Coquitlam-Buntzen Water Use Plan

Lower Coquitlam River Substrate Quality Assessment

Implementation Year 6

Reference: COQMON #8

Study Period: 2012-2013

G3 Consulting Ltd.

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Lower Coquitlam River Substrate Quality Assessment

COQMON#8

Annual Report Year 1 (2012 /13)

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EXECUTIVE SUMMARY

G3 Consulting Ltd. (G3) was retained by BC Hydro to complete the *Lower Coquitlam River Substrate Quality Assessment* in salmonid spawning and rearing habitat in the Lower Coquitlam River from 2012 to 2017. A primary objective of this study is to evaluate the effectiveness of flushing flow provisions intended to increase fish productivity through improved substrate quality in the Lower Coquitlam River.

As part of the Coquitlam River Water Use Plan (WUP), eight (8) separate monitoring programs have been implemented with the objectives and monitoring indicators reported to BC's Comptroller of Water Rights. The *Lower Coquitlam River Substrate Quality Assessment* is the focus of this report and one of the eight monitoring programs. The following is the first annual data report that provides an update on the project activities and results of three (3) surveys undertaken October 2012, January 2013 and May 2013. Data reporting on substrate quality performance measures is conducted annually, while analysis of effectiveness of flushing flows will be done in the third year and again at the end of the review period.

Substrate quality at six (6) sampling sites in the Lower Coquitlam River was assessed by measuring percent (%) particle size distribution for surficial and subsurface (<10.0 mm) samples. Subsurface sample material >10.0 mm also underwent pebble counts (not yet available at the time of this reporting). Surficial sediments consisted of higher percentages (%) of clay and silt in October 2012 and January 2013, coinciding with high discharge periods in the Lower Coquitlam River. Particle sizes in subsurface sediments collected October 2012 and January 2013 were highest in percentage (%) sand and gravel and lowest in May 2013. No flushing flows occurred in 2012 or 2013.

Suitable substrates for spawning and rearing were observed at the sampling sites; however, given this was the first year of sampling there was limited data from which to draw conclusions as to whether flushing flows were effective at mobilizing sediments and whether sediment particle size profiles at each site are a reflection of discharge or other environmental factors. Analysis of substrate quality results will require several years of data to develop robust correlations between substrate quality results and fish productivity.

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1.0 INTRODUCTION

G3 Consulting Ltd. (G3) was retained by BC Hydro to complete the Lower Coquitlam River Substrate Quality Assessment in salmonid spawning and rearing habitat in the Lower Coquitlam River from 2012 to 2017. The Lower Coquitlam Substrate Quality Assessment was established by BC Hydro as part of the Coquitlam-Buntzen Water Use Plan (WUP) to investigate the effectiveness of channel substrate flushing flows in improving substrate quality.

As part of the Coquitlam River WUP eight (8) separate monitoring programs have been implemented with the objectives and monitoring indicators reported to BC's Comptroller of Water Rights. Of the eight (8) programs the *Lower Coquitlam River Substrate Quality Assessment* is the focus of this annual report. The primary objective of this program is to evaluate the effectiveness of flushing flow provisions outlined in the Coquitlam Buntzen WUP to increase fish productivity through improved substrate quality in the Lower Coquitlam River. The Consultative Committee (CC) for the WUP agreed on a set of operating conditions that includes two (2) flow release regimes:

- Treatment 1: releases between 0.8 m^3/s - 1.7 m^3/s; and,
- Treatment 2: releases between 1.1 m^3/s - 5.9 m^3/s depending on the time of year.

The *Lower Coquitlam River Substrate Quality Assessment* involves monitoring of substrate quality three (3) times (fall, winter and mid spring) over five (5) annual field surveys. Surveys are to be repeated at representative spawning and rearing sites in the Lower Coquitlam River with primary efforts focused on specific areas (Reaches 2 and 3). The primary indicator assessed was particle size distribution of surficial and subsurface samples and included secondary indicators of substrate quality (e.g., embeddedness, dominant/subdominant substrate sizes). Substrate quality is reported annually with an analysis of the effectiveness of flushing flows done and reported every third year and at the end of the review period (2017). Previous program photo documentation of substrates in 2003 was determined to be inadequate in addressing management objectives; however, was continued in this program to enable comparisons of results from this and previous studies. Bulk sampling is recommended when flushing flows (releases of 30 m^3/s - 50 m^3/s) occur from Coquitlam Dam. No flushing flows occurred in 2012 or 2013 and, therefore, no bulk sampling was undertaken.

This annual data report provides an update on the project activities and results of surveys undertaken October 2012, January 2013 and May 2013 and includes:

- a review of the effectiveness of the surficial and subsurface sediment as an indicator of substrate quality; and,
- an assessment of general trends in the surficial and subsurface data from October 2012 to May 2013.

This chapter (One) outlines the study background and objectives. Chapter Two discusses study design and methodology for field and laboratory work. Chapter Three provides and discusses program results from October 2012, January 2013 and May 2013. Chapter Four provides program conclusions and recommendations followed by cited references. Appendices provide details of sampling locations, raw data, and QA/QC data.

1.1 Perspective & Background

The Coquitlam River watershed is one of many on the north shore of the lower reach of the Fraser River in the Lower Mainland region of BC. It is primarily located within the municipalities of Coquitlam and Port Coquitlam and includes the Coquitlam Lake Reservoir, above Coquitlam Dam. From this catchment area, at least thirty watercourses flow into a highly developed lower watershed that drains into the Fraser River and subsequently outflows into the Strait of Georgia. The largest contributors to the Coquitlam River flow are Or, Hoy, Scott and Pinnacle Creeks. Since the early 1900s the river has been dammed to provide a consistent water supply and power generation to support growing communities in the Lower Mainland. Gravel operations began in and along the Coquitlam River in the 1950's and commercial logging along the watershed in the 1960s and 1970s. Development pressures and impacts on the watershed are the focus of numerous volunteer, government and private sector initiatives, projects and plans. High, eroding glaciolacustrine terrace scarps near the mouth of Or creek are a notable source of silt and clay (NHC, 2007). The other tributaries drain smaller, less rugged watersheds further downstream and provide additional sources of sediment to the river. Bank erosion along the lower Coquitlam River has provided minimal input of sediment. In the gravel mines located along the Coquitlam River (Reach 2b), wastewater is treated in settling ponds then discharged into the river. Most of the sediment introduced to the river from gravel mines now consists of fine sands, silt and clays and can create frequent turbidity events below the point of discharge (NHC, 2007). In the past, coarser sediments were also delivered to the river from these mines (NHC, 2007). In the past, the City of Coquitlam has periodically monitored turbidity and suspended sediment concentration upstream and downstream of the gravel mines; however, data was not available at the time of this report.

1.2 Monitoring Program Rationale

The consultative committee (CC) for the Water Use Plan (WUP) highlighted two (2) factors affecting fisheries productivity in the Lower Coquitlam River (BC Hydro, 2005):

1. instream flows: timing/magnitude of flow released from Coquitlam Dam were evaluated in terms of habitat benefits (BC Hydro, 2003a); and,
2. substrate quality: fine sand content and availability of substrate suitable for spawning and overwintering (NHC, 2002).

The CC noted that habitat quality could be increased through improved substrate quality and commissioned a study to investigate how flow releases could be used to improve substrate quality (NHC, 2002). The study concluded that short-term, high magnitude flow releases from Coquitlam Dam ("flushing flows") would be highly effective at mobilizing fines from the channel bedload and recruit gravel through erosion and bedload movement. Based on Fisheries Technical Committee (FTC) recommendations, the CC supported annual flushing flow releases of 30-50m^3/s from the Coquitlam Dam for 3-5 days/year, coinciding with peak inflows from Or Creek. Given that the effectiveness of this decision was not fully assessed the CC wanted to monitor substrate quality on a seasonal basis throughout the review period and also better understand if there may be linkages between fish productivity and substrate quality.

1.3 Monitoring Program Requirements & Objectives

1.3.1 Management Questions

Future water use decisions such as dam releases require that the following questions related to flushing flows be addressed in this monitoring program:

Question: *Will recommended flushing flow operations result in improvements to substrate quality and fish productivity in the Lower Coquitlam River?*

The procedure used to assess how substrate composition effect habitat quality and fish productivity in the Lower Coquitlam River involves a review of fish productivity results in conjunction with substrate quality monitoring data. Substrate quality indicators and methods of data collection can vary significantly and depend on the dominant channel and substrate forms evaluated. For the purpose of this study, and to maintain interpretive and comparative consistency, substrate quality will be assessed using surficial fine material and subsurface material (<10 mm). An analysis of both regulated and unregulated flushing flow events will also be undertaken. Given that substrate quality is linked to spawning and rearing success (Bjornn and Reiser 1991) an assessment of whether substrate quality is limiting fish productivity in the Lower Coquitlam River will eventually be undertaken by:

1. assessing whether there is a correlation between substrate quality results and fish productivity; and,

2. comparing field monitoring results with established biostandards (e.g., relating spawning and rearing success to substrate quality).

1.3.2 Key Water Use Decision Affected

The results from this study will help assess substrate conditions and effectiveness of unregulated flushing flow events. By 2017, the evaluation of both flow releases outlined in the Coquitlam-Buntzen WUP will be completed and based on the results from this and other studies, BC Hydro will recommend a base flow regime to the Consultative Committee (CC) for the WUP. Flow recommendations will:

a) meet the objective of optimizing fish interests in the Lower Coquitlam River; and,

b) be constrained within the two (2) releases being tested in consideration of Metro Vancouver planning requirements (BC Hydro, 2002). Recommendations from BC Hydro will be vetted through the WUP CC to ensure it has their understanding and support.

1.4 Project Objectives

The primary objective of this substrate quality assessment was to:

- establish and document sampling locations for the 2012 – 2017 substrate monitoring program; and,
- develop and implement methodologies to assess the potential effects associated with both natural system flows and BC Hydro flushing events on substrate quality.

1.5 Past Results & Recommendations

Northwest Hydraulic Consultants (NHC) previous substrate monitoring studies under the Lower Coquitlam River Substrate Quality Assessment COQMON#8 occurred 2007-2012. Field sampling has been conducted to measure substrate quality during spawning, incubation and emergence periods for salmonids and designed to assess changes in substrate conditions to fish productivity. NHC used two (2) methods (bulk sampling and photogrammetric analysis) to characterize substrate surface grain size distribution. Freeze-core sampling was attempted as an alternative method for collecting bulk subsurface samples in which the sample material is frozen *in situ* with liquid nitrogen prior to extraction to enable collection within the wetted channel without the loss of fine sediment fractions that would occur with a manually excavated sample; however, the substrate was too coarse to insert the sampling device into the bed, except at a few isolated spots where only small samples could be obtained. Given the problems with the freeze-core technique, results of the field sampling effort were not reported and the technique discontinued.

NHC (2006; 2010) reported that the type surface material analysed in the Lower Coquitlam River became finer after the occurrence of flushing flows. There have been two (2) unmanaged flushing flows (i.e., 30 m^3/s – 50 m^3/s) from the Coquitlam Dam and two (2) dam release augmented flows that were close to flushing flow criteria. In each of the these events the quantity of fines were found to have decreased suggesting flushing flow experiments were successful; however, changes in substrate were temporary and within a range of natural variability expected.

In general, definitive links between flows and changes in surface grain size distribution have, to date, not been established due to previous assessment methods and high natural variability. Photo sampling was unsuccessful in addressing management objectives and recommended to be discontinued. Further, it was recommended that bulk sampling be continued, but only after an official flushing flow (i.e., 30 m^3/s – 50 m^3/s. It was also recommended that additional exposed gravel bars be sampled if additional suitable monitoring locations could be identified (NHC, 2012). Freeze-core sampling in the wetted channel was also shown to be unsuccessful and recommended to be re-evaluated.

1.6 Lower Coquitlam River: Channel Morphology & Substrate

The Lower Coquitlam River was previously divided into five (5) reaches by BC Hydro. Reach 4 is the uppermost reach, extending between the Coquitlam Dam and Or Creek confluence. Reach 3 extends downstream from the Or Creek confluence to the upstream end of the gravel mining area. Reach 2 includes the gravel mining area and extends downstream yet north of Lougheed Highway. Two sub-reaches exist along the area of gravel mines (Reach 2B) and further downstream through an urbanized area (Reach 2A). Reach 1 extends approximately 0.6 km upstream and 1.2 km downstream, south of Lougheed Highway, at or near an alluvial fan. Reach 0 is the lowermost reach, extending across the Fraser River floodplain and was not included in the monitoring program. Channel gradient declines in a downstream direction along the Lower Coquitlam River from 1.8% in Reaches 3 and 4, 1.1% in Reach 2, 0.4% in Reach 1 and 0.07% in Reach 0 (NHC, 2012).

Reaches 2 and 3 were the primary focus of current monitoring program. The channel morphology at these locations was described by NHC (2006; 2012). Reach 3 was dominated by coarse sediment from Or Creek with channel bed and bars comprised primarily of boulders. Reach 3 was also noted to have clusters of larger boulders. Reach 2 was dominated by boulder bars and riffles, separated by long pools and glides. In general, bars tended to be larger, less active and more vegetated than at Reach 3 (NHC, 2011). Smaller, unvegetated cobble bars, located within narrowed channels were suggested to be indicative of more recent temporary river bedload (NHC, 2012). Sand and granules were noted to be abundant in the interstices of pool and glide bed material. Isolated lag boulders occurred throughout Reach 2 with greater accumulations of sand and granules located downstream.

2.0 METHODOLOGY

This section provides methodologies employed during the 2012-2013 substrate quality monitoring program.

2.1 Site Reconnaissance, Selection, Classifications & Mapping

Prior to selecting field sites for the 2012-2017 monitoring program, a review of previous NHC substrate monitoring reports was conducted to locate past photo sample sites and sieve sample sites. A field reconnaissance identified locations and areas of salmon rearing and redds. Reach transects and sampling sites were established and permanent site markers eastablished using rebar as stakes.

