DRAFT REPORT

Adaptive Management Strategy 2013 Annual Report

Deltaport Third Berth, Delta, BC

Prepared for:
Vancouver Fraser Port Authority
100 The Pointe
999 Canada Place
Vancouver, BC V6C 3T4

Prepared by:

HEMMERA
250 – 1380 Burrard Street
Vancouver, BC V6Z 2H3

nhc (northwest hydraulic consultants)
30 Gostick Place
North Vancouver, BC V7M 3G3

Precision Identification Biological Consultants
3622 West 3rd Avenue
Vancouver, BC V6R 1L9

File: 499-002.24
April 2014

HEMMERA

Suite 250 – 1380 Burrard Street
Vancouver, BC V6Z 2H3
T: 604.669.0424
F: 604.669.0430
hemmera.com

April 10, 2014
File: 499-002.24

Vancouver Fraser Port Authority
100 The Pointe
999 Canada Place
Vancouver, BC V6C 3T4

Attn: Carolina Eliasson, Environmental Specialist

Dear Ms. Eliasson,

Re: DRAFT – Adaptive Management Strategy 2013 Annual Report, Deltaport Third Berth, Delta, BC

Hemmera is pleased to provide you with an electronic copy of the draft Adaptive Management Strategy (AMS) 2013 Annual Report, completed as part of the Deltaport Third Berth construction project.

We appreciate the opportunity to work with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned at 604.669.0424 regarding any questions or further information that you may require.

Regards,
Hemmera

Bonnie Marks

Bonnie Marks, M.A.Sc., P.Eng., PMP
Project Manager

EXECUTIVE SUMMARY

At the request of the Vancouver Fraser Port Authority (VFPA), Hemmera Envirochem Inc. (Hemmera), Northwest Hydraulics Consultants (NHC) and Precision Identification (Precision) are pleased to provide the Adaptive Management Strategy (AMS) 2013 Annual Report for the Deltaport Third Berth (DP3) project. The AMS is designed to provide an early warning system, so that steps can be taken to mitigate risks well before valued ecosystem components are affected. The AMS is an eight year study (2007 – 2014) focussed on the Roberts Bank intercauseway ecosystem. This program assesses the potential for negative trends in the ecosystem from marine eutrophication and dendritic channelization linked to DP3 construction and operation.

The main AMS monitoring program components include coastal geomorphology, surface water and sediment quality, eelgrass distribution, benthic community structure, and coastal seabird/shorebird composition. It is challenging to separate specific potential effects related to DP3 from the inherent natural environmental (reference sampling sites well away from DP3 indicate high natural variability for many parameters). By monitoring physical, chemical and biological conditions, early detection of any potential negative effects from DP3 is possible. Such early detection is valuable in determining the nature of proactive response as part of an overall adaptive management approach.

Some of the major signs of eutrophication would include a sustained increase in nutrient concentrations, primary productivity (and chlorophyll *α* concentrations) as well as a decrease in dissolved oxygen and water clarity. No such increases or decreases have been observed in the intercauseway area since AMS data collection began in 2007.

This report summarizes and interprets the findings of the seventh year (2013) of the AMS program, and provides recommendations for the eight year of monitoring (2014). To date, overall findings of the program do not suggest any emerging negative trends linked to DP3 construction or operation.

COASTAL GEOMORPHOLOGY

Based on recommendations made in the 2011 Annual Report (Hemmera 2012b), with the exception of the coastal geomorphology mapping activity, the field-based coastal geomorphology studies were discontinued in 2012. Orthophotograph interpretation was conducted in 2013 to detect potential large-scale geomorphic adjustments to the study area (the intercauseway area) and Coastal Geomorphology Mapping (topographic and bathymetric surveying) was conducted as a follow-up to the surveys that were done in 2007 and 2010. Additional effort was focused on studying the potential effects that the crest protection structure surrounding the tug basin may have had on localised eelgrass losses identified in 2012 and the results are presented in a separate report provided in **Appendix C** to this annual report.

Construction-related activities in 2007 led to the formation of 'new' drainage channels in the mud flats adjacent to the DP3 perimeter dike. The 2012 study of the Area of New Drainage Channels indicates that only very small amounts of sediment are being transported within these channels, and that the cross sectional shape of the channels has gradually flattened since their formation. Orthophoto mapping indicates the location of these new drainage channels has remained consistent since 2008, following small adjustments immediately following their formation in 2007.

Orthophoto mapping indicates that the large system of dendritic channels (these dendritic channels originally developed during the 1980s) continues to shift laterally and change in shoreward extent. The amplitude of channel meanders, as determined from the 2013 orthophotographs, is larger than has previously been observed, and the width of the channels is greater near their seaward end than has previously been observed. However, there has been an overall reduction in the maximum landward extent of the dendritic channels. This is the first year of the AMS program in which the channels have not continued to extend landward. The changes to the large system of dendritic channels are not a result of DP3 construction. The system of channels near the BC Ferries causeway has experienced only small changes relative to previous years prior to when the two separate channels joined together.

The 2013 orthophotographs also show that the sediment deposits located along the east side of the Deltaport causeway that have formed from material originating from the East Causeway Habitat Compensation Project sites have diminished in size. Observations made during the 2013 Coastal Mapping surveys indicate that additional sediment may be washed out of this area under certain tide and weather conditions.

Topographic and Bathymetric surveys of the intercauseway area were conducted as part of the coastal geomorphology mapping component of the AMS program. These surveys have been conducted in 2007, 2010, and 2013 in order to identify and track changes that may be occurring within the surveyed area. Coastal mapping based on the 2013 surveys was compared to that from the 2010 and 2007 surveys. This comparison shows changes to the majority of the tidal flats which are very small, as well as localized areas in which there are apparent large bed elevation changes in the tidal flats. These large changes are in some cases real and in other cases may be artefacts of irregularities in depth sounder signal data (presence of dense eelgrass beds induced signal "noise").

In general, ongoing changes within the intercauseway area have been detected through the interpretation of orthophotographs and through comparison of the digital elevation models created from the coastal mapping survey data; however, with the exception of the new drainage channels and some localized changes to the dyke structures around the tug basin, the changes seen using these methods cannot be directly attributed to construction of the DP3 project. It is recommended that the orthophotograph interpretation and associated channel mapping of the intercauseway area continue for the last year of the AMS program as it supports the eelgrass mapping component.

SURFACE WATER AND SEDIMENT QUALITY

The AMS program includes nine surface water and sediment quality monitoring stations:

- One in the ditch that drains into the intercauseway area near the base of the BC Ferries Causeway (DP01).
- Six intercauseway stations (DP02, DP03, DP04, DP05, DP08, and DP09).
- Two distant reference stations, located at the north end of Roberts Bank (DP06 and DP07).

All stations are located in intertidal areas, with the exception of two subtidal stations, DP05 and DP07 (they are located closest to the Strait of Georgia).

The 2013 surface water and sediment monitoring was carried out quarterly with surface water and sediment samples analyzed for nutrients quarterly and metals in Q1 only. Data evaluation focused on comparisons of the chemistry data to applicable regulatory guidelines and standards, as well as, the assessment of temporal and spatial quality trends. Overall, metal and nutrient concentrations in surface water and sediment were within the same range as in previous years except as discussed below.

Other than the total boron in surface water samples collected from DP02 to DP09, there were no exceedances of the regulatory guidelines noted in Q1-2013. Total boron concentrations measured during 2013 were comparable to previous results and normal for coastal marine water in Canada. A number of metal parameters (copper, manganese, and nickel) exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch) which is similar to previous years.

Similar to previous years, there were no metal exceedances of applicable regulatory criteria in sediment in 2013. The highest metal concentrations in sediment for 2013 were generally observed at the agricultural ditch station DP01 followed by the intercauseway stations DP05 and DP09 and then reference station DP06. These four sediment samples had higher silt and clay content than the other samples based on the grain size data. Based on the lithium normalization technique, these metal results are considered reflective of natural background conditions.

Overall, based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation. It is recommended that the analysis of surface water and sediment samples for metals be discontinued.

Consistent with previous years, the highest nutrient concentrations and lowest dissolved oxygen were measured in the agricultural ditch near the base of the causeway (DP01), and are likely related to upland agricultural inputs. Concentrations in surface water of chlorophyll *a*, phosphorus, TKN, organic nitrogen and total nitrogen where elevated at DP05 (subtidal station) in Q2-2013 with chlorophyll *a*, phosphorus, TKN, and organic nitrogen above the AMS thresholds (developed under SAC guidance and explained in Section 3.2.3.2). This sample had notably higher turbidity and TSS readings than the other samples and is likely correlated with the elevated nutrients. The concentrations of these parameters were within the range of previous results on other quarters of 2013.

As in previous years, nutrient concentrations were higher in sediments in the intercauseway than at the reference stations. This likely relates to higher biological activity within the intercauseway (as compared to the exposed location of the reference stations at the mouth of the Fraser River) and not to DP3 construction or operations. Two stations had concentrations of one or more parameters above the AMS thresholds in 2013: total nitrogen at DP05 in Q1, sulphide and TOC at DP05 in Q2 and sulphide at DP04 in Q3. Regarding total nitrogen in Q1, other stations including the reference stations also showed elevated total nitrogen in Q1. Sulphide and TOC concentrations have been above AMS thresholds historically at DP05 and nutrient parameters are typically higher at this location given its subtidal location. The elevated sulphide at DP04 in Q3 is thought to be related to a field observation of dark grey colour and black layer on surface possibly indicating anoxic conditions which would increase sulphide. The sulphide concentration at DP04 was not elevated in any of the other quarters of 2013, or historically, hence this observation in 2013 does not imply long term change.

Overall, nutrient concentrations in the intercauseway area have not shown an increasing, or decreasing, trend in the seven years of AMS monitoring (2007 – 2013). There are potential seasonal trends for organic nitrogen, TKN, and chlorophyll α in surface water with higher concentrations detected in Q2 and Q3. The average N:P ratio for surface water using 2007-2013 data is 19:1 which is close to the predicted Redfield ratio of 16:1 and a trend plot of this molar ratio indicates all data points close to the Redfield ratio except one station during one event (at station DP04 in Q4-2011).

Based on the data collected to date, there is no evidence of eutrophication occurring as a result of DP3 construction or operation.

EELGRASS

The eelgrass distribution in the Area of New Drainage Channels and in other locations where change had been noted in 2012 were mapped on July 7 and August 6 and 7, 2013. The eelgrass health and vigour field survey was conducted on July 20 through 24, 2013.

The assessment of epiphyte load and absence of *Beggiatoa* sp. indicate that the eelgrass habitat was healthy and functioning well with the exception of a localized area behind the tug basin. This localized area behind the tug basin was further studied in 2013 and results are contained in a separate report within Appendix C. The epiphyte growth in this localized area is considered extreme as in many cases entire shoots, including the young leaves, were encased with epiphytes. This extreme epiphyte growth shades the lower portion of the eelgrass and impacts plant growth. The area of eelgrass loss contains fine silty substrate with indications of anaerobic conditions, which were confirmed by sediment samples with high sulphide concentrations. Decomposition of epiphytes can elevated sulphide, and phosphorus, concentrations in sediment and potentially impact eelgrass growth. It is hypothesized that the reduced tidal flow and ponding water results in higher water temperatures in which the eelgrass is present for periods of time which enhances epiphyte growth. A detailed elevation survey of the bed surface in this area behind the tug basin confirmed an area that is directly ponded (i.e. does not drain at low tides) and a shallow ponded area through which flow is disturbed. Drainage of these areas is blocked at tide heights below approximately 1 m (chart datum). The localized area of eelgrass loss is within the directly ponded and shallow ponded areas. Prior to construction of DP3, the area now behind the tug basin was free to drain to the open Strait of Georgia.

The productivity (LAI) of *Z. marina* at the intercauseway sites and at the sites west of the Deltaport Causeway in 2013 was not extreme; it was similar to most of the years included in this study. The productivity at all the reference sites in Boundary Bay was greater than average. Productivity differences between the intercauseway area and the reference sites are likely due to localized environmental influences.

The development of DP3 resulted in a loss of *Z. marina* habitat in the area that was altered by sediment deposition from the formation of new drainage channels adjacent to DP3 (as discussed in previous reports). The eelgrass habitat in this area increased slightly between 2012 and 2013.

There are no changes recommended to the eelgrass program for 2014.

SUMMARY OF RECOMMENDATIONS

To date, the data collected during the AMS monitoring program indicates no widespread physical nor biological change in the intercauseway area following DP3 construction and operation.

Based on the findings to date, the following adaptations to the AMS program are recommended for 2014:

- Discontinue the annual metals analysis in surface water and sediment samples as data collected to date does not indicate increasing concentrations as a result of DP3 construction or operation.

ACKNOWLEDGEMENTS

Hemmera gratefully acknowledges the contributions of our additional project team members:

Coastal Geomorphology:	Northwest Hydraulic Consultants Ltd. 30 Gostick Place North Vancouver, BC V7M 3G2
Eelgrass Assessment:	Precision Identification 3622 West 3rd Avenue Vancouver, BC V6R 1L9
Vessel Services:	Ross Wetzel 18341 72nd Avenue Surrey, BC V4N 3G6
Analytical Laboratory:	ALS Environmental 1988 Triumph Street Vancouver, BC V5L 1K5
Biological Laboratory:	Biologica Environmental Services Ltd. Suite H50 Nootka Ct. 634 Humboldt Street Victoria, BC V8W 1A4

In addition, Hemmera would also like to acknowledge the effort and contributions of the following individuals:

Vancouver Fraser Port Authority:	
	Carolina Eliasson, Environmental Specialist Carrie Brown, Environmental Specialist
Scientific Advisory Committee:	Rowland Atkins, M.Sc., P.Geo. Senior Geomorphologist, Golder Associates Ltd. Terri Sutherland, PhD Research Scientist, Science Branch, Department of Fisheries and Oceans Ron Ydenberg, PhD Department of Biological Sciences, Simon Fraser University

TABLE OF CONTENTS

List of Tables *(within text)*

List of Tables *(following text)*

List of Figures *(within text)*

List of Figures *(following text)*

List of Appendices

GLOSSARY OF TERMS

ADCP	Acoustic Doppler Current Profiler
AWAC	Acoustic Wave and Current Meter
AMS	Adaptive Management Strategy
BC	British Columbia
BCF	BC Ferries
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CSR	Contaminated Sites Regulation
CWS	Canadian Wildlife Service
DF	Difference Factor
DP3	Deltaport Third Berth
DFO	Department of Fisheries and Oceans
DO	Dissolved Oxygen
DoD	Depth of Disturbance
DQO	Data Quality Objectives
EC	Environment Canada
Hs	Significant Wave Height
LAI	Leaf Area Index
MAL	Marine Aquatic Life
MEDS	Marine Environmental Data Service
NHC	Northwest Hydraulic Consultants
NTU	Nephalometric Turbidity Units
PC	Point Count
PDA	Personal Digital Assistant
PDO	Pacific Decadal Oscillation
QA/QC	Quality Assurance/Quality Control
RDL	Reported Detection Limit
RPD	Relative Percent Difference
RTK GPS	Real-Time Kinematic Global Positioning System
SAC	Scientific Advisory Committee
SARA	Species at Risk Act

$SedQC_{ss}$	Sediment Criteria for Sensitive Marine and Estuarine Sediments
SEM	Standard Error of the Mean
SIMS	Seabed Imaging and Mapping System
TFN	Tsawwassen First Nation
TKN	Total Kjeldahl Nitrogen
Tp	Wave Period
TSS	Total Suspended Solids
VFPA	Vancouver Fraser Port Authority
WHSRN	Western Hemispheric Shorebird Reserve Network
WQG	Water Quality Guidelines

1.0 INTRODUCTION

At the request of the Vancouver Fraser Port Authority (VFPA), Hemmera Envirochem Inc. (Hemmera), Northwest Hydraulics (NHC) and Precision Identification (Precision) are pleased to provide this 2013 Annual Report for the Adaptive Management Strategy (AMS) for the Deltaport Third Berth (DP3) project. This report summarizes and interprets the findings of the seventh year (2013) of the AMS program, and provides recommendations for adapting the program for the eight year of monitoring.

Similar to previous annual reports, the document is structured as follows:

- Results section: presents the 2013 results.
- Discussion section: compares the 2013 data to previous results.
- Conclusions and Recommendations section: includes a discussion of overall trends of the AMS program and provides recommendations for adaptations of the monitoring program.

1.1 BACKGROUND

1.1.1 DP3 Project Description

Deltaport is a marine container terminal located on Roberts Bank in Delta, BC (**Figure 1**). The DP3 project involved the construction to accommodate an additional ship berth along with approximately twenty hectares of land for an expanded container storage yard and dredging to deepen the existing ship channel and creation of an adjacent tug moorage area.

The DP3 project was subject to both the provincial *British Columbia Environmental Assessment Act* and the federal *Canadian Environmental Assessment Act*. The environmental assessment involved a large number of studies including coastal geomorphology, water quality, sediment quality, marine resources, coastal seabirds and waterfowl, vegetation and wildlife, archaeology, socio-economics, noise, visual and lighting, air quality, and road, rail and ship traffic. This report is available from the BC Environmental Assessment Office website (http://www.eao.gov.bc.ca/). As part of the acceptance of the environmental assessment by the BC Environmental Assessment Office were recommendations by Environment Canada – Canadian Wildlife Service (CWS) that an AMS be developed to provide practical advance warning of potential emerging negative ecosystem trends during project construction and operation.

A timeline of post-construction and key operation activities is presented in **Table 1.1-1**.

All terminal construction was complete in 2009, with construction of habitat compensation features completed in 2010. The terminal began operations in January 2010. There were no known construction activities of significance in 2012 or 2013 and therefore, the timeline in **Table 1.1-1** below does not go beyond 2011. It is noted that on December 7, 2012, a large bulk carrier docking at Westshore Terminals at Roberts Bank collided with a coal conveyor resulting in spillage of approximately 30 tonnes of coal into the water. This accident is unrelated to DP3 construction or operation. The coal was recovered from the seabed floor between January 13 and 15, 2013 using a suction dredge guided by divers.

Table 1.1-1 DP3 Timeline of Post-construction and Operation Activities

Site Activities	Timeline									
	2009		2010				2011			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Marine Construction Demobilization	DCL demobilized from site in July 2009									
TSI Terminal Finishing Works (land based) including electrical, paving, drainage	On-going	Completed December 2009								
DP3 official opening and start of operations			Operations start January 2010	On-going						
East Causeway Habitat Compensation Project		Start of Construction September 2009	On-going	On-going	On-going	Construction complete September 2010				
Removal of Temporary Barge Ramp Facility (Tug Basin)										November 8 to December 5

1.1.2 AMS Project Objectives

The objectives of the AMS project are to undertake a science-based systematic approach to the monitoring of the Roberts Bank intercauseway ecosystem to reduce uncertainty and assess the potential for negative trends in the ecosystem from marine eutrophication and dendritic channelization. This approach should:

1. Provide practical advance warning of potential emerging negative ecosystem trends during DP3 construction and operation.
2. Establish actions that VFPA would undertake to prevent or mitigate negative trends that exceed applicable thresholds and may be linked to the DP3 project.

The AMS includes monitoring methods to specifically identify and mitigate potential environmental effects in the following areas of concern (the AMS project team member completing the work is shown in brackets):

- Coastal geomorphology (NHC).
- Surface water quality (Hemmera).
- Sediment quality (Hemmera).
- Eelgrass distribution (Precision).
- Benthic community structure (Hemmera).
- Coastal seabird / shorebird composition (Hemmera).

1.2 SCOPE OF WORK

The AMS support program has been implemented to address concerns and meet requirements of stakeholders such as Environment Canada (EC), the Department of Fisheries and Oceans (DFO) and the CWS as well as other legislation, guidelines, and best management practices applicable to the work. The AMS involves the identification, management, prevention, and mitigation of environmental effects that may result from DP3 construction. The AMS program also undergoes an independent peer review by a Scientific Advisory Committee (SAC), comprised of scientists with expertise in the various study areas of the AMS, appointed by VFPA and EC.

The scope-of-work for the annual report involved completion of the following tasks:

- Analysis of orthophotograph data that were collected, in part, to support coastal geomorphology/oceanography monitoring.
- Analysis of quarterly data from surface water quality monitoring.
- Analysis of quarterly data from sediment quality monitoring.
- Analysis of eelgrass data collected during Q3 period.

- Evaluating the data relative to the objectives of the AMS program. Data evaluation included looking at both temporal and spatial trends in the data observed during the year as well as comparison to data collected from previous years, where applicable.
- Providing recommendations based on the findings to date, for adaptations to the AMS program and/or mitigation measures that may be required if adverse impacts are observed.

A detailed list of monitoring activities completed between 2007 and 2013 is presented in **Table 1**. A chronology of key adaptations to the AMS program implemented from 2007 through to 2013 is presented in **Table 2**. A summary of the rationale for the adaptations is presented in **Table 3**.

1.2.1 Coastal Geomorphology

The physical environment of the study area for the AMS monitoring program provides the basis for the ecological features and functions that define Roberts Bank. NHC has responsibility for the Coastal Geomorphology portion of the AMS monitoring program for the area defined as the intercauseway portion of the Roberts Bank tidal flats, extending shoreward to the dikes and seaward to the delta foreslope and includes the deeper waters in the vicinity of the new terminal. The tidal flats represent the sub-aqueous top-set beds of the Fraser River Delta and at Roberts Bank the zone is generally featureless except for the development of tidal channels. Prior to the construction of the BC Ferries and Deltaport causeways, this area would have been swept by the Fraser River plume, depositing sediments and nutrients. The environment was also shaped by wind-generated waves and tidal currents from the Strait of Georgia. With the construction of the causeways, beginning in the early 1950s, the processes affecting the intercauseway area have been modified, primarily through diversion of the Fraser plume, a reduction in wave energy, and the expansion of eelgrass beds on the tidal flats.

A comprehensive Coastal Geomorphology Study of the Roberts Bank area was completed by NHC as part of the environmental impact assessment phase of the project (NHC 2004). This document provides background and rationale that have informed the design of the present monitoring program. In particular, the Coastal Geomorphology Study provides a very detailed description of the history of the natural and human-influenced evolution of the study area, with particular emphasis on providing greater detail for the proximal portions of the study area and less detail for the distal regions. The approach taken by the Coastal Geomorphology Study was to view the intercauseway portion of Roberts Bank as a relatively isolated zone, cut off from geomorphically significant inputs of sediment but also partially protected from the higher energy waves and currents that continue to shape the rest of the delta front.

The Coastal Geomorphology portion of the AMS monitoring program includes six primary activities:

- Monitoring of the physical conditions in the area around the Crest Protection Structure (**Figure 2**).
- Automated monitoring of turbidity in the water column on the tidal flats (**Figure 3**).

- Automated monitoring of erosion and deposition on the tidal flats in the immediate vicinity of the new terminal (**Figure 4**). A graphical display of how these values are determined is shown in **Figure 5**.
- Collection and analysis of sediment samples at the DoD rod sites for analysis of grain size (**Figure 4**).
- Interpretation of orthophotographs for the purpose of detecting large-scale geomorphic adjustments to the study area.
- Coastal geomorphology mapping, consisting of hydrographic and topographic surveys.
- Wave monitoring (**Figure 3**).

Based on recommendations included in the AMS 2009 Annual Report (Hemmera, 2010), the instrumentation used to monitor both turbidity and waves was removed during the Q3-2010 monitoring period, thus marking the termination of the wave and turbidity monitoring portions of the AMS program. Based on recommendations included in the AMS 2011 Annual Report (Hemmera, 2012b), the remaining field-based components of the monitoring program - including the Crest Protection Structure monitoring, monitoring of erosion and deposition, and collection and analysis of sediment samples for grain size analysis - were discontinued as of January 1, 2012. The remaining field-based monitoring activity: Coastal geomorphology mapping, was scheduled as an intermittent activity (every three years) and was conducted in 2013.

1.2.2 Surface Water Quality

Changes in surface water chemistry are one of the first indicators of emerging ecosystem trends. The objectives of the surface water study are to identify any early trends suggesting that eutrophication is occurring or that metal concentrations are increasing as a result of DP3 construction or operation.

In the context of the AMS, marine eutrophication has been defined as an enrichment of nutrients in the intercauseway area surface water and sediment that affects, or has the potential to affect, the health and stability of the marine ecosystem at Roberts Bank. The primary source of nutrients from Deltaport is primarily treated sewage effluent. The sewage treatment plant was constructed as part of the initial Deltaport container terminal development in 1997 and provides secondary treatment of sewage prior to discharge. The sewage treatment plant is permitted under a Ministry of Water Land and Air Protection (MWLAP) effluent permit PE-14865 to discharge treated effluent into the Deltaport ship berth at a depth of 12 metres below mean low water. The projected increase in sewage output from the DP3 project was considered to be minimal. Other sources of nutrients to the DP3 area include agricultural inputs from the surrounding area and from the Fraser River, municipal waste discharges, upwelling from Georgia Straight, and bird and wildlife excreta.

Historical water quality data for Roberts Bank and the surrounding data were available from data compilations conducted by Triton (2001) and Swain et al. (1998).

It should be noted that the potential for large-scale eutrophication in the Strait of Georgia is considered low for two reasons. First, total primary productivity is insensitive to moderate increases or decreases in nitrogen concentrations because nitrogen concentrations in the Georgia Strait are naturally elevated (2-20 µM) (Mackas and Harrison 1997). Second, the intercauseway area is subject to regular tidal and nutrient exchange.

If eutrophication were occurring, one would first expect to see an increase in nutrient concentrations, followed by an increase in chlorophyll *α* and a decrease in dissolved oxygen and clarity, as primary productivity increased (OSPAR 2005). Nuisance algal blooms would decrease the amount of light penetrating the water column, affecting eelgrass growth and sediment chemistry. Seasonal hypoxia in summer months, resulting from increased plant growth due longer days and warmer water temperatures, would precede more widespread hypoxia and reduced water transparency (OSPAR 2005). **Table 1.2-1** below describes the progression of eutrophication.

Table 1.2-1 Progression of Eutrophication

Nutrient Enrichment	Primary Symptoms	Secondary Symptoms
• Increased concentrations of nitrogen and phosphorus. • Changes in nutrient ratios.	• Increased phytoplankton primary production and biomass. • Changed phytoplankton community structure. • Harmful algal blooms. • Increased growth of short-lived nuisance macroalgae. • Increased sedimentation of organic matter.	• Reduced water transparency. • Altered distribution of long-lived submerged vegetation. • Altered benthic invertebrate communities. • Reduced bottom water oxygen concentrations. • Kills of bottom-dwelling fish and invertebrates.

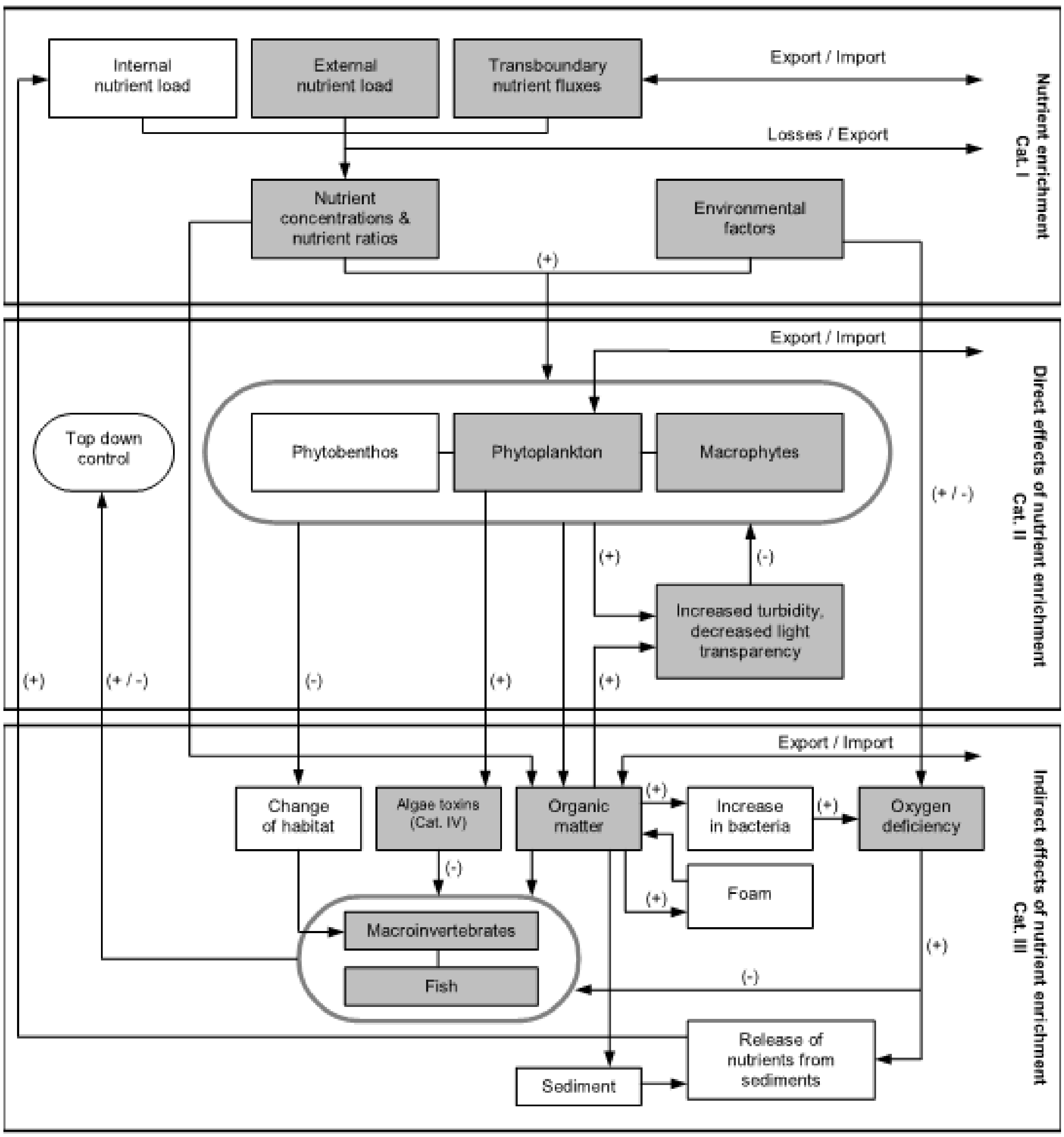
Figure 1.2-1 provides a more detailed illustration of the feedback loops involved in the eutrophication process. The illustration is taken from the Oslo Paris Commission document title 'Ecological Quality Objectives for the Greater North Sea with Regard to Nutrients and Eutrophication Effects' (OSPAR 2005).

As noted above, surface water chemistry is used as a first tier indicator of potential eutrophication in the intercauseway area at Roberts Bank.

Surface water samples have been collected by Hemmera at seven fixed surface water and sediment monitoring stations since 2007 (**Figures 6** and **7**). Surface water samples were collected at two additional fixed sampling stations in the intercauseway area beginning in 2009 that were added to enhance the benthic invertebrate sampling program as per recommendations from the SAC.

In addition to the quarterly monitoring, the waters of the upper end of the DP3 turning basin (near DP04) were also monitored continuously (every 15 minutes) for pH, temperature, and dissolved oxygen using a YSI 6600V2 buoy-mounted sonde. The sonde was damaged twice by storms during continuous deployment in 2007 and 2008 so, in 2009, to avoid damage due to storm events, the sonde was no longer deployed continuously but rather for approximately one week each quarter. Quarterly deployment of the Sonde was discontinued in 2012.

Figure 1.2-1 Generic Conceptual Framework to Assess Eutrophication (OSPAR 2005)



1.2.3 Sediment Quality

Changes in sediment chemistry are also an indicator of emerging ecosystem trends. The objectives of the sediment chemistry study are the same as for surface water: to identify any trends suggesting that eutrophication is occurring or that metal concentrations are increasing as a result of DP3 construction or operation.

An extensive sediment sampling program was conducted to the east and west of the Deltaport causeway prior to DP3 construction (Hemmera 2004). Historical sediment data for the reference area are presented in Stancil (1980).

Changes in sediment chemistry would be expected to occur after trends signalling eutrophication were noted in surface water. The decomposition of algae would lead to an increase in nutrient concentrations in sediment, a decrease in redox values, and an increase in sulphide concentrations (Sutherland et. al. 2007). Metal concentrations in sediment could potentially increase as a result of co-deposition with sulphides. Sediment chemistry is also used as a first tier indicator of potential eutrophication in the intercauseway area at Roberts Bank as changes in sediment chemistry would be expected to affect the composition of the benthic invertebrate community and the health of the eelgrass community (Diaz & Rosenberg 1995, Smith et al, 1988, De Casabianca et al. 1997, Flindt et al. 1997, Terrados et al. 1999).

1.2.4 Eelgrass

Eelgrass (*Zostera* spp.) meadows provide a variety of ecological services that assist in the maintenance of healthy estuarine and marine habitats. Eelgrass habitat is considered essential habitat because it is the basis of primary production that supports both economically and ecologically important finfish and shellfish populations (Duarte et al. 2008). The three dimensional habitat provided by eelgrass meadows provides protection from predators, cover during low tide to reduce desiccation, and is a direct and indirect food source for many species (Wyllie-Echeverria 2003). Native eelgrass (*Z. marina*) meadows support numerous commercially important finfish and shellfish species (Orth and Heck 1980, Phillips 1984, Heck et al. 1989, 1995, 2003, Fredette et al. 1990, Short et al. 1993, Dean and Haldorson 2000, Beck et al. 2001). The eelgrass provides a substrate and habitat for numerous species epiphytes, epibenthos, and benthos which add to the overall productivity of the habitat (Fredette et al. 1990).

Ducks, swans, and geese are known to forage on *Z. marina* during migration. Black brant geese are dependant of *Z. marina* as their primary food source; their migration route follows *Z. marina* meadows between Alaska to Mexico (Wyllie-Echeverria and Ackerman 2003). Herons are known to forage for prey extensively in *Z. marina* meadows (Essinger 2007). Baldwin and Lovvorn reported that waterfowl distribution in Boundary Bay, British Columbia was related to the presence of *Zostera* spp. (1994a), and that the expansion of *Z. japonica* habitat at that location resulted in a local increase in the abundance of dabbling ducks and brant (1994b).

Eelgrass shoots produce new leaves throughout the year. The average number of leaves produced by a shoot in one year is 27.9 although the average mean number of leaves per shoot is 4.2 (Duarte, 1991). The mature leaves die throughout the year, but storm events during the autumn and winter induce leaf breakage. The dead and broken leaves break down to form particulate detritus which supports a variety of consumers from bacteria to sea cucumbers (Lui et al, 2013, Vähätalo and Søndergaard 2002).

Zostera species sequester large amounts of carbon; the productivity of a healthy eelgrass meadow rivals that of most oceanic and terrestrial ecosystems (Mateo et al. 2007). Eelgrass produces oxygen through photosynthesis and releases it into the water and sediment (Constanza et al. 1997, Marba et al. 2007).

Zostera species increase decomposition rates in sediments, regulate nutrient cycles, and accelerate nutrient regeneration (Short 1987, Hansen et al. 2000).

Zostera meadows act as a filter trapping and binding sediments (Fonseca 1992, Heiss et al. 2000) and removing contaminants (Lyngby and Brix 1982, Francoise et al. 1989, Hoven et al. 1999). The *Zostera* leaves baffle currents and waves reducing coastal erosion (Koch and Verduin 2001).

Roberts Bank, including the intercauseway area, supports the largest native eelgrass (*Zostera marina*) meadow in southern British Columbia. Dramatic increases in the area colonized by native eelgrass occurred between 1967 and 2003 (Durance 2004a and 2004b, Harrison 2004).

The large increases in *Z. marina* habitat at this location are likely the result of several factors:

- The Deltaport causeway deflects the plume of the Fraser River, hence the turbidity of the water over the intercauseway eelgrass bed has decreased since the causeway was developed. The reduction in turbidity results in increased photoperiod duration and intensity for the eelgrass, which may have stimulated growth and reproduction.
- The BC Ferry causeway may protect the eelgrass bed from severe south easterly winter storms. Eelgrass beds along the Washington and Oregon coast are often partially removed by winter storms. Although this has never been formally documented in British Columbia there is evidence that it occurs in Boundary Bay.
- The introduction and rapid mudflat colonization by *Z. japonica* may have resulted in ponding of water at higher elevations during low tide (Tarbotton and Harrison 1996). This may have enabled *Z. marina*, which is more susceptible to desiccation, to colonize areas higher than previously possible. Once established *Z. marina* could out compete (shade) the smaller *Z. japonica*.
- Studies conducted during the 1970s and 1980s along the Pacific coast determined that the successful establishment of *Z. marina* from seedlings was very rare. However, in the last decade researchers have noted the successful establishment of many seedlings in eelgrass beds from California to British Columbia (S. Wyllie-Escherverria, pers. comm.; C. Durance, pers. obs.). It is possible that the increased amount of available light accelerates seedling development, enhancing seedling survival. Billions of *Zostera* seeds are produced in the intercauseway annually, hence even a small increase in survivorship could lead to a dramatic increase in density and distribution.

Z. japonica, an introduced species of eelgrass, was first identified in the intercauseway area in 1976 (Harrison and Bigley 1982). The area colonized *by Z. japonica* rapidly increased to 317 hectares by 2003 (FREMP, 2003). *Z. japonica* colonized areas that were above the optimal range for *Z. marina.*

Zostera populations are declining globally; primarily due to anthropogenic stresses (Short and Wyllie-Escheverria, 1996, 2000). The specific factors responsible for declines include: increased nutrient inputs resulting in decreased light availability (Kemp et al. 1983, Moore et al 1997); increased nitrogen loading leading to increased algal abundance (den Hartog 1994, Short and Burdick, 1996, Bowen and Valiela 2001); organic enrichment resulting in sediment reducing conditions and anoxia (De Casabianca et al. 1997, Flindt et al. 1997, Terrados et al. 1999); elevated sulphide levels impacting root metabolism (Smith et al, 1988), nutrient uptake (Pregnall et al. 1984), and photosynthetic processes (Goodman et al. 1995); physical disturbance through fishing practices; and shoreline development including dredging, filling, and shoreline hardening (Moore and Short 2007).

Z. marina is often used as an indicator species to monitor and/or assess ecosystem health since changes in light availability or water quality conditions will affect the distribution, abundance, and growth of the species (Dennison et al. 1993, Short et al. 1993, Short, 2011). Therefore, the AMS program monitors the health and vigour of *Z. marina* and the distribution of *Z. marina* and *Z. japonica* in the intercauseway area of Roberts Bank. Changes in surface water and sediment chemistry would be expected to affect the health of the eelgrass community and thus the composition of the benthic invertebrate community; therefore eelgrass health and vigour are used as a second tier indicator.

1.2.4.1 Eelgrass Survey Objectives and Rationale

The eelgrass survey was designed to detect changes in the eelgrass habitat of the intercauseway area and to determine whether any changes were caused directly or indirectly by the development of DP3. The specific objectives of the eelgrass monitoring plan are:

- To map the distribution of eelgrass (*Z. marina and Z. japonica*) the intercauseway annually via remote sensing.
- To monitor the vigour and species composition of eelgrass at the nine reference stations (**Figures 8** and **9**) that were established for the Deltaport Third Berth EA, and to record the presence of epiphytes and *Beggiatoa* sp. at each of these stations annually.
- To map the lower limit of eelgrass of eelgrass distribution within the intercauseway area using the Seabed Imaging and Mapping System (SIMS) every three years (2009, 2012) and in the final AMS year (2014).

The objectives were based on rationale provided in the literature by numerous seagrass scientists and by decades of experience studying the Roberts Bank eelgrass meadows. The rationale behind each of the objectives is explained in the following sections.

1.2.4.2 Distribution Map

The distribution of *Z. marina* and *Z. japonica* may vary inter annually due to natural factors that include: climate; mean sea level; and the timing, duration, and amplitude of low and high tides. Anthropogenic impacts that cause changes in light availability, water quality conditions, or sedimentation / erosion rates could also alter the distribution of the two *Zostera* species.

A baseline map of the eelgrass distribution was prepared in 2003 for the Deltaport Third Berth Project Marine Resources Impact Assessment (Triton 2004). The annual AMS eelgrass surveys map the current distribution of both species and use the maps to detect changes that have occurred relative to 2003 and previous AMS study years.

1.2.4.3 Eelgrass Health and Vigour

Slight changes in light availability or water quality conditions can affect the productivity of *Z. marina*. The relative productivity of *Z. marina* was estimated at eleven reference stations as part of the Deltaport Third Berth Project Marine Resources Impact Assessment (Triton 2004). Nine of the original reference stations were selected for the AMS. These stations are monitored annually to detect changes in eelgrass productivity. The stations that were selected included all those located in the intercauseway, two west of the Deltaport Causeway, and three in Boundary Bay as shown on **Figures 8** and **9**. Changes in the intercauseway eelgrass productivity could be related to influences other than the development of DP3, the data from stations west of the Deltaport Causeway could assist in differentiating between changes caused by the development of DP3 and other local sources such as the Fraser River plume. The Boundary Bay stations (**Figure 9**) were selected to provide data to assess effects of large scale environmental variation on eelgrass.

The eelgrass habitat at Site 1 was very similar to that at Site 2 in 2003 (**Figure 8**). Site 2 was selected due to its proximity to DP3. Site 1 was selected as a reference by which to assess changes in the eelgrass habitat adjacent to DP3 should they occur. The habitat in the vicinity of Site 1 changed from dense continuous *Z. marina* in 2003 to patchy mixed eelgrass by 2008, Site 1 was no longer suitable for comparison to Site 2, therefore a new station, Site 1B was established (**Figure 8**). The eelgrass habitat at Site 1B is very similar to that at Site 2. Site 1 was renamed Site 1A (**Figure 8**), monitoring will continue at this site as the data may provide insight into the evolution of the sand lobe.

The three reference stations in Boundary Bay were selected in 2003 to represent eelgrass habitat within a range similar to the sites included in the 2003 Roberts Bank study area. Reference site WR1 is located near the upper limit of the eelgrass bed; the *Z. marina* at this location is similar in stature and density to *Z. japonica*. The 2003 Roberts Bank study area included a site west of the Deltaport Causeway that provided habitat similar to WR1 in Boundary Bay; this site was not included in the AMS surveys due to the absence of this habitat type within the intercauseway area. The reference site WR1 was surveyed each year while waiting for the tide to ebb providing access to WR2 and WR3; however since WR1 is not similar to any sites in the intercauseway the data from WR1 is not assessed for the AMS. Reference site WR2 is slightly lower than site WR1 and therefore supports larger plants. Site WR3 is the deepest and supports the largest plants of the three reference sites in Boundary Bay.

The productivity of eelgrass varies seasonally, thus the annual sampling is conducted at a date comparable, within a few weeks, to the date when the 2003 data was collected.

A variety of epiphytes colonize eelgrass; these are an important food source for many organisms and add to the overall productivity of the habitat (van Montfrans, J. et al., 1984). It has been reported that the presence of epiphytes on eelgrass leaves may reduce desiccation during low tide through entrapment and retention of moisture (Penhale et al., 1977). However, there have been several instances where epiphyte populations have surpassed natural levels and smothered eelgrass to the extent the habitat was severely impacted or destroyed (Fertig et al., 2013, Kemp et al., 1983, Orth et al., 1983, Borum et al., 1080).). Two causes for these extensive epiphyte increases have been identified; eutrophication (Short et al., 1995) and over fishing or the removal of other predators (Hughes et al., 2013, Jorgensen et al., 2007). Eutrophication has occurred in poorly flushed estuaries when the nutrient load, usually from upland sources, increases. The added nutrients encouraged the growth of epiphytes that smothered the eelgrass (Baden et al., 2012). The epiphytes comprise a lower level on many food webs. Epiphytes are consumed by small grazers (amphipods, copepods, etc.) that are then consumed by small fish; small fish are eventually consumed by larger fish. The extensive removal of large fish via commercial fishing unbalances the system. The abundance of small fish increases because fewer are consumed by large fish. The increase in small fish abundance leads to a decrease in the grazer population that would have otherwise kept the epiphytes in balance (Baden, S. et al., 2012, Lewis et al., 2012). A recent study (Hughes et al., 2013) found that the re-introduction of sea otters to an estuary enhanced eelgrass growth. The sea otters consumed crabs leading to an increase in epiphyte grazer density which reduced the epiphyte load on eelgrass.

The AMS monitors the relative abundance of epiphytes at each of the reference stations annually as an early indicator of potential degradation within the eelgrass habitat.

Beggiatoa sp. is frequently used as an indicator species to identify degraded marine habitats. The filamentous preteobacteria forms visible whitish mats in many polluted marine environments, especially those with eutrophic sediments rich in hydrogen sulphide and low in oxygen. *Beggiatoa* sp. has not been observed at Roberts Bank however the eelgrass survey team searches for evidence of it during the other field surveys, as it would indicate a decline in the health of the ecosystem. The VFPA would be notified immediately if *Beggiatoa* sp. was discovered in the intercauseway area. A monitoring program would be immediately developed and implemented.

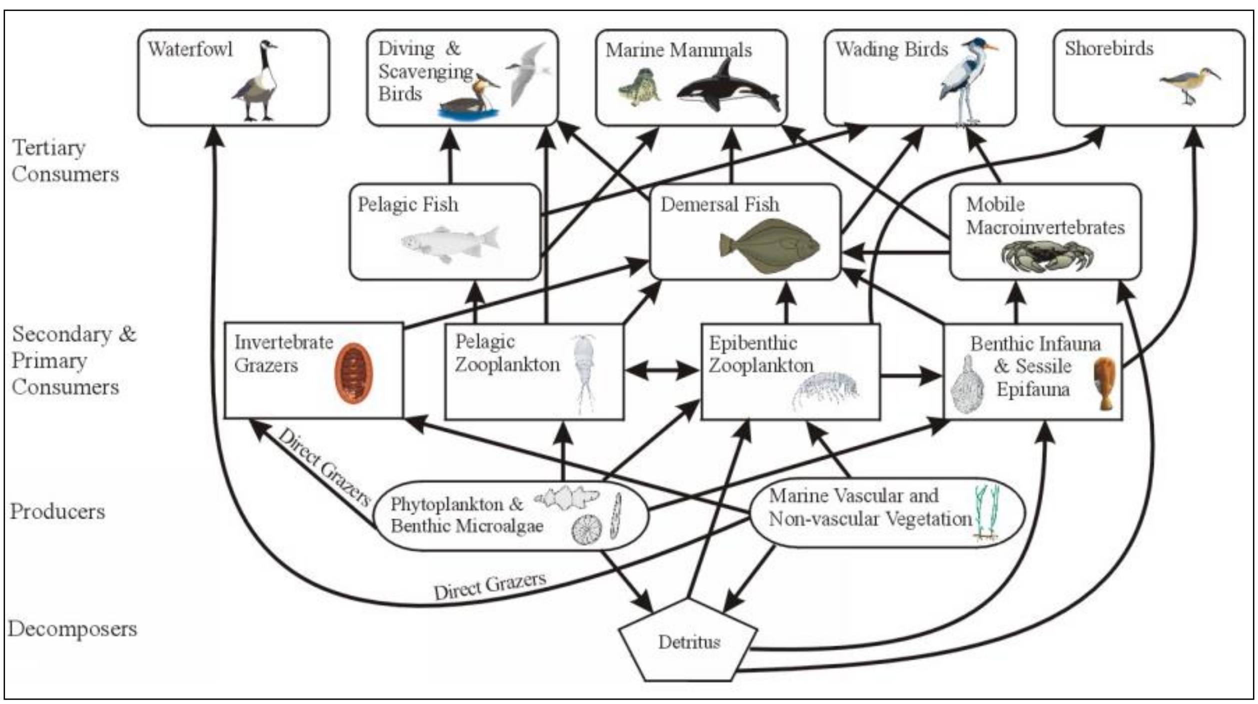
1.2.4.4 Lower Limit of Eelgrass Distribution

The lower limit of eelgrass distribution is dependant on many factors including; light penetration (turbidity), current, and substrate type. The lower limit of an established eelgrass meadow may be decreased by anthropogenic impacts that increase turbidity (e.g. suspended sediments, nutrients) or increase currents (e.g. bow thrusters, vessel traffic). The maximum depth of eelgrass distribution along highly developed portions of the eastern coast of the United States is less than one metre, while in the clear waters off of Alaska it has been recorded at depths greater than 30 metres. The lower limit of the intercauseway eelgrass meadow is not usually visible on orthophotos due to the influence of the turbid Fraser River. The extent that is visible on the photographs is dependant not only on the turbidity at the time of filming but also on the tide height. The annual remote sensing mapping is not capable of determining the depth limit of eelgrass in the inter causeway. In order to assess whether the depth distribution of eelgrass has changed over time the lower limit of the eelgrass meadow is mapped tri-annually (2009, 2012) using an integrated remotely operated towed video camera and GPS system, and will be mapped in the final year of the AMS (2014).

1.2.5 Benthic Community

Benthic invertebrates play a critical role in maintaining ecosystem health, as a food source for birds, fish, and macroinvertebrates (Peterson et al. 2000) (**Figure 1.2-2**).

Figure 1.2-2 Conceptual Marine Food Web for Roberts Bank (Triton 2004)



Subtidal habitats tend to be physically predictable. In contrast, intertidal habitats are characterized by greater variability in physical factors, including waves, tidal currents, erosion, slope, light, air exposure, temperature, salinity, and sediment stability. Burd et al. (1998) note that the influence of these factors, as well as biological factors, can lead to spatial heterogeneity of intertidal assemblages in what appear to be similar habitats. An earlier study by Burd et al. (1987) in the intertidal zone in Boundary Bay found that not only sediment grain size, but also the presence of eelgrass affected the species assemblage, with benthic communities in eelgrass beds structurally different and more diverse than those in nearby bare sediments.

Changes in the benthic invertebrate community linked to eutrophication would only be expected to occur after changes in surface water chemistry and/or sediment chemistry were noted. In the initial stages, benthic invertebrate abundance would be expected to increase as a result of increased nutrient availability. Benthic invertebrates can cope with oxygen depletion to varying degrees (days to month). As the amount of oxygen available in sediment decreased, the structure of the benthic invertebrate community would be expected to change, with more tolerant suspension and burrowing detritus feeders increasing in abundance. Signs of such change would include an increase in the ratio of polychaetes to amphipods and an increase in the ratio of *polychaeta sedentaria* to *polychaeta errantia*.

In cases of severe eutrophication, overall benthic invertebrate abundance would be expected to decrease significantly, with only the most tolerant species surviving. This would result from a combination of factors including excessive organic matter deposition, oxygen depletion, and the presence of high concentrations of ammonia and free sulphides in sediment pore water. For benthic habitats, much of the increased primary production is delivered directly to microbial loops (Baird et al. 2004). Higher rates of microbial decomposition can deplete dissolved oxygen near the sediment–water interface and produce hydrogen sulphide that enters pore water, and eventually the water column (Diaz & Rosenberg 1995). Organic matter deposition can also directly smother benthic invertebrates. Therefore, benthic community, like eelgrass health and vigour, is also a second tier indicator.

The goal of the benthic invertebrate community analysis of the AMS is to determine if changes in ecosystem processes and characteristics that may indicate increased nutrient loading and/or altered sediment transport regimes are evident based on especially temporal changes in the benthic invertebrate community. Natural variability in benthic invertebrate communities can make it difficult to determine if subtle changes are occurring as a result of seabed eutrophication or other causes. Site-specific factors will affect the composition of the benthic invertebrate community and its sensitivity to increased nutrient loading.

1.2.6 Birds

The Fraser River Delta provides habitat that is international in its significance for a wide variety of birds including waterfowl, shorebirds, coastal seabirds, Great Blue Herons, and raptors. Annually, approximately 1.4 million birds use the Delta during the peak of migration (Butler and Campbell 1987). The Fraser River Estuary, which includes Roberts Bank and the intercauseway area between the Deltaport Causeway and the BC Ferries Causeway, provides critical habitat for the largest wintering concentrations of waterbirds and raptors in Canada (BC Waterfowl Society 2006).

Two listed species that use the region include the Great Blue Heron (*Ardea herodias*) and Black Brant Geese (*Branta bernicla*) (Brant). Great Blue Heron (*fannini* subspecies) are listed federally by the Committee on the Status of Endangered Wildlife (COSEWIC) under the *Species at Risk Act* (SARA, Schedule 1) as a species of 'Special Concern'. Provincially, the coastal *fannini* subspecies is blue-listed due to declining populations attributed primarily to human development and in part to increasing disturbance from eagle populations (Gebauer and Moul 2001). Brant are also provincially blue-listed. Blue-listed organisms are indigenous species or subspecies considered to be of Special Concern in British Columbia, but whose populations are not so imperilled as to be considered threatened with, or in danger of, extirpation (i.e., red-listed).

Due to the potential for disturbance to this habitat resulting from Deltaport Third Berth construction, Hemmera monitored waterfowl and coastal seabird use of the intercauseway from 2007 to 2009 as part of the Deltaport AMS (Hemmera 2008a, 2008b, 2008c, 2009). The main objectives of this work were to provide data towards answering a concern regarding potential marine eutrophication, changes to coastal erosion processes and the distribution and composition of local biota, including shorebirds and coastal seabirds in the intercauseway area. The bird study data were considered one indicator of ecosystem structure and function on a relatively broad spatial-temporal scale. Ecosystem changes leading to adverse ecosystem effects (e.g., eutrophication and erosion) that might have been attributable to DP3 construction activity would likely have been first detected through monitoring at a finer scale (e.g., water quality, benthic community, and eelgrass monitoring). Therefore, bird monitoring was considered a third tier indicator of potential eutrophication.

An additional concern was that construction activities could potentially alter bird feeding and/or resting behaviours and bioenergetics. As such, monitoring bird relative abundance, distribution and behaviour in the context of the DP3 construction activity was conducted as an important indicator of construction-related effects to a valued ecosystem component.

Due to the possibility that changes to the ecosystem over time can affect key species such as Great Blue Heron, Brant, Western Sandpiper (*Calidris mauri*), and Dunlin (*Calidris alpina*), monitoring bird usage within the intercauseway area was part of the overall strategy to monitor ecosystem structure and function in the intercauseway area. To that end, the following bird study objectives were identified for studies conducted between 2007 and 2009:

1. Determine whether there are impacts to Brant and Great Blue Heron usage of the intercauseway area during critical periods of construction and operation.
2. Determine whether there are impacts on coastal seabird and shorebird usage of the intercauseway area during construction.

Construction of Deltaport Third Berth was completed in December 2009. Results for the first three years of monitoring indicated that overall bird abundance and habitat use within the intercauseway area did not differ significantly compared to pre-construction surveys conducted from 2003-2004 (Hemmera 2005).

In 2010, after completing three years of coastal waterbird point count surveys and following consultation with Port Metro Vancouver, the scope of bird surveys was changed to focus on two species, Brant and Great Blue Heron. Then after review of the 2011 data, and in consultation with Scientific Advisory Committee (SAC), the decision was made to discontinue Brant surveys in 2012 and continue with Great Blue Heron surveys for one more year using windshield survey methodologies described in **Appendix A**. The Great Blue Heron surveys were discontinued in at the end of 2012.

1.3 FIELD METHODOLOGIES

The detailed field methodologies for the various survey and sampling methods are included in the Detailed Workplan document prepared for the VFPA by Hemmera (2007a) and a summary is also attached in **Appendix A** (updated to reflect 2011 changes). The following sections provide some of the basic methodology along with any methodological variations that were necessary for completion of the work. Field methods undertaken in 2013 to investigate the localized changes to eelgrass behind the tug basin are described in a separate report in Appendix C.

1.3.1 Coastal Geomorphology

Monitoring for the AMS program began in April 2007 and has continued through 2012. However, the field-based components of the monitoring program were discontinued as of January 1, 2012, based on recommendations made in the 2011 AMS annual report (Hemmera, 2012b). The following sub-sections provide a summary of the methodology and timing for each monitoring activity. A detailed description of the methodology is presented in **Appendix A**.

1.3.1.1 Crest Protection Structure Monitoring

Monitoring of the Crest Protection Structure was discontinued at the end of 2011. No additional data were collected in 2013 related to this activity. **Figure 2** shows the former locations of the monitoring cross-sections as well as the monitoring points on the Crest Protection Structure.

1.3.1.2 Automated Turbidity Monitoring

Automated Turbidity Monitoring was discontinued during 2010. No additional data were collected during 2012 under this activity. The previous location of the turbidity instrument is shown in **Figure 3**.

1.3.1.3 Monitoring of Erosion and Deposition

Monitoring of erosion and deposition was discontinued as of January 1, 2012. No additional data were collected during 2013 under this activity. The previous locations of the DoD rods are shown in **Figure 4** and **Figure 5** illustrates the sequential measurements that were made to calculate maximum scour and net deposition when the DoD rods were being measured. All DoD rods were removed from the study area in May 2012.

1.3.1.4 Sediment Samples

Collection of sediment samples was discontinued as of January 1, 2012. No additional data were collected during 2013 under this activity.

1.3.1.5 Interpretation of Orthophotographs

Orthophotographic mapping was proposed in the AMS Plan for the purpose of tracking the dendritic channelization process as well as other geomorphic features within the study area. Aerial photographs of the study area are scheduled to be taken on a yearly basis during summer low tides in July. The 2013 photos were flown on July 23 when the lowest predicted tide was 0.5 m Chart Datum. Aerial photos were evaluated to assess trends and patterns of erosion and/or accretion on the tidal flats as well as changes to any other significant features such as tidal channels. This evaluation is conducted annually and covers the entire intercauseway tidal flat area. The methodology consists of overlaying successive ortho-rectified photographs using GIS mapping techniques to delineate and identify morphological changes on the tidal flats. A set of systematic mapping protocols was developed to map geomorphic features and allow comparison between photos taken in successive years. Mapping was completed by a geomorphologist who is familiar with the physical environment of Roberts Bank. The resulting maps show the location of tidal channels, areas of erosion or sand accretion, significant geomorphic features, and changes in vegetation between successive surveys.

1.3.1.6 Coastal Geomorphology Mapping

Coastal geomorphology mapping was included as part of the AMS geomorphology monitoring to assess topographic changes due to long-term erosion or accretion of the intercauseway tidal flats in the general vicinity of DP3. A combined bathymetric and topographic survey of the tidal flats using Real Time Kinematic (RTK) GPS positioning was carried out in 2007. This survey was repeated in the summer of 2010 using the same survey instrumentation, and again in the summer of 2013. Data were collected along the same transects that were previously surveyed in order to generate a Digital Elevation Model (DEM) that could be compared to the two previous DEMs. This data is presented in the results and discussions sections below.

1.3.1.7 Wave and Current Monitoring

The Wave and Current Monitoring activity was discontinued during 2010. No additional data were collected during 2013 under these activities. The former locations of the wave sensors are shown on **Figure 3**.

1.3.2 Surface Water Quality

Surface water samples were collected quarterly by Hemmera at the seven fixed surface water and sediment monitoring stations illustrated on **Figure 6** (DP01, DP02, DP03, DP04, DP05, DP06, and DP07). In Q1 only, surface water samples were collected at DP08 and DP09 (**Figure 6**), as per the recommendations from the SAC. The surface water samples were added to provide co-located surface water samples to enhance the interpretation benthic invertebrate sampling program results. These surface water stations were monitored for water quality only in 2013.

A representative surface water sample was collected one metre below the surface at each intertidal sampling station using a Van Dorn sampler. At subtidal sampling stations DP05 and DP07, water samples were collected at two depths: the A level (1.0 metres below the water surface) and the B level (2.0 metres above the sediment). At DP01, located in a tidally influenced drainage ditch discharging to the intercauseway area, samples were collected from 0.5 m below surface from under the dyke bridge (**Figure 7**). Surface water sampling dates are presented in **Table 1**. The detailed methodology and the field and laboratory quality assurance and quality control (QA/QC) measures are as outlined in **Appendix A**.

The parameters analyzed for each surface water sample included:

- Temperature.
- pH.
- Hardness.

- Salinity.
- Metals (Q1 only in 2011).
- Chlorine[1].
- Turbidity and total suspended solids (TSS).
- Nutrients (Phosphate, Phosphorus, Ortho-phosphorus, Total Kjeldahl Nitrogen (TKN), Total Nitrogen, Ammonia, Nitrate, Nitrite and Organic Nitrogen).
- Clarity (via secchi disc).
- Chlorophyll *α.*

The detailed methodology and the field and laboratory quality assurance and quality control (QA/QC) measures are as outlined in **Appendix A**.

The station nearest the DP3 construction area (DP04), was also monitored continuously for a number of water quality parameters (pH, temperature, conductivity, and dissolved oxygen) using a YSI 6600V2 buoy-mounted sonde operated in conjunction with the DP3 construction environmental monitoring program. Since 2010, the sonde was deployed on an intermittent basis, generally for one week period during the quarterly monitoring program, to avoid damage due to storm events. The sonde monitoring program was discontinued at the beginning of 2012 and field water quality parameters were collected at the time of sampling collection during the quarterly events.

A 20% difference between the measured parameter intercauseway and reference station results was initially proposed to gauge the potential for impacts; however, AMS results from 2007 suggested that baseline conditions at the intercauseway and reference stations differed by more than 20%. As such, an alternate approach to evaluating the data was adopted in 2008.

The minimum and maximum concentrations recorded during each quarterly sampling event in 2013 for each parameter of interest were noted and three categories of approximately equal range were created. The average concentration for the parameter over the four quarters was then calculated at each station and the value categorized as low, intermediate, or high, with low average values represented by small dots and high average values represented by large dots. This method facilitated the identification of spatial trends in metal and nutrient concentrations and the comparison of spatial trends in sediment and surface water data. Temporal trends for select parameters were also graphed.

[1] Chlorine was analyzed only in the sample collected at station DP01. The purpose of this parameter relates to the presence of an immediately up-gradient recreational water park and concerns of discharge to the intercauseway area.

1.3.3 Sediment Quality

Quarterly sediment sampling was completed by Hemmera at the same time as the surface water sampling at the stations illustrated on **Figure 6**. A representative sediment grab sample was collected from each of the nine stations using a Ponar sampler. Sediment samples were analyzed for the following parameters:

- Metals (Q1 only in 2011).
- Total nitrogen.
- Ammonia.
- Nutrients.
- Redox (Eh).
- Hydrogen sulphide (H_2S).

The detailed methodology and the field and laboratory QA/QC measures are as outlined in **Appendix A**. The sediment data was analyzed following the same procedure as the surface water data.

1.3.4 Eelgrass

1.3.4.1 Distribution and Mapping

The digital orthophotographs were not available before the last of the daytime low low tides of the year. The field survey ground truthed the eelgrass habitat distribution in the intercauseway area focusing on areas where change has occurred over time before reviewing the orthophotographs. A handheld computer with GPS and GIS capabilities was used to confirm and/or determine the boundaries and species composition polygons that were mapped in 2012. Additional GPS data were collected while travelling to and from the monitoring stations. The distribution of eelgrass in the vicinity of the sand lobe was basely solely on orthophoto interpretation.

Digital orthophotographs (2013) were interpreted using the field survey data to develop a base layer for mapping the current distribution of eelgrass in the intercauseway area. The criterion for minimum polygon size was 50 m by 50 m.

The results of the orthophotograph interpretation and field surveys were combined with the GIS layer developed for the Coastal Geomorphology component of this study that delineates channels in the study area to produce a map detailing the 2013 distribution of eelgrass within the study area.

The eelgrass habitat within the area that was altered by sediment deposition in the Area of New Drainage Channels adjacent to DP3 was mapped at a finer scale. The Coastal Geomorphology data was reviewed by NHC to determine the boundaries of the area that was altered. The intertidal portion of the area potentially affected was surveyed at low tide to search for changes in eelgrass distribution that had occurred since 2012. The team followed the 2012 polygon boundaries and if changes were noted then additional GPS data was recorded. The team walked the upper perimeter of the area to search for new eelgrass colonization within the small channels. The subtidal portion of the area that was altered was viewed from the road adjacent to the site. The orthophotos, waypoint data, and field notes were used to map each habitat type within the area. The GIS data was used by NHC to produce a 2013 map of the area and to estimate the total area occupied by each habitat type. The area (m^2) of each habitat type was calculated then converted to hectares and reduced to two decimal places.

1.3.4.2 Monitoring Eelgrass Vigour and Health at the Established Stations

The survey assesses the health and growth of eelgrass at nine of the eelgrass monitoring stations that were established for the DP3 Environmental Assessment, including four stations in the intercauseway area, two stations west of the Deltaport Causeway (**Figure 8**), and three reference stations in Boundary Bay (**Figure 9**).

The parameters that were quantified at each of the stations included total shoot density, reproductive shoot density, shoot length, and shoot width[2]. Means were calculated from 20 replicate samples at each station.

The relative productivity at each station was calculated using a Leaf Area Index (LAI) formula. The LAI is calculated as follows:

$$\text{LAI} = \text{mean density } (\#/m^2) \times \text{mean shoot length (m)} \times \text{mean shoot width (m)}$$

The data for each parameter at each station from 2003 and from 2007 to 2013 were used to create histograms to demonstrate the trends over time.

T-tests using the Bonferroni correction adjustment were used to test for significant differences between years for each parameter, except in cases where there was no variation within a data set. A standard paired two-sample, 2-tailed t-test was used in cases where the Bonferroni correction adjustment could not be applied.

The presence or absence of *Beggiatoa sp.* and relative density of epiphytes and was recorded at each of the stations. Photographs were taken at each site to document the epiphytic cover for future reference.

---

[2] Quadrat sampling along transects as described in *Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia* (Precision 2002).

1.3.5 Benthic Community

Sediment samples for benthic community analysis were not collected in 2013 and no future benthic sampling events are planned.

1.3.6 Birds

As discussed in **Section 1.2.6**, Brant windshield surveys were discontinued at the end of 2011 and Great Blue Heron windshield surveys were discontinued at the end of 2012. The windshield survey methodology is documented in **Appendix A** and involved stopping at a subset of the point count stations, and at other locations with good vantage points of the intercauseway, to count all visible Brant or Great Blue Herons, with no minimum time requirement. A single windshield survey consists of one complete assessment of the intercauseway from points along the Deltaport and BC Ferries Causeways and Tsawwassen First Nation lands (**Figure 10**). At each observation station, biologists recorded 1) weather data, 2) the number of Great Blue Heron and their flight direction, if applicable; 3) bird behaviour; 4) the distance target species were from the shoreline, and 5) any sources of disturbance, if applicable. Windshield surveys were conducted at the most ideal time to identify the maximum number of individuals within a short period of time.

2.0 RESULTS

The following sections provide a summary of key findings for the AMS quarterly monitoring events during 2013.

2.1 BACKGROUND INFORMATION

2.1.1 Weather, Tides and Fraser River

Winds, waves, tidal currents and Fraser River discharges provide the main driving forces for the physical processes occurring at Roberts Bank. This chapter provides a brief overview of these parameters for the duration of the 2013 monitoring period. Comparisons to historical conditions were made using statistical techniques to provide an assessment of the overall frequency and magnitude of these driving forces.

Reference stations for environmental data collected outside of the AMS program were chosen based on proximity to the site, quality of data, and length of historical record. It is recognised that conditions within the AMS Intercauseway Area may differ somewhat from those measured at the external stations, both in terms of magnitude as well as timing but an in-depth analysis of these variations is outside the scope of the AMS. The primary purpose of presenting these data is to provide an independent evaluation of the relative wind and wave conditions compared to historical conditions in order to put the data collected for the AMS Monitoring Program into context. The wind and wave analysis based on the external stations provides a useful proxy measurement of the overall energy regime affecting the site.

2.1.2 Winds and Waves

Deltaport Terminal is exposed to waves from the northwest, west, south-west, south and south-east. **Figure 11** shows the fetch lengths measured at 10 degree intervals from a point near the offshore end of the terminal. The offshore (deepwater) wave conditions are governed by the fetch length, wind speed and wind duration. There are no continuous long-term wave or wind measurements at Deltaport. However, hourly wind data for the period from January to December 2012 were obtained from Vancouver International Airport, which has the longest continuous record in the area. Wave heights and wave periods have been recorded at Halibut Bank by Fisheries and Oceans Canada through the Marine Environmental Data Service (MEDS) program. The Halibut Bank station is located in the Strait of Georgia approximately mid-way between Nanaimo and Sechelt and 45 km northwest of Deltaport. The combination of wind and wave measurements provides a reasonable basis for characterizing the deepwater wave climate near Deltaport in 2012. The wind speed and direction data were used to hindcast the deepwater wave conditions at the site using a standard calculation relating fetch length, wind speed, and wind duration to wave height, while the measurements at Halibut Bank provided an independent check of the predictions. Knowledge of the deepwater wave conditions from the hindcast data provides a useful contextual comparison for evaluating the wave data that was previously collected at the three stations within the study area and continue to provide a context for the relative amount of wave energy that the study area is exposed to.

Wind speed and wind direction were tabulated for four periods: January-March (**Table 4**), April-June (**Table 5**), July-September (**Table 6**) and October-December (**Table 7**). The values in these tables represent the number of observations (hourly data) in each speed class and direction range. The time series of wind measurements was also reviewed to identify specific storm events over the monitoring period. In this case, a storm event was defined as having a sustained wind speed greater than 30 km/h (**Table 8**). Each storm event was analysed in terms of the factors that are most important to the geomorphic outcome: time that winds were greater than 30 km/h, corresponding tide levels, and estimated significant wave height (Hs) and wave period (Tp). An evaluation of the historical probability of occurrence for exceedence of the maximum wind speed provides additional context.

The storm with the highest winds event of the year, regardless of direction, occurred in the January-March period and was from the west with a maximum wind speed of 63 km/h and winds that remained above 30 km/h for eleven hours. Despite having the highest winds, the relatively shorter fetch length from the west and relatively short duration of the storm during this March 20th event predicted wave heights of only 1.3 m. Two other storms in February had waves of 1.2 m or greater. The strong wind events in this period came from nearly all cardinal directions except the north and southeast, with seven observations exceeding 40 km/h (**Table 8**). Of the eleven storm events in this period, five are predicted to have generated waves smaller than 1 m (Hs), according to hindcast calculations.

During the April-June period, there were nine storms, including six storms with maximum wind speed exceeding 40 km/h (**Table 8**), which came from the west and northwest. This period also saw the two largest predicted wave events of the year at 2.0 m and 2.2 m (Hs). The largest waves were generated during a storm that occurred on April 11 that had a maximum wind speed of only 43 km/h from the west, but which lasted for fourteen hours. The second largest waves were generate during a storm that occurred on April 29/30, had a higher maximum wind speed and a longer duration (27 hours) but some lulls during the storm resulted in a slightly lower wave height than the April 11 storm. The July-September period had only three identified storm events, none of which had a maximum wind speed that exceeded 40 km/h, but an event on September 29 generated waves of 1.9 m (Hs) during an 8 hour storm that began in the southeast, backed into the east for four hours then veered rapidly into the south and then southwest as the storm ended.

There were six storms that were identified in the October-December period, and all came from the west except one storm that came from the northwest. All events but one had winds exceeding 40 km/h but the largest waves produced would have been just over 1.3 m (Hs) and two of these events would have produced waves of less than 0.5 m in height. The third and fourth highest winds of the year that occurred in a storm occurred in this period with winds of only 53 km/h. These events occurred on October 8 and December 18, with waves 1.3 m and 1.2 m (Hs) respectively.

A frequency analysis was carried out on the wind and wave data to assess the relative magnitude of the 2013 events versus the long-term conditions. Estimates of long-term frequency and duration of wind events and wave conditions were summarized in NHC (2004). **Figure 12** shows cumulative frequency distribution (percent time exceedence) plots of wind speed for the four seasons as measured at Vancouver Airport. **Figure 13** shows similar plots for wave heights recorded at Halibut Bank. In 2013, the percent time exceedence curve for winds matches very closely to the long-term curve for January to March. For the April to June the 2013 curve was shifted upwards in the range from 10 km/h to 20 km/h, indicating that these wind speeds were exceeded slightly more often than the long-term average. For the July to September period, winds between 5 km/h and 30 km/h were exceeded more often than the long-term average, while in the October to December period the curve is shifted downwards for winds between 10 km/h and 35 km/h.

2.1.2.1 Inter-annual Comparisons

A comparison of the 2013 wave data to the long-term average conditions based on the period of record (data collected from 1953 to 2006) is in general agreement with the overall trend to relatively smaller storms recorded in the storm table (**Table 8**). For the January to March period, the percent time wave exceedence curve for 2013 lies below the long-term average for wave heights between 0 m and approximately 1.7 m, indicating that waves in this range were exceeded less often than the average year. For both the April to June and July to September periods there was a slightly lower incidence of waves between 0.3 m and 1.0 m in height as compared to the long-term average. The October to December period showed quite a large decrease in the percent time that waves of between 0 m and 1.7 m were exceeded.

Overall, the wind and wave conditions in 2013 were generally less severe than the average conditions over the period of record.

2.1.3 Tides

Tide levels are predicted by the Canadian Hydrographic Service at Tsawwassen using observed levels at Point Atkinson (**Figure 14** to **Figure 17**) as a reference station. Tide levels were also measured by NHC at Deltaport from June 14, 2007 using a pressure transducer and data logger. The record from this instrument contains a number of gaps caused by accidental damage and wilful tampering of the installation, and ends on July 3, 2008 when the instrument was permanently removed.

The tides are mixed, semi-diurnal, that exhibit differences in elevation between successive high waters and successive low waters. The sequence of the tides typically follows the pattern of Higher High Water to Higher Low Water to Lower High Water to Lower Low Water, although this pattern is reversed approximately 15% of the days in a tide cycle as the tides switch from spring to neap. Lower Low Water occurs in daylight hours between April and August while during the fall and winter season Lower Low

Water occurs during the night time. The tide range undergoes a bi-weekly variation due to the influence of the moon. Spring tides, having the largest range, occur 15 days apart, 26 hours after a new or full moon. The maximum tidal ranges occur near the time of the summer and winter solstice. The minimum tidal range occurs around the time of the Spring and Autumn equinoxes.

The highest tide of 2013 occurred on June 25, during a calm period immediately prior to a moderate wind event of just over 30 km/h. The predicted High Water at Point Atkinson was 4.8 m (Chart Datum) at 20:00 h, while the highest tide level recorded at Point Atkinson was 4.98 m.

2.1.4 Fraser River Discharge and Sediment Inflow

The Fraser River hydrograph has a characteristic nival-regime, with the flow rising in late April, peaking in May and early June, then receding through the late summer and fall. The lowest annual discharge typically occurs in March.

The Fraser River adds approximately 18 million tonnes of sand, silt and clay sediment to the Strait of Georgia each year on average. Suspended sediment concentrations typically rise to between 500 mg/L to 1,000 mg/L during the May-June freshet season, then decline through the late summer and fall to between 100 to 200 mg/L. Sediment concentrations in the low flow winter season typically range between 50 to 100 mg/L (McLean and Church, 1986).

Virtually the entire sand load is deposited in the delta front off the main arm jetty near Steveston. Due to the isolated nature of the intercauseway portion of Roberts Bank and the presence of the Deltaport Causeway, even the fine clay-sized sediment in the Fraser plume is deflected into the deep waters of the Strait of Georgia (**Figure 18**).

Information on conditions during 2013 is based on preliminary data from Water Survey of Canada and is still subject to revision. The 2013 freshet was not particularly large, reaching a maximum discharge of 10,100 m^3/s in Hope and 10,540 m^3/s in Mission around May 16, which is just slightly larger than the 2-year return period flood. By the first week of August the discharge had reduced to 3,000 m^3/s at Hope, and then continued to decrease slowly through the fall, reaching 2,000 m^3/s in the middle of September with typical discharge fluctuations in response to local rainfall events during this period. The peak freshet was slightly smaller than a 5-year return period flood and was notable for its relatively early onset and rapid decline. No sediment measurements were made on the Fraser River in 2013. However, based on a comparison with previous years of observations it is very likely that the total load in 2013 was much smaller than the mean annual load of around 18 million tonnes. Based on previous years observations it is expected that the highest sediment concentrations would have reached approximately 1,000 mg/L in mid-May, decreasing to a few hundred mg/L by early-August.

2.1.5 Post-construction Activities

Construction activities associated with development of the terminal were completed in December 2009 and commercial operation of the terminal commenced in mid-January 2010 (**Table 1.1-1**). Post-construction activities in 2010 were related to development of the habitat compensation features along the east side of the Deltaport causeway. This activity involved replacing the existing rock rip-rap that is currently protecting the east side of the Deltaport Causeway with structures designed to create a more complex range of habitat types. The habitat compensation features were substantially completed in September, 2010. DP3 post-construction activities in 2011 were limited to the removal of the temporary barge ramp that was located in the tug basin. Removal occurred between November 8 and December 5, 2011. There were no known activities of significance in 2012 or 2013 at DP3. As noted in Section 1.1.1, an accident at the Westshore Terminal resulted in approximately 30 tonnes of coal being spilled into the water.

2.2 COASTAL GEOMORPHOLOGY

2.2.1 Crest Protection Structure Monitoring

No Crest Protection Structure monitoring was conducted during 2013.

2.2.2 Automated Turbidity Monitoring

No turbidity monitoring was conducted during 2013.

2.2.3 Monitoring of Erosion and Deposition

No monitoring of erosion and deposition was conducted during 2013.

2.2.4 Sediment Samples

No sediment sampling program was conducted in 2013.

2.2.5 Interpretation of Orthophotographs

The study area for this monitoring activity includes the entire area of Roberts Bank within the intercauseway tidal flats. **Figure 19** shows the results of the orthophotographic interpretation, which was completed using GIS mapping techniques under the direction of the project geomorphologist. Areas of disturbance, including the active channel zone, shown in light purple, are areas where channel activity or deposition is occurring, but individual bars and/or channels are too small to be mapped individually. Sand bars, either large forms near the low-tide edge of the tidal flats or smaller channel point bars, have been mapped in yellow. Tidal channels are delineated in green – a dark green colour for channels large enough to have its banks mapped with double lines and light green for smaller channels in which the banks are unresolvable at a scale of 1:1,000.

The main features of interest shown in **Figure 19** include:

1. New drainage channels that formed at the north-eastern margin of the perimeter dike.
2. Formation of sand bars on the tidal flats on the seaward side of the Crest Protection Structure.
3. The large system of dendritic channels draining into the turning basin.
4. The tidal channels adjacent to the BC Ferries Causeway.
5. Sand bars located along the Deltaport Causeway (east side) appearing to originate from the East Causeway Habitat Compensation Project.

Items 2 through 4 are historic features that pre-date the DP3 project and have been identified and described in detail previously (NHC, 2004). Specific changes to these features that have occurred between 2012 and 2013 are detailed in Section 3 where relevant.

Item 5 refers to a series of sand bar features adjacent to the Deltaport Causeway that were first identified in the 2012 orthophotograph. As stated in the 2012 Annual Report (Hemmera 2013), these sand bars appear to have formed as a result of fine sediments washing out of the East Causeway Habitat Compensation Project, which then migrated seaward. This supposition was supported by observations made during the 2013 coastal geomorphology mapping surveys, during which the bars and their source material were observed in the field. These sand bars appear much smaller in area in the 2013 orthophotographs compared to the 2012 orthophotographs, which may be caused by eelgrass recovery and growth in this area rather than further distribution of the sediment.

Figure 20 shows a comparison of the Area of New Drainage Channels (from Item 1 above) as mapped in July 2012, to the same area as mapped in July 2013. **Figure 21** shows the outline of the large dendritic channels (from Item 3 above) that were digitized from the 2012 and 2013 orthophotos, and displays changes to the channels between these years, based on the AMS channel mapping methodology.

2.2.6 Coastal Geomorphology Mapping

The baseline coastal geomorphology mapping survey was completed in 2007 and the results were presented in the AMS 2007 Annual Report (Hemmera 2008d). The survey was repeated during the summer of 2010, and again during the summer of 2013, in accordance with the AMS workplan. Topographic and hydrographic survey techniques were used to acquire bed elevations in the intercauseway area, extending from the toe of the Deltaport causeway approximately halfway across the intercauseway tidal flats, and from the toe of the shoreward dyke at the northeast extent of the tidal flats to the delta foreslope on the seaward side of the Crest Protection Structure. This data has been compiled to display the elevation contours in Chart Datum produced from processing the raw data in AutoCad Civil 3D.

In addition to providing an overview assessment of any elevation changes of the tidal flats near the Deltaport Causeway and DP3, this survey was designed to assess changes to the area of new drainage channels and the larger region of dendritic channels, and to determine any potential changes to the depths and locations of channels, bars, and scour around the Crest Protection Structure that are undetectable through orthophoto interpretation.

Figure 22, **Figure 23**, and **Figure 24** show the DEM surfaces from 2007, 2010, and 2013, respectively, that were generated from the three surveys. **Figure 25** shows the change in elevation that was calculated between the 2013 and 2010 surfaces, **Figure 26** shows the change in elevation between the 2013 and 2007 surfaces, and **Figure 27** shows a zoomed in view of change in elevation in the Area of New Drainage Channels. These figures are discussed further in **Section 3.1.6** of this report.

2.2.7 Wave and Current Monitoring

No wave or current monitoring was conducted during 2013.

2.3 SURFACE WATER QUALITY

2.3.1 Quality Assurance / Quality Control

For metals in surface water, the data quality objective (DQO) for precision was to obtain a relative percent difference (RPD) of less than 20%. The DQO for completeness was 100%. In general the RPDs met the DQOs and it was concluded that the data were, on the whole, reliable and met project requirements for laboratory and field duplicate QA/QC evaluation. Detailed QA/QC evaluations are presented in the quarterly reports. A summary of issues encountered is presented in **Table 9** and discussed below.

The RPDs for chlorophyll *a* in 2013 were 47% in Q2, 105% in Q3, and 27% in Q4. In all three quarters the concentrations of chlorophyll *a* in the original and duplicate samples were within the range of previously detected concentrations. As reported in previous annual reports (Hemmera 2012a, 2012b, 2013), chlorophyll *a* RPDs have not meet the DQO in more than two quarters a year and is likely a result of differences in total suspended solids between the samples. The elevated RPDs are therefore not considered indicative of sampling or laboratory quality control issues.

2.3.2 Chemistry

The parameters analyzed as indicators of potential toxicity to marine organisms were compared against the BC Water Quality Guidelines (WQG) for the Protection of Marine Aquatic Life (MAL) and the Canadian Council of Ministers of the Environment (CCME) MAL WQG. The data are presented in **Table 10**.

2.3.2.1 Metals

Surface water samples were analysed only in Q1 of 2013 and data is provided on **Table 10**. Other than the total boron in surface water samples (excluding ditch station DP01), there were no exceedances of the regulatory guidelines noted in Q1. Total boron concentrations measured during 2013 from these locations (DP02 to DP09) ranged from 1,770 to 4,290 µg/L. This is compatible with boron concentrations in coastal marine water in Canada (typically ranges from 3,700 to 4,300 µg/L) (Moss and Nagpal, 2003).

A number of metal parameters exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch). In Q1-2013, copper, manganese and nickel exceeded the regulatory guidelines. These same metals have exceeded the regulatory guidelines in previous years.

2.3.2.2 Eutrophication-related Parameters

Surface water samples were analysed quarterly in 2013 for eutrophication parameters and data is provided on **Table 10**. Nitrate concentrations met the CCME MAL of 16 mg/L. There is no other regulatory criteria applicable to nutrients in seawater. Results of eutrophication-related parameters in the context of the potential for eutrophication are presented in the discussion section (**Section 3.2**).

2.3.2.3 Sonde

The quarterly deployment of the Sonde was discontinued at the beginning of 2012 as agreed upon with SAC. Field water quality measurements of temperature, pH, conductivity, dissolved oxygen, redox and turbidity were collected with a YSI probe at the time of surface water sampling each quarter as presented on **Table 10**. The averages for each field parameter by quarter were calculated (excluding DP01) and are summarized in the table below. Field measurements of temperature, pH and dissolved oxygen are consistent with 2012 measurements (on average less than 15% difference) and within the ranges measured using the weekly sonde deployment prior to 2012.

Table 2.3-1 Average Field Water Quality Measurements by Quarter (2013)

Quarter	Average				
	Temperature (ºC)	pH	Dissolved Oxygen (mg/L)	Redox (mV)	Turbidity (NTU)
Q1	6.8	7.9	11	305	1.1
Q2	13.7	8.1	11	186	11
Q3	12.3	8.0	8.2	160	2.3
Q4	5.5	7.9	9.0	136	1.4

2.4 Sediment Quality

2.4.1 Quality Assurance / Quality Control

For sediment, the DQOs were a RPD of less than 20%. Except for the parameters discussed below, RPDs were less than 20% in 2013 and the sediment data set was considered complete and accurate based on the results of the field and laboratory QA/QC. Detailed QA/QC evaluations are presented in the quarterly reports. A summary of issues encountered is presented in **Table 9**.

In each quarter, one or more organic parameters had RPDs greater than the DQO of 20%. Elevated RPD values for 2013 ranged from 25% to 97%. All data in 2013 was within the previously observed range and elevated RPDs are likely due to the heterogeneity of the sediment samples. The data was considered valid.

2.4.2 Sediment Chemistry

The sediment chemistry data is presented on **Table 11**. The sediment toxicity parameters (metals) were compared against the BC Contaminated Sites Regulation (CSR), Schedule 9 Generic Numerical Sediment Criteria for sensitive marine and estuarine sediments ($SedQC_{ss}$). Similar to previous years, no exceedances of the $SedQC_{ss}$ were measured during the Q1 monitoring event.

There are no regulatory criteria applicable to nutrients in sediment. Nutrient concentrations will be discussed in the context of potential eutrophication in **Section 3.3**.

2.4.3 Grain Size

Grain size samples were collected by Hemmera during the Q1 monitoring event and data is provided in **Table 11**. Sediment grain size ranged from sand with trace silt and clay to sand and silt with some clay. This is consistent with grain size results from NHC and Hemmera from previous years.

2.5 Eelgrass

2.5.1 Distribution and Mapping

The eelgrass distribution in the Area of New Drainage Channels and in other locations where change had been noted in previous years was mapped on July 5, and August 6 and 7, 2013.

The air photographs were taken during low tide on July 23, 2013 and available as digital orthophotographs on October 11, 2013. The orthophotographs were interpreted using the data from the field survey. Additional data were collected for this section while monitoring Eelgrass Vigour and Health at the Roberts Bank Stations between July 20 and 23, 2013.

The 2013 and 2003 distribution of eelgrass within the study area is shown in **Figure 28**. The eelgrass distribution maps produced for the AMS between 2007 and 2012 are provided in **Appendix B.**

2.5.1.1 Intercauseway Area

Z. japonica is an annual species that recruits from seeds each spring; therefore the distribution and density of this species may vary greatly between years. The base of the rip rap along the majority of the eastern edge of the Deltaport causeway is located at approximately 3 m (chart datum) and is near the upper limit for *Z. japonica* in the intercauseway. The distribution and cover of *Z. japonica* in this area varies from continuous to patchy to unvegetated mud between years (**Appendix B, Figure 28**). The *Z. japonica* distribution and density in this area in 2013 was similar to that of 2003, 2007, and 2008. A series of recently developed sand bars were mapped along the Deltaport causeway in 2012; the majority of these had disappeared by the 2013 survey as the areas were re-colonized by *Z. japonica*. Small patches of *Z. marina* were noted in small drainage channels along the causeway, near the sand bars, however these were very small (< 5 m^2) and therefore were not mapped.

The area classified as patchy, as opposed to continuous, within the main *Z. japonica* meadow has increased annually since 2010. The landward edge of the continuous *Z. japonica* meadow in the northeast corner of the intercauseway retreated seaward between 2003 and 2011 (**Appendix B**). A comparison of the GIS maps from 2003 and 2011 revealed that the continuous *Z. japonica* meadow has retreated approximately 230 m since 2003 in this area. The trend reversed in 2012 as the landward edge of *Z. japonica* in this area moved landward; the distance recolonized varied between 25 and 280 metres. The landward edge of the continuous *Z. japonica* meadow retreated by a maximum of 500 metres by the 2013 survey in some areas while it remained unchanged in others (**Figure 28, Appendix B**).

The boundaries and size of transition zone southeast of the sand lobe has varied since 2003 as it did during the 1980s; the cover has remained continuous (**Figure 28**). A sand bar developed along a drainage channel near the ferry causeway that increased in size between 2003 and 2007 (**Figure B-1**). Most of the sand bar was colonized by a patchy distribution of *Z. marina* and *Z. japonica* by 2008 (**Figure B-2**). The area continued to support a patchy distribution of both species in 2009, except for a small area where two drainage channels had connected (**Figure B-3**). The current within the channel during tidal exchanges eliminated the eelgrass in its path. The density of both eelgrass species increased along the northern perimeter of the 'sand bar' by 2010 resulting in an increase in the area occupied by the continuous mixed zone and the continuous *Z. japonica* zone (**Figure B-4**). The conversion of patchy habitat in this area to continuous habitat continued into 2013 (**Figure B-5, Figure 28**).

The landward boundary of continuous *Z. marina* habitat and the seaward boundary of continuous *Z. japonica* habitat southeast of the sand lobe complex, in the middle of the intercauseway, both migrated seaward between 2003 and 2011 (**Appendix B**). The distance that the polygon boundaries have migrated was variable; the distance midway between the sand lobe complex and the re-vegetating sandbar to the southeast discussed above was measured using GIS. The continuous *Z. japonica* meadow had expanded approximately 280 m seaward while the continuous *Z. marina* meadow has retreated approximately 210 m seaward. The edge of the continuous *Z. marina* meadow remained unchanged between 2011 and 2013. The continuous mixed zone that lies between the continuous *Z. japonica* and continuous *Z. marina* zones expanded shoreward between 2011 and 2012, resulting in a polygon boundary between the continuous mixed and continuous *Z. japonica* very similar to that which was mapped in 2003 (**Figure B-6**). The shoreward continuous mixed zone boundary moved shoreward between 2012 and 2013 by a distance that varied between 40 and 220 metres (**Figure 28**).

There were eelgrass (*Z. marina* and *Z. japonica*) increases and losses in the vicinity of the sand lobe complex between the 2011 and 2012 surveys. The majority of the increases were in the northern and western areas while the majority of the losses occurred in the southern and eastern areas of the complex. The 2013 survey found additional eelgrass increases in all areas that had been affected by sand lobe development (**Figure 28)**.

The landward border of the continuous *Z. marina* meadow between the sand lobe and the Deltaport causeway that was mapped in 2003 had developed areas of patchy distribution by 2007 (**Figure B-1**). The area of patchy *Z. marina* distribution in this location varied inter-annually between 2007 and 2010 (**Figures B-2 to B-4**). The 2011 field survey determined that most of the patchy *Z. marina* habitat documented between 2007 and 2010 supported continuous coverage at this location. The density of *Z. marina* continued to increase over the following year and by the 2012 field survey was very similar to that of 2003, continuous coverage by *Z. marina* persisted through 2013 (**Figure 28**).

The transition zone northwest of the sand lobe between continuous *Z. marina* and continuous *Z. japonica* habitat where the two *species* co-existed to provide continuous coverage in 2003 changed considerably over time (**Appendix B**, **Figure 28**). The transition zone in this area had encroached into monocultures of *Z. marina* and *Z. japonica* by 2007. The enlarged transition zone became patchy by 2008 (**Figure B-2**). The majority of the patchy transition zone developed into patchy *Z. japonica* habitat by 2009 (**Figure B-3**), due to the loss of *Z. marina* in this area. The area formerly classified as mixed transition zone continued to support patchy *Z. japonica* in 2010; however there were many *Z. marina* seedlings amongst the *Z. japonica* in the north western part of this polygon. Many of the seedlings survived and multiplied, the 2011 survey documented the expansion of mixed patchy habitat into the area classified as patchy *Z. japonica* in 2010 (**Figure B-4**). The density of both eelgrass species increased into 2012 resulting in a large area in the western part of this area being classified as mixed continuous; *Z. japonica* was the dominant cover however *Z. marina* was present throughout this polygon. The density of *Z. marina* increased over the next year however *Z. japonica* remained the dominant species. The area between the mixed continuous polygon and the sand lobe was classified as patchy mixed in 2012 (**Figure B-6**); it was re-classified as patchy *Z. japonica* in 2013 (**Figure 28**) although there were a few Z. marina shoots in the area. The majority of this patchy *Z. japonica* polygon was blanketed in a dense layer of filamentous green algae.

2.5.1.2 Area of New Drainage Channels

Sediment deposition and drainage channel formation adjacent to the perimeter dyke, termed the Area of New Drainage Channels, in the intercauseway area in 2007 altered the eelgrass distribution in that area (**Figure B-1**). The lower portion of the *Z. marina* bed and some of patches of *Z. marina* survived through 2008 (**Figure B-2**).

The extent of the potentially altered area (i.e. Area of New Drainage Channels) was redefined in 2010 and reduced from approximately 12 hectares to 6 hectares; including only the area closest to the perimeter dyke (**Figure 2.5-1**).

The area occupied by each habitat type in 2003 and annually between 2010 and 2013 within the redefined area was calculated using GIS (**Table 2.5-1**). The majority of the unvegetated channels in the intercauseway are dominated by sand substrates; AMS eelgrass mapping previous to 2011 classified all unvegetated channels as 'sand'. However, the channels near the Deltaport causeway are mud; therefore the unvegetated classifications have been changed from mud to mudflat and from sand to unvegetated channel.

The area (m^2) colonized by eelgrass in 2008 in the vicinity of the area that was altered by sediment deposition from the new drainage channel formation was estimated using GIS and found to be comparable with the area occupied by eelgrass at this location in 2003. The 2009 survey found that surviving eelgrass had continued to multiply. A large portion of the area that was classified as patchy *Z. marina* in 2008 and 2009 had been colonized by *Ulva* sp. by 2010; eelgrass was absent in this area.

The surviving portion of the main Z. *marina* bed expanded into 2011 (**Figure B-5**). The continuous *Z. marina* polygon in the south eastern end of this area had expanded into an area classified as patchy in 2010 (**Figure B-4**), and the adjacent patchy polygon had expanded into an area that was un-vegetetated in 2010 (**Figure B-4**). *Z. marina* started to colonize a large area (725 m^2) northwest of the patchy polygon in 2011; however since the density was less than one per m^2 the classification remained unvegetated. The density and distribution of *Z. marina* also increased in several of the small channels.

The 2012 survey documented a decrease in the area colonized by Z. marina, especially in the area of continuous coverage (**Figure B-6**). The total area colonized by *Z. japonica* was greater than that documented in 2011 (**Table 2.5-1**); however all areas colonized by *Z. japonica* were patchy in 2012. The main losses were in the central and southern parts of the study area. There were slight increases in *Z. marina* habitat in the western corner of the study area; the eastern corner remained unchanged.

The area of continuous *Z. marina* decreased between 2012 and 2013 however the area of patchy *Z. marina* increased over this period resulting in a net increase of 0.5 hectare in the total area occupied by *Z. marina.* The area occupied by *Z. japonica* decreased by 0.33 hectares between 2012 and 2013; most of the decrease was due to an increase in patchy *Z. marina* and mudflat habitat. The total unvegetated portion of the area that was altered by sediment deposition from the new drainage channels decreased by 0.18 hectares between the 2012 and 2013 surveys.

Figure 2.5-2 Delineation and 2013 Habitat Classification of the Area that was Altered by Sediment Deposition from the Formation of New Drainage Channels and Assessed for Habitat Changes.

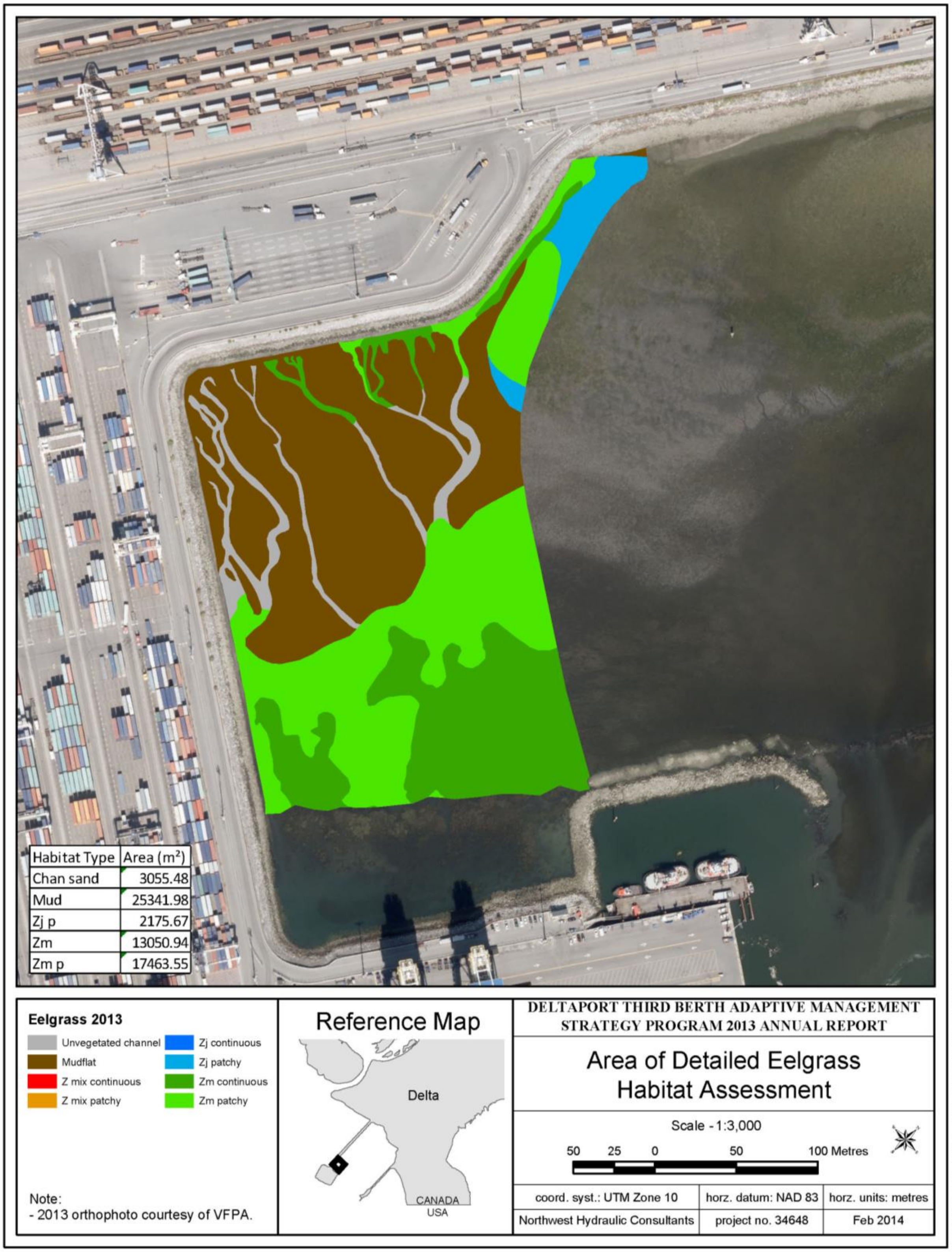


Table 2.5-1 Area Occupied by each Habitat Type in 2003 and 2010 through 2013 in the Area of New Drainage Channels.

	Area (ha.)					
Habitat	**2003**	**2010**	**2011**	**2012**	**2013**	**Change between 2012 and 2013**
Z. marina continuous	4.45	2.06	2.17	1.71	1.30	-0.41
Z. marina patchy	0	0.62	0.96	0.84	1.75	0.91
Z. mixed continuous	0	0	0.03	0	0	0
Z. mixed patchy	0	0.11	0.10	0	0	0
Total Z. marina	4.45	2.79	3.26	2.55	3.05	0.50
Z. japonica continuous	0	0.44	0.16	0	0	0
Z. japonica patchy	0	0.18	0.29	0.55	0.22	-0.33
Total Z. japonica	0	0.62	0.45	0.55	0.22	-0.33
Mudflat	1.66	2.43	2.20	2.64	2.53	-0.11
Unvegetated channel	0	0.28	0.22	0.36	0.30	-0.06
Total Unvegetated	1.66	2.71	2.41	3.01	2.83	-0.18
Total Combined	6.11	6.11	6.12	6.11	6.11	0.00

2.5.2 Monitoring Eelgrass Vigour and Health

The field survey was conducted between July 20 and 24, 2013. The station originally referred to as Site 1 was renamed Site 1A in 2009, at which time Site 1B was added.

The epiphyte load at all stations was ranked as typical. *Beggiatoa sp.* was not present at any of the sites, nor was it observed when travelling to or from the sites.

The *Z. marina* distribution was classified as continuous at all Sites except Site 1A where it was patchy and coexisted with *Z. japonica* and was classified as continuous mixed. *Z. japonica* was absent from all sites except Site 1A where it was classified as dense.

The parameters that were quantified at each of the stations included total shoot density, reproductive shoot density, shoot length, and shoot width. Means were calculated from 20 samples at each station, except at Site 1A. *Z. marina* was present in only 14 of the quadrat samples at Site 1A, therefore the mean shoot length and width was based on a sample size of 14. Mean values were reduced to one decimal place (**Table 2.5-2)**. Leaf Area Index values were calculated using two decimal places for each parameter in the equation (**Table 2.5-2**). The LAI calculation for Site 1A used the shoot length and width data from all 20 replicates; zeros were entered in cases where *Z. marina* was absent. A summary of the monitoring data from 2003 and the annual AMS surveys is provided in **Appendix B**.

Leaf Area Indices (LAI) integrate total density, shoot length, and shoot width to estimate relative productivity. Histograms of the LAI data are presented in **Figures 2.5-2 through 2.5-5**. The LAI data from Site 2 at Roberts Bank is compared with the data from Site WR3 in Boundary Bay (**Figure 2.5-6**). Histograms for each of the individual parameters are provided in **Appendix B**.

Table 2.5-2 Mean Eelgrass Shoot Density (Total and Reproductive), Length, and Width at Each Reference Station in 2013.

Site (#)	Total Density (#/0.25m^2)	Length (cm)	Width (mm)	Reproductive Shoot Density (#/0.25m^2)
Intercauseway near Deltaport Causeway				
1.A	4.0	71.4	7.0	0
1.B	20.9	189.5	7.8	2.4
2	26.2	187.2	8.3	1.0
Intercauseway area near Ferry Causeway				
5	15.2	196.2	8.6	0.2
6	18.4	165.2	8.2	0.7
West of Deltaport Causeway				
3	16.2	166.0	8.1	0.6
4	13.7	172.8	8.2	0.2
Boundary Bay				
WR1	160.8	41.1	4.2	0
WR2	60.1	137.0	6.8	1.8
WR3	38.6	191.6	7.2	0.9

T-tests using the Bonferroni correction adjustment were used to test for significant differences between years for each parameter, except in cases where there was no variation within a data set. A standard paired two-sample, 2-tailed t-test was used in cases where the Bonferroni correction adjustment could not be applied. The 2013 data from Site 1B was compared with the data from Site 1A for 2008, 2007, and 2003. The results of the analysis comparing the data from 2013 with that from previous years are summarized in **Table 2.5-3**; the p-values are provided in **Appendix B**.

Table 2.5-3 Years When the Data Were Significantly Different from that Recorded in 2013.

Site (#)	Total Density	Length	Width	LAI	Reproductive Shoot Density
Intercauseway near Deltaport Causeway					
1A	2003, 2007, 2008	2003, 2007	2003, 2007	2003, 2007, 2008	2003, 2007,
1B	2010, 2011	2003, 2007, 2008	2003, 2008	2008, 2010, 2011	2008, 2012
2	2008, 2010, 2011	2003, 2007, 2008, 2009	2008, 2011	2003, 2010	-
Intercauseway Area near BC Ferries Causeway					
5	2009, 2010	2007, 2012	2003, 2009	2012	2009
6	2010	2003, 2008	-	-	-
West of Deltaport Causeway					
3	-	2003, 2008, 2009	-	-	-
4	2008, 2010	-	2003	2010, 2011	-
Boundary Bay					
WR1	All years	2007, 2010, 2011	2011	2003, 2007, 2009, 2011, 2012	2003, 2008, 2010
WR2	All years	2009, 2012		All years	2008, 2011, 2012
WR3	2003, 2007, 2009	2003, 2007, 2012	2012	2003, 2007	2011

Note: * Bonferroni Correction Factor could not be applied. Standard 2- sample, 2-tailed, t-tests were used to analyze data in cases where the variance was zero within a data set and the Bonferroni Correction Factor could not be applied.

Figure 2.5-2 LAI data from Roberts Bank, intercauseway near Deltaport Causeway, Sites 1A, 1B, and 2

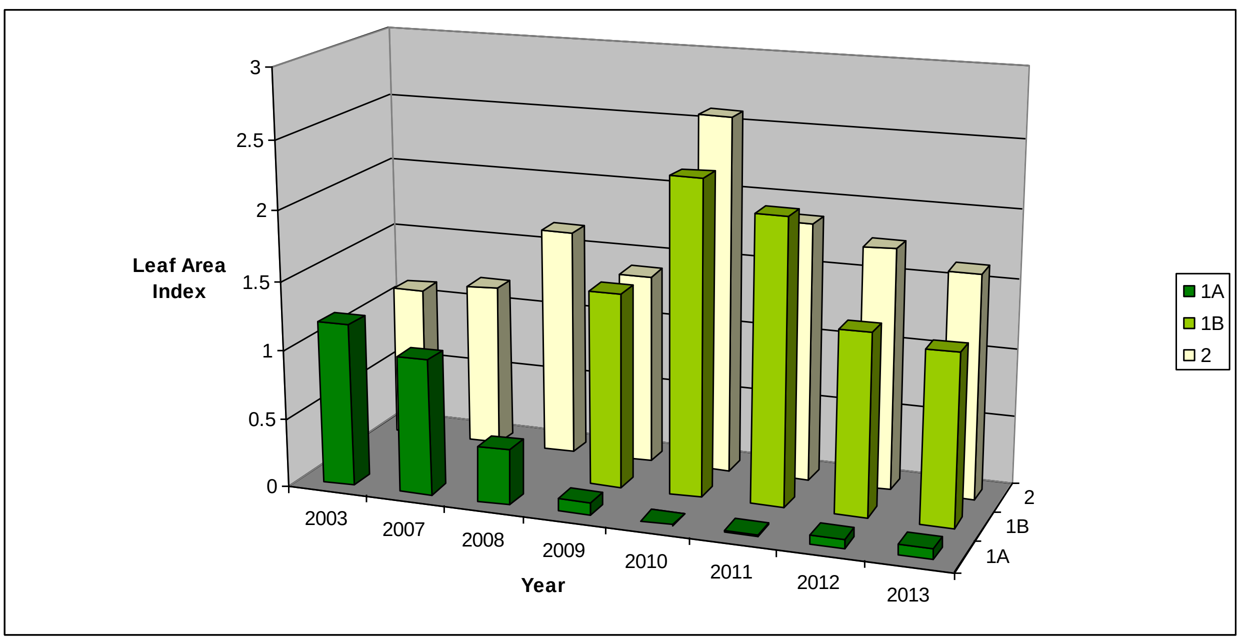


Figure 2.5-3 LAI data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

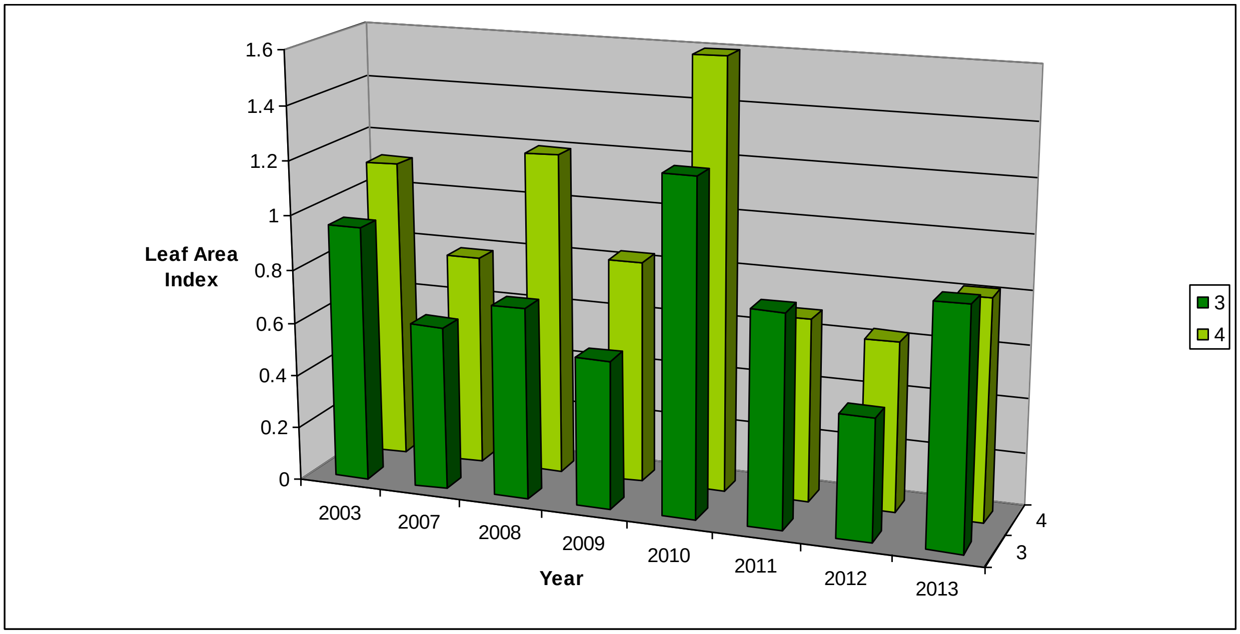


Figure 2.3-4 LAI data from Roberts Bank, intercauseway area near the Ferry Causeway, Sites 5 and 6.

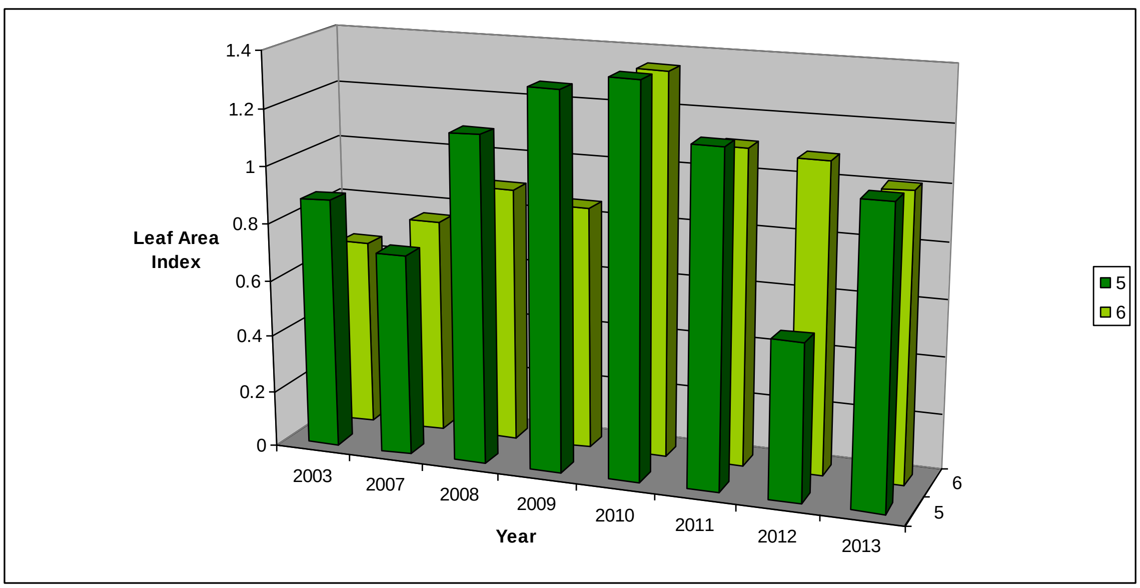


Figure 2.5-5 LAI data from Boundary Bay, Sites WR1, WR2, and WR3.

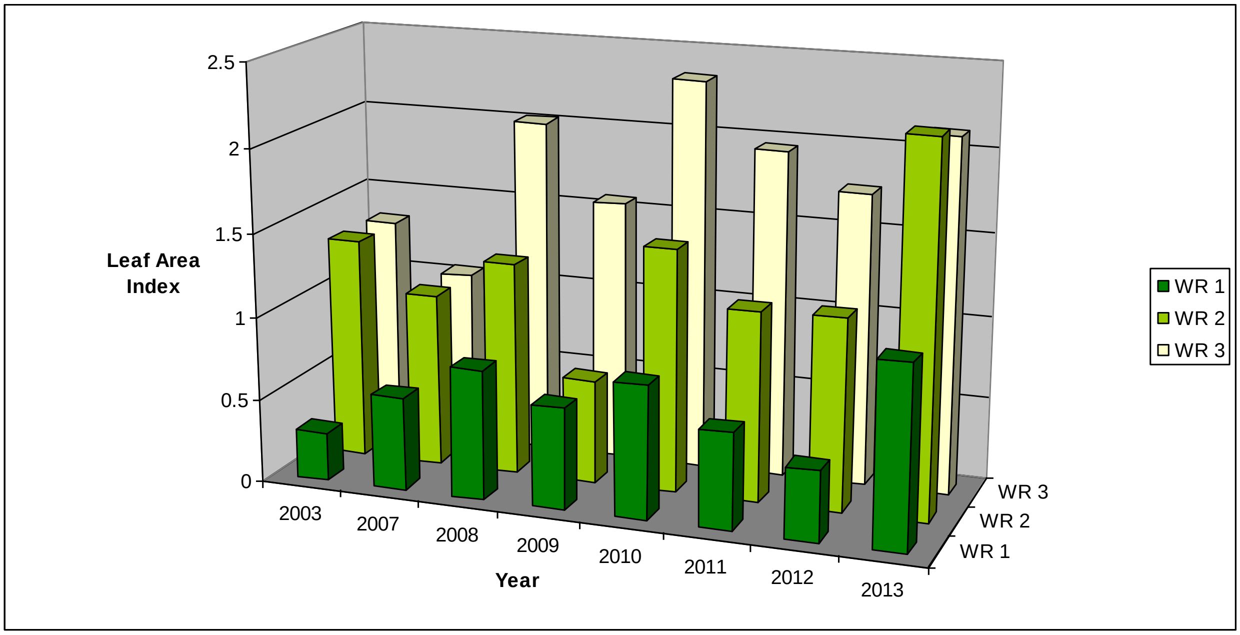
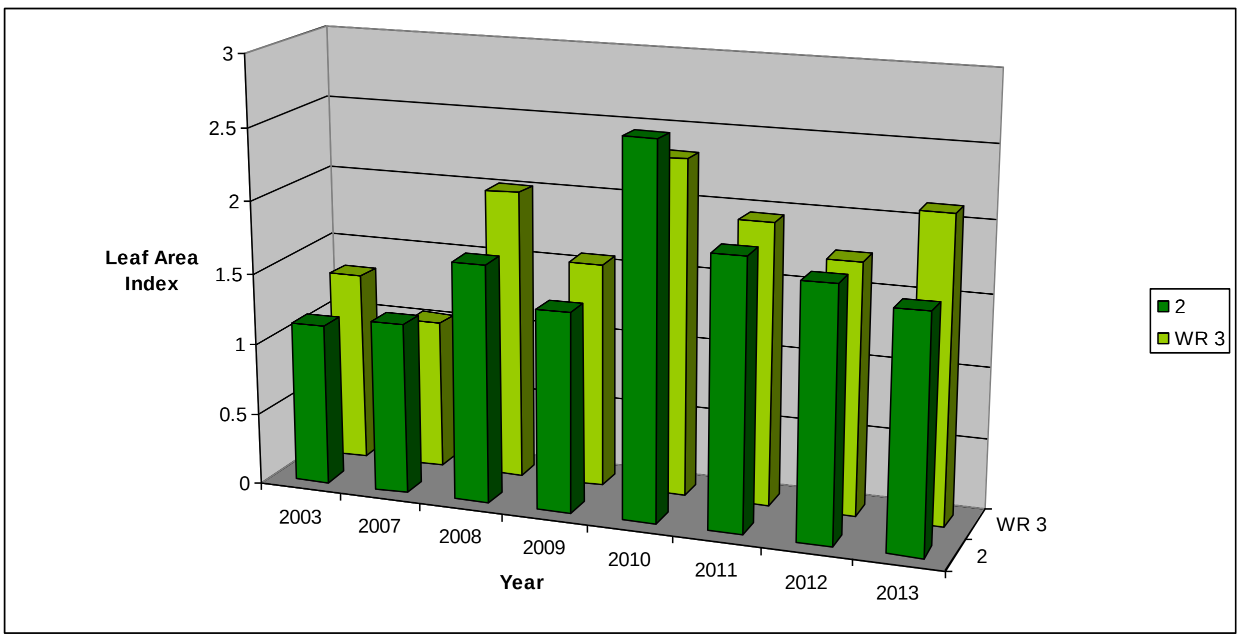


Figure 2.5-6 LAI data from Site 2 at Roberts Bank and from Site WR3 in Boundary Bay.



3.0 DISCUSSION

3.1 COASTAL GEOMORPHOLOGY

One of the primary objectives of the AMS monitoring program is to make an assessment of the possible effects of the DP3 project on the surrounding physical environment of the Roberts Bank tidal flats, specifically, the intercauseway area. Data collection for the AMS program was initiated in April 2007, after construction operations for the DP3 project had already begun, albeit in the early stages of construction. As a result, the Coastal Geomorphology Report (NHC, 2004) prepared for the DP3 Environmental Assessment, as well as aerial photographs and some limited hydrographic surveys, provide the only baseline data for which a comparison of the pre- and post-project conditions can be made. However, the rate of change of the processes affecting the physical environment in the vicinity of Deltaport is not rapid, and it is reasonable to expect that the parameters that are being monitored would have represented near-baseline conditions at the onset of the project. Analysis of the present data set therefore involves discussion of the existing conditions and attempting to place these existing conditions in the context of observations made in the AMS 2007 Annual Report (Hemmera 2008d).

3.1.1 Crest Protection Structure Monitoring

Monitoring of the Crest Protection Structure was not conducted during 2013. A discussion of the final results of this portion of the AMS monitoring program can be found in the 2011 Annual Report (Hemmera 2012a).

3.1.2 Automated Turbidity Monitoring

Turbidity monitoring was discontinued in 2010. There are no results related to this activity in 2013.

3.1.3 Monitoring of Erosion and Deposition

Monitoring of erosion and deposition was not conducted during 2013 and all DoD rods were removed from the study area in May 2012.

3.1.4 Sediment Samples

The sediment sampling program was discontinued following Q4-2011. A discussion of the final results of this portion of the AMS monitoring program can be found in the 2011 Annual Report (Hemmera 2012b).

3.1.5 Interpretation of Orthophotographs

The study area for this monitoring activity, as outlined in the Detailed AMS Workplan (Hemmera, 2007), includes the area of Roberts Bank within the intercauseway portion of the tidal flats. Important changes to the physical environment have been ongoing since the initiation of construction activities for the BC Ferries Causeway and terminal in 1958. These changes have been extensively documented in the Coastal Geomorphology Study (NHC, 2004) and include formation of large systems of dendritic channels, lateral expansion of eelgrass beds, and dredging for expansion of the ship turning basin.

Aerial photographs of the study area are flown in July each year during a low tide event, and subsequently ortho-rectified to create the series of orthophotographs. The changes discussed in this section refer to those that have occurred between the July 2012 and July 2013 imaging dates.

Five main areas of geomorphic change have been identified from the interpretation and mapping of the orthophotos:

1. New drainage channels that formed at the north-eastern margin of the perimeter dike in 2007.
2. Formation of sand bars on the tidal flats on the seaward side of the Crest Protection Structure.
3. The large system of dendritic channels draining into the turning basin.
4. The tidal channels adjacent to the BC Ferries Causeway.
5. New sand bars located along Deltaport Causeway.

These features are shown in **Figure 19**. **Figure 20** shows a detailed view of the Area of New Drainage Channels.

3.1.5.1 Area of New Drainage Channels

The Area of New Drainage Channels that first became visible in the 2007 orthophoto were initially formed by seawater and supernatant leaking from the perimeter dike enclosing the DP3 footprint. The south side of the perimeter dike was sealed with sand in July 2007 and flow was observed to have decreased from the perimeter dike the next day. Some leakage of sediment-laden waters was reported within this period but the precise quantity is not known. By the time the 2008 monitoring began, the area within the DP3 footprint had been filled with sediment from dredging activities and water drainage from the dike had ceased.

The channels affected an area of approximately 3.4 hectares, roughly divided between a zone of erosion and a zone of deposition. The channels on the upper mud flats (above approximately 1.5 m (Chart Datum) elevation), which were mostly free of vegetation, initially incised into the soft sediment and carried a large amount of material into the lower tidal flats immediately shoreward of the Crest Protection Structure. The deposition zone resembles that of an alluvial fan and coincides with an area of medium to dense eelgrass beds. Areas within the eelgrass were observed to be buried under the soft sediment within the deposition zone.

These channels have not undergone appreciable lateral migration since the previous orthophotographs taken in 2012. The footprint of the active channel zone is also largely the same; however, tide height at the time of the airphoto acquisition greatly influences the perceived lower elevation extent of the active channel zone in this area, which accounts for most of the differences in the active channel zone mapping here in recent years. Whereas the expansion of eelgrass beds observed in the 2008 photos was largely confined to the upper mud flats, according to orthophotos from 2009, 2010, 2011, eelgrass had also colonized the lower flats. In 2012, part of this lower region experienced a loss of eelgrass. A separate study was conducted to examine the eelgrass loss in this area (**Appendix C**).

On June 4, 2012, following recommendations made in the 2011 Annual Report, a final field inspection was conducted to assess the current conditions and processes impacting these new drainage channels. This site visit, in combination with a variety of other desktop analyses, was used to summarize the body of knowledge related to the formation of these channels and provide an assessment of their long-term stability.

Annual orthophoto mapping has defined the lateral position of the new drainage channels since their initial formation. Between the 2007 and 2008 orthophotos, there was some slight lateral migration of the channels, whereas since 2008, the channels have not moved by a measurable distance.

Topographic and bathymetric surveys conducted in 2007, 2010, and 2013 also indicate no measurable change to the average surface elevation in this area. However, the spatial resolution of these surveys is not sufficient to determine localized changes in elevation within the channels themselves. Both casual observations and oblique photographs have documented a gradual reduction in the angle of the banks of these channels since their initial formation. Observations made during the site visit on June 4, 2012, which corresponded with a rapidly dropping tide, indicate that these channels are not actively transporting sediment. This is supported by the observation that very fine and soft sediments have persisted in this area since the formation of the channels. The conclusion of this investigation is that no further significant changes are likely to occur to the Area of New Drainage Channels. Additional detail related to this investigation is presented in the 'new channels memo' included as **Appendix C** of the 2012 Annual Report (Hemmera 2013).

3.1.5.2 Sand Bars Seaward of the Crest Protection Structure

The portion of the tidal flats on the seaward side of the Crest Protection Structure has a much higher level of exposure to waves than the areas behind the structure. Breaking waves have often been observed in this area but never on the landward side of the structure. Sand bar features in this area appear only slightly different in 2013 than they did in 2012. These differences are attributed more to variations in tide height, cloud cover, and sun angle between the orthophotos than to changes in the size and shape of the sand bars. The decreased magnitude and frequency of storms that occurred between imaging dates in 2012 and 2013 is reflected by the stable nature of the sand bars in this area over this period, as well as changes noted to the dendritic channel system below.

Natural modification of the sand bars in this area is expected to continue, with wave action and tidal flow moving the existing sediment along the edge of the turning basin, and some new sediment coming from the existing tidal channels. Prior to 2012, the DoD rods in this area measured some of the largest amounts of erosion and deposition within the study area, and the Crest Protection Structure monitoring cross-sections captured some of the largest changes in elevation measured on the tidal flats in close proximity to the Crest Protection Structure.

3.1.5.3 Large System of Dendritic Channels

The large system of dendritic channels shown in **Figure 21** was the focus of detailed geomorphic and hydrodynamic analysis as part of the Coastal Geomorphology Study (NHC, 2004). Historic orthophotos show that these channels evolved gradually since the ship turning basin was originally dredged in 1969 and developed further, following expansion of the turning basin and construction of the Crest Protection Structure in 1982. The system of channels and sand bars presently extends over a large area of the tidal flats. The sand bars alone covered an area of over 30 hectares in 2002. The results of previous analysis (Coastal Geomorphology Study, NHC 2004) concluded that the formation of these large channels is related to historic dredging of the ship turning basin. Given that they are relatively removed from the assumed area of influence of the new DP3, it is unlikely that they are being influenced by, or have influence on the present project.

The main features of interest in the large dendritic channels include the main trunk channel, a very large sand deposit at the shoreward end of the trunk channel, referred to as the ‘sand lobe’, and a system of smaller ‘tributary’ channels extending from the trunk channel shoreward across the tidal flats. **Figure 21** shows the outline of the channels that were digitized from the 2012 and 2013 orthophotos. The trunk channel has remained relatively stable, but the orthophoto comparison shows small changes to the rest of the system since July 2012.

Several of the tributary channels appear to have become inactive or diminished in width and extent, while only one small tributary channel appears to have extended shoreward. The footprint of the sand lobe appears to have changed somewhat over the past year, as the channels that bound it on either side have migrated slightly, although the size of the feature has remained unchanged. In general, recovery of eelgrass in the outer tributary channels has resulted in a decrease in the areal extent of the dendritic channel system and associated nearby active channel zone; however, the channels appear to have increased in width and migrated laterally more over this period than in previous periods, making more tortuous meanders.

Between July 2012 and July 2013, the majority of the dendritic channels have become narrower at their landward extent, and have been colonised with eelgrass to the point of becoming inactive in these higher elevation areas of the tidal flats. In **Figure 21**, these sections of abandoned channel are mapped in light pink. As this figure only reflects changes in channels that have been classified as 'wide channels', these reaches of inactive channel are often classified as 'narrow channels' in **Figure 19**, and have not entirely disappeared. In the northern arms of the larger (southern) trunk channel, there has been some landward extension, as has occurred in previous years. These sections of channel are mapped in green in **Figure 21**. On the smaller (northern) trunk, there is also a section of channel that appears to have extended off the end of the trunk channel section relative to the previous year. However this area contains a sand bar and an active channel zone that are difficult to distinguish from the main channel section at varying tide heights. This is unlikely to represent significant growth of this trunk channel section.

This is the first time during the AMS program that an overall reduction in the landward extent of the dendritic channels has been observed. The south-eastern arm of dendritic channels (which extends toward the BC ferries causeway) experienced the largest decrease in channel length during the previous year. This section of channel had previously undergone the most rapid growth in recent years.

In contrast to the decrease in channel lengths and widths at the landward extent of most of the dendritic channels, there has been growth in the width of the channels and the amplitude of the channel meanders within the 'mid-elevation sections' of the dendritic channels – those sections that are shoreward of the large sand bar and shoreward of the upper 'tributary' channels. This is shown clearly in **Figure 21** where the green areas (2013 channel area) appears larger and meander wider than the pink areas (2012 channel area).

At the base of the smaller trunk channel, a new channel has formed that connects diagonally between the trunk channel and the small channel parallel to the Crest Protection Structure. The sand lobe feature appears to have changed only at its margins, where the dendritic channels either side of it have migrated laterally. A very small channel that bisects the sand lobe has expanded during the previous year and has been mapped as a 'wide channel' in **Figure 19** for the first time.

These changes to the channels are likely the result of a lower energy tidal year between July 2012 and July 2013 than has occurred for many years previously. The maximum tide heights were smaller during this period, and consequently the outgoing tides generated slower currents, and therefore did not mobilize the bed within these sections of channel. This is turn resulted in positive feedback system with expansion of eelgrass within these channels, which further diminished water velocities within the channels, and decreased erosion. Because the channels conveyed less water at their extents, there was compensation in the form of increased erosion and energy dissipation within the 'middle sections' of the channels and thus the larger meander amplitudes.

3.1.5.4 Channel Development along the BC Ferries Causeway

The tidal channel and its tributaries that have formed adjacent to the BC Ferries Terminal do not appear to be related to any of the activities of Deltaport but the channels fall within the study area for the interpretation of orthophotographs portion of the AMS monitoring program. These channels appear to have formed initially in response to expansion of the ferry terminal and have continued to expand shoreward over the last several decades as a result of tidal drainage, resulting in a wide trunk channel running parallel to the causeway. A small channel on the upper tidal flats, which formed in response to overland drainage from the agricultural lands east of the dikes (**Figure 19**), joined with this main trunk channel at some time between July 2008 and July 2009, as noted in the 2009 Annual Report (Hemmera, 2010). Since the connection of the main trunk channel with this smaller channel, both channels appear to have stopped their expansion.

Between July 2011 and July 2012, changes in the area surrounding the connecting point of these two channels have been quite small relative to changes in this area in previous years. This suggests that the connection of the two channels has resulted in increased stability of the channels and decreased rates of sedimentation on the tidal flats in this area. Between 2012 and 2013, this area has similarly experienced very little change. The narrower drainage channel has continued to migrate in a meandering pattern near to where it joins the trunk channel, while remaining very stable higher up the tidal flats. The trunk channel and small dendritic arms extending from it have experienced only very small changes over the past year. Sand bars both in the trunk channel section and within the narrower dendritic section have continued to experience small changes as the channels migrate slightly each year.

3.1.5.5 Development of Sand Bars along the Deltaport Causeway

A series of small (60 – 5,700 m^2) sand or fine gravel deposits were identified in the 2012 orthophotos that are located along the east side of the Deltaport Causeway. These deposits have been mapped as ‘sand bars’ in **Figure 19**. The sediment appears to have originated from the nearby East Causeway Habitat Compensation sites, where there has been an observed loss of material (*pers. comm.*, G.L. Williams). This sediment has likely been transported out of these alcoves during certain dropping tidal conditions during which there is rapid outflow of water from the alcoves. The material is then deposited very close to the causeway as it encounters the slower moving water on the tidal flats.

