^3/s$) | 0.6 | 0.6 | 0.4 |
| Mean Annual Flow (439 $m^3/s$) | 1.1 | 1.1 | 0.7 |
| High Flow (4770 $m^3/s$) | 2.2 | 2.2 | 1.7 |

### 5.4.4 Bed Shear Velocity Magnitude

**Figures 5.25 through 5.28** display the simulated bed shear velocity magnitude throughout the study reach under each of the flow conditions. The figures show that the trends followed by the bed shear velocity magnitude are very similar to that of the velocity magnitude, where the maximum bed shear velocities are experienced in the areas just upstream of, or in the main channel bends, depending on the flow. As with the velocity magnitude, the highest values of the bed shear velocity magnitude result from the high-flow scenario. This case should be considered in the final design. **Table 5.5** presents the bed shear velocity magnitude at the proposed outfall structure site as well as at the upstream and downstream boundary for each flow scenario.

**Table 5.5**
**Modeled Bed Shear Velocity Magnitude at the Site and Upstream and Downstream Boundary**

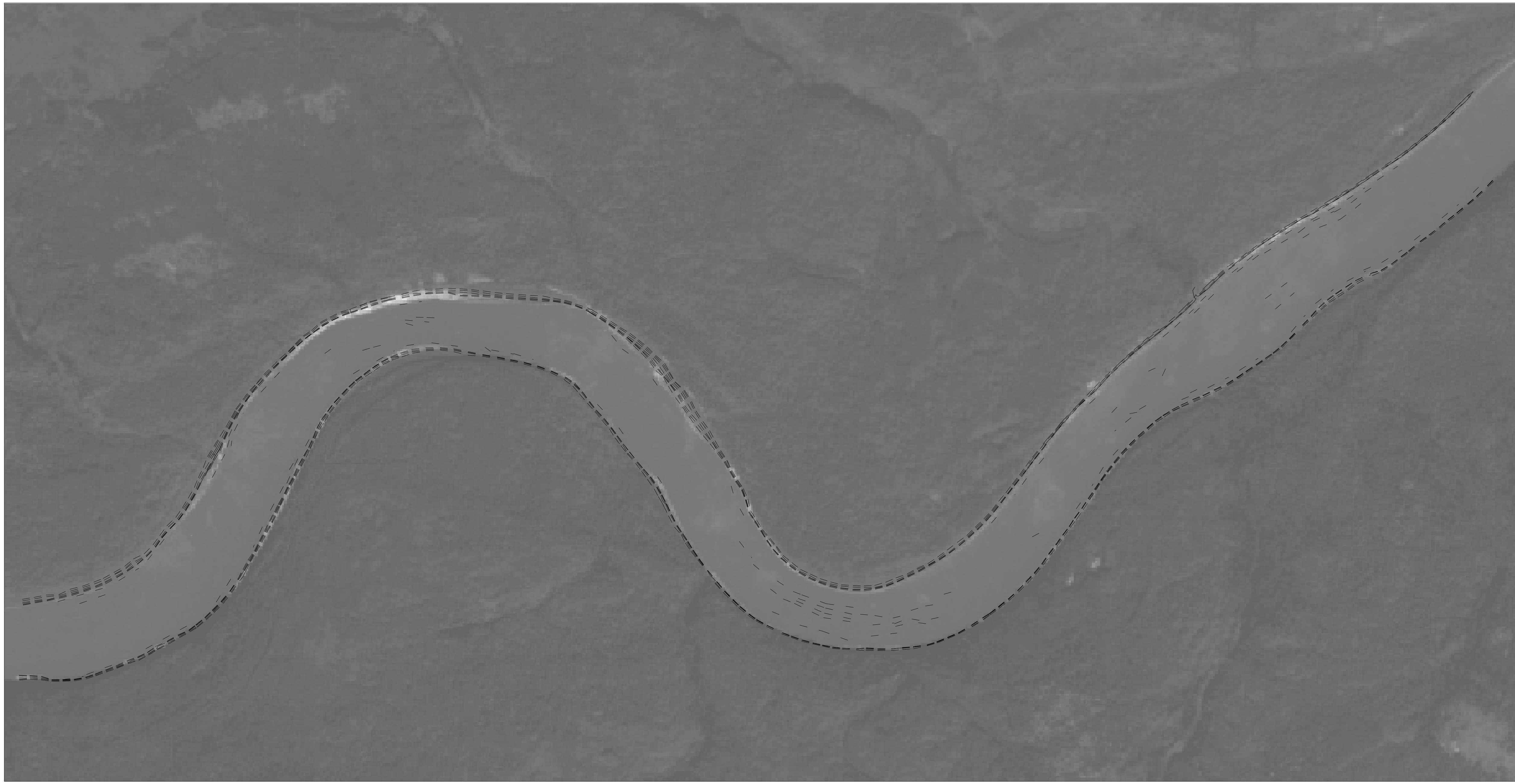
| Scenario (Discharge) | Proposed Site Shear Velocity (m/s) | Upstream Average Shear Velocity (m/s) | Downstream Average Shear Velocity (m/s) |
|---|---|---|---|
| Open Water Low Flow (188 $m^3/s$) | 0.07 | 0.08 | 0.04 |
| Annual Low Flow (169 $m^3/s$) | 0.06 | 0.07 | 0.03 |
| Mean Annual Flow (439 $m^3/s$) | 0.09 | 0.10 | 0.05 |
| High Flow (4770 $m^3/s$) | 0.15 | 0.15 | 0.10 |

### 5.4.5 Cumulative Discharge

**Figures 5.29 through 5.32** exhibit the cumulative discharge along the channel under each of the flow conditions. For higher flow conditions, the flow is very evenly distributed throughout the channel. As flows decrease, the distribution becomes less uniform. For low-flow scenarios, flow spreading begins to develop as the channel widens towards to the downstream boundary.

Scale

500.0 m



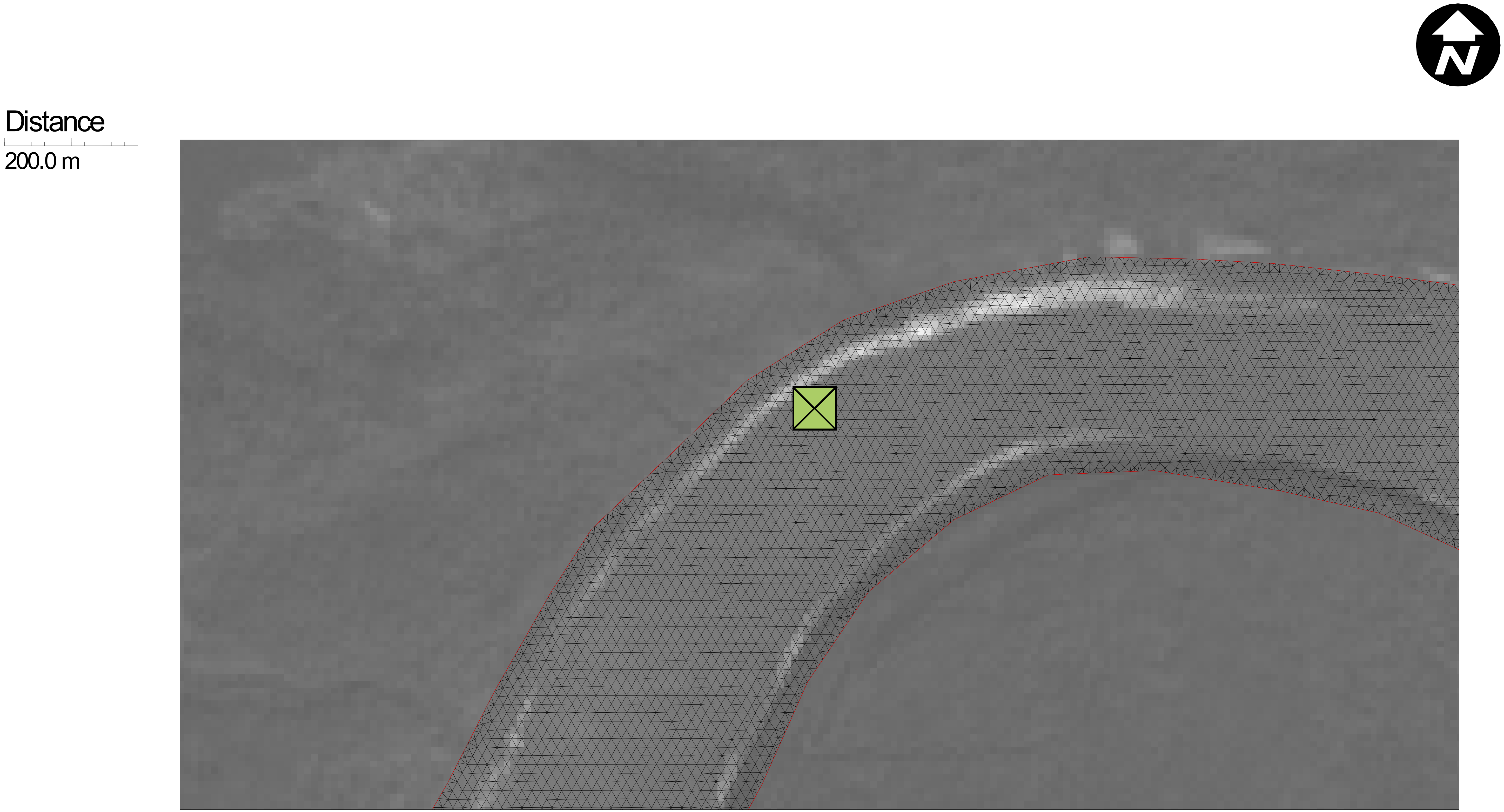
- - - - River2D Breaklines

Background Data from GeoBase®

SCALE AS SHOWN

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.1 |
| AMEC Project No.: SX0373305 | | Breakline Locations | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

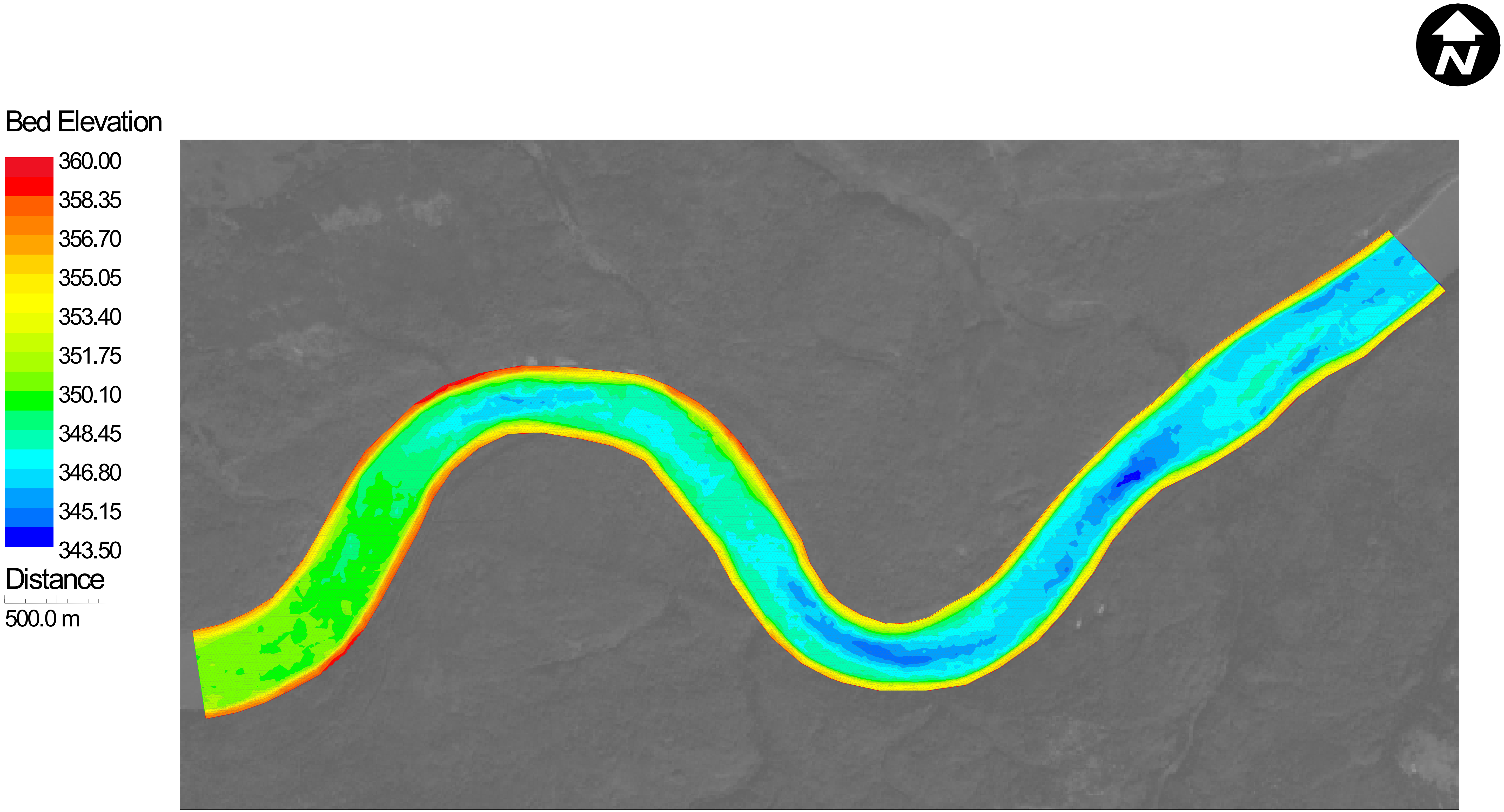
Outfall/Diffuser (Approximate)

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.2 |
| AMEC Project No.: SX0373305 | | River2D Computational Mesh Near Proposed Outfall/Diffuser | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

Background Data from GeoBase®

SCALE AS SHOWN

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.3 |
| DWN BY: RBA | CHK'D BY: RBA | Bed Elevation Contour Map | amec |

Map Path: L:\Water\PROJECT\EW...

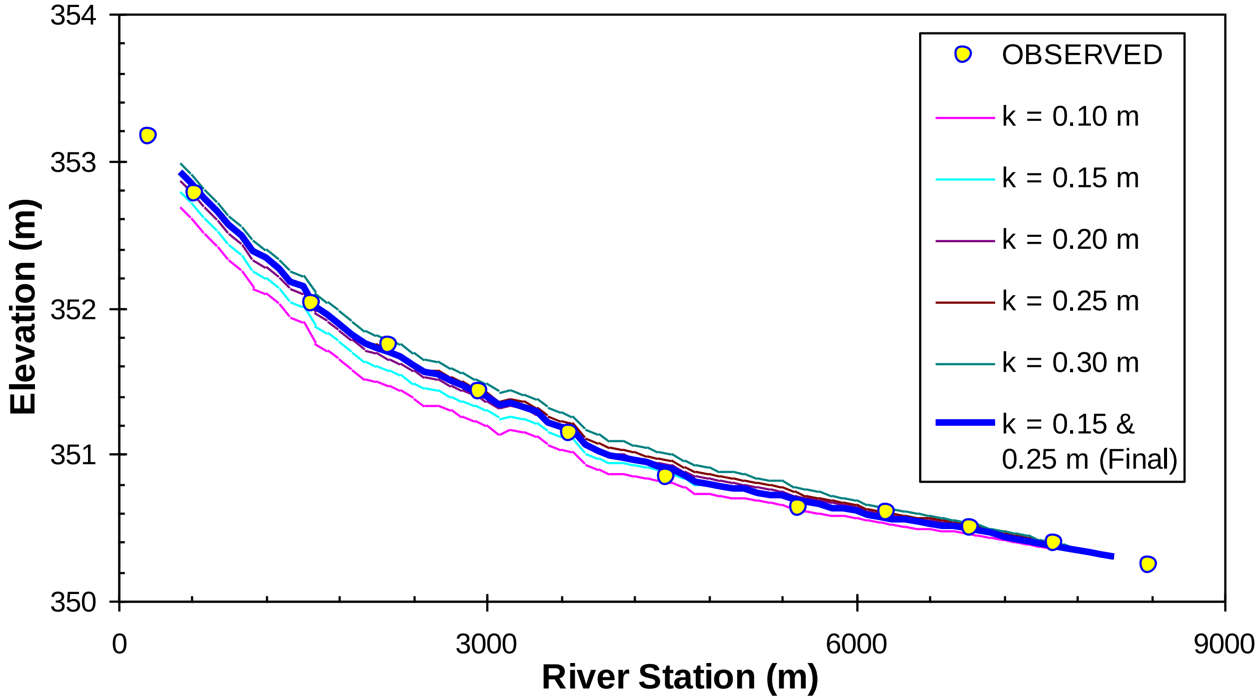
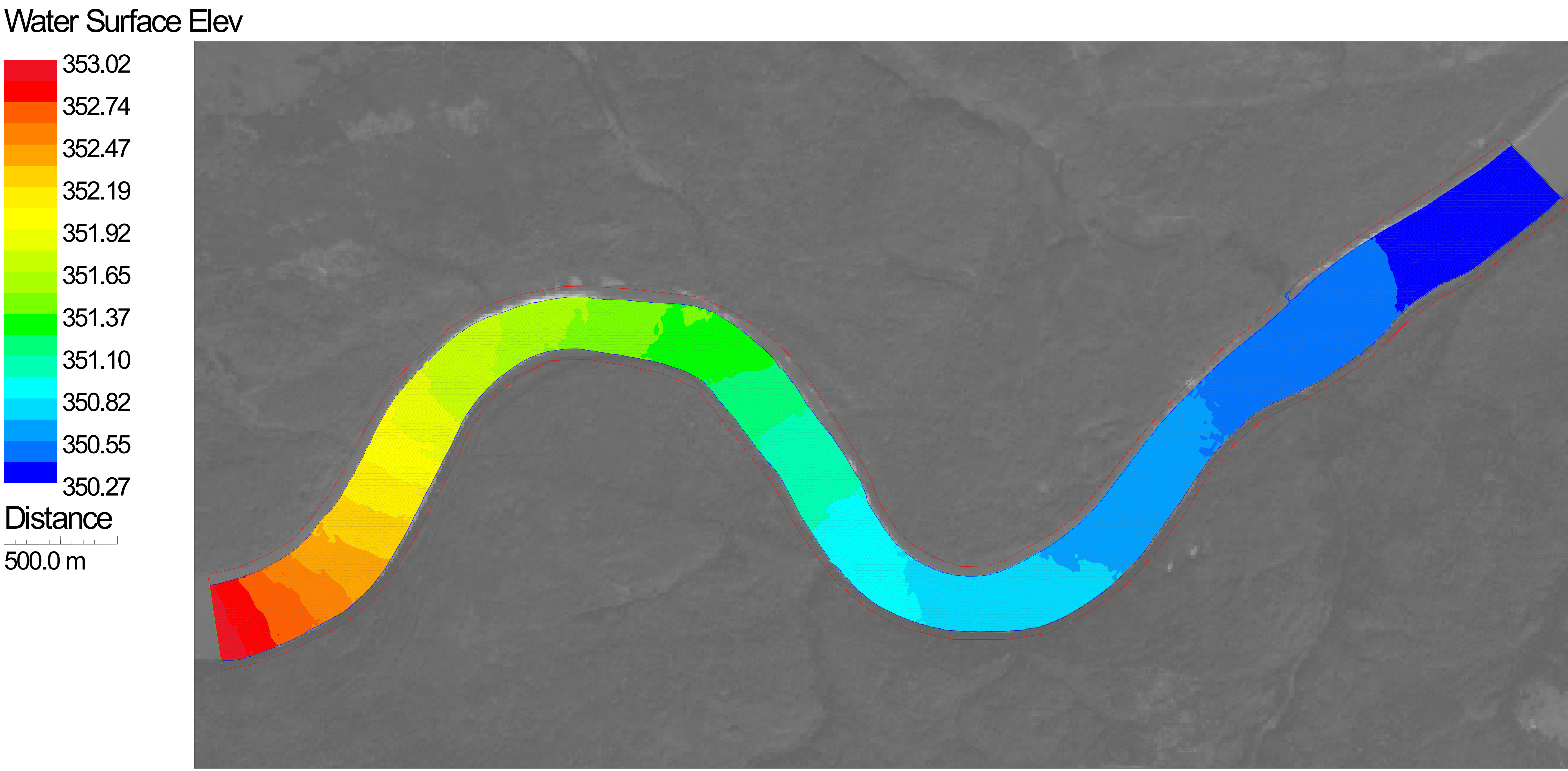



**Figure 5.4 Water Surface Profile Calibration (River2D)**




Model Boundary

**DISCHARGE**
**1168 m$^3$/s**

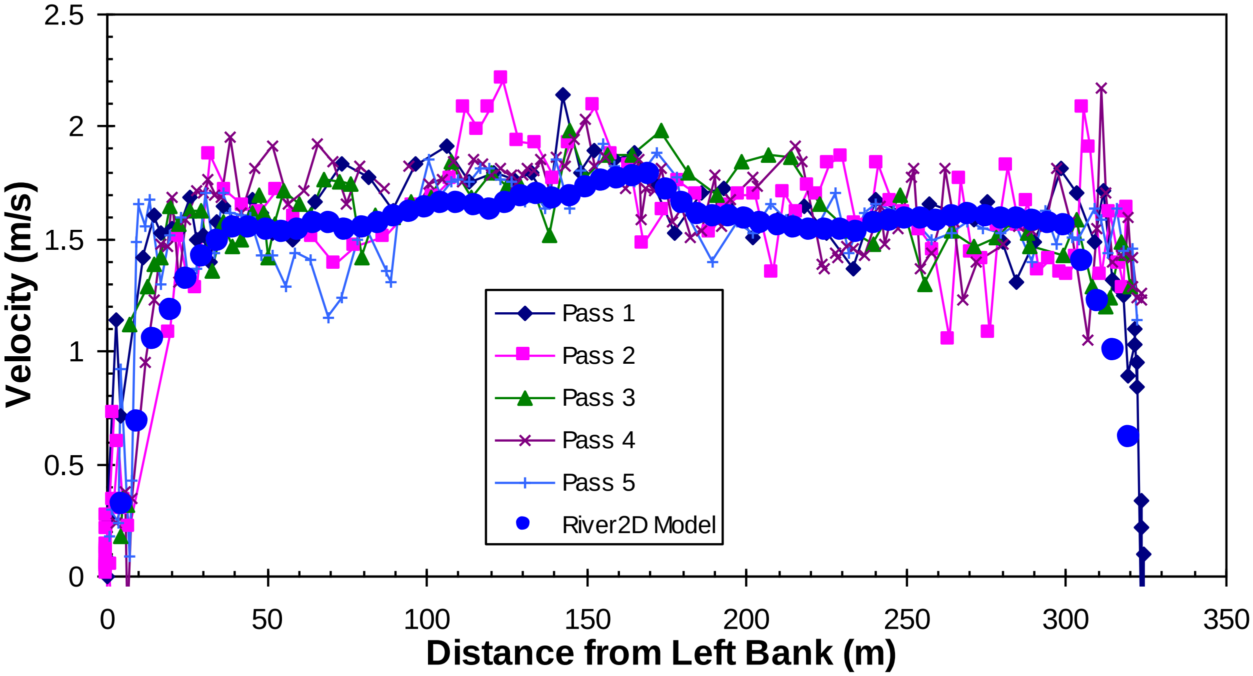
Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.5 |
| AMEC Project No.: SX0373305 | | Simulated Water Surface Elevation (Calibrated Model) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...

a)




b)

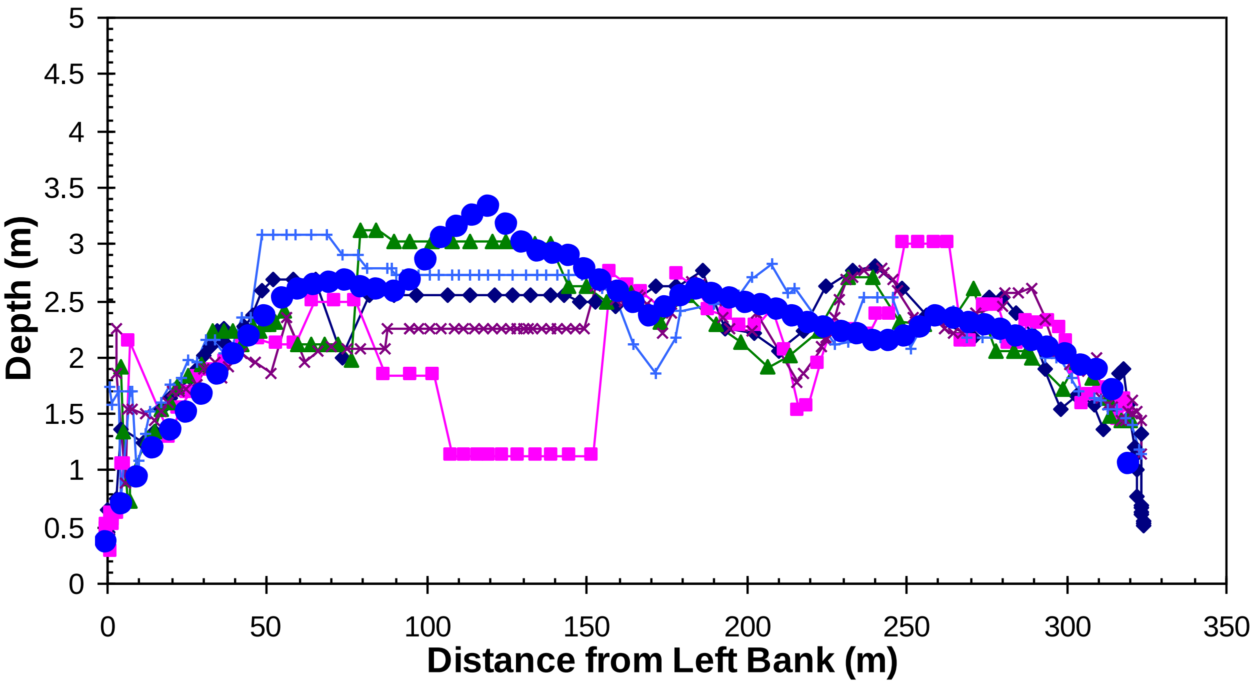
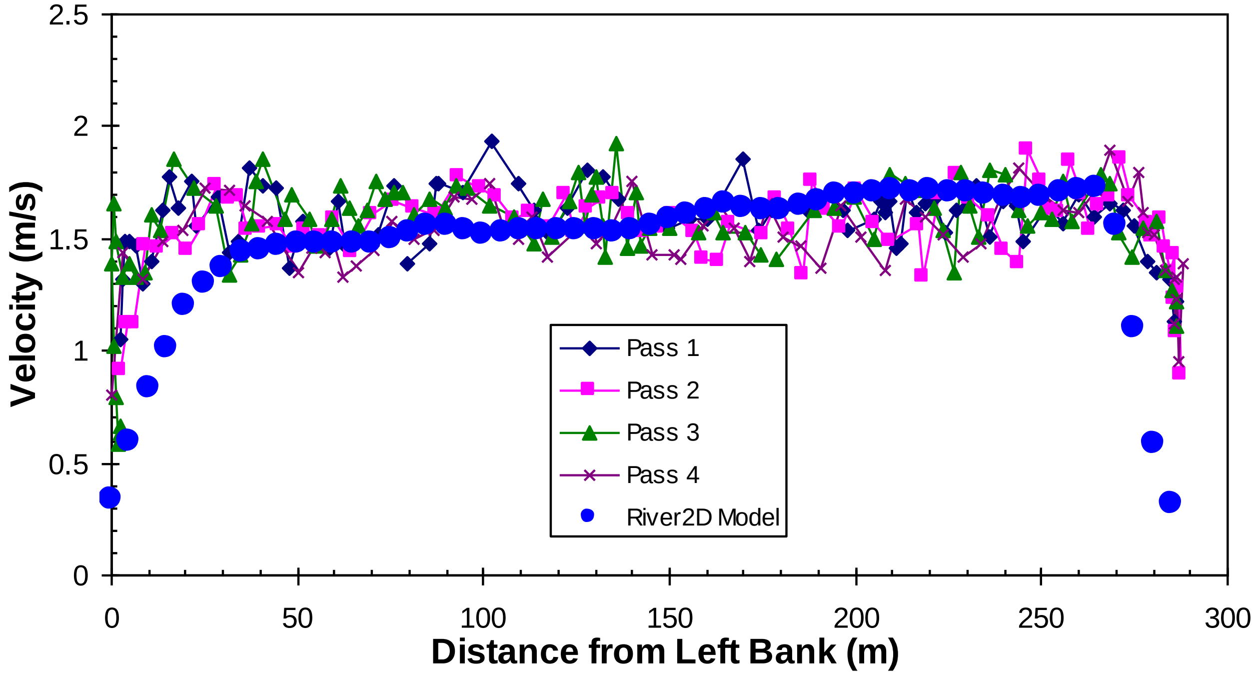



**Figure 5.6 Comparisons Between Observed and Modeled (a) Velocity and (b) Depth at Section A-A.**

a)




b)

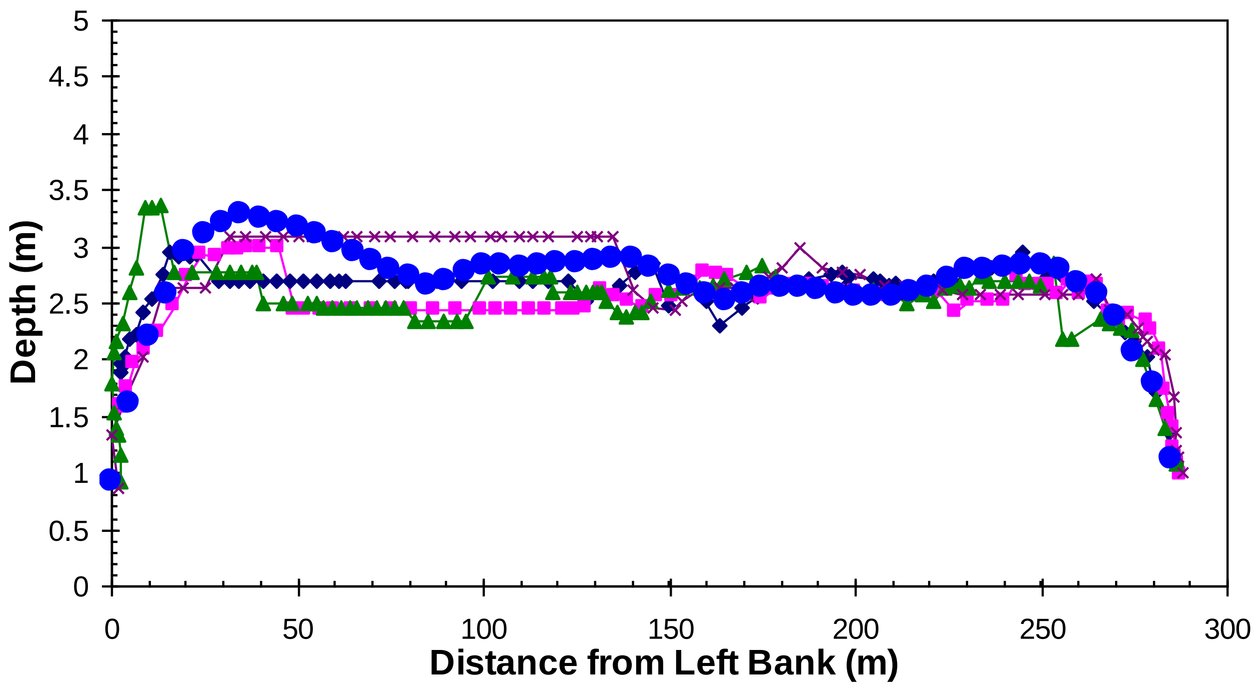
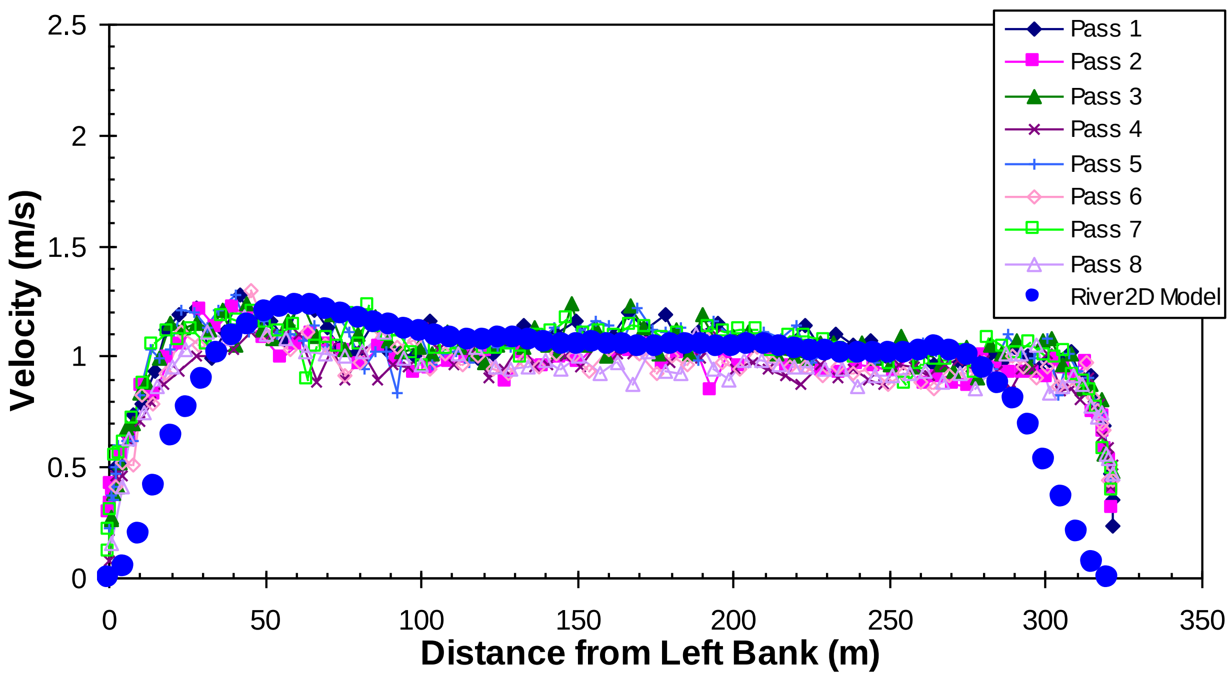



**Figure 5.7 Comparisons Between Observed and Modeled (a) Velocity and (b) Depth at Section B-B**

a)




b)

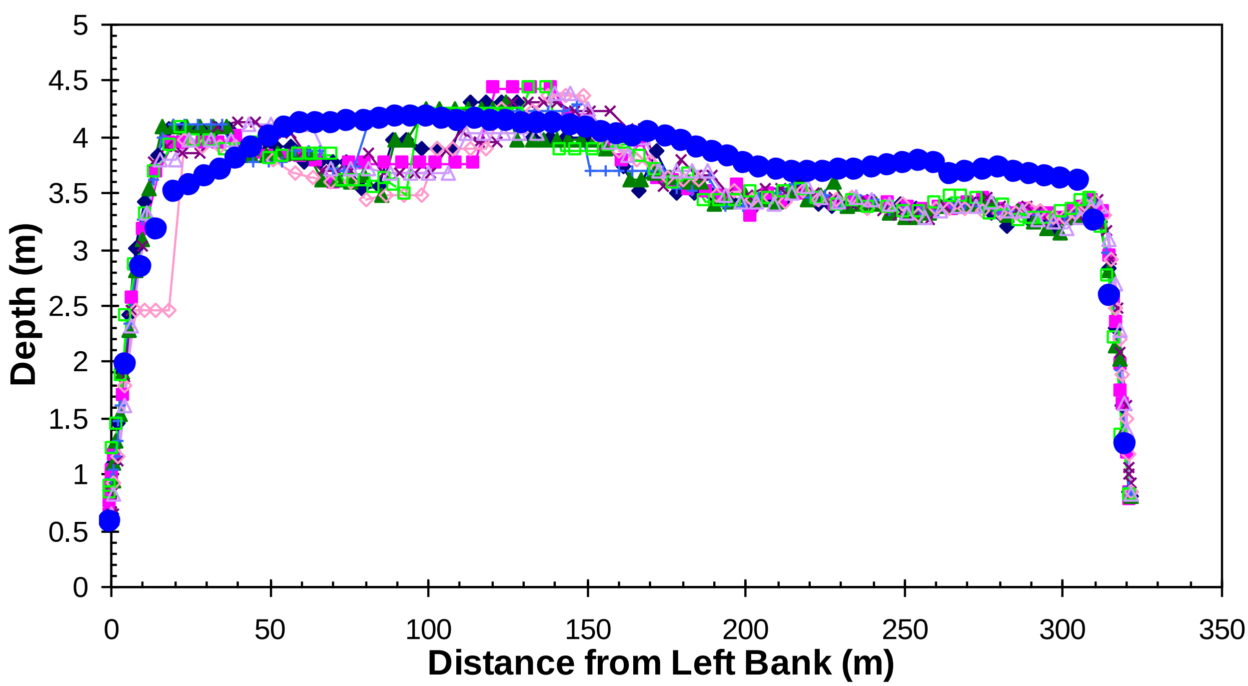
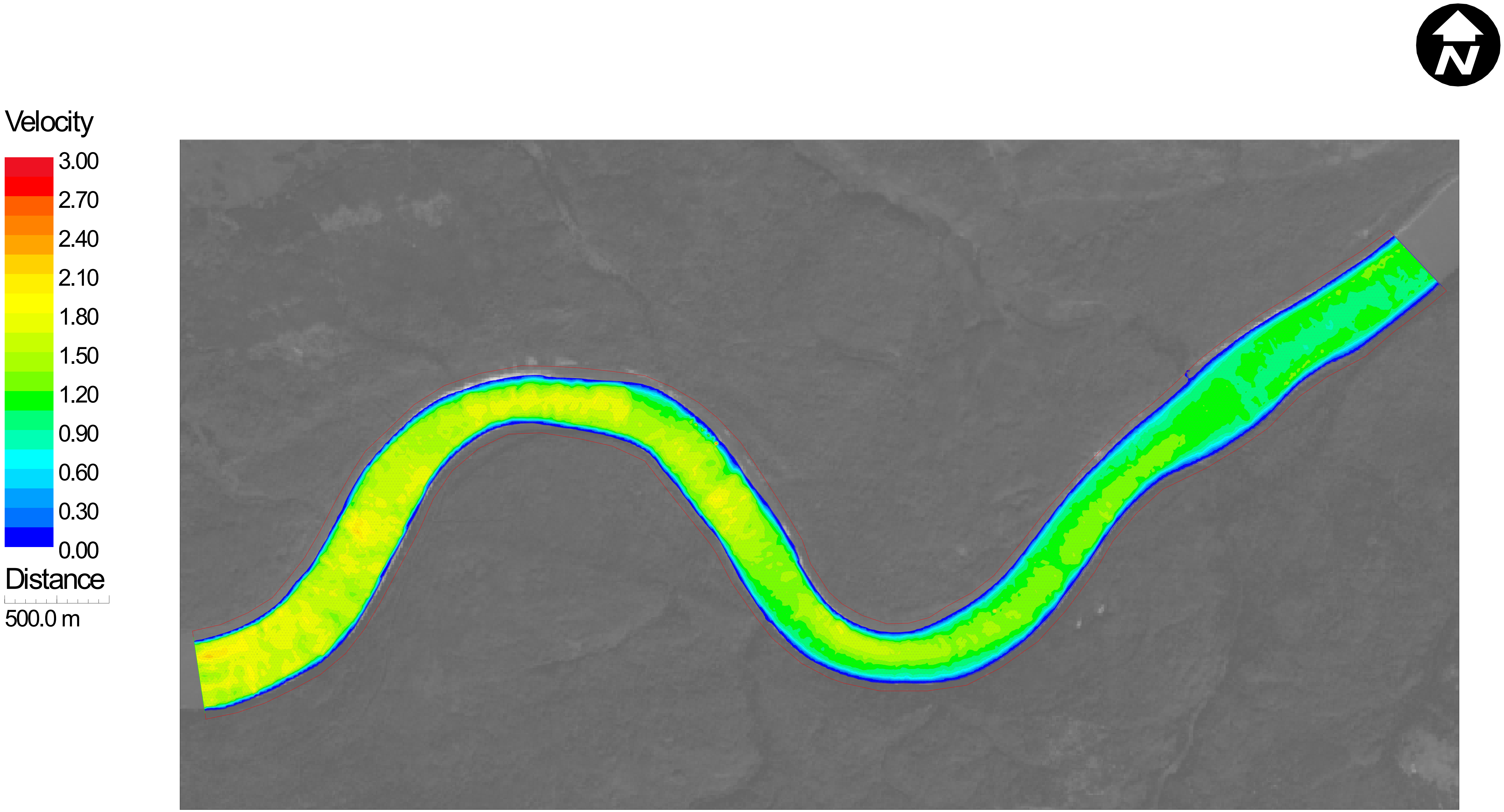