Six (6) sampling sites were established during the reconnaissance survey (October 2012): Site 1 (Reach 2a), Sites 2, 3 and 4 (Reach 2b) and Sites 5 and 6 (Reach 3); (Figure A1 in Appendix 1). Two (2) sampling locations are positioned at each site (i.e., upstream and downstream) and a total of six (6) replicate samples collected at each sample site. Preliminary assessments for confounding influences, habitat classification and mapping, vegetation (aquatic and terrestrial), presence of any wildlife, erosional and depositional areas, slope of stream banks, propensity for banks to erode or be undercut, general water flow and depth was conducted for each site. Photographs were taken of all cardinal directions for each reach and site. Comments on local disturbance indicators (local erosion, sediment sources) and other factors were also considered during analysis and recorded as necessary.

2.2 Water Level Loggers

Two (2) HOBO brand, Model U20 water level data loggers were installed one (1) each in Reach 3 and Reach 2b; (Photo A1 and Photo A2 respectively and Figure A2). These units are capable of storing water depth up to 10 meters and retain supportive metrics such as water temperature, barometric pressure, in addition to water level (on an hourly basis). Results are used in conjunction with flow data to develop an understanding of flow and depth scenarios at each site prior to and after each sampling event. During each sampling period, results are downloaded from the data logger, the unit recalibrated, batteries refreshed and logger returned to the river. Loggers are camouflaged to prevent vandalism and tapering and labeled with research and contact information in the event they are discovered. Water level data was retrieved from one (1) logger (Reach 3) October 2013. The second data logger (Reach 2) was stolen or destroyed.

2.3 Field Monitoring

2.3.1 Habitat Reconnaissance

A fish habitat assessment was conducted at each site following the RIC standard (MOE, 2008). Photographs were taken of the upstream and downstream direction of the stream. Photographs were also taken of stream morphology and features which may be considered during analysis including islands, gravel bars, large woody debris placement and other factors affecting stream morphology and salmon habitat. Public access, constructed side channels, changes in riparian vegetation was also recorded. Each site will be continually monitored for changes in habitat and recorded accordingly.

2.3.2 Surficial & Subsurface Substrate Samples

Each site was located with a map and GPS coordinates and confirmed by locating the site markers. GPS coordinates were recorded for each site at each sampling event. All sites descriptions and habitat classifications were recorded/updated as required and photographs of all cardinal directions taken. Substrate samples were taken from within the wetted channel in flowing water. Once a suitable location within the sampling site was selected the Hess sampler was placed in the substrate and twisted to aid penetration and embedded the bottom of the sampler. Sampling cannot be conducted in water deeper than 40 cm as water will flow over the top of the Hess Sampler. A 20µm mesh window faces upstream, to allow filtered water to flow into the unit and aid flushing of the surficial sample into the cup. It is important to not block the mesh window preventing water flowing through the Hess Sampler. During October sampling period, redds were identified and avoided before sampling commenced. No fish were caught in the sampler.

A photograph which included a grey point scale of the substrate within the Hess sampler was taken for each sample. Each field technician then took a visual observation of embeddedness and results recorded and averaged (n=3). The D_{95} (dominant substrate) and D_{50} (subdominant substrate) was then removed from the Hess Sampler. D_{95} (cm) is the diameter of the bed material larger than 95% of the materials in the stream channel. The first step was for the observer to estimate the range of particle sizes within the Hess Sampler then identify the D_{95}, larger than 95% of all other materials. The D_{95} was then measured along the B axis. The B axis is the intermediate axis of the particle (i.e. the side that the particle rolls along if flow is sufficient). If D_{95} was too fine to measure then a value of zero (0) is recorded. D_{95} can be larger than D if boulders are found in the channel (D does not consider lag boulders). D represents the size of the largest particle on the channel bed that will be moved at channel forming flow levels (GFP, 1996). If boulders are buried or too large to measure, the b axis is then estimated and the reduced precision is recorded. Once the D_{95} and D_{50} (50% of all other materials are finer than the D_{50}) are measured they were placed in a pre-labeled pail. In general embeddedness estimates between field personnel were within ±10% and considered a consistently reliable indicator of surficial substrate. Penetration and water depth within the Hess Sampler was also recorded.

Surficial samples were obtained by churning over substrates within the Hess Sampler 20 times using a small hand trowel. Surficial sediments were flushed through the downstream 20µm mesh tunnel and rinsed into a collecting cup then transferred to a labeled container. Samples were sent to Maxxam laboratories (Burnaby) for percent (%) particle size distribution analysis in coolers with accompanying chain of custody forms (COC).

Remaining material within the Hess Sampler (subsurface sample) was removed using a trowel to the bottom of the penetration depth reached by the Hess Sampler and added to the labeled pail. The subsurface samples were then sent to the G3 warehouse for drying and processing. Total subsurface sample weight and volume was recorded. Six replicate samples (n=6) were taken at each site per sampling event each year (6 replicates x 6 sites x 3 times per year=108 per year).

2.3.3 Sample Sieving & Processing

Samples transported to G3's warehouse were checked in on arrival. Samples were then weighed and prepped for drying. Each sample was spread over clean plastic polyethylene sheeting in a drying rack and contained within its own cell to prevent contamination with other samples. Sample drying occurred at room temperature with drying time improved using commercial drying fans directed upward so as to not disturb the samples while improving airflow. Samples were left to dry completely before the sample was crushed and sieved.

Once samples were dry the dry weight was recorded then sieved through a 10.0 mm sieve. Particles <10.0 mm, which passed through the sieve, were placed in a pre-labeled sample bag, weighed then sent to Maxxam laboratories (Burnaby) along with accompanying COC forms. Particles >10.0 mm were volumetrically assessed, weighed and determination of frequency taken. The current method of assessment established, a frequency for each category: medium gravel (9-16 mm), coarse gravel (17-32 mm), very coarse gravel (33-64 mm), small cobble (65-90 mm), medium cobble (91-128 mm); large cobble (128-256 mm) and boulder (>256 mm). During processing samples were photographed with a photo greyscale and labeled at each stage of processing.

2.3.4 Bulk-Sieve Subsurface Samples

Sample flows are monitored on a regular basis via contact with the City of Coquitlam and Water Survey Canada to obtain data from their *in situ* flow meters to confirm if flushing flows have occurred. No flushing flows occurred between October 2012 and May 2013 and, therefore, no bulk sampling was conducted.

2.4 QA/QC & Data Management

Quality Assurance and Quality Control (QA/QC) procedures and practices were implemented to ensure program integrity at every level and incorporated into work plans, management strategy and protocols for handling and recording information.

Instrumentation used in surveys are calibrated regularly to ensure they are performing accurately and backup meters used to verify and support measurements taken. Transcription or entry errors were checked by cross referencing and data reviewed by alternate staff members (20-25% of entered data). If an error greater than 5% is encountered the entire dataset was scrutinized.

3.0 RESULTS & DISCUSSION

Substrate quality at six (6) sampling sites in the Lower Coquitlam River was evaluated by assessing percent (%) particle size distribution for surficial and subsurface (<10.0 mm) samples. Subsurface sample material >10.0 mm underwent statistically random sub-sampling for pebble counts. At the time of reporting, analysis of sample fractions >10.0 mm had not yet been completed. Mean values of six (6) replicate samples <10.0 mm was assessed for each site surveyed over three (3) time periods (October 2012, January 2013 and May 2013). Surficial substrate quality was the primary indicator assessed, while subsurface quality was a secondary indicator. For the purpose of this report trends between sites and sampling periods are limited until completion of the study; however, some limited analysis is provided below. Relationships between the river flow and river substrate is a primary overall objective of the study to be discussed at its conclusion; however, some preliminary assessment has begun along with preliminary potential relationships between particle size and percent (%) distributions of substrate between sample sites and time of year.

Historical hydrometric mean monthly discharge data from Environment Canada (EC) from 1993 to 2013 for Coquitlam River at Port Coquitlam ranged from 0.803 m^3/s to 48.2 m^3/s. Discharge data from EC is recorded downstream of all sampling sites and accounts for discharges from all tributaries to the Lower Coquitlam River (Appendix1; Figure A3).

Yearly comparisons showed peaks in discharge (September to January) from 2003 to 2007. The average monthly discharge from 1993 to 2002 remained below 10 m^3/s with a few notable exceptions (Chart A1). Monthly comparisons show peaks discharge October through January over the ten (10) year period which coincides with fall and winter sampling period dates (October and January) (Chart A2). Discharge from October through January has been consistently high over the ten year period. The average monthly flow for the remaining year was below 10 m^3/s, and includes summer sampling period dates.

3.1 Surficial Sediments

Surficial sediments were analyzed for percent (%) particle size distribution of clay, silt and sand. Data for the six (6) replicates samples taken from each site were averaged. The mean percent (%) particle size distribution of surficial substrate samples indicated that sand was dominant with silt being subdominant at Sites 1 through 6 of Lower Coquitlam River (Appendix 4; Chart A3). The mean percent (%) silt in surficial samples collected October 2012 were greater or equal to the mean percent (%) clay at Sites 1 through 6 (Appendix 4; Chart A4). Mean sand percent (%) particle size in surficial samples collected October 2012, January 2013 and May 2013 was consistently high for Sites 1 thorough 6 (Appendix 4; Chart A5) and ranged from 69.67% ±7.91% to 92.00% ±1.41% (Appendix 3; Table A1). Mean percent (%) clay and silt showed more variability fluctuations. Mean percent (%) clay ranged from 1.78% ±1.43% to 8.8% ±7.04% with the lowest mean values at Site 6 (1.78% ±1.43%) in January 2013 and at Site 3 (8.8% ±7.04%) in May 2013 (Appendix 4; Chart A6; Appendix 3; Table A2). Site 3 had the highest mean clay percent (%) in October 2012, January 2013 and May 2013 (7.12% ±3.15%, 6.57% ±5.25% and 8.80% ±7.04%, respectively; Appendix 3; Table A2). The mean percent (%) silt in October 2012, January 2013 and May 2013 were <15.00% at Sites 1 through 6 (Appendix 4; Chart A7), with the exception of Site 3 in January 2013 and May 2013 (22.15% ±17.72% and 20.25% ±16.20%, respectively; Appendix 3; Table A3) and Site 6 in May 2013 (21.50% ±17.20%).

Overall surficial sediments consisted of higher percent (%) particle size clay and silt October 2012 and January 2013 coinciding when the Lower Coquitlam River discharge was highest. Lowest mean percent (%) values clay and silt (May 2013), occurred while the Lower Coquitlam River discharge was at its lowest recorded values.

3.2 Subsurface Sediments

Subsurface sediments were sieved through a 10.0 mm sieve and analysed for particle size distribution of clay, silt, sand and gravel. At the time of writing subsurface sediment classification for sediment >10.0

mm were not yet completed. Data for sediment size classes under 10.0 mm for the six (6) replicates were averaged and presented in Charts A8-A12, Appendix 4. The mean percent (%) (n=6) particle size distribution of subsurface substrates indicated that gravel was dominant with sand being subdominant at Sites 1 through 6 (Appendix 4; Chart A8). Mean percent (%) gravel in October 2012 and January 2013 ranged from 46.33% ±7.41% to 76.83% ±15.26% at Sites 1 through 6 (Appendix 4; Charts A9, A10, A11). Lowest mean percent (%) gravel occurred at Site 2 in October 2012 and January 2013 (46.33% ±7.41% and 58.00% ±14.25%, respectively; Appendix 3, Table A5). Mean percent (%) sand in subsurface samples from October 2013, January 2013 and May 2013, ranged from 22.40% ±15.47% to 52.67% ±7.54% for Sites 1 through 6 (Appendix 4; Chart A13). Highest mean percent (%) sand was at Site 1 (January 2013) and Site 2 (October 2013), (47.83% ±7.20% and 52.67% ±7.54%, respectively). The lowest mean percent (%) sand (22.40% ±15.47% and 29.67% ±10.51%) was found at Site 5 (Appendix 3; Table A6).

Overall mean percent (%) in subsurface sediments collected October 2012 (29.67% ±10.51% to 52.67% ± 7.54% and 46.33% ±7.41 to 69.00% ±10.23%) and January 2013 (22.40% ±15.47 to 47.83% ±7.20 and 51.33% ±7.23% to 76.83% ±15.26%) was highest in sand and gravel respectively, being lowest in May 2013 (34.33% ±4.82% to 41.17% ±9.99% and 55.33% ±10.58% to 62.67% ±4.82%, for sand and gravel respectively).

3.3 Sediment Quality

This annual data report summarizes results for the previous survey year. Interpretive analytical reports are to be provided in year three and at the end of the program to address management questions and hypotheses identified above, including correlation to fish productivity and substrate quality biostandards.

Sediment quality is integral to both spawning and rearing success for salmonids and provides important habitat requirements for cover. When spawning, salmonids build gravel nests (redds) which are designed to hold eggs within the interstitial spaces in the substrate. Appropriate interstitial space between substrate enables oxygenated water to flow over eggs, supplying oxygen to embryos (Keeley and Slaney, 1996). Finer substrate sizes such as sand and silt can ultimately reduce flow of water and oxygen to developing embryos and result in reduced survival. Substrates for rearing salmonids provide protection from fast currents as well as habitat for aquatic invertebrates, a main food source for salmon fry. Emergence can also be difficult if alevins cannot pass through interstitial spaces in substrate. Bjornn and Resier (1991) noted difficulty with emergence when fine sediment percentages (<6.4 mm) were >30% to 40% volume. While size of rearing substrate may vary between individual species (depending on their size), rearing salmonids are associated with gravel and larger sized substrates that are relatively free of high levels of fine particles (Keeley and Slaney, 1996).

Separate and concomitant monitoring for the Coquitlam River monitoring program involves the monitoring of adult escapement and smolt outmigration of four anadromous species (coho, steelhead, chum and pink). Coho and steelhead reside in freshwater longer than chum and pink which emigrate soon after emergence. As such, coho and steelhead smolt production is used as an indicator for freshwater production while chum and pink smolt production and egg-to-smolt survival can help determine quality of spawning substrate for eggs.