In the 2013 orthophoto, these sand bars appear much smaller than in the 2012 orthophoto. Observations made during the 2013 Coastal Mapping surveys indicate that there is sediment remaining in the East Causeway Habitat Compensation sites that can potentially migrate out under favourable tide and weather conditions. These deposits of sand are visible from the ground as raised mounds and have been partially overgrown by eelgrass, which accounts for their reduced areal extent in the 2013 orthophotos. These features are also discussed as they relate to eelgrass distribution in **Section 3.4**.

3.1.6 Coastal Geomorphology Mapping

A digital elevation model (DEM) was created from the survey data collected in 2013 (**Figure 24**). The 2013 surface was then compared against the surfaces created from the previous two surveys in 2007 (**Figure 22**) and 2010 (**Figure 23**) by subtraction of these surfaces from the 2013 surface. These comparison surfaces are shown in **Figure 25** and **Figure 26**, which are contour models of the differences in elevation between the two surveys, providing the location and magnitude of bed elevation changes between the two periods.

While efforts were made to collect survey data at the same locations in each year, this is inherently difficult to do using bathymetric survey techniques, and the data can be highly influenced by site conditions. In addition, the eelgrass on the tidal flats interferes with the acoustic signal from the boat-mounted echo sounder, which then results in 'signal noise' in the regions which were surveyed by boat (see below). Areas that were surveyed on foot (using an RTK rover to collect point data), show only slight differences between the two surveys, and contrast most significantly where micro scale features were surveyed in one year and not the other. The majority of the tidal flats were surveyed on foot, while areas that required a higher density of point data (such as within the area of dendritic channels), as well as lower elevation areas that were not accessible on foot, were surveyed by boat. Where topographic and bathymetric data were both collected over the same area, the topographic data was preferentially selected for inclusion in the surface models to improve accuracy, and was also used to filter the noisy signal from nearby areas of dense eelgrass that were surveyed by boat.

The signal noise that results when hydrographic surveys are collected over dense eelgrass comes from the acoustic signal alternately reflecting off the floating eelgrass strands higher up within the water column as from the bed surface. This can cause up to two meters of variability in the elevation data. Knowledge of the area combined with diligent processing of the bathymetric data is necessary to reduce this noise as much as possible, but the survey precision is unavoidably affected. The bathymetric surveys are a necessity in many of the regions of the study area that are of particular interest in order to survey areas of deep water with a high density of points in a timely manner. These include the majority of the channels near to and parallel to the Crest Protection Structure, the area of tidal channels, and the Area of New Drainage Channels. During the 2013 surveys, additional effort was made to survey a portion of these areas on foot during short low tide windows to better define some of the critical features. In addition, both the boat and ground surveys were expanded over a larger area to include the extent of the dendritic channels area, as these channels cover a much larger area than they did in 2007 when the survey plan was conceived. Additional detail was also collected along the perimeter of the DP3 footprint, and around the tug basin, in order to better define the extent of the tidal flats in these areas and the current dimensions of the tug basin crest protection structure.

The Area of New Drainage Channels has been surveyed with a relatively high density of data points in each of the surveys, although the extent of the surveys increased in 2013 to cover the lower elevation areas and the tug basin crest protection structure. **Figure 26** shows that this region has seen very little elevation change since it was first surveyed in 2007. There are a few isolated spots of noticeable difference along the original Crest Protection Structure that are likely related to variation in the survey extents between the different surfaces and not reflective of real change.

The Crest Protection Structure, while very stable (based on past CPS monitoring sections and photos), is surrounded by dense patches of eelgrass, both in the parallel channels on the shoreward side, and on the sand bars on the seaward side. Noise from the bathymetry data collected in this area is therefore very difficult to filter, so it is necessary to rely primarily on the topographic data that was collected in this area, which has lower spatial density than the associated bathymetry data. Along the top of the Crest Protection Structure, the change figures (**Figure 26**) indicates that there has been minimal change during the six years between the 2007 and 2013 surveys.

The tidal channel system and surrounding area has experienced the largest of the changes that have occurred within the study area. While the orthophoto mapping clearly illustrates the expansion of these channels, the coastal geomorphology mapping surveys provide detail on the elevation changes, which obviously the imagery lacks. Of particular note is the middle section of the main Trunk Channel. Both **Figure 25 and Figure 26** show that the bed in the Trunk Channel has been lower with each subsequent survey. In 2007, the minimum elevation measured within the channel was -2.0 m (Chart Datum). In 2010, the minimum value was -2.7 m (Chart Datum), and in 2013 the minimum value was -3.2 m CD. It is not possible to provide a definitive explanation of this trend as there are no other historical surveys against which to make a comparison, but it is noted that this portion of the Trunk Channel is dominated by shoreward sediment movement so this could be related to decade-scale changes to the tidal patterns.

A lateral spur extension near the southern end of the Crest Protection Structure was originally constructed in an attempt to prevent the formation of a channel parallel to the Crest Protection Structure. This lateral spur resulted in a very deep scour hole on the shoreward side of the Crest Protection Structure. The change figures indicate that this hole is much shallower than in the past; however this is possibly an artefact of the survey. This scour hole is quite deep but is confined within a relatively narrow section of channel and so it is possible that the survey tracks did not happen to cross through the very bottom of the scour hole.

The dendritic channels region shows significant changes in elevation that appear as bands along the margins of the existing channel (as defined by the orthophoto mapping). These changes correspond to the migration of the dendritic channels as they move laterally over the tidal flats in a process similar to the meandering of a river. This migrating pattern has been tracked by the orthophoto mapping conducted annually and presented in each of the annual reports since 2008. Other changes to this region outside of the channel boundaries are minimal (less than 25 cm of erosion or deposition).

Seaward of the Crest Protection Structure the area in which there is overlapping data between the two surfaces is confined to a narrow strip along the Crest Protection Structure. Consequently the change figures do not include the majority of the sand bars in this area. In this area, the 2013 surface is more similar to the 2010 surface than to the 2007 surface. This could indicate that the erosion measured between 2007 and 2010 was an artefact of eelgrass interferences with the bathymetry data in this area in 2007, rather than significant erosion.

In both **Figure 25** and **Figure 26,** the majority of the surveyed region of the tidal flats plots within the change bands from -0.25 m to 0 m, and 0 to 0.25 m of relative change. This is consistent with a visual comparison of the 2007 surface (**Figure 22**) with the 2010 surface (**Figure 23**) and the 2013 surface (**Figure 24**), the 25 cm elevation contours appear to be in very similar locations, particularly in the upper tidal flats. Elevation changes on a gently sloping surface result in lateral movement of the contours between surveys. The contours on the 2013 surface are much closer to the location of the contours on the 2007 surface than to the 2010 surface, suggesting that the small decrease in elevation seen in the 2010 surface relative to the 2007 surface was related to uncertainty in the GPS signal, rather than an actual loss of elevation on the tidal flats. The exceptions to this are within the tidal channels, where the measured elevation losses are reflective of real changes, as described above.

3.1.7 Wave and Current Monitoring

The wave and current monitoring portion of the Coastal Geomorphology program was discontinued in 2010. The wave climate affecting the study area was assessed based on wind data collected at Vancouver Airport and compared to wave data measured at Halibut Bank (see **Section 2.1.2**).

3.2 Surface Water Quality

The discussion of surface water quality monitoring results considered both spatial and temporal trends.

Results from stations DP02, DP03, and DP04 (intertidal stations in the intercauseway area) were compared to results from DP06 (intertidal reference station). The results from station DP05 (subtidal station in the intercauseway area) were compared to those from DP07 (subtidal reference station). The surface samples (A level) and deeper samples (B level) at the subtidal stations were also considered separately. As noted in **Section 1.3.2**, the A level samples at DP05 and DP07 were collected one metre below the surface of the water and B level samples were collected 2.0 metres above the sediment bed. Station DP01 (drainage ditch station) was not included in this comparison as it has no associated reference station.

3.2.1 Spatial Trends between Intercauseway and Reference Stations

The data collected within the intercauseway area were compared with the results from the reference stations in **Figures 29** and 30. Note that the values presented in **Figures 29** and 30 include only data for 2013 as they are intended to capture spatial trends in 2013. Temporal trends (2007 to 2013) are captured in **Figures 31** and **32** and on trend plots in **Appendix D** and **E**.

3.2.1.1 Metals

Figure 29 compares metal concentrations at the nine monitoring stations within the first quarter of 2013. The metals selected for **Figure 29** include arsenic, barium, cadmium, copper, lead and zinc as these metals have established regulatory guidelines, exceeded regulatory guidelines during the AMS program or have been detected consistently above their RDL. Other regulated metals parameters, including beryllium, chromium, mercury, selenium and silver, were not included as most values were less than the RDL. Uranium was not included as concentrations were typically less than 2% of the BC WQG.

Similar to previous years, the highest metal concentrations in surface water were measured at DP01 and, as discussed in **Section 2.3.2.1**, a number (copper, manganese and nickel) exceed regulatory guidelines in Q1-2013 (similar to previous years). There were no exceedances of regulatory guidelines for metals in any of the other surface water samples in Q1-2013, except boron as discussed in **Section 2.3.2.1**. In summary, excluding DP01 data, spatial trends include:

- Arsenic concentrations were less than detection in all samples (<2 µg/L).
- Barium concentrations were generally higher at the reference sites (DP06 & DP07A) and at DP04 and DP09 than the other intercauseway stations.
- Boron concentrations were generally lower at the reference sites (DP06 & DP07A) and at DP04 and DP09 that the other intercauseway stations.
- Cadmium concentrations were similar across all stations with the highest at DP07B.
- Copper concentrations were similar across all stations with highest concentrations at the reference site DP06 and at DP09.
- Lead concentrations were mainly below the method detection limit (<0.3 µg/L) with highest concentration at DP02.
- Zinc concentrations were below the method detection limit at all stations except DP06.

Metal concentrations at the A and B levels at DP05 were more similar than metal concentrations at the A and B levels at DP07. Similar to 2010, 2011 and 2012, the pattern in metal concentrations measured at DP07A is different from concentrations of some metals (boron, calcium, copper, magnesium, potassium, sodium) at DP06, suggesting a more variable influence of Fraser River inputs.

3.2.1.2 Eutrophication-related Parameters

Figure 30 shows spatial trends in eutrophication-related parameters. As with previous years, the lowest dissolved oxygen and the highest chlorophyll α, ammonia, phosphate, TKN and total nitrogen concentrations in surface water were measured at DP01. The elevated concentrations at DP01 are attributed to upland fertilizer inputs. Fertilizers are applied to agricultural land upgradient of DP01 to enhance agricultural crop growth. Excess nutrients subsequently make their way in groundwater and surface water that is conveyed to the drainage ditch where DP01 is located (**Figure 7**).

Dissolved oxygen measurements between the intercauseway area and the reference sites are similar (DP02 to DP05 average = 9.9 mg/L, DP06 to DP07 average =9.6 mg/L for data set 2007 to 2013). The dissolved oxygen concentrations were generally the lowest each quarter at the deeper subtidal stations DP05B and DP07B, and in the highest range at intertidal stations DP02, DP03 and DP08. The elevated dissolved oxygen readings measured at these intertidal stations were likely a function of the presence of eelgrass at these stations. Relatively low dissolved oxygen was expected at DP05B and DP07B, as dissolved oxygen typically decreases with depth below surface.

Spatial trends observed in 2013 were relatively elevated nutrient concentrations (ammonia, TKN, nitrate, total nitrogen, phosphate) at DP01 (likely a result of upland run-off) as compared with other stations and higher chlorophyll *a*, phosphorus, TKN, organic nitrogen and total nitrogen at DP05 compared to other stations in Q2-2013.

Similar to previous years, other spatial trends observed using the 2007 to 2013 data set include:

- The average ammonia concentrations are higher and more variable for the reference stations (0.033 mg/L) than the intercauseway (0.022 mg/L). Generally lower concentrations of ammonia have been measured in the samples from the deeper stations (DP05B, DP07B).
- Similar phosphate (both inorganic and ortho) concentrations have been detected in the intercauseway area sampling stations and the shallow reference stations. Generally, higher phosphate concentrations have been measured in the samples from the deeper stations (DP05B, DP07B).
- The average TKN concentrations are slightly lower for the reference stations (average = 0.16 mg/L) than the intercauseway (average = 0.19 mg/L). Generally lower concentrations of TKN have been measured in the samples from the deeper stations (DP05B, DP07B).
- Generally, the concentrations of chlorophyll α are higher and more variable at the intercauseway stations (average = 1.6 mg/L) then the reference stations (average = 0.63 mg/L).

The spatial analysis did not suggest a trend towards eutrophication.

3.2.2 Temporal Trends

3.2.2.1 Metals

Metal concentrations in surface water do not show clear increasing or decreasing temporal trends between quarters or consistent seasonal patterns (**Figure 31**). Both the highest metal concentrations and the greatest variability have been consistently observed at DP01.

Trend plots for metals grouped by intercauseway stations (DP02 to DP05, DP08, & DP09) and reference stations (DP06 to DP07) have been prepared using data from 2007 to 2013 and are attached as **Appendix D**. A review of the trend graphs indicates the same as last year's evaluation:

- Intercauseway stations and reference stations have similar concentrations of metals with reference stations having slightly higher mean values (2007-2010) and higher variability for cadmium, copper and zinc.
- Concentrations of metals at intercauseway stations were all less than CCME/BC WQG between 2007 and 2013, except for copper in one sample collected from DP05A in Q1-2007. Reference stations had one or more exceedances of CCME/BC WQG for cadmium, copper and zinc.
- No increasing trend in metal concentrations.

3.2.2.2 Eutrophication-related Parameters

Temporal trends (2007 to 2013) for eutrophication parameters are captured in **Figures 32** and **35**. The chlorophyll *a*, nitrate, nitrite, TKN, nitrogen, phosphorus and ammonia concentrations do not exhibit an increasing trend, or for dissolved oxygen a decreasing trend, over the course of seven years of monitoring when all parameters are plotted together on a log scale by all events (**Figure 32**) or by quarter (**Figure 35**).

Trend graphs for each eutrophication parameter grouped by intercauseway stations (DP02 to DP05, DP08 & DP09) and reference stations (DP06 to DP07) are provided in **Appendix E**. A review of the trend graphs for surface water indicates the same as last year's evaluation:

- Dissolved oxygen measurements do not fluctuate notably over time but indicate a potential seasonal pattern with lower dissolved oxygen in Q3 and/or Q4 events.
- Ammonia concentrations in the intercauseway stations appear to have decreased between 2007 and 2009. The reference stations DP06 and DP07 have higher and more variable ammonia concentrations and appear to have decreased over a longer time period (i.e. 2007 to 2013) as compared to the intercauseway stations. Since Q1-2011, ammonia concentrations at the intercauseway stations tend to be higher in Q1 and lower in Q3 indicating a potential seasonal trend. This trend is somewhat mirrored in reference station 7A only.
- Phosphate concentrations (both inorganic and ortho) do not indicate a trend over the entire 2007 to 2013 time period. There does appear to be a seasonal trend in phosphate concentrations within both the intercauseway and the reference stations with higher concentrations (peaks on the trend graph) in Q4 sampling events (November or December).

- Nitrate, nitrite and total nitrogen concentrations have generally been less than detection limits or just above detection limit since Q2-2009 at the intercauseway and reference sampling stations (except for total nitrogen and nitrate at DP04 in Q4 of 2011).
- TKN and organic nitrogen concentrations do not indicate a trend over the entire 2007 to 2013 time period. Higher concentrations generally occur in Q2 or Q3 sampling events which indicates a seasonal trend in the data.
- Chlorophyll α concentrations do not indicate an increasing trend over the entire 2007 to 2013 time period. However, higher than average concentrations were measured during the majority of Q2 and Q3 sampling events at both intercauseway and reference sampling stations.

The temporal analysis does not suggest a trend towards eutrophication.

3.2.3 Ecosystem Health and Function

Metal and nutrient concentrations in surface water have not shown an increasing trend in the seven years of AMS monitoring (2007 – 2013). As such, DP3 construction and operation are not considered to have had a negative impact on water quality in the intercauseway area. In 2010, Hemmera recommended reducing the frequency of metal monitoring to once per year and analyzing metals in surface water only in Q1. The results for metals from 2011 to 2013, plus the preparation of trend graphs (**Appendix D**), further support that DP3 construction and operation is not negatively impacting the water quality in the intercauseway area.

Phosphorus and nitrogen are two key nutrients associated with plant growth. Increasing concentrations of either may signal an increased risk of algal blooms or eutrophication. In marine environments, nitrogen is the limiting nutrient. Nitrate accounted for the bulk of total nitrogen in the water samples (**Figure 32**). Ammonium is the form of nitrogen preferentially taken up by aquatic plants from surface waters. For phosphorus, orthophosphate, the soluble, inorganic fraction, is the form taken up by plants.

Other key parameters that may act as indicators for eutrophication include chlorophyll *α,* dissolved oxygen, and TSS. Chlorophyll *α* levels fluctuate naturally with the seasons; rainfall, warm summer water temperatures and light levels lead to greater phytoplankton numbers, and therefore higher chlorophyll *α* levels. However, long-term elevated concentrations of chlorophyll *α* can reflect an increase in nutrient loads and increasing trends can indicate eutrophication. An increase in TSS can also signal an increase in phytoplankton or detritus associated with eutrophication although inorganic particulate matter may account for a significant portion of TSS and confound any trends.

A literature review on parameters used to monitor eutrophication was conducted in 2009. Sources considered included:

- National Oceanic and Atmospheric Association.
- Australian and New Zealand Environment Conservation Council.

- European Environment Agency.
- HELCOM – Baltic Sea.
- OSPAR – North-East Atlantic;
- Canadian Council of Ministers of the Environment (CCME).

While most jurisdictions proposed gauging the potential for eutrophication by establishing local or regional baseline conditions, the CCME presented the following criteria from work by Vollenweider et al. (1998) and Bricker et al. (1999); **Tables 3.2-1** and **Table 3.2-2** respectively.

Table 3.2-1 Criteria for Evaluating Trophic Status of Marine Systems (Vollenweider et al. 1998)

Trophic Status	TN (mg/L)	TP (mg/L)	Chlorophyll α (µg/L)
Oligotrophic	< 0.26	<0.10	<1
Mesotrophic	≥0.26-0.35	≥0.10-0.30	≥1-3
Eutrophic	≥0.35-0.40	≥0.30-0.40	≥3-5
Hypereutrophic	≥0.40	≥0.40	≥5

Table 3.2-2 Trophic Status Classification Based on Nutrient and Chlorophyll (Bricker et al. 1999)

Degree of Eutrophication	TN (mg/L)	TP (mg/L)	Chlorophyll α (µg/L)
Low	0-≤0.1	0-≤0.01	0-≤5
Medium	>0.1-≤1	>0.01-≤0.1	>5-≤20
High	>1	>0.1	>20-≤60

The average total nitrogen concentration in the intercauseway area using the 7 years of data (2007-2013) was 1.2 mg/L indicating a high degree of enrichment under both classification systems. This average is biased upwards by elevated concentrations measured between 2007 and 2008 during construction. The average total nitrogen concentration in the intercauseway area using the last 5 years of data (2009 to 2013) is 0.68 mg/L indicating a medium degree of eutrophication under Bricker's classification. The Strait of Georgia is naturally elevated nitrogen concentrations (Mackas and Harrison 1997).

The average total phosphorus concentration in the intercauseway area using the 7 years of data (2007-2013) was 0.07 mg/L, which falls in the medium range under Bricker's classification system and oligotrophic under Vollenweider's classification system.

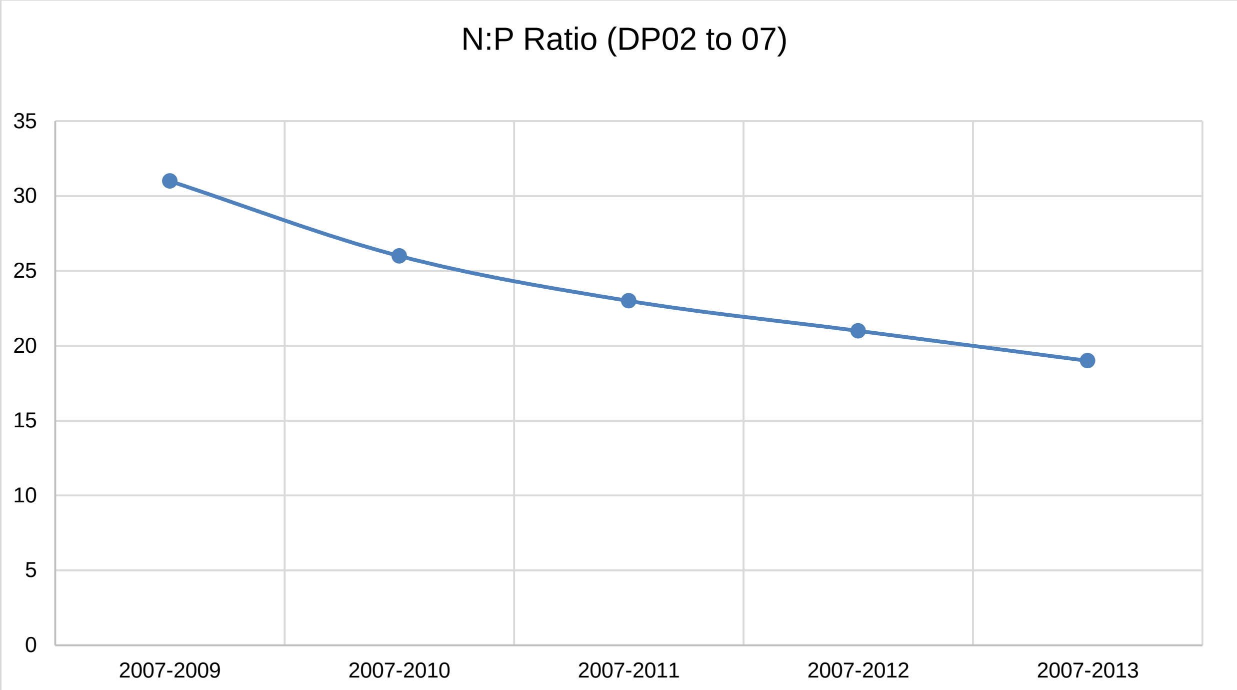
The average chlorophyll α concentration in the intercauseway area using the 7 years of data (2007-2013) was 1.6 µg/L, which is considered a low degree of eutrophication by Bricker and mesotrophic by Vollenweider.

Following discussions with VFPA and SAC in 2010, graphs showing the relationship between nitrate to ammonia and total nitrogen to total phosphorus in surface water were prepared to determine if station-specific or area-wide trends in these ratios exist which might be used as a line of evidence in evaluating ecosystem health (**Figure 33** and **Figure 34**). When present in excess, ammonia is toxic to organisms. Under eutrophic conditions, ammonia would be expected to accumulate. **Figure 33** suggests that while nitrate concentrations vary from station to station, the ammonia concentrations fall in a more restricted range (0 to 0.1 mg/L), except at DP01 (where there are nutrient inputs from upland sources and surface water in the drainage ditch is not oxygenated to the same extent as surface water in the intercauseway area or at the reference sites).

The Redfield ratio is the atomic ratio of carbon, nitrogen, and phosphorus found in the deep ocean and named after Alfred C. Redfield who first described this ratio in a 1934 article. The Redfield ratio defines the optimal C:N:P ratio in the marine environment as 106:16:1. In particular, the N:P ratio of 16:1 is considered the optimal ratio for phytoplankton growth. Eutrophication can lead to a shift in this ratio.

To understand how the Redfield ratio compares to data within the study area (DP02 to DP07), the average N:P ratio was calculated for five time periods (2007-2013, 2007-2012, 2007-2011, 2007-2010 and 2007-2009). A plot of these ratios is provided in **Figure 3.2-1** below. As shown on the plot below, the average N:P ratio for the data periods has been decreasing each year with the current data set (2007-2013) ratio (19:1) close to the Redfield ratio of 16:1. The N:P ratio for the early data sets (2007-2009, 2007-2010, 2007-2011) are biased upwards by the higher total nitrogen concentrations measured in 2008 during DP3 construction (see **Figure 34** which shows several outliers and nitrogen trend graph in **Appendix E**).

Figure 3.2-1 Nitrogen to Phosphorus (N:P) Ratios for Different Surface Water Data Sets



The trend graph for the N:P ratio for intercauseway stations with concentrations of total nitrogen and phosphorus converted to a molar concentrations is provided in **Appendix F**. The trend graph shows that from 2009 to 2013 the N:P ratio using molar concentrations is close to the predicted Redfield ratio of 16:1, except for one event (DP04 in Q4-2011). The trend graph in Appendix F and Figure 3.2-1 above do not indicate a trend towards eutrophication based on the N:P ratio.

3.2.3.1 Site-specific Nutrient Thresholds

Naturally occurring nutrient concentrations vary spatially and temporally. To detect potential eutrophication (or environmental change), and account for this natural variability, site-specific criteria (or thresholds) are developed (where there is sufficient site-specific information to do so).

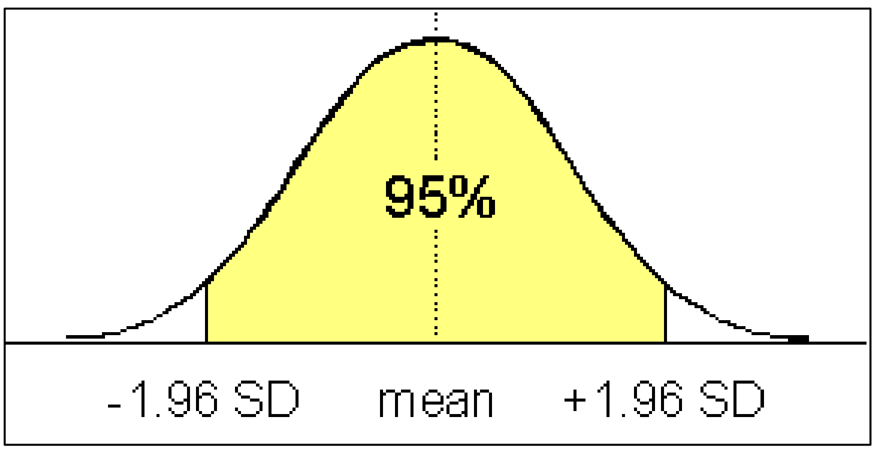
In the case of Roberts Bank sufficient information for site specific criteria, and eutrophication thresholds, have historically been unavailable. However, the AMS program was designed to provide both the site-specific information and thresholds to identify potential eutrophication at Roberts Bank. The following information relates to what the criteria, or thresholds, are and how data collected in 2013 relates to these thresholds.

3.2.3.2 AMS Threshold Identification

The AMS thresholds for evaluating potential environmental change (e.g., eutrophication) were established in conjunction with PMV and the AMS Scientific Advisory Committee in 2012 and presented in the final 2011 annual report (Hemmera 2012b). The AMS threshold for each parameter is the mean +/- 1.96 multiplied by the standard deviation (SD) of the mean (μ):

$$\text{AMS Threshold} = \mu \pm 1.96 \times SD$$

Assuming a normal distribution, this AMS threshold captures data or results that exceed 95% of the natural variability as shown in the graph below. Since eutrophication may lead to increases in nutrient parameters concentrations and decreases in dissolved oxygen, the AMS threshold for dissolved oxygen has been set at the lower limit (i.e. negative) and all other AMS thresholds has been set at the upper limit (i.e. positive).



The first four years of AMS data (2007-2010) were used to define background conditions in the intercauseway area (DP02 to DP05). This is reasonable as three years of data is considered sufficient for defining background conditions by the Australian and New Zealand Environment Conservation Council.

Parameters that were observed above the AMS thresholds in 2013 include **(Table 10**, **Appendix E)**:

- Total phosphorus, TKN, organic nitrogen, chlorophyll α at intercauseway station DP05B in Q2 (June 2013).

The other intercauseway stations (DP02 to DP04, DP5A) were not elevated in Q2 and all had relatively similar concentrations. Ammonia was also elevated at DP05B compared to the other intercauseway stations but not above the AMS threshold. Higher concentrations of these parameters were not detected at the reference stations during the same monitoring event. The higher concentrations detected at DP05B is likely related to the fact that this sample had higher turbidity (73.1 NTU) and TSS (221 mg/L) than the other stations where turbidity ranged from 2.96 to 3.45 NTU and TSS ranged from 4.8 to 6.2

mg/L. One possible explanation for the increased turbidity and TSS is the sediment bed was inadvertently disturbed during sample collection. A review of the total nitrogen to total phosphorus ratio (N:P) trend graph (Appendix F) indicates the ratio of this sample is close to the predicted of 16:1 and similar to previous events. Given these elevated results are at the deep subtidal location and occurred one time within 2013, it is unlikely that these results are an indication of eutrophication in the intercauseway.

As documented in the May 2012 letter to VFPA regarding development of site-specific AMS thresholds, an exceedance of the AMS threshold is not necessarily indicative of eutrophication and a tiered-approach would be used to evaluate exceedances. In the context of the tiered evaluation approach, variations in water quality levels from 2013 does not warrant additional investigation. For example, no parameters were above the nutrient thresholds for more than two sequential monitoring events or concentrations were elevated both in the intercauseway area and at the reference stations. This parameters will continued to be monitored quarterly in 2014 and evaluated against the tiered evaluation approach.

3.3 SEDIMENT QUALITY

Similar to surface water, the discussion of sediment quality results considered both spatial and temporal trends, with particular attention given to parameters associated with eutrophication.

A lithium geonormalizing technique was applied to distinguish between metals inputs from anthropogenic sources and natural variations in background metal concentrations. Lithium occurs predominantly in several common silicate minerals where it substitutes for potassium, sodium, and magnesium and has been shown to be an effective means to normalize metals concentrations to background (Sutherland et. al. 2007).

Figure 36 shows sediment metals parameters normalized to lithium for 2007 to 2013. For most parameters, the normalized metal parameters lay close to the regression line suggesting natural background concentrations. In 2013, notable points that plotted higher or lower than the regression line include the drainage ditch station DP01 for arsenic, chromium, nickel, titanium, sodium and zinc, DP05 for sodium, titanium, zinc and DP09 for arsenic, sodium and zinc based on the **Figure 36** plot. These three locations had higher content of silt and clay than the other samples based on the grain size data from Q1-2013 (**Table 11**). Based on the lithium normalization and previous results, these metal results are considered reflective of natural background conditions.

3.3.1 Spatial Trends between Intercauseway and Reference Stations

Figures 37 and **38** show a comparison of the relative variation of sediment metals and eutrophication-related parameters between the intertidal intercauseway stations (DP02, DP03, DP04, DP05, DP08, and DP09) and their associated reference samples (DP06 and DP07).

3.3.1.1 Metals

Figure 37 shows spatial trends in metals concentrations for the CSR Schedule 9 sediment metals parameters (arsenic, chromium, copper, mercury and zinc)[3]. Similar to previous years, metal concentrations were highest at DP01, DP05 and DP09. As discussed above and shown on **Figure 36A**, the metal concentrations, specifically arsenic and zinc, are considered natural based on normalization to lithium. The reference station DP06 also had a higher arsenic concentration in 2013 compared to the other locations, which has been noted in previous years (ex. 2009). Metal concentrations at DP01 (near agricultural ditch) were similar to 2012 which as noted in last year's report (Hemmera 2013) appeared to be higher when compared to previous spatial trend figures in annual reports for 2008 through 2011 (Hemmera 2009, 2010, 2012a, 2012b). The other intercauseway stations (DP02 to DP04, DP08) had metal concentrations in sediment similar to those measured at reference station DP07.

3.3.1.2 Eutrophication-related Parameters

As with surface water, phosphorus and nitrogen in sediment are two key nutrients associated with plant growth. Increasing concentrations of either may signal an increased risk of eutrophication. In sediment, nitrate is the primary nitrogen source for aquatic plants; however, both nitrite and ammonia have the potential to undergo nitrification to nitrate. Elevated TKN concentrations are usually the result of sewage and manure discharges to water bodies.

As in previous years, concentrations of eutrophication-related parameters in sediments at the intercauseway stations were greater than those at the reference stations (**Figure 38**). As shown on **Figure 38**, the highest concentrations of eutrophication-related parameters at the intercauseway stations were measured at DP01 (all parameters), DP05 (except for ammonia and total phosphorous which is the same as previous years) and DP09 (TKN and TN similar to 2010 and 2011 results). DP01 is influenced by the agricultural runoff. Station DP05 is located in the subtidal environment within the intercauseway area and consistently has higher concentrations than the other sampling locations (see trend graphs in **Appendix E**). The lower phosphorous concentrations at DP05 are likely related to its location outside of the eelgrass beds.

The spatial analysis does not suggest a trend towards eutrophication.

[3] Cadmium and lead were not included in the spatial trend graphs as concentrations were less than the RDL for all samples. CSR Schedule 9 sediment criteria are generally adopted by federal regulators in BC due to the extensive federal input into their development.

3.3.2 Temporal Trends

3.3.2.1 Metals

Metal concentrations within the intercauseway and at the reference stations in 2013 were similar to those from 2007 to 2012 (**Figure 39** and **Appendix D**). Similarly, station DP01 (located near the agricultural runoff ditch west of the BC Ferries causeway) showed the greatest variability in metal concentrations between 2007 and 2013. Reasons for this variability are likely related to seasonal or yearly changes in the quality of sediment deposited by the agricultural runoff. Given DP01's distance from DP3 and its location at the point where the agricultural ditch enters the mud flats, this variability is not likely related to DP3 construction or eutrophication.

Review of temporal metal concentration trend graphs, for the 2007 to 2013 time period, (**Appendix D**) indicate the same conclusions as in 2012:

- Intercauseway stations and reference stations have similar concentrations of metals.
- Concentrations of metals at intercauseway and reference stations were all less than the CSR sediment criteria between 2007 and 2013.
- No increasing trend in metal concentrations.

3.3.2.2 Eutrophication-related Parameters

Concentrations of eutrophication parameters within the intercauseway and at the reference stations in 2013 were similar to those from 2007 to 2012 (**Figures 40** and **41**, **Appendix E**). Total phosphorus concentrations showed very little variation at the seven stations monitored over the seven year monitoring period (**Figure 40**). Sulphide concentrations were most variable of the eutrophication parameters, especially at DP01 (located near the agricultural runoff ditch west of the BC Ferries causeway). Short term increases in sulphide have been noted at the intercauseway stations; however, there does not appear to be an increasing trend in sulphide concentrations over the 2007 to 2013 time period. It is noted that a field protocol changes was made for the sulphide analysis (hold time <24 hr) starting in Q3 of 2009 and thus the data is more reliable after that date.

Review of temporal concentration trend graphs for each eutrophication parameters (**Appendix E**) indicate the same conclusions as in 2012:

- Ammonia concentrations do not indicate a trend over time or show a distinct seasonal trend across all stations.
- Total phosphorus, TKN and sulphide concentrations do not indicate a trend over time or seasonal trend.
- Total nitrogen concentrations do not indicate a trend over time or seasonal.
- Organic nitrogen concentrations and total organic carbon do not indicate a trend over time or seasonal trend.

It is noted that for this report, DP08 & DP09 data has been added to the trend graphs (**Appendix E, F**). These stations are only sampled in Q1 and had not been previously plotted on the trend graphs. The trend plots may indicate an increasing trend at DP09 (located behind the tug basin in area of new drainage channels) for total nitrogen and TOC when 2013 data is included, further data is required to determine if this is an actual trend.

The temporal analysis does not suggest a trend towards eutrophication.

3.3.3 Ecosystem Health and Function

The spatial and temporal analysis of the sediment data does not show a trend towards eutrophication or increases in metal concentrations resulting from DP3 construction or operation. Given that metal concentrations in sediment have not shown an increasing trend over the seven years of the AMS program, it is unlikely that metal inputs from the construction and operation of DP3 will affect the overall concentration of metals in sediments within the intercauseway.

Following discussions with VFPA and SAC in 2010, graphs showing the relationship between total nitrogen and total phosphorus, TOC and total nitrogen, and TOC and total phosphorus in sediment were prepared to determine if station-specific or area-wide trends in these nutrient ratios exist which might be used as a line of evidence in evaluating ecosystem health (**Figures 42**, **43**, and **44**).

As noted in **Section 3.2.3,** the Redfield ratio defines the C:N:P ratio in the marine environment as 106:16:1. Eutrophication can lead to a shift in the Redfield ratio. However, given the lack of temporal trends in the intercauseway area or the reference stations towards eutrophication, the C:N:P ratios are considered to reflect those naturally occurring in the study area.

Neither the N:P nor the C:P ratios corresponded to the Redfield ratio but these ratios do not very widely at each station over the seven year sampling period (except for DP01) as shown on **Figures 42** and **44**. As shown on **Figure 43**, the C:N ratio for sediment data is generally consistent with the Redfield ratio except DP01 and DP05 are noted as having a higher C:N ratio than other stations. The average C:N ratio for DP02 to DP07 using 2007 to 2013 data set was 7.7, falling close to the predicted ratio of 6.6. This ratio is similar to the C:N ratio calculated for the 2007 to 2012 data set of 7.8, 2007 to 2011 data set of 7.6, 2007 to 2010 data set of 7.6 and 2007 to 2009 data set of 7.8. Trend graphs for the Redfield ratios in sediment were also prepared and are provided in **Appendix F**. These graphs do not indicate any notable increases or decreases in these ratios over the 2007 to 2013 monitoring period. It is noted that the trend graph indicates more variability in the C:P and C:N ratio at DP05 between 2012 and 2013 than previous years but this is also seen in the reference station DP06.

3.3.3.1 AMS Threshold Identification

As discussed in **Section 3.2.3.1**, AMS thresholds for evaluating potential environmental change (e.g., eutrophication) were set for each parameter as:

$$\text{AMS Threshold} = \mu +/- 1.96 \times SD$$

AMS thresholds, based on 2007-2010 data, for the individual eutrophication parameters are shown on the trend graphs contained in **Appendix E**.

Most eutrophication parameters were not measured above the AMS thresholds. However, two stations (DP04 and DP05) did have concentrations above the AMS thresholds in 2013. Total nitrogen at DP05 was detected above the AMS threshold in Q1-2013. Other intercauseway stations and the reference stations had elevated total nitrogen in Q1-2013 (see total nitrogen trend graph **Appendix E)**. In addition, typically DP05 has higher concentrations for all eutrophication parameters (than the other intercauseway stations) and this is likely due to it being subtidal (as opposed to intertidal).

Sulphide and TOC at DP05 were detected above the AMS threshold in Q2-2013 sampling event. Sulphide and TOC concentrations at DP05 was detected above the AMS threshold in two quarters of 2012. Higher sulphide concentrations would be expected at DP05 as the sediments are not exposed to air due to subtidal location. The field observation at this location in Q2 was brown colour then black which could indicate anoxic conditions. The TOC measured at the reference station DP06 in Q2 was also elevated over previous results.

Sulphide at DP04 was detected above the AMS threshold in Q3-2013. The field observation noted for this sample was colour of brown and dark grey (similar to DP05) and a black layer on the sediment surface. The dark colour of the sediment could indicate anoxic conditions resulting in higher sulphide concentration. It is noted that the concentration was higher than previous results but was back to normal range in Q4.

3.4 EELGRASS DISCUSSION

3.4.1 Eelgrass Distribution and Mapping Discussion

The intercauseway eelgrass meadow is composed of three main habitat types. A large *Z. marina* bed, a large *Z. japonica* bed, and a transition zone located between the two *Zostera* beds. The transition zone tends to be slightly above the optimal elevation for *Z. marina* and usually supports a mix of both species. *Z. japonica* can't compete with *Z. marina* for space but it is opportunist and can colonize the area between *Z. marina* shoots. The size and boundaries of the transition zone was shown to vary with climate during the 1980s (Harrison, P.G. 1984). Warm dry summers resulted in desiccation of some of the *Z. marina* in this area enabling *Z. japonica* to prosper. Cool summers resulted in an increase in *Z. marina* at this location and hence a decrease in the amount of *Z. japonica.*

Z. japonica is an annual species; the shoots typically live less than one year and germinate from seed in the spring. Therefore the distribution and density of this species tends to vary considerably between years and is strongly influenced by climate. However, there appears to be a trend beyond inter-annual variation occurring in the upper areas of the main *Z. japonica* meadow (adjacent to the unvegetated mudflat). An area of patchy *Z. japonica* was first noted in this meadow in 2010 (**Figure D-4**), the size of the area has increased annually since (**Figure D-5**, **Figure 28**). A second area, east of the first, developed into patchy habitat in 2011 (**Figure D-5**) and expanded into 2013 (**Figure 28**). It is possible that sediment accretion in parts the upper intertidal has occurred and resulted in an elevation that is sub-optimal for *Z. japonica* resulting in a patchy distribution.

Several small sand bars developed perpendicular to the east side of Deltaport causeway by 2012 in an area that has either been patchy or continuous *Z. japonica* since 2003 (**Figure 28**). The majority of the sand bars had disappeared by 2013; the areas were re-colonized by *Z. japonica*.

The boundaries and size of transition zone northwest of the sand lobe have changed considerably since 2003. The 2008 eelgrass field surveys noted vertical rhizome growth of *Z. marina* in this area and suggested that this was a response to recent sediment deposition. It was suggested that the sediment deposition may have resulted from the evolution of the sand lobe and associated dendritic channels since the area of diminished eelgrass productivity extended to the sand lobe. The majority of the transition zone had developed into patchy *Z. japonica* habitat by 2009, although a relatively small area at the north western end of this zone continued to support both species. The 2010 field survey noted *Z. marina* seedlings in the area classified as patchy *Z. japonica* adjacent to the mixed patchy zone. The seedlings survived and multiplied by 2011 resulting in an expansion of the mixed patchy habitat. The 2012 survey found that the density of both species had increased over the last year resulting in continuous distribution; *Z. japonica* was dominant. The density of Z. marina increased into 2013 however Z. japonica remained the dominant species. The habitat between this polygon and the sand lobe was classified as patchy mixed in 2012 and as patchy *Z. japonica* in 2013. The dense blanket of filamentous green algae that covered this polygon may have impacted the ability of *Z. marina* to grow during the summer of 2013.

The boundary and size of the transition zone south east of the sand lobe has also varied over time, although to a lesser extent. The landward boundary retreated in 2008 and then began advancing landward in 2011. The edge of the continuous *Z. marina* meadow was unchanged between 2011 and 2013. The shoreward continuous mixed zone boundary moved shoreward between 2012 and 2013 by a distance that varied between 40 and 220 metres.

The total area (m^2) of vegetated habitat in the area of new drainage channels, colonized by *Z. marina* or *Z. japonica*, increased over the last year, although there was a loss of continuous *Z. marina* habitat. A detailed discussion relating to the changes that have occurred in the area of recent loss is provided in **Appendix C**.

3.4.2 Eelgrass Vigour and Health Discussion

Research has shown that eutrophication may lead to an elevated epiphyte load on eelgrass. The epiphyte load on the eelgrass at all stations on Roberts Bank and at the reference stations at Boundary Bay in 2013 was comparable to previous years at the time these beds were surveyed.

Beggiatoa sp. is often used as an indicator species to identify degraded marine habitats. The filamentous preteobacteria forms visible whitish mats in many polluted marine environments, especially those with sediments rich in hydrogen sulphide. *Beggiatoa* sp. was not noted at either Roberts Bank or Boundary Bay during the 2013 eelgrass surveys.

The distribution of *Zostera marina* and the absence of *Z. japonica* at all sampling stations except Site 1A was consistent with records from previous years. Site 1A is located in an area that evolved from continuous *Z. marina* in 2003 to patchy mixed zone by 2007 then developed into mixed continuous by 2012. The habitat in the vicinity of Site 1A remained mixed continuous into 2013. (**Section 2.5.1**).

The eelgrass density, shoot morphology, and relative productivity are compared between sampling dates in **Sections 3.4.2.1** through **3.4.2.6**.

3.4.2.1 Intercauseway near Deltaport Causeway, Sites 1A, 1B, and 2

Site 2 was originally selected due to its proximity to DP3 (**Figure 8**). The eelgrass habitat at Site 1 was very similar to that at Site 2 in 2003, and was selected as a reference by which to assess changes in the eelgrass habitat adjacent to DP3 should changes occur. The habitat at Site 1 changed subsequent to 2003 and was no longer suitable for comparison to Site 2, therefore a new station, Site 1B was established in 2009 (**Figure 8**). The eelgrass habitat at Site 1B is very similar to that at Site 2. Site 1 was renamed Site 1A; monitoring will continue at this site as it may provide insight into the evolution of the sand lobe.

The eelgrass habitat in the vicinity of Site 1A has changed since 2003, it evolved from dense, continuous *Z. marina* to a patchy distribution of relatively sparse *Z. marina* and *Z. japonica* by 2009 and into 2010. The density of both species increased in the vicinity of Site 1A in 2011; however the area continued to have a patchy distribution. The density of both species continued to increase into 2012; the combined cover by *Z. marina* and *Z. japonica* was continuous. The combined cover remained continuous in 2013.

The shoot size at Site 1A decreased between 2003 and 2008, after which it remained relatively stable through 2012. The shoot size increased in 2013; however the difference was not significant. The length and width in 2013 were significantly different from 2003 and 2007. The density decreased from 2008 through 2010 and then increased annually from 2010 through 2013. The 2013 shoot density was significantly different from that recorded in 2003, 2007, and 2008. The LAI has increased at this site annually since 2010; however the difference is not significant. The LAI values for Site 1A in 2012 were significantly different from that site in 2008 and all previous years of this study. Reproductive shoots have not been noted at this site since 2009. The reproductive shoot density in 2013 was significantly different from that of the 2003 and 2007 datasets.

The data from Site 1B was compared with that from Site 1A for the years 2008, 2007, and 2003.

The total shoot density at Site 1B in 2013 was less than in previous years; however the differences were only significant when compared with the 2010 and 2011 data. The shoot length in 2013 was similar to the data from 2009 through 2012, however it was greater than in 2003, 2007, and 2008; these differences were significant. The mean shoot width at this site was similar to most other years, however it was less than in 2003 and greater than in 2008; these differences were significant. The LAI was similar to most other years except 2010 and 2011 which were the most productive years and 2003 which was the least productive; these differences were all significant. The reproductive shoot density was similar to most other years except 2008 and 2012 when it was much lower; these differences were significant.

The total shoot density at Site 2 was less than in 2008, 2010, and 2011; these differences were significant. The total shoot density was similar to that recorded in all the other years. The mean shoot length at Site 2 in 2013 was similar to the three previous years of this study, however it was greater than in 2003 and 2007 through 2009; these differences were significant. The mean shoot width was within the range recorded in most previous years, although it was greater than in 2008 and 2011; these differences were significant. The LAI at Site 2 was the greatest in 2010 and the lowest in 2003; the LAI in 2013 was significantly different from both these years but none of the other years. The reproductive shoot density was similar to that recorded previously at this site; there were no significant differences between years.

3.4.2.2 Intercauseway Area near BC Ferries Causeway, Sites 5 and 6.

The total shoot density at Site 5 was similar to most other years included in this study, however it was less than in 2009 and in 2010; these differences were significant. The mean shoot length at this site was greatest in 2010 and least in 2007; the differences between 2013 and these years was significant, other comparisons were not. The mean shoot width at Site 5 was the greatest in 2003 and the least in 2009, the mean shoot width in 2013 was significantly different from these years but not the others included in this study. The LAI at this site in 2013 was similar to that of all other years except 2012 when it was much lower; the difference was significant. The reproductive shoot density at this site was the greatest in 2009; the difference between 2013 and 2009 was significant, comparisons between other years were not.

The total shoot density at Site 6 in 2013 was within the range of most other years with the exception of 2010 when it was much greater; the difference was significant. The mean shoot length in 2013 was the greatest recorded in this study; however the difference was only significant when compared with data from 2003 and 2010. The mean shoot width, LAI, and reproductive shoot density in 2013 was similar to all other years, there were no significant differences.

3.4.2.3 West of Deltaport Causeway, Sites 3 and 4.

The total shoot density at Site 3 was within the ranges recorded previously at this site; none of the comparisons indicated significant differences. The mean shoot length was greater in 2013 than in previous years of this study; the differences between 2013 and the other years were significant for all except 2010, 2011, and 2012. There were no significant differences between shoot width, LAI, or reproductive shoot density when the data from 2013 was compared with previous years.

The mean total shoot density at Site 4 was similar to most previous years except 2008 and 2010 when it was much greater; the differences were significant. The length of shoots at Site 4 were within the ranges previously recorded; there were no significant differences between 2013 and other years. The mean shoot width was the greatest at this site in 2003; a comparison between the 2003 and 2013 data found a significant difference, there were no other significant differences between years. The LAI was lower in 2010 and 2011 than in other years. The difference in LAI between 2013 and these years were significant, comparisons with other years found no significant differences. There were no significant differences between the data sets for reproductive shoot density in 2013 when compared with previous years.

3.4.2.4 Boundary Bay, Sites WR1, WR2, and WR3.

Site WR1 is higher than any areas supporting *Z. marina* in the intercauseway at Roberts Bank, the plants are smaller and the habitat not comparable to any of the other sites in the AMS. The data collected at this site may be useful for future projects but is not relevant for the AMS, and therefore it will not be included in this discussion.

The total shoot density at Site WR2 was much greater than that recorded in previous years; the difference was significant between 2013 and all other years. The shoot length was similar to most other years except 2009 and 2012 when it the shoots were much shorter; these differences were significant. The mean shoot width in 2013 was not significantly different from any of the others years in this study. The LAI was the greater in 2013 than in the previous years of this study; there were significant differences between 2013 and all other years. The mean density of reproductive shoots was considerably less than in 2008, 2011, and 2012; these differences were significant, comparisons between 2013 and other year years were not.

The total shoot density at WR3 was greater than in all previous years of the study with the exception of 2010; the differences were significant for all comparisons except 2008, 2010, 2011, and 2012. The mean shoot length was greater than in previous years of this study except for 2003 and 2009; the differences were significant for the years 2003, 2007, and 2012. The mean shoot width in 2013 was similar to most other years; however it was significantly different from 2012. The LAI was similar to the years 2008 through 2012, but greater than in 2003 and 2007; these differences were significant. The reproductive shoot density was similar to the other years with the exception of 2011 at which time there were not any flowering shoots; the difference was significant.

3.4.2.5 Roberts Bank Site 2 and Boundary Bay, Site WR3.

The inter-annual variation in productivity at a Roberts Bank site and at a reference site in Boundary Bay were compared (**Figure 2.5-6**). Site 2 at Roberts Bank was selected for the comparison because it is the site closest to DP3. Site WR3 in Boundary Bay was selected for comparison because the shoot length and width at this location are very similar to that at Site 2.

The trends in productivity tend to be very similar between the two sites over time, however in 2013 WR3 increased while Site 2 decreased slightly.

3.4.2.6 Inter Annual Variation in Productivity

The trends in productivity between years were similar for most of the intercauseway sites. The productivity was the greatest in 2010 followed by 2011, and was the lowest in 2003 and 2007. The main exception was Site 1A where the productivity decreased from 2003 through 2010 then increased between 2011 and 2013 relative to 2010. The productivity at the intercauseway sites declined slightly with the exception of Site 5. Site 5 declined sharply in 2012 and has since recovered.

The productivity at the sites west of the Deltaport causeway was also the greatest in 2010; however there was not a clear trend for the other years. These sites are more strongly influenced by the Fraser River plume than are the intercauseway sites; this may be one of the factors that contributes to the variability in productivity at these sites.

The trends in productivity between years at the Boundary Bay sites were similar those at the intercauseway sites until 2013. The productivity at the Boundary Bay sites in 2013 was greater than in most previous years while the productivity at the intercauseway sites was only slightly greater than the average from previous years of this study.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 COASTAL GEOMORPHOLOGY

The coastal geomorphology portion of the AMS monitoring program has been ongoing for almost 81 months from its inception in April 2007 to the end of 2013. Upon review of the data that was collected and analysed in support of the AMS, the majority of the initial monitoring activities have now been discontinued. Large-scale monitoring through interpretation of orthophotographs (annual) and bathymetric and topographic surveys (completed this year) provide ongoing, high-level information.

To date, the most notable change within the study area was the 2007 formation of 'new drainage channels' on the mud flats adjacent to the DP3 perimeter dike. Observations in the field indicate that only very small amounts of sediment continue to be transported within these channels. Mapping from the orthophotographs shows that the position of the channels has not changed between the time that the 2008 and 2013 photos were taken, and the existing DoD rod data indicates a much lower level of erosion and deposition in this area than the period immediately following their formation.

No other long-term physical changes have occurred on the tidal flats that could be attributed to the construction of DP3, which is consistent with predictions made in the Coastal Geomorphology Report (NHC, 2004). It became apparent in 2012 that the habitat compensation project on the east side of the Deltaport Causeway has had a direct influence on the study area as sand and/or fine gravel appears to have been washed out of the project and has deposited lower down on the mud flats. Although a supply sediment remains in the habitat project area for potential seaward transport, the impacted area is recovering from the initial introduction of material and eelgrass is colonising parts of the sand bars.

The majority of the elevation differences that show up in the subsequent coastal geomorphology mapping surveys lies within the effective accuracy of the surveys (+/- 25 cm). Within this tolerance, most areas have remained stable or can be related to ongoing processes, such as migration of tidal channels. A fairly large change in bed level has been observed in the main Trunk Channel, with a decrease in bed elevation (scour) of up to 1.2 m since 2007. Although it is not possible to provide a definitive analysis, it is not likely to be related to DP3, but rather to variation in the patterns of tide heights that occurs over decades.

Among the objectives and schedule of the AMS monitoring program is a phasing out of monitoring activities on a reasonable timeline if the field evidence supports such action. Based on the results of the AMS Coastal Geomorphology monitoring program to date, all field-based quarterly data collection has already been discontinued. The orthophotograph interpretation of the intercauseway area is conducted, in part, to support eelgrass mapping and so should be continued until the completion of the AMS program.

4.2 SURFACE WATER QUALITY

The 2013 surface water monitoring took place quarterly with surface water samples analyzed for nutrients quarterly and metals in Q1 only.

4.2.1 Metals

Other than the total boron in surface water samples collected from DP02 to DP09, there were no exceedances of the regulatory guidelines noted in Q1. Total boron concentrations measured during 2013 were comparable to previous results and normal for coastal marine water in Canada.

A number of metal parameters exceeded the regulatory guidelines in the surface water sampled collected from station DP01 (located downstream of the agricultural ditch). In Q1-2013, copper, manganese and nickel exceeded the regulatory guidelines at DP01. These metals have exceeded the regulatory guidelines in previous years.

Overall, based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation.

4.2.2 Nutrients

Consistent with previous years, the highest nutrient concentrations and lowest dissolved oxygen were measured in the agricultural ditch near the base of the causeway (DP01), and are likely related to upland agricultural inputs. Elevated concentrations of chlorophyll *a*, phosphorus, TKN, organic nitrogen and total nitrogen where elevated at DP05 in Q2-2013 with chlorophyll *a*, phosphorus, TKN, and organic nitrogen above the AMS thresholds. This sample had significantly higher turbidity and TSS readings than the other samples and is likely correlated with the elevated nutrients. The concentrations of these parameters were within the range of previous results on other quarters of 2013.

Overall, nutrient concentrations in the intercauseway area have not shown an increasing, or decreasing, trend for dissolved oxygen, in the seven years of AMS monitoring (2007 – 2013). There are potential seasonal trends for organic nitrogen, TKN, and chlorophyll α with higher concentrations detected in Q2 and Q3. In addition, phosphate concentrations within both the inter-tidal causeway and the reference stations tend to be higher in Q4 sampling events (November or December). The average N:P ratio for surface water using 2007-2013 data is 19:1 which is close to the predicted Redfield ratio of 16:1 and a trend plot of this molar ratio indicates all data points close to the Redfield ratio except one station during one event (DP04, Q4-2011).

Based on the data collected to date, there is no evidence of eutrophication occurring as a result of DP3 construction or operation.

4.3 SEDIMENT QUALITY

The 2013 sediment monitoring took place quarterly with samples analyzed for nutrients quarterly and metals annual in Q1.

4.3.1 Metals

Similar to previous years, there were no metal exceedances of applicable regulatory criteria in sediment in 2013. The highest metal concentrations in sediment for 2013 were observed at stations DP01, DP05 and DP09. These three sediment samples had higher silt and clay content than the other samples based on the grain size data which may influence the metal concentrations. Based on the lithium normalization technique, these metal results are considered reflective of natural background conditions.

No notable temporal trends have been observed in the metals data from the sampling stations. Based on the data collected to date, there is no evidence of increasing concentrations of metals or metals loading as a result of the DP3 construction or operation.

4.3.2 Nutrients

As in previous years, nutrient concentrations were higher in sediments in the intercauseway than at the reference stations. This likely relates to higher biological activity within the intercauseway (as compared to the exposed location of the reference stations at the mouth of the Fraser River) and not related to DP3 construction or operations. Neither nutrients nor other eutrophication-related parameters exhibited a temporal trend in sediment.

Two stations had concentrations of one or more parameters above the AMS thresholds in 2013: total nitrogen at DP05 in Q1, sulphide and TOC at DP05 in Q2 and sulphide at DP04 in Q3. Regarding total nitrogen in Q1, other stations including the reference stations also showed elevated total nitrogen in Q1. Sulphide and TOC concentrations have previous been above AMS thresholds at DP05 and nutrient parameters are typically higher at this location given its subtidal location. The elevated sulphide at DP04 in Q3 is thought to be related to a field observation of dark grey colour and black layer on surface possibly indicating anoxic conditions which would increase sulphide. The sulphide concentration at DP04 was not elevated in any of the other quarters of 2013.

Based on the data collected to date, no evidence of eutrophication occurring as a result of DP3 construction or operation has been observed.

4.4 EELGRASS

The assessment of epiphyte load and the absence of *Beggiatoa* sp. were consistent with results from previous years and indicate that the eelgrass habitat was in good condition at all of the AMS monitoring sites. The area behind the tug basin supported elevated levels of epiphytes; this is discussed **in Appendix C**.

It appears that the area colonized by *Z. marina* and *Z. japonica* on and adjacent to the sand lobe have increased over the last year.

The productivity (LAI) of *Z. marina* at most of the intercauseway sites in 2013 was average. The only exception was Site 1A. The productivity at Site 1A remains low but has increased by 33% over the last year. The productivity at Site 5, near the Tsawwassen Ferry Causeway decreased in 2012 relative to previous years; the site was within the normal range in 2013. The productivity at the Boundary Bay sites was much greater than average; this is may be due to variation in a localized environmental factor or site specific influences.

The development of DP3 resulted in a loss of *Z. marina* habitat in the area that was altered by sediment deposition from the formation of new drainage channels adjacent to DP3 (as indicated by the changes in hectares of continuous and patchy *Z. marina* habitat when comparing the 2003 and 2013 data). The 2010 bathymetric data demonstrated that the loss was not due to sediment accretion in the area. The eelgrass habitat in this area increased between 2010 and 2011, however a decrease was observed in 2012. The habitat in 2013 was similar to that documented in 2012. A detailed discussion of the changes that have occurred in this area since 2011 is provided in **Appendix C**.

There are no other indications that the development of DP3 has negatively affected the intercauseway eelgrass habitat. No changes to the eelgrass survey program are recommended for 2014.

4.5 SUMMARY

To date, the data collected during the AMS monitoring program indicates no widespread physical or biological change in the intercauseway area following DP3 construction and operation.

Based on the findings to date, the following adaptations to the AMS program are recommended for 2014:

- Discontinue the annual metals analysis in surface water and sediment samples as data collected to date does not indicate increasing concentrations as a result of DP3 construction or operation;

5.0 CLOSING

We trust that the information contained in this draft report meets your needs at this time. If you have any questions, please do not hesitate to contact the undersigned.

Report prepared by:
Hemmera

DRAFT

David Clegg, B.Sc.
Environmental Scientist

DRAFT

Bonnie Marks, M.A.Sc., P.Eng., PMP
Environmental Engineer/Project Manager

NHC

DRAFT

Derek Ray, M.Sc., P.Geo.
Geomorphologist/Hydrologist

Precision Identification

DRAFT

Cynthia Durance, R.P.Bio.
Habitat Ecologist

Overall document review by:
Hemmera

DRAFT

Ben Wheeler, M.Sc., R.P.Bio.
Project Director & Senior Technical Reviewer

6.0 REFERENCES

Australia and New Zealand Environment Conservation Council (ANZECC), 2001. Australian Water Quality Guidelines for Fresh and Marine Waters.

Australian Online Coastal Information 2012. Z Coasts Online Information System. Accessed August 28, 2012. http://www.ozcoasts.gov.au/indicators/sediment_org_matter.jsp

Baden, S., A. Emanuelsson, L. Pihl, C. Svensson, and P. Åberg. 2012. Shift in seagrass food web structure over decades is linked to overfishing. Mar. Ecol. Prog. Ser. 451:61-73.

Baldwin, J.R., and J.R. Lovvorn. 1994a. Habitats and tidal accessibility of marine foods of dabbling ducks and brant in Boundary Bay, British Columbia. Marine Biology 120:627-638.

Baldwin, J.R. and J.R. Lovvorn. 1994b. Expansion of seagrass habitats by the exotic Zostera japonica, and its use by dabbling ducks and brant in Boundary Bay, British Columbia. Marine Ecology Progress Series 103:119-127.

BC Ministry of Environment (BCMOE). 2006a. British Columbia Approved Water Quality Guidelines, 2006 Edition. September 1998, updated August, 2006.

BCMOE. 2006b. A Compendium of Working Water Quality Guidelines for British Columbia. 1998. Updated August 2006.

Beck, M.W., K.L. Heck, K.W. Able, D.L. Childers, D.B. Eggleston, B.M. Gillanders, B. Halpern, C.G. Hays, K. Hoshino, T.J. Minello, R.J. Orth, P.F. Sheridan, and M.P. Weinstein. 2001. The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. Bioscience: 51:663-641.

Bird Studies Canada. 2009. British Columbia Coast Bird Watch ‑ Newsletter of the BC Coastal Waterbird and Beached Bird Surveys. September 2009. Volume 2.

Borum, J., and S. Wium-Anderson. 1980. Biomass and production of epiphytes on eelgrass (*Zostera marina* L.) in the Øresund, Denmark. Ophelia 1:57-64.

Bowen, J.L. and I. Valiela. 2001. The ecological effects of urbanization on coastal watersheds: Historical increase in nitrogen loads and eutrophication of Waquoit Bay estuaries. Canadian Journal of Fisheries and Aquatic Science 58:1489-155.

Baird D, Christian RR, Peterson CH, Johnson GA. 2004. Consequences sequences of hypoxia on estuarine food web and ecosystem function: energy diversion from consumers to microbes. Ecol Appl 14:805‑822

British Columbia Contaminated Sites Regulation (BC CSR). BC Reg. 375/96 (Effective April 1997 and amended July 1999, February 2002, November 2003, and July 2004 and July 2007).

British Columbia Waterfowl Society. 2006. International significance of the Fraser Estuary. Available: http://www.reifelbirdsanctuary.com/fraser.html

Burd, B.J., P.A.G. Barnes, C.A. Wright, and R.E. Thompson. 2008. A review of subtidal benthic habitats and invertebrate biota of the Strait of Georgia, British Columbia. Marine Environmental Research. 66: S3‑S38.

Burd, B.J., D. Moore, and R.O. Brinkhurst. 1987. Distribution and Abundance of Macrobenthic Fauna from Boundary and Mud Bays near the British Columbia/US Border. Canadian Technical Report of Hydrography and Ocean Sciences 84, pp. 1‑34.

Butler, R.W. 1997. The Great Blue Heron. UBC Press, Vancouver, BC.

Butler, R.W., and R.W. Campbell. 1987. The birds of the Fraser River Delta: populations, ecology, and international significance. Occasional Paper No. 65. Canadian Wildlife Service.

Butler, R.W., and R.J. Cannings. 1989. Distribution of birds in the intertidal portion of the Fraser River Delta, British Columbia. Technical Report Series No. 93. Canadian Wildlife Service.

Butler, R.W, and P.C.F. Shepherd, and M.J.F. Lemon. 2002. Site fidelity and local movements of migrating western sandpipers on the Fraser River estuary. Wilson Bulletin 114(4): 485-490.

Canadian Council of Ministers of the Environment (CCME), 2007. Canadian Guidance Framework for the Management of Nutrients in Nearshore Marine Systems: Scientific Supporting Document.

Canadian Council of Ministers of the Environment (CCME), 1999. Canadian Water Quality Guidelines. Updated July, 2006.

Constanza, R., R. d’Arge,R. deGroot, S. Farber, M. Grasso, B. Hannon, K. Limberg, and S. Naeem. 1997. The value of the worlds ecosystem services and Natural Capitol. Nature 387: 253-260.

De Casabianca, M.L., T. Laugier, and D. Collart. 1997. Impact of shellfish farming eutrophication on benthic macrophyte communities in Thau Lagoon, France. Aquaculture Inter 5: 301-314.

Dean, T., and L. Halderson. 2000. The distribution of nearshore fishes in kelp and eelgrass communities in Prince William Sound, Alaska: Associations with vegetation and physical habitat characteristics. Environmental Biology of Fishes 57: 271-287

Dean, H., K. 2008. The use of polychates (annelida) as indicators species of marine pollution: a review. Revista de Biologia Tropical / International Journal of Tropical Biology and Conservation 56 (4): 11-38.

den Hartog, C. 1994. Suffocation of a littoral *Zostera* bed by *Enteromorpha radiate*. Aquatic Botany: 47:3-14.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Steveson, V. Carter, S. Kollar, P. Bergstrom, and R. Batiuk. 1993. Assessing water quality with submerged aquatic vegetation. Bioscience 43:86-94.

Diaz R.J. and Rosenberg R. 1995. Marine benthic hypoxia: a review of its ecological effects and the behavioural responses of benthic macrofauna. Oceanographic Marine Biology Annual Review. 33:245‑303

Duarte, C.L. 1991. Allometric scaling of seagrass form and productivity. Mar. Ecol. Prog. Ser. Vol. 77: 289-300.

Duarte C.M., J. Borum, F. Short, and D. Walker. 2008. Seagrass Ecosystems: Their global status and prospects. In: Polunin NVC (ed) Aquatic Ecosystems: Trends and Global Prospects. Cambridge University Press.

Dunster, J. and Dunster, K. 1996. Dictionary of Natural Resource Management. UBC Press, Vancouver, Canada.

Durance, C. 2004b. Eelgrass mapping and habitat increases in the Fraser River Estuary. Pacific Estuarine Research Conference. Port Townsend, Washington, USA. May 2004.

ECL Envirowest Consultants Limited. 2004. Technical Volume 5 Deltaport Third Berth Project coastal seabird and waterfowl resources impact assessment. Prepared for the Vancouver Port Authority in support of the Roberts Bank Container Expansion Project.

Environment Canada. 2005. Black Brant Geese as an indicator of wildlife sustainability in the Georgia Basin. Available: http://www.ecoinfo.org/env_ind/region/brantgeese/brantgeese_e.cfm

Essinger, A.M. 2007. Great blue herons in Puget Sound. Puget Sound Nearshore Partnership Report no. 2006-06. Seattle District, U.S. Army Corps of Engineers, Seattle Washington, USA.

Fertig, B., M. J. Kennish, and G. P. Sakowicz. 2013. Changing eelgrass (Zostera marinaL.) characteristics in a highly eutrophic temperate coastal lagoon. Aq. Bot. 104:70-79.

Flindt, MR., L. Kamp-Neilson, J.C. Marques, M.A. Pardal, M. Bocci, G. Bendoricchio, G. Salomsen, S.N. Neilsen, and S.I. Jorgensen. 1997. Description of three shallow estuaries: Mondego River (Portugal), Roskilde Fjord (Denmark), and the lagoon of Venice (Italy). Ecological Modelling 102:17-31.

Fonseca, M.S., J.C. Zieman, G.W. Thayer, and J.S. Fisher. 1983. The role of current velocity in structuring eelgrass *Zostera marina* meadows. Est. Coast Shelf Sci 17:367-380.

Fonseca, M. 1992. A preliminary evaluation of wave attenuation by four species of seagrass. Estuary, Coastal, and Shelf Science 35:565-576.

Fonseca, M.S. and S.S. Bell. 1998. Influence of physical setting on seagrass landscapes near Beaufort, North Carolina, USA. Mar Ecol Prog Ser 171:109-121.

Francoise, R., F.T. Short, and J.H. Weber. 1989. Accumulation and persistence of Tributyltin in eelgrass (*Zostera marina* L.) tissue. Environmental Science Technology 23:191-196.

Fredette, T.J., R. Diaz, J.J. van Montfrans, and R.J. Orth. 1990. Secondary production within a seagrass bed (*Zostera marina- Ruppia maritima*) in lower Chesapeake Bay. Estuaries 13:431-440.

FREMP. 2003. A living working river; Habitat Inventory. Fraser River Estuary Management Plan. http://www.bieapfremp.org/fremp/pdf_files/Habitat%20Brochure%20May04%20copy.pdf

Gebauer, M.B., and I.E. Moul. 2001. Status report of the great blue heron in British Columbia. Wildlife working report No. WR-102. Ministry of Environment, Lands and Parks, Wildlife Branch, Victoria, British Columbia.

Goodman, J.L., K.A. Moore, and W.C. Dennison. 1995. Photosynthetic response of eelgrass (*Zostera marina* L.) to light and sediment sulphide in a shallow barrier island lagoon. Aquat. Bot. 50:37-47.

Hansen, J.W., J.W. Udy, C.J. Perry, W.C. Dennison, and B.A. Lomstein. 2000. Effect of the seagrass *Zostera capricorni* on sediment microbial processes. Marine Ecology Progress Series 199: 83-96.

Harrison, P.G. and R.E. Bigley. 1982. The recent introduction of the seagrass *Zostera japonica* to Aschers, and Graebn. to the Pacific Coast of North America. Canadian Journal of Aquatic Sciences 39:1642-1648.

Harrison, P.G. 1984. The biology of seagrasses in the intercauseway area of Roberts Bank, B.C. Prepared for the Port of Vancouver.

Harrison, P.G. and M. Dunn. 2004. Fraser River delta ecosystems, their distribution and importance to migratory birds in the Fraser Delta, British Columbia; Issues of an Urban Estuary. (ed.) B.J. Groulx, D.C. Mosher, J.L. Luternauer, and D.E. Bilderback; Geological Survey of Canada Bulletin 567; 173-188.

Heck, K.L., K.W. Able, M.P. Fahay, and C.T. Roman. 1989. Fishes and decapod crustaceans of Cape Cod eelgrass meadows: Species composition, seasonal abundance patterns, and comparison with unvegetated substrate. Estuaries 12:59-65.

Heck, K.L., K.W. Able, C.T. Roman, and M.P. Fahay. 1995. Composition, abundance, biomass, and production of macrofauna in a New England estuary: Comparisons among eelgrass meadows and other nursery habitats. Estuaries 18:379-389.

Heck, K.L., G. Hays, and R.J. Orth. 2003. Critical evaluation of the nursery role hypothesis for seagrass meadows. Marine Ecology Progress Series 253:123-136.

Heiss, W.M., A.M. Smith, and P.P. Keith. 2000. Influence of the small intertidal seagrass *Zostera novazelandica* on linear water flow and sediment texture. New Zealand Journal of Marine and Freshwater Resources 34:689-694.

Hemmera. 2005. Environmental Assessment Application for the Deltaport Third Berth Project.

Hemmera, 2008a. Adaptive Management Strategy Quarterly Report: Q2-2007, Deltaport Third Berth (Final Rep*ort)*. Prepared by Hemmera Envirochem, NHC, and Precision for Vancouver Port Authority, February, 2008, 134 pp.

Hemmera, 2008b. Adaptive Management Strategy Quarterly Report: Q3-2007, Deltaport Third Berth (Final Report). Prepared by Hemmera Envirochem, NHC, and Precision for Vancouver Port Authority, February, 2008, 141 pp.

Hemmera, 2008c. Adaptive Management Strategy Quarterly Report: Q4-2007, Deltaport Third Berth (Final Report). Prepared by Hemmera Envirochem, NHC, and Precision for Vancouver Port Authority, January, 2008, 134 pp.

Hemmera, 2008d. Deltaport Third Berth Adaptive Management Strategy 2007 Annual Report. Prepared by Hemmera, NHC, and Precision for Vancouver Fraser Port Authority, July, 2008, 216pp.

Hemmera, 2009. Adaptive Management Strategy 2008 Annual Report, Deltaport Third Berth (Final Report). Prepared by Hemmera Envirochem NHC, and Precision, for Vancouver Fraser Port Authority, September, 2009, 305pp.

Hemmera, 2010. Deltaport Third Berth Adaptive Management Strategy 2009 Annual Report. Prepared by Hemmera, NHC, and Precision for Vancouver Fraser Port Authority, September, 2010, 344pp.

Hemmera, 2012a. Deltaport Third Berth Adaptive Management Strategy 2010 Annual Report. Prepared by Hemmera NHC, and Precision, for Vancouver Fraser Port Authority, March 2012, 408pp.

Hemmera, 2012b. Deltaport Third Berth Adaptive Management Strategy 2011 Annual Report. Prepared by Hemmera NHC, and Precision, for Vancouver Fraser Port Authority, November 2012, 597pp.

Hemmera, 2013. Deltaport Third Berth Adaptive Management Strategy 2012 Annual Report. Prepared by Hemmera NHC, and Precision, for Vancouver Fraser Port Authority, September 2013, 344pp.

Hjulström, F., 1935. Studies of the Morphological Activity of Rivers as Illustrated by the River Fyris. Bull. Geol. Inst. Uppsala, 25.

Hoven, H.M., H.E. Gaudette, and F.T. Short. 1999. Isotope ratios of 206Pb/207Pb in an estuary. Mar Environ Res 48:377-387.

Hughes, B.B., R. Eby, E. Van Dyke, M. T. Tinkera, C. I. Marksd, K. S. Johnsone, and K. Wassona. 2013. Recovery of a top predator mediates negative eutrophic effects on seagrass. PNAS http://www.elkhornslough.org/research/PDF/Hughes_etal_2013_PNAS_otters_eelgrass.pdf

Jorgensen, P., S. E. Ibarra-Obando1, J. D. Carriquiry. 2007. Top-down and bottom-up stabilizing mechanisms in eelgrass meadows differentially affected by coastal upwelling. Mar. Ecol. Prog. Ser. 333:81-93.

Kemp, W.M., W.R. Boynton, J.C. Stevenson, R.R. Twilley, and J.C. Means. 1983. The decline of submersed vascular plants in upper Chesapeake Bay: Summary of results concerning possible causes. Marine Technology Society J 17:78-89.

Kelsall, J.P. and K. Simpson. 1980. A three‐year study of the Great Blue Heron in southwestern British Columbia. Proc. Col. Waterbird Grp. (1979) 3:69‐ 74.

Kemp, W.M., W.R. Boynton, R. R. Twilley, J.C. Stevenson, and J.C. Means. 1983. The decline of submerged vas- cular plants in upper Chesapeake Bay: Summary of results concerning possible causes. Mar. Sot. Technol. J. 17: 78- 89.

Koch, E. W. and S. Beer. 1996. Tides, light, and the distribution of Zostera marina in Long Island Sound, USA. Aquat Bot: 53: 97-107.

Koch, E.W. and J.J. Verdin. 2001. Measurements of physical parameters in seagrass habitats. In: Short F.T. and R.G. Coles (eds) Global Seagrass Research Methods, pp 325-344. Elsevier Science B.V., Amsterdam.

Larkum, A., E. Drew, and P. Ralph. 2006. Chapter 14: Photosynthesis and metabolism in seagrasses at the cellular level. In Seagrasses: Biology, Ecology and Conservation. Larkum, A., R. Orth, and C. Duarte (eds) Springer, The Netherlands.

Lee,S.Y., C.J. Kwon, and C. Chung. 2000. Distribution of Zostera (Zosteraceae) and habitat characteristics in the eastern coastal waters of Korea. J Korean Fish Soc 33:501-507.

Lewis, L.S. and T.W. Anderson. 2012. Top-down control of epifauns by fishes enhances seagrass production. Ecology Vol. 93; 2746-2757. PNAS 110; 15313-15318

Liu, X., Y. Zhou, H. Yang, and S. Ru. 2013. Eelgrass detritus as a food source for the sea cucumber Apostichopus japonicus Selenka (Echinidermata: Holothuroidea) in coastal waters of North China: an experimental study in flow-through systems. PloS one 8:e58293

Lyngby, J.E. and H. Brix. 1982. Seasonal and environmental variations in cadmium, copper, lead, and zinc concentrations in eelgrass (*Zostera marina* L.) in Limfjord, Denmark. Aquatic Botany.14:59-74.

Mackas, D.L. and P.J. Harrison. 1997. Nitrogenous nutrient sources and sinks in the Juan de Fuca/Strait of Georgia/Puget Sound Estuarine System: Assessing Potential for Eutrophication. Estuarine, Coastal, and Shelf Science. 44:1‑21.

Mantua, N.J., S.R. Hare, Y. Zhang, J.M. Wallace, and R.C. Francis. 1997. A Pacific decadal climate oscillation with impacts on salmon. Bulletin of the American Meteorological Society, Vol. 78, pp 1069-1079.

Marba, N., M. Holmer, E. Gacia, and C. Barron. 2007. Chapter 6, Seagrass Beds and Coastal Biogeochemistry. In Seagrasses: Biology, Ecology and Conservation. Larkum, A., R. Orth, and C. Duarte (eds) Springer, The Netherlands.

Mateo, M.A., Cebrian, K. Dunton, and T. Mutchler. 2007. Chapter 7, Carbon flux in Seagrass Ecosystems. In Seagrasses: Biology, Ecology and Conservation. Larkum,A, R. Orth, and C. Duarte (eds.) Springer, The Netherlands.

McLean, D. G. and M. A. Church, 1986. A Re-Examination of Sediment Transport Observations in the Lower Fraser River. Water Resources Branch, Environment Canada, IWD-HQ-SS-86-6, Ottawa, 53 pp.

Moore, J.E., Colwell, M.A., Mathis, R.L., and J.M. Black. 2004. Staging of Pacific flyway brant in relation to eelgrass abundance and site isolation, with special consideration of Humboldt Bay, California. Biological Conservation 115:475-486.

Moore, K.A., R.J. Orth, and J.F. Nowak. 1993. Environmental regulation of seed germination in Zostera marina L. (eelgrass) in Chesapeake Bay: Effects of light, oxygen, and sediment burial. Aquat. Bot. 45:79-91.

Moore, K.A. and F.T. Short. 2007. Chapter 16, Biology of *Zostera*. In Seagrasses: Biology, Ecology and Conservation. Larkum, A, R. Orth, and C. Duarte Eds. Springer, The Netherlands.

Moore, K.A., R.L. Wetzel, and R.J. Orth. 1997. Seasonal pulses of turbidity and their relation to eelgrass (*Zostera marina* L.) survival in an estuary. Journal of Marine Biology Ecology 215: 115-134.

Moss, S.A. and Nagpal, N.K. 2003. Ambient Water Quality Guidelines for Boron: Overview Report. BC Ministry of Water Land and Air Protection - Water, Air and Climate Change Branch.

Neilsen, J., S. Helema, and B. Schone. 2008. Shell growth history of geoduck clam (Panopea abrupta) in Parry Passage, British Columbia, Canada: Temporal variation in annuli and the Pacific Decadal Oscillation. Journal of Oceanography, Volume 64, Number 6, 951-960, DOI: 10.1007/s10872-008-0078-1

NHC, 2007a. Deltaport Third Berth Habitat Compensation, Dendritic Channel Intervention. Northwest Hydraulic Consultants Ltd. Discussion paper to Vancouver Port Authority, February 2007.

NHC, 2007b. Correlating Turbidity and Suspended Solids. Memo prepared by Northwest Hydraulic Consultants Ltd. for Hemmera Envirochem in support of the Roberts Bank DP3 AMS Program and Vancouver Port Authority, November 5, 2007, 6 pp.

NHC, 2004. Roberts Bank Container Expansion, Coastal Geomorphology Study. Northwest Hydraulic Consultants and Triton Consultants Ltd. Final report to Vancouver Port Authority, October 2004.

Orth, R.J. and K.L Heck. 1980. Structural components of eelgrass (*Zostera marina*) meadows in the lower Chesapeake Bay. Estuaries 3: 278-288.

Orth., R.J. and K. A. Moore. 1983. Chesapeake Bay: An unprecedented decline in submerged aquatic vegetation. Science: 222:51-52.

Oslo Paris Commission (OSPAR), 2005. Ecological Quality Objectives for the Greater North Sea with Regard to Nutrients and Eutrophication Effects

Penhale, P.A. 1977. Macrophyte-epiphyte biomass and productivity in an eelgrass (Zostera marina) community. J. Exp. Mar. Biol. Ecol. 26:211-224.

Peterson C.H., C.H. Summerson, E. Thomson, H.S. Lenihan, J.H. Grabowski, L. Manning, F. Micheli, G. Johnson. 2000. Synthesis of linkages between benthic and fish communities as a key to protecting essential fish habitat. Bulletin of Marine Science. 66:759‐744

Phillips, R.C. 1984. The ecology of eelgrass meadows in the Pacific Northwest: A community profile. U.S. Fish & Wildlife Service FWS/OBS-84/24. 85pp.

Pregnall, A.M., R.D. Smith, T.A. Kursar, and R.S. Alberte. 1984. Metabolic adaptation of *Zostera marina* (eelgrass) to diurnal periods of root anoxia. Mar Biol 83: 141-147.

Short, F.T. 1983. The seagrass Zostera marina: Plant morphology and bed structure in relation to sediment ammonium in Izembek Lagoon, Alaska. Aquat Bot 16: 149-161.

Short, F.T. 1987. Effects of sediment nutrients on seagrasses: Literature review and mesocosm experiments. Aquat Bot 27: 41-57.

Short, F.T. and D.M. Burdick. 1996. Quantifying eelgrass habitat loss in relation to housing development and nitrogen loading in Waquoit Bay, Massachusetts. Estuaries 19; 730-739.

Short, F.T., D.M. Burdick, J. Wolf, and G.E.Jones. 1993. Eelgrass in Estuarine Research Reserves along the east coast, U.S.A. Part 1. Declines from pollution and disease and Part 2. Management of Eelgrass meadows. NOAA-Coastal Ocean Program Publication.

Short, F.T., D.M. Burdick, and J.E. Kaldy. 1995. Mesocosm experiments quantify the effects of eutrophication on eelgrass, Zostera marina. Limnol. Oceanogr. 40 (4): 740-749.

Short, F.T. and S. Wyllie-Escheverria. 1996. Natural and human induced disturbance of seagrasses. Environmental Conservation 23:17-27.

Short, F.T. and S. Wyllie-Escheverria. 2000. Global seagrass declines and the effect of climate change. In: Sheppard, C.R.C. (ed) Seas at the millennium: An environmental evaluation. Vol. III: Global issues and processes, pp 10-11. Pergamon, Elsevier, Amsterdam.

Short, F. T. 2011. Eelgrass adopted as an indicator of Puget Sound Health. Puget Sound Partnership, Tacoma, Washington, USA.

Smith, F.T, A.M. Pregnall, and R.S. Alberte. 1988. Effects of anaerobiosis on root metabolism of *Zostera marina* (eelgrass): Implications for survival in reducing sediments. Marine Biology 98:131-141.

Sutherland, T.F., S.A. Petersen, C.D. Levings and A.J. Martin, 2007. Distinguishing between natural and aquaculture-derived sediment concentrations of heavy metals in the Broughton Archipelago, British Columbia. Marine Pollution Bulletin. 54,1452-2460.

Sutherland, T.F., C.D. Levings, S.A. Petersen. P. Boon, and B. Piercey, 2007. The use of meiofauna as an indicator of benthic organic enrichment associated with salmonid aquaculture. Marine Pollution Bulletin. 54, 1249-1261.

Swain, L.G., D.G. Walton, B. Phippen, H. Lewis, S. Brown, G. Bamford, D. Newsom, and I. Lundman. 1998. Water quality assessment and objectives for the Fraser River from Hope to Sturgeon and Roberts Banks, first update, technical appendix. Ministry of Environment, Land and Parks, Province of British Columbia, Victoria, BC.

Tarbotton, M. and P.G. Harrison. 1996. A Review of the Recent Physical and Biological Development of the Southern Roberts' Bank Seagrass System 1950 - 1994. Triton Consultants Ltd. Vancouver, British Columbia, Canada

Terrados, J., C.M. Duarte, L. Camp-Neilsen, N.S.R. Agawin, E. Gacia, D. Lacap, M.D. Fortes, J. Borum, M. Lubanski, and T. Greive. 1999. Are seagrass growth and survival constrained by the reducing conditions of the sediment? Aquatic Botany 65:175-197.

Thom, R., A. Borde, S. Rumrill, D. Woodruf, G. Williams, J. Southard, and S. Sargeant. 2003. Factors influencing spatial and annual variability in eelgrass (Zostera marina L.) meadows in Willapa Bay, Washington, and Coos Bay, Oregon, estuaries. Estuaries Vol. 26, No. 48, p.1117-1129.

Thom, R., A. Borde, S. Blanton, D. Woodruf, and G. Williams. 2001. The influence of climate variation and change on structure and processes in nearshore vegetated communities of Puget Sound and other Northwest estuaries. Puget Sound Research 2001.

Triton Environmental Consultants. 2004. Deltaport Third Berth Project Marine Resources Impact Assessment. Prepared for the Vancouver Port Authority.

Triton Environmental Consultants. 2001. Roberts Bank Cumulative Environmental Effects Study: Marine Habitat Study. Prepared for the Vancouver Port Authority.

VFPA and Hemmera. 2007. Deltaport Third Berth Adaptive Management Strategy Detailed Workplan.

Vancouver Fraser Port Authority, Janaury 2011. Port Metro Vancouver Operations Environmental Assessment Certificate Compliance Report. Prepared for the BC Environmental Assessment Office.

Vähätalo, A. V, and M. Søndergaard. 2002. Carbon transfer from detrital leaves of eelgrass (Zostera marina) to bacteria. Aquatic Botany 73:265–273.

Van Montfrans, J, L.W. Wetzel, and R.J. Orth. 1984. Epiphyte-grazer relationships in seagrass meadows: Consequences for seagrass growth and production. Estuaries & Coasts Vol. 7 Issue 4, pp 289-309.

Wall, C.C., Peterson B., and Gobler C., 2008: Facilitation of

Wallace, J. M., and D. S. Gutzler, 1981: Teleconnections in the geopotential height field during the Northern Hemisphere Winter. Mon. Wea. Rev., 109, 784-812.

Wang, F. And P.M. Chapman. 1999. Biological Implications of Sulphide in Sediment – A Review Focusing on Sediment Toxicity. Environmental Toxicology and Chemistry. 18: 11: 2526-2532.

Wyllie-Escheverria, S. and J.D. Ackerman. 2003. The seagrasses of the Pacific Coast of North America. In: Green, E.P. and F.T. Short (eds) World Atlas of Seagrasses, pp 199-206. University of California Press, Berkeley, USA.

Yamada, S, A. Shanks, M. Kosro. 2011. Predicting year class strength of crab soecies from ocean conditions. Pacific Estuarine Research conference. Astoria, Oregon. March 3-5, 2011.

Zhang, Y., J.M. Wallace, D.S. Battisti, 1997: ENSO-like interdecadal variability: 1900-93. J. Climate, 10, 1004-1020.

7.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera Envirochem Inc. (Hemmera), based on work conducted by the project team of Hemmera, Northwest Hydraulic Consultants (NHC) and Precision Identification (the Project Team) for the sole benefit and exclusive use of the Vancouver Fraser Port Authority. The material in it reflects the Project Team's best judgment in light of the information available to it at the time of preparing this report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. The members of the Project Team accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

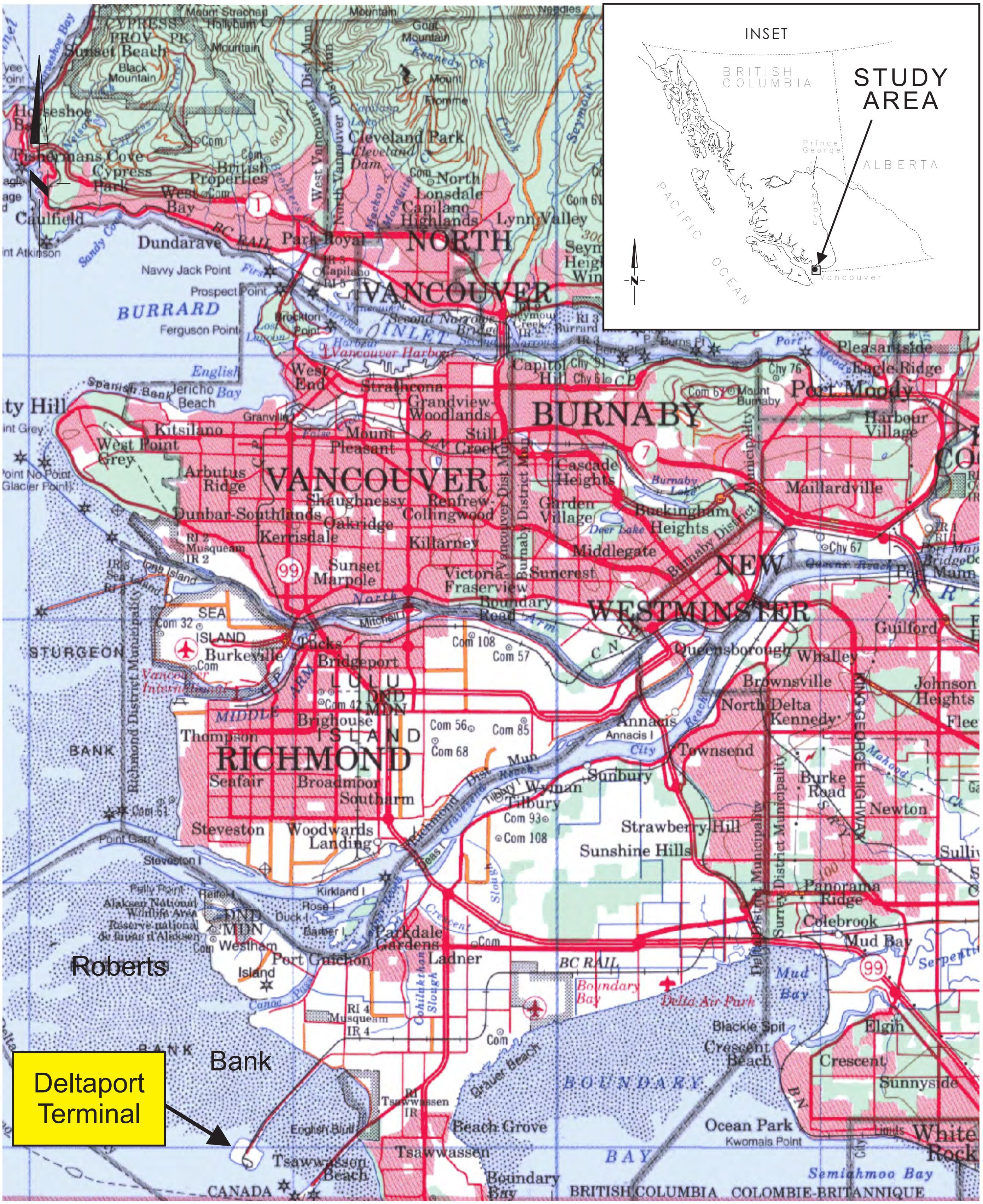
The Project Team has performed the work as described above and made the findings and conclusions set out in this report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This report represents a reasonable review of the information available to the Project Team within the established scope, work schedule and budgetary constraints. The conclusions and recommendations contained in this report are based upon applicable legislation existing at the time the report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the report. Regulatory implications discussed in this report were based on the applicable legislation existing at the time this report was written.

In preparing this report, the Project Team have relied in good faith on information provided by others as noted in this report, and has assumed that the information provided by those individuals is both factual and accurate. The members of the Project Team accept no responsibility for any deficiency, mis-statement or inaccuracy in this report resulting from the information provided by those individuals.

The liability of the members of the Project Team to the Vancouver Fraser Port Authority shall be limited to injury or loss caused by the negligent acts of the Project Team. The total aggregate liability of Hemmera and the members of the Project Team related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of the members of the Project Team for services rendered on this project.

FIGURES



HEMMERA

CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

SITE LOCATION

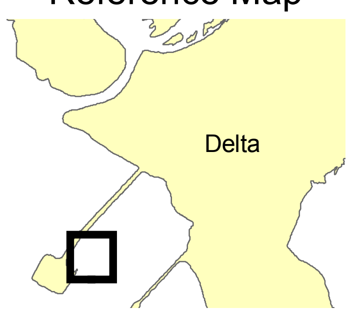
PROJECT No.		
499-002.24	March 2014	FIGURE 1

Legend

- Monitoring Sites
- Topographic Sections

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Crest Protection Structure Monitoring Site Location Map

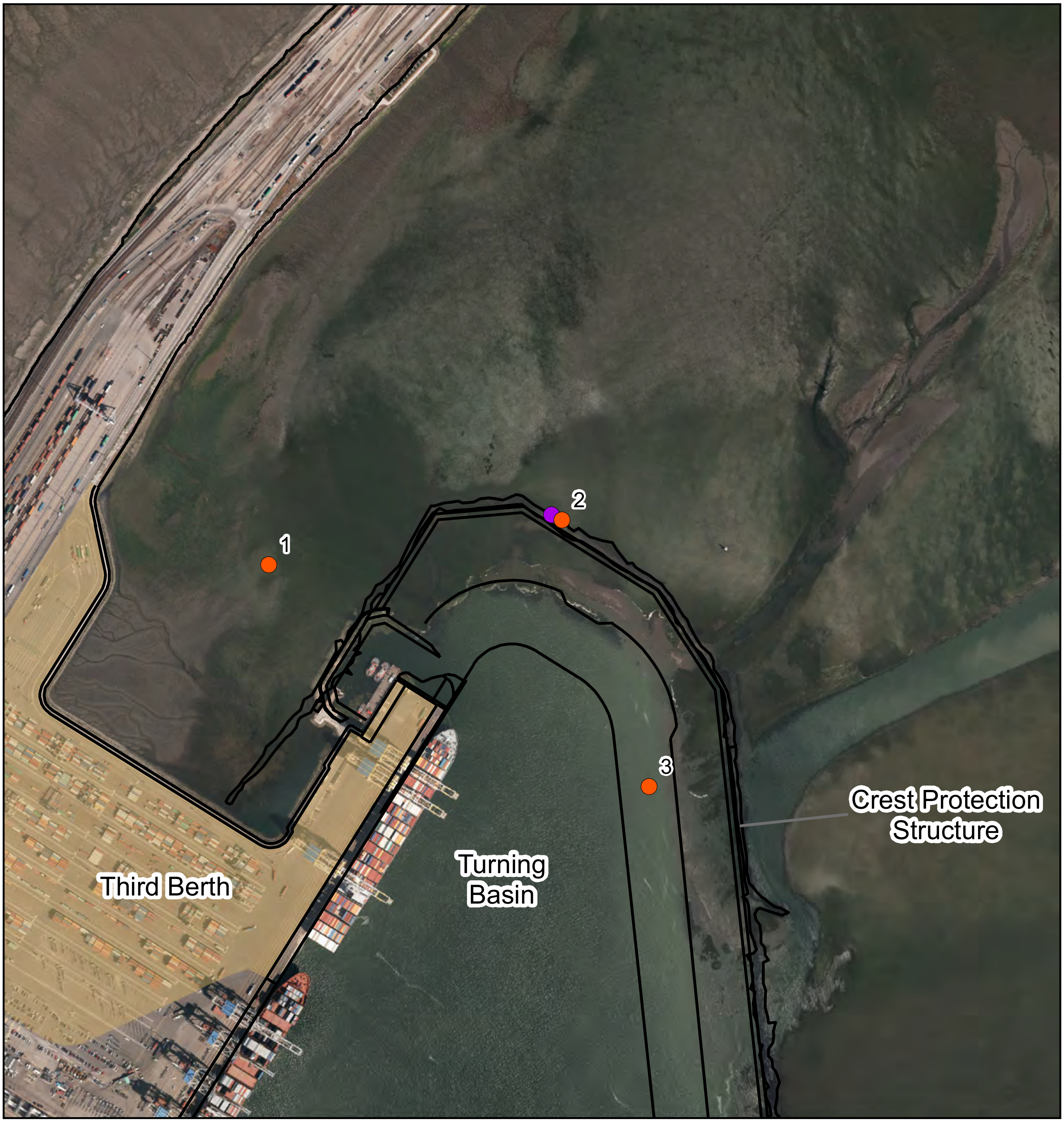
Scale - 1:7,500

100 50 0 100 200 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	February 2014

MSN, 34648 Deltaport Monitoring\GIS\Fig_CrestProtectionSites.mxd

Figure 2

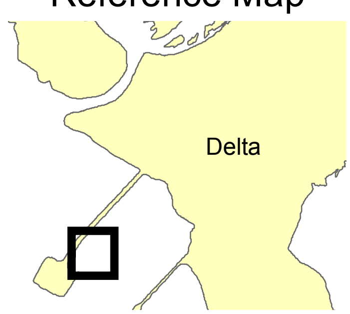


Legend

- Wave Sensor
- Turbidity Sensor 2

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Instrumentation Site Location Map

Scale - 1:7,500

100 50 0 100 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	March 2014

CM, 34648 Deltaport Monitoring\GIS\Fig_AllInstrumentSites.mxd

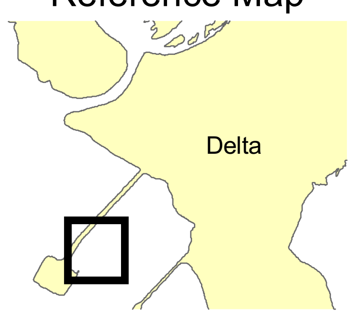
Figure 3

Legend

● Existing DOD Rod

Note:
- July 29, 2011 orthophoto image courtesy of VFPA.

Reference Map



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Depth of Disturbance Rods Location Map

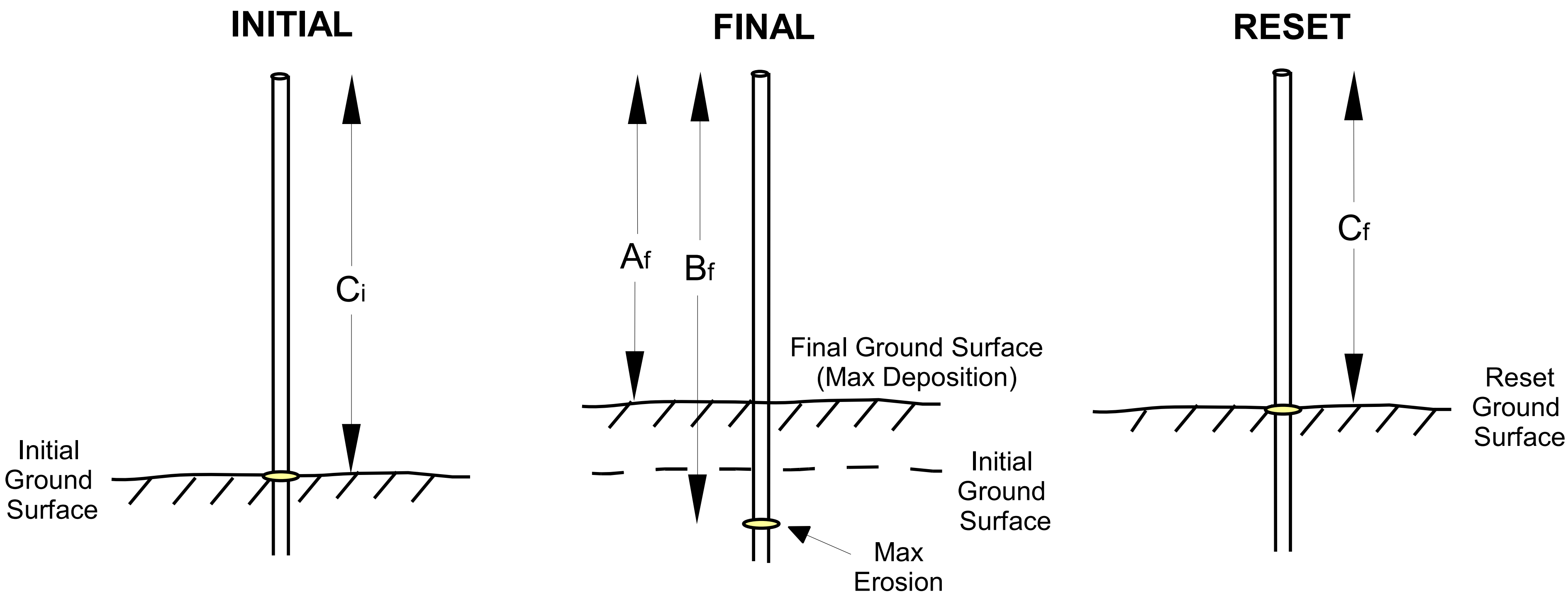
Scale - 1:10,000

100 50 0 100 200 300 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	March 2014

PGH, 34648 Deltaport Monitoring\GIS\Fig_DepthOfDisturbanceSites.mxd

Figure 4



A = Height Above Ground
B = Height Above Washer
C = Reset: Height Above Ground/Washer

Deposition = $B_f - A_f$
Erosion = $B_f - C_i$ (if $B_f - C_i < 0$, then $B_f - C_i$ set to 0 to remove error)
Net Change = Deposition – Erosion

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Bed Level Change Computations at Depth of Disturbance Rods

northwest hydraulic consultants | project no. 3-4648 | March 2014

Figure 5

UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

Note: DP8 & DP9 are only monitored in Q1.

HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

SURFACE WATER, SEDIMENT & BENTHIC INVERTEBRATE MONITORING STATIONS

PROJECT No. 499-002.24 | March 2014 | FIGURE 6

LEGEND

✳ Water Quality Sampling Station

SCALE 1:5,000 (metres)
0 100 200

HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

DETAILED LOCATION OF SAMPLE DP01

PROJECT No.		
499-002.24	March 2014	FIGURE 7

REFERENCE DRAWINGS

ŏ Base Map Information Provided by Triton Consultants Ltd., dated Sept 2004.

ŏ Envirowest Environmental Consultants Figure 'Appendix A', dated Nov. 1, 2004.

HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

EELGRASS STATION REFERENCE LOCATIONS (DELTAPORT AREA)

PROJECT No.		
499-002.24	March 2014	FIGURE 8

LEGEND

◆ Eelgrass Sampling Station (UTM Coordinates Shown)

Note: The shallow and deep station are each approximately 10 metres away from the mid station.

HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

EELGRASS REFERENCE STATION LOCATION (BOUNDARY BAY AREA)

PROJECT No.		
499-002.24	March 2014	FIGURE 9

Legend

100	Contour Line Label	
●	Species Specific (GBHE & BRAN) "windshield" survey locations	

Common Name
GBHE
Great Blue Heron
BRAN
Brant

1:25,000

900 450 0 900 Meters

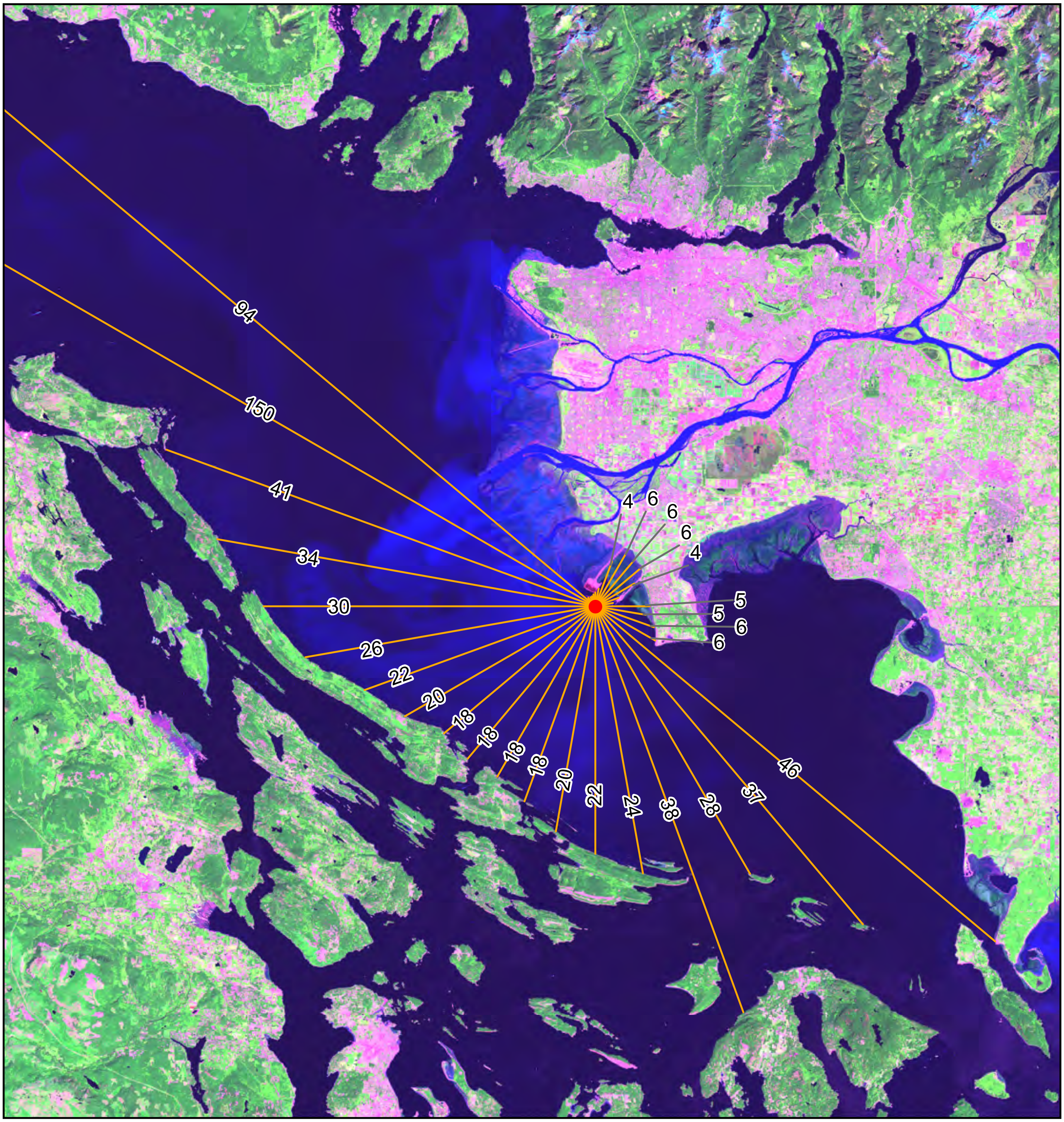
HEMMERA

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

BIRD SURVEY TRANSECT LOCATIONS

PROJECT NO: 499-002.24 | March 2014 | FIGURE 10



Legend

Reference Point

Fetch Lengths at 10˚ intervals (km)

Note:
- July 30, 2000 Landsat composite image courtesy of Geogratis.

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Fetch Lengths at Deltaport

Scale - 1:500,000

10 5 0 10 Kilometres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
northwest hydraulic consultants	project no. 3-4648	March 2014

PGH/MSN, 34648 Deltaport Monitoring\GIS\Fig_FetchLength.mxd

Figure 11

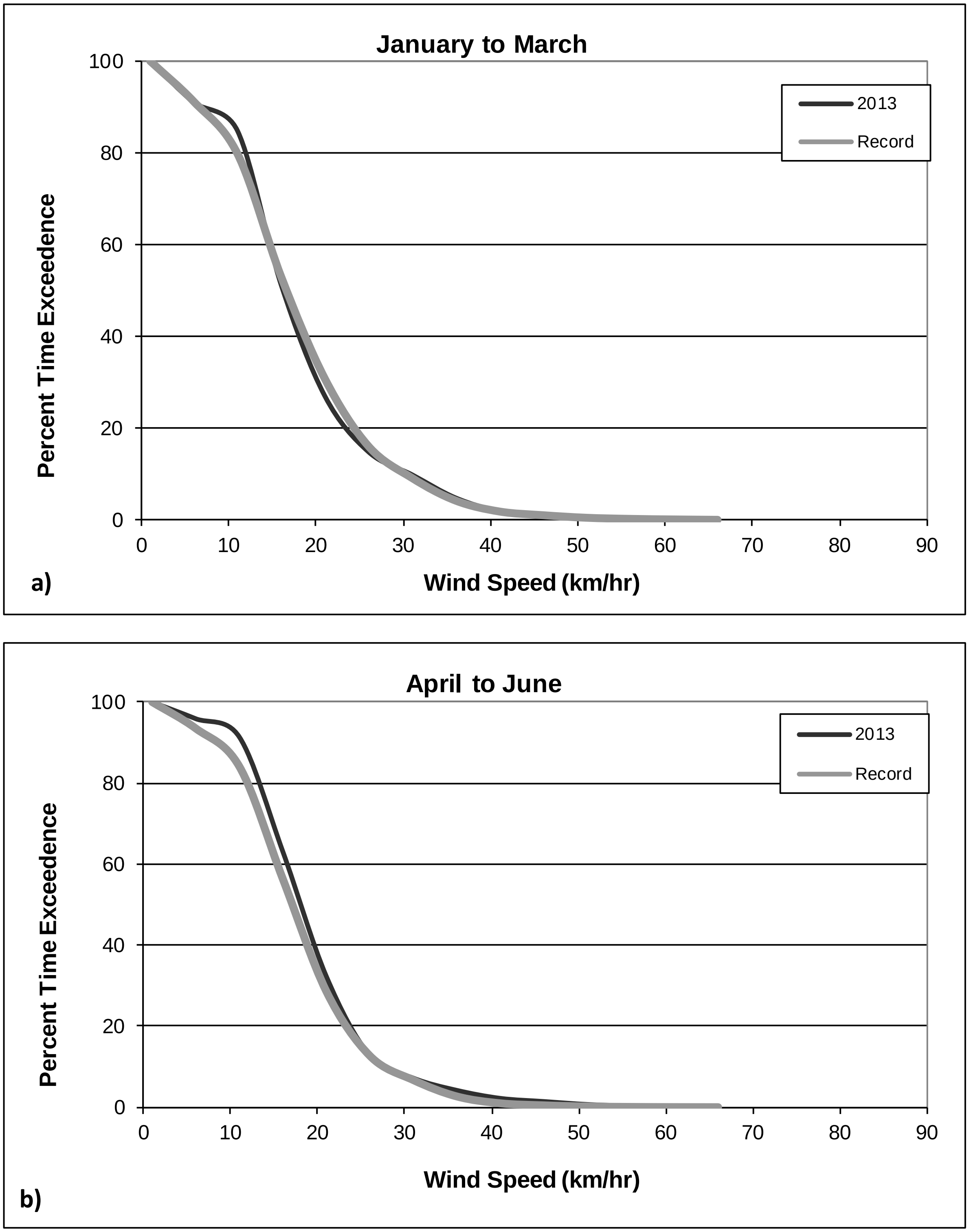


Figure 12. Summary of hourly wind speed measured at Vancouver International Airport for the period a) January to March, and b) April to June.

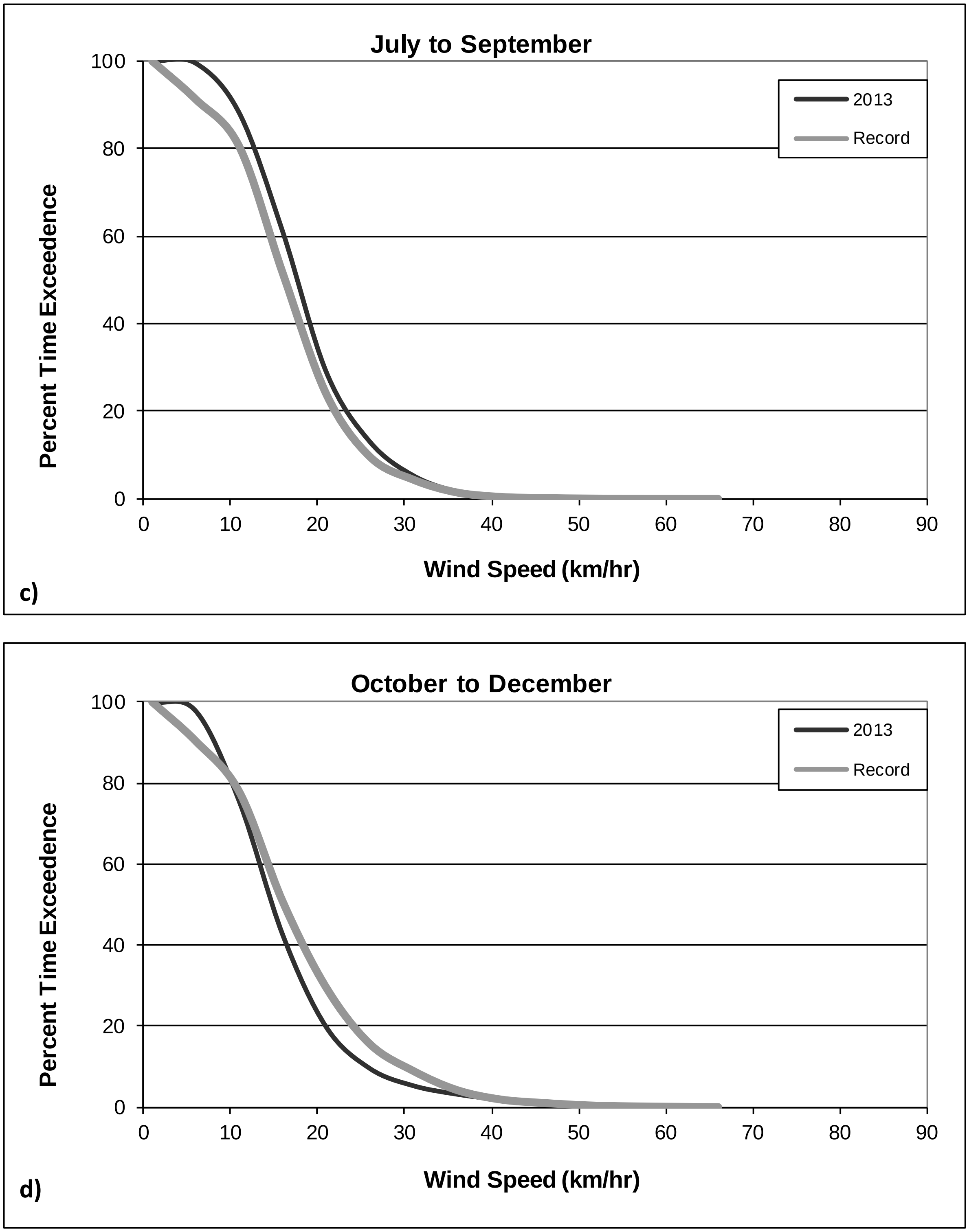
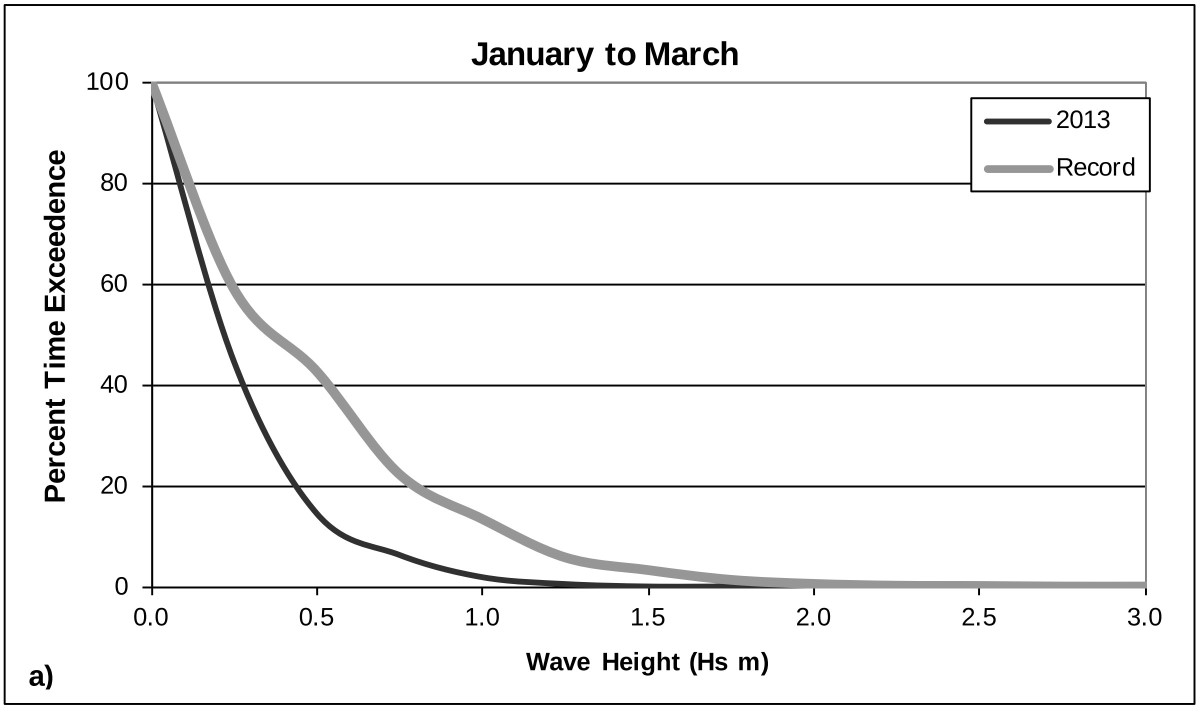


Figure 12. Summary of hourly wind speed measured at Vancouver International Airport for the period c) July to September and d) October to December.



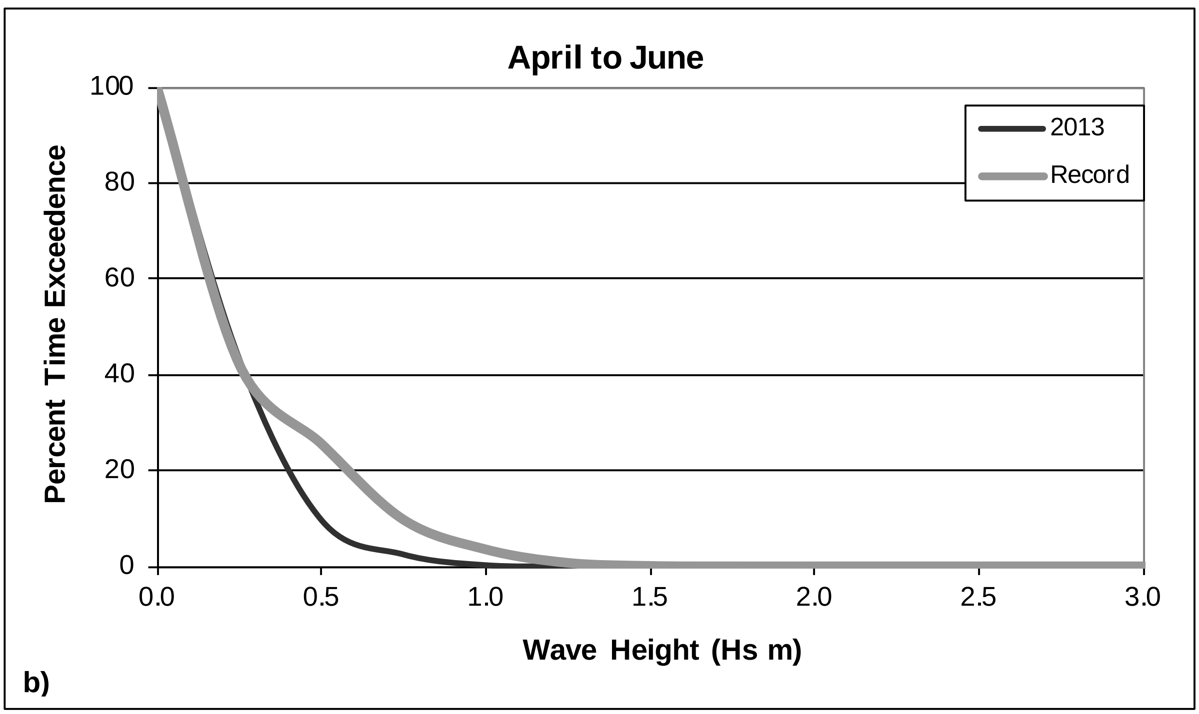


Figure 13. Summary of wave data from Station #46146 (Halibut Bank) for the period a) January to March, and b) April to June.

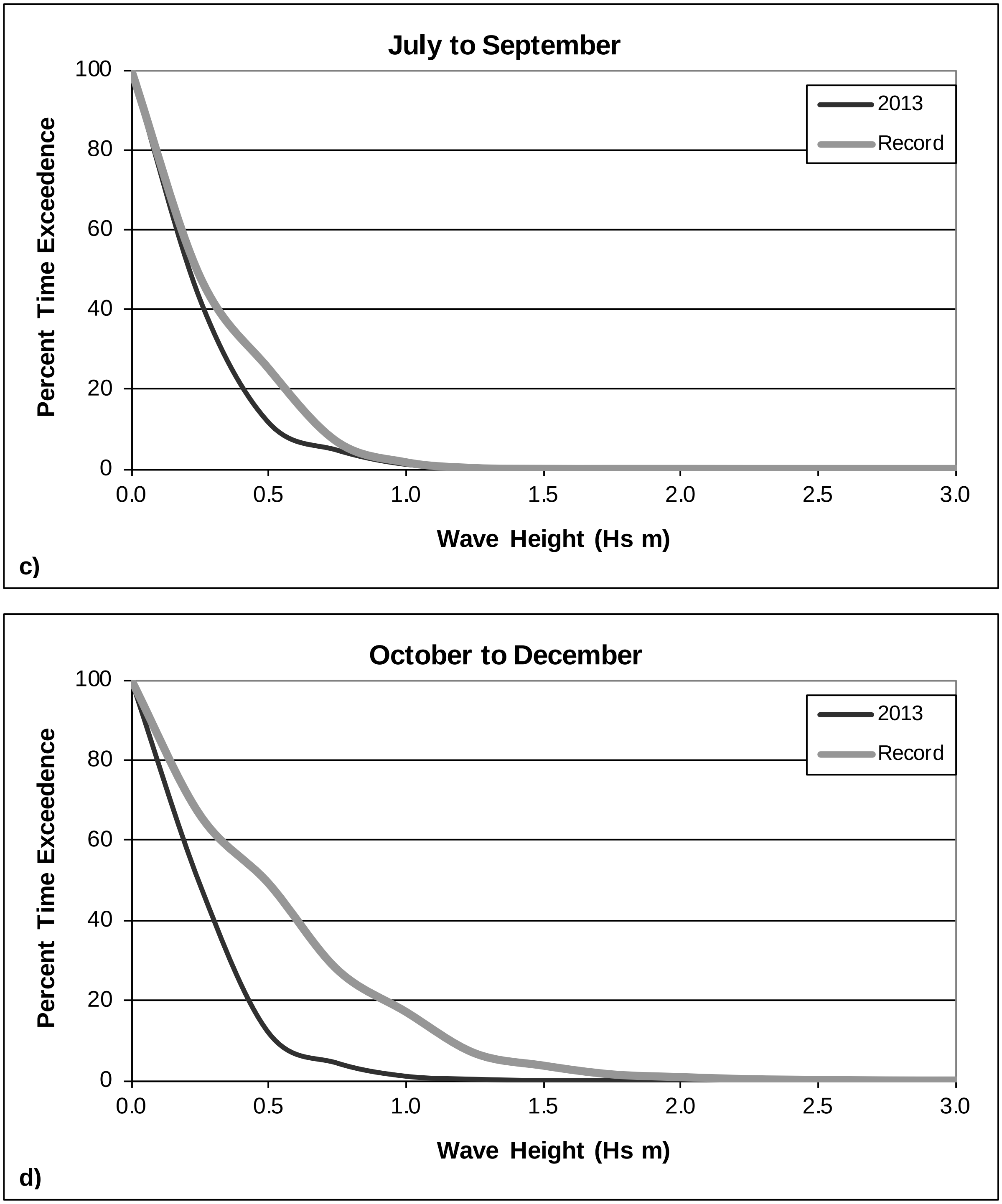


Figure 13. Summary of wave data from Station #46146 (Halibut Bank) for the period c) July to September, and b) October to December.

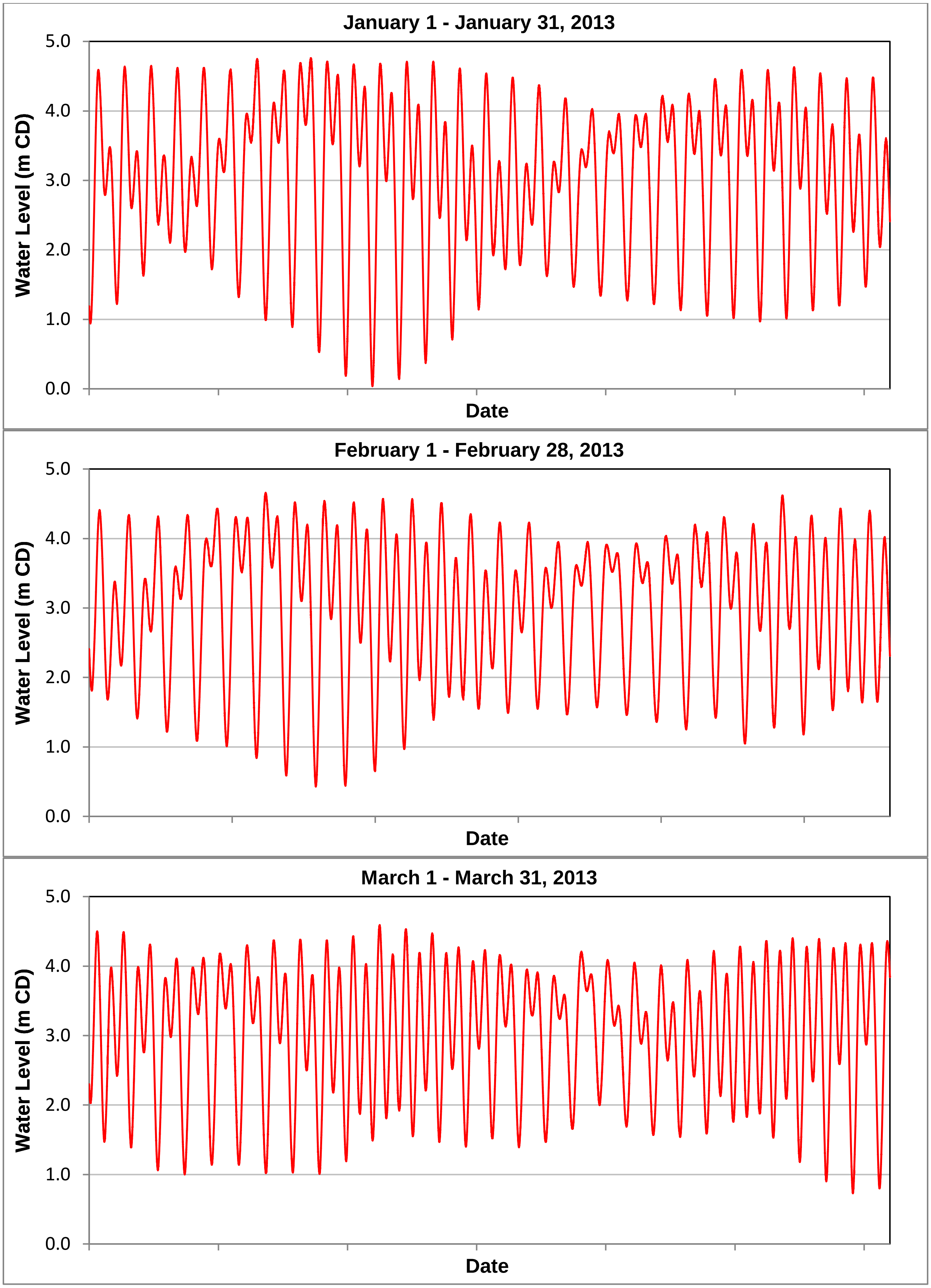


Figure 14. Observed Tide Levels at Point Atkinson, January to March 2013.

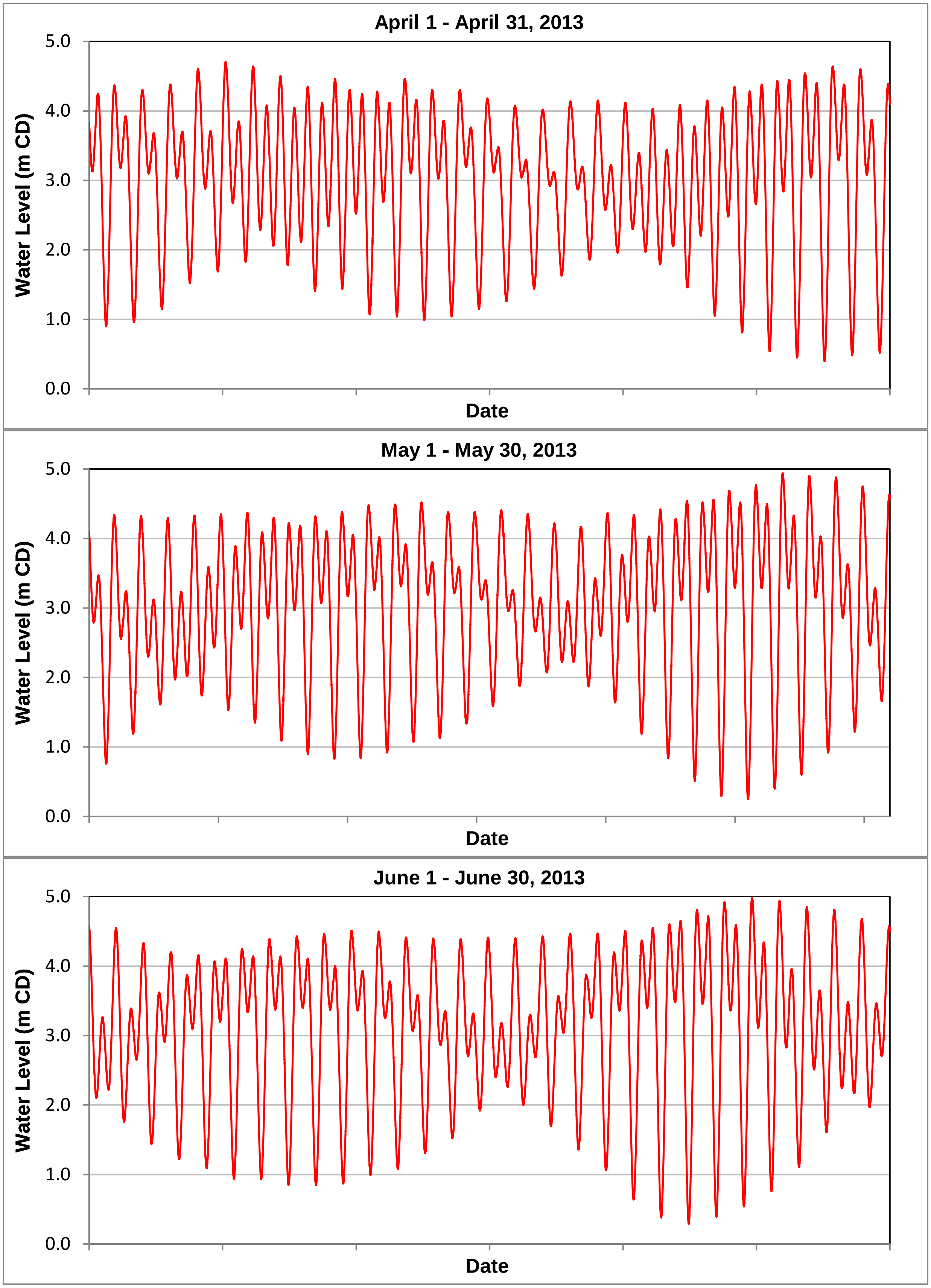


Figure 15. Observed Tide Levels at Point Atkinson, April to June 2013.