**Figure 5.8 Comparisons Between Observed and Modeled (a) Velocity and (b) Depth at Section C-C**




Model Boundary

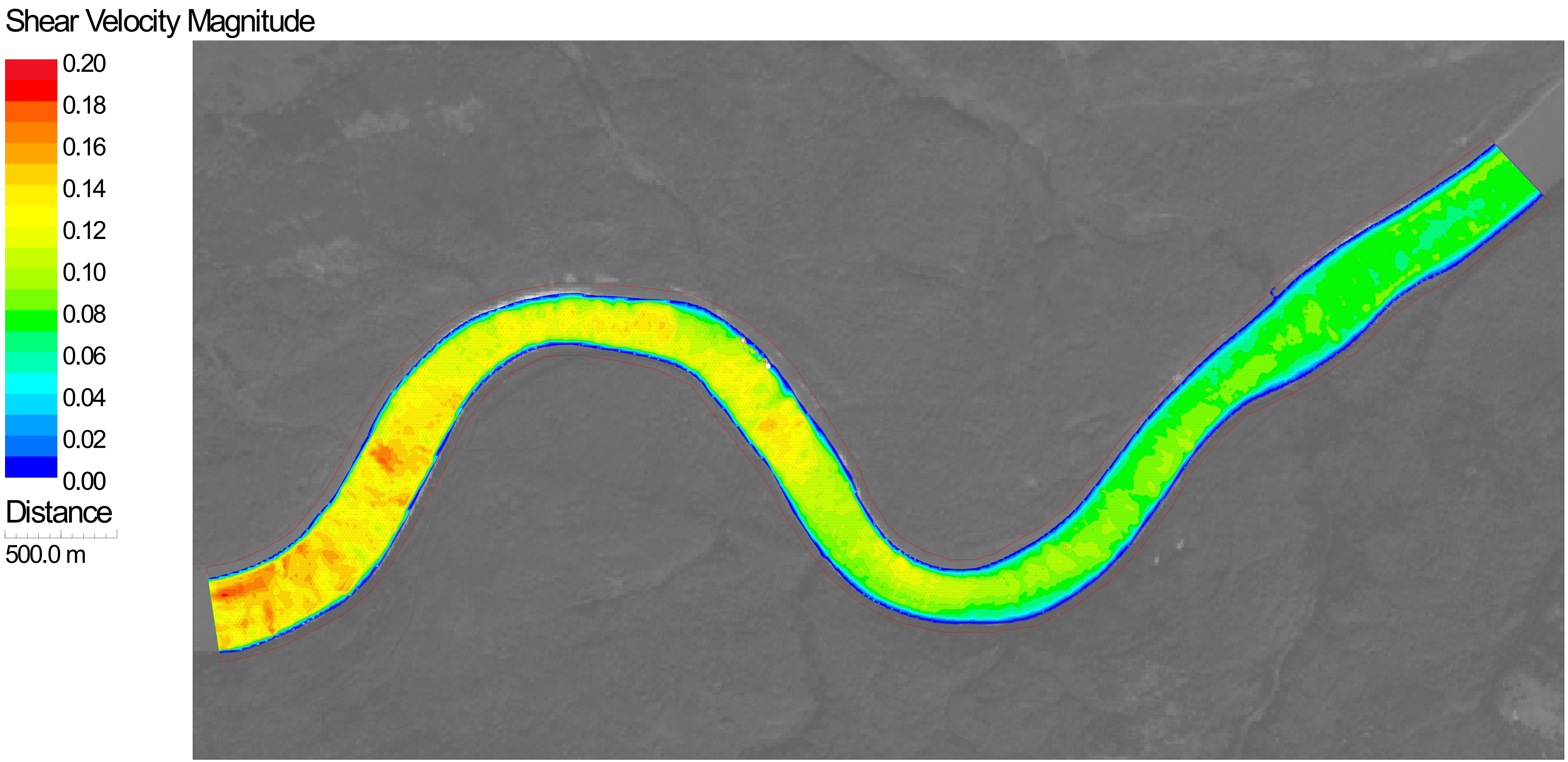
**DISCHARGE**
**1168 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.9 |
| AMEC Project No.: SX0373305 | | Simulated Velocity Magnitude (Calibrated Model) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

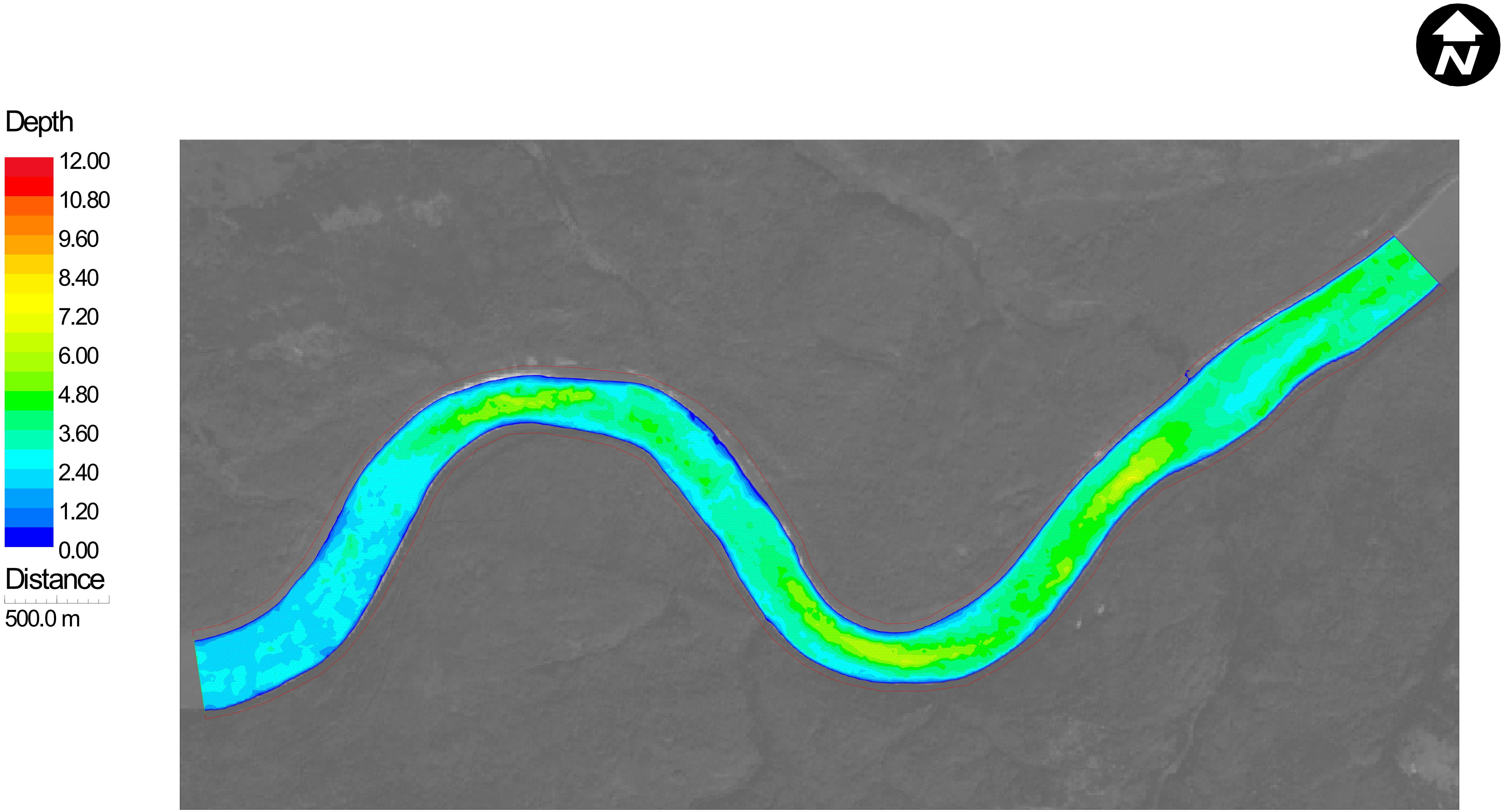
**DISCHARGE**
**1168 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.10 |
| AMEC Project No.: SX0373305 | | Simulated Shear Velocity Magnitude (Calibrated Model) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

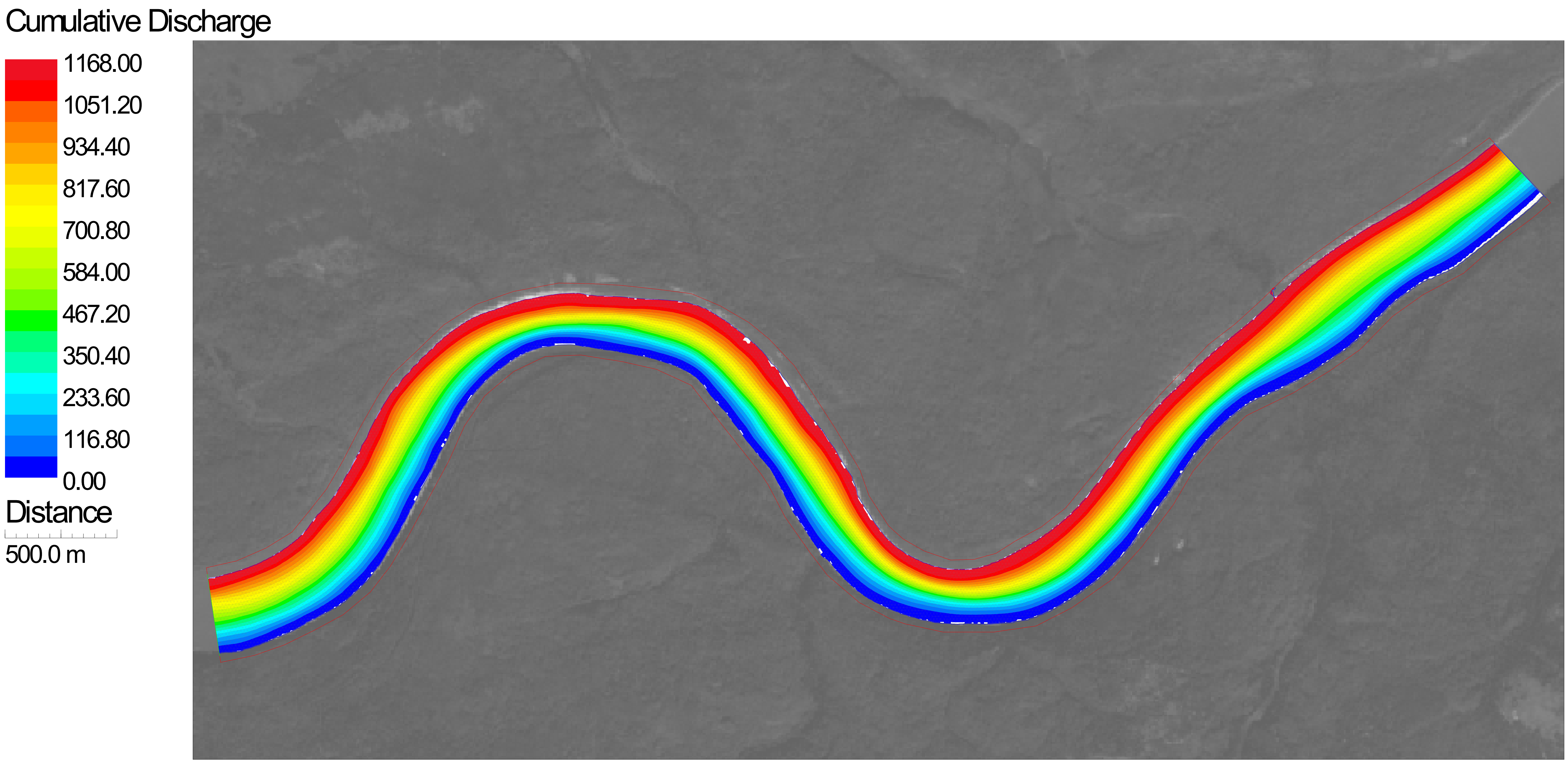
**DISCHARGE**
**1168 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.11 |
| AMEC Project No.: SX0373305 | | Simulated Depth (Calibrated Model) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

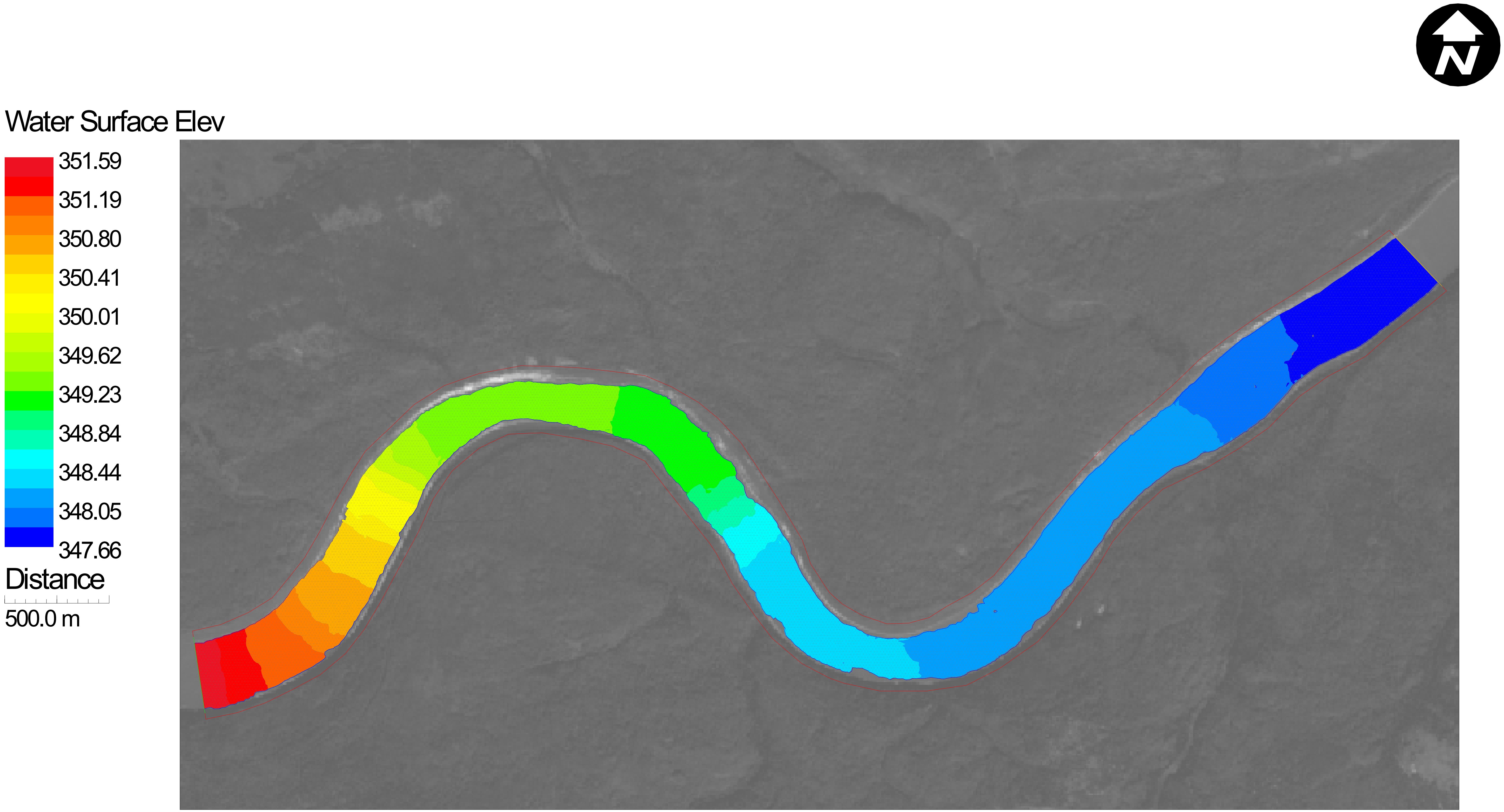
**DISCHARGE**
**1168 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.12 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Cumulative Discharge (Calibrated Model) | amec |

Map Path: L:\Water\PROJECT\EW...



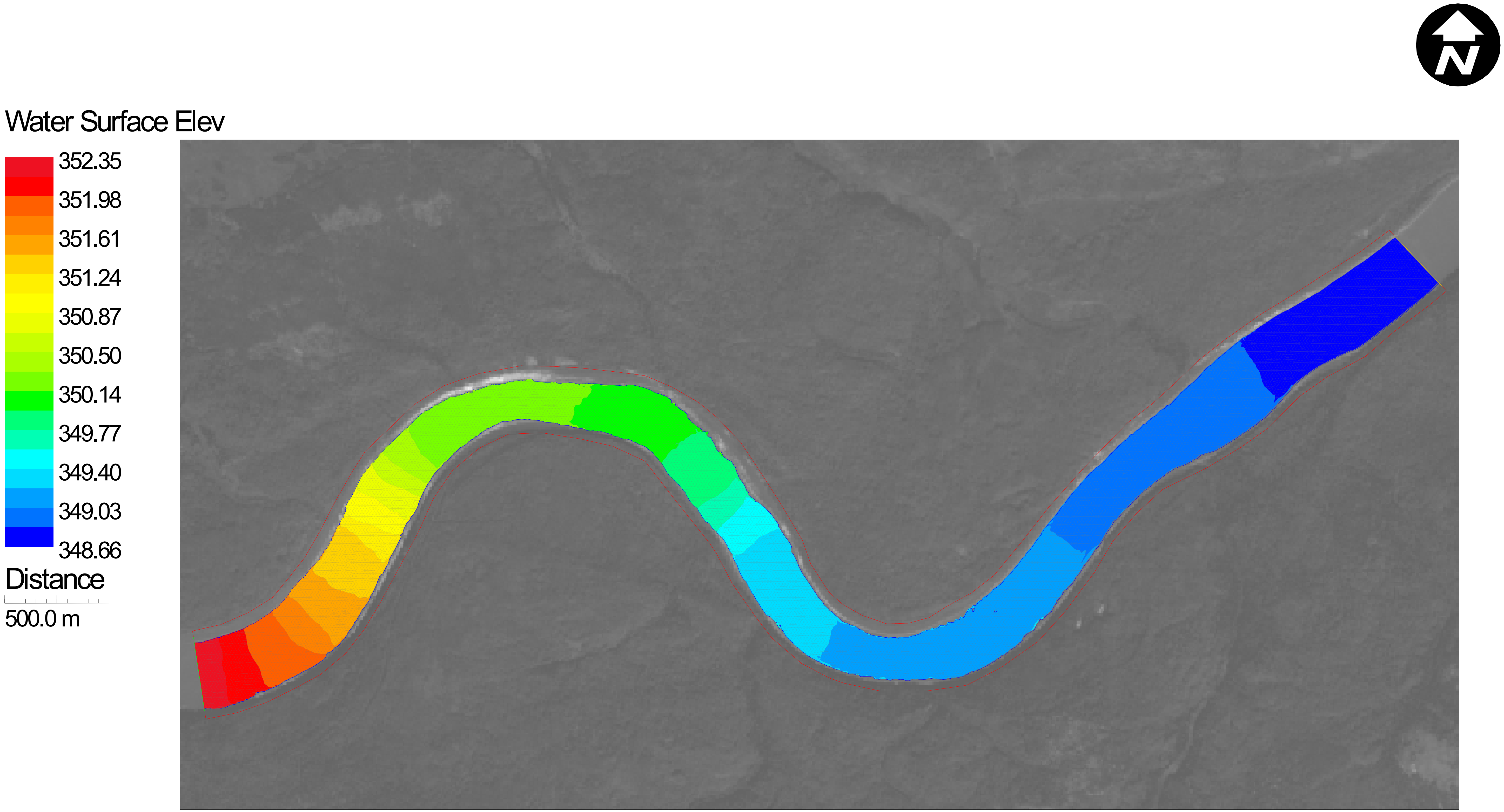

Model Boundary

**DISCHARGE**
**188 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.13 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Water Surface Elevation (7Q10 Open Water Low Flow) | amec |




Model Boundary

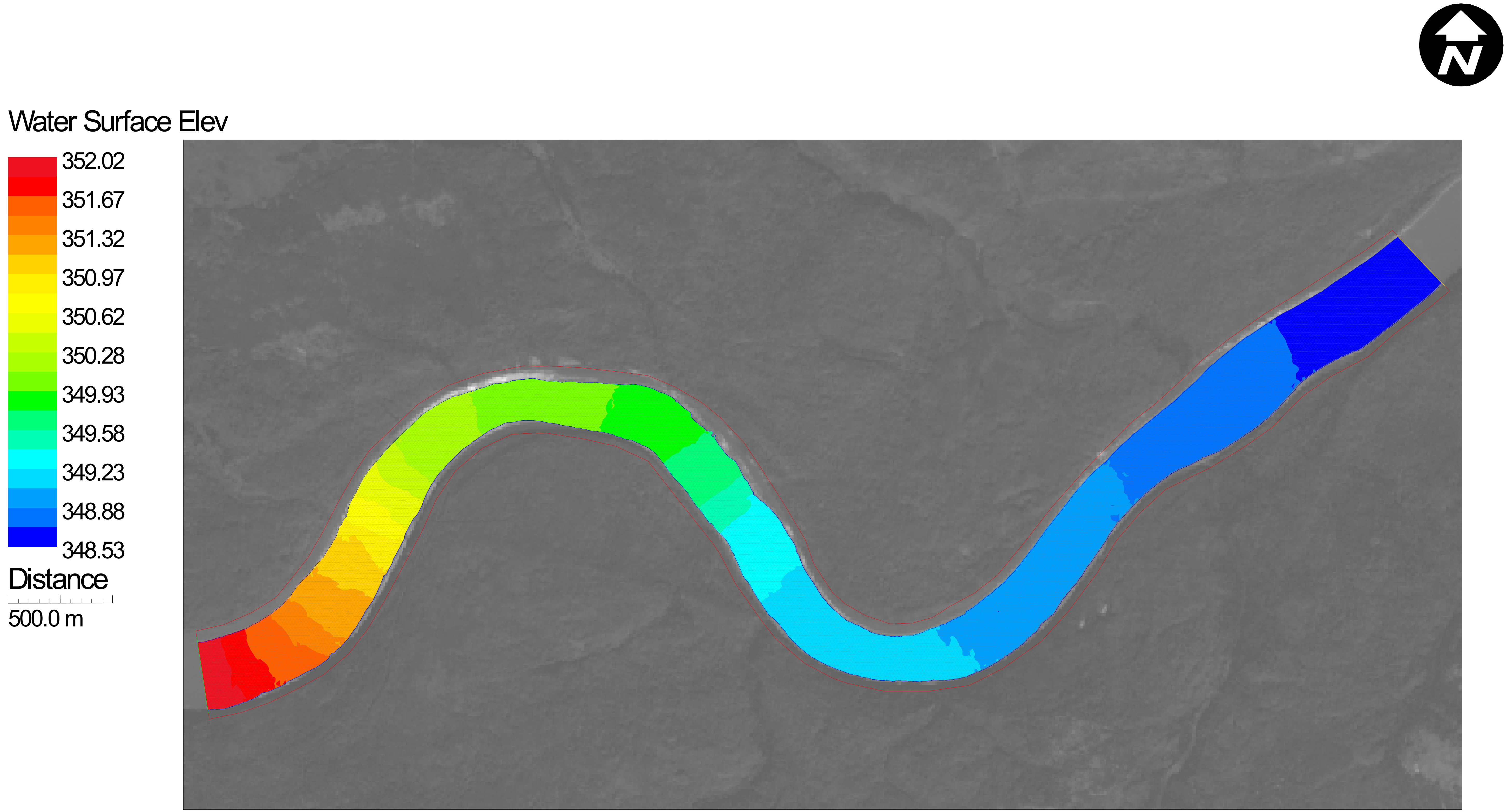
**DISCHARGE**
**169 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.14 |
| AMEC Project No.: SX0373305 | | Simulated Water Surface Elevation (7Q10 Ice-Covered Low Flow) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

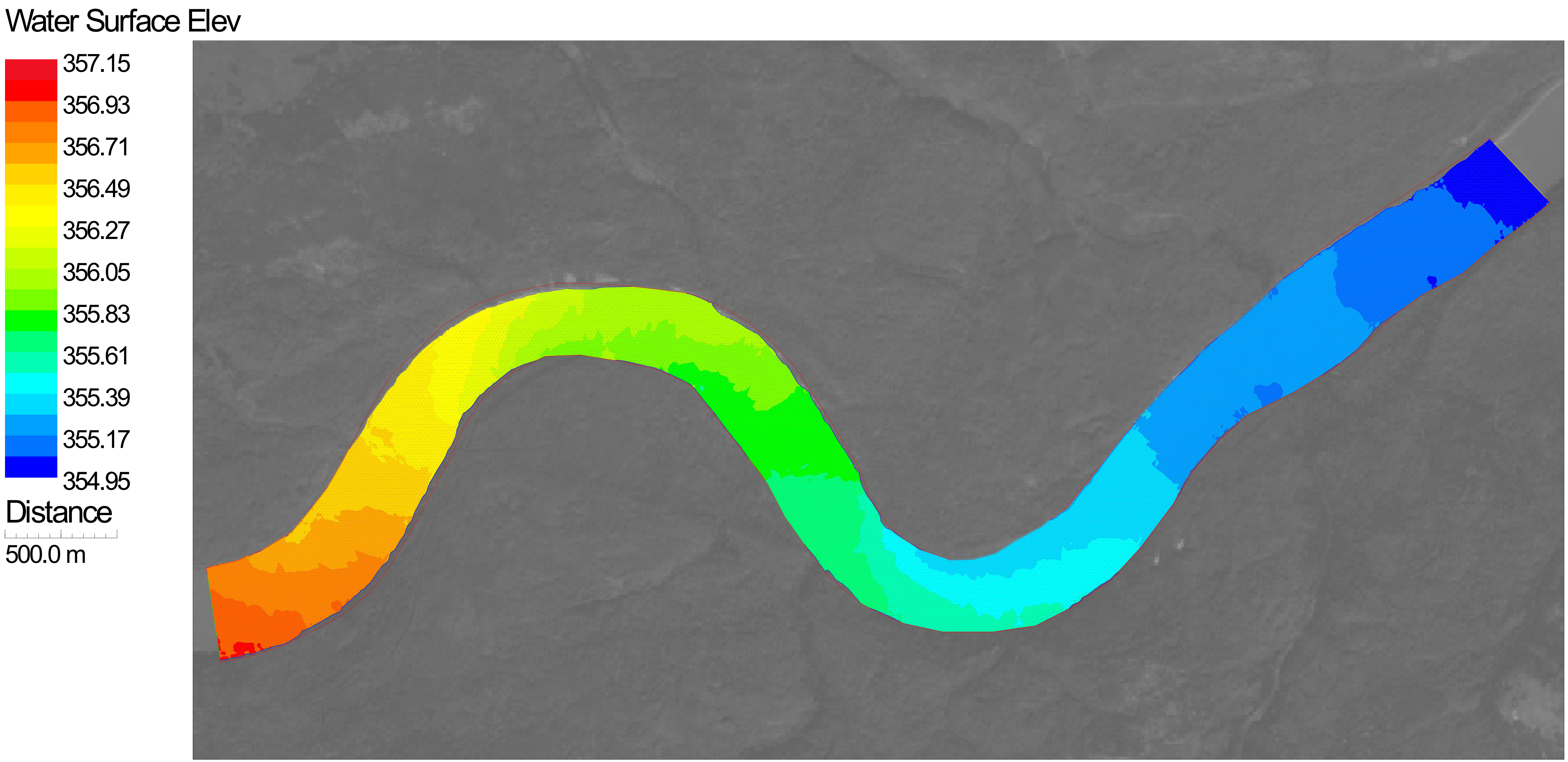
**DISCHARGE**
**439 m³/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.15 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Water Surface Elevation (Mean Annual Discharge) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

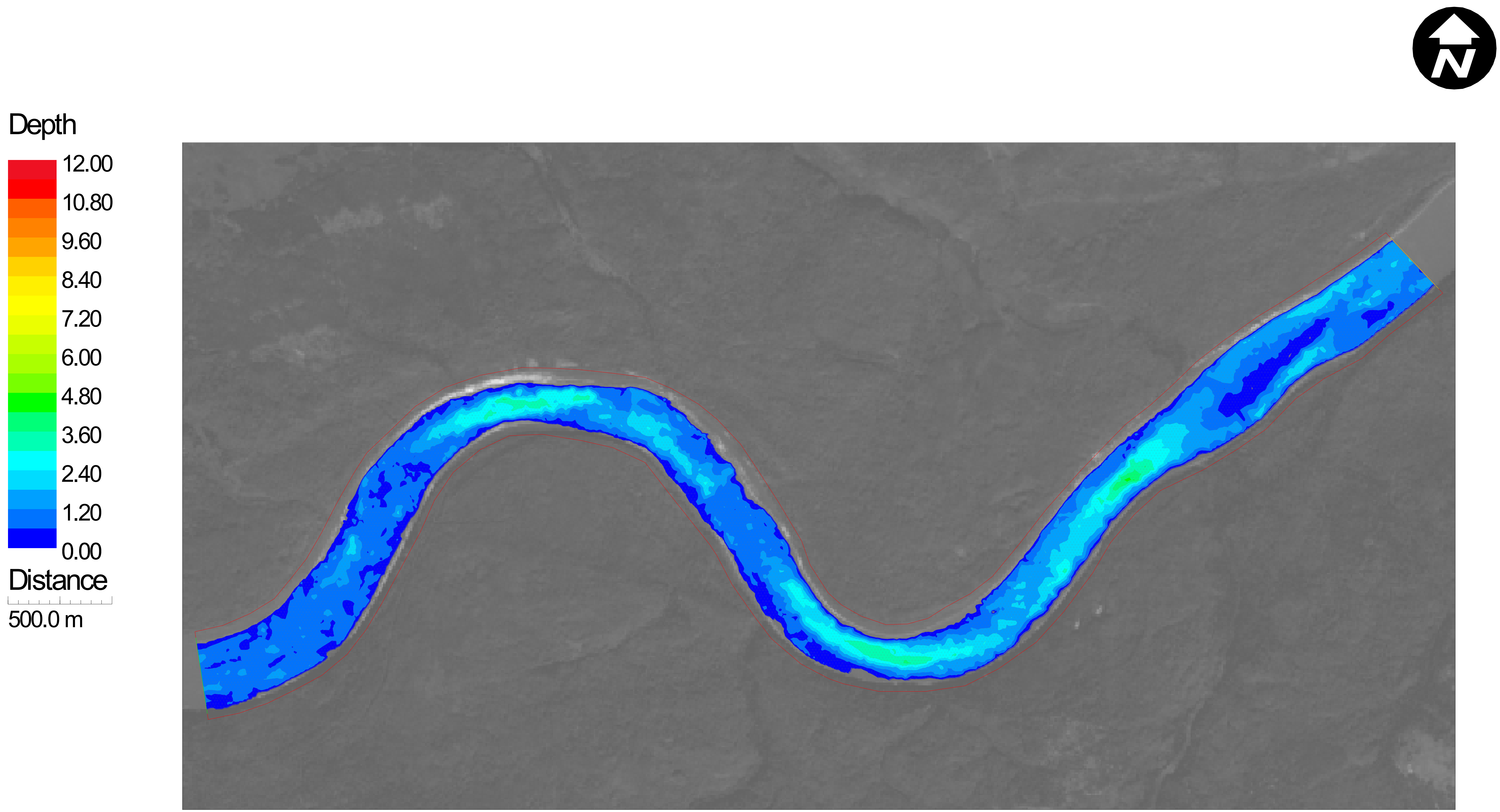
Background Data from GeoBase®

**DISCHARGE**
**4770 $m^3$/s**

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.16 |
| DWN BY: RBA | CHK'D BY: RBA | River2D Simulated Water Surface Elevation (1:100 Year Discharge) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

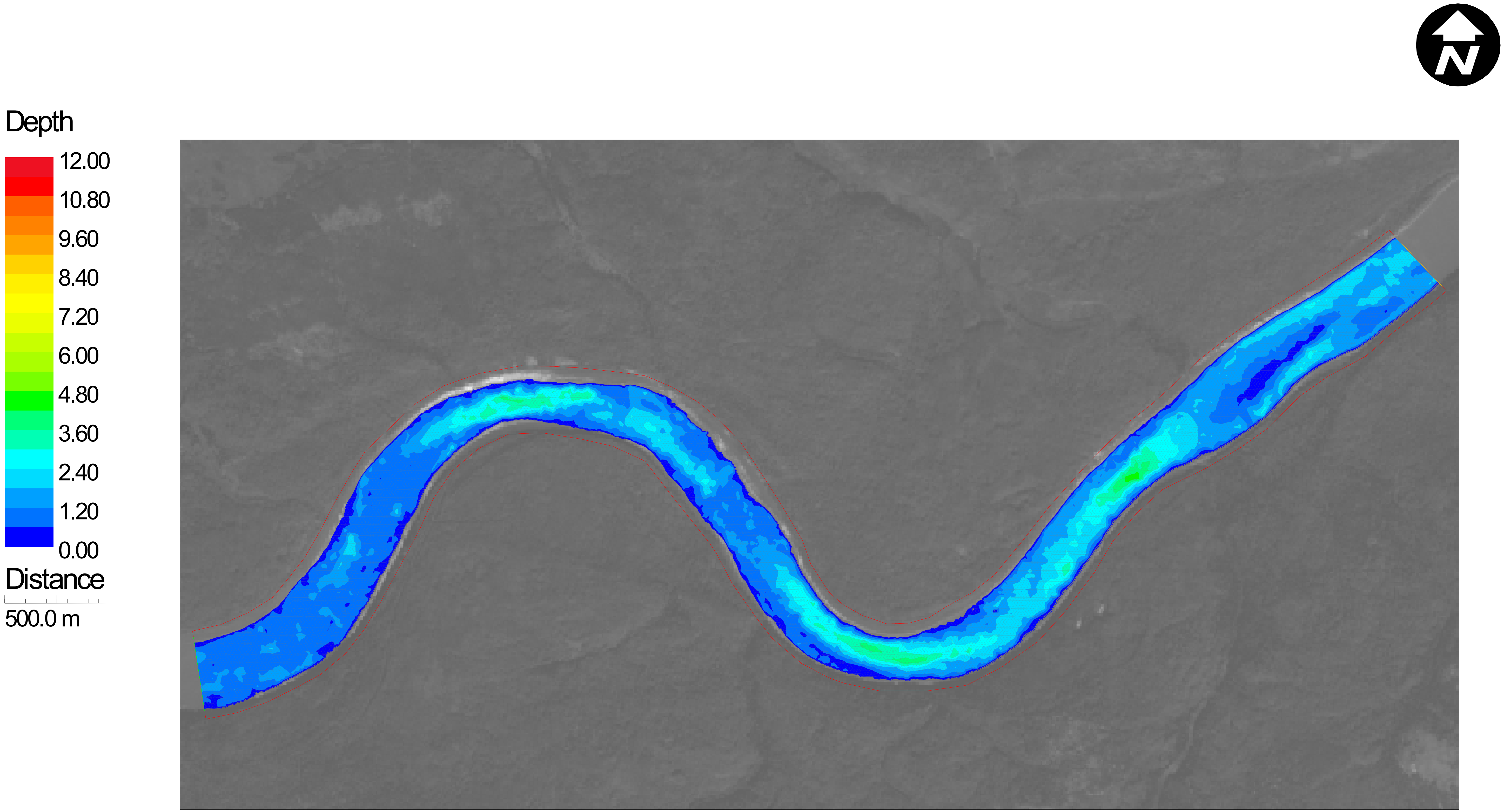
**DISCHARGE**
**188 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.17 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Depth (7Q10 Open-Water Low Flow) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

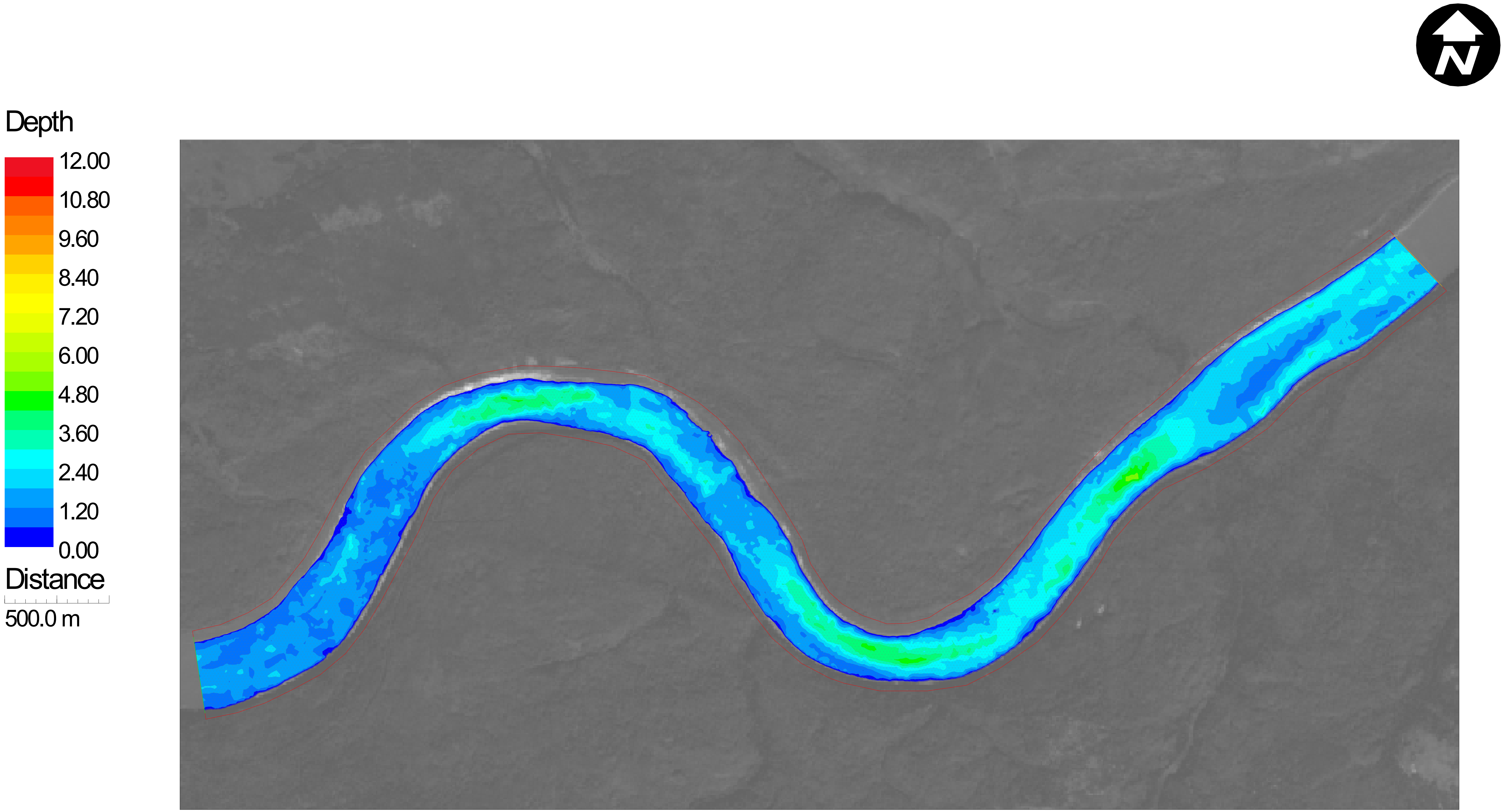
**DISCHARGE**
**169 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.18 |
| AMEC Project No.: SX0373305 | | Simulated Depth (7Q10 Ice-Covered Low Flow) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...