Suitable substrates for spawning and rearing were observed at each of the six (6) sampling sites; however, given this is the first year of sampling there is limited data with which to draw any conclusions. Analysis of substrate quality results will require several years of data to develop robust correlations between substrate quality results and fish productivity.

4.0 SUMMARY & RECOMMENDATIONS

G3 Consulting Ltd. (G3) completed the 2012-2013 substrate quality report for BC Hydro as part of their requirements under the Water Use Plan (WUP) as part of ongoing evaluations of substrate conditions in salmonid spawning and rearing habitat in the Lower Coquitlam River. To evaluate the effectiveness of flushing flows and their effectiveness of improving substrate quality in the Lower Coquitlam River surficial fines and subsurface <10.0 mm substrates were measured in the laboratory as percentage (%) particle size. Six (6) replicate samples were collected at each sample location and mean values were used for each site surveyed over these periods of assessment (October 2012, January 2013 and May 2013). Site 1 is the most downstream location and Site 6 the most upstream location.

Data collected to date indicates that surficial sediment provides sufficient data from which to assess substrate quality used by salmonids for spawning and rearing habitat and effectiveness of discharge at cleaning those substrates. Overall surficial substrate consisted of higher percent (%) particle size clay and silt in October 2012 (2.40% ±1.06% to 7.12% ±3.15% and 4.30% ±3.41% to 11.33% ±3.74%, respectively; Appendix 3; Table A2-A3) and January 2013 (1.78% ±1.43% to 6.57% ±5.25% and 4.93%±3.95% to 22.15±17.72%, respectively; Appendix 3; Table A2-A3) coinciding when the Lower Coquitlam River discharge was highest. Lowest mean percent (%) values clay and silt in May 2013 (2.13% ±1.71% to 8.82% ±7.05 and 7.77% ±6.21% to 21.50% ±17.20%, respectively; Appendix 3; Table A2-A3) and occurred while river discharge was at its lowest.

Subsurface sediments sieved through a 10.0 mm sieve and analytically analyzed for particle size distribution of clay, silt sand and gravel indicated that gravel was dominant with sand being subdominant at Sites 1 through 6 over three (3) time periods (October 2012, January 2013 and May 2013). The lowest mean percent (%) gravel occurred at Site 2 in October 2012 and January 2013. Highest mean percent (%) sand was noted at Site 1 and Site 2, while the lowest mean sand percent (%) was found at Site 5. Given this is the first year of sampling there was limited data from with which to draw conclusions as to whether flushing events are successful at mobilizing sediments and whether sediment particle size profiles at each site are due to discharge or a reflection of other environmental factors. Subsequent years of study will improve the resolution and ability to draw conclusions.

Applied methods appeared effective to date and future sampling events should continue with these methods:

- surficial sediment collection using a modified Hess sampler;
- visual embeddedness estimates;
- photographic support of embeddedness; and,
- D50 & D95 measurements.

5.0 REFERENCES

BC Hydro, 2005. Coquitlam-Buntzen Water Use Plan: Monitoring program terms of reference, Burnaby, BC.

BC Hydro, 2003a. Lower Coquitlam River 2003 Instream flow needs assessment: interim report on transect data collection. Prepared for the BC Hydro Coquitlam Dam Water Use Plan project, Burnaby, BC.

BC Hydro, 2002. Coquitlam Dam Water Use Plan Consultative Report. Prepared for the BC Hydro Coquitlam Dam Water Use Plan project, Burnaby, BC.

BC Hydro, 2005. Coquitlam-Buntzen Water Use Plan: Monitoring Program Terms of Reference. Prepared for the BC Hydro Coquitlam Dam Water Use Plan project, Burnaby, BC.

BC MWLAP, 2002. Guidelines for Monitoring Fine Sediment Deposition in Streams. BC

Bjornn, T., C. Reiser, D., W, 1991. Habitat Requirements of salmonids in streams. Influences of forest and rangeland management on salmonid fishes and their habitat. American Fisheries Society. Special Publication 19.

Church, M., A. McLean, D., G & Wolcott, J., F, 1987. River Bed Gravels: Sampling and Analysis. Sediment Transport in Gravel-Bed Rivers. Ed. C. R. Thorne, J. C.Bathurst, and R. D. Hey. John Wiley and Sons, 1987. 43-88.

Descloux, S., Datry, T., Philippe, M. and Marmonier, P. 2010. Comparison of Different Techniques to Assess Surface and Subsurface Streambed Colmation with Fine Sediments. International Review of Hydrobiology. 95:520–540.

Fritz, M., S. and D., P MacKinnon. 2007. Required sample size to detect the mediated effect. Psychology Science, In Press

Helsel, D., R, 2012. Statistics for Censored Environmental Data Using Minitab and R. 324p

Hoenig, J., M. Heisey, D., M, 2001. The Abuse of Power: The Pervasive Fallacy of Power Calculations in Data Analysis. The American Statistician, 55: 19-24.

Keeley E.R., and P.A. Slaney. 1996. Quantitative measures of rearing and spawning habitat characteristics for stream-dwelling salmonids: guidelines for habitat restoration. Province of British Columbia, Ministry of Environment, Lands and Parks, and Ministry of Forests. Watershed Restoration Project Report 4: 34 p.

Ministry of Environment (MOE). 2008. Reconnaissance (1:20,000) Fish and Fish Habitat Inventory Site Card Field Guide. 41p

NHC, 2012. Coquitlam River 2011 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 25p + appendices

NHC, 2010. Coquitlam River 2009 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 19p + appendices

NHC, 2008. Coquitlam River 2007 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 28p + appendices

NHC, 2007. Coquitlam River 2006 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 26p + appendices

NHC, 2006. Coquitlam River 2003 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 26p + appendices

NHC, 2004. Coquitlam River 2003 Substrate Monitoring Program. Prepared for BC Hydro and Power Authority, Burnaby, BC. 27p + appendices

NHC. 2001. Coquitlam River channel morphology and substrate condition study. Prepared for BC Hydro and Power Authority, Burnaby, BC. 35p + appendices

Quilty, E. 2003. Water Quality Objectives Attainment Monitoring for the Coquitlam River in 2002. Report prepared by QA Environmental Consulting for the Environmental Quality Section. Ministry of Water, Land and Air Protection. , Lower Mainland Region.

Schuett-Hames, D. Pleus, A, 1996. Salmonid Spawning Habitat Availability: A Literature Review with Recommendations for a Watershed Analysis Monitoring. 32p

Sneath, P., H.,A. Sokal, R., R, 1973. Numerical taxonomy: The principles and practice of numerical classification. 573p

Sylte, T and C. Fischenich. 2003. Assessment Methods for Measuring Embeddedeness Measurements. StreamNotes. www.Stream.FS.Fed.US/news/index.html

Tappel, P and T. Bjornn, 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135

Zar, J., H. 1999. Biostatistical Analysis 4th Edition. 663p

Appendices

Appendix 1: Figures
Appendix 2: Photographs
Appendix 3: Tables
Appendix 4: Charts
Appendix 5: Status of Tasks to be Completed
Appendix 6: Raw Laboratory Data & QA/QC

Appendix 1

Figures

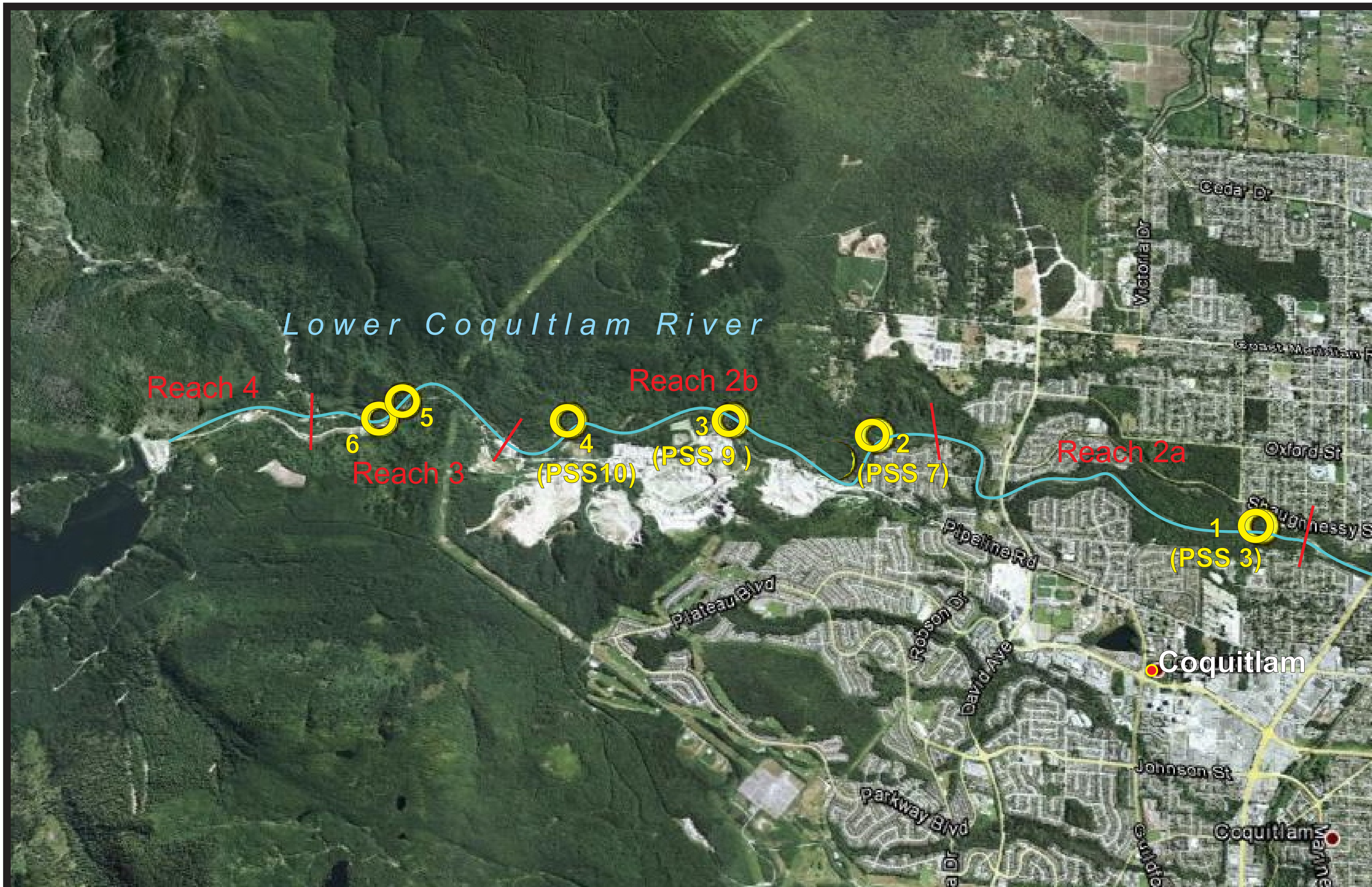

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Figure A1: COQMON Overview Map
Imagery: 2013 © Digital Globe
Creation Date: 1 November 2013, by MT

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Figure 2: Water Level Logger Locations
Imagery: 2013 © Digital Globe
Creation Date: 1 November 2013, by MT

0 250 1,250 2,500
Metres

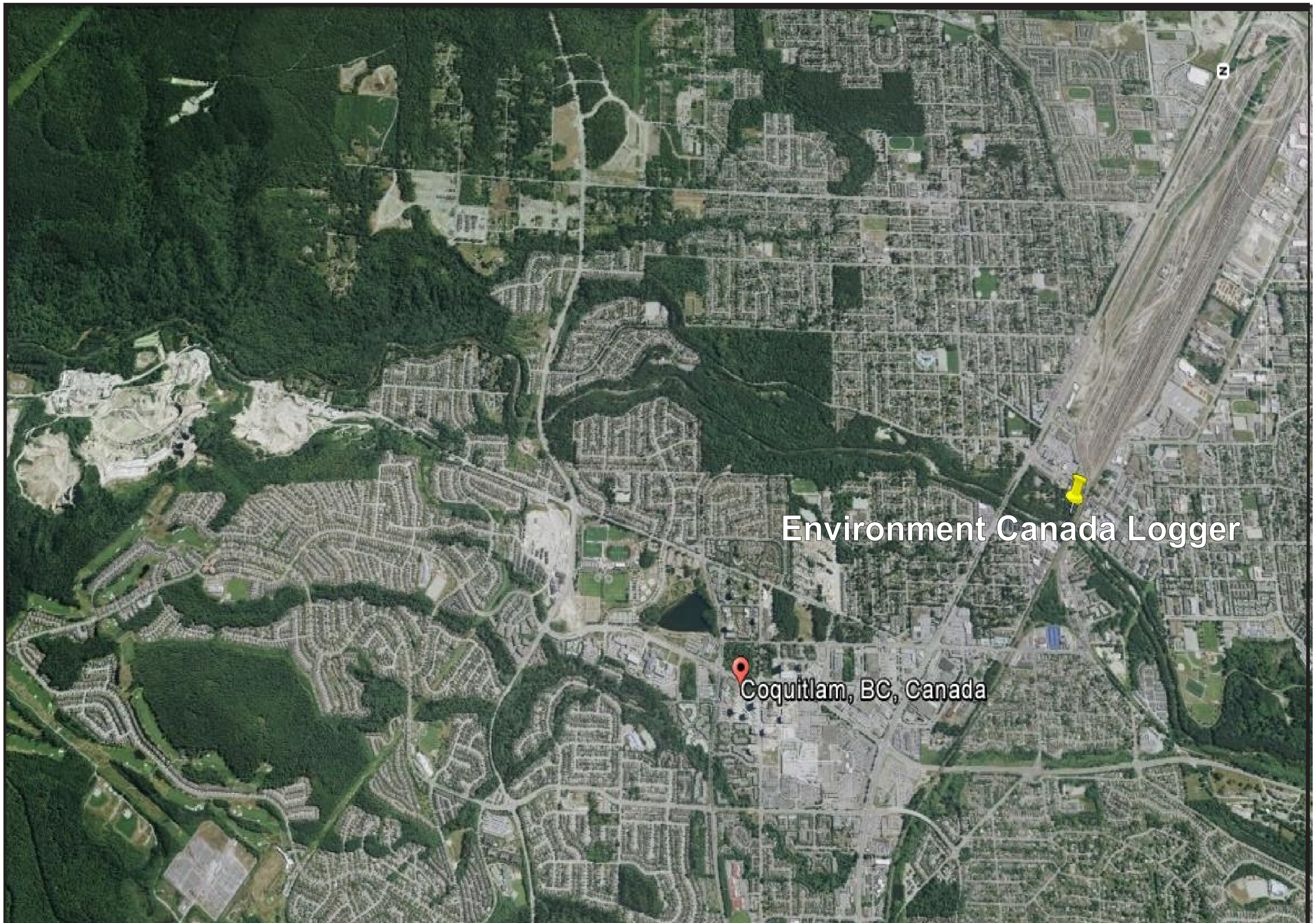

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Figure A3: Location of Environment
Canada discharge logger
Imagery: 2013 © Digital Globe
Creation Date: 1 November 2013, by MT

0 100 600 1200
Metres

Appendix 2

Photographs

Photographs A1-6

Photo A1: Water Logger Submerged and cabled to Cinder Block at Reach 3

Photo A2: Logger located at Reach 2b

Photo A3: Site 1

Photo A4: Sample preparation October 2012

Photo A5: Sampling January 2013

Photo A6: Sampling January 2013

Photographs A7-12

Photo A7: Sampling January 2013

Photo A8: Subsurface sample inside Hess Sampler.