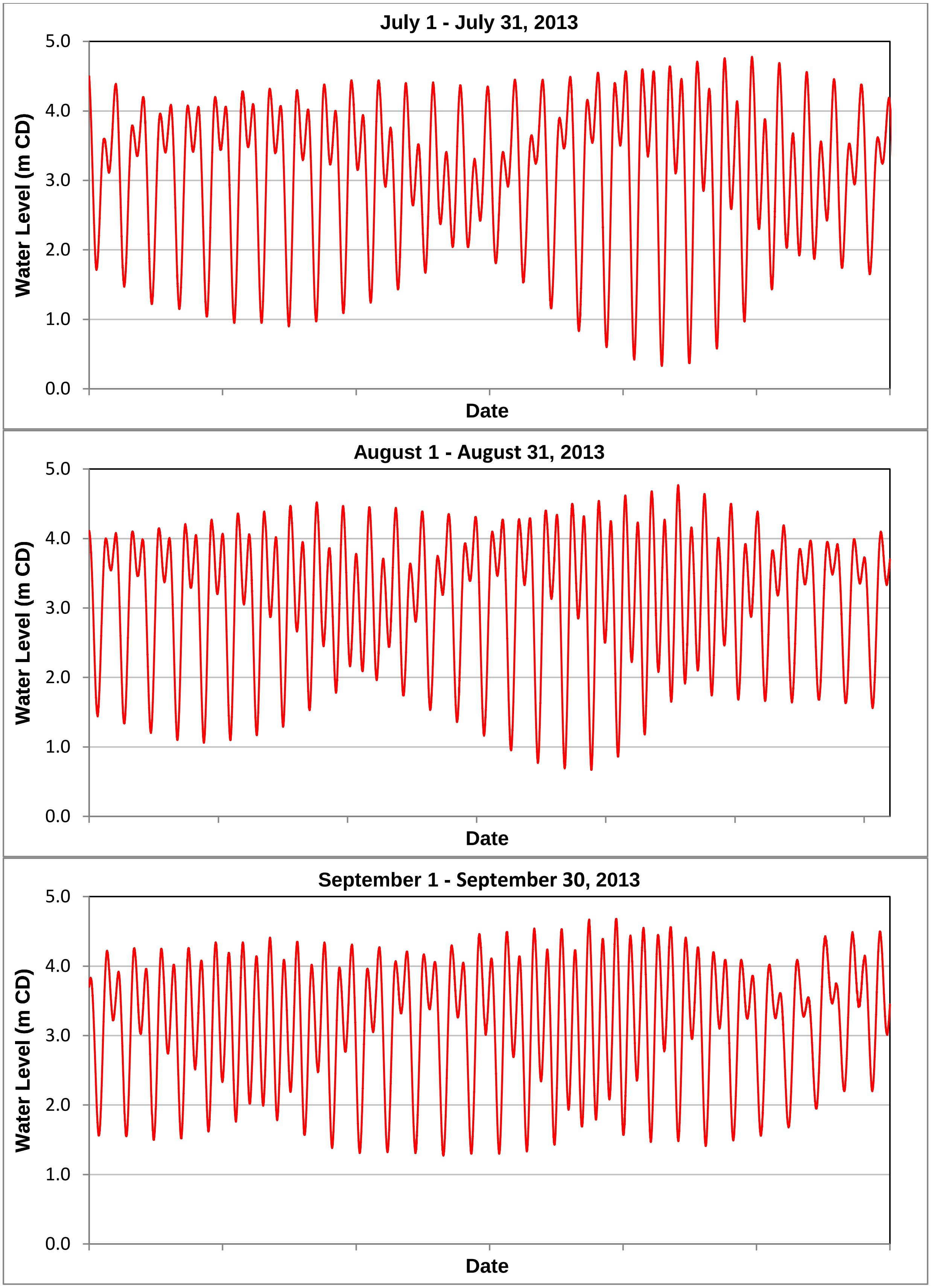


Figure 16. Observed Tide Levels at Point Atkinson, July to September 2013.

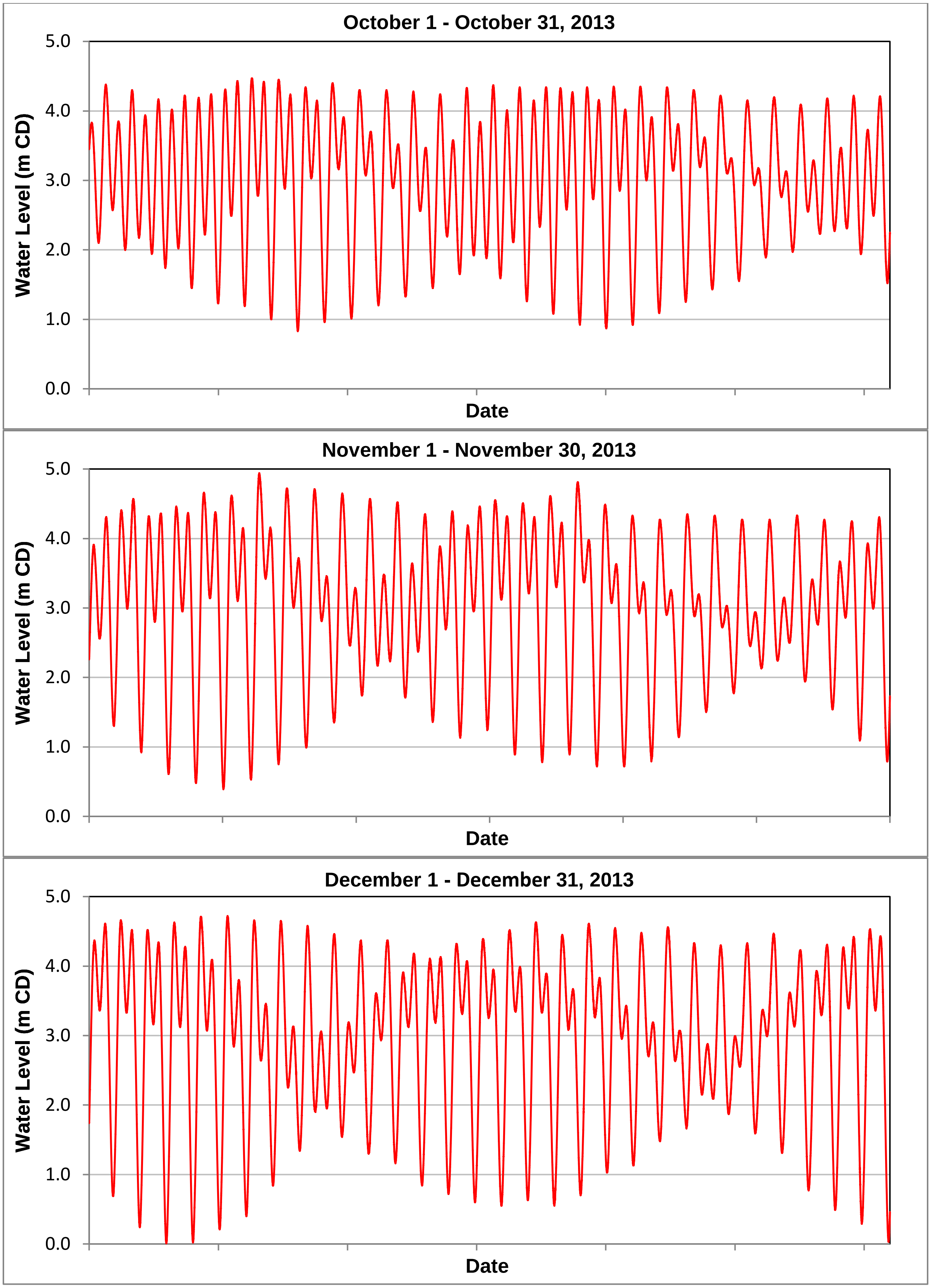


Figure 17. Observed Tide Levels at Point Atkinson, October to December 2013.

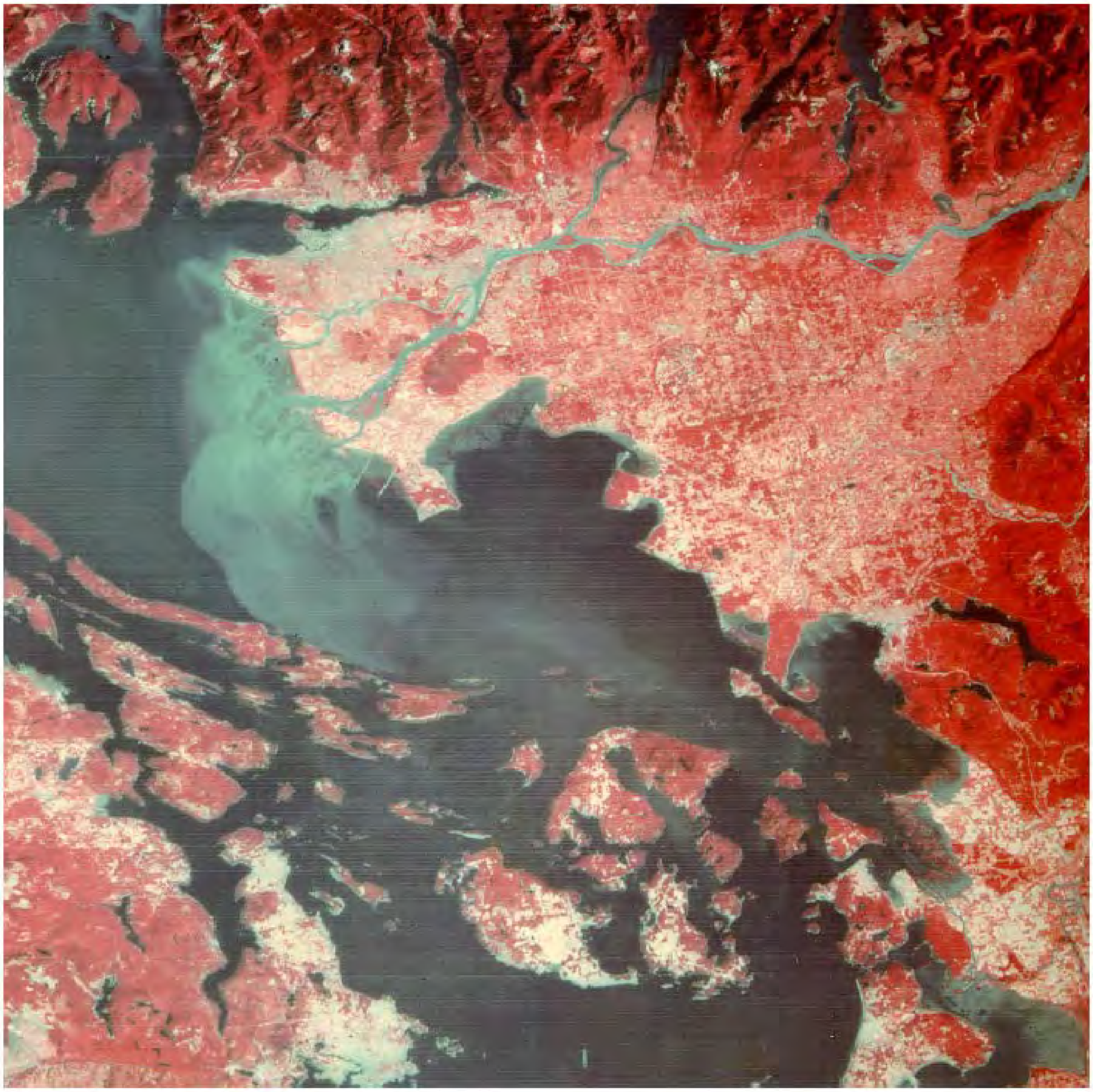


Figure 18. Fraser River Plume deflected by Roberts Bank Causeway during Ebb Tide (image 1982 Colour IR).

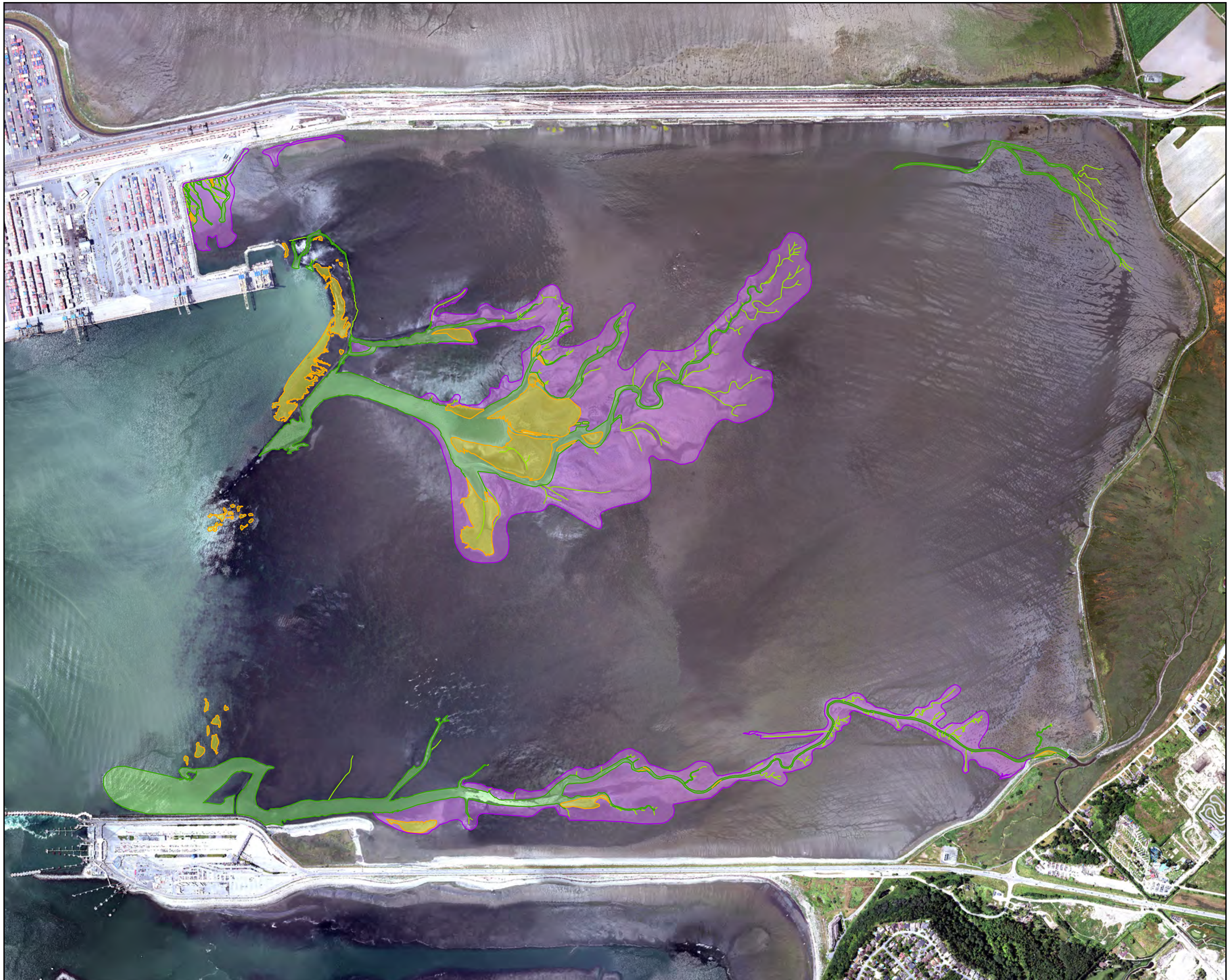
DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

2013 Orthophoto Interpretation

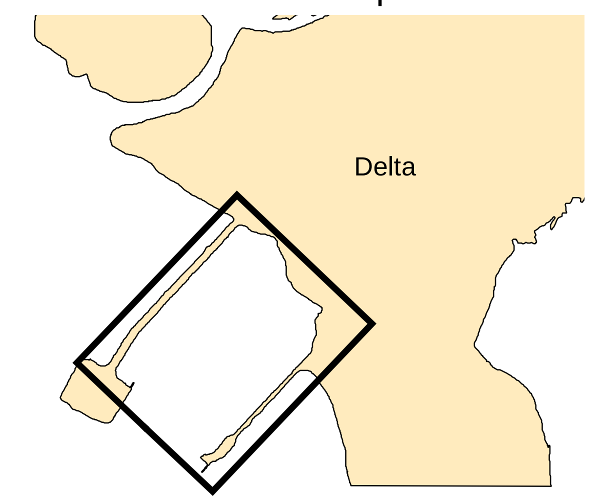
Scale - 1:15,000

0 200 400 600 800 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	February 2014



Reference Map



Legend

2013 Channel Mapping

- BAR
- ACTIVE CHANNEL ZONE
- WIDE CHANNEL
- NARROW CHANNEL
- BAR
- CHANNEL
- ACTIVE CHANNEL ZONE

Note:
- July 23, 2013 orthophoto supplied by VFPA.

\\192.168.100.12\Projects\Projects\34648 DP3 AMS\GIS\2013_Fig_Mapping\2013_pgh.mxd

Figure 19

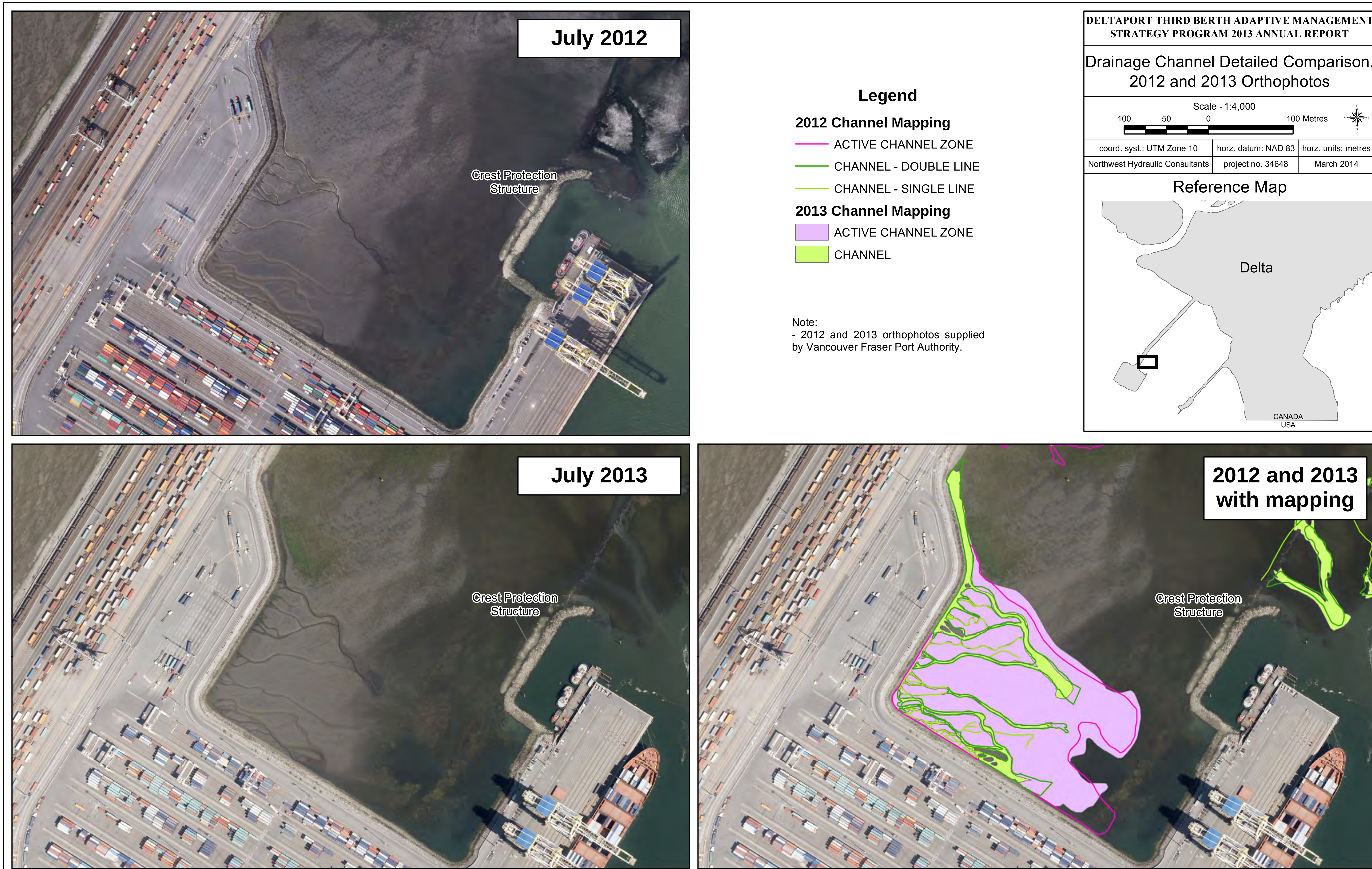
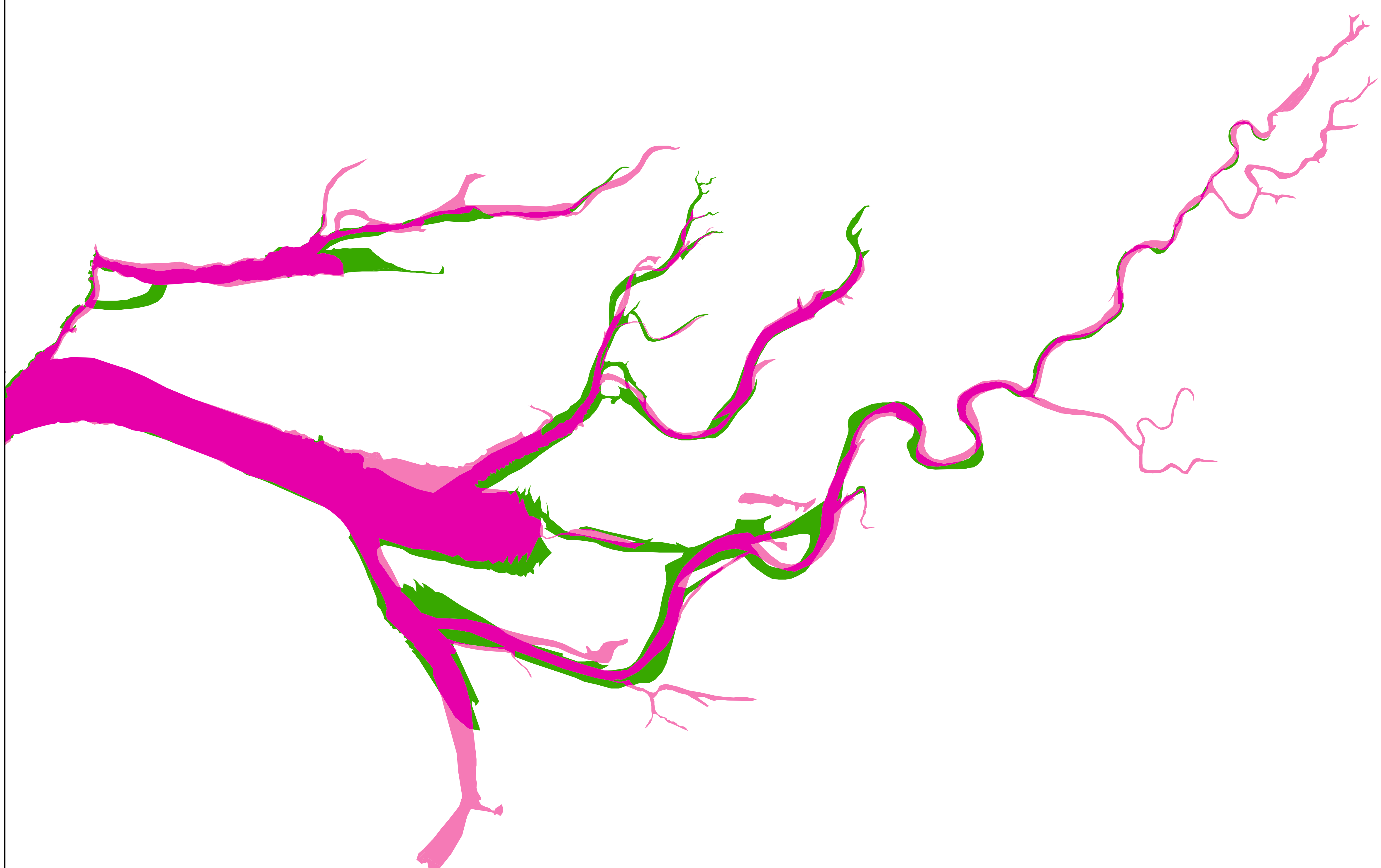

July 2012
Crest Protection Structure
July 2013
Crest Protection Structure
2012 and 2013 with mapping
Crest Protection Structure
Legend
2012 Channel Mapping
ACTIVE CHANNEL ZONE
CHANNEL - DOUBLE LINE
CHANNEL - SINGLE LINE
2013 Channel Mapping
ACTIVE CHANNEL ZONE
CHANNEL
Note:
- 2012 and 2013 orthophotos supplied by Vancouver Fraser Port Authority.
DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT
Drainage Channel Detailed Comparison, 2012 and 2013 Orthophotos
Scale - 1:4,000
100 50 0 100 Metres
coord. syst.: UTM Zone 10
horz. datum: NAD 83
horz. units: metres
Northwest Hydraulic Consultants
project no. 34648
March 2014
Reference Map
Delta
CANADA
USA
JXD, \\mainfile.nhc-van.com\Projects\Projects\34648 DP3 AMS\GIS\Fig_New2013Channels.mxd

Figure 20



DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

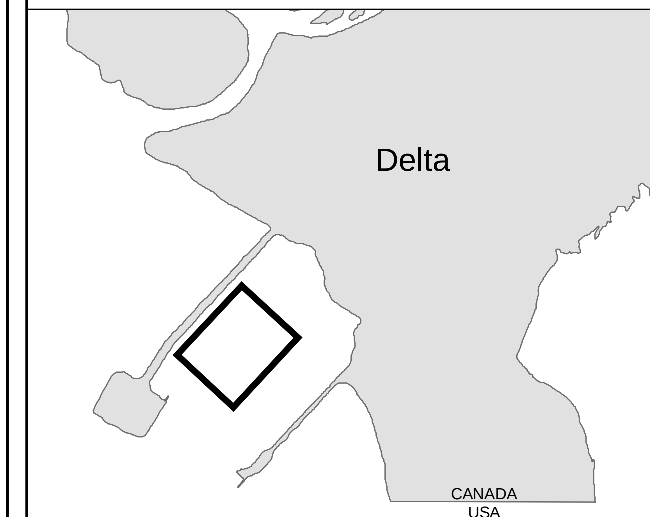
Mapped Channel Changes Based on 2012 and 2013 Orthophotos

Scale - 1:6,000

100 50 0 100 200 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	Jan 2014

Reference Map



Legend

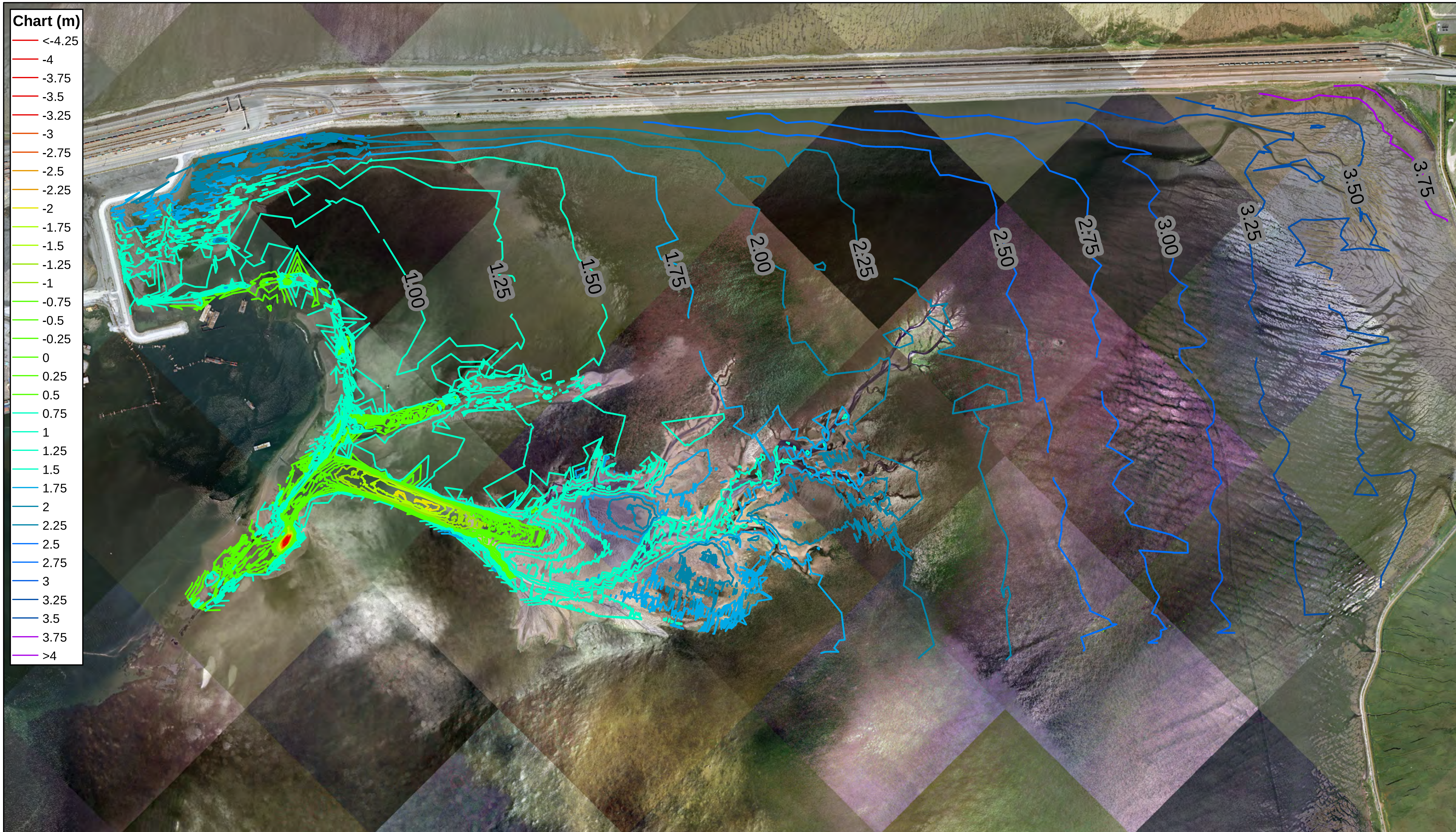
2012 to 2013

- channel in 2012 (not in 2013)
- channel in 2012 and 2013 (no change)
- channel in 2013 (not in 2012)

Note:
- Variation in conditions such as tide level, vegetation growth and water clarity may influence the accuracy of change mapping between 2012 and 2013.

JXD,\\192.168.100.12\Projects\Projects\34648 DP3 AMS\GIS\2013_Fig_Mapping2013Comp2012.mxd

Figure 21



HEMMERA

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

nhc
northwest hydraulic consultants

DATA SOURCES: JULY, 2007 ORTHOPHOTO SUPPLIED BY VFPA

SCALE - 1:10,000

0 50 100 200 300 400 Meters

N

Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

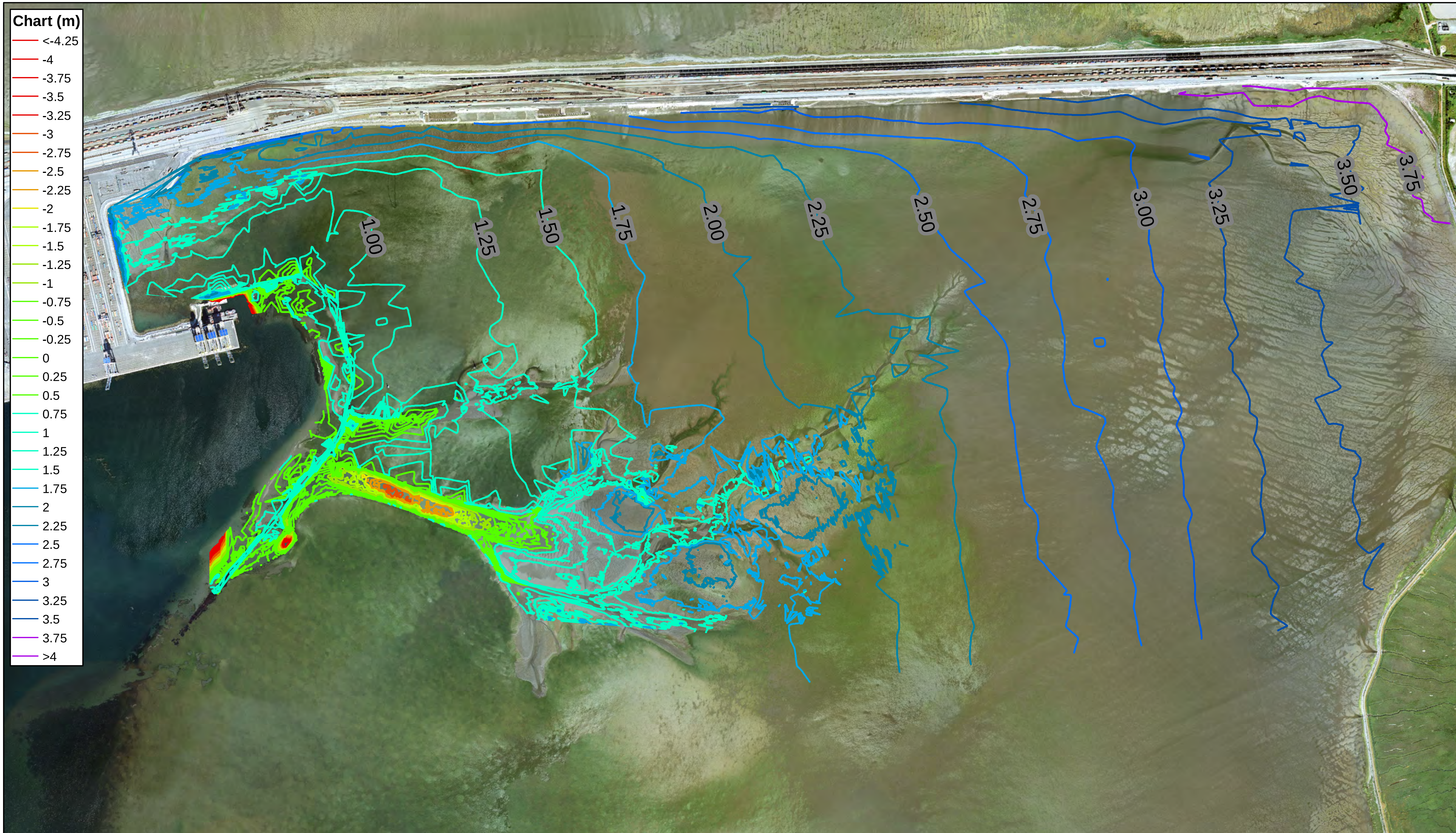
Job: 34648 | Date: 18-MAR-2014

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

2007 COASTAL MAPPING

FIGURE 22

JXD, \\mainfile.nhc-van.com\Projects\Projects\34648 DP3 AMS\Meetings\Consultants-SAC 2014 Jan\contour\MXDs\CoastalMappingContours_PGH_2007_Ver10.mxd



HEMMERA

nhc northwest hydraulic consultants

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

DATA SOURCES: JULY, 2010 ORTHOPHOTO SUPPLIED BY VFPA

SCALE - 1:10,000

0 50 100 200 300 400 Meters

N

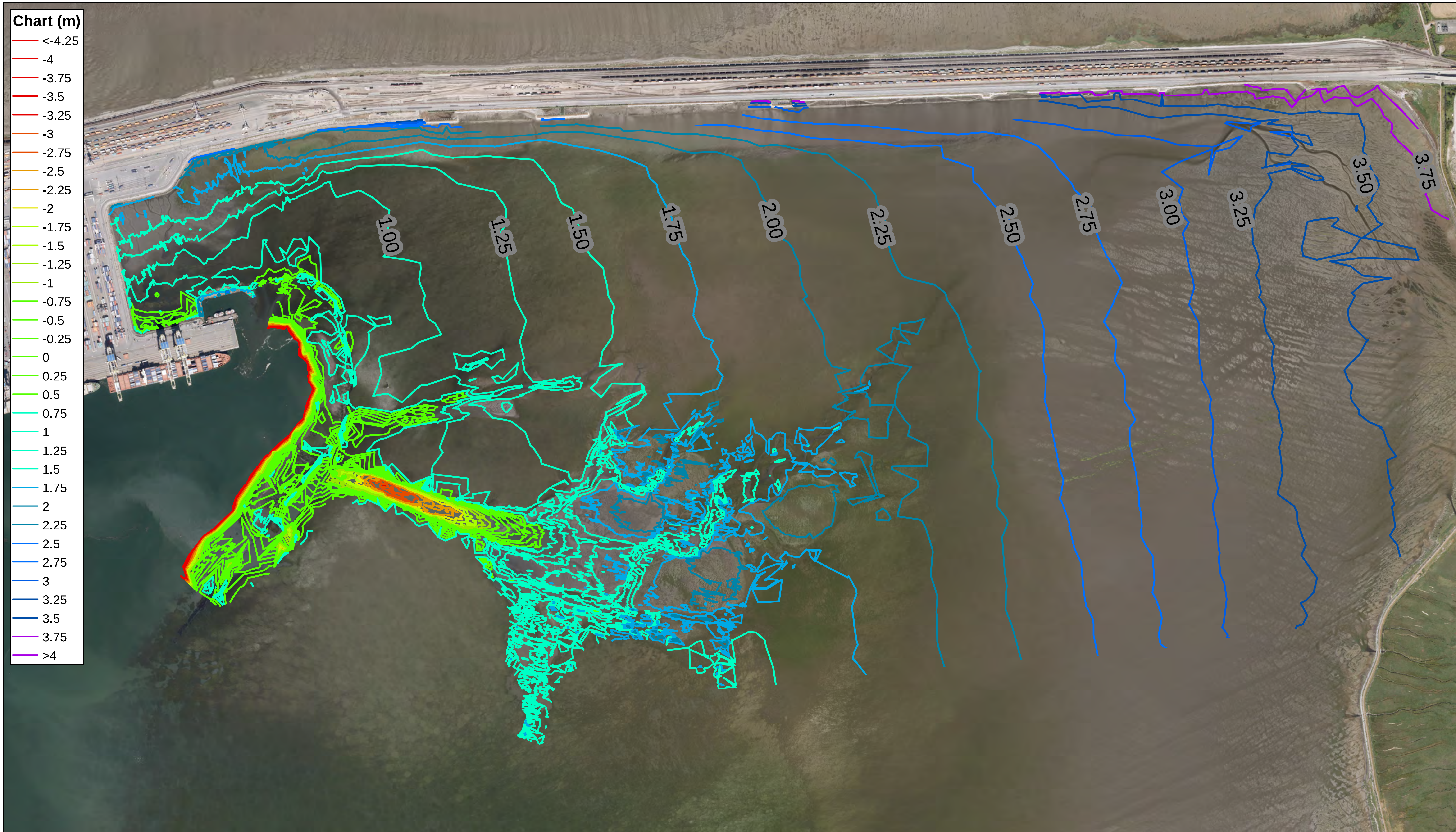
Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

Job: 34648 | *Date: 18-MAR-2014*

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

2010 COASTAL MAPPING

FIGURE 23



HEMMERA

nhc northwest hydraulic consultants

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

DATA SOURCES: JULY 23, 2013 ORTHOPHOTO SUPPLIED BY VFPA

SCALE - 1:10,000

0 50 100 200 300 400 Meters

N

Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

Job: 34648 *Date: 18-MAR-2014*

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM
2013 ANNUAL REPORT
2013 COASTAL MAPPING

FIGURE 24

HEMMERA

nhc northwest hydraulic consultants

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

DATA SOURCES: JULY 23, 2013 ORTHOPHOTO SUPPLIED BY VFPA

SCALE - 1:10,000

0 50 100 200 300 400 Meters

N

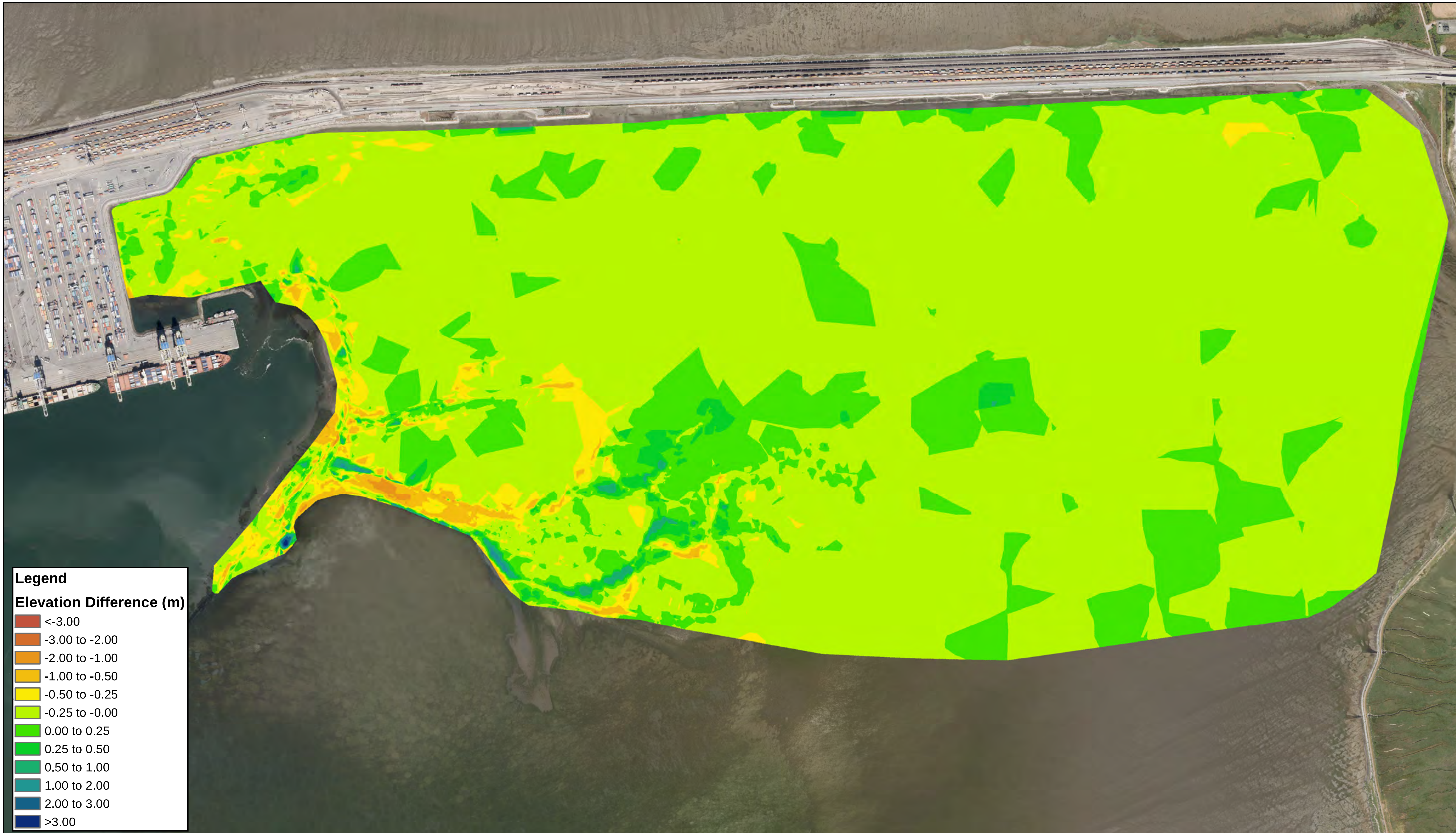
Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

Job: 34648 *Date: 18-MAR-2014*

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM
COASTAL MAPPING:
COMPARISON SURFACE 2013-2010

FIGURE 25

JXD, \\vrainfile.nhc-van.com\Projects\34648 DP3 AMS\GIS\CoastalMapping_ComparisonSurface2013-2010_JXD.mxd



HEMMERA

nhc northwest hydraulic consultants

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

DATA SOURCES: JULY 23, 2013 ORTHOPHOTO SUPPLIED BY VFPA

SCALE - 1:10,000

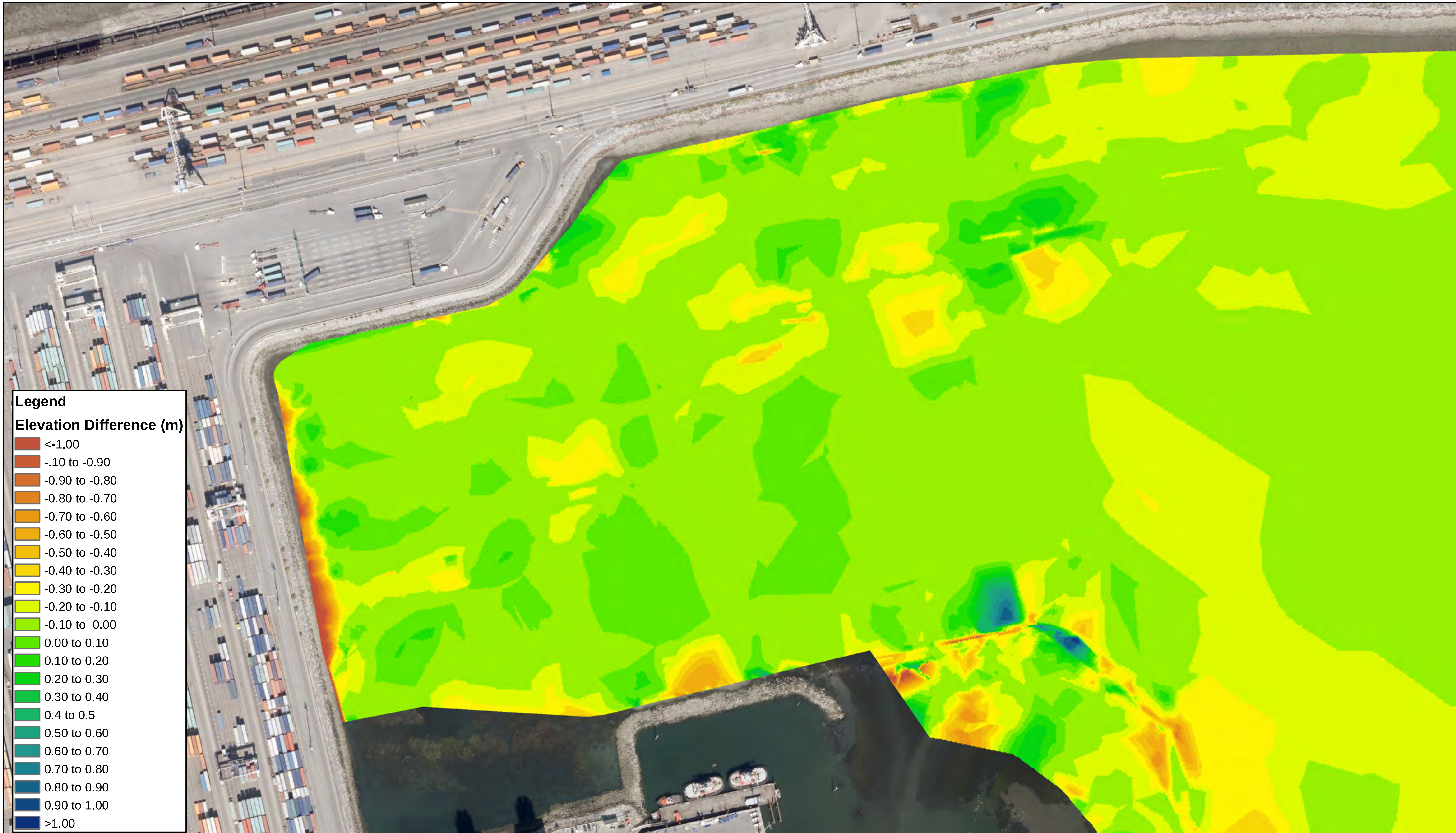
Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

Job: 34648 *Date: 18-MAR-2014*

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM
COASTAL MAPPING:
COMPARISON SURFACE 2013-2007

FIGURE 26

JXD, \\mainfile.nhc-van.com\Projects\Projects\34648 DP3 AMS\GIS\CoastalMapping_ComparisonSurface2013-2007_JXD.mxd



HEMMERA

nhc northwest hydraulic consultants

HEMMERA Envirochem Inc.
250 - 1380 Burrard Street
Vancouver, B.C. V6Z 2H3

DATA SOURCES: JULY 23, 2013 ORTHOPHOTO SUPPLIED BY VFPA

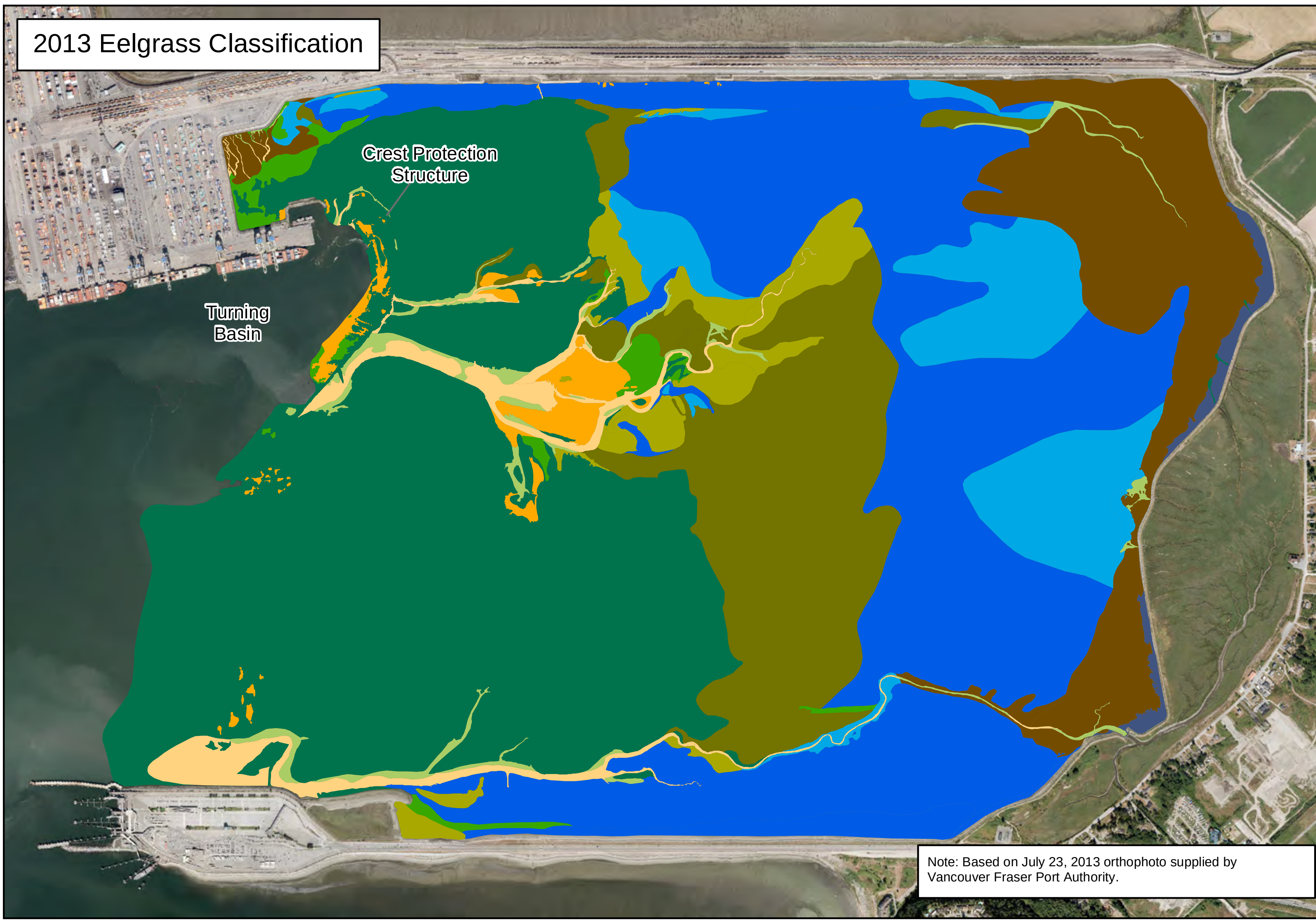
Coordinate System: NAD 1983 UTM ZONE 10N
Units: METERS

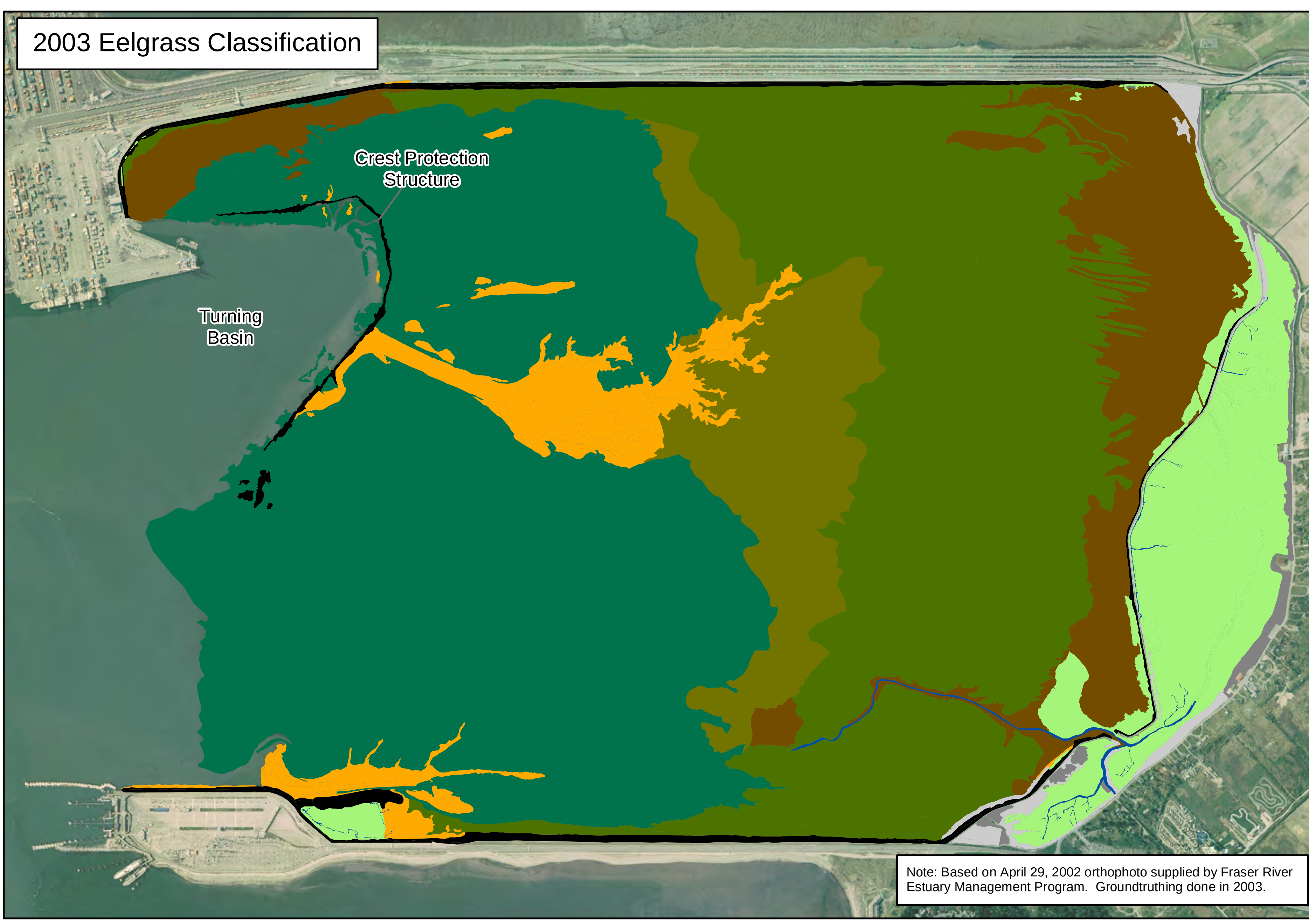
Job: 34648 | *Date: 18-MAR-2014*

DELTAPORT THIRD BIRTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM
COASTAL MAPPING:
COMPARISON SURFACE 2013-2010
ZOOMED-IN VIEW

FIGURE 27

JXD, \\mainfile.nhc-van.com\Projects\Projects\34648 DP3 AMS\GIS\CoastalMapping_ComparisonSurface2013-2010_Zoomed_JXD.mxd





2013 Eelgrass Classification

- Zostera marina - continuous
- Zostera marina - patchy
- Zostera mix - continuous
- Zostera mix - patchy
- Zostera marina - channel
- Z. japonica - continuous
- Z. japonica - patchy
- Unvegetated channel
- Mudflats
- Sand
- Backshore

2003 Eelgrass Classification

- Z. marina
- Zostera mixed
- Z. japonica
- Marsh
- Rocky Habitat
- Channel
- Mud
- Sand
- Shrubs
- Grass

DELTAPORT THIRD BERTH ADAPTIVE MANAGEMENT STRATEGY PROGRAM 2013 ANNUAL REPORT

Eelgrass Classification 2003 and 2013

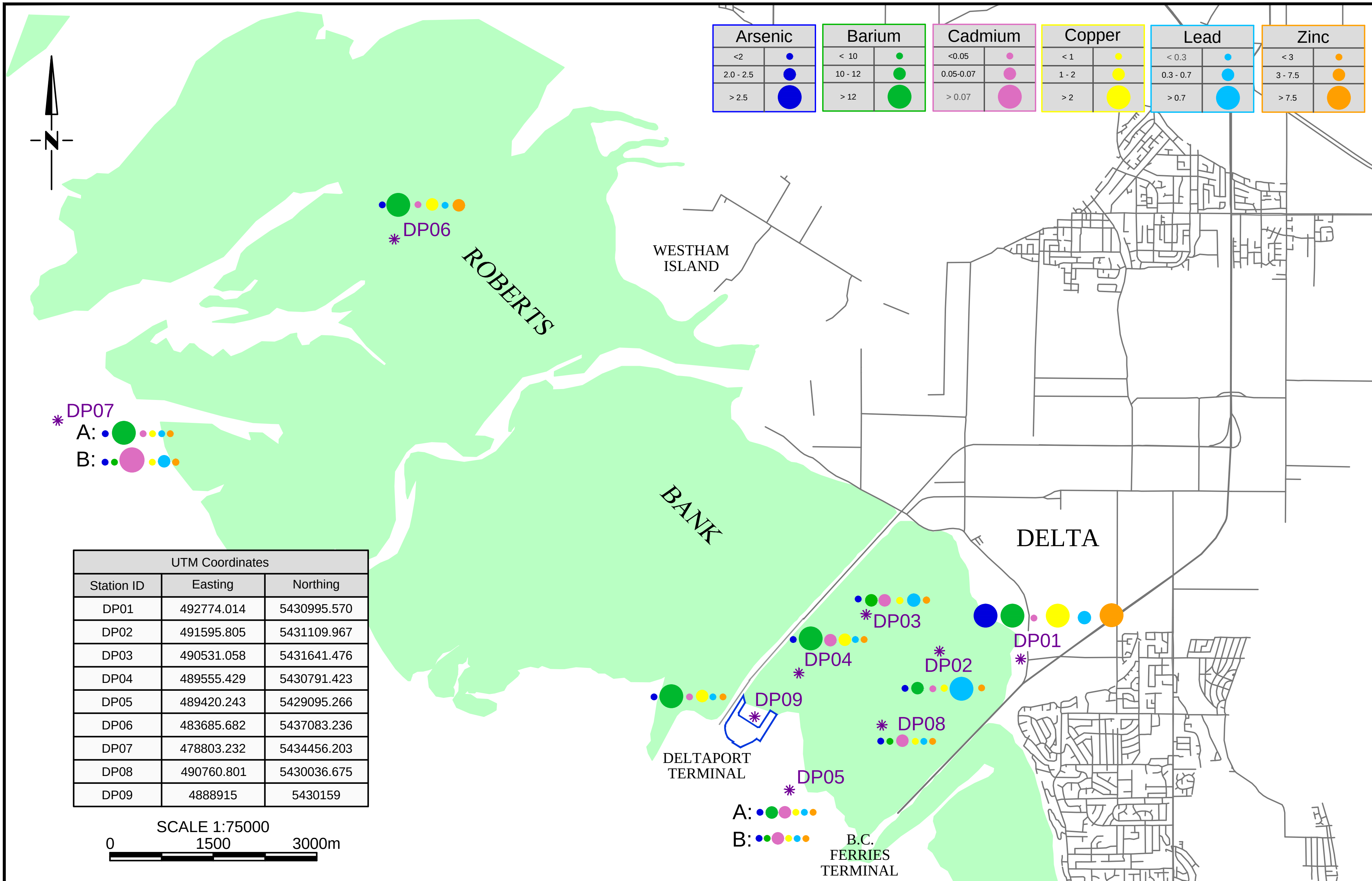
Scale - 1:20,000

500 250 0 500 Metres

coord. syst.: UTM Zone 10	horz. datum: NAD 83	horz. units: metres
Northwest Hydraulic Consultants	project no. 34648	Mar 2014

Figure 28

JXD, \\192.168.100.12\Projects\Projects\34648 DP3 AMS\GIS\EelgrassMapping\34648_JXD_FigEelgrass2013and2003.mxd



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
Water
Tidal Mud & Sand
✳ Sampling Station
A: Surface (Shallow) Station
B: Bottom (Deep) Station

Note: Units for all parameters are µg/L, unless otherwise noted.

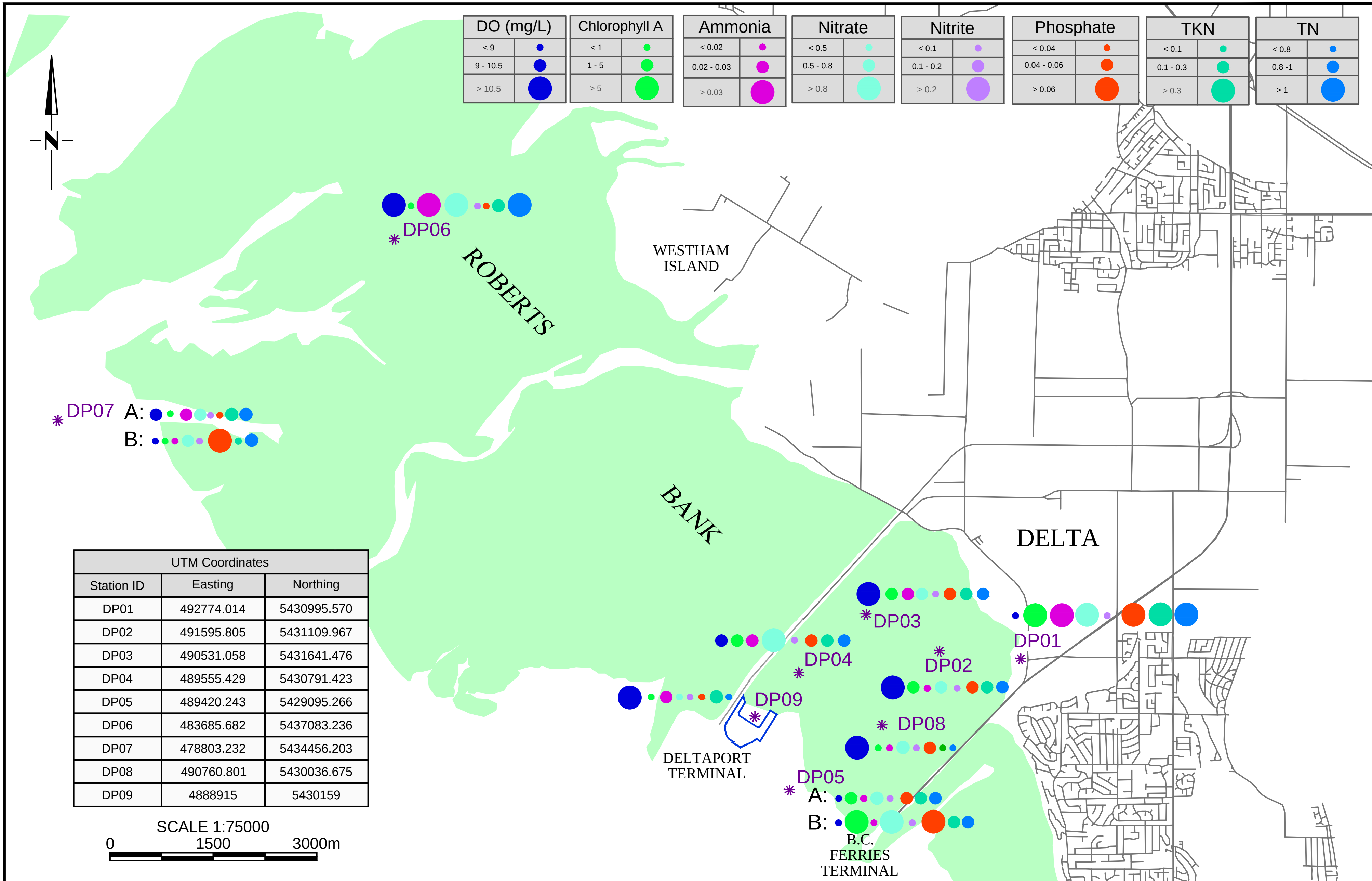
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

SPATIAL TRENDS OF METAL PARAMETERS IN SURFACE WATER (2013)

PROJECT No. 499-002.24	March 2014	FIGURE 29



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
- Water
- Tidal Mud & Sand
- ✳ Sampling Station
- A: Surface (Shallow) Station
- B: Bottom (Deep) Station

Note: Units for all parameters are µg/L, unless otherwise noted.

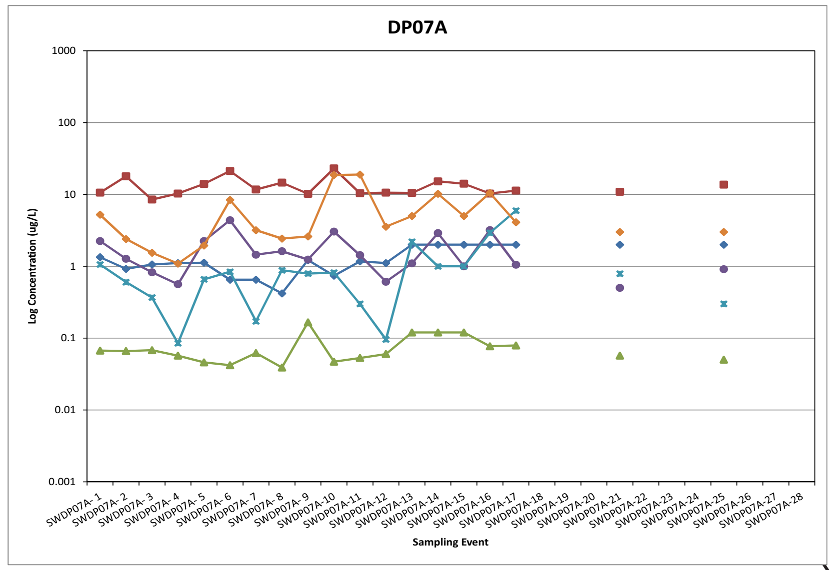
HEMMERA

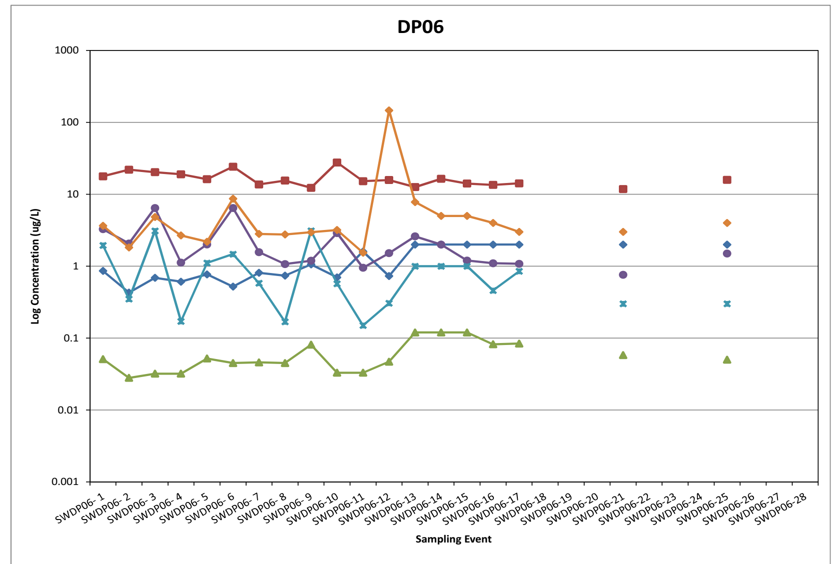
CLIENT: PORT METRO vancouver

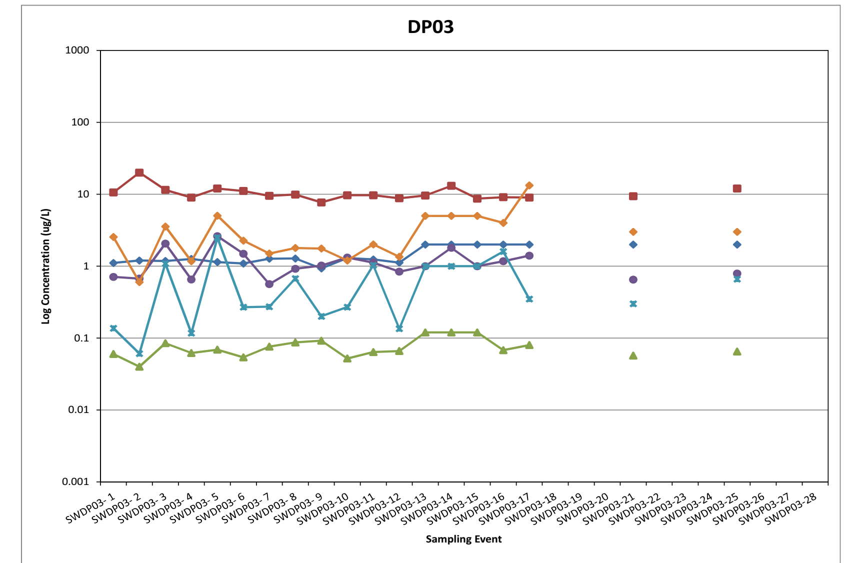
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

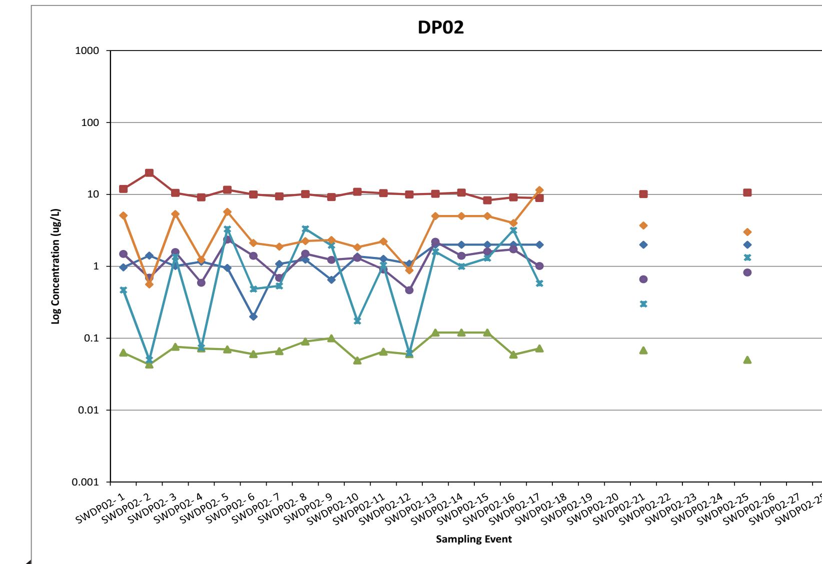
SPATIAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER (2013)

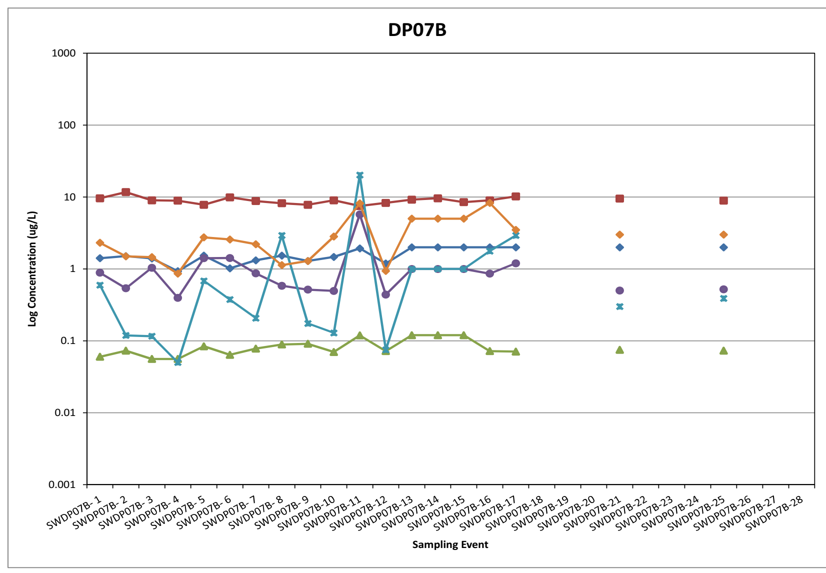
PROJECT No. 499-002.24 | March 2014 | FIGURE 30

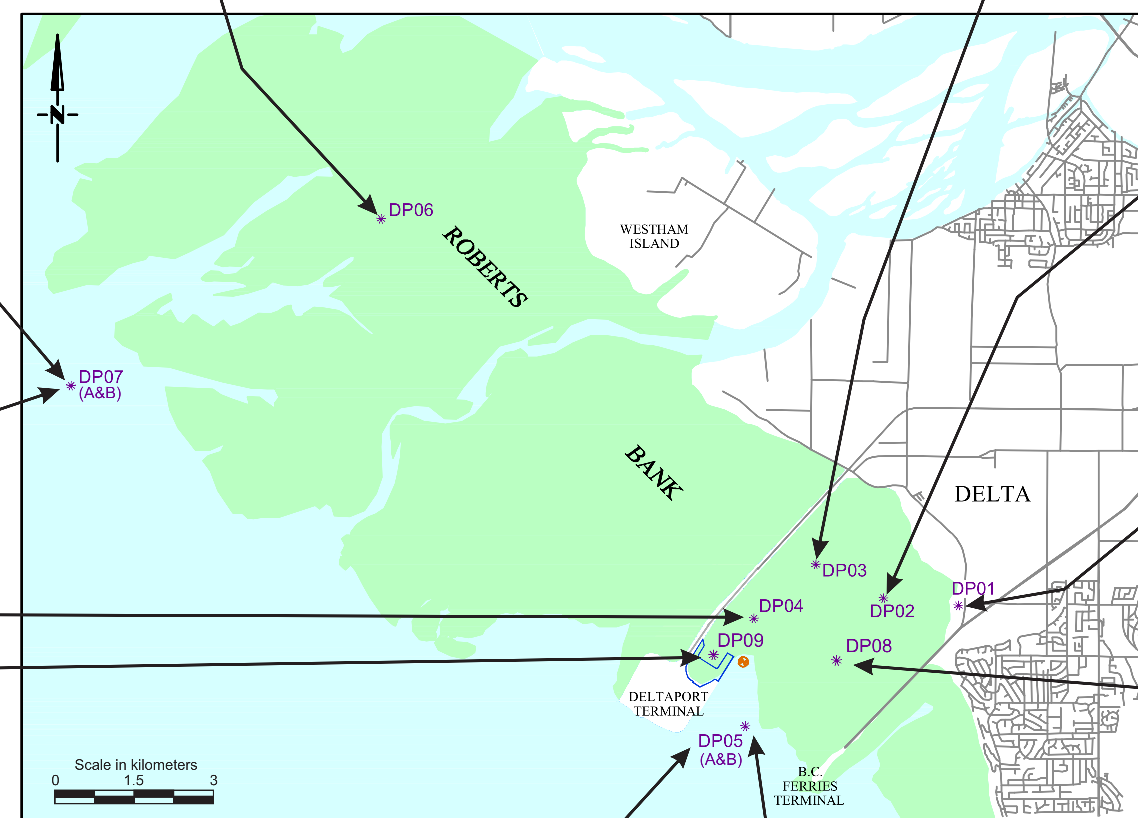


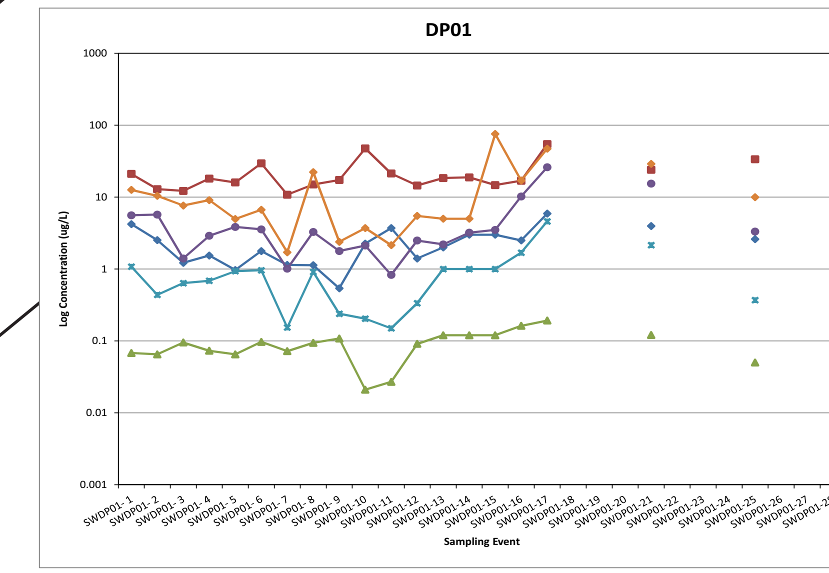


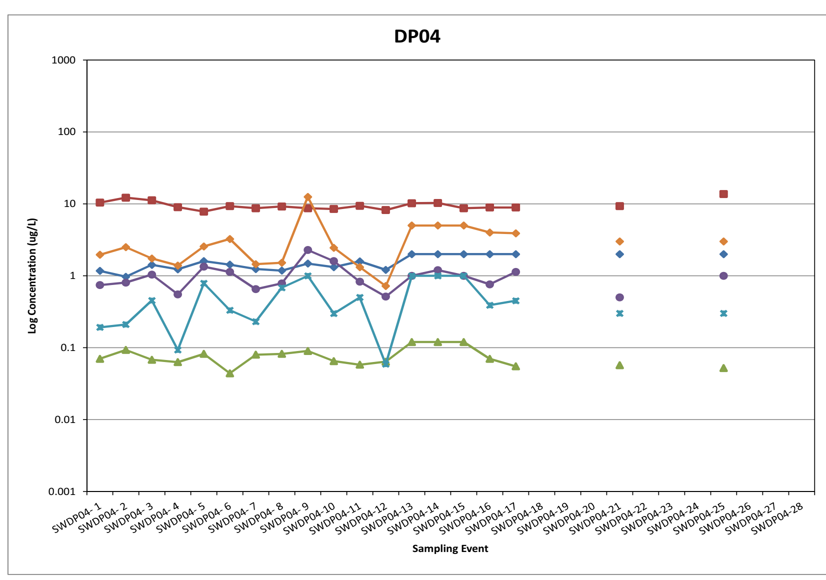


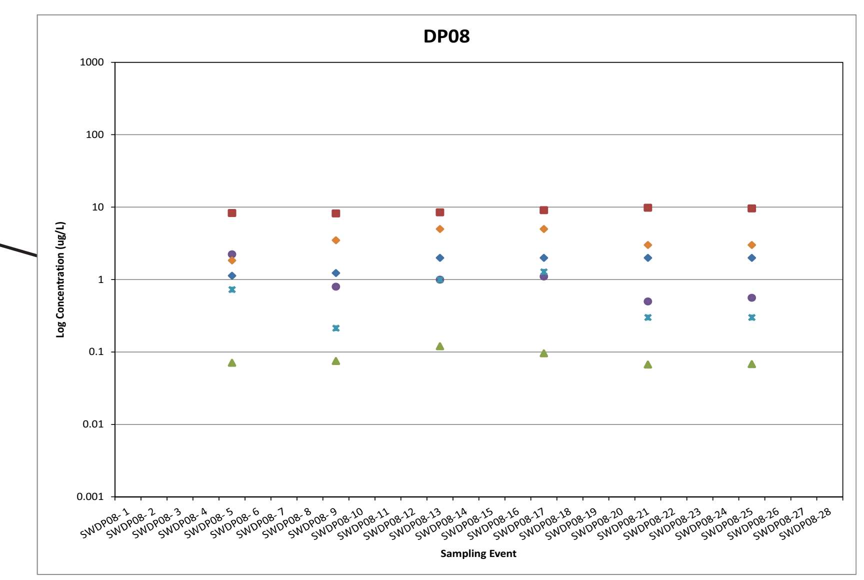


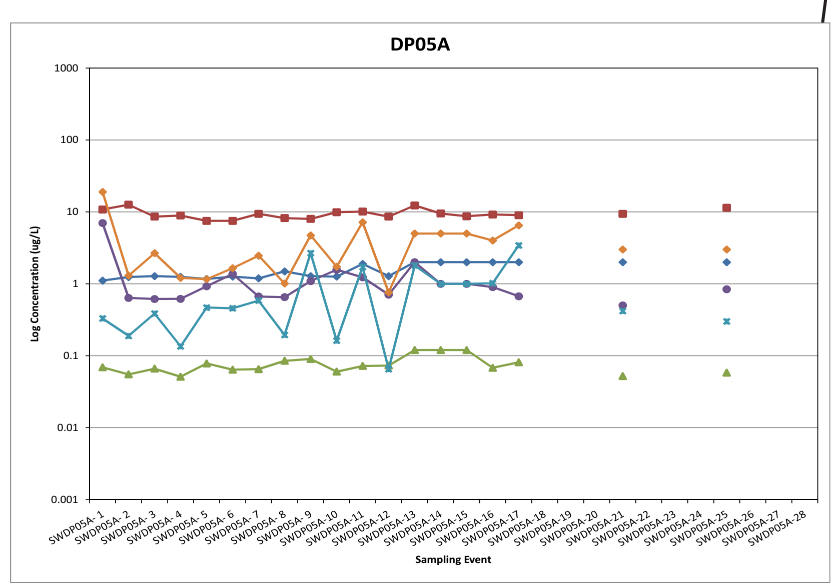


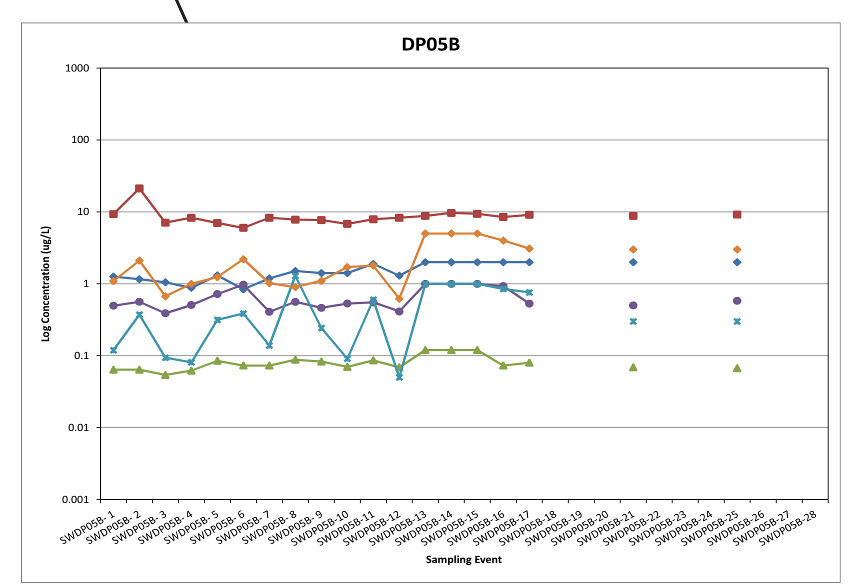


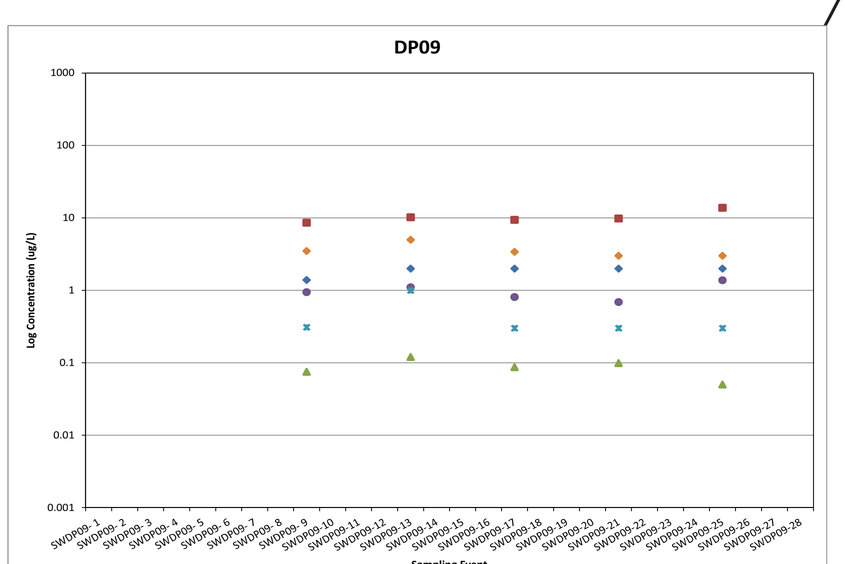












Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend
- Surface Water / Arsenic
- Surface Water / Barium
- Surface Water / Cadmium
- Surface Water / Copper
- Surface Water / Lead
- Surface Water / Zinc

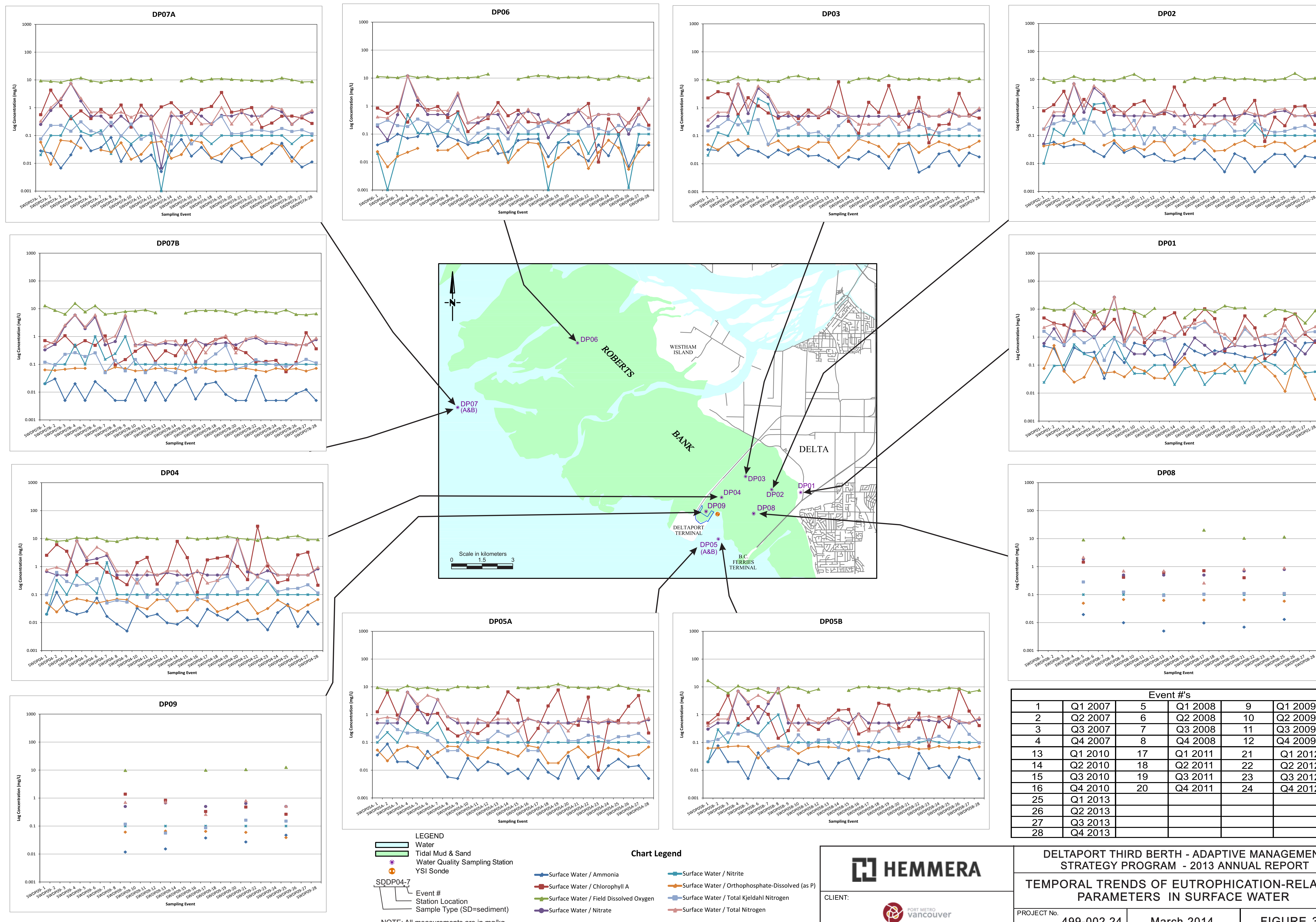
HEMMERA

CLIENT: Port Metro Vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF METALS IN SURFACE WATER

PROJECT No.		
499-002.24	March 2014	FIGURE 31



Event #'s							
1	Q1 2007	5	Q1 2008	9	Q1 2009		
2	Q2 2007	6	Q2 2008	10	Q2 2009		
3	Q3 2007	7	Q3 2008	11	Q3 2009		
4	Q4 2007	8	Q4 2008	12	Q4 2009		
13	Q1 2010	17	Q1 2011	21	Q1 2012		
14	Q2 2010	18	Q2 2011	22	Q2 2012		
15	Q3 2010	19	Q3 2011	23	Q3 2012		
16	Q4 2010	20	Q4 2011	24	Q4 2012		
25	Q1 2013						
26	Q2 2013						
27	Q3 2013						
28	Q4 2013						

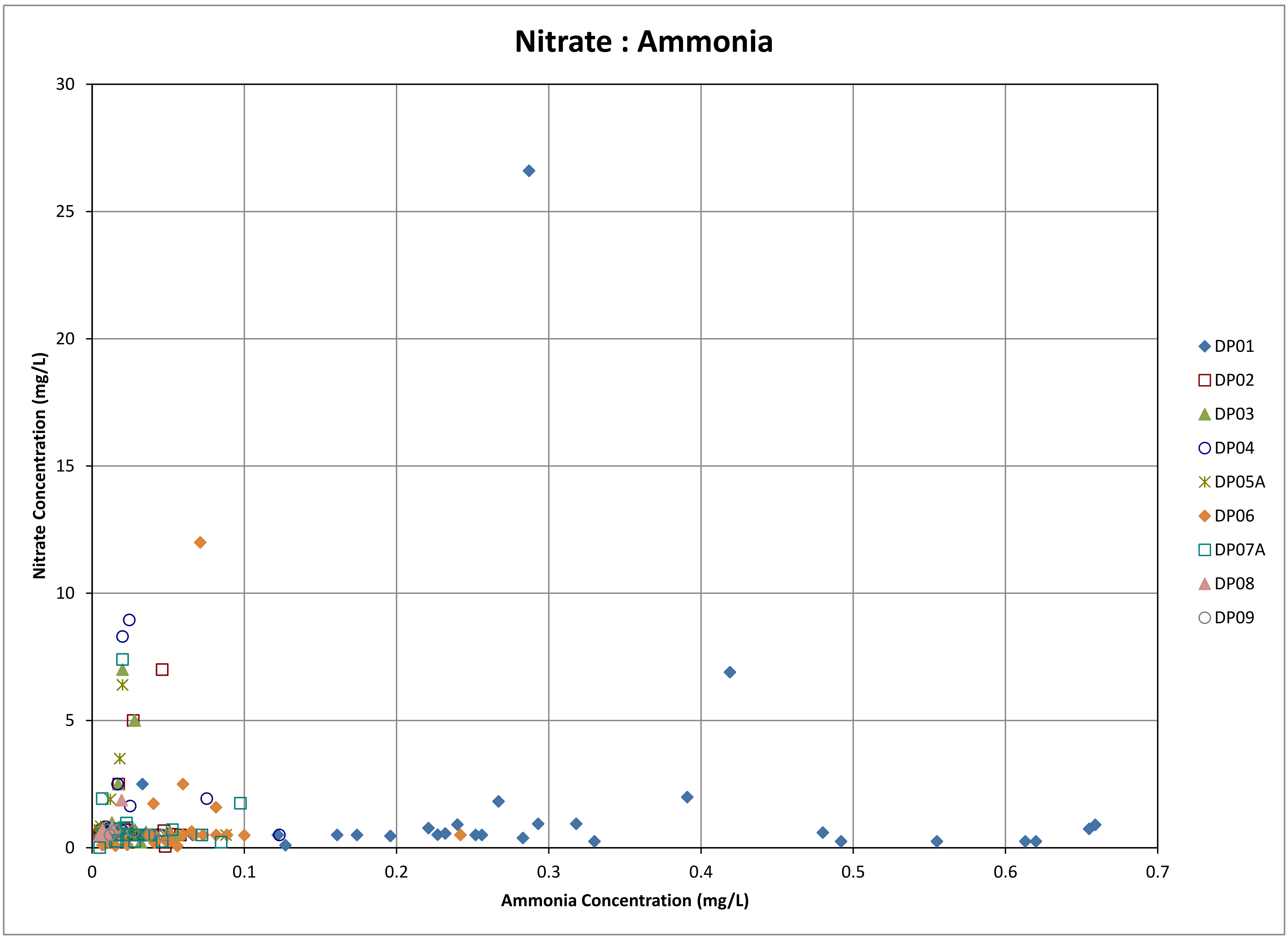
HEMMERA

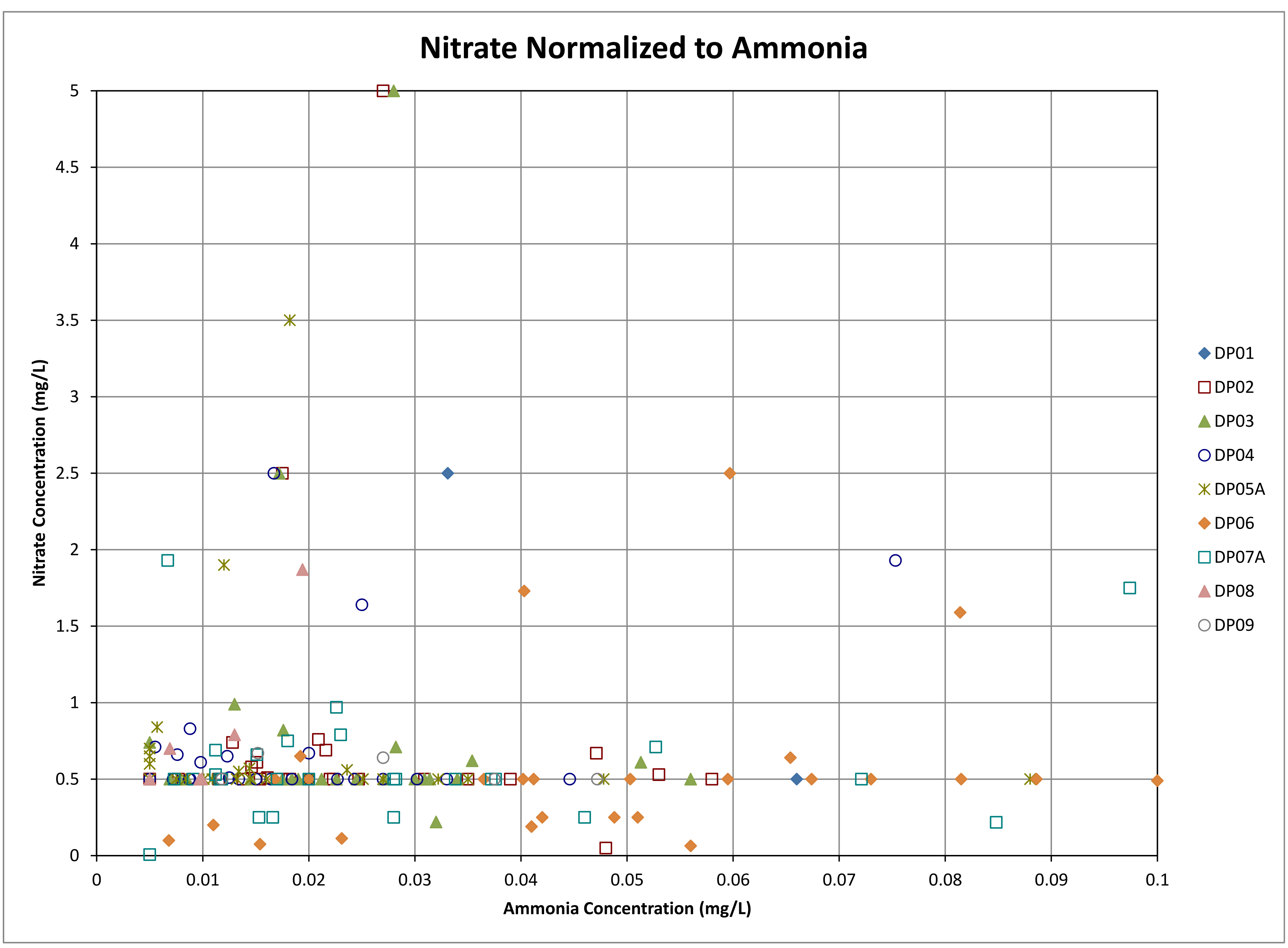
CLIENT: Port Metro Vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER

PROJECT No.		
499-002.24	March 2014	FIGURE 32





Note: This graph shows a close-up view of the same lower concentration data shown above.

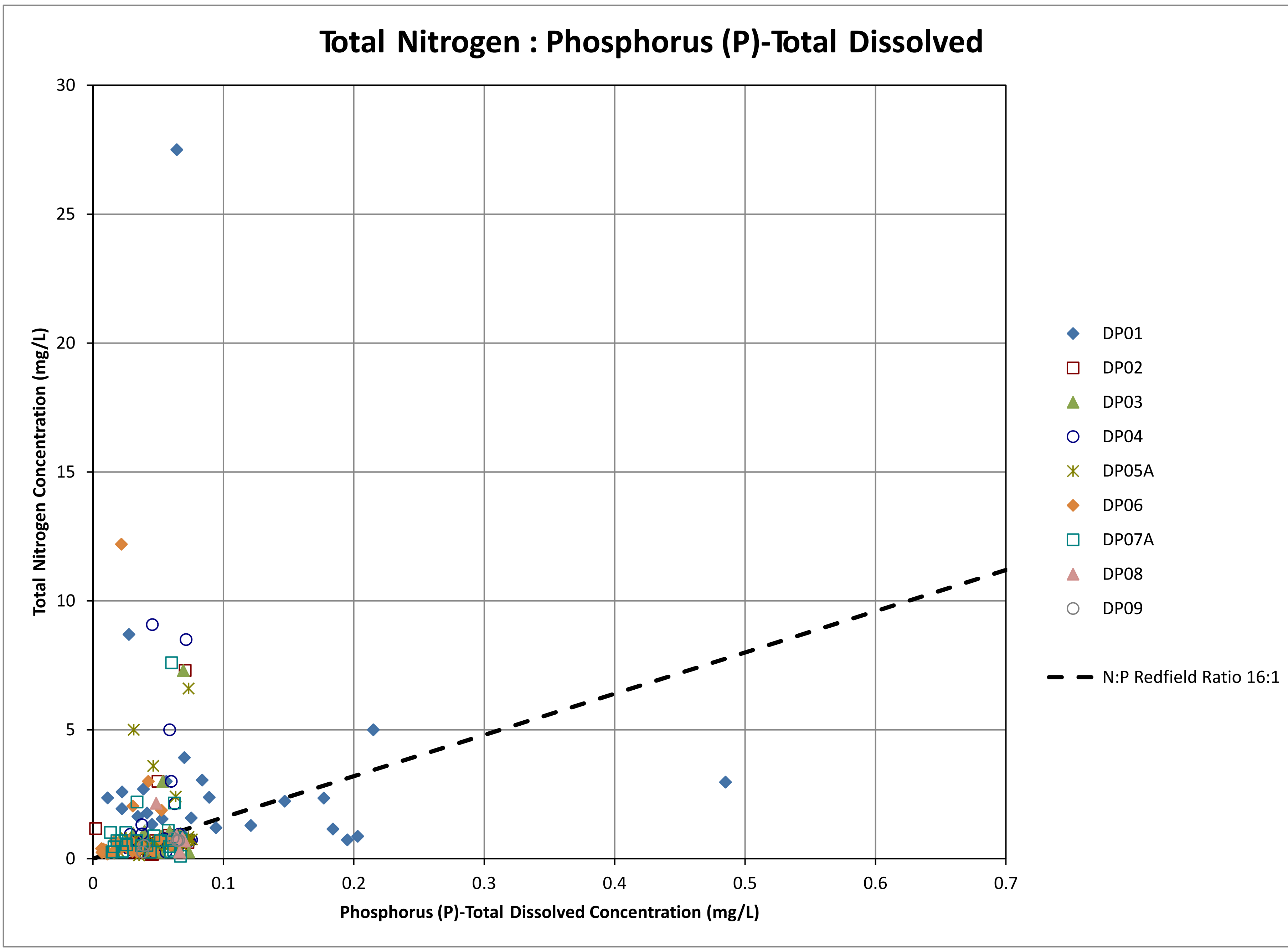
HEMMERA

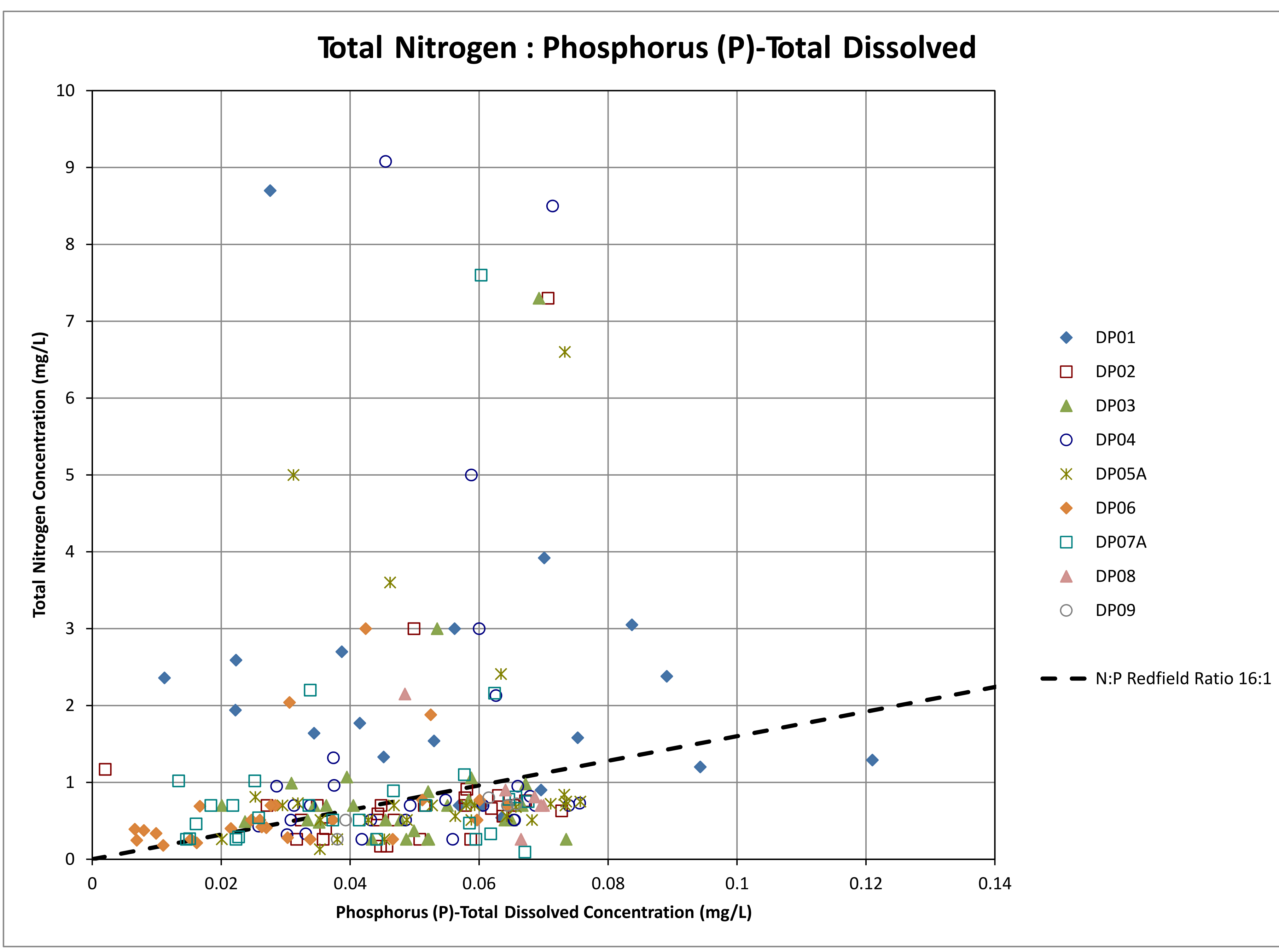
CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

RATIO OF NITRATE TO AMMONIA IN SURFACE WATER

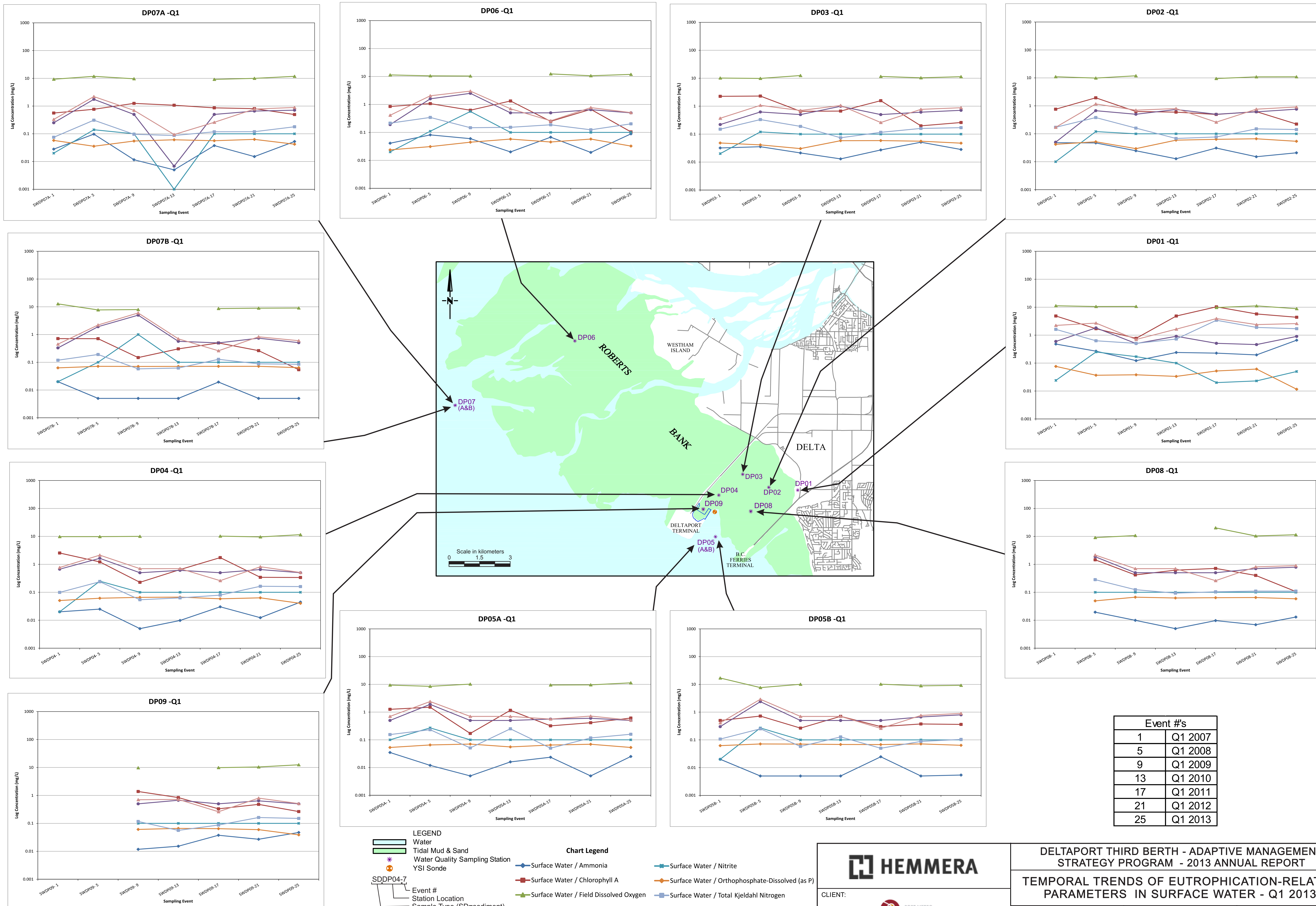
PROJECT No. 499-002.24	March 2014	FIGURE 33





Note: This graph shows a close-up view of the same lower concentration data shown above.