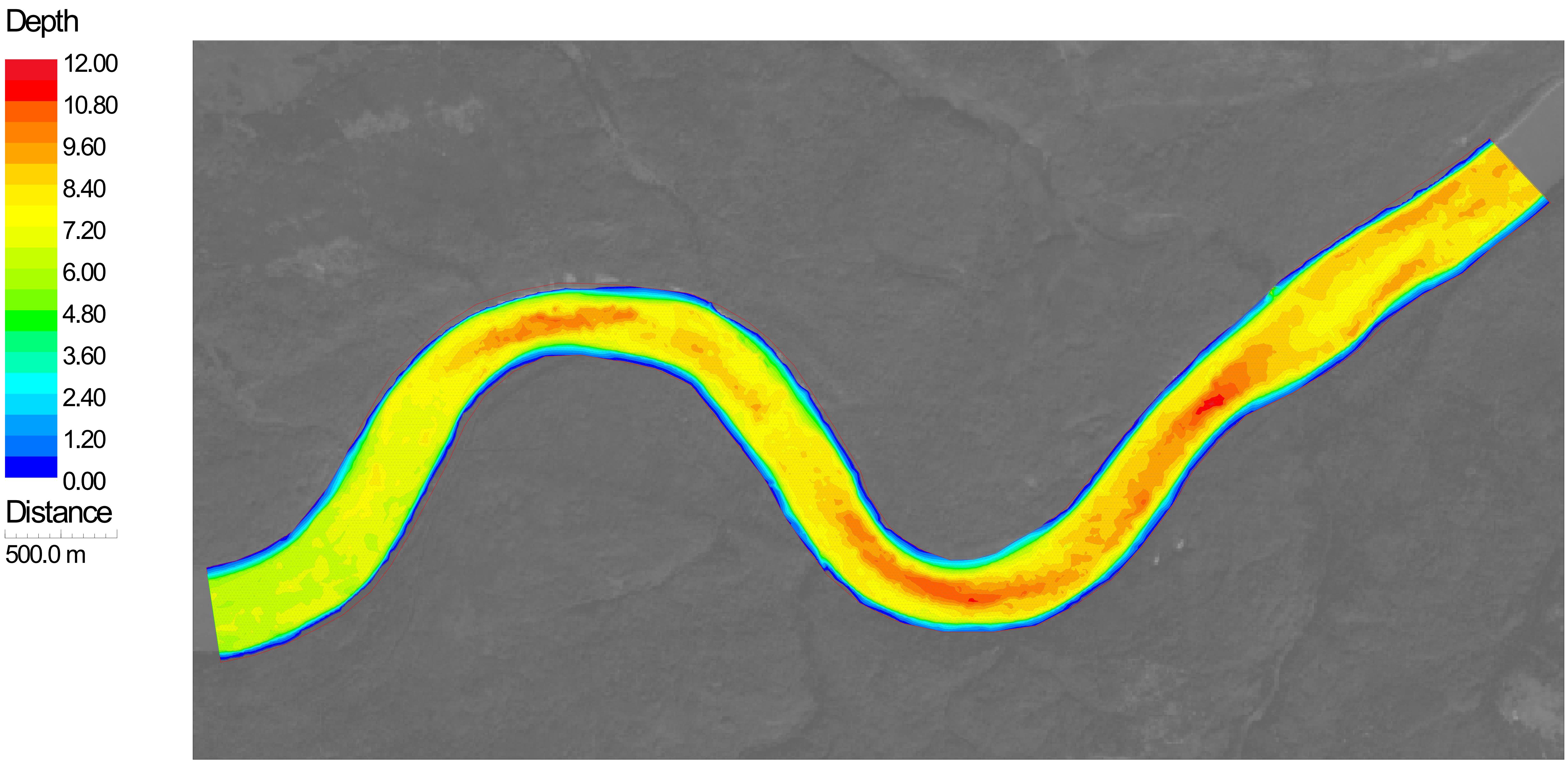

Model Boundary

**DISCHARGE**
**439 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.19 |
| AMEC Project No.: SX0373305 | | Simulated Depth (Mean Annual Discharge) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |




Model Boundary

**DISCHARGE**
**4770 m³/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

CLIENT: Shore Gold Inc.

AMEC Project No.: SX0373305

DWN BY: RBA | CHK'D BY: RBA

SHORE GOLD RIVER SURVEY

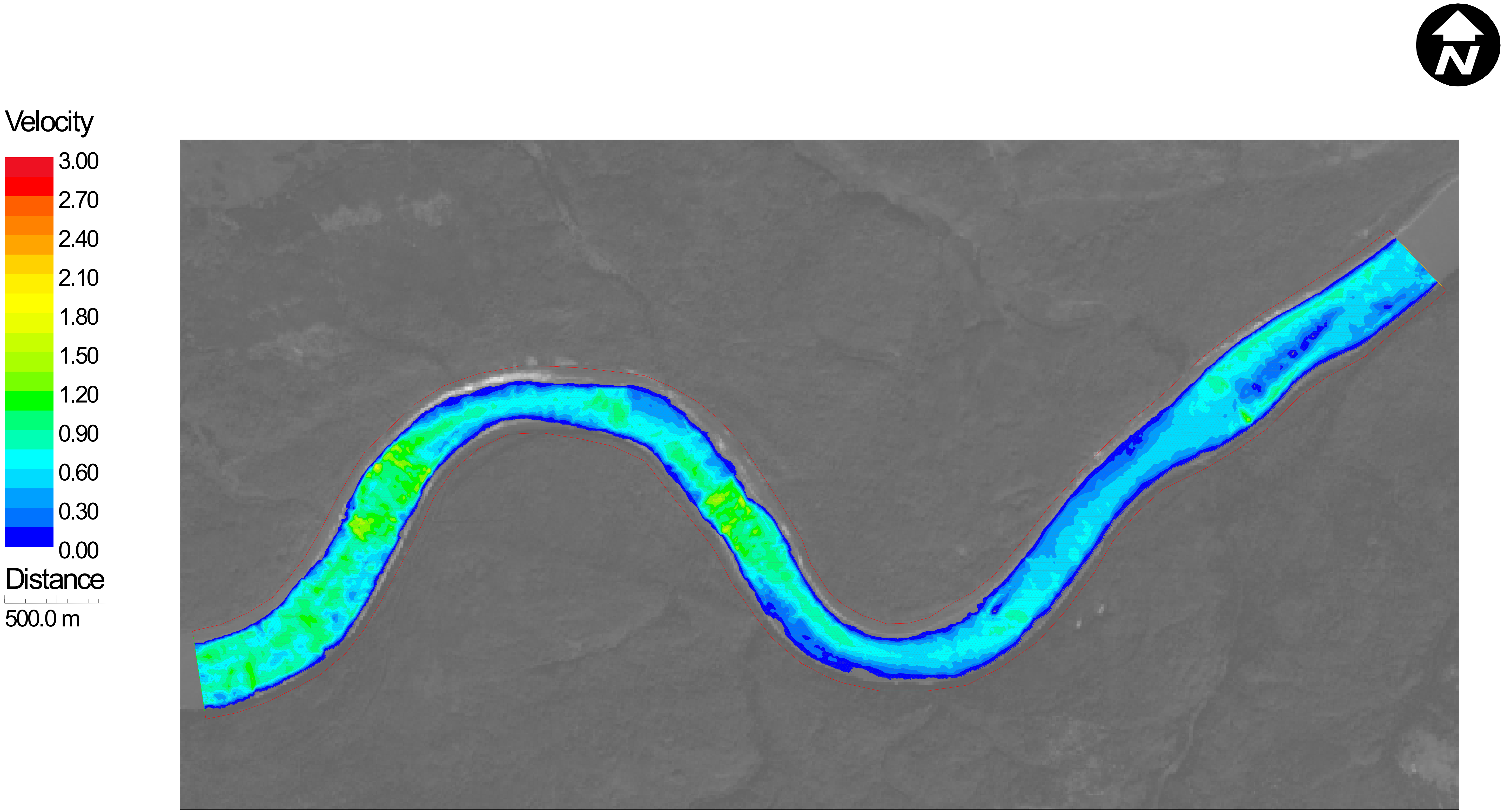
Simulated Depth
(1:100 Year Discharge)

November 2010

FIGURE 5.20

amec

Map Path: L:\Water\PROJECT\EW\...




Model Boundary

**DISCHARGE**
**188 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

CLIENT: Shore Gold Inc.

AMEC Project No.: SX0373305

DWN BY: RBA | CHK'D BY: RBA

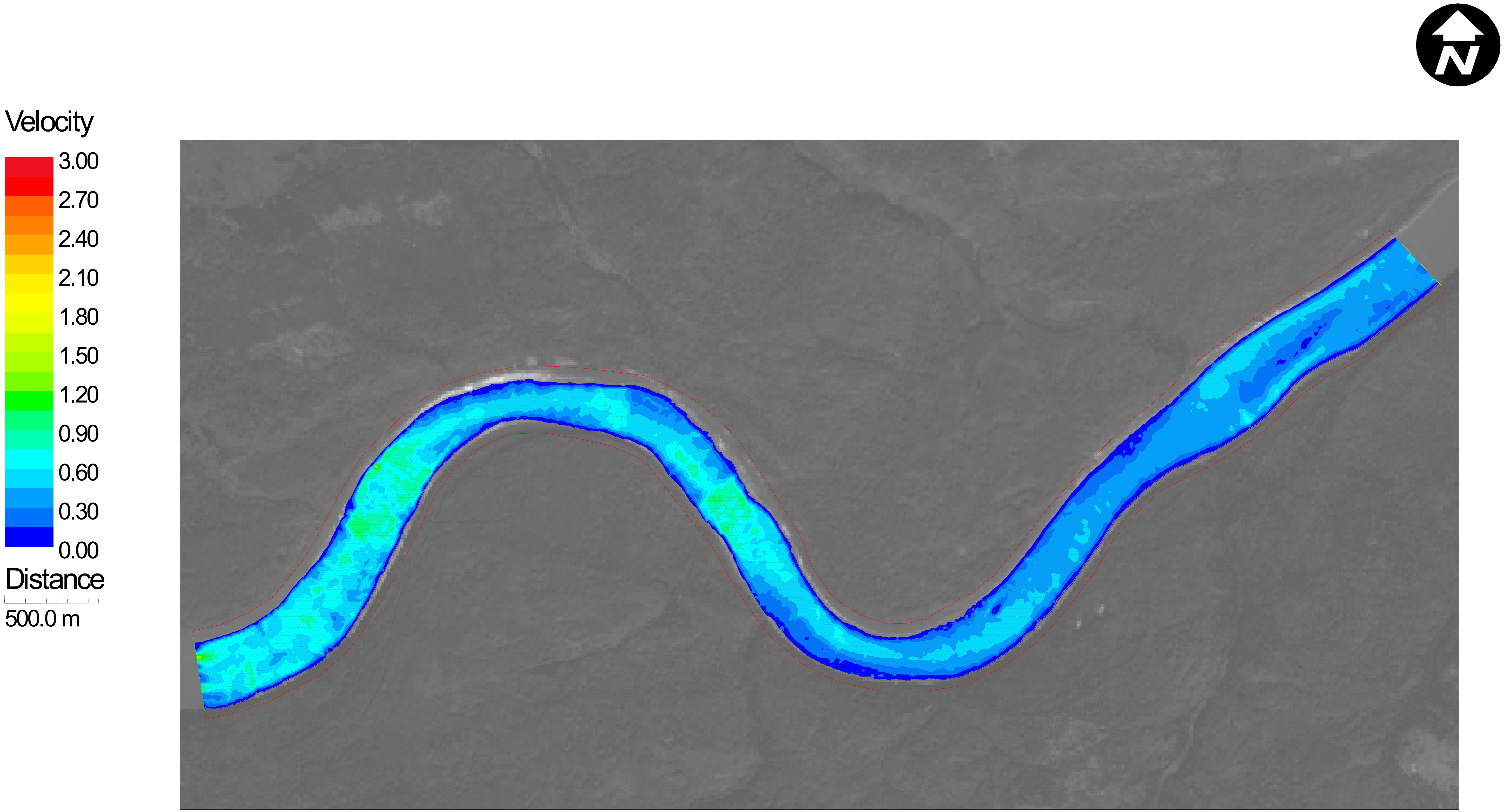
SHORE GOLD RIVER SURVEY

Simulated Velocity Magnitude
(7Q10 Open-Water Low Flow)

November 2010

FIGURE 5.21

amec




Model Boundary

**DISCHARGE**
**169 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

CLIENT: Shore Gold Inc.

AMEC Project No.: SX0373305

DWN BY: RBA | CHK'D BY: RBA

SHORE GOLD RIVER SURVEY

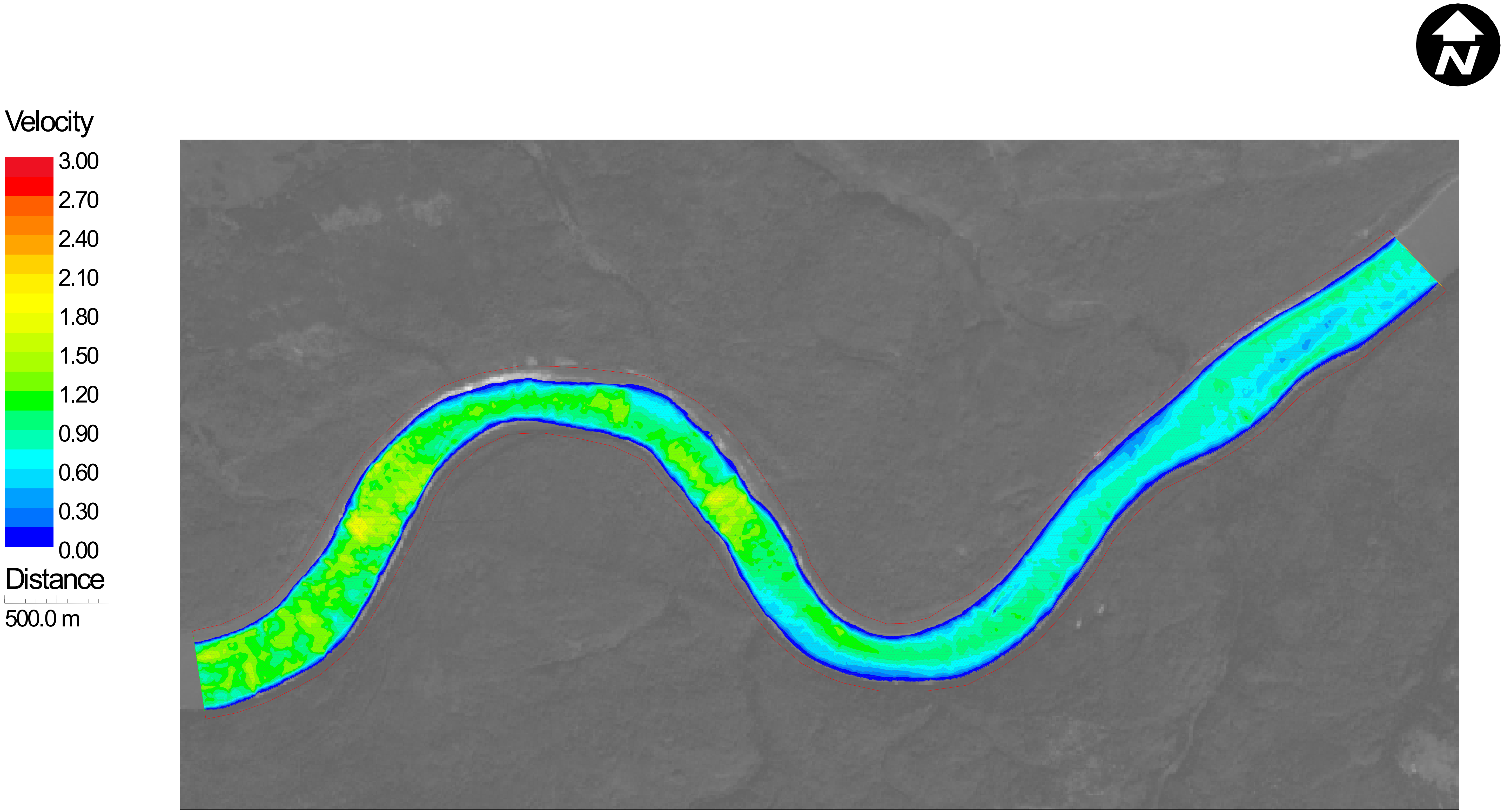
Simulated Velocity Magnitude
(7Q10 Ice-Covered Low Flow)

November 2010

FIGURE 5.22

amec

Map Path: L:\Water\PROJECT\EW\...



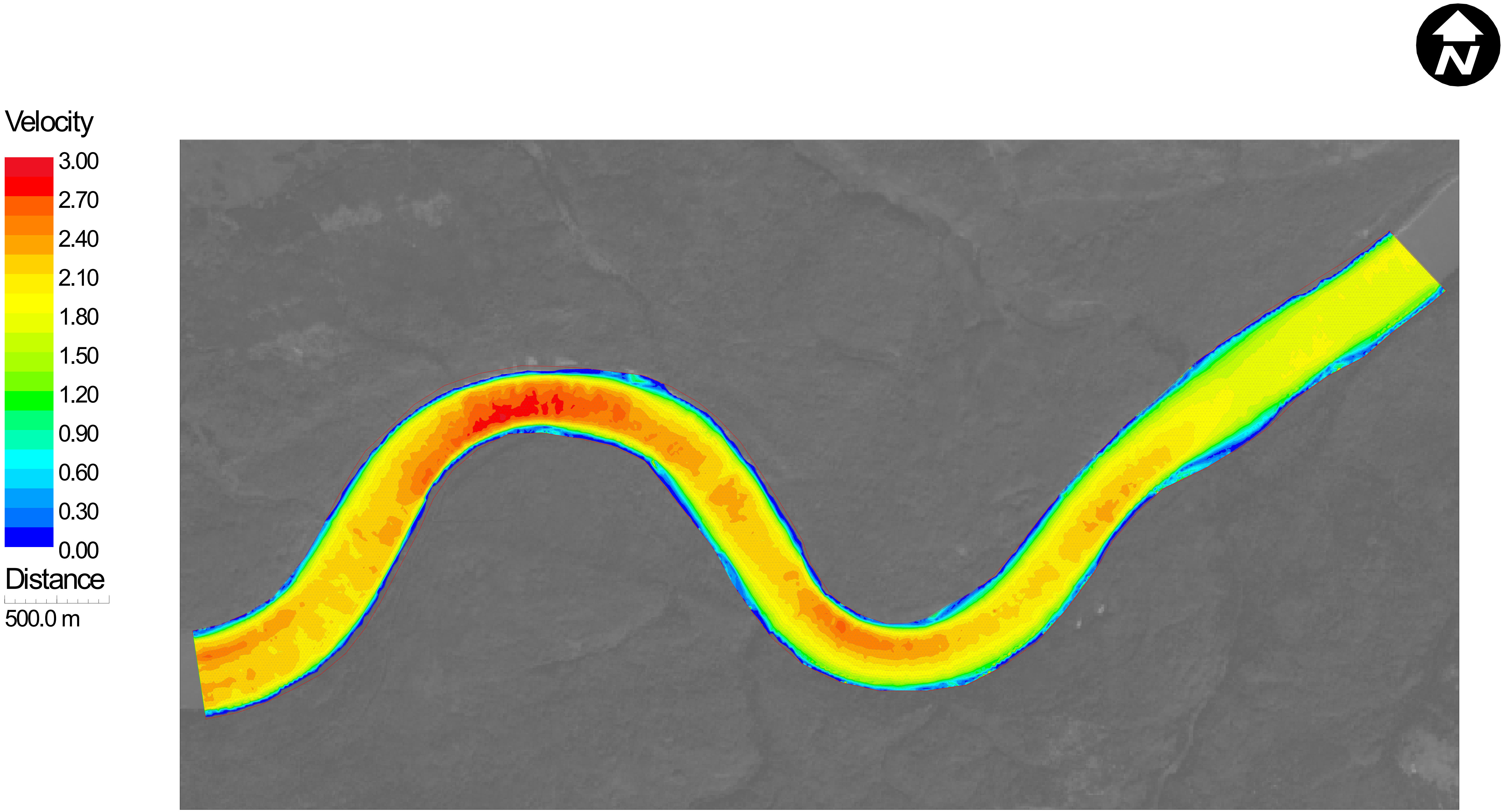

Model Boundary

**DISCHARGE**
**439 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.23 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Velocity Magnitude (Mean Annual Discharge) | amec |




Model Boundary

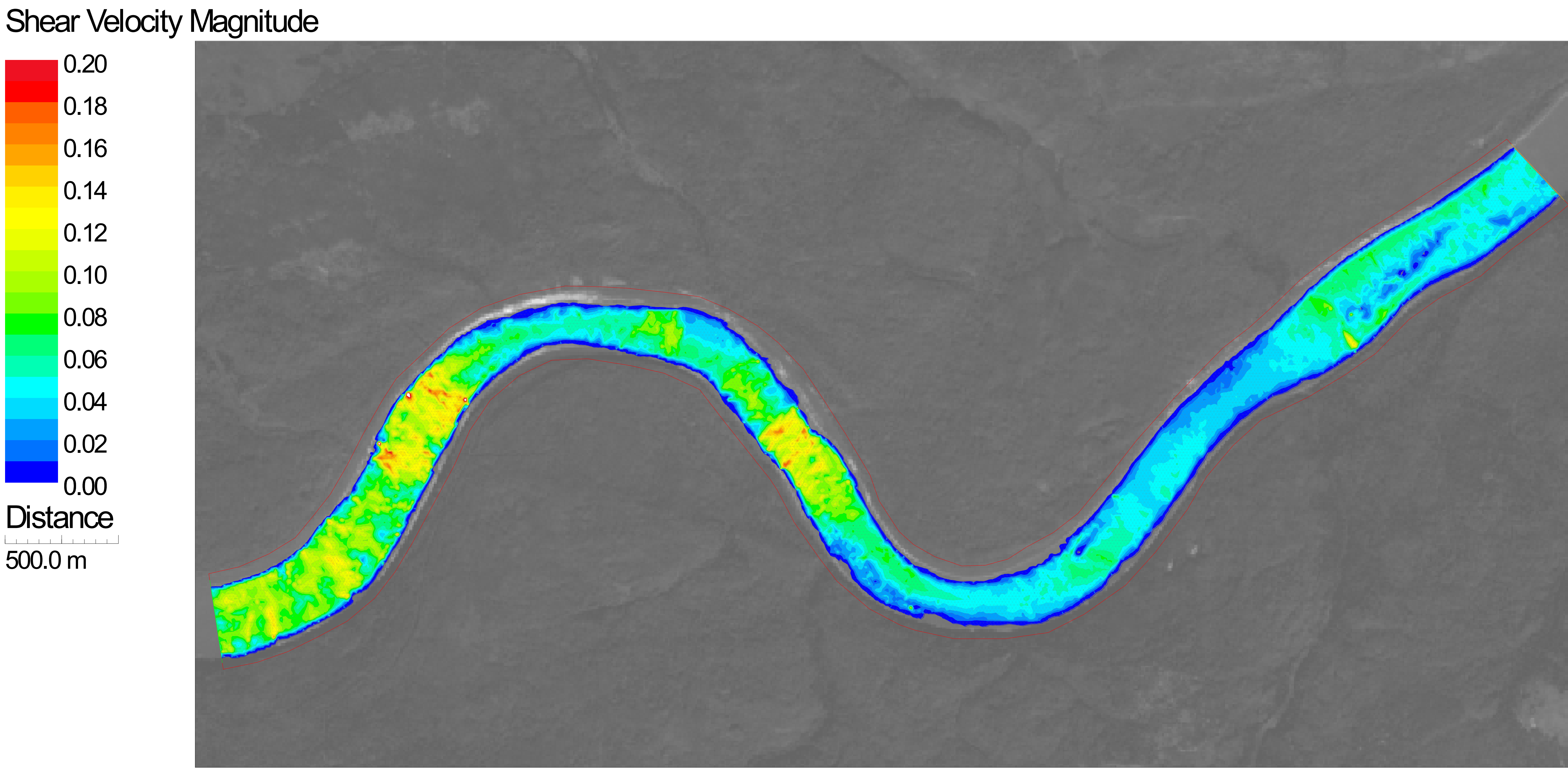
**DISCHARGE**
**4770 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | | |
|---|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.24 |
| AMEC Project No.: SX0373305 | | Simulated Velocity Magnitude (1:100 Year Discharge) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

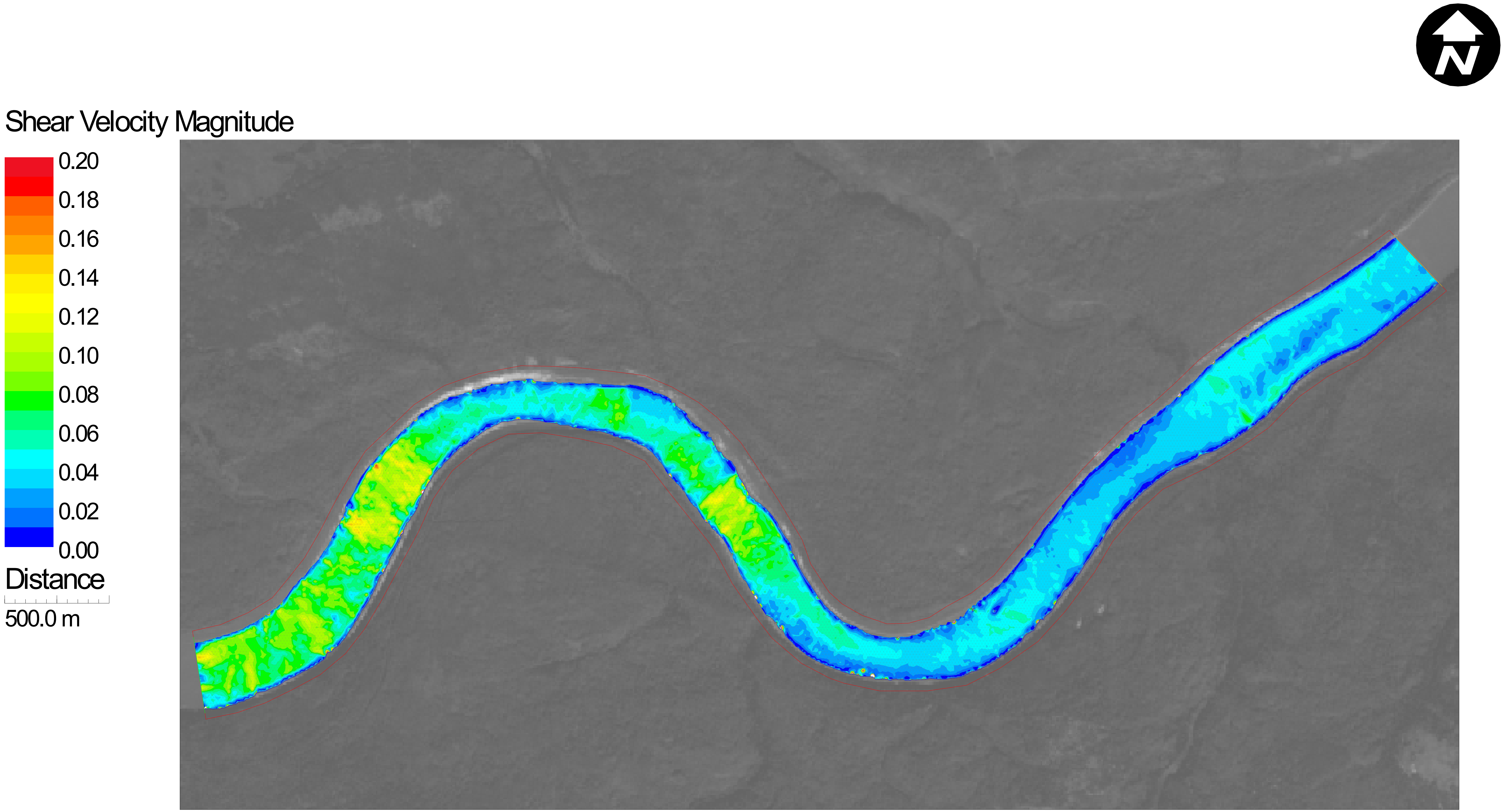
**DISCHARGE**
**188 m³/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.25 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Shear Velocity Magnitude (7Q10 Open-Water Low Flow) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

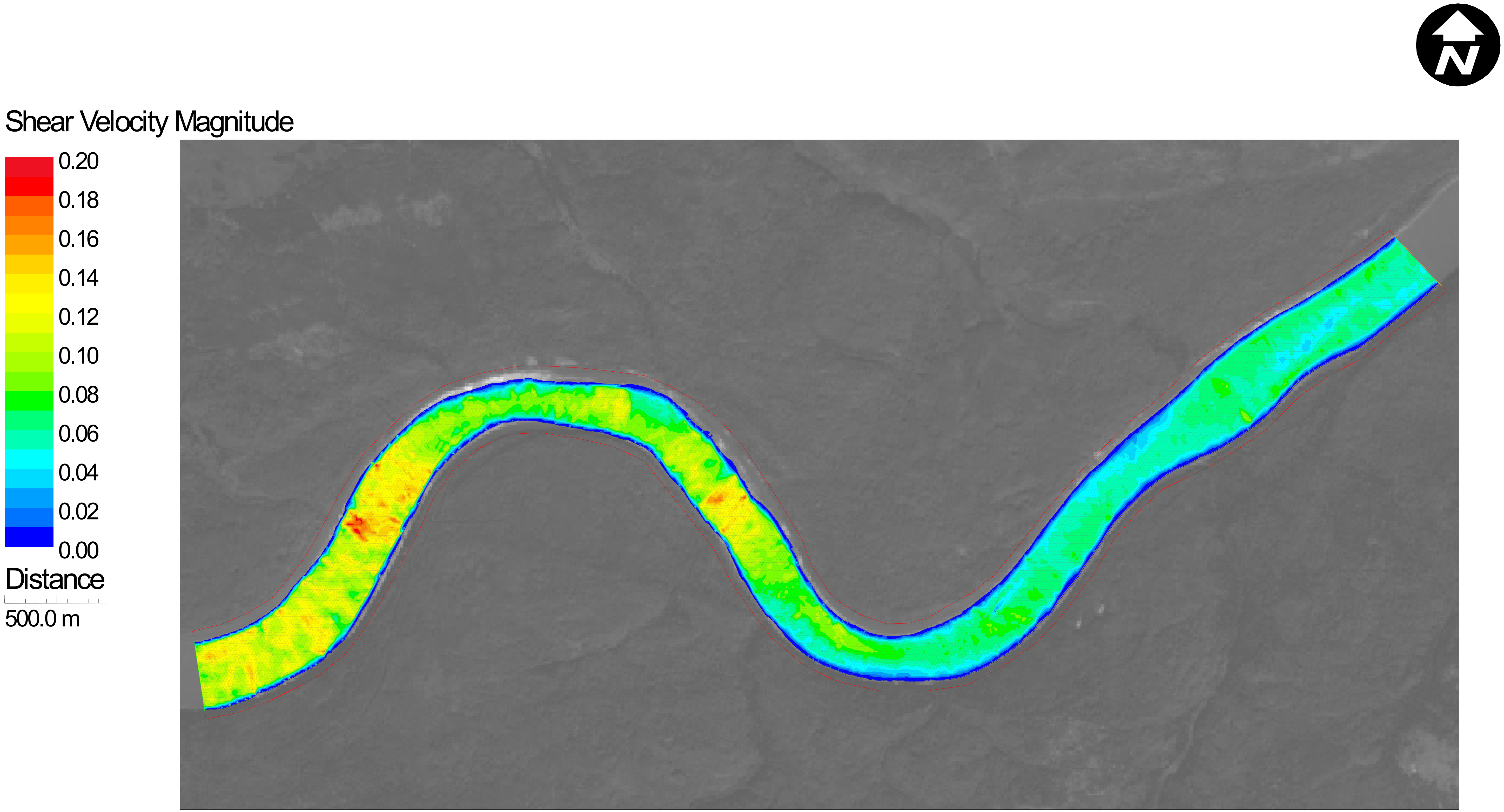
**DISCHARGE**
**169 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | |
|---|---|---|
| CLIENT: Shore Gold Inc. | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | FIGURE 5.26 |
| DWN BY: RBA / CHK'D BY: RBA | Simulated Shear Velocity Magnitude (7Q10 Ice-Covered Low Flow) | amec |

Map Path: L:\Water\PROJECT\EW...



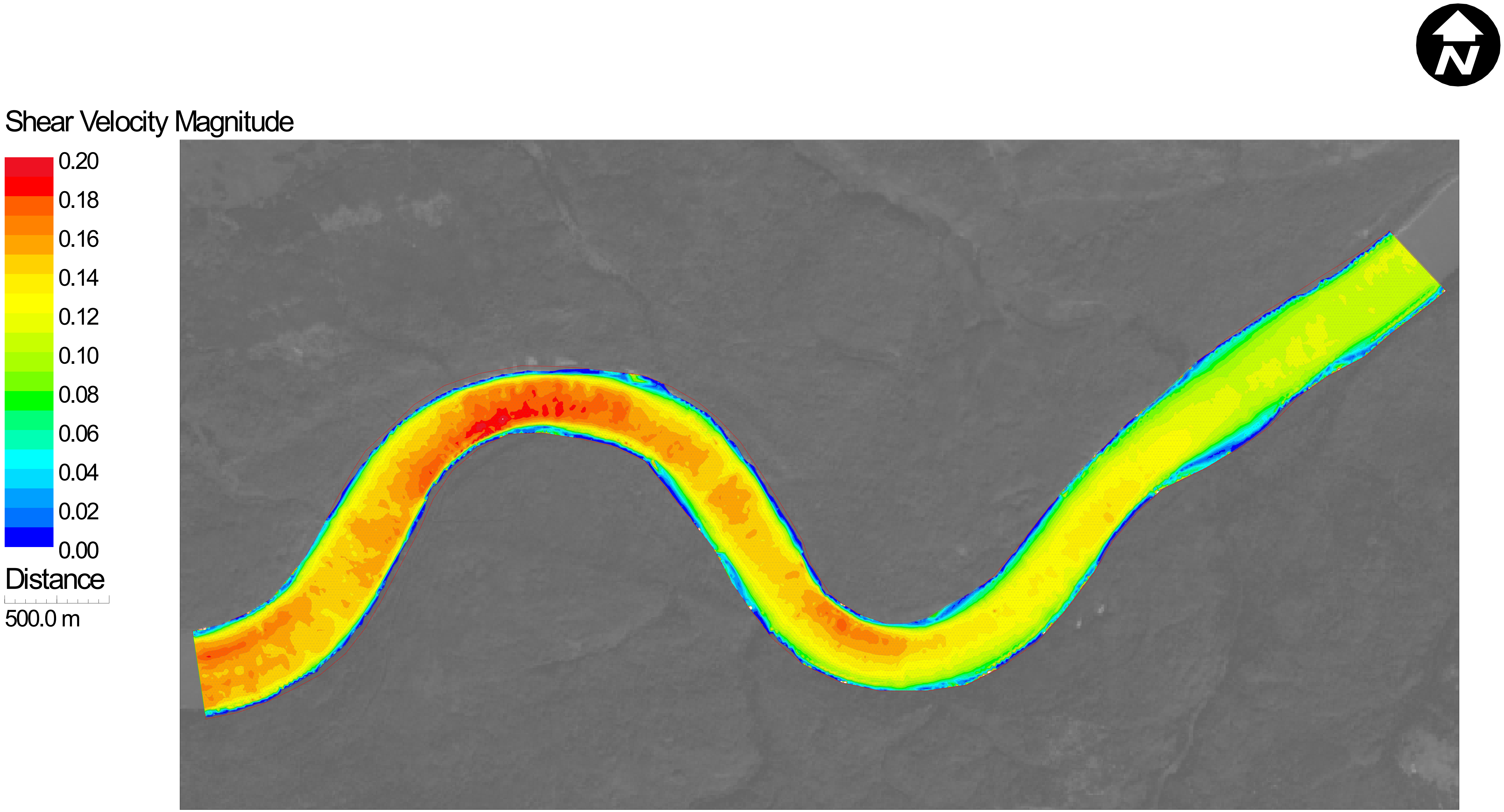

Model Boundary

**DISCHARGE**
**439 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| | | | FIGURE 5.27 |
| AMEC Project No.: SX0373305 | | Simulated Shear Velocity Magnitude (Mean Annual Discharge) | amec |
| DWN BY: RBA | CHK'D BY: RBA | | |




Model Boundary

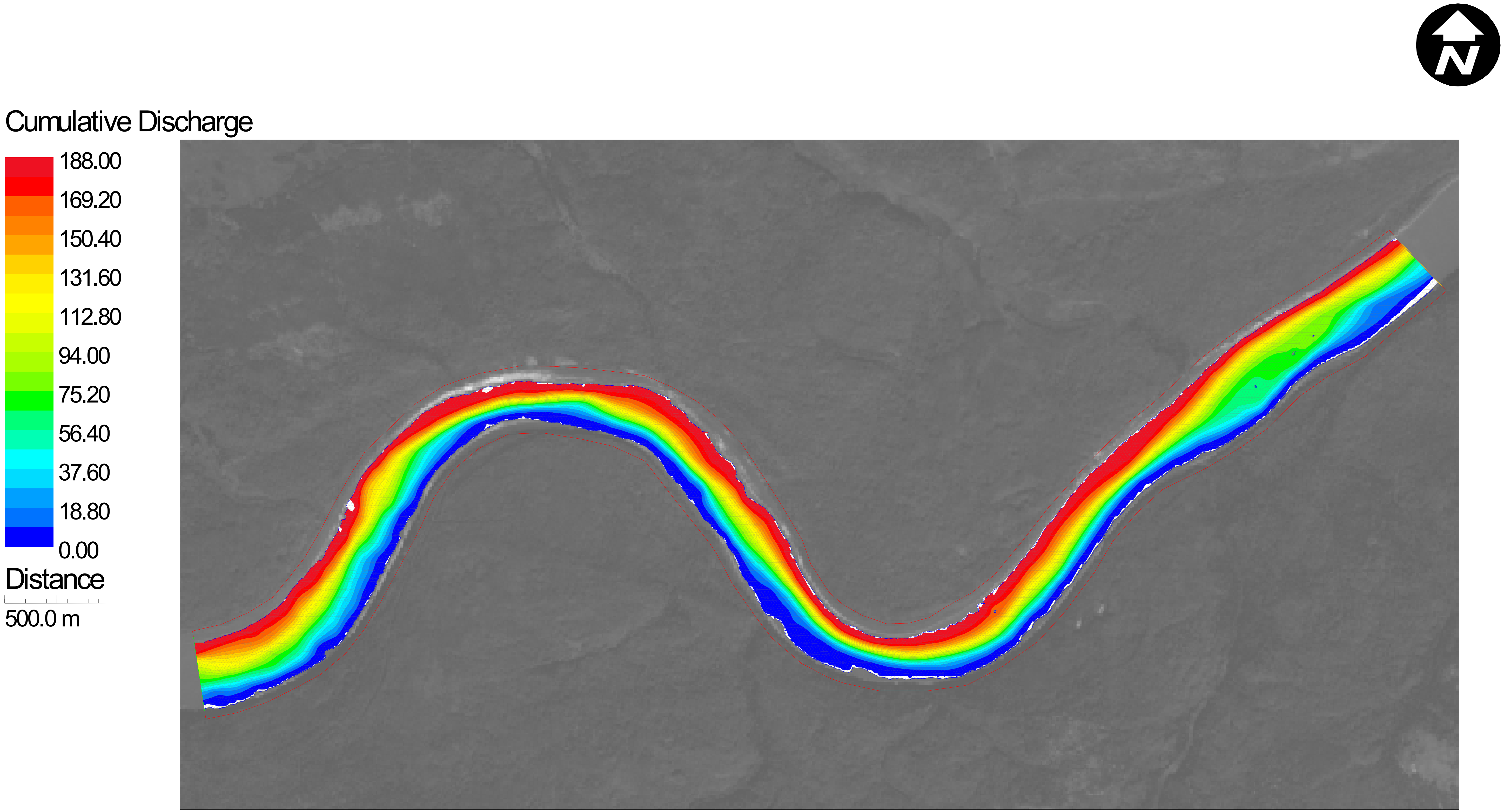
**DISCHARGE**
**4770 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.28 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Shear Velocity Magnitude (1:100 Year Discharge) | amec |

Map Path: L:\Water\PROJECT\EW...