Photo A9: Hess Sampler in river substrate, facing upstream to aid flushing of fines from sample into downstream funnel

Photo A10: Sample identification placed in pre-labeled pail with sample

Photo A11: Hess Sampler being churned over 20 times with trowel

Photo A12: D50 and D95 substrate being selected for measurements

Photographs A13-18

Photo A13: Modified Hess Sampler with 20 micron mesh to prevent loss of fine particles

Photo A14: Surface sediment flushed and collected into a 20 µm filter

Photo A15: Salmonid eggs located in the Lower Coquitlam River

Photo A16: Salmonids spawning in Lower Coquitlam River

Photo A17: Drying rack used to prepare sample for seiving

Photo A18: Subsurface samples placed on clean polyethylene sheets on drying rack

Photographs A19-24

Photo A19: Labeled subsurface samples in drying rack. Cell location and sample recorded

Photo A20: Labeled sample in drying rack

Photo A21: Subsurface <10 mm sample weighed before sending to laboratory for particle size analysis

Photo A22: Subsurface > 10 mm being volumetrically assessed

Appendix 3

Tables

Table A1: Mean Percent (%) Sand in Surficial Samples (October 2012 - May 2013)			
Site	October 2012	January 2013	May 2013
	Mean (% ± SD)	Mean (% ± SD)	Mean (% ± SD)
1	86.83 (±11.35)	92.00 (±1.41)	81.17 (±21.57)
2	89.67 (±6.18)	85.83 (±3.93)	84.83 (±3.62)
3	81.67 (±2.75)	71.33 (±12.30)	71.00 (±14.55)
4	87.50 (±1.98)	82.33 (±7.25)	85.67 (±5.15)
5	86.00 (±8.74)	83.00 (±3.27)	89.33 (±4.82)
6	91.67 (±5.47)	91.50 (±4.11)	69.67 (±7.91)

(SD=Standard Deviation, N = 6)

Table A2: Mean Percent (%) Clay in Surficial Samples (October 2012 - May 2013)			
Site	October 2012	January 2013	May 2013
	Mean (% ± SD)	Mean (% ± SD)	Mean (% ± SD)
1	5.40 (±8.04)	3.15 (±2.52)	5.32 (±4.25)
2	2.40 (±1.06)	3.38 (±2.71)	3.43 (±2.75)
3	7.12 (±3.15)	6.57 (±5.25)	8.80 (±7.04)
4	3.90 (±1.54)	3.78 (±3.03)	2.13 (±1.71)
5	4.92 (±2.71)	4.27 (±3.41)	2.95 (±2.36)
6	4.12 (±2.82)	1.78 (±1.43)	8.82 (±7.05)

(SD=Standard Deviation, N = 6)

Table A3: Mean Percent (%) Silt in Surficial Samples (October 2012 - May 2013)			
Site	October 2012	January 2013	May 2013
	Mean (% ± SD)	Mean (% ± SD)	Mean (% ± SD)
1	7.87 (±5.53)	4.93 (±3.95)	13.77 (±11.02)
2	8.10 (±5.79)	11.15 (±8.92)	12.03 (±9.63)
3	11.33 (±3.74)	22.15 (±17.72)	20.25 (±16.20)
4	8.63 (±2.19)	13.95 (±11.16)	12.17 (±9.74)
5	9.02 (±6.02)	12.73 (±10.19)	7.77 (±6.21)
6	4.30 (±3.41)	6.78 (±5.43)	21.50 (±17.20)

(SD=Standard Deviation, N = 6)

Table A4: Mean Monthly Discharge m^3/s (1993-2013) Lower Coquitlam River												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
1993	4.64	2.15	5.91	6.88	4.38	2.37	1.40	0.90	0.80	1.98	3.97	7.37
1994	8.33	6.11	8.88	4.95	3.24	3.11	2.02	1.29	1.80	4.18	6.76	11.70
1995	7.37	9.21	6.84	3.90	4.21	2.80	2.28	3.52	2.06	8.22	32.30	29.10
1996	13.20	5.64	3.33	7.80	3.80	1.74	1.45	1.39	2.82	7.99	6.47	5.26
1997	9.07	5.25	10.20	7.54	7.10	4.82	4.62	1.76	4.80	20.30	7.76	7.33
1998	8.57	6.70	5.79	3.41	4.55	2.59	1.99	0.96	0.95	4.34	17.90	18.00
1999	11.10	8.15	6.06	4.73	6.78	8.24	7.64	4.26	2.51	6.63	13.20	10.20
2000	5.03	4.55	5.81	5.13	8.95	7.42	3.98	2.80	3.52	4.64	4.34	5.04
2001	5.41	3.08	4.77	5.46	5.65	3.93	2.17	4.36	2.34	5.61	7.85	12.30
2002	17.30	7.58	4.57	8.99	7.21	6.83	2.84	1.63	2.07	1.62	17.00	5.78
2003	9.23	3.97	9.73	6.57	3.58	2.45	1.96	1.43	1.55	30.17	19.60	11.50
2004	9.64	4.76	6.40	4.41	4.71	3.19	2.01	2.82	3.65	5.20	9.95	48.20
2005	34.70	7.29	5.76	8.33	4.15	3.27	2.88	1.68	2.39	7.16	6.52	10.50
2006	27.80	5.47	4.51	6.79	8.03	4.55	2.02	1.60	1.64	3.23	50.70	6.83
2007	11.50	6.31	31.5	7.65	5.59	5.54	6.40	2.48	2.22	9.19	32.10	26.00
2008	5.55	4.60	4.39	4.07	9.02	5.41	2.94	4.15	2.00	5.48	13.30	9.83
2009	10.90	8.12	9.50	9.22	10.3	5.91	4.58	6.18	4.72	10.30	22.10	10.90
2010	17.90	7.74	8.00	8.71	7.85	12.80	2.52	3.26	10.80	12.60	8.42	12.90
2011	20.90	7.18	10.20	8.13	10.00	6.57	5.42	4.15	9.70	15.40	10.00	9.05
2012	11.10	7.49	9.21	8.91	7.40	7.10	4.17	3.44	2.62	22.60	21.30	12.10
2013	8.16	7.39	16.50	10.90	8.84	4.49	1.93	3.06	5.43	8.33	7.74	

Table A5: Mean Percent (%) Gravel in Subsurface Samples (October 2012-May 2013)			
Site	**October 2012**	**January 2013**	**May 2013**
	Mean	**Mean**	**Mean**
1	64.17 (±12.07)	51.33 (±7.23)	59.00 (±7.24)
2	46.33 (±7.41)	58.00 (±14.25)	57.33 (±5.59)
3	64.17 (±13.64)	71.50 (±9.57)	55.33 (±10.58)
4	66.17 (±14.17)	68.50 (±10.94)	62.67 (4.82)
5	69.00 (±10.23)	76.83 (±15.26)	61.00 (±6.23)
6	59.17 (±9.32)	61.00 (±9.73)	58.67 (±9.27)

(SD=Standard Deviation, N = 6)

Table A6: Mean Percent (%) Sand in Subsurface Samples (October 2012-May 2013)			
Site	October 2012	January 2013	May 2013
	Mean	Mean	Mean
1	35.17 (± 12.37)	47.83 (±7.20)	36.00 (±7.13)
2	52.67 (±7.54)	41.33 (±14.19)	38.33 (±5.82)
3	34.67 (±13.63)	27.33 (±9.41)	41.17 (±9.99)
4	32.50 (±13.79)	30.67 (±10.98)	34.33 (±4.82)
5	29.67 (±10.51)	22.40 (±15.47)	36.20 (±6.24)
6	39.50 (±9.67)	37.83 (±9.94)	38.83 (±8.63)

(SD=Standard Deviation, N = 6)

Appendix 4

Charts

A1: Yearly Discharge m^3/s of Coquitlam River (1993 – 2013)
A2: Monthly Discharge m^3/s of Coquitlam River (1993-2013)
A3: Mean Surficial Particle Size Percentage (%) October 2012 – May 2013
A4: Mean Surficial Particle Size Percentage (%) October 2012
A5: Mean Surficial Particle Size Sand Percentage (%) October 2012 – May 2013
A6: Mean Clay Surficial Particle Size Percentage (%) October 2012 – May 2013
A7: Mean Silt Surficial Particle Size Percentage (%) October 2012 – May 2013
A8: Mean Percentage (%) of Sand and Gravel <10mm, in Subsurface samples October 2012 – May 2013
A9: Mean Gravel Percentage (%) <10mm, in Subsurface samples October 2012-May 2013
A10: Mean Sand and Gravel Percentage (%) <10mm, in Subsurface samples October 2012
A11: Mean Subsurface Sand and Gravel Percentage (%) <10mm, in Subsurface samples May 2013
A12: Mean Subsurface Sand and Gravel Percentage (%) <10mm, in Subsurface samples October 2012 – May 2013

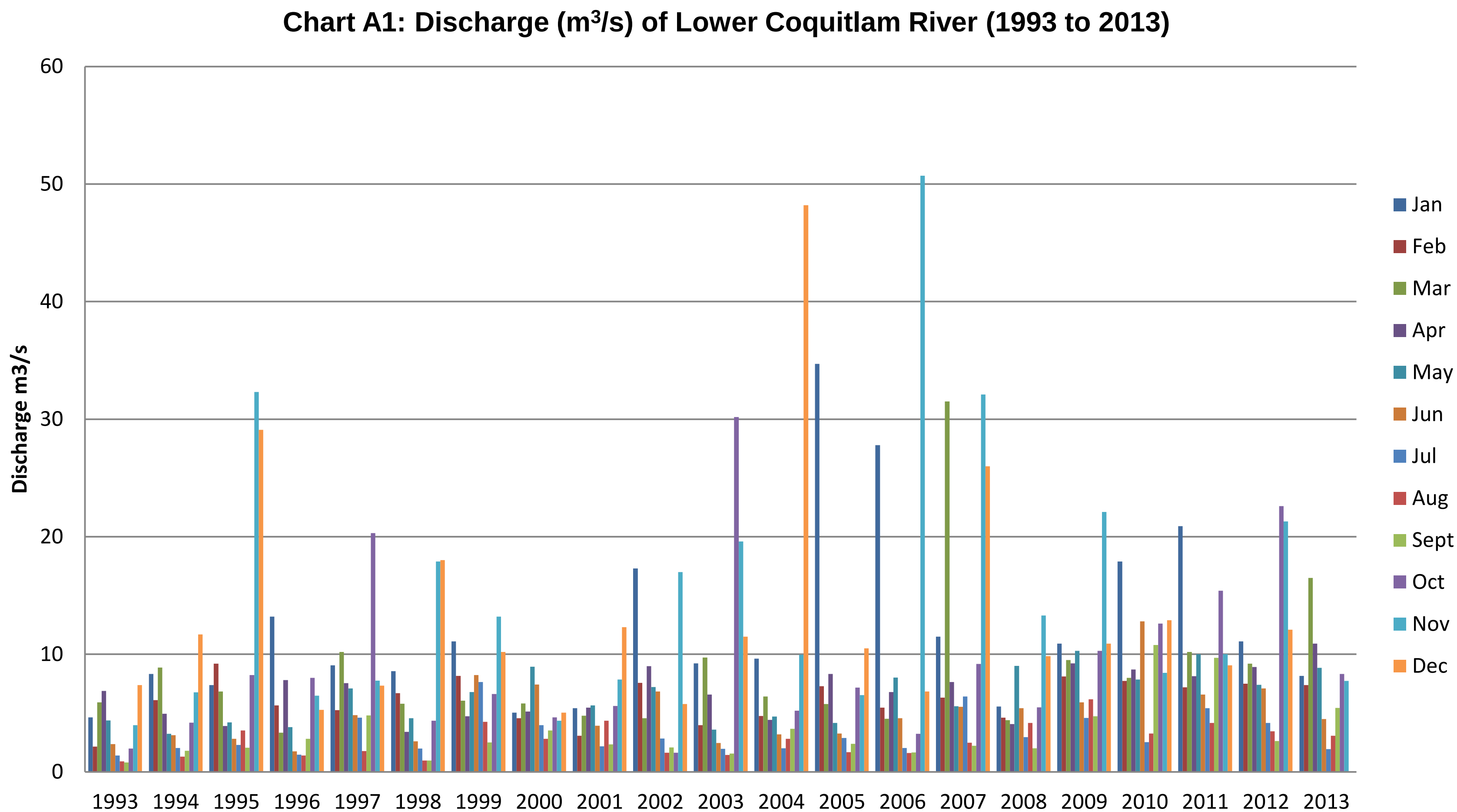
Chart A1: Discharge (m3/s) of Lower Coquitlam River (1993 to 2013)
Discharge m3/s
60
50
40
30
20
10
0
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
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Jan
Feb
Mar
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Jul
Aug
Sept
Oct
Nov
Dec