HEMMERA	DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT		
	RATIO OF TOTAL NITROGEN TO TOTAL PHOSPHORUS IN SURFACE WATER		
CLIENT: PORT METRO vancouver	PROJECT No. 499-002.24	March 2014	FIGURE 34



LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

Event #'s	
1	Q1 2007
5	Q1 2008
9	Q1 2009
13	Q1 2010
17	Q1 2011
21	Q1 2012
25	Q1 2013

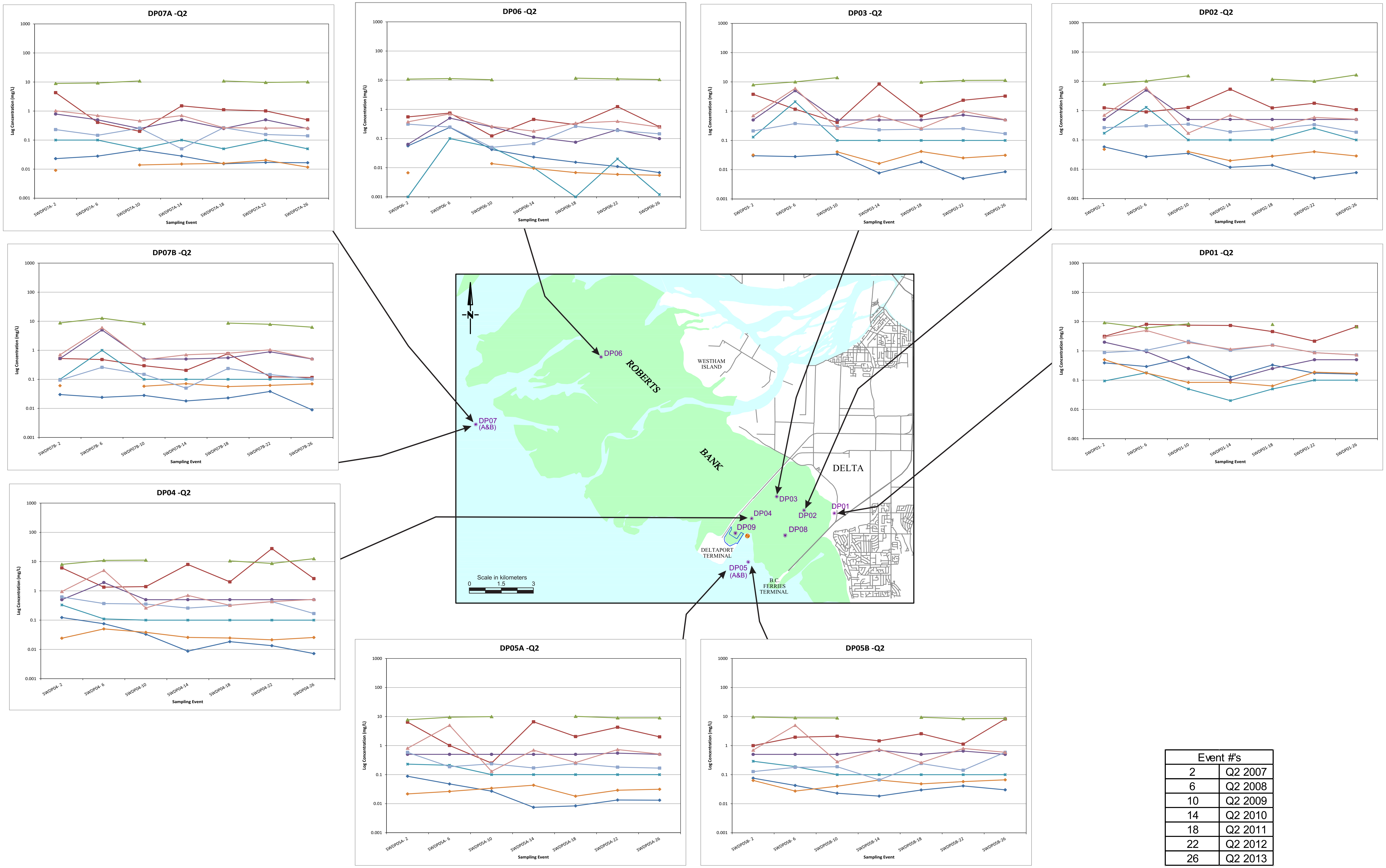
HEMMERA

CLIENT: Port Metro Vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q1 2013

PROJECT No.		
499-002.24	March 2014	FIGURE 35-Q1



Event #'s	
2	Q2 2007
6	Q2 2008
10	Q2 2009
14	Q2 2010
18	Q2 2011
22	Q2 2012
26	Q2 2013

LEGEND

- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

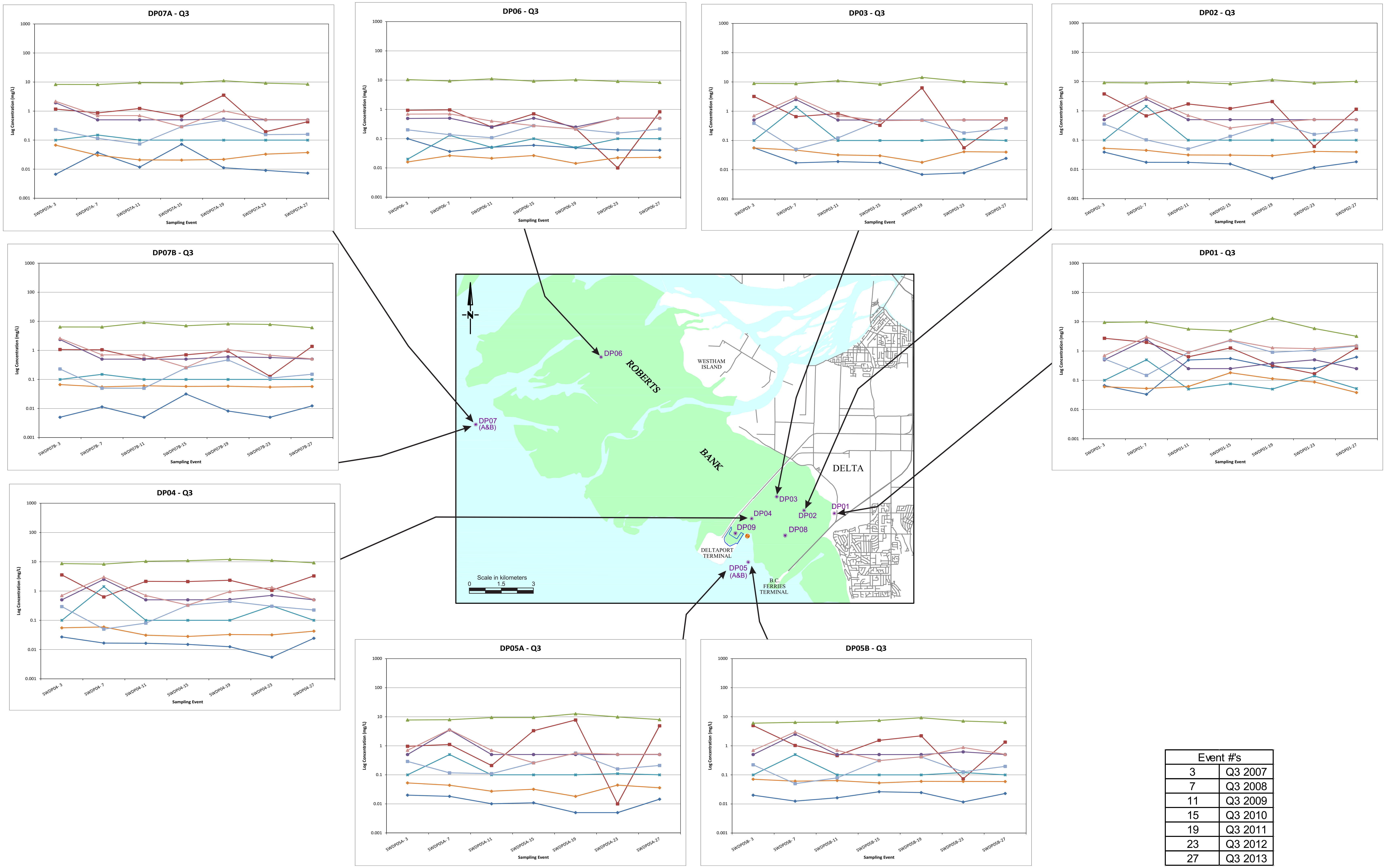
HEMMERA

CLIENT: Port Metro Vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q2 2013

PROJECT No.		
499-002.24	March 2014	FIGURE 35-Q2



Event #'s	
3	Q3 2007
7	Q3 2008
11	Q3 2009
15	Q3 2010
19	Q3 2011
23	Q3 2012
27	Q3 2013

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend
- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

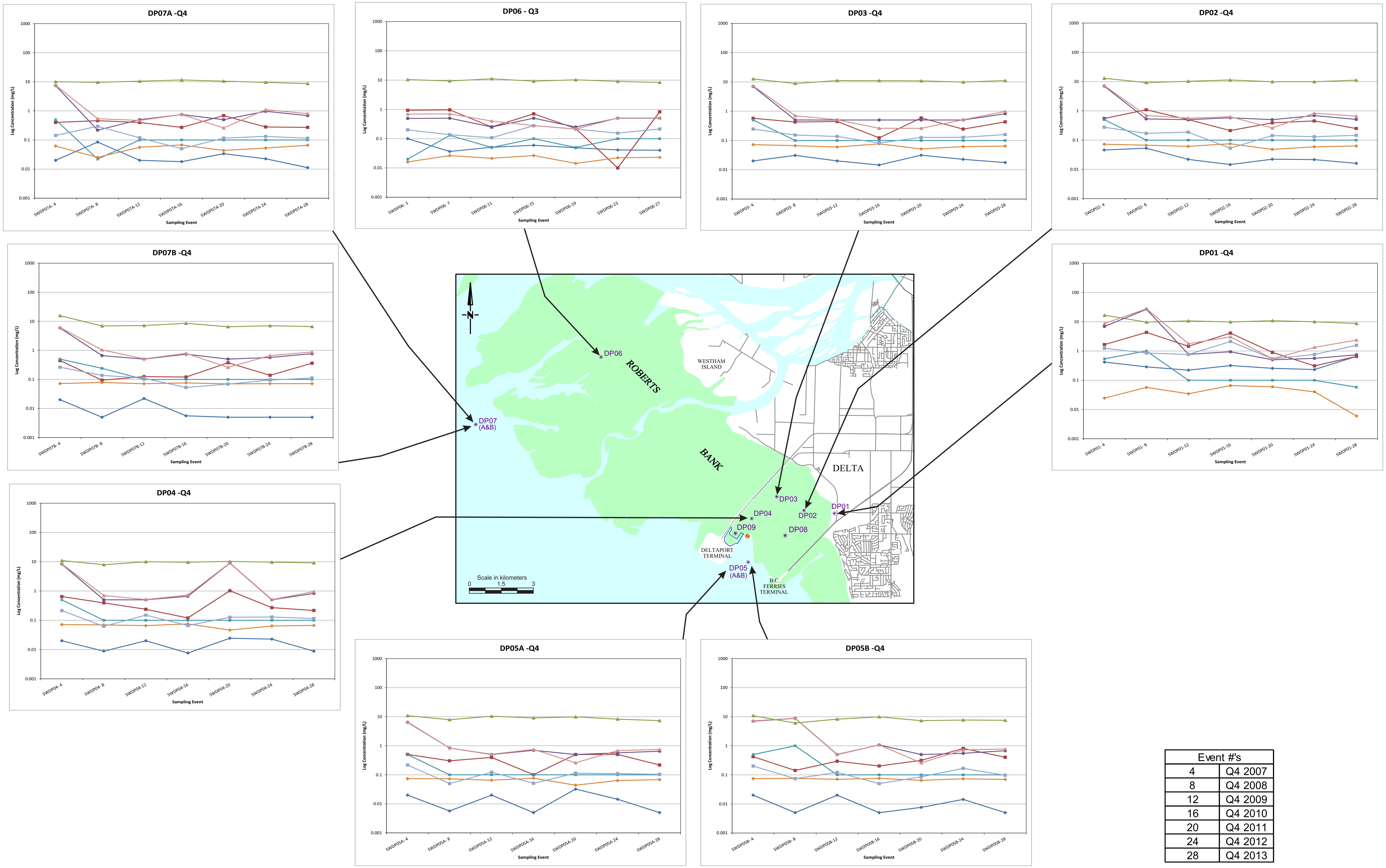
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q3 2013

PROJECT No. 499-002.24	March 2014	FIGURE 35-Q3



Event #'s	
4	Q4 2007
8	Q4 2008
12	Q4 2009
16	Q4 2010
20	Q4 2011
24	Q4 2012
28	Q4 2013

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend
- Surface Water / Ammonia
- Surface Water / Chlorophyll A
- Surface Water / Field Dissolved Oxygen
- Surface Water / Nitrate
- Surface Water / Nitrite
- Surface Water / Orthophosphate-Dissolved (as P)
- Surface Water / Total Kjeldahl Nitrogen
- Surface Water / Total Nitrogen

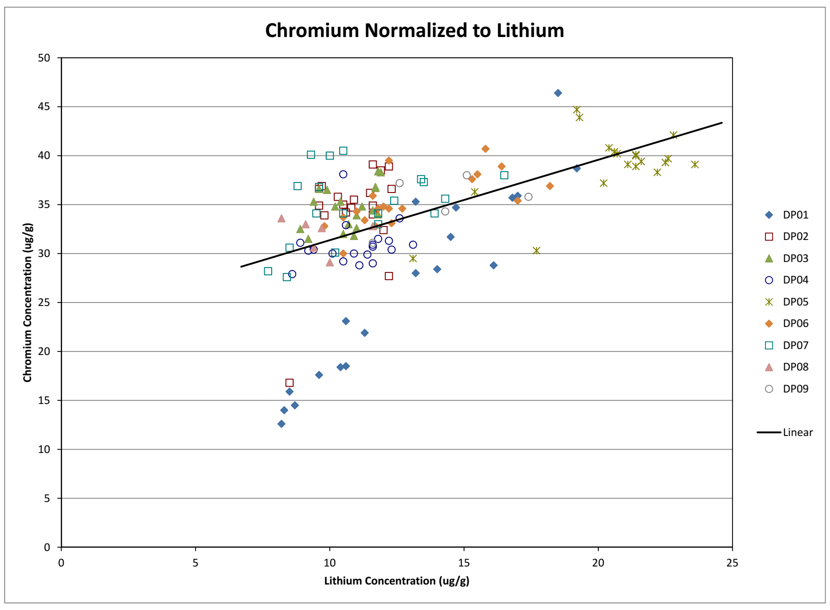
HEMMERA

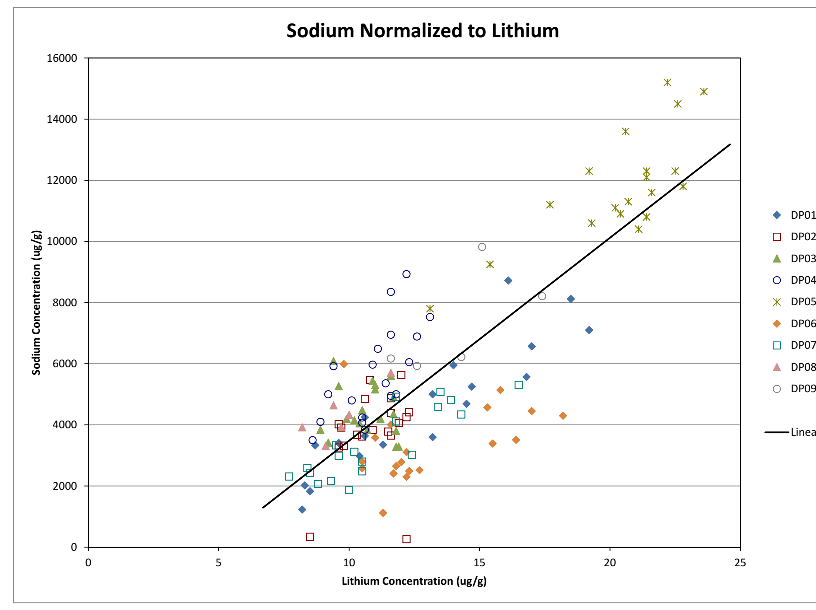
CLIENT: Port Metro Vancouver

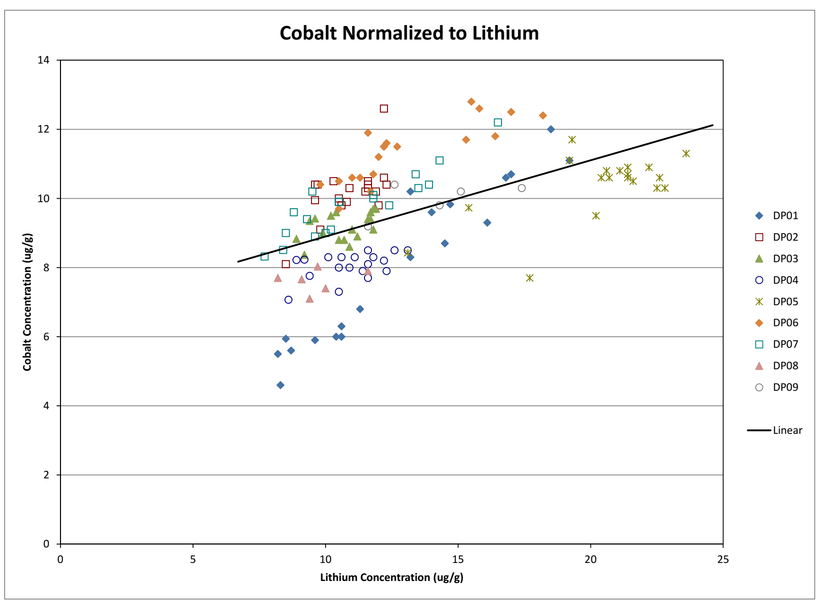
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

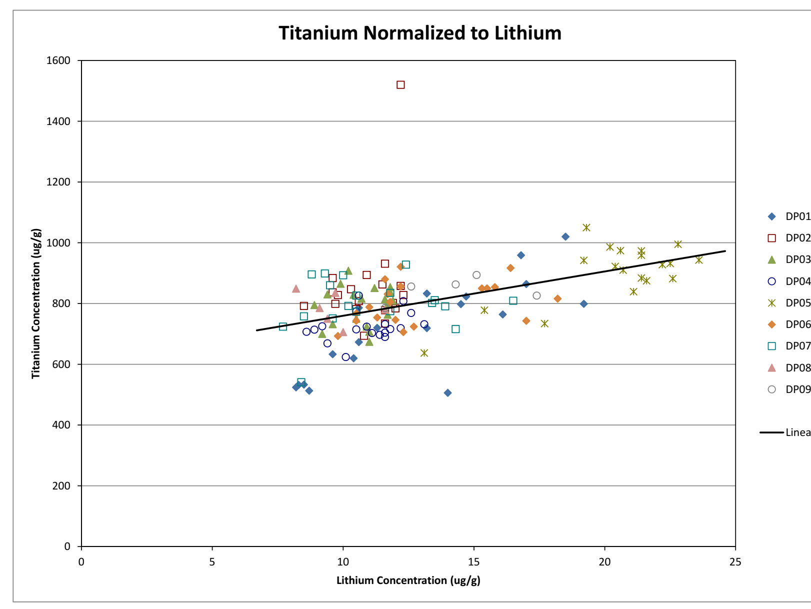
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SURFACE WATER - Q4 2013

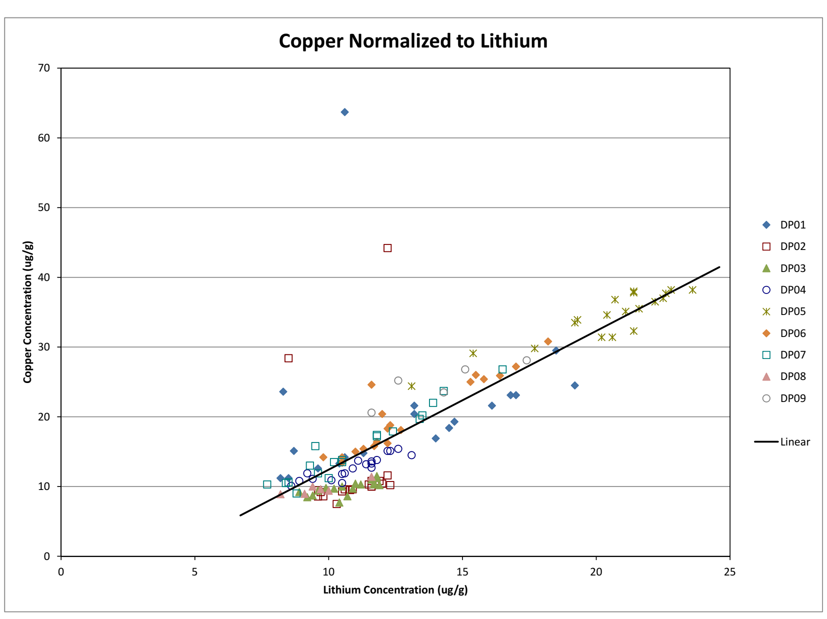
PROJECT No.	Date	Figure
499-002.24	March 2014	FIGURE 35-Q4

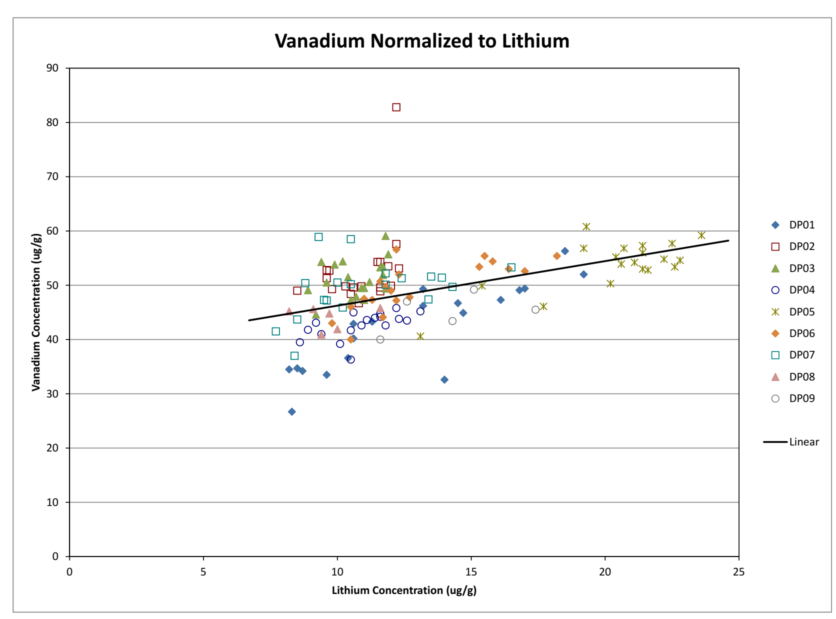


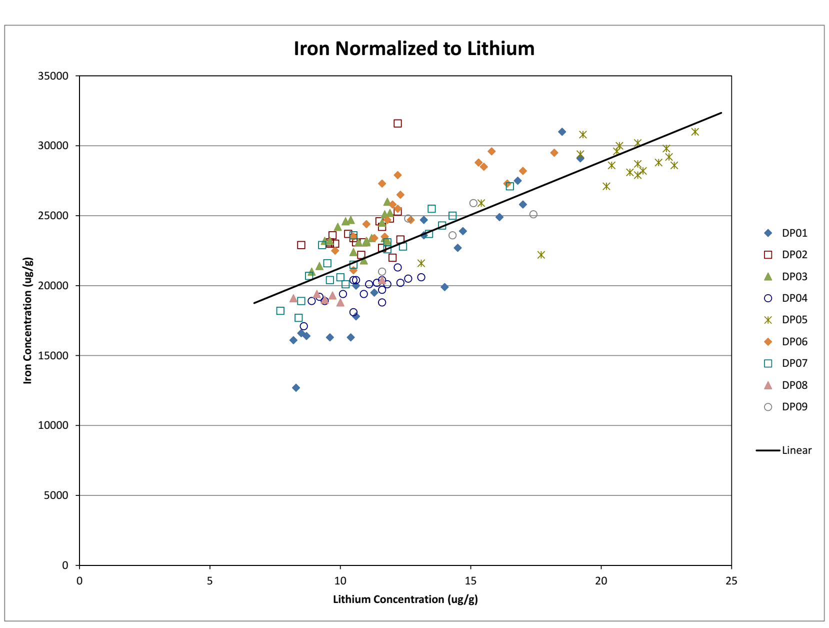


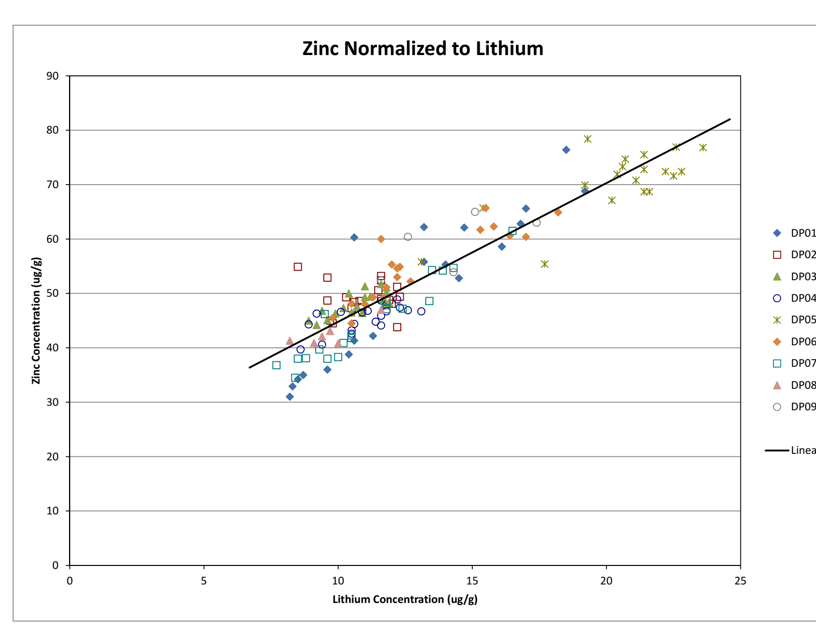












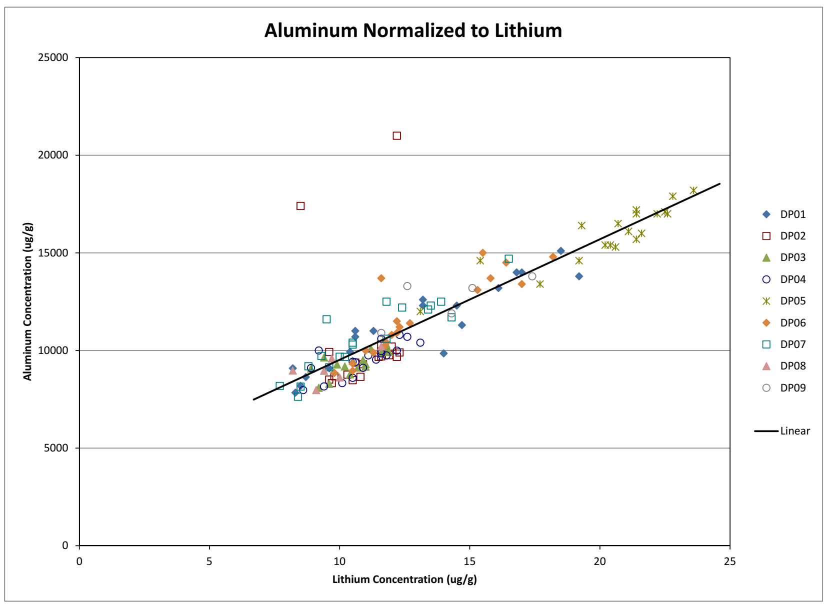
HEMMERA

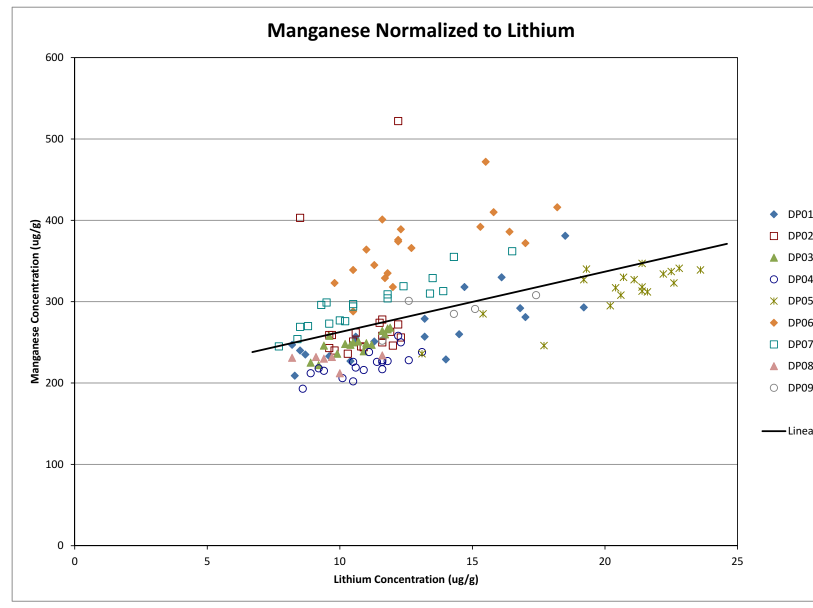
CLIENT: PORT METRO vancouver

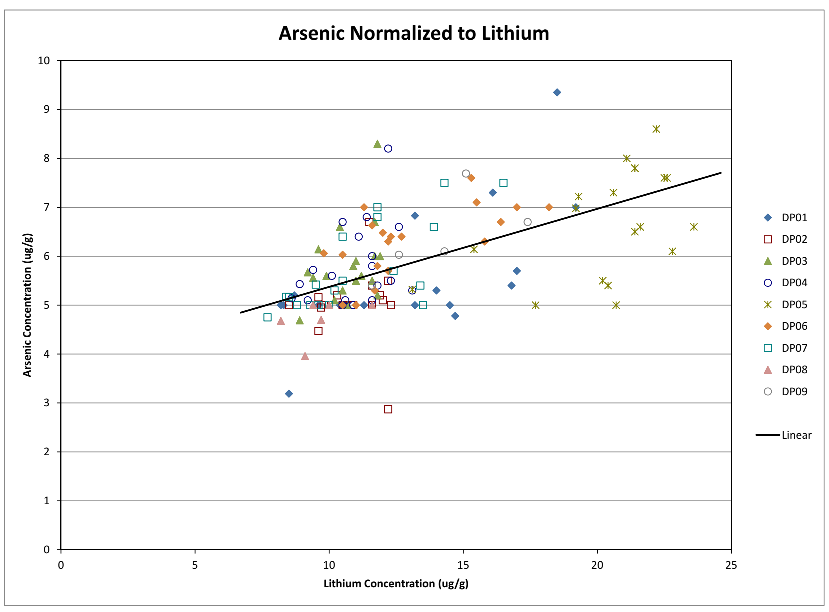
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

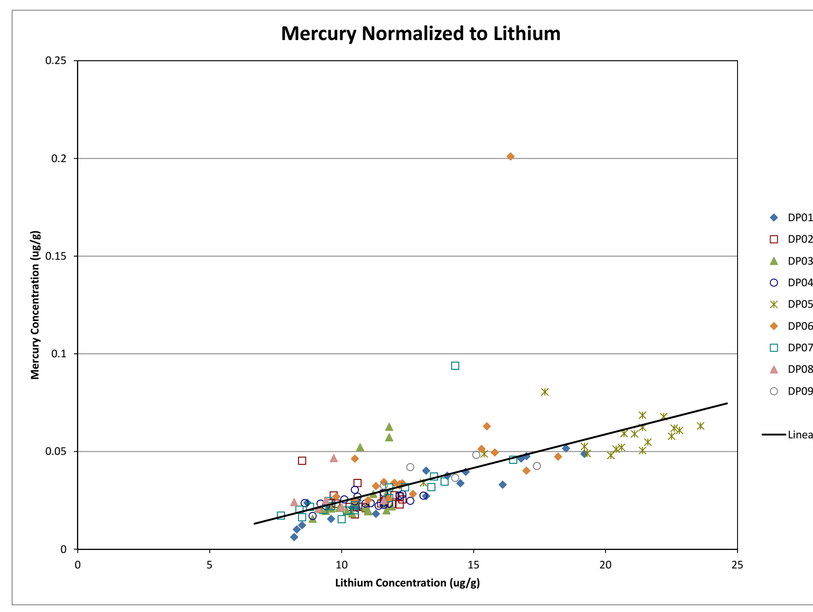
METAL CONCENTRATIONS IN SEDIMENT NORMALIZED TO LITHIUM BY STATION (ALL DATA)

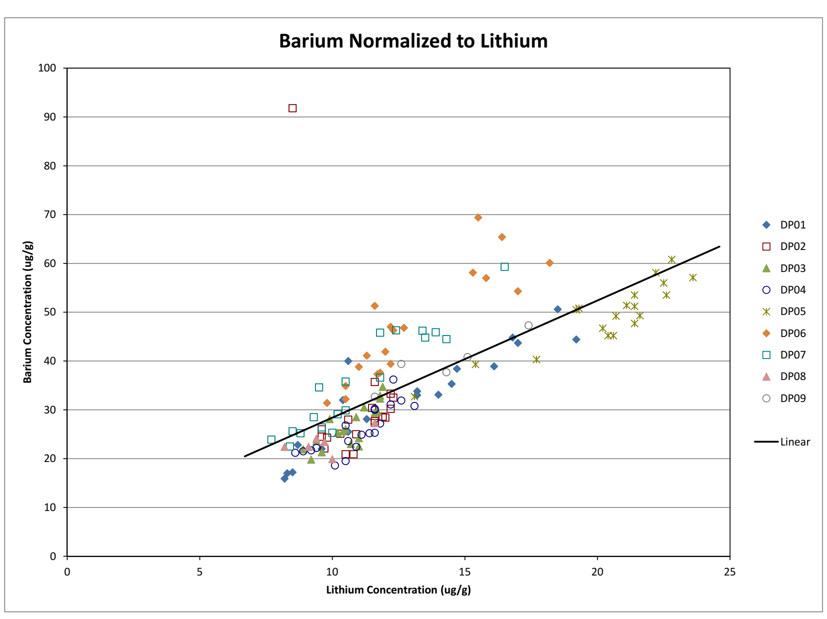
PROJECT No. 499-002.24 | March 2014 | FIGURE 36-A

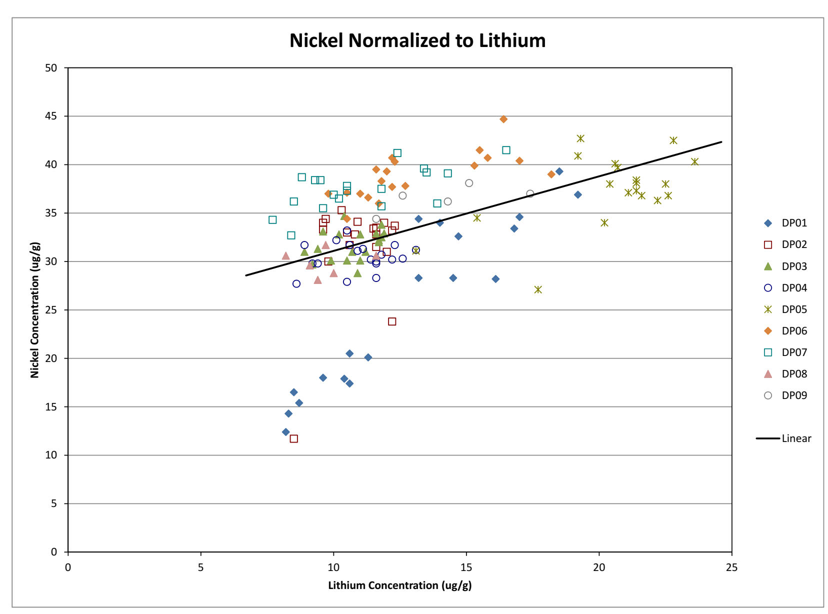


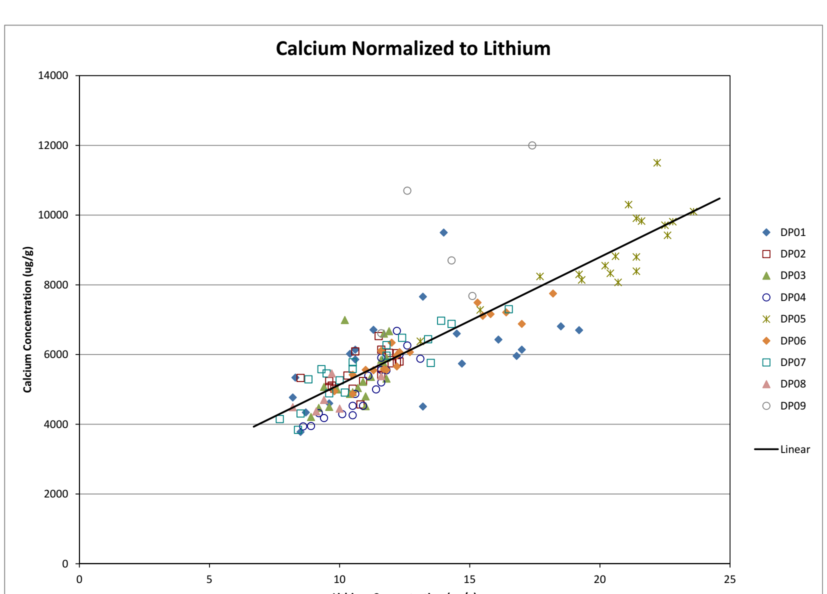


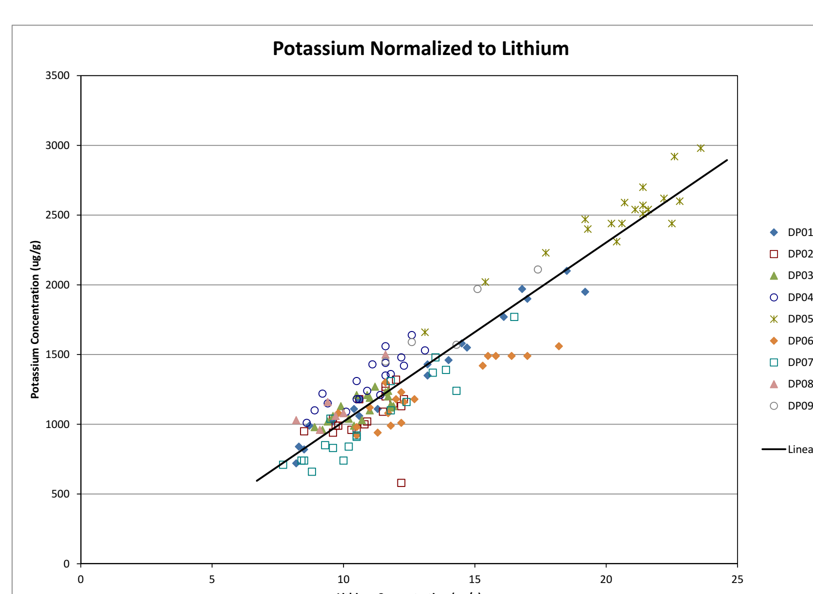












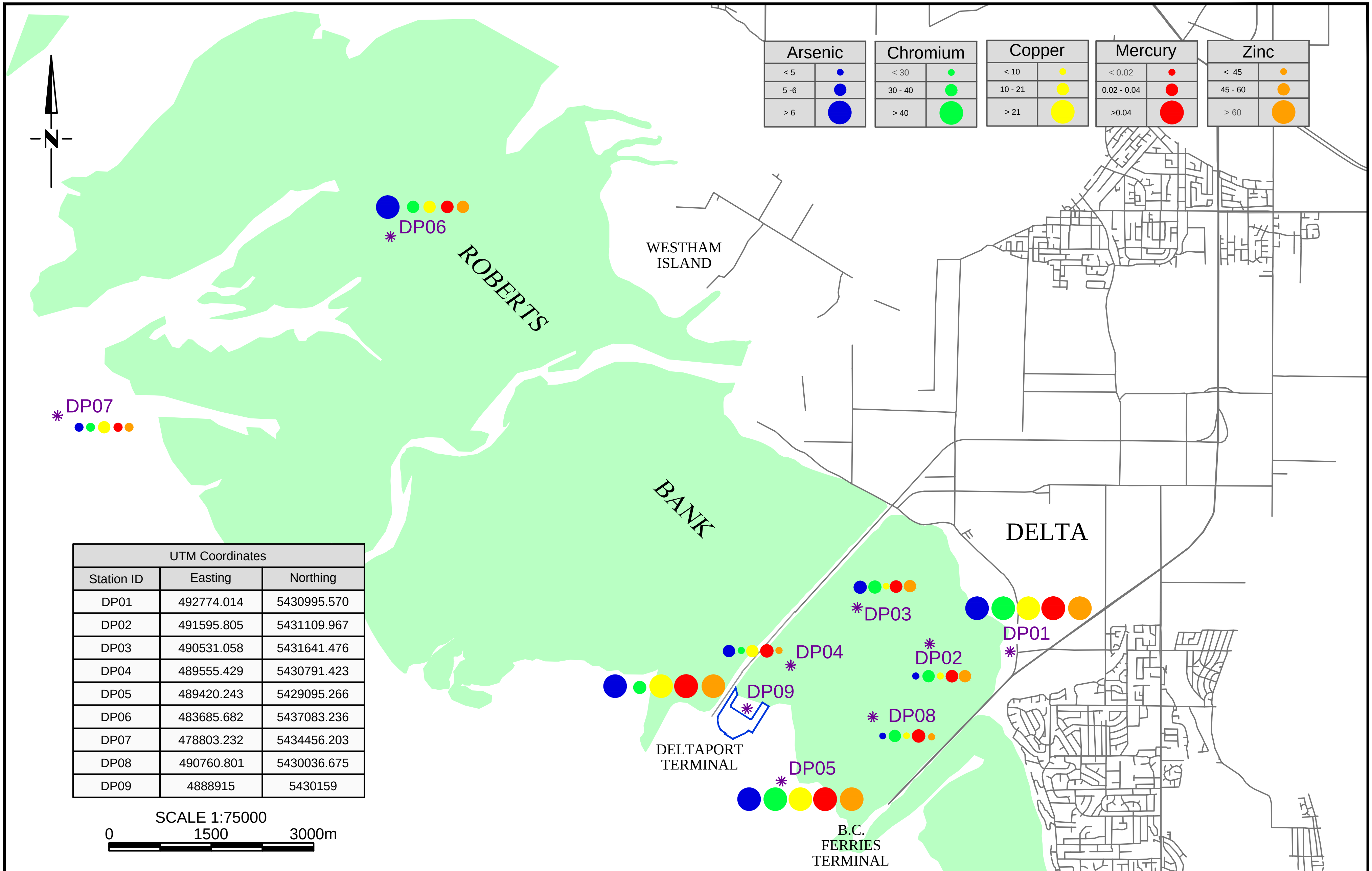
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

METAL CONCENTRATIONS IN SEDIMENT NORMALIZED TO LITHIUM BY STATION (ALL DATA)

PROJECT No.		
499-002.24	March 2014	FIGURE 36-B



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
Water
Tidal Mud & Sand
Sampling Station
Note: Units for all parameters are µg/g, unless otherwise noted.

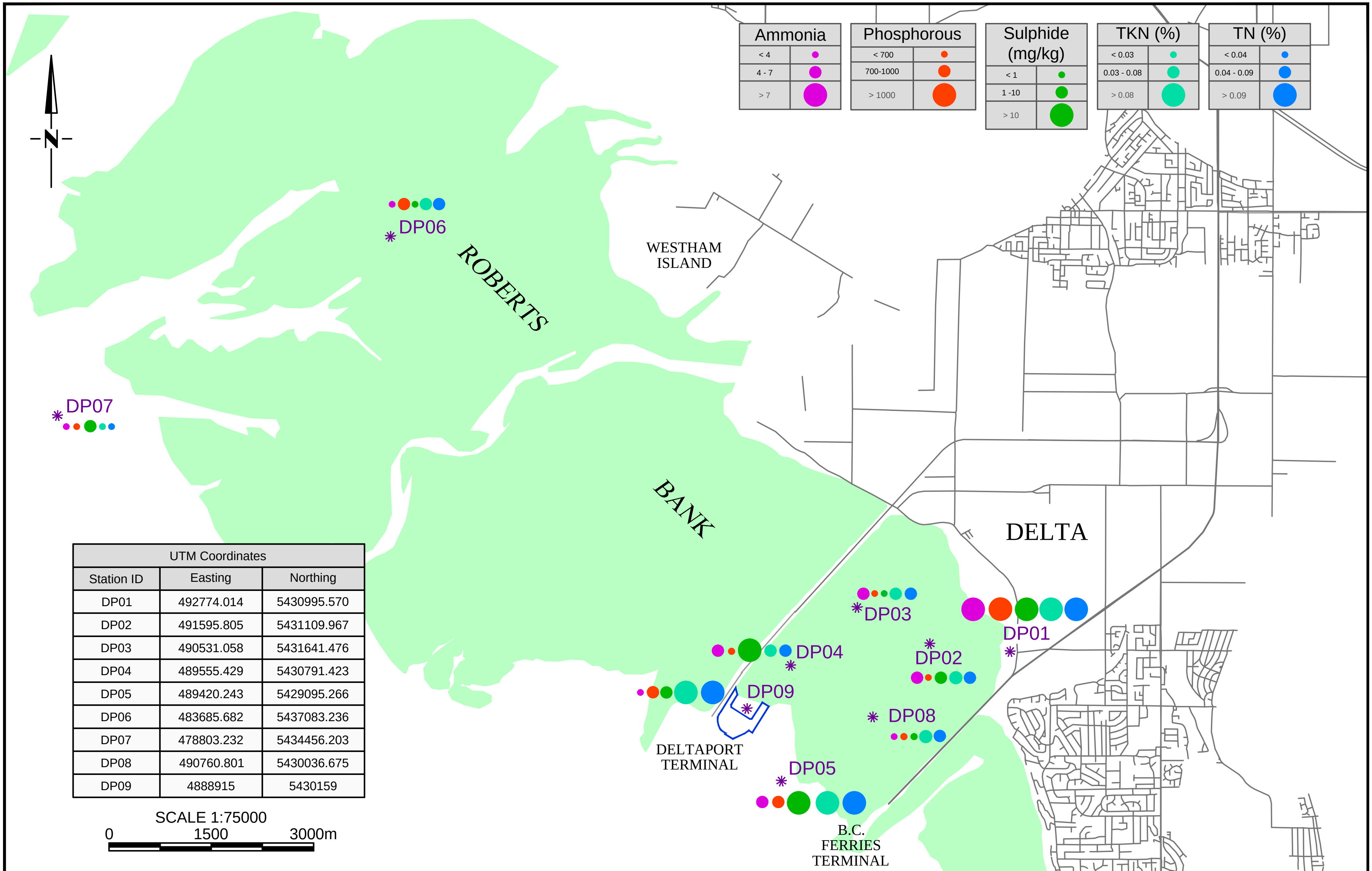
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

SPATIAL TRENDS OF METALS IN SEDIMENT (2013)

PROJECT No. 499-002.24	March 2014	FIGURE 37



UTM Coordinates		
Station ID	Easting	Northing
DP01	492774.014	5430995.570
DP02	491595.805	5431109.967
DP03	490531.058	5431641.476
DP04	489555.429	5430791.423
DP05	489420.243	5429095.266
DP06	483685.682	5437083.236
DP07	478803.232	5434456.203
DP08	490760.801	5430036.675
DP09	4888915	5430159

LEGEND
Water
Tidal Mud & Sand
Sampling Station
Note: Units for all parameters are μg/g, unless otherwise noted.

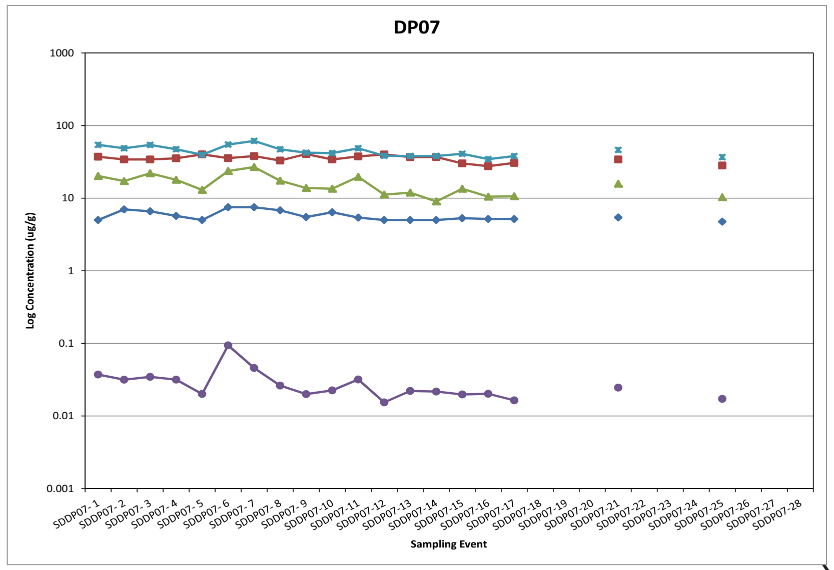
HEMMERA

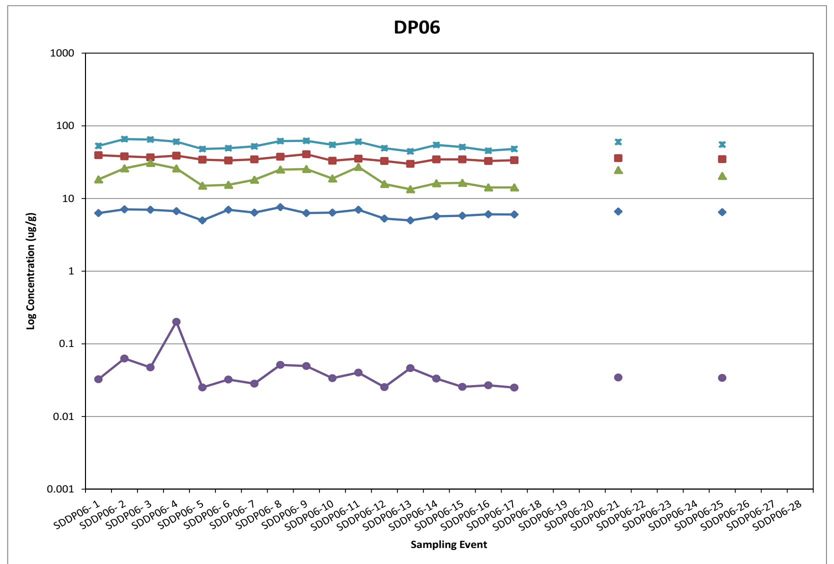
CLIENT: PORT METRO vancouver

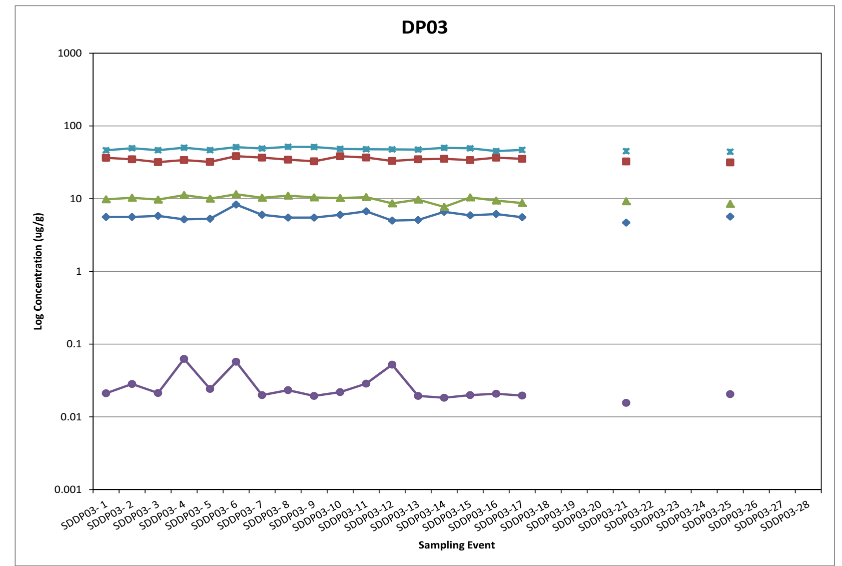
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

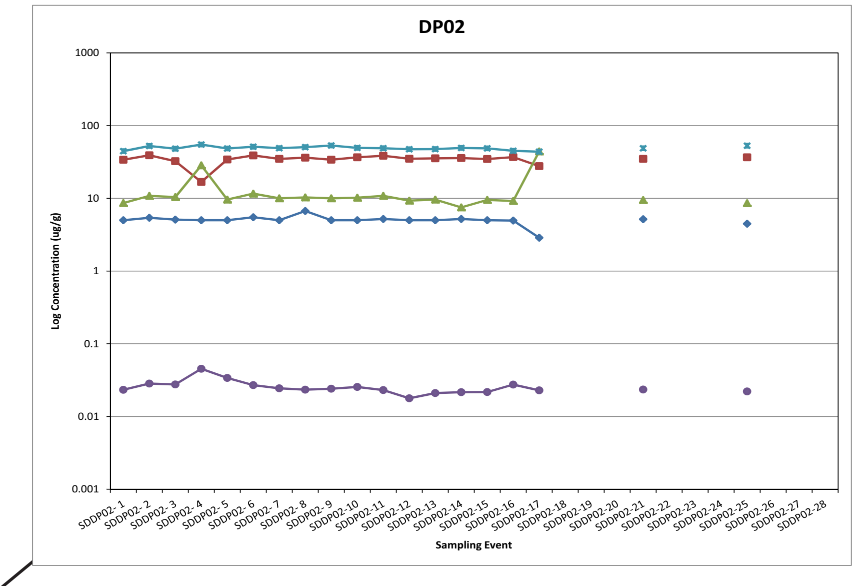
SPATIAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (2013)

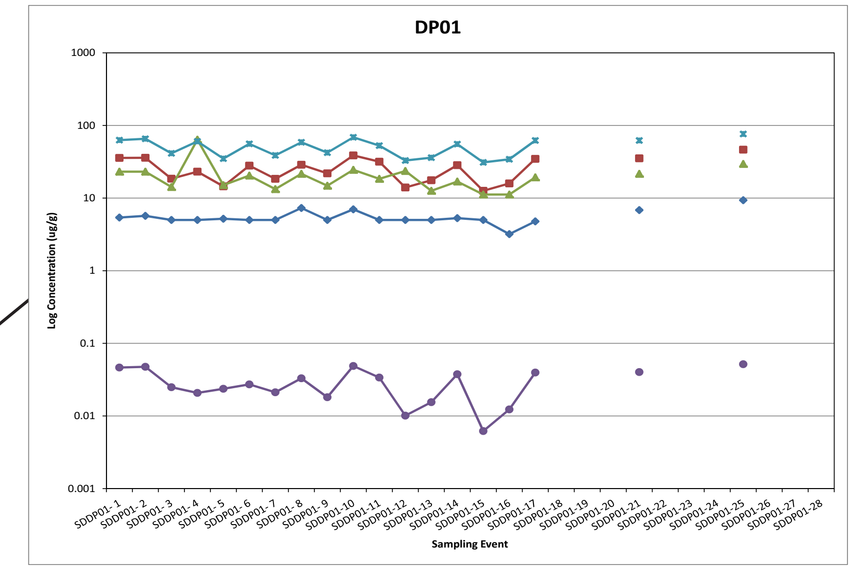
PROJECT No. 499-002.24	March 2014	FIGURE 38

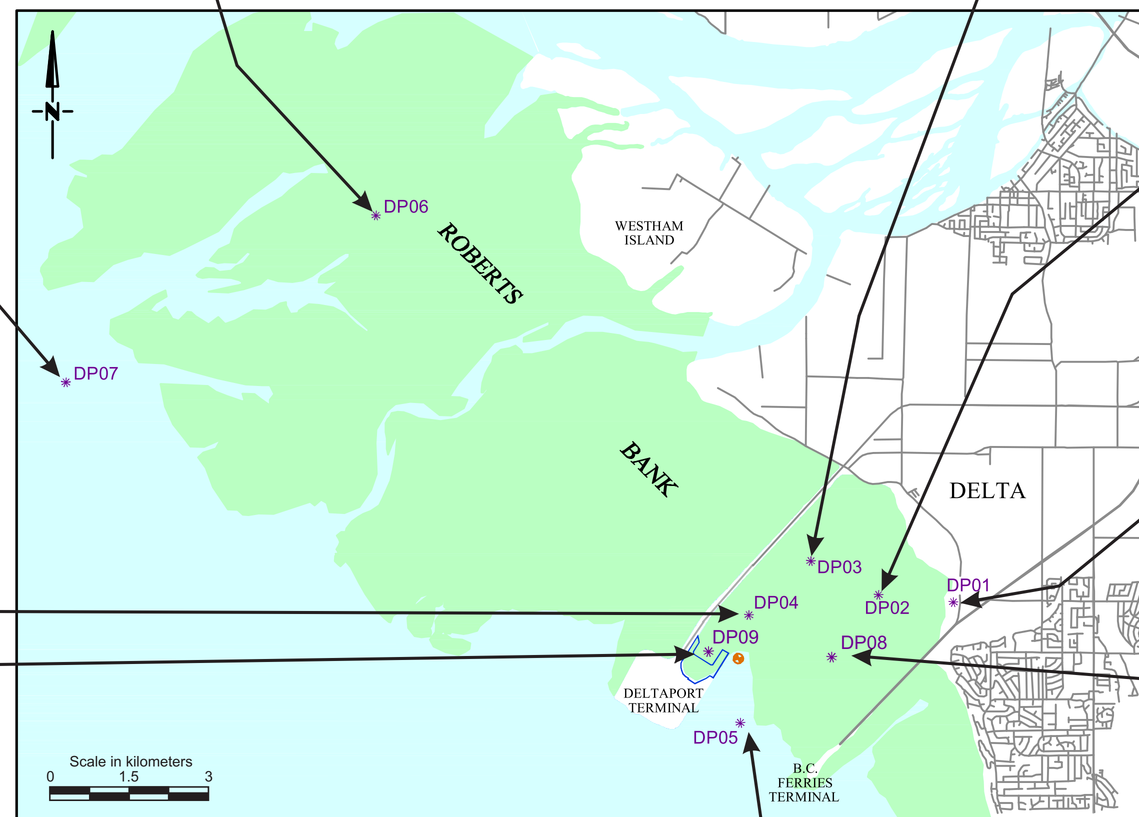


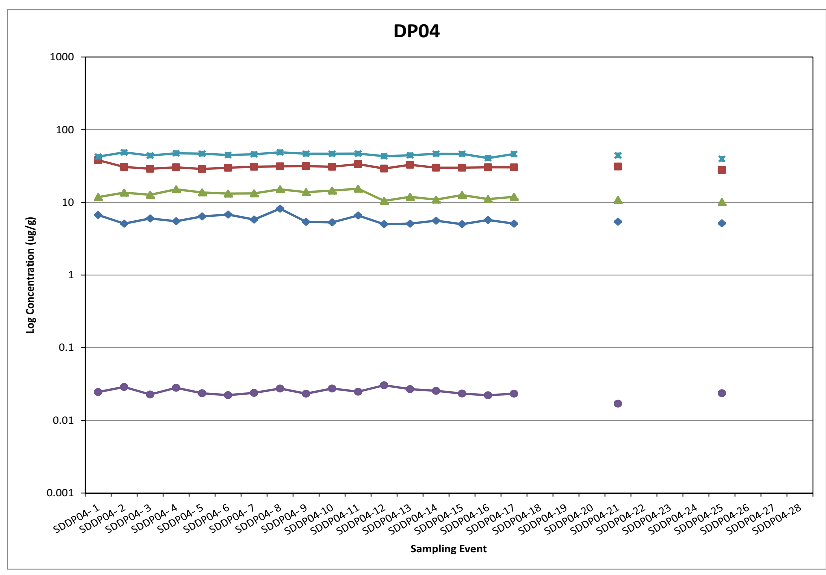


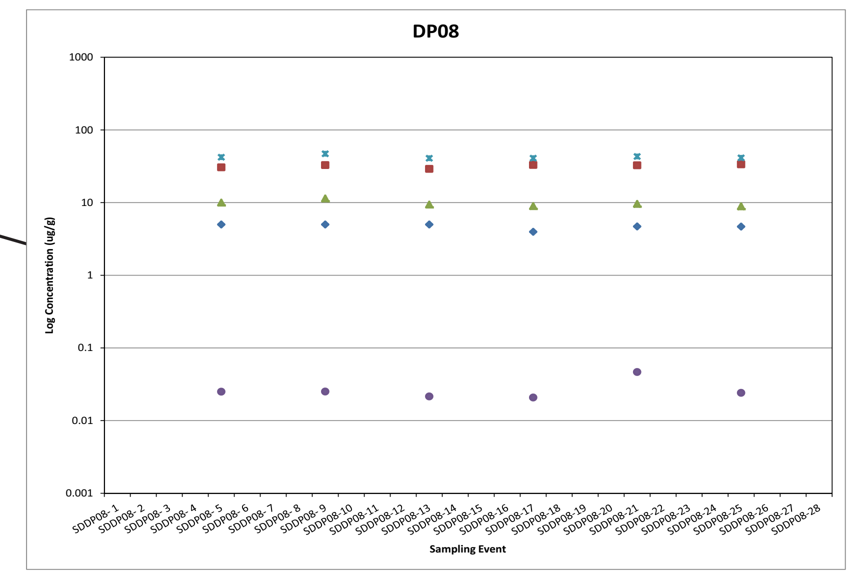


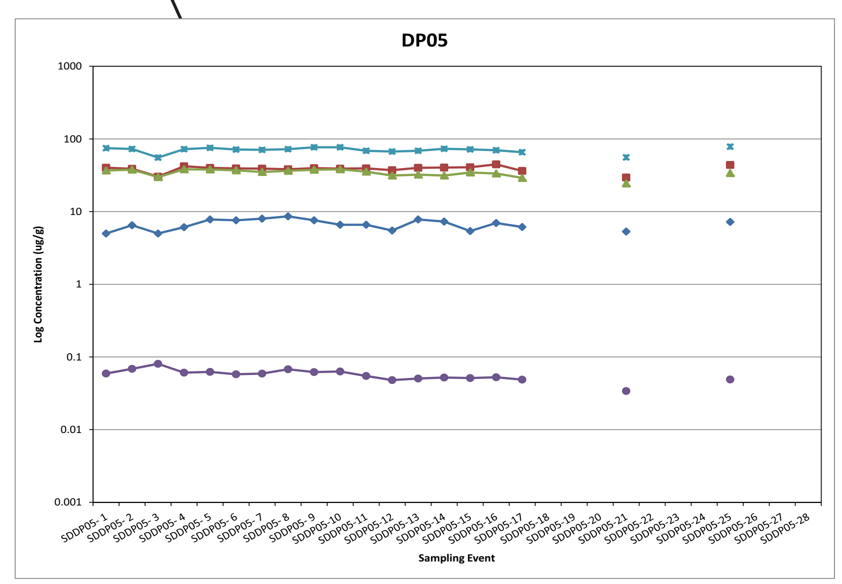


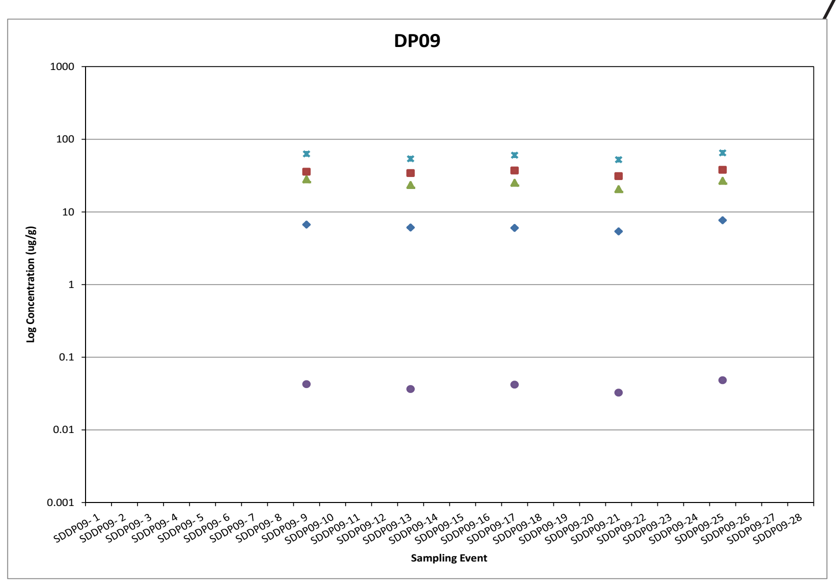












Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend
Sediment / Arsenic
Sediment / Chromium
Sediment / Copper
Sediment / Mercury
Sediment / Zinc

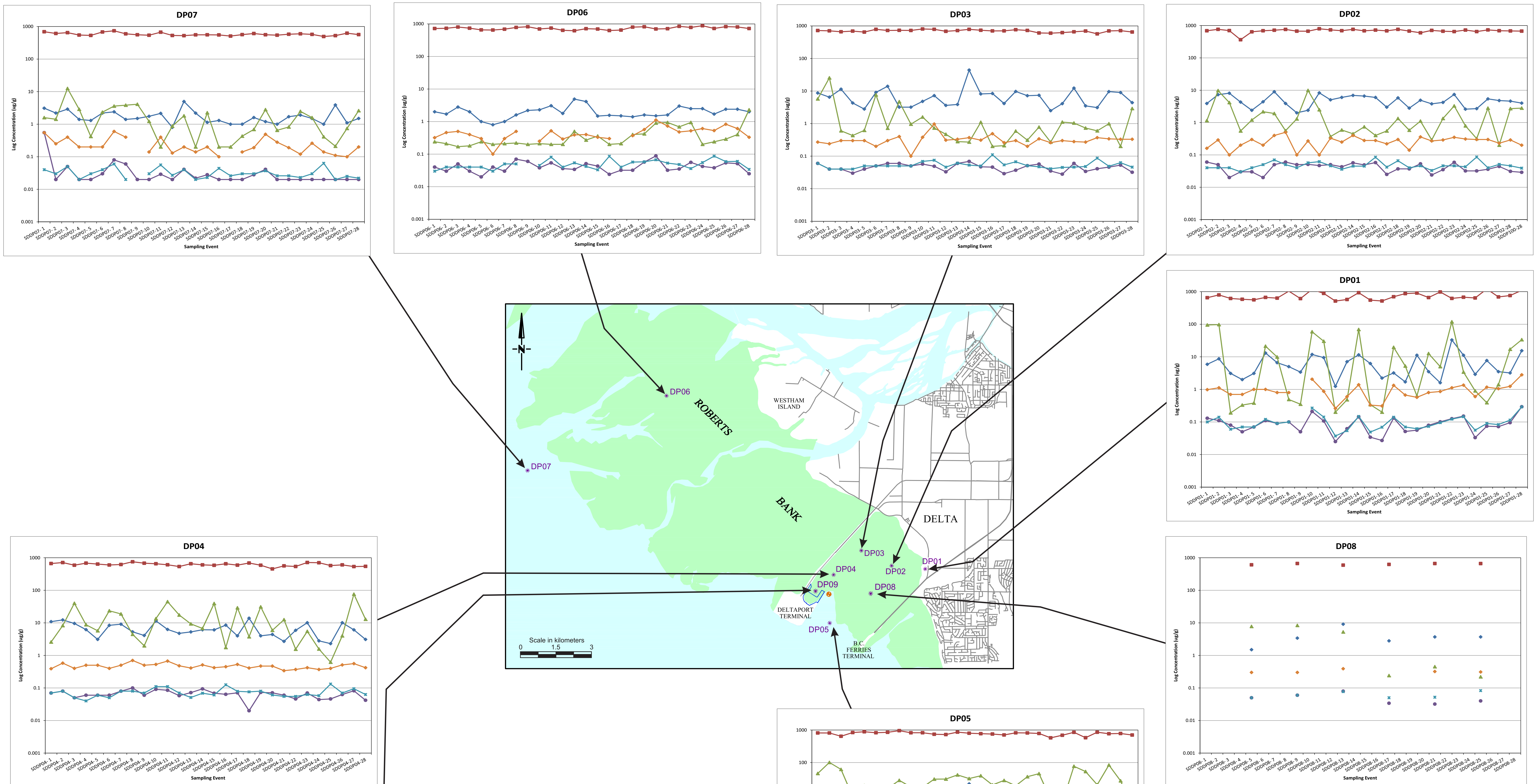
HEMMERA

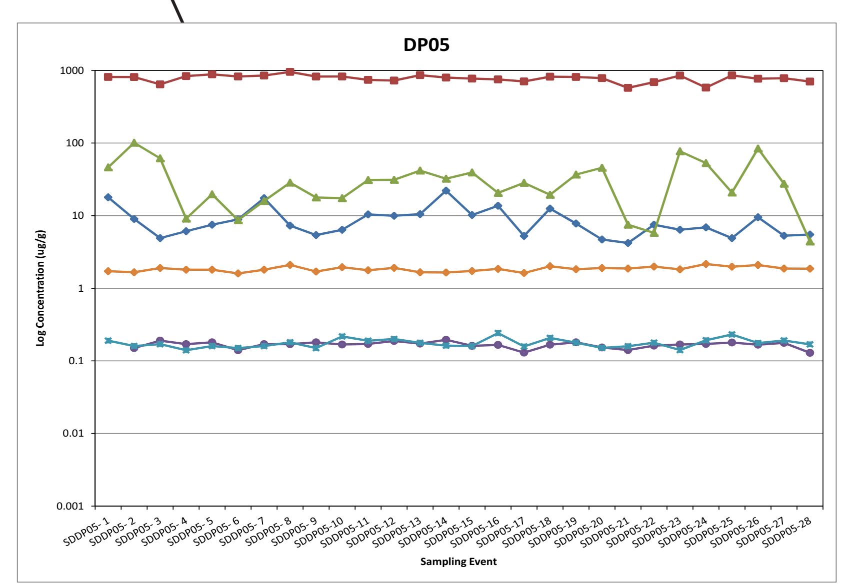
CLIENT: PORT METRO vancouver

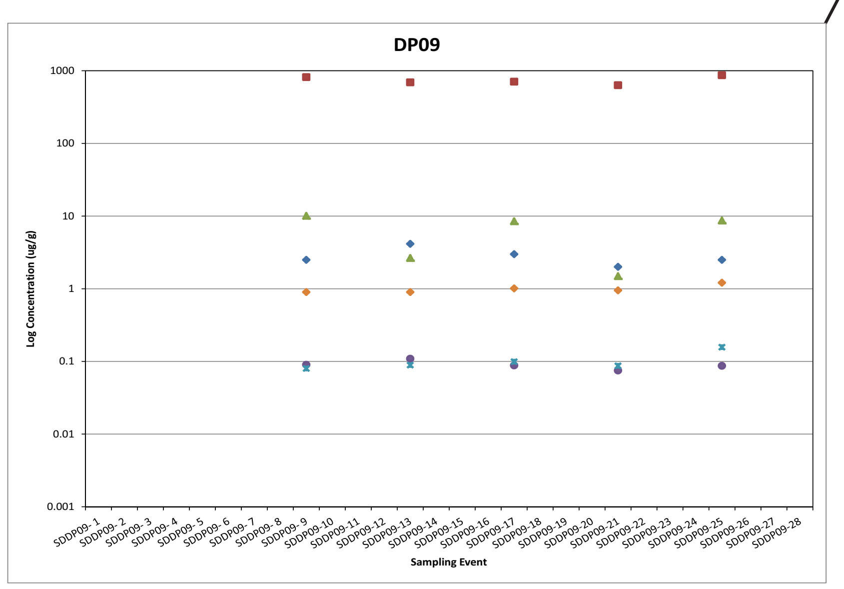
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF METALS IN SEDIMENT

PROJECT No.		
499-002.24	March 2014	FIGURE 39







Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

Chart Legend

- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon

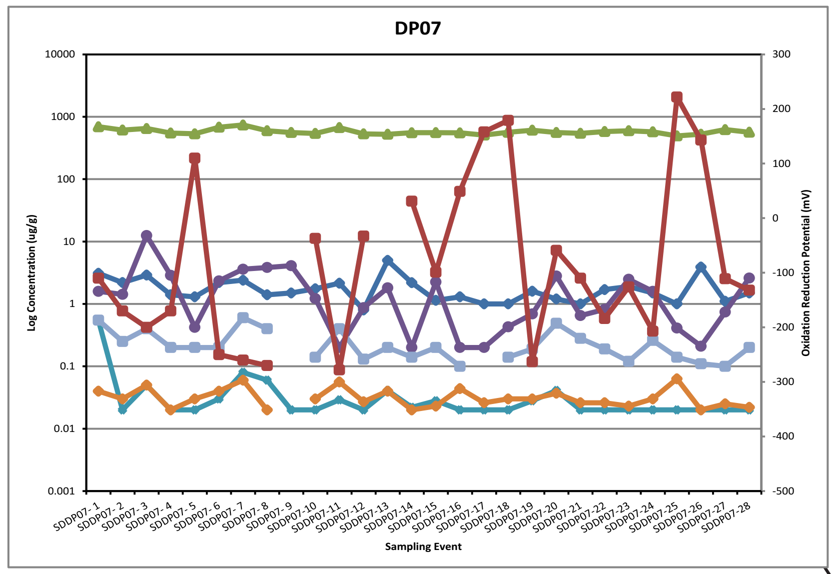
HEMMERA

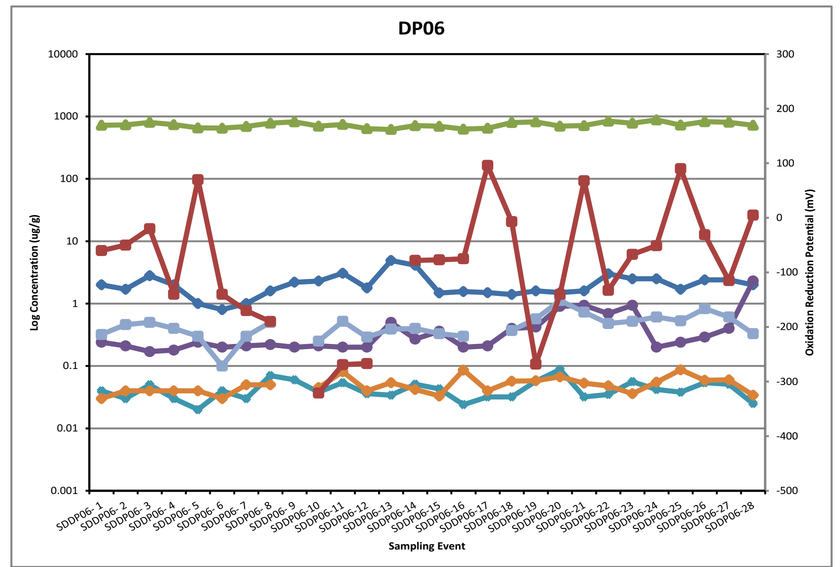
CLIENT: PORT METRO vancouver

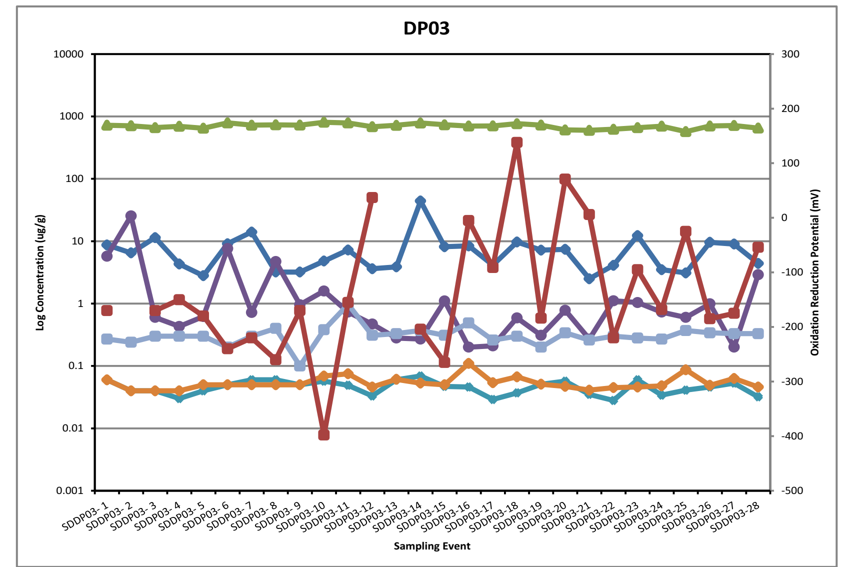
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

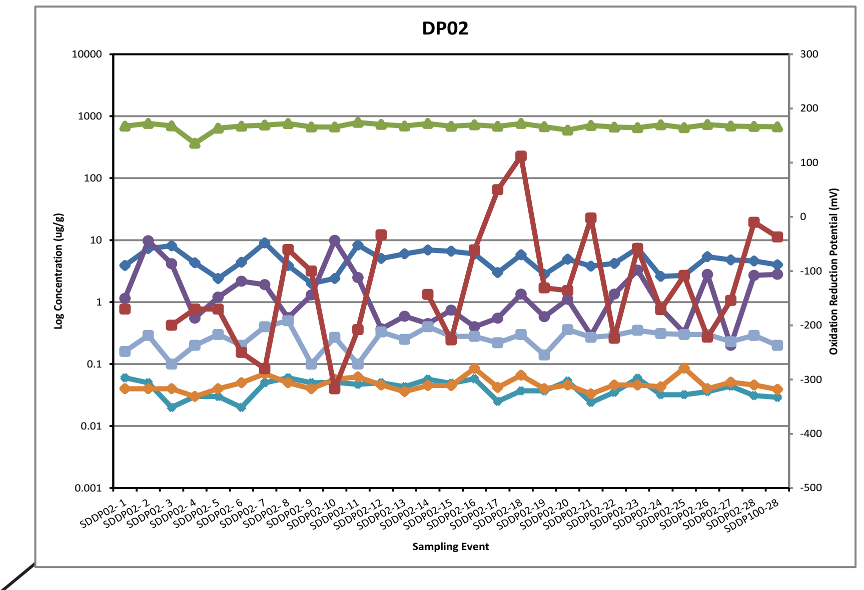
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (ALL QUARTERS)

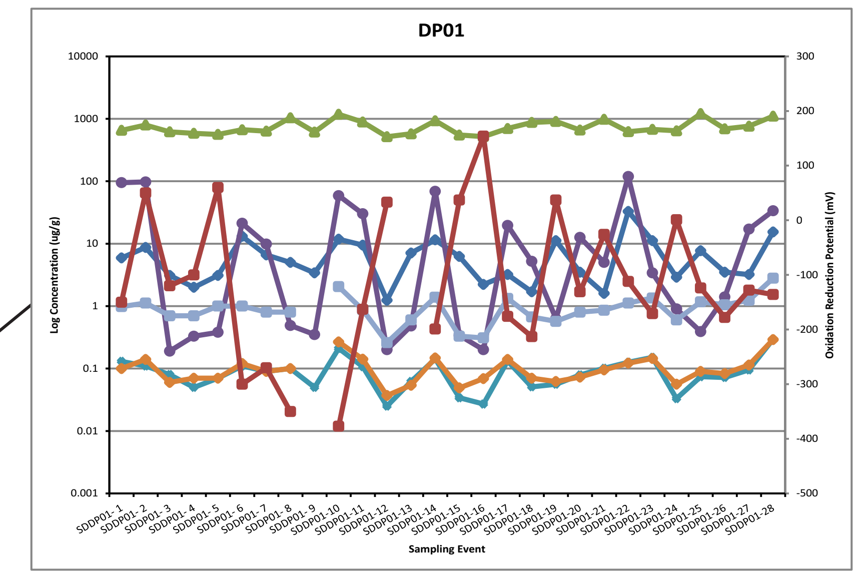
PROJECT No. 499-002.24 | March 2014 | FIGURE 40a

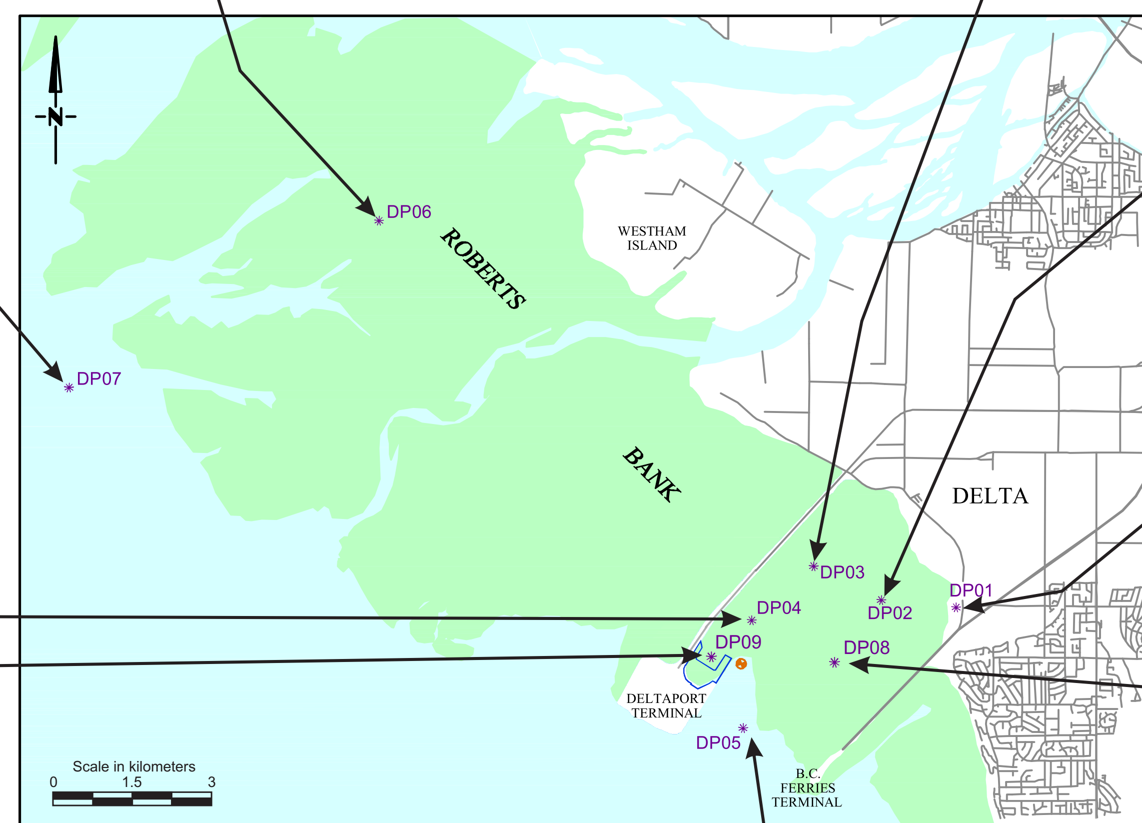


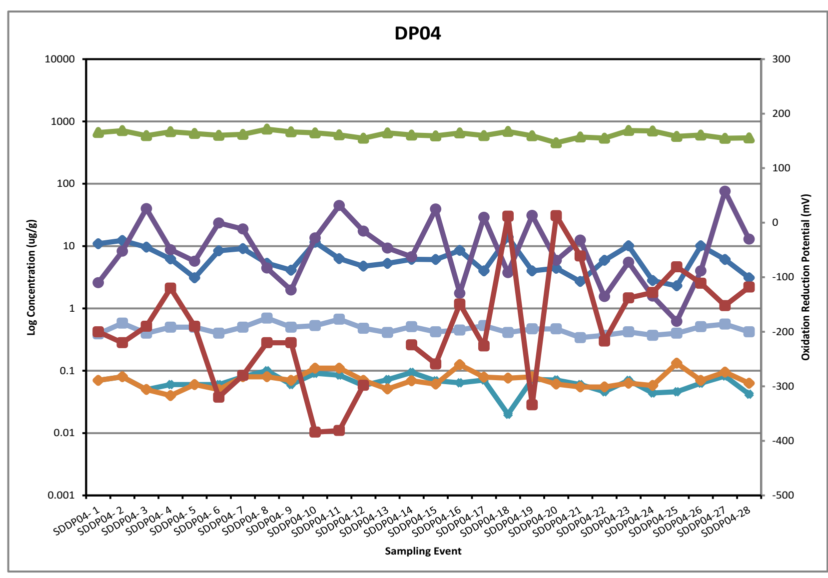


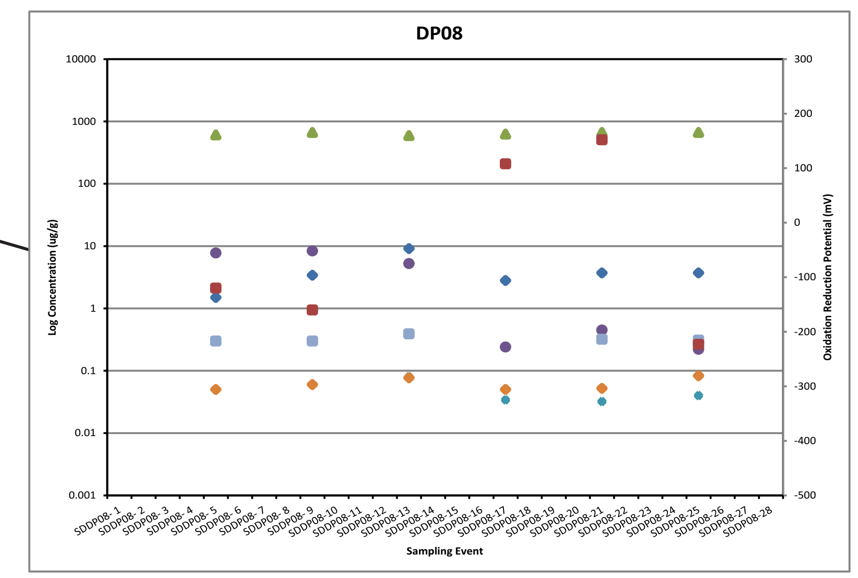


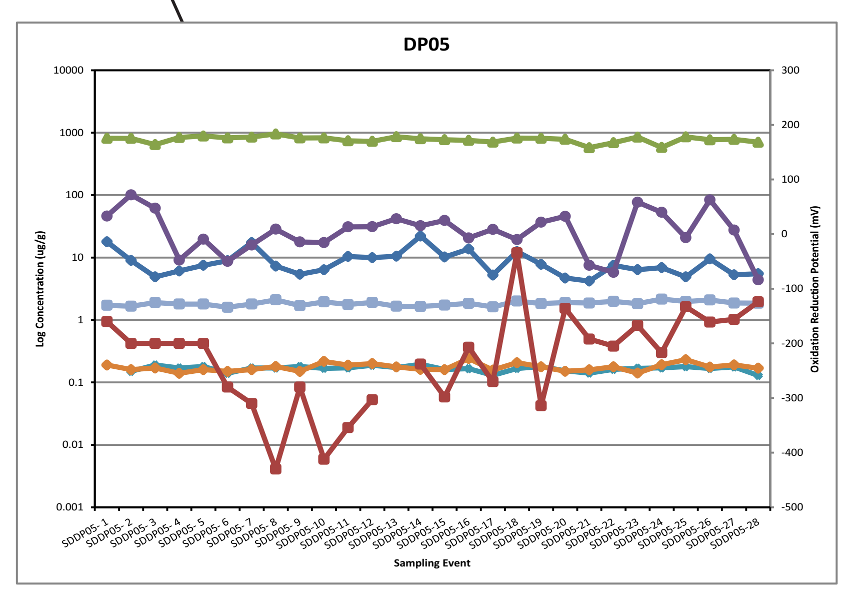


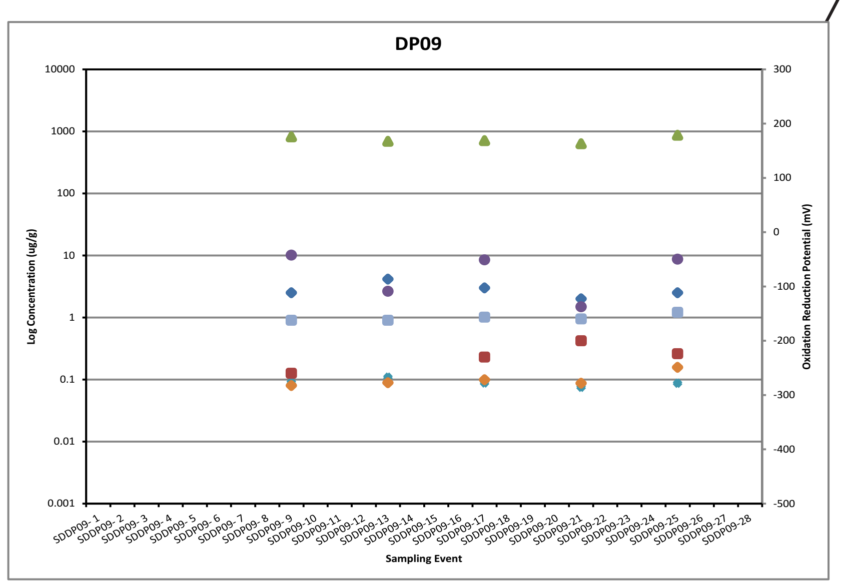












Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon
- Sediment / Oxidation Reduction Potential

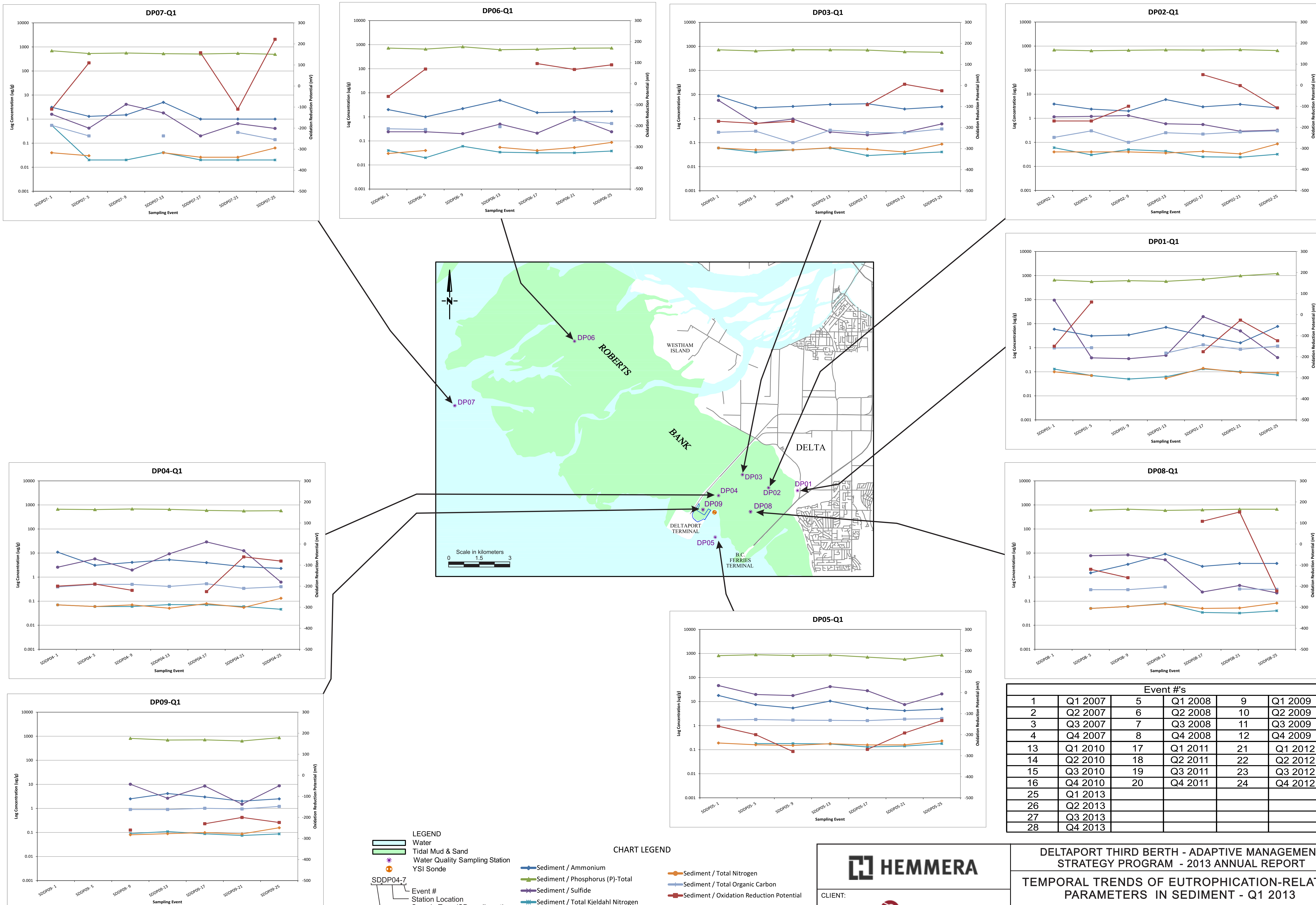
HEMMERA

CLIENT:
PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT (ALL QUARTERS w/ORP)

PROJECT No. 499-002.24 | March 2014 | FIGURE 40b



Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde
SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
Sediment / Ammonium
Sediment / Phosphorus (P)-Total
Sediment / Sulfide
Sediment / Total Kjeldahl Nitrogen
Sediment / Total Nitrogen
Sediment / Total Organic Carbon
Sediment / Oxidation Reduction Potential

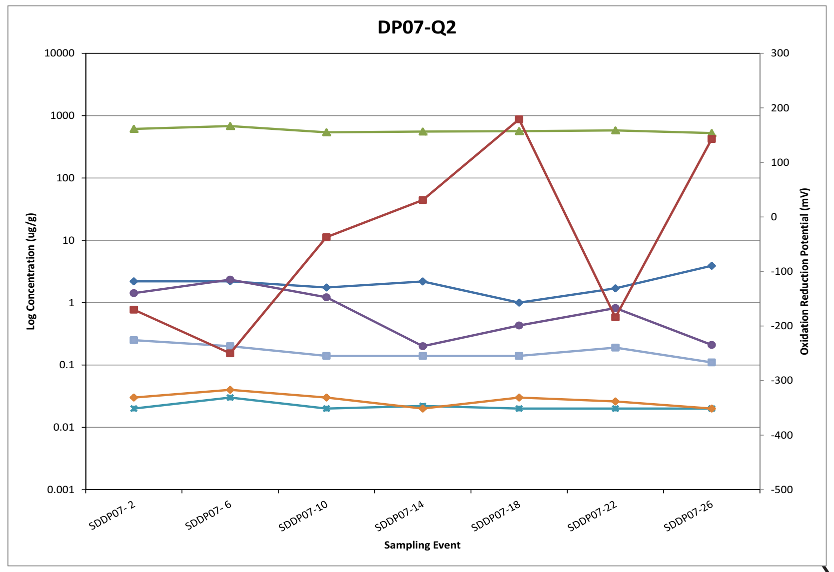
HEMMERA

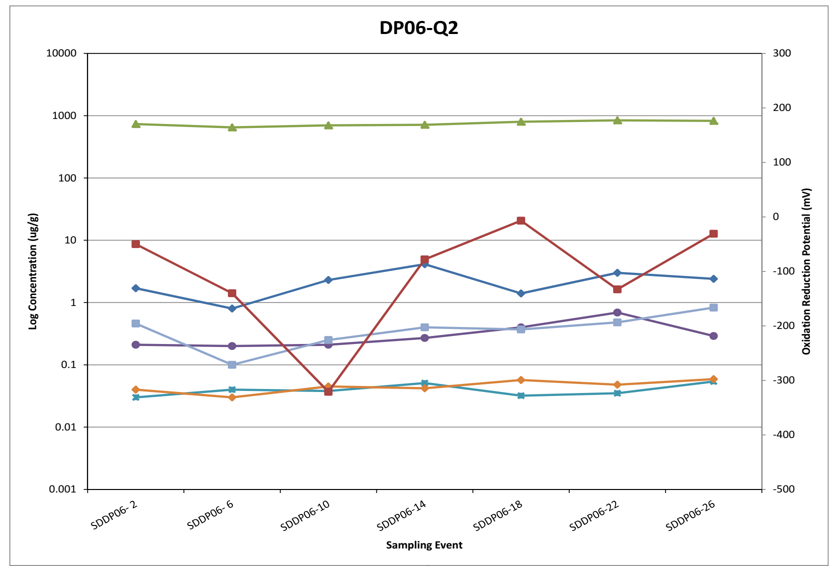
CLIENT: PORT METRO vancouver

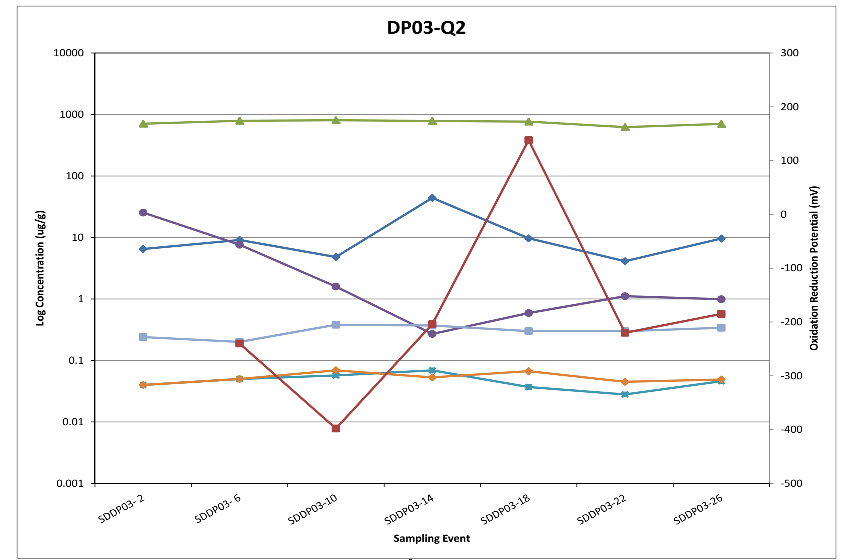
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

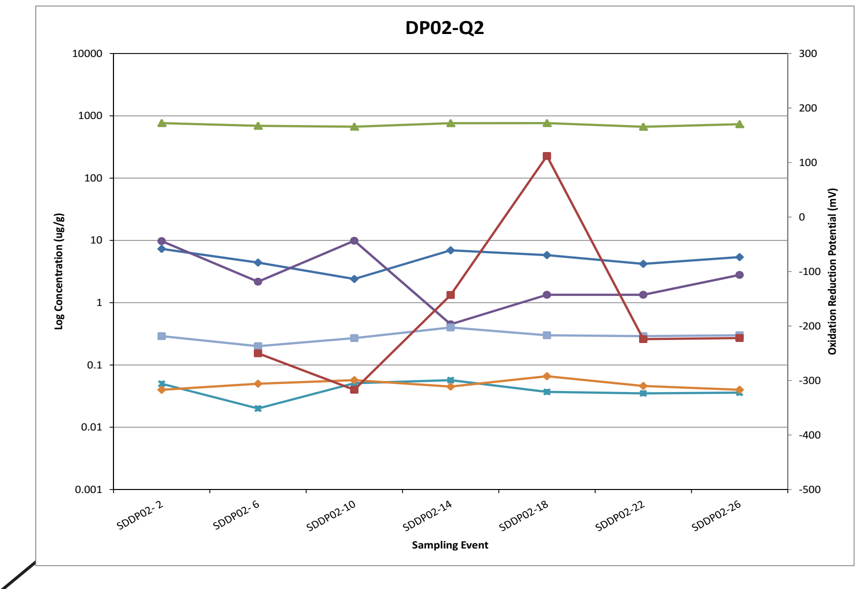
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT - Q1 2013

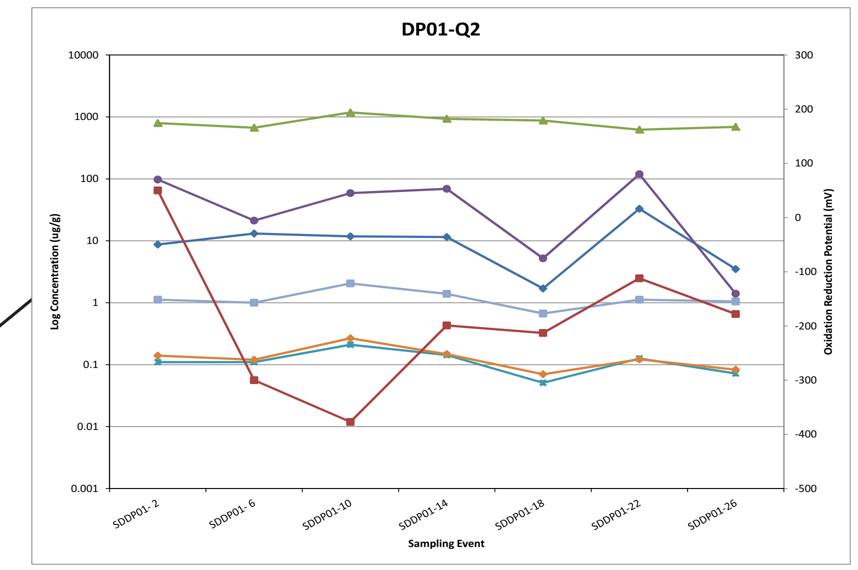
PROJECT No. 499-002.24 | March 2014 | FIGURE 41-Q1

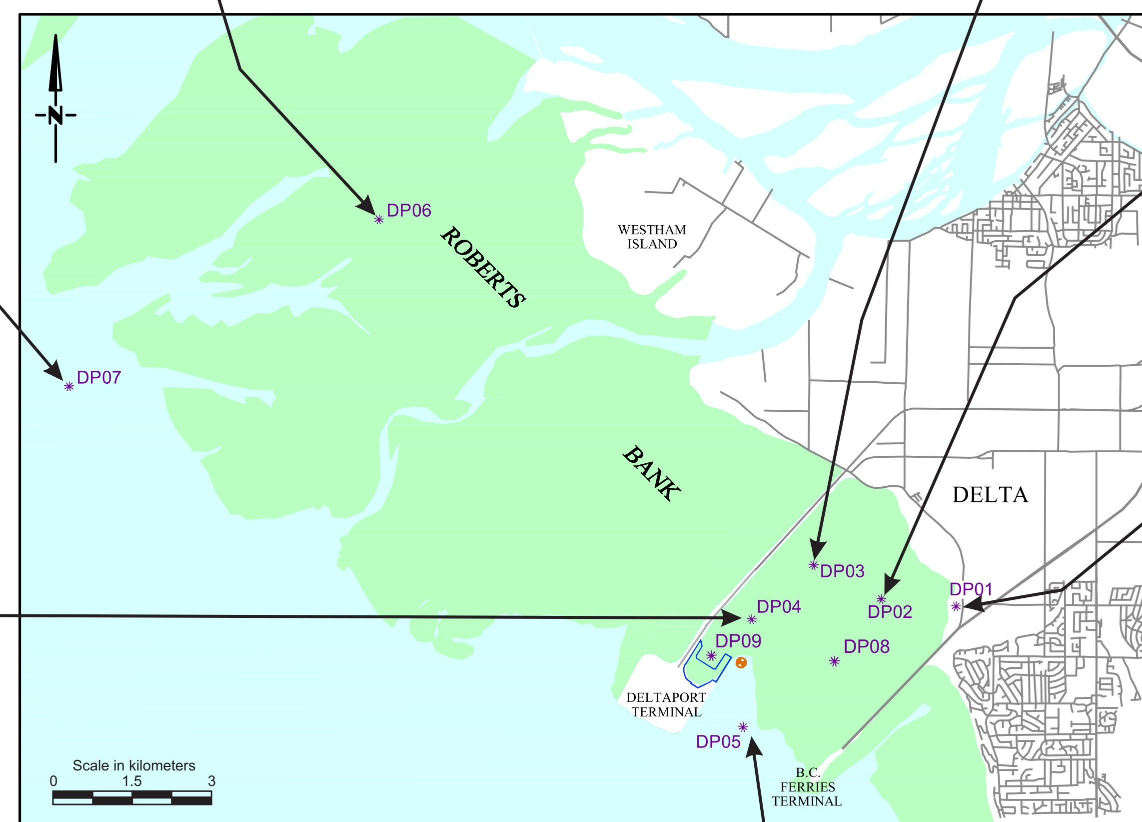


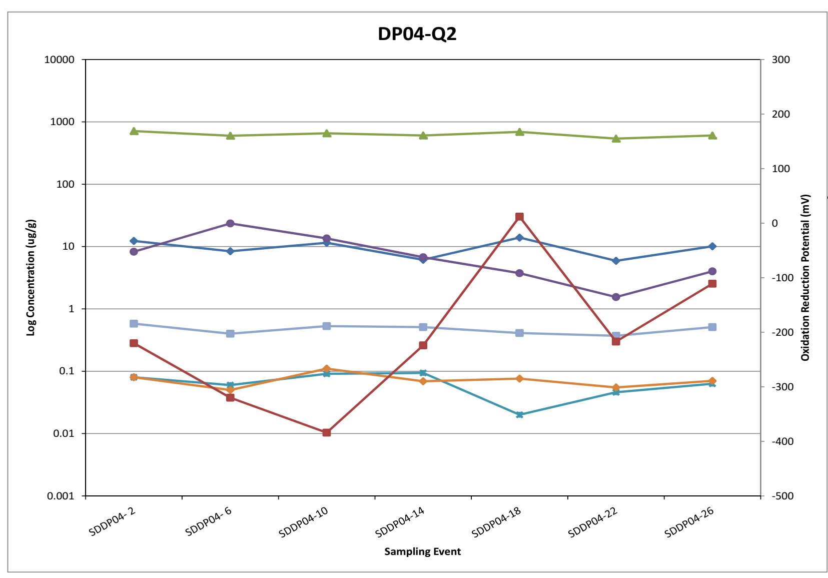


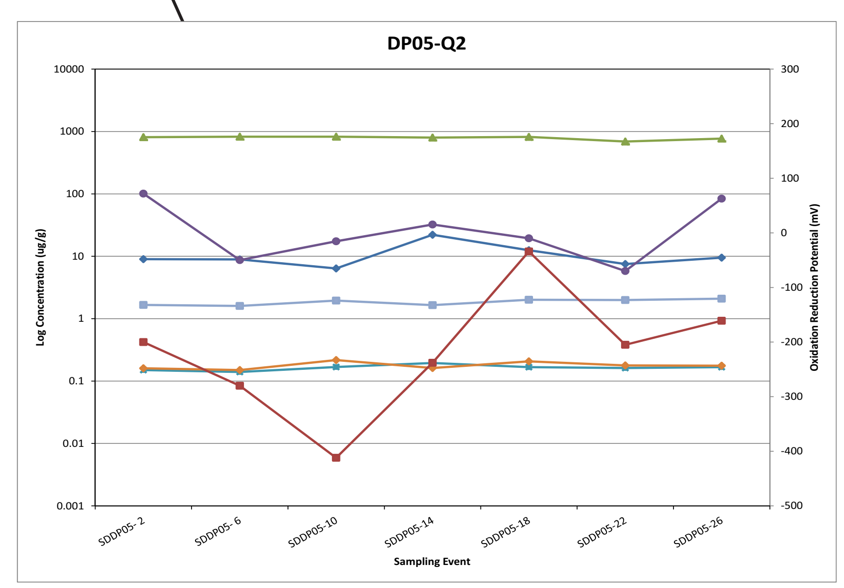












Event #'s

1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon
- Sediment / Oxidation Reduction Potential

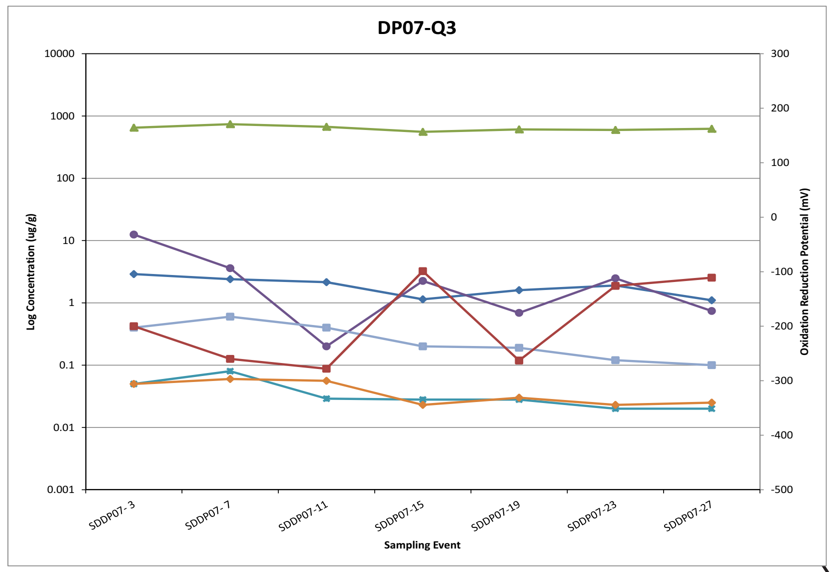
HEMMERA

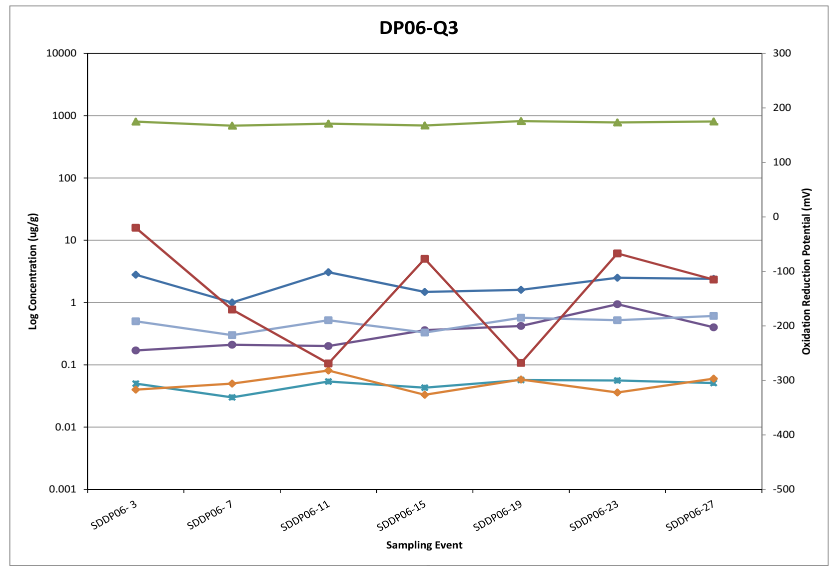
CLIENT: PORT METRO vancouver

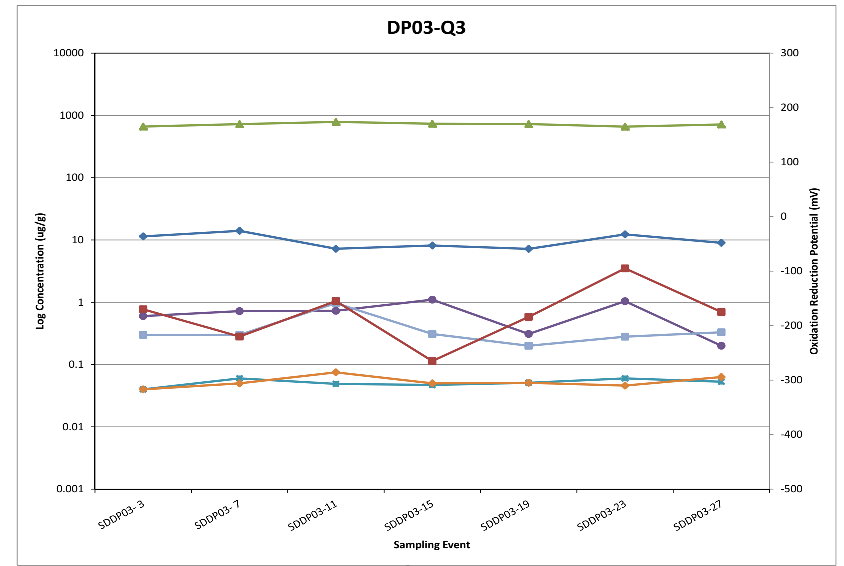
DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

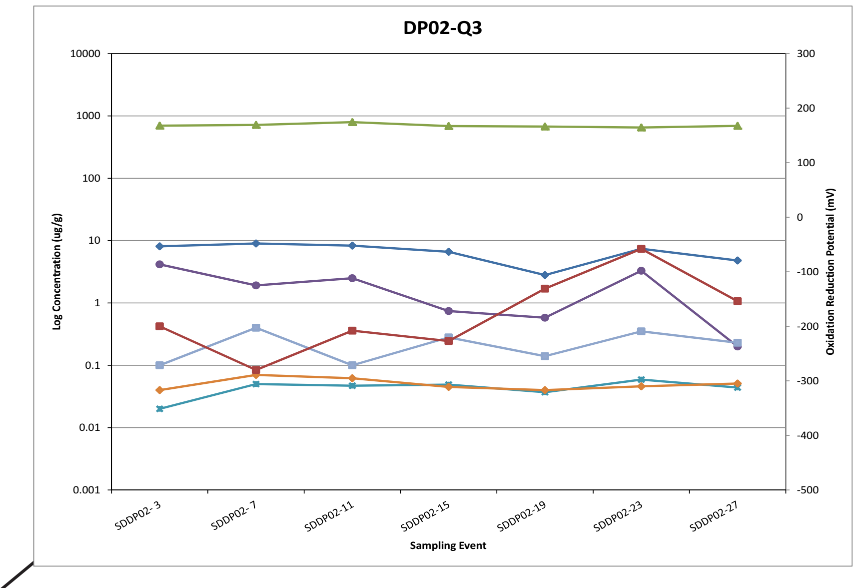
TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT - Q2 2013

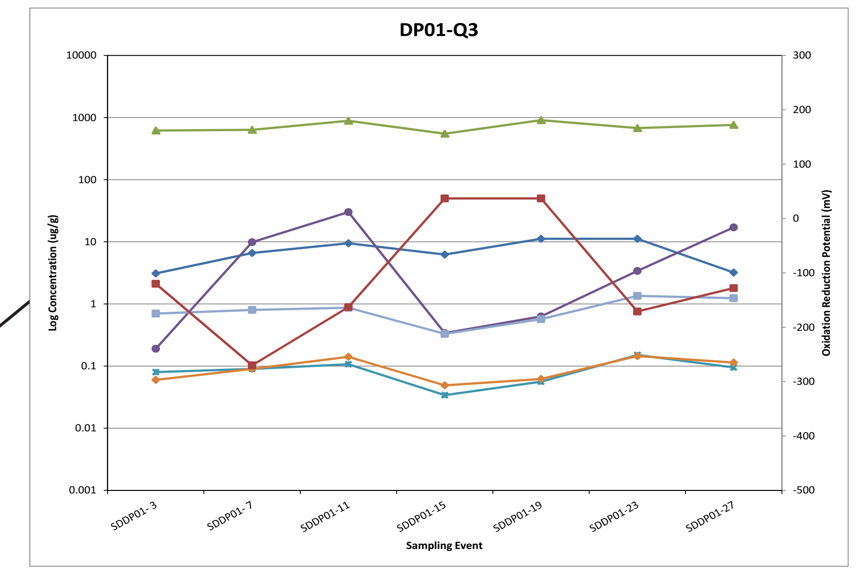
PROJECT No. 499-002.24 | March 2014 | FIGURE 41-Q2

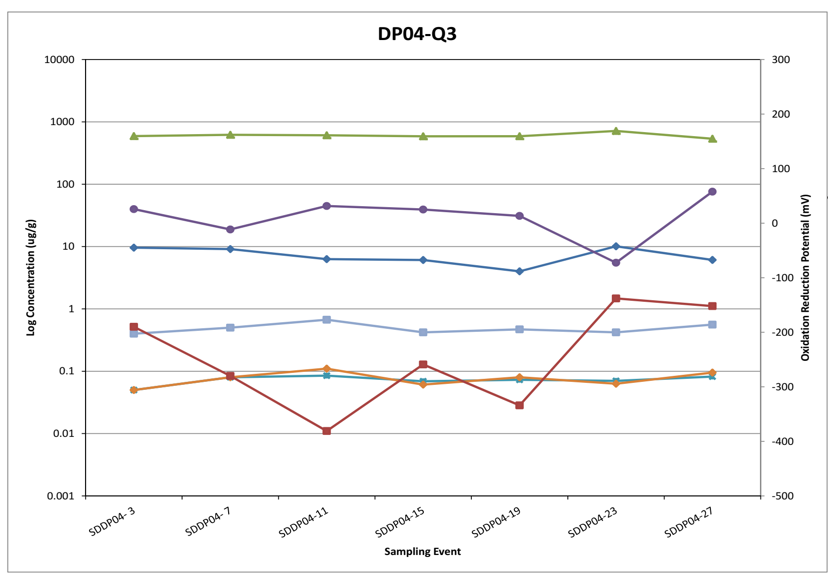


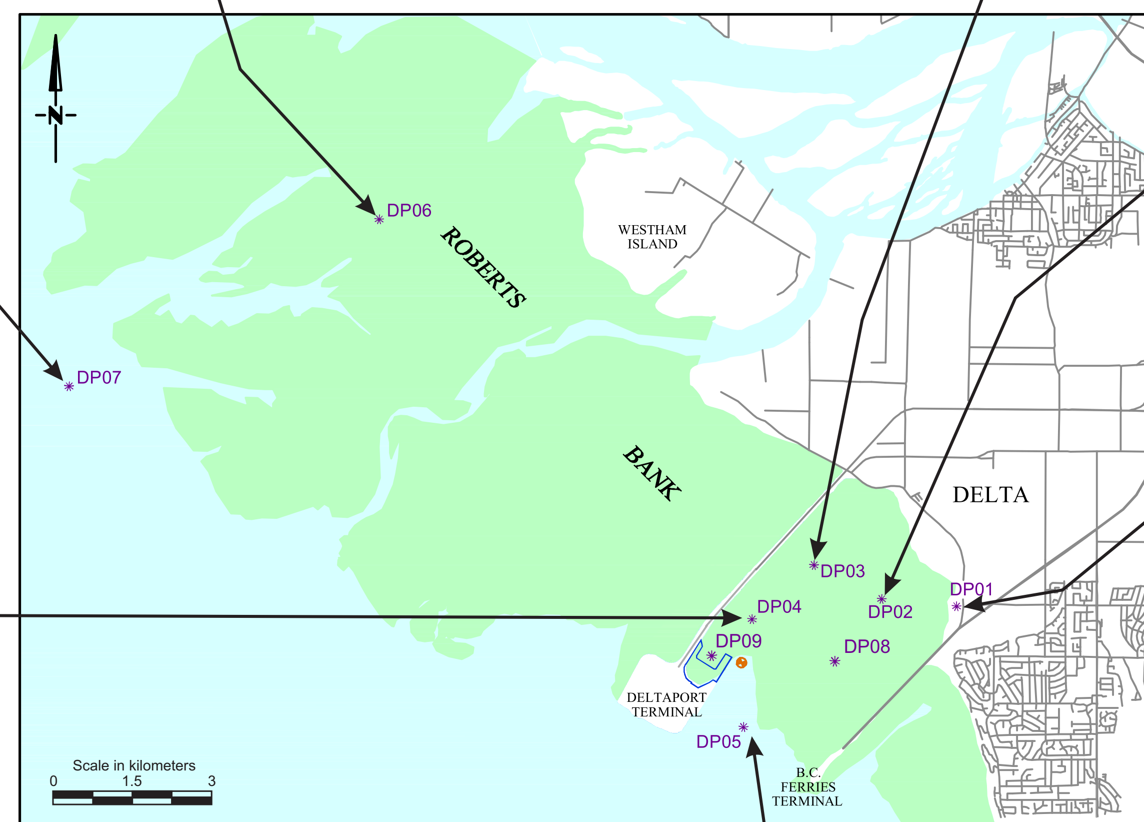


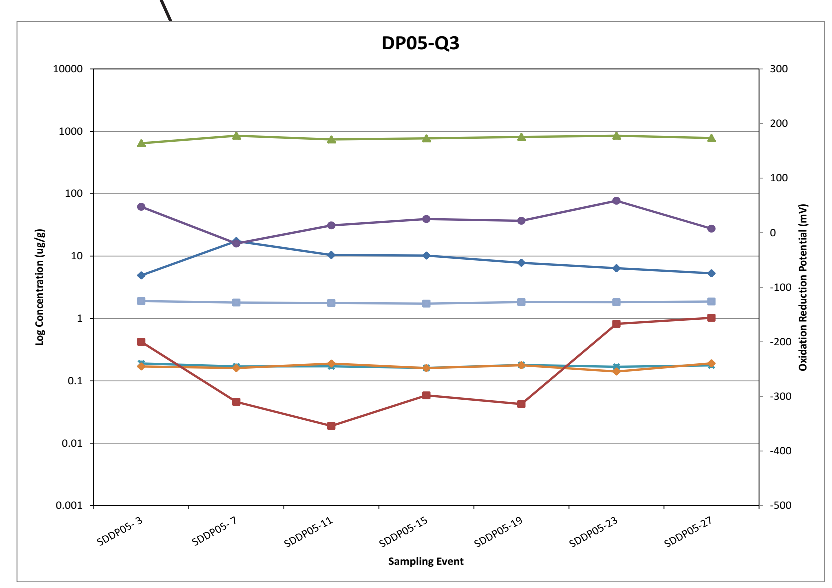












Event #'s							
1	Q1 2007	5	Q1 2008	9	Q1 2009		
2	Q2 2007	6	Q2 2008	10	Q2 2009		
3	Q3 2007	7	Q3 2008	11	Q3 2009		
4	Q4 2007	8	Q4 2008	12	Q4 2009		
13	Q1 2010	17	Q1 2011	21	Q1 2012		
14	Q2 2010	18	Q2 2011	22	Q2 2012		
15	Q3 2010	19	Q3 2011	23	Q3 2012		
16	Q4 2010	20	Q4 2011	24	Q4 2012		
25	Q1 2013						
26	Q2 2013						
27	Q3 2013						
28	Q4 2013						

LEGEND
Water
Tidal Mud & Sand
Water Quality Sampling Station
YSI Sonde

SDDP04-7
Event #
Station Location
Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon
- Sediment / Oxidation Reduction Potential

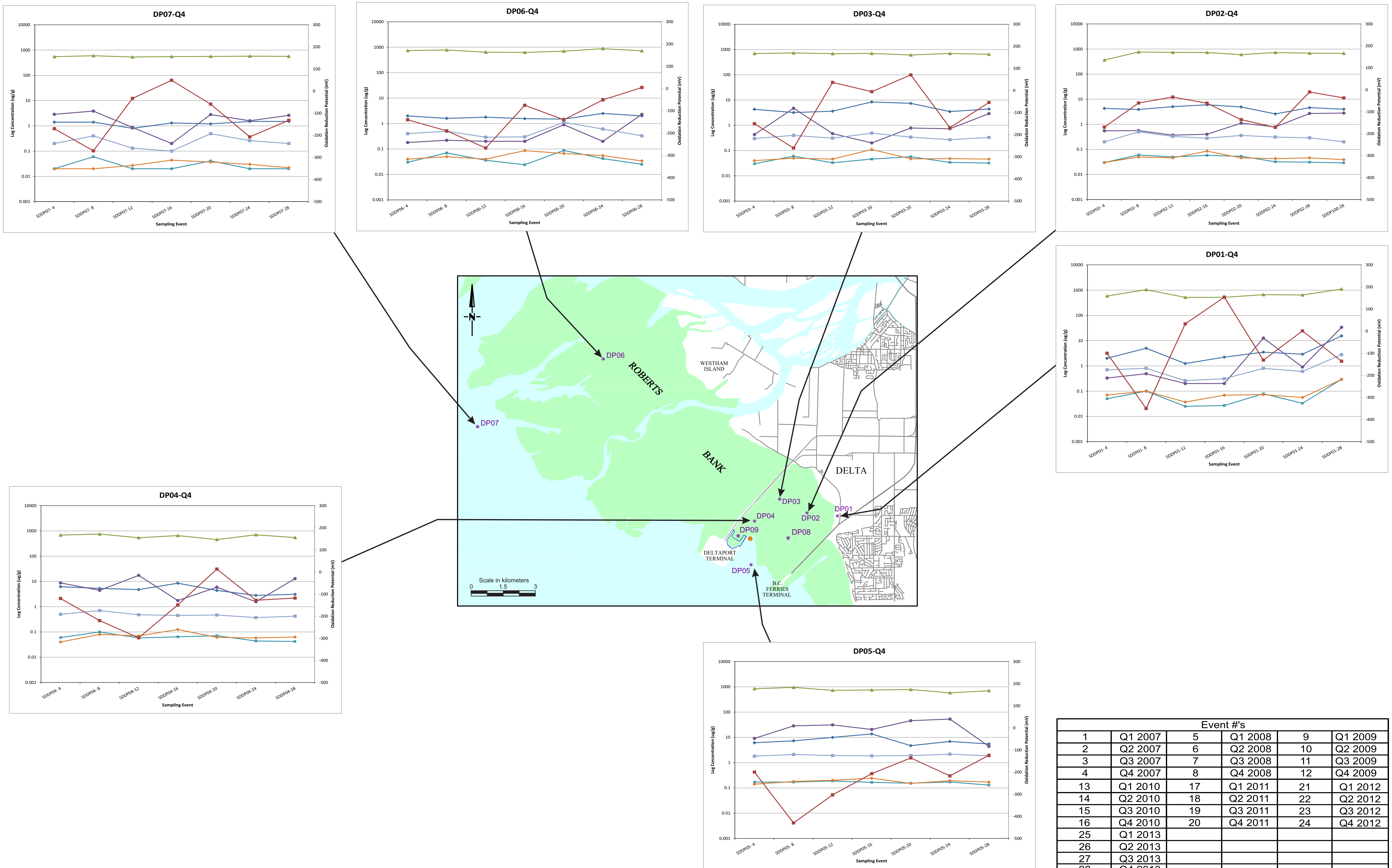
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT - Q3 2013

PROJECT No. 499-002.24 | March 2014 | FIGURE 41-Q3



Event #'s					
1	Q1 2007	5	Q1 2008	9	Q1 2009
2	Q2 2007	6	Q2 2008	10	Q2 2009
3	Q3 2007	7	Q3 2008	11	Q3 2009
4	Q4 2007	8	Q4 2008	12	Q4 2009
13	Q1 2010	17	Q1 2011	21	Q1 2012
14	Q2 2010	18	Q2 2011	22	Q2 2012
15	Q3 2010	19	Q3 2011	23	Q3 2012
16	Q4 2010	20	Q4 2011	24	Q4 2012
25	Q1 2013				
26	Q2 2013				
27	Q3 2013				
28	Q4 2013				

LEGEND
- Water
- Tidal Mud & Sand
- Water Quality Sampling Station
- YSI Sonde

SDDP04-7
- Event #
- Station Location
- Sample Type (SD=sediment)

NOTE: All measurements are in mg/kg

CHART LEGEND
- Sediment / Ammonium
- Sediment / Phosphorus (P)-Total
- Sediment / Sulfide
- Sediment / Total Kjeldahl Nitrogen
- Sediment / Total Nitrogen
- Sediment / Total Organic Carbon
- Sediment / Oxidation Reduction Potential

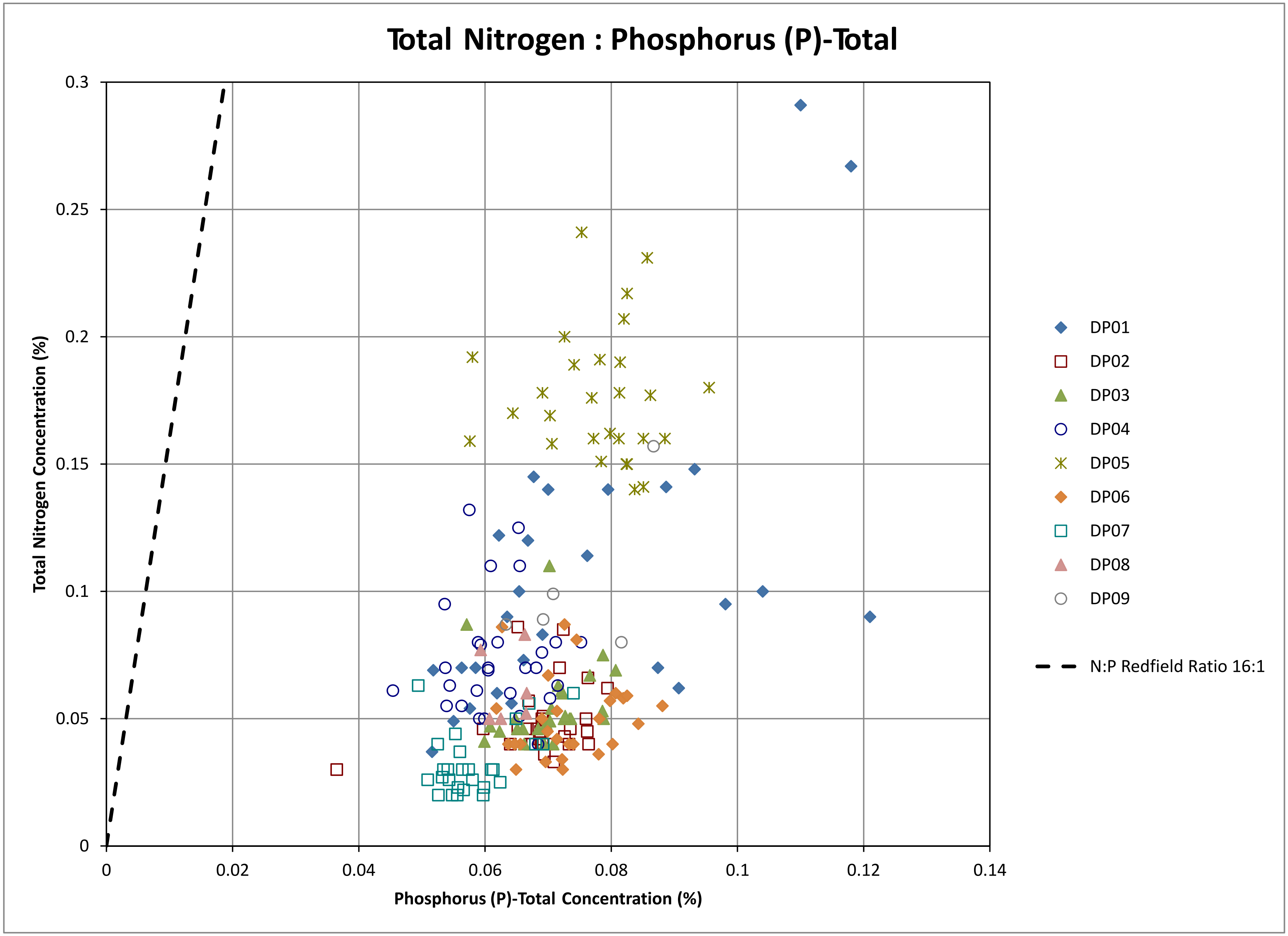
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

TEMPORAL TRENDS OF EUTROPHICATION-RELATED PARAMETERS IN SEDIMENT - Q4 2013

PROJECT No. 499-002.24 | March 2014 | FIGURE 41-Q4



HEMMERA

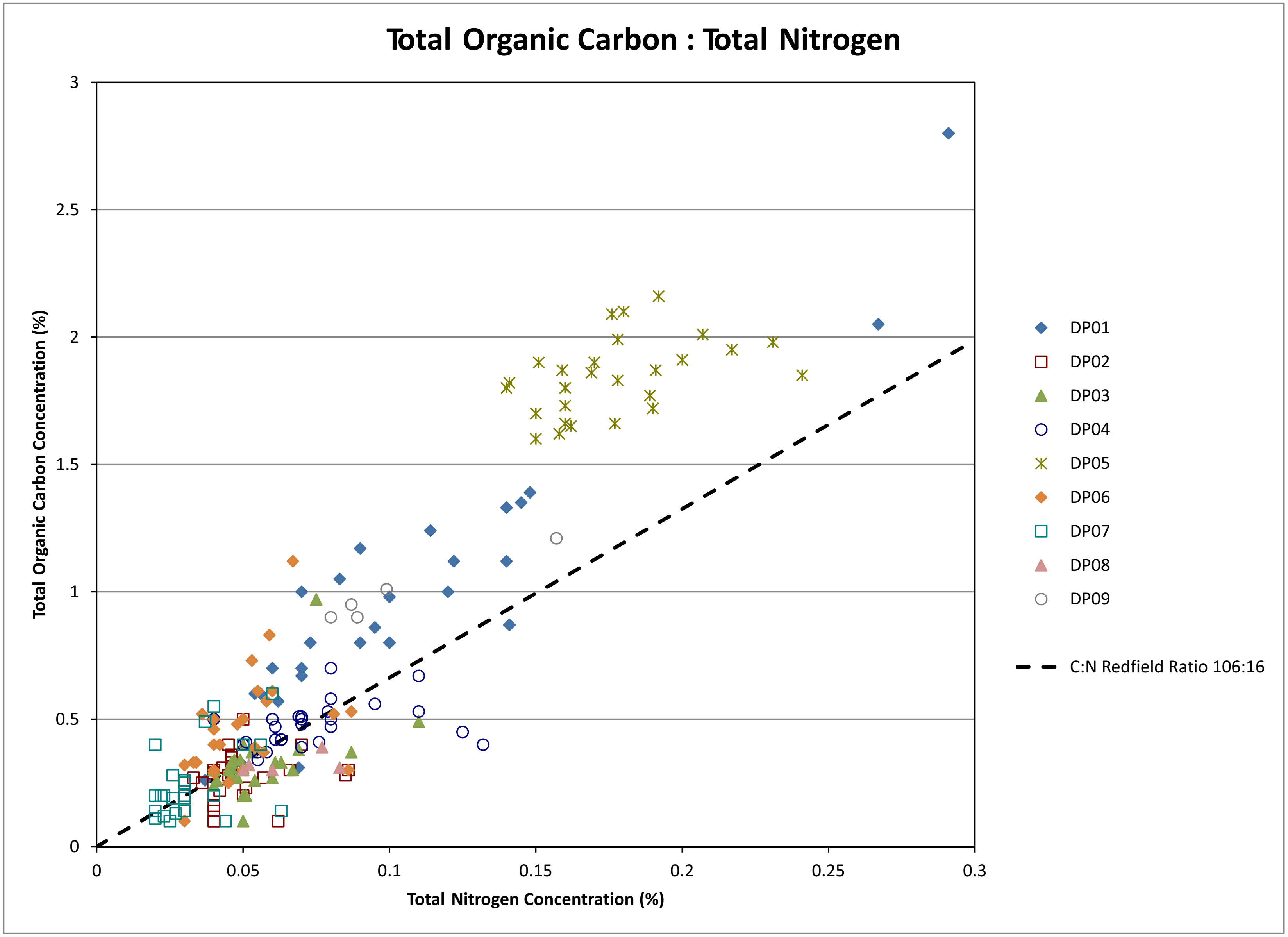
CLIENT:

PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

RATIO OF TOTAL NITROGEN TO TOTAL PHOSPHORUS IN SEDIMENT (2007 TO 2013)

PROJECT No. 499-002.24	March 2014	FIGURE 42



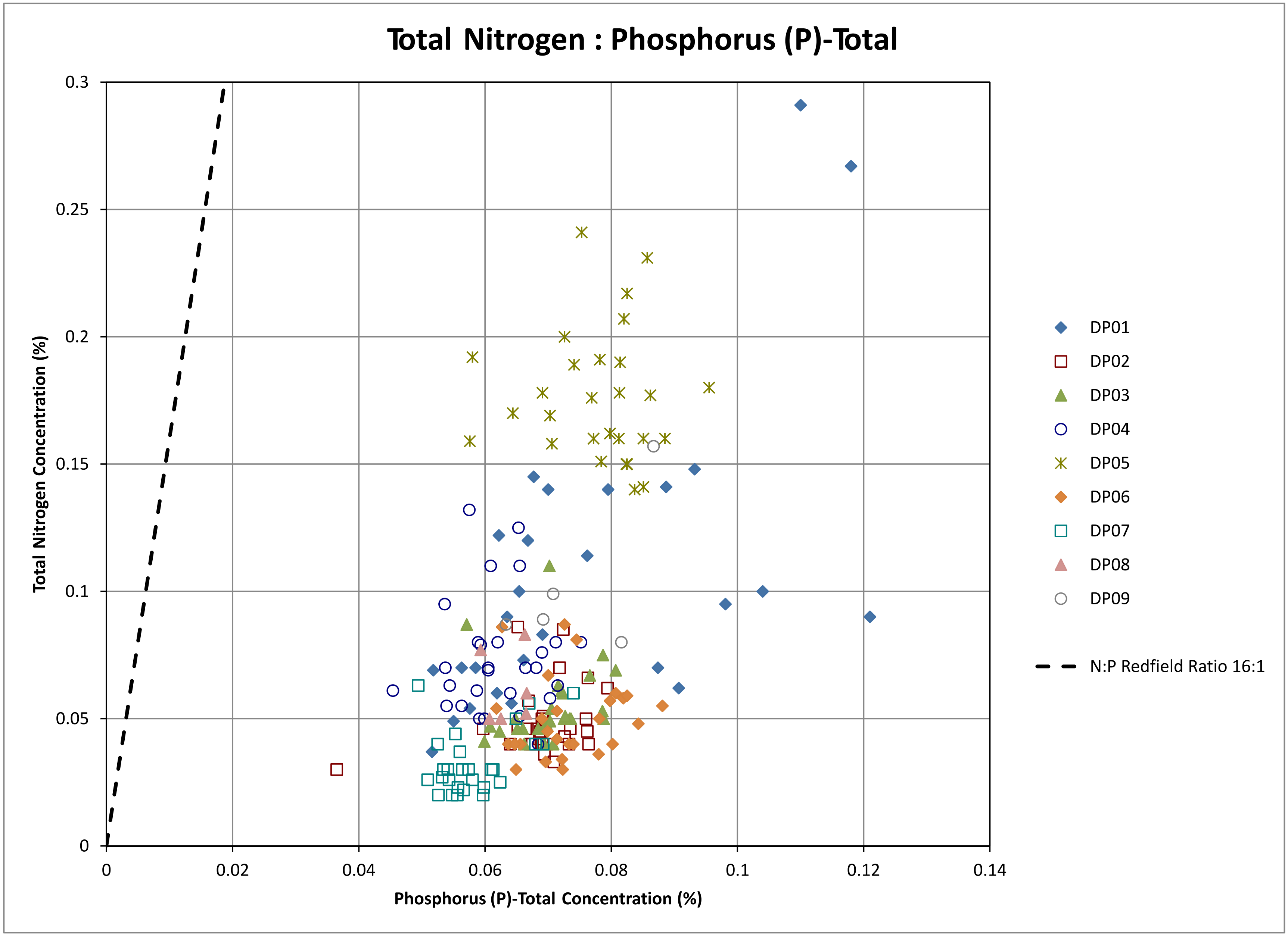
HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

RATIO OF TOTAL ORGANIC CARBON TO TOTAL NITROGEN IN SEDIMENT (2007 TO 2013)

PROJECT No.		
499-002.24	March 2014	FIGURE 43



HEMMERA

CLIENT: PORT METRO vancouver

DELTAPORT THIRD BERTH - ADAPTIVE MANAGEMENT STRATEGY PROGRAM - 2013 ANNUAL REPORT

RATIO OF TOTAL NITROGEN TO TOTAL PHOSPHORUS IN SEDIMENT (2007 TO 2013)

PROJECT No.		
499-002.24	March 2014	FIGURE 44

TABLES

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2007	1	March 22 - 24	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 24 - 25	Bird Survey
		April 7 - 12	Bird Survey
		April 20	Install DoD Rods Sediment Samples Crest Protection Monitoring - photos only
		April 23 - 24	Bird Survey
	2	May 7 - 8	Bird Survey
		May 22 - 23	Bird Survey
		June 5 - 6	Bird Survey
		June 18 - 19	Bird Survey
		June 20 - 21	Sediment and Surface Water Quality Sampling
		July 3 - 4	Bird Survey
		July 12 - 16	Eelgrass Survey
		July 16 - 17	Bird Survey
		July 30	DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download Aerial Photographs
	3	July 30 - 31	Bird Survey
		August 17 - 18	Bird Survey
		August 30 - 31	Bird Survey
		September 14 - 15	Bird Survey
		October 1 - 2	Sediment and Surface Water Quality Sampling
		October 2	DoD Rods Sediment Samples Crest Protection Monitoring - surveys only
		October 2 - 3	Bird Survey
		October 18 - 20	Bird Survey
		October 29	Remaining DoD Rods Remaining Sediment Samples Turbidity Sensor Download
	4	November 1 - 4	Bird Survey
		November 15 - 16	Bird Survey
		November 27	DoD Rods Crest Protection Monitoring - no surveys (equipment failure) Turbidity Sensor Download - Sensor 2 only
		November 29 - 30	Bird Survey
		December 10	Sediment and Surface Water Quality Sampling
		December 15	Bird Survey
		December 28	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2008	1	January 11	Bird Survey
		January 21	DoD Rods Crest Protection Monitoring - surveys only Turbidity Sensor Download - Sensor 2 only
		January 23	Bird Survey
		February 8	Bird Survey
		February 22 - 25	Bird Survey
		March 3-5	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 10 - 12	Bird Survey
		March 27 - 29	Bird Survey
	2	April 9	DoD Rods Installation of 6 additional DoD Rods Sediment Samples Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Install Wave Sensors
		April 10 - 11	Bird Survey
		April 24 - 25	Bird Survey
		May 8 - 9	Bird Survey
		May 22 - 23	Bird Survey
		May 29 - 30	Sediment and Surface Water Quality Sampling
		June 23	Bird Survey
	3	July 3	DoD Rods Installation of 2 additional DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Aerial Photographs Wave Sensors Download
		July 22	Bird Survey
		August 14 - 17	Eelgrass Survey
		August 19	Bird Survey
		September 20 - 21	Bird Survey
		September 23 - 24	Sediment and Surface Water Quality Sampling
	4	October 14	Bird Survey
		October 17	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 & #2 only
		November 20	Bird Survey
		December 10	Sediment and Surface Water Quality Sampling
		December 17 - 20	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2009	1	February 7	DoD Rods Wave Sensors Download - #1 & #2 only
		March 5	Crest Protection Monitoring - surveys only Install replacement Turbidity Sensor Installed Wave Sensors - #1 & #3 only
		January 26	Bird Survey
		February 19	Bird Survey
		February 23 - 24	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 26 - 27	Bird Survey
	2	April 15 - 16	Bird Survey
		April 27	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 & #2 only
		May 4 - 7	Bird Survey
		May 20	Bird Survey
		May 20	Sediment and Surface Water Sampling
		May 20	Wave Sensors Download - #3 only
		May 26	Install replacement for Turbidity Sensor 2 (new design)
		June 12	Bird Survey
		June 23	Tidal Current Monitoring - collection of ADCP measurements
	3	July 17	Bird Survey
		July 20	DoD Rods Crest Protection Monitoring - photos & surveys Turbidity Sensor Download - Sensor 2 only Wave Sensors Download - #1 and #2 only Aerial Photographs
		August 14 - 17	Eelgrass Survey
		August 13	Bird Survey
		September 14	Bird Survey
		September 14 - 15	Sediment and Surface Water Quality Sampling
		September 15	Wave Sensors Download - #3 only
			Install replacement Wave Sensor #2
	4	October 8	Reprogram Wave Sensor #2
		October 17 - 18	Bird Survey
		November 3	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor 2 only Wave Sensors - #1 & #2 only
		November 15	Bird Survey
		December 3	Sediment and Surface Water Quality Sampling
		December 13	Bird Survey

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2010	1	January 17	Bird Survey
		January 23	Wave Sensor #3 - instrument not located
		January 28 - 30	DoD Rods Crest Protection Monitoring - surveys only Turbidity Sensor Download - Sensor #2 only Wave Sensors Download - #1 and #2 only
		February 17	Bird Survey
		March 8 - 9	Sediment, Surface Water, and Benthic Invertebrate Sampling
		March 16	Bird Survey
	2	April 5	Wave Sensor #1 removed Wave Sensor #3 reinstalled
		April 14	Bird Survey
		May 16 - 17	DoD Rods Sediment Samples Turbidity Sensor Download - Sensor #2 only Wave Sensors Downloaded - Sensors #1 and #2 only
		May 18 - 27	Topographic Surveys begin- 2 days
		June 7	Wave Sensor Download - Sensor #3 only
		June 7 - 8	Sediment and Surface Water Quality Sampling
		June 14 - 17	Bathymetric Surveys begin - 3 days
		June 15	Bird Survey
	3	July 9	Aerial Photographs
		July 9 - 12	Eelgrass Survey
		July 14	Bird Survey
		August 9	DoD Rods Crest Protection Monitoring - surveys and photos Turbidity Sensor Download - Sensor #2 only Wave Sensor Download - Sensor #2 only
		August 20	Bird Survey
		August 30 - 31	Sediment and Surface Water Quality Sampling
		August 31	Wave Sensor Removal - Sensors #2 and #3 Turbidity Sensor #2 Removal
	4	November 7 - 8	DoD Rods Sediment Samples
		December 2	Sediment and Surface Water Quality Sampling

Table 1: Monitoring Dates

Year	Quarter	Date	Monitoring Activity
2011	1	January 18	DoD Rods
			Crest Protection Monitoring - surveys only
		February 16	Bird Survey
		March 2 - 4	Sediment, Surface Water, and Benthic Invertebrate Samples
		March 6	Bird Survey
	2	April 13	Bird Survey
		April 19	DoD Rods
			Sediment Samples
		June 8 - 9	Sediment and Surface Water Quality Sampling
		June 20	Bird Survey
	3	July 13	DoD Rods
			Crest Protection Monitoring - surveys and photos
		July 19	Bird Survey
		July 28-August1	Eelgrass Survey
		August 11-12	Eelgrass Survey
		August 19	Bird Survey
		September 6 - 7	Sediment and Surface Water Quality Sampling
	4	October 29	DoD Rods
			Sediment Samples
		November 7 - 8	Sediment and Surface Water Quality Sampling
2012	1	February 20 & 21	Sediment and Surface Water Quality Sampling
	2	May 8	DoD Rods Decomissioning
			Sediment Grain Size Variability Investigation
		May 29	Sediment and Surface Water Quality Sampling
		June 15	Bird Survey
	3	July 16	Bird Survey
		July 29 - Aug 1	Eelgrass Survey
		August 13 & 15	Eelgrass Survey
		August 15	Bird Survey
		September 2	SIMS Survey
		September 5	Sediment and Surface Water Quality Sampling
	4	December 6 & 10	Sediment and Surface Water Quality Sampling
2013	1	February 18 & 19	Sediment and Surface Water Quality Sampling
	2	May 24 to 28	Topographic and bathymetric surveys
		June 4	Sediment and Surface Water Quality Sampling
	3	July 5, August 6 & 7	Eelgrass Survey (Mapping Distribution)
		July 20 to 24	Eelgrass Survey (Health and Vigour)
		July 30	Topographic and bathymetric surveys
		September 24	Sediment and Surface Water Quality Sampling
	4	October 21	Topographic and bathymetric surveys
		December 9 & 10	Sediment and Surface Water Quality Sampling

Table 2: Chronology of Adaptations to the Monitoring Programs

Activity & Sub-task	Date	Event	Description
Crest Protection Structure			
Photographs	April 19, 2007	Program Inception	Established initial photo points (CRST 01 to 14).
	July 30, 2007	Q2-2007	Establish additional photo monitoring point (CRST 15).
	July 3, 2008	Q3-2008	Last quarterly monitoring - switch to annual photos.
	January 2012	Discontinued	Discontinued annual photographs based on 6 years of monitoring results
Surveys	July 30, 2007	Q2-2007	Establish 5 monitoring cross sections.
	July 3, 2008	Q3-2008	Last quarterly monitoring - switch to bi-annual surveys (Q1 and Q3).
	January 2012	Discontinued	Discontinued bi-annual surveys based on 6 years of monitoring results
Turbidity Monitoring			
Sensors	June 14, 2007	Sensor Installation	Two sensors installed in study area.
	July 12, 2007	Move Sensor	Sensor 1 moved from tide channel to new location inside Crest Protection Structure.
	July 31, 2007	Replace Sensor	Sensor 2 malfunctioning so replaced with temporary instrument.
	Oct 30, 2007	Sensor Failure	Sensor 1 malfunctioning due to water penetration, replaced with temporary instrument.
	Mar 6, 2008	Sensor Failure	Temporary instrument failed due to water penetration, replaced with original repaired Sensor 1
	April 10, 2008	Sensor Failure	Original Sensor 1 instrument failed due to water penetration. Sensor 1 removed from site permanently.
	Feb 7, 2009	Sensor Missing	Sensor installation disturbed during abnormal weather event. Turbidity Sensor 2 missing. All data back to 17 Oct, 2008 lost with instrument.
	May 26, 2009	New Sensor Installed	Replacement for Sensor 2 installed. Re-start turbidity monitoring
	31 Aug, 2010	Sensor Removal	Completion of tubidity monitoring program.
Tide Gauge	June 14, 2007	Gauge Installation	Installation on caisson.
	Sept 6, 2007	Gauge Damaged	Gauge damaged and repaired, loss of some data.
	Oct 29, 2007	Gauge Damaged	Instrument dangling from rope, apparently tampered with.
	April 10, 2008	Gauge Damaged	Pipe housing missing.
	April 21, 2008	Gauge Repaired	Pipe housing replaced.
	July 3, 2008	Gauge Damaged	Pipe housing missing - instrument secured temporarily
	Oct 17, 2008	Gauge Damaged	Removed from site permanently. Rely on CHS gauge data.
Water Samples	May 17, 2007	Data Collection	Collection of water samples. Turbidity of samples very low.
	Nov 5, 2007	TSS Memo	NHC memo outlining methodology for relating turbidty to total suspended solids. Suspend collection of water samples.
Monitoring of Erosion and Deposition			
DoD Rods	April 19, 2007	Installation	Twenty-six rods installed.
	April 9, 2008	Installation	Additional six rods installed in area of new drainage channels
	July 3, 2008	Installation	Additional 2 rods installed in pond feature.
	January 2012	Discontinued	Decommissioned DoD rods and discontinued quartering monitoring based on 6 years of monitoring results
Sediment Samples			
Sediment Sampling	April 19, 2007	Program Inception	Samples collected at each DoD rod location on a bi-annual basis.
	January 2012	Discontinued	Discontinued bi-annual monitoring based on 6 years of monitoring results
Orthophotographic Interpretation			
Aerial Photos	July 14, 2007	Photos	Annual aerial photos of the study area flown commences (ongoing)
Coastal Geomorphology Mapping			
Bathymetric & Topographic Surveys	July 8, 2007	Surveys	Combined bathymetric and topographic surveys (completed in 2007, 2010 and 2013)
	July 13, 2007	Surveys	Topographic surveys, bathymetric surveys suspended due to rough seas.
	Nov 7, 2007	Surveys	Bathymetric surveys completed.
	May 18, 2010	Surveys	Topographic surveys
	May 19, 2010	Surveys	Topographic surveys
	Jun 14, 2010	Surveys	Bathymetric surveys begin.
	Jun 17, 2010	Surveys	Bathymetric surveys completed.
	May to Oct 2013	Surveys	Combined topographic and Bathymetric surveys completed during this period depending on tides.