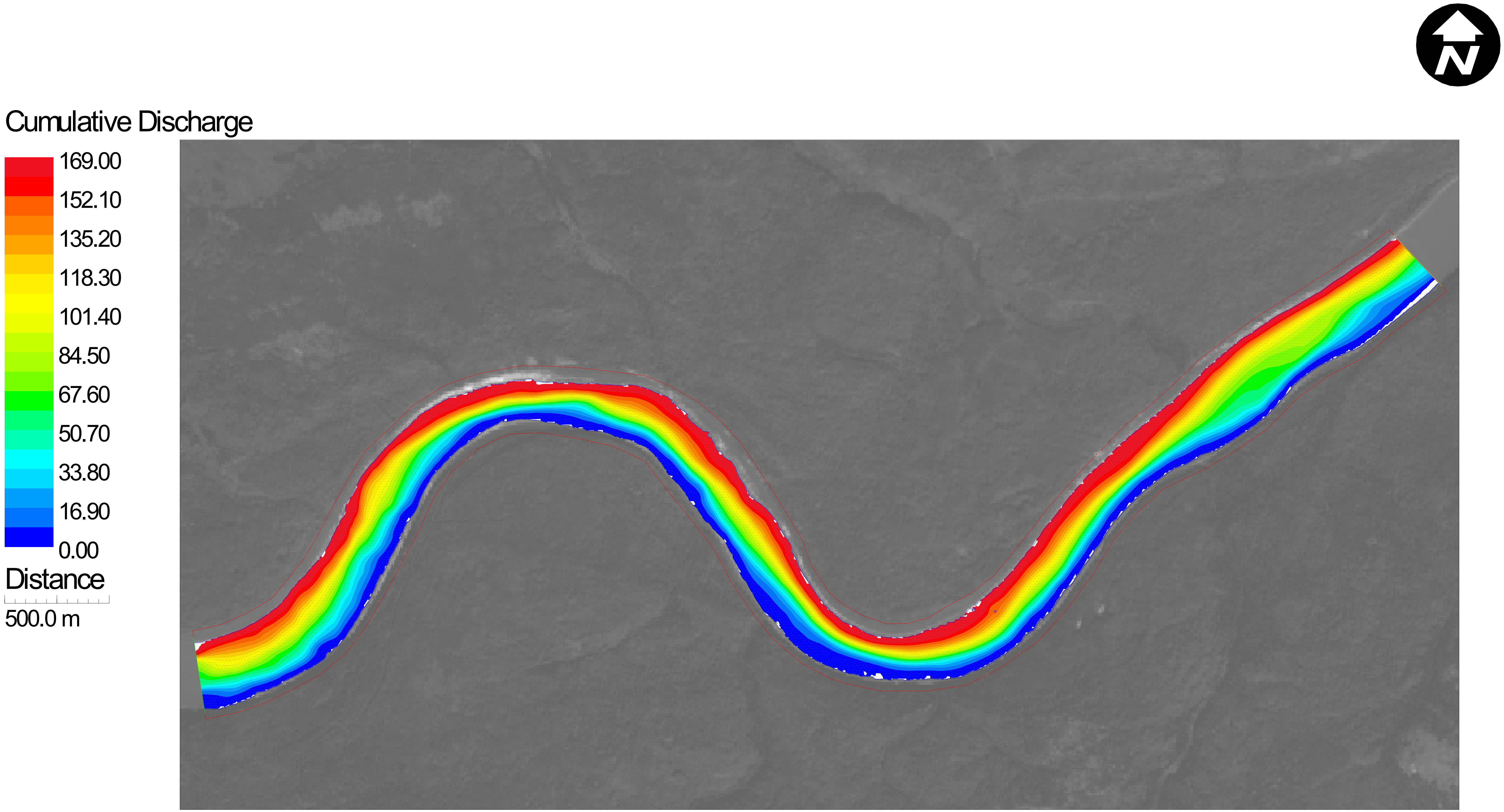

Model Boundary

**DISCHARGE**
**188 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.29 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Cumulative Discharge (7Q10 Open-Water Low Flow) | amec |




Model Boundary

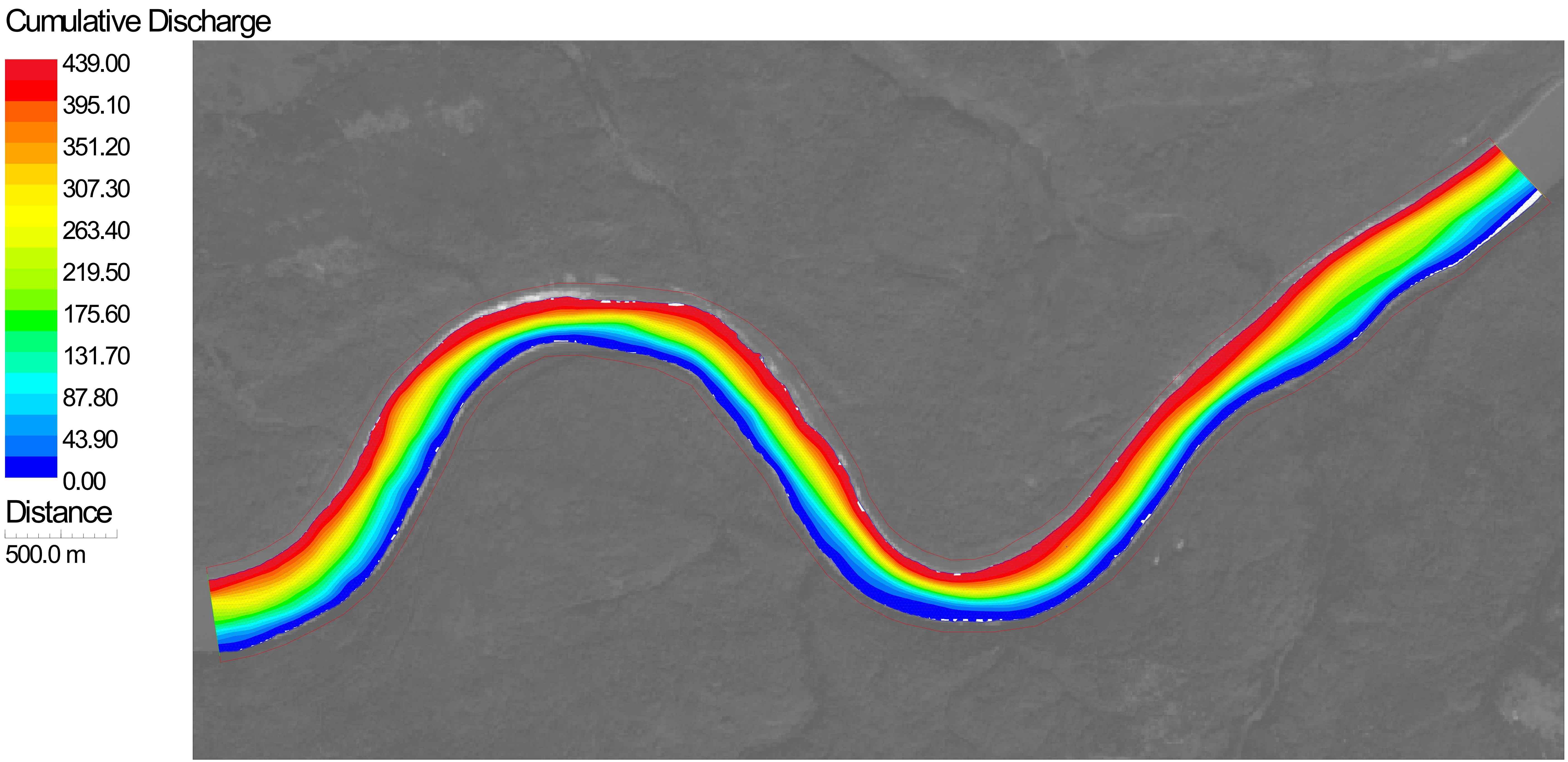
**DISCHARGE**
**169 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | |
|---|---|---|
| CLIENT: Shore Gold Inc. | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | FIGURE 5.30 |
| DWN BY: RBA / CHK'D BY: RBA | Simulated Cumulative Discharge (7Q10 Ice-Covered Low Flow) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

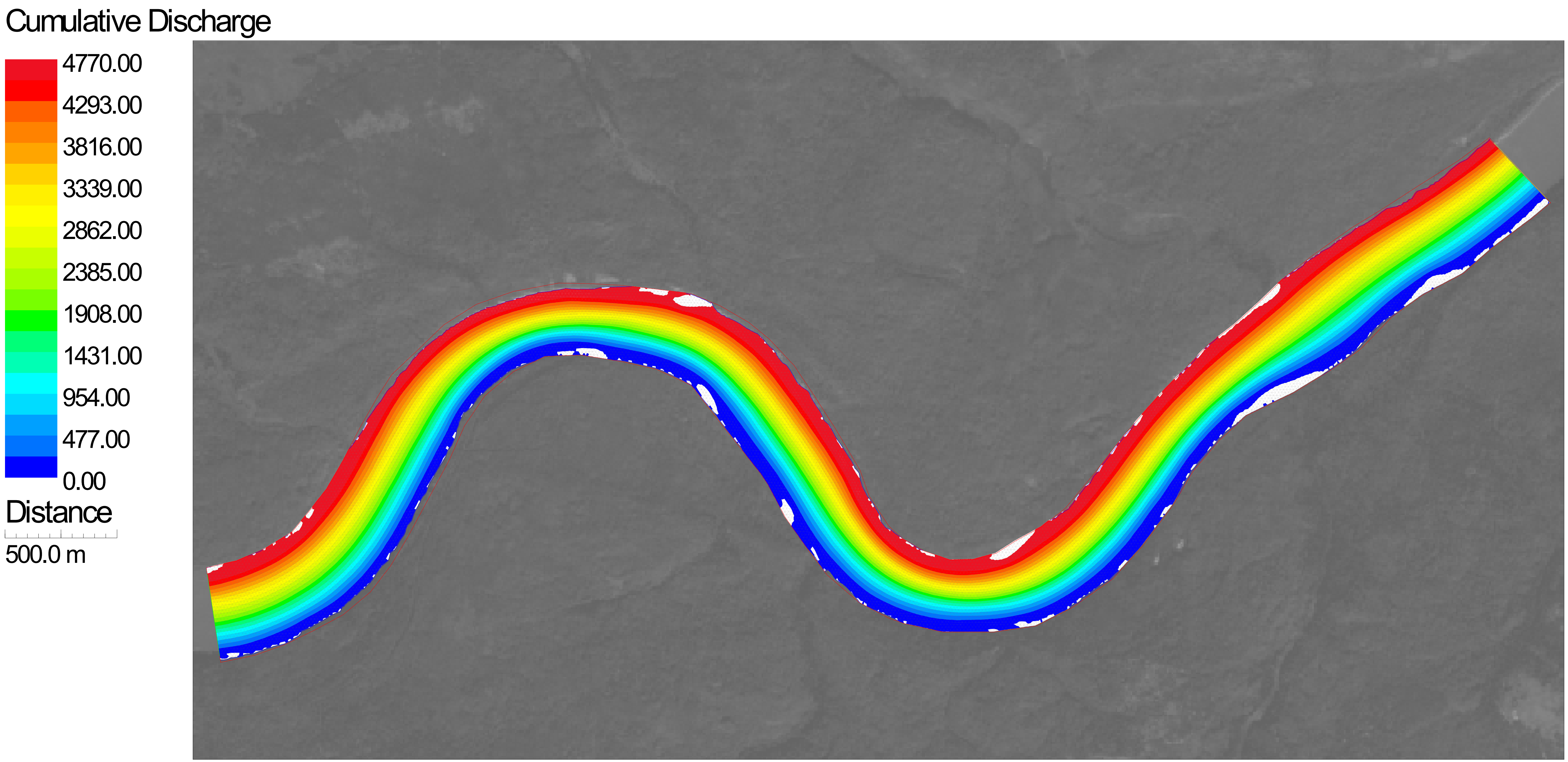
**DISCHARGE**
**439 $m^3/s$**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.31 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Cumulative Discharge (Mean Annual Discharge) | amec |

Map Path: L:\Water\PROJECT\EW...




Model Boundary

**DISCHARGE**
**4770 m$^3$/s**

Background Data from GeoBase®

**SCALE AS SHOWN**

| | | | |
|---|---|---|---|
| CLIENT: Shore Gold Inc. | | SHORE GOLD RIVER SURVEY | November 2010 |
| AMEC Project No.: SX0373305 | | | FIGURE 5.32 |
| DWN BY: RBA | CHK'D BY: RBA | Simulated Cumulative Discharge (1:100 Year Discharge) | amec |

# 6.0 SEDIMENT CHARACTERISTICS

## 6.1 Introduction

It is necessary to characterize the size of bed sediment as its movement can create bed forms such as ripples and dunes on the stream bed that have varying degrees of impact on a river outfall or diffuser. Archived sediment data was retrieved for several WSC stations along the North Saskatchewan, South Saskatchewan, and Saskatchewan Rivers near the proposed site. Bed material data obtained from each of the station records were analysed to estimate the bed sediment characteristics at the proposed site. This information was subsequently used to determine the estimated dimensions of bed forms that may develop as a result of hydraulic action on the river bed material.

## 6.2 Methodology

Bed material data are available at the WSC hydrometric gauge locations summarized in **Table 6.1**.

**Table 6.1**
**List of Water Survey of Canada Sediment Gauges Near the Study Site**

| Station | Name | Period of Record | Location Relative to Study Site | Number of Samples |
|---|---|---|---|---|
| 05GG001 | North Saskatchewan River at Prince Albert | 1958 to 1995 | Upstream | 331 |
| 05HG001 | South Saskatchewan River at Saskatoon | 1961 to 1995 | Upstream | 26 |
| 05KD005 | Saskatchewan River above Sipanok Channel | 1954 to 1956 | Downstream | 2 |

Since no representative data are available in the proximity of the proposed site, bed material data from all three of the sites listed in **Table 6.1** were examined and the data gathered from the two upstream stations were compared with the data for the downstream station. The average value of all of the measurements available at each site was computed and assumed to be representative of the bed material at that station.

## 6.3 Bed Material Data

The average values of the bed material measurements available at each of the three WSC sites are shown graphically on a semi-log plot in **Figure 6.1**. This figure indicates that the data from the three stations are very consistent. The bed material is predominantly sand and contains less than 10% gravel and less than 20% silt. Estimated values of median grain size ($D_{50}$) for the three sites range from 0.24 mm to 0.32 mm.

While the available bed material data indicate that the bed material is predominantly sand, it should be noted that coarse fractions have been measured along the North Saskatchewan River at Prince Albert (05GG001). During the field program discussed in Section 3.0, most of the shoreline was submerged and the channel bed was not visible due to high amounts of suspended sediment in the water. As a result, a visual assessment of the bed material composition was not possible. Photographs supplied by CanNorth (see **Figure 6.2**) from May 2008 indicate that there is some coarser material present on the bed and banks. It is uncertain whether that is widespread and representative of the channel bed. Since there have not been any bed material samples taken at the study site, it is recommended that confirmation of bed material gradation be conducted at time of detailed design so that the bed form analysis can be refined. For the purpose of this analysis, sand with a $D_{50}$ of 0.28 mm was taken as the representative bed material.

## 6.4 Analysis of Bed Forms

Bed forms are depositional features created by the movement of bed materials due to the flow of a river. In a lower-flow regime, bed form types include ripples, dunes and washed-out dunes, depending on the flow conditions. This regime, which is initiated with the beginning of motion, has a large resistance to flow and a small capacity to transport sediment. In the area of transition from a low- to a high-flow regime, a plane bed is formed. In an upper-flow regime, bed form types include anti-dunes, as well as chutes and pools, depending on the flow. The upper-flow regime is characteristic of a small resistance to flow and large amounts of sediment transport (Simons and Senturek, 1992). It important to predict the type and size of bed form that may be produced since bed forms may affect the performance of an in-river structure. If the effluent discharge does not exit the structure with enough energy to move through the bed form, deposition may cause blockage of the outfall and require constant maintenance. Outfall or diffuser design must therefore take into consideration the size of bed forms that may be created so that they can be constructed above the crest of any likely bed forms.

Predictions of the type of bed forms that may be created as a result of hydraulic action on the river channel perimeter were made through graphical analysis of several important variables. This empirical approach is commonly used as there is an absence of universally acceptable analytical solutions for such predictions. The variables which have been determined to affect the creation of bed forms in alluvial channels require the knowledge of local water depth, velocity, bed shear velocity, slope of the water surface, cross-section area, and top width. These values were obtained from the *River2D* model in the vicinity of the proposed diffuser for three different discharges: the mean annual flow (439 $m^3$/s), the calibration flow (1168 $m^3$/s) and the 1:100-year flood (4770 $m^3$/s, as determined through flood frequency analysis). Low-flow conditions were not considered to be important for bed formation processes. After determining the type of bed form that could be expected, the sizes of the bed form were estimated using a set of empirical relationships.

### 6.4.1 Prediction of Bed Form Type

There are several variables which have been found to affect the creation of bed forms in alluvial channels. The variables calculated from information received from River2D for the proposed effluent discharge location include stream power, Froude number, shear intensity factor, dimensionless particle parameter, particle settling velocity, shear velocity Reynolds number, transport stage parameter, grain Froude number, and mobility parameter. Using the data obtained from the model, the parameters described above were calculated and then plotted onto the relevant graphs allowing predictions of bed form types to be made. The details of this analysis are contained in **Appendix C**. **Table 6.2** summarizes the predictions of all of the relationships examined.

**Table 6.2**
**Results of Predictions of Bed Form Type Based on Flow Scenario**

| Variables Used | Flow Scenario/Discharge ($m^3/s$) | | | Applicability |
|---|---|---|---|---|
| | Mean Annual | Calibration | 1:100-Year | |
| | 439 | 1168 | 4770 | |
| Stream Power; Mean Particle Diameter | upper regime | upper regime | upper regime | Relationship not proven for large rivers. |
| Froude Number; Hydraulic Depth | lower regime | lower regime | off the chart | Use in combination with relationship below. |
| Slope; Shear Intensity Factor | transition | transition | transition | Use in combination with relationship above. |
| Ratio of Bed Shear Velocity to Settling Velocity; Shear Velocity Reynolds Number | plane bed/ anti-dunes | plane bed/ anti-dunes | n/a | Based on data for flow depth up to 3 m. |
| Dimensionless Particle Diameter; Shear Velocity Reynolds Number | flat bed | anti-dunes | anti-dunes | Based on data from alpine rivers. |
| Froude Number; Ratio of Depth to Mean Particle Diameter | dunes | dunes | n/a | Based on data for flow depth up to 3 m. |
| Transport Stage Parameter; Mean Particle Diameter | plane bed / anti-dunes | plane bed/ anti-dunes | plane bed/ anti-dunes | Relationship not proven for large rivers. |
| Grain Froude Number; Slope | lower regime | lower regime | upper regime | |
| Mobility Parameter; Dimensionless Particle Diameter | ripples | ripples | ripples | |

The results demonstrate definite variability in the predictions of bed form types based on the relationship used. For example, using the Froude number versus ratio of depth to mean particle diameter relationship, it is predicted that the resulting bed forms are dunes. However, this relationship is limited as it is based on data with a flow depth of up to 3 m. The plot of transport stage parameter versus mean particle diameter results in a plane bed/anti-dunes prediction; however, this relationship has not been proven for large rivers. Since these inconsistencies make a conclusive analysis difficult, the Froude number, which is an indicator of the flow regime, was used to draw conclusions about the bed form type. In the study area, this value is low (in the order of 0.2) for the range of flow conditions analysed. Therefore it is anticipated that a lower regime dominates. Since many of the other investigated parameters plotted in the higher regions on their corresponding charts, it is concluded that dunes would be the most likely bed form to appear. With the prediction of the bed type, the height and length of dunes were estimated.

### 6.4.2 Prediction of Bed Form Size

Several equations exist in literature that aid in predicting the size of dunes on a sand river bed. Using hydraulic characteristics obtained from the model, these equations were used to make predictions of bed form sizes at the calibration and 1:100-year flow conditions. The results of each equation were analysed and the average value of each of the equations was chosen as representative of the dune height and length. The details of this analysis are contained in **Appendix D**. A comparison was also made with observations from the field at calibration flow conditions.

**Table 6.3** presents a summary of all predicted dune heights and dune lengths resulting from each proposed equation. The results in this table indicate that there is some variation in each of the sets of results.

**Table 6.3**
**Summary of Dune Height and Length for Each Proposed Method**

| Method | Flow Scenario | Height (m) | Wavelength (m) |
|---|---|---|---|
| Allen (1963) | Calibration | 0.36 | 7.20 |
| | 1:100-year | 0.88 | 24.08 |
| Yalin (1964) | Calibration | 0.56 | 16.75 |
| | 1:100-year | 1.17 | 35.00 |
| Goswami (1967) | Calibration | 0.34 | 7.98 |
| | 1:100-year | 0.70 | 18.61 |
| Julien and Klaassen (1995) | Calibration | 0.50 | 20.94 |
| | 1:100-year | 0.84 | 43.75 |
| Karim (1999) | Calibration | 0.81 | 20.94 |
| | 1:100-year | 1.73 | 43.75 |

**Table 6.4** presents the estimated dune height and wave length, based on the average value of the calculations used above. In order for the outfall to maintain satisfactory operation, it is advised that it be placed at a height above any possible dune formation; i.e., above the estimated dune crest elevation obtained by adding half the estimated dune height to the mean bed elevation.

**Table 6.4**
**Predicted Sizes (height and length) of Dune Formations Based on Flow Scenario**

| | Dune Size | |
|---|---|---|
| **Flow Scenario** | **Height (m)** | **Wave Length (m)** |
| 1:100-year (4770 $m^3$/s) | 1.0 | 33.0 |
| Calibration (1168 $m^3$/s) | 0.5 | 14.8 |

Several straight longitudinal paths of surveyed depth sounding data were plotted to see if any bed forms could be identified; however, the data was inconclusive in terms of any well defined bed forms. A site survey during low-flow conditions would be required to more accurately assess bed form type and size.

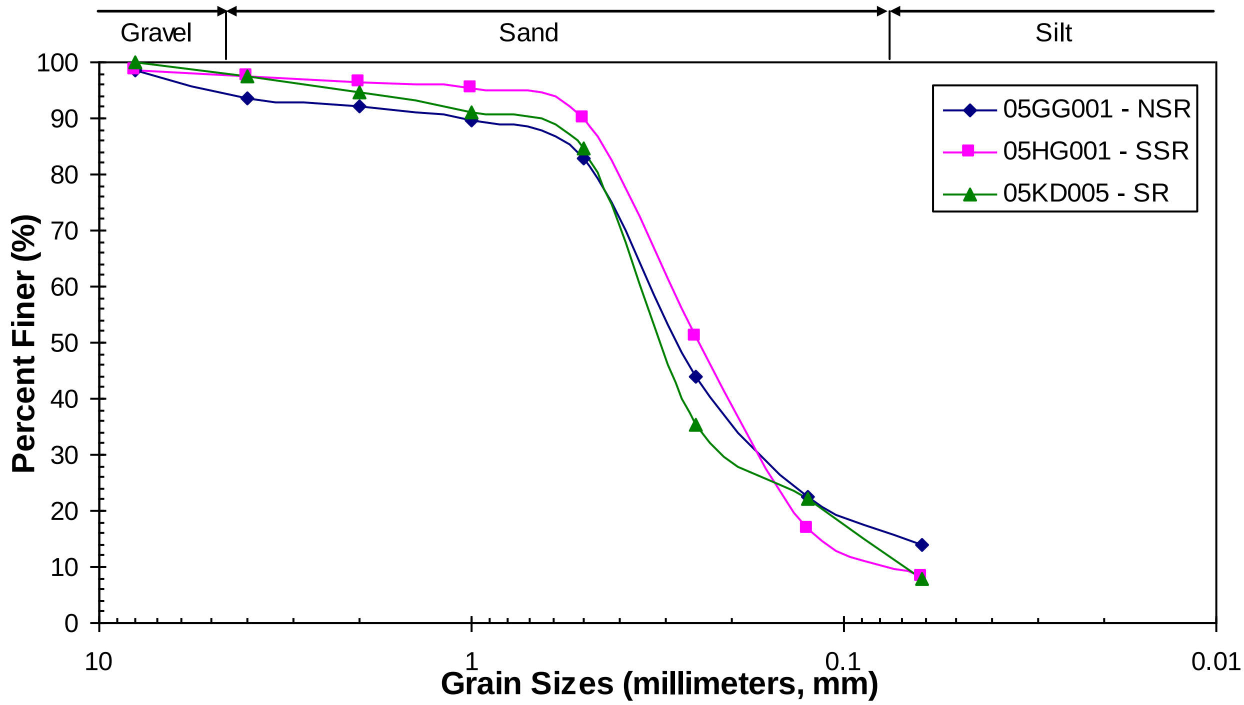



**Figure 6.1 Comparison of Average Bed Material Size Distribution for the Available Data**

**Figure 6.2 Photograph of the Study Site Showing Bed Material, May 2008 (provided by CanNorth)**

# 7.0 ICE JAM CONSIDERATIONS

## 7.1 Introduction

Ice action is an important consideration for all types of river engineering structures in Canada. The Saskatchewan River at the study site is expected to be affected by ice conditions for approximately 5 months of every year. Under many circumstances, a solid and intact winter ice-cover forms on rivers that increases hydraulic resistance to flow and raises water levels. This scenario generally does not create a problem for a river outfall or diffuser that is properly designed. However, some sites can be prone to ice jam formation either during freeze-up (in the fall or early winter), break-up (in the spring), or both. An ice jam is a highly dynamic, unstable event where ice becomes broken into many pieces that accumulate into a much thicker, rougher ice-cover. The formation and release of ice jams can exert extremely high forces capable of damaging or destroying structures in or along rivers and result in flow velocities, discharges, and water levels that can far exceed typical design flood values.

The frequency and severity of ice jams is difficult to predict and highly site-specific. Unfortunately, there are no observations or documentation of ice jam activity within the study area. Nonetheless, the relative impacts of ice jam occurrence should be addressed as they pertain to the proposed effluent discharge structure to guide subsequent phases of the design and to provide a basis for recommending an appropriate river ice monitoring program.

Through two-dimensional modeling, both an open water and ice-covered low-flow scenario was analysed in detail to quantify the effect of a solid, intact ice-cover on flow depths and velocities throughout the study reach (Section 5.0). To further meet the objectives outlined above, estimates of velocities and depths at the proposed effluent discharge location under plausible ice jam conditions were considered. This was accomplished using the U.S. Army Corps of Engineers' Hydrologic Engineering Center River Analysis System (HEC-RAS), a one-dimensional hydrodynamic model. In addition to evaluating the potential impacts of a river ice jam, the likelihood of a dynamic break-up mechanism, with the associated potential for bed and bank scour causing damage to the proposed outfall structure, was qualitatively evaluated.

## 7.2 Ice Jam Model

HEC-RAS model geometry is input in the form of natural channel cross sections with specified spacing. Using the model geometry from the *River2D* bed file, cross sections were extracted every 200 m throughout the 7.5 km study reach. Interpolated sections, spaced 25 m apart, were created between these sections in order to facilitate one-dimensional ice jam modeling.

The same channel roughness heights were used in the HEC-RAS model as were used in the *River2D* model. That is, a value of $k_s$ of 0.25 m was used for the upstream half of the reach and a $k_s$ value of 0.15 m was used for the downstream part of the reach. The model was run with the same conditions used to calibrate the 2-D model: a known downstream boundary condition and an inflow discharge of 1168 $m^3/s$. In order to ensure that the 1-D model produced the same results as the 2-D model, the corresponding water surface profiles were plotted and compared. **Figure 7.1** demonstrates that the results of the two hydraulic models are the same.

For the case of the continuous intact ice-covered conditions, a normal depth downstream boundary condition with a slope of 0.13 m/km was found to be suitable. The water surface elevation of the ice-covered low-flow scenario (inflow discharge of 169 $m^3$/s and 0.7 m continuous ice thickness) is compared with that of the 2-D ice-covered simulation in **Figure 7.2**. From this figure it can be seen that both models produce equivalent results. This downstream boundary condition was used for all the subsequent ice jam model simulations.

## 7.3 Simulation Results

Ice jam simulations were conducted using three different flow scenarios. These include the ice-covered low-flow scenario of 169 $m^3$/s; the 50% equalled or exceeded discharge value of 450 $m^3$/s for the month of April; and, the 10% equalled or exceeded discharge value of 750 $m^3$/s for the month of April (as determined through monthly flow duration curves – **Appendix B**). These values were chosen to represent a range of plausible conditions experienced at the time of spring river ice break-up. A pseudo-steady equilibrium jam formulation was used in the analysis. For each scenario, an ice jam was assumed to cover the entire reach, with the toe of the jam located near the downstream boundary and the head of the jam near the upstream boundary. Typical parameters of ice jam roughness, friction angle, porosity, stress ratio and maximum velocity were evaluated and applied to the model. The default values and the range of values used are included in **Table 7.1**.

**Table 7.1**
**Default and Applied Values of Typical Ice Jam Parameters**

| Ice Jam Parameter | Default Value | Value(s) Applied |
|---|---|---|
| Ice Jam Roughness | n/a | 0.06 |
| Friction Angle (°) | 45 | 45 to 55 |
| Porosity | 0.4 | 0.4 |
| Stress Ratio | 0.33 | 0.33 |
| Maximum Velocity (m/s) | 1.5 | 1.2 to 1.5 |

Using the details described above, an assessment of the velocity and flow depth at the proposed outfall site was conducted for each flow scenario. **Figures 7.3 through 7.5** show the modeled ice jam profiles and the water surface elevation under each flow scenario.

### 7.3.1 Velocity

The mean velocity of water at the proposed diffuser site was considered for each given flow scenario. Mean velocity was lowest under continuous ice-covered low-flow conditions of 169 $m^3$/s and the highest for an ice jam occurring at low-flow conditions of 169 $m^3$/s. Each of the velocities simulated for an ice-covered condition are lower than those for the 1:100-year flood of 4770 $m^3$/s, thus the 1:100-year flood event would appear to be the most critical for detailed design when considering velocity. However, it is important to note that ice jams are by nature very dynamic and non-uniform features, so the mean channel velocity may not accurately represent the maximum local velocity near the outlet structure. A summary of velocities in the vicinity of the proposed outfall structure is presented in **Table 7.2**.

**Table 7.2**
**Velocities at the Proposed Outfall Structure Under Various Flow and Ice Conditions**

| Flow Scenario ($m^3/s$) | Velocity (m/s) |
|---|---|
| 188 (no ice cover) | 0.66 |
| 169 (continuous ice cover) | 0.50 |
| 169 (ice jam) | 0.77 |
| 450 (ice jam) | 0.71 |
| 750 (ice jam) | 0.73 |
| 4770 (1:100-year flood) | 2.18 |

### 7.3.2 Depth

Flow depths and ice thickness were considered for each given flow scenario along a cross-section near the proposed effluent discharge site. A summary of this analysis is presented in **Table 7.3**. Depths were the lowest for an ice jam occurring at a flow of 169 $m^3/s$, suggesting that a low-flow ice jam scenario may be critical for final placement of the outfall structure. The ice thickness is greatest for the case of 450 $m^3/s$. As noted in the previous section, ice jams are by nature very dynamic and non-uniform features, so the depth under an ice jam will vary substantially both laterally and transversely throughout its evolution and among individual ice jam events.

**Table 7.3**
**Depths and Ice Thickness at the Proposed Outfall Structure**
**Under Various Flow and Ice Conditions**

| Flow Scenario ($m^3/s$) | Estimated Depth at Outfall (m) | Ice Thickness (m) |
|---|---|---|
| 188 (no ice cover) | 0.9 to 2.0 | – |
| 169 (continuous ice cover) | 1.1 to 2.2 | 0.7 |
| 169 (ice jam) | 0.7 to 1.8 | 2.2 |
| 450 (ice jam) | 2.4 to 3.5 | 2.3 |
| 750 (ice jam) | 3.8 to 4.9 | 2.0 |

### 7.3.3 Other Considerations

As can be seen from the figures displaying ice jam simulation results, there are several locations where the thickness of the ice jam is increased. These locations correspond with areas that exhibit a decrease in channel slope, a bend, or narrowing of the river. Such areas tend to have a higher potential for an ice jam to develop, but their occurrence is highly site-specific. As the proposed effluent discharge location is near both a bend and change in bed slope, the potential for bed and bank scour causing damage to the proposed outfall structure as a result of ice jams is increased. This must be considered in addition to an assessment of the velocity and depth when proceeding to final design of the effluent discharge structure.