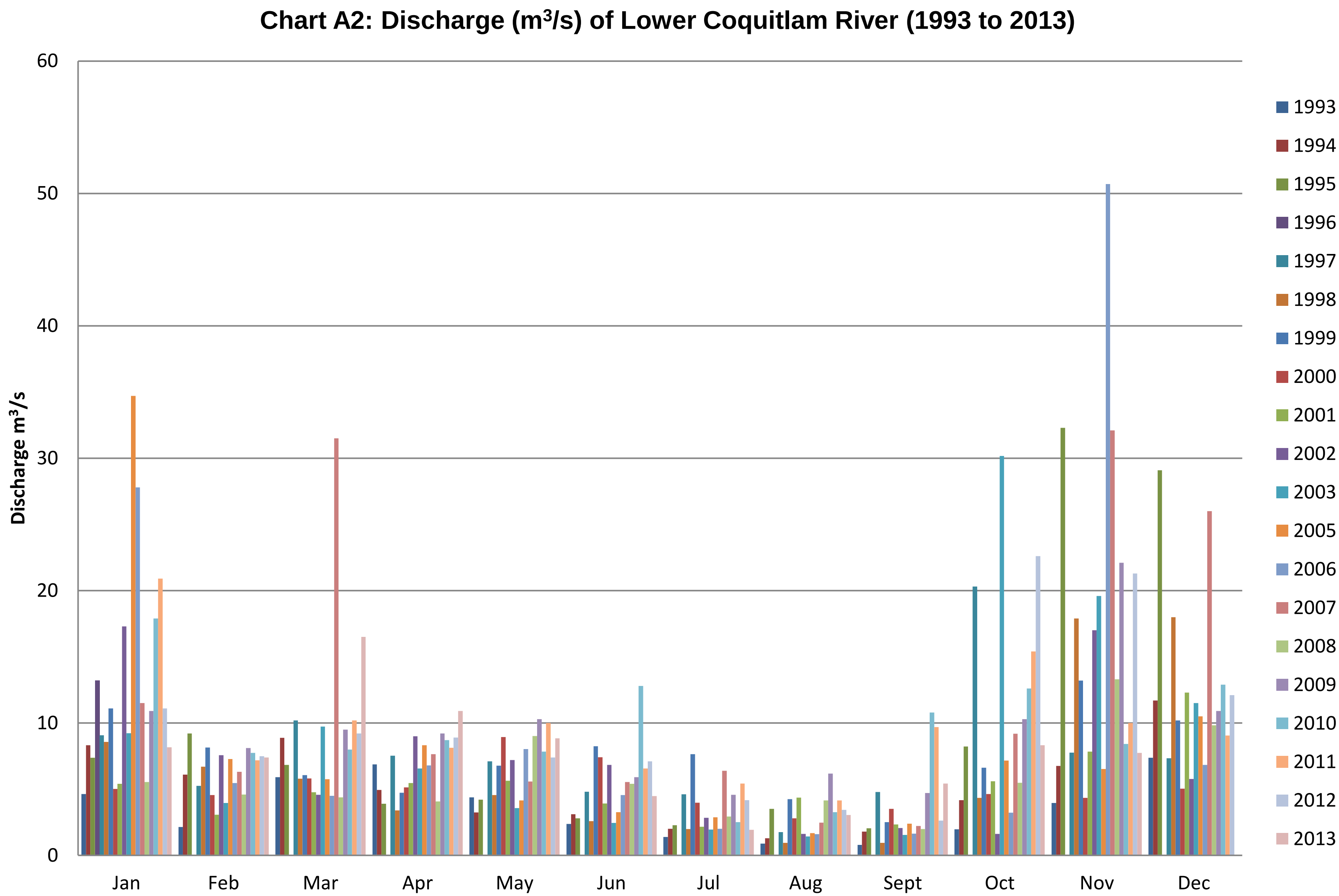


Chart A2: Discharge (m³/s) of Lower Coquitlam River (1993 to 2013)
Discharge m³/s
0
10
20
30
40
50
60
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2005
2006
2007
2008
2009
2010
2011
2012
2013

Chart A3: Mean Percent (%) Particle Size Distribution in Surficial Samples (October 2012 - May 2013)

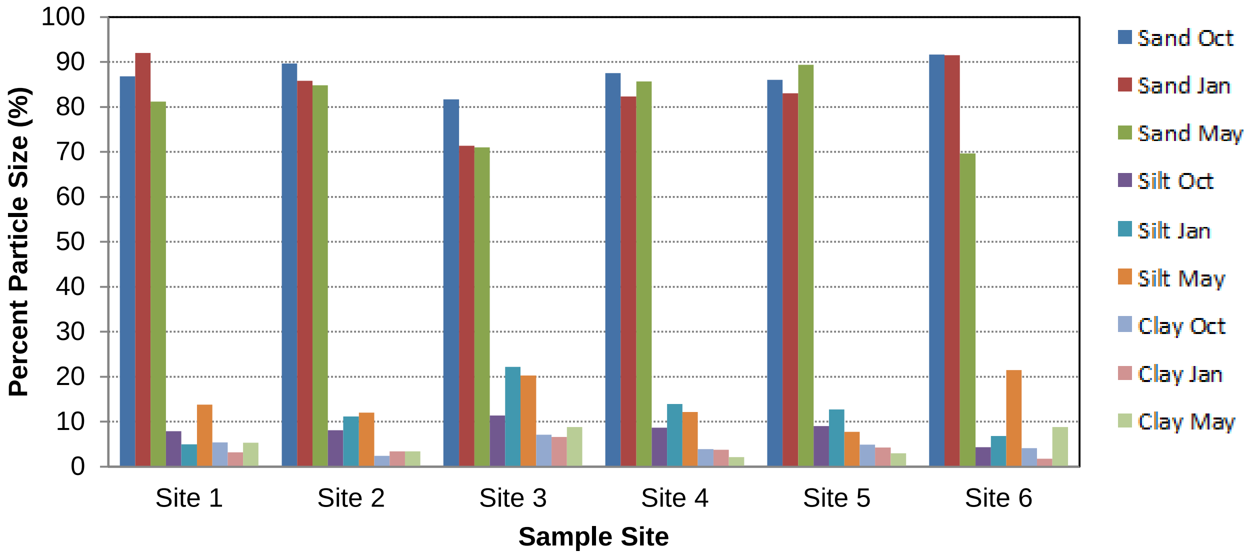
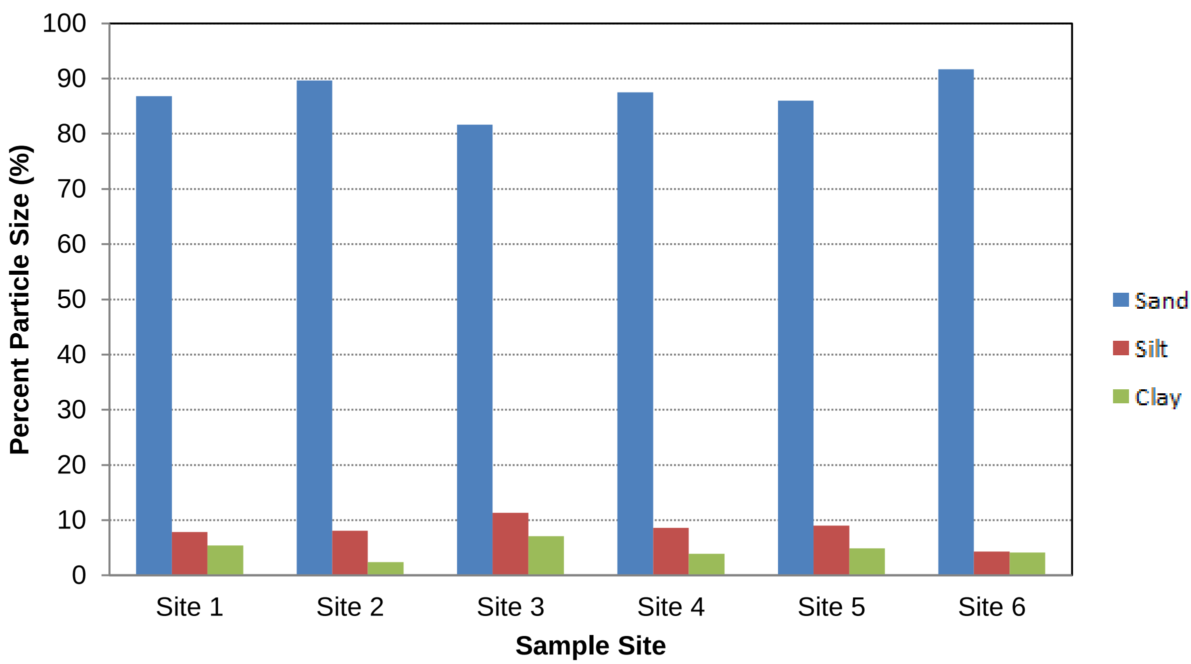


Chart A4: Mean Percent (%) Particle Size Distribution in Surficial Samples (October 2012)



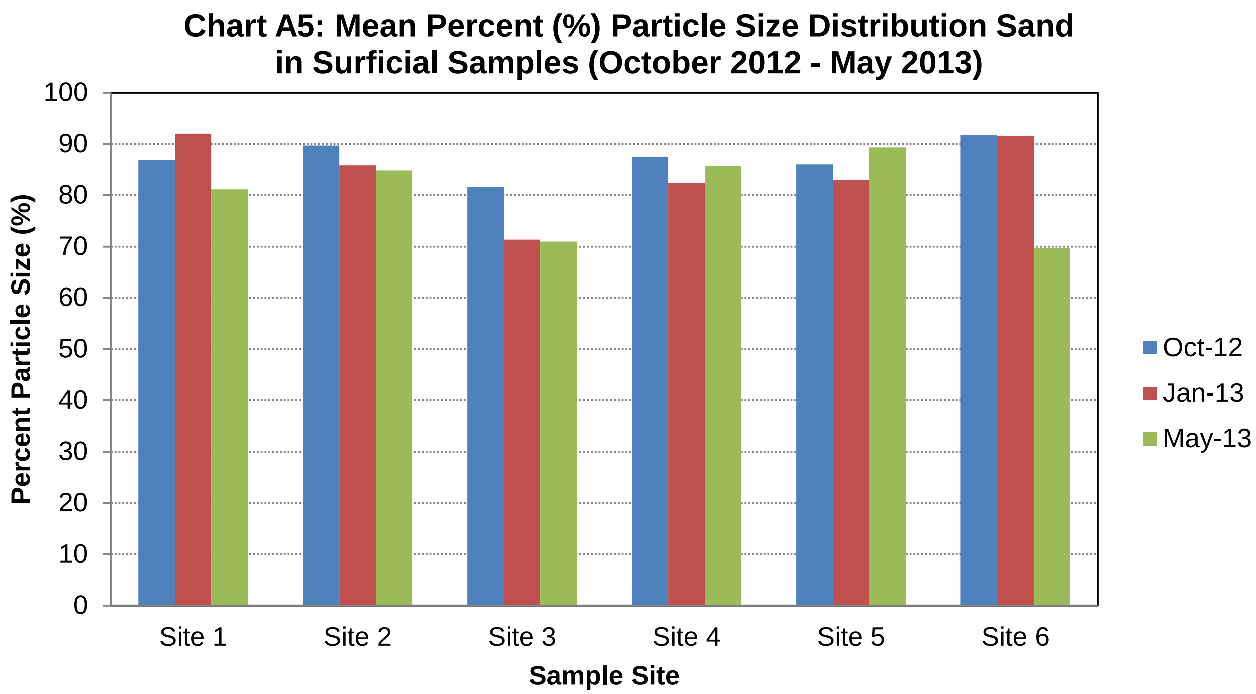


Chart A5: Mean Percent (%) Particle Size Distribution Sand in Surficial Samples (October 2012 - May 2013)
Percent Particle Size (%)
100
90
80
70
60
50
40
30
20
10
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Sample Site
Oct-12
Jan-13
May-13

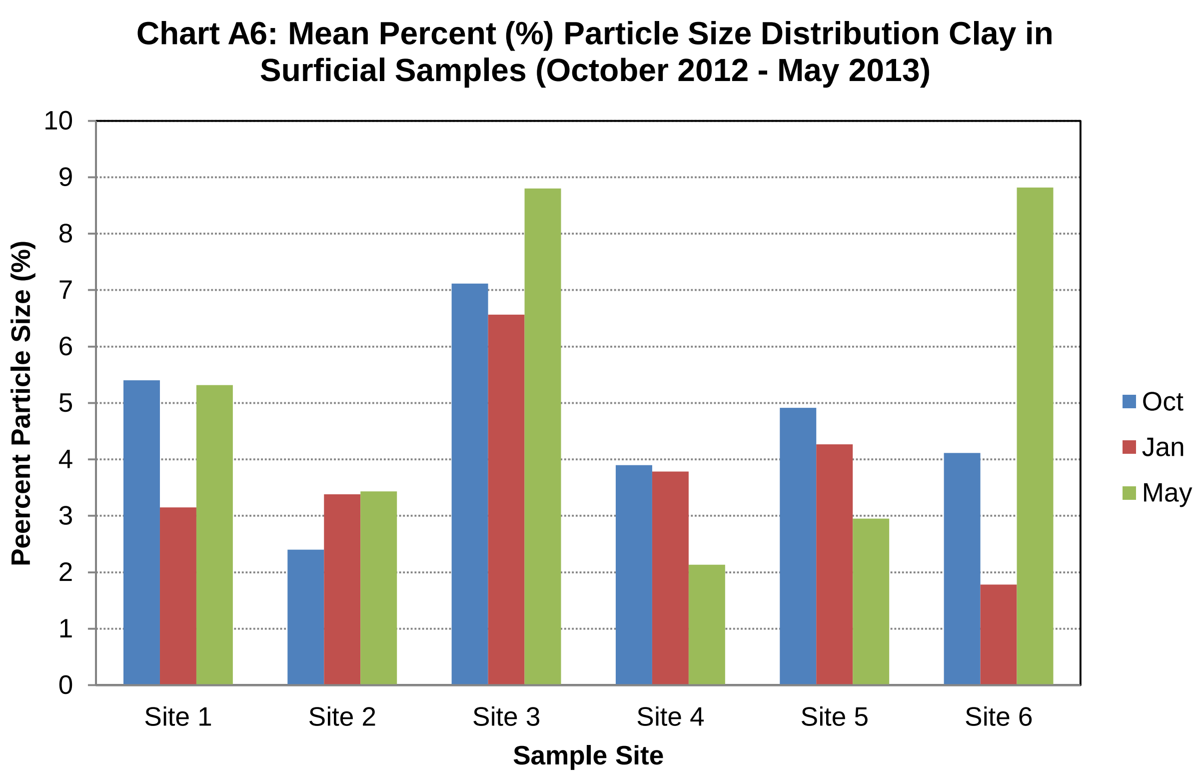


Chart A6: Mean Percent (%) Particle Size Distribution Clay in Surficial Samples (October 2012 - May 2013)
Peercent Particle Size (%)
10
9
8
7
6
5
4
3
2
1
0
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Sample Site
Oct
Jan
May