Table 2: Chronology of Adaptations to the Monitoring Programs

Activity & Sub-task	Date	Event	Description
Wave and Current Monitoring			
AWAC (work by ASL)	Feb 20, 2007	AWAC Deployed	
	April 20, 2007	AWAC Recovered	Found to have been dragged several hundred metres, pressure sensors not functioning.
	June 6, 2007	AWAC Re-Deployed	
	Sept 27, 2007	AWAC Damaged	Burial by temporary sediment placement. Recovered but damaged beyond repair.
NHC Wave Sensors	Jan 30, 2008	NHC Memo	Alternative strategy for current and wave monitoring
	April 10, 2008	Wave Sensors Installed	
	May 4, 2008	Sensor #3 Dragged	NHC contacted by Vancouver Pile and Dredge on June 19, instrument was dragged by tug boat operator.
	June 23, 2008	Sensor #3 Re-Deployed	
	Sept, 2008	Sensor #3 Removed	Sensor removed by DP3 construction worker to facilitate construction activity.
	Feb 7, 2009	Sensor #1 and #2 Dragged	Sensor #1 found to have been dragged approximately 200 metres. Sensor #2 found about 10-20 metres from original location.
	Mar 5, 2009	Sensor #3 Re-Deployment	
	April 27, 2009	Sensor #1 Removed	Sensor removed and sent to supplier for re-calibration after dragging episode.
	May 26, 2009	Sensor #1 Re-Deployed	
	July 20, 2009	Sensor #2 Removed	Sensor failed due to water penetration.
	Sep 15, 2009	New Sensor #2 Installed	
	Jan 28, 2010	Sensor #3 Missing	Instrument and data from Sep to Dec 2009 lost.
	28 Jan, 2010	Sensor #3 Missing	Instrument and data from Sep to Dec 2009 lost.
	5 Apr, 2010	Sensor location change	Sensor #1 removed. Sensor #3 reinstalled.
	31 Aug, 2010	Sensor Removal	Sensors #2 and #3 removed. Completion of wave monitoring program.
ADCP Tidal Current Measurements	June 23, 2009	Data Collection	ADCP measurments of tidal currents to verify results of NHC numerical modelling.
Sediment, Surface Water, and Benthic Invertebrate Sampling			
Quality Monitoring Program	June 20, 2007	Q2-2007	PAH and TBT dropped from sediment analytical program
			Dissolved iron added to surface water analytical program
	Dec 10, 2007	Q4-2007	Rush sulphide analysis implemented
	Mar 3, 2008	Q1-2008	Additional sampling station (DP08) added for benthic invertebrate sampling events
	Feb 23, 2009	Q1-2009	Additional sampling station (DP09) added for benthic invertebrate sampling events
	January 2009	Q1-2009	Implementation of Sonde deployment one week per quarter
	Mar 3 - 4, 2011	Q1-2011	Conducted benthic sampling in Q1 2011, instead of Q1 2012 (as per SAC comments Dec 2010)
	Mar 3 - 4, 2011	Q1-2011	Implementation of metals analysis for surface water and sediment samples only in Q1 (ongoing)
	January 2012	Discontinued	Discontinuation of the weekly Sonde deployment
Bird Surveys			
Surveys	June 23, 2008	Q2-2008	Survey frequency reduced to monthly
			Distance categories changed to larger categories
			TFN transect discontinued
			Point count stations on TFN merged
	Nov 20, 2008	Q4-2008	Implementation of windshield surveys for focal species (great blue heron and brant)
	January 2012	Discontinued	Discontinuation of brant windshield surveys based on 6 years of monitoring data
	January 2013	Discontinued	Discontinuation of great blue heron windshield surveys based on 7 years of monitoring data
Eelgrass Surveys			
Distribution Mapping Field Survey	Sept 7-8, 2007	Surveys	Annual surveys to ground-truth orthophoto interpretation commences (ongoing)
Eelgrass Health & Vigour	July 12-16, 2007	Surveys	Annual monitoring at nine reference stations commences
	July 19-23, 2009	Surveys	Annual monitoring at ten reference stations (ongoing)
SIMS Survey	August 25, 2009	Surveys	Triennial towed video survey to determine the lower limit of eelgrass distribution in the inter-causeway
SIMS Survey	September 2, 2012	Surveys	Triennial towed video survey to determine the lower limit of eelgrass distribution in the inter-causeway

Table 3: Rationale for Adaptations to the Adaptive Management Strategy

Change	Reason for Change	Reference
Dissolved iron analysis added for surface water	To determine if total iron exceedances were linked to particulate matter	Sec 2.2.2 (Q1-2007)
TBT not analyzed in sediment	No TBT source associated with DP3 construction, none detected in Q1-2007	Sec 1.3.1 (Q2-2007)
PAHs not analyzed in surface water	No PAH source associated with DP3 construction, none detected in Q1-2007	Sec 1.3.2 (Q2-2007)
Rush (24-hour) sulphide analysis implemented	To minimize sulphide volatilization	
Station DP08 added	To provided better spatial coverage in the inter-causeway area	Sec. 4.2 (2008 Annual report)
Station DP09 added	To evaluate the impact of new drainage channels in the inter-causeway area	Sec. 4.5 (2008 Annual report)
Addition of 8 new DoD rods	To provide greater resolution in area of new drainage channels & pond	Sec 4.1.1 (2007 Annual Report)
Removal of Turbidity Sensor 1	Turbidity levels not very high; harsh operating conditions; expensive repairs; redundancy with Turbidity Sensor 2	Sec 4.1.3 (2007 Annual Report)
Modifications to bird survey methodology	To increase the efficiency of data collection	Sec 4.6 (2007 Annual Report)
Reduction in Crest Protection surveys	Reduction to twice a year because measured very little change.	Sec 4.1.2 (2007 Annual Report)
Windshield surveys for Brant and Heron	To obtain a more accurate assessment of brant and heron numbers after reduction in point count stations at TFN and Tsawwassed Ferry transects	Sec 4.6 (2007 Annual Report)
Addition of 3 wave sensors	To replace destroyed AWAC and monitor wave height and wave period	NHC memo to VFPA of Jan 30, 2008
DP08 station added to benthic invertebrate sampling program	To provide better spatial coverage in the inter-causeway area	Sec 1.3.5 (Q1-2008)
Removal of Tide Gauge	Harsh operating conditions; developed relation between Point Atkinson station and local tide gauge	Sec 1.3.1.2 (Q3-2008)
Addition of an eelgrass reference station	Habitat changes at one of the established sites	Sec. 4.4 (2008 Annual report)
DP09 station added to benthic invertebrate sampling program	To provide better spatial coverage in the inter-causeway area	Sec 1.3.2 (2009 Annual Report)
Removal of Wave Sensors #2 and #3 and Turbidity Sensor	Completion of wave and turbidity monitoring program. DP3 not negatively affecting suspended sediment or wave heights.	Sec 4.1 (2009 Annual Report)
Wave Sensor #1 moved to location of Wave Sensor #3	Incoming wave heights more significant for determination of wave attenuation and overall wave climate.	Sec 2.2.7 (Q2-2010)
Conducted benthic sampling in Q1 2011, instead of Q1 2012	To have have a total of four years of annual benthic data (as per SAC comments Dec 2010)	Sec 5.5 (2010 Annual Report)
Conducted metals analysis of surface water and sediment in Q1 only beginning 2011	Metal concentrations to date did not exhibit a temporal trend and there is no evidence of metals loading as a result of DP3 construciton or operation	Sec 4.2 (2010 Annual Report)
Discontinued remaining field-based quarterly Coast Geomorphology monitoring program	No long-term physical changes have occurred on the tidal flats that could be attributed to the construction of DP3 (other than area of new drainage channels)	Sec 4.1 (2011 Annual Report)
Discontinue the benthic invertebrate program	No evidence of statistically significant temporal trends, or of spatial trends, that might be associated with the construction and operation of the DP3 project.	Sec 4.5 (2011 Annual Report)
Discontinued the Brant windshield surveys	No project affects have been documented to affect Brant use of the inter-causeway;	Sec 4.6 (2011 Annual Report)
Discontinue deployment of the sonde on weekly basis during quarterly events	Numerous issue with the Sonde deployment and data download. Field measurements collected with a Sonde during sample collection available.	Sec 1.3.2 (2012 Annual Report)
Discontinued the Great Blue Heron windshield surveys	No project affects have been documented to affect Great Blue Heron use of the inter-causeway;	Sec 4.6 (2012 Annual Report)

Table 4: Summary of Wind Speed and Direction January to March, 2013

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	29	6	43	12	6	4	13	20
5-10	91	24	281	78	34	32	88	93
10-15	45	18	207	69	21	34	87	42
15-20	13	6	112	35	21	18	36	21
20-25	10	2	37	25	8	1	15	10
25-30	7	2	35	16	8	9	26	6
30-35	4	2	23	10	10	3	9	1
35-40	1		11	3		2	2	
40-45			13	2	2	1		
45-50			2			1	1	
50-55								
55-60								
60-65							1	
65-70								
Total	200	60	764	250	110	105	278	193

Note:

Total records =	1960	h
Total time winds calm =	194	h
Total observations =	2154	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-January to March, 2013

Table 5: Summary of Wind Speed and Direction April to June, 2013

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	7	1	27	18	7	4	17	17
5-10	43	17	189	74	53	61	95	86
10-15	37	11	179	107	58	71	117	93
15-20	20	3	88	57	34	50	108	66
20-25	9	1	26	21	11	14	26	14
25-30	5	1	13	17	6	6	12	6
30-35	6	1	11	4	8	2	7	4
35-40	1	1	6	1	1	1	3	3
40-45	2		6	2	2	2	1	1
45-50		1	4				3	
50-55			1	1			3	
55-60			1				1	
60-65								
65-70								
Total	130	37	551	302	180	211	393	290

Note:

Total records =	2094	h
Total time winds calm =	84	h
Total observations =	2178	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-April to June, 2013

Table 6: Summary of Wind Speed and Direction July to September, 2013

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	28	7	116	40	12	11	7	30
5-10	45	13	183	112	58	43	79	67
10-15	47	26	155	141	68	64	112	94
15-20	18	8	83	68	28	35	67	44
20-25	8	3	35	35	18	19	26	27
25-30	10	3	14	6	4	16	12	14
30-35		1	5	6		4	6	4
35-40	1		1	1		1	1	6
40-45								
45-50			1					
50-55								
55-60								
60-65								
65-70								
Total	157	61	593	409	188	193	310	286

Note:
Total records = 2197 h
Total time winds calm = 9 h
Total observations = 2206 h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-July to September, 2013

Table 7: Summary of Wind Speed and Direction October to December, 2013

Wind Speed (km/h)	N	NE	E	SE	S	SW	W	NW
0-5	24	44	251	40	19	16	56	43
5-10	31	46	352	61	34	39	104	61
10-15	34	26	188	59	28	22	96	49
15-20	23	16	80	24	16	18	37	11
20-25	8	3	33	11	7	6	19	7
25-30	5	4	21	3		1	6	6
30-35	2	3	12	6		1	3	3
35-40	1	2	10	1	1	2	1	
40-45			5	1	1	2	1	1
45-50	1		3	1	1	2		
50-55		1	1			1		
55-60	1							
60-65								
65-70								
Total	130	145	956	207	107	110	323	181

Note:

Total records =	2159	h
Total time winds calm =	27	h
Total observations =	2186	h

Hourly Wind Speed and Direction Recorded at Vancouver International Airport-October to December, 2013

Table 8: Storm Events during 2013 Monitoring Period

Start Date	Start time (LST)	End Date	End time (LST)	Time at Max Speed	Water Level at Start *m*	Water Level at End *m*	Water Level at Max *m*	Wind Speed Maximum *km/h*	Wind Speed Average *km/h*	Probability of Exceedence *(%)*	Wind Direction at Max *10's deg*	Wind Direction Average *10's deg*	Hs m	Tp sec
28/01/2013	4:00	28/01/2013	8:00	6:00	3.35	4.45	4.47	33	31.0	4.80%	W	W	0.35	2.21
06/02/2013	18:00	07/02/2013	4:00	23:00	1.79	4.65	1.87	33	31.5	4.80%	E	E	1.04	4.20
16/02/2013	21:00	17/02/2013	3:00	1:00	3.16	3.06	3.41	39	34.0	1.67%	W	W	0.45	2.46
22/02/2013	13:00	22/02/2013	18:00	13:00	3.87	2.87	3.87	43	35.0	0.93%	S	SW	0.32	2.05
23/02/2013	10:00	23/02/2013	16:00	10:00	3.01	3.73	3.01	41	35.7	1.18%	W	W	1.20	4.41
25/02/2013	6:00	25/02/2013	11:00	10:00	4.61	2.76	3.08	50	37.7	0.30%	W	SW	1.24	4.49
02/03/2013	14:00	03/03/2013	7:00	4:00	1.55	4.02	2.92	44	37.6	0.81%	W	W	1.17	4.37
16/03/2013	17:00	17/03/2013	10:00	4:00	2.29	3.58	3.24	46	35.7	0.61%	W	W	0.54	2.58
18/03/2013	7:00	18/03/2013	14:00	10:00	3.74	1.98	3.69	44	38.6	0.81%	W	W	1.18	4.43
20/03/2013	8:00	20/03/2013	18:00	16:00	3.72	2.02	2.46	63	37.2	0.05%	W	SW	1.28	4.32
21/03/2013	19:00	22/03/2013	5:00	1:00	1.70	3.67	3.76	41	33.8	1.18%	NW	NW	0.91	3.93
10/04/2013	11:00	10/04/2013	17:00	13:00	1.53	4.10	1.80	46	38.4	0.61%	W	W	1.17	4.22
11/04/2013	0:00	11/04/2013	13:00	4:00	2.52	1.25	3.95	43	35.6	0.93%	W	W	2.24	6.33
12/04/2013	22:00	13/04/2013	3:00	0:00	4.02	3.40	3.28	50	39.7	0.30%	W	W	0.56	2.63
29/04/2013	2:00	30/04/2013	4:00	8:00	3.29	3.17	4.12	59	44.8	0.09%	W	W	2.01	5.50
02/05/2013	15:00	02/05/2013	18:00	16:00	1.64	1.39	1.30	43	37.8	0.93%	NW	NW	0.93	3.79
19/05/2013	6:00	19/05/2013	11:00	11:00	2.40	2.90	2.90	33	31.5	4.80%	NW	NW	0.88	3.84
20/05/2013	19:00	21/05/2013	0:00	20:00	2.61	4.10	2.66	44	34.3	0.81%	NW	NW	1.33	4.68
01/06/2013	23:00	02/06/2013	0:00	1:00	4.37	2.46	4.44	35	32.6	3.14%	W	NW	0.41	2.39
02/06/2013	9:00	02/06/2013	13:00	9:00	2.05	3.35	2.05	35	33.0	3.14%	W	NW	1.21	4.54
26/07/2013	21:00	27/07/2013	4:00	22:00	4.65	2.14	4.34	39	32.6	1.67%	W	NW	0.44	2.45
25/09/2013	21:21	25/09/2013	15:00	10:00	3.89	3.27	4.08	36	32.7	2.77%	NW	NW	1.00	4.16
29/09/2013	15:00	29/09/2013	22:00	18:00	4.42	3.62	3.72	39	33.3	1.67%	E	SE	1.87	5.80
08/10/2013	1:00	08/10/2013	8:00	6:00	1.01	4.45	3.77	53	37.3	0.21%	W	W	1.33	4.51
02/11/2013	9:00	02/11/2013	13:00	13:00	3.22	3.76	3.76	37	33.8	2.40%	W	NW	1.04	4.26
19/11/2013	4:00	19/11/2013	20:00	8:00	3.24	3.05	4.73	50	40.9	0.30%	W	W	1.35	4.63
01/12/2013	22:00	02/12/2013	12:00	23:00	0.70	3.53	0.82	45	35.2	0.69%	NW	W	0.46	2.44
18/12/2013	5:00	18/12/2013	14:00	8:00	3.97	3.67	4.53	53	40.6	0.21%	W	W	1.19	4.12
27/12/2013	15:00	27/12/2013	18:00	16:00	3.52	1.75	2.90	40	35.5	1.30%	W	W	0.42	2.40

Note 1: Water level data from Point Atkinson (Station #7795). Have previously shown strong correlation between PtAtkinson and local tide gauge.
Note 2: Wind data from Vancouver International Airport.
Note 3: Wave hindcasting performed at seaward end of Roberts Bank Causeway.
Note 4: Annual probability of exceedence for maximum hourly wind speed based on analysis of 1953 to 2006 hourly wind data from Vancouver International Airport.

Table 9: Summary of Quality Assurance/Quality Control Issues for 2013

Surface Water	
Q1 2013	All RPDs below the DQO
Q2 2013	Chloropyll A had an RPD in excess of the DQO at 47% The chlorophyll a data was within the range detected in the previous quarters and the data is considered valid.
Q3 2013	Chloropyll A had an RPD in excess of the DQO at 105% The chlorophyll a data was within the range detected in the previous quarters and the data is considered valid.
Q4 2013	Chloropyll A had an RPD in excess of the DQO at 27% BC Ministry of Environment DQO for organics in water is 30% and therefore the chlorophyll a data is considered valid.
Sediment	
Q1 2013	Sulfide had an RPD in excess of the DQO at 27% Sulfide samples were collected directly from the ponar without homogenization of the samples. (i.e. sulfides are volatile, this limits the lab's ability to homogonize the samples, thereby often resulting in variability). The data is considered valid.
Q2 2013	Ammonium, sulphide, TKN, TN, ON, TOC had RPDs in excess of the DQO (25% to 97%). This is likely due to heterogeneity of the sample and the duplicate. All data within previous range and is considered valid.
Q3 2013	Ammonium marginaly exceeded the DQO with an RPD of 29%. This is likely due to heterogeneity of the sample and the duplicate. The data is considered valid.
Q4 2012	ORP had an RPD in excess of the DQO at 57% This is likely due to heterogeneity of the sample and the duplicate. The data is within previous range and considered valid.

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

			Location ID:	DP01													
			Sample ID:	SWDP01-1	SWDP01-2	SWDP01-3	SWDP01-4	SWDP01-5	SWDP01-6	SWDP01-7	SWDP01-8	SWDP01-9	SWDP01-10	SWDP01-11	SWDP01-12	SWDP01-13	SWDP01-14
			Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010
Parameter	***AMS Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.3	-	0.5	0.5	0.5	0.4	0.5	0.3	0.3	0.3	0.3	0.1	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	0.5	-	0.5	-	-	1	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.93	-	12.4	2.73	8.14	14.8	14.8	4.4	7.58	17.73	16.95	5.48	-	-
Field pH	-	-	-	7.31	-	-	7.79	7.96	8.16	7.94	7.49	7.62	7.59	6.4	7.5	-	-
Field Conductivity (uS/cm)	-	-	-	6696	-	31208	23489	38716	11400	42835	24952	26011	9123	13321	31580	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	11.26	-	9.48	16.67	10.56	6.14	9.92	9.7	10.63	8.42	5.64	10.69	-	-
Field Redox, Uncorrected (mV)	-	-	-	121.3	-	207	199	-16.6	82.1	-83	-292	-296.2	70.8	278	135.7	-	-
Field Turbidity (NTU)	-	-	-	46.16	-	-	-	-	-	-	9.4	-	12	3	0.87	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	651	974	4740	-	3990	1460	5280	4500	4340	1160	1530	3330	-	-
Total Suspended Solids (mg/L)	-	-	-	22	27.2	43.7	21.5	22.2	35.9	20.7	14.4	-	24.5	11	23.8	20.7	18.7
Turbidity (NTU)	-	-	-	-	-	-	15.9	5.31	19.3	7.18	11.7	-	14.7	5.24	24.6	13.8	8.7
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0761	0.503	0.06	0.0245	0.0367	0.175	0.0524	0.057	0.0381	0.0839	0.0616	0.0345	0.0334	0.0845
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.147	0.485	0.0569	0.0276	0.0387	0.215	0.0562	0.0643	0.0605	0.0222	0.0696	0.0415	0.0344	0.184
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.48	0.391	0.066	0.419	0.267	0.293	0.0331	0.287	0.122	0.613	0.492	0.221	0.24	0.127
Nitrate (mg/L)	5.23	-	16	0.595	1.99	<0.500	6.9	1.82	0.94	<2.500	26.6	<0.500	<0.250	<0.250	0.77	0.91	0.1
Nitrite (mg/L)	0.978	-	-	0.024	0.094	<0.100	0.54	0.25	0.18	<0.500	<1.000	0.17	<0.050	<0.050	<0.100	<0.100	<0.020
Silicon Dioxide (mg/L)	-	-	-	9.3	4.8	-	-	-	4.2	-	-	-	-	12.3	8.5	7.6	6.2
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	<0.200	<0.200	<0.200	<0.200	<0.100	<0.100	<0.100	<0.100	<0.100	-	<0.100	<0.100	<0.100
Phosphorus (P) (mg/L)	0.089	-	-	0.299	0.654	0.0948	0.203	0.0819	0.411	0.0802	0.103	0.0872	0.0951	0.102	0.177	0.132	0.305
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	1.61	0.879	0.535	1.24	0.628	1.05	0.147	0.852	0.508	2.12	0.898	0.762	0.726	1.05
Total Nitrogen (mg/L)	5.92	-	-	2.23	2.97	<0.700	8.7	2.7	<5.000	<3.000	27.5	<0.700	1.94	0.9	1.77	1.64	1.15
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	1.13	0.488	-	0.819	0.36	0.757	0.114	0.565	0.386	1.51	0.406	0.541	0.486	0.923
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	4.84	3.15	2.72	1.65	1.7	8.1	1.98	4.32	0.769	7.58	0.636	1.45	4.83	7.4
Dissolved Metals																	
Iron	-	-	-	-	14	<300	10	<10	32	<10	25	12	52	56	23	53	<50
Total Metals																	
Aluminum	-	-	-	674	<500	<500	388	110	150	<200	<300	<100	184	59	490	168	148
Antimony	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	4.22	2.52	1.22	1.54	0.97	1.78	1.14	1.13	0.54	2.26	3.71	1.4	<2	3
Barium	-	200 [8]	-	21	12.9	12.2	18.1	16	29.5	10.8	15	17.3	47.5	21.3	14.5	18.4	18.8
Beryllium	-	100 [9]	-	<10	<10	<50	<25	<50	<50	<50	<50	<50	<10	<25	<50	<0.5	<0.5
Bismuth	-	-	-	<10	<10	<50	<25	<50	<50	<50	<50	<50	<10	<25	<50	<0.5	<0.5
Boron	-	1200 [4]	-	610	860	**3500**	**2010**	**2800**	**2000**	**3200**	**3000**	**2800**	840	1040	**2300**	**2410**	1000
Cadmium	-	0.12 [7]	0.12	0.068	0.065	0.095	0.073	0.065	0.097	0.072	0.094	0.108	0.021	0.027	0.091	<0.12	<0.12
Calcium	-	-	-	65800	79800	346000	203000	266000	110000	343000	301000	279000	105000	128000	218000	209000	102000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<10**	**<10**	**<50**	**<25**	**<50**	**<50**	**<50**	**<50**	**<50**	**<10**	**<25**	**<50**	<1	<1
Cobalt	-	-	-	1.51	0.781	0.348	1.33	0.782	0.546	0.226	0.762	0.444	1.31	0.46	1.5	1.37	0.65
Copper	-	3 [18]	-	**5.59**	**5.71**	1.4	2.9	**3.85**	**3.56**	1.01	**3.27**	1.78	2.12	0.827	2.49	2.2	**3.2**
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	2070	718	451	1060	490	1080	324	590	204	962	426	1070	1340	1030
Lead	-	140 [18]	-	1.08	0.437	0.637	0.687	0.935	0.96	0.154	0.912	0.239	0.204	<0.15	0.335	<1	<1
Lithium	-	-	-	<100	<100	<500	<250	<500	<500	<500	<500	<500	<100	<250	<500	92	36
Magnesium	-	-	-	118000	188000	1070000	576000	808000	288000	1070000	911000	885000	219000	295000	675000	608000	207000
Manganese	-	100 [11]	-	**175**	75	13.5	**135**	80.5	63.8	11.1	68.2	68.6	**246**	**293**	100	**156**	**131**
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	2.6	5.8	8.2	6.1	8	6.3	8.4	8.3	6.4	2.7	<2.5	5.1	6.4	3.6
Nickel	-	8.3 [12]	-	8.25	5.62	1.49	5.71	4.15	2.92	1.12	6.14	2.88	6.87	1.92	5.82	7.02	4.98
Potassium	-	-	-	45200	64900	355000	188000	273000	92000	329000	280000	241000	62500	91000	204000	185000	64000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56.3	19.7
Selenium	-	-	-	<0.50	0.56	0.88	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2
Silicon	-	-	-	5070	3170	2960	7370	2680	3040	1660	4590	2600	4390	6910	6330	4960	3590
Silver	-	3 [18]	-	<0.20	<0.2	<1	<0.5	<1	<1	<1	<1	<1	<0.2	<0.5	<1	<0.2	<0.2
Sodium	-	-	-	1070000	1480000	7990000	4580000	6470000	2330000	8620000	7300000	7660000	1680000	2440000	5380000	5180000	1550000
Strontium	-	-	-	892	1200	6600	3270	4590	3300	5720	4880	5030	1370	1860	3820	3670	1320
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<2.0	<2	<10	<5	<10	<10	<10	<10	<10	<2	<5	<10	<1	<1
Titanium	-	-	-	21	<20	<100	<100	<100	<100	<100	<100	<100	<20	<100	<100	6.7	5.4
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	0.629	0.392	1.99	1.41	1.92	0.197	2.03	2.16	2.01	0.628	0.63	1.78	1.81	1.02
Vanadium	-	50 [14]	-	<20	<20	**<100**	<50	**<100**	**<100**	**<100**	**<100**	**<100**	<20	<50	**<100**	1.99	2.33
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	12.6	10.4	7.64	9.08	4.96	6.66	1.71	22.3	2.39	3.71	2.15	5.48	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]														
			Location ID:	DP01													
			Sample ID:	SWDP01-15	SWDP01-16	SWDP01-17	SWDP01-18	SWDP01-19	SWDP01-20	SWDP01-21	SWDP01-22	SWDP01-23	SWDP01-24	SWDP01-25	SWDP01-26	SWDP01-27	SWDP01-28
			Date Sampled:	31/08/2010	02/12/2010	11/03/2011	08/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012	19/02/2013	04/06/2013	25/09/2013	09/12/2013
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.2	0.3	0.5	0.2	0.1	0.2	0.1	0.5	0.25	0.1	0.1	0.1	0.1	0.1
Field Tests																	
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5 (bottom)	-
Field Temperature (ºC)	-	-	-	15.47	5.55	7.5	16.31	20.8	6.93	5.97	-	19.15	5.5	7.1	19.72	13.4	0.73
Field pH	-	-	-	6.9	7.15	6.33	6.78	7.55	7.27	6.69	-	7.66	7.67	6.69	7.99	7	5.69
Field Conductivity (uS/cm)	-	-	-	12460	26399	-	18826	10026	32999	3758	-	23840	34300	1165.5	32525	9489	12423
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	4.88	9.83	9.73	8.07	13.05	10.83	11.14	-	5.88	9.97	8.84	6.66	3.19	8.7
Field Redox, Uncorrected (mV)	-	-	-	-3.9	167.3	140.7	319.4	278	163.6	125.5	-	222.1	197.5	180.7	99.1	191.4	162.8
Field Turbidity (NTU)	-	-	-	23.9	0.95	-	0.94	5.07	7.69	68.8	-	36.5	-	22.2	4.46	14.8	6.34
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	1390	2780	526	-	-	-	471	-	-	-	1030	-	-	-
Total Suspended Solids (mg/L)	-	-	-	35.3	73	203	41.1	7.6	28.2	81.3	30.6	237	49.5	35.6	30.8	48.6	66.1
Turbidity (NTU)	-	-	-	25.2	146	231	24.6	7.07	16.5	102	10.2	87.6	24.3	30.3	6.83	20.2	34.1
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.181	0.0657	0.0522	0.0634	0.113	0.0598	0.0611	0.188	0.0873	0.0402	0.0116	0.17	0.0381	0.006
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.177	0.0837	0.0701	0.0753	0.121	0.0635	0.0891	0.203	0.0943	0.0452	0.0223	0.195	0.053	0.0112
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.555	0.318	0.227	0.33	0.283	0.256	0.196	0.174	0.252	0.232	0.659	0.161	0.62	0.655
Nitrate (mg/L)	5.23	-	16	<0.250	0.94	0.51	<0.250	0.38	<0.500	0.46	<0.500	<0.500	0.56	0.9	<0.500	<0.250	0.74
Nitrite (mg/L)	0.978	-	-	0.076	<0.100	<0.020	<0.050	<0.050	<0.100	0.023	<0.100	0.14	<0.100	<0.050	<0.100	0.052	0.058
Silicon Dioxide (mg/L)	-	-	-	6.6	9.4	10.4	7.4	5.8	5.9	7.47	2.92	3.5	8.21	17.4	3.28	11.6	17.5
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Phosphorus (P) (mg/L)	0.089	-	-	0.309	0.531	0.921	0.273	0.184	0.123	0.522	0.292	0.427	0.188	0.221	0.283	0.214	0.237
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	2.27	2.11	3.41	1.58	0.905	0.538	1.89	0.874	1.06	0.763	1.7	0.725	1.48	1.56
Total Nitrogen (mg/L)	5.92	-	-	2.35	3.05	3.92	1.58	1.29	0.54	2.38	0.87	1.2	1.33	2.59	0.73	1.54	2.36
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	1.71	1.79	3.18	1.25	0.622	0.282	1.7	0.699	0.809	0.531	1.04	0.564	0.863	0.907
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	1.27	4.08	10.3	4.58	0.323	0.895	5.73	2.15	0.167	0.31	4.37	6.72	1.26	0.652
Dissolved Metals																	
Iron	-	-	-	12.6	76	372	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	300	1720	8130	-	-	-	3250	-	-	-	297	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	0.347	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	3	2.5	5.9	-	-	-	3.96	-	-	-	2.6	-	-	-
Barium	-	200 [8]	-	14.7	16.9	54.6	-	-	-	24	-	-	-	33.6	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	0.115	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.25	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	1110	**2360**	470	-	-	-	406	-	-	-	960	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	**0.162**	**0.192**	-	-	-	**0.121**	-	-	-	<0.05	-	-	-
Calcium	-	-	-	113000	186000	56600	-	-	-	47200	-	-	-	105000	-	-	-
Cesium	-	-	-	<0.5	<0.5	0.65	-	-	-	0.283	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	**3.98**	**16.4**	-	-	-	**7.5**	-	-	-	1.23	-	-	-
Cobalt	-	-	-	0.71	2.19	6.11	-	-	-	3.99	-	-	-	3.14	-	-	-
Copper	-	3 [18]	-	**3.5**	**10.2**	**26**	-	-	-	**15.4**	-	-	-	**3.32**	-	-	-
Gallium	-	-	-	<0.5	<0.5	2.22	-	-	-	0.88	-	-	-	<0.5	-	-	-
Iron	-	-	-	1110	2930	13400	-	-	-	6210	-	-	-	2950	-	-	-
Lead	-	140 [18]	-	<1	1.69	4.6	-	-	-	2.15	-	-	-	0.37	-	-	-
Lithium	-	-	-	44	82	20	-	-	-	17.8	-	-	-	24	-	-	-
Magnesium	-	-	-	269000	562000	93300	-	-	-	85800	-	-	-	186000	-	-	-
Manganese	-	100 [11]	-	**120**	98.3	**287**	-	-	-	**160**	-	-	-	**410**	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	**0.017**	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	3	5.7	5.5	-	-	-	4.08	-	-	-	3.4	-	-	-
Nickel	-	8.3 [12]	-	3.23	**11.4**	**26.5**	-	-	-	**17.9**	-	-	-	**11.7**	-	-	-
Potassium	-	-	-	86000	172000	33000	-	-	-	31200	-	-	-	55700	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.025	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	23.7	50.3	17.7	-	-	-	11.3	-	-	-	12.7	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<1	-	-	-	<2	-	-	-
Silicon	-	-	-	5130	13200	25300	-	-	-	10700	-	-	-	9730	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.025	-	-	-	<0.1	-	-	-
Sodium	-	-	-	2190000	4620000	714000	-	-	-	708000	-	-	-	1440000	-	-	-
Strontium	-	-	-	1720	3270	620	-	-	-	553	-	-	-	1220	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.05	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	0.053	0.116	-	-	-	0.027	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	0.84	-	-	-	0.407	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	12	80.2	358	-	-	-	159	-	-	-	19.3	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<0.05	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	0.78	1.79	1.65	-	-	-	0.956	-	-	-	1.42	-	-	-
Vanadium	-	50 [14]	-	2.62	7.85	25.2	-	-	-	11.2	-	-	-	2.4	-	-	-
Yttrium	-	-	-	<0.5	1.37	3.68	-	-	-	2.08	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	75.5	17	47.1	-	-	-	29	-	-	-	10	-	-	-
Zirconium	-	-	-	<0.5	1.12	2.7	-	-	-	1.95	-	-	-	0.53	-	-	-

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP02-1	SWDP02-2	SWDP02-3	SWDP02-4	SWDP02-5	SWDP02-6	SWDP02-7	SWDP02-8	SWDP02-9	SWDP02-10	SWDP02-11	SWDP02-12	SWDP02-13	SWDP02-14
			Location ID:	DP02													
			Sample ID:	SWDP02-1	SWDP02-2	SWDP02-3	SWDP02-4	SWDP02-5	SWDP02-6	SWDP02-7	SWDP02-8	SWDP02-9	SWDP02-10	SWDP02-11	SWDP02-12	SWDP02-13	SWDP02-14
			Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	1.2	-	1	-	1.9	1.1	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	6.94	16.1	11.4	4.95	7.31	14.98	13.27	6.78	7.84	17.5	16	6.11	-	-
Field pH	-	-	-	7.89	8.38	-	7.67	8.06	7.79	7.8	7.69	7.64	8.69	7.94	7.68	-	-
Field Conductivity (uS/cm)	-	-	-	32960	36600	31678	44274	40843	34500	43985	29268	29291	39001	36006	40989	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	10.99	-	9.18	13.01	9.87	10.23	9.04	9.24	11.89	15.44	9.63	10.24	-	-
Field Redox, Uncorrected (mV)	-	-	-	248.7	231	214	274	-25.6	255.6	-13	-336	-348.6	168	201.2	135.1	-	-
Field Turbidity (NTU)	-	-	-	-	1.7	-	-	-	-	-	1.95	2.7	4.4	1.5	2.04	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	3550	4060	4850	-	4620	4050	5190	5540	5240	4610	4260	4710	-	-
Total Suspended Solids (mg/L)	-	-	-	12	28	21.7	8.8	13	30.7	34	21.1	-	18.5	11.7	13.8	18	14
Turbidity (NTU)	-	-	-	-	-	-	1.79	1.62	2.9	1.22	3.16	-	3.29	1.31	2.5	4.08	2.89
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.042	0.0479	0.0527	0.0724	0.0519	-	0.0449	0.0669	0.0294	0.0399	0.0312	0.0612	0.0592	0.0196
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0457	0.0579	0.0515	0.0707	<0.002	-	0.0499	0.0653	0.0448	0.0447	0.0349	0.0637	0.0578	0.0271
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.048	0.058	0.039	0.046	0.0471	0.027	0.0175	0.053	0.0247	0.035	0.0174	0.022	0.0128	0.0117
Nitrate (mg/L)	5.23	-	16	<0.050	<0.500	<0.500	***7***	0.67	<5.000	<2.500	0.53	<0.500	<0.500	<0.500	<0.500	0.74	<0.500
Nitrite (mg/L)	0.978	-	-	<0.010	0.17	<0.100	<0.500	0.12	***1.3***	***1.43***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	3.1	1.5	-	-	2.4	-	-	3.4	-	-	1.8	3.3	2.4	<1.000
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0568	0.0688	0.0637	0.0735	0.0606	-	0.0588	0.0742	0.0418	0.0608	0.0448	0.0721	0.0653	0.0483
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.171	0.262	0.355	0.276	0.381	0.304	0.102	0.17	0.16	0.347	<0.050	0.187	0.068	0.189
Total Nitrogen (mg/L)	5.92	-	-	0.17	<0.700	<0.700	***7.3***	1.17	***<6.000***	<3.000	0.7	<0.700	0.17	<0.700	0.56	0.8	<0.700
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.123	-	-	0.23	0.334	0.277	0.085	0.117	0.135	0.312	<0.060	-	<0.060	0.177
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	0.758	1.25	3.79	0.547	1.94	0.905	0.675	1.09	0.628	1.28	1.72	0.501	0.595	***5.39***
Dissolved Metals																	
Iron	-	-	-	-	<10	<300	<10	<10	<10	<10	<10	<10	<10	11	<10	<50	<50
Total Metals																	
Aluminum	-	-	-	<100	<200	<100	<100	<100	160	<100	<100	<100	<100	<100	<100	55	59
Antimony	-	-	-	<10	21	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	0.97	1.41	1.01	1.16	0.95	<0.2	1.08	1.24	0.65	1.37	1.27	1.09	<2	<2
Barium	-	200 [8]	-	11.9	<20	10.5	9.1	11.6	10	9.4	10.1	9.2	10.9	10.4	10	10.2	10.6
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Boron	-	1200 [4]	-	**2700**	**2900**	**3700**	**3600**	**3000**	**2700**	**3400**	**3500**	**4000**	**3000**	**3300**	**3300**	**3810**	**3440**
Cadmium	-	0.12 [7]	0.12	0.063	0.043	0.076	0.072	0.07	0.06	0.066	0.09	0.1	0.049	0.065	0.06	<0.12	<0.12
Calcium	-	-	-	236000	267000	348000	340000	284000	261000	342000	353000	337000	302000	278000	305000	321000	270000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**64**	**<50**	<1	<1
Cobalt	-	-	-	0.136	0.092	0.1	0.112	0.06	0.158	0.071	0.085	0.151	0.167	<0.05	0.062	<0.5	<0.5
Copper	-	3 [18]	-	1.49	0.696	1.58	0.591	2.36	1.4	0.69	1.5	1.23	1.31	0.905	0.465	2.2	1.4
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	116	46	111	69	31	138	67	84	103	131	33	73	105	147
Lead	-	140 [18]	-	0.469	<0.05	1.36	0.074	3.31	0.484	0.535	3.33	1.96	0.174	1.04	0.062	1.6	<1
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	163	130
Magnesium	-	-	-	718000	825000	1100000	1100000	950000	824000	1050000	1130000	1070000	936000	867000	959000	1020000	895000
Manganese	-	100 [11]	-	11.2	6.21	7.45	8.25	6.21	13.2	5.23	8.63	13.1	11.1	6.46	5.64	7.12	8.86
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	0.019	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	5.5	12.4	9.1	9.4	9	5.6	9.6	7.7	9.6	9.4	8.1	8.4	9.8	7
Nickel	-	8.3 [12]	-	0.879	0.612	0.758	0.737	0.835	0.994	0.611	0.759	0.995	0.659	0.481	0.538	0.73	0.65
Potassium	-	-	-	242000	271000	366000	362000	281000	249000	331000	344000	305000	279000	257000	286000	309000	259000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	96.5	70.4
Selenium	-	-	-	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2
Silicon	-	-	-	1650	880	1540	1930	1370	1260	1150	1920	700	770	1130	1940	1470	530
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2
Sodium	-	-	-	6340000	7230000	8250000	8150000	7900000	7060000	8690000	8930000	9390000	7880000	7700000	8290000	8930000	6490000
Strontium	-	-	-	4470	5060	7200	5820	5610	4520	6050	5480	6010	5000	5380	6070	5960	4650
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	13	<10	<10	<10	<1	<1
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	1.56	0.949	2.09	2.08	1.75	1.79	2.1	2.26	2.41	1.86	1.92	1.75	2.75	1.91
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.45
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	5.1	0.56	5.35	1.24	5.72	2.11	1.88	2.25	2.32	1.84	2.22	0.88	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	DP02													
Location ID:				DP02													
Sample ID:				SWDP02-15	SWDP02-16	SWDP02-17	SWDP02-18	SWDP02-19	SWDP02-20	SWDP02-21	SWDP02-22	SWDP02-23	SWDP02-24	SWDP02-25	SWDP02-26	SWDP02-27	SWDP02-28
Date Sampled:				30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	1	0.8	1.2	0.5	1	0.75	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	2.4	-	-	-	1.5	1.4 (bottom)	0.75 (bottom)	1.2 (bottom)	1.75	1.5	1.5	0.5 (bottom)	1.75
Field Temperature (ºC)	-	-	-	14.87	7.47	5.35	12.4	17.35	7.69	6.76	15.4	15.04	6.68	7.24	19.28	12.69	1.83
Field pH	-	-	-	6.05	7.73	7.55	5	8.2	7.57	7.78	8.48	8.01	7.92	7.93	8.86	7.88	9.07
Field Conductivity (uS/cm)	-	-	-	36620	44858	43499	19000	36299	40469	29200	33844	33030	38520	46070	34006	43976	47440
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	8.44	11.36	9.48	11.83	11.54	9.89	10.89	10.07	8.97	9.89	10.95	16.63	10.22	11.2
Field Redox, Uncorrected (mV)	-	-	-	203	242.2	394.3	335.2	258.5	240.6	266.1	179	203.9	372.6	327.1	182.8	164.6	79.6
Field Turbidity (NTU)	-	-	-	0.87	1.27	1.14	6.28	1.39	1.04	1.25	11.2	0.72	-	1.2	2.45	1.16	1.31
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4650	5410	5390	-	-	-	5010	-	-	-	4860	-	-	-
Total Suspended Solids (mg/L)	-	-	-	17.3	13.7	10.2	6.6	3.9	<2.000	<2.000	24.8	2.4	<3.000	2.4	6.2	4.3	<2.000
Turbidity (NTU)	-	-	-	0.96	1.47	1.08	4.08	2.13	1.53	1.93	6.89	1.11	1.99	1.87	3.32	1.57	1.52
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0308	0.0751	0.0634	0.0278	0.0295	0.0482	0.0663	0.0398	0.0412	0.0591	0.0539	0.0284	0.0395	0.0632
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0358	0.0728	0.0587	0.0317	0.0362	0.0508	0.0672	0.0443	0.0468	0.063	0.0581	0.0324	0.0442	0.0619
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0154	0.0146	0.0309	0.0138	<0.005	0.0223	0.0151	<0.005	0.0115	0.0216	0.0209	0.0077	0.0182	0.0161
Nitrate (mg/L)	5.23	-	16	<0.500	0.58	<0.500	<0.500	<0.500	<0.500	0.61	<0.500	<0.500	0.69	0.76	<0.500	<0.500	0.51
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.25	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	<1.000	3.7	2.8	2.8	<1.000	2.9	2.86	1.48	0.96	3.83	2.56	1.15	1.5	<2.500
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0514	0.079	0.0607	0.0543	0.0587	0.0569	0.076	0.097	0.0545	0.0657	0.0625	0.0402	0.05	0.0705
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.135	0.053	0.077	0.237	0.4	0.143	0.15	0.333	0.158	0.131	0.142	0.184	0.22	0.146
Total Nitrogen (mg/L)	5.92	-	-	<0.260	0.63	<0.260	<0.260	0.4	<0.260	0.76	0.59	<0.510	0.83	0.91	<0.510	<0.510	0.66
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.12	<0.060	<0.060	0.223	***0.4***	0.121	0.13	0.333	0.146	0.109	0.121	0.176	0.202	0.129
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	1.2	0.212	0.493	1.24	2.07	0.389	0.622	1.79	0.061	0.453	0.223	1.08	1.14	0.249
Dissolved Metals																	
Iron	-	-	-	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	16.8	38	21.3	-	-	-	25.7	-	-	-	103	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	8.3	9.1	8.9	-	-	-	10.1	-	-	-	10.6	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3620**	**4470**	**4210**	-	-	-	**4310**	-	-	-	**3790**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	0.059	0.072	-	-	-	0.068	-	-	-	<0.05	-	-	-
Calcium	-	-	-	311000	357000	344000	-	-	-	318000	-	-	-	342000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.05	<0.05	-	-	-	0.098	-	-	-	0.099	-	-	-
Copper	-	3 [18]	-	1.6	1.72	1.01	-	-	-	0.66	-	-	-	0.82	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	<50	60	36	-	-	-	52	-	-	-	200	-	-	-
Lead	-	140 [18]	-	1.3	3.18	0.58	-	-	-	<0.3	-	-	-	1.33	-	-	-
Lithium	-	-	-	153	157	160	-	-	-	169	-	-	-	146	-	-	-
Magnesium	-	-	-	940000	1100000	1110000	-	-	-	1020000	-	-	-	972000	-	-	-
Manganese	-	100 [11]	-	3.9	3.76	2.55	-	-	-	5.58	-	-	-	7.78	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	8.4	9.2	9.1	-	-	-	10	-	-	-	9.1	-	-	-
Nickel	-	8.3 [12]	-	0.63	<0.5	0.53	-	-	-	0.78	-	-	-	0.57	-	-	-
Potassium	-	-	-	280000	334000	323000	-	-	-	308000	-	-	-	320000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	81.4	95.5	93.6	-	-	-	99.3	-	-	-	90.2	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	620	1690	1670	-	-	-	1660	-	-	-	1810	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	7990000	9250000	9150000	-	-	-	8820000	-	-	-	8980000	-	-	-
Strontium	-	-	-	5430	6410	6340	-	-	-	5860	-	-	-	6110	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<5	<5	<5	-	-	-	<5	-	-	-	5.9	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.35	2.66	2.46	-	-	-	2.63	-	-	-	2.53	-	-	-
Vanadium	-	50 [14]	-	1.36	1.6	1.46	-	-	-	1.74	-	-	-	1.72	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<4	11.4	-	-	-	3.7	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

			Location ID:	DP03													
			Sample ID:	SWDP03-1	SWDP03-2	SWDP03-3	SWDP03-4	SWDP03-5	SWDP03-6	SWDP03-7	SWDP03-8	SWDP03-9	SWDP03-10	SWDP03-11	SWDP03-12	SWDP03-13	SWDP03-14
			Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Parameter	***AMS Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.8	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	8.53	14.9	11.6	6.38	6.57	16.16	13.23	7.46	7.82	14.69	16.24	6.22	-	-
Field pH	-	-	-	7.8	8.55	-	7.73	8.01	7.88	7.8	7.76	7.7	8.5	8.03	7.73	-	-
Field Conductivity (uS/cm)	-	-	-	10089	31300	31175	44401	38157	37169	44296	30029	29101	40202	36040	40513	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	10.14	-	8.87	12.65	9.85	10.01	8.72	8.86	12.47	13.98	10.97	11.11	-	-
Field Redox, Uncorrected (mV)	-	-	-	236.1	258.6	230	252	-249.2	235.2	-1	-325.9	-354.5	148.5	229.1	160	-	-
Field Turbidity (NTU)	-	-	-	1.2	5.2	-	-	-	-	-	1.72	3.9	2.5	0.9	1.02	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4750	3440	4590	-	4170	4460	5380	5450	5200	4740	4180	4570	-	-
Total Suspended Solids (mg/L)	-	-	-	8	23.3	26.3	16.8	14.3	33.3	25.3	19.1	-	15.8	17.7	24.5	8	14
Turbidity (NTU)	-	-	-	-	-	-	1.69	1.42	3.7	1.12	2.47	-	1.55	1.22	1.64	3.05	2.11
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0482	0.0317	0.0555	0.072	0.0412	**-**	0.0467	0.0664	0.0303	0.0407	0.0322	0.0597	0.0581	0.0163
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0499	0.0405	0.0551	0.0693	0.0395	**-**	0.0535	0.0667	0.0363	0.0487	0.0344	0.064	0.0588	0.0201
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.032	0.03	0.056	<0.020	0.0354	0.028	0.0172	0.0309	0.0212	0.034	0.019	<0.020	0.013	0.0077
Nitrate (mg/L)	5.23	-	16	0.22	<0.500	<0.500	***7***	0.62	<5.000	<2.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.99	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	0.13	<0.100	<0.500	0.12	***2.1***	***1.37***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.2	1.6	-	-	2.1	-	-	3	-	-	1.8	3.2	2.5	<1.000
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.100	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0589	0.0641	0.0764	0.0734	0.0474	-	0.0605	0.0721	0.0436	0.0526	0.0443	0.0668	0.067	0.0391
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.15	0.211	0.385	0.246	0.331	0.378	<0.050	0.153	0.189	0.298	0.122	0.137	0.074	0.23
Total Nitrogen (mg/L)	5.92	-	-	0.37	<0.700	<0.700	***7.3***	1.07	***<6.000***	<3.000	<0.700	<0.700	0.26	<0.700	0.51	1.06	<0.700
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	-	-	-	0.246	0.296	0.351	<0.060	0.122	0.168	0.264	0.103	-	0.061	0.222
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	2.25	3.77	3.19	0.572	2.3	1.17	0.652	0.427	0.656	0.414	0.831	0.445	0.667	***8.47***
Dissolved Metals																	
Iron	-	-	-	-	<10	<300	<10	<10	12	<10	<10	<10	<10	<10	<10	<50	<50
Total Metals																	
Aluminum	-	-	-	<100	<200	<200	<100	<100	130	<100	<100	<100	<100	<100	<100	45	41
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	1.11	1.2	1.18	1.26	1.14	1.09	1.27	1.28	0.93	1.3	1.24	1.12	<2	<2
Barium	-	200 [8]	-	10.6	<20	11.5	9	12	11.1	9.5	9.9	7.7	9.7	9.7	8.8	9.6	13.1
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Boron	-	1200 [4]	-	**3500**	**2600**	**3700**	**3500**	**2800**	**3100**	**3400**	**3600**	**3900**	**3000**	**2800**	**3200**	**4450**	**4760**
Cadmium	-	0.12 [7]	0.12	0.06	0.04	0.085	0.062	0.069	0.054	0.076	0.087	0.092	0.052	0.064	0.066	<0.12	<0.12
Calcium	-	-	-	305000	216000	338000	358000	258000	286000	344000	347000	335000	308000	269000	298000	331000	300000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**63**	**<50**	<1	<1
Cobalt	-	-	-	0.069	0.079	0.166	0.052	0.065	0.156	0.059	0.066	0.136	0.096	<0.05	0.055	<0.5	<0.5
Copper	-	3 [18]	-	0.709	0.672	2.06	0.652	2.61	1.49	0.562	0.921	1.02	1.32	1.12	0.839	<1	1.8
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	55	63	186	59	31	158	58	71	111	51	37	54	95	95
Lead	-	140 [18]	-	0.137	0.061	1.09	0.117	2.49	0.269	0.273	0.674	0.201	0.27	1.03	0.135	<1	<1
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	173	184
Magnesium	-	-	-	968000	703000	1080000	1160000	857000	909000	1100000	1110000	1060000	964000	852000	928000	1060000	924000
Manganese	-	100 [11]	-	5.88	7.13	11.4	4.16	7.7	12.9	5.44	6.07	14	6.75	6.82	5.79	6.62	8.37
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	7.6	7.6	9.8	8.8	7.6	6.5	10.3	8.5	8.4	8.9	7.1	7.1	10.7	9.5
Nickel	-	8.3 [12]	-	0.528	0.536	1.01	0.446	0.675	0.943	0.465	0.612	0.83	0.402	0.521	0.56	0.81	0.84
Potassium	-	-	-	309000	226000	363000	385000	251000	275000	338000	332000	306000	284000	256000	285000	318000	271000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	103	99
Selenium	-	-	-	0.51	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.82	<0.5	<0.5	<0.5	<0.5	<2	<2
Silicon	-	-	-	1410	1360	1890	1860	1260	1130	1700	1680	710	760	1090	1820	1440	580
Silver	-	3 [18]	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2
Sodium	-	-	-	7340000	5770000	8290000	8620000	7130000	7740000	8850000	8610000	9320000	8100000	7680000	8200000	9220000	6800000
Strontium	-	-	-	5970	4270	6850	5960	5220	5060	6010	5590	6110	5140	4570	5510	6110	4860
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	1.96	1.24	1.99	1.77	1.85	1.9	2.24	2.4	2.26	1.72	1.91	1.71	2.77	2.75
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.41	1.7
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	2.55	0.6	3.56	1.17	5.04	2.27	1.5	1.79	1.76	1.2	2.01	1.35	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP03-15	SWDP03-16	SWDP03-17	SWDP03-18	SWDP03-19	SWDP03-20	SWDP03-21	SWDP03-22	SWDP03-23	SWDP03-24	SWDP03-25	SWDP03-26	SWDP03-27	SWDP03-28
Location ID:				DP03													
Date Sampled:				30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	1	1	1.2	0.4	1	0.9	0.5	0.4	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	2.5	-	-	-	1.4	1.6 (bottom)	0.9 (bottom)	1.3 (bottom)	1.5	1.6	1.5	1.5 (bottom)	1.75
Field Temperature (ºC)	-	-	-	15.08	7.1	5.59	15.03	16.4	7.06	6.18	14.96	14.03	6.4	7.01	15.73	12.63	2.16
Field pH	-	-	-	7.4	7.76	7.74	7.94	8.26	7.54	7.81	8.39	8.05	7.92	7.97	8.37	7.89	7.95
Field Conductivity (uS/cm)	-	-	-	38190	45009	44168	20975	35404	40558	27367	33007	32370	39980	45215	37325	44179	47240
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	8.39	11.04	11.6	9.8	14.26	10.85	10.34	11.26	10.39	9.89	11.36	11.4	8.79	11.1
Field Redox, Uncorrected (mV)	-	-	-	139	250.1	305.1	279	256.1	206.1	273	189.3	284	361.2	319.8	238.3	195.5	158
Field Turbidity (NTU)	-	-	-	1.07	0.32	4.94	4.51	1.22	1.15	1.71	4.2	0.78	-	1.16	8.74	1.52	1.16
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4580	5540	5450	-	-	-	4690	-	-	-	4460	-	-	-
Total Suspended Solids (mg/L)	-	-	-	10	13	18.2	8.8	5.9	<2.000	2.2	8	2.8	<3.000	3	5.4	4.5	2.1
Turbidity (NTU)	-	-	-	1.25	1.78	4.89	4.94	2.42	1.39	2.55	3.46	1.21	1.57	2.64	3.38	2.81	1.45
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0302	0.0764	0.0587	0.0419	0.0179	0.0513	0.0558	0.0252	0.0414	0.0618	0.0475	0.0311	0.0401	0.0644
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0352	0.0735	0.0522	0.0434	0.0237	0.052	0.0584	0.0309	0.0455	0.065	0.0521	0.0334	0.0478	0.0672
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0175	0.0145	0.0271	0.0184	0.0069	0.0314	0.0513	<0.005	0.0078	0.0226	0.0282	0.0085	0.0245	0.0176
Nitrate (mg/L)	5.23	-	16	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.61	0.74	<0.500	<0.500	0.71	<0.500	<0.500	0.82
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.11	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	1.1	3.9	2.9	2.6	1.3	2.7	3.03	1.24	1.14	3.58	2.58	1.76	1.57	<2.500
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0437	0.0786	0.0813	0.0578	0.0496	0.0568	0.0684	0.0506	0.0524	0.08	0.0547	0.0466	0.0582	0.0704
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	***0.475***	0.082	0.116	0.242	***0.493***	0.127	0.16	0.253	0.181	0.128	0.17	0.17	0.264	0.159
Total Nitrogen (mg/L)	5.92	-	-	0.48	<0.260	<0.260	<0.260	0.49	<0.260	0.77	0.99	<0.510	<0.510	0.88	<0.510	<0.510	0.98
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	***0.458***	0.068	0.089	0.224	***0.486***	0.096	0.11	0.253	0.173	0.105	0.141	0.161	0.239	0.141
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	0.33	0.123	1.57	0.687	***6.24***	0.588	0.198	2.36	0.056	0.244	0.26	3.27	0.552	0.431
Dissolved Metals																	
Iron	-	-	-	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	15.8	26	107	-	-	-	27.6	-	-	-	78.2	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	8.7	9.1	9	-	-	-	9.4	-	-	-	12	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**<u>3690</u>**	**<u>4640</u>**	**<u>4380</u>**	-	-	-	**<u>4220</u>**	-	-	-	**<u>3660</u>**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	0.068	0.08	-	-	-	0.057	-	-	-	0.065	-	-	-
Calcium	-	-	-	310000	364000	347000	-	-	-	303000	-	-	-	302000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.05	0.106	-	-	-	0.113	-	-	-	0.094	-	-	-
Copper	-	3 [18]	-	<1	1.17	1.4	-	-	-	0.65	-	-	-	0.79	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	<50	52	206	-	-	-	62	-	-	-	120	-	-	-
Lead	-	140 [18]	-	<1	1.6	0.35	-	-	-	<0.3	-	-	-	0.66	-	-	-
Lithium	-	-	-	153	164	161	-	-	-	156	-	-	-	137	-	-	-
Magnesium	-	-	-	925000	1120000	1110000	-	-	-	954000	-	-	-	900000	-	-	-
Manganese	-	100 [11]	-	3.6	3.62	5.25	-	-	-	7.34	-	-	-	8.76	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	8.4	9.4	9.1	-	-	-	9.1	-	-	-	8.6	-	-	-
Nickel	-	8.3 [12]	-	0.59	0.66	1.63	-	-	-	0.87	-	-	-	0.69	-	-	-
Potassium	-	-	-	282000	348000	323000	-	-	-	292000	-	-	-	280000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	81.3	98.1	96.5	-	-	-	90.1	-	-	-	85.9	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	680	1700	1870	-	-	-	1760	-	-	-	1760	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	8020000	9640000	9160000	-	-	-	8250000	-	-	-	7900000	-	-	-
Strontium	-	-	-	5490	6680	6320	-	-	-	5530	-	-	-	5380	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<5	<5	<5	-	-	-	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.26	2.62	2.49	-	-	-	2.51	-	-	-	2.54	-	-	-
Vanadium	-	50 [14]	-	1.31	1.57	1.64	-	-	-	1.52	-	-	-	1.55	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<4	13.3	-	-	-	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP04-1	SWDP04-2	SWDP04-3	SWDP04-4	SWDP04-5	SWDP04-6	SWDP04-7	SWDP04-8	SWDP04-9	SWDP04-10	SWDP04-11	SWDP04-12	SWDP04-13	SWDP04-14
Location ID:				DP04													
Date Sampled:				23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	1.7	-	2.2	-	1.9	2.2	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.6	-	11.1	6.96	6.9	14.69	12.23	8.56	7.17	11.62	15.8	7.15	-	-
Field pH	-	-	-	7.89	-	-	7.75	7.99	7.95	7.73	7.76	7.59	8.13	8.02	7.74	-	-
Field Conductivity (uS/cm)	-	-	-	42603	-	32241	44592	45283	37722	45518	31575	30014	42909	35973	41659	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.79	-	8.66	10.95	9.8	11.02	8.29	7.92	10.02	11.26	10.36	9.97	-	-
Field Redox, Uncorrected (mV)	-	-	-	261.2	-	242	239	-36.9	205.4	54	-325.7	-368.4	172.7	235.1	171.8	-	-
Field Turbidity (NTU)	-	-	-	0	-	-	-	-	-	-	1.37	0.9	2.3	0.8	0.8	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	5060	4280	4970	-	5140	4510	5610	5790	5450	5180	4040	4800	-	-
Total Suspended Solids (mg/L)	-	-	-	6	27.2	26.3	23.5	19.6	3.2	27.3	22.4	-	13.8	17	21.2	9.3	16.7
Turbidity (NTU)	-	-	-	-	-	-	1.44	1.16	1.49	1.1	1.68	-	1.58	0.72	1.41	5.03	2.05
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0507	0.0241	0.0552	0.0712	0.0613	0.0501	0.0591	0.0695	0.0657	0.0383	0.031	0.0657	0.0671	0.0257
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0548	0.0286	0.0493	0.0714	0.0626	0.0588	0.06	0.0687	0.0739	0.0418	0.0338	0.0654	0.0606	0.0313
Inorganics																	
Ammonia (mg/L)	0.065	-	-	<0.020	***0.123***	0.027	<0.020	0.025	***0.0753***	0.0167	0.0088	<0.005	0.033	0.0164	<0.020	0.0098	0.0087
Nitrate (mg/L)	5.23	-	16	0.67	<0.500	<0.500	***8.3***	1.64	1.93	<2.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.61	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	0.33	<0.100	<0.500	0.25	0.11	***1.41***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.1	2	-	-	-	1.4	-	3	-	-	1.8	3	2.4	<1.000
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0612	0.0489	0.0687	0.076	0.0652	0.0666	0.0709	0.0714	0.0755	0.059	0.0407	0.0746	0.0667	0.0503
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.099	***0.62***	0.294	0.214	0.238	0.369	<0.050	0.062	0.054	0.354	0.08	0.15	0.063	0.258
Total Nitrogen (mg/L)	5.92	-	-	0.77	0.95	<0.700	***8.5***	2.13	<5.000	<3.000	<0.700	<0.700	0.26	<0.700	0.51	<0.700	<0.700
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	-	***0.497***	-	0.214	0.213	0.294	<0.060	<0.060	<0.060	0.321	0.064	-	<0.060	0.249
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	2.54	***6.09***	3.55	0.645	1.22	1.34	0.629	0.393	0.227	1.4	2.14	0.237	0.649	***8.01***
Dissolved Metals																	
Iron	-	-	-	-	<10	<300	<10	<10	23	<10	<10	<10	<10	10	<10	<50	<50
Total Metals																	
Aluminum	-	-	-	<100	<100	<100	<100	<100	110	<100	<100	<100	<100	<100	<100	67	43
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	1.17	0.97	1.42	1.23	1.6	1.43	1.24	1.18	1.48	1.32	1.59	1.21	<2	<2
Barium	-	200 [8]	-	10.4	12.2	11.2	9	7.8	9.3	8.7	9.2	8.7	8.5	9.4	8.2	10.2	10.3
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Boron	-	1200 [4]	-	**3500**	**3300**	**3800**	**3600**	**3700**	**2900**	**3500**	**3700**	**4100**	**3400**	**2800**	**3200**	**4360**	**4240**
Cadmium	-	0.12 [7]	0.12	0.07	0.093	0.068	0.063	0.082	0.044	0.08	0.082	0.09	0.065	0.058	0.064	<0.12	<0.12
Calcium	-	-	-	322000	251000	362000	359000	337000	309000	357000	372000	353000	335000	262000	314000	317000	338000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**61**	**<50**	<1	<1
Cobalt	-	-	-	<0.05	0.056	0.081	0.055	0.057	0.107	0.056	<0.05	<0.05	0.083	<0.05	<0.05	<0.5	<0.5
Copper	-	3 [18]	-	0.743	0.804	1.04	0.552	1.34	1.13	0.652	0.784	2.28	1.6	0.828	0.514	<1	1.2
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	21	17	72	52	32	80	61	44	51	42	26	43	127	84
Lead	-	140 [18]	-	0.192	0.21	0.454	0.093	0.785	0.332	0.231	0.682	0.997	0.299	<0.5	0.059	<1	<1
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	165	159
Magnesium	-	-	-	1030000	886000	1170000	1160000	1040000	908000	1150000	1180000	1110000	1060000	822000	975000	1030000	1040000
Manganese	-	100 [11]	-	3.22	5.77	6.86	4.5	4.85	10.1	5.6	4.22	4.2	4.75	5.93	4.12	6.99	5.78
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	7.5	9.1	9.4	9.9	9.7	5.6	10.3	8.5	10.6	11.1	6.1	5.8	10.2	8.7
Nickel	-	8.3 [12]	-	0.421	0.56	0.798	0.508	0.559	0.762	0.473	0.507	0.777	0.417	0.444	0.467	0.71	0.61
Potassium	-	-	-	331000	264000	387000	376000	361000	288000	357000	345000	319000	307000	248000	297000	312000	307000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.7	88.9
Selenium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2
Silicon	-	-	-	1170	1010	1420	1920	1430	910	1930	1500	1450	860	980	1730	1560	640
Silver	-	3 [18]	-	<1	<1	<1	<1	1.4	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2
Sodium	-	-	-	7840000	6840000	8790000	8450000	8440000	8000000	9410000	8900000	9770000	8800000	7480000	8530000	8970000	7670000
Strontium	-	-	-	6100	5040	7200	6250	5740	4800	6410	5690	6630	5810	4780	5800	5970	5510
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	1.74	1.28	1.9	1.94	2.27	1.67	2.4	2.38	2.35	1.93	1.81	1.73	2.63	2.57
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.68
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	1.96	2.5	1.74	1.39	2.56	3.25	1.45	1.52	12.5	2.45	1.32	0.72	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

			Location ID:	DP04													
			Sample ID:	SWDP04-15	SWDP04-16	SWDP04-17	SWDP04-18	SWDP04-19	SWDP04-20	SWDP04-21	SWDP04-22	SWDP04-23	SWDP04-24	SWDP04-25	SWDP04-26	SWDP04-27	SWDP04-28
			Date Sampled:	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Parameter	***AMS Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	1	2.4	2	0.5	1	1.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	3	-	-	-	1.7	2.5 (bottom)	1.5 (bottom)	1.5	2	1.25	2	1.5 (bottom)	2
Field Temperature (ºC)	-	-	-	15.06	8.08	5.85	14.8	15.39	8.08	6.94	11.53	13.82	6.7	6.43	13.96	12.51	5.87
Field pH	-	-	-	7.72	7.75	7.82	8	8.06	7.59	7.78	7.84	7.93	7.89	8.07	8.34	9.51	8.16
Field Conductivity (uS/cm)	-	-	-	37960	45412	44170	16626	36816	34910	27372	41907	32360	40740	40505	39137	45390	46470
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	10.89	9.63	10.2	10.6	12	10.26	9.58	8.67	11.07	9.68	11.53	12.58	9.21	9.14
Field Redox, Uncorrected (mV)	-	-	-	122.3	251.3	231.3	264	259	197.9	276.2	167.1	329.4	368.2	307.2	215.5	136	98.9
Field Turbidity (NTU)	-	-	-	1.12	0.04	5.44	4.3	0.64	0.94	0.79	4.6	0.7	-	2.74	1.15	1.35	0.78
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4730	5450	5410	-	-	-	5010	-	-	-	3530	-	-	-
Total Suspended Solids (mg/L)	-	-	-	<3.000	15	24.2	7.2	3	<2.000	<2.000	20.2	6.7	3.3	4.9	4.8	4.4	<2.000
Turbidity (NTU)	-	-	-	0.98	1.01	7.05	4.34	1.21	1.59	1.52	7.6	1.3	1.62	3.65	2.96	1.34	1.02
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0281	0.075	0.0584	0.0245	0.0326	0.0463	0.0632	0.0212	0.0318	0.0638	0.0401	0.0255	0.0425	0.0668
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0331	0.0756	0.0559	0.0302	0.0375	0.0455	0.0679	0.0258	0.0374	0.0655	0.0432	0.0308	0.0486	0.066
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.015	0.0076	0.0302	0.0184	0.0125	0.0244	0.0123	0.0134	0.0055	0.0227	0.0446	0.0072	0.0243	0.0088
Nitrate (mg/L)	5.23	-	16	<0.500	0.66	<0.500	<0.500	0.51	***8.95***	0.65	<0.500	0.71	<0.500	<0.500	<0.500	<0.500	0.83
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.31	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	1.2	3.5	2.9	1.8	1.4	3.1	2.95	1.04	0.75	3.78	3.1	1.22	1.58	<2.500
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0438	0.0798	0.0825	0.0494	0.0517	0.0603	0.0781	0.0806	0.063	0.0704	0.0498	0.0432	0.0585	0.0727
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.326	0.066	0.079	0.32	***0.444***	0.127	0.164	0.428	0.302	0.129	0.16	0.168	0.224	0.115
Total Nitrogen (mg/L)	5.92	-	-	0.33	0.73	<0.260	0.32	0.96	***9.08***	0.82	0.43	1.32	<0.510	<0.510	<0.510	<0.510	0.95
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.311	<0.060	<0.060	0.302	***0.431***	0.103	0.152	***0.415***	0.297	0.106	0.115	0.161	0.199	0.106
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	2.1	0.12	1.74	2.03	2.33	1.02	0.343	***27.8***	1.06	0.27	0.338	2.63	3.28	0.216
Dissolved Metals																	
Iron	-	-	-	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	16.6	25.5	99.7	-	-	-	14.1	-	-	-	117	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	8.7	8.9	8.9	-	-	-	9.3	-	-	-	13.7	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3650**	**4640**	**4380**	-	-	-	**4560**	-	-	-	**2860**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	0.07	0.055	-	-	-	0.057	-	-	-	0.052	-	-	-
Calcium	-	-	-	320000	359000	345000	-	-	-	318000	-	-	-	235000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.05	0.137	-	-	-	<0.05	-	-	-	0.107	-	-	-
Copper	-	3 [18]	-	<1	0.76	1.13	-	-	-	<0.5	-	-	-	1	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	<50	41	213	-	-	-	29	-	-	-	205	-	-	-
Lead	-	140 [18]	-	<1	0.39	0.45	-	-	-	<0.3	-	-	-	<0.3	-	-	-
Lithium	-	-	-	149	161	162	-	-	-	166	-	-	-	103	-	-	-
Magnesium	-	-	-	955000	1110000	1100000	-	-	-	1020000	-	-	-	714000	-	-	-
Manganese	-	100 [11]	-	3.7	3.28	5.61	-	-	-	3.97	-	-	-	11.5	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	8.3	9.4	9.4	-	-	-	10.2	-	-	-	6.7	-	-	-
Nickel	-	8.3 [12]	-	0.52	0.56	0.92	-	-	-	0.59	-	-	-	0.74	-	-	-
Potassium	-	-	-	294000	341000	323000	-	-	-	308000	-	-	-	228000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	80.7	98.9	98.7	-	-	-	96.5	-	-	-	64.5	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	830	1610	1900	-	-	-	1590	-	-	-	2220	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	8290000	9450000	9140000	-	-	-	8750000	-	-	-	6240000	-	-	-
Strontium	-	-	-	5710	6530	6310	-	-	-	5810	-	-	-	4410	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<5	<5	<5	-	-	-	<5	-	-	-	6.2	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.28	2.62	2.59	-	-	-	2.6	-	-	-	1.83	-	-	-
Vanadium	-	50 [14]	-	1.38	2.02	1.73	-	-	-	1.75	-	-	-	1.4	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<4	3.9	-	-	-	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

	Location ID:			DP05A													
	Sample ID:			SWDP05A-1	SWDP05A-2	SWDP05A-3	SWDP05A-4	SWDP05A-5	SWDP05A-6	SWDP05A-7	SWDP05A-8	SWDP05A-9	SWDP05A-10	SWDP05A-11	SWDP05A-12	SWDP05A-13	SWDP05A-14
	Date Sampled:			22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010
Parameter	***AMS Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	3.6	4.3	-	-	2.8	2	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.59	-	10.6	7.77	7.08	13.47	12.46	8.92	7.15	12.05	15.78	7.9	-	-
Field pH	-	-	-	7.77	-	-	7.58	7.87	7.53	791	7.69	7.45	8.09	7.94	7.73	-	-
Field Conductivity (uS/cm)	-	-	-	43311	-	32657	44533	44250	37260	40733	32678	30023	40238	35306	42330	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.42	-	7.73	10.86	8.48	9.5	7.91	7.9	10.22	9.95	9.4	10.39	-	-
Field Redox, Uncorrected (mV)	-	-	-	251.9	-	253	221	-40.2	201.4	-86	-322.7	-346.8	209.8	299.4	152.3	-	-
Field Turbidity (NTU)	-	-	-	3.87	-	-	-	-	-	-	0.71	0.75	2.8	0.75	0.62	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4370	3750	5040	-	5250	4430	4800	5470	5460	4760	4040	4790	-	-
Total Suspended Solids (mg/L)	-	-	-	8.7	18.5	15.7	30.8	14.2	9.9	11.3	7.1	-	13.8	14.3	10.5	45.3	16
Turbidity (NTU)	-	-	-	-	-	-	0.88	0.58	1.66	1.87	1.17	-	1.99	1.05	1.18	25	1.18
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0531	0.0217	0.0527	0.0735	0.0654	0.0264	0.0438	0.0727	0.0704	0.034	0.0273	0.0652	0.0556	0.0433
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.058	0.0253	0.0527	0.0733	0.0634	0.0312	0.0462	0.0732	0.0734	0.0353	0.0295	0.0682	0.0593	0.0468
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.035	***0.088***	<0.020	<0.020	0.012	0.0478	0.0182	0.0057	<0.005	0.027	0.0101	<0.020	0.016	0.0075
Nitrate (mg/L)	5.23	-	16	<0.50	<0.500	<0.500	***6.4***	1.9	<0.500	3.5	0.84	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Nitrite (mg/L)	0.978	-	-	<0.10	0.23	<0.100	<0.500	0.27	0.21	<0.500	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.8	2.5	-	-	-	1.2	-	-	-	-	2	3	3	1.4
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0634	0.0418	0.0604	0.0766	0.0687	0.0409	0.0501	0.0811	0.0775	0.042	0.0368	0.0694	0.089	0.0588
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.155	***0.585***	0.289	0.217	0.232	0.187	0.117	<0.050	0.051	0.236	0.11	0.123	0.25	0.17
Total Nitrogen (mg/L)	5.92	-	-	<0.70	0.81	<0.700	***6.6***	2.41	<5.000	3.6	0.84	<0.700	0.13	<0.700	0.51	<0.700	<0.700
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.12	***0.497***	-	0.217	0.22	0.139	0.099	<0.060	<0.060	0.209	0.1	-	0.234	0.163
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	1.26	***6.42***	0.96	0.504	1.5	1.01	1.11	0.304	0.17	0.25	0.209	0.397	1.16	***6.6***
Dissolved Metals																	
Iron	-	-	-	-	<10	<300	<10	<10	22	<10	12	<10	<10	<10	<10	<50	<50
Total Metals																	
Aluminum	-	-	-	<100	<100	<100	<100	<100	160	<100	<100	<100	<100	<100	<100	330	24
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	1.11	1.24	1.28	1.25	1.17	1.26	1.19	1.49	1.28	1.26	1.89	1.28	<2	<2
Barium	-	200 [8]	-	10.8	12.6	8.6	8.9	7.5	7.5	9.4	8.2	8	9.9	10.1	8.6	12.3	9.5
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Boron	-	1200 [4]	-	**3300**	**3000**	**3700**	**3500**	**3500**	**2800**	**3000**	**3700**	**4000**	**2900**	**3000**	**3200**	**3570**	**4080**
Cadmium	-	0.12 [7]	0.12	0.069	0.055	0.066	0.051	0.078	0.064	0.065	0.085	0.09	0.06	0.072	0.073	<0.12	<0.12
Calcium	-	-	-	285000	228000	359000	350000	346000	300000	312000	350000	352000	312000	263000	309000	320000	349000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**52**	**<50**	<1	<1
Cobalt	-	-	-	0.082	0.059	0.064	<0.05	<0.05	0.098	0.064	<0.05	<0.05	0.095	<0.05	<0.05	<0.5	<0.5
Copper	-	3 [18]	-	**6.99**	0.636	0.615	0.617	0.924	1.37	0.666	0.652	1.09	1.57	1.23	0.706	2	1
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	68	18	47	23	22	81	54	41	48	50	26	68	610	<50
Lead	-	140 [18]	-	0.33	0.189	0.386	0.135	0.468	0.457	0.585	0.195	2.67	0.162	1.71	0.065	1.8	<1
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	159	156
Magnesium	-	-	-	887000	772000	1170000	1140000	1070000	893000	978000	1120000	1110000	966000	821000	975000	1010000	1080000
Manganese	-	100 [11]	-	6.48	7.97	5.43	2.28	2.49	8.43	5.85	3.33	2.21	7.05	6.86	3.44	14.8	3.45
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	6.9	7.1	9.4	9.5	7.2	6.5	9.8	8	10.6	9.6	7.5	7.1	9	8.5
Nickel	-	8.3 [12]	-	0.593	0.568	0.582	0.356	0.59	0.941	0.546	0.493	0.562	0.51	0.61	0.47	1.53	0.51
Potassium	-	-	-	296000	239000	384000	374000	366000	277000	306000	316000	317000	285000	250000	300000	315000	313000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	92.6	86.7
Selenium	-	-	-	<0.50	0.62	<0.5	0.59	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2	<2
Silicon	-	-	-	1580	1380	1380	1750	1550	850	1350	1730	1530	1020	1220	1670	3260	650
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2
Sodium	-	-	-	7620000	6280000	8700000	8370000	8590000	7800000	8060000	9750000	9720000	8130000	7500000	8610000	9200000	7890000
Strontium	-	-	-	5750	4330	7050	6170	5860	4790	5250	5670	6250	5000	4900	5770	6010	5620
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	13.5	<5
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	1.92	1.32	2.05	1.74	2.19	1.81	2	2.56	2.39	1.82	1.93	2.12	2.6	2.51
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	2.41	1.46
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	19	1.3	2.67	1.21	1.16	1.65	2.46	1.01	4.72	1.73	7.18	0.76	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

			Location ID:	DP05A													
			Sample ID:	SWDP05A-15	SWDP05A-16	SWDP05A-17	SWDP05A-18	SWDP05A-19	SWDP05A-20	SWDP05A-21	SWDP05A-22	SWDP05A-23	SWDP05A-24	SWDP05A-25	SWDP05A-26	SWDP05A-27	SWDP05A-28
			Date Sampled:	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Parameter	***AMS Threshold*** [20]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	1	0.5	0.5	0.5	1	3	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	3	-	-	-	2	5	1.5	2	3.75	1.5	1.25	2	3
Field Temperature (ºC)	-	-	-	14.76	8.34	6.81	14.2	14.73	8.48	7.07	10.07	12.88	8.13	6.65	13.88	13.1	7.88
Field pH	-	-	-	8.1	7.72	7.79	7.95	8.14	7.66	7.7	7.66	7.82	7.7	8.01	8.15	7.87	7.77
Field Conductivity (uS/cm)	-	-	-	39300	45216	44945	12934	29150	32550	30950	44060	31860	41760	41827	39044	44492	47670
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.4	9.1	9.49	10.16	12.6	9.87	9.59	9.01	9.84	8.26	11.35	9.03	7.96	7.34
Field Redox, Uncorrected (mV)	-	-	-	93.2	257.8	220.7	268.1	269.9	251.7	260.2	202.1	285.8	364.3	300.6	189.4	90.5	142.1
Field Turbidity (NTU)	-	-	-	0.48	0.21	1.22	4.94	0.68	0.79	0.63	1.3	0.7	-	1.7	2.13	1.01	0.69
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	4960	5670	5580	-	-	-	5090	-	-	-	4220	-	-	-
Total Suspended Solids (mg/L)	-	-	-	10	16.3	4.2	7.6	5.7	<2.000	<2.000	3	<2.000	<2.000	2.4	5.4	3	<2.000
Turbidity (NTU)	-	-	-	0.86	1.01	0.78	5.21	1.62	1.88	1.31	1.66	1.16	1.36	1.95	3.45	1.19	1.05
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0319	0.0766	0.0649	0.0181	0.0181	0.0439	0.0693	0.0291	0.0443	0.0636	0.0531	0.0314	0.0358	0.0684
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.038	0.0757	0.0643	0.0201	0.0563	0.0453	0.0711	0.0319	0.0488	0.0657	0.0588	0.0354	0.0428	0.0735
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0109	<0.005	0.0236	0.0084	<0.005	0.0322	<0.005	0.0134	<0.005	0.0144	0.0251	0.0132	0.0145	<0.005
Nitrate (mg/L)	5.23	-	16	<0.500	0.7	0.56	<0.500	<0.500	<0.500	0.6	0.55	<0.500	0.57	<0.500	<0.500	<0.500	0.65
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.11	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	1.3	3.7	2.8	3	1.7	3.1	2.75	1.47	1.72	3.29	2.68	1.6	1.5	<2.500
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0482	0.0759	0.0737	0.0322	0.0533	0.0493	0.0737	0.0405	0.0584	0.071	0.0614	0.0491	0.053	0.0746
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.258	0.051	<0.050	0.24	***0.56***	0.114	0.117	0.181	0.159	0.11	0.159	0.168	0.21	0.104
Total Nitrogen (mg/L)	5.92	-	-	<0.260	0.75	0.56	<0.260	0.56	<0.260	0.72	0.73	<0.510	0.68	<0.510	<0.510	<0.510	0.75
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.247	<0.060	<0.060	0.232	***0.56***	0.082	0.117	0.168	0.159	0.095	0.134	0.154	0.195	0.104
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	3.3	0.101	0.319	2.05	***7.72***	0.499	0.414	4.29	<0.010	0.504	0.61	2	4.86	0.218
Dissolved Metals																	
Iron	-	-	-	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	12.2	14	15.3	-	-	-	7.7	-	-	-	64.1	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	8.7	9.2	8.9	-	-	-	9.4	-	-	-	11.4	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**3930**	**4640**	**4550**	-	-	-	**4660**	-	-	-	**3670**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	0.068	0.081	-	-	-	0.052	-	-	-	0.058	-	-	-
Calcium	-	-	-	336000	371000	363000	-	-	-	335000	-	-	-	312000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	0.064	-	-	-
Copper	-	3 [18]	-	<1	0.9	0.67	-	-	-	<0.5	-	-	-	0.84	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	<50	26	28	-	-	-	13	-	-	-	103	-	-	-
Lead	-	140 [18]	-	<1	1.02	3.42	-	-	-	0.42	-	-	-	<0.3	-	-	-
Lithium	-	-	-	161	163	171	-	-	-	173	-	-	-	136	-	-	-
Magnesium	-	-	-	1000000	1150000	1140000	-	-	-	1030000	-	-	-	835000	-	-	-
Manganese	-	100 [11]	-	3.54	3.05	1.91	-	-	-	2.34	-	-	-	6.61	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	8.7	9.7	9.6	-	-	-	10.5	-	-	-	8.7	-	-	-
Nickel	-	8.3 [12]	-	0.51	0.58	0.52	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Potassium	-	-	-	306000	351000	341000	-	-	-	326000	-	-	-	291000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	85.2	99.3	103	-	-	-	102	-	-	-	84.1	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	880	1620	1690	-	-	-	1580	-	-	-	1860	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	8640000	9740000	9590000	-	-	-	9210000	-	-	-	8200000	-	-	-
Strontium	-	-	-	5920	6760	6700	-	-	-	6090	-	-	-	5630	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<5	<5	<5	-	-	-	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.38	2.7	2.57	-	-	-	2.57	-	-	-	2.32	-	-	-
Vanadium	-	50 [14]	-	1.44	1.51	1.47	-	-	-	1.72	-	-	-	1.6	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<4	<3	-	-	-	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Parameter	AMS Threshold [20]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP05B-1	SWDP05B-2	SWDP05B-3	SWDP05B-4	SWDP05B-5	SWDP05B-6	SWDP05B-7	SWDP05B-8	SWDP05B-9	SWDP05B-10	SWDP05B-11	SWDP05B-12	SWDP05B-13	SWDP05B-14
Location ID:				DP05B													
Date Sampled:				24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	10	-	0.5	0.5	14	13	0.5	14	14	13	15	15	15	14
Field Tests																	
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.3	-	10.1	7.54	7.22	11.66	11.14	9.13	7	9.3	11.43	8.75	-	-
Field pH	-	-	-	7.76	-	-	7.62	7.82	7.6	7.63	7.65	7.45	7.9	7.6	7.64	-	-
Field Conductivity (uS/cm)	-	-	-	45143	-	33099	44917	46613	42172	45770	33418	30189	47097	45499	45616	-	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	16.92	-	***6.02***	10.86	7.66	9.06	6.42	6.08	10.08	8.96	6.55	8.29	-	-
Field Redox, Uncorrected (mV)	-	-	-	227.2	-	251	230	-73.5	206.9	-66	-305.7	-351.2	210.9	258.1	145.5	-	-
Field Turbidity (NTU)	-	-	-	10.19	-	-	-	-	-	-	1.11	0.9	2.2	0.1	0.61	-	-
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	5210	5120	-	5300	4790	5500	5600	5520	5440	5310	5060	-	-
Total Suspended Solids (mg/L)	-	-	-	20.2	36.5	51.7	14.8	12.9	19.9	11.3	4.4	-	27.8	17.7	19.2	6	16.7
Turbidity (NTU)	-	-	-	-	-	-	1.46	0.72	2.04	1.07	1.32	-	2.04	0.43	1.23	0.78	0.87
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.062	0.0634	0.0708	0.0745	0.0713	0.0273	0.0608	0.0754	0.0706	0.04	0.0639	0.0705	0.0685	0.0655
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0688	0.0648	0.0683	0.067	0.0704	0.0326	0.0622	0.0777	0.074	0.0414	0.0666	0.0704	0.0755	0.0669
Inorganics																	
Ammonia (mg/L)	0.065	-	-	<0.020	***0.076***	<0.020	<0.020	<0.005	0.0426	0.0125	<0.005	<0.005	0.023	0.0163	<0.020	<0.005	0.0183
Nitrate (mg/L)	5.23	-	16	0.3	<0.500	<0.500	***7***	2.39	<0.500	<2.500	***8.8***	<0.500	<0.500	<0.500	<0.500	<0.500	0.69
Nitrite (mg/L)	0.978	-	-	<0.020	0.29	<0.100	<0.500	0.27	0.19	<0.500	***<1.000***	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.3	2.3	-	-	-	<1.000	-	-	-	-	2.2	3	2.4	2
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.0705	0.0716	0.0713	0.0844	0.0726	0.0435	0.0638	0.078	0.0776	0.0507	0.0697	0.0751	0.0762	0.0742
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.107	0.128	0.222	0.201	0.251	0.179	<0.050	0.074	0.058	0.188	0.079	0.122	0.128	0.066
Total Nitrogen (mg/L)	5.92	-	-	0.41	<0.700	<0.700	***7.2***	2.91	<5.000	<3.000	***8.9***	<0.700	0.28	<0.700	0.51	<0.700	0.75
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	-	<0.070	-	0.201	0.251	0.136	<0.060	0.074	<0.060	0.165	0.063	-	0.128	<0.060
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	0.5	1	4.96	0.422	0.722	1.95	1.03	0.142	0.266	2.11	0.462	0.295	0.706	1.46
Dissolved Metals																	
Iron	-	-	-	-	<10	<300	<10	<10	22	<10	14	<10	<10	<10	<10	<50	<50
Total Metals																	
Aluminum	-	-	-	<100	<300	<100	<100	<100	130	<100	<100	<100	<100	<100	<100	<10	26
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	1.26	1.16	1.05	0.88	1.31	0.84	1.19	1.51	1.41	1.41	1.89	1.3	<2	<2
Barium	-	200 [8]	-	9.3	21.2	7.1	8.3	7	6	8.3	7.8	7.7	6.8	7.9	8.3	8.8	9.7
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<0.5	<0.5
Boron	-	1200 [4]	-	**3800**	**3900**	**3500**	**3500**	**3700**	**3100**	**3500**	**3600**	**4000**	**3300**	**3900**	**3500**	**4170**	**4510**
Cadmium	-	0.12 [7]	0.12	0.064	0.064	0.054	0.062	0.085	0.073	0.073	0.088	0.083	0.07	0.086	0.069	<0.12	<0.12
Calcium	-	-	-	345000	309000	395000	359000	348000	320000	357000	364000	356000	351000	346000	327000	346000	365000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**54**	**<50**	<1	<1
Cobalt	-	-	-	<0.050	0.052	<0.05	<0.05	<0.05	0.086	<0.05	<0.05	<0.05	0.075	<0.05	<0.05	<0.5	<0.5
Copper	-	3 [18]	-	0.496	0.562	0.389	0.507	0.721	0.974	0.408	0.561	0.464	0.532	0.552	0.413	<1	<1
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Iron	-	-	-	29	51	22	38	27	109	35	46	30	45	24	38	<50	<50
Lead	-	140 [18]	-	0.119	0.373	0.094	0.081	0.315	0.387	0.139	1.29	0.243	0.091	<0.6	<0.05	<1	<1
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	179	169
Magnesium	-	-	-	1090000	1080000	1290000	1170000	1080000	970000	1120000	1140000	1120000	1110000	1080000	1030000	1090000	1200000
Manganese	-	100 [11]	-	2.47	3.58	2.31	2.89	1.76	7.02	3.68	2.59	1.96	2.78	3.32	3.2	2.1	2.49
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	8.9	9.4	8.2	10.5	8.7	7.8	9.8	8.5	9.7	11.2	9.5	8.4	10.2	9.4
Nickel	-	8.3 [12]	-	0.64	0.52	0.416	0.425	0.565	0.735	0.479	0.481	0.475	0.377	0.418	0.46	<0.5	<0.5
Potassium	-	-	-	348000	329000	415000	387000	371000	298000	352000	319000	328000	325000	326000	314000	336000	350000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	107	95.5
Selenium	-	-	-	<0.50	<0.5	0.69	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.76	<0.5	<2	<2
Silicon	-	-	-	1340	1380	1560	1810	1530	750	1470	1630	1600	720	1340	1620	1200	1160
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<0.2	<0.2
Sodium	-	-	-	8230000	8620000	9380000	8660000	8660000	8200000	9270000	9900000	9930000	9210000	9800000	8980000	9320000	9390000
Strontium	-	-	-	6680	6300	6460	6290	5700	5320	6340	5730	6420	5970	6450	6280	6520	6790
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<0.5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<1	<1
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<5	<5
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	<1
Uranium	-	100 [13]	-	1.97	1.28	1.82	1.87	2.4	2.29	2.27	2.65	2.36	2.05	2.48	1.74	2.62	2.74
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	1.52	1.55
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5
Zinc	-	55 [19]	-	1.09	2.1	0.67	1	1.24	2.2	1.02	0.9	1.1	1.71	1.79	0.62	<5	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results (2007 - 2013)

			Location ID:	DP05B													
			Sample ID:	SWDP05B-15	SWDP05B-16	SWDP05B-17	SWDP05B-18	SWDP05B-19	SWDP05B-20	SWDP05B-21	SWDP05B-22	SWDP05B-23	SWDP05B-24	SWDP05B-25	SWDP05B-26	SWDP05B-27	SWDP05B-28
			Date Sampled:	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Parameter	***AMS Threshold* [20]**	**BCWQG MAL [3,4]**	**CCME MAL [5,6]**														
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	15.5	17	15	14	13	14.5	14	14	14	14.5	15	13	16.5	15
Field Tests																	
Secchi Depth (m)		-	-	-	3	-	-	-	2	5	1.5	2	3.75	1.5	1.25	2	3
Field Temperature (ºC)	-	-	-	12.39	8.38	6.68	10.24	12.02	9.32	7.2	9.36	10.5	8.42	7.58	9.98	10.57	7.45
Field pH	-	-	-	8.07	7.7	7.6	7.74	7.83	7.58	7.7	7.69	7.6	7.75	7.84	7.8	7.74	7.63
Field Conductivity (uS/cm)	-	-	-	42400	45886	44703	32712	32013	45978	31500	45743	31170	43090	48424	47136	49753	47330
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	7.48	9.93	10.19	9.47	9.24	7.32	8.86	8.47	7.12	7.72	9.25	8.63	6.41	7.57
Field Redox, Uncorrected (mV)	-	-	-	93.6	259.2	220.8	275.2	276.6	242.4	254.4	199.7	282	342.5	299.5	196.2	89.3	127.3
Field Turbidity (NTU)	-	-	-	0.75	0.17	0.78	2.67	1.16	0.25	0.4	1.2	0.37	-	0.33	37.63	3.24	1.13
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	5400	5700	5660	-	-	-	5260	-	-	-	5170	-	-	-
Total Suspended Solids (mg/L)	-	-	-	17.3	13	12.2	9.2	6.6	<2.000	<2.000	4.4	3.9	33.5	<3.000	221	17.5	<2.000
Turbidity (NTU)	-	-	-	0.81	1.22	0.56	3.37	3.28	1.21	1.37	1.57	1.22	10.4	1.16	73.1	4.59	1.31
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0529	0.0759	0.0679	0.0484	0.0599	0.065	0.0717	0.0578	0.0595	0.0732	0.0639	0.0665	0.0591	0.0697
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0567	0.0758	0.069	0.0488	0.0628	0.0659	0.0734	0.0576	0.0655	0.077	0.0661	0.0652	0.0651	0.0715
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0263	<0.005	0.0246	0.0297	0.0246	0.0076	<0.005	0.0411	0.0117	0.0143	0.0054	0.0301	0.0229	<0.005
Nitrate (mg/L)	5.23	-	16	<0.500	1.07	<0.500	<0.500	<0.500	<0.500	0.67	0.65	0.62	0.55	0.8	<0.500	<0.500	0.68
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	0.12	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	1.7	3.5	2.8	1.4	2.3	2.6	2.76	1.94	2.15	3.72	2.53	2.5	1.99	<2.500
Total Inorganics																	
Chlorine (mg/L)	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	0.089	-	-	0.062	0.0804	0.0752	0.0675	0.0798	0.0695	0.0808	0.0676	0.073	0.118	0.0694	***0.377***	0.0843	0.0778
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.31	<0.050	<0.050	0.242	0.417	0.086	0.088	0.143	0.127	0.167	0.104	***0.588***	0.196	0.097
Total Nitrogen (mg/L)	5.92	-	-	0.31	1.07	<0.260	<0.260	0.42	<0.260	0.76	0.8	0.88	0.72	0.9	0.59	<0.510	0.78
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.284	<0.060	<0.060	0.212	***0.392***	0.078	0.088	0.102	0.116	0.153	0.099	***0.558***	0.174	0.097
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	1.54	0.202	0.301	2.57	2.21	0.316	0.375	1.13	0.073	0.813	0.361	***8.25***	1.34	0.404
Dissolved Metals																	
Iron	-	-	-	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	14.5	25.2	14	-	-	-	10.3	-	-	-	32.4	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	9.4	8.5	8.8	-	-	-	8.8	-	-	-	9.2	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**<u>4280</u>**	**<u>4700</u>**	**<u>4440</u>**	-	-	-	**<u>4700</u>**	-	-	-	**<u>4140</u>**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	0.073	0.08	-	-	-	0.069	-	-	-	0.067	-	-	-
Calcium	-	-	-	360000	378000	357000	-	-	-	339000	-	-	-	349000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Copper	-	3 [18]	-	<1	0.93	0.53	-	-	-	<0.5	-	-	-	0.58	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	<50	41	24	-	-	-	16	-	-	-	57	-	-	-
Lead	-	140 [18]	-	<1	0.85	0.76	-	-	-	<0.3	-	-	-	<0.3	-	-	-
Lithium	-	-	-	170	165	167	-	-	-	173	-	-	-	154	-	-	-
Magnesium	-	-	-	1090000	1160000	1130000	-	-	-	1070000	-	-	-	1040000	-	-	-
Manganese	-	100 [11]	-	3.08	2.88	1.76	-	-	-	1.86	-	-	-	2.83	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	9.9	9.4	9.5	-	-	-	10.5	-	-	-	9.6	-	-	-
Nickel	-	8.3 [12]	-	0.5	0.58	0.67	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Potassium	-	-	-	336000	354000	334000	-	-	-	332000	-	-	-	335000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	91.7	100	98.1	-	-	-	104	-	-	-	96.9	-	-	-
Selenium	-	-	-	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	1140	1740	1680	-	-	-	1480	-	-	-	1580	-	-	-
Silver	-	3 [18]	-	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	9350000	9940000	9420000	-	-	-	9330000	-	-	-	9390000	-	-	-
Strontium	-	-	-	6500	6840	6530	-	-	-	6210	-	-	-	6380	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	<5	<5	<5	-	-	-	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	2.56	2.61	2.57	-	-	-	2.68	-	-	-	2.59	-	-	-
Vanadium	-	50 [14]	-	1.48	1.5	1.49	-	-	-	1.75	-	-	-	1.59	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<4	3.1	-	-	-	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS Threshold [5]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP06-1	SWDP06-2	SWDP06-3	SWDP06-4	SWDP06-5	SWDP06-6	SWDP06-7	SWDP06-8	SWDP06-9	SWDP06-10	SWDP06-11	SWDP06-12	SWDP06-13
Location ID:				DP06												
Date Sampled:				23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010
Sample Info																
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3	0.5	0.5
Field Tests																
Secchi Depth (m)		-	-	-	-	0.6	0.9	0.4	-	0.5	1	-	-	-	-	-
Field Temperature (ºC)	-	-	-	6.4	-	12.4	3.96	6.23	6.4	13.51	7.74	6.08	14.63	17.44	5.51	-
Field pH	-	-	-	7.81	-	6.5	7.45	7.97	7.81	7.83	7.47	7.69	8.24	7.8	6.73	-
Field Conductivity (uS/cm)	-	-	-	20042	-	4877	11517	24116	20042	23071	24000	19360	10344	14450	15133	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	11.4	-	10.4	12.26	10.55	11.4	9.35	9.95	10.39	10.38	11.09	13.94	-
Field Redox, Uncorrected (mV)	-	-	-	207	-	212	176	-64.9	207	-22	-273.9	265.2	168.4	167.8	189.9	-
Field Turbidity (NTU)	-	-	-	18.92	-	-	-	-	-	-	5.48	1.7	24	5.6	8.27	-
Physical Tests																
Hardness, Total (CaCO3) (mg/L)	-	-	-	1950	212	615	-	2530	139	2640	1710	3940	767	1610	1800	-
Total Suspended Solids (mg/L)	-	-	-	12.7	28.5	12.9	12.2	25.3	94.7	35.3	9.1	-	19.8	-	19.8	67.3
Turbidity (NTU)	-	-	-	-	-	-	8.75	14	86.3	16.5	7.93	-	25.9	7.15	10.9	23.3
Dissolved Inorganics																
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0237	0.0067	0.016	0.0224	0.031	-	0.0264	0.0267	0.0446	0.0138	0.0214	0.0259	0.0576
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.027	0.008	0.0167	0.0218	0.0306	-	0.0284	0.0277	0.0424	0.0153	0.0215	0.0263	0.0644
Inorganics																
Ammonia (mg/L)	0.065	-	-	0.041	0.056	***0.1***	***0.071***	***0.0814***	***0.242***	0.0365	***0.0815***	0.0597	0.042	0.051	***0.073***	0.02
Nitrate (mg/L)	5.23	-	16	0.19	0.0634	0.49	***12***	1.59	<0.500	<0.500	<0.500	<2.500	<0.250	<0.250	<0.500	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	<0.001	<0.020	<0.500	0.11	<0.100	0.13	<0.100	0.56	<0.050	<0.050	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	3.7	4.9	-	-	-	-	-	4.4	-	-	3	4.4	3
Total Inorganics																
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0486	0.0477	0.0298	0.0343	0.0528	-	0.0602	0.0415	0.0523	0.0404	0.0292	0.0497	0.099
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.214	0.312	0.2	0.186	0.343	0.247	0.137	0.284	0.147	<0.050	0.108	0.167	0.152
Total Nitrogen (mg/L)	5.92	-	-	0.41	0.375	0.69	***12.2***	2.04	<0.700	<0.700	<0.700	<3.000	0.26	<0.400	0.42	<0.700
Organics																
Organic Nitrogen (mg/L)	0.392	-	-	-	0.256	-	0.115	0.261	<0.070	0.1	0.203	0.087	<0.070	<0.070	-	0.132
Microbiological Analysis																
Chlorophyll A	5.11	-	-	0.847	0.554	0.932	0.267	1.07	0.747	0.964	0.389	0.622	0.123	0.251	0.358	1.33
Dissolved Metals																
Iron	-	-	-	-	21	-	11	<10	59	<10	19	<10	23	11	14	<50
Total Metals																
Aluminum	-	-	-	226	1110	170	200	282	1170	<500	181	<100	523	151	367	364
Antimony	-	-	-	<5	<0.5	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<0.5
Arsenic	-	12.5 [17]	12.5	0.86	0.43	0.69	0.61	0.77	0.52	0.81	0.74	1.06	0.7	1.6	0.73	<2
Barium	-	200 [8]	-	17.8	22	20.3	19	16.2	24.2	13.7	15.5	12.3	27.7	15.2	15.8	12.6
Beryllium	-	100 [9]	-	<25	<2.5	<50	<10	<25	<1	<50	<25	<50	<10	<25	<25	<0.5
Bismuth	-	-	-	<25	<2.5	<50	<10	<25	<1	<50	<25	<50	<10	<25	<25	<0.5
Boron	-	1200 [4]	-	**1310**	129	<1000	740	**1760**	65	**1700**	1120	**2700**	490	1120	**1220**	**3480**
Cadmium	-	0.12 [7]	0.12	0.051	0.028	0.032	0.032	0.052	0.045	0.046	0.045	0.081	0.033	0.033	0.047	<0.12
Calcium	-	-	-	133000	24500	49400	79900	168000	19300	170000	111000	246000	53400	110000	117000	312000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Chromium	-	1.5 [10]	1.5	**<25**	**4.1**	**<50**	**<10**	**<25**	**2.2**	**<50**	**<25**	**<50**	**<10**	**<25**	**<25**	<1
Cobalt	-	-	-	0.252	0.394	0.189	0.161	0.252	1.2	0.398	0.147	0.054	0.37	0.159	0.238	<0.5
Copper	-	3 [18]	-	**3.27**	2.07	**6.45**	1.12	2.01	**6.45**	1.57	1.07	1.19	2.89	0.95	1.52	2.6
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Iron	-	-	-	300	369	161	218	329	1350	599	231	53	467	159	310	737
Lead	-	140 [18]	-	1.95	0.349	3.1	0.171	1.11	1.47	0.58	0.169	3.11	0.571	<0.15	0.306	<1
Lithium	-	-	-	<250	<25	<500	<100	<250	<10	<500	<250	<500	<100	<250	<250	156
Magnesium	-	-	-	393000	36600	119000	225000	513000	22100	539000	348000	807000	154000	324000	367000	951000
Manganese	-	100 [11]	-	22.8	38.8	39.1	21.9	21.3	74	23.9	18.8	11.2	27.7	21.9	28	18.9
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	0.017	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	2.6	1.26	<5	2.3	5.1	0.62	5.3	3.1	5.6	2.3	3	<2.5	8.8
Nickel	-	8.3 [12]	-	1.16	1.43	0.953	0.834	1.32	4.47	1.57	0.928	0.762	1.63	0.715	1.26	2
Potassium	-	-	-	123000	12000	37000	75000	178000	7000	170000	104000	226000	44200	97000	112000	277000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90.4
Selenium	-	-	-	<0.5	0.61	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2
Silicon	-	-	-	2320	3330	2250	2840	2620	5340	2890	2810	1920	4810	2150	3130	2990
Silver	-	3 [18]	-	<0.5	<0.05	<1	<0.2	<0.5	0.022	<1	<0.5	<1	<0.2	<0.5	<0.5	<0.2
Sodium	-	-	-	3090000	257000	905000	1890000	4140000	162000	5040000	3140000	7120000	1200000	2720000	2910000	8360000
Strontium	-	-	-	2080	253	869	1320	2860	164	3020	1860	5440	900	1850	2070	5490
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Thallium	-	-	-	<5	<0.5	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Tin	-	-	-	<5	2.22	<10	<2	<5	<0.2	<10	<5	<10	<2	<5	<5	<1
Titanium	-	-	-	<100	25	<100	<100	<100	53	<100	<100	<100	46	<100	<100	16
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1
Uranium	-	100 [13]	-	0.937	0.221	0.432	0.58	1.34	0.263	1.26	0.872	1.72	0.453	0.842	0.833	2.49
Vanadium	-	50 [14]	-	<50	5	**<100**	<20	<50	3.5	**<100**	<50	**<100**	<20	<50	<50	2.33
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Zinc	-	55 [19]	-	3.65	1.82	4.83	2.68	2.19	8.68	2.81	2.76	2.97	3.19	1.54	147	7.8
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS *Threshold* [5]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP06-14	SWDP06-15	SWDP06-16	SWDP06-17	SWDP06-18	SWDP06-19	SWDP06-20	SWDP06-21	SWDP06-22	SWDP06-23	SWDP06-25	SWDP06-26	SWDP06-27	SWDP06-28
Location ID:				DP06													
Date Sampled:				07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	1	0.25	1	0.5	1	1.9	0.5	0.5	0.5	0.5	0.5
Field Tests																	
Secchi Depth (m)		-	-	-	-	1.1	-	-	-	1.2	2.7 (bottom)	0.25	0.75	2	0.25	0.5	1.5
Field Temperature (ºC)	-	-	-	-	14.98	6.02	4.47	13.66	16.98	7.75	6.5	12.78	14.47	6.6	15.17	13.66	4.16
Field pH	-	-	-	-	7.1	7.74	7.81	6.38	7.73	7.77	7.81	8.94	7.71	7.6	7.9	7.54	7.66
Field Conductivity (uS/cm)	-	-	-	-	20580	28438	29578	80300	6297	22722	25054	746	18750	31418	2850	23799	37240
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	-	9.23	11.06	12.39	11.78	10.24	10.87	10.64	11.08	9.05	11.89	10.54	8.33	10.76
Field Redox, Uncorrected (mV)	-	-	-	-	8.5	165.9	340	205.3	187.4	229.3	268.5	106.9	221.6	334.8	185.6	206.9	145.6
Field Turbidity (NTU)	-	-	-	-	3.55	3.43	5.03	43.8	7.87	1.87	1.31	32.8	3.54	0.78	22.07	8.78	3.34
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	2530	3290	3470	-	-	-	4280	-	-	2150	-	-	-
Total Suspended Solids (mg/L)	-	-	-	10.7	13.3	7.7	9.6	65.7	11.7	4.4	2.2	47.2	9.9	3.8	39.6	15.3	4.4
Turbidity (NTU)	-	-	-	13.9	4.95	4.61	5.38	53.1	10.4	4.28	2.12	30.9	7.93	2.98	37.6	8.32	3.19
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0095	0.0265	0.0504	0.0453	0.0068	0.0143	0.0324	0.0576	0.0059	0.0223	0.0324	0.0055	0.023	0.0495
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.011	0.0303	0.0512	0.0466	0.0099	0.0162	0.0338	0.0601	0.0066	0.0247	0.0373	0.0069	0.026	0.0525
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0231	0.0595	***0.0654***	***0.0674***	0.0154	0.0488	0.0503	0.0192	0.011	0.0412	***0.0886***	0.0068	0.0402	0.0403
Nitrate (mg/L)	5.23	-	16	0.112	<0.500	0.64	<0.500	0.0749	<0.250	<0.500	0.65	0.2	<0.500	<0.500	0.0993	<0.500	1.73
Nitrite (mg/L)	0.978	-	-	<0.010	<0.100	<0.100	<0.100	<0.001	<0.050	<0.100	<0.100	<0.020	<0.100	<0.100	0.0012	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	4.7	2.7	4.9	3.8	6.2	4	3.7	3.18	5.73	3.45	4.3	5.34	2.6	2.7
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	<0.100	<0.100	<0.100	0.39	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0264	0.0443	0.0635	0.0561	0.0714	0.0329	0.0421	0.0653	0.0579	0.0367	0.0426	0.0437	0.0426	0.0597
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.067	0.277	0.125	0.187	0.262	0.213	0.138	0.124	0.189	0.154	0.202	0.145	0.214	0.153
Total Nitrogen (mg/L)	5.92	-	-	0.18	0.28	0.77	<0.260	0.337	0.213	<0.260	0.77	0.391	<0.510	<0.510	0.246	<0.510	1.88
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	<0.060	0.217	<0.060	0.12	0.247	0.164	0.087	0.105	0.178	0.112	0.114	0.138	0.174	0.113
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	0.453	0.704	0.272	0.248	0.301	0.223	0.285	0.669	1.24	<0.010	0.104	0.252	0.826	0.207
Dissolved Metals																	
Iron	-	-	-	<50	<5	<10	<10	-	-	-	-	-	-	-	-	-	-
Total Metals																	
Aluminum	-	-	-	370	86.7	83.5	81.9	-	-	-	18.3	-	-	81.5	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	<2	-	-	-	<2	-	-	<2	-	-	-
Barium	-	200 [8]	-	16.4	14.1	13.5	14.2	-	-	-	11.8	-	-	15.9	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	390	**2060**	**2890**	**2950**	-	-	-	**3870**	-	-	**1770**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	<0.12	0.082	0.084	-	-	-	0.058	-	-	<0.05	-	-	-
Calcium	-	-	-	39000	166000	213000	227000	-	-	-	277000	-	-	143000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.5	0.113	0.153	-	-	-	0.052	-	-	0.101	-	-	-
Copper	-	3 [18]	-	2	1.2	1.1	1.08	-	-	-	0.76	-	-	1.5	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Iron	-	-	-	423	133	165	168	-	-	-	39	-	-	174	-	-	-
Lead	-	140 [18]	-	<1	<1	0.46	0.85	-	-	-	<0.3	-	-	<0.3	-	-	-
Lithium	-	-	-	<20	82	97	107	-	-	-	140	-	-	58	-	-	-
Magnesium	-	-	-	87600	514000	670000	705000	-	-	-	871000	-	-	435000	-	-	-
Manganese	-	100 [11]	-	25.6	16.1	15.8	13.4	-	-	-	7.29	-	-	18.3	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	<2	4.8	6	6.5	-	-	-	8.5	-	-	4.3	-	-	-
Nickel	-	8.3 [12]	-	1.23	0.77	0.93	1.09	-	-	-	0.56	-	-	0.75	-	-	-
Potassium	-	-	-	25300	155000	201000	213000	-	-	-	268000	-	-	132000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Rubidium	-	-	-	8.2	44.1	60	64.2	-	-	-	84	-	-	36.9	-	-	-
Selenium	-	-	-	<2	<2	<2	<2	-	-	-	<2	-	-	<2	-	-	-
Silicon	-	-	-	4280	1750	2210	2360	-	-	-	1820	-	-	2570	-	-	-
Silver	-	3 [18]	-	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	<0.1	-	-	-
Sodium	-	-	-	728000	4110000	5560000	5580000	-	-	-	7500000	-	-	3600000	-	-	-
Strontium	-	-	-	554	3050	3910	4170	-	-	-	5030	-	-	2580	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	<1	-	-	-	<1	-	-	<1	-	-	-
Titanium	-	-	-	13.3	<5	<5	<5	-	-	-	<5	-	-	<5	-	-	-
Tungsten	-	-	-	<1	<1	<1	<1	-	-	-	<1	-	-	<1	-	-	-
Uranium	-	100 [13]	-	<0.5	1.29	1.66	1.76	-	-	-	2.15	-	-	1.17	-	-	-
Vanadium	-	50 [14]	-	1.23	0.98	1.18	1.18	-	-	-	1.5	-	-	0.93	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	<5	<5	<4	<3	-	-	-	<3	-	-	4	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS Threshold[5]	BCWQG MAL[3,4]	CCME MAL[5,6]	SWDP07A-1	SWDP07A-2	SWDP07A-3	SWDP07A-4	SWDP07A-5	SWDP07A-6	SWDP07A-7	SWDP07A-8	SWDP07A-9	SWDP07A-10	SWDP07A-11	SWDP07A-12	SWDP07A-13
Location ID:				DP07A												
Date Sampled:				24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010
Sample Info																
Sample Depth, Below Water Surface (m)		-	-	0.5	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																
Secchi Depth (m)		-	-	-	-	5.2	2	1.8	-	1	1.2	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.85	-	10.8	6.62	6.27	12.05	13.36	8.07	7.2	10.64	16.19	7.01	-
Field pH	-	-	-	7.8	-	-	7.64	7.94	6.1	7.6	7.78	7.69	7.77	7.85	7.63	-
Field Conductivity (uS/cm)	-	-	-	43933	-	32350	39268	23905	48340	31003	25693	41521	13999	31966	30289	-
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	9.27	-	8.27	10.1	11.81	9.27	8.2	9.6	9.62	10.85	9.52	10.51	-
Field Redox, Uncorrected (mV)	-	-	-	180.3	-	257	172	-74	290.5	135	-276.2	-329.4	250.1	217.6	192.5	-
Field Turbidity (NTU)	-	-	-	1.2	-	-	-	-	-	-	5.45	1.1	23	1.1	1.49	-
Physical Tests																
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	2140	5110	-	2510	484	3380	5840	4830	992	3590	4090	-
Total Suspended Solids (mg/L)	-	-	-	33.6	21.2	3.7	22.2	12.7	48.7	6	11.8	-	25.8	11.7	17.8	21.3
Turbidity (NTU)	-	-	-	-	-	-	2.21	4.88	50	4.86	7.07	-	28	1.44	2.1	10.8
Dissolved Inorganics																
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0578	0.0091	0.0672	0.0618	0.0356	-	0.0302	0.0253	0.0548	0.0139	0.0209	0.056	0.0608
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0618	0.0134	0.0624	0.0603	0.0338	-	0.0336	0.0258	0.0517	0.0161	0.0218	0.0585	0.0671
Inorganics																
Ammonia (mg/L)	0.065	-	-	0.028	0.023	0.0067	<0.020	***0.0974***	0.028	0.0372	***0.0848***	0.0116	0.046	0.0118	<0.020	<0.005
Nitrate (mg/L)	5.23	-	16	0.25	0.79	1.93	***7.4***	1.75	<0.500	<0.500	0.218	<0.500	<0.250	<0.500	<0.500	0.0068
Nitrite (mg/L)	0.978	-	-	<0.020	<0.100	<0.100	<0.500	0.14	<0.100	0.15	0.022	<0.100	<0.050	<0.100	<0.100	<0.001
Silicon Dioxide (mg/L)	-	-	-	2.1	3.2	-	-	-	-	-	4.7	-	-	2	3.1	2.6
Total Inorganics																
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0644	0.0352	0.0638	0.069	0.0452	-	0.0447	0.0349	0.0662	0.0447	0.0321	0.0616	0.0836
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.075	0.23	0.233	0.143	0.31	0.146	0.115	0.296	0.096	0.258	0.074	0.119	0.087
Total Nitrogen (mg/L)	5.92	-	-	0.33	1.02	2.16	***7.6***	2.2	<0.700	<0.700	0.54	<0.700	0.46	<0.700	0.47	0.094
Organics																
Organic Nitrogen (mg/L)	0.392	-	-	-	0.207	-	0.143	0.213	0.119	0.078	0.211	0.084	0.212	0.062	-	0.087
Microbiological Analysis																
Chlorophyll A	5.11	-	-	0.561	4.3	1.17	0.401	0.766	0.407	0.864	0.462	1.25	0.2	1.23	0.399	1.07
Dissolved Metals																
Iron	-	-	-	-	<10	-	<10	<10	24	<10	18	<10	20	<10	<10	<50
Total Metals																
Aluminum	-	-	-	<100	<400	<100	<100	102	723	<200	<200	<100	781	<100	<100	133
Antimony	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<0.5
Arsenic	-	12.5 [17]	12.5	1.34	0.92	1.06	1.11	1.12	0.65	0.65	0.42	1.22	0.74	1.17	1.11	<2
Barium	-	200 [8]	-	10.6	17.9	8.5	10.3	14	21.2	11.7	14.6	10.2	23	10.4	10.6	10.5
Beryllium	-	100 [9]	-	<50	<25	<50	<50	<25	<5	<50	<50	<50	<10	<50	<50	<0.5
Bismuth	-	-	-	<50	<25	<50	<50	<25	<5	<50	<50	<50	<10	<50	<50	<0.5
Boron	-	1200 [4]	-	**3900**	**1560**	**4000**	**3000**	**1860**	300	**2100**	1000	**3500**	600	**2500**	**2800**	**4080**
Cadmium	-	0.12 [7]	0.12	0.067	0.066	0.068	0.057	0.046	0.042	0.062	0.039	0.166	0.047	0.053	0.06	<0.12
Calcium	-	-	-	332000	133000	338000	296000	167000	41600	215000	371000	294000	68300	234000	257000	327000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Chromium	-	1.5 [10]	1.5	<50	<25	<50	<50	<25	<5	<50	<50	<50	<10	55	<50	<1
Cobalt	-	-	-	<0.050	0.123	<0.05	0.056	0.108	0.864	0.181	0.131	<0.05	0.335	0.054	0.07	<0.5
Copper	-	3 [18]	-	2.25	1.27	0.825	0.563	2.25	**4.38**	1.45	1.62	1.24	**3.04**	1.43	0.609	1.1
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Iron	-	-	-	36	92	<10	55	127	1020	240	205	28	443	29	62	275
Lead	-	140 [18]	-	1.06	0.601	0.368	0.085	0.657	0.841	0.172	0.882	0.792	0.816	<0.3	0.096	2.2
Lithium	-	-	-	<500	<250	<500	<500	<250	<50	<500	<500	<500	<100	<500	<500	174
Magnesium	-	-	-	1060000	439000	1040000	942000	508000	92300	690000	1190000	994000	199000	729000	838000	1070000
Manganese	-	100 [11]	-	2.3	13.9	1.93	5.33	12.3	55.7	15.4	16.8	6.35	20.9	7.88	7.54	9.71
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	0.013	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	10.5	4.4	9.5	8.7	4.9	0.97	5.8	<5	8.7	2.9	5.2	6.1	9.4
Nickel	-	8.3 [12]	-	0.558	0.767	0.453	0.503	0.898	3.43	0.947	0.901	0.685	1.97	1.03	0.606	1.11
Potassium	-	-	-	333000	137000	297000	318000	178000	28100	221000	354000	277000	56700	218000	248000	341000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101
Selenium	-	-	-	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<2
Silicon	-	-	-	1120	1990	1350	1890	2180	3960	2090	1490	1640	5180	1210	1820	2020
Silver	-	3 [18]	-	<1.0	<0.5	<1	<1	<0.5	<0.1	<1	<1	<1	<0.2	<1	<1	<0.2
Sodium	-	-	-	7920000	3570000	8420000	7170000	4110000	753000	5800000	9170000	8700000	1610000	6210000	7190000	9800000
Strontium	-	-	-	6530	2520	7580	5190	2980	562	3690	1670	6780	1130	4050	4800	6360
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Thallium	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<0.5
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Tin	-	-	-	<10	<5	<10	<10	<5	<1	<10	<10	<10	<2	<10	<10	<1
Titanium	-	-	-	<100	<50	<100	<100	<100	34	<100	<100	<100	57	<100	<100	5.1
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1
Uranium	-	100 [13]	-	2.08	0.762	1.94	1.76	1.25	0.399	1.52	0.783	2.05	0.512	1.62	1.59	2.53
Vanadium	-	50 [14]	-	**<100**	<50	**<100**	**<100**	<50	<10	**<100**	**<100**	**<100**	<20	**<100**	**<100**	1.71
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5
Zinc	-	55 [19]	-	5.22	2.4	1.54	1.09	1.95	8.38	3.18	2.43	2.6	18.6	18.9	3.56	<5
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.5

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS Threshold[5]	BCWQG MAL[3,4]	CCME MAL[5,6]	DP07A														
Sample ID:				SWDP07A-14	SWDP07A-15	SWDP07A-16	SWDP07A-17	SWDP07A-18	SWDP07A-19	SWDP07A-20	SWDP07A-21	SWDP07A-22	SWDP07A-23	SWDP07A-24	SWDP07A-25	SWDP07A-26	SWDP07A-27	SWDP07A-28
Date Sampled:				07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Info																		
Sample Depth, Below Water Surface (m)		-	-	0.5	0.5	0.5	1	0.5	0.5	0.5	2	3, 3	0.5	0.5	0.5	0.5	0.5	0.5
Field Tests																		
Secchi Depth (m)		-	-	-	-	2.1	-	-	-	2.5	4.5	0.25	1.5	0.5	1.5	0.25	1.5	2
Field Temperature (ºC)	-	-	-	-	16.68	7.06	6.03	13.31	15.62	8.25	6.55	11.57	14.03	7.17	6.17	12.93	12.74	6.3
Field pH	-	-	-	-	8.13	7.65	7.78	7.28	7.91	7.76	7.63	7.98	7.88	7.94	8.04	8.07	7.73	7.42
Field Conductivity (uS/cm)	-	-	-	-	17400	40000	41139	19190	26236	31266	25278	38272	25150	36350	31800	8890	43395	43850
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	-	9.3	11.59	9.16	10.86	11.08	10.52	9.96	9.67	9.16	9.58	11.81	10.11	8.45	8.67
Field Redox, Uncorrected (mV)	-	-	-	-	58.2	250	267.5	233.8	302.5	224.2	230.9	175.9	310	299.8	274.9	134.8	198.8	156.7
Field Turbidity (NTU)	-	-	-	-	3.08	0.14	2.17	24.5	2.22	0.83	0.51	3.1	0.95	-	1.14	10.3	0.79	1.25
Physical Tests																		
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	1940	4850	4310	-	-	-	4490	-	-	-	3310	-	-	-
Total Suspended Solids (mg/L)	-	-	-	10.7	5.3	16.3	8.2	32	6.5	5.6	4.4	6.4	3.7	<3.000	4	25.4	3.7	<2.000
Turbidity (NTU)	-	-	-	8.33	3.25	2.33	1.95	25.9	3.92	1.64	1.61	4.04	2.47	1.32	2.98	24.3	0.97	0.98
Dissolved Inorganics																		
Orthophosphate (as P) (mg/L)	0.087	-	-	0.015	0.0206	0.0677	0.0563	0.0158	0.0218	0.0438	0.0629	0.0203	0.0329	0.0529	0.0422	0.0117	0.0374	0.066
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0184	0.0227	0.0676	0.0595	0.0151	0.0252	0.0441	0.0646	0.0223	0.0373	0.0577	0.0467	0.0146	0.0414	0.0657
Inorganics																		
Ammonia (mg/L)	0.065	-	-	0.0282	***0.0721***	0.018	0.0376	0.0153	0.0112	0.0338	0.0151	0.017	0.0091	0.0226	0.0527	0.0166	0.0073	0.0112
Nitrate (mg/L)	5.23	-	16	<0.500	<0.500	0.75	<0.500	<0.250	0.53	<0.500	0.66	<0.500	<0.500	0.97	0.71	<0.250	<0.500	0.69
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.050	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.050	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	3.7	3	3.7	3.4	4.9	2.5	3.1	3.18	2.12	2.27	3.48	3.41	5.03	1.73	<2.500
Total Inorganics																		
Chlorine (mg/L)	-	-	-	-	<0.100	<0.100	<0.100	0.2	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.032	0.0293	0.0759	0.0638	0.0474	0.0383	0.0506	0.0692	0.0299	0.0445	0.062	0.0509	0.0415	0.0487	0.0691
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	<0.050	0.291	<0.050	0.118	0.267	***0.486***	0.116	0.119	0.156	0.155	0.133	0.179	0.14	0.159	0.115
Total Nitrogen (mg/L)	5.92	-	-	<0.700	0.29	0.75	<0.260	0.267	1.02	<0.260	0.78	<0.260	<0.510	1.1	0.89	<0.260	<0.510	0.81
Organics																		
Organic Nitrogen (as P) (mg/L)	0.392	-	-	<0.060	0.219	<0.060	0.08	0.252	***0.475***	0.082	0.104	0.139	0.146	0.11	0.126	0.123	0.151	0.103
Microbiological Analysis																		
Chlorophyll A	5.11	-	-	1.51	0.672	0.271	0.861	1.11	3.53	0.691	0.807	1.01	0.195	0.28	0.495	0.5	0.429	0.271
Dissolved Metals																		
Iron	-	-	-	<50	<5	<10	<10	-	-	-	-	-	-	-	-	-	-	-
Total Metals																		
Aluminum	-	-	-	171	52.4	42.7	32.3	-	-	-	12.8	-	-	-	81.8	-	-	-
Antimony	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Barium	-	200 [8]	-	15.2	14.1	10.3	11.3	-	-	-	10.9	-	-	-	13.7	-	-	-
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Bismuth	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Boron	-	1200 [4]	-	**<u>1500</u>**	**<u>1530</u>**	**<u>4220</u>**	**<u>3650</u>**	-	-	-	**<u>4070</u>**	-	-	-	**<u>2650</u>**	-	-	-
Cadmium	-	0.12 [7]	0.12	<0.12	<0.12	0.077	0.079	-	-	-	0.057	-	-	-	<0.05	-	-	-
Calcium	-	-	-	124000	130000	321000	291000	-	-	-	295000	-	-	-	223000	-	-	-
Cesium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Chromium	-	1.5 [10]	1.5	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Cobalt	-	-	-	<0.5	<0.5	0.062	0.052	-	-	-	<0.05	-	-	-	0.088	-	-	-
Copper	-	3 [18]	-	2.9	<1	**<u>3.19</u>**	1.05	-	-	-	<0.5	-	-	-	0.91	-	-	-
Gallium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Iron	-	-	-	243	76	80	67	-	-	-	24	-	-	-	141	-	-	-
Lead	-	140 [18]	-	<1	<1	2.92	5.97	-	-	-	0.79	-	-	-	<0.3	-	-	-
Lithium	-	-	-	57	62	147	137	-	-	-	147	-	-	-	95	-	-	-
Magnesium	-	-	-	377000	393000	983000	870000	-	-	-	911000	-	-	-	669000	-	-	-
Manganese	-	100 [11]	-	19.9	12.1	6.84	7.18	-	-	-	5.04	-	-	-	11.9	-	-	-
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	3.6	4	8.6	7.8	-	-	-	8.9	-	-	-	6.4	-	-	-
Nickel	-	8.3 [12]	-	0.98	0.58	0.64	0.91	-	-	-	<0.5	-	-	-	0.57	-	-	-
Potassium	-	-	-	113000	117000	299000	265000	-	-	-	288000	-	-	-	216000	-	-	-
Rhenium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Rubidium	-	-	-	32.3	33.1	89.1	79.6	-	-	-	89	-	-	-	60.1	-	-	-
Selenium	-	-	-	<2	<2	<2	<2	-	-	-	<2	-	-	-	<2	-	-	-
Silicon	-	-	-	2570	1810	1760	1960	-	-	-	1710	-	-	-	2270	-	-	-
Silver	-	3 [18]	-	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1	-	-	-
Sodium	-	-	-	3000000	3140000	8270000	7610000	-	-	-	8110000	-	-	-	5870000	-	-	-
Strontium	-	-	-	2240	2340	5740	5120	-	-	-	5400	-	-	-	4160	-	-	-
Tellurium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Thallium	-	-	-	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05	-	-	-
Thorium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Tin	-	-	-	<1	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Titanium	-	-	-	6.4	<5	<5	<5	-	-	-	<5	-	-	-	<5	-	-	-
Tungsten	-	-	-	<1	<1	<1	<1	-	-	-	<1	-	-	-	<1	-	-	-
Uranium	-	100 [13]	-	1.05	1.02	2.39	2.15	-	-	-	2.39	-	-	-	1.72	-	-	-
Vanadium	-	50 [14]	-	1.12	0.89	1.35	1.23	-	-	-	1.53	-	-	-	1.19	-	-	-
Yttrium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-
Zinc	-	55 [19]	-	10.2	<5	10.5	4.1	-	-	-	<3	-	-	-	<3	-	-	-
Zirconium	-	-	-	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5	-	-	-