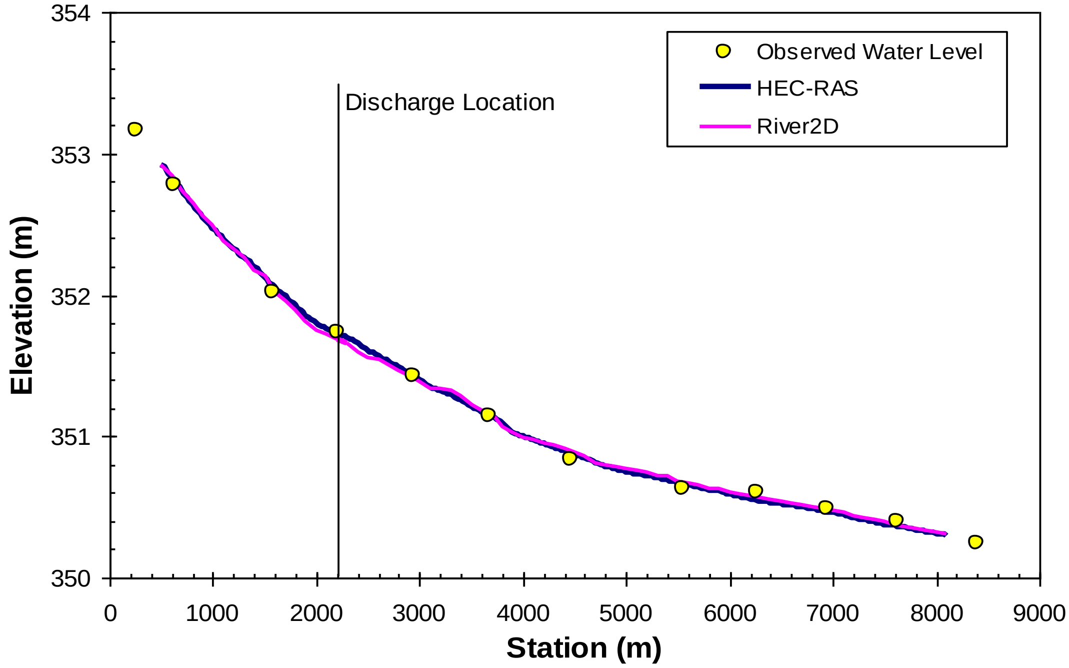



**Figure 7.1 Water Surface Profile Calibration (HEC-RAS and River2D)**

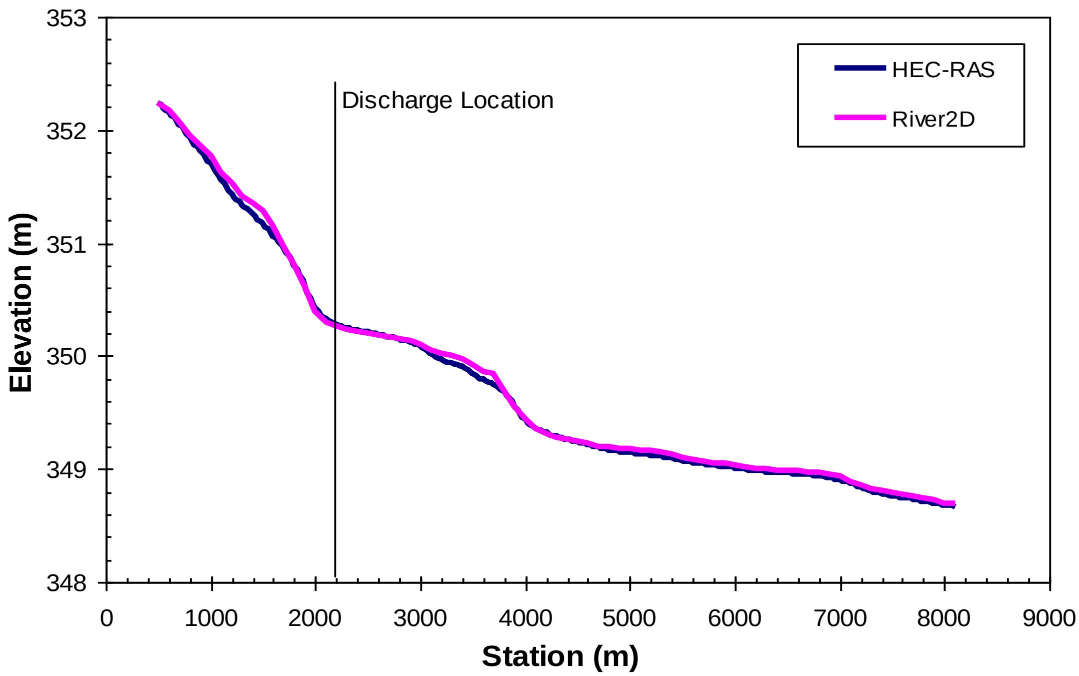



**Figure 7.2 Simulated Water Surface Elevation Modeled using HEC-RAS and River2D (7Q10 Ice-covered Low Flow)**

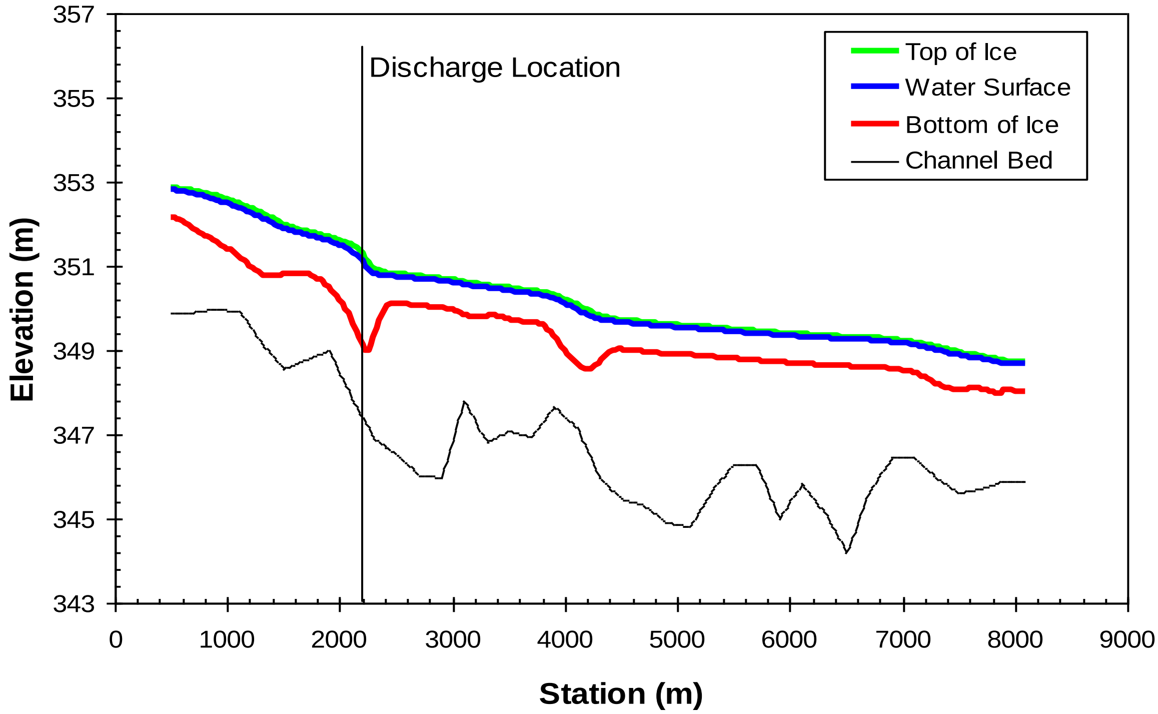



**Figure 7.3 Simulated Ice Jam Profile and Water Surface Elevation (7Q10 Open Water Low Flow)**

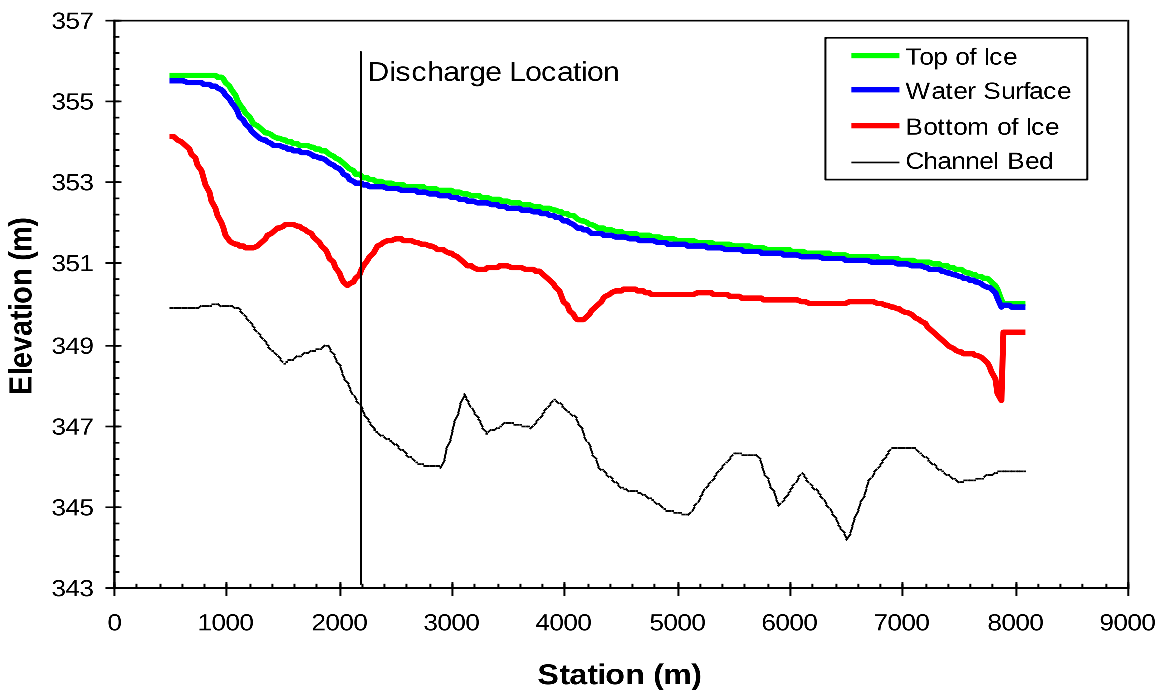



**Figure 7.4 Simulated Ice Jam Profile and Water Surface Elevation (April Mean Discharge)**

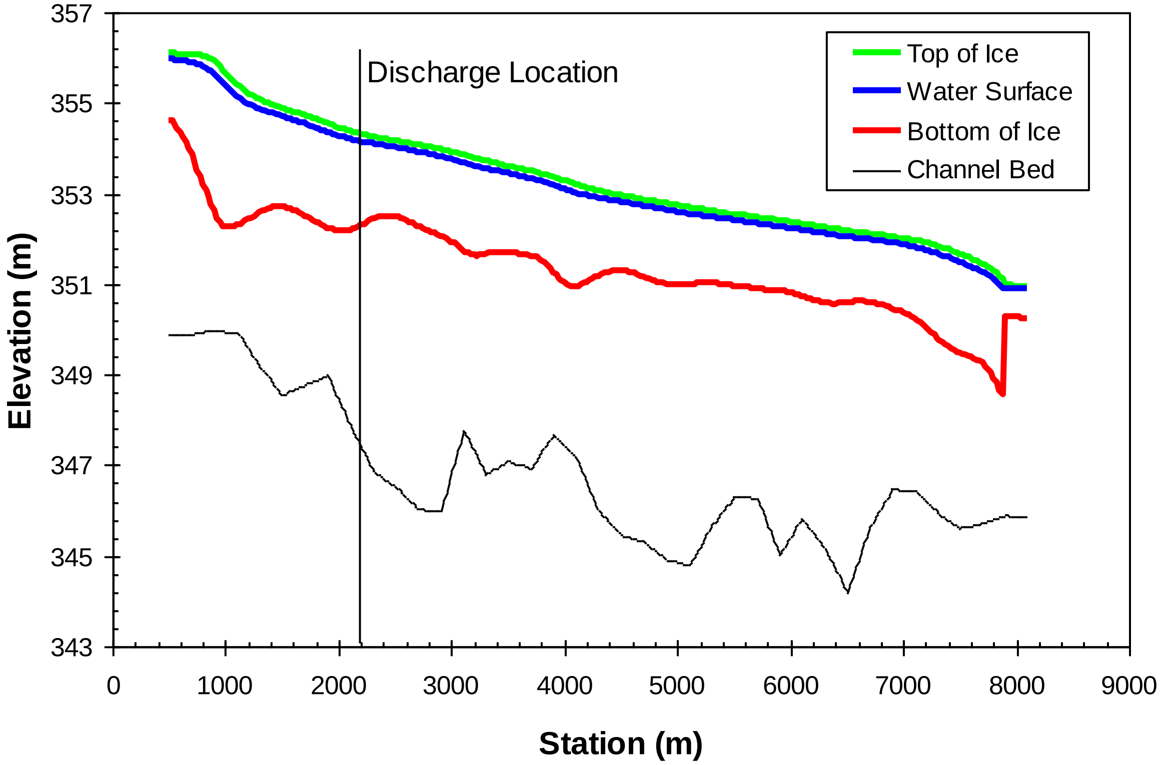



**Figure 7.5 Simulated Ice Jam Profile and Water Surface Elevation (Selected April High Discharge)**

## 8.0 SUMMARY AND RECOMMENDATIONS

AMEC Earth & Environmental (AMEC) was retained by **Shore Gold Inc.** to undertake a hydrotechnical modeling study with the goal of evaluating effluent mixing in the Saskatchewan River for the *Star Diamond Project*. This part of the report discussed details of the field program, river hydrology, river hydraulics, sediment characteristics and river ice jam considerations applicable to the design of an outfall or diffuser structure. Instream mixing and details of effluent dispersion are covered in Part 2 of this report.

In June 2010, a comprehensive field program that included measurements of bathymetry, water levels, flow velocities, and discharge were carried out on the Saskatchewan River near the proposed effluent discharge structure location. From data collected in the field program, several key observations could be made about the study reach. The 7.5 km study reach encompasses two distinct sub-reaches: a steeper upper reach, with higher velocities and shallower depths, and a wider, more mildly-sloping lower reach, with lower velocities and greater depths. Throughout the study site, the flow is relatively uniform across the channel under most conditions, and there are no islands or dominant mid-channel bars that divide the flow and promote transverse mixing. Based on the conditions experienced at the site during the time of survey, it was evident that there is some degree of backwater effect from the hydropower reservoir located downstream. A calibrated unit discharge downstream boundary condition was used to account for this in the model. It would be beneficial to survey a water surface profile at a different (lower) discharge to provide additional validation information that can be used later in detailed design.

In order to develop discharges relevant to river engineering design, a hydrological analysis was carried out. Streamflow records from the North Saskatchewan River at Prince Albert and the South Saskatchewan River at Saskatoon were used to construct a historical data series for the site. Using this data, a 7Q10 low-flow analysis was carried out for both the open water and annual case. These values were determined to be 188 $m^3$/s and 169 $m^3$/s, respectively. A flood frequency analysis was carried out in order to quantify the 1:100-year design discharge. This value, 4770 $m^3$/s, was used to assess higher velocities near the proposed outfall site and to predict the type and size of bed forms. From discharge measurements taken at the time of the survey, the calibration flow for modeling was determined to be 1168 $m^3$/s. This value was validated through hydrological analysis using the available real-time gauge data at the sites mentioned above. Flood frequency analysis also determined that these flow conditions were approximately equivalent to a 1:2-year flow.

A reliable two-dimensional hydrodynamic model was created using the data collected during the survey. This model provided essential supporting information for dispersion modeling and sediment analysis. It was also used to model various flow scenarios to assess depth and velocity design considerations for the proposed outfall structure. It was determined that the open water low-flow scenario resulted in the lowest depths at the site of the diffuser and that the high-flow scenario resulted in the highest plausible velocities that would be experienced at the proposed site over the range of flows considered. Output from the model included mapping of water surface elevation, velocity magnitude, bed shear velocity magnitude, flow depth and cumulative discharge throughout the study reach.

Based on sediment data available from Water Survey of Canada at three sites, an analysis of bed forms was conducted. It was found that due to the limited sediment data at the site and empirically-based relationships available in the literature, bed form type and size were difficult to assess. The best estimate of sediment characteristics given the available data is a sand-bed channel with a mean particle diameter of 0.28 mm. However, from photographs of the site, it can be seen that some gravels and cobbles are present along the channel banks. Assuming a sand bed channel is representative of the study site, an analysis of bed form type was inconclusive based on several different relationships. Although some of the methods examined indicated upper regime bed forms, low Froude numbers in the order of 0.2 throughout the reach support the conclusion that the most likely bed form types are dunes. An estimation of size, based on the average value of several relationships, suggests that dunes formed may be 0.5 to 1.0 m in height, depending on the flood severity considered. Direct observations and sampling of bed material during a low-flow period are recommended as part of the detailed engineering design of the effluent discharge structure following environmental approvals.

Although no ice jam activity has been documented in the study reach, the impacts of a hypothetical ice jam scenario were considered. The site of the proposed discharge structure is located near a river bend and a transition to mild slope, which is a type of area that is known to favour ice jam formation. A pseudo steady-state equilibrium ice jam was modeled throughout the entire study reach at three different flow scenarios: 169 $m^3$/s, 450 $m^3$/s and 750 $m^3$/s. While the model did not highlight any notable effects on water velocities experienced at the site, the smallest depths below the ice cover may be experienced if an ice jam were to occur at low-flow conditions. Simulations indicated a range of flow depths near the structure from 0.7 to 1.8 m under the ice jam conditions considered. Since ice jams are very dynamic and non-uniform by nature, it is important to note that the depth under an ice jam can vary substantially both laterally and transversely throughout its evolution and among individual ice jam events. To proactively gain a better understanding of how the river ice regime might impact the detailed design of an effluent discharge structure, ice observations should be made along the study reach in the winter and/or immediately after break-up.

## 9.0 CLOSURE

This report has been prepared for the exclusive use of **Shore Gold Inc**. This report is based on, and limited by, the interpretation of data, circumstances, and conditions available at the time of completion of the work as referenced throughout the report. It has been prepared in accordance with generally accepted engineering practices. No other warranty, express or implied, is made.

Respectfully yours,

**AMEC Earth & Environmental**

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2 *December 2010*

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Permit to Practice No. P-4546

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# PART 2

# DISPERSION MODELING STUDY

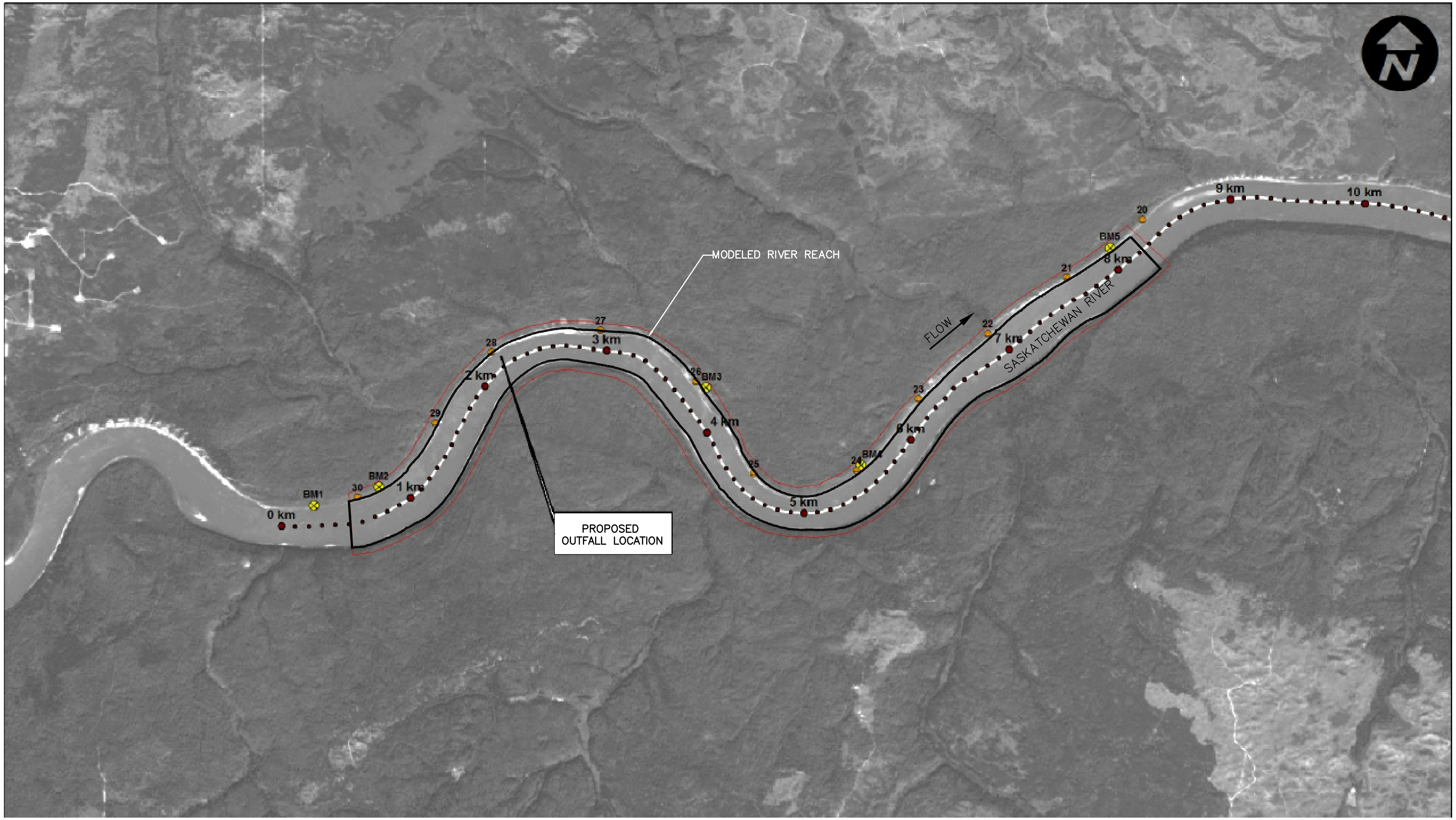
## 1.0 INTRODUCTION

This dispersion modeling study was undertaken by AMEC Earth & Environmental (AMEC) to assist Shore Gold Inc. with project design of a diffuser/outfall location on the Saskatchewan River and the preparation of permitting for the Star Diamond Project. This study addresses the prediction of chloride concentrations in the Saskatchewan River that are expected to result from the discharge of groundwater to the river. Groundwater will be collected from an open pit perimeter well field system, and will be conveyed to the Saskatchewan River through a pipeline. Groundwater quality analysis indicated that chloride is the primary salinity parameter of interest from drinking water and protection of aquatic life perspectives. There is no current or proposed use of the Saskatchewan River for drinking water within the bounds of the model domain; nor are there any water supply systems immediately downstream on the Saskatchewan River that currently draw drinking water from the river.

The location plan of the Saskatchewan River Outfall and the Modeled River Reach are shown in **Figure 1.1**. The proposed outfall site is located approximately 40 km downstream of the confluence of the North Saskatchewan and South Saskatchewan Rivers. The outfall location is positioned opposite the north bank of the Saskatchewan River between Duke and FALC Ravines at approximate coordinates E519546, N5897068 (NAD27). This site is approximately 600 m downstream of the originally planned discharge site. The location was selected such that sufficient depth of water above the diffuser or outfall would be available for its normal operation during the low-flow conditions.

The total length of the river reach included in the current model is approximately 8.0 km. Background chloride concentrations reported by SRK Consulting (2009) for the Saskatchewan River varied from 5 mg/L to 10 mg/L (average 7.4 mg/L) for various river flow conditions. It was assumed that the 10 mg/L value measured on 18 May 2008 is representative of the background chloride concentration for the 10-year return period, 7-day ice-covered low-flow (7Q10) condition. The average of 7 mg/L was assumed to be representative of the background chloride concentration for the average-flow condition. Saskatchewan River average annual and ice-covered 7Q10 flows at this location have been calculated at 37 930 000 $m^3$/d (439 $m^3$/s) and 14 600 000 $m^3$/d (169 $m^3$/s), respectively. Open water low flow for the river has been calculated at 16 200 000 $m^3$/d (188 $m^3$/s). The well field discharge is expected to achieve a steady-state condition discharge of approximately 199 000 $m^3$/d (2.3 $m^3$/s). Well field water salinity values have been estimated at 1725 mg/L for chloride. AMEC's understanding is that the discharge value given by Shore Gold Inc. is a conservative estimate.

The chloride concentration in the Saskatchewan River for the average annual-flow condition, after complete mixing with well field water, was calculated at 16 mg/L (or 9 mg/L above background). The maximum predicted chloride concentration in the Saskatchewan River, after complete mixing, during the extreme low-flow (7Q10) condition, was calculated at 33 mg/L (or 23 mg/L above background).

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|---|---|---|
| AMEC PROJECT NO: SX03733 | TITLE: **LOCATION PLAN OF SASKATCHEWAN RIVER OUTFALL AND THE MODELED RIVER REACH** | FIGURE 1.1 |
| DWN BY: CG / CHK BY: SS | | amec |

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The purpose of this modeling work is to establish the mixing and dispersion potentials of mine water in the Saskatchewan River downstream of the discharge location, for open water low-flow and average-flow conditions. The results of the modeling exercise will assist in the decision making process for the outfall design, and provide backup data for permitting.

Hydraulic parameters and flow characteristics of the river reach that were used to construct and calibrate the model were determined from water level and discharge measurements along the reach, together with bathymetric and ice thickness data, as well as topographic maps and aerial photographs. The data set of historical discharges at the site was estimated from recorded data combined for the hydrometric stations upstream of confluence: North Saskatchewan River at Prince Albert, South Saskatchewan River at Saskatoon and St. Louis; and downstream of confluence: Saskatchewan River at Nipawin and below Tobin Lake. Detailed descriptions of the field program, hydrology, river hydraulics and sediment characteristics of the reach are provided in the Preliminary Hydrotechnical Evaluation Report.

The following sections summarize the collation and utilization of the river data for the construction and calibration of flow and transport models for the river reach, simulation of mixing of the mine water plume, and the results of the study. Unless otherwise stated, all concentrations mentioned in the report are additive to the river background total chloride concentrations described above. Also the results are directly proportional to the initial concentrations and can be used to assess the concentrations of any other conservative substance dissolved in the effluent. Conservative substances are those that normally do not increase or decrease in the water column as a result of chemical reactions, biological activity, or adsorption onto suspended solids.

## 2.0 HYDROLOGY AND HYDRAULIC CHARACTERISTICS

A comprehensive field program was undertaken for the 8 km long study reach over the period of June 24th through June 28th, 2010. During this time, a detailed bathymetric survey, water level surveys and discharge measurements were completed. Throughout the survey, horizontal and vertical positioning was achieved using survey-grade Trimble® R6/R8 GNSS RTK-GPS receivers. The channel bed survey was conducted from a boat with an OHMEX SonarLite 2000 depth sounder and RTK-GPS attached. Bathymetric contours were generated from the bed point data using a contouring software program, extrapolated to the river banks by interpolation with the topographic data. Details of the field program are given in the Hydrotechnical Modeling Study (Part 1 of this report).

Characteristic background river flows (discharges) at the site were obtained by statistical analysis of daily discharges computed from the Water Survey of Canada (WSC) station data. Hydraulic parameters (velocity, water depths, etc.) for the outfall reach were obtained from analysis of water level and discharge measurements for the open water condition.

### 2.1 Saskatchewan River Discharge

Mean annual discharge and low-flow discharges were estimated based on an analysis of historical streamflow data for the Saskatchewan River which are available from the WSC division of Environment Canada stations near the proposed site listed in **Table 2.1**.

**Table 2.1**
**Regional Water Survey Canada Hydrometric Stations**

| WSC Station | Name | Period of Record | Drainage Area ($km^2$) | Comments |
|---|---|---|---|---|
| 05GG001 | North Saskatchewan River at Prince Albert | 1910 to 2009 | 131 000 | Upstream of confluence; regulated since 1962. |
| 05HG001 | South Saskatchewan River at Saskatoon | 1911 to 2009 | 141 000 | Upstream of confluence; regulated since 1968. |
| 05HH001 | South Saskatchewan River at St. Louis | 1958 to 1997 | 148 000 | Upstream of confluence; regulated since 1968. |
| 05KD001 | Saskatchewan River at Nipawin | 1945 to 1948; 1951 to 1962 | 287 000 | Downstream of confluence; regulated since 1968. |
| 05KD003 | Saskatchewan River below Lake Tobin | 1962 to 2009 | 289 000 | Downstream of confluence; regulated since 1963. |

The approach and the methodology followed for this work were described in Sections 1.2 and 1.3 of the Preliminary Hydrotechnical Evaluation Report. The mean annual discharge, design modeling value for the Saskatchewan River near the Shore Gold outfall site was determined to be 439 $m^3$/s, or 37 900 000 $m^3$/d. The one-in-10-year 7-day low-flow discharges (7Q10 low flow) were determined for both the open water condition and the annual case to be 188 $m^3$/s or 16 200 200 $m^3$/d and 169 $m^3$/s or 14 600 000 $m^3$/d, respectively.

By comparison, the design effluent discharge rate is 2.3 $m^3$/s or 199 000 $m^3$/day (assumed constant), which represents approximately 0.53% of mean annual flow, and 1.2% of the modelled open water 7Q10 flow. The modeling analysis was conducted for open water conditions as the model cannot account for ice cover effects. However, mixing under ice at the predicted lower flow value of 14 600 000 $m^3$/d is expected to be as good as, or better than, that achieved in the open water condition with a flow of 16 200 000 $m^3$/d (see Part 1, Section 5.4 – *Model Simulation Results* for comparison of depths and velocities under ice conditions).

Saskatchewan River design discharge values are summarized in **Table 2.2**.

**Table 2.2**
**Saskatchewan River at Shore Gold Discharge Characteristics**

| Description | Daily Discharge | | Notes |
|---|---|---|---|
| | ($m^3$/s) | $Mm^3$/day | |
| Mean Annual Discharge | 439 | 37.9 | |
| 7Q10 for open water period | 188 | 16.2 | June 1 – October 31 |
| 7Q10 for annual period | 169 | 14.6 | Lowest flow of the year always occurs during winter with ice cover present |

## 2.2 Channel Description

The river reach has two 90° bends within 4 km downstream of the proposed outfall. The radii of the first and second bends are approximately 650 and 500 m, respectively. The last 2 km of the river channel is straight. The width of the channel varies from a minimum 260 m at the proposed outfall location to a maximum of 380 m at a point 5 km downstream of the outfall. The typical side-slope of the channel is 7H:1V for the reach. The proposed outfall position is located opposite the north bank of the river channel where the side slope is approximately 8H:1V. The valley walls confine the channel. The river substrate material is predominantly comprised of sand and contains less than 10% gravel. There are occasional expressions of coarser material consisting mainly of cobbles to boulders. Relatively high roughness coefficients (n = 0.030 for the lower and 0.050 for the upper half of the reach) were selected as being representative for the river reach based on substrate and turbulent conditions at the site. The roughness coefficients were varied slightly for the low- and average-flow conditions during model calibrations.

## 3.0 FLOW AND TRANSPORT MODELING

Effluent plume dispersion and dilution calculations were performed with the help of a numerical flow and transport model. Estimates of chloride concentrations in the river associated with mine water discharge were determined using the model in the river reach downstream of the outfall location.

Two mixing scenarios were investigated corresponding to river flows for the 1:10-year 7-day open water low-flow (7Q10) condition, and for the annual average-flow condition. Positioning of the outfall pipe at the proposed discharge location was assumed to extend 70 m towards the middle of the river from the water edge corresponding to the average-flow condition. Model assumptions, construction, input data, calibration and results are summarized below.

### 3.1 Model Description

The model used in the analysis was AQUASEA (1992). AQUASEA is a two-dimensional, depth-averaged flow and transport model using a mixed (staggered) Galerkin finite element method with triangular elements. It is designed to simulate hydraulic flow in estuaries, rivers, lakes and coastal areas. The flow model is based on the solution of two-dimensional shallow water equations including bed resistance, wind stress and nonlinear convection terms. The transport model includes sources, decay, and convective and dispersive transport.

The simplifying assumptions used for the dispersion modeling of the mine water discharge at the Saskatchewan River outfall site were as follows:

- differences between the model averaged, and actual river depths, are small and will not change the flow regime and overall results obtained through the modeling;
- the bottom friction coefficient is estimated during the flow model calibration, and is based in part on field observations and other river reaches with similar morphology;
- other flow and transport parameters, such as transverse and longitudinal dispersion coefficients, were estimated from published data for similar river reaches;
- the effluent discharge is chemically conservative (chloride in solution);
- the flow in the river is uniform and steady; the effects of rapids and secondary currents on the flow regime and mixing are ignored. The reach exhibits generally consistent channel morphology within the modeled river reach;
- the river velocities govern mixing in the river; the initial mixing due to momentum of the mine water inflow is neglected. Mine water enters the river at a constant rate, discharged from the end of the outfall pipe at 70 m from the north riverbank at average flow, and is completely mixed with river water in the vertical water column;
- salinity concentrations in the plume are small enough so as not to create significant density gradients in any direction; and,
- no tributaries or streams enter or leave the study reach with the exception of the discharge from the mine water outfall.

In general, it should be noted that the assumptions used to construct the model provide an indication that the results of the dispersion modeling, and the associated chloride concentration distribution within the Saskatchewan River channel, are conservative.

Bathymetric information, based on previously collected data including field observations, was incorporated into the finite element grids constructed as shown in **Figure 3.1**. Initially all riverbed elevation data were contoured with a contouring software. The riverbed map was then completed by interpolation to integrate it with the topographic contours.

The river bottom elevations were digitized into the model elements as illustrated in **Figure 3.2**, and used for the respective flow calibration runs of high- (flow during the field program), average- and low-flow conditions.

The finite element model grid contains 12 775 triangular elements and 6 682 nodes. The element sizes vary from approximately 2 m near the outfall to 100 m further away from the source. Separate flow scenarios were analysed for the river, with and without the outfall operation, during model calibration and simulation stages.

Considering the assumption of uniform flow in the simulated river channel, and ignoring small head losses through the reach, hydraulic gradients in the model were estimated to be small (less than 0.0005). The hydraulic gradient for the upper half of the reach was estimated to be in the order of 0.0006 due to the shallower depths; and, the hydraulic gradient for the deeper lower half of the reach was estimated to be in the order of 0.00015. The hydraulic gradients were adjusted during the calibration of flow simulations and verified with the River2D model analysis results. The Manning roughness coefficient for the river reach was estimated from values listed in literature for similar channels. The river bottom friction constant (Chezy's coefficient - *C*) was calculated using Pavlovskii formula (Chow 1960):

$$C = 1.5 \frac{R^y}{n}$$

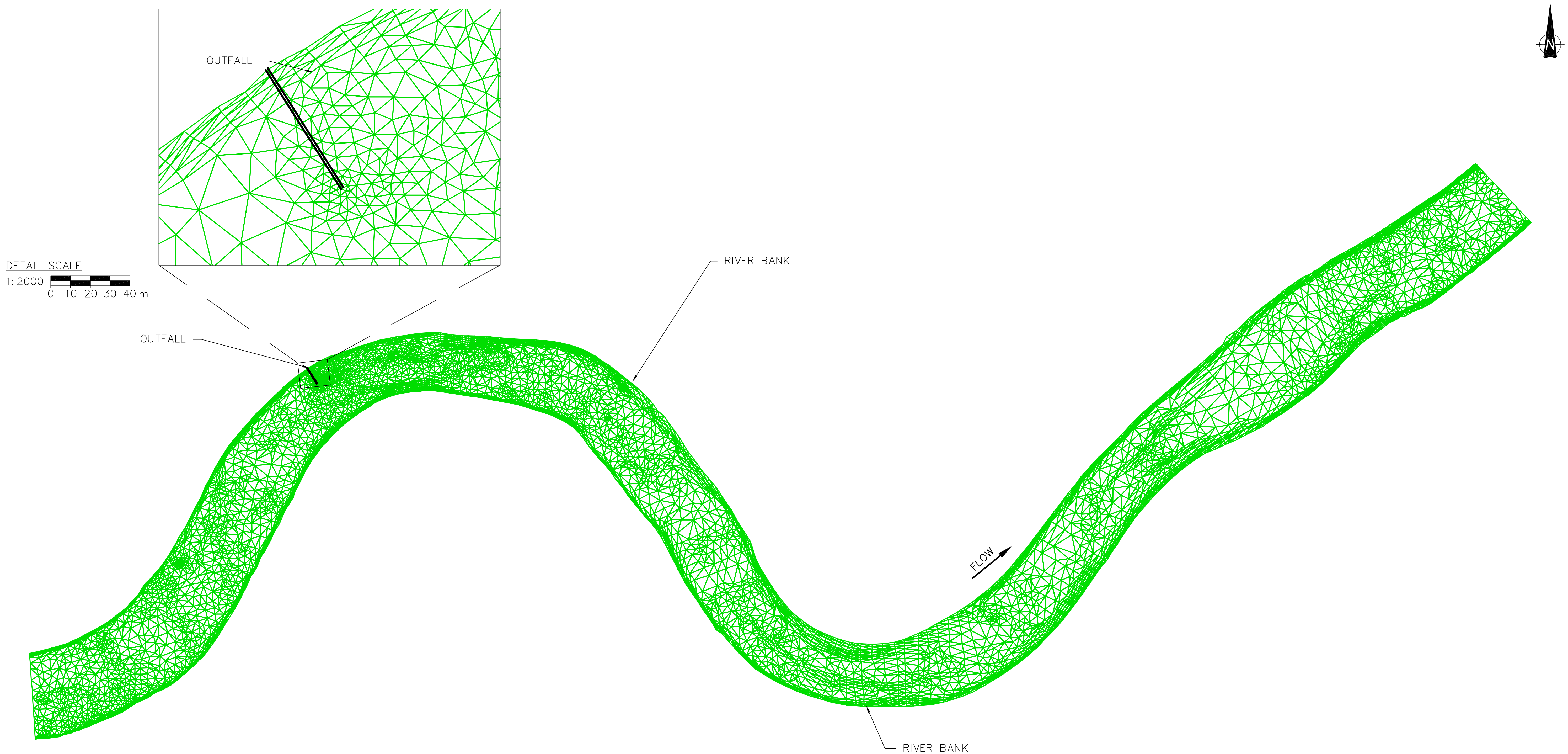
*Where*: $n$ = the Manning roughness coefficient

$R$ = the hydraulic radius calculated as a ratio of area of cross-section to the wetted perimeter

and

$$y = 1.5\sqrt{n} \qquad \text{for } R<1.0 \text{ m}$$

In the model grid, flow and mass flux calculation boundaries were installed at points approximately 500 m, 4000 m and 6000 m downstream from the outfall location. Also, several time series nodes were selected at similar grid locations for flow and transport. Time series flow and concentration data accumulated at these calculation boundaries, and at the selected time series nodes, were used to check model variables at the end of each calibration and simulation run.

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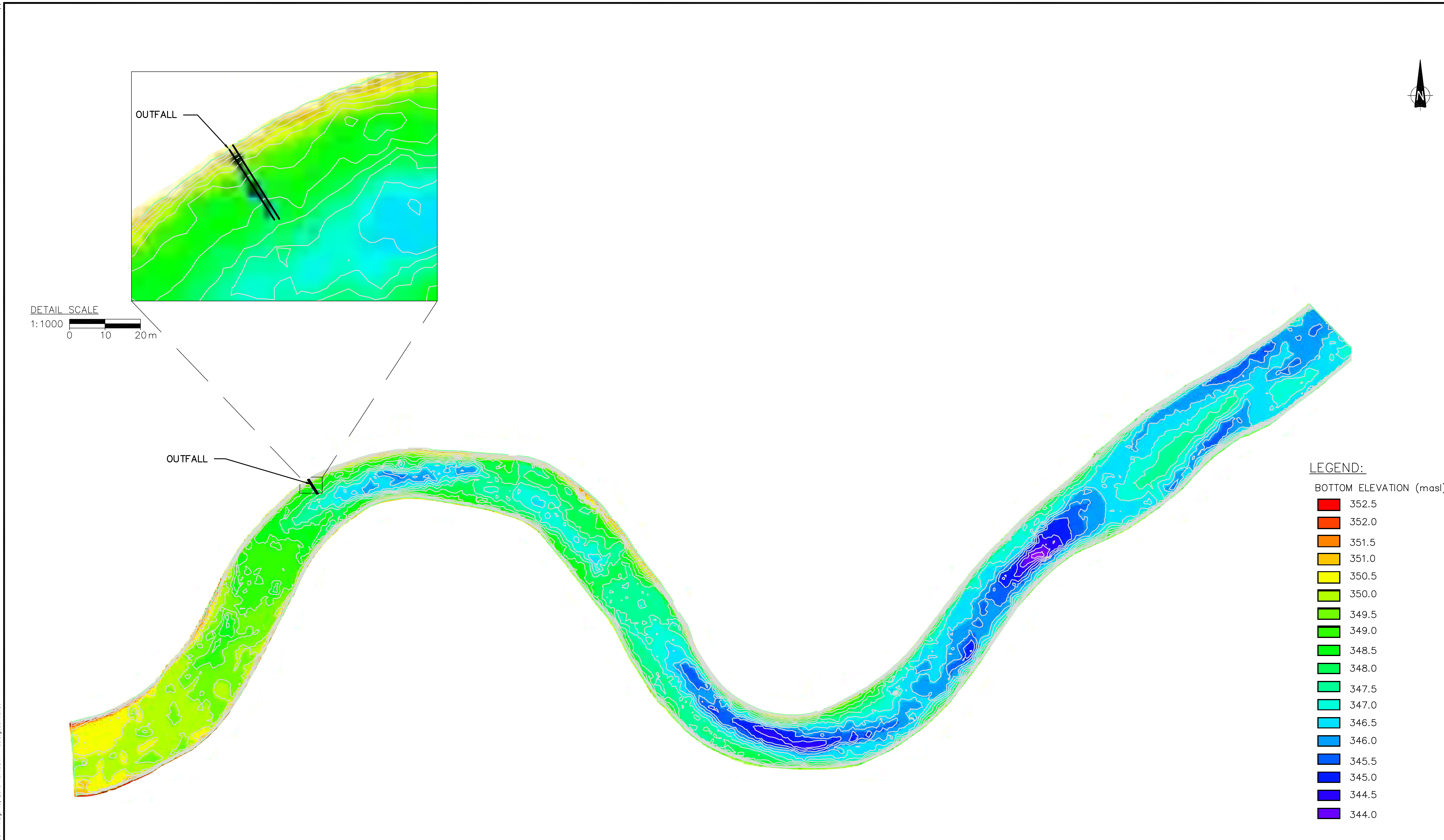
| DWN BY: CG | CHK BY: SS | TITLE: FINE ELEMENT GRID AND MODEL BOUNDARIES | amec |

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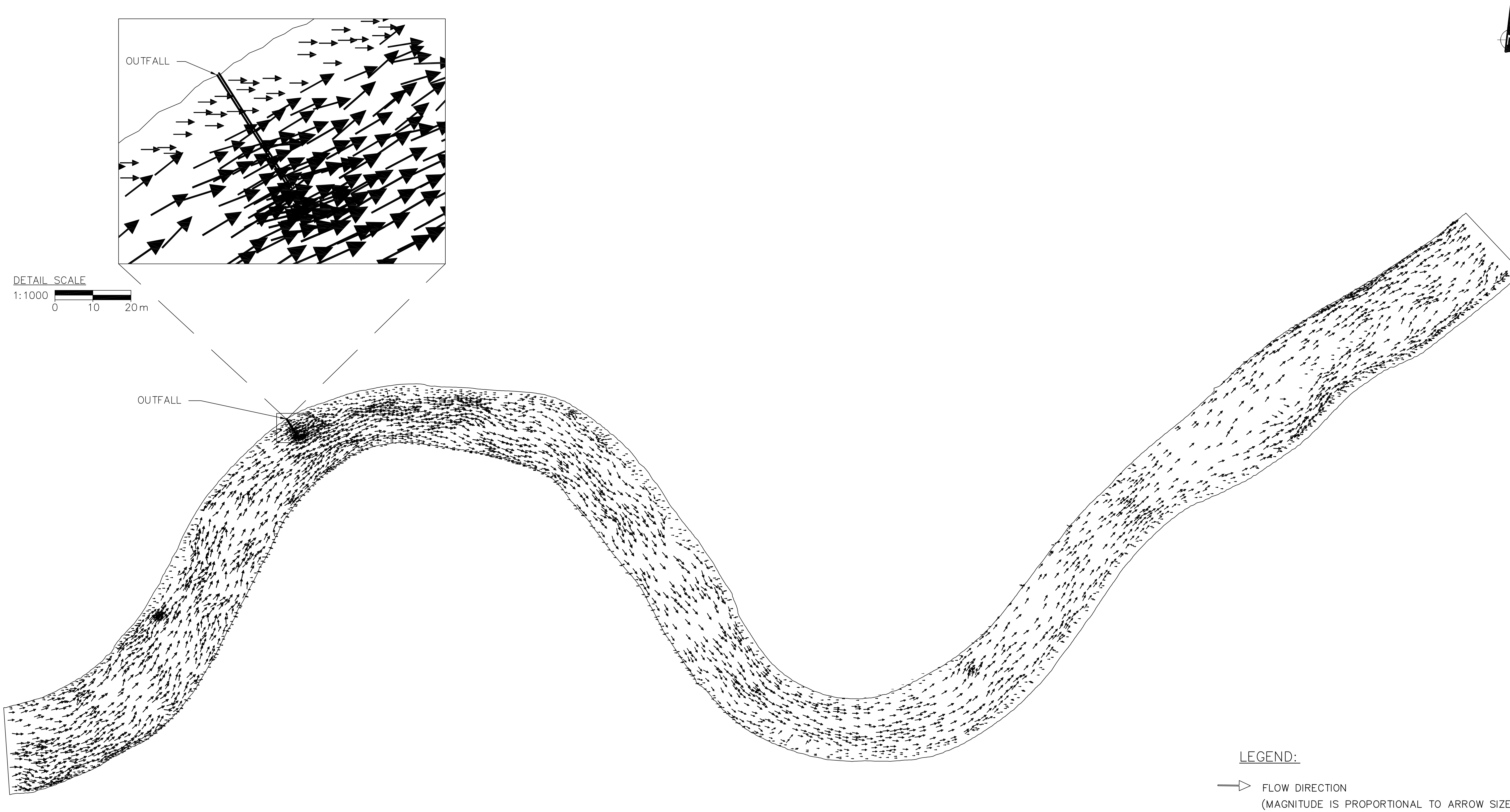
| DWN BY: CG | CHK BY: SS | TITLE: MODEL BATHYMETRY OF SASKATCHEWAN RIVER | amec |

### 3.2 Model Calibration

The flow model was run to generate the observed high-flow rate (1168 $m^3/s$) by varying Chezy's friction coefficient and comparing the simulated velocities and flow rates throughout the river reach with the observed values. Modeled velocities were also compared with the estimated velocity distribution and flow rate calculated with another flow model (River2D). The estimated low-flow rate of 188 $m^3/s$, corresponding to the open water 7Q10 flow condition, was achieved in the model using Chezy's friction coefficients of 26 $m^{1/2}/s$ and 28 $m^{1/2}/s$ for the upstream halves and the downstream half of the river reach, respectively. The estimated flow rate of 439 $m^3/s$, corresponding to the average river flow condition, was achieved in the model simulations using Chezy's friction coefficients of 30 $m^{1/2}/s$ and 32 $m^{1/2}/s$ for the upstream half and the downstream halves of the river reach, respectively. The velocities modeled with AQUASEA were generally the same as those observed and/or found by River2D.