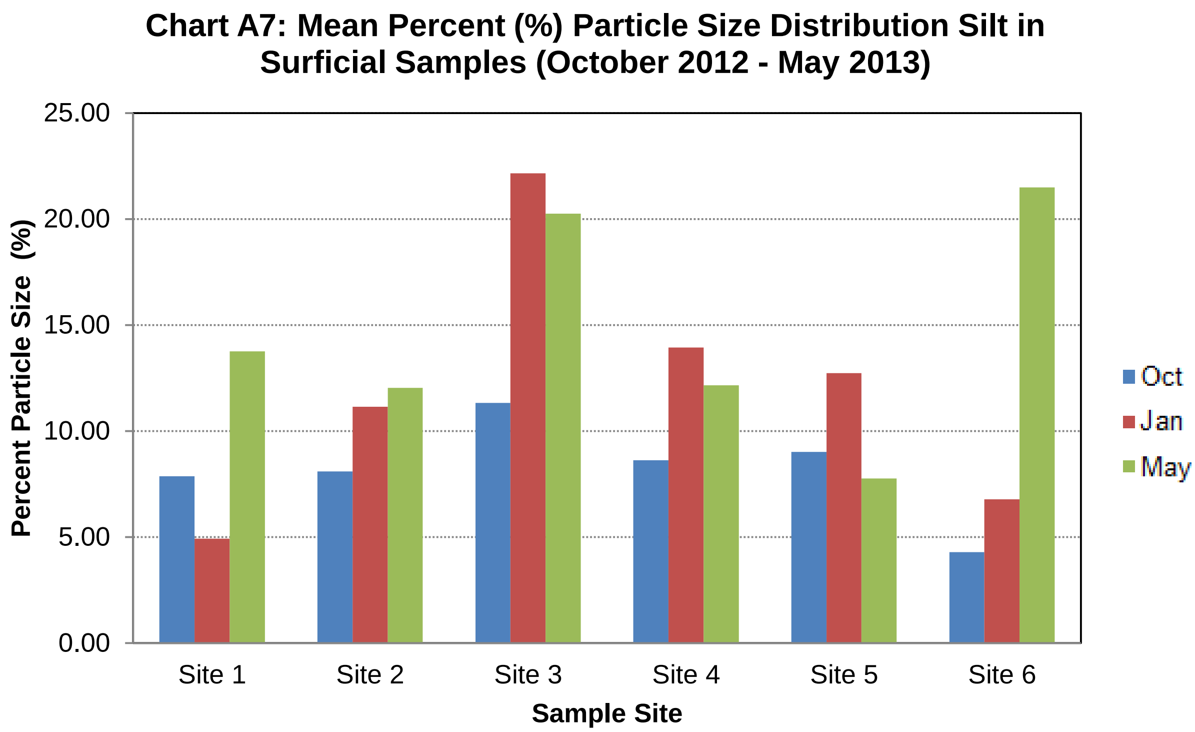


Chart A7: Mean Percent (%) Particle Size Distribution Silt in Surficial Samples (October 2012 - May 2013)
25.00
20.00
15.00
10.00
5.00
0.00
Percent Particle Size (%)
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Sample Site
Oct
Jan
May

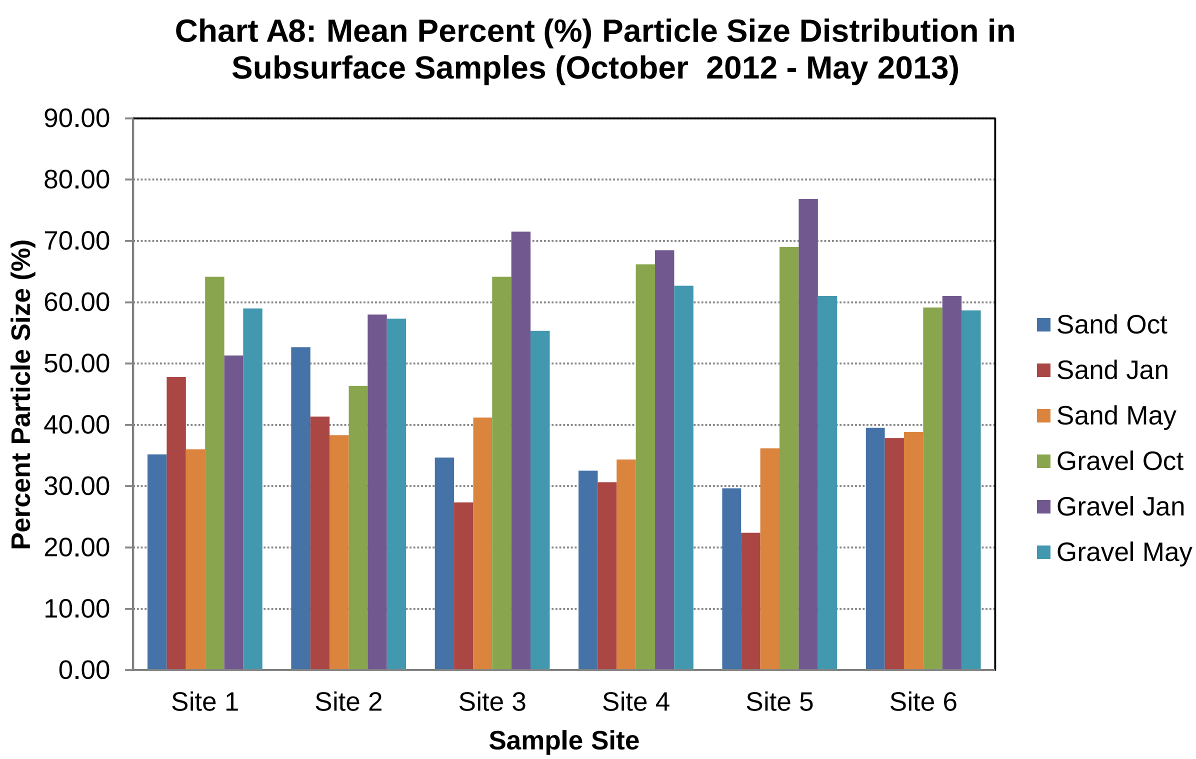


Chart A8: Mean Percent (%) Particle Size Distribution in Subsurface Samples (October 2012 - May 2013)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Percent Particle Size (%)
Site 1
Site 2
Site 3
Site 4
Site 5
Site 6
Sample Site
Sand Oct
Sand Jan
Sand May
Gravel Oct
Gravel Jan
Gravel May

Chart A9: Mean Percent (%) Particle Size Distribution Gravel in Subsurface Samples (October 2012 - May 2013)

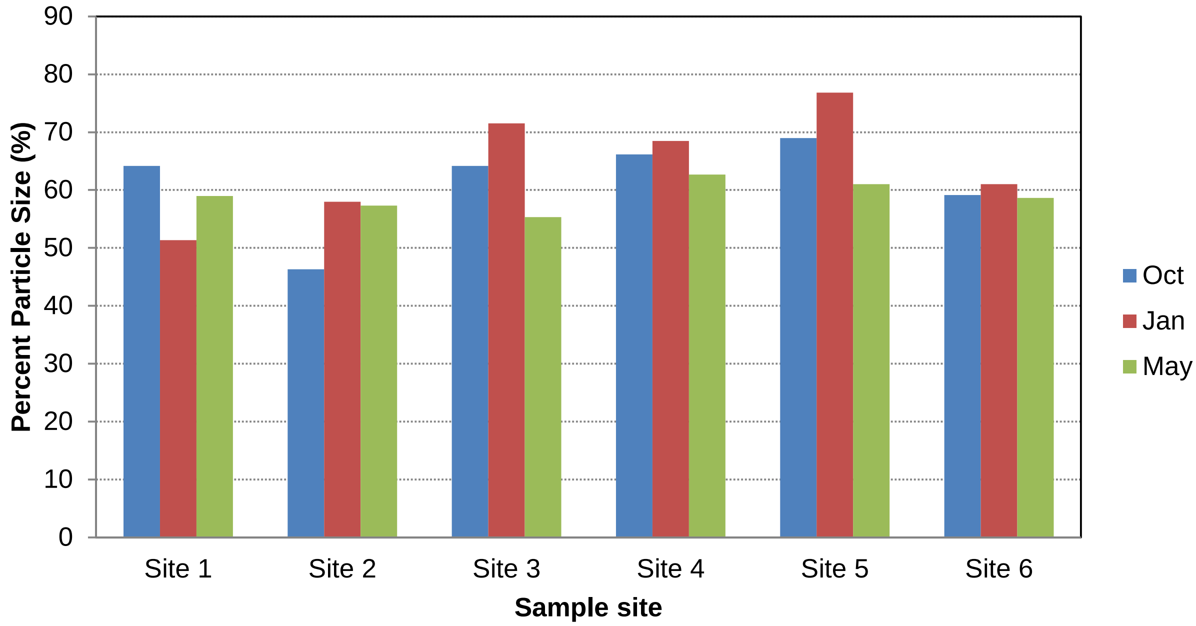


Chart A10: Mean Percent (%) Particle Size Distribution Sand & Gravel in Subsurface Samples (October 2012)

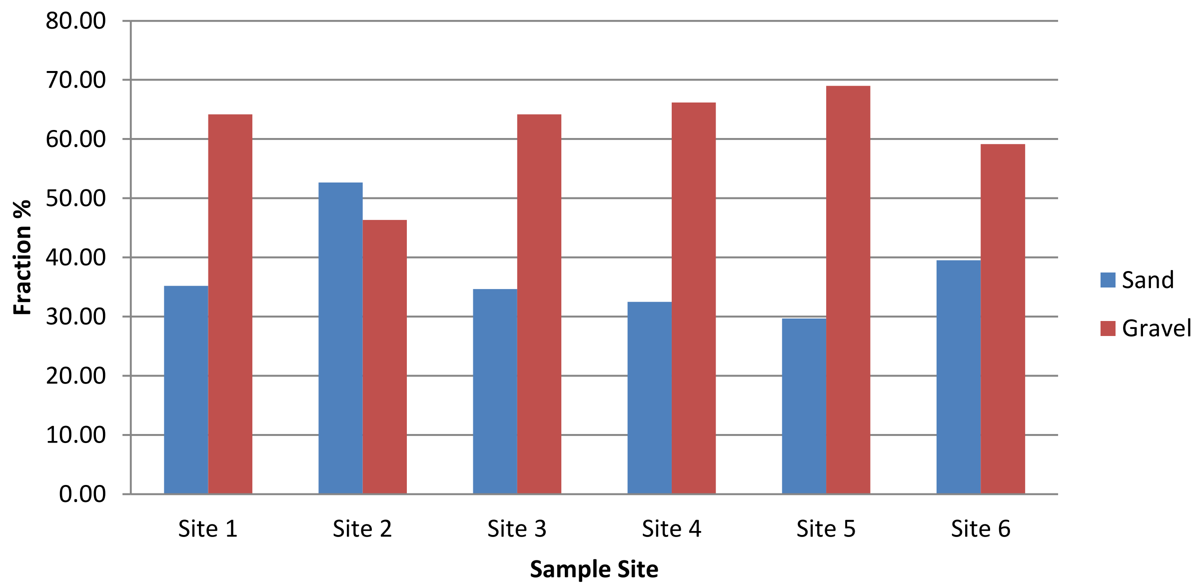


Chart A11: Mean Percent (%) Particle Size Sand & Gravel in Subsurface Samples (January 2013)

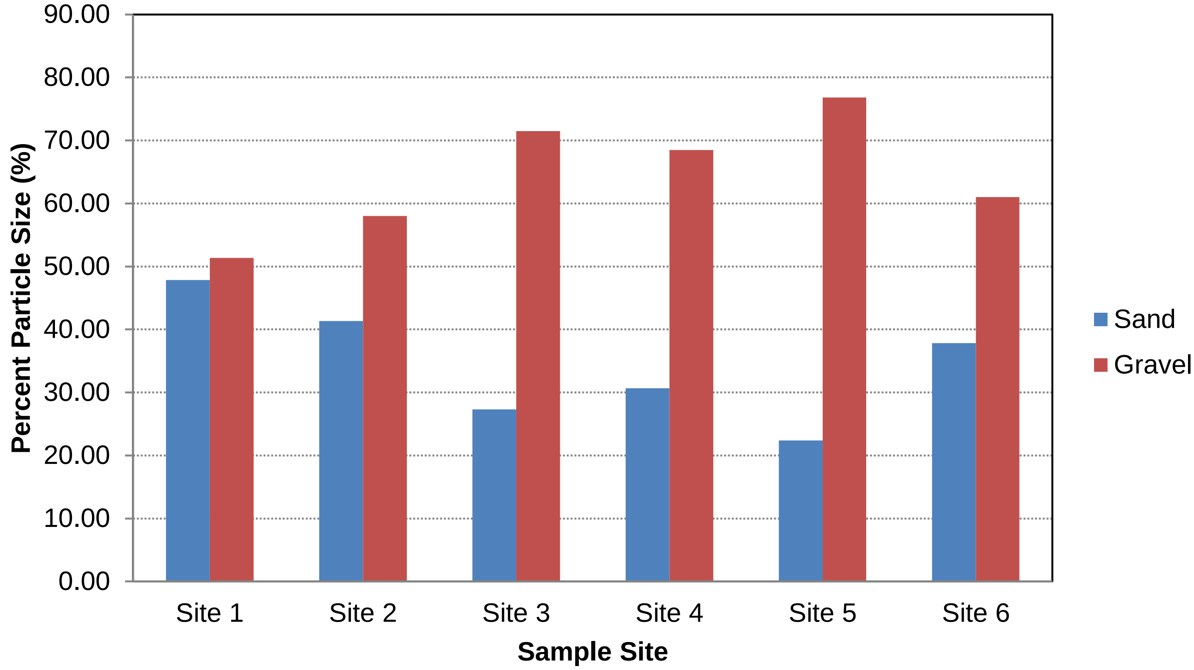


Chart A12: Mean Percent (%) Particle Size Distribution Sand & Gravel in Subsurface Samples (May 2013)