Table 10: AMS Surface Water Chemistry Results

			Location ID:	DP07B											
			Sample ID:	SWDP07B-1	SWDP07B-2	SWDP07B-3	SWDP07B-4	SWDP07B-5	SWDP07B-6	SWDP07B-7	SWDP07B-8	SWDP07B-9	SWDP07B-10	SWDP07B-11	SWDP07B-12
			Date Sampled:	24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009
Parameter	***AMS Threshold*** [5]	**BCWQG MAL** [3,4]	**CCME MAL** [5,6]												
Sample Info															
Sample Depth, Below Water Surface (m)		-	-	13	-	0.5	0.5	22	20.5	0.5	20	20	18	20	20
Field Tests															
Secchi Depth (m)		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Field Temperature (ºC)	-	-	-	7.85	-	10.3	7.12	7.23	7.85	11.32	9.19	7.15	8.7	11.93	8.91
Field pH	-	-	-	7.73	-	-	7.61	7.78	7.73	7.53	7.65	7.63	7.75	7.2	7.58
Field Conductivity (uS/cm)	-	-	-	45970	-	32733	41778	46773	45970	45421	34323	30447	47732	45260	46179
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	12.75	-	6.39	15.58	7.71	12.75	6.38	6.91	7.96	8.28	9.1	7.15
Field Redox, Uncorrected (mV)	-	-	-	200.2	-	255	223	-92.7	200.2	-25	-272.2	-329.9	262.2	227.2	157.6
Field Turbidity (NTU)	-	-	-	0.09	-	-	-	-	-	-	0.42	0.95	2.5	0.25	0.99
Physical Tests															
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	5130	5210	-	5420	4260	5460	6060	5520	5530	5400	5240
Total Suspended Solids (mg/L)	-	-	-	10.9	25.2	51	9.5	15.3	38	31.3	18.4	-	21.2	19.7	25.2
Turbidity (NTU)	-	-	-	-	-	-	1.7	0.48	4.3	5.84	0.9	-	2.3	0.75	1.75
Dissolved Inorganics															
Orthophosphate (as P) (mg/L)	0.087	-	-	0.063	0.0606	0.0665	0.0719	0.0717	-	0.0554	0.0788	0.0708	0.0579	0.0605	0.0712
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0656	0.0597	0.059	0.0667	0.0711	-	0.0588	0.0774	0.0757	0.0578	0.0665	0.0736
Inorganics															
Ammonia (mg/L)	0.065	-	-	<0.020	0.03	<0.005	<0.020	<0.005	0.024	0.0114	<0.005	<0.005	0.028	<0.005	0.022
Nitrate (mg/L)	5.23	-	16	0.33	0.52	2.36	***5.9***	1.92	<5.000	<0.500	0.66	<5.000	<0.500	<0.500	<0.500
Nitrite (mg/L)	0.978	-	-	<0.020	<0.100	<0.100	<0.500	0.1	***<1.000***	0.15	0.24	***<1.000***	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.1	2.3	-	-	-	-	-	2.6	-	-	2.2	2.9
Total Inorganics															
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0671	0.0666	0.0678	0.0745	0.0856	-	0.0771	0.0723	0.0772	0.0638	0.0687	0.0774
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.119	0.094	0.229	0.263	0.191	0.259	<0.050	0.138	0.058	0.149	<0.050	0.11
Total Nitrogen (mg/L)	5.92	-	-	0.45	<0.700	2.59	***6.1***	2.21	***<6.000***	<0.700	1.04	***<6.000***	0.47	<0.700	0.51
Organics															
Organic Nitrogen (mg/L)	0.392	-	-	-	<0.070	-	0.263	0.191	0.235	<0.060	0.138	<0.060	0.121	<0.060	-
Microbiological Analysis															
Chlorophyll A	5.11	-	-	0.714	0.521	1.07	0.445	0.71	0.481	1.05	0.0944	0.148	0.295	0.502	0.125
Dissolved Metals															
Iron	-	-	-	-	<10	-	<10	<10	<10	<10	<10	<10	<10	<10	<10
Total Metals															
Aluminum	-	-	-	<100	<300	<100	<100	<100	260	<300	<200	<100	<100	<100	<100
Antimony	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic	-	12.5 [17]	12.5	1.41	1.51	1.4	0.93	1.53	1.02	1.32	1.53	1.29	1.47	1.93	1.19
Barium	-	200 [8]	-	9.6	11.7	9	8.9	7.8	9.9	8.8	8.2	7.8	9	7.5	8.3
Beryllium	-	100 [9]	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Bismuth	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Boron	-	1200 [4]	-	**4000**	**4000**	**4000**	**3400**	**3600**	**2900**	**3500**	**3800**	**4000**	**3500**	**3700**	**3600**
Cadmium	-	0.12 [7]	0.12	0.06	0.073	0.056	0.056	0.084	0.064	0.078	0.089	0.091	0.07	0.119	0.072
Calcium	-	-	-	346000	305000	334000	344000	364000	282000	352000	382000	334000	357000	349000	342000
Cesium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chromium	-	1.5 [10]	1.5	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**<50**	**59**	**<50**
Cobalt	-	-	-	<0.050	0.065	<0.05	<0.05	<0.05	0.225	0.224	<0.05	<0.05	0.075	0.07	<0.05
Copper	-	3 [18]	-	0.887	0.539	1.04	0.396	1.41	1.42	0.868	0.584	0.516	0.495	**5.74**	0.439
Gallium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron	-	-	-	32	49	<10	32	17	315	363	28	29	45	115	67
Lead	-	140 [18]	-	0.597	0.119	0.116	<0.05	0.682	0.376	0.207	2.92	0.175	0.129	20.2	0.075
Lithium	-	-	-	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500
Magnesium	-	-	-	1100000	1060000	1060000	1110000	1100000	863000	1110000	1240000	1140000	1130000	1100000	1070000
Manganese	-	100 [11]	-	2.03	9.46	1.86	2.87	1.68	15.5	10.4	2.32	1.85	2.93	6.25	3.52
Mercury	-	-	0.016	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	-	-	-	9.9	9.3	9.9	8.3	10.3	6.2	10.1	9.2	9.3	12.9	7.4	7.8
Nickel	-	8.3 [12]	-	0.362	0.646	0.42	0.388	0.265	1.14	1.07	0.457	0.568	0.359	0.627	0.472
Potassium	-	-	-	351000	321000	297000	367000	379000	262000	343000	370000	319000	335000	324000	322000
Rhenium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rubidium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Selenium	-	-	-	<0.50	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.58	<0.5	<0.5	<0.5	<0.5
Silicon	-	-	-	1380	1300	1330	1770	1610	1760	1660	1540	1580	1070	1370	1630
Silver	-	3 [18]	-	<1.0	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sodium	-	-	-	8270000	8350000	8300000	8220000	8400000	7430000	8960000	9520000	9980000	9480000	9800000	9280000
Strontium	-	-	-	6850	6130	7450	5900	5910	4750	6330	5930	7890	6270	6260	6550
Tellurium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Thorium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tin	-	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Titanium	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Tungsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uranium	-	100 [13]	-	2.01	1.44	1.79	1.8	1.86	1.87	2.35	2.5	2.35	1.83	2.37	1.74
Vanadium	-	50 [14]	-	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**	**<100**
Yttrium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zinc	-	55 [19]	-	2.31	1.5	1.46	0.86	2.75	2.57	2.21	1.13	1.29	2.82	8.16	0.94
Zirconium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS Threshold [5]	BCWQG MAL [3,4]	CCME MAL [5,6]													
			Location ID:	DP07B												
			Sample ID:	SWDP07B-13	SWDP07B-14	SWDP07B-15	SWDP07B-16	SWDP07B-17	SWDP07B-18	SWDP07B-19	SWDP07B-20	SWDP07B-21	SWDP07B-22	SWDP07B-23	SWDP07B-24	SWDP07B-25
			Date Sampled:	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013
Sample Info																
Sample Depth, Below Water Surface (m)		-	-	-	21	21	26	28	21.2	18	20	19	20	21.5	20	20
Field Tests																
Secchi Depth (m)		-	-	-	-	-	2.1	-	-	-	2.5	4.5	0.25	1.5	0.5	1.5
Field Temperature (ºC)	-	-	-	-	-	12.2	8.52	8.63	9.73	11.76	9.66	7.23	8.48	10.77	8.75	7.64
Field pH	-	-	-	-	-	7.76	7.63	7.7	7.58	7.67	7.53	7.54	7.8	7.71	7.83	7.81
Field Conductivity (uS/cm)	-	-	-	-	-	41400	45686	45047	31936	32082	45750	30454	47322	30810	43460	47812
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	-	-	7.05	8.54	8.63	8.64	8.14	6.49	8.92	7.85	7.8	7.04	9.05
Field Redox, Uncorrected (mV)	-	-	-	-	-	67.7	250.2	266.1	306.1	307.6	229.6	236.5	179.7	296	299.9	279
Field Turbidity (NTU)	-	-	-	-	-	0.83	2.39	1.17	3.4	8.2	0.82	0.21	1.3	0.37	-	-0.73
Physical Tests																
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	-	5380	5300	4820	-	-	-	5400	-	-	-	5280
Total Suspended Solids (mg/L)	-	-	-	16	14.7	12	17	7.6	16	60.7	64.4	2.6	3	8.4	27.5	<2.000
Turbidity (NTU)	-	-	-	2.37	1.89	0.8	1.29	1.23	3.25	23.2	14.5	1.23	0.78	0.44	4.79	0.6
Dissolved Inorganics																
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0712	0.0708	0.0575	0.0759	0.0717	0.0563	0.0585	0.0702	0.0717	0.062	0.0546	0.0716	0.0641
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0774	0.0726	0.0612	0.0752	0.0727	0.0579	0.0615	0.0705	0.0745	0.0623	0.0616	0.0751	0.0701
Inorganics																
Ammonia (mg/L)	0.065	-	-	<0.005	0.018	0.0316	0.0056	0.0194	0.0229	0.0082	<0.005	<0.005	0.0383	<0.005	<0.005	<0.005
Nitrate (mg/L)	5.23	-	16	0.57	<0.500	<0.500	0.74	<0.500	0.55	0.6	<0.500	0.74	0.89	0.57	0.57	0.51
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.7	2.1	2	3.6	3.1	1.6	2.3	2.5	2.62	2.06	1.95	3.29	2.35
Total Inorganics																
Chlorine (mg/L)	-	-	-	-	-	<0.100	<0.100	<0.100	<0.100	-	-	-	-	-	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0851	0.0747	0.0638	0.0773	0.0777	0.067	0.113	0.117	0.0741	0.0661	0.0712	0.0992	0.0695
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.062	<0.050	0.25	0.053	0.128	0.236	***0.471***	0.069	0.088	0.146	0.111	0.095	0.085
Total Nitrogen (mg/L)	5.92	-	-	<0.700	<0.700	<0.260	0.79	<0.260	0.79	1.07	<0.260	0.83	1.04	0.68	0.66	0.6
Organics																
Organic Nitrogen (mg/L)	0.392	-	-	0.062	<0.060	0.218	<0.060	0.109	0.213	***0.463***	0.069	0.088	0.107	0.111	0.095	0.085
Microbiological Analysis																
Chlorophyll A	5.11	-	-	0.305	0.204	0.703	0.121	0.498	0.769	0.943	0.375	0.263	0.123	0.127	0.139	0.054
Dissolved Metals																
Iron	-	-	-	<50	<50	<5	<10	<10	-	-	-	-	-	-	-	-
Total Metals																
Aluminum	-	-	-	277	51	18.7	19.8	17.2	-	-	-	8.1	-	-	-	21.1
Antimony	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Arsenic	-	12.5 [17]	12.5	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-	<2
Barium	-	200 [8]	-	9.2	9.6	8.5	9	10.2	-	-	-	9.5	-	-	-	8.9
Beryllium	-	100 [9]	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Bismuth	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Boron	-	1200 [4]	-	**<u>4340</u>**	**<u>4520</u>**	**<u>4210</u>**	**<u>4660</u>**	**<u>4150</u>**	-	-	-	**<u>4850</u>**	-	-	-	**<u>4290</u>**
Cadmium	-	0.12 [7]	0.12	<0.12	<0.12	<0.12	0.072	0.071	-	-	-	0.075	-	-	-	0.073
Calcium	-	-	-	354000	347000	358000	345000	323000	-	-	-	342000	-	-	-	356000
Cesium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Chromium	-	1.5 [10]	1.5	<1	<1	<1	<0.7	<0.4	-	-	-	<0.5	-	-	-	<0.5
Cobalt	-	-	-	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05
Copper	-	3 [18]	-	<1	<1	<1	0.86	1.2	-	-	-	<0.5	-	-	-	0.52
Gallium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Iron	-	-	-	65	94	<50	36	38	-	-	-	13	-	-	-	22
Lead	-	140 [18]	-	<1	<1	<1	1.77	2.92	-	-	-	<0.3	-	-	-	0.39
Lithium	-	-	-	199	174	176	161	155	-	-	-	186	-	-	-	162
Magnesium	-	-	-	1090000	1130000	1090000	1080000	974000	-	-	-	1100000	-	-	-	1070000
Manganese	-	100 [11]	-	2.89	10.2	3.85	3.77	4.34	-	-	-	1.72	-	-	-	1.63
Mercury	-	-	0.016	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	11	9.5	9.6	9.2	8.8	-	-	-	10.7	-	-	-	10.1
Nickel	-	8.3 [12]	-	0.66	0.6	0.57	<0.5	0.86	-	-	-	<0.5	-	-	-	<0.5
Potassium	-	-	-	320000	332000	333000	327000	299000	-	-	-	335000	-	-	-	340000
Rhenium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Rubidium	-	-	-	108	98	92	96.7	91.4	-	-	-	108	-	-	-	103
Selenium	-	-	-	<2	<2	<2	<2	<2	-	-	-	<2	-	-	-	<2
Silicon	-	-	-	1570	1240	1240	1580	1760	-	-	-	1540	-	-	-	1480
Silver	-	3 [18]	-	<0.2	<0.2	<0.2	<0.1	<0.1	-	-	-	<0.1	-	-	-	<0.1
Sodium	-	-	-	9720000	8850000	9270000	9120000	8520000	-	-	-	9410000	-	-	-	9480000
Strontium	-	-	-	6330	6400	6420	6270	5770	-	-	-	6290	-	-	-	6450
Tellurium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Thallium	-	-	-	<0.5	<0.5	<0.5	<0.05	<0.05	-	-	-	<0.05	-	-	-	<0.05
Thorium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Tin	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-	<1
Titanium	-	-	-	<5	<5	<5	<5	<5	-	-	-	<5	-	-	-	<5
Tungsten	-	-	-	<1	<1	<1	<1	<1	-	-	-	<1	-	-	-	<1
Uranium	-	100 [13]	-	2.78	2.89	2.53	2.51	2.37	-	-	-	2.65	-	-	-	2.66
Vanadium	-	50 [14]	-	1.46	1.78	1.55	1.36	1.27	-	-	-	1.78	-	-	-	1.61
Yttrium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5
Zinc	-	55 [19]	-	<5	<5	<5	8.3	3.5	-	-	-	<3	-	-	-	<3
Zirconium	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	<0.5	-	-	-	<0.5

Table 10: AMS Surface Water Chemistry Results

Parameter	AMS Threshold [5]	BCWQG MAL [3,4]	CCME MAL [5,6]	SWDP07B-26	SWDP07B-27	SWDP07B-28	SWDP08-5	SWDP08-9	SWDP08-13	SWDP08-17	SWDP08-21	SWDP08-25	SWDP09-9	SWDP09-13	SWDP09-17	SWDP09-21	SWDP09-25
Location ID:							DP08						DP09				
Date Sampled:				04/06/2013	24/09/2013	10/12/2013	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	18/02/2013	25/02/2009	09/03/2010	03/03/2011	20/02/2012	18/02/2013
Sample Info																	
Sample Depth, Below Water Surface (m)		-	-	17	24.5	21	0.5	0.5	0.5	1	1	0.5	0.5	0.5	1	1	0.5
Field Tests																	
Secchi Depth (m)		-	-	0.25	1.5	2	2.1	-	-	-	2.5 (bottom)	2.5	-	-	-	2	1.75
Field Temperature (ºC)	-	-	-	8.77	10.67	8.17	6.76	7.16	-	6.34	6.9	7.13	7.22	-	6.19	6.16	5.93
Field pH	-	-	-	7.64	7.65	7.32	7.94	7.49	-	7.65	7.78	7.95	7.45	-	7.81	7.84	8.1
Field Conductivity (uS/cm)	-	-	-	48078	47680	46110	42599	29566	-	44770	29957	45860	29594	-	44310	27909	32797
Field Dissolved Oxygen (mg/L)	6.02 [21]	-	-	6.23	6.05	6.58	9.04	10.7	-	20.19	10.34	11.44	9.72	-	9.87	10.41	12.48
Field Redox, Uncorrected (mV)	-	-	-	147.2	198.2	183.2	89.7	-379.3	-	382.6	258.5	309.7	-366.8	-	180.4	272.5	299.8
Field Turbidity (NTU)	-	-	-	0.92	0.79	1.25	-	1.9	-	1.84	0.42	0.26	-	-	1.35	1.27	2.08
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	-	-	4720	5430	-	5190	5000	5090	5370	-	5420	4670	3210
Total Suspended Solids (mg/L)	-	-	-	7.4	5.2	16	9.3	-	5.3	10.9	<2.000	<3.000	-	12	17.6	2.4	4.5
Turbidity (NTU)	-	-	-	2.88	1.06	4.34	1.1	-	0.75	1.19	1.2	1.36	-	5.36	1.71	2.59	3.73
Dissolved Inorganics																	
Orthophosphate (as P) (mg/L)	0.087	-	-	0.0701	0.0571	0.0717	0.0493	0.0667	0.0624	0.0639	0.0649	0.0584	0.0607	0.0661	0.0645	0.0596	0.0388
Phosphorus (P), Total Dissolved (mg/L)	0.087	-	-	0.0681	0.0604	0.0706	0.0485	0.07	0.0696	0.0665	0.0686	0.0641	0.0644	0.0658	0.038	0.0615	0.0393
Inorganics																	
Ammonia (mg/L)	0.065	-	-	0.0089	0.0123	<0.005	0.0194	0.0099	<0.005	0.0097	0.0069	0.013	0.0118	0.0152	0.0375	0.027	0.0472
Nitrate (mg/L)	5.23	-	16	<0.500	<0.500	0.77	1.87	<0.500	<0.500	<0.500	0.7	0.79	<0.500	0.67	<0.500	0.64	<0.500
Nitrite (mg/L)	0.978	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	-	2.19	1.89	<2.500	-	-	2.5	3	2.88	2.52	-	2.5	3	2.91	3.3
Total Inorganics																	
Chlorine (mg/L)	-	-	-	-	-	-	-	-	-	<0.100	-	-	-	<0.100	<0.100	-	-
Phosphorus (P) (mg/L)	-	-	-	0.0687	0.0672	0.0897	0.0531	0.0793	0.0726	0.0713	0.0718	0.0625	0.0681	0.0767	0.0726	0.0718	0.0463
Total Kjeldahl Nitrogen (mg/L)	0.434	-	-	0.103	0.151	0.112	0.283	0.124	0.093	0.104	0.11	0.11	0.117	0.056	0.087	0.162	0.15
Total Nitrogen (mg/L)	5.92	-	-	<0.510	<0.510	0.88	2.15	<0.700	<0.700	<0.260	0.81	0.9	<0.700	0.72	<0.260	0.8	<0.510
Organics																	
Organic Nitrogen (mg/L)	0.392	-	-	0.094	0.139	0.112	0.263	0.114	0.093	0.094	0.1	0.097	0.105	<0.060	<0.060	0.135	0.103
Microbiological Analysis																	
Chlorophyll A	5.11	-	-	0.116	1.37	0.361	1.45	0.417	0.619	0.713	0.401	0.106	1.38	0.838	0.331	0.478	0.264
Dissolved Metals																	
Iron	-	-	-	-	-	-	<10	<10	<50	<10	-	-	<10	<50	<10	-	-
Total Metals																	
Aluminum	-	-	-	-	-	-	<100	<100	<10	16.5	14	31.2	<100	204	24.3	24.4	106
Antimony	-	-	-	-	-	-	<10	<10	<0.5	<0.5	<0.5	<0.5	<10	<0.5	<0.5	<0.5	<0.5
Arsenic	-	12.5 [17]	12.5	-	-	-	1.13	1.23	<2	<2	<2	<2	1.39	<2	<2	<2	<2
Barium	-	200 [8]	-	-	-	-	8.3	8.2	8.5	9.1	9.8	9.6	8.6	10.2	9.2	9.8	13.8
Beryllium	-	100 [9]	-	-	-	-	<50	<50	<0.5	<0.5	<0.5	<0.5	<50	<0.5	<0.5	<0.5	<0.5
Bismuth	-	-	-	-	-	-	<50	<50	<0.5	<0.5	<0.5	<0.5	<50	<0.5	<0.5	<0.5	<0.5
Boron	-	1200 [4]	-	-	-	-	**3400**	**4100**	**4490**	**4480**	**4650**	**3940**	**4300**	**4140**	**4410**	**4450**	**2690**
Cadmium	-	0.12 [7]	0.12	-	-	-	0.071	0.075	<0.12	0.096	0.067	0.068	0.075	<0.12	0.087	0.099	<0.05
Calcium	-	-	-	-	-	-	317000	336000	359000	344000	323000	342000	330000	329000	347000	301000	214000
Cesium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Chromium	-	1.5 [10]	1.5	-	-	-	<50	<50	<1	<0.4	<0.5	<0.5	<50	<1	<0.4	<0.5	<0.5
Cobalt	-	-	-	-	-	-	0.07	<0.05	<0.5	<0.05	<0.05	0.051	<0.05	<0.5	<0.05	0.074	0.13
Copper	-	3 [18]	-	-	-	-	2.23	0.797	<1	1.1	<0.5	0.56	0.945	1.1	0.81	0.69	1.38
Gallium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Iron	-	-	-	-	-	-	32	81	<50	33	27	53	87	171	57	51	180
Lead	-	140 [18]	-	-	-	-	0.728	0.214	<1	1.28	<0.3	<0.3	0.309	<1	<0.3	<0.3	<0.3
Lithium	-	-	-	-	-	-	<500	<500	196	170	177	146	<500	157	164	162	97
Magnesium	-	-	-	-	-	-	954000	1110000	1110000	1050000	1020000	1030000	1100000	1040000	1110000	951000	649000
Manganese	-	100 [11]	-	-	-	-	5.74	3.62	2.66	2.28	3.3	4.09	3.92	7.26	3.47	6.43	11
Mercury	-	-	0.016	-	-	-	<0.01	<0.01	<0.01	<0.01	-	-	<0.01	<0.01	<0.01	-	-
Molybdenum	-	-	-	-	-	-	10.2	8.5	9.8	9.8	10.1	9.2	10.1	9.5	9.2	9.8	6.5
Nickel	-	8.3 [12]	-	-	-	-	0.422	0.512	0.66	0.74	<0.5	<0.5	0.556	0.74	0.79	0.55	0.81
Potassium	-	-	-	-	-	-	335000	297000	332000	320000	317000	325000	298000	313000	323000	291000	208000
Rhenium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Rubidium	-	-	-	-	-	-	-	-	107	101	98.3	91.4	-	95	99	96.4	61
Selenium	-	-	-	-	-	-	<0.5	1.68	<2	<2	<2	<2	0.82	<2	<2	<2	<2
Silicon	-	-	-	-	-	-	1360	1530	1440	1590	1540	1590	1530	1540	1690	1610	2110
Silver	-	3 [18]	-	-	-	-	<1	<1	<0.2	<0.1	<0.1	<0.1	<1	<0.2	<0.1	<0.1	<0.1
Sodium	-	-	-	-	-	-	7440000	9340000	9970000	9060000	8880000	9030000	9330000	9100000	9070000	8140000	5620000
Strontium	-	-	-	-	-	-	5560	5430	6480	6170	5880	6180	5490	6050	6310	5410	3980
Tellurium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Thallium	-	-	-	-	-	-	<10	<10	<0.5	<0.05	<0.05	<0.05	<10	<0.5	<0.05	<0.05	<0.05
Thorium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Tin	-	-	-	-	-	-	<10	<10	<1	<1	<1	<1	<10	<1	<1	<1	<1
Titanium	-	-	-	-	-	-	<100	<100	<5	<5	<5	<5	<100	<5	<5	<5	5.4
Tungsten	-	-	-	-	-	-	-	-	<1	<1	<1	<1	-	<1	<1	<1	<1
Uranium	-	100 [13]	-	-	-	-	2.11	2.13	2.62	2.61	2.58	2.49	2.21	2.67	2.52	2.56	1.7
Vanadium	-	50 [14]	-	-	-	-	**<100**	**<100**	1.31	1.48	1.69	1.51	**<100**	1.63	1.42	1.5	1.3
Yttrium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5
Zinc	-	55 [19]	-	-	-	-	1.84	<3.5	<5	5	<3	<3	<3.5	<5	3.4	<3	<3
Zirconium	-	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5

Table 10: AMS Surface Water Chemistry Results

(1) All values are reported as µg/L unless otherwise noted
(2) - = No standard or not analyzed
(3) BCWQG = BC Water Quality Guidelines (Approved and Working), updated to January 2010
(4) BCWQG MAL = British Columbia Water Quality Guidline Marine Aquatic Life water use
(5) CCME = Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines, 1999, updated to November 30, 2011
(6) CCME MAL = Chapter 4, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Marine, updated to November 30, 2011
(7) Working - Maximum
(8) Working - Maximum, adverse effects on bivalves, under ministry review
(9) Working - Maximum, minimal risk, under ministry review
(10) Working - Maximum, under ministry review (Unknown full reference)
(11) Working - Maximum, to protect consumers of shellfish
(12) Working - Maximum, 4 day average
(13) Working - Maximum, minimal risk
(14) Working - Maximum, 99% level of protection
(15) CCME MAL stipulates pH not < 7 and not > 8.7
(16) CCME MAL stipulates Salinity (%) not <= 10
(17) BCWQG MAL = British Columbia Water Quality Guidline for the protection of Marine Aquatic Life, interim guideline
(18) Approved - Maximum
(19) Approved - Maximum, To protect aquatic life from acute or lethal effects
(20) AMS Thresholds = Mean + 1.96 x Standard Deviation of data set (DP02 to DP05 for 2007 to 2010)
(21) AMS Threshold for field dissolved oxygen is Mean - 1.96 x Standard Deviation.

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Parameter	AMS Threshold [5]	BCCSR SedQC(SS) Marine [3,4]																												
		Location ID:	DP01																											
		Sample ID:	SDDP01-1	SDDP01-2	SDDP01-3	SDDP01-4	SDDP01-5	SDDP01-6	SDDP01-7	SDDP01-8	SDDP01-9	SDDP01-10	SDDP01-11	SDDP01-12	SDDP01-13	SDDP01-14	SDDP01-15	SDDP01-16	SDDP01-17	SDDP01-18	SDDP01-19	SDDP01-20	SDDP01-21	SDDP01-22	SDDP01-23	SDDP01-24	SDDP01-25	SDDP01-26	SDDP01-27	SDDP01-28
		Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	09/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012	19/02/2013	04/06/2013	25/09/2013	09/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.01	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.05	0.00-0.10	0.00-10.00	0.00-0.10	0.00-0.10	-	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10
Physical Tests																														
Moisture (%)	-	-	36.9	44	30.8	23.6	25.6	29.1	25.8	25.8	14	42.7	31.4	18.6	26.8	49.1	17.2	17.2	39.5	40	34.6	37.3	37.1	22.9	46.9	26.1	55.1	32.3	38.7	57.2
Oxidation Reduction Potential (mV)	-	-	-150	50	-120	-100	60	-300	-270	-350	-	-377	-163	33	-	-199	37	154	-176	-213	37	-131	-26	-112	-171	1	-124	-178	-128	-136
pH	-	-	8.03	7.89	8.01	7.75	8.02	8.12	7.63	7.75	8.13	7.46	8.03	8.12	7.95	7.71	8.28	7.79	7.81	-	-	-	7.19	-	-	-	7.51	-	-	-
Grain Size																														
Clay (<0.004 mm) (%)	-	-	10	-	-	-	-	-	-	-	2	-	-	-	1	-	2.06	1.42	8.42	-	3.89	-	9.25	-	-	-	10.9	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	30	-	-	-	-	-	-	-	6	-	-	-	8	-	13.2	6.04	48.6	-	26	-	45.7	-	-	-	35	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	57	-	-	-	-	-	-	-	28	-	-	-	59	-	84.1	41.1	41.6	-	70.1	-	44	-	-	-	48.7	-	-	-
Gravel (>2.00 mm) (%)	-	-	3	-	-	-	-	-	-	-	64	-	-	-	32	-	0.67	51.5	1.42	-	<0.10	-	1.13	-	-	-	5.39	-	-	-
Total Inorganics																														
Ammonium	19.8	-	5.9	8.7	3.1	2	3.1	13.1	6.6	5	3.4	11.8	9.48	1.24	7.09	11.5	6.24	2.22	3.2	1.7	11.2	3.5	1.6	32.9	11.2	2.9	7.7	3.5	3.2	15.4
Available Phosphate	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	12.2	3.8	6.4	21.4	13.2	15.2	49.3	5.4	13.2	14.7	12.5	13.2	14.8
Phosphorus	897	-	654	795	619	585	563	668	635	1040	614	1180	887	516	576	932	550	518	700	874	907	661	981	622	677	642	1210	691	762	1100
Sulfide	49.5	-	95	97.5	<0.19	0.33	0.38	21.2	9.86	0.49	0.35	58.8	30.1	<0.20	0.48	69	0.34	<0.20	19.6	5.21	0.63	12.6	5	119	3.4	<0.90	<0.39	1.4	17.1	33.6
Total Kjeldahl Nitrogen (%)	0.186	-	0.13	0.11	0.08	0.05	0.07	0.11	0.09	0.1	0.05	0.21	0.107	0.025	0.062	0.143	0.034	0.027	0.132	0.051	0.056	0.079	0.101	0.126	0.151	0.033	0.074	0.072	0.095	0.294
Total Nitrogen (%)	0.197	-	0.1	0.14	0.06	0.07	0.07	0.12	0.09	0.1	-	0.267	0.141	0.037	0.054	0.148	0.049	0.069	0.14	0.07	0.062	0.073	0.095	0.122	0.145	0.056	0.09	0.083	0.114	0.291
Organics																														
Organic Nitrogen (%)	0.183	-	0.13	0.11	0.08	0.05	0.07	0.11	0.09	0.1	0.05	0.209	0.106	0.025	0.061	-	0.033	0.027	-	0.051	0.055	0.079	0.101	0.123	0.15	0.032	0.073	0.072	0.095	0.293
Total Organic Carbon (%)	1.98	-	0.98	1.12	0.7	0.7	1	1	0.8	0.8	-	2.05	0.87	0.26	0.6	1.39	0.33	0.31	1.33	0.67	0.57	0.8	0.86	1.12	1.35	0.6	1.17	1.05	1.24	2.8

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP01																											
		Sample ID:	SDDP01-1	SDDP01-2	SDDP01-3	SDDP01-4	SDDP01-5	SDDP01-6	SDDP01-7	SDDP01-8	SDDP01-9	SDDP01-10	SDDP01-11	SDDP01-12	SDDP01-13	SDDP01-14	SDDP01-15	SDDP01-16	SDDP01-17	SDDP01-18	SDDP01-19	SDDP01-20	SDDP01-21	SDDP01-22	SDDP01-23	SDDP01-24	SDDP01-25	SDDP01-26	SDDP01-27	SDDP01-28
		Date Sampled:	22/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	08/06/2010	31/08/2010	02/12/2010	11/03/2011	09/06/2011	07/09/2011	08/11/2011	21/02/2012	29/05/2012	05/09/2012	10/12/2012	19/02/2013	04/06/2013	25/09/2013	09/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.01	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.05	0.00-0.10	0.00-10.00	0.00-0.10	0.00-0.10	-	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																												
Total Metals																														
Aluminum	-	-	14000	14000	10700	11000	8640	12300	9930	13200	11000	13800	12300	7840	9090	9850	9090	8190	11300	-	-	-	12600	-	-	-	15100	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.11	0.3	-	-	-	0.23	-	-	-	0.33	-	-	-
Arsenic	-	26	5.4	5.7	<5.0	<5.0	5.2	<5.0	<5.0	7.3	<5.0	7	<5.0	<5.0	<5.0	5.3	<5.0	3.19	4.78	-	-	-	6.83	-	-	-	9.35	-	-	-
Barium	-	-	44.8	43.7	25.5	40	22.8	33.8	32	38.9	28.1	44.4	35.3	17	22	33.1	15.9	17.2	38.4	-	-	-	33	-	-	-	50.6	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.20	0.26	-	-	-	0.3	-	-	-	0.39	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	0.16	-	-	-	0.129	-	-	-	0.165	-	-	-
Calcium	-	-	5960	6140	5860	6140	4340	7660	6020	6430	6710	6700	6600	5340	4600	9500	4770	3780	5740	-	-	-	4510	-	-	-	6810	-	-	-
Chromium	-	99	35.7	35.9	18.5	23.1	14.5	28	18.4	28.8	21.9	38.7	31.7	14	17.6	28.4	12.6	15.9	34.7	-	-	-	35.3	-	-	-	46.4	-	-	-
Cobalt	-	-	10.6	10.7	6	6.3	5.6	8.3	6	9.3	6.8	11.1	8.7	4.6	5.9	9.6	5.5	5.94	9.83	-	-	-	10.2	-	-	-	12	-	-	-
Copper	-	67	23.1	23.1	14.2	63.7	15.1	20.4	13.3	21.6	14.8	24.5	18.4	23.6	12.6	16.9	11.2	11.2	19.3	-	-	-	21.6	-	-	-	29.5	-	-	-
Iron	-	-	27500	25800	17800	20000	16400	23600	16300	24900	19500	29100	22700	12700	16300	19900	16100	16600	23900	-	-	-	24700	-	-	-	31000	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	3.02	7.64	-	-	-	6.2	-	-	-	7.8	-	-	-
Lithium	-	-	16.8	17	10.6	10.6	8.7	13.2	10.4	16.1	11.3	19.2	14.5	8.3	9.6	14	8.2	8.5	14.7	-	-	-	13.2	-	-	-	18.5	-	-	-
Magnesium	-	-	10400	10700	7080	6450	5840	8390	6490	9570	7390	11500	9090	5100	6090	9740	6100	5830	9130	-	-	-	8410	-	-	-	10800	-	-	-
Manganese	-	-	292	281	257	254	235	279	227	330	251	293	260	209	233	229	247	240	318	-	-	-	257	-	-	-	381	-	-	-
Mercury	-	0.43	0.0464	0.0476	0.0249	0.0208	0.0237	0.0272	0.0212	0.033	0.0181	0.0488	0.0338	0.0101	0.0155	0.0376	0.0062	0.0123	0.0396	-	-	-	0.0402	-	-	-	0.0516	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<0.50	1.35	-	-	-	0.76	-	-	-	0.92	-	-	-
Nickel	-	-	33.4	34.6	17.4	20.5	15.4	28.3	17.9	28.2	20.1	36.9	28.3	14.3	18	34	12.4	16.5	32.6	-	-	-	34.4	-	-	-	39.3	-	-	-
Potassium	-	-	1970	1900	1180	1060	990	1350	1110	1770	1110	1950	1580	840	1020	1460	720	820	1550	-	-	-	1430	-	-	-	2100	-	-	-
Selenium	-	-	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.20	0.2	-	-	-	0.21	-	-	-	0.36	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	0.11	-	-	-
Sodium	-	-	5570	6570	4250	3640	3330	5000	2980	8720	3350	7100	4690	2020	3410	5950	1230	1830	5250	-	-	-	3600	-	-	-	8120	-	-	-
Strontium	-	-	42.9	41.8	28.9	38.6	29.1	37.9	28.6	45.4	33.9	43.6	37.2	32.6	28.7	58.4	23.6	20.6	37.8	-	-	-	36.5	-	-	-	56.4	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	0.102	-	-	-	0.091	-	-	-	0.122	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	5.1	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	959	864	673	786	513	833	620	764	720	799	798	532	633	506	524	533	823	-	-	-	719	-	-	-	1020	-	-	-
Vanadium	-	-	49.1	49.4	42.9	40.2	34.2	49.3	36.6	47.3	43.3	52	46.7	26.7	33.5	32.6	34.5	34.7	44.9	-	-	-	46.2	-	-	-	56.3	-	-	-
Zinc	-	170	62.8	65.6	41.3	60.3	35	55.8	38.8	58.6	42.2	68.8	52.8	32.9	36	55.3	31	34.2	62.1	-	-	-	62.2	-	-	-	76.4	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Parameter	AMS Threshold[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP02-1	SDDP02-2	SDDP02-3	SDDP02-4	SDDP02-5	SDDP02-6	SDDP02-7	SDDP02-8	SDDP02-9	SDDP02-10	SDDP02-11	SDDP02-12	SDDP02-13	SDDP02-14
Location ID:			DP02													
Date Sampled:			22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10
Physical Tests																
Moisture (%)	-	-	28	32.2	33	34	30.8	33.2	33.8	34	31.1	32.3	30.1	29.5	34.7	32.1
Oxidation Reduction Potential (mV)	-	-	-170	-	<-200	-170	-170	-250	-280	-60	-100	-317	-208	-33	-	-143
pH	-	-	7.92	7.74	8.17	8.04	7.89	7.97	7.82	7.71	7.75	8.01	8.06	7.91	7.85	7.89
Grain Size																
Clay (<0.004 mm) (%)	-	-	2	-	-	-	3	-	-	-	4	-	-	-	1	-
Silt (0.004-0.063 mm) (%)	-	-	3	-	-	-	4	-	-	-	6	-	-	-	6	-
Sand (0.063-2.00 mm) (%)	-	-	95	-	-	-	93	-	-	-	88	-	-	-	93	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	1	-	-	-	<1.0	-
Total Inorganics																
Ammonium	19.8	-	3.9	7.3	8.1	4.3	2.4	4.4	9	3.9	2	2.4	8.31	5.05	6	6.93
Available Phosphate	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus	897	-	691	764	698	365	703	763	718	760	671	669	794	735	694	762
Sulfide	49.5	-	1.15	9.74	4.16	0.55	1.2	2.17	1.91	0.56	1.3	9.88	2.49	0.37	0.59	0.45
Total Kjeldahl Nitrogen (%)	0.186	-	0.06	0.05	<0.02	0.03	0.03	<0.02	0.05	0.06	0.05	0.051	0.047	0.05	0.043	0.057
Total Nitrogen (%)	0.197	-	0.04	0.04	0.04	0.03	0.04	0.05	0.07	0.05	0.04	0.057	0.062	0.046	0.036	0.045
Organics																
Organic Nitrogen (%)	0.183	-	0.06	0.05	<0.02	0.03	0.03	<0.02	0.05	0.06	0.05	0.051	0.046	0.049	0.042	-
Total Organic Carbon (%)	1.98	-	0.16	0.29	0.1	0.2	0.3	0.2	0.4	0.5	0.1	0.27	<0.10	0.33	0.25	0.4

Parameter	SDDP02-15	SDDP02-16	SDDP02-17	SDDP02-18	SDDP02-19	SDDP02-20	SDDP02-21	SDDP02-22	SDDP02-23	SDDP02-24	SDDP02-25	SDDP02-26	SDDP02-27	SDDP02-28
Location ID:	DP02													
Date Sampled:	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.15	0.00-4.00	0.00-0.05	0.00-0.07	-	0.00-0.07	0.00-0.10	0.00-0.15	0.00-0.10
Physical Tests														
Moisture (%)	35.5	31.8	32.1	32.8	33.3	28.6	27.9	33.2	35.8	29.7	30.4	26.8	30	29.9
Oxidation Reduction Potential (mV)	-227	-61	50	112	-131	-136	-2	-224	-58	-171	-108	-222	-154	-10
pH	7.56	7.58	7.86	-	-	-	7.87	-	-	-	7.9	-	-	-
Grain Size														
Clay (<0.004 mm) (%)	0.88	3.54	2.08	-	3.28	-	2.5	-	-	-	2.72	-	-	-
Silt (0.004-0.063 mm) (%)	16.8	8.23	15.2	-	11.8	-	12.9	-	-	-	8.67	-	-	-
Sand (0.063-2.00 mm) (%)	82.3	88.2	82.6	-	84.9	-	84.1	-	-	-	88.6	-	-	-
Gravel (>2.00 mm) (%)	<0.10	<0.10	0.11	-	<0.10	-	0.53	-	-	-	<0.10	-	-	-
Total Inorganics														
Ammonium	6.6	5.99	2.99	5.8	2.8	4.9	3.8	4.2	7.4	2.6	2.7	5.4	4.8	4.6
Available Phosphate	-	14.5	13.5	16.3	13.1	14	17.1	14.8	16.1	10.6	11.3	20	14.5	12.7
Phosphorus	688	724	686	763	675	597	709	667	652	726	652	733	692	682
Sulfide	0.74	0.4	0.55	1.34	0.58	1.11	<0.29	1.34	3.28	<0.79	0.32	2.79	<0.20	<2.7
Total Kjeldahl Nitrogen (%)	0.049	0.058	0.025	0.037	0.037	0.053	0.024	0.035	0.059	0.032	0.032	0.036	0.044	0.031
Total Nitrogen (%)	0.045	0.085	0.042	0.066	0.04	0.046	0.033	0.046	0.046	0.043	0.086	0.04	0.051	0.046
Organics														
Organic Nitrogen (%)	0.049	0.058	0.025	0.037	0.037	0.053	0.023	0.035	0.058	0.032	0.032	0.036	0.044	0.031
Total Organic Carbon (%)	0.28	0.28	0.22	0.3	0.14	0.36	0.27	0.29	0.35	0.31	0.3	0.3	0.23	0.29

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP02													
		Sample ID:	SDDP02-1	SDDP02-2	SDDP02-3	SDDP02-4	SDDP02-5	SDDP02-6	SDDP02-7	SDDP02-8	SDDP02-9	SDDP02-10	SDDP02-11	SDDP02-12	SDDP02-13	SDDP02-14
		Date Sampled:	22/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10
Parameter	***AMS Threshold***[5]	**BCCSR SedQC(SS) Marine**[3,4]														
Total Metals																
Aluminum	-	-	8680	10300	10200	17400	9380	9670	9700	9670	9950	9900	9760	8480	9300	8760
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic	-	26	<5.0	5.4	5.1	<5.0	<5.0	5.5	<5.0	6.7	<5.0	<5.0	5.2	<5.0	<5.0	5.2
Barium	-	-	24.3	35.7	28.4	91.8	28	30.2	27.3	30.4	27.7	32.5	28.6	20.9	25	25.1
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium	-	-	5020	6140	5750	5330	6090	6040	5600	6530	5420	5800	6050	5020	5240	5400
Chromium	-	99	33.9	39.1	32.4	16.8	34.2	38.9	34.9	36.2	34	36.6	38.5	35	35.5	35.8
Cobalt	-	-	9.1	10.4	9.8	8.1	9.8	10.6	10.5	10.2	10.3	10.4	10.2	10	10.3	10.5
Copper	-	67	8.6	10.8	10.4	28.4	9.6	11.6	10	10.3	10	10.2	10.8	9.3	9.6	7.5
Iron	-	-	23000	24200	22000	22900	23100	25300	22700	24600	22700	23300	24800	23400	23100	23700
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Lithium	-	-	9.8	11.6	12	8.5	10.6	12.2	11.6	11.5	11.6	12.3	11.9	10.5	10.9	10.3
Magnesium	-	-	8020	9520	9370	4930	8510	9340	9120	8910	9120	9410	9310	8620	8580	9010
Manganese	-	-	240	278	246	403	262	272	258	274	250	256	263	251	244	236
Mercury	-	0.43	0.0233	0.0284	0.0276	0.0453	0.0339	0.027	0.0244	0.0234	0.0241	0.0255	0.0231	0.0178	0.021	0.0216
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	-	-	30	33.5	31	11.7	31.7	33.2	32.8	33.4	31.5	33.7	34	33	34.1	35.3
Potassium	-	-	990	1240	1320	950	1180	1130	1200	1090	1270	1180	1150	970	1020	960
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Sodium	-	-	3320	3650	5630	340	4850	4250	4870	3780	4390	4410	4060	3620	3830	3680
Strontium	-	-	28.7	32.9	28.2	41.7	28.7	28.5	27.6	30.3	27.5	28.3	29.5	26.3	27.9	29.2
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium	-	-	828	931	784	792	808	858	734	863	778	828	802	782	894	847
Vanadium	-	-	49.3	54.3	49.9	49	49.6	57.6	49.6	54.3	48.9	53.1	53.5	48.4	49.8	49.8
Zinc	-	170	44.5	52.4	48.1	54.9	48.4	51.2	49	50.6	53.2	49.4	48.8	47.3	47.5	49.3

		Location ID:	DP02													
		Sample ID:	SDDP02-15	SDDP02-16	SDDP02-17	SDDP02-18	SDDP02-19	SDDP02-20	SDDP02-21	SDDP02-22	SDDP02-23	SDDP02-24	SDDP02-25	SDDP02-26	SDDP02-27	SDDP02-28
		Date Sampled:	30/08/2010	02/12/2010	02/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.15	0.00-4.00	0.00-0.05	0.00-0.07	-	0.00-0.07	0.00-0.10	0.00-0.15	0.00-0.10
Parameter	***AMS Threshold***[5]	**BCCSR SedQC(SS) Marine**[3,4]														
Total Metals																
Aluminum	-	-	8650	8330	21000	-	-	-	9920	-	-	-	8510	-	-	-
Antimony	-	-	<10	0.18	0.13	-	-	-	0.2	-	-	-	0.2	-	-	-
Arsenic	-	26	<5.0	4.95	2.87	-	-	-	5.16	-	-	-	4.47	-	-	-
Barium	-	-	20.9	22.1	33.3	-	-	-	26	-	-	-	24.5	-	-	-
Beryllium	-	-	<0.50	0.21	0.29	-	-	-	0.22	-	-	-	0.22	-	-	-
Bismuth	-	-	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.10	<0.10	-	-	-	0.067	-	-	-	<0.050	-	-	-
Calcium	-	-	4570	5110	5780	-	-	-	5240	-	-	-	5070	-	-	-
Chromium	-	99	34.7	36.9	27.7	-	-	-	34.9	-	-	-	36.6	-	-	-
Cobalt	-	-	9.9	10.4	12.6	-	-	-	10.4	-	-	-	9.95	-	-	-
Copper	-	67	9.5	9.21	44.2	-	-	-	9.46	-	-	-	8.57	-	-	-
Iron	-	-	22200	23600	31600	-	-	-	23000	-	-	-	23100	-	-	-
Lead	-	69	<30	3.77	2	-	-	-	3.81	-	-	-	3.47	-	-	-
Lithium	-	-	10.8	9.7	12.2	-	-	-	9.6	-	-	-	9.6	-	-	-
Magnesium	-	-	9000	8260	11200	-	-	-	8630	-	-	-	8180	-	-	-
Manganese	-	-	245	259	522	-	-	-	259	-	-	-	243	-	-	-
Mercury	-	0.43	0.0217	0.0275	0.0229	-	-	-	0.0235	-	-	-	0.0221	-	-	-
Molybdenum	-	-	<4.0	0.65	<0.50	-	-	-	<0.50	-	-	-	<0.50	-	-	-
Nickel	-	-	32.8	34.4	23.8	-	-	-	34	-	-	-	33.3	-	-	-
Potassium	-	-	1000	990	580	-	-	-	1040	-	-	-	940	-	-	-
Selenium	-	-	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Silver	-	-	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	5470	3910	260	-	-	-	4020	-	-	-	3260	-	-	-
Strontium	-	-	27	26.5	25.2	-	-	-	28.6	-	-	-	25.7	-	-	-
Thallium	-	-	<1.0	0.078	<0.050	-	-	-	0.079	-	-	-	0.079	-	-	-
Tin	-	-	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	694	799	1520	-	-	-	884	-	-	-	837	-	-	-
Vanadium	-	-	46.7	52.7	82.8	-	-	-	51.3	-	-	-	52.8	-	-	-
Zinc	-	170	48.6	45	43.8	-	-	-	48.7	-	-	-	52.9	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Parameter	AMS Threshold[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP03-1	SDDP03-2	SDDP03-3	SDDP03-4	SDDP03-5	SDDP03-6	SDDP03-7	SDDP03-8	SDDP03-9	SDDP03-10	SDDP03-11	SDDP03-12	SDDP03-13	SDDP03-14
Location ID:			DP03													
Date Sampled:			23/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10
Physical Tests																
Moisture (%)	-	-	25.5	31.2	30.4	29.5	32.8	30.2	30.5	34.6	35.6	27.8	25.1	26.2	31.7	34.4
Oxidation Reduction Potential (mV)	-	-	-170	-	-170	-150	-180	-240	-220	-260	-170	-398	-155	37	-	-204
pH	-	-	7.99	7.9	8.13	7.83	7.96	7.96	7.94	7.81	7.91	8.04	8.01	7.9	7.92	7.92
Grain Size																
Clay (<0.004 mm) (%)	-	-	3	-	-	-	3	-	-	-	3	-	-	-	1	-
Silt (0.004-0.063 mm) (%)	-	-	3	-	-	-	3	-	-	-	5	-	-	-	5	-
Sand (0.063-2.00 mm) (%)	-	-	94	-	-	-	94	-	-	-	91	-	-	-	93	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	2	-
Total Inorganics																
Ammonium	19.8	-	8.7	6.5	11.4	4.3	2.8	9.1	14	3.2	3.2	4.81	7.23	3.62	3.87	***44.1***
Available Phosphate	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus	897	-	723	708	662	694	648	788	725	734	726	807	787	684	721	786
Sulfide	49.5	-	5.73	25.4	0.6	0.43	0.62	7.63	0.72	4.72	0.96	1.59	0.73	0.47	0.28	0.27
Total Kjeldahl Nitrogen (%)	0.186	-	0.06	0.04	0.04	0.03	0.04	0.05	0.06	0.06	0.05	0.057	0.049	0.033	0.06	0.069
Total Nitrogen (%)	0.197	-	0.06	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.069	0.075	0.046	0.061	0.053
Organics																
Organic Nitrogen (%)	0.183	-	0.06	0.04	0.04	0.03	0.04	0.05	0.06	0.06	0.05	0.056	0.048	0.033	0.06	-
Total Organic Carbon (%)	1.98	-	0.27	0.24	0.3	0.3	0.3	0.2	0.3	0.4	<0.1	0.38	0.97	0.31	0.33	0.37

Parameter	SDDP03-15	SDDP03-16	SDDP03-17	SDDP03-18	SDDP03-19	SDDP03-20	SDDP03-21	SDDP03-22	SDDP03-23	SDDP03-24	SDDP03-25	SDDP03-26	SDDP03-27	SDDP03-28
Date Sampled:	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.00-0.05	0.00-0.06	-	0.00-0.04	0.00-0.10	0.00-0.10	0.00-0.10
Physical Tests														
Moisture (%)	37.5	33.4	29.5	35.1	31.9	28.8	28.9	32.6	34.8	26.5	27.2	27.6	35.7	30.6
Oxidation Reduction Potential (mV)	-265	-5	-91	138	-184	71	6	-220	-95	-168	-25	-185	-175	-54
pH	8	7.62	7.72	-	-	-	7.69	-	-	-	8	-	-	-
Grain Size														
Clay (<0.004 mm) (%)	2.97	2.68	1.76	-	2.3	-	2.63	-	-	-	2.56	-	-	-
Silt (0.004-0.063 mm) (%)	9.64	8.85	10.9	-	11.2	-	9.72	-	-	-	7.38	-	-	-
Sand (0.063-2.00 mm) (%)	87.4	88.5	85.5	-	86.5	-	87.6	-	-	-	90.1	-	-	-
Gravel (>2.00 mm) (%)	<0.10	<0.10	1.79	-	<0.10	-	0.1	-	-	-	<0.10	-	-	-
Total Inorganics														
Ammonium	8.15	8.41	4.14	9.7	7.2	7.4	2.5	4.1	12.3	3.5	3.1	9.6	9	4.4
Available Phosphate	-	11.2	11.3	22.2	15.3	14.8	13.9	14.3	17.9	10.7	13.3	21.3	18.8	11.8
Phosphorus	736	702	705	766	727	608	599	623	660	697	571	703	716	651
Sulfide	1.1	<0.20	<0.21	0.59	0.31	0.78	<0.27	1.11	1.04	<0.73	0.6	0.99	<0.20	<2.9
Total Kjeldahl Nitrogen (%)	0.047	0.046	0.029	0.037	0.051	0.057	0.035	0.028	0.06	0.034	0.041	0.046	0.053	0.032
Total Nitrogen (%)	0.05	0.11	0.054	0.067	0.051	0.047	0.041	0.045	0.046	0.048	0.087	0.049	0.063	0.046
Organics														
Organic Nitrogen (%)	0.046	0.045	0.028	0.037	0.05	0.056	0.035	0.028	0.059	0.034	0.04	0.045	0.052	0.031
Total Organic Carbon (%)	0.31	0.49	0.26	0.3	0.2	0.34	0.26	0.3	0.28	0.27	0.37	0.34	0.33	0.33

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Parameter	AMS Threshold[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP03-1	SDDP03-2	SDDP03-3	SDDP03-4	SDDP03-5	SDDP03-6	SDDP03-7	SDDP03-8	SDDP03-9	SDDP03-10	SDDP03-11	SDDP03-12	SDDP03-13	SDDP03-14	SDDP03-15	SDDP03-16	SDDP03-17	SDDP03-18	SDDP03-19	SDDP03-20	SDDP03-21	SDDP03-22	SDDP03-23	SDDP03-24	SDDP03-25	SDDP03-26	SDDP03-27	SDDP03-28
Location ID:			DP03																											
Date Sampled:			23/03/2007	21/06/2007	02/10/2007	10/12/2007	03/03/2008	29/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.04	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.00-0.05	0.00-0.06	-	0.00-0.04	0.00-0.10	0.00-0.10	0.00-0.10
Total Metals																														
Aluminum	-	-	9280	10100	9500	10300	9470	9920	10100	9900	9310	9930	9980	9120	9180	8780	9170	8290	9640	-	-	-	9070	-	-	-	8090	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.2	0.51	-	-	-	0.21	-	-	-	0.21	-	-	-
Arsenic	-	26	5.6	5.6	5.8	5.2	5.3	8.3	6	5.5	5.5	6	6.7	<5.0	5.1	6.6	5.9	6.14	5.56	-	-	-	4.69	-	-	-	5.67	-	-	-
Barium	-	-	28.1	30.5	28.5	32.9	26	32.3	29.7	29.4	24.2	34.7	29.6	23	25.3	25.6	22.5	21.3	23.6	-	-	-	21.9	-	-	-	19.8	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.22	0.21	-	-	-	0.21	-	-	-	0.21	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.053	-	-	-	<0.050	-	-	-
Calcium	-	-	5000	5360	5220	5310	4920	5910	5740	5850	4800	6670	6600	5040	6990	4870	4520	4500	5070	-	-	-	4210	-	-	-	4470	-	-	-
Chromium	-	99	36.5	34.8	31.8	34	32	38.4	36.7	34.4	32.6	38.3	36.8	33	34.8	35.3	33.9	36.6	35.3	-	-	-	32.5	-	-	-	31.5	-	-	-
Cobalt	-	-	9	8.9	8.6	9.1	8.8	9.7	9.6	9.4	9.1	9.7	9.4	8.8	9.5	9.6	9.1	9.42	9.35	-	-	-	8.83	-	-	-	8.37	-	-	-
Copper	-	67	9.8	10.3	9.7	11.2	10	11.5	10.3	11	10.4	10.2	10.5	8.6	9.7	7.7	10.4	9.42	8.71	-	-	-	9.21	-	-	-	8.47	-	-	-
Iron	-	-	24200	23400	21800	23200	22400	26000	23400	24500	23100	25200	25100	23100	24600	24700	23200	23200	23200	-	-	-	21000	-	-	-	21400	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.72	23.9	-	-	-	4.15	-	-	-	3.96	-	-	-
Lithium	-	-	9.9	11.2	10.9	11.8	10.5	11.8	11.7	11.6	11	11.9	11.7	10.7	10.2	10.4	11	9.6	9.4	-	-	-	8.9	-	-	-	9.2	-	-	-
Magnesium	-	-	8190	8810	8420	7960	7950	8960	8780	8780	8710	9010	8740	8210	8190	8770	8820	7890	8410	-	-	-	7660	-	-	-	7480	-	-	-
Manganese	-	-	236	247	239	267	250	266	260	264	247	268	260	251	248	247	249	258	246	-	-	-	225	-	-	-	222	-	-	-
Mercury	-	0.43	0.0211	0.0283	0.0213	0.0627	0.0242	0.0573	0.0199	0.0233	0.0194	0.0219	0.0286	0.0522	0.0194	0.0183	0.0199	0.0208	0.0196	-	-	-	0.0156	-	-	-	0.0205	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.56	<0.50	-	-	-	0.53	-	-	-	<0.50	-	-	-
Nickel	-	-	30.1	31	28.8	33.8	30.1	32.5	32.2	32.9	30.1	32.9	32	31	32.8	34.7	32.8	33.1	31.3	-	-	-	31	-	-	-	29.7	-	-	-
Potassium	-	-	1130	1270	1210	1140	1210	1120	1240	1230	1190	1130	1200	1030	1040	990	1100	1060	1020	-	-	-	980	-	-	-	960	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	4200	4200	5440	3800	4480	3280	4910	5610	5160	3290	4350	3830	4150	4050	5300	5270	6090	-	-	-	3840	-	-	-	3420	-	-	-
Strontium	-	-	29.6	30.7	27.4	31.8	25.7	30	30.3	30.2	26.7	35.4	33.6	29.8	37.7	29.1	28.5	26.9	36.8	-	-	-	23.8	-	-	-	27.4	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	<0.050	-	-	-	<0.050	-	-	-	<0.050	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	865	851	724	838	750	854	763	814	674	809	799	816	908	829	707	732	830	-	-	-	795	-	-	-	700	-	-	-
Vanadium	-	-	53.8	50.6	49.5	49.4	47.2	59.1	51.9	53.3	47.3	55.7	53.4	47.9	54.4	51.5	49.5	50.5	54.3	-	-	-	49.1	-	-	-	44.6	-	-	-
Zinc	-	170	46.3	49.4	46.4	50.2	46.5	51.1	49	51.7	51.3	48.3	47.8	47.6	47.3	50	49.3	45.1	46.8	-	-	-	45	-	-	-	44.2	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Parameter	*AMS Threshold*[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP04-1	SDDP04-2	SDDP04-3	SDDP04-4	SDDP04-5	SDDP04-6	SDDP04-7	SDDP04-8	SDDP04-9	SDDP04-10	SDDP04-11	SDDP04-12	SDDP04-13	SDDP04-14
Location ID:			DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04
Date Sampled:			23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.08	0.00-0.05	0.00-0.05	0.00-0.10	0.00-0.10
Physical Tests																
Moisture (%)	-	-	36.8	41.5	33.3	33.6	35.5	32.6	33.7	47.4	36.5	39.3	42.5	27.3	39.7	36.9
Oxidation Reduction Potential (mV)	-	-	<-200	-220	-190	-120	-190	-320	-280	-220	-220	-384	-381	-298	-	-224
pH	-	-	7.86	8.55	8.21	7.88	8.06	7.92	7.95	7.72	8.18	7.81	8.18	7.84	7.89	7.92
Grain Size																
Clay (<0.004 mm) (%)	-	-	4	-	-	-	3	-	-	-	4	-	-	-	2	-
Silt (0.004-0.063 mm) (%)	-	-	6	-	-	-	15	-	-	-	9	-	-	-	7	-
Sand (0.063-2.00 mm) (%)	-	-	91	-	-	-	80	-	-	-	87	-	-	-	90	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	1	-	-	-	<1	-	-	-	<1.0	-
Total Inorganics																
Ammonium	19.8	-	10.9	12.3	9.6	6.2	3.1	8.4	9.1	5.3	4.1	11.5	6.28	4.76	5.28	6.13
Available Phosphate	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus	897	-	664	712	591	684	640	599	620	752	681	655	609	537	655	605
Sulfide	49.5	-	2.58	8.25	39.9	8.76	5.71	23.5	18.8	4.44	1.97	13.5	44.7	17.4	9.3	6.74
Total Kjeldahl Nitrogen (%)	0.186	-	0.07	0.08	0.05	0.06	0.06	0.06	0.08	0.1	0.06	0.091	0.085	0.058	0.072	0.094
Total Nitrogen (%)	0.197	-	0.07	0.08	0.05	0.04	0.06	0.05	0.08	0.08	0.07	0.11	0.11	0.07	0.051	0.069
Organics																
Organic Nitrogen (%)	0.183	-	0.07	0.08	0.07	0.06	0.06	0.06	0.08	0.1	0.06	0.09	0.085	0.058	0.071	-
Total Organic Carbon (%)	1.98	-	0.39	0.58	0.4	0.5	0.5	0.4	0.5	0.7	0.5	0.53	0.67	0.48	0.41	0.51

Parameter	SDDP04-15	SDDP04-16	SDDP04-17	SDDP04-18	SDDP04-19	SDDP04-20	SDDP04-21	SDDP04-22	SDDP04-23	SDDP04-24	SDDP04-25	SDDP04-26	SDDP04-27	SDDP04-28
Location ID:	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04	DP04
Date Sampled:	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.00-0.10	0.00-0.06	-	0.00-0.20	0.00-0.10	0.00-0.15	0.00-0.10
Physical Tests														
Moisture (%)	39.5	34.1	38.6	26.8	34	31.4	27.7	35.4	42.7	30	28.7	27.7	41.5	30.2
Oxidation Reduction Potential (mV)	-259	-149	-226	12	-334	13	-61	-217	-138	-128	-81	-111	-152	-118
pH	7.64	7.5	7.82	-	-	-	7.34	-	-	-	7.63	-	-	-
Grain Size														
Clay (<0.004 mm) (%)	2.55	2.71	2.54	-	5.25	-	2.46	-	-	-	2.83	-	-	-
Silt (0.004-0.063 mm) (%)	11.7	9.01	10.1	-	10.4	-	7.28	-	-	-	5.29	-	-	-
Sand (0.063-2.00 mm) (%)	85.7	88.3	87.3	-	84.4	-	90.1	-	-	-	91.9	-	-	-
Gravel (>2.00 mm) (%)	<0.10	<0.10	<0.10	-	<0.10	-	0.16	-	-	-	<0.10	-	-	-
Total Inorganics														
Ammonium	6.09	8.52	3.99	13.9	4	4.4	2.7	5.9	10.1	2.8	2.3	10.1	6.1	3.1
Available Phosphate	-	18.7	8.3	32.2	9.4	17.6	15.6	19.4	30	13.7	14.6	28.7	10.1	6.3
Phosphorus	587	653	593	690	589	454	563	539	715	703	575	605	536	544
Sulfide	39.3	1.75	29	3.74	31	5.9	12.5	1.55	5.5	1.57	0.62	4	***76***	12.9
Total Kjeldahl Nitrogen (%)	0.069	0.064	0.071	<0.020	0.073	0.071	0.06	0.046	0.07	0.044	0.046	0.063	0.082	0.042
Total Nitrogen (%)	0.061	0.125	0.079	0.076	0.08	0.061	0.055	0.055	0.063	0.058	0.132	0.07	0.095	0.063
Organics														
Organic Nitrogen (%)	0.068	0.063	0.071	<0.020	0.073	0.071	0.06	0.046	0.069	0.044	0.045	0.062	0.081	0.042
Total Organic Carbon (%)	0.42	0.45	0.53	0.41	0.47	0.47	0.34	0.37	0.42	0.37	0.4	0.51	0.56	0.42

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP04																											
		Sample ID:	SDDP04-1	SDDP04-2	SDDP04-3	SDDP04-4	SDDP04-5	SDDP04-6	SDDP04-7	SDDP04-8	SDDP04-9	SDDP04-10	SDDP04-11	SDDP04-12	SDDP04-13	SDDP04-14	SDDP04-15	SDDP04-16	SDDP04-17	SDDP04-18	SDDP04-19	SDDP04-20	SDDP04-21	SDDP04-22	SDDP04-23	SDDP04-24	SDDP04-25	SDDP04-26	SDDP04-27	SDDP04-28
		Date Sampled:	23/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	20/09/2008	26/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	09/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.08	0.00-0.05	0.00-0.05	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.03	0.00-0.10	0.00-10.00	0.00-0.10	0.00-0.06	-	0.00-0.20	0.00-0.10	0.00-0.15	0.00-0.10
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																												
Total Metals																														
Aluminum	-	-	9420	10600	9850	10800	9750	9530	9970	9990	9750	10400	10700	8600	9400	8330	9110	8160	10000	-	-	-	9100	-	-	-	7970	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.18	0.23	-	-	-	0.19	-	-	-	0.17	-	-	-
Arsenic	-	26	6.7	5.1	6	5.5	6.4	6.8	5.8	8.2	5.4	5.3	6.6	<5.0	5.1	5.6	5	5.72	5.1	-	-	-	5.43	-	-	-	5.14	-	-	-
Barium	-	-	26.8	30	25.3	36.2	24.9	25.2	30.2	31.1	27.2	30.8	31.9	19.5	23.6	18.6	22.4	22.2	21.7	-	-	-	21.5	-	-	-	21.2	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.21	0.21	-	-	-	0.21	-	-	-	0.21	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.12	0.16	-	-	-	0.145	-	-	-	0.109	-	-	-
Calcium	-	-	4530	5560	5200	6000	5390	5000	5910	6680	5550	5880	6260	4260	4870	4290	4530	4180	4320	-	-	-	3950	-	-	-	3940	-	-	-
Chromium	-	99	38.1	30.7	29	30.4	28.8	29.9	30.9	31.3	31.5	30.9	33.6	29.2	32.9	30	30	30.4	30.3	-	-	-	31.1	-	-	-	27.9	-	-	-
Cobalt	-	-	8	8.1	7.7	7.9	8.3	7.9	8.5	8.2	8.3	8.5	8.5	7.3	8.3	8.3	8	7.76	8.23	-	-	-	8.22	-	-	-	7.07	-	-	-
Copper	-	67	11.8	13.6	12.7	15.1	13.7	13.2	13.3	15.1	13.8	14.5	15.4	10.5	11.9	10.9	12.6	11.1	11.9	-	-	-	10.8	-	-	-	10.1	-	-	-
Iron	-	-	20400	20400	18800	20200	20100	20200	19700	21300	20100	20600	20500	18100	20400	19400	19400	18900	19200	-	-	-	18900	-	-	-	17100	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.95	5.25	-	-	-	4.57	-	-	-	3.91	-	-	-
Lithium	-	-	10.5	11.6	11.6	12.3	11.1	11.4	11.6	12.2	11.8	13.1	12.6	10.5	10.6	10.1	10.9	9.4	9.2	-	-	-	8.9	-	-	-	8.6	-	-	-
Magnesium	-	-	7670	9040	8690	7940	8360	7960	8380	8790	8330	9260	8830	7490	8000	8340	8490	7260	8240	-	-	-	7880	-	-	-	7090	-	-	-
Manganese	-	-	226	226	217	250	238	226	228	258	227	238	228	202	219	206	216	215	218	-	-	-	212	-	-	-	193	-	-	-
Mercury	-	0.43	0.0245	0.0288	0.0227	0.0281	0.0236	0.0222	0.0239	0.0274	0.0233	0.0274	0.0248	0.0304	0.0269	0.0255	0.0234	0.0221	0.0233	-	-	-	0.017	-	-	-	0.0236	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.77	1.63	-	-	-	0.83	-	-	-	<0.50	-	-	-
Nickel	-	-	33.2	29.8	28.3	31.7	31.3	30.2	30	30.2	30.7	31.2	30.3	27.9	31.7	32.2	31.1	29.8	29.8	-	-	-	31.7	-	-	-	27.7	-	-	-
Potassium	-	-	1310	1560	1440	1420	1430	1210	1350	1480	1360	1530	1640	1180	1180	1090	1240	1150	1220	-	-	-	1100	-	-	-	1010	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.5	<2.0	<2.1	<0.20	<0.20	-	-	-	<0.20	-	-	-	0.21	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	4240	8350	6950	6050	6490	5360	4950	8930	5000	7530	6890	4070	3840	4800	5970	5920	5000	-	-	-	4100	-	-	-	3500	-	-	-
Strontium	-	-	30.4	34.8	27.4	38.5	29.2	27.5	29.4	35.7	28.6	33.2	32.5	25.6	27.6	24.8	27.9	26.6	28.9	-	-	-	22.9	-	-	-	23.9	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.106	0.11	-	-	-	0.116	-	-	-	0.095	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	774	732	690	808	703	697	704	719	716	732	769	715	826	624	724	669	725	-	-	-	714	-	-	-	707	-	-	-
Vanadium	-	-	41.7	44.7	44.2	43.8	43.6	44	44.7	45.8	42.6	45.2	43.5	36.3	45	39.2	42.6	41	43.1	-	-	-	41.8	-	-	-	39.5	-	-	-
Zinc	-	170	42.6	48.7	44.1	47.4	46.8	44.8	45.9	48.9	46.7	46.7	46.9	43.2	44.4	46.6	46.5	40.6	46.3	-	-	-	44.3	-	-	-	39.7	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP05																											
		Sample ID:	SDDP05-1	SDDP05-2	SDDP05-3	SDDP05-4	SDDP05-5	SDDP05-6	SDDP05-7	SDDP05-8	SDDP05-9	SDDP05-10	SDDP05-11	SDDP05-12	SDDP05-13	SDDP05-14	SDDP05-15	SDDP05-16	SDDP05-17	SDDP05-18	SDDP05-19	SDDP05-20	SDDP05-21	SDDP05-22	SDDP05-23	SDDP05-24	SDDP05-25	SDDP05-26	SDDP05-27	SDDP05-28
		Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.12	0.00-0.10	0.00-0.12	0.00-0.12	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.20	0.00-15.00	0.00-0.30	0.00-0.15	-	0.00-0.25	0.00-0.20	0.00-0.20	0.00-0.20
Parameter	***AMS Threshold***[5]	**BCCSR SedQC(SS) Marine**[3,4]																												
Physical Tests																														
Moisture (%)	-	-	46.7	54.4	51.5	52	51.7	49.6	54.6	54.6	52.9	54.7	48.7	50	52	54.3	50	51.6	50.7	51.1	48.8	53.8	46	50.4	53.4	52.2	49.4	51.7	54.6	49.2
Oxidation Reduction Potential (mV)	-	-	-160	-200	<-200	<-200	<-200	-280	-310	-430	-280	-412	-354	-303	-	-238	-298	-207	-270	-34	-314	-136	-192	-205	-167	-217	-133	-161	-156	-124
pH	-	-	8.17	7.98	8.1	7.86	7.83	7.89	7.71	7.91	7.83	7.76	8.04	8.19	7.88	7.86	7.7	7.64	7.83	-	-	-	7.81	-	-	-	7.83	-	-	-
Grain Size																														
Clay (<0.004 mm) (%)	-	-	16	-	-	-	15	-	-	-	17	-	-	-	16	-	11.8	9.68	10.9	-	14.7	-	14.3	-	-	-	13.6	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	41	-	-	-	53	-	-	-	49	-	-	-	49	-	30.6	56.7	54.8	-	55.7	-	50.9	-	-	-	52.7	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	44	-	-	-	33	-	-	-	34	-	-	-	35	-	57.6	33.6	34.3	-	29.6	-	34.8	-	-	-	33.7	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	<1	-	-	-	<1.0	-	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-	-	-	<0.10	-	-	-
Total Inorganics																														
Ammonium	19.8	-	17.9	9	4.9	6.1	7.5	8.9	17.4	7.3	5.4	6.38	10.4	9.96	10.5	***22.1***	10.2	13.7	5.25	12.5	7.8	4.7	4.2	7.5	6.4	6.9	4.9	9.5	5.3	5.5
Available Phosphate	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	15.7	4.4	29.7	10.8	3.9	10.7	7.3	6.9	9.8	4.5	15.5	4.2	3.9
Phosphorus	897	-	814	812	644	837	885	825	851	***955***	824	825	741	726	862	798	772	753	706	820	813	784	576	691	851	580	857	769	782	703
Sulfide	49.5	-	46.2	***101***	***61.6***	9.1	19.7	8.69	15.9	28.5	17.8	17.4	31	31.2	41.8	32.3	39.3	20.6	28.3	19.4	36.8	45.7	7.5	5.8	***77***	***53***	20.8	***84***	27.5	4.4
Total Kjeldahl Nitrogen (%)	0.186	-	-	0.15	***0.19***	0.17	0.18	0.14	0.17	0.17	0.18	0.168	0.171	***0.188***	0.173	***0.195***	0.161	0.166	0.13	0.167	0.18	0.153	0.141	0.162	0.168	0.171	0.179	0.167	0.177	0.129
Total Nitrogen (%)	0.197	-	0.19	0.16	0.17	0.14	0.16	0.15	0.16	0.18	0.15	***0.217***	0.189	***0.2***	0.177	0.162	0.16	***0.241***	0.158	***0.207***	0.178	0.151	0.159	0.178	0.141	0.192	***0.231***	0.176	0.191	0.169
Organics																														
Organic Nitrogen (%)	0.183	-	-	0.15	***0.19***	0.16	0.18	0.14	0.17	0.17	0.18	0.167	0.17	***0.187***	0.172	-	0.16	0.164	0.13	0.166	0.179	0.153	0.14	0.162	0.167	0.17	0.179	0.166	0.176	0.129
Total Organic Carbon (%)	1.98	-	1.72	1.66	1.9	1.8	1.8	1.6	1.8	***2.1***	1.7	1.95	1.77	1.91	1.66	1.65	1.73	1.85	1.62	***2.01***	1.83	1.9	1.87	***1.99***	1.82	***2.16***	***1.98***	***2.09***	1.87	1.86

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP05																											
		Sample ID:	SDDP05-1	SDDP05-2	SDDP05-3	SDDP05-4	SDDP05-5	SDDP05-6	SDDP05-7	SDDP05-8	SDDP05-9	SDDP05-10	SDDP05-11	SDDP05-12	SDDP05-13	SDDP05-14	SDDP05-15	SDDP05-16	SDDP05-17	SDDP05-18	SDDP05-19	SDDP05-20	SDDP05-21	SDDP05-22	SDDP05-23	SDDP05-24	SDDP05-25	SDDP05-26	SDDP05-27	SDDP05-28
		Date Sampled:	24/03/2007	20/06/2007	02/10/2007	10/12/2007	05/03/2008	30/05/2008	21/09/2008	27/11/2008	24/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	03/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.12	0.00-0.10	0.00-0.12	0.00-0.12	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.20	0.00-15.00	0.00-0.30	0.00-0.15	-	0.00-0.25	0.00-0.20	0.00-0.20	0.00-0.20
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																												
Total Metals																														
Aluminum	-	-	16500	17000	13400	17900	17200	17100	16100	17000	17000	18200	16000	15400	15700	15300	15400	14600	14600	-	-	-	12000	-	-	-	16400	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.37	0.33	-	-	-	0.26	-	-	-	0.46	-	-	-
Arsenic	-	26	<5.0	6.5	5	6.1	7.8	7.6	8	8.6	7.6	6.6	6.6	5.5	7.8	7.3	5.4	6.98	6.14	-	-	-	5.32	-	-	-	7.22	-	-	-
Barium	-	-	49.2	51.2	40.3	60.8	53.5	56	51.4	58.1	53.5	57.1	49.3	46.7	47.7	45.2	45.2	50.5	39.3	-	-	-	32.7	-	-	-	50.8	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.54	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.36	0.29	-	-	-	0.25	-	-	-	0.36	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.91	<0.50	0.63	<0.50	0.64	<0.50	<0.50	0.35	0.31	-	-	-	0.259	-	-	-	0.36	-	-	-
Calcium	-	-	8070	8390	8240	9810	9910	9710	10300	11500	9420	10100	9830	8550	8800	8820	8330	8300	7280	-	-	-	6380	-	-	-	8140	-	-	-
Chromium	-	99	40.2	38.9	30.3	42.1	40	39.3	39.1	38.3	39.7	39.1	39.4	37.2	40.1	40.4	40.8	44.7	36.3	-	-	-	29.5	-	-	-	43.9	-	-	-
Cobalt	-	-	10.6	10.6	7.7	10.3	10.9	10.3	10.8	10.9	10.6	11.3	10.5	9.5	10.7	10.8	10.6	11.1	9.73	-	-	-	8.43	-	-	-	11.7	-	-	-
Copper	-	67	36.8	37.8	29.8	38.2	38	37	35.1	36.5	37.7	38.2	35.5	31.4	32.3	31.4	34.6	33.5	29.1	-	-	-	24.4	-	-	-	33.9	-	-	-
Iron	-	-	30000	28700	22200	28600	30200	29800	28100	28800	29200	31000	28200	27100	27900	29600	28600	29400	25900	-	-	-	21600	-	-	-	30800	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	8.73	6.58	-	-	-	5.86	-	-	-	7.54	-	-	-
Lithium	-	-	20.7	21.4	17.7	22.8	21.4	22.5	21.1	22.2	22.6	23.6	21.6	20.2	21.4	20.6	20.4	19.2	15.4	-	-	-	13.1	-	-	-	19.3	-	-	-
Magnesium	-	-	12200	12400	10200	11600	12300	12100	12500	12500	13100	13100	12200	11100	12200	12800	12200	11500	10900	-	-	-	8760	-	-	-	12200	-	-	-
Manganese	-	-	330	318	246	341	347	337	327	334	323	339	312	295	313	308	317	327	285	-	-	-	236	-	-	-	340	-	-	-
Mercury	-	0.43	0.0592	0.0686	0.0805	0.0608	0.0623	0.0578	0.059	0.0678	0.0619	0.0631	0.0548	0.048	0.0505	0.0521	0.0512	0.0526	0.0488	-	-	-	0.034	-	-	-	0.049	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	1.74	1.18	-	-	-	1.15	-	-	-	1.07	-	-	-
Nickel	-	-	39.7	37.3	27.1	42.5	38.1	38	37.1	36.3	36.8	40.3	36.8	34	38.4	40.1	38	40.9	34.5	-	-	-	31.1	-	-	-	42.7	-	-	-
Potassium	-	-	2590	2510	2230	2600	2700	2440	2540	2620	2920	2980	2540	2440	2570	2440	2310	2470	2020	-	-	-	1660	-	-	-	2400	-	-	-
Selenium	-	-	<2.0	<2.0	<3.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.50, <3.2	0.46	0.41	-	-	-	0.35	-	-	-	0.56	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	0.13	0.12	-	-	-	<0.10	-	-	-	0.13	-	-	-
Sodium	-	-	11300	10800	11200	11800	12100	12300	10400	15200	14500	14900	11600	11100	12300	13600	10900	12300	9250	-	-	-	7800	-	-	-	10600	-	-	-
Strontium	-	-	47.7	49.5	41.8	58.7	54.2	53.2	51	59.7	52.5	58.1	49.6	52.2	54.3	55.3	50.4	49.7	46.6	-	-	-	38.1	-	-	-	52.3	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	0.158	0.145	-	-	-	0.114	-	-	-	0.155	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	910	884	734	995	959	932	839	928	882	943	875	986	973	974	922	942	778	-	-	-	637	-	-	-	1050	-	-	-
Vanadium	-	-	56.8	56	46.1	54.6	57.3	57.7	54.2	54.8	53.4	59.2	52.8	50.3	53	53.9	55.2	56.8	49.9	-	-	-	40.6	-	-	-	60.8	-	-	-
Zinc	-	170	74.7	72.8	55.4	72.4	75.5	71.6	70.8	72.4	76.9	76.8	68.7	67.1	68.7	73.3	71.9	69.9	65.7	-	-	-	55.8	-	-	-	78.4	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

Sample ID:	AMS Threshold[5]	BCCSR SedQC(SS) Marine[3,4]	SDDP06-1	SDDP06-2	SDDP06-3	SDDP06-4	SDDP06-5	SDDP06-6	SDDP06-7	SDDP06-8	SDDP06-9	SDDP06-10	SDDP06-11	SDDP06-12	SDDP06-13	SDDP06-14
Location ID:			DP06													
Date Sampled:			23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010	07/06/2010
Sample Depth (m):			0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.10	0.00-0.07	0.00-0.10	0.00-0.10
Physical Tests																
Moisture (%)	-	-	30.4	32.6	32.4	27.2	34	27.4	26.6	32.6	31.7	30.6	30	26.6	28	28.9
Oxidation Reduction Potential (mV)	-	-	-60	-50	-20	-140	70	-140	-170	-190	-	-321	-269	-267	-	-78
pH	-	-	7.87	7.92	7.99	7.95	8	8.01	7.82	7.83	7.85	7.76	7.97	7.99	7.95	7.8
Grain Size																
Clay (<0.004 mm) (%)	-	-	7	-	-	-	3	-	-	-	8	-	-	-	6	-
Silt (0.004-0.063 mm) (%)	-	-	16	-	-	-	8	-	-	-	30	-	-	-	27	-
Sand (0.063-2.00 mm) (%)	-	-	78	-	-	-	88	-	-	-	59	-	-	-	66	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	4	-	-	-	<1.0	-
Total Inorganics																
Ammonium	19.8	-	2	1.7	2.8	2	1	<0.8	1	1.6	2.2	2.3	3.07	1.78	4.9	4.13
Available Phosphate	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-
Phosphorus	897	-	723	733	802	713	656	649	690	781	820	699	745	637	618	714
Sulfide	49.5	-	0.24	0.21	<0.17	<0.18	0.24	<0.20	0.21	0.22	<0.20	<0.21	<0.20	<0.20	0.5	0.27
Total Kjeldahl Nitrogen (%)	0.186	-	0.04	0.03	0.05	0.03	0.02	0.04	0.03	0.07	0.06	0.038	0.054	0.036	0.034	0.051
Total Nitrogen (%)	0.197	-	0.03	0.04	0.04	0.04	0.04	0.03	0.05	0.05	-	0.045	0.081	0.04	0.054	0.042
Organics																
Organic Nitrogen (%)	0.183	-	0.04	0.03	0.05	0.03	0.02	0.04	0.03	0.07	0.06	0.037	0.054	0.035	0.033	-
Total Organic Carbon (%)	1.98	-	0.32	0.46	0.5	0.4	0.3	<0.1	0.3	0.5	-	0.25	0.52	0.29	0.39	0.4

Sample ID:	SDDP06-15	SDDP06-16	SDDP06-17	SDDP06-18	SDDP06-19	SDDP06-20	SDDP06-21	SDDP06-22	SDDP06-23	SDDP06-24	SDDP06-25	SDDP06-26	SDDP06-27	SDDP06-28
Location ID:	DP06													
Date Sampled:	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.15	0.00-10.00	0.00-0.50	0.00-0.08	-	0.00-0.15	0.00-0.10	0.00-0.10	0.00-0.08
Physical Tests														
Moisture (%)	30.5	28.8	30	35.5	35.7	33.3	32	34.4	39.9	26.8	28.4	28.5	31.1	26.4
Oxidation Reduction Potential (mV)	-77	-75	96	-7	-268	-140	68	-133	-67	-51	90	-31	-115	5
pH	7.71	7.56	7.73	-	-	-	7.87	-	-	-	8.09	-	-	-
Grain Size														
Clay (<0.004 mm) (%)	4.92	2.1	4.85	-	14.1	-	11.6	-	-	-	9.06	-	-	-
Silt (0.004-0.063 mm) (%)	23.3	14	18.2	-	71.1	-	47.5	-	-	-	39.3	-	-	-
Sand (0.063-2.00 mm) (%)	71.8	83.9	77	-	14.8	-	40.8	-	-	-	51.7	-	-	-
Gravel (>2.00 mm) (%)	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-	-	-	<0.10	-	-	-
Total Inorganics														
Ammonium	1.48	1.56	1.5	1.4	<1.6	1.5	<1.6	3	2.5	2.5	1.7	2.4	2.4	2
Available Phosphate	-	8.5	10.1	9.2	5.4	6.5	7	8.3	8.6	6.5	7.1	5.2	8.4	8.4
Phosphorus	696	627	647	798	819	700	714	843	780	881	726	825	807	722
Sulfide	0.36	<0.20	<0.21	0.4	0.42	0.9	0.94	<0.69	0.94	<0.20	<0.24	<0.29	<0.40	<2.3
Total Kjeldahl Nitrogen (%)	0.043	0.024	0.032	0.032	0.057	0.088	0.032	0.035	0.056	0.042	0.038	0.054	0.051	0.025
Total Nitrogen (%)	0.033	0.086	0.04	0.057	0.058	0.067	0.053	0.048	0.036	0.055	0.087	0.059	0.06	0.034
Organics														
Organic Nitrogen (%)	0.043	0.024	0.032	0.032	0.057	0.088	0.032	0.035	0.056	0.042	0.038	0.054	0.05	0.024
Total Organic Carbon (%)	0.33	0.3	-	0.37	0.57	1.12	0.73	0.48	0.52	0.61	0.53	0.83	0.61	0.33

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP06																											
		Sample ID:	SDDP06-1	SDDP06-2	SDDP06-3	SDDP06-4	SDDP06-5	SDDP06-6	SDDP06-7	SDDP06-8	SDDP06-9	SDDP06-10	SDDP06-11	SDDP06-12	SDDP06-13	SDDP06-14	SDDP06-15	SDDP06-16	SDDP06-17	SDDP06-18	SDDP06-19	SDDP06-20	SDDP06-21	SDDP06-22	SDDP06-23	SDDP06-24	SDDP06-25	SDDP06-26	SDDP06-27	SDDP06-28
		Date Sampled:	23/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	15/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	06/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.08	0.00-0.05	0.00-0.10	0.00-0.07	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.15	0.00-10.00	0.00-0.50	0.00-0.08	-	0.00-0.15	0.00-0.10	0.00-0.10	0.00-0.08
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																												
Total Metals																														
Aluminum	-	-	11500	15000	14800	14500	10000	9890	11400	13100	13700	11200	13400	10200	9330	10900	10400	8850	8960	-	-	-	13700	-	-	-	10800	-	-	-
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	0.26	0.28	-	-	-	0.37	-	-	-	0.35	-	-	-
Arsenic	-	26	6.3	7.1	7	6.7	5	7	6.4	7.6	6.3	6.4	7	5.3	<5.0	5.7	5.8	6.06	6.03	-	-	-	6.63	-	-	-	6.48	-	-	-
Barium	-	-	47	69.4	60.1	65.4	38.8	41.1	46.8	58.1	57	46.3	54.3	37.3	34.9	39.4	37.6	31.4	32.2	-	-	-	51.3	-	-	-	41.9	-	-	-
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.22	0.23	-	-	-	0.27	-	-	-	0.27	-	-	-
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.52	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.10	<0.10	-	-	-	0.118	-	-	-	0.108	-	-	-
Calcium	-	-	5660	7110	7750	7210	5560	5550	6070	7490	7160	6070	6880	5580	5420	5980	5560	4950	4870	-	-	-	6110	-	-	-	6340	-	-	-
Chromium	-	99	39.5	38.1	36.9	38.9	34.3	33.4	34.6	37.6	40.7	33.1	35.4	32.8	30	34.6	34.6	32.8	33.7	-	-	-	35.9	-	-	-	34.8	-	-	-
Cobalt	-	-	11.5	12.8	12.4	11.8	10.6	10.6	11.5	11.7	12.6	11.6	12.5	10.2	9.7	11.5	10.7	10.4	10.5	-	-	-	11.9	-	-	-	11.2	-	-	-
Copper	-	67	18.3	26	30.8	25.9	15	15.4	18.1	25	25.4	18.8	27.2	15.8	13.4	16.2	16.4	14.2	14.2	-	-	-	24.6	-	-	-	20.4	-	-	-
Iron	-	-	27900	28500	29500	27300	24400	23400	24700	28800	29600	26500	28200	23500	21100	25500	24700	22500	23500	-	-	-	27300	-	-	-	25800	-	-	-
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	4.99	4.61	-	-	-	5.33	-	-	-	4.91	-	-	-
Lithium	-	-	12.2	15.5	18.2	16.4	11	11.3	12.7	15.3	15.8	12.3	17	11.7	10.5	12.2	11.8	9.8	10.5	-	-	-	11.6	-	-	-	12	-	-	-
Magnesium	-	-	9720	11300	11900	10100	8990	9080	9560	10500	11300	9830	10900	8960	8730	10200	9760	8530	8420	-	-	-	9950	-	-	-	9520	-	-	-
Manganese	-	-	376	472	416	386	364	345	366	392	410	389	372	329	288	374	335	323	339	-	-	-	401	-	-	-	318	-	-	-
Mercury	-	0.43	0.0326	0.0629	0.0474	0.201	0.0251	0.0323	0.0283	0.0513	0.0495	0.0337	0.0402	0.0254	0.0463	0.0333	0.0256	0.0269	0.025	-	-	-	0.0344	-	-	-	0.034	-	-	-
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	0.7	<0.50	-	-	-	0.68	-	-	-	0.51	-	-	-
Nickel	-	-	37.7	41.5	39	44.7	37	36.6	37.8	39.9	40.7	40.3	40.4	36	34.4	40.7	38.3	37	37.1	-	-	-	39.5	-	-	-	39.3	-	-	-
Potassium	-	-	1230	1490	1560	1490	1120	940	1180	1420	1490	1160	1490	1080	920	1010	990	1080	980	-	-	-	1300	-	-	-	1180	-	-	-
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<2.0	<0.20	<0.20	-	-	-	0.26	-	-	-	0.27	-	-	-
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	<0.10	-	-	-
Sodium	-	-	3110	3390	4300	3510	3580	1120	2520	4570	5140	2490	4450	2410	2580	2300	2650	5990	2800	-	-	-	4010	-	-	-	2780	-	-	-
Strontium	-	-	36.7	41.6	40.4	43.9	31.3	29	31.6	39.2	40.1	32	38.8	32.8	27.4	32.7	32.2	31.1	29.8	-	-	-	36.3	-	-	-	35.1	-	-	-
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<0.050	<0.050	-	-	-	0.056	-	-	-	0.055	-	-	-
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	-	-	921	850	816	917	788	754	724	850	854	706	743	831	743	856	805	693	767	-	-	-	880	-	-	-	746	-	-	-
Vanadium	-	-	56.6	55.4	55.4	53	47.5	47.3	47.8	53.4	54.4	52	52.6	44.1	40	47.2	49.7	43	46	-	-	-	50.7	-	-	-	49	-	-	-
Zinc	-	170	53	65.7	64.9	60.6	48	49.3	52.2	61.7	62.3	54.9	60.4	49.3	44.5	54.6	51.1	45.5	48.1	-	-	-	60	-	-	-	55.3	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP07																											
		Sample ID:	SDDP07-1	SDDP07-2	SDDP07-3	SDDP07-4	SDDP07-5	SDDP07-6	SDDP07-7	SDDP07-8	SDDP07-9	SDDP07-10	SDDP07-11	SDDP07-12	SDDP07-13	SDDP07-14	SDDP07-15	SDDP07-16	SDDP07-17	SDDP07-18	SDDP07-19	SDDP07-20	SDDP07-21	SDDP07-22	SDDP07-23	SDDP07-24	SDDP07-25	SDDP07-26	SDDP07-27	SDDP07-28
		Date Sampled:	24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.08	0.00-0.08	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.20	0.00-6.00	0.00-0.10	0.00-0.06	-	0.00-0.20	0.00-5.00	0.00-0.15	0.00-0.10
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]																												
Physical Tests																														
Moisture (%)	-	-	28.5	29.4	26.1	26.3	24.5	24.4	36.7	31.8	24.8	21.1	22.6	22.1	25.5	20.1	26.5	22.4	22.9	19.1	24.2	25.9	24.2	19.6	26.9	19.9	24.5	20.5	23.1	24
Oxidation Reduction Potential (mV)	-	-	-110	-170	<-200	-170	110	-250	-260	-270	-	-37	-278	-33	-	31	-99	49	158	179	-263	-59	-110	-184	-126	-207	222	143	-111	-132
pH	-	-	8.04	8.16	8.13	8.1	8.24	8.11	7.86	8	8.29	8	8.18	8.01	8.2	8.01	7.87	7.56	7.72	-	-	-	8.18	-	-	-	8.02	-	-	-
Grain Size																														
Clay (<0.004 mm) (%)	-	-	7	-	-	-	2	-	-	-	4	-	-	-	2	-	2.1	1.44	1.27	-	6.28	-	4.87	-	-	-	1.74	-	-	-
Silt (0.004-0.063 mm) (%)	-	-	15	-	-	-	4	-	-	-	6	-	-	-	5	-	4.1	2.57	5.33	-	19.9	-	16.3	-	-	-	2.28	-	-	-
Sand (0.063-2.00 mm) (%)	-	-	78	-	-	-	93	-	-	-	87	-	-	-	92	-	93.8	96	93.3	-	73.8	-	78.8	-	-	-	96	-	-	-
Gravel (>2.00 mm) (%)	-	-	<1	-	-	-	<1	-	-	-	2	-	-	-	<1.0	-	<0.10	<0.10	0.1	-	<0.10	-	<0.10	-	-	-	<0.10	-	-	-
Total Inorganics																														
Ammonium	19.8	-	3.1	2.2	2.9	1.4	1.3	2.2	2.4	1.4	1.5	1.75	2.15	<0.80	4.98	2.19	1.14	1.3	<1.0	<1.0	<1.6	1.2	<1.0	1.7	1.9	1.5	<1.0	3.9	1.1	1.5
Available Phosphate	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	14.2	12.5	11.1	11.5	8.5	10.1	10.5	12.7	7.8	11.2	10.6	9.9	10.9
Phosphorus	897	-	692	613	649	548	534	680	740	597	559	541	670	532	525	556	557	553	509	564	610	560	543	580	598	574	494	526	624	566
Sulfide	49.5	-	1.59	1.42	12.5	2.87	0.42	2.34	3.6	3.84	4.1	1.22	0.2	0.87	1.81	<0.20	2.25	<0.20	<0.20	0.43	0.69	2.8	0.65	0.82	2.48	1.59	0.41	0.21	0.74	2.6
Total Kjeldahl Nitrogen (%)	0.186	-	***0.55***	<0.02	0.05	0.02	<0.02	0.03	0.08	0.06	<0.02	0.02	0.029	<0.020	0.041	0.022	0.028	<0.020	<0.020	<0.020	0.028	0.041	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Total Nitrogen (%)	0.197	-	0.04	0.03	0.05	<0.02	0.03	0.04	0.06	0.02	-	0.03	0.056	0.027	0.04	<0.020	0.023	0.044	0.026	0.03	0.03	0.037	0.026	0.026	0.023	0.03	0.063	<0.020	0.025	0.022
Organics																														
Organic Nitrogen (%)	0.183	-	-	<0.02	0.05	0.02	<0.02	0.03	0.08	0.06	<0.02	0.02	0.028	<0.020	0.041	-	0.028	<0.020	<0.020	<0.020	0.028	0.041	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Total Organic Carbon (%)	1.98	-	0.55	0.25	0.4	0.2	0.2	0.2	0.6	0.4	-	0.14	0.4	0.13	0.2	0.14	0.2	<0.10	-	0.14	0.19	0.49	0.28	0.19	0.12	0.26	0.14	0.11	<0.10	0.2

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP07													
		Sample ID:	SDDP07-1	SDDP07-2	SDDP07-3	SDDP07-4	SDDP07-5	SDDP07-6	SDDP07-7	SDDP07-8	SDDP07-9	SDDP07-10	SDDP07-11	SDDP07-12	SDDP07-13	SDDP07-14
		Date Sampled:	24/03/2007	20/06/2007	01/10/2007	10/12/2007	04/03/2008	29/05/2008	20/09/2008	26/11/2008	23/02/2009	20/05/2009	14/09/2009	03/12/2009	08/03/2010	07/06/2010
		Sample Depth (m):	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.05	0.00-0.07	0.00-0.08	0.00-0.08	0.00-0.10	0.00-0.10	0.00-0.10
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]														
Total Metals																
Aluminum	-	-	12300	12500	12500	12200	9720	11700	14700	10600	10300	10400	12100	9680	9140	9190
Antimony	-	-	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arsenic	-	26	<5.0	7	6.6	5.7	<5.0	7.5	7.5	6.8	5.5	6.4	5.4	<5.0	<5.0	<5.0
Barium	-	-	44.8	45.8	45.9	46.3	28.5	44.5	59.3	36.6	29.9	35.8	46.2	25.3	26.4	25.2
Beryllium	-	-	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.5	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Cadmium	-	2.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium	-	-	5760	6270	6970	6480	5580	6880	7300	5970	5780	5590	6440	5260	4890	5290
Chromium	-	99	37.3	34.1	34.1	35.4	40.1	35.6	38	33	40.5	34.1	37.6	40	36.8	36.9
Cobalt	-	-	10.3	10.1	10.4	9.8	9.4	11.1	12.2	10	9.9	9.9	10.7	9	8.9	9.6
Copper	-	67	20.2	17.2	22	17.9	13	23.7	26.8	17.4	13.8	13.5	19.7	11.2	11.9	9
Iron	-	-	25500	22600	24300	22800	22900	25000	27100	23100	23600	21500	23700	20600	20400	20700
Lead	-	69	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30	<30
Lithium	-	-	13.5	11.8	13.9	12.4	9.3	14.3	16.5	11.8	10.5	10.5	13.4	10	9.6	8.8
Magnesium	-	-	10300	9650	10400	9010	8890	10700	11100	9340	9250	8920	10200	8790	8620	8950
Manganese	-	-	329	309	313	319	296	355	362	304	294	297	310	277	273	270
Mercury	-	0.43	0.0372	0.0316	0.0346	0.0317	0.0201	0.0939	0.0458	0.0262	0.02	0.0225	0.0318	0.0154	0.0221	0.0217
Molybdenum	-	-	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel	-	-	39.2	35.7	36	41.2	38.4	39.1	41.5	37.5	37.8	37.3	39.6	36.9	35.5	38.7
Potassium	-	-	1480	1310	1390	1160	850	1240	1770	1100	910	920	1370	740	830	660
Selenium	-	-	<2.0	<2.0	<2.0	<2.0	<3.0	<2.0	<2.0	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0
Silver	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Sodium	-	-	5080	4110	4810	3020	2160	4340	5310	4920	2800	2480	4590	1870	2990	2070
Strontium	-	-	33.8	31.4	32.3	33.9	25.6	32.9	37.2	27.6	25.8	25	31.2	23.5	23.9	22.1
Thallium	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tin	-	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium	-	-	811	835	791	928	899	716	809	775	826	773	802	893	751	896
Vanadium	-	-	51.6	50.1	51.4	51.3	58.9	49.7	53.3	52.2	58.5	50.2	47.4	50.5	47.2	50.4
Zinc	-	170	54.3	48.6	54.2	47.2	39.7	54.7	61.5	47.1	42.3	41.8	48.6	38.3	38	38.1

Location ID:	DP07													
Sample ID:	SDDP07-15	SDDP07-16	SDDP07-17	SDDP07-18	SDDP07-19	SDDP07-20	SDDP07-21	SDDP07-22	SDDP07-23	SDDP07-24	SDDP07-25	SDDP07-26	SDDP07-27	SDDP07-28
Date Sampled:	30/08/2010	02/12/2010	04/03/2011	08/06/2011	06/09/2011	07/11/2011	20/02/2012	29/05/2012	05/09/2012	10/12/2012	18/02/2013	04/06/2013	24/09/2013	10/12/2013
Sample Depth (m):	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.10	0.00-0.07	0.00-0.20	0.00-6.00	0.00-0.10	0.00-0.06	-	0.00-0.20	0.00-5.00	0.00-0.15	0.00-0.10
Parameter														
Total Metals														
Aluminum	9670	7630	8150	-	-	-	11600	-	-	-	8180	-	-	-
Antimony	<10	0.16	0.18	-	-	-	0.26	-	-	-	0.17	-	-	-
Arsenic	5.3	5.17	5.16	-	-	-	5.42	-	-	-	4.75	-	-	-
Barium	29.1	22.5	25.6	-	-	-	34.6	-	-	-	23.9	-	-	-
Beryllium	<0.50	<0.20	<0.20	-	-	-	0.23	-	-	-	<0.20	-	-	-
Bismuth	<20	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Cadmium	<0.50	<0.10	<0.10	-	-	-	0.078	-	-	-	<0.050	-	-	-
Calcium	4910	3840	4310	-	-	-	5460	-	-	-	4150	-	-	-
Chromium	30.1	27.6	30.6	-	-	-	34.1	-	-	-	28.2	-	-	-
Cobalt	9.1	8.51	9	-	-	-	10.2	-	-	-	8.32	-	-	-
Copper	13.5	10.5	10.6	-	-	-	15.8	-	-	-	10.3	-	-	-
Iron	20100	17700	18900	-	-	-	21600	-	-	-	18200	-	-	-
Lead	<30	2.75	2.7	-	-	-	3.74	-	-	-	2.62	-	-	-
Lithium	10.2	8.4	8.5	-	-	-	9.5	-	-	-	7.7	-	-	-
Magnesium	9160	7460	7960	-	-	-	8870	-	-	-	7900	-	-	-
Manganese	276	254	269	-	-	-	299	-	-	-	245	-	-	-
Mercury	0.0198	0.0202	0.0164	-	-	-	0.0246	-	-	-	0.0172	-	-	-
Molybdenum	<4.0	<0.50	<0.50	-	-	-	<0.50	-	-	-	<0.50	-	-	-
Nickel	36.5	32.7	36.2	-	-	-	38.4	-	-	-	34.3	-	-	-
Potassium	840	740	740	-	-	-	1040	-	-	-	710	-	-	-
Selenium	<2.0	<0.20	<0.20	-	-	-	<0.20	-	-	-	<0.20	-	-	-
Silver	<2.0	<0.10	<0.10	-	-	-	<0.10	-	-	-	<0.10	-	-	-
Sodium	3120	2590	2430	-	-	-	3330	-	-	-	2310	-	-	-
Strontium	24.7	20.4	23.5	-	-	-	28.3	-	-	-	20.5	-	-	-
Thallium	<1.0	0.083	0.082	-	-	-	0.086	-	-	-	0.073	-	-	-
Tin	<5.0	<2.0	<2.0	-	-	-	<2.0	-	-	-	<2.0	-	-	-
Titanium	792	541	758	-	-	-	860	-	-	-	724	-	-	-
Vanadium	45.9	37	43.7	-	-	-	47.3	-	-	-	41.5	-	-	-
Zinc	40.9	34.5	38	-	-	-	46.2	-	-	-	36.8	-	-	-

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP08						DP09				
		Sample ID:	SDDP08-5	SDDP08-9	SDDP08-13	SDDP08-17	SDDP08-21	SDDP08-25	SDDP09-9	SDDP09-13	SDDP09-17	SDDP09-21	SDDP09-25
		Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	18/02/2013	25/02/2009	09/03/2010	03/03/2011	20/02/2012	18/02/2013
		Sample Depth (m):	0.00-0.05	0.00-0.08	0.00-0.10	0.00-0.10	0.00-4.00	0.00-0.20	0.00-0.07	0.00-0.10	0.00-0.10	0.00-15.00	0.00-0.25
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]											
Physical Tests													
Moisture (%)	-	-	30.2	32.3	32.5	27	25.7	27	39.5	40.2	36.4	37.5	52.6
Oxidation Reduction Potential (mV)	-	-	-120	-160	-	108	152	-223	-260	-	-230	-200	-224
pH	-	-	7.84	7.97	7.92	7.44	7.63	7.66	8.05	7.96	8.02	7.7	7.77
Grain Size													
Clay (<0.004 mm) (%)	-	-	2	3	3	3.09	1.94	2.03	7	6	6.34	6.64	6.62
Silt (0.004-0.063 mm) (%)	-	-	3	5	4	6.53	8.88	4.66	34	31	37.7	32.6	29.3
Sand (0.063-2.00 mm) (%)	-	-	94	91	93	90.4	89.2	93.3	59	63	56	60.8	64
Gravel (>2.00 mm) (%)	-	-	<1	<1	<1.0	<0.10	<0.10	<0.10	1	<1.0	<0.10	<0.10	<0.10
Total Inorganics													
Ammonium	19.8	-	1.5	3.4	9.11	2.8	3.7	3.7	2.5	4.15	2.99	2	2.5
Available Phosphate	-	-	-	-	-	24.7	28.8	17.9	-	-	7	11.3	7.2
Phosphorus	897	-	607	666	593	625	665	663	816	692	708	633	867
Sulfide	49.5	-	7.76	8.34	5.25	0.24	0.45	<0.22	10.1	2.65	8.5	1.49	8.7
Total Kjeldahl Nitrogen (%)	0.186	-	0.05	0.06	0.08	0.034	0.032	0.04	0.09	0.109	0.088	0.075	0.087
Total Nitrogen (%)	0.197	-	0.05	0.06	0.077	0.05	0.052	0.083	0.08	0.089	0.099	0.087	0.157
Organics													
Organic Nitrogen (%)	0.183	-	0.05	0.06	0.079	0.034	0.032	0.04	0.09	0.108	0.087	0.075	0.087
Total Organic Carbon (%)	1.98	-	0.3	0.3	0.39	-	0.32	0.31	0.9	0.9	1.01	0.95	1.21

Table 11: AMS Sediment Chemistry Results (2007 - 2013)

		Location ID:	DP08						DP09				
		Sample ID:	SDDP08-5	SDDP08-9	SDDP08-13	SDDP08-17	SDDP08-21	SDDP08-25	SDDP09-9	SDDP09-13	SDDP09-17	SDDP09-21	SDDP09-25
		Date Sampled:	04/03/2008	25/02/2009	08/03/2010	04/03/2011	20/02/2012	18/02/2013	25/02/2009	09/03/2010	03/03/2011	20/02/2012	18/02/2013
		Sample Depth (m):	0.00-0.05	0.00-0.08	0.00-0.10	0.00-0.10	0.00-4.00	0.00-0.20	0.00-0.07	0.00-0.10	0.00-0.10	0.00-15.00	0.00-0.25
Parameter	***AMS Threshold*** [5]	**BCCSR SedQC(SS) Marine** [3,4]											
Total Metals													
Aluminum	-	-	8960	10200	8620	7970	9590	8970	13800	11900	13300	10900	13200
Antimony	-	-	<10	<10	<10	0.18	0.2	0.18	<10	<10	0.24	0.22	0.39
Arsenic	-	26	<5.0	<5.0	<5.0	3.96	4.7	4.68	6.7	6.1	6.03	5.4	7.69
Barium	-	-	24.1	27.3	19.9	22.4	23.4	22.4	47.3	37.7	39.4	32.7	40.8
Beryllium	-	-	<0.50	<0.50	<0.50	<0.20	0.23	<0.20	<0.50	<0.50	0.28	0.23	0.32
Bismuth	-	-	<20	<20	<20	<0.20	<0.20	<0.20	<20	<20	<0.20	<0.20	<0.20
Cadmium	-	2.6	<0.50	0.5	<0.50	<0.10	0.075	<0.050	0.76	<0.50	0.27	0.207	0.259
Calcium	-	-	4700	5380	4450	4370	5460	4490	12000	8700	10700	6610	7680
Chromium	-	99	30.6	32.8	29.1	33	32.6	33.6	35.8	34.3	37.2	31.1	38
Cobalt	-	-	7.1	7.9	7.4	7.66	8.03	7.7	10.3	9.8	10.4	9.19	10.2
Copper	-	67	10	11.4	9.4	8.95	9.61	8.9	28.1	23.5	25.2	20.6	26.8
Iron	-	-	19000	20400	18800	19400	19300	19100	25100	23600	24800	21000	25900
Lead	-	69	<30	<30	<30	3.46	3.8	3.28	<30	<30	4.76	4.21	5.96
Lithium	-	-	9.4	11.6	10	9.1	9.7	8.2	17.4	14.3	12.6	11.6	15.1
Magnesium	-	-	7540	8890	7890	7310	8090	8110	12100	10100	10700	9090	10500
Manganese	-	-	230	234	212	232	232	231	308	285	301	252	291
Mercury	-	0.43	0.025	0.0251	0.0215	0.0208	0.0466	0.0241	0.0426	0.0365	0.042	0.0326	0.0483
Molybdenum	-	-	<4.0	<4.0	<4.0	<0.50	<0.50	<0.50	<4.0	<4.0	0.59	0.53	0.69
Nickel	-	-	28.1	30.6	28.8	29.6	31.7	30.6	37	36.2	36.8	34.4	38.1
Potassium	-	-	1160	1500	1080	960	1060	1030	2110	1570	1590	1450	1970
Selenium	-	-	<2.0	<2.0	<2.0	<0.20	<0.20	<0.20	<2.0	<2.0	0.23	0.24	0.4
Silver	-	-	<2.0	<2.0	<2.0	<0.10	<0.10	<0.10	<2.0	<2.0	<0.10	<0.10	<0.10
Sodium	-	-	4640	5700	4330	3310	3920	3920	8210	6220	5930	6170	9820
Strontium	-	-	26.5	28.8	24.2	25.4	29.2	24.4	53.7	44.6	58.4	37.4	51
Thallium	-	-	<1.0	<1.0	<1.0	0.11	0.117	0.097	<1.0	<1.0	0.125	0.119	0.126
Tin	-	-	<5.0	<5.0	<5.0	<2.0	<2.0	<2.0	<5.0	<5.0	<2.0	<2.0	<2.0
Titanium	-	-	750	780	706	785	835	849	826	863	856	785	894
Vanadium	-	-	40.9	45.8	41.9	45.6	44.8	45.2	45.5	43.4	47	40	49.2
Zinc	-	170	42.1	47	40.8	40.9	43.1	41.3	63	53.9	60.4	52.4	65

Table 11: AMS Sediment Chemistry Results

(1) All values are reported as µg/g unless otherwise noted
(2) - = No standard or not analyzed
(3) BCCSR = BC Environmental Management Act, Contaminated Sites Regulation, B.C. Reg. 375/96, including amendments up to B.C. Reg. 6/2013; effective January 24, 2013
(4) BCCSR SedQC(SS) Marine = Schedule 9, Column IV, Marine and Estuarine Sediment, Sensitive Site
(5) AMS Thresholds = Mean + 1.96 x Standard Deviation of data set (DP02 to DP05 for 2007 to 2010)

APPENDIX A
Methodology

A-1 GEOMORPHOLOGY

A-1.1 INVESTIGATION METHODOLOGY

The main components of the monitoring program are based on the recommendations provided in the Deltaport Third Berth (DP3) Adaptive Management Strategy (AMS). Based on this information and Northwest Hydraulic Consultants' (NHC) general understanding of the processes at Deltaport, the detailed geomorphological monitoring work plan is described below. The field based monitoring components of crest protection monitoring, erosion and deposition monitoring, and sediment sampling were discontinued at the beginning of 2012.

A-1.1.1 Crest Protection Monitoring

The purpose of crest protection monitoring is to detect channel incision, headcutting or dendritic channel formation around perimeter crest protection. The monitoring covers the entire perimeter of the crest protection structure, with particular focus in the vicinity of the tug basin and DP3 structures. Field reconnaissance and site observations are made quarterly during low tide by a qualified geomorphologist. Fixed points were established on the ground for taking repeat photography and for conducting terrestrial surveys. Ground surveys are carried out using a Real Time Kinematic (RTK) global positioning system (GPS) station to measure the dimensions of channels that are present or subsequently form.

A-1.1.2 Automated Monitoring of Erosion and Deposition

Measurements of the temporal variation in erosion and deposition at specified locations are collected using conventional erosion pins (depth of disturbance pins). The depth of disturbance (DoD) rods are monitored at three-month intervals during the course of other field investigations (Crest Protection Structure monitoring and bed sediment sampling). The DoD rods have been spaced at 150-m intervals and located on the tidal flats above 0.5 m chart datum in elevation. Conventional depth of disturbance rods consist of a length of rebar that is embedded into the tidal flats and a large flat disk with a central hole (similar to a washer) is placed over it, flush with the ground. The initial distance from the top of the rebar to the disk is recorded at the time of installation. If the ground is lowered as a result of scour, the distance from the top of the rebar to the disk will increase over time. If deposition occurs, the sediment buries the disk. Vegetation accumulation on the DoD rod may occur on a seasonal basis related to growth and die off of the various plant species found at Roberts Bank. The presence of vegetation is noted and photo-documented and the height of accumulated weed is recorded. Accumulated weed is carefully removed to expose the bare sediments underneath and allow measurement of washer burial or scour as described above. Quarterly observations are made to determine the magnitude of erosion and deposition.

A-1.1.3 Sediment Samples

Sediment samples are scheduled for collection twice yearly, once in the spring and once in the fall, post Fraser River freshet. Samples are collected at each DoD rod site using a shallow hand corer. The top 10 cm of the sample are removed from the core and stored in a freezer until analysis to ensure that biological activity does not alter the percent fines. A sampling depth of 10 cm was chosen to ensure that there is sufficient sediment to perform a robust grain size analysis and to ensure that the sample captures undisturbed sediments at depth as well as newly deposited sediments. Preliminary monitoring of the DoD rods has demonstrated that a 10 cm sampling depth is appropriate at a majority of the sites. The first set of samples was collected at a distance of 5 m to the north of each rod. To avoid re-sampling in the same hole, subsequent sampling is rotated around the rod location.

The primary purpose of the laboratory analysis is to determine the particle size distribution of the samples. Subsequent results will be compared to determine if a fining or coarsening trend is occurring. The following is a description of the methodology used to determine the organic content of the sample, analyzed by ALS Laboratories:

> The sample is introduced into a quartz tube where it undergoes combustion at 900° C in the presence of oxygen. Combustion gases are first carried through a catalyst bed in the bottom of the combustion tube, where oxidation is completed and then carried through a reducing agent (copper), where the nitrogen oxides are reduced to elemental nitrogen. This mixture of N_2, CO_2, and H_2O is then passed through an absorber column containing magnesium perchlorate to remove water. N_2 and CO_2 gases are then separated in a gas chromatographic column and detected by thermal conductivity.

The remaining sample is then put through a series of sieves and a hydrograph to provide a graph of percent finer by weight down to 0.5 mm.

A-1.1.4 Interpretation of Ortho Photographs

Aerial photographs are evaluated to assess trends and patterns of erosion and/or accretion on the tidal flats. This evaluation is conducted annually and covers the entire inter-causeway tidal flat area. The methodology consists of overlaying successive ortho-rectified photographs using GIS mapping techniques to delineate and identify morphological changes on the tidal flats. The maps show areas of erosion or sand accretion and changes in vegetation between successive surveys.

A-1.1.5 Coastal Geomorphology Mapping

This task assesses topographic changes due to long-term erosion or accretion adjacent to the terminal. An initial baseline survey was completed at the start of the study. The surveys will be repeated every three to four years. The highest resolution surveys are made near DP3. More limited surveys are made across the shallow inter-tidal flats where the relief is very low. Precise bathymetric surveying is performed using RTK GPS positioning for horizontal control and single beam digital echo sounding.

A-1.2 DATA EVALUATION

This section summarizes the geomorphological data that will be evaluated and interpreted for the monitoring components presented above. Interpretation of the DoD measurements and bathymetric survey data is straightforward, and is not included below. Results are provided only in the quarterly reports with data interpretation and discussion provided in the annual reports.

A-1.2.1 Crest Protection Monitoring

Comparisons of repeat terrestrial photographs will be performed to show seasonal and long-term changes. Comparison of ground surveys to document scour or erosion from channel formation or headcutting processes. This interpretation will be supplemented by assessment of annual aerial photography and periodic low-level over flights from a fixed wing aircraft, as described in **Section A-1.1.4**.

A-1.2.2 Sediment Samples

Measurements of short-term accretion and erosion will be correlated with met-ocean conditions (wave and tide conditions), construction activities and changes in vegetation or eelgrass. Comparisons will also be made with surveyed topographic changes along the Crest Protection and results of the photographic monitoring.

A-1.2.3 Interpretation of Ortho Photographs

Overlay maps will be interpreted to assess the key factors that are controlling morphological changes on the tidal flats. Results will be compared with other long-term assessments (as documented previously in the Coastal Geomorphology Study, NHC 2004). The results of this investigation will be integrated with other related studies on eelgrass extent and distribution in order to provide a complete understanding of any habitat changes.

A-2 SURFACE WATER

A-2.1 INVESTIGATION METHODOLOGY

Fixed surface water and sediment quality monitoring stations are established adjacent to the Deltaport facility, within the inter-causeway area and at two reference locations along Robert's Bank. The locations are described as follows:

- One station (Station DP01) in the ditch near the base of the ferry terminal causeway to monitor nutrient and sediment loading from upland sources.
- Two stations (Stations DP02 and DP03) located in the intertidal portion of the inter-causeway area within the eelgrass beds.
- One station (Station DP04) in the intertidal portion of the inter-causeway area at the head of the ship turning basin adjacent to DP3.

- One station (Station DP05) in the subtidal portion of the inter-causeway area within the ship turning basin adjacent to DP3.
- One intertidal reference station (Station DP06) located off Westham Island northwest of Deltaport.
- One subtidal reference station (Station DP07) located off Westham Island northwest of Deltaport.
- One station (Station DP08 added in 2008) in the intertidal portion of the inter-causeway area between DP02 and DP05.
- One station (Station DP09 added in 2009) in the intertidal area adjacent to DP3.

The surface water sampling methodology outlined below, including sample implement decontamination procedures, is based on the protocols developed for the Puget Sound Estuary Program (PSEP 1996). Representative surface water samples will be collected from each of the sampling stations.

A vessel equipped with a 5-litre Van Dorn sampler, constructed of clear lexan, will be used to collect surface water samples at each station. One water sample will be collected just below the surface and for the subtidal samples; one surface water sample will also be collected at a depth of two metres above the seafloor. As with the sediment sample, the surface water sampling stations will be located using a GPS. The vessel will be equipped with a depth sounder, however, to ensure that the sampler is triggered at an appropriate depth a two metre rope with a weight at the end will be attached to the base of the Van Dorn. To minimize the turbidity plume from disturbed sediment, the sampler will be lowered slowly and carefully as it approaches the bottom (based on depth sounder readings). Tripping the sampler is then delayed approximately one minute is used to allow currents at the site to transport turbidity generated by the weight out of the area of the sampler. Each recovered water sample will be examined to ensure acceptable sample quality, including no entrained sediment, and the water in the sampler decanted into laboratory prepared sample bottles. The five litre Van Dorn volume is sufficient to meet sample volume requirements. Similar to the sediment sampling process, field observations will be recorded at each station during sample collection. Field observations will include general information (e.g., station name, date, time), and a description of the site location, GPS coordinates, water depth and characteristics (e.g., colour, odour, turbidity).

As part of our quality assurance program, Hemmera will also undertake a number of measures including consistent use of the same field technicians, daily field reporting between field technicians and project manager, and submission of samples in laboratory supplied sterile sampling containers under chain of custody, following the directions provided by the analytical laboratory, etc. The required laboratory reported detection limits have been pre-determined with the laboratory so that the results can be compared to the appropriate regulatory screening levels. The detection limits and regulatory screening levels are provided in the AMS Detailed Workplan. One blind field duplicate sediment sample will also be collected during each sampling event to further assist in the evaluation of data quality. The data quality objective (DQO) for precision will be measured using the relative percent differences (RPD) between characterization and duplicate samples (to evaluate data precision) as well as percent completeness to evaluate the effectiveness of the sampling program with respect to the project objectives. Due to the limited number of samples, the DQO for completeness is 100%. The DQOs for precision will be 20% RPD for inorganic parameters and 50% RPD for organic parameters. The quality assurance program will also include review of the analytical laboratory's quality control results.

The samples will be stored in coolers on ice and transported directly to the laboratory at the end of the sampling day (approximately 1.5 hour travel time).

The waters of the upper end of the DP3 turning basin (near DP04) will be monitored continuously for a number of water quality parameters (pH, temperature, conductivity, dissolved oxygen, and turbidity) using a YSI buoy-mounted sonde. As of 2009, the sonde was no longer deployed continuously (due to damaged by storms) but rather for approximately one week each quarter during quarterly sampling programs. As of 2012, the sonde was no longer deployed weekly. Field water quality parameters were measured at the time of sample collected during each quarterly sampling program.

A-2.2 SAMPLE ANALYSES

The parameters analyzed to facilitate data interpretation include:

- Temperature.
- pH.
- Hardness.
- Salinity.

The parameters being analyzed to assess the presence/absence of toxicants include:

- Metals (analysed quarterly until the end of 2010 and annually in Q1 starting in 2011).
- Chlorine[1].

Several of the water quality parameters were also selected for their use in facilitating identification of marine eutrophication and/or construction impacts. These include:

- Turbidity, TSS, Clarity (secchi disk).
- Nutrients (Phosphate, Phosphorus, Ortho-phosphorus, Total Kjeldahl Nitrogen (TKN), Total Nitrogen, Ammonia, Nitrate, Nitrite and Organic Nitrogen N).
- Chlorophyll *a.*

These parameters are analysed quarterly at DP01 to DP07 and annually in Q1 at DP08 and DP09.

1 Chlorine will be collected from the ditch station only. The purpose is to evaluate potential impacts from chlorine to the inter-causeway area as historical releases of water from a nearby upland water park have been documented. Polycyclic aromatic hydrocarbons (PAHs) have been dropped from the program as no exceedances were noted during the Q1-2007 event.

A-2.3 DATA EVALUATION

As indicated above, a number of the monitored surface water parameters are to support data interpretation purposes and therefore do not require action levels. The other parameters collected, as indicators of potential toxicity to marine organisms, will be compared against the applicable provincial and federal water quality screening levels:

- British Columbia Approved Water Quality Guidelines (Criteria), 1998 Edition.
- A Compendium of Working Water Quality Guidelines for British Columbia, 2001 Update.
- Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines, 2006 Update.

These analytical results will be provided in the quarterly reports with data interpretation and discussion of the sampling results provided only in the annual reports.

The remaining results will be presented in each quarterly report with evaluation for negative trends occurring within each annual report. As with the sediment sampling program, the data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the results from the relevant reference stations elsewhere along Robert's Bank. A 20-percent difference between the eutrophication parameter inter-causeway and far-field results was originally proposed as a preliminary indicator of a potential for eutrophication impacts. Since 2012, data is compared against site-specific nutrient thresholds calculated based on the mean + 1.96 x standard deviation for the 2007-2010 data set. A comparison of the analytical results against these nutrient thresholds is provided in the quarterly reports and further discussion provided within the annual report

A-3 SEDIMENT

A-3.1 INVESTIGATION METHODOLOGY

As with the surface water sampling program, representative sediment grab samples will be collected from each sampling station on a quarterly basis (four times per year). The sampling methodology outlined below, including sample implement selection and decontamination procedures, is based on the protocols developed for the Puget Sound Estuary Program (PSEP 1996)[2]. A shallow draft vessel equipped with an 8.2 L Ponar grab sampler will be used to collect the sediment samples. Field staff will work from the ditch bank to collect samples from the sediments at Station 1. Sampling stations will be located using global positioning system (GPS) coordinates. Each recovered grab sample will be examined to ensure acceptable sample quality, the supernatant water in the sampler will be decanted and the upper 5 cm of sediment will be placed in a clean stainless steel mixing bowl. Repeated grab samples may be required to

[2] Puget Sound Estuary Program (PSEP) 1996. Recommended Guidelines for Sampling Marine Sediment, Water Column, and Tissue in Puget Sound. Prepared by King County Environmental Laboratory for Puget Sound Estuary Program, U.S. Environmental Protection Agency, Region 10, Seattle, WA.

fulfill sample volume requirements. The sample will be mixed with a stainless steel spoon until homogenous in texture and colour. However, sediment for hydrogen sulphide analysis will be collected prior to mixing to minimize oxidation and volatilization. Field observations will be recorded at each station during sample collection and will include general information (e.g., station name, date, time), a description of the site location, GPS coordinates, water depth, sediment characteristics (e.g., grain size, colour, odour, debris, visual contamination), and a record of the amount of effort required for sediment collection.

Aliquots of sediment for chemical analysis will be collected in 250mL laboratory prepared glass jars with Teflon lids for submission to the project laboratory for analysis of the parameters listed in **Section A-3.2**. The sediment samples are collected and transported to the lab generally by 5:30 pm the day the samples are collected. Sediment samples are placed in jars and immediately stored in a covered cooler with ice to keep them at a cold state, at or near 4^{o}C for delivery to the laboratory. All samples are analysed within the laboratory holding time.

Sediment samples for sulphide analysis are collected prior to homogenization and are placed in jars with no headspace in order to minimize the potential for oxidation. As with the other parameters, sulphide sample jars are then placed immediately on ice. The laboratory holding time for sulphides is 24 hours to minimize potential loss through volatilization and increase the reliability of results. Sulphide analysis is via the laboratory method is described below:

- Add 8 – 12 drops of sodium hydroxide to a centrifuge tube to 5 g (based on dry weight) of sample into the tube.
- Add water.
- Shake for 20 minutes, then centrifuge.
- Filtered supernatant through a 0.45 micro filter.
- Transfer an aliquot to a test tube containing zinc acetate.
- Bulk the sample with MQ water and analyze colourimetrically.

The field sampling equipment (i.e., Ponar, bowls and spoons, etc.) will be decontaminated prior to sample collection at each station. This involves an initial rinse with site seawater, followed by washing with Alconox soap, a second rinse with site seawater, and final rinse with distilled water in accordance with the PSEP (1996) methodology.

Quality assurance measures (staff, sample handling, field duplicates and DQO) for the sediment sampling program will be the same as those outlined for the surface water sampling program (**Section A-2.1**) above. The detection limits and regulatory screening levels for sediment samples are provided in the AMS Detailed Workplan.

A-3.2 Sample Analyses

Sediment samples are analyzed for the following parameters:

- Metals were analyzed as indicators of potential toxicity to marine organisms (Tributlytin was analyzed only during the Q1-2007 event). Metals were analysed quarterly until the end of 2010 and annually in Q1 starting in 2011.
- Parameters measured to evaluate sediment eutrophication include:
  - Total nitrogen.
  - Ammonia.
  - TKN.
  - Total organic nitrogen.
  - Phosphorous.
  - Redox (Eh).
  - Hydrogen sulphide (H_2S).
- Sediment grain size samples are collected annually in Q1.

Except as noted above, these parameters are analysed quarterly at DP01 to DP07 and annually in Q1 at DP08 and DP09.

A-3.3 Data Evaluation

The toxicity parameters, when sampled, will be compared against the BC Contaminated Sites Regulation, Schedule 9 Generic Numerical Sediment Criteria for sensitive marine and estuarine sediments ($SedQC_{ss}$) and the Puget Sound Dredge Disposal Analysis (PSDDA) criteria for TBT as indicated in the AMS workplan document. These analytical results will be provided in the quarterly reports. Anomalous results will be highlighted and briefly discussed. Data interpretation and discussion of the sampling results will be provided only in the annual reports

The remaining sediment quality parameters will be evaluated within each annual report for observable trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the sediment results from the reference stations and with data from previous years sampling. A 20-percent difference between the eutrophication parameter inter-causeway and far-field results or between results from year to year was originally proposed as an indicator of a potential for eutrophication impacts. Since 2012, data is compared against site-specific nutrient thresholds calculated based on the mean + 1.96 x standard deviation for the 2007-2010 data set. A comparison of the analytical results against these nutrient thresholds is provided in the quarterly reports and further discussion provided within the annual report

A-4 EELGRASS

A-4.1 INVESTIGATION METHODOLOGY

A-4.1.1 Eelgrass Distribution and Mapping

Aerial photograph interpretation will be used to develop a base layer for mapping the current distribution of eelgrass in the inter-causeway area. Aerial photograph flights used for the eelgrass monitoring program are to be flown in July 2007 and at the same time in subsequent years. The amount of cloud cover, sun angle, and season at the time when the photos are flown; and the resolution of the photos, will determine whether it is possible to distinguish between areas that support a monoculture of *Z. japonica* and areas that support a monoculture of *Zostra marina*. There is a 'transition' zone between these two habitats in the inter causeway area where the two species co-exist. It may be possible to approximate the boundaries of the transition area from the photos. Homogenous habitat types will be delineated to form polygons. We have proposed a minimum polygon size of 50 m by 50 m; however, this may be modified through discussions with Vancouver Fraser Port Authority (VFPA).

A field survey will follow the aerial photograph interpretation to confirm and/or determine the species composition of each polygon. The boundaries of the transition area will likely need to be determined on-site and mapped using a GPS. *Zostra japonica* is an annual species; although a small percentage of the shoots may survive throughout the winter. To accurately map the distribution of this species the field survey should be completed between June and early September.

The data collected during the field survey would be incorporated onto the base layer by Hemmera to create a GIS map that accurately depicts the current distribution of eelgrass in the inter-causeway area.

A-4.1.2 Monitoring Eelgrass Vigour and Health at the Established Stations

The annual eelgrass vigour and health survey will be conducted during one of the low tide cycles between mid July and mid August and will assess the health and growth of eelgrass at nine of the eelgrass monitoring stations that were established for the DP3 Environmental Assessment and one additional monitoring station that was added in 2008. The monitoring stations include four stations in the inter-causeway area, two stations west of the Westshore Coal Terminal and Deltaport Causeway, and three reference stations in Boundary Bay.

The parameters that will be monitored at each of the stations will include those assessed for the baseline study; shoot density, shoot length, and shoot width[3]. This data will be used to calculate Leaf Area Indices (LAI) at each location.

[3] Quadrat sampling along transects as described in *Methods for Mapping and Monitoring Eelgrass Habitat in British Columbia* (Precision 2002).

The distribution of *Zostra marina* at each station will be classified as patchy, continuous, or absent. The percent cover of *Zostra japonica* will be ranked according to the following scale: <1% present; 1% to 40% sparse; 41% – 75% moderate; >75% dense.

The monitoring plan includes noting the presence or absence of epiphytes at each of the stations. It would be possible for Ms. Durance, based on her 25 experience with this population of eelgrass to further classify the presence of epiphytes in the inter-causeway area as typical, less than usual, or more than usual.

The presence or absence of *Beggiatoa* sp. will also be noted. Ms. Durance has never observed *Beggiatoa* sp. at Roberts Bank. In the unlikely event that it is noted during an annual monitoring event, a strategy would need to be developed so that increases or decreases in the area covered by this species could be assessed. The location of the *Beggiatoa* sp. would be recorded using a GPS, for future reference. If there is sufficient time available the crew will map the area covered by *Beggiatoa* sp. VFPA will be notified immediately, with suggestions as to how to modify the AMS to include mapping and monitoring changes in the distribution of this species.