At the end of calibration, the simulated velocities for low-flow in the river varied from 0.08 m/s to 1.2 m/s. In the areas closer to the river banks the velocities would be much smaller, being as low as 0.08 m/s. The simulated velocity distribution in the river reach for the low-flow condition is shown in **Figure 3.3**. The arrow position, length and size reflect the direction and magnitude of flow velocity in the figure. In the average-flow simulations, flow velocities varied from 1.44 m/s near the outfall, to 0.88 m/s near the downstream end of the study reach. The flow parameters for each scenario after calibration are summarized in **Table 3.1**.

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| | | | FIGURE 3.3 |
| AMEC PROJECT NO: SX03733 | | TITLE: SIMULATED VELOCITY DISTRIBUTION IN THE RIVER REACH (LOW FLOW CONDITION) | amec |
| DWN BY: CG | CHK BY: SS | | |

*PLOT 1:1=B (L)

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**Table 3.1**
**Flow Parameters After Calibration**

| Scenario | Discharge $m^3/s$ | Model Variable Depth (m) | Variable Channel Velocity (m/s) | Chezy's Coefficient C* $m^{1/2}/s$ |
|---|---|---|---|---|
| Low Flow | 188 | 0.0–4.3 | 0.0–1.2 | 26–28 |
| Average Flow | 439 | 0.0–5.0 | 0.0–1.4 | 30–32 |
| High Flow | 1168 | 0.0–7.1 | 0.0–1.6 | 36–38 |

* The numbers indicate average bottom friction factors assigned to the upstream and downstream half of the reach respectively.

## 3.3 Transport Model Simulations

The transport model was designed to use the same grid as well as the velocities generated in the flow model. Before transport runs were performed, the flow and velocities in the reach were generated through flow runs associated with each scenario. Mine water discharge was simulated in the transport model as a continuous source with a constant discharge rate, tracing chloride concentrations with time. The following assumptions were used in simulating the outfall:

- the outfall discharges mine water near the north bank of the river, where the water depth is greater than 2.5 m during the low flow. No diffuser is used at the end of the discharge pipe;
- the outfall pipe extends away from the bank, towards the middle of the river, making an approximate 90° angle with the river flow lines;
- the total mine water discharge rate is 199 000 $m^3$/day (2.3 $m^3$/s) and constant;
- the concentration of chloride in the mine water being discharged is 1725 mg/L;
- the low-flow rate in the river is 16 200 000 $m^3$/day (188 $m^3$/s), uniform and steady;
- the average flow rate in the river is 37 900 000 $m^3$/day (439 $m^3$/s), uniform and steady; and,
- flow conditions under ice were not investigated.

The modeling scenarios investigated plume migration in the river downstream of the outfall for low-flow and average-flow conditions for the 70 m outfall pipe. The upstream boundary condition was assigned a specified concentration of zero. The downstream boundary was assigned a zero concentration gradient indicating only convective transport of mass through the boundary because of the large distance away from the source. The source boundary was selected on the model grid to coincide with the outfall pipe as shown in **Figure 3.1**.

The main parameters required in the transport model – the longitudinal and transverse dispersion coefficients – were estimated from the literature for similar channels having uniform flows at 1.0 $m^2$/s and 0.3 $m^2$/s, respectively. The representative transverse dispersion coefficients, as determined by field tests and laboratory experiments, were summarized in Sumer (1976) and Beltaos (1978). The transverse dispersion coefficient is typically five to ten times smaller than the longitudinal dispersion coefficient for straight channels. Due to the meanders and river morphology a slightly larger transverse dispersion coefficient was used for the river reach.

Transport simulations were conducted for a chloride concentration of 1725 mg/L, estimated to exist in the mine water discharge at the end of the outfall pipe. For the purposes of modeling, chloride ions were again conservatively assumed to be resistant to decay, sorption or other processes that would remove them from solution in the river water. The background river chloride concentrations (see Section 1 for values) were assumed constant everywhere in the river reach modeled, and they were not included in the transport simulations.

***Low Flow***

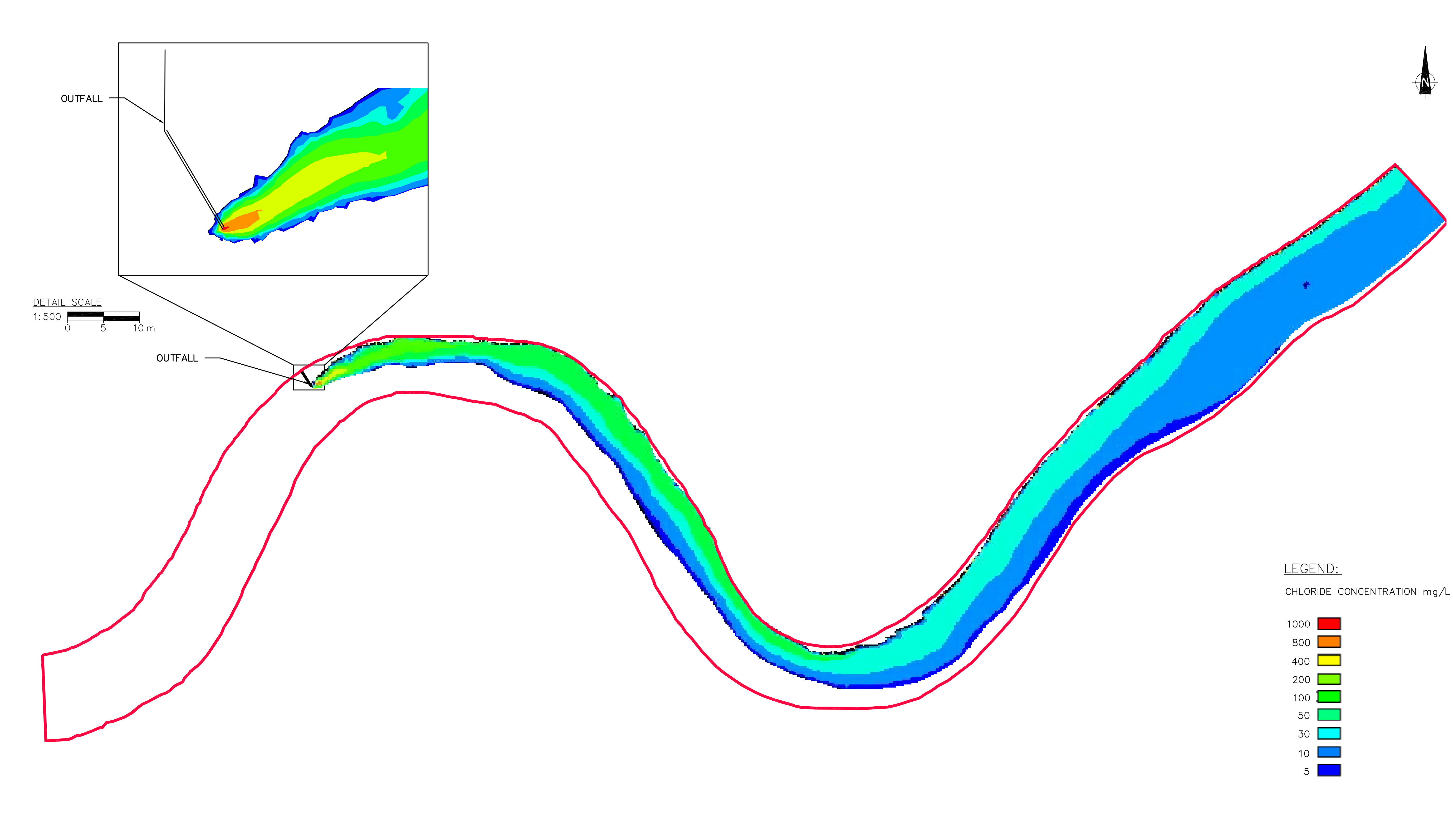
**Table 3.2**, pertaining to the 7Q10 low-flow condition for the 70 m outfall, summarizes chloride concentrations found after modeling along the riverbank at 100 m downstream of the outfall location, and at 500 to 1000 m intervals thereafter, progressing downstream from the outfall to the end of the modeled river reach (approximately 6 km downstream of the outfall). The lateral distances of 0 m, 10 m, 25 m, 50 m, 75 m, and 100 m, from the riverbank encompass the main portion of the dispersion plume to the end of the reach. The maximum concentrations for chloride are also shown for each downstream distance, recognizing that maximum concentrations do not necessarily coincide with any of the discrete profile distances of 0 m, 10 m, 25 m, 50 m, 75 m or 100 m from shore.

**Figure 3.4**, shows the modeled river concentrations of chloride in the river reach for low-flow conditions for the 70 m outfall. It should be noted that the tip of the outfall pipe is only 60 m away from the water edge corresponding to the low flow in the river.

**Table 3.2**
**Simulated Concentrations of Chloride as a**
**Result of Mine Water Discharge into the River during Low Flow**

| Lateral Distance from the River Bank (m)* | Stations Along River (m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100 | 500 | 1000 | 1500 | 2000 | 3000 | 4000 | 5000 | 6000 |
| | Chloride Concentration (mg/l) | | | | | | | | |
| 0 | 0 | 6 | 7 | 8 | 10 | 24 | 43 | 39 | 33 |
| 10 | 2 | 90 | 76 | 36 | 63 | 39 | 43 | 39 | 33 |
| 25 | 26 | 94 | 74 | 69 | 62 | 46 | 42 | 38 | 32 |
| 50 | 252 | 93 | 67 | 64 | 53 | 45 | 41 | 36 | 30 |
| 75 | 7 | 59 | 54 | 58 | 43 | 41 | 37 | 32 | 27 |
| 100 | 0 | 11 | 39 | 45 | 29 | 33 | 32 | 28 | 23 |
| 125 | | 0 | 28 | 27 | 17 | 24 | 25 | 23 | 18 |
| 150 | | | 13 | 14 | 9 | 14 | 19 | 21 | 13 |
| 175 | | | 0 | 5 | 5 | 6 | 14 | 19 | 11 |
| 200 | | | | 0.5 | 0 | 0 | 9 | 17 | 9.5 |
| 250 | | | | 0 | | | 4 | 14 | 9 |
| 300 | | | | | | | 0 | 13 | 9** |
| 350 | | | | | | | | 8** | |
| Max. at transect. | 260 | 99 | 76 | 72 | 63 | 47 | 43 | 39 | 33 |

* Outfall at 60 m away from the river bank.
** Plume reaches the opposite river bank.

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| | | | FIGURE 3.4 |
| AMEC PROJECT NO: SX03733 | | TITLE: SIMULATED CHLORIDE CONCENTRATIONS (ABOVE GROUND) -LOW FLOW CONDITION -70M OUTFALL | amec |
| DWN BY: CL | CHK BY: SS | | |

Based on the results of transport simulations for the low-flow condition, the plume generated for chloride follows the north shore of the river, expands transversally to approximately 120 m at 500 m and touches the north bank of the river. It contracts to 80 m at 750 m and expands again to 170 m at 1.1 km downstream of the outfall. The plume contracts to 110 m at 2.5 km, where the river enters the second bend and gets deeper. Later about 5 km downstream of the outfall, the plume expands laterally to approximately 350 m reaching to the other bank. The plume front travels at an average velocity of approximately 1.5 km/h, reaching the end of the reach (6.0 km) in about 4 hours. The plume front travels slower through the deeper sections of the river.

The mass flux entering and leaving the reach was computed in the model at flux boundaries installed into the model grids at various transects, to verify that no significant loss of chloride mass occurred in the reach during model simulations. Conservation of the total amount of chloride flowing in and out of the study reach was checked to verify model reliability against numerical dispersion and convergence in time. Review of the time series data accumulated in a file at the end of the low-flow transport simulations indicated that the total mass flux reached a steady state at 6.0 km downstream after approximately 4.5 hrs of operation of the outfall.

Modeling has demonstrated that the chloride concentration entering into the river would be immediately diluted by river water to approximately 62% at the outfall location during the open water low-flow conditions. It should be noted that the model does not solve for the near field (jet) dispersion, and that the concentrations in the river in close proximity to the outfall are approximate. The plume chloride concentration along the north bank at a distance of 500 m downstream of the outfall would be 90 mg/L. At a point 1000 m downstream, the chloride plume concentration near the bank would be diluted to approximately 76 mg/L for a 70 m outfall (**Table 3.2**). During low flow, at the end of the reach, the plumes' maximum chloride concentration was predicted at approximately 33 mg/L (less than 2% of the initial concentration). The lateral (across channel) maximum concentration gradient at the end of the reach was approximately 13 mg/L/100 m. A comparison of concentrations at the end of each river bend (approximately 2.0 km and 4.0 km downstream of the outfall) indicated that the plume expanded laterally at these two locations, likely due to higher velocities, shallower depths and greater transverse velocity gradients at these locations.

Another scenario with a shorter (40 m) outfall was also run to test the behaviour of the plume if the mine discharge is closer to the bank. Model results with the plume generated from the 40 m outfall indicated two to three times higher river concentrations within 500 m downstream of the outfall. At a point 1000 m downstream, the chloride plume concentration near the bank would be diluted to approximately 100 mg/L. Further downstream, the plume had similar characteristics to the one generated by the 70 m outfall scenario with chloride concentrations at the bank reducing to 35 mg/L before the plume left the study reach. The maximum difference between the 40 m and 70 m outfall plume concentrations at the end of the reach was 2 mg/L.

### *Mixing Under Ice Cover*

An important feature of rivers and channels is that their morphology and flow-resistance behaviour vary interactively with flow and ice conditions. Depending on flow magnitude, ice covers modify the interaction, over a range of scales in space and time. The surface ice would create another friction boundary at the top of the water column, resulting in a greater variability in vertical velocity gradients compared to open water flow conditions. Ice-cover influences flow distribution, solute transport by ice, solute transport under ice, and channel morphology. The impacts can include raised water levels, laterally redistributed flow, secondary currents, and other effects. Hydraulic and physical properties of flow under ice and the influence of ice-cover on flow and bed load transport are discussed in Hains (2004), White (1999) and Smith (1995).

The 7Q10 low flow under ice cover was estimated as 169 $m^3/s$ (14 600 000 $m^3/d$) for the study reach. The flow under ice would take place through a larger cross-sectional area with smaller average longitudinal velocities compared with the open water low-flow condition. However, under ice the flow would be diverted transversally in braided channels formed by ice jams and water frozen to the bottom at shallow areas. Mixing would be enhanced due to these braided channels and secondary currents. It was estimated that the mixing under ice cover would be greater than, or at least similar to, the open water low-flow scenario investigated with the numerical model. It should be noted that further downstream, where the plume is completely mixed with the low-flow rate given for the under-ice condition, the chloride concentrations would be in the order of 33 mg/L (23 mg/L above background).

River ice flow considerations are discussed in detail in the Preliminary Hydrotechnical Evaluation Report.

### *Average Flow*

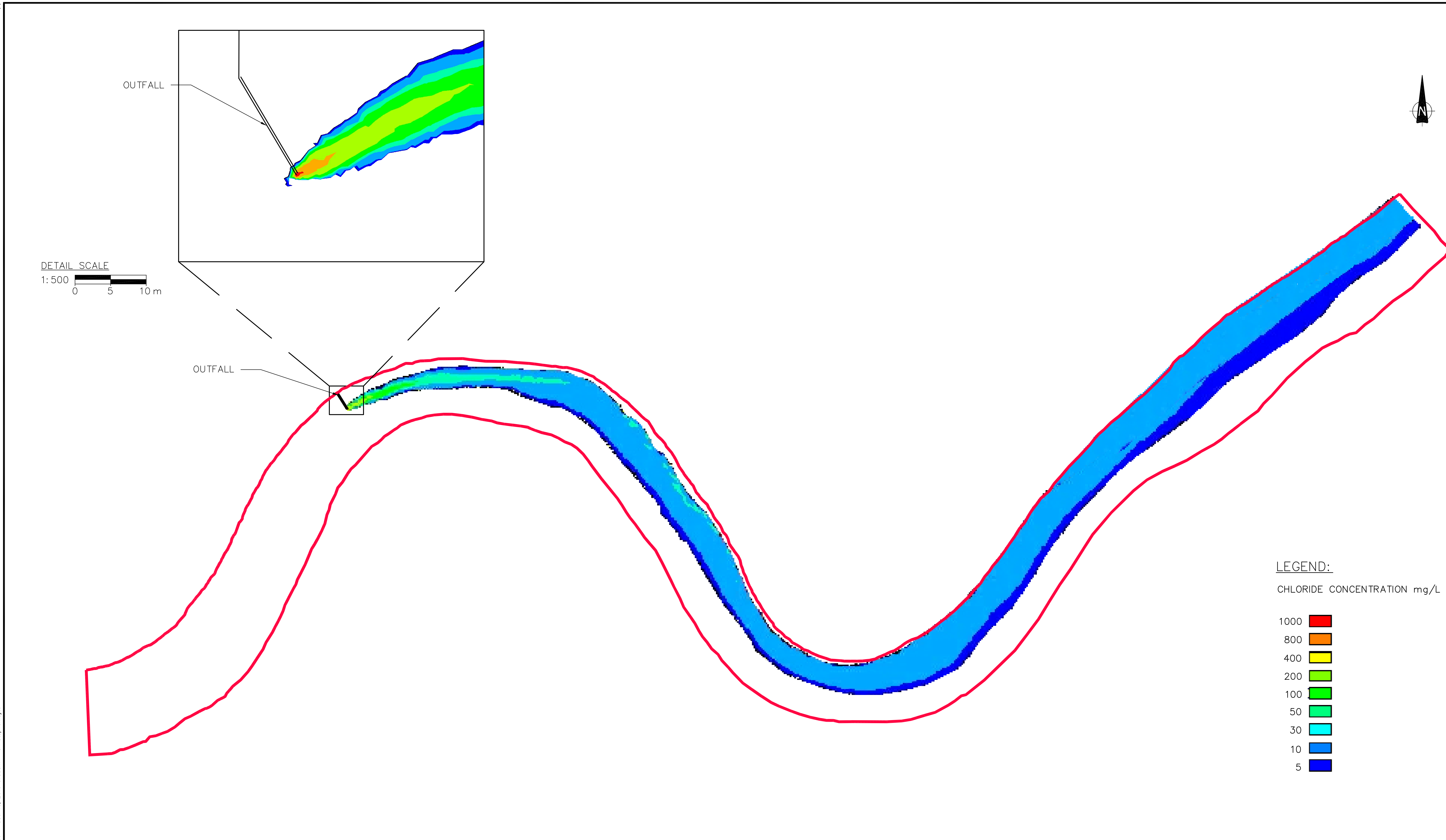
**Table 3.3** summarizes the predicted concentrations chloride for average-flow conditions at the same locations mentioned for the low-flow condition. **Figure 3.5** shows modeled chloride concentration distribution in the river reach for average-flow conditions for the 70 m outfall. No model runs were done for 40 m outfall for average-flow conditions.

Model output concentrations are directly proportional to input loadings, such that if the chloride concentration of 1725 mg/L at the outfall were to be replaced with a chloride concentration of 862.5 mg/L, then river concentrations would be decreased by half, excluding background values.

**Table 3.3**
**Simulated Concentrations of Chloride as a**
**Result of Mine Water Discharge into the River during Average Flow**

| Lateral Distance from the River Bank (m)* | Stations Along River (m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 100 | 500 | 1000 | 1500 | 2000 | 3000 | 4000 | 5000 | 6000 |
| | Chloride Concentration (mg/l) | | | | | | | | |
| 0 | 0 | 2 | 20 | 26 | 26 | 25 | 22 | 23 | 20 |
| 10 | 0 | 5.5 | 28 | 29 | 30 | 26.5 | 24 | 23 | 20 |
| 25 | 0 | 23 | 29 | 30 | 29 | 26 | 23.8 | 22 | 19 |
| 50 | 67 | 42 | 31 | 28 | 27 | 24 | 22 | 20 | 17 |
| 75 | 55 | 15 | 27 | 26 | 21 | 21 | 19 | 17 | 14 |
| 100 | 0 | 0 | 19 | 20 | 15 | 15 | 15 | 13 | 11 |
| 125 | | | 11 | 12 | 9 | 9 | 10.5 | 10 | 7 |
| 150 | | | 5 | 5 | 3 | 4 | 6.5 | 8 | 4 |
| 175 | | | 0 | 0 | 0 | 0 | 4 | 7 | 3 |
| 200 | | | | | | | 1.5 | 5.5 | 2 |
| 250 | | | | | | | 0 | 3 | 1 |
| 300 | | | | | | | | 1.5 | 0.5** |
| 350 | | | | | | | | 0 | |
| Max. at transect. | 116 | 42 | 31 | 30 | 30 | 26.5 | 24 | 23 | 20 |

* Outfall at 70 m away from the bank.
** Plume reaches the opposite river bank.




MAIN SCALE
1:5000
0 50 100 m

| | | | |
|---|---|---|---|
| CLIENT | | PROJECT: SHORE GOLD RIVER SURVEY | 08–10 |
| | | | FIGURE 3.5 |
| AMEC PROJECT NO: SX03733 | | TITLE: SIMULATED CHLORIDE CONCENTRATIONS (ABOVE GROUND) AVERAGE FLOW CONDITION -70M OUTFALL | |
| DWN BY: CL | CHK BY: SS | | |

For the average-flow condition, transport simulations indicated that the chloride plume follows the north shore of the river, expands transversally to approximately 100 m at a point 500 m downstream of the outfall, and contracts to 75 m at 750 m downstream of the outfall. The plume then expands again to 160 m at 1.0 km downstream, and contracts down to 105 m at 2.5 km downstream before the second bend in the river reach. The modeled plume front travels at an average velocity of approximately 2.0 km/h, reaching the end of the study reach (6.0 km) in about 3 hours.

The mass flux entering and leaving the reach was computed in the model and it was verified that no significant loss of mass occurred in the reach during average-flow model simulations. In the average-flow condition, the chloride concentration entering into the river will stay separated from the bank and will not reach the north bank until a point approximately 700 m downstream of the outfall. At 1000 m downstream, the chloride concentration near the bank would be diluted to approximately 20 mg/L, (**Table 3.3**). In general, the chloride plume stayed near the outfall bank of the river for the entire length of the reach. During the average-flow condition, at the end of the reach, the plumes' maximum chloride concentration was approximately 20 mg/L (approximately 1% of the initial concentration). The lateral maximum concentration gradient was approximately 10 mg/L/100 m for chloride.

## 4.0 SUMMARY AND CONCLUSIONS

The loading of chloride ions to the Saskatchewan River, as a continuous mine water discharge, was estimated using a numerical flow and transport model. Hydraulic parameters (velocity, water depths, etc.) characteristic of the outfall reach were obtained from analysis of water level and discharge measurements for open water conditions in the reach, as well as detailed bathymetric data obtained through a comprehensive field program undertaken over the period of June 24th through June 28th, 2010. During this time, a detailed bathymetric survey, water level surveys and discharge measurements were completed. The channel bed survey was conducted from a boat with a depth sounder and attached GPS. Bathymetric contours were generated from the bed point data using a contouring software package and extrapolated to the river banks by interpolation with the topographic data.

Characteristic discharges at the site were obtained by statistical analysis of daily discharges computed from the WSC station data. The hydraulic parameters (velocity, water depths, etc.) characteristic of the outfall reach were obtained from analysis of water level and discharge measurements for the open water condition. These parameters were used as baseline data to calibrate the flow and transport model AQUASEA, which was used to estimate plume concentrations downstream of the proposed outfall location.

Based on a discharge of 199 000 $m^3$/day and mine water, chloride concentration of 1725 mg/L, the flow and transport modeling indicated that the outfall concentrations would be reduced by dilution and hydrodynamic mixing. During low flow, at a point 500 m downstream of the 70 m outfall, the predicted maximum chloride concentration was 90 mg/L near (10 m removed) the riverbank and the plume centreline was 25 m from the bank transversally, where a peak chloride concentration of 99 mg/L was predicted. The plume width was approximately 95 m for 70 m outfall at 500 m. For comparison, the federal government is currently in the process of developing a Canadian Water Quality Guideline for chloride for the protection of aquatic life. The suggested concentration value in the development document (which is preliminary) is 128 mg/L for the freshwater environment. British Columbia, the only province that to our knowledge has an established water quality guideline for the protection of aquatic life, has set a guideline value of 150 mg/L (Nagpal et al. 2003).

For the 40 m outfall offshore distance condition, , the plume centreline chloride concentration was predicted at 315 mg/L at a point 500 m downstream of the outfall. The plume width for this condition was approximately 85 m for 40 m outfall at 500 m. The plume generated by the 40 m outfall was closer to the river bank with higher peaks at the centreline. At 100 m downstream from the 40 m outfall the plume centreline chloride concentration was predicted at approximately 590 mg/L.

Modeling also predicted that the chloride concentrations would be reduced at faster rates in areas of the reach where there are relatively higher flow velocities, shallower depths and secondary currents due to meanders. Maximum chloride concentrations at the end of the reach, in the low-flow condition, were reduced to 33 mg/L (2% of initial concentration). The maximum transverse concentration gradient at the end of the reach for chloride was approximately 13 mg/L/100m.

Due to the conservative modeling assumptions as specified in Section 3.0, it should be noted that actual chloride concentrations in the Saskatchewan River during mine water discharge (excluding background additions to the computed values), are expected to be lower than those predicted by the modeling. Any features that influence the flow path (rapids, islands, meanders, etc.), the effects of which were averaged during modeling, would also increase turbulence, initiate secondary currents and promote mixing. These factors would further contribute to reducing overall predicted concentrations.

## 5.0 CLOSURE

The investigations and activities presented in this report were conducted in accordance with generally accepted hydrotechnical and environmental assessment principles and practice. The report has been compiled by AMEC based on information assembled by AMEC.

Should any questions arise concerning the preparation of this report or its conclusions, please contact the undersigned at your convenience.

Yours truly,

**AMEC Earth & Environmental**

03 December 2010

Sukru Sumer, Ph.D., P.Eng.
Senior Associate Environmental Engineer

Reviewed by:

David A. Simms, Ph.D.
Principal, Environmental
Assessment and Resource
Development

SS/DAS/hb/lb

Permit to Practice No. P-4546

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# APPENDIX A

## Velocity and Discharge Measurements

Save Close

UNIVERSITY OF ALBERTA

Discharge Measurement Summary Date

**Station Information**
Station Number
Station Name
Location

**Measurement Information**
Measurement No.
Compiled By
Checked By

**Personnel and Equipment**
Party
Boat/Motor/Platform

**Rating Information**

| | | | | | |
|---|---|---|---|---|---|
| Gage Height | | Rating Discharge | | Rating No. | |
| GH Change | | Index Velocity | | Meas. Rating | |
| % Diff. | 0.0% | Rated Area | | Control Code | |

**System Information**

| | |
|---|---|
| Serial # | M509 |
| System Frequency | 3000 kHz |
| Firmware Version | 9.6 |
| RiverSurveyor Ver | v4.50 |

**System Setup**

| | | | |
|---|---|---|---|
| # of Cells | 20 | Averaging Interval | 5.0 |
| Cell Size | 0.20 | Magnetic Decl. | 10.1 |
| Blanking Distance | 0.20 | Salinity | 0.00 |
| Transducer Depth | 0.06 | Echo Sounder | Not Pres. |

**Discharge Calculation Settings**

| | | | | | |
|---|---|---|---|---|---|
| Velocity Ref. | GPS | Top Estimate | Power | Left Bank | Sloped |
| Track Ref. | GPS | Bottom Est. | Power | Right Bank | Sloped |
| Depth Reference | ADP | Area Method | none | Orient. Profiles | all |

**Computed Discharge Results**

| | |
|---|---|
| Width | 329.2 |
| Area | 705.7 |
| Mean Velocity | 1.58 |
| Discharge | 1117.9 |
| % Measured | 67.0 |
| Adj. Mean Velocity | 0 |

**Diagnostic Files**
Moving Bed Test
Compass Cal
Pressure Cal
Depth Calibration

**Measurement Results**

| | | Discharge | | | | | | Distance | | | | Time | | Mean Vel | | #Profiles | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tr# | | Top | Middle | Bottom | Left | Right | Total | Left | Right | Total | Area | Start | End | Boat | Water | Total | Bad |
| 16 | R | 207.3 | 779.02 | 191.33 | 0 | 0 | 1177.7 | 0.0 | 3.2 | 326.6 | 728.6 | 11:40 | 11:47 | 0.81 | 1.62 | 80 | 0 |
| 26 | L | 200.1 | 617.56 | 172.29 | 0 | 5.6515 | 995.6 | 3.0 | 6.0 | 326.9 | 631.2 | 11:47 | 11:56 | 0.62 | 1.58 | 103 | 0 |
| 27 | R | 204.27 | 797.59 | 179.52 | 0.97894 | 0 | 1182.4 | 8.0 | 6.0 | 328.5 | 747.2 | 11:56 | 12:02 | 0.91 | 1.58 | 69 | 0 |
| 35 | L | 198.47 | 732.36 | 128.43 | 0 | -2.6705 | 1056.6 | 8.0 | 5.0 | 332.4 | 661.0 | 12:02 | 12:12 | 0.56 | 1.60 | 114 | 0 |
| 42 | R | 202.89 | 826.44 | 146.69 | 1.1379 | 0 | 1177.2 | 5.0 | 5.0 | 331.6 | 760.5 | 12:12 | 12:19 | 0.70 | 1.55 | 92 | 0 |
| Mean | | 202.61 | 750.6 | 163.65 | 0.42337 | 0.59618 | 1117.9 | 4.8 | 5.0 | 329.2 | 705.7 | Total | 04:40 | 0.72 | 1.58 | 92 | 0 |
| SDev | | 3.4764 | 81.852 | 25.594 | 0.58244 | 3.0534 | 86.538 | 3.4 | 1.1 | 2.7 | 56.5 | | | 0.14 | 0.03 | | |
| COV | | 0.017 | 0.109 | 0.156 | 1.376 | 5.122 | 0.077 | 0.713 | 0.227 | 0.008 | 0.080 | | | 0.198 | 0.016 | | |

Tr16=AMEC1006241146.ADP; Tr26=AMEC1006241153.ADP; Tr27=AMEC1006241202.ADP; Tr35=AMEC1006241208.ADP; Tr42=AMEC1006241218.ADP;

**Comments**

Note: Units for the above parameters are: Distance (m), Velocity (m/s), Area (m2), Discharge (m3/s)

Save Close

UNIVERSITY OF ALBERTA

# Discharge Measurement Summary

Date

**Station Information**

Station Number

Station Name

Location

**Measurement Information**

Measurement No.

Compiled By

Checked By

**Personnel and Equipment**

Party

Boat/Motor/Platform

**Rating Information**

| | | | | | |
|---|---|---|---|---|---|
| Gage Height | | Rating Discharge | | Rating No. | |
| GH Change | | Index Velocity | | Meas. Rating | |
| % Diff. | 0.0% | Rated Area | | Control Code | |

**System Information**

| | |
|---|---|
| Serial # | M509 |
| System Frequency | 3000 kHz |
| Firmware Version | 9.6 |
| RiverSurveyor Ver | v4.50 |

**System Setup**

| | | | |
|---|---|---|---|
| # of Cells | 20 | Averaging Interval | 5.0 |
| Cell Size | 0.20 | Magnetic Decl. | 10.1 |
| Blanking Distance | 0.20 | Salinity | 0.00 |
| Transducer Depth | 0.06 | Echo Sounder | Not Pres. |

**Discharge Calculation Settings**

| | | | | | |
|---|---|---|---|---|---|
| Velocity Ref. | GPS | Top Estimate | Power | Left Bank | Sloped |
| Track Ref. | GPS | Bottom Est. | Power | Right Bank | Sloped |
| Depth Reference | ADP | Area Method | none | Orient. Profiles | all |

**Computed Discharge Results**

| | |
|---|---|
| Width | 302.2 |
| Area | 720.0 |
| Mean Velocity | 1.56 |
| Discharge | 1122.2 |
| % Measured | 68.5 |
| Adj. Mean Velocity | 0 |

**Diagnostic Files**

Moving Bed Test

Compass Cal

Pressure Cal

Depth Calibration

**Measurement Results**

| | | Discharge | | | | | | Distance | | | | Time | | Mean Vel | | #Profiles | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tr# | | Top | Middle | Bottom | Left | Right | Total | Left | Right | Total | Area | Start | End | Boat | Water | Total | Bad |
| 47 | R | 172.27 | 797.12 | 125.78 | 7.7429 | 0 | 1102.9 | 10.0 | 6.0 | 299.3 | 703.1 | 13:03 | 13:10 | 0.64 | 1.57 | 88 | 0 |
| 51 | L | 183.94 | 687.92 | 252.56 | 0 | -1.9118 | 1122.5 | 10.0 | 6.0 | 300.4 | 715.3 | 13:11 | 13:17 | 0.69 | 1.57 | 83 | 0 |
| 54 | R | 173.92 | 734.5 | 164.95 | -2.1915 | 0 | 1071.2 | 10.0 | 7.0 | 304.4 | 678.3 | 13:20 | 13:28 | 0.56 | 1.58 | 103 | 0 |
| *60* | *L* | *179.1* | *856.53* | *153.71* | *0* | *2.9938* | *1192.3* | *10.0* | *6.0* | *304.7* | *783.5* | *13:29* | *13:35* | *0.80* | *1.52* | *72* | *0* |
| Mean | | 177.31 | 769.02 | 174.25 | 1.3879 | 0.27049 | 1122.2 | 10.0 | 6.3 | 302.2 | 720.0 | Total | 04:40 | 0.67 | 1.56 | 87 | 0 |
| SDev | | 5.2936 | 73.521 | 54.74 | 4.3609 | 2.0269 | 51.297 | 0.0 | 0.5 | 2.8 | 45.0 | | | 0.10 | 0.03 | | |
| COV | | 0.030 | 0.096 | 0.314 | 3.142 | 7.493 | 0.046 | 0.000 | 0.080 | 0.009 | 0.063 | | | 0.151 | 0.017 | | |

Tr47=AMEC1006241309.ADP; Tr51=AMEC1006241317.ADP; Tr54=AMEC1006241326.ADP; Tr60=AMEC1006241335.ADP;

**Comments**

Note: Units for the above parameters are: Distance (m), Velocity (m/s), Area (m2), Discharge (m3/s)

Save Close

UNIVERSITY OF ALBERTA

# Discharge Measurement Summary

Date

**Station Information**

Station Number
Station Name
Location

**Measurement Information**

Measurement No.
Compiled By
Checked By

**Personnel and Equipment**

Party
Boat/Motor/Platform

**Rating Information**

| | | | | | |
|---|---|---|---|---|---|
| Gage Height | | Rating Discharge | | Rating No. | |
| GH Change | | Index Velocity | | Meas. Rating | |
| % Diff. | 0.0% | Rated Area | | Control Code | |

**System Information**

| | |
|---|---|
| Serial # | M509 |
| System Frequency | 3000 kHz |
| Firmware Version | 9.6 |
| RiverSurveyor Ver | v4.50 |

**System Setup**

| | | | |
|---|---|---|---|
| # of Cells | 20 | Averaging Interval | 5.0 |
| Cell Size | 0.20 | Magnetic Decl. | 10.1 |
| Blanking Distance | 0.20 | Salinity | 0.00 |
| Transducer Depth | 0.07 | Echo Sounder | Not Pres. |

**Discharge Calculation Settings**

| | | | | | |
|---|---|---|---|---|---|
| Velocity Ref. | GPS | Top Estimate | Power | Left Bank | Sloped |
| Track Ref. | GPS | Bottom Est. | Power | Right Bank | Sloped |
| Depth Reference | ADP | Area Method | none | Orient. Profiles | all |

**Computed Discharge Results**

| | |
|---|---|
| Width | 324.8 |
| Area | 1157.0 |
| Mean Velocity | 1.01 |
| Discharge | 1168.0 |
| % Measured | 76.8 |
| Adj. Mean Velocity | 0 |

**Diagnostic Files**

Moving Bed Test
Compass Cal
Pressure Cal
Depth Calibration

**Measurement Results**

| | | Discharge | | | | | | Distance | | | | Time | | Mean Vel | | #Profiles | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tr# | | Top | Middle | Bottom | Left | Right | Total | Left | Right | Total | Area | Start | End | Boat | Water | Total | Bad |
| *1* | *R* | *144.77* | *941.19* | *149.01* | *0.46286* | *0.13203* | *1235.6* | *2.8* | *1.8* | *324.4* | *1155.7* | *08:54* | *09:00* | *0.83* | *1.07* | *74* | *0* |
| 3 | L | 131.54 | 851.63 | 133.61 | -0.26622 | -0.21782 | 1116.3 | 2.8 | 1.8 | 325.3 | 1155.5 | 09:01 | 09:07 | 0.80 | 0.97 | 78 | 0 |
| 4 | R | 143.5 | 946.8 | 132.32 | 0.16495 | 0.29583 | 1223.1 | 1.7 | 2.1 | 324.0 | 1154.6 | 09:07 | 09:14 | 0.74 | 1.06 | 85 | 0 |
| 6 | L | 129.19 | 861.28 | 121.56 | 0.069379 | 0.32896 | 1112.4 | 3.0 | 1.8 | 325.3 | 1169.3 | 09:15 | 09:21 | 0.80 | 0.95 | 75 | 0 |
| *7* | *R* | *143.48* | *947.5* | *143.48* | *0.1314* | *0.40373* | *1235* | *1.7* | *2.7* | *325.1* | *1169.5* | *09:21* | *09:28* | *0.75* | *1.06* | *84* | *0* |
| *8* | *L* | *131.02* | *834.84* | *130.44* | *0.62211* | *0.23936* | *1097.2* | *3.4* | *1.8* | *325.1* | *1134.6* | *09:28* | *09:34* | *0.89* | *0.97* | *71* | *0* |
| 9 | R | 142.51 | 932.48 | 139.05 | 0.10777 | 0.26316 | 1214.4 | 1.7 | 1.9 | 324.3 | 1155.3 | 09:42 | 09:48 | 0.78 | 1.05 | 81 | 0 |
| 10 | L | 129.7 | 856.57 | 123.26 | 0.12552 | 0.25115 | 1109.9 | 2.7 | 1.8 | 325.1 | 1161.2 | 09:49 | 09:54 | 0.96 | 0.96 | 66 | 0 |
| Mean | | 136.96 | 896.54 | 134.09 | 0.17722 | 0.21205 | 1168 | 2.5 | 2.0 | 324.8 | 1157.0 | Total | 01:00 | 0.82 | 1.01 | 77 | 0 |
| SDev | | 7.1209 | 49.385 | 9.4595 | 0.2666 | 0.19031 | 63.689 | 0.7 | 0.3 | 0.5 | 11.0 | | | 0.07 | 0.05 | | |
| COV | | 0.052 | 0.055 | 0.071 | 1.504 | 0.897 | 0.055 | 0.273 | 0.161 | 0.002 | 0.009 | | | 0.087 | 0.053 | | |

Tr1=AMEC1006280955.ADP; Tr3=AMEC1006281002.ADP; Tr4=AMEC1006281008.ADP; Tr6=AMEC1006281016.ADP; Tr7=AMEC1006281022.ADP; Tr8=AMEC1006281029.ADP; Tr9=AMEC1006281043.ADP; Tr10=AMEC1006281050.ADP;