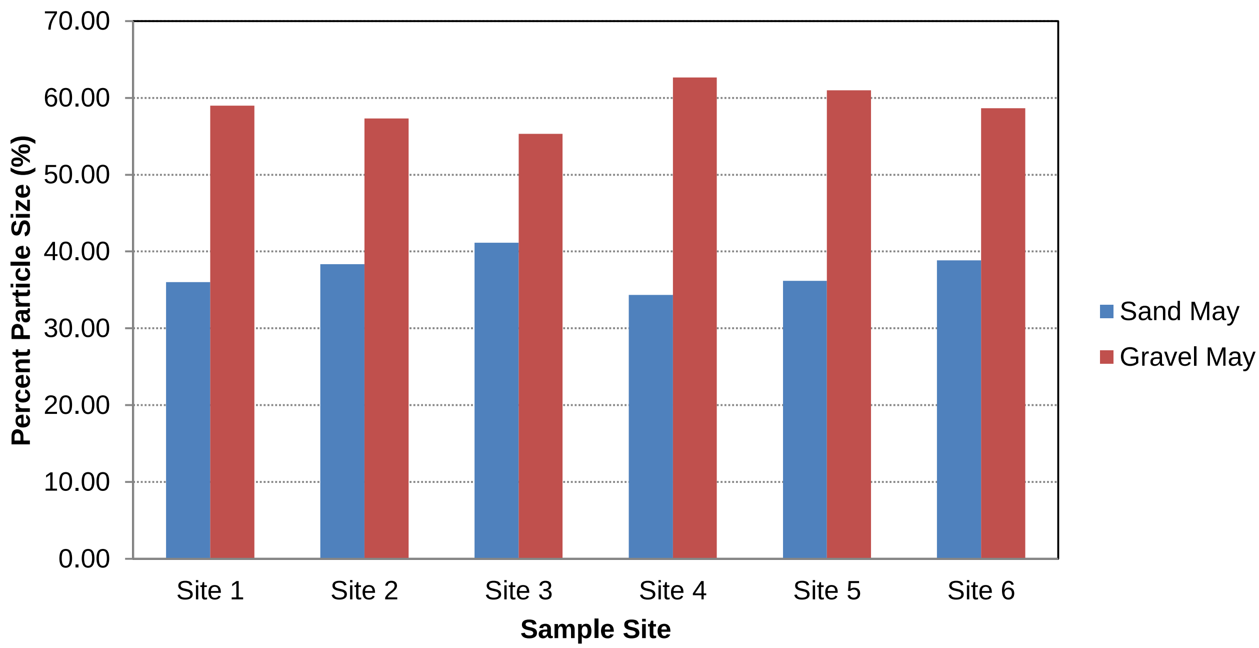
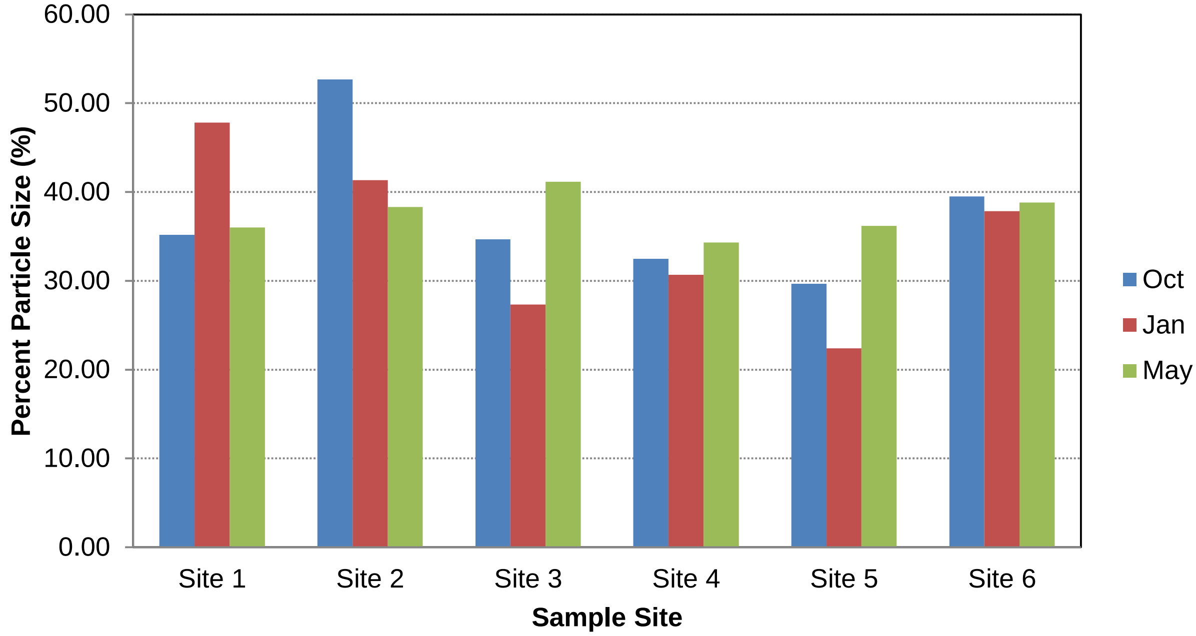


Chart A13: Mean Percent (%) Particle Size Distribution Sand in Subsurface Samples (October 2012 - May 2013)



Appendix 5

Status of Tasks to be Completed

Status of Tasks to be Completed (2012-2014)

Task	Status	Estimated Date of Completion
Task 1: Project Management		
• Project start-up, meetings with BC Hydro	Completed	October 2012
• Establish schedule and milestones	Completed	October 2012
Task 2: Field Reconnaissance Survey		
• Locate previous study locations	Completed	October 2012
• Identify salmon spawning and rearing locations	Completed	October 2012
• Establish permanent site markers	Completed	October 2012
• Install water level loggers (2)	Completed	December 2012
• Habitat assessment	Completed	October 2013
Task 3: Field Collections (2012-2014)		
• October 2012	Completed	October – December 2012
• February 2013	Completed	February 2013
• May 2013	Completed	May 2013
• October 2013	Completed	October , 2013
• January 2014	Pending	January 20, 2014
• May 2014	Pending	May 6, 2014
• September 2014	Pending	September 2, 2014
Task 4: Sample Processing (2012-2014)		
• October 2012	Complete	Complete
• February 2013	Complete	Complete
• May 2013	Complete	Complete
• October 2013	In Progress	In Progress
• January 2014	Pending	Jan 16 – Mar 15 2014
• May 2014	Pending	May 9 – Jul 25 2014
• September 2014	Pending	Sept 5 – Nov 15 2014
Task 5: Data Entry, Analysis and Interpretation		
Conduct data review, assimilation, entry to excel for processing and stats, interpretation and reporting 2013	In Progress	Late May – Late November 2013
Conduct data review, assimilation, entry to excel for processing and stats, interpretation and reporting 2014	Pending	Late May – Late November 2014
Task 7: Reporting		
Status update	In Progress	Oct 31, 2013
Draft Annual Report in Word Format as per proposal and Terms of Reference	Pending	Nov 15, 2013
Final Annual Report: incorporating comments and produced as one bookmarked PDF copy and bound hard copies according to Terms of Reference	Pending	Dec 15, 2013

Appendix 6

Raw Laboratory Data
QA/QC data

Surficial Raw Laboratory Data (Percent (%) Particle Size Distribution				
Sample	Sample	Sand (%)	Silt (%)	Clay (%)
1	12PYG338120-1U1S	93	6.6	0.4
2	12PYG338120-1U2S	95	5.3	0
3	12PYG338120-1U3S	97	2.0	1.0
4	12PYG338120-1D1S	79	18	3.5
5	12PYG338120-1D2S	65	12	23
6	12PYG338120-1D3S	92	3.3	4.5
7	12PYG338120-2U1S	76	21	3.2
8	12PYG338120-2U2S	93	5.1	1.9
9	12PYG338120-2U3S	92	6.5	1.5
10	12PYG338120-2D1S	92	5.4	2.9
11	12PYG338120-2D2S	91	5.5	4
12	12PYG338120-2D3S	94	5.1	0.9
13	12PYG338120-3U1S	82	6.8	12
14	12PYG338120-3U2S	86	8.2	5.6
15	12PYG338120-3U3S	81	14	5.2
16	12PYG338120-3D1S	78	18	4
17	12PYG338120-3D2S	79	10	11
18	12PYG338120-3D3S	84	11	4.9
19	12PYG338120-4U1S	84	11	5.4
20	12PYG338120-4U2S	89	8	2.7
21	12PYG338120-4U3S	88	7.1	4.9
22	12PYG338120-4D1S	86	12	2.3
23	12PYG338120-4D2S	90	8	2.2
24	12PYG338120-4D3S	88	5.7	5.9
25	12PYG338120-5U1S	90	5	5
26	12PYG338120-5U2S	70	20	9.4
27	12PYG338120-5U3S	82	11	6.9
28	12PYG338120-5D1S	85	11	4.4
29	12PYG338120-5D2S	98	1	1
30	12PYG338120-5D3S	91	6.1	2.8
31	12PYG338120-6U1S	93	3.4	3.4
32	12PYG338120-6U2S	92	2.7	5.1
33	12PYG338120-6U3S	95	2.6	2.5
34	12PYG338120-6D1S	80	11	9.9
35	12PYG338120-6D2S	93	4.6	2.3
36	12PYG338120-6D3S	97	1.5	1.5
37	12PYG33813J-1U1S	92	6.7	1.3

Surficial Raw Laboratory Data (Percent (%) Particle Size Distribution				
Sample	Sample	Sand (%)	Silt (%)	Clay (%)
38	12PYG33813J-1U2S	93	4.9	2
39	12PYG33813J-1U3S	89	6.2	5.2
40	12PYG33813J-1D1S	93	2.4	4.9
41	12PYG33813J-1D2S	92	4.9	3.3
42	12PYG33813J-1D3S	93	4.5	2.2
43	12PYG33813J-2U1S	82	15	3.3
44	12PYG33813J-2U2S	87	11	2.6
45	12PYG33813J-2U3S	81	18	1
46	12PYG33813J-2D1S	85	12	3.6
47	12PYG33813J-2D2S	93	4.9	2.3
48	12PYG33813J-2D3S	87	6	7.5
49	12PYG33813J-3U1S	82	12	5.6
50	12PYG33813J-3U2S	78	18	4.7
51	12PYG33813J-3U3S	88	8.9	2.6
52	12PYG33813J-3D1S	59	32	9
53	12PYG33813J-3D2S	67	24	8.8
54	12PYG33813J-3D3S	54	38	8.7
55	12PYG33813J-4U1S	87	10	2.7
56	12PYG33813J-4U2S	85	13	2
57	12PYG33813J-4U3S	86	10	3.6
58	12PYG33813J-4D1S	71	23	6
59	12PYG33813J-4D2S	91	5.7	3.4
60	12PYG33813J-4D3S	74	22	5
61	12PYG33813J-5U1S	78	16	5.7
62	12PYG33813J-5U2S	80	14	6.3
63	12PYG33813J-5U3S	82	16	2.6
64	12PYG33813J-5D1S	87	8.4	4.3
65	12PYG33813J-5D2S	86	11	3
66	12PYG33813J-5D3S	85	11	3.7
67	12PYG33813J-6U1S	90	7.4	2.6
68	12PYG33813J-6U2S	93	4.3	2.9
69	12PYG33813J-6U3S	98	1	1
70	12PYG33813J-6D1S	89	9.6	1.4
71	12PYG33813J-6D2S	85	13	2.2
72	12PYG33813J-6D3S	94	5.4	0.6
73	12PYG33813M-1U1S	90	6.1	3.5
74	12PYG33813M-1U2S	91	8.1	0.9

Surficial Raw Laboratory Data (Percent (%) Particle Size Distribution				
Sample	Sample	Sand (%)	Silt (%)	Clay (%)
75	12PYG33813M-1U3S	93	4.9	2.5
76	12PYG33813M-1D1S	89	7.6	3.9
77	12PYG33813M-1D2S	91	8.9	0.1
78	12PYG33813M-1D3S	33	47	21
79	12PYG33813M-2U1S	86	10	4.1
80	12PYG33813M-2U2S	91	6.2	2.5
81	12PYG33813M-2U3S	81	19	0
82	12PYG33813M-2D1S	80	14	7
83	12PYG33813M-2D2S	86	12	2.5
84	12PYG33813M-2D3S	85	11	4.5
85	12PYG33813M-3U1S	91	7.5	1.5
86	12PYG33813M-3U2S	83	13	3.9
87	12PYG33813M-3U3S	62	28	9.7
88	12PYG33813M-3D1S	81	12	7.7
89	12PYG33813M-3D2S	55	32	13
90	12PYG33813M-3D3S	54	29	17
91	12PYG33813M-4U1S	85	13	2.2
92	12PYG33813M-4U2S	77	19	3.6
93	12PYG33813M-4U3S	85	12	2.8
94	12PYG33813M-4D1S	94	5	1
95	12PYG33813M-4D2S	89	10	1
96	12PYG33813M-4D3S	84	14	2.2
97	12PYG33813M-5U1S	85	11	4
98	12PYG33813M-5U2S	81	14	5
99	12PYG33813M-5U3S	95	2.3	2.6
100	12PYG33813M-5D1S	91	6.4	2.5
101	12PYG33813M-5D2S	91	6.8	2.7
102	12PYG33813M-5D3S	93	6.1	0.9
103	12PYG33813M-6U1S	75	20	5.1
104	12PYG33813M-6U2S	69	19	12
105	12PYG33813M-6U3S	64	26	10
106	12PYG33813M-6D1S	57	28	15
107	12PYG33813M-6D2S	71	21	7.1
108	12PYG33813M-6D3S	82	15	3.7