A-4.1.3 SIMS Survey

A Subtidal Imaging and Mapping System (SIMS) survey will be used to determine the lower limit of eelgrass in the inter-causeway during the summer of 2009 and 2012. The SIMS method and equipment is only available through Archipelago Marine Research (AMR).

SIMS is a towed video system developed to carry out systematic mapping of marine vegetation, macroinvertebrates, seafloor substrates and morphology from the intertidal zone to depths of about 40m. The field of view is approximately 1 m by 2-3 m. The acquired imagery (digital video format) is geo-referenced using differential GPS with positions and time “burned onto” the video imagery with one-second update intervals. Depth of the towfish is also shown on the image. The towfish is maintained at an elevation of 1-1.5 m above the seafloor. Tow speed for SIMS is about 1 knot (2 km/hr) yielding a line coverage of 12 to 15 km in a typical survey day. A seven metre vessel provided and operated by Arrawac Marine Services is used to conduct the survey. A laptop computer is used for pre-plotting the navigation lines and for showing the vessel track lines during the survey. The position, depth and video time data is stored in custom MS Access database format developed for the SIMS classification system.

The video imagery is classified (by a geologist and a biologist) for substrate, epiflora (macrophytes) and epifauna (including fish) using a standard substrate and biotic classification system initially developed for the Province of British Columbia. The SIMS database system allows data entry for each second of video imagery collected. The interpreted data are interfaced with ArcView for map production. Typically the survey product is a comprehensive portfolio of maps, developed in GIS format, showing sediment type, major vegetative features, macroinvertebrates and fish observations and an interpretation of valued and sensitive biophysical features.

A-4.2 DATA EVALUATION

An eelgrass distribution map will be produced annually, based on aerial photograph interpretation and confirmed by ground truthing. A brief report will accompany a map that assesses changes that were observed in a local and regional context. This information will be compiled and summarized within each annual report for consideration by the SAC.

Natural eelgrass densities may vary significantly between years due to climatic changes. Although the mean density tends to be stable over time, environmental change such as El Niňo events may lead to severe changes in density. An El Niňo winter followed by a La Niňa summer once resulted in a ten-fold density increase in at least several eelgrass beds in British Columbia and Washington State. Data (vigour and epiphyte load) from the inter-causeway would be compared with many other sites in addition to Boundary Bay to ascertain whether changes subsequent to development at Roberts Bank are due to impacts attributable to the DP3 project, other non-DP3 anthropogenic causes, or natural causes.

A-5 BENTHIC COMMUNITY

A-5.1 INVESTIGATION METHODOLOGY

Benthic community health in the inter-causeway area is linked to sediment quality and water quality; and it is anticipated that if significant changes are seen in benthic community health, effects would also be observed in surface water quality and/or sediment quality (see **Sections A-2** and **A-3**). Therefore, sediment samples for benthic community analysis will be co-located with surface water and sediment samples from six of the seven sampling stations identified for the surface water and sediment quality monitoring programs. No benthic samples will be collected for station DP-01 as this station is located in a drainage ditch discharging to the inter-causeway area. The samples for benthic invertebrate analysis will be collected separately during the sediment sampling program. Samples will be preserved and packaged in the field, as required, and shipped to Biologica Environmental Services, Ltd., who process the samples and report taxonomic results to Hemmera.

The first benthic community sampling event will be completed during the first quarterly sampling event prior to the start of dredging. The next benthic invertebrate sample collection event is scheduled to occur during the Q1-2008 sampling event in March 2008. During the March 2008 event, a fourth benthic sampling station will be sampled. The location will form the fourth corner of a rectangle created by connecting stations DP02, DP03 and DP04 and the new station. Water quality and sediment samples will be collected at this station only during the benthic community sampling event and not during subsequent quarterly monitoring events. Further benthic community sampling will be completed at the end of construction during the first post-construction quarterly sediment sampling event. To facilitate data management, a fixed naming convention will be used. For instance, DP01A-1 will denote a sample collected at DP01, with the letter distinguishing between the three benthic invertebrate samples collected at this location, and the number specifying that the sample was collected during the first benthic invertebrate sampling event.

To capture inherent variability potentially present at the stations, three replicates will be initially collected per station for the benthic community sampling (*Benthic Marine Habitats and Communities of the Southern Kaipara*, Aukland Regional Council Technical Publication 275). Should the results of statistical analysis of variance of richness and abundance in the first year's benthic community sampling indicate acceptable variance observed between the replicates, we propose to reduce the sampling to one replicate sample per station during the second event. We have proposed an acceptable level of variance as being less than 20%.

Sampling methodology will be similar to that for the sediment sampling described in **Section A-3.1** but with some modifications. For the benthic community sample, the supernatant water is not decanted. After examination of grab quality, including consistent sample volume between stations, the sediment is placed in a plastic container (Tupperware bin) and transferred to a pre-cleaned stainless steel screening station on shore. The sample contents are gently rinsed through a 1.0 mm mesh sieve using seawater strained for zooplankton using a fine nylon mesh. The sample material remaining on 1.0 mm sieves is transferred into 1 L plastic containers and preserved in a 10% solution of formalin buffered with marble chips. These samples are then transported to Biologica for taxonomic identification. Taxonomic identification of benthic invertebrates will be down to the species level, where practical, and include both the diversity (number of species) and abundance of individuals for adult, juvenile and intermediate life stages.

A-5.2 DATA INTERPRETATION

As stated in the AMS, infaunal and epifaunal benthic community results will be evaluated and the data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the benthic results from reference stations elsewhere along Robert's Bank. A 20-percent difference from elsewhere along Robert's Bank will be used as an indicator of a potential for benthic community impacts in the inter-causeway area requiring further discussion within the final annual report.

Benthic community health is linked to sediment quality and water quality; therefore, it is expected that if significant changes are seen in benthic community health, effects would also be observed in surface sediment quality and/or water quality.

The sampling results will also be compared to video observations made during the SIMS survey that is part of the Eelgrass program (**Section A-4.1.3**). As stated above, the video imagery will be used for epiflora (macrophytes) and epifauna (including demersal fish) classification using a standard system initially developed for the Province of British Columbia. The SIMS database system allows data entry for each second of video imagery collected. The interpreted data are interfaced with ArcView showing sediment type, major vegetative features, macroinvertebrates and fish observations and an interpretation of valued and sensitive biophysical features.

A-6 BIRDS

A-6.1 INVESTIGATION METHODOLOGY

Hemmera has conducted coastal seabird surveys as part of the DP3 AMS from 2007 until the present. As of May 2008, the survey methodology previously used in the DP3 AMS, DP3 supporting studies, and by CWS was modified to incorporate adaptations to the original scope of the AMS. Following input from Hemmera and discussion with the Scientific Advisory Committee (SAC) and CWS, these adaptations were implemented pursuant to SAC and CWS recommendations (see 2008, 2009, and 2010 Adaptive Management Strategy Annual Reports). Additional adaptations were implemented as of February 2010 to focus surveys exclusively on two focal species – great blue heron and brant. For these species, Hemmera conducts time effective “windshield” peak count surveys during the key timing windows. Brant surveys focus on the winter and spring migration use of the inter-causeway area during the months of February, March, and April. Great blue heron surveys focus on use of the inter-causeway area for foraging in the months of June, July, and August. The windshield survey methodology is described below. Brant surveys were discontinued in 2012.

Windshield surveys are a fast and efficient method for determining peak numbers of focal species within the inter-causeway area. The windshield survey methodology involves stopping at a subset of point count stations (PC) to count all visible individuals of the given focal species, with no minimum time requirement. Bird studies are completed along the following three transects:

- Deltaport Transect: South side of Deltaport Causeway (PC 12 – 19);
- Tsawwassen First Nation (TFN) Transect: TFN Lands (PC 103, 105, 109, and 115);
- BC Ferries Transect: BC Ferries Causeway (point count stations 118, 120, 122, 124, and 126).

There are a subset of three PC stations on the Deltaport Transect, two PC stations on the TFN Transect and three PC stations on the BC Ferries Transect. A new subset of PC stations was identified for the 2011 windshield surveys because of changes to accessibility along all three transects (see Figure 10 of 2011 annual report for the new subset of PC stations). The plot size at each PC station has an approximate area of 0.5 km^2 (0.5 km x 1 km).

Observers use binoculars and spotting scopes to identify species and record the location of brant within the inter-causeway. Observers record weather data at each station, count individuals and groups of birds and document bird behaviour. Data is recorded into a hand-held PDA with digital forms that are consistent with those used by VFPA and Canadian Wildlife Service (CWS) in past bird studies. Observers count birds within the following distance categories:

- 100 m inland to the shore (TFN Transect only).
- 0 – 250 m from shore.
- 250 – 500 m from the shore.
- > 500 m to approximately 1 km.

The distance of brant and heron are recorded from the point count station. If large numbers of birds are observed within a sample plot, then observers block off a group of individuals, count them, and extrapolate to the whole of the flock. Birds observed in flight are recorded as ‘flyovers’ and the flight direction is recorded.

Windshield surveys are conducted once a month during key timing windows for each focal species: spring for brant (February – April), and summer for great blue heron (June – August). Windshield surveys are conducted at the most ideal time to identify the maximum number of individuals within a short period of time. For brant, this is within approximately one hour on either side of the peak high tide during the winter months, when brant flock together in the middle of the inter-causeway area, making them more visible to observers. Similarly, the most productive time to count great blue heron is within one hour on either side of the peak low tide during the summer months, when herons forage in the eelgrass beds.

A-6.2 Data Evaluation

The rapid assessment methodology of the windshield survey technique allows an accurate count of great blue heron or brant using the inter-causeway area to be collected, as the short duration of surveys minimizes possible recounting of individuals. However, the short duration of windshield surveys minimizes the ability to collect data about the spatial distribution of birds. This will likely limit the ability to report on spatial distribution of birds within the inter-causeway area. Hemmera’s biologists believe that data from Years 1-3 of the AMS and baseline studies has well documented habitat use patterns within the inter-causeway area. Hemmera biologists also note that the monthly frequency and short (but efficient) duration of windshield surveys may not entirely encompass variability in bird populations or account for movement in and out of the inter-causeway area from day to day, which may obscure more accurate seasonal patterns.

Data collected will be compared to pre-construction and construction period data to determine whether operation and post-construction activities result in changes in species use of the inter-causeway. Hemmera will import the baseline data into its data management system to facilitate interpretation. Data interpretation will include comparisons between baseline monitoring, construction, and post-construction results. Possible analyses may include temporal trend analyses (e.g., linear regression) to detect positive or negative changes in focal species use of the inter-causeway. VFPA will be notified if negative trends are observed during data interpretation. Additionally, Hemmera will provide VFPA with recommendations, if necessary, to implement or modify mitigation measures to prevent or attenuate observed negative ecosystem trends. The data will be reported in event summary reports for each survey, quarterly reports and annual reports.

APPENDIX B

Eelgrass Distribution Maps, Graphs, Data, and Statistics

APPENDIX B: EELGRASS

Figures and tables are provided in the following order:

Figure B-1 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2003 and 2007

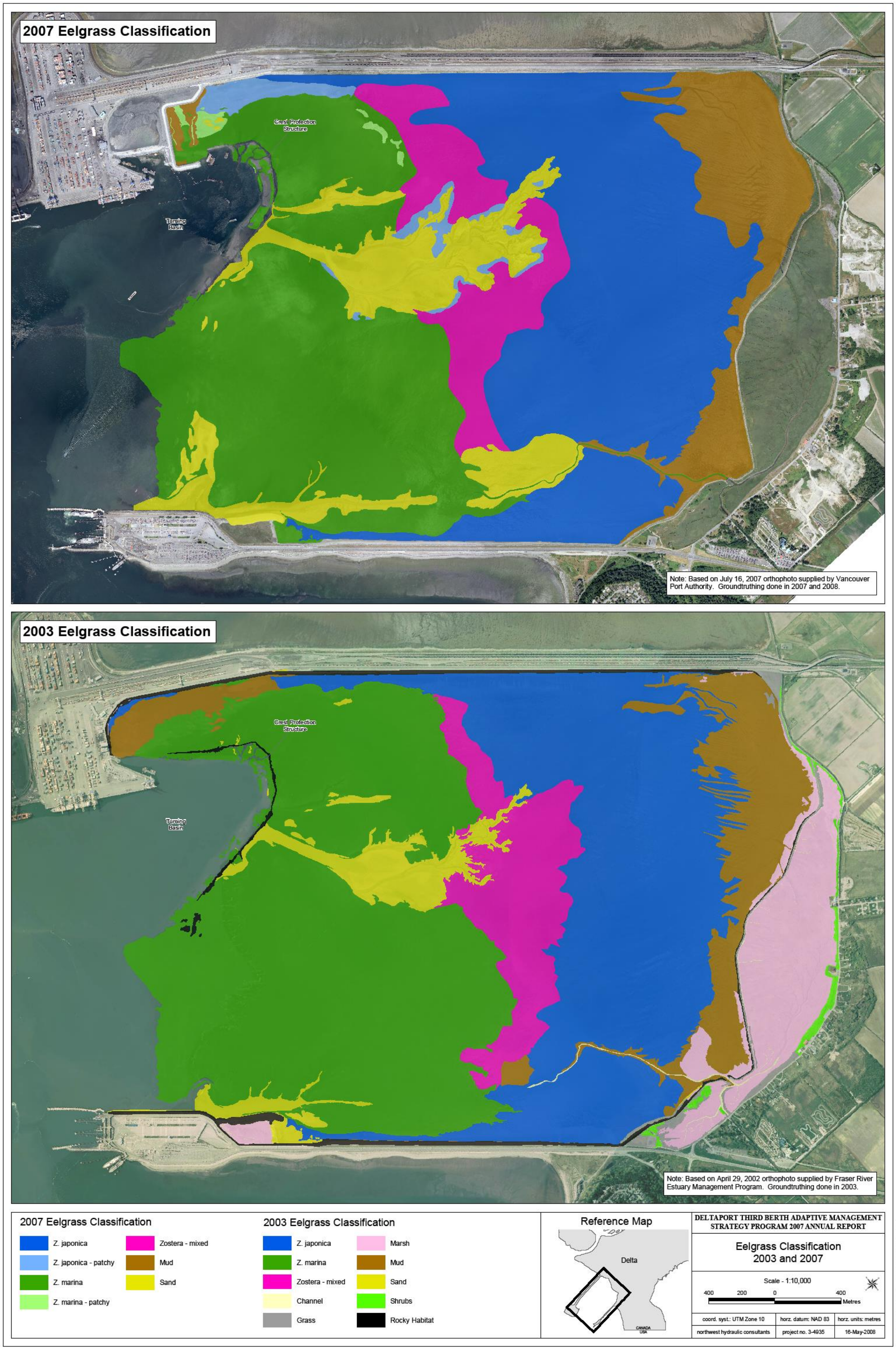


Figure B-2 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2008

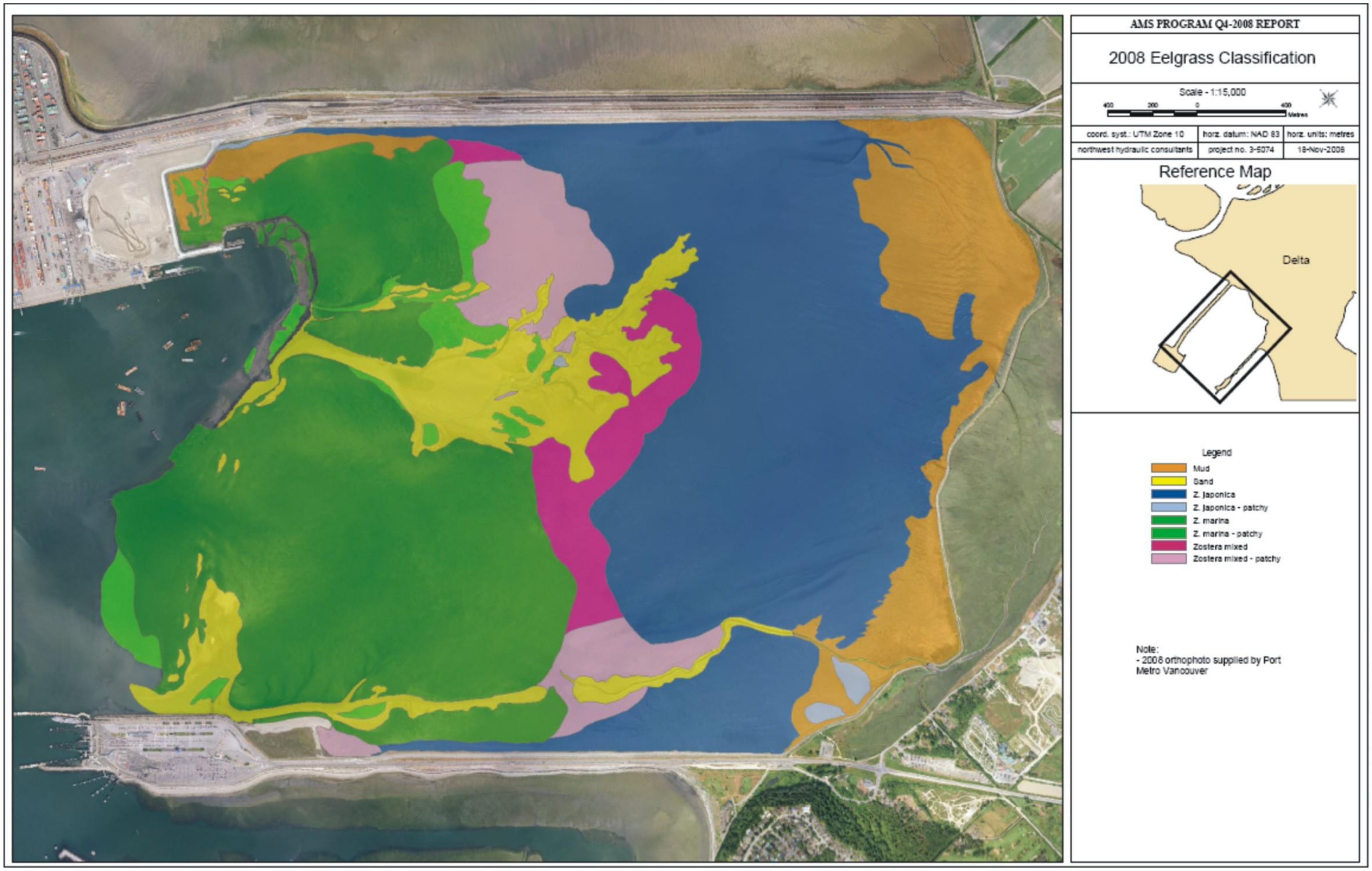


Figure B-3 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2009

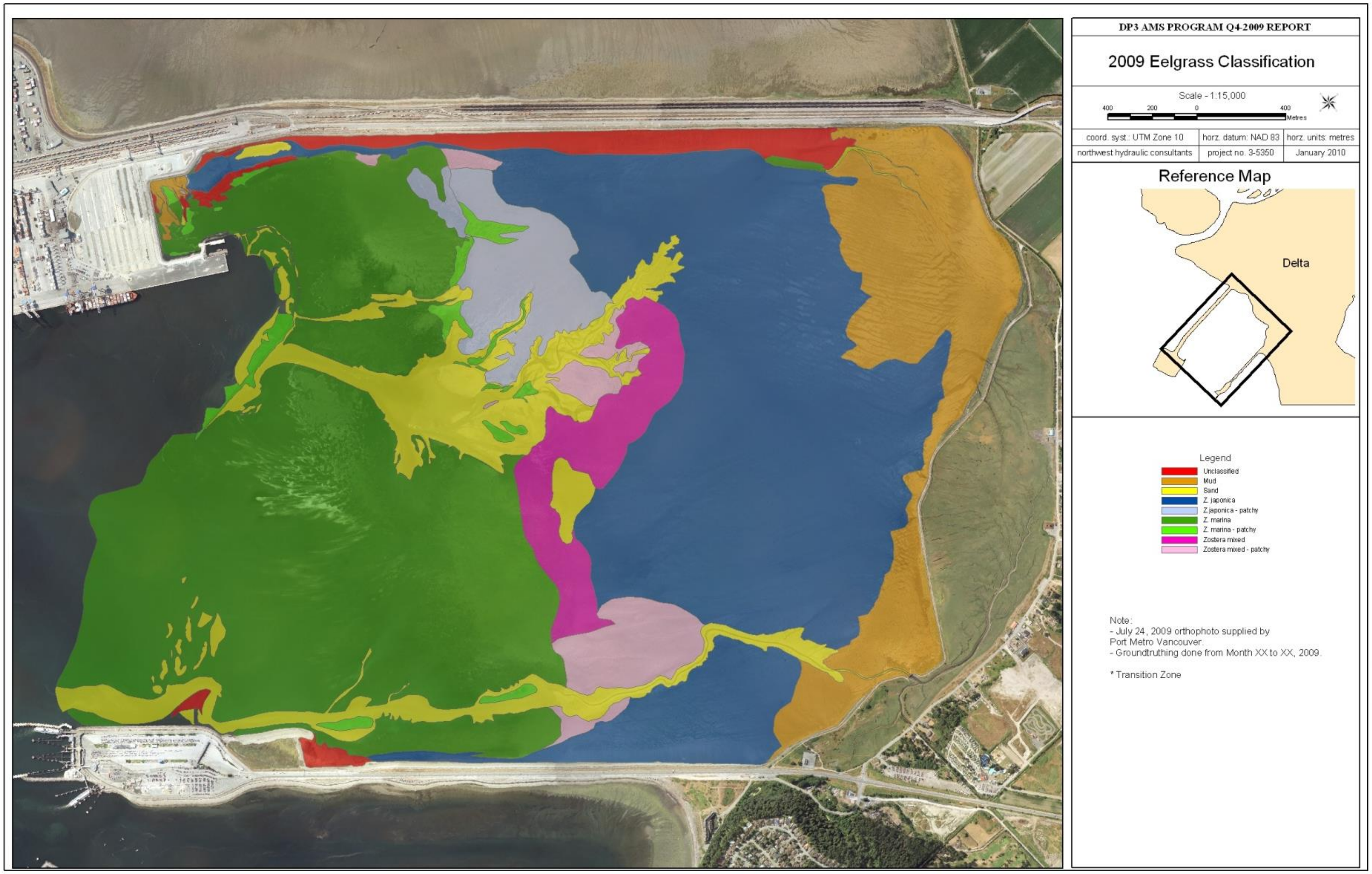


Figure B-4 Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2010.

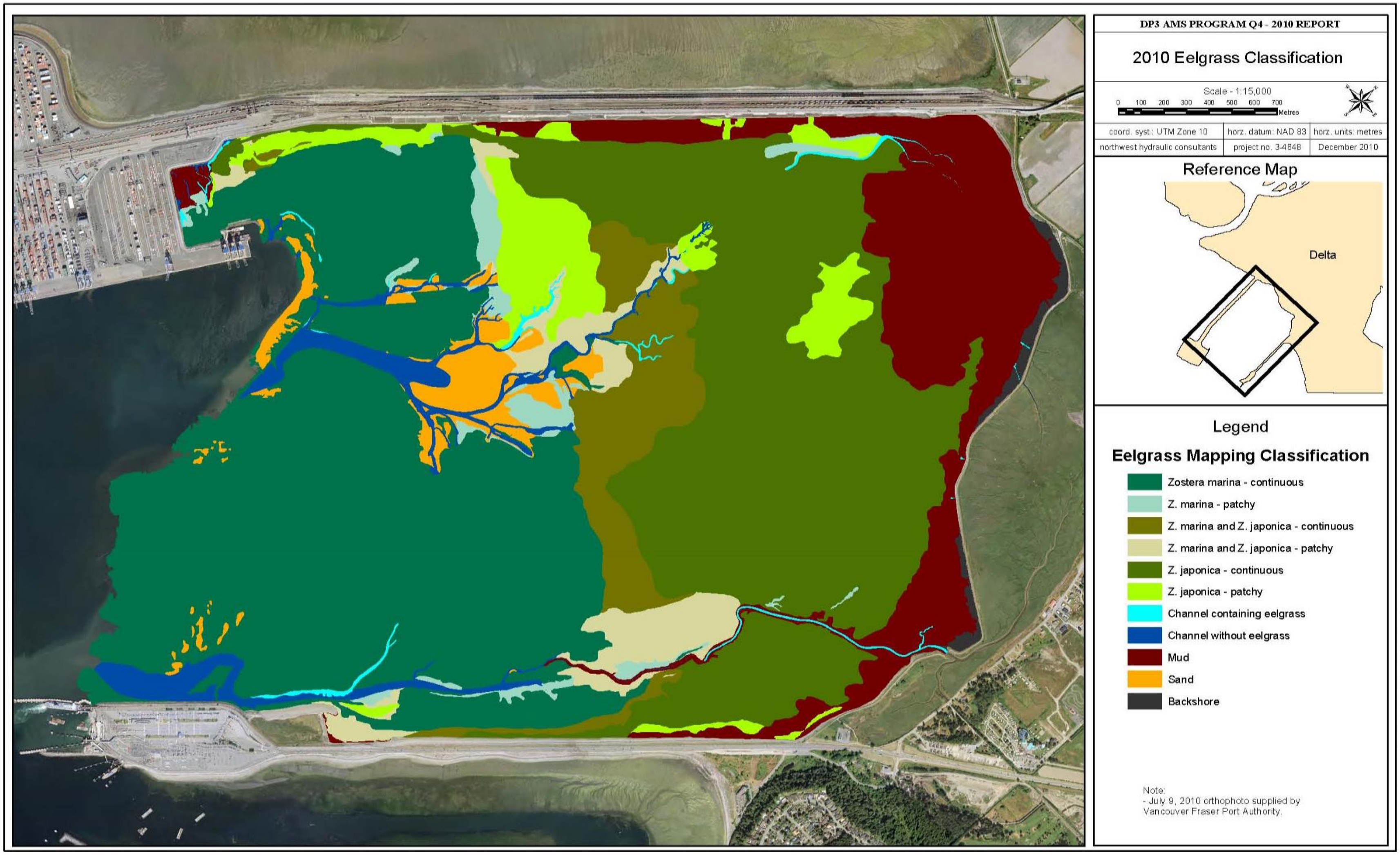


Figure B-5 **Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2011.**

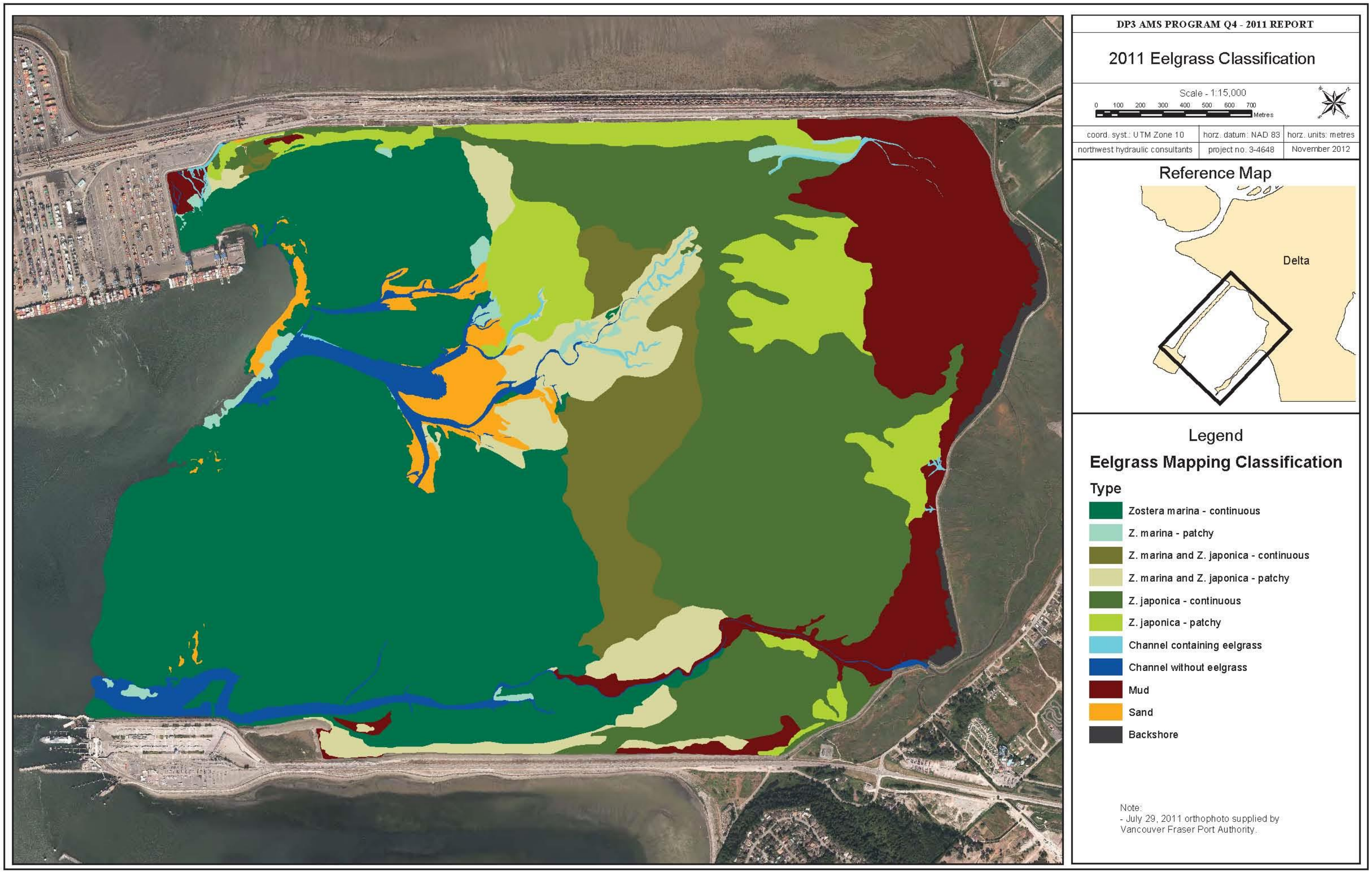


Figure B-6 **Eelgrass distribution in the inter-causeway based on orthophoto interpretation and field surveys conducted in 2012.**

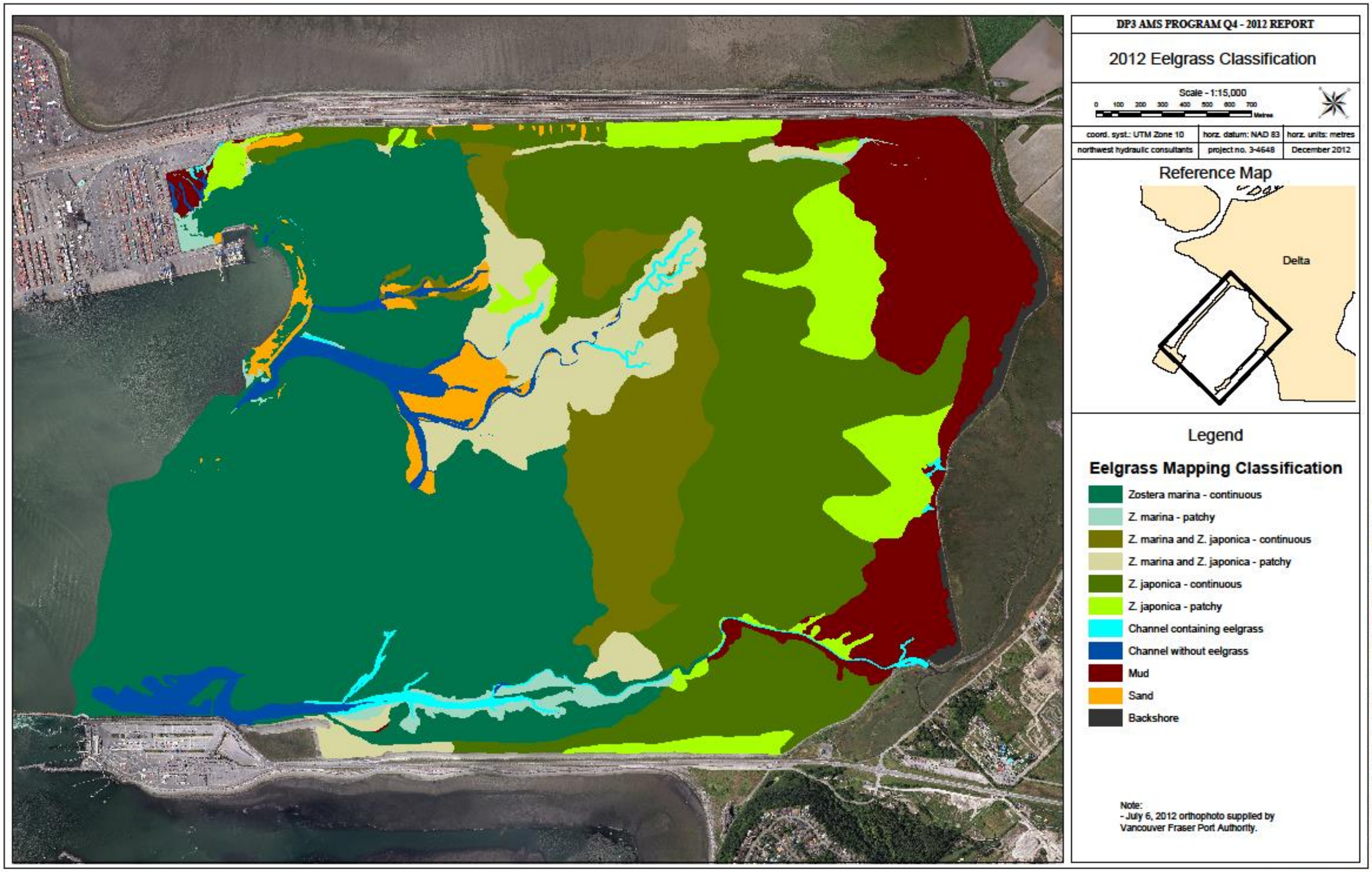


Figure XX

Figure B-7 **Mean eelgrass shoot density data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2**

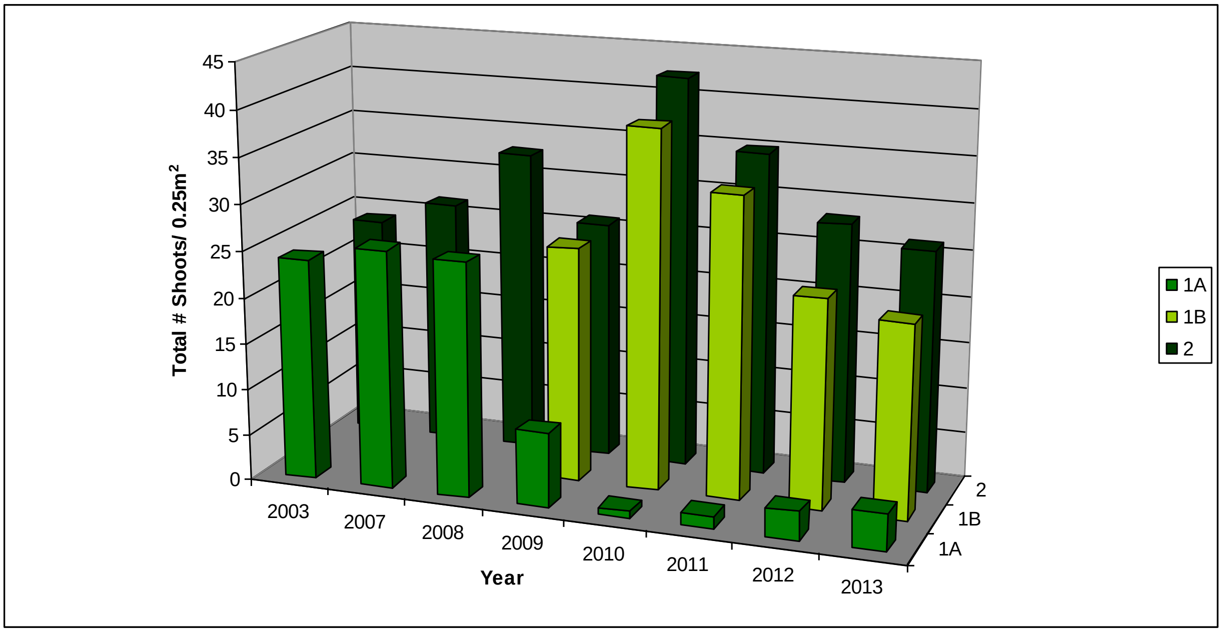


Figure B-8 **Mean eelgrass shoot density data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4**

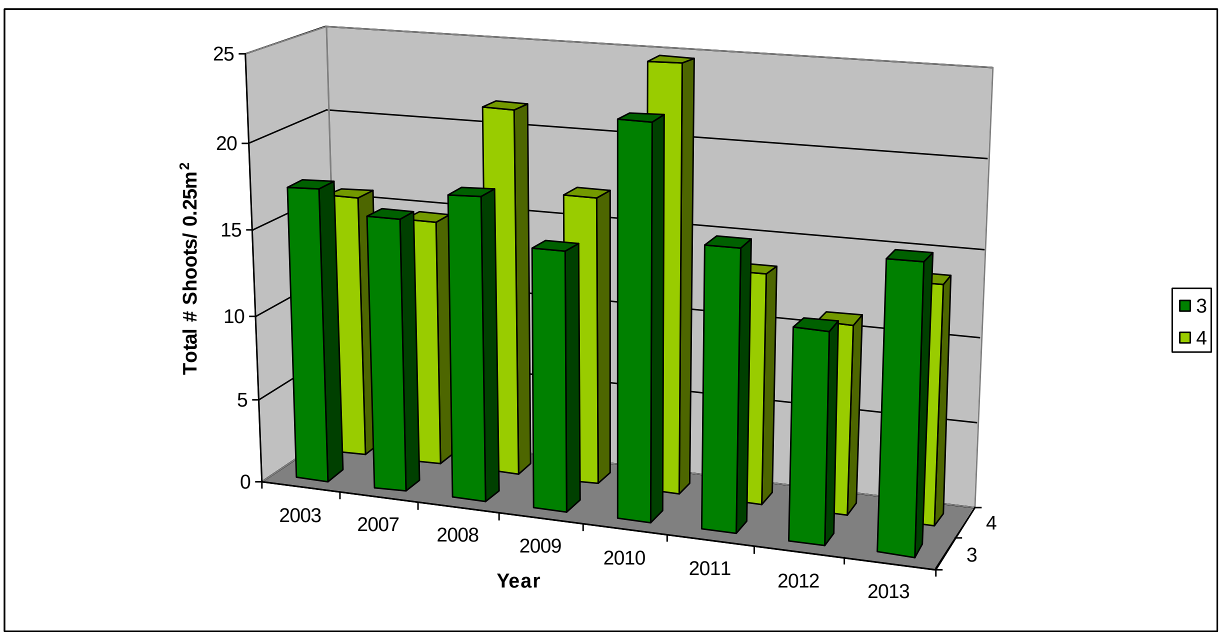


Figure B-9 Mean eelgrass shoot density data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

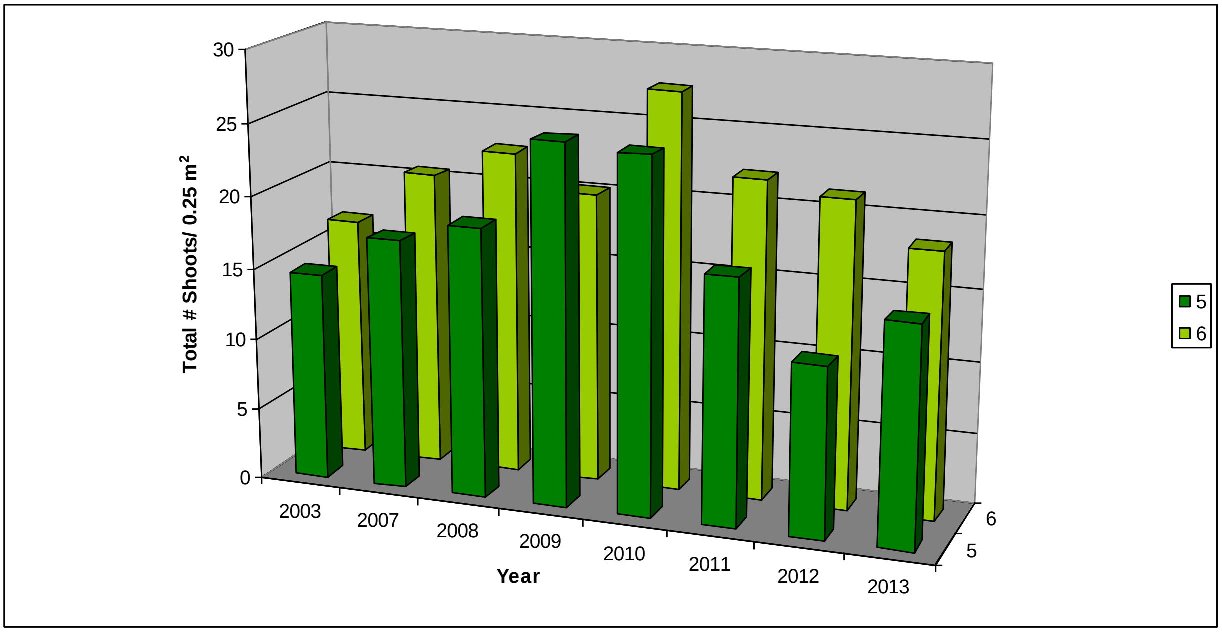


Figure B-10 Mean eelgrass shoot density data from Boundary Bay, Sites WR1, WR2, and WR3

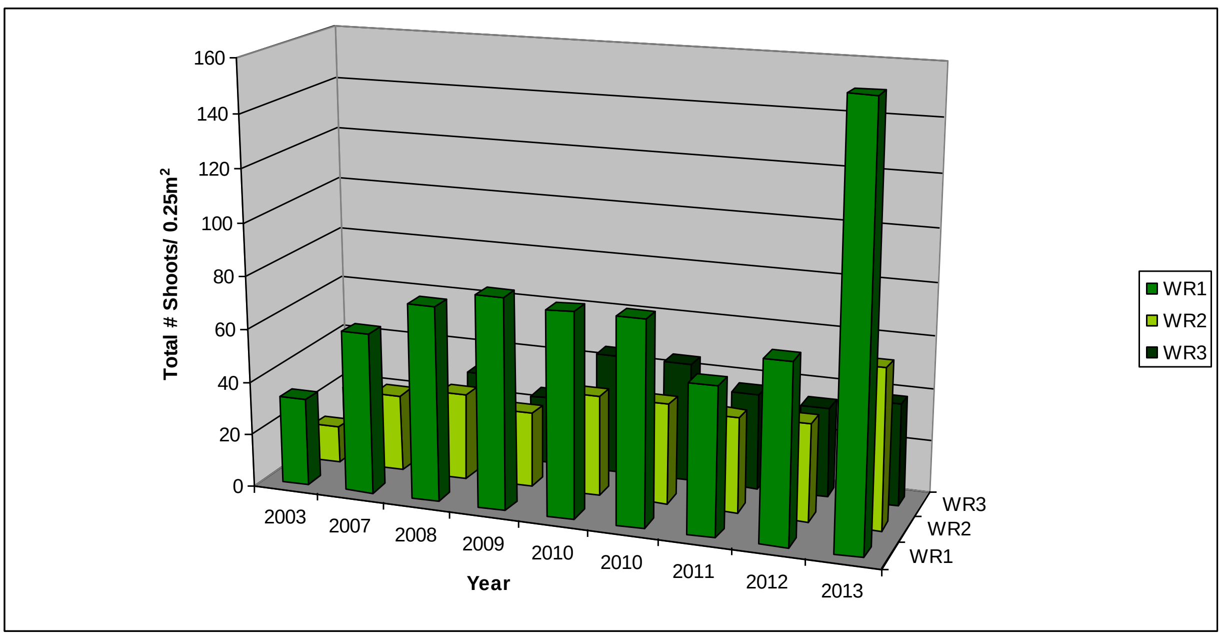


Figure B-11 Mean eelgrass shoot length data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

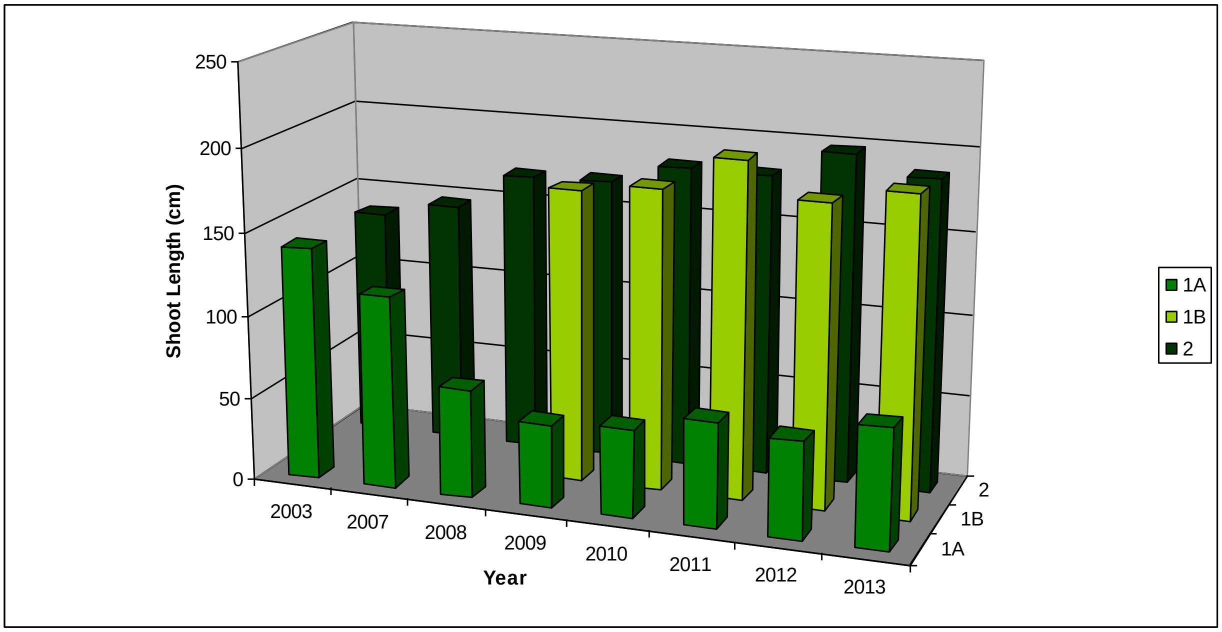


Figure B-12 Mean eelgrass shoot length data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

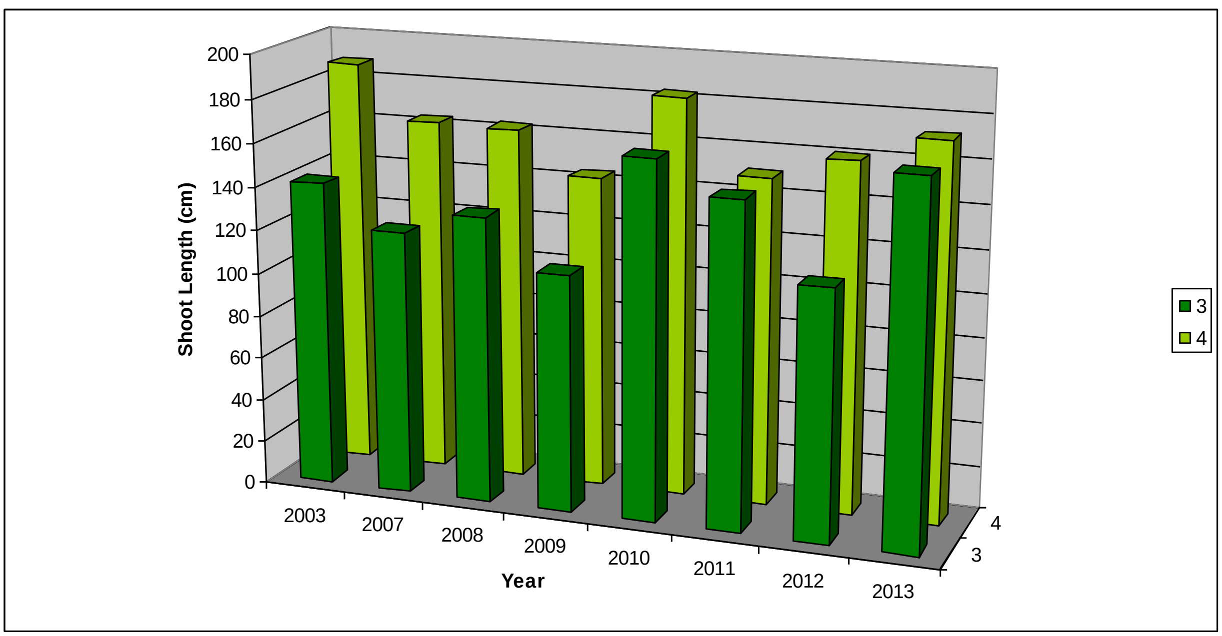


Figure B-13 Mean eelgrass shoot length data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

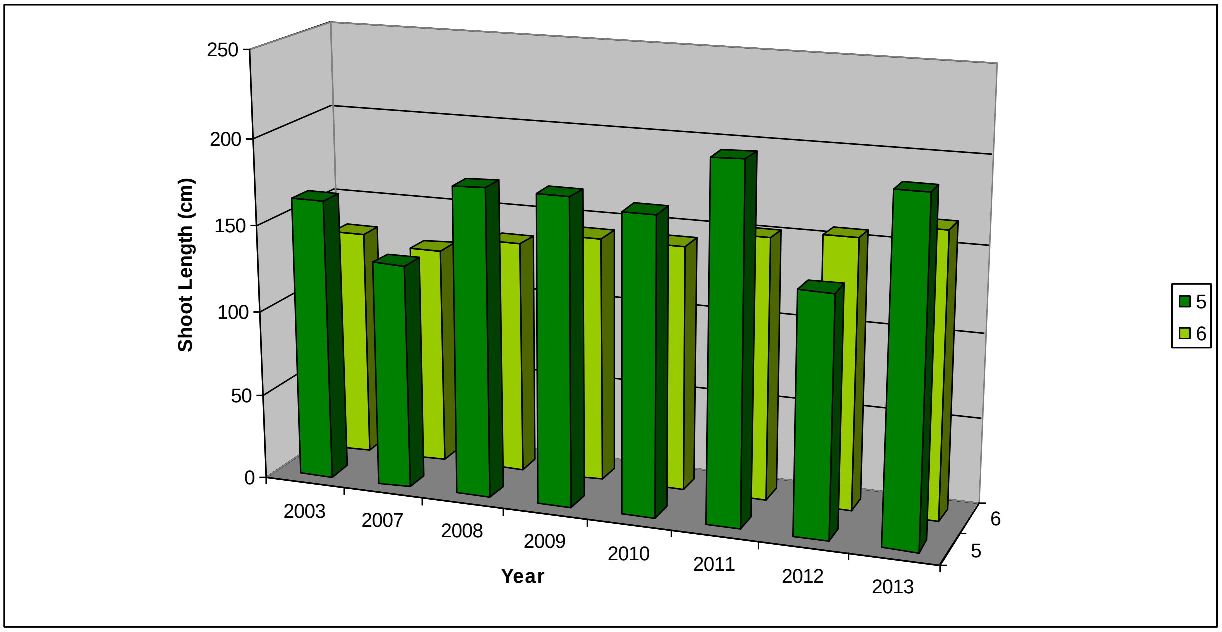


Figure B-14 Mean eelgrass shoot length data from Boundary Bay, Sites WR1, WR2, and WR3

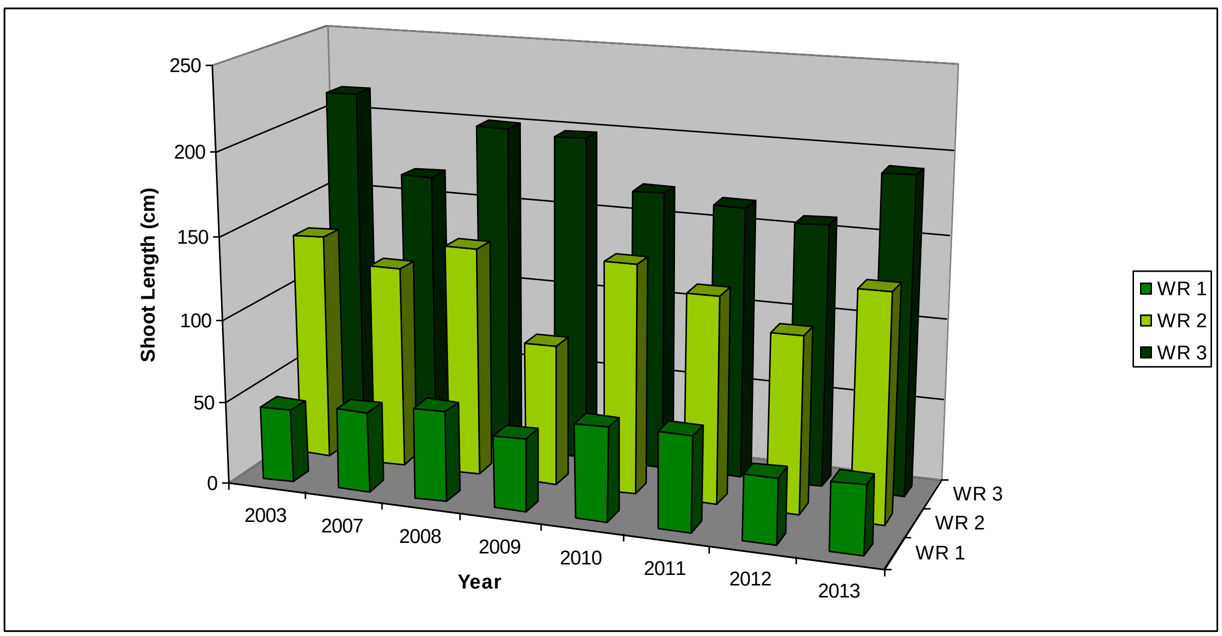


Figure B-15 Mean eelgrass shoot width data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

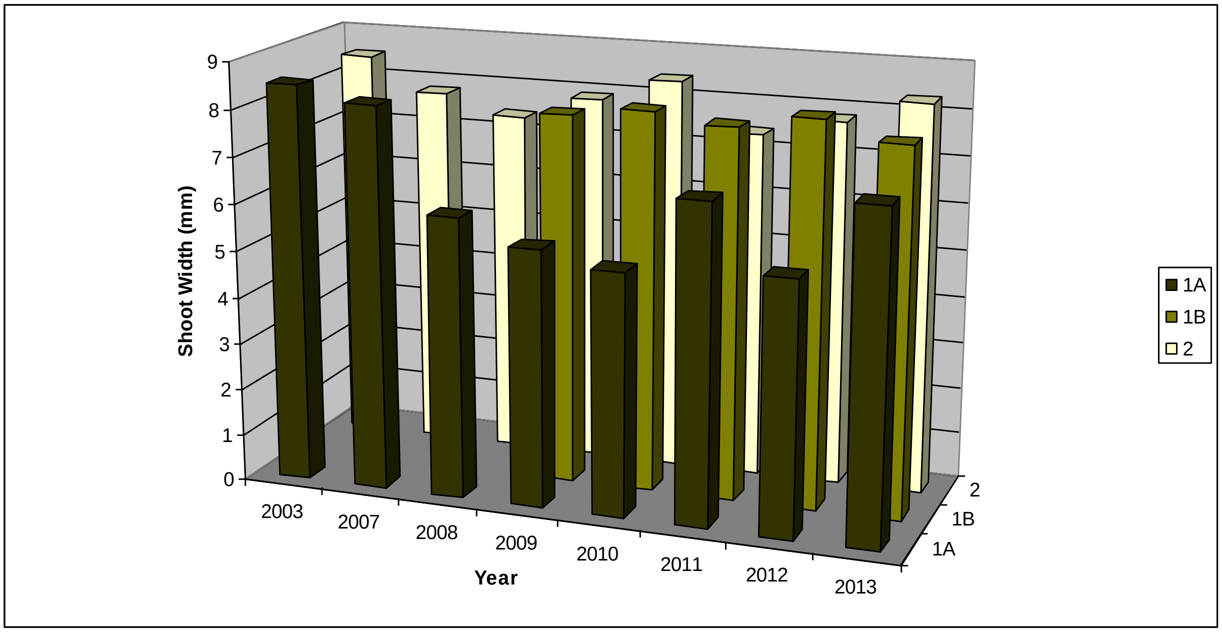


Figure B-16 Mean eelgrass shoot width data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

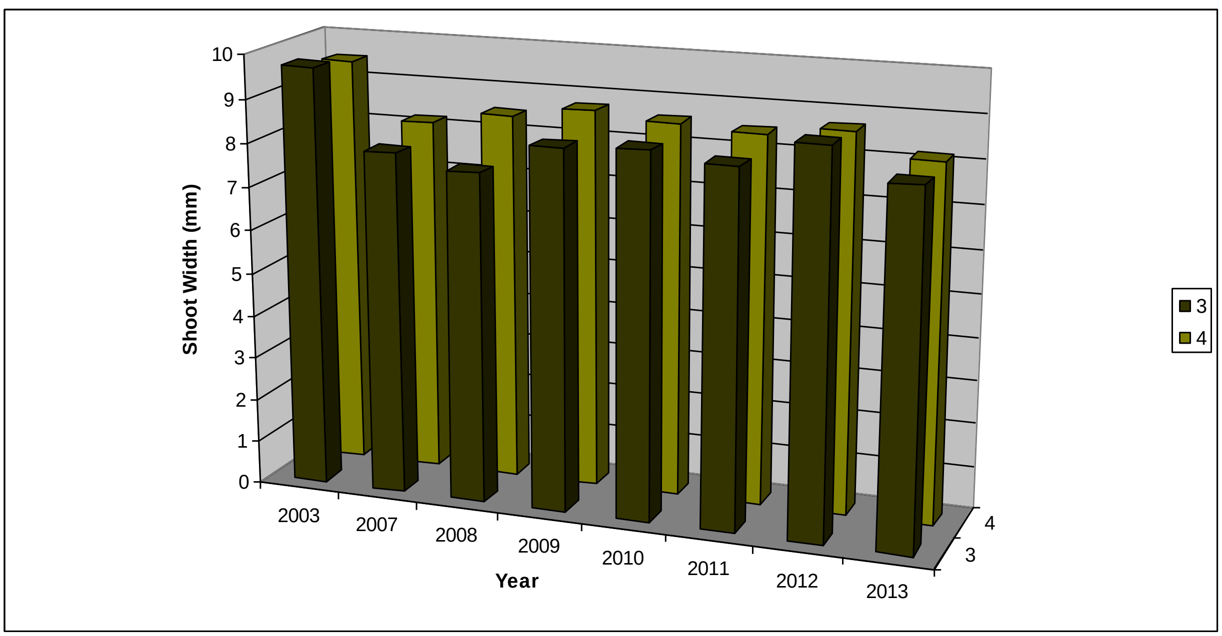


Figure B-17 Mean eelgrass shoot width data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

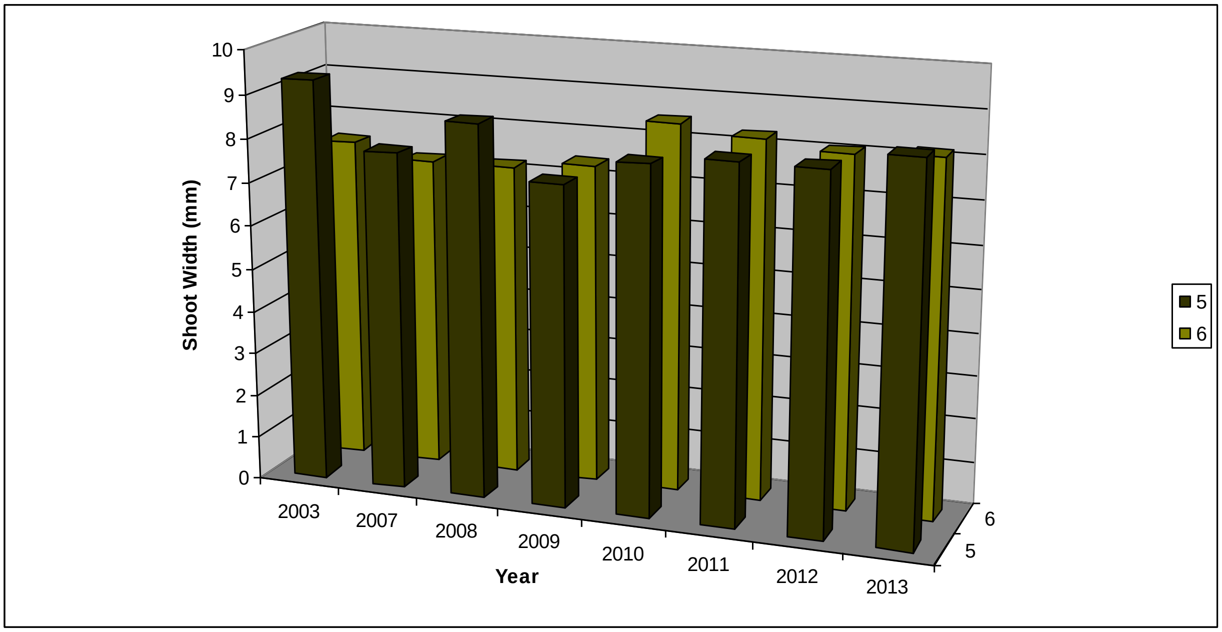


Figure B-18 Mean eelgrass shoot width data from Boundary Bay, Sites WR1, WR2, and WR3

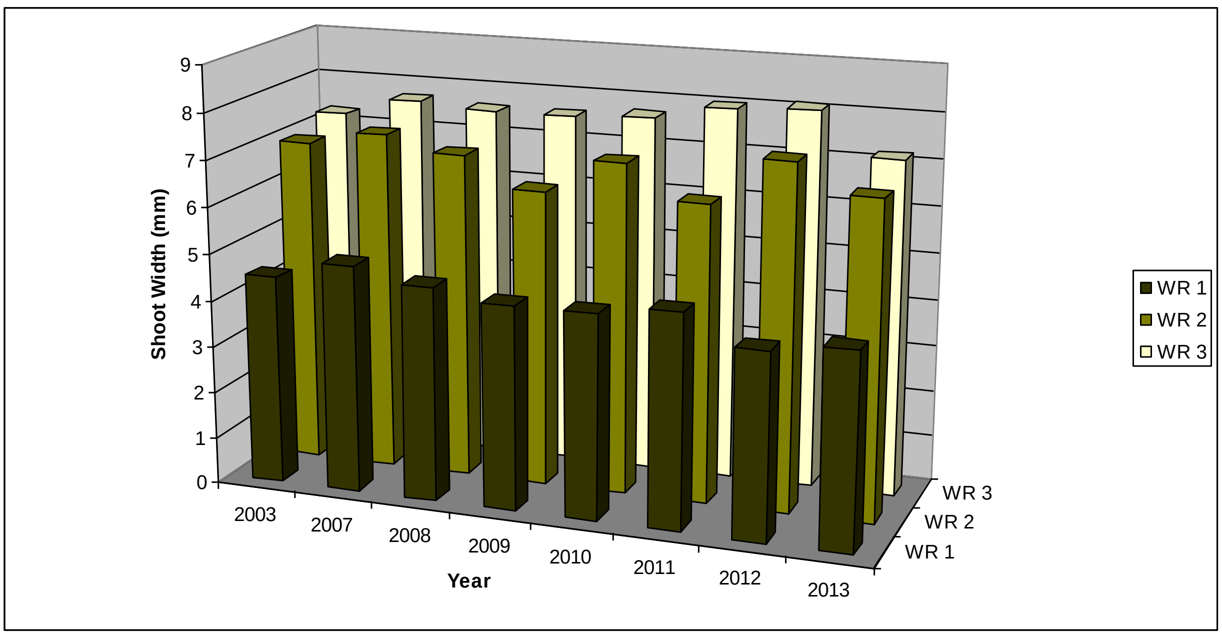


Figure B-19 Mean reproductive shoot density data from Roberts Bank, Inter-causeway near Deltaport Causeway, Sites 1A, 1B, and 2

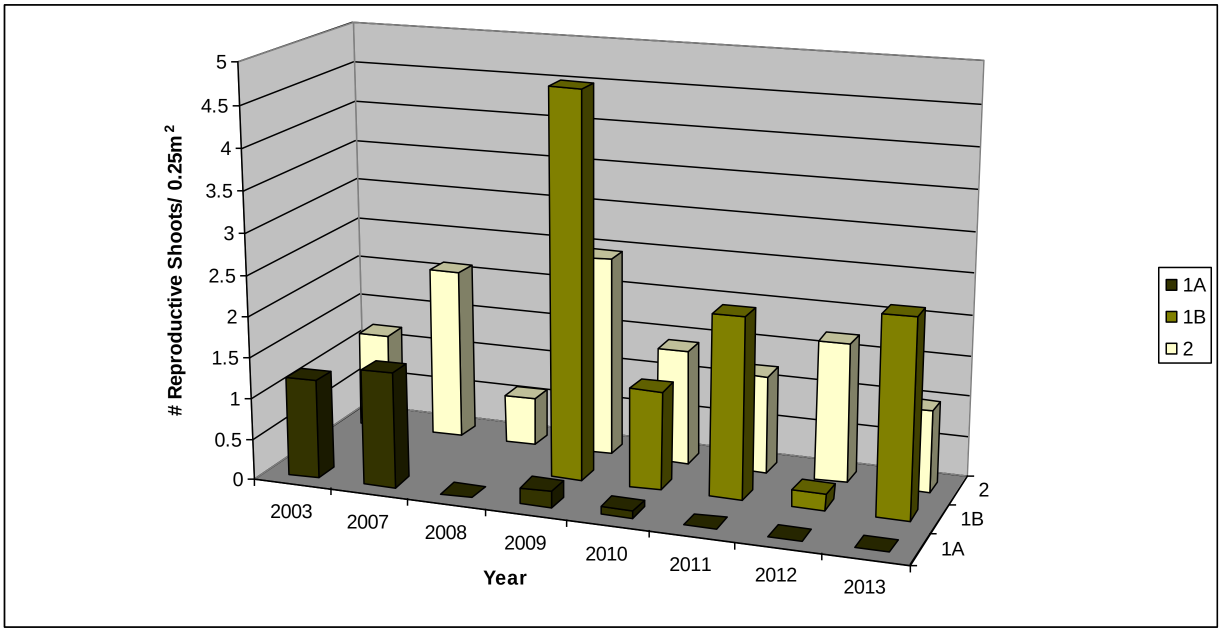


Figure B-20 Mean reproductive shoot density data from Roberts Bank, west of Deltaport Causeway, Sites 3 and 4

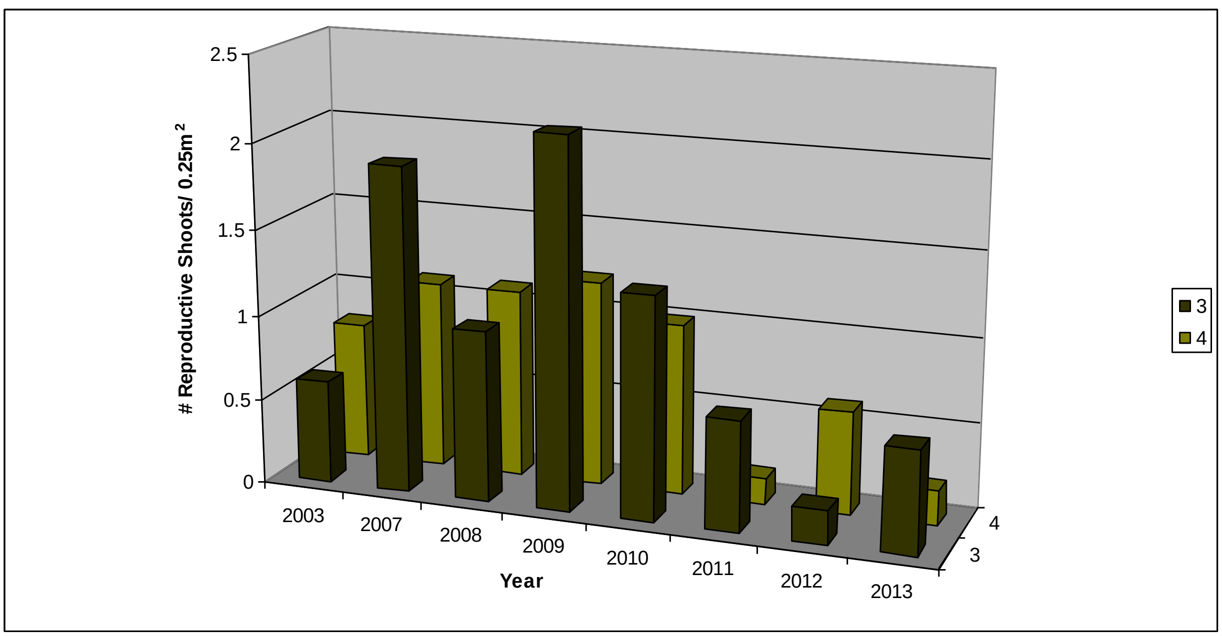


Figure B-21 Mean eelgrass reproductive shoot density data from Roberts Bank, Inter-causeway near Ferry Causeway, Sites 5 and 6

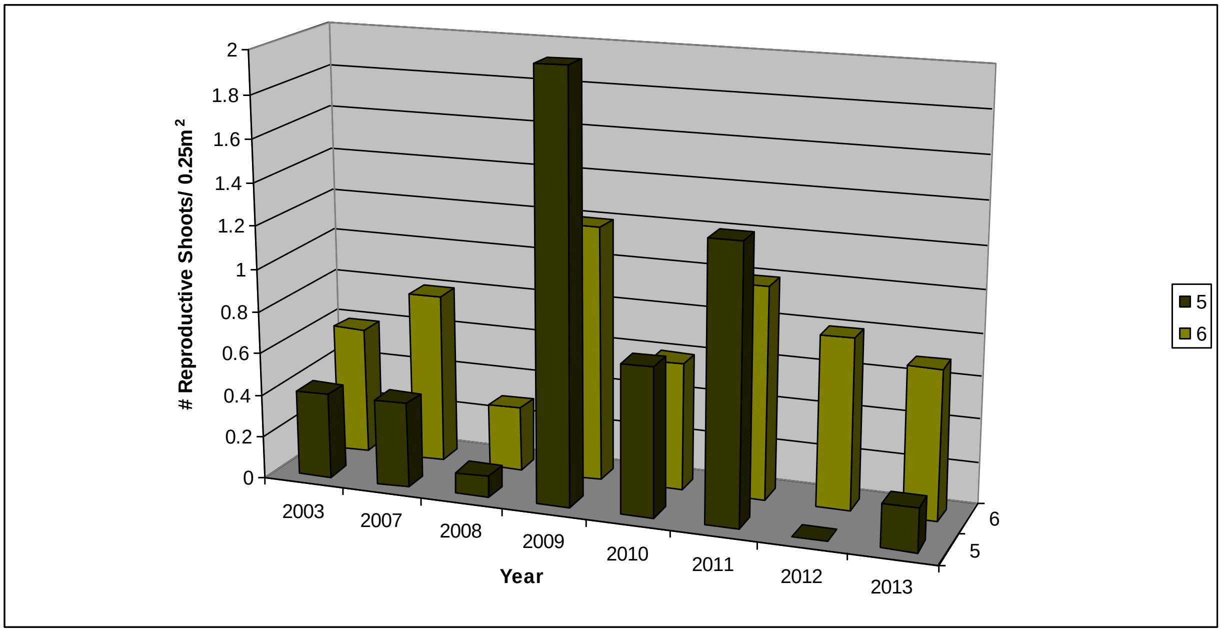


Figure B-22 Mean eelgrass reproductive shoot density data from Boundary Bay, Sites WR1, WR2, and WR3

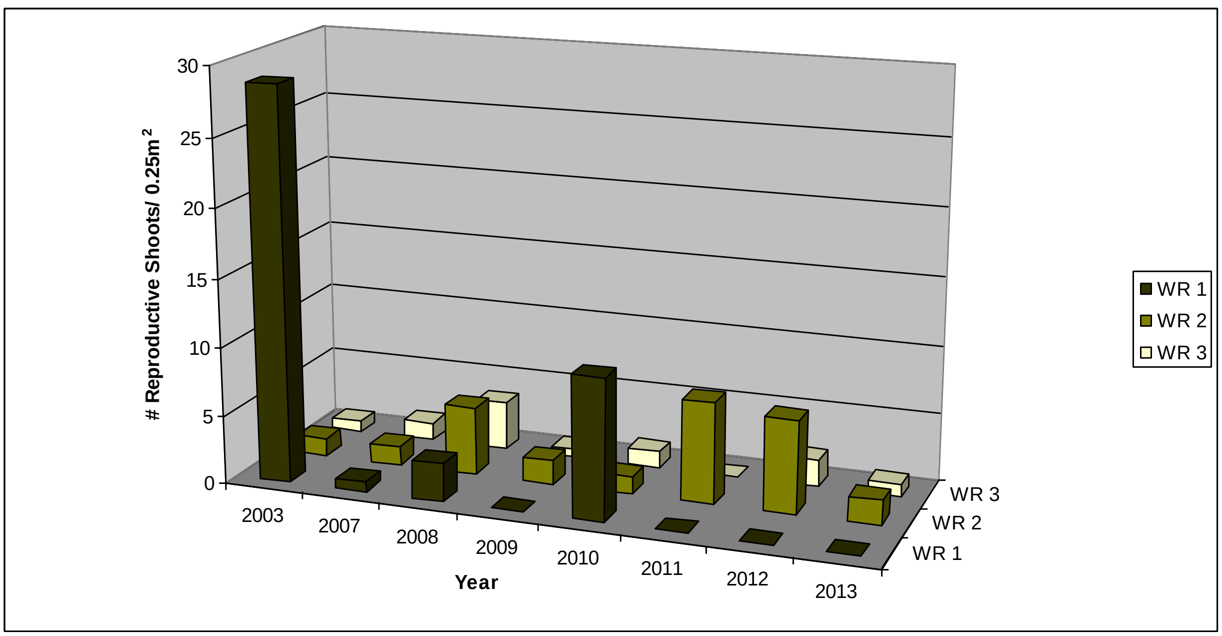
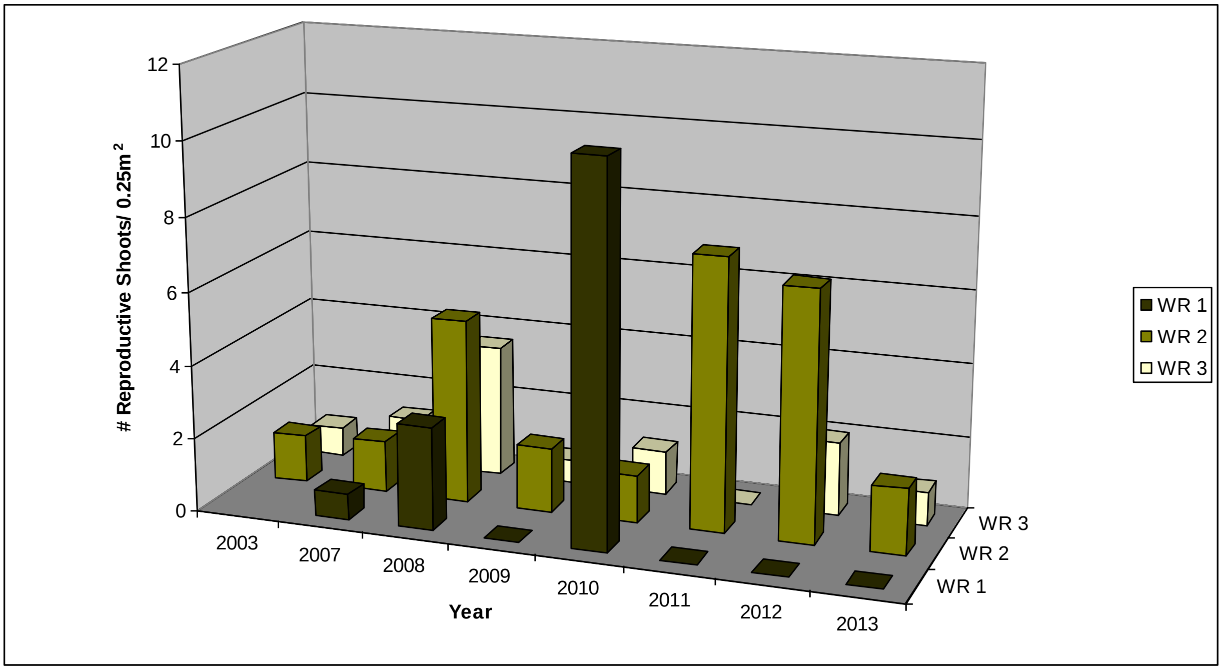


Figure B-23 Mean eelgrass reproductive shoot density data from Boundary Bay, Sites WR1, WR2, and WR3



Note: The data for Site WR1 in 2003 has been omitted.

Table B-1 Mean Eelgrass Shoot Density (total and reproductive) at Each Reference Station in 2003 and 2007 through 2013.

Site	Total Density (#/0.25m^2)								Reproductive Shoot Density (#/0.25m^2)							
	2013	2012	2011	2010	2009	2008	2007	2003	2013	2012	2011	2010	2009	2008	2007	2003
Inter-causeway area near Deltaport Causeway																
1A	4.0	3.1	1.4	0.8 (1.8)*	8.1	25.4	25.8	24	0	0	0	0	0.2	0	1.4	1.2
1B	20.9	22.6	32.6	38.8	25.4	-	-	-	2.4	0.2	2.2	1.2	4.7	-	-	-
2	26.2	28.2	35.0	42.4	25.8	32.8	26.5	23.9	1.0	1.7	1.2	1.4	2.45	0.6	2.1	1.2
Inter-causeway area near BC Ferries Causeway																
5	15.2	11.8	17.1	24.6	25	18.8	17.4	14.5	0.2	0	1.3	0.7	2	0.1	0.4	0.4
6	18.4	21.3	22.2	27.6	20.2	22.6	20.6	16.8	0.7	0.8	1	0.6	1.2	0.3	0.8	0.6
West of Deltaport Causeway																
3	16.2	12.0	16.1	22.5	15	17.65	16	17.3	0.6	0.2	0.65	1.3	2.15	1	1.9	0.6
4	13.7	11.0	13.4	24.8	16.9	21.6	14.7	15.7	0.2	0.6	0.15	1.0	1.2	1.1	1.1	0.8
Boundary Bay																
WR1	160.8	67.2	55.6	76.8	79.4	73.8	60.6	33	0	0	0	10.25	0	2.8	0.7	28.7
WR2	60.1	36.6	35.7	37.8	28.53	32.4	29.4	14	1.8	6.8	7.4	1.3	1.75	5.0	1.4	0.5
WR3	38.6	34.1	36.6	45.1	26.05	32.5	19.9	21	0.9	2	0	1.2	0.63	3.6	1.3	0.8

Notes: Means are based on a sample of twenty replicates.
* Values in parentheses includes mature shoots and seedlings.

Table B-2 Mean Eelgrass Shoot Length, Width, and LAI at Each Reference Station from 2007 through 2013, and in 2003

Site	Length (cm)								Width (mm)								LAI							
	2013	2012	2011	2010	2009	2008	2007	2003	2013	2012	2011	2010	2009	2008	2007	2003	2013	2012	2011	2010	2009	2008	2007	2003
Inter-causeway area near Deltaport Causeway																								
1A	71.4	57.9	63.1	52.7	50	65	115.8	140	7.0	5.4	6.8	5.2	5.5	6	8.2	8.5	0.08	0.06	0.02	0.009	0.09	0.4	0.99	1.18
1B	189.5	180.8	201.2	180.8	175.4	-	-	-	7.8	8.2	7.9	8.1	7.9	-	-	-	1.24	1.32	2.07	2.28	1.42	-	-	-
2	187.2	198.05	181.4	182.2	170.1	168.9	146.7	137.6	8.3	7.8	7.4	8.4	7.9	7.4	7.8	8.5	1.63	1.75	1.88	2.59	1.39	1.66	1.19	1.12
Inter-causeway area near BC Ferries Causeway																								
5	196.2	138.3	206.3	172.5	178	179	130.7	163.5	8.6	8.2	8.2	8.0	7.4	8.6	7.8	9.3	1.04	0.63	1.17	1.37	1.32	1.15	0.71	0.88
6	165.2	156.3	152.0	142.95	143.15	135.8	127.3	132.4	8.2	8.1	8.3	8.5	7.4	7.2	7.2	7.5	1.01	1.09	1.11	1.35	0.86	0.9	0.76	0.66
West of Deltaport Causeway																								
3	166.0	115.0	149.8	164.5	109.5	132.15	121.8	141.1	8.1	8.8	8.2	8.4	8.3	7.6	7.9	9.7	0.88	0.45	0.79	1.24	0.55	0.71	0.61	0.95
4	172.8	161.2	150.7	183.4	144.15	163.35	164	188.8	8.2	8.7	8.5	8.6	8.75	8.5	8.2	9.5	0.82	0.63	0.68	1.60	0.83	1.2	0.79	1.12
Boundary Bay																								
WR1	41.1	38.8	57.8	56.7	44	54.4	48.4	44.4	4.2	4.0	4.6	4.4	4.4	4.6	4.9	4.5	1.09	0.42	0.58	0.80	0.61	0.78	0.56	0.29
WR2	137.0	106.15	124.9	138.4	85	139	122.7	137.4	6.8	7.4	6.4	7.1	6.3	7	7.3	7	2.22	1.15	1.14	1.46	0.62	1.28	1.04	0.54
WR3	191.6	158.4	165.0	169.4	198.35	201	167.4	215.2	7.2	8.5	8.0	7.7	7.6	7.6	7.7	7.3	2.12	1.75	1.96	2.34	1.57	2.02	1.04	1.33

Notes: Means are based on a sample of twenty replicates.

Bonferroni adjusted probability values using separate variances are provided followed by the probability values calculated using pooled variance in brackets. p-values <0.0025 were considered significant (0.05/20). The Bonferroni adjustment requires that each data set has variation; standard two-sample, 2-tailed t-tests were used to analyze data in cases where the variance was zero within one of the datasets. The reproductive shoot density was 0 at several sites on several sampling dates; these comparisons could not be analyzed statistically. NS has been used to denote comparisons of identical datasets to indicate that the identical datasets are Not Significantly different from each other.

Table B-3 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2003

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.000	0.000	0.000	0.000	0.000*
1B	0.061 (0.056)	0.000	0.000*	1.0	0.140 (0.137)
2	0.321 (0.317)	0.000	0.201*	0.000	1.0
Inter-causeway near Ferry Causeway					
5	1.0	0.003	0.002	1.0	0.783 (0.781)
6	1.0	0.000	0.071 (0.054)	0.014 (0.013)	1.0
West of Coal Port Causeway					
3	1.0	0.000	0.000	1.0	1.0
4	0.431 (0.404)	1.0	0.000	0.080 (0.079)	0.396 (0.388)
Boundary Bay					
WR1	0.000	0.003	0.023 (0.022)	0.000	0.000*
WR2	0.000	1.0	1.0	0.000	0.029 (0.022)
WR3	0.000	0.000	1.0	0.000	1.0

Note: * Standard t-test p-value (not adjusted)

Table B-4 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2007

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.000	0.000	0.002 (0.001)	0.000	0.000*
1B	0.099 (0.096)	0.000	0.657 (0.646)	0.161 (0.159)	0.345 (0.352)
2	1.0	0.000	0.151 (0.145)	0.003	0.285
Inter-causeway near Ferry Causeway					
5	1.0	0.000	0.021 (0.019)	0.089 (0.083)	1.0
6	0.576	0.009 (0.007)	0.016	0.208 (0.207)	1.0
West of Coal Port Causeway					
3	1.0	0.000	1.0	0.034 (0.031)	0.015 (0.014)
4	1.0	1.0	1.0	1.0	0.046 (0.042)
Boundary Bay					
WR1	0.000	0.003	0.023 (0.022)	0.000	0.074*
WR2	0.000	0.452 (0.443)	0.243 (0.235)	0.000	1.0
WR3	0.000	0.000	0.024 (0.018)	0.000	1.0

Note: * Standard t-test p-value (not adjusted)

Table B-5 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2008

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.000	0.323 (0.299)	0.922 (0.885)	0.000	NS
1B	0.172 (0.166)	0.000	0.000	0.000	0.000*
2	0.000	0.002	0.001	1.0	1.0
Inter-causeway near Ferry Causeway					
5	0.190(0.180)	0.197 (0.180)	1.0	1.0	1.0
6	0.014 (0.013)	0.001	0.013 (0.012)	1.0	0.317 (0.308)
West of Coal Port Causeway					
3	1.0	0.002	0.089 (0.087)	0.329 (0.319)	1.0
4	0.000	0.986 (0.983)	1.0	0.016	0.085 (0.081)
Boundary Bay					
WR1	0.000	0.005 (0.002)	0.068 (0.065)	0.242 (0.240)	0.000*
WR2	0.000	1.0	1.0	0.000	0.000
WR3	0.129	1.0	0.394	1.0	0.039 (0.029)

Note: * Standard t-test p-value (not adjusted)

Table B-6 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2009

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.009 (0.006)	1.0	1.0	1.0	0.042*
1B	0.024	0.005	1.0	0.357 (0.356)	0.004
2	1.0	0.002 (0.003)	0.194	0.094	0.146 (0.143)
Inter-causeway near Ferry Causeway					
5	0.000	0.158 (0.144)	0.000	0.164 (0.156)	0.001 (0.000)
6	1.0	0.007 (0.006)	0.044 (0.035)	1.0	0.601 (0.596)
West of Coal Port Causeway					
3	1.0	0.000	1.0	0.014	0.012 (0.010)
4	0.191	0.008	0.811 (0.805)	1.0	0.029 (0.026)
Boundary Bay					
WR1	0.000	0.302 (0.300)	0.213 (0.209)	0.001 (0.000)	NS
WR2	0.000	0.000	0.298 (0.288)	0.000	0.036 (0.031)
WR3	0.000	1.0	0.285	0.163 (0.162)	1.0

Note: * Standard t-test p-value (not adjusted)

Table B-7 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2010

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.065 (0.052)	0.005	0.005 (0.004)	0.033 (0.022)	NS
1B	0.000	0.391 (0.387)	0.609 (0.606)	0.000	0.160 (0.159)
2	0.000	1.0	1.0	0.000	1.0
Inter-causeway near Ferry Causeway					
5	0.000	0.027 (0.020)	0.054 (0.053)	0.095 (0.093)	1.0
6	0.000	0.006 (0.005)	1.0	0.033	1.0
West of Coal Port Causeway					
3	0.020 (0.019)	1.0	1.0	0.097 (0.093)	0.396 (0.393)
4	0.000	0.848(0.847)	1.0	0.000	0.101(0.096)
Boundary Bay					
WR1	0.000	0.000	0.592 (0.586)	0.108	0.000*
WR2	0.000	1.0	1.0	0.000	1.0
WR3	0.053 (0.051)	0.001	0.043 (0.034)	0.944 (0.935)	1.0

Note: * Standard t-test p-value (not adjusted)

Table B-8 Bonferroni adjusted Probability Values Attained for Each Parameter Using a Two-sample t-test Comparing Data Sets from 2013 and 2011

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	0.205 (0.191)	0.138	0.240	0.181 (0.166)	NS
1B	0.000	0.127 (0.123)	1.0	0.000	1.0
2	0.000	1.0	0.000	0.108 (0.107)	1.0
Inter-causeway near Ferry Causeway					
5	1.0	1.0	0.332 (0.329)	1.0	0.175 (0.150)
6	0.102 (0.101)	0.202 (0.198)	1.0	1.0	1.0
West of Coal Port Causeway					
3	1.0	0.077 (0.076)	1.0	1.0	1.0
4	0.236 (0.233)	0.000	1.0	0.002	0.411 (0.387)
Boundary Bay					
WR1	0.000	0.000	0.002 (0.001)	0.000	NS
WR2	0.000	0.084 (0.076)	0.367 (0.357)	0.000	0.000
WR3	1.0	0.000	0.003	1.0	0.000*

Note: * Standard t-test p-value (not adjusted)

Table B-9 Bonferroni adjusted probability values attained for each parameter using a two-sample t-test comparing data sets from 2013 and 2012.

Site #	Total Density	Length	Width	LAI	Reproductive Density
Inter-causeway near Coal Port Causeway					
1A	1.0	0.144	0.086	1.0	NS
1B	1.0	1.0	0.278 (0.270)	1.0	0.000
2	0.917	1.0	0.273 (0.266)	1.0	0.986
Inter-causeway near Ferry Causeway					
5	0.166 (0.145)	0.000	0.608 (0.603)	0.001	0.186*
6	0.252	1.0	1.0	1.0	1.0
West of Coal Port Causeway					
3	1.0	0.002	1.0	1.0	1.0
4	0.570	0.806	0.400	0.631 (0.630)	0.829 (0.824)
Boundary Bay					
WR1	0.000	1.0	1.0	0.000	NS
WR2	0.000	0.000	0.147 (0.146)	0.000	0.000
WR3	0.254 (0.245)	0.000	0.000	0.102 (0.092)	0.034 (0.033)

APPENDIX C

Eelgrass Loss Investigation Behind Tug Basin

HEMMERA

Suite 250 – 1380 Burrard Street
Vancouver, BC V6Z 2H3
T: 604.669.0424
F: 604.669.0430
hemmera.com

April 10, 2014
File: 499-002.19

Port Metro Vancouver
100 The Pointe
999 Canada Place
Vancouver, BC V6C 3T4

Attn: Carolina Eliasson, Environmental Specialist

Dear Ms. Eliasson,

Re: Draft – Letter Report on Investigation of Potential Factors in the Loss of Eelgrass Behind the Tug Basin at Deltaport Third Berth (DP3)

Hemmera, in conjunction with Northwest Hydraulics Consultants Ltd. (NHC) and Precision Identification Biological Consultants (Precision), are providing this letter report to document potential factors relating to an area of observed eelgrass loss (AOEL) behind the tug basin at Deltaport Third Berth (DP3). This work was completed under Adaptive Management Strategy (AMS) program.

This report outlines the study background, methods, results, conclusions and recommendations.

1.0 INTRODUCTION

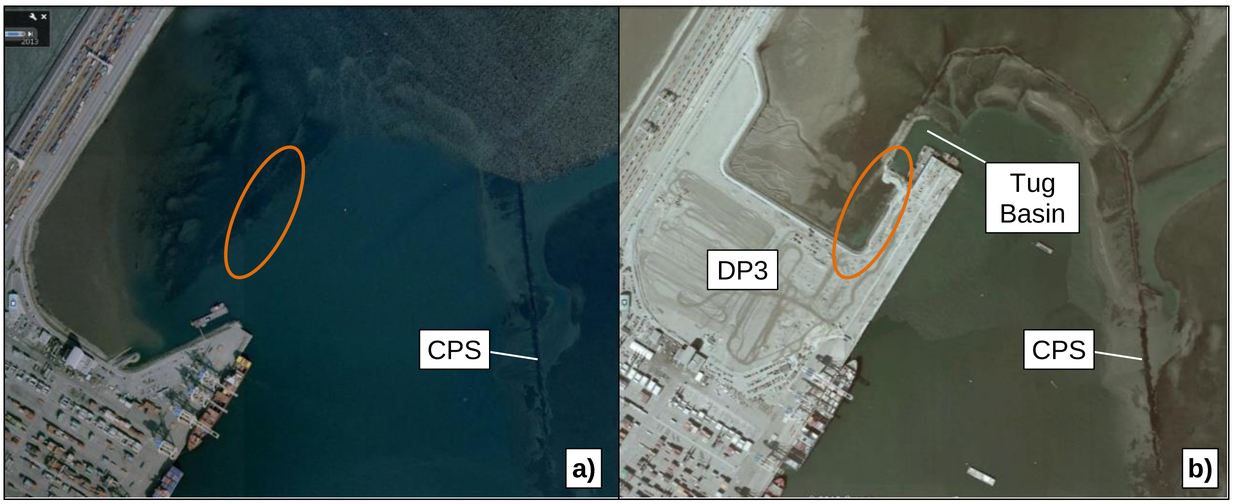
1.1 BACKGROUND

A summary of the background that led to the investigation is provided below:

- Localized eelgrass loss, change from continuous *Z. marina* to patchy *Z.marina*, behind the tug basin was observed by the study team in 2012. This loss was reported to the Science Advisory Committee (SAC) at the annual SAC-Consultants meeting in February 2013.
- A site visit was conducted on April 2, 2013 by NHC (Derek Ray), Precision (Cynthia Durance), SAC (Ron Ydenberg and Rowland Atkins) and PMV (Kim Keskinen) to identify potential causes, and potential additional AMS studies.
- There was discussion at both meetings regarding inadequate drainage in the AOEL during a dropping tide due to the elevated rock berm around the tug basin (**Figure 1-1**). The large rock berm was installed around the perimeter of the tug basin (tug basin berm) during DP3 construction and separates the dredged tug basin from the intertidal mudflats.

- Heavy epiphytic growth on the eelgrass was noted during the site visit in the AOEL for the time of year and it was postulated that incomplete tidal flushing could be contributing to degraded water quality conditions (e.g. lower dissolved oxygen, higher turbidity, higher temperature, etc.).
- Potential physical interventions were discussed to improve flushing, for example, to install a drainage structure in the tug basin berm (French drain or culvert). However, prior to making recommendation for physical changes, the SAC members felt that additional monitoring would be appropriate to investigate whether the loss in eelgrass could be caused by changes in water quality and circulation in this area.

Figure 1-1 Approximate location of the AOEL is within the orange oval, based on a 2004 image (a) and 2009 image (b).



1.2 OBJECTIVES

The primary objective of the investigation was to determine the cause of the observed eelgrass loss behind the tug basin adjacent to DP3. In order to meet this objective, our scope of work was to:

- Monitor tidal elevations during a dropping tide to measure the lag in flow within the ponded area;
- Confirm the extent of the area that is not draining completely or 'flushing' behind the tug basin and what elevation of the crest-protection structure would allow the area to drain;
- Assess the condition of the surviving eelgrass and examine the areas where eelgrass loss occurred to determine whether there are any indications as to the cause of the loss;
- Assess whether changes in water quality can be measured and if they could be a potential factor in the loss of eelgrass in this area; and,
- Provide recommendations based on the data collected.

2.0 METHODS

2.1 OVERVIEW

The approach to our scope of work was to incorporate tasks into already planned AMS field programs for efficiency and to minimize costs. The task undertaken to meet the objectives included:

- Desktop review of existing data including:
  - sediment and surface water data collected behind the tug basin as part of the AMS project;
  - location of stormwater outfalls; and
  - acid rock drainage issues potentially associated with rock used in the berm construction.
- Collect water levels behind and within the tug basin over a summer tidal cycle.
- Collect additional survey points over the tug basin berm and tidal flats as part of the planned coastal geomorphology mapping survey.
- Map the area behind the tug basin that is not flushing or draining and compare to the AOEL.
- Conducted a detailed survey of the eelgrass behind the tug basin at low tide to examine the eelgrass for signs of disease, herbivory and unusual rhizome growth.
- Collection of surface water and sediment samples during AMS quarterly monitoring events (June and September) and during one summer tidal event.
- Collection of field parameter profiles during the above events.
- Hold two project team meetings to discuss the findings to date and any proposed changes or addition to the tasks.
- Prepare a letter report to document the investigation and provide recommendations based on the data collected.

2.2 WATER LEVEL SURVEY & TOPOGRAPHIC SURVEYS

Water levels were monitored during a dropping and rising tide cycle in both the AOEL and the tug basin (which is assumed to be in equilibrium with the Strait of Georgia) on July 22, 2013. Two Solinst Leveloggers were installed on either side of the tug basin rock berm to monitor water levels from approximately 8.30 am to 7.30 pm, while a barologger measured atmospheric pressure for use in post-processing.

Topographic and bathymetric surveys were completed in 2013 as part of the Coastal Geomorphology Mapping activity of the AMS. Additional topographic survey information was collected on July 22, 2013 to better define the elevation of the tug basin rock berm.

2.3 EELGRASS SURVEY

A detailed field survey of the areas where eelgrass loss has occurred in the AOEL, and of the adjacent areas where eelgrass has survived, was conducted to search for clues that may explain why the eelgrass has died in some areas but not in others. The survey examined the remaining eelgrass for signs of disease, herbivory, and unusual rhizome growth. The epiphyte load on the eelgrass was assessed and compared to the sites visited annually for the AMS. The areas of eelgrass loss were examined for signs of recovery and the sediment examined visually for differences relative to that in areas where the eelgrass has survived.

A snorkel survey of the AOEL was conducted during low tide (0.3 m) on July 22, 2013. Observations relating to water temperature and stratification, sediment colour and suspension, epiphyte cover, rhizome health, and leaf blade health were recorded; these are summarized in **Section 3.2.1** and discussed in **Section 3.2.3**.

The density of eelgrass shoots in areas with continuous coverage was assessed using a 0.25 m^2 quadrat. Twenty quadrats were assessed and the mean calculated.

2.3.1 Leaf Blade Health (Disease)

An epidemic wasting disease caused by *Labyrinthula* sp., a pathogenic marine slime mold, eliminated many populations of eelgrass along Atlantic Coasts in the 1930s (Muehlstein et al., 1991). The slime mold is common in eelgrass beds throughout Temperate and Mediterranean regions although it generally occurs at relatively low levels and does not seem to impair eelgrass health. The environmental and biological factors that lead to the massive increase of *Labyrinthula* sp. and subsequent loss of eelgrass in 1930s is not known (Muehlstein et al., 1988). There has been recent concern that levels *Labyrinthula* sp. is increasing in some areas and has caused several local declines along the Atlantic US Coast (Short et al., 1987).

Labyrinthula sp. is known to be common throughout the Pacific Northwest although it has never caused the major declines in eelgrass habitat that it did along the Atlantic Coast. The disease causes necrotic lesions on the leaves that form black rectangles.

The leaves of the eelgrass in the AOEL were examined for lesions during the snorkel survey. Laboratory tests are required to confirm the presence of the mold; the black rectangles may only be used as an indicator that it may be present.

2.4 DESKTOP STUDIES

At the April 2013, a number of potential theories were raised by SAC relating to causes of the eelgrass loss: storm-water outfalls and acid rock drainages. Hence, to address these theories some additional effort/research was undertaken to locate existing outfalls and sources of rock for DP3 construction. In addition, data from the AMS program for the nearest station to the ABTB was reviewed for indications of temporal trends.

2.5 SURFACE WATER AND SEDIMENT SURVEY

The objective of surface water and sediment survey was to provide a snapshot of water quality near surface and near bottom during June and September, coinciding with the AMS Q2 and Q3 events, and over a summer tidal cycle at locations within and adjacent to the AOEL. Method used to collect surface water and sediment quality samples followed AMS methodology (see Appendix A of this annual report) as described below.

2.5.1 June & September Events

Existing stations DP09 and three new stations RB-10-1[1], DP10 & DP11 were sampled during the June and September at the same time as the AMS Q2 and Q3 surface water and sediment quality monitoring program. As shown on **Figure 1**, location DP09 is located in an area with no eelgrass, locations DP10 and DP11 are located within the AOEL but on either side of the old CPS, and RB-10-1 is located to the north of the AOEL but within a patch of continuous *Z. Marina*.

At all 4 locations, both near surface (0.5 m below surface) and near bottom water samples (0.5 m above bottom surface) plus sediment samples were collected. Surface samples were labelled with an 'A' extension and bottom samples with a 'B' extension. Surface water samples were analysed for the same AMS eutrophication parameters. Field measurements of pH, dissolved oxygen, ORP, turbidity, salinity and conductivity were also be collected. Sediment samples were analysed for the same AMS eutrophication parameters. Sampling was done at higher tide levels in order to access the area with the boat used during the quarterly monitoring program.

During these monitoring events, profiles of field parameters using a Sonde YSI were collected at all four stations. The YSI was lowered into the water and readings were collected approximately every second. Data was downloaded from the YSI into excel and made into graphs.

2.5.2 Summer Tidal Event

A one day monitoring and sampling event was conducted over a tidal cycle in late July to determine if water quality near the bed is degraded compared to near surface and elsewhere in this area during the summer when water quality may be most affected (i.e. oxygen depletion most likely).

---

[1] Station RB-10-1 has been established for Roberts Bank Terminal 2 (RBT2) Project surface water and sediment baseline studies.

Monitoring consisted of the collection of field water quality profiles using a Sonde YSI (i.e. dissolved oxygen, temperature, conductivity, ORP, salinity, TSS) at various times during the tide cycle (e.g. within a 12 hr period – high, dropping, low, rising). Profiles were collected at 6 locations (DP04, DP09, DP10, DP11, RB 10-1 and tug basin). Stations DP04 and tug basin were meant as 'control' sites. During the event, surface water samples were collected for analysis of eutrophication parameters and cations/anions at various tidal stages as summarized in the table below. **Table 3** outlines the monitoring plan for the summer tidal event,

3.0 RESULTS

3.1 WATER LEVEL & TOPOGRAPHIC SURVEYS

3.1.1 Hydraulic Control

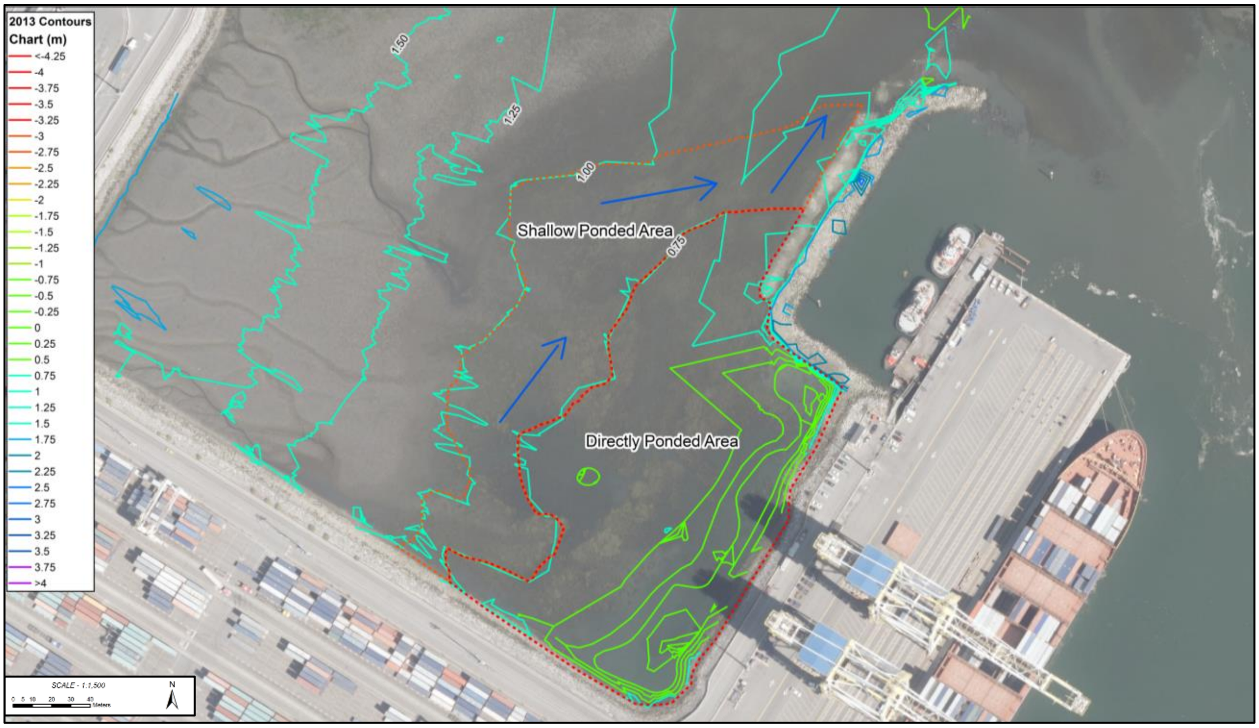
The extent of ponding is controlled by the hydraulic influence of the tug basin rock berm. **Figure 3-1** shows that the tidal flats slope towards the DP3 terminal, while the elevation of the rock berm is at a fairly constant elevation of approximately 2 m (Chart Datum) extending across the slope of the tidal flats. Prior to construction of the DP3 terminal, tidal water behind the rock berm was free to drain to the open Strait of Georgia (**Figure 1-1**). Under the current configuration, tidal water flows over the rock berm at higher tide heights and then around the berm across the tidal flats at lower tide heights. Drainage is completely blocked at tide heights below approximately 1 m (Chart Datum).

Figure 3-1 The Tidal flats in the vicinity of the Tug Basin during a summer low tide of approximately 0.6 m (Chart Datum).

3.1.2 Area of Ponding

The data from the topographic and bathymetric surveys completed in 2013 as part of the AMS field work were used to generate the contours shown in **Figure 3-2**, as well as, to define the extents of the Directly Ponded Area and the Shallow Ponded Area.

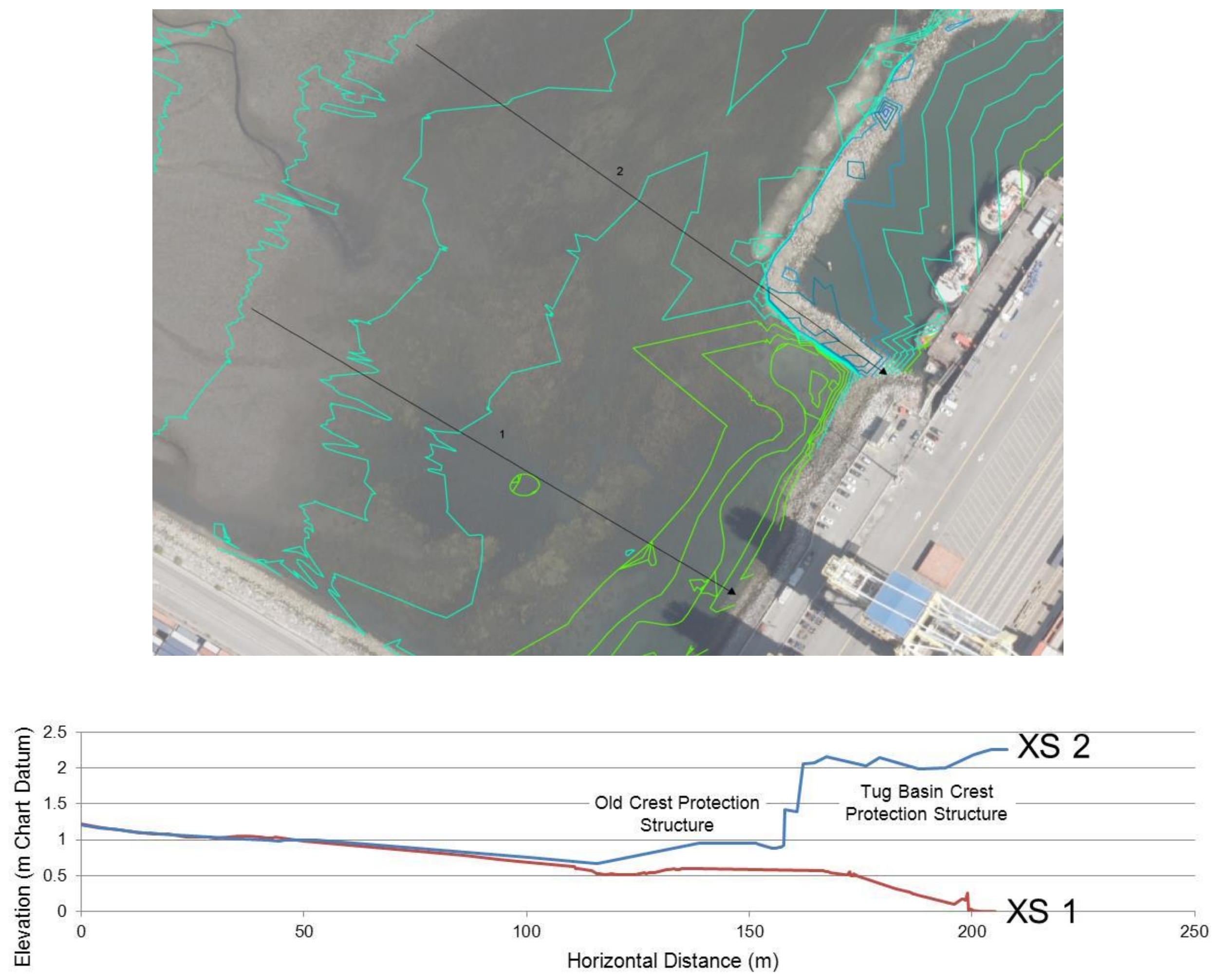
Figure 3-2 Elevation contours on the tidal flats in the vicinity of the Tug Basin that were used to define the extent of the 'Directly Ponded Area' and the 'Shallow Ponded Area'. The arrows indicate the direction of ebb tide flow through the Shallow Ponded Area.



The extent of the Directly Ponded Area has been shown using the 0.75 m (Chart Datum) contour. Although the water level did not drop below 1.0 m (Chart Datum) on July 22, 2013, it is thought that during a very low tide, water levels in the Directly Ponded Area could drop further if given sufficient time. The AOEL is within this Directly Ponded Area.

The extent of the Shallow Ponded Area is defined using the 1.0 m contour. This zone represents an area characterised by hummocky topography and the presence of eelgrass. Flow through this zone follows an indefinite, dispersed pathway with high friction bed, which contributes to the long time lag in water levels between the Ponded Areas and the Tug Basin. This effect is further illustrated in **Figure 3-3**, which shows cross sections that relate the elevation of the surrounding tidal flats to the elevation of the old CPS and the tug basin rock berm.

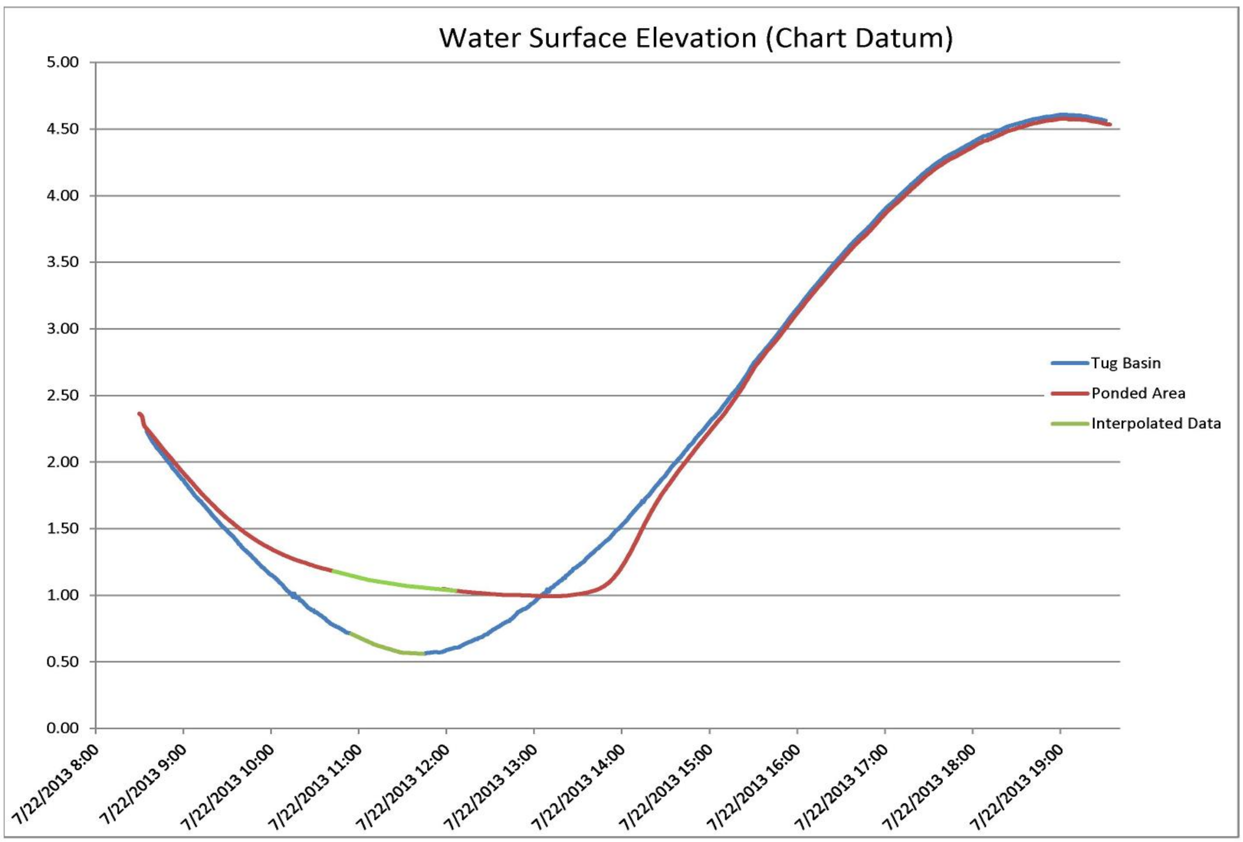
Figure 3-3 Cross sections through tidal flats and the Crest Protection Structures.



3.1.3 Water Level Lag

Figure 3-4 shows that the water levels in the Directly Ponded Area, and within the AOEL, are essentially in phase with the tide height in the open Strait of Georgia (via the Tug Basin) for tide heights above 2 m (Chart Datum) but that there is a lag on both the dropping and rising tide, below this height. As the tide drops, the water surface elevation in the Ponded Area begins to diverge from that in the Tug Basin to reach a minimum elevation of 1 m (Chart Datum) approximately 45 min after low tide. This minimum water elevation in the Ponded Area is maintained for almost two hours until the tide in the Tug Basin exceeds 1.5 m (Chart Datum), at which point the water level in the Ponded Area rises rapidly. As a result of the tide height monitoring, we have identified two areas of influence: i) a Directly Ponded Area, and ii) a Shallow Ponded Area.

Figure 3-4 Water levels measured during a dropping and rising tide on July 22, 2013 in the Tug Basin and in the Ponded Area. A portion of the data was interpolated because the tide dropped below the initial logger installation.



3.2 EELGRASS SURVEY

3.2.1 Field Observations

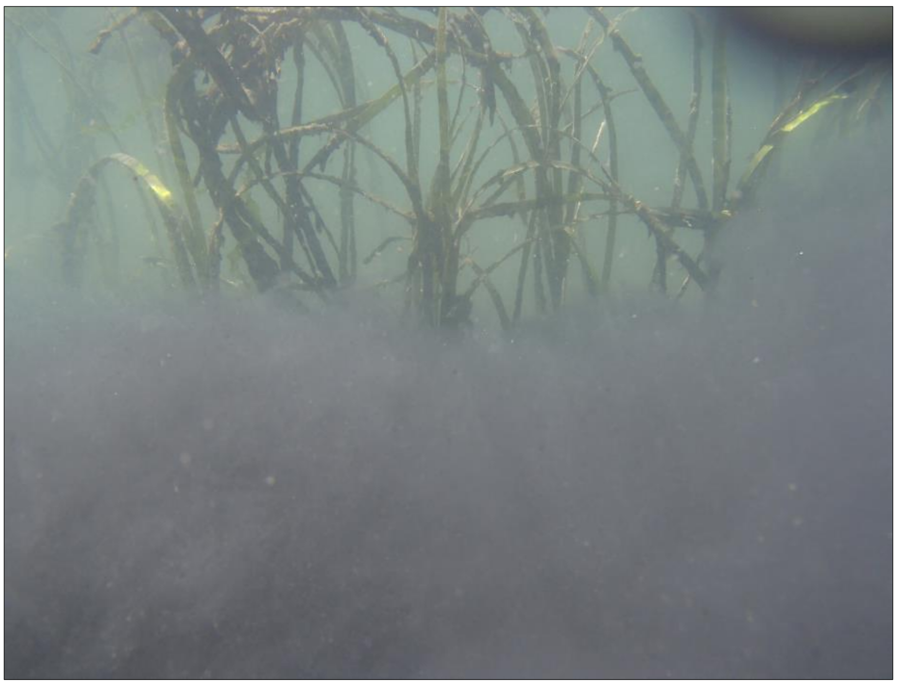
Field observations from the snorkelling survey conducted in the AOEL are described below.

3.2.1.1 Water temperature

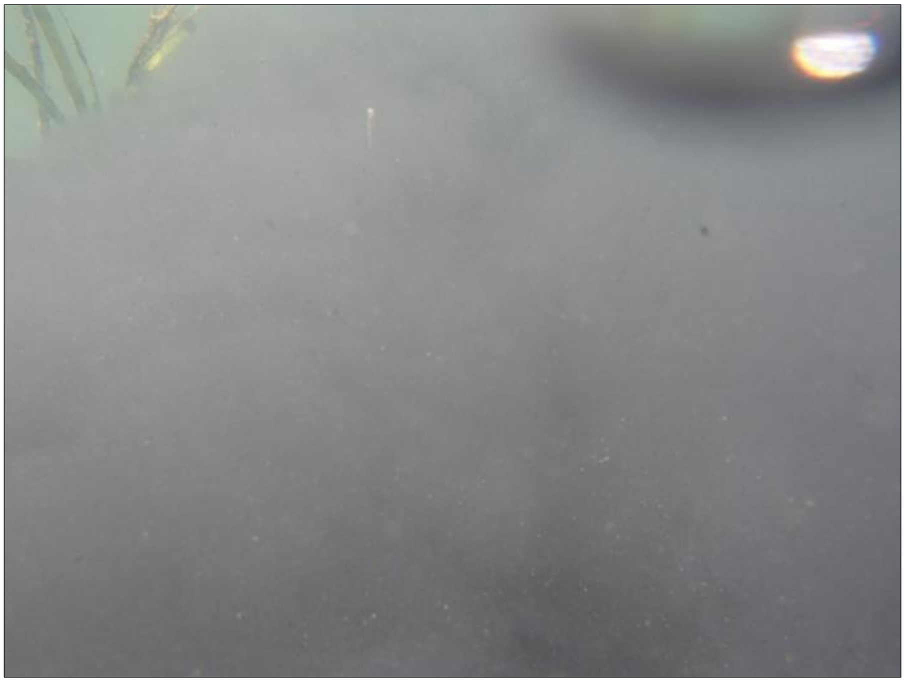
The water column was highly stratified; the upper 10 to 15 cm felt much warmer than the water below.

3.2.1.2 Sediment Observations

The sediment in the AOEL was easily suspended and once disturbed required time to settle and did not disperse horizontally. A finger was used to disturb the sediment simulating the effect that a crab burying might have. The sediment plume was captured in a series of photographs. Photographs 1 through 3 provided below show the sediment plume rising to the surface. The fine silty substrate was black and smelt strongly of sulphide, which are indications of anaerobic conditions. The sediment around the four inter-causeway AMS eelgrass monitoring stations have a greater percentage of sand relative to silt, is lighter in colour, and does not smell strongly of sulphide.



Photograph 1 Sediment plume rising immediately following disturbance.



Photograph 2 Sediment plume slowly rising vertically through the eelgrass.

Photograph 3 Sediment plume at the surface several minutes after disturbance.

3.2.1.3 Epiphyte Cover

Typically, only the oldest leaves that are dying are heavily colonized by epiphytes. The epiphyte growth in the AOEL behind the tug basin was considered extreme during the survey since in many cases entire shoots, including the young leaves, were encased in epiphytes.

Typical epiphyte cover in the inter-causeway is shown in **Photograph 4**; the photograph was taken one day before the snorkel survey. **Photographs 5** and **6** were taken during the snorkel survey and show the dense epiphyte cover in the AOEL.

Photograph 4 Typical epiphyte coverage during July in the inter-causeway eelgrass meadow.

Photograph 5 Dense epiphytes coat the eelgrass leaves floating on the surface during low tide in the AOEL behind tug basin.

Photograph 6 Dense epiphytic growth on eelgrass slightly below the surface during low tide in the AOEL. Note the reduced epiphytic growth on the lower parts of the eelgrass leaves; an indication of light limitation below the surface.

3.2.1.4 Rhizome Health

Eelgrass rhizome health is often used an indicator of plant health. Unhealthy rhizomes tend to be narrow, black, and break easily. Several rhizomes were examined; all appeared healthy.

3.2.1.5 Leaf Blade Health (Disease)

The leaves of the eelgrass in the AOEL were examined for necrotic lesions and lesions or black rectangles were not detected.

3.2.1.6 Herbivory

Eelgrass shoots were examined for signs of herbivory; including shredded and torn leaves. There were no indications of herbivory in the area.

3.2.2 Eelgrass Comparison 2013 to 2012

The distribution of patchy and continuous eelgrass within the AOEL and behind the tug basin in July 2013 was compared with that of July 2012. Several of the areas that were patchy in 2012 have developed into continuous cover since then however, the density in these areas was low (the mean density was 26 shoots/m^2). The mean density recorded in this area in 2003 was 96 shoots/m^2. AMS Site 2 is the AMS eelgrass monitoring site nearest to the tug basin; the density at this site in July 2013 was 105 shoots/m^2. The mean density in 2003 and at AMS Site 2 in 2013 were also based on a sample of twenty replicates.

3.2.3 Discussion

In AOEL, the rhizomes appeared healthy and there were no indications that *Labyrinthula* sp. was negatively impacting the eelgrass. Signs of herbivory were absent. The area of continuous coverage increased slightly since 2012, however, the shoot density in areas of continuous distribution was much lower than it was in 2003 and at the nearest AMS Site in 2013.

The reduced tidal flows and ponding of water, as discussed in **Section 3.1,** in the AOEL have resulted in greater than usual surface water temperatures during low tide as discussed in **Section 3.4.6**. It is hypothesized that the elevated temperature due to water ponding and reduction in flow enhances epiphyte growth. The enhanced epiphyte growth shades the eelgrass directly by covering the upper portion of the leaves and in by shading the lower portion. Shading impacts the plants ability to grow causing low densities and in some cases patchy distribution or complete loss. The detritial epiphytes would settle onto the sediment surface around the eelgrass shoots and lead to elevated sediment sulphide levels, an increased Biological Oxygen Demand (BOD), and lower dissolved oxygen in the water column. All of these factors have the potential to impair eelgrass growth.

Net photosynthesis for eelgrass has been shown to decrease above 12° C in the Pacific Northwest (Thom et al., 2001); the warmer low tide water temperature and longer low tide duration may also contribute to the eelgrass declines.

It is likely that the surviving eelgrass would be able to re-colonize the AOEL if tidal flow through the area was improved and ponding was eliminated.

3.3 Desktop Review

3.3.1 AMS Results for DP09

The AMS program has one sediment and surface water monitoring station near the area of eelgrass loss behind the tug basin (**Figure 1**). This station (DP09) is located on the southeast edge of the 'area of new drainage channels' and has been monitored since 2009 annually in Q1. Surface water and sediment analytical data collected as part of the AMS program between 2009 and 2013 from DP09 is provided on **Figures 1** and **2** attached to this letter report. Notable trends in the data observed on the DP09 trend graphs include potential increases since 2009 for ammonia and TKN in surface water, decreases in phosphorus parameters in surface water, and elevated total nitrogen and phosphorus in sediment during 2013 (**Figures 3-5** through **3-9**).