**Comments**

Note: Units for the above parameters are: Distance (m), Velocity (m/s), Area (m2), Discharge (m3/s)

# APPENDIX B

# Monthly Flow Duration Curves

Appendix B
Monthly Flow Duration Curves

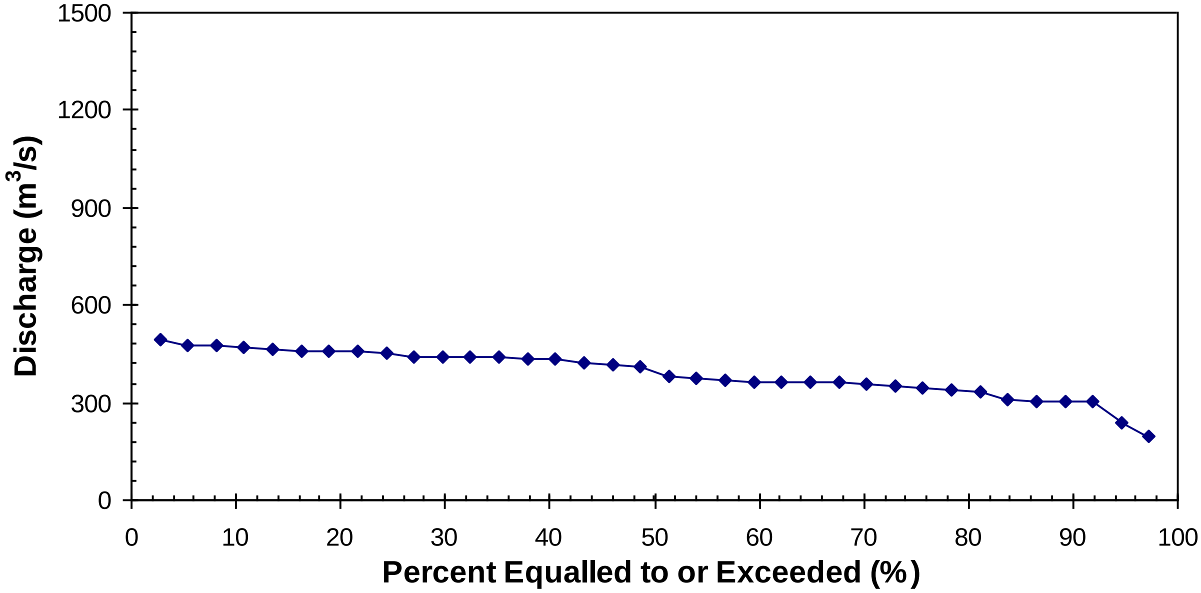


**Figure B1** **Flow duration curve for January, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–1986; 1992–2009.**

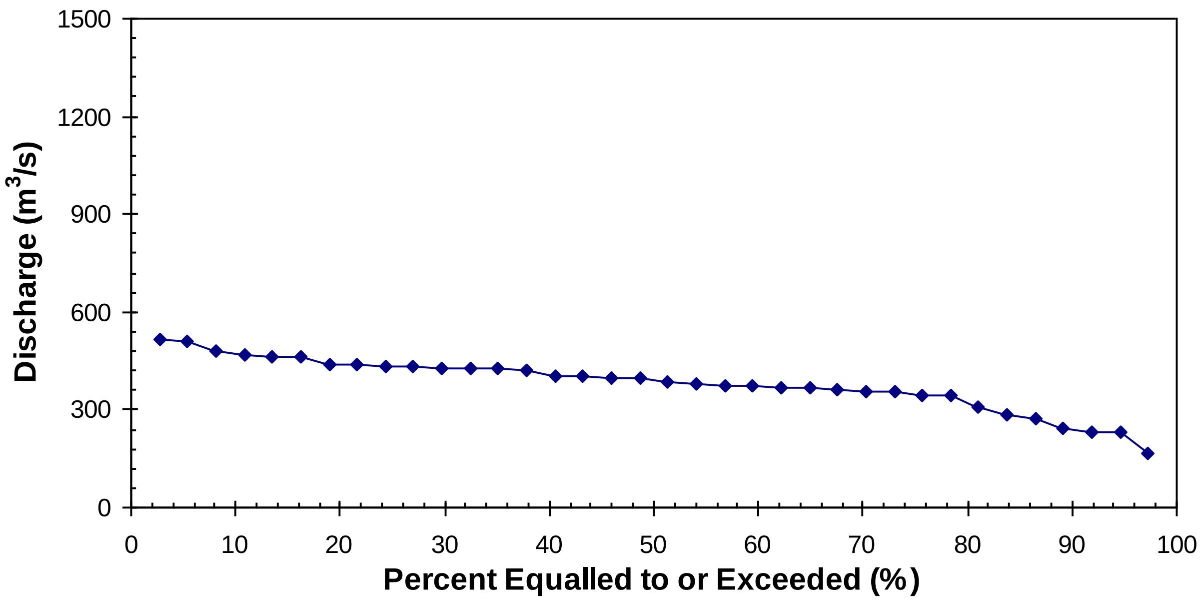


**Figure B2** **Flow duration curve for February, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–1986; 1992–2009.**

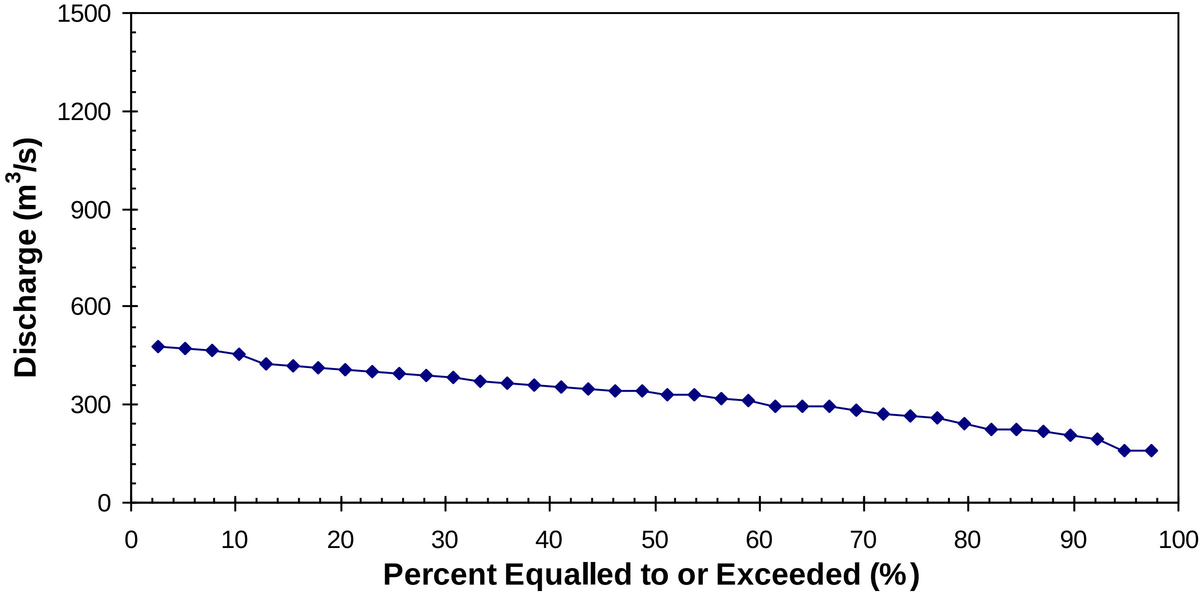


**Figure B3** **Flow duration curve for March, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–1988; 1992–2009.**

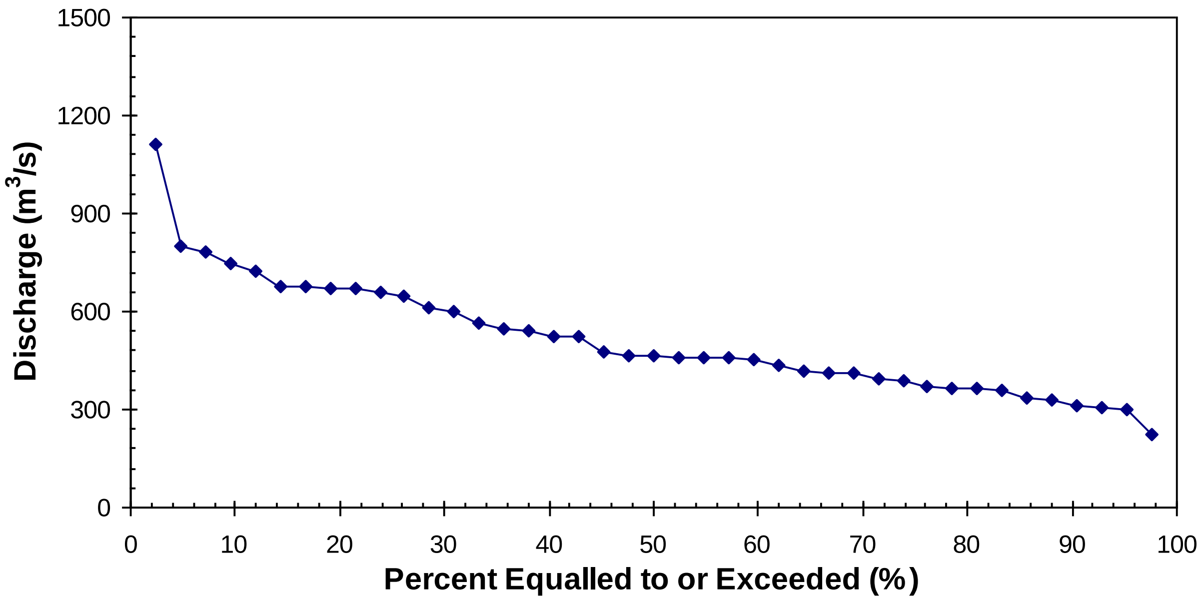


**Figure B4** **Flow duration curve for April, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

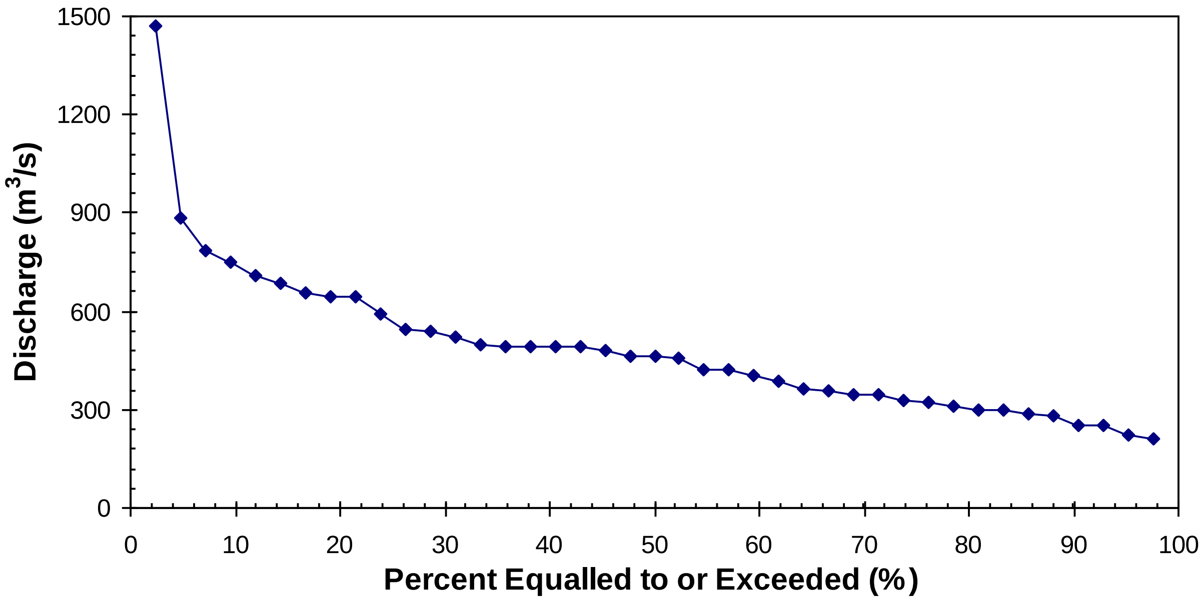


**Figure B5** **Flow duration curve for May, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

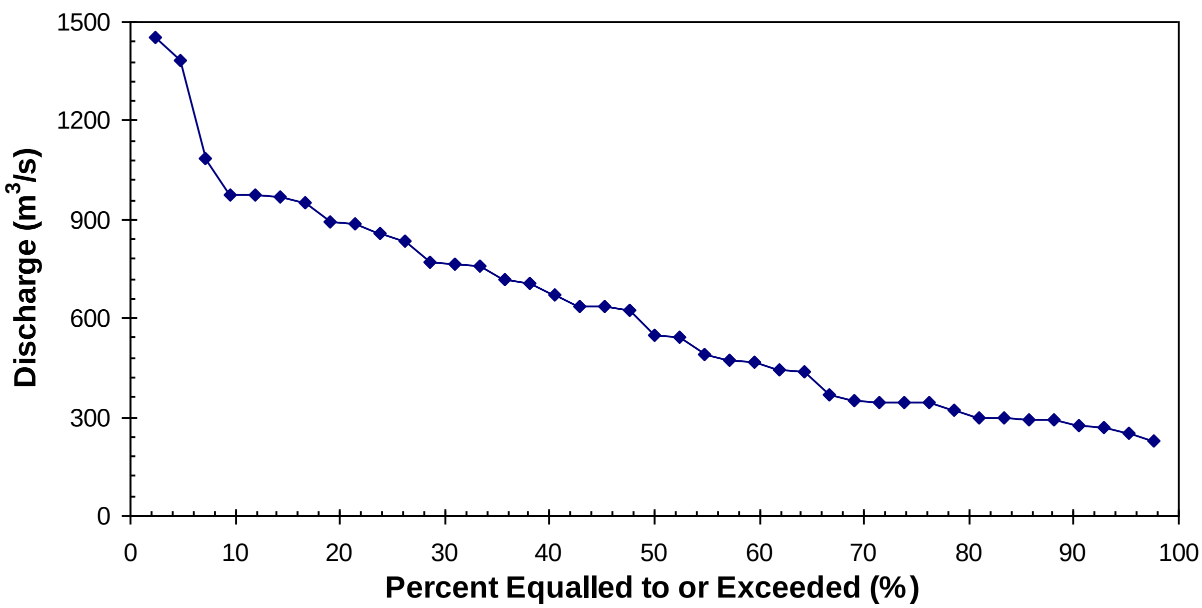


**Figure B6** **Flow duration curve for June, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

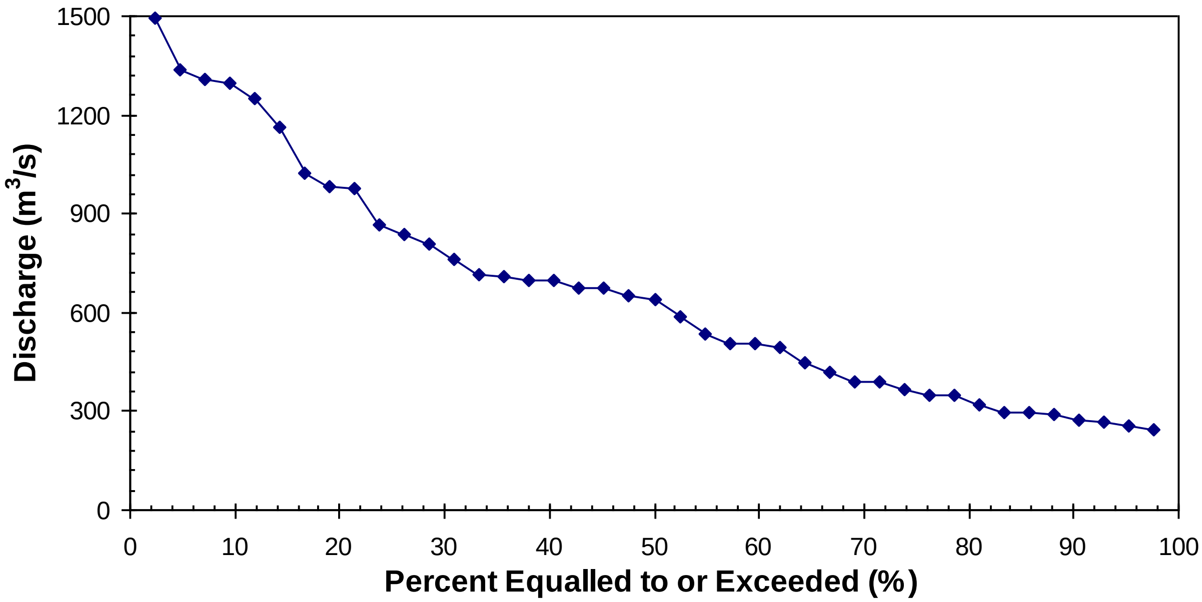


**Figure B7** **Flow duration curve for July, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

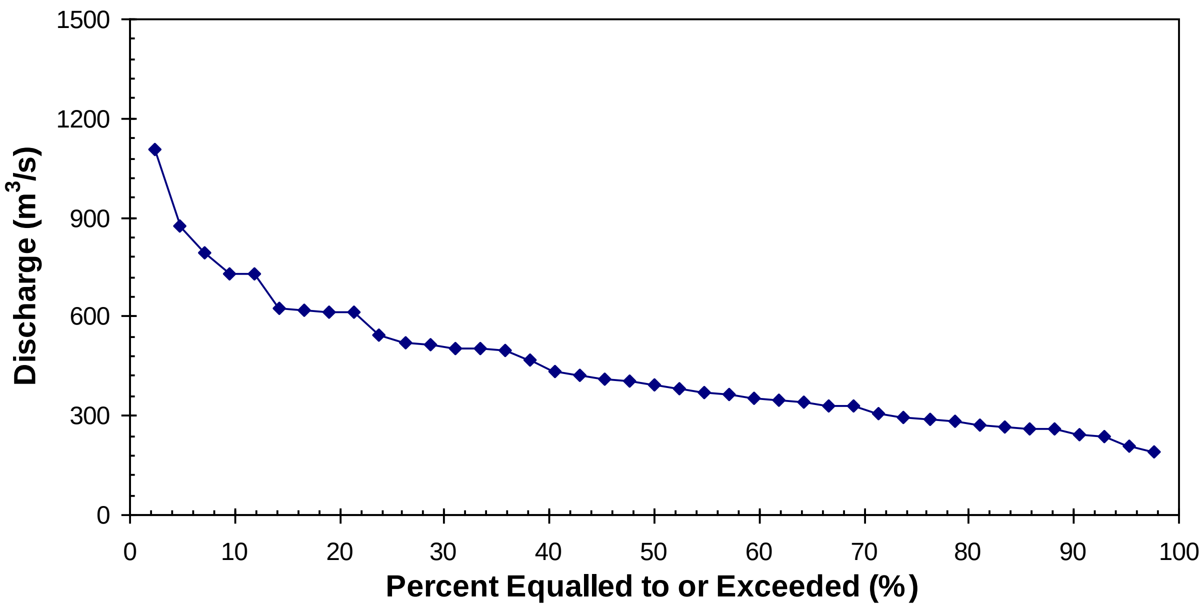


**Figure B8** **Flow duration curve for August, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

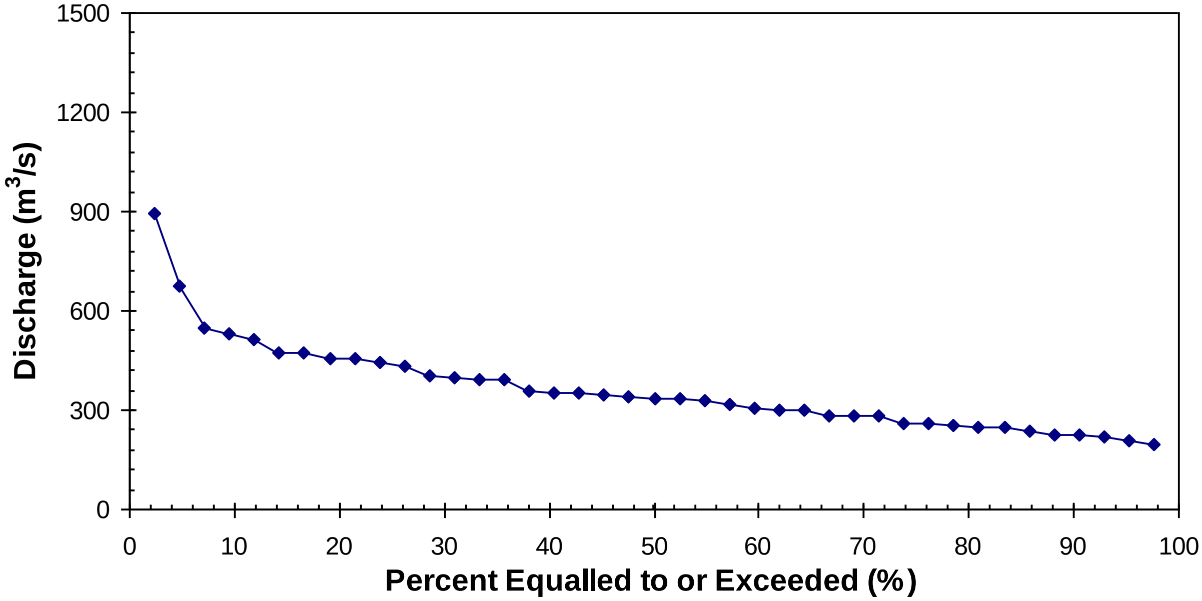


**Figure B9** **Flow duration curve for September, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

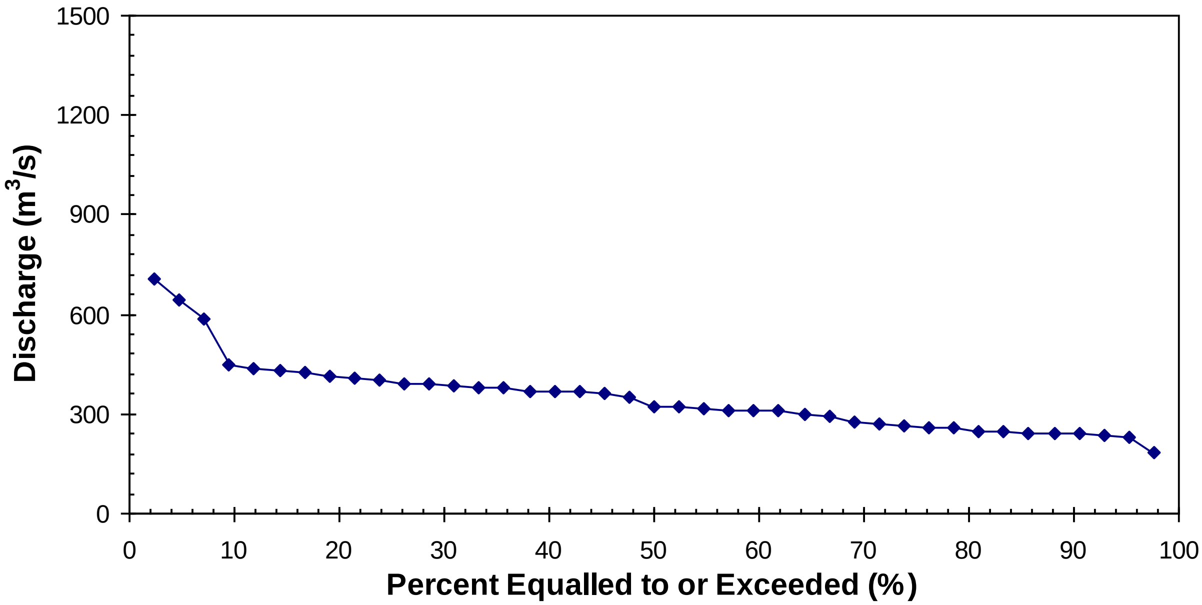


**Figure B10** **Flow duration curve for October, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

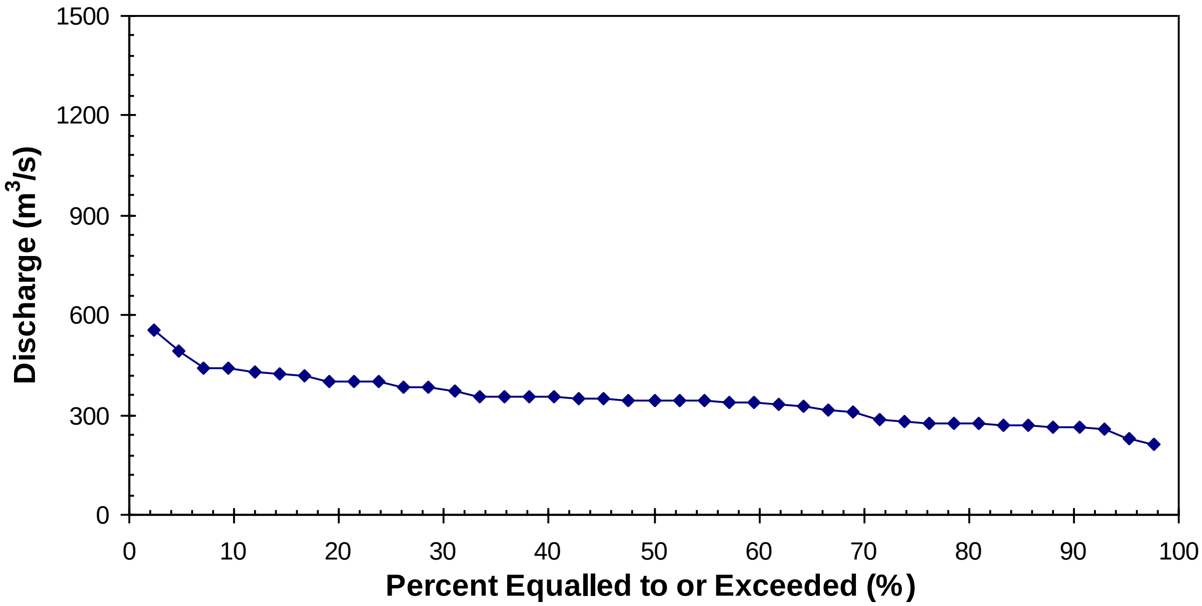


**Figure B11 Flow duration curve for November, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

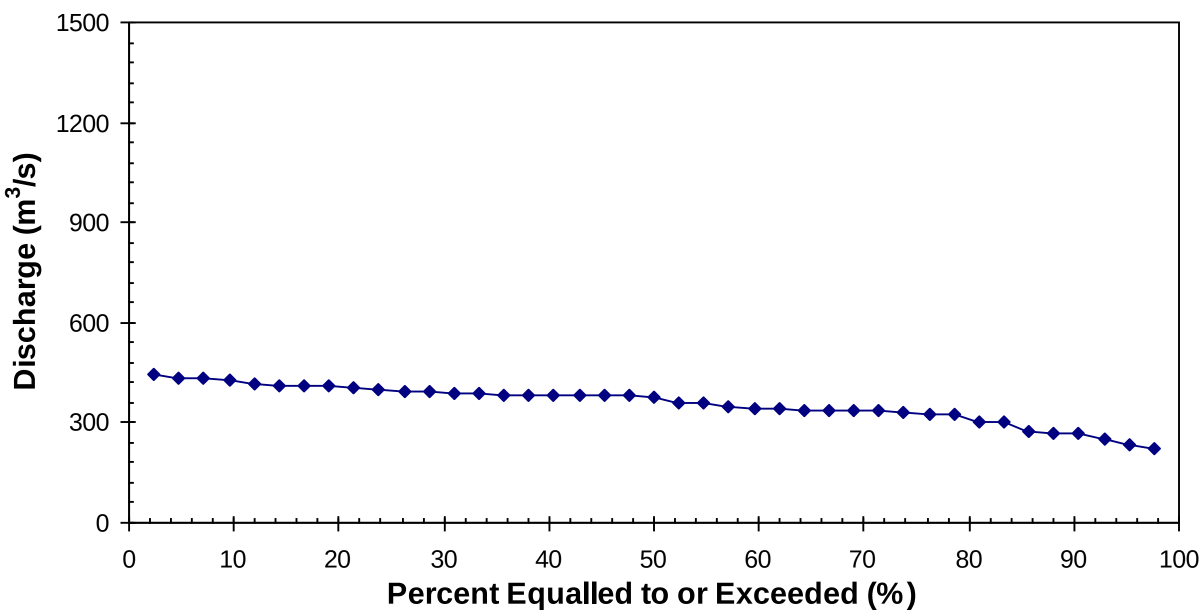


**Figure B12 Flow duration curve for December, site based on data from the North Saskatchewan River at Prince Albert (05GG001) and the South Saskatchewan River at Saskatoon (05HG001), 1969–2009.**

# APPENDIX C

# Detailed Bed Form Type Analysis

Appendix C
Detailed Bed Form Type Analysis

### Stream Power and Mean Particle Diameter

The first relationship considered was of bed forms to stream power and median fall diameter of bed sediment (mean bed material size), $D_{50}$, as developed by Simons and Richardson (1966). The stream power can be defined as:

$$\textit{Stream Power} = \tau_0 v \quad [1]$$

where $\tau_0$ = $v_*^2 \rho$ (local bed shear stress, $N/m^2$) [2]
$v$ = local depth-averaged velocity (m/s)
$v_*$ = local bed shear velocity (m/s)
$\rho$ = density of water (assumed to be 1000 $kg/m^3$)

This relation has been shown to work well for natural streams; however, there has been noted difficulty in the case of large rivers (Simons and Şenturk, 1992). Under each of the three flow conditions (mean annual, calibration, and 1:100-year flow), the calculated stream power, given the mean bed material size of 0.28 mm, suggests that anti-dunes may form.

### Froude Number and Hydraulic Depth

The next set of empirical relationships, developed by Athaullah (1968), are meant to be used together to best predict bed form type. The first relationship is a function of the Froude number, *Fr*, and the ratio of hydraulic mean depth (area of the cross-section divided by the top width of the channel) to the mean bed material size, $R/D_{50}$. The Froude number, Fr, is defined by the following:

$$Fr = \frac{v}{\sqrt{gD}} \quad [3]$$

where $g$ = acceleration due to gravity (assumed to be 9.81 $m/s^2$)
$D$ = local water depth (m)

The Froude number represents a ratio of inertia and gravitational forces on the fluid, while $R/D_{50}$ corresponds to the relative roughness (Simons and Şenturk, 1992). Under mean annual and calibration flow conditions, this relationship proposes that the flow is in the so-called lower regime. This relationship does not encompass the conditions present at the 1:100-year flow, so no conclusion about regime can be made for this flow scenario.

### Slope and Shear Intensity Factor

The second relationship of the set is a function of the slope of the energy gradient and the shear intensity factor. The shear intensity factor, Ψ, is defined by the following equation:

$$\psi = \frac{v_*^2}{\left(\frac{\rho_s - \rho}{\rho}\right) g D_{50}} \quad [4]$$

where $\rho_s$ = density of sand (assumed to be 2650 kg/m$^3$)

$D_{50}$ = mean bed material size (m)

The slope of the energy gradient represents the effect of form roughness on energy dissipation, while the shear intensity factor quantifies to the ability of the fluid to move sediment (Simons and Şenturk, 1992). Under each of the three flow conditions (mean annual, calibration and 1:100-year flow), this relationship suggests that the flow may be in a transitional state where dunes or anti-dunes may form.

**Ratio of Bed Shear Velocity to Settling Velocity and Shear Velocity Reynolds Number**

Several dimensionless bed form and flow regime discriminators were also examined. The first of these was a function of the ratio of bed shear velocity to settling velocity and the shear velocity Reynolds number, proposed by Liu (1957) and later extended by Simons and Richardson (1961). The particle settling velocity, $v_s$, as determined by Soulsby (1997) is as follows:

$$v_s = \frac{\nu}{D_{50}}\left[\left(0.36^2 + 1.049 D_*\right)^{1/2} - 10.36\right] \qquad [5]$$

where $\nu$ = kinematic viscosity (assumed to be 1 x 10$^{-6}$ m$^2$/s)

$$D_* = D_{50}\left[\frac{g\left(\frac{\rho_s - \rho}{\rho}\right)}{\nu^2}\right]^{1/3} \text{ (dimensionless particle parameter)} \qquad [6]$$

The shear velocity Reynolds number, Re*, is defined by the following equation:

$$R_e^* = \frac{v_* D_{50}}{\nu} \qquad [7]$$

Few field data were incorporated into Simons and Richardson's analysis; however, it may be used to make predictions of bed forms in flow depths of up to 3 m (Garcia, 2008). This is noted, as in the case of the 1:100-year flood, flow depths exceed 3 m, making the analysis invalid. Under mean annual and calibration flow conditions, this relationship suggests that anti-dunes may form.

**Dimensionless Particle Diameter and Shear Velocity Reynolds Number**

Another dimensionless relationship examined to predict bed forms is a function of the dimensionless particle diameter and the shear velocity Reynolds number, proposed by Bonnefille-Pernecker (after Bechteler *et al*, 1991). This relationship has been used to analyse sediment transport conditions in alpine rivers (Garcia, 2008). Under mean annual-flow conditions, this relationship suggests that a flat bed will form. Under the calibration and 1:100-year flow conditions, this relationship indicates that anti-dunes will form.

**Froude Number and Ratio of Depth to Mean Particle Diameter**

A bed form chart for medium sand developed by Vanoni (1974) was explored. This relationship of bed form to Froude number, *Fr*, and the ratio of water depth to sediment size, $D/D_{50}$, can provide reasonable estimates of bed forms for a flow depth up to approximately 3 m (Shen and Julien, 1993). This is noted, as in the case of the 1:100-year flood, flow depths exceed 3 m, making the analysis invalid. Under mean annual and calibration flow conditions, this relationship suggests that dunes may form.

**Transport Stage Parameter and Mean Particle Diameter**

Van Rijn (1984) proposed a relationship in which the transport stage parameter and dimensionless particle diameter can be used to predict bed form types. The transport stage parameter, T, is defined as:

$$T = \frac{\tau_s^* - \tau_c^*}{\tau_c^*} \qquad [8]$$

where $$\tau_s^* = \frac{\tau_0}{\rho g \left(\frac{\rho_s - \rho}{\rho}\right) D_{50}} \text{ (bed shear stress due to skin/grain friction)} \qquad [9]$$

$$\tau_c^* = \frac{1}{2}\left[0.22\left(D_{50}\frac{\sqrt{g\left(\frac{\rho_s-\rho}{\rho}\right)D_{50}}}{\nu}\right)^{-0.6} + 0.06\exp\left(-17.77\left(D_{50}\frac{\sqrt{g\left(\frac{\rho_s-\rho}{\rho}\right)D_{50}}}{\nu}\right)^{-0.6}\right)\right] \qquad [10]$$

(critical shear stress for motion based on the Sheild's diagram, as proposed by Brownlie, 1981)

Both laboratory experiments and field data were used to create this relationship. However, it must be noted that there have been reservations about the applicability of this relationship to large alluvial rivers where the Froude number is never larger than 0.2 to 0.3, as dunes have been found to exist where the relationship predicts that anti-dunes will form (Garcia, 2008). Under each of the three flow conditions (mean annual, calibration and 1:100-year flow), this relationship proposes that anti-dunes may form. Note here that the Froude number ranges from 0.21 to 0.23 for the various flow conditions, indicating that this relationship may not be adequate.

## Grain Froude Number and Slope

Using the grain Froude number and slope, Brownlie (1983) created a relationship delineating the bed form transition zone from lower regime to upper regime. The grain Froude number, Fg, is defined as:

$$Fg = \frac{v}{\sqrt{g\left(\frac{\rho_s - \rho}{\rho}\right)D_{50}}} \quad [11]$$

This analysis was based on both flume and river data (Garcia, 2008). Under mean annual and calibration flow conditions, this relationship suggests that flows proposed at the outfall/diffuser site will fall into the lower regime. However, for the 1:100-year flow, this relationship suggests that flows will be in the upper regime.

## Mobility Parameter and Dimensionless Particle Diameter

The last relationship investigated was one proposed by van den Berg and van Gelder (1993). Bed forms are predicted as a function of the mobility parameter and the dimensionless particle diameter. The mobility parameter, θ', (van Rijn, 1984) is defined as follows:

$$\theta^{'} = \frac{v^2}{g\left(\frac{\rho_s - \rho}{\rho}\right)D_{50}\left(C^{'}\right)^2} \quad [12]$$

where $C^{'}$ = $18 \log \frac{4D}{D_{90}}$ (coefficent) [13]

$D_{90}$ = sediment size for which 90% is finer (m)

This analysis was based on both flume and field observations (Garcia, 2008). Under each of the three flow conditions (mean annual, calibration and 1:100-year flow), this relationship suggests that ripples may form.

# APPENDIX D

# Detailed Bed Form Size Analysis

Appendix D
Detailed Bed Form Size Analysis

**Allen (1963)**

The first set of equations used was proposed by Allen (1963). Based on physical reasoning and analysis of observed data, the equations are as follows:

$$\log D = 0.8271 \log A + 0.8901 \qquad [14]$$

where $D$ = local water depth (m)
$A$ = dune height (m)

and,

$$\log A = 0.7384 \log L - 1.0746 \qquad [15]$$

where $L$ = dune length (m)

**Yalin (1964)**

The second set of equations used was proposed by Yalin (1964). This set of equations is based on the study of geometric properties of ripples and dunes through the analysis of mechanical processes. The equations proposed are as follows:

$$\frac{A}{D} = \frac{1}{6} \qquad [16]$$

and, for large values of the Reynolds number, $R_e^*$:

$$L = 5D \qquad [17]$$

**Goswami (1967)**

Goswami (1967) presents an equation where dune height is a function of length. The ratio of mean flow depth to dune height is obtained from a graph that relates it with slope and mean particle diameter. Once this ratio is determined, the following relationship can be used:

$$A = 0.055 L^{0.87} \qquad [18]$$

**Julien and Klaassen (1995)**

Based on a number of laboratory experiments and field data, Julien and Klaassen (1995) propose a set of equations to estimate dune size. These are as follows:

$$\frac{L}{D} = 6.25 \qquad [19]$$

and

$$A = 2.5D\left(\frac{D_{50}}{D}\right)^{0.3} \qquad [20]$$

where $D_{50}$ = mean bed material size (m)

**Karim (1999)**

Finally, the last set of equations examined was that of Karim (1999). This approach considers that energy loss due to form drag is related to the head loss across a sudden expansion in an open channel. Applicable to ripples, dunes, transition and anti-dunes, the equation has been proven to work well in laboratory settings; however, it does not fully capture the results of field data (Garcia, 2008). The equations are as follows:

$$\frac{A}{D} = \left[\frac{\left\{S_e - 0.0168\left(\frac{D_{50}}{D}\right)^{0.33} Fr^2\right\}\left(\frac{L}{D}\right)^{1.20}}{0.47 Fr^2}\right]^{0.73} \qquad [21]$$

where $S_e$ = energy slope (m/m)
$Fr$ = Froude number (dimensionless)

and, for dunes:

$$\frac{L}{D} = 6.25 \qquad [22]$$

29 April 2011
SX0373307

Shore Gold Inc.
300-224 4th Avenue South
Saskatoon, SK   S7K 5M5

**Attention: Ethan Richardson, M.Sc., P.Eng.**
**Environmental Manager**

Dear Mr. Richardson:

**Re: Conceptual Design of a Diffuser on the Saskatchewan River for the Shore Gold Star Diamond Project**

## 1.0 INTRODUCTION

AMEC is pleased to provide Shore Gold with the following conceptual design of a diffuser on the Saskatchewan River for the Star Orion South Diamond Project near Fort à la Corne, SK. The purpose of this report is to outline the major design considerations and provide an initial estimate of materials quantities needed for construction. This initial assessment includes relevant cost factors such as:

- Anticipated project footprint;
- Approximate pipe length, diameter, and number of pipes;
- Construction methods;
- Materials and corrosion protection;
- Necessary erosion and sedimentation protection;
- Mitigation of river ice effects.