Subsurface Raw Laboratory Data (Percent (%) Particle Size Distribution					
Sample	Sample	Sand (%)	Silt (%)	Clay (%)	Gravel (%)
1	12PYG33812O-1U1B	49	<2.0	<2.0	51
2	12PYG33812O-1U2B	38	<2.0	<2.0	61
3	12PYG33812O-1U3B	10	<2.0	<2.0	89
4	12PYG33812O-1D1B	33	<2.0	<2.0	66
5	12PYG33812O-1D2B	37	<2.0	<2.0	62
6	12PYG33812O-1D3B	44	<2.0	<2.0	56
7	12PYG33812O-2U1B	51	<2.0	<2.0	48
8	12PYG33812O-2U2B	49	<2.0	<2.0	50
9	12PYG33812O-2U3B	59	<2.0	<2.0	39
10	12PYG33812O-2D1B	47	<2.0	<2.0	52
11	12PYG33812O-2D2B	66	<2.0	<2.0	34
12	12PYG33812O-2D3B	44	<2.0	<2.0	55
13	12PYG33812O-3U1B	29	<2.0	<2.0	69
14	12PYG33812O-3U2B	54	<2.0	<2.0	45
15	12PYG33812O-3U3B	28	<2.0	<2.0	72
16	12PYG33812O-3D1B	33	<2.0	<2.0	65
17	12PYG33812O-3D2B	50	<2.0	<2.0	49
18	12PYG33812O-3D3B	14	<2.0	<2.0	85
19	12PYG33812O-4U1B	9	<2.0	<2.0	90
20	12PYG33812O-4U2B	24	<2.0	<2.0	75
21	12PYG33812O-4U3B	51	<2.0	<2.0	47
22	12PYG33812O-4D1B	30	<2.0	<2.0	69
23	12PYG33812O-4D2B	36	<2.0	<2.0	63
24	12PYG33812O-4D3B	45	2	<2.0	53
25	12PYG33812O-5U1B	23	<2.0	<2.0	75
26	12PYG33812O-5U2B	18	<2.0	<2.0	80
27	12PYG33812O-5U3B	45	<2.0	<2.0	54
28	12PYG33812O-5D1B	19	<2.0	<2.0	80
29	12PYG33812O-5D2B	41	<2.0	<2.0	58
30	12PYG33812O-5D3B	32	<2.0	<2.0	67
31	12PYG33812O-6U1B	23	<2.0	<2.0	75
32	12PYG33812O-6U2B	47	<2.0	<2.0	52
33	12PYG33812O-6U3B	40	<2.0	<2.0	59
34	12PYG33812O-6D1B	38	<2.0	<2.0	61
35	12PYG33812O-6D2B	35	<2.0	<2.0	63
36	12PYG33812O-6D3B	54	<2.0	<2.0	45
37	12PYG33813J-1U1B	49	<2.0	<2.0	51

Subsurface Raw Laboratory Data (Percent (%) Particle Size Distribution					
Sample	Sample	Sand (%)	Silt (%)	Clay (%)	Gravel (%)
38	12PYG33813J-1U2B	53	<2.0	<2.0	45
39	12PYG33813J-1U3B	50	<2.0	<2.0	49
40	12PYG33813J-1D1B	51	<2.0	<2.0	48
41	12PYG33813J-1D2B	52	<2.0	<2.0	48
42	12PYG33813J-1D3B	32	<2.0	<2.0	67
43	12PYG33813J-2U1B	34	<2.0	<2.0	65
44	12PYG33813J-2U2B	56	<2.0	<2.0	44
45	12PYG33813J-2U3B	52	<2.0	<2.0	47
46	12PYG33813J-2D1B	22	<2.0	<2.0	78
47	12PYG33813J-2D2B	57	<2.0	<2.0	42
48	12PYG33813J-2D3B	27	<2.0	<2.0	72
49	12PYG33813J-3U1B	34	<2.0	<2.0	65
50	12PYG33813J-3U2B	22	<2.0	<2.0	77
51	12PYG33813J-3U3B	36	<2.0	<2.0	62
52	12PYG33813J-3D1B	14	<2.0	<2.0	85
53	12PYG33813J-3D2B	39	<2.0	<2.0	60
54	12PYG33813J-3D3B	19	<2.0	<2.0	80
55	12PYG33813J-4U1B	27	<2.0	<2.0	72
56	12PYG33813J-4U2B	51	<2.0	<2.0	49
57	12PYG33813J-4U3B	35	<2.0	<2.0	63
58	12PYG33813J-4D1B	19	<2.0	<2.0	80
59	12PYG33813J-4D2B	33	<2.0	<2.0	66
60	12PYG33813J-4D3B	19	<2.0	<2.0	81
61	12PYG33813J-5U1B	8.2	<2.0	<2.0	91
62	12PYG33813J-5U2B	25	<2.0	<2.0	74
63	12PYG33813J-5U3B	18	<2.0	<2.0	81
64	12PYG33813J-5D1B	32	<2.0	<2.0	67
65	12PYG33813J-5D2B	49	<2.0	<2.0	51
66	12PYG33813J-5D3B	2.2	<2.0	<2.0	97
67	12PYG33813J-6U1B	49	<2.0	<2.0	50
68	12PYG33813J-6U2B	47	<2.0	<2.0	52
69	12PYG33813J-6U3B	43	<2.0	<2.0	56
70	12PYG33813J-6D1B	25	<2.0	<2.0	73
71	12PYG33813J-6D2B	24	<2.0	<2.0	75
72	12PYG33813J-6D3B	39	<2.0	<2.0	60
73	12PYG33813M-1U1B	27	4.3	<2.0	67
74	12PYG33813M1U2B	39	<2.0	2.8	57

Subsurface Raw Laboratory Data (Percent (%) Particle Size Distribution					
Sample	Sample	Sand (%)	Silt (%)	Clay (%)	Gravel (%)
75	12PYG33813M-1U3B	48	3	2.6	46
76	12PYG33813M-1D2B	32	<2.0	3	63
77	12PYG33813M-1D3B	34	2.7	<2.0	62
78	12PYG33813M-2U1B	50	<2.0	2.7	46
79	12PYG33813M-2U2B	40	3.8	<2.0	56
80	12PYG33813M-2U3B	38	2.7	<2.0	58
81	12PYG33813M-2D1B	36	2	2.6	59
82	12PYG33813M-2D2B	57	4	<2.0	38
83	12PYG33813M-2D3B	52	<2.0	2	45
84	12PYG33813M-3U1B	39	<2.0	<2.0	58
85	12PYG33813M-3U2B	32	<2.0	<2.0	66
86	12PYG33813M-3U3B	30	<2.0	2.9	67
87	12PYG33813M-3D1B	37	<2.0	3.8	58
88	12PYG33813M-3D2B	29	<2.0	2.6	68
89	12PYG33813M-3D3B	42	<2.0	2.7	55
90	12PYG33813M-4U1B	30	<2.0	2.1	67
91	12PYG33813M-4U2B	31	<2.0	2.9	66
92	12PYG33813M-4U3B	39	<2.0	2.5	58
93	12PYG33813M-4D1B	35	<2.0	<2.0	62
94	12PYG33813M-4D2B	33	<2.0	2.5	64
95	12PYG33813M-4D3B	42	<2.0	2.2	55
96	12PYG33813M-5U1B	37	<2.0	<2.0	61
97	12PYG33813M-5U2B	25	2.5	<2.0	71
98	12PYG33813M-5D1B	35	<2.0	<2.0	64
99	12PYG33813M-5D2B	42	<2.0	2.7	54
100	12PYG33813M-5D3B	42	<2.0	2.4	55
101	12PYG33813M-6U1B	29	<2.0	<2.0	70
102	12PYG33813M-6U2B	43	<2.0	<2.0	55
103	12PYG33813M-6U3B	51	<2.0	2.7	46
104	12PYG33813M-6D1B	26	<2.0	<2.0	72
105	12PYG33813M-6D2B	35	<2.0	<2.0	63
106	12PYG33813M-6D3B	35	<2.0	<2.0	63

Quality Assurance Report Maxxam Job Number VB372254 Surficial Samples collected in October 2012							
QA/QC Batch Number	QC Type	Parameter Analyses	Date	Value	Recovery	Units	QC Limits
7109241	QC Standard	% sand by hydrometer	8/24/2013	N/A	104	%	86 - 114
		% silt by hydrometer	8/24/2013	N/A	94	%	84 - 116
		clay content	8/24/2013	N/A	108	%	75 - 125
	RPD	% sand by hydrometer	8/24/2013	0.1	N/A	%	35
		% silt by hydrometer	8/24/2013	NC	N/A	%	35
		clay content	8/24/2013	NC	N/A	%	35
7109251	QC Standard	% sand by hydrometer	8/24/2013	N/A	100	%	86 - 114
		% silt by hydrometer	8/24/2013	N/A	101	%	84 - 116
		clay content	8/24/2013	N/A	99	%	75 - 125
	RPD	% sand by hydrometer	8/24/2013	0	N/A	%	35
		% silt by hydrometer	8/24/2013	NC	N/A	%	35
		clay content	8/24/2013	NC	N/A	%	35
7112423	QC Standard	% sand by hydrometer	8/25/2013	N/A	105	%	86 - 114
		% silt by hydrometer	8/25/2013	N/A	91	%	84 - 116
		clay content	8/25/2013	N/A	112	%	75 - 125
	RPD	% sand by hydrometer	8/25/2013	0	N/A	%	35
		% silt by hydrometer	8/25/2013	NC	N/A	%	35
		clay content	8/25/2013	NC	N/A	%	35
7112436	QC Standard	% sand by hydrometer	8/25/2013	N/A	102	%	86 - 114
		% silt by hydrometer	8/25/2013	N/A	93	%	84 - 116
		clay content	8/25/2013	N/A	117	%	75 - 125
	RPD	% sand by hydrometer	8/25/2013	1.1	N/A	%	35
		% silt by hydrometer	8/25/2013	3	N/A	%	35
		clay content	8/25/2013	1	N/A	%	35
7113000	QC Standard	% sand by hydrometer	8/26/2013	N/A	102	%	86 - 114
		% silt by hydrometer	8/26/2013	N/A	96	%	84 - 116
		clay content	8/26/2013	N/A	107	%	75 - 125
	RPD	% sand by hydrometer	8/26/2013	1.2	N/A	%	35
		% silt by hydrometer	8/26/2013	1.2	N/A	%	35
		clay content	8/26/2013	1.6	N/A	%	35
7113092	QC Standard	% sand by hydrometer	8/26/2013	N/A	95	%	86 - 114
		% silt by hydrometer	8/26/2013	N/A	99	%	84 - 116
		clay content	8/26/2013	N/A	120	%	75 - 125
	RPD	% sand by hydrometer	8/26/2013	1.4	N/A	%	35
		% silt by hydrometer	8/26/2013	NC	N/A	%	35
		clay content	8/26/2013	NC	N/A	%	35

NC = (RPD): The RPD was not calculated. The level of analytic detection in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
N/A = Non available

Quality Assurance Report Maxxam Job Number VB371956 Subsurface Samples collected in October 2012							
QA/QC Batch Number	QC Type	Parameter Analyses	Date	Value	Recovery	Units	QC Limits
7094161	QC Standard	% sand by hydrometer	8/20/2013	N/A	99	%	75 - 125
		% silt by hydrometer	8/20/2013	N/A	88	%	75 - 125
		clay content	8/20/2013	N/A	119	%	75 - 125
	RPD	% sand by hydrometer	8/20/2013	9.2	N/A	%	35
		% silt by hydrometer	8/20/2013	NC	N/A	%	35
		clay content	8/20/2013	NC	N/A	%	35
		gravel	8/20/2013	6.5	N/A	%	35
7094593	QC Standard	% sand by hydrometer	8/20/2013	N/A	101	%	75 - 125
		% silt by hydrometer	8/20/2013	N/A	93	%	75 - 125
		clay content	8/20/2013	N/A	108	%	75 - 125
	RPD	% sand by hydrometer	8/20/2013	0	N/A	%	35
		% silt by hydrometer	8/20/2013	NC	N/A	%	35
		clay content	8/20/2013	NC	N/A	%	35
		gravel	8/20/2013	0	N/A	%	35
7095349	QC Standard	% sand by hydrometer	8/20/2013	N/A	120	%	75 - 125
		% silt by hydrometer	8/20/2013	N/A	101	%	75 - 125
		clay content	8/20/2013	N/A	85	%	75 - 125
	RPD	% sand by hydrometer	8/20/2013	0.8	N/A	%	35
		% silt by hydrometer	8/20/2013	NC	N/A	%	35
		clay content	8/20/2013	NC	N/A	%	35
		gravel	8/20/2013	1.2	N/A	%	35
7095627	QC Standard	% sand by hydrometer	8/22/2013		100	%	75 - 125
		% silt by hydrometer	8/22/2013		88	%	75 - 125
		clay content	8/22/2013		118	%	75 - 125
	RPD	% sand by hydrometer	8/22/2013	2.7	N/A	%	35
		% silt by hydrometer	8/22/2013	2	N/A	%	35
		clay content	8/22/2013	21.8	N/A	%	35
		gravel	8/22/2013	25.7	N/A	%	35

NC = (RPD): The RPD was not calculated. The level of analytic detection in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
N/A = Non available