Figure 3-5 DP09 Surface Water Trend Plot for Nitrogen Parameters

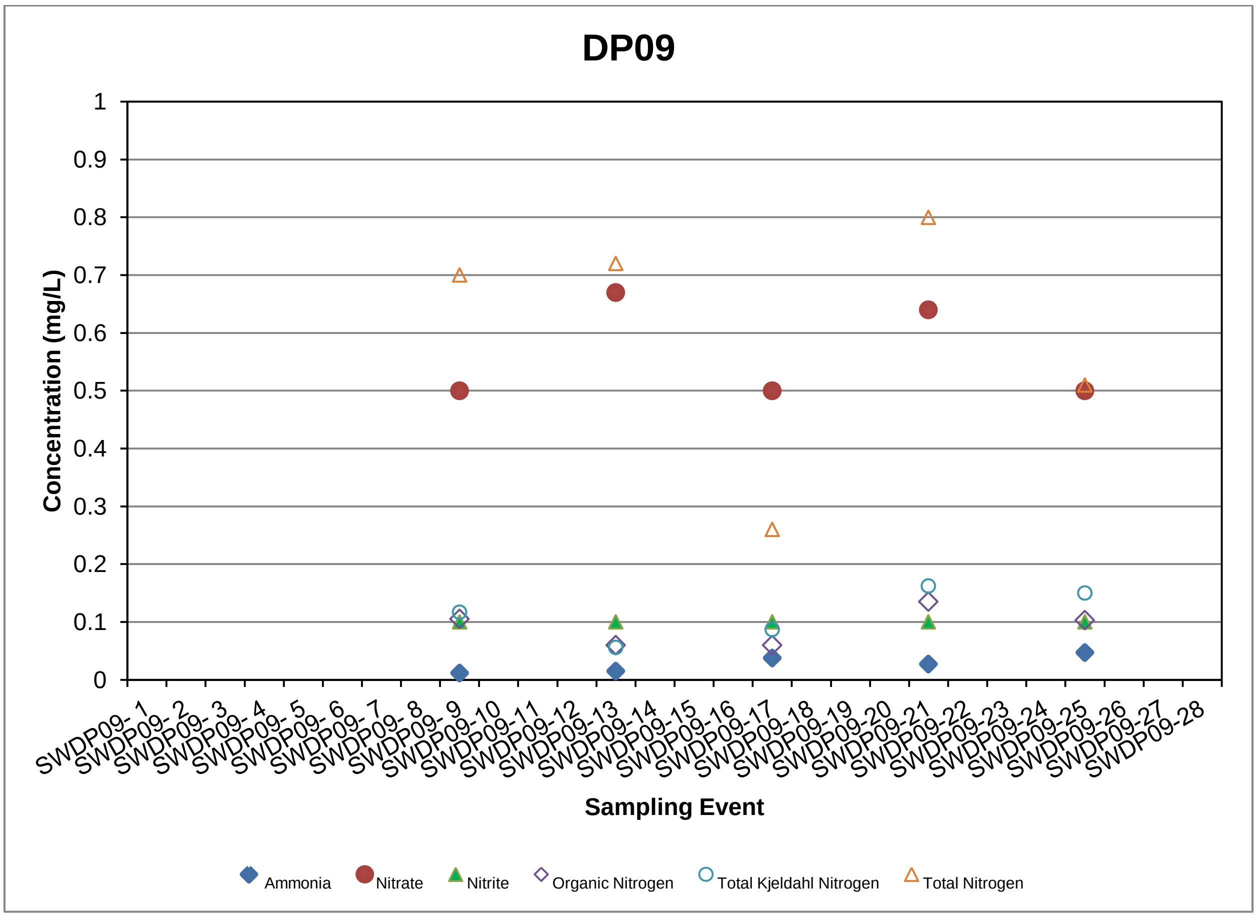


Figure 3-6 DP09 Surface Water Trend Plot for Phosphorus Parameters

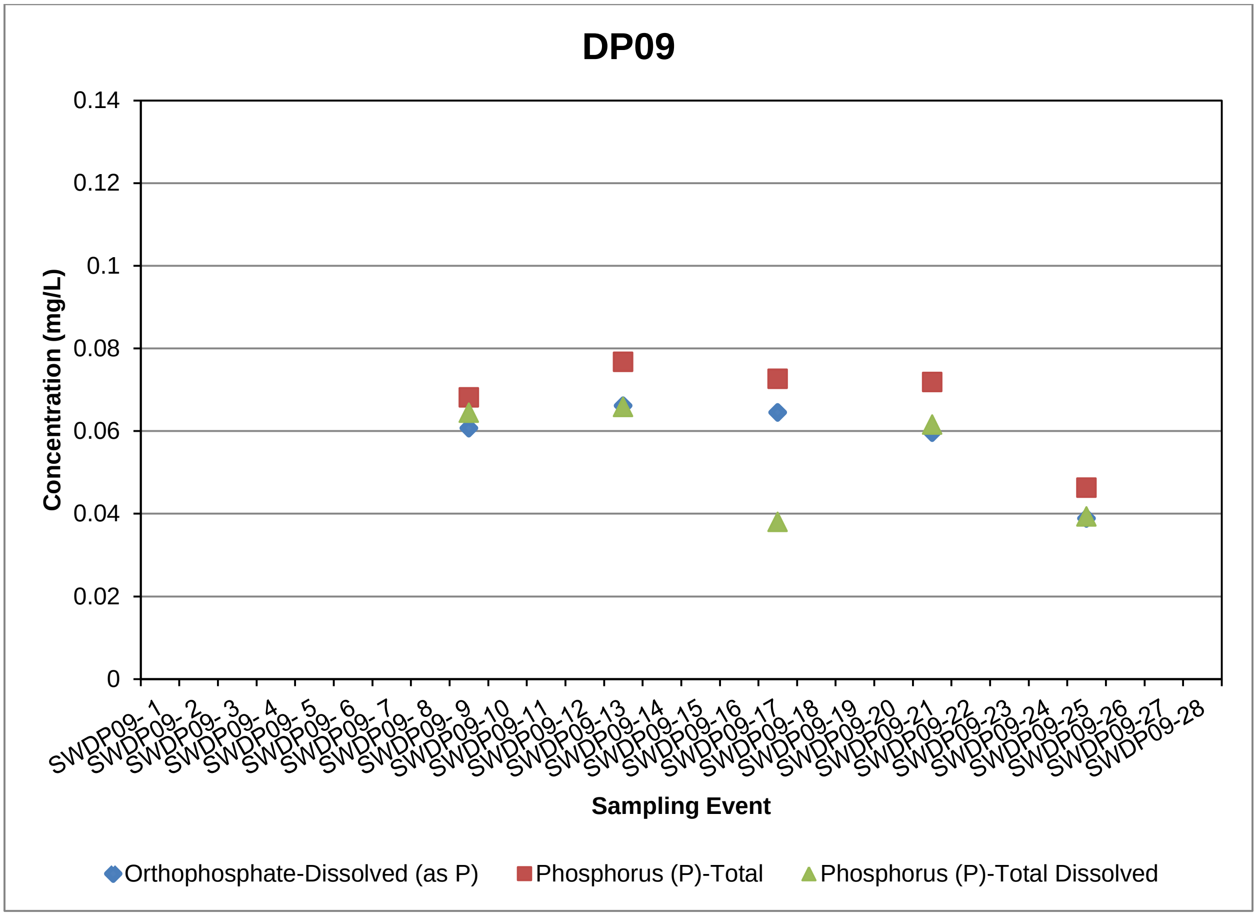


Figure 3-7 DP09 Sediment Trend Plot for Ammonium, Sulfide and TOC

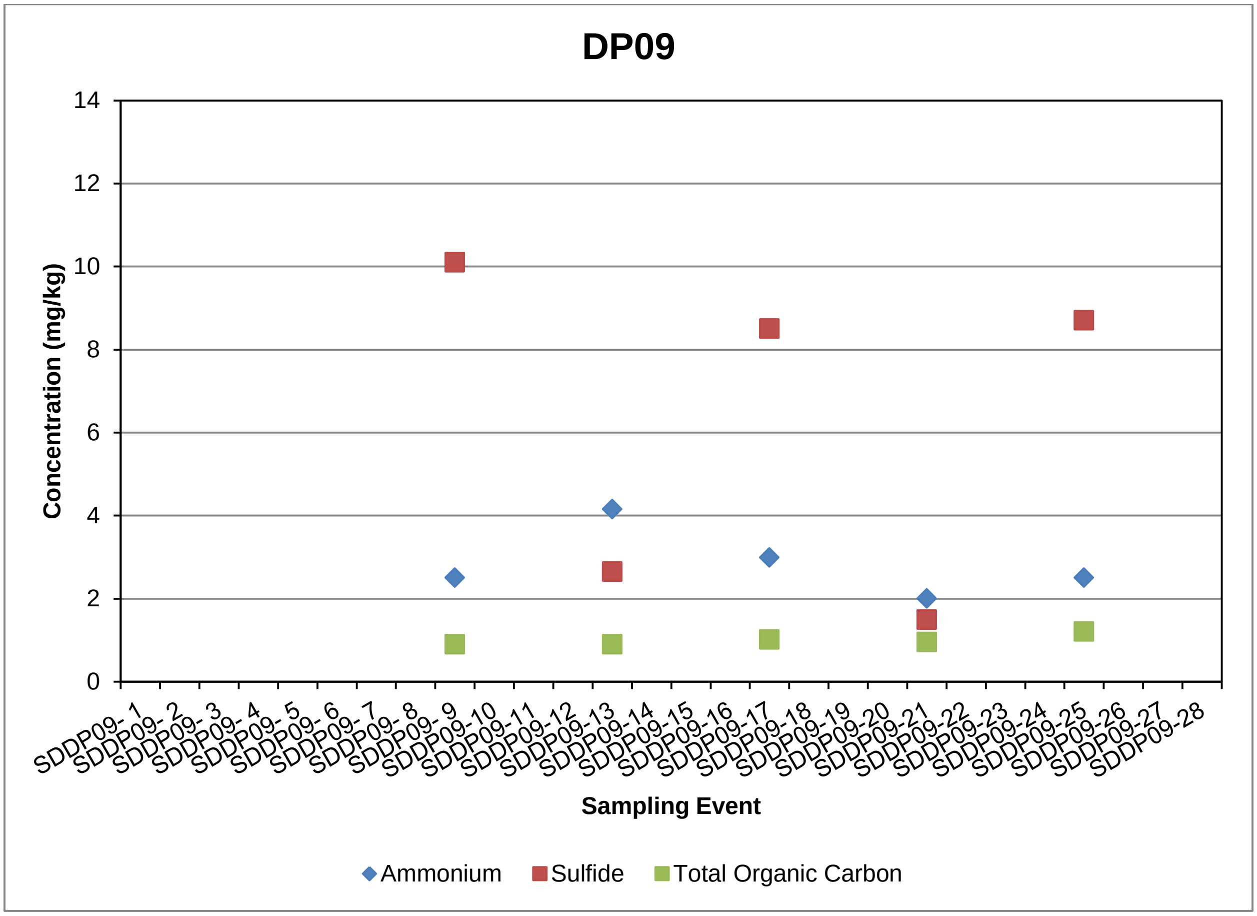


Figure 3-8 DP09 Sediment Trend Plot for Nitrogen Parameters

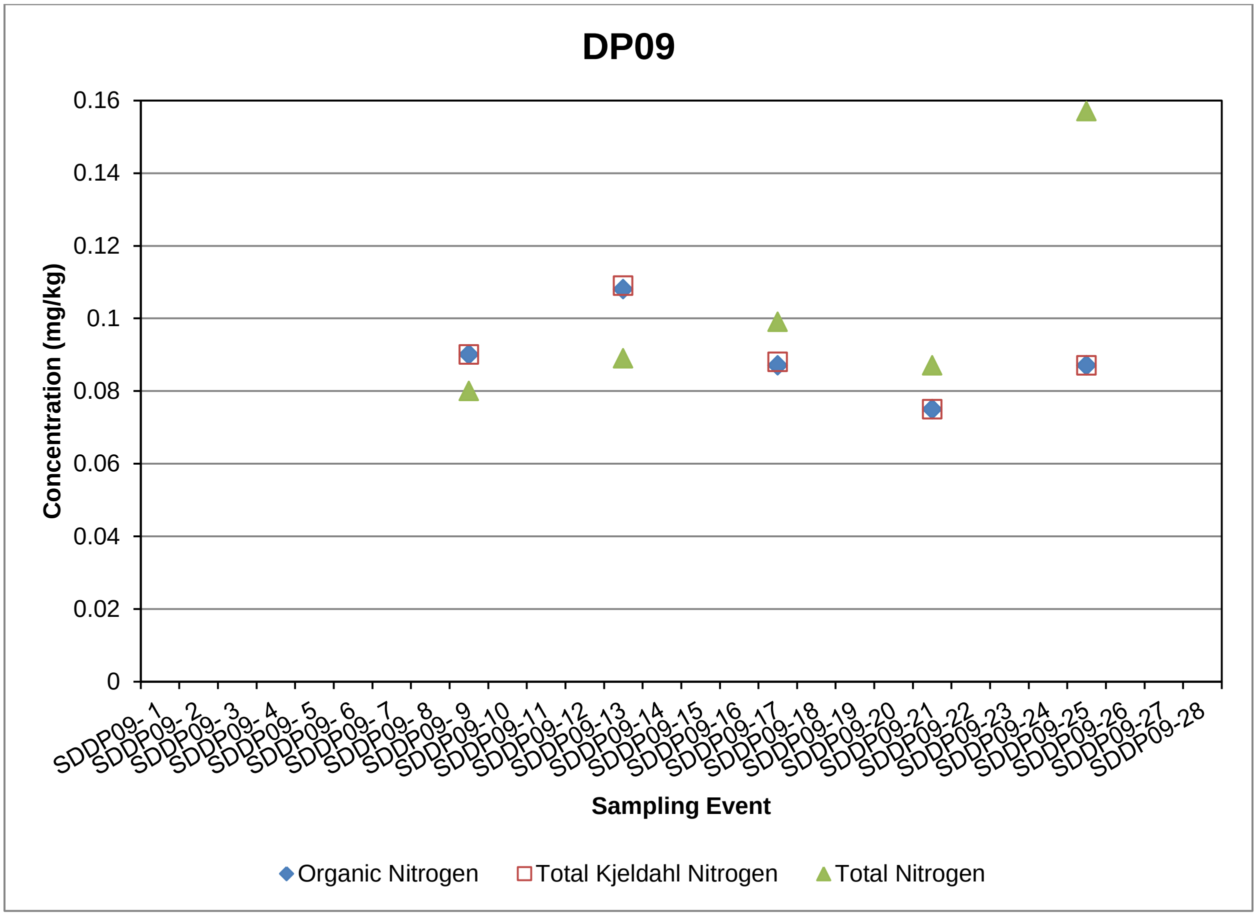
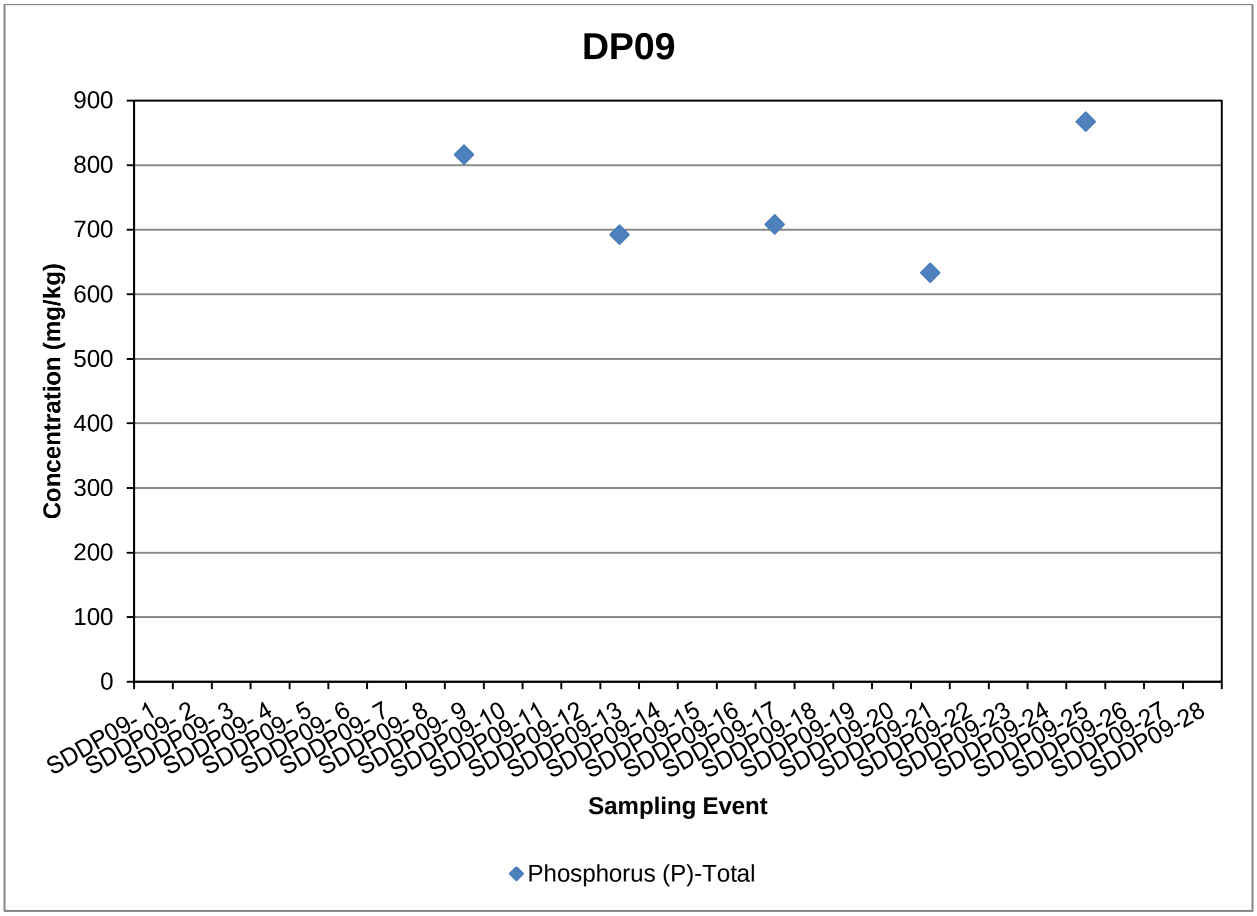


Figure 3-9 DP09 Sediment Trend Plot for Total Phosphorus



3.3.2 Stormwater Outfalls

The locations of stormwater outfalls was reviewed based on information provided by PMV. No new stormwater outfalls were constructed as part of DP3 and none discharge directly into the AOEL. The closest locations are two outfalls along the Deltaport causeway as shown in **Figure 3-10** below. There is a relatively small volume of stormwater runoff compared to the large volume of water that is exchanged during a typical daily tide cycle. Also, the freshwater inputs from rain falling directly on the tidal flats (or tidal waters covering the tidal flats) would dilute the relative input of direct stormwater runoff by a factor of more than ten to one. Furthermore, the density difference between freshwater from atmospheric precipitation and saline marine waters would favour evacuation of the stormwater runoff to the open waters of the Strait of Georgia rather than accumulation within the AOEL.

Figure 3-10 Location of stormwater outfalls along the Delataport causeway.

3.3.3 Acid Rock Drainage

Minerals present in the rock installed around the perimeter of the DP3 footprint and used to construct the tug basin rock berm could be reacting with seawater to result in negative water quality indicators. Of greatest concern are metals leaching (ML) and the production of minerals that could result in acidification (ex. low pH) of the receiving waters (acid rock drainage or ARD). We could find no conclusive information regarding the source of the rock, although the assumption is that the rock was sourced from one of a number of quarries on Texada Island. Given the varied geology of the Texada Island quarries, it was not possible to conclusively rule out ML or ARD, nor did this issue appear to have been specifically addressed in the EA study for DP3 (DFO and EC, 2006).

In the absence of information that would indicate whether the existing riprap has the potential to generate ARD or ML, the study relies on indications of these issues from the field data. Analytical results from the AMS program do not indicate increasing concentrations of metals, or decreasing pH, in the intercauseway stations (Hemmera 2013). In addition, the data collected as part of this work at stations in this study as discussed below do not indicate ARD or ML conditions. Furthermore, the twice daily exchange of tidal water would tend to dilute the effect of ARD or ML from the riprap if it was present.

3.4 Surface Water & Sediment

3.4.1 Surface Water Quality – June & September

Figure 1 presents the surface water analytical results for the four stations collected in June and September 2013 at the same time as AMS quarterly monitoring program. The data for DP9 collected as part of the AMS is also provided on **Figure 1**. The data from the June and September surveys is provided on **Table 1**. Laboratory reports are provided as **Attachment #3**.

A review of the data presented on **Figure 1** indicates:

- Field parameters (dissolved oxygen, pH, redox, temperature, turbidity) are not notably different between station RB-10-1 (area of continuous eelgrass) and stations DP10 & DP11 (area of patchy eelgrass) located within the AOEL.
- Temperature was 2 degrees different between the surface and bottom samples at DP10 & DP11 whereas RB-10-1 had no difference in temperature between the surface and bottom samples during the June event. This indicates more stratification of temperature at locations DP10 & DP11 within the AOEL during this event.
- No discernable overall spatial trend for ammonium and nitrogen parameters analysed.
- Chlorophyll *a* concentrations, when comparing samples collected 0.5 m from mudflat bottom, are generally lower at DP09 (no eelgrass present) and higher at DP11 in the AOEL and RB-10-1 outside of the AOEL within continuous eelgrass.
- Notable higher concentrations (>50% difference) in deep samples (B) than shallow samples (A) for TSS, chlorophyll *a*, and total phosphorus at all stations sampled in June and at some stations for some parameters in September regardless of whether within the AOEL or outside of it.

It is noted that samples collected in June and September were at different tide stages (rising tide vs near high tide) which may influence observed concentrations (discussed in **Section 3.4.4)**.

3.4.2 Sediment Quality – June & September

Figure 2 presents the sediment analytical results for the four stations collected in June and September 2013 along with DP9 data from the AMS program. The data from the June and September 2013 surveys is provided on **Table 2** and laboratory reports are provided in **Attachment #3**.

A review of the data presented on **Figure 2** indicates:

- Higher negative ORP at RB-10-1 (continuous eelgrass) than the stations within AOEL and with no eelgrass present.
- Lower ammonium at DP09 (no eelgrass) then the other stations but no notable difference between stations with in the AOEL and the station in continuous eelgrass.

- Lowest sulphide at DP09 (no eelgrass) with highest sulphide concentrations at DP10 in the AOEL. Sulphide concentrations at DP10, DP11 and RB-10-1 all located behind the tug basin are higher than those measured in the intercauseway area as part of the AMS program (sulphide concentrations <100 ppm).
- Higher TOC, TKN, total nitrogen and organic nitrogen at DP10 (within AOEL) then DP11 (within AOEL) and RB-10-1 (outside AOEL in continuous eelgrass).
- Lower total phosphorus concentrations at RB-10-1 (continuous eelgrass) then at DP10 & 11 within the AOEL.

3.4.3 Field Parameter Profiles – June & September

Figure 3 presents the field measurements profiles for temperature, pH, salinity and dissolved oxygen collected in June & September at the same time as the AMS quarterly monitoring program.

A review of the data presented on **Figure 3** indicates:

- Stations DP09, DP10, DP11 and RB-10-1 have similar profiles for June & September events except for salinity and temperature in June (see next bullet).
- The June data indicates greater range of salinity at DP10 & DP11 (19 to 28 psu) within the AOEL then DP09 and RB-10-1 (24 to 28 psu). This indicates more stratification, possibly related to ponding of water, at DP10 and DP11 in the AOEL.
- The September profiles indicate slight increases in salinity (26 to 28 psu) with depth. The difference is salinity profiles between June and September is likely a function of the profile in September collected near high tide and/or the influence of the Fraser River freshet in June.
- Temperature profiles for June show 2 to 4 degrees difference between surface temperature and depth with an increase in temperature at the bottom of the water column noted at DP09, DP10 and DP11 but not at RB10-1. The profiles indicate greater stratification and differences in temperature at DP10 & DP11 in the AOEL.
- Dissolved oxygen increases with depth at all stations during the June event while dissolved oxygen concentrations are higher in September but slightly decreases with depth (likely due to data take at high tide or time of year). All stations have a similar profile.
- pH did not vary much with location or depth and less than 1 unit difference between June and September.

3.4.4 Surface Water Quality - Summer Tidal Event

Figure 4 provides a summary of the surface water results collected during the July 22, 2013 tidal event and **Table 4** presents the analytical data collected this event. Laboratory reports are provided as **Attachment #3**.

A review of the data indicates:

Phosphorus (dissolved, ortho and total)

- During the falling tide (9 am), DP10 in AOEL had the lowest ortho phosphate, dissolved phosphorus and total phosphorus concentrations while DP09 (no eelgrass) had the highest concentrations.
- Total phosphorus was the highest at DP11 in the AOEL at 1 pm before to water moved into this area due to rising tide.
- Concentrations were generally similar at high tide (7 pm) at all stations except for total phosphorus at RB-10-1 located outside of the AOEL in continuous eelgrass (note that the TSS and turbidity was high in this sample likely resulting in higher total phosphorus concentration due entrained solids).

Nitrogen (ammonia, nitrate, nitrite, total, TKN, organic)

- During the falling tide (9 am), DP10 had the lowest concentrations of ammonia while DP11 had the highest concentrations. Ammonia at DP11 decreased during the tidal cycle. Both of these locations are in the AOEL.
- Ammonia concentrations did fluctuate over the tide cycle with higher concentrations in the AOEL (DP10 & DP11) and less than detection at DP04 and RB-10-1 during the rising tide (4 pm).
- Organic nitrogen and TKN did not vary notably between stations or over the tide cycle.
- Nitrate, nitrite and total nitrogen were below analytical detection limits in all samples analysed.

Chlorophyll *a*

- During the falling tide (9 am), DP10 had the highest concentrations of chlorophyll *a* while DP04 had the lowest concentrations. DP10 decreased in concentration over the tide cycle while DP11 increased. Both DP10 & DP11 are within the AOEL.
- The lowest chlorophyll *a* concentration during the event was at DP11 in the AOEL at 1 pm just before the water returned to this area due to rising tide.

3.4.5 Field Parameter Profiles – Summer Tidal Event

Profiles by depth and by time for each station (tug basing, DP04, DP09, DP10, DP11 and RB-10-1) of field measurements (temperature, pH, salinity, dissolved oxygen and ORP) collected during the summer tidal event are provided in **Attachments #1** and **#2** respectively.

A summary of the data is provided below.

- All stations had no difference in **pH** measurements with depth and little difference with time (approximately 0.5 units). pH appears to increase slightly with incoming tide and then decrease by high tide (example pH around 8 on rising tide and around 7.7 high tide). All stations had similar pH readings with the tug basin generally having the lowest and DP04 having the highest.

- All stations had no difference in **ORP** measurements with depth except the two within the AOEL: DP10 had decreasing ORP near the bed during rising and high tide and DP11 had decreasing ORP near the bed at low tide and start of rising tide. All stations showed a difference in ORP readings with time (i.e tide stage) with ORP measurements the highest during falling tide (approximately 300 mV) and lowest near high tide (approximately 150 mV).
- All stations had variation in **salinity** with depth (5 to 10 psu). These variations with depth appear to be less at high tide and salinity readings are higher at high tide at all stations. DP10 and DP11 within the AOEL appear to have more variation in salinity measurements with depth than other stations.
- Only DP04 had no variation in **temperature** with depth which is not located behind the tug basin. Most stations showed decreasing temperature with depth on each time profile except DP09 and DP10 which showed increasing temperature with depth (2 to 4 degrees) near 2 pm (approximately 2 hrs after low tide) and likely reflect the incoming water being warmed by the tidal flats that have been exposed to the sun during low tide. All stations had the pattern of water temperature increasing between falling tide, low tide and initial stage of rising tide but then decreasing during the remaining rising tide and a high tide. Most stations had a variation of up to 10 degrees over the tidal cycle. All stations had similar temperature readings at high tide (approximately 13 degrees) except DP04 (approximately 15.5 degrees).
- All stations had variations in **dissolved oxygen** with depth and tide stage. The tug basin had the least variation with depth. The profile measurements indicate low dissolved oxygen (<3 mg/L) below surface at DP11 in the AOEL immediately before low tide. However, dissolved oxygen appears to increase during the ponding stage at DP11 based on profile measurements. Dissolved oxygen one-time measurements taken during sample collection were the lowest at DP11 in the AOEL and DP11 had dissolved oxygen <3 mg/L at 9:48 am and 1:20 pm (**Figure 3**). **Figure 3-4** indicates the ponded area was still ponded at this time. All stations had similar dissolved oxygen readings at high tide (approximately 4 mg/L).

3.4.6 Overall Surface Water & Sediment Summary

An overall summary of the surface water and sediment data evaluated for this program is provided below:

- No notable differences in surface water field parameters or concentrations of nutrient parameters (ex. chlorophyll *a*, phosphorus, ammonia) in the AOEL versus the area outside in continuous eelgrass (RB-10-1) during the June and September events. During the July tidal event, ponded water at low tide in DP11 within the AOEL may have higher phosphorus parameters and lower chlorophyll *a* but mixes by high tide and concentrations are then same as other stations.
- Sulphide concentrations at DP10 and DP11 within the AOEL measured during the June and September events are an order of magnitude higher than the mean sulphide concentration of the intercauseway stations monitored as part of the AMS program and support the observation of strong sulphide smell during the snorkel survey of the eelgrass loss area. As discussed in **Section 3.2.3**, decomposition of the epiphytes that fall from the eelgrass onto the sediment surface can elevated sediment sulphide levels and impact eelgrass roots and impair growth. **Table 3-1** below presents the sulphide sediment data from June and September for the stations behind the tug basin and the closest AMS intercauseway station to the tug basin (DP04).

- Total phosphorus concentrations in sediment from the June event at DP10 and DP11 within the AOEL were also higher than the intercauseway area stations monitored as part of the AMS program and higher than RB-10-1 station (continuous eelgrass). The higher phosphorus levels in sediment within the ponded area are also thought to be related to the decomposition of epiphytes. Station DP10 also had higher TOC, TKN, total nitrogen and organic nitrogen concentrations and lower available phosphate in sediment then stations DP11 and RB-10-1. **Table 3-1** below presents the total phosphorus sediment data from June and September for the 4 stations behind the tug basin and the closest AMS intercauseway station to the tug basin.

Table 3-1 Summary of Sulphide and Phosphorus data in sediment for June & September, 2013

			Sulphide		Phosphorus	
	Station	**Eelgrass**	6/4/2013	9/24/2013	6/4/2013	9/24/2013
	DP04	Continuous	4	76	605	536
Behind Tug Basin	DP09	None	9.4	12	709	606
	DP10	Patchy	388	518	1020	710
	DP11	Patchy	239	304	901	630
	RB-10-1	Continuous	249	219	674	582

(1) All values are reported as µg/g unless otherwise noted

- The snapshot June event did indicate higher surface water temperatures than bottom temperatures within the AOEL (DP10 & DP11) during a rising tide. The summer tidal event indicated higher temperatures in the AOEL (DP10 & DP11) during ponding for a period of 2 to 3 hours. A plot of temperature readings at surface, mid and bottom at DP10 and DP11 collected on July 22nd are provided in **Figures 3-11** and 3**-12** below (lagged or ponded time is approximately from 11 am to 2 pm). In addition, the ponded water had low dissolved oxygen near the bed (<3 mg/L) during the July 22nd event. The low dissolved oxygen could be related to the decomposition of epiphytes and/or related to seasonal hypoxia.
- While other stations with and without eelgrass also showed higher temperature with low water column (DP09, DP10, RB-10-1), these stations have no or little water ponding. At high tide, the water quality is comparable to other stations indicating full mixing of the water column is occurring on a daily basis.

Figure 3-11 Temperature over time for DP10 within AOEL during July 22nd tidal monitoring event

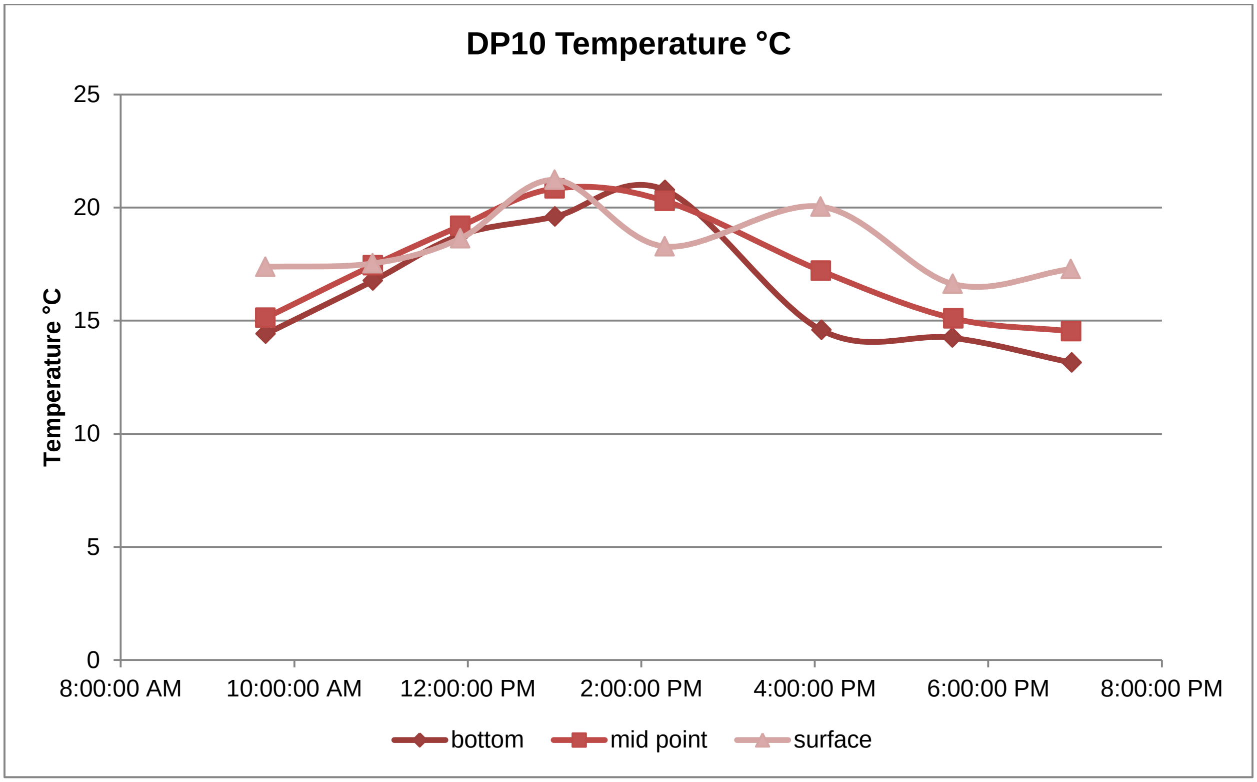
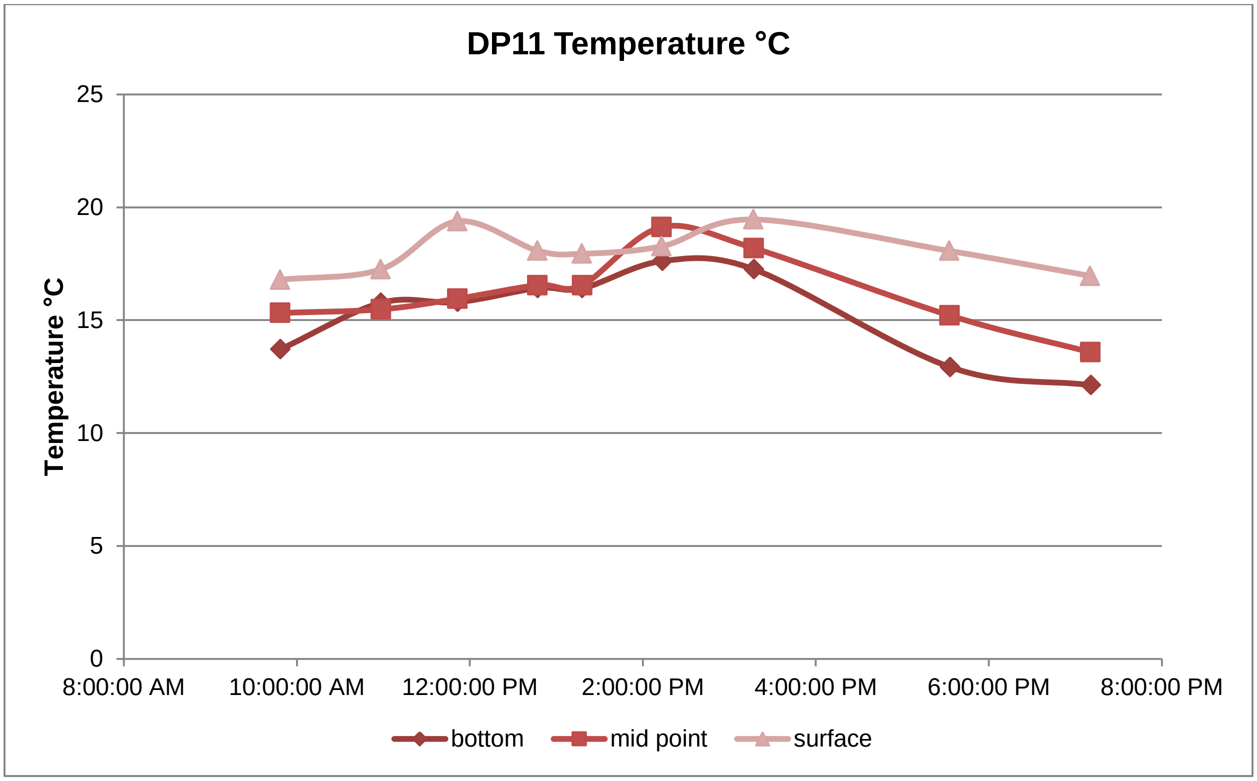


Figure 3-12 Temperature over time for DP11 within AOEL during July 22nd tidal monitoring event



4.0 DISCUSSION

The primary conclusions of the investigation to determine the cause of the AOEL behind the tug basin at DP3 are:

- The AOEL is directly ponded (i.e. does not drain at low tides).
- Drainage of the AOEL is blocked at tide heights below approximately 1 m (chart datum).
- There is a drainage lag between the tug basin and the AOEL.
- Prior to DP3 construction, the AOEL was free to drain to the Strait of Georgia.
- Epiphytic growth in the AOEL is considered extreme (given that young leaves typically not prone to epiphytic growth were encased in ephiphytes).
- The AOEL contains fine silty substrate with indications of anaerobic conditions (black colour, sulphide smell).
- Sulfide and phosphorous concentrations in the AOEL were elevated (in comparison to areas outside of the AOEL).
- Detected increased sulfide concentrations may explain observed sulfide smells during the snorkel survey within the AOEL; increased sulfide levels may be attributed to observed decaying eelgrass in the AOEL.
- High temperature and low dissolved oxygen levels were measured with the AOEL during the time of ponding over a tidal cycle with July
- Evidence collected from this study suggests reduced tidal flows and ponding water in the AOEL results in conditions unfavorable for eelgrass health.

5.0 RECOMMENDATIONS

Based on the above evidence and conclusions, effort to address (mitigate) ponding in the AOEL is likely warranted. Improved drainage of the AOEL will likely result in conditions more favorable for eelgrass health and recolonization.

We appreciate the opportunity to work with you on this project and trust that this work plan is satisfactory to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

Report prepared by:
Hemmera

DRAFT

Bonnie Marks, M.A.Sc., P.Eng., PMP
Senior Project Manager

Report prepared by:
NHC

DRAFT

Derek Ray, M.Sc., P.Geo.
Geomorphologist/Hydrologist

Precision Identification

DRAFT

Cynthia Durance, R.P.Bio.
Habitat Ecologist

Overall document review by:
Hemmera

DRAFT

Ben Wheeler, M.Sc., R.P.Bio.
Project Director / Senior Technical Reviewer

6.0 REFERENCES

DFO and EC, 2006. Deltaport Third Berth Expansion Project: Comprehensive Study Report. Report prepared by Fisheries and Oceans Canada and Environment Canada, 5 July 2006, 213 pp + appendices.

Hemmera, 2013. Deltaport Third Berth Adaptive Management Strategy 2012 Annual Report. Prepared by Hemmera NHC, and Precision, for Vancouver Fraser Port Authority, September 2013, 344pp.

Muehlstein L.K., D. Porter, and F.T. Short. 1988. *Labyrinthula* sp., a marine slime mold producing the symptoms of wasting disease in eelgrass, *Zostera marina*. Mar. Bio. 99; 465-472

Muehlstein L.K., D. Porter, and F.T. Short. 1991. *Labyrinthula zosterae* sp. nov., the causative agent of wasting disease of eelgrass, *Zostera marina*. Mycologia Vol. 83, No. 2:180-191.

Short, F.T., L.K. Muehlstein, and D. Porter. 1987. Eelgrass wasting disease: cause and recurrence of a marine epidemic. Biol. Bull. 173; 557-562.

Thom, R.M., A. B. Borde, S.L. Blanton, D.L. Woodruff, and G.D. Williams. 2001. The influence of climate variation and change on structure and processes in nearshore vegetated communities of Puget Sound and other Northwest estuaries. Proceedings of Puget Sound Research 2001.

7.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera Envirochem Inc., based on work conducted by the project team of Hemmera, Northwest Hydraulic Consultants (NHC) and Precision Identification (the Project Team) for the sole benefit and exclusive use of Vancouver Fraser Port Authority. The material in it reflects the Project Team's best judgment in light of the information available to it at the time of preparing this Report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. The members of the Project Team accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this Report.

The Project Team has performed the work as described above and made the findings and conclusions set out in this Report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

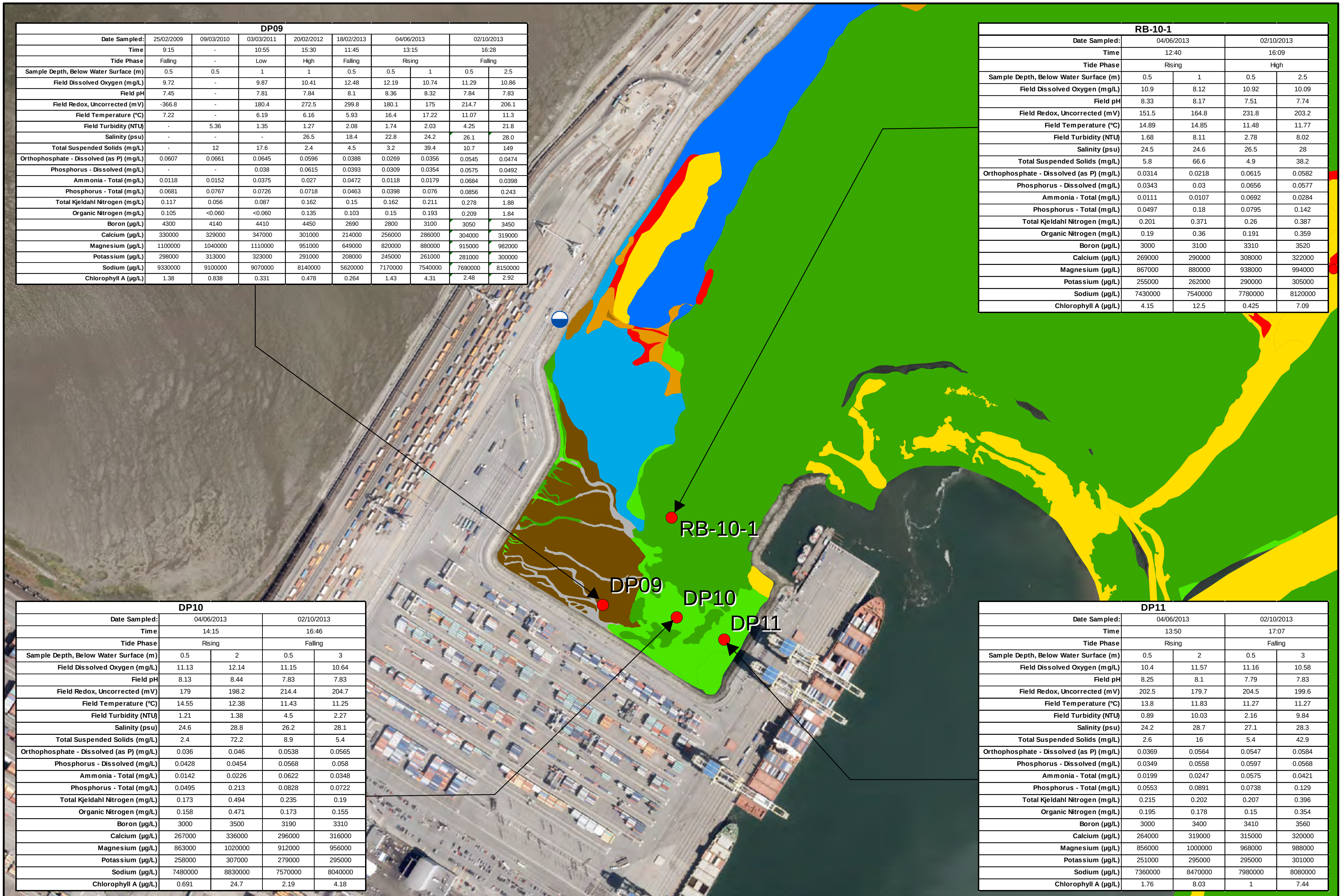
This Report represents a reasonable review of the information available to the Project Team within the established Scope, work schedule and budgetary constraints. It is possible that the levels of contamination or hazardous materials may vary across the Site, and hence currently unrecognised contamination or potentially hazardous materials may exist at the Site. No warranty, expressed or implied, is given concerning the presence or level of contamination on the Site, except as specifically noted in this Report. The conclusions and recommendations contained in this Report are based upon applicable legislation existing at the time the Report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the Report. Regulatory implications discussed in this Report were based on the applicable legislation existing at the time this Report was written.

In preparing this Report, the Project Team have relied in good faith on information provided by others as noted in this Report, and has assumed that the information provided by those individuals is both factual and accurate. The members of the Project Team accept no responsibility for any deficiency, mis-statement or inaccuracy in this Report resulting from the information provided by those individuals.

The liability of the members of the Project Team to Vancouver Fraser Port Authority shall be limited to injury or loss caused by the negligent acts of the Project Team. The total aggregate liability of Hemmera and the members of the Project Team related to this agreement shall not exceed the lesser of the actual damages incurred, or the total fee of the members of the Project Team for services rendered on this project.

FIGURES

Document Path: O:\475-499\499port\002\19\AMS_Y_4_to_6_SWSDB\mxd\140224_499-002.19_SWSDB_Fig01_Seawater.mxd



DP09									
Date Sampled:	25/02/2009	09/03/2010	03/03/2011	20/02/2012	18/02/2013	04/06/2013		02/10/2013	
Time	9:15	-	10:55	15:30	11:45	13:15		16:28	
Tide Phase	Falling	-	Low	High	Falling	Rising		Falling	
Sample Depth, Below Water Surface (m)	0.5	0.5	1	1	0.5	0.5	1	0.5	2.5
Field Dissolved Oxygen (mg/L)	9.72	-	9.87	10.41	12.48	12.19	10.74	11.29	10.86
Field pH	7.45	-	7.81	7.84	8.1	8.36	8.32	7.84	7.83
Field Redox, Uncorrected (mV)	-366.8	-	180.4	272.5	299.8	180.1	175	214.7	206.1
Field Temperature (ºC)	7.22	-	6.19	6.16	5.93	16.4	17.22	11.07	11.3
Field Turbidity (NTU)	-	5.36	1.35	1.27	2.08	1.74	2.03	4.25	21.8
Salinity (psu)	-	-	-	26.5	18.4	22.8	24.2	26.1	28.0
Total Suspended Solids (mg/L)	-	12	17.6	2.4	4.5	3.2	39.4	10.7	149
Orthophosphate - Dissolved (as P) (mg/L)	0.0607	0.0661	0.0645	0.0596	0.0388	0.0269	0.0356	0.0545	0.0474
Phosphorus - Dissolved (mg/L)	-	-	0.038	0.0615	0.0393	0.0309	0.0354	0.0575	0.0492
Ammonia - Total (mg/L)	0.0118	0.0152	0.0375	0.027	0.0472	0.0118	0.0179	0.0684	0.0398
Phosphorus - Total (mg/L)	0.0681	0.0767	0.0726	0.0718	0.0463	0.0398	0.076	0.0856	0.243
Total Kjeldahl Nitrogen (mg/L)	0.117	0.056	0.087	0.162	0.15	0.162	0.211	0.278	1.88
Organic Nitrogen (mg/L)	0.105	<0.060	<0.060	0.135	0.103	0.15	0.193	0.209	1.84
Boron (µg/L)	4300	4140	4410	4450	2690	2800	3100	3050	3450
Calcium (µg/L)	330000	329000	347000	301000	214000	256000	286000	304000	319000
Magnesium (µg/L)	1100000	1040000	1110000	951000	649000	820000	880000	915000	982000
Potassium (µg/L)	298000	313000	323000	291000	208000	245000	261000	281000	300000
Sodium (µg/L)	9330000	9100000	9070000	8140000	5620000	7170000	7540000	7690000	8150000
Chlorophyll A (µg/L)	1.38	0.838	0.331	0.478	0.264	1.43	4.31	2.48	2.92

RB-10-1				
Date Sampled:	04/06/2013		02/10/2013	
Time	12:40		16:09	
Tide Phase	Rising		High	
Sample Depth, Below Water Surface (m)	0.5	1	0.5	2.5
Field Dissolved Oxygen (mg/L)	10.9	8.12	10.92	10.09
Field pH	8.33	8.17	7.51	7.74
Field Redox, Uncorrected (mV)	151.5	164.8	231.8	203.2
Field Temperature (ºC)	14.89	14.85	11.48	11.77
Field Turbidity (NTU)	1.68	8.11	2.78	8.02
Salinity (psu)	24.5	24.6	26.5	28
Total Suspended Solids (mg/L)	5.8	66.6	4.9	38.2
Orthophosphate - Dissolved (as P) (mg/L)	0.0314	0.0218	0.0615	0.0582
Phosphorus - Dissolved (mg/L)	0.0343	0.03	0.0656	0.0577
Ammonia - Total (mg/L)	0.0111	0.0107	0.0692	0.0284
Phosphorus - Total (mg/L)	0.0497	0.18	0.0795	0.142
Total Kjeldahl Nitrogen (mg/L)	0.201	0.371	0.26	0.387
Organic Nitrogen (mg/L)	0.19	0.36	0.191	0.359
Boron (µg/L)	3000	3100	3310	3520
Calcium (µg/L)	269000	290000	308000	322000
Magnesium (µg/L)	867000	880000	938000	994000
Potassium (µg/L)	255000	262000	290000	305000
Sodium (µg/L)	7430000	7540000	7780000	8120000
Chlorophyll A (µg/L)	4.15	12.5	0.425	7.09

DP10				
Date Sampled:	04/06/2013		02/10/2013	
Time	14:15		16:46	
Tide Phase	Rising		Falling	
Sample Depth, Below Water Surface (m)	0.5	2	0.5	3
Field Dissolved Oxygen (mg/L)	11.13	12.14	11.15	10.64
Field pH	8.13	8.44	7.83	7.83
Field Redox, Uncorrected (mV)	179	198.2	214.4	204.7
Field Temperature (ºC)	14.55	12.38	11.43	11.25
Field Turbidity (NTU)	1.21	1.38	4.5	2.27
Salinity (psu)	24.6	28.8	26.2	28.1
Total Suspended Solids (mg/L)	2.4	72.2	8.9	5.4
Orthophosphate - Dissolved (as P) (mg/L)	0.036	0.046	0.0538	0.0565
Phosphorus - Dissolved (mg/L)	0.0428	0.0454	0.0568	0.058
Ammonia - Total (mg/L)	0.0142	0.0226	0.0622	0.0348
Phosphorus - Total (mg/L)	0.0495	0.213	0.0828	0.0722
Total Kjeldahl Nitrogen (mg/L)	0.173	0.494	0.235	0.19
Organic Nitrogen (mg/L)	0.158	0.471	0.173	0.155
Boron (µg/L)	3000	3500	3190	3310
Calcium (µg/L)	267000	336000	296000	316000
Magnesium (µg/L)	863000	1020000	912000	956000
Potassium (µg/L)	258000	307000	279000	295000
Sodium (µg/L)	7480000	8830000	7570000	8040000
Chlorophyll A (µg/L)	0.691	24.7	2.19	4.18

DP11				
Date Sampled:	04/06/2013		02/10/2013	
Time	13:50		17:07	
Tide Phase	Rising		Falling	
Sample Depth, Below Water Surface (m)	0.5	2	0.5	3
Field Dissolved Oxygen (mg/L)	10.4	11.57	11.16	10.58
Field pH	8.25	8.1	7.79	7.83
Field Redox, Uncorrected (mV)	202.5	179.7	204.5	199.6
Field Temperature (ºC)	13.8	11.83	11.27	11.27
Field Turbidity (NTU)	0.89	10.03	2.16	9.84
Salinity (psu)	24.2	28.7	27.1	28.3
Total Suspended Solids (mg/L)	2.6	16	5.4	42.9
Orthophosphate - Dissolved (as P) (mg/L)	0.0369	0.0564	0.0547	0.0584
Phosphorus - Dissolved (mg/L)	0.0349	0.0558	0.0597	0.0568
Ammonia - Total (mg/L)	0.0199	0.0247	0.0575	0.0421
Phosphorus - Total (mg/L)	0.0553	0.0891	0.0738	0.129
Total Kjeldahl Nitrogen (mg/L)	0.215	0.202	0.207	0.396
Organic Nitrogen (mg/L)	0.195	0.178	0.15	0.354
Boron (µg/L)	3000	3400	3410	3560
Calcium (µg/L)	264000	319000	315000	320000
Magnesium (µg/L)	856000	1000000	968000	988000
Potassium (µg/L)	251000	295000	295000	301000
Sodium (µg/L)	7360000	8470000	7980000	8080000
Chlorophyll A (µg/L)	1.76	8.03	1	7.44

Sampling Locations
Storm Sewer Outfall

Eelgrass 2012
Sand
Z mix continuous
Z mix patchy
Zj continuous
Zj patchy
Zm continuous
Zm patchy
Mud
Chan sand

N
0 25 50 75 100 125 150
Meters
NAD 1983 UTM Zone 10N

PORT METRO vancouver

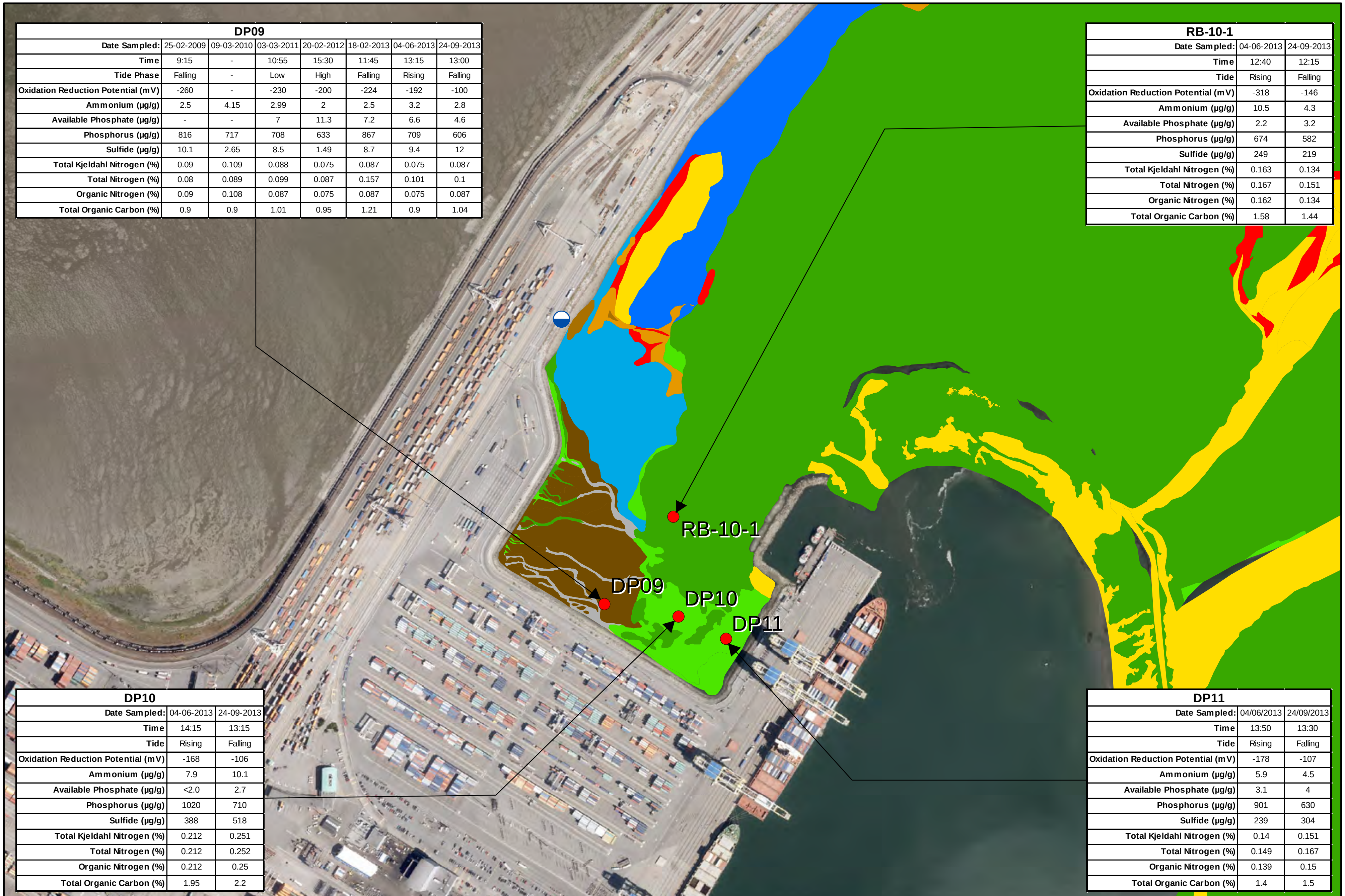
HEMMERA

Tug Basin Eelgrass Loss Assessment

Seawater Analytical Results Summary

Delta Port Third Birth AMS | Date: 2/26/2014 | Figure 1

Document Path: O:\475-499\499port\002\19AMS_Y_4_to_6_SWSDB\mxd\140224_499-002.19_SWSDB_Fig02_Sediment.mxd



DP09

Date Sampled:	25-02-2009	09-03-2010	03-03-2011	20-02-2012	18-02-2013	04-06-2013	24-09-2013
Time	9:15	-	10:55	15:30	11:45	13:15	13:00
Tide Phase	Falling	-	Low	High	Falling	Rising	Falling
Oxidation Reduction Potential (mV)	-260	-	-230	-200	-224	-192	-100
Ammonium (µg/g)	2.5	4.15	2.99	2	2.5	3.2	2.8
Available Phosphate (µg/g)	-	-	7	11.3	7.2	6.6	4.6
Phosphorus (µg/g)	816	717	708	633	867	709	606
Sulfide (µg/g)	10.1	2.65	8.5	1.49	8.7	9.4	12
Total Kjeldahl Nitrogen (%)	0.09	0.109	0.088	0.075	0.087	0.075	0.087
Total Nitrogen (%)	0.08	0.089	0.099	0.087	0.157	0.101	0.1
Organic Nitrogen (%)	0.09	0.108	0.087	0.075	0.087	0.075	0.087
Total Organic Carbon (%)	0.9	0.9	1.01	0.95	1.21	0.9	1.04

RB-10-1

Date Sampled:	04-06-2013	24-09-2013
Time	12:40	12:15
Tide	Rising	Falling
Oxidation Reduction Potential (mV)	-318	-146
Ammonium (µg/g)	10.5	4.3
Available Phosphate (µg/g)	2.2	3.2
Phosphorus (µg/g)	674	582
Sulfide (µg/g)	249	219
Total Kjeldahl Nitrogen (%)	0.163	0.134
Total Nitrogen (%)	0.167	0.151
Organic Nitrogen (%)	0.162	0.134
Total Organic Carbon (%)	1.58	1.44

DP10

Date Sampled:	04-06-2013	24-09-2013
Time	14:15	13:15
Tide	Rising	Falling
Oxidation Reduction Potential (mV)	-168	-106
Ammonium (µg/g)	7.9	10.1
Available Phosphate (µg/g)	<2.0	2.7
Phosphorus (µg/g)	1020	710
Sulfide (µg/g)	388	518
Total Kjeldahl Nitrogen (%)	0.212	0.251
Total Nitrogen (%)	0.212	0.252
Organic Nitrogen (%)	0.212	0.25
Total Organic Carbon (%)	1.95	2.2

DP11

Date Sampled:	04/06/2013	24/09/2013
Time	13:50	13:30
Tide	Rising	Falling
Oxidation Reduction Potential (mV)	-178	-107
Ammonium (µg/g)	5.9	4.5
Available Phosphate (µg/g)	3.1	4
Phosphorus (µg/g)	901	630
Sulfide (µg/g)	239	304
Total Kjeldahl Nitrogen (%)	0.14	0.151
Total Nitrogen (%)	0.149	0.167
Organic Nitrogen (%)	0.139	0.15
Total Organic Carbon (%)	1.4	1.5

PORT METRO vancouver

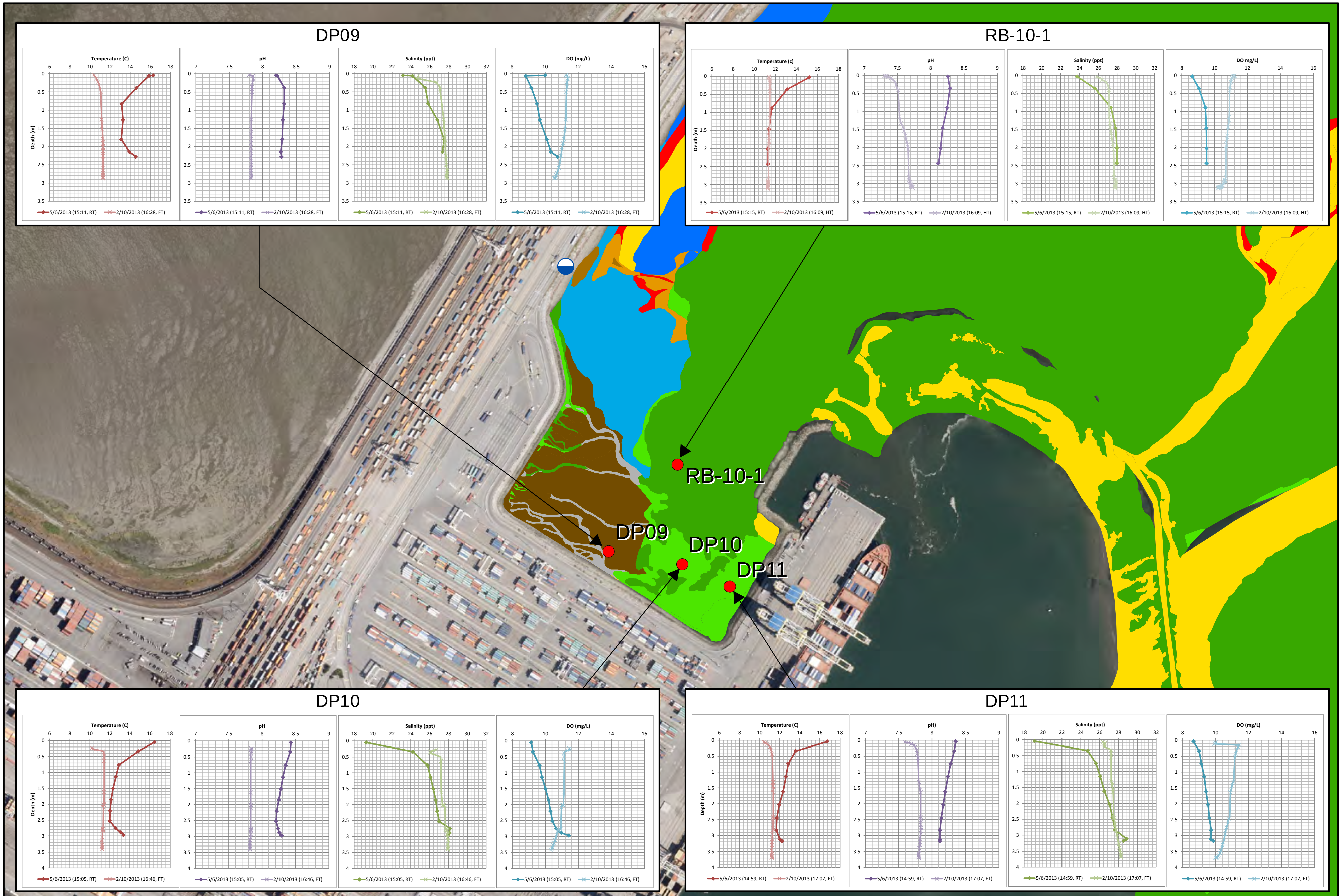
HEMMERA

Tug Basin Eelgrass Loss Assessment

Sediment Analytical Results Summary

Delta Port Third Birth AMS | Date: 2/26/2014 | Figure 2

Document Path: O:\475-499\499port\002\19\AMS_Y_4_to_6_SWSDB\mxd\140224_499-002.19_SWSDB_Fig03_SeawaterProfile1.mxd



● Sampling Locations
◒ Storm Sewer Outfall

RT = Rising Tide
FT = Falling Tide
HT = High Tide
LT = Low Tide

Eelgrass 2012
- Sand
- Z mix continuous
- Z mix patchy
- Zj continuous
- Zj patchy
- Zm continuous
- Zm patchy
- Mud
- Chan sand

N

0 25 50 75 100 125 150
Meters

NAD 1983 UTM Zone 10N

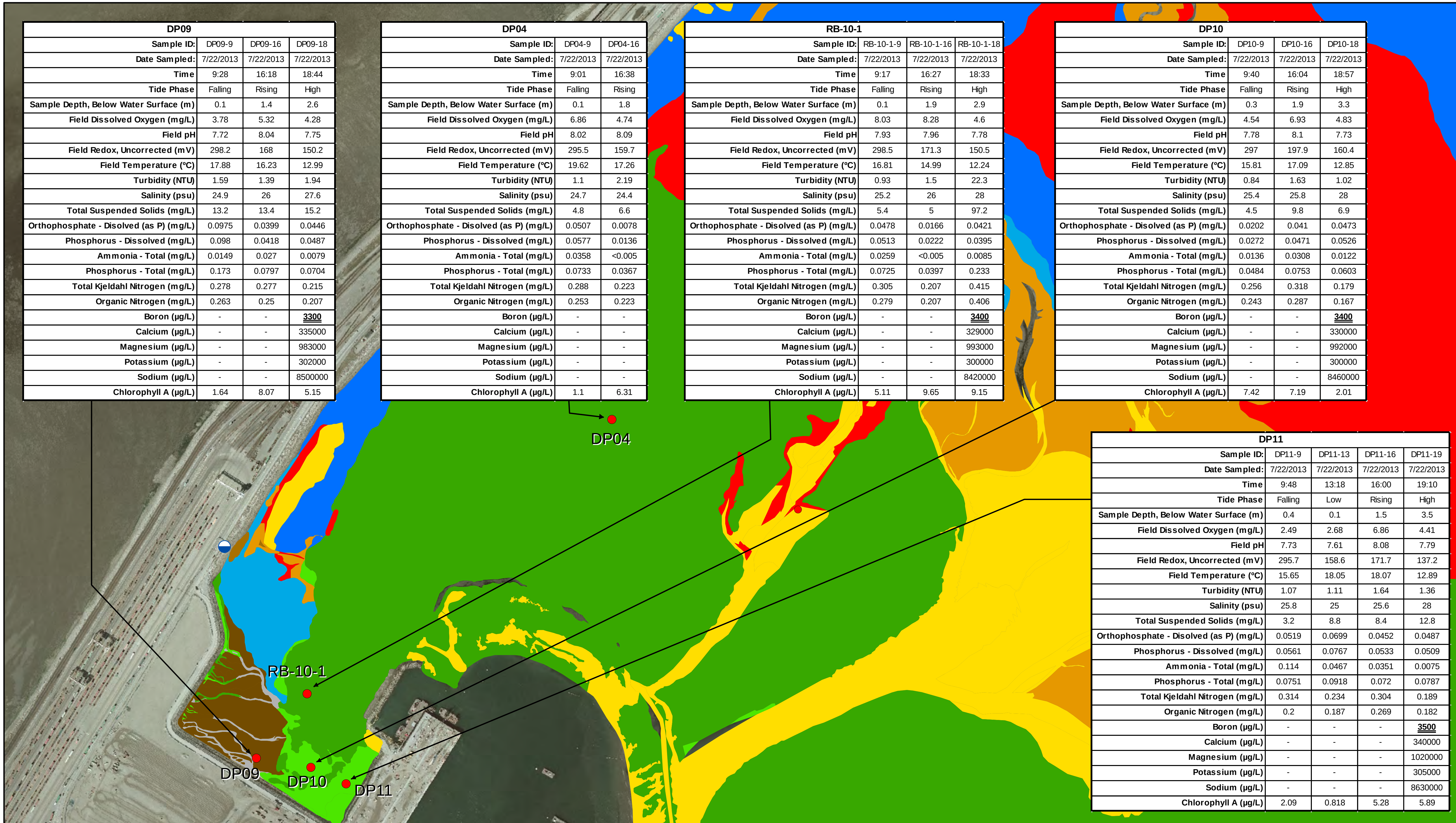
PORT METRO vancouver

HEMMERA

Tug Basin Eelgrass Loss Assessment

Seawater Profiles with Depth

Delta Port Third Birth AMS | Date: 2/24/2014 | Figure 3



DP09

Sample ID:	DP09-9	DP09-16	DP09-18
Date Sampled:	7/22/2013	7/22/2013	7/22/2013
Time	9:28	16:18	18:44
Tide Phase	Falling	Rising	High
Sample Depth, Below Water Surface (m)	0.1	1.4	2.6
Field Dissolved Oxygen (mg/L)	3.78	5.32	4.28
Field pH	7.72	8.04	7.75
Field Redox, Uncorrected (mV)	298.2	168	150.2
Field Temperature (°C)	17.88	16.23	12.99
Turbidity (NTU)	1.59	1.39	1.94
Salinity (psu)	24.9	26	27.6
Total Suspended Solids (mg/L)	13.2	13.4	15.2
Orthophosphate - Disolved (as P) (mg/L)	0.0975	0.0399	0.0446
Phosphorus - Dissolved (mg/L)	0.098	0.0418	0.0487
Ammonia - Total (mg/L)	0.0149	0.027	0.0079
Phosphorus - Total (mg/L)	0.173	0.0797	0.0704
Total Kjeldahl Nitrogen (mg/L)	0.278	0.277	0.215
Organic Nitrogen (mg/L)	0.263	0.25	0.207
Boron (µg/L)	-	-	<u>**3300**</u>
Calcium (µg/L)	-	-	335000
Magnesium (µg/L)	-	-	983000
Potassium (µg/L)	-	-	302000
Sodium (µg/L)	-	-	8500000
Chlorophyll A (µg/L)	1.64	8.07	5.15

DP04

Sample ID:	DP04-9	DP04-16
Date Sampled:	7/22/2013	7/22/2013
Time	9:01	16:38
Tide Phase	Falling	Rising
Sample Depth, Below Water Surface (m)	0.1	1.8
Field Dissolved Oxygen (mg/L)	6.86	4.74
Field pH	8.02	8.09
Field Redox, Uncorrected (mV)	295.5	159.7
Field Temperature (°C)	19.62	17.26
Turbidity (NTU)	1.1	2.19
Salinity (psu)	24.7	24.4
Total Suspended Solids (mg/L)	4.8	6.6
Orthophosphate - Disolved (as P) (mg/L)	0.0507	0.0078
Phosphorus - Dissolved (mg/L)	0.0577	0.0136
Ammonia - Total (mg/L)	0.0358	<0.005
Phosphorus - Total (mg/L)	0.0733	0.0367
Total Kjeldahl Nitrogen (mg/L)	0.288	0.223
Organic Nitrogen (mg/L)	0.253	0.223
Boron (µg/L)	-	-
Calcium (µg/L)	-	-
Magnesium (µg/L)	-	-
Potassium (µg/L)	-	-
Sodium (µg/L)	-	-
Chlorophyll A (µg/L)	1.1	6.31

RB-10-1

Sample ID:	RB-10-1-9	RB-10-1-16	RB-10-1-18
Date Sampled:	7/22/2013	7/22/2013	7/22/2013
Time	9:17	16:27	18:33
Tide Phase	Falling	Rising	High
Sample Depth, Below Water Surface (m)	0.1	1.9	2.9
Field Dissolved Oxygen (mg/L)	8.03	8.28	4.6
Field pH	7.93	7.96	7.78
Field Redox, Uncorrected (mV)	298.5	171.3	150.5
Field Temperature (°C)	16.81	14.99	12.24
Turbidity (NTU)	0.93	1.5	22.3
Salinity (psu)	25.2	26	28
Total Suspended Solids (mg/L)	5.4	5	97.2
Orthophosphate - Disolved (as P) (mg/L)	0.0478	0.0166	0.0421
Phosphorus - Dissolved (mg/L)	0.0513	0.0222	0.0395
Ammonia - Total (mg/L)	0.0259	<0.005	0.0085
Phosphorus - Total (mg/L)	0.0725	0.0397	0.233
Total Kjeldahl Nitrogen (mg/L)	0.305	0.207	0.415
Organic Nitrogen (mg/L)	0.279	0.207	0.406
Boron (µg/L)	-	-	<u>**3400**</u>
Calcium (µg/L)	-	-	329000
Magnesium (µg/L)	-	-	993000
Potassium (µg/L)	-	-	300000
Sodium (µg/L)	-	-	8420000
Chlorophyll A (µg/L)	5.11	9.65	9.15

DP10

Sample ID:	DP10-9	DP10-16	DP10-18
Date Sampled:	7/22/2013	7/22/2013	7/22/2013
Time	9:40	16:04	18:57
Tide Phase	Falling	Rising	High
Sample Depth, Below Water Surface (m)	0.3	1.9	3.3
Field Dissolved Oxygen (mg/L)	4.54	6.93	4.83
Field pH	7.78	8.1	7.73
Field Redox, Uncorrected (mV)	297	197.9	160.4
Field Temperature (°C)	15.81	17.09	12.85
Turbidity (NTU)	0.84	1.63	1.02
Salinity (psu)	25.4	25.8	28
Total Suspended Solids (mg/L)	4.5	9.8	6.9
Orthophosphate - Disolved (as P) (mg/L)	0.0202	0.041	0.0473
Phosphorus - Dissolved (mg/L)	0.0272	0.0471	0.0526
Ammonia - Total (mg/L)	0.0136	0.0308	0.0122
Phosphorus - Total (mg/L)	0.0484	0.0753	0.0603
Total Kjeldahl Nitrogen (mg/L)	0.256	0.318	0.179
Organic Nitrogen (mg/L)	0.243	0.287	0.167
Boron (µg/L)	-	-	<u>**3400**</u>
Calcium (µg/L)	-	-	330000
Magnesium (µg/L)	-	-	992000
Potassium (µg/L)	-	-	300000
Sodium (µg/L)	-	-	8460000
Chlorophyll A (µg/L)	7.42	7.19	2.01

DP11

Sample ID:	DP11-9	DP11-13	DP11-16	DP11-19
Date Sampled:	7/22/2013	7/22/2013	7/22/2013	7/22/2013
Time	9:48	13:18	16:00	19:10
Tide Phase	Falling	Low	Rising	High
Sample Depth, Below Water Surface (m)	0.4	0.1	1.5	3.5
Field Dissolved Oxygen (mg/L)	2.49	2.68	6.86	4.41
Field pH	7.73	7.61	8.08	7.79
Field Redox, Uncorrected (mV)	295.7	158.6	171.7	137.2
Field Temperature (°C)	15.65	18.05	18.07	12.89
Turbidity (NTU)	1.07	1.11	1.64	1.36
Salinity (psu)	25.8	25	25.6	28
Total Suspended Solids (mg/L)	3.2	8.8	8.4	12.8
Orthophosphate - Disolved (as P) (mg/L)	0.0519	0.0699	0.0452	0.0487
Phosphorus - Dissolved (mg/L)	0.0561	0.0767	0.0533	0.0509
Ammonia - Total (mg/L)	0.114	0.0467	0.0351	0.0075
Phosphorus - Total (mg/L)	0.0751	0.0918	0.072	0.0787
Total Kjeldahl Nitrogen (mg/L)	0.314	0.234	0.304	0.189
Organic Nitrogen (mg/L)	0.2	0.187	0.269	0.182
Boron (µg/L)	-	-	-	<u>**3500**</u>
Calcium (µg/L)	-	-	-	340000
Magnesium (µg/L)	-	-	-	1020000
Potassium (µg/L)	-	-	-	305000
Sodium (µg/L)	-	-	-	8630000
Chlorophyll A (µg/L)	2.09	0.818	5.28	5.89

PORT METRO vancouver

Tug Basin Eelgrass Loss Assessment

Seawater Analytical
Results Summary - July Tidal Event

HEMMERA

Delta Port Third Birth AMS | Date: 2/20/2014 | Figure 4

Path: O:\1475-499\499port\002\19\AMS_Y_4_to_6_SWSDB\mxd\140220_499-002.19_SWSDB_Fig04_Seawater.mxd

TABLES

Table 1: Surface Water Analytical Results Collected During AMS Q2 Q3 - Tug Basin Eelgrass Loss Assessment

		Location ID:	DP09						DP10			
		Sample ID:	SWDP09A-26	SWDP101-26	RPD[10]	SWDP09B-26	SWDP09A-27	SWDP101-27	SWDP10A-26	SWDP10B-26	SWDP10A-27	SWDP10B-27
		Date Sampled:	04/06/2013	04/06/2013	%	04/06/2013	02/10/2013	02/10/2013	04/06/2013	04/06/2013	02/10/2013	02/10/2013
Parameter	BCWQG MAL[3,4]	CCME MAL[5,6]										
Sample Info												
Sample Depth, Below Water Surface (m)	-	-	0.5	0.5	-	1	0.5	2.5	0.5	2	0.5	3
Field Tests												
Field Conductance, Specific (uS/cm)	-	-	35930	35930	-	43192	42330	43234	46622	470717	42381	43482
Field Dissolved Oxygen (mg/L)	-	-	12.19	12.19	-	10.74	11.29	10.86	11.13	12.14	11.15	10.64
Field pH	-	-	8.36	8.36	-	8.32	7.84	7.83	8.13	8.44	7.83	7.83
Field Redox, Uncorrected (mV)	-	-	180.1	180.1	-	175	214.7	206.1	179	198.2	214.4	204.7
Field Temperature (ºC)	-	-	16.4	16.4	-	17.22	11.07	11.3	14.55	12.38	11.43	11.25
Field Turbidity (NTU)	-	-	1.74	1.74	-	2.03	4.25	21.8	1.21	1.38	4.5	2.27
Secchi Disk Depth (m)	-	-	1.3	1.3	-	1.3	1.5	1.5	2	2	2	2
Physical Tests												
Hardness, Total (CaCO3) (mg/L)	-	-	4020	3990	1%	4340	-	-	4220	5040	-	-
pH	-	7-8.7[8]	8.09	8.22	2%	8.31	7.81	7.86	8.26	7.77	7.88	7.87
Salinity (psu)	-	-	22.8	22.8	0%	24.2	26.1	28	24.6	28.8	26.2	28.1
Total Suspended Solids (mg/L)	-	-	3.2	4.4	32%	39.4	10.7	149	2.4	72.2	8.9	5.4
Turbidity (NTU)	-	-	2.7	2.55	6%	4.17	5.02	39.8	2.14	20	4.74	2.45
Dissolved Inorganics												
Phosphate, Ortho (mg/L)	-	-	0.0269	0.0304	12%	0.0356	0.055	0.047	0.036	0.046	0.054	0.057
Phosphorus (mg/L)	-	-	0.0309	0.03	3%	0.0354	0.058	0.049	0.0428	0.0454	0.057	0.058
Inorganics												
Nitrate (mg/L)	-	16	<0.500	<0.500	nc	<0.500	<0.100	<0.100	<0.500	<0.500	<0.100	<0.100
Nitrite (mg/L)	-	-	<0.100	<0.100	nc	0.12	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Silicon Dioxide (mg/L)	-	-	1.43	1.48	3%	1.11	1.96	1.92	1.28	1.67	2.26	1.78
Total Inorganics												
Ammonia (mg/L)	-	-	0.0118	0.0121	3%	0.0179	0.068	0.04	0.0142	0.0226	0.062	0.035
Phosphorus (mg/L)	-	-	0.0398	0.0408	2%	0.076	0.086	0.243	0.0495	0.213	0.083	0.072
Total Kjeldahl Nitrogen (mg/L)	-	-	0.162	0.158	3%	0.211	0.278	1.88	0.173	0.494	0.235	0.19
Total Nitrogen (mg/L)	-	-	<0.510	<0.510	nc	<0.510	<0.510	<0.511	<0.510	<0.510	<0.512	<0.513
Organics												
Organic Nitrogen (mg/L)	-	-	0.15	0.145	3%	0.193	0.209	1.84	0.158	0.471	0.173	0.155
Total Metals												
Boron	1200[4]	-	2800	2800	0%	3100	3050	3450	3000	3500	3190	3310
Calcium	-	-	256000	253000	1%	286000	304000	319000	267000	336000	296000	316000
Magnesium	-	-	820000	816000	0%	880000	915000	982000	863000	1020000	912000	956000
Potassium	-	-	245000	239000	2%	261000	281000	300000	258000	307000	279000	295000
Sodium	-	-	7170000	6440000	11%	7540000	7690000	8150000	7480000	8830000	7570000	8040000
Microbiological Analysis												
Chlorophyll A	-	-	1.43	2.03	35%	4.31	2.48	2.92	0.691	24.7	2.19	4.18

Table 1: Surface Water Analytical Results Collected During AMS Q2 Q3 - Tug Basin Eelgrass Loss Assessment

		Location ID:	DP11				RB-10-1					
		Sample ID:	SWDP11A-26	SWDP11B-26	SWDP11A-27	SWDP11B-27	SWRB-10-1A-26	SWRB-10-1B-26	SWRB-10-1A-27	SWDP100-27	RPD[10]	SWRB-10-1B-27
		Date Sampled:	04/06/2013	04/06/2013	02/10/2013	02/10/2013	04/06/2013	04/06/2013	02/10/2013	02/10/2013	02/10/2013	02/10/2013
Parameter	**BCWQG MAL [3,4]**	**CCME MAL [5,6]**										
Sample Info												
Sample Depth, Below Water Surface (m)	-	-	0.5	2	0.5	3	0.5	1	0.5	0.5	-	2.5
Field Tests												
Field Conductance, Specific (uS/cm)	-	-	43300	45610	42464	43307	39493	39438	42326	42326	-	43425
Field Dissolved Oxygen (mg/L)	-	-	10.4	11.57	11.16	10.58	10.9	8.12	10.92	10.92	-	10.09
Field pH	-	-	8.25	8.1	7.79	7.83	8.33	8.17	7.51	7.51	-	7.74
Field Redox, Uncorrected (mV)	-	-	202.5	179.7	204.5	199.6	151.5	164.8	231.8	231.8	-	203.2
Field Temperature (ºC)	-	-	13.8	11.83	11.27	11.27	14.89	14.85	11.48	11.48	-	11.77
Field Turbidity (NTU)	-	-	0.89	10.03	2.16	9.84	1.68	8.11	2.78	2.78	-	8.02
Secchi Disk Depth (m)	-	-	2	2	1.5	1.5	1.5	1.5	1.5	1.5	-	1.5
Physical Tests												
Hardness, Total (CaCO3) (mg/L)	-	-	4190	4920	-	-	4240	4350	-	-	-	-
pH	-	7-8.7 [8]	8.16	7.95	7.88	7.87	8.17	8.12	7.9	7.79	1%	7.67
Salinity (psu)	-	-	24.2	28.7	27.1	28.3	24.5	24.6	26.5	26.6	0%	28
Total Suspended Solids (mg/L)	-	-	2.6	16	5.4	42.9	5.8	66.6	4.9	5.5	12%	38.2
Turbidity (NTU)	-	-	2.24	3.03	3.1	12.5	3.32	17.5	3.18	3.2	1%	10.6
Dissolved Inorganics												
Phosphate, Ortho (mg/L)	-	-	0.0369	0.0564	0.055	0.058	0.0314	0.0218	0.062	0.061	2%	0.058
Phosphorus (mg/L)	-	-	0.0349	0.0558	0.06	0.057	0.0343	0.03	0.066	0.061	8%	0.058
Inorganics												
Nitrate (mg/L)	-	16	<0.500	<0.500	<0.100	<0.100	<0.500	<0.500	<0.100	<0.100	nc	<0.100
Nitrite (mg/L)	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	nc	<0.100
Silicon Dioxide (mg/L)	-	-	1.32	1.65	1.9	1.86	1.09	0.56	2.06	2.06	0%	1.7
Total Inorganics												
Ammonia (mg/L)	-	-	0.0199	0.0247	0.058	0.042	0.0111	0.0107	0.069	0.07	1%	0.028
Phosphorus (mg/L)	-	-	0.0553	0.0891	0.074	0.129	0.0497	0.18	0.08	0.079	1%	0.142
Total Kjeldahl Nitrogen (mg/L)	-	-	0.215	0.202	0.207	0.396	0.201	0.371	0.26	0.248	5%	0.387
Total Nitrogen (mg/L)	-	-	<0.510	<0.510	<0.514	<0.515	<0.510	<0.510	<0.516	<0.517	nc	<0.518
Organics												
Organic Nitrogen (mg/L)	-	-	0.195	0.178	0.15	0.354	0.19	0.36	0.191	0.178	7%	0.359
Total Metals												
Boron	1200 [4]	-	3000	3400	3410	3560	3000	3100	3310	3390	2%	3520
Calcium	-	-	264000	319000	315000	320000	269000	290000	308000	307000	0%	322000
Magnesium	-	-	856000	1000000	968000	988000	867000	880000	938000	933000	1%	994000
Potassium	-	-	251000	295000	295000	301000	255000	262000	290000	290000	0%	305000
Sodium	-	-	7360000	8470000	7980000	8080000	7430000	7540000	7780000	7730000	1%	8120000
Microbiological Analysis												
Chlorophyll A	-	-	1.76	8.03	1	7.44	4.15	12.5	0.425	0.859	68%	7.09

Notes for Table 1

(1) All values are reported as µg/L unless otherwise noted
(2) - = No standard or not analyzed
(3) BCWQG = BC Water Quality Guidelines (Approved and Working), updated to January 2010
(4) BCWQG MAL = British Columbia Water Quality Guidline Marine Aquatic Life water use
(5) CCME = Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines, 1999, updated to November 30, 2011
(6) CCME MAL = Chapter 4, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Marine, updated to November 30, 2011
(7) Working - Maximum (Unknown full reference)
(8) CCME MAL stipulates pH not < 7 and not > 8.7
(9) CCME MAL stipulates Salinity (%) not <= 10
(10) RPD = Relative percent Difference. RPD is calcuated as the difference between a sample and it's duplicate, over the average of the two values.
nc = not calculated. The sample or the duplicate value is less than five times the laboratory detection limit and the RPD is not caculated.

Table 2: Sediment Analytical Results Collected During AMS Q2 Q3 - Tug Basisn Eelgrass Loss Assessment

	Location ID:	DP09				DP10		DP11		RB-10-1	
	Sample ID:	SDDP09-26	SDDP101-26	RPD [5] (%)	SDDP09-27	SDDP10-26	SDDP10-27	SDDP11-26	SDDP11-27	SDRB-10-1-26	SDRB-10-1-27
	Date Sampled:	04/06/2013	04/06/2013		24/09/2013	04/06/2013	24/09/2013	04/06/2013	24/09/2013	04/06/2013	24/09/2013
	Sample Depth (m):	0.00-0.15	0.00-0.15		0.00-0.20	0.00-0.20	0.00-0.20	0.00-0.20	0.00-0.20	0.00-0.20	0.00-0.15
Parameter	**BCCSR SedQC(SS) Marine [3,4]**										
Sample Info											
Field Colour (text)	-	brown and black	brown and black	-	brown and dark grey	brown and black	brown and dark grey	brown and black	brown and dark grey	black	brown and dark grey
Field Grain Size (text)	-	sandy silt	sandy silt	-	silty sand	silt	sand and silt	silt	sand and silt	silt	silty sand
Comment (text)	-	worms, top 1 cm brown then black	worms, top 1 cm brown then black	-	shell fragments, eelgrass, invertebrates, coal dust on surface	eelgrass, top 1 cm brown then black	shell fragments, eelgrass, invertebrates, black layer on surface	top 1 cm brown then black	shell fragments, dead eelgrass, black layer on surface, rotten egg odor	eelgrass	shell fragments, trace eelgrass, invertebrates, black layer on surface
Sample Depth, Below Water Surface (m)	-	1.5	1.5	-	2.2	2.2	2.7	2.7	2.9	1.5	2.4
Physical Tests											
Moisture (%)	-	34.7	37.1	7%	38.6	65.4	63.6	55.1	52.8	53.8	51.8
Oxidation Reduction Potential (mV)	-	-192	-260	30%	-100	-168	-106	-178	-107	-318	-146
Total Inorganics											
Ammonium	-	3.2	3.5	9%	2.8	7.9	10.1	5.9	4.5	10.5	4.3
Available Phosphate	-	6.6	6.2	6%	4.6	<2.0	2.7	3.1	4	2.2	3.2
Phosphorus	-	709	805	13%	606	1020	710	901	630	674	582
Sulfide	-	9.4	6.8	32%	12	388	518	239	304	249	219
Total Kjeldahl Nitrogen (%)	-	0.075	0.073	3%	0.087	0.212	0.251	0.14	0.151	0.163	0.134
Total Nitrogen (%)	-	0.101	0.078	26%	0.1	0.212	0.252	0.149	0.167	0.167	0.151
Organics											
Organic Nitrogen (%)	-	0.075	0.072	4%	0.087	0.212	0.25	0.139	0.15	0.162	0.134
Total Organic Carbon (%)	-	0.9	0.85	6%	1.04	1.95	2.2	1.4	1.5	1.58	1.44

Notes for Table 2

(1) All values are reported as µg/g unless otherwise noted
(2) - = No standard or not analyzed
(3) BCCSR = BC Environmental Management Act, Contaminated Sites Regulation, B.C. Reg. 375/96, including amendments up to B.C. Reg. 6/2013; effective January 24, 2013
(4) BCCSR SedQC(SS) Marine = Schedule 9, Column IV, Marine and Estuarine Sediment, Sensitive Site
(5) RPD = Relative percent Difference. RPD is calcuated as the difference between a sample and it's duplicate, over the average of the two values.
nc = not calculated. The sample or the duplicate value is less than five times the laboratory detection limit and the RPD is not caculated.

Table 3: Monitoring Plan for the Summer Tidal Event

AMS/Eelgrass Loss Assessment - Summer Tidal Event Monitoring Plan - July 22, 2013

	Time	Tide Height (m)	CTD Profile & WL	Sampling
Falling Tide	4:00 AM	4.2		
	5:00 AM	4.1		
	6:00 AM	3.8		
	7:00 AM	3.2		
	8:00 AM	2.4	x (6)	
	9:00 AM	1.7	x (4)	x (3)
	10:00 AM	1	x (2)	
	11:00 AM	0.5	x (1)	
Low Tide	11:41 AM	0.4	x (1)	
Rising Tide	12:00 PM	0.5	x (1)	
	1:00 PM	0.8	x (2)	x (1*) to be sampled just before water enters DP11 over the old crest protection structure
	2:00 PM	1.4	x (3)	
	3:00 PM	2.1	x (4)	x (4)
	4:00 PM	2.9	x (6)	
	5:00 PM	3.6	x (6)	
	6:00 PM	4.1	x (6)	
	7:00 PM	4.3		x (4*)
High Tide	7:08 PM	4.3	x (6)	

WL - elevation of top of water surface behind tank basin and within tank basin to be collected

CTD profile - with YSI sonde instrument (DO, temp, conductivity, ORP, salinity, pH etc.) approximately 1 profile/hr for accessible sites

(#) - estimated number of sites likely accessible based on tide height and bottom surface of mud flats.

(1) means DP11, (2) means DP10 & DP11 (3) means DP 10 & 11 & RB10-1 (4) means DP 09, 10, 11 & RB10-1 (6) means DP 09, 10 , 11, RB10-1 & DP04/RB-10-2 & Inside Tug Basin

Sampling - collect samples for submission to ALS for eutrophication parameters (same parameters as Q2 event except no silicon dioxide) at all events with addition of select metals for high tide samples

All surface samples to be collected 0.5 m off the bottom of mud flats

Duplicate - one duplicate sample will be collected for eutrophication analysis.

* - samples to be collected within the tug basin for archiving at the lab for potential analysis depending on CTD results

Table 4: July 22, 2013 Surface Water Analytical Results - Eelgrass Loss Assessment

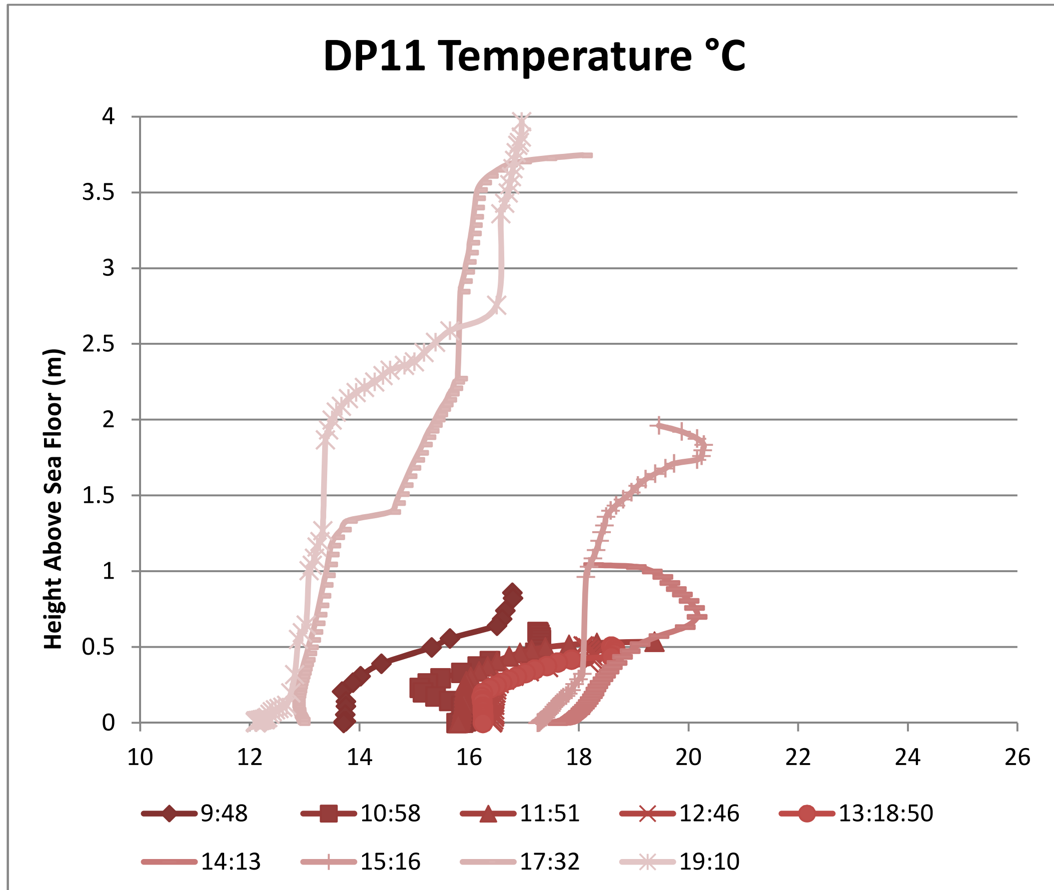
	Location ID:		DP04		DP09			DP10			DP11				RB-10-1		
	Sample ID:		DP04-9	DP04-16	DP09-9	DP09-16	DP09-18	DP10-9	DP10-16	DP10-18	DP11-9	DP11-13	DP11-16	DP11-19	RB-10-1-9	RB-10-1-16	RB-10-1-18
	Date Sampled:		22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013	22/07/2013
Parameter	**BCWQG MAL [3,4]**	**CCME MAL [5,6]**															
Sample Info																	
Water Depth (m)	-	-	0.6	2.3	0.2	1.9	3.1	0.8	2.4	3.8	0.9	0.5	2	4	0.6	2.4	3.4
Sample Depth, Below Water Surface (m)	-	-	0.1	1.8	0.1	1.4	2.6	0.3	1.9	3.3	0.4	0.1	1.5	3.5	0.1	1.9	2.9
Tide	-	-	Falling	Rising	Falling	Rising	High	Falling	Rising	High	Falling	Low	Rising	High	Falling	Rising	High
Sample Time	-	-	9:01	16:38	9:28	16:18	18:44	9:40	16:04	18:57	9:48	13:18	16:00	19:10	9:17	16:27	18:33
Field Tests																	
Field Conductance, Specific (uS/cm)	-	-	39863	39725	40385	42257	44719	41919	41543	44675	42468	41431	40993	44624	41016	43227	45322
Field Dissolved Oxygen (mg/L)	-	-	6.86	4.74	3.78	5.32	4.28	4.54	6.93	4.83	2.49	2.68	6.86	4.41	8.03	8.28	4.6
Field pH	-	-	8.02	8.09	7.72	8.04	7.75	7.78	8.1	7.73	7.73	7.61	8.08	7.79	7.93	7.96	7.78
Field Redox, Uncorrected (mV)	-	-	295.5	159.7	298.2	168	150.2	297	197.9	160.4	295.7	158.6	171.7	137.2	298.5	171.3	150.5
Field Temperature (ºC)	-	-	19.62	17.26	17.88	16.23	12.99	15.81	17.09	12.85	15.65	18.05	18.07	12.89	16.81	14.99	12.24
Physical Tests																	
Hardness, Total (CaCO3) (mg/L)	-	-	-	-	-	-	4880	-	-	4910	-	-	-	5040	-	-	4910
pH	-	7-8.7 [8]	8.04	8.07	7.8	8.13	7.93	7.97	8.13	7.93	7.93	7.92	8.11	7.93	8.07	8.12	7.92
Salinity (psu)	-	-	24.7	24.4	24.9	26	27.6	25.4	25.8	28	25.8	25	25.6	28	25.2	26	28
Total Suspended Solids (mg/L)	-	-	4.8	6.6	13.2	13.4	15.2	4.5	9.8	6.9	3.2	8.8	8.4	12.8	5.4	5	97.2
Turbidity (NTU)	-	-	1.1	2.19	1.59	1.39	1.94	0.84	1.63	1.02	1.07	1.11	1.64	1.36	0.93	1.5	22.3
Dissolved Inorganics																	
Phosphate, Ortho (mg/L)	-	-	0.0507	0.0078	0.0975	0.0399	0.0446	0.0202	0.041	0.0473	0.0519	0.0699	0.0452	0.0487	0.0478	0.0166	0.0421
Phosphorus (mg/L)	-	-	0.0577	0.0136	0.098	0.0418	0.0487	0.0272	0.0471	0.0526	0.0561	0.0767	0.0533	0.0509	0.0513	0.0222	0.0395
Inorganics																	
Nitrate (mg/L)	-	16	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
Nitrite (mg/L)	-	-	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Total Inorganics																	
Ammonia (mg/L)	-	-	0.0358	<0.005	0.0149	0.027	0.0079	0.0136	0.0308	0.0122	0.114	0.0467	0.0351	0.0075	0.0259	<0.005	0.0085
Phosphorus (mg/L)	-	-	0.0733	0.0367	0.173	0.0797	0.0704	0.0484	0.0753	0.0603	0.0751	0.0918	0.072	0.0787	0.0725	0.0397	0.233
Total Kjeldahl Nitrogen (mg/L)	-	-	0.288	0.223	0.278	0.277	0.215	0.256	0.318	0.179	0.314	0.234	0.304	0.189	0.305	0.207	0.415
Total Nitrogen (mg/L)	-	-	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510	<0.510
Organics																	
Organic Nitrogen (mg/L)	-	-	0.253	0.223	0.263	0.25	0.207	0.243	0.287	0.167	0.2	0.187	0.269	0.182	0.279	0.207	0.406
Total Metals																	
Boron	1200 [4]	-	-	-	-	-	**3300**	-	-	**3400**	-	-	-	**3500**	-	-	**3400**
Calcium	-	-	-	-	-	-	335000	-	-	330000	-	-	-	340000	-	-	329000
Magnesium	-	-	-	-	-	-	983000	-	-	992000	-	-	-	1020000	-	-	993000
Potassium	-	-	-	-	-	-	302000	-	-	300000	-	-	-	305000	-	-	300000
Sodium	-	-	-	-	-	-	8500000	-	-	8460000	-	-	-	8630000	-	-	8420000
Microbiological Analysis																	
Chlorophyll A	-	-	1.1	6.31	1.64	8.07	5.15	7.42	7.19	2.01	2.09	0.818	5.28	5.89	5.11	9.65	9.15

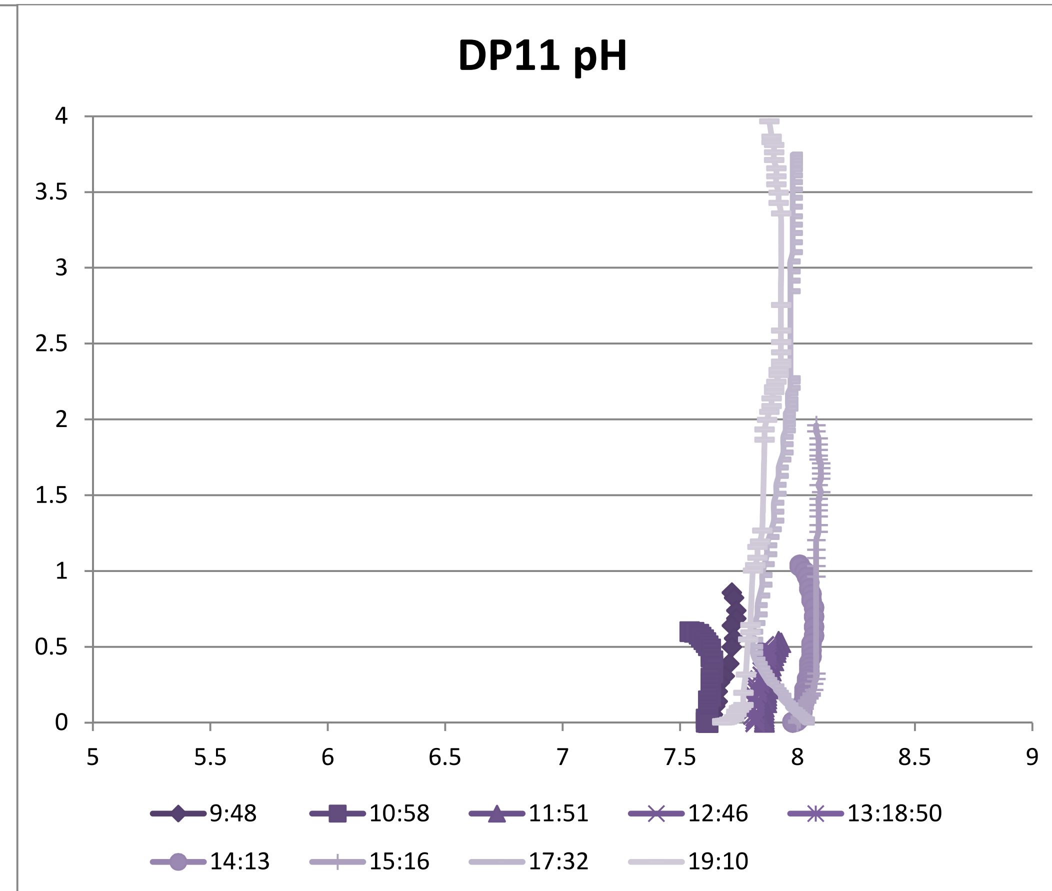
Notes for Table 4

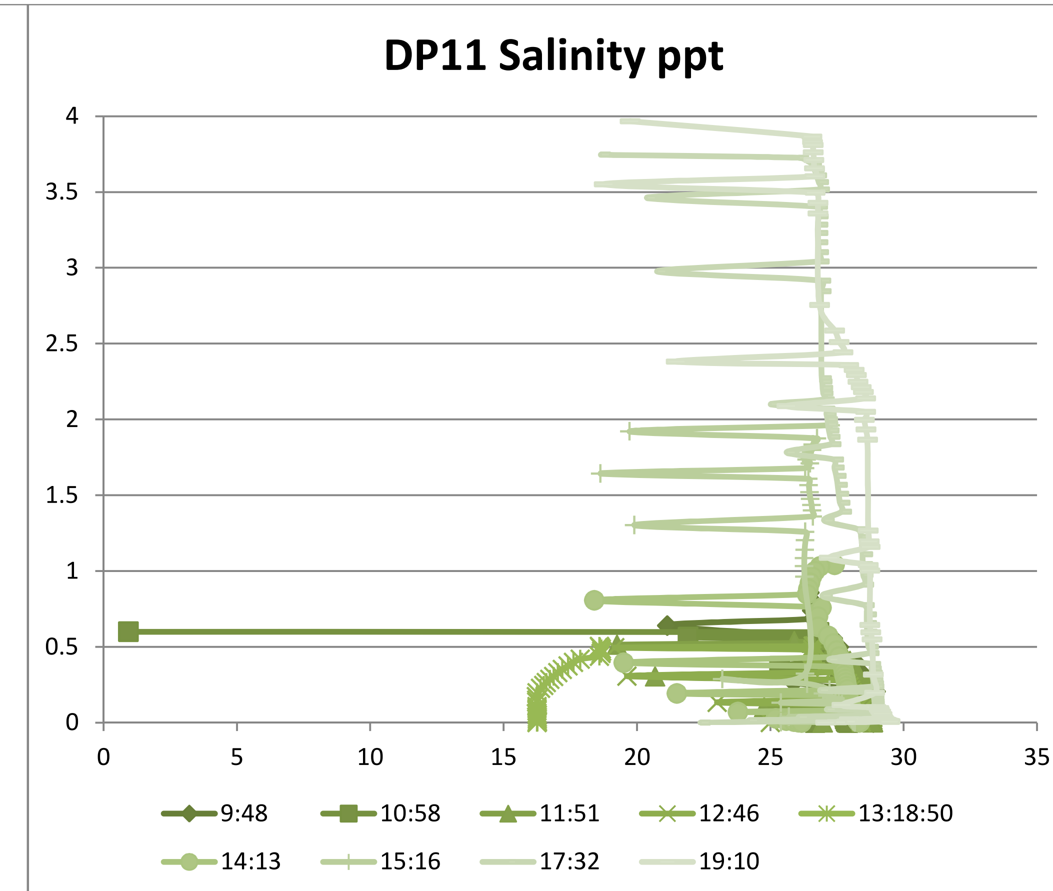
(1) All values are reported as µg/L unless otherwise noted
(2) - = No standard or not analyzed
(3) BCWQG = BC Water Quality Guidelines (Approved and Working), updated to January 2010
(4) BCWQG MAL= British Columbia Water Quality Guidline Marine Aquatic Life water use
(5) CCME = Canadian Council of Ministers of the Environment, Canadian Environmental Quality Guidelines, 1999, updated to November 30, 2011
(6) CCME MAL = Chapter 4, Canadian Water Quality Guidelines for the Protection of Aquatic Life, Marine, updated to November 30, 2011
(7) Working - Maximum (Unknown full reference)
(8) CCME MAL stipulates pH not < 7 and not > 8.7
(9) CCME MAL stipulates Salinity (%) not <= 10

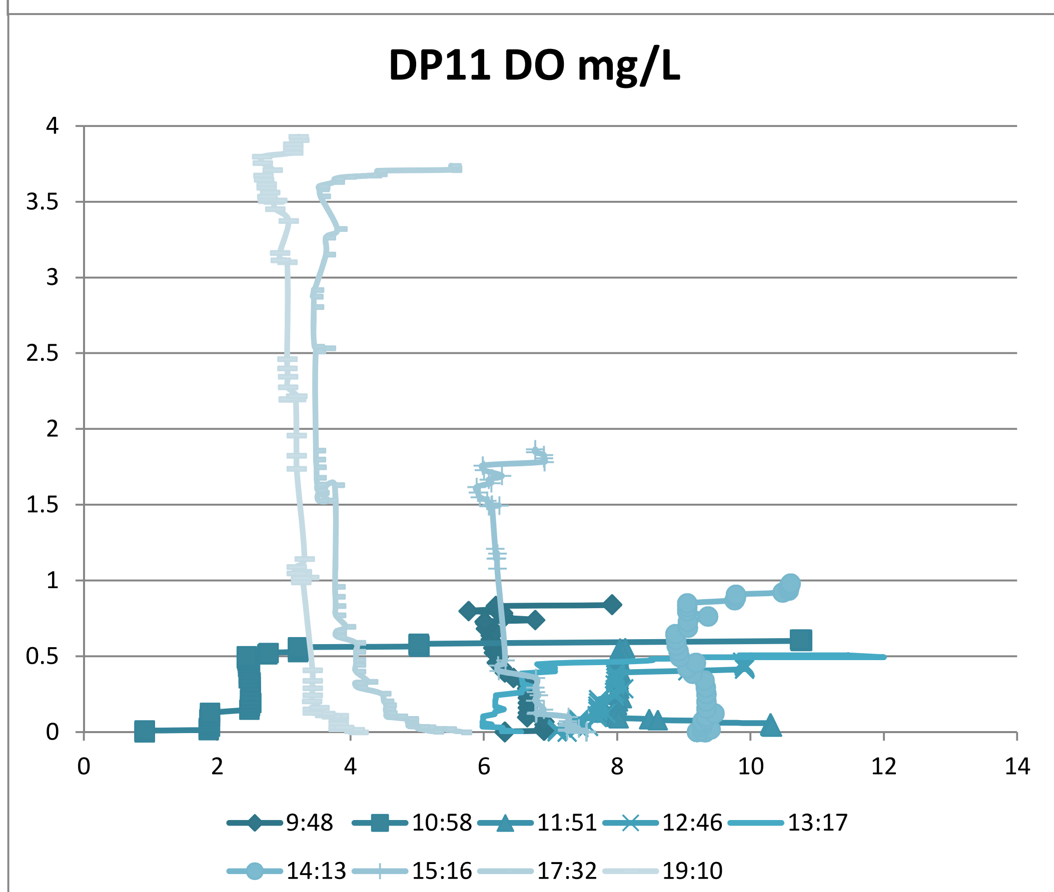
ATTACHMENT #1

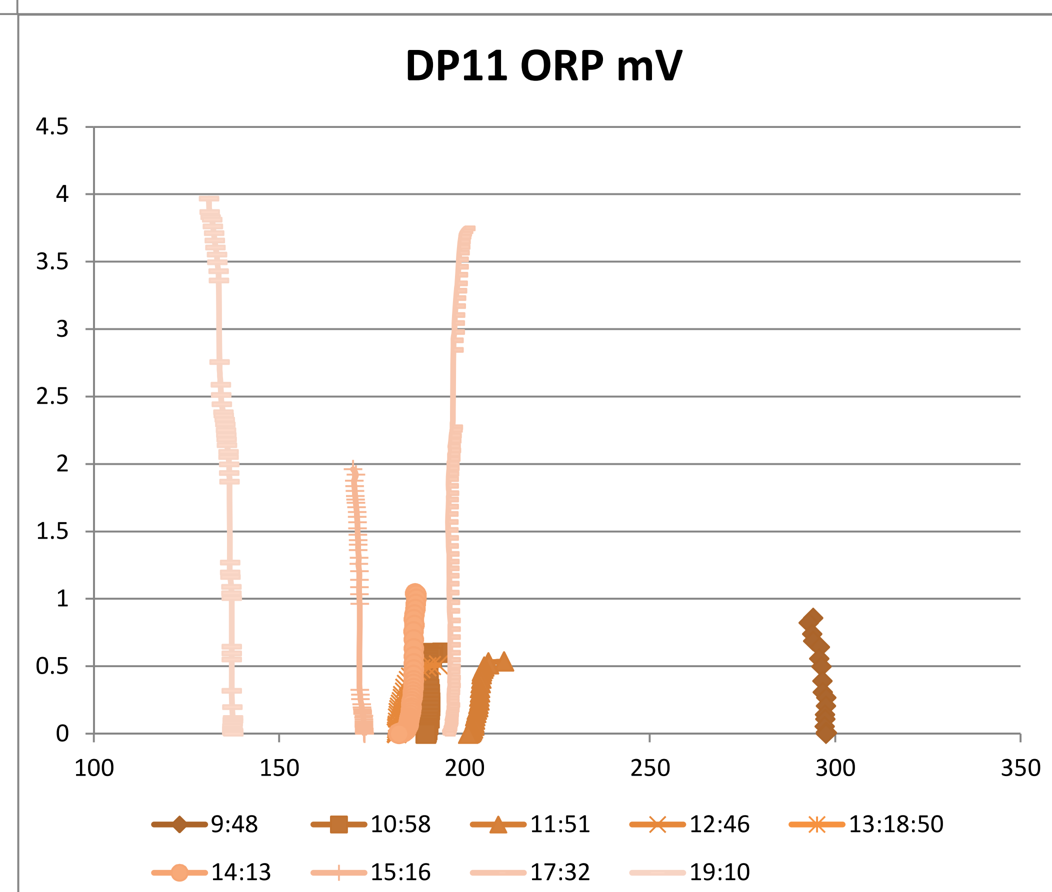
July 22nd Water Profiles by Station

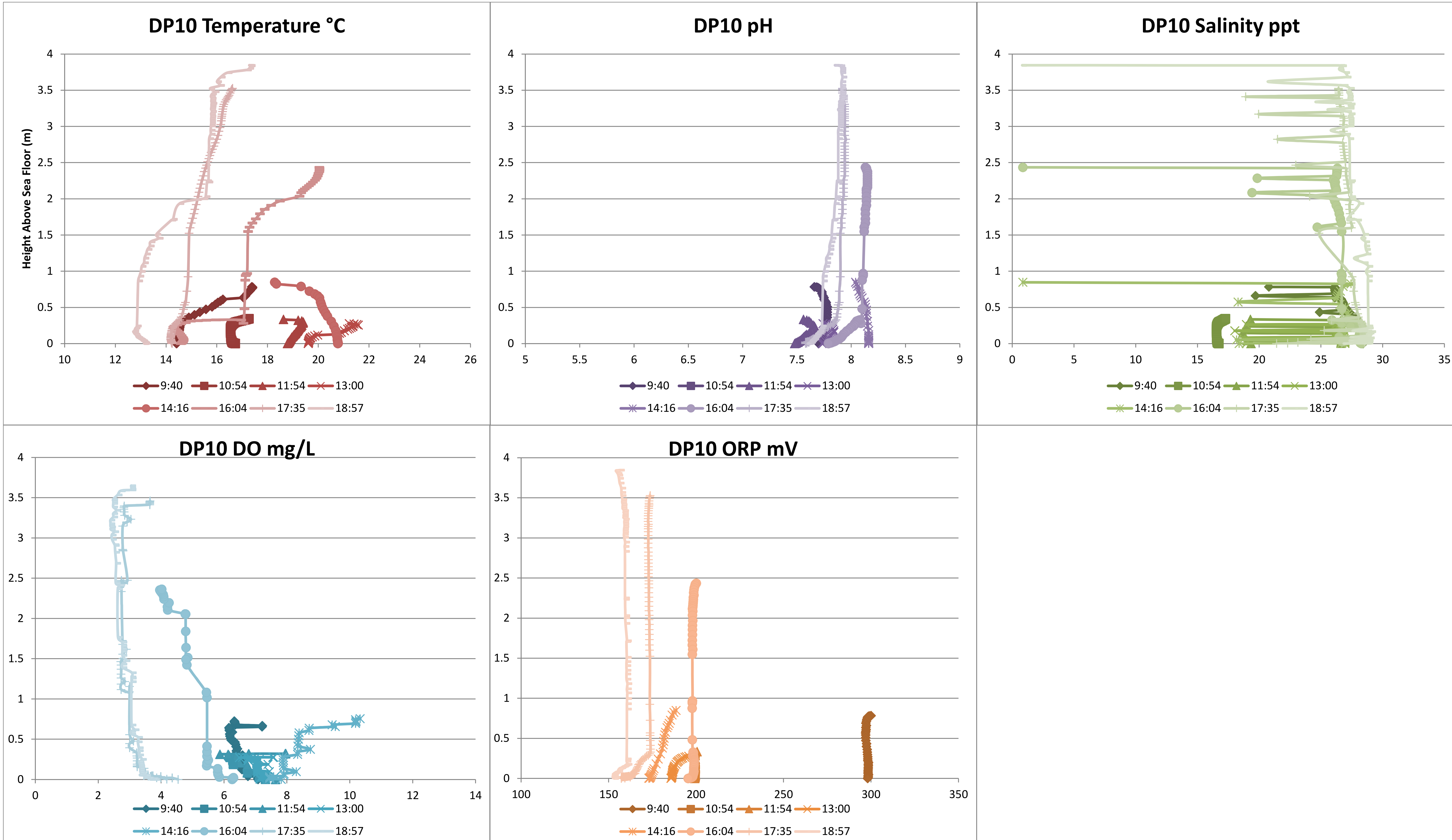

DP11 Temperature °C
Height Above Sea Floor (m)
0 0.5 1 1.5 2 2.5 3 3.5 4
10 12 14 16 18 20 22 24 26
9:48 10:58 11:51 12:46 13:18:50
14:13 15:16 17:32 19:10

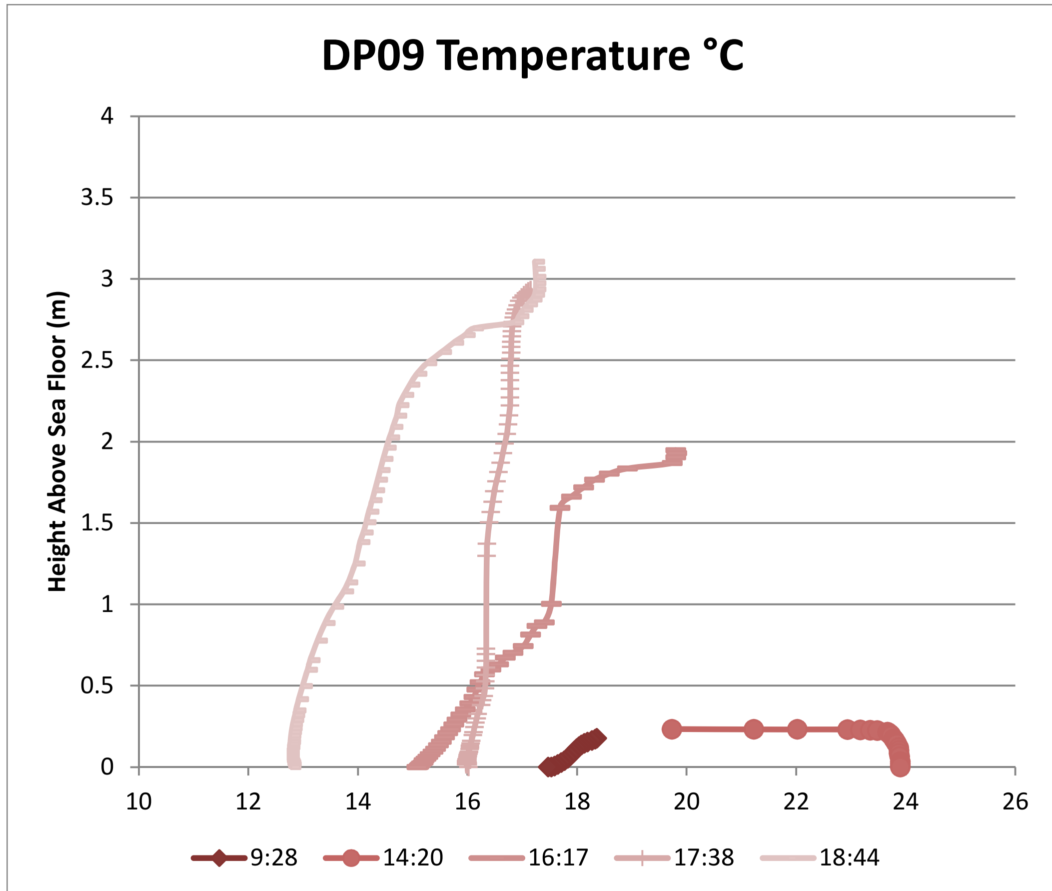

DP11 pH
0 0.5 1 1.5 2 2.5 3 3.5 4
5 5.5 6 6.5 7 7.5 8 8.5 9
9:48 10:58 11:51 12:46 13:18:50
14:13 15:16 17:32 19:10

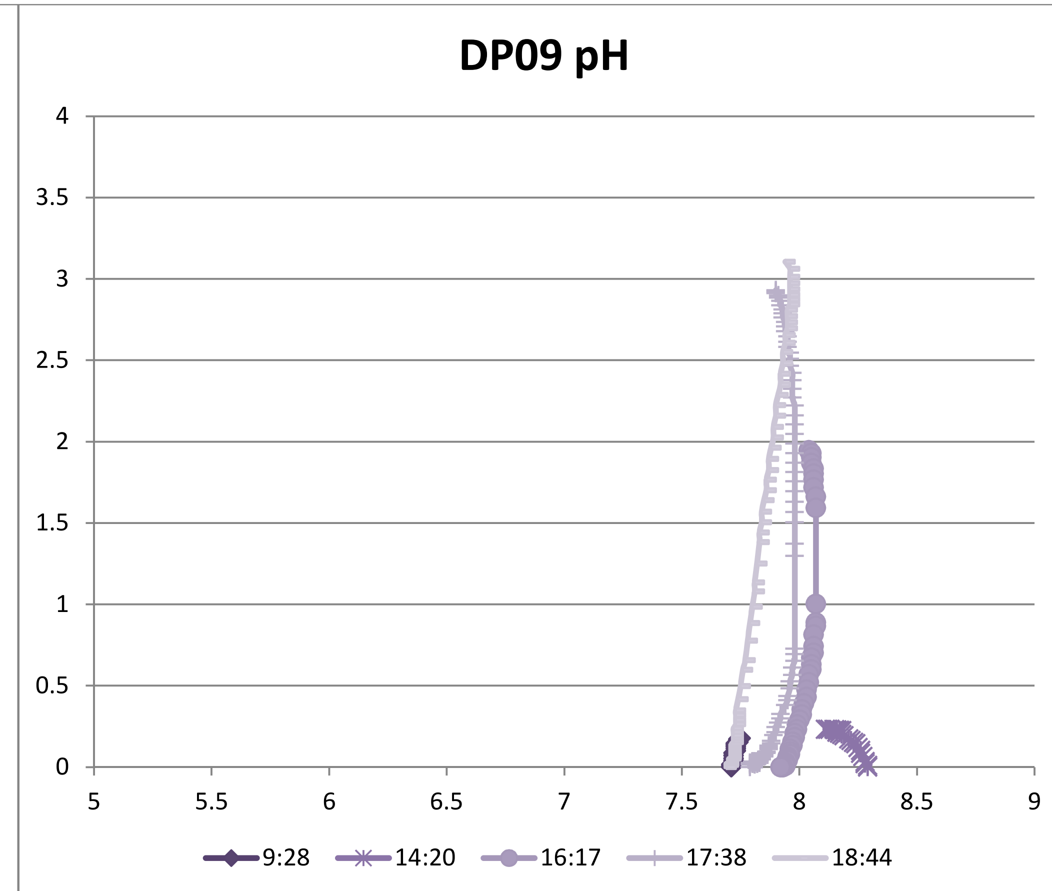

DP11 Salinity ppt
0 0.5 1 1.5 2 2.5 3 3.5 4
0 5 10 15 20 25 30 35
9:48 10:58 11:51 12:46 13:18:50
14:13 15:16 17:32 19:10

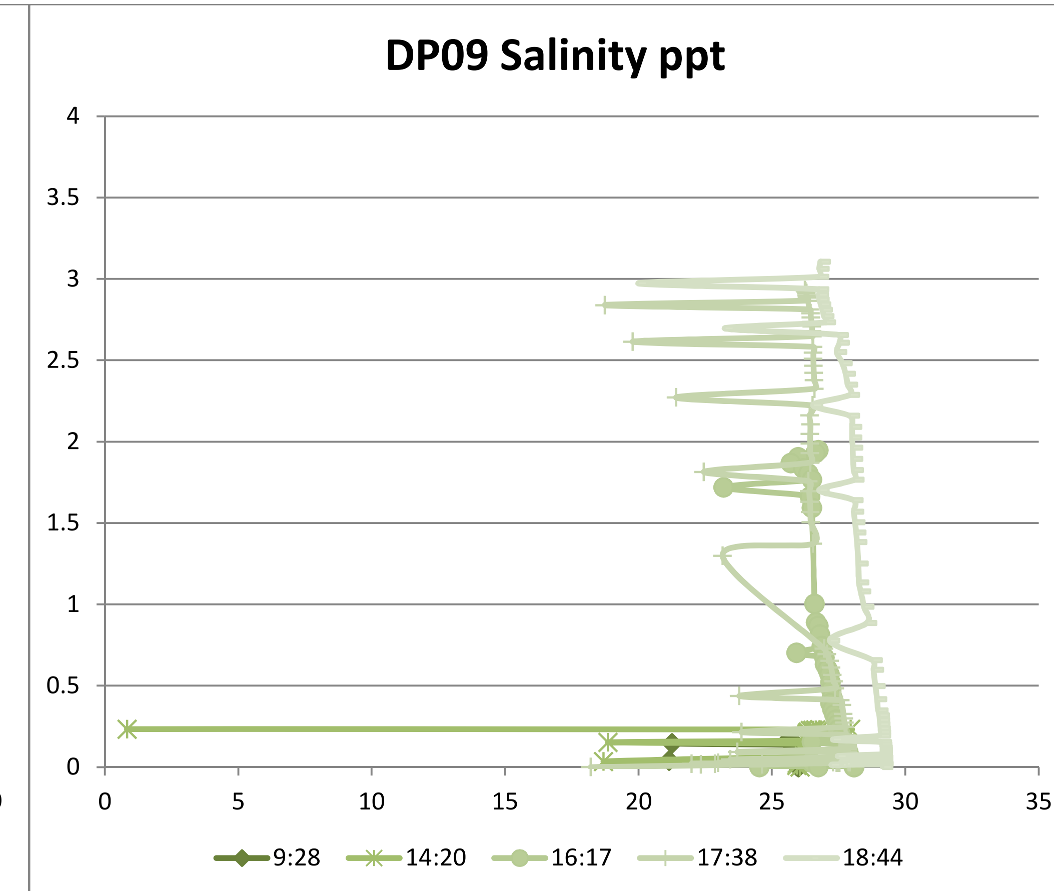

DP11 DO mg/L
0 0.5 1 1.5 2 2.5 3 3.5 4
0 2 4 6 8 10 12 14
9:48 10:58 11:51 12:46 13:17
14:13 15:16 17:32 19:10

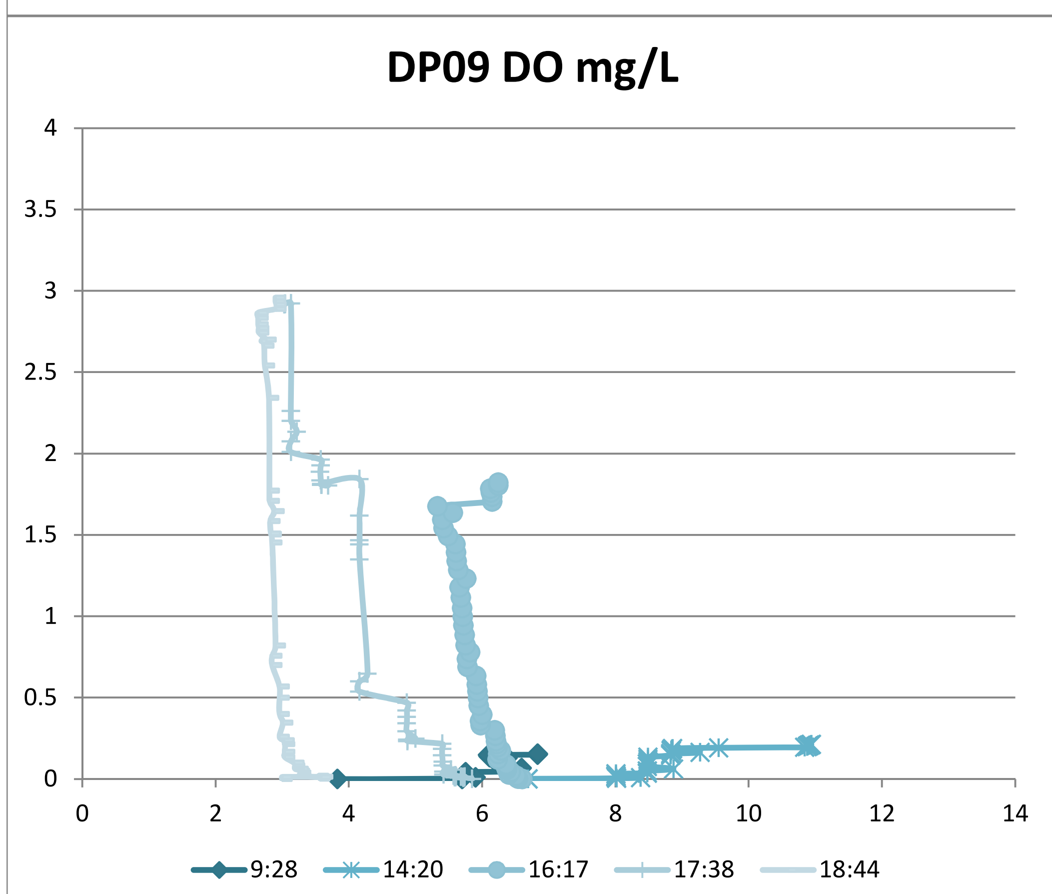

DP11 ORP mV
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5
100 150 200 250 300 350
9:48 10:58 11:51 12:46 13:18:50
14:13 15:16 17:32 19:10

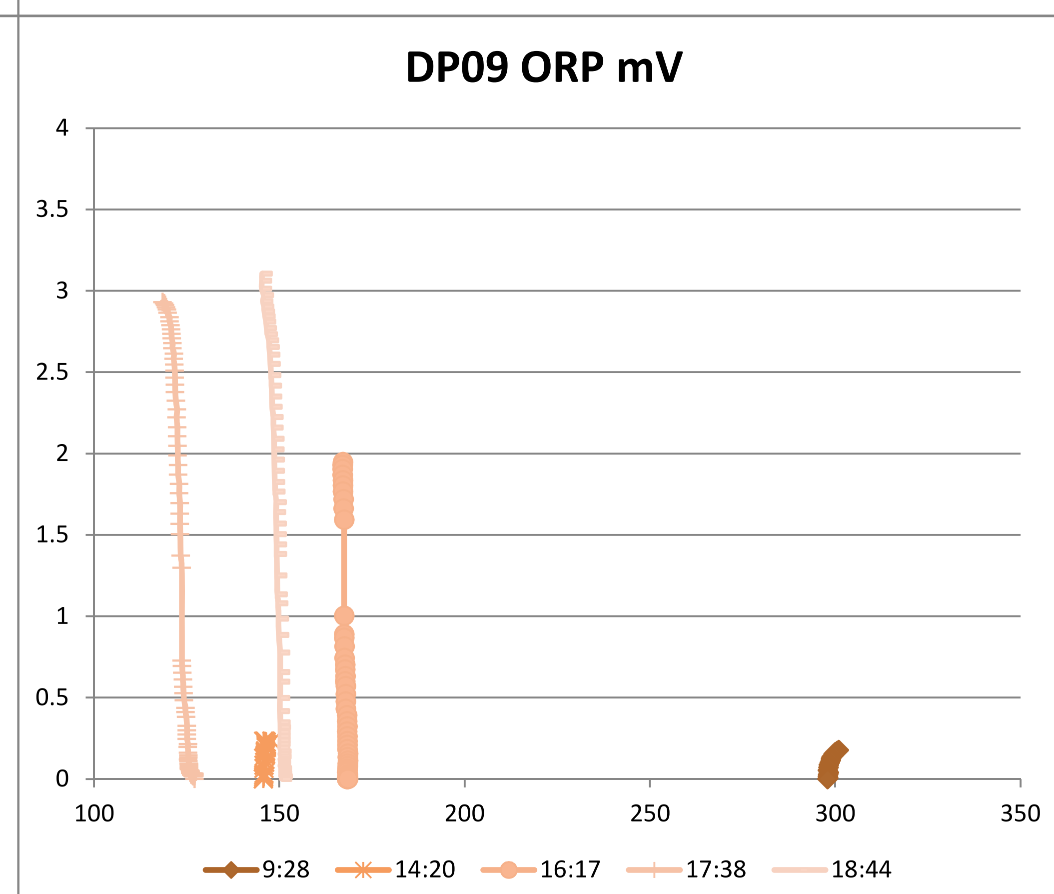

DP10 Temperature °C
Height Above Sea Floor (m)
9:40 10:54 11:54 13:00
14:16 16:04 17:35 18:57
DP10 pH
9:40 10:54 11:54 13:00
14:16 16:04 17:35 18:57
DP10 Salinity ppt
9:40 10:54 11:54 13:00
14:16 16:04 17:35 18:57
DP10 DO mg/L
9:40 10:54 11:54 13:00
14:16 16:04 17:35 18:57
DP10 ORP mV
9:40 10:54 11:54 13:00
14:16 16:04 17:35 18:57

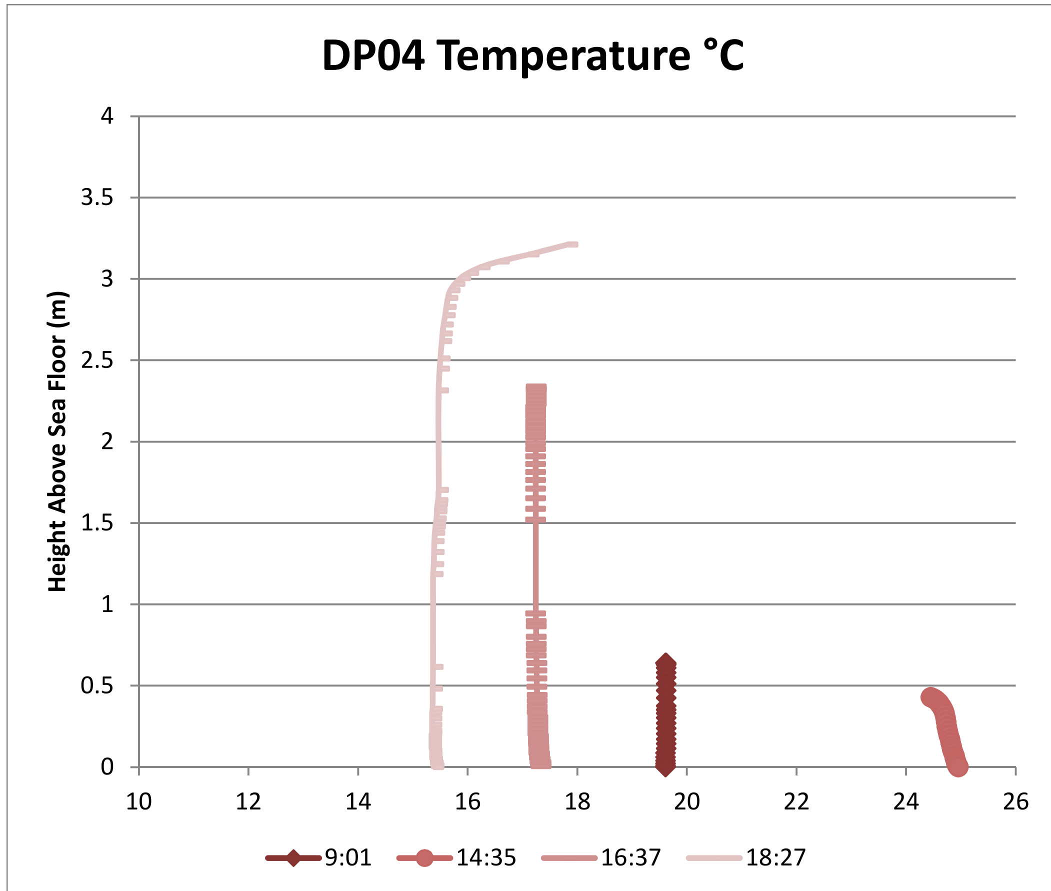

DP09 Temperature °C
Height Above Sea Floor (m)
0 0.5 1 1.5 2 2.5 3 3.5 4
10 12 14 16 18 20 22 24 26
9:28 14:20 16:17 17:38 18:44