The works included in the design are restricted to those in the river and supporting infrastructure on the shore. The supply pipeline, pumps (if any), access road, and other utility connections are not included in this work since designs for these are being prepared by others.

## 2.0 CONCEPTUAL DESIGN

The diffuser design is based on the following general assumptions:

- Constant effluent discharge rate of 199,000 $m^3$/d (or 2.3 $m^3$/s);
- Effluent chloride concentration of 1,725 mg/L;
- Minimum depth of 2 m above the diffuser ports at the 7Q10 (169 $m^3$/s) low flow under ice-covered conditions (maximum ice thickness is 70 cm).

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## 2.1 Site Plan and Bathymetry

The site proposed previously by AMEC (2010) is shown in **Figure 1**. At this location, the river has a total width of approximately 265 m at the 1:2 year flood level and an average depth (under ice) of just less than 2 m during the 7Q10 low-flow. An approximate representation of the diffuser pipe and coffer dam footprint is indicated on **Figure 1**.

The channel cross section based on the June 2010 bathymetry survey conducted by AMEC and simulated depth under ice at the 7Q10 design discharge is shown in **Figure 2**. The zone which does not meet the minimum depth criteria of at least 2.3 m is shaded on the cross section.

Further review of the bathymetry data indicates that a section approximately 100 m downstream (closer to the FALC Ravine) would provide access to greater depths in the middle of the channel, which would improve mixing performance and reduce the chances of the diffuser being affected by ice forces and sedimentation. AMEC recommends Shore Gold consider siting the diffuser at this downstream location. The primary cost consideration for using the alternate site would be a change in the on land supply pipeline length. Depending on the planned approach route from the mine, this difference may or may not be significant.

## 2.2 Diffuser Configuration

Considering the design discharge rate, minimum depth criteria, and typical design assumptions for similar structures, the diffuser should have the following principal characteristics:

| | |
|---|---|
| Number of ports | 40 |
| Port diameter | 150 mm |
| Port spacing | 1.5 m |
| Riser height | 300 mm above the river bed |
| Diffuser length | 60.0 m |
| Diffuser pipe diameter | 1200 mm |

Along the diffuser pipe, risers will extend upwards into the flow, equipped with a 90° elbow and a custom fabricated nozzle oriented horizontally and in-line with the flow (facing downstream) as illustrated in **Figure 3**. The diffuser pipe diameter will be reduced along its length to balance the discharge through each port. It is anticipated that 2 reductions along the diffuser length will be adequate to achieve this. The reduced pipe diameters, their length and the exact specifications for the nozzles will need to be confirmed through numerical hydraulic modeling at the detailed design phase. For the present estimate, a constant diffuser pipe diameter of 1200 mm is assumed.

The diffuser pipe will extend approximately 50 m horizontally into the river bank, where it will intersect a drop shaft. This 1200 mm diameter shaft will be approximately 15 m deep, extending from the invert of the diffuser pipe to the ground surface above. A plunge pool box will likely be necessary at the base of the shaft to dissipate energy before flow enters the diffuser pipe. Since the supply pipe details from the mine site are not known, the details of the drop shaft configuration will need to be determined at a later stage of the design. The preferred installation method (open trench versus trenchless) of the diffuser pipe will also factor into the size of the working shaft (3000 to 4600 mm diameter) that must be excavated for construction.

The above diffuser design parameters are preliminary and will be refined during the detailed design phase. A numerical model such as CORMIX is required to confirm the effluent dispersion into the river water meets target concentration criteria. It is understood that this work will also be completed at a later date.

### 2.3 Materials and Corrosion Protection

Diffuser structures of this type are generally constructed using steel pipe for its overall strength and workability. It is imperative that the risers and nozzles protruding above the river bed are robust enough to withstand wear and abrasion from debris moving near the bed over the life of the project. On shore components such as manholes and drop shafts may be constructed from concrete.

Corrosion protection should be provided for the diffuser pipe by installing a sacrificial anode on the steel pipe where it enters the base of the drop shaft. Overall considerations for corrosion protection will take into account the service life of the mine and the diffuser.

### 2.4 Erosion Protection

The diffuser pipe will be positioned close to the existing river bed to minimize the required length of the risers (and head losses). It is anticipated that riprap will be required to armour the existing bed along the segment with risers where the depth of cover is small. Based on previous modeling results (AMEC, 2010), the maximum depth-averaged velocity in the vicinity of the diffuser is 3 m/s at the 1:100 year discharge. Port discharge velocities are approximately 3 m/s as well. Initial estimates suggest that 300 mm nominal diameter riprap, 600 mm thick placed to a width of 3 m on both sides of the diffuser pipe would provide adequate protection along a total length of 75 m.

## 3.0 CONSTRUCTION METHODS

Construction approach and staging requires some consideration of the river bed material and restrictions on obstruction of flow with coffer dams during construction. Transport Canada requires that at no time during construction should more than 2/3 of the channel be obstructed. For a diffuser to be effective, it must be constructed in the deepest portion of the channel, which is near the middle of the river at this location.

The 190 m long diffuser pipe extending into the river from the drop shaft on shore may be constructed either by open trench method, trenchless methods (e.g. pipe jacking), or a combination thereof. The conceptual design presented in **Figure 1** and quantities listed in **Section 4.0** assume that the main diffuser pipe can be installed using trenchless methods.

For installation by open trench methods, a wider excavation and worksite area would be required to lay the 1200 mm diameter diffuser pipe below the existing river bed in wet sand. It is estimated that the width of the worksite would increase to between 1.5 and 2 times the 20 m width shown in the site concept plan. For an open trench installation of the diffuser pipe between the shoreline and the drop shaft, a shorter drop shaft and sloping diffuser pipe segment below the existing river bank could be considered. The suitability of each method for construction will require more detailed knowledge of the site geotechnical conditions and the preferred construction method should be determined in consultation with potential contractors prior to or during the detailed design phase.

To accommodate work within the channel while minimizing the obstruction to flow, a vertical (sheet pile or caisson) coffer dam, installed by barge, will be required to maximize clearance around the worksite. Also, given that the river bed material in this reach is predominantly sand, isolation and dewatering of an instream worksite enclosed by earthen coffer dam will be difficult or ineffective. The proposed coffer dam and temporary access berm layout shown in **Figure 1** will satisfy restrictions on allowable channel obstruction. It should be noted that an earthen coffer dam segment that is parallel to the flow will connect the access berm to the coffer dam that surrounds the diffuser worksite area. The access berm will be fitted with three 900 mm culverts to reduce upstream afflux against the berm during high flows and maintain circulation of flow on the downstream side of the berm. The crown of the culverts would be set at the 1:2 year water surface elevation.

A typical staging approach for the instream works to construct the diffuser pipe would proceed as follows:

- Construct earthen access berm and coffer dam end wall;
- Install coffer dam in the middle of the river (by barge);
- Install electrical and pump services to worksite area for dewatering;
- Place the 1200 mm diameter diffuser pipe;
- Place riprap armouring around the diffuser pipe and fit crown of pipe with risers and nozzles;
- Remove (vibrate out) sheet pile walls by barge;
- Remove earthen coffer dam and temporary access berm.

It is anticipated that the allowable period for construction activities within the channel authorized by the Department of Fisheries and Oceans (DFO) Canada will be late summer or approximately July 15 through October 1. This period will avoid impacts on spring and fall spawning fish. The coffer dam and temporary access berm should extend up to at least the 1:5 year flood elevation of 352.9 m.

## 4.0 MATERIALS ESTIMATES

**Table 1** summarizes the materials estimates required for construction based on the conceptual diffuser design and proposed construction approach. The quantities and materials specifications will be refined as numerical modeling of the pipe hydraulics and near-field effluent mixing progresses through the detailed design phase to be completed at a later date.

**Table 1**
**Preliminary Materials Estimates for Shore Gold Diffuser Construction**

| Item No. | Description | Component | Qty | Unit |
|---|---|---|---|---|
| **Diffuser Structure** | | | | |
| 1 | 1200 mm Standard Wall Steel Pipe | Diffuser Pipe | 190 | m |
| 2 | 1200 mm End Cap | Diffuser Pipe End | 1 | unit |
| 3 | 150 mm Steel Pipe | Port Riser | 50 | m |
| 4 | 90° Elbow 150 mm | Port Riser | 40 | unit |
| 5 | Prefabricated Nozzle | Nozzle | 40 | unit |
| 6 | Riprap (300 mm nominal diameter) | Armouring of Diffuser Pipe | 500 | $m^3$ |
| 7 | Concrete Drop Shaft (1200 mm approx. diameter) | Connection to Diffuser Pipe | 15 | m depth |
| **Construction Materials** | | | | |
| 8 | Sheet Pile (install, remove, and haul off-site) | Coffer Dam | 180 | m length |
| 9 | Fill (place, remove, and haul off-site) | Access Berm / Coffer Dam | 12,000 | $m^3$ |
| 10 | Gravel (place, remove, and haul off-site) | Gravel Armour for Access Berm | 800 | $m^3$ |
| 11 | 900 mm Culvert (Total of 3) | Access Berm | 36 | m |
| 12 | Excavation (remove and haul off-site) | Expose Diffuser Pipe | 350 | $m^3$ |

## 5.0 RECOMMENDATIONS

AMEC recommends that Shore Gold integrate the following work into their overall mine site development plan and scheduling:

- Detailed design and numerical modeling of diffuser hydraulics and near-field mixing;
- Geotechnical site investigation to confirm subsurface conditions pertinent to placement of the diffuser pipe and construction of the drop shaft;
- Site survey during low-water to confirm bed material composition and channel section bathymetry (adequate observations of the bed material were not possible during the 2010 bathymetry survey by AMEC due to high flows);
- Design of fish habitat compensation and application for regulatory approval from DFO for HADD (Harmful Alteration, Disruption, or Destruction) of fish habitat.

AMEC can provide Shore Gold with assistance through each of these tasks leading up to final design and tendering.

## 6.0 CLOSURE

This report is based on and limited by the interpretation of data, circumstances, and conditions available at the time of completion of the work as referenced throughout the report. This report has been prepared for the exclusive use of **Shore Gold Inc.** and their agents for specific application to this project site. The work was conducted in accordance with the scope of work prepared for this project, and no other warranty, expressed or implied, is made.

We trust that the information within this report satisfies your requirements. Should you have any questions or require any additional information, please feel free to contact the undersigned at your earliest convenience.

Yours truly,

**AMEC Earth & Environmental**


Reviewed by:

<original signed by>

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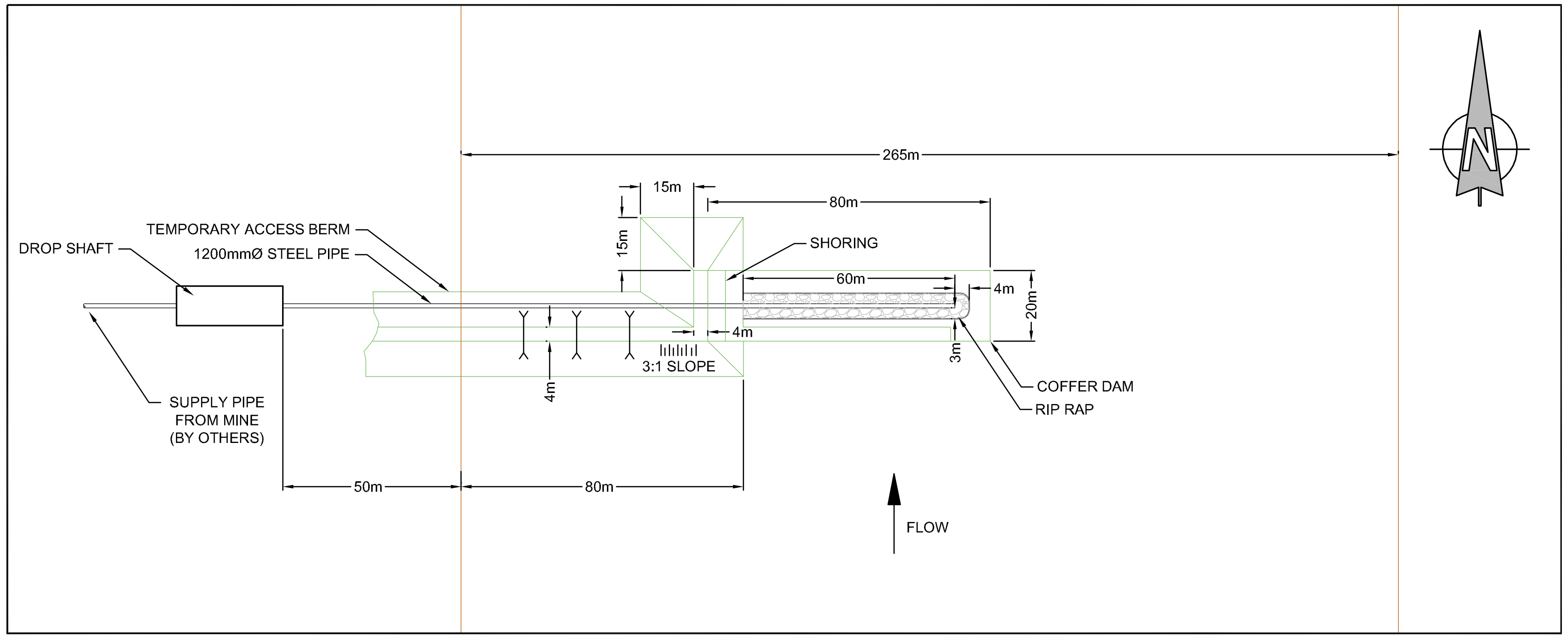
Permit to Practice No. P-4546

## 7.0 REFERENCES

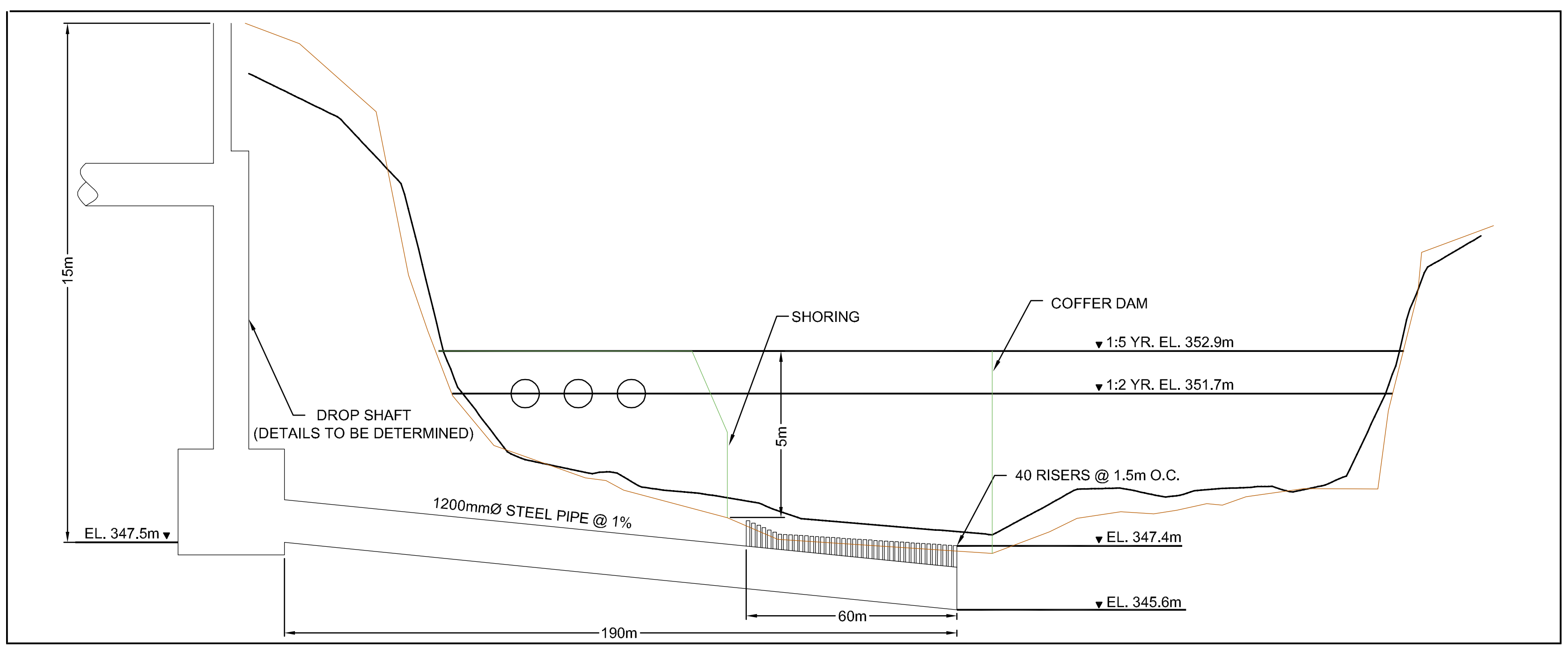
AMEC 2010. “Saskatchewan River Hydrotechnical and Dispersion Modeling Study, Star Diamond Project -2010”, September 2010.

# FIGURE 1

# SITE PLAN AND ELEVATION

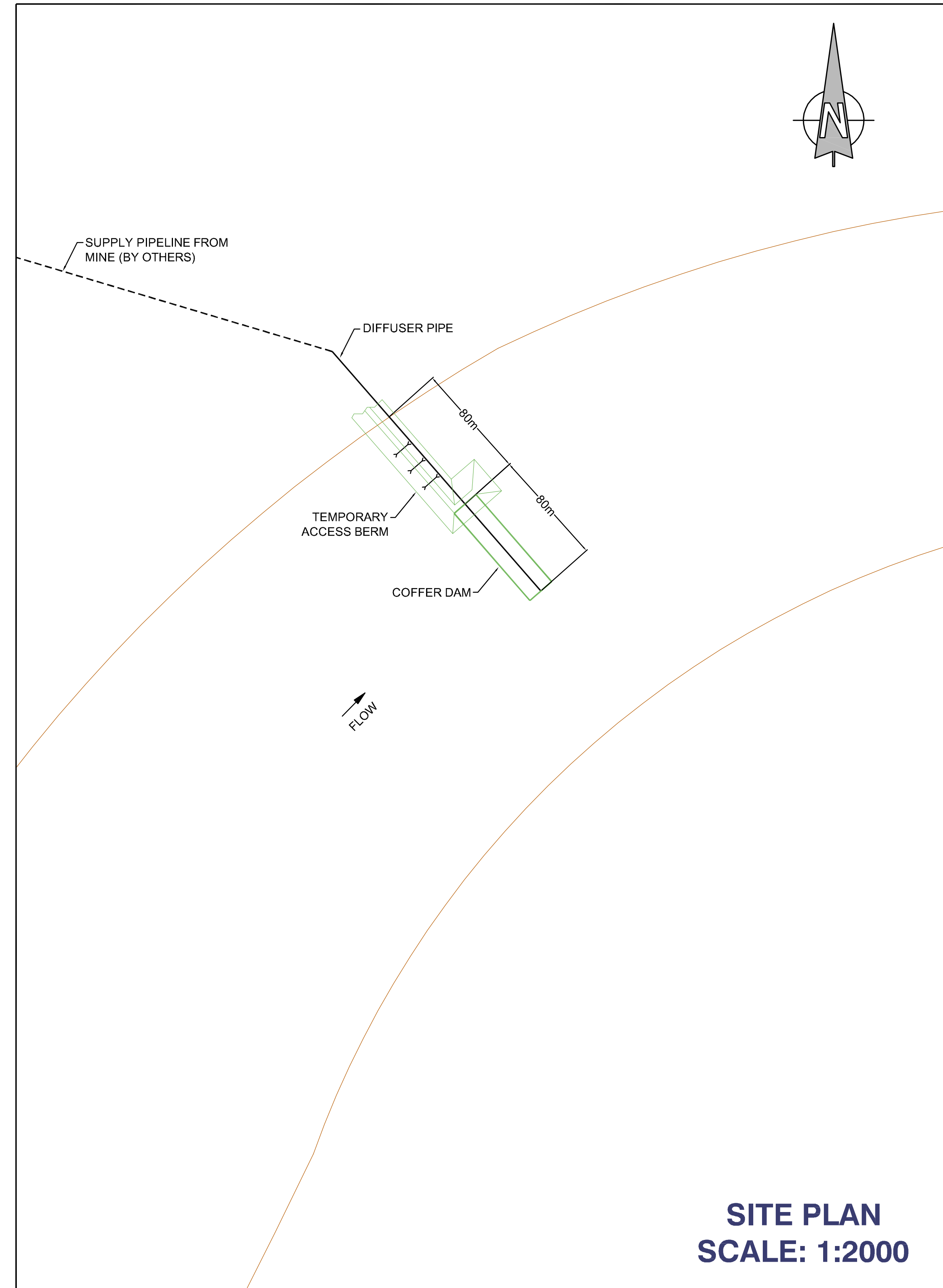



PLAN VIEW
SCALE: 1:1000




ELEVATION VIEW
SCALE: 1:1000

NOTE: CONCEPT DRAWINGS - NOT FOR CONSTRUCTION.
(ALL DIMENSIONS ARE APPROXIMATE)




SITE PLAN
SCALE: 1:2000

Shore Gold Inc.

AMEC Earth and Environmental

DIFFUSER
STAR ORION SOUTH DIAMOND PROJECT

| PROJECT NO.: | DATE: | DRAWN BY: | SCALE: |
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SITE - PLAN & ELEVATION

**FIGURE 2**

**CHANNEL CROSS SECTION AT THE PROPOSED DIFFUSER LOCATION**

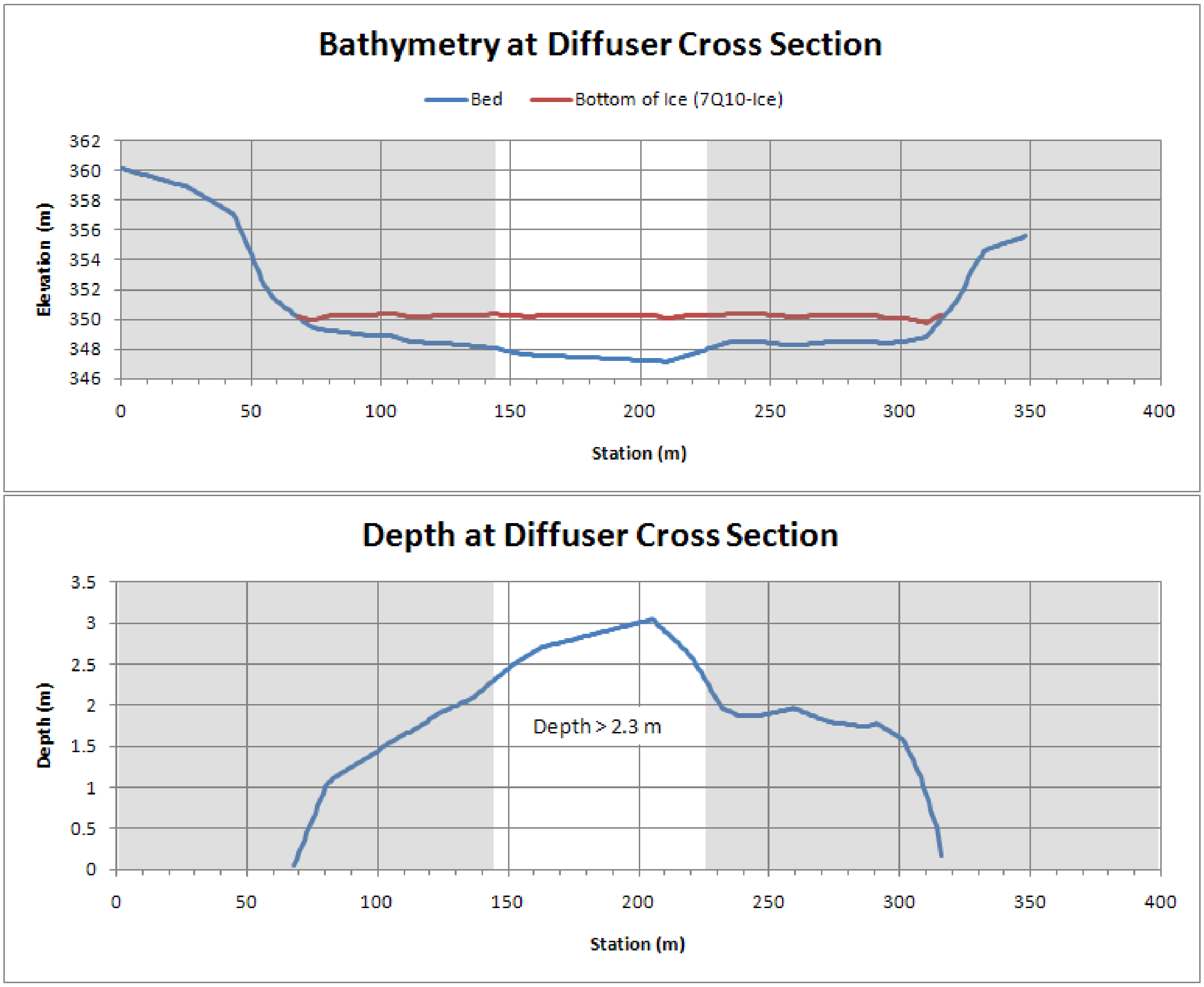
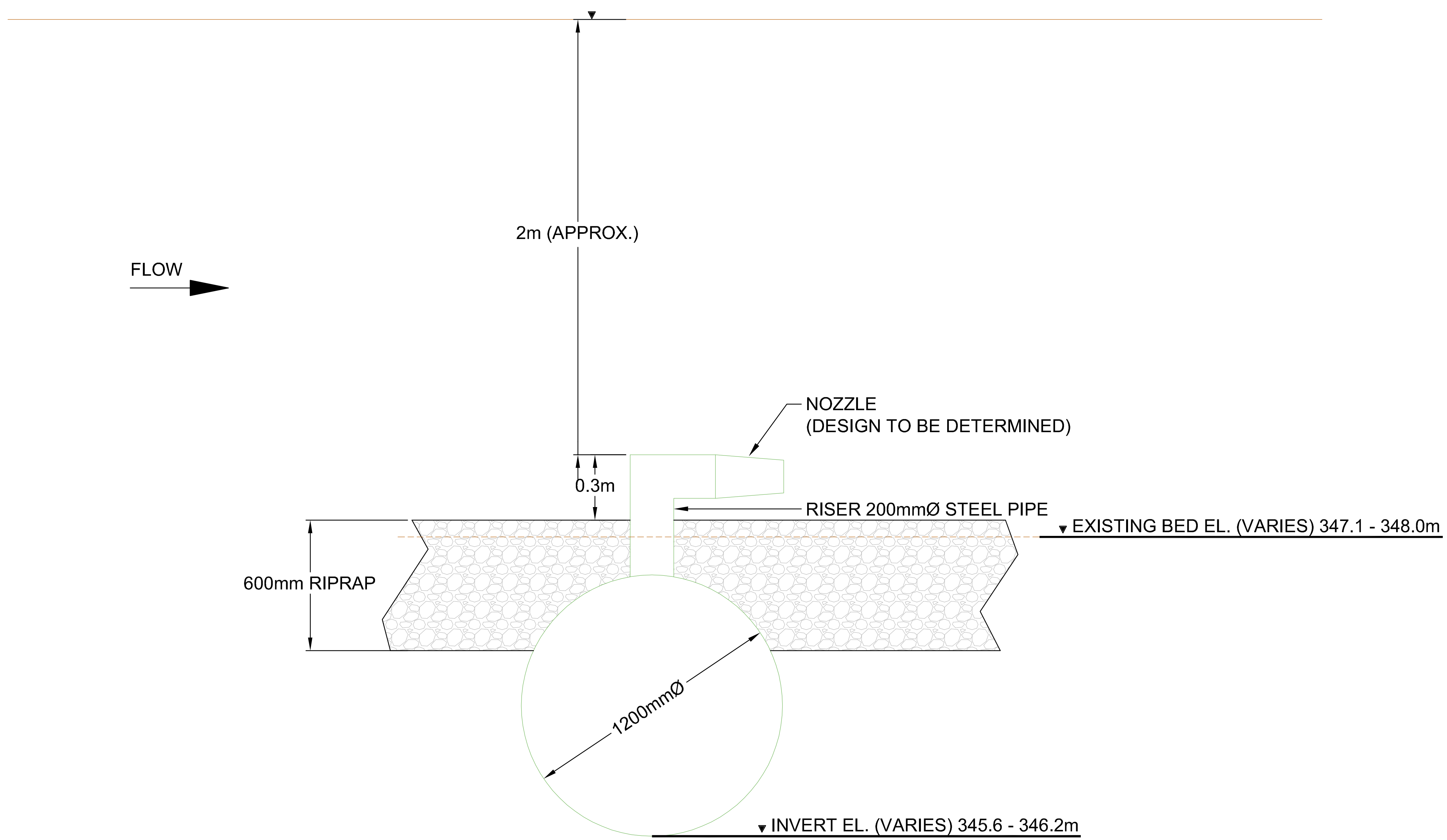



**Figure 1 Channel Cross Section at the Proposed Diffuser Location.**

# FIGURE 3

# RISER DETAIL

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STAR ORION SOUTH DIAMOND PROJECT

# RISER DETAIL

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# Memo

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| To | **Ian Judd-Henrey** | From | **Sukru Sumer** |
| Company | **20 July 2011** | Direct Tel. | **403-387-1783** |
| File No. | **SX0373302** | Cc. | **Dennis Yee** |
| Subject | **Saskatchewan River Dispersion Modeling – Diffuser Plume Estimate** | | |

The Saskatchewan River flow and transport model was prepared in August 2010 to assist with project design and the preparation of permitting for the Shore Gold Mine. The model addressed the prediction of chloride concentrations in the river that are expected to result from the discharge of groundwater to the river from the end of an outfall pipe. The model construction details and the predictions of chloride concentrations in the Saskatchewan River that are expected to result from the discharge of well field groundwater to the river are summarized in the AMEC (2010). Shore Gold has decided to investigate the diffuser option for the outfall; and, in order to help in the preliminary evaluation, asked AMEC Earth and Environmental (AMEC) to estimate the chloride concentrations in the Saskatchewan River using the existing Far Field model.

This technical memorandum summarizes the results of simulation of chloride plume generated at the proposed diffuser pipe location during the low river flow 14,602,000 $m^3$/d (7Q10). The diffuser pipe is assumed to 60 m long and has 13 ports which are 5 m apart. The model used is a 2D flow and transport model designed to analyze far field mixing of point, areal and/or line sources in rivers. The source of the chloride plume in this model was represented with a depth averaged point source at a short distance downstream of each port of the diffuser. This is an approximation of the source concentration which occurs at a short distance downstream of the diffuser pipe and/or the port. Over this distance the turbulent jet velocities reduces down to ambient river velocities. The length of this distance is also called the near field length. The plume behavior in the near field is analyzed with turbulent jet momentum equations which include the initial velocity of the jet at the diffuser port and some other flow parameters. The near field and the detailed hydraulic design of the diffuser were not attempted during this preliminary evaluation.

The diffuser located along the low flow width of the Saskatchewan River at the previously selected discharge location was assumed to be 60 m long. The total well field discharge, 120,000 $m^3$/d, and its chloride concentration, 1700 mg/l, were distributed across the 60 m width of the river. The simulations of the low flow in the river were done to update the model hydraulic flow regime integrating the diffuser discharge configuration. The flow rates at each port were selected equal to 1/13 of the total discharge. Transport model runs indicated that the chloride concentrations in the river width reduce to values varying between approximately 21 to 26 mg/l above background at 40 m downstream of the source (shown in Figure 1). The variability in

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concentrations in lateral direction is a function of river water depth and the rate of discharge through the port. The transport model results and the summary of chloride concentrations along a lateral line at 40 m downstream of the source were illustrated in Figure 2.

The two dimensional far field model simulations for a diffuser generated plume indicated that the chloride concentrations in low flow in the river reaches approximately 25 mg/l above background at approximately 40 m downstream of the source location. It should be noted that the source location for the far field model is the location at which the diffuser turbulent jet velocities slows down reaching river flow velocities and also where the vertical mixing is complete. This location is a short distance downstream from the diffuser pipe and can be determined with near field analysis.

Modeling has shown that extending the outfall pipe into the river will improve the transverse as well as longitudinal dispersion of the chloride plume in the river. Furthermore, discharging through a diffuser located in the deeper and faster moving middle section of the river would result increased mixing and lower plume concentrations.

Please contact Sukru Sumer at (403) 387-1783, if you have any questions regarding this technical memorandum.

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# Figures

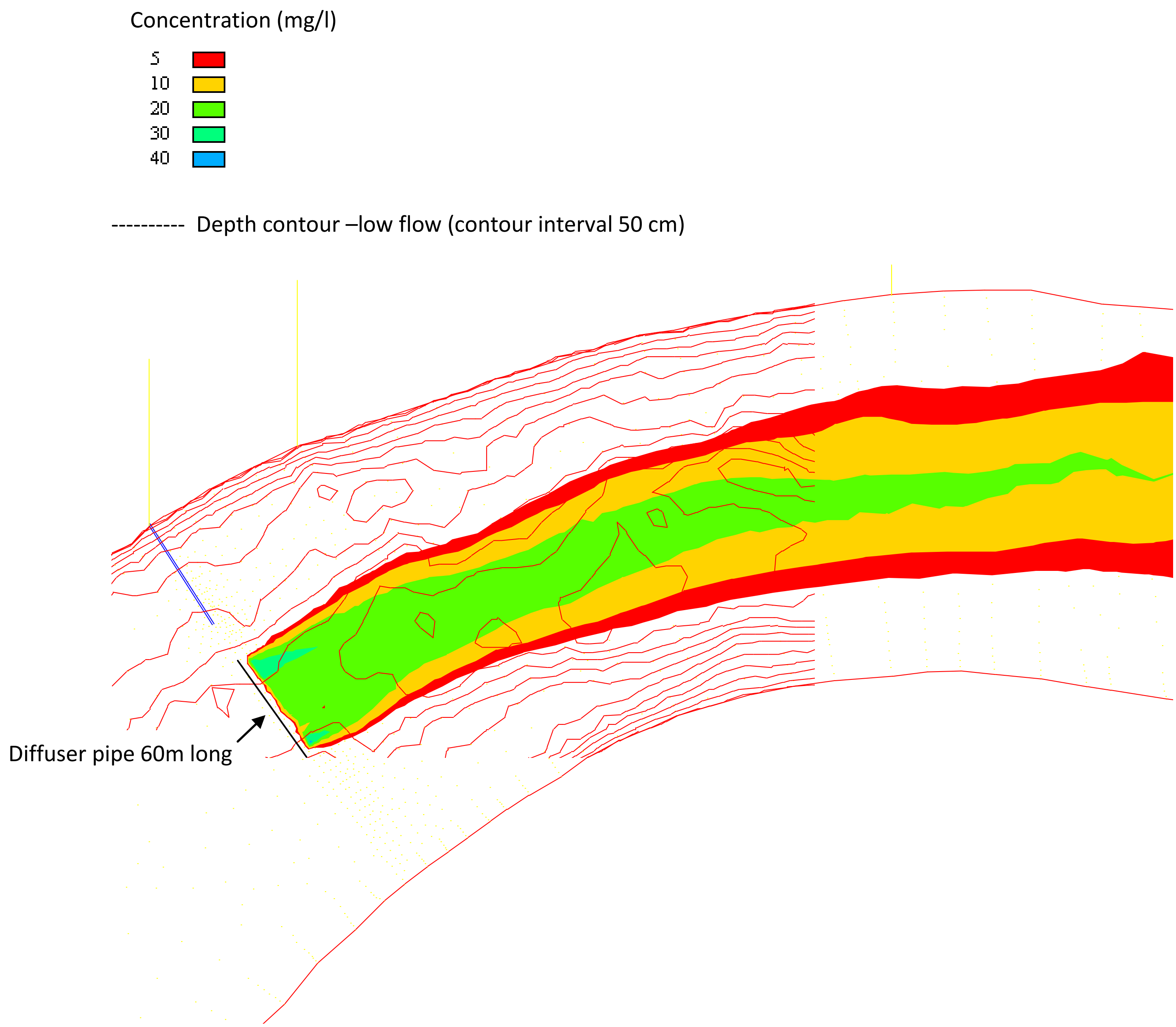


FIGURE 1 – Chloride Concentrations Downstream of the Diffuser simulated by far field model

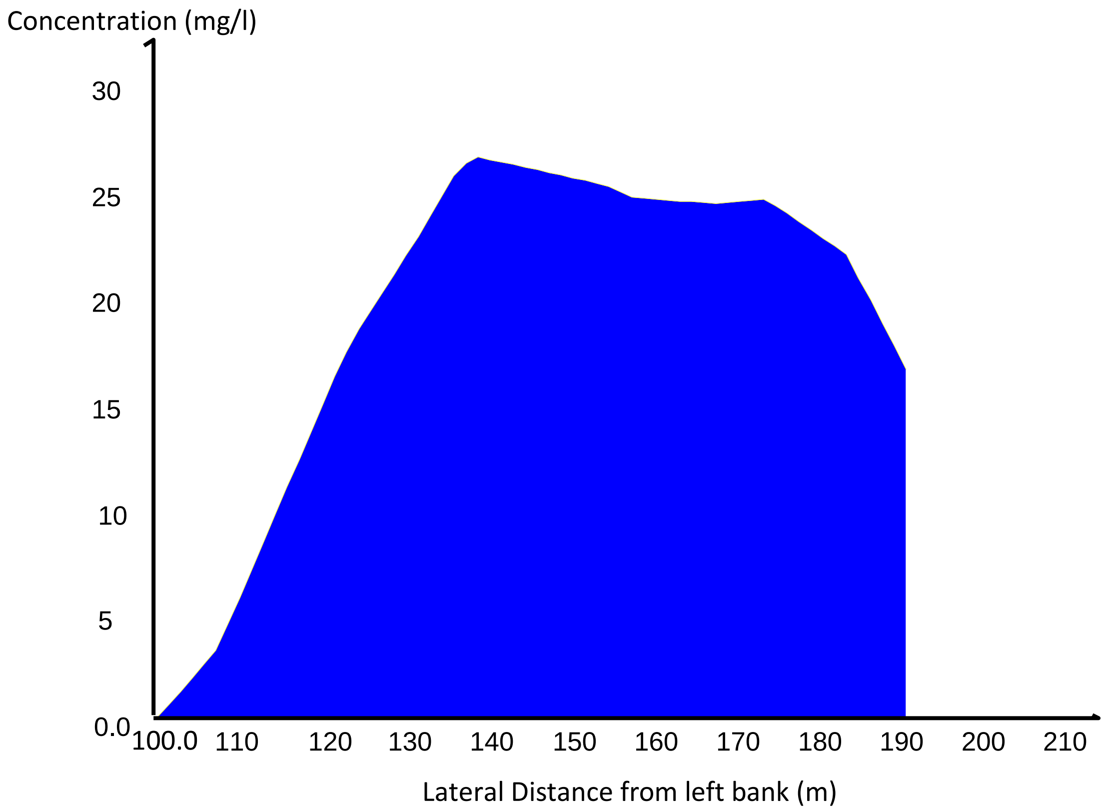


FIGURE 2 – Chloride Concentration in the River at 40 m Downstream of the Source

# Appendix E

# Limitations

# Limitations

1. The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.

2. The report has been prepared in accordance with generally accepted environmental study and/or engineering practices. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.

3. The services performed and outlined in this report were based, in part, upon visual observations of the site and attendant structures. Our opinion cannot be extended to portions of the site which were unavailable for direct observation, reasonably beyond the control of AMEC Earth & Environmental, a division of AMEC Americas Limited.

4. The objective of this report was to assess environmental conditions at the site, within the context of our contract and existing environmental regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations was not included in our contract for services.

5. Our observations relating to the condition of environmental media at the site are described in this report. It should be noted that compounds or materials other than those described could be present in the site environment.

6. The conclusions of this report are based in part, on the in Mannville Formation data provided by others. The possibility remains that unexpected environmental conditions may be encountered at the site in locations not specifically investigated. Should such an event occur, AMEC Earth & Environmental, a division of AMEC Americas Limited, must be notified in order that we may determine if modifications to our conclusions are necessary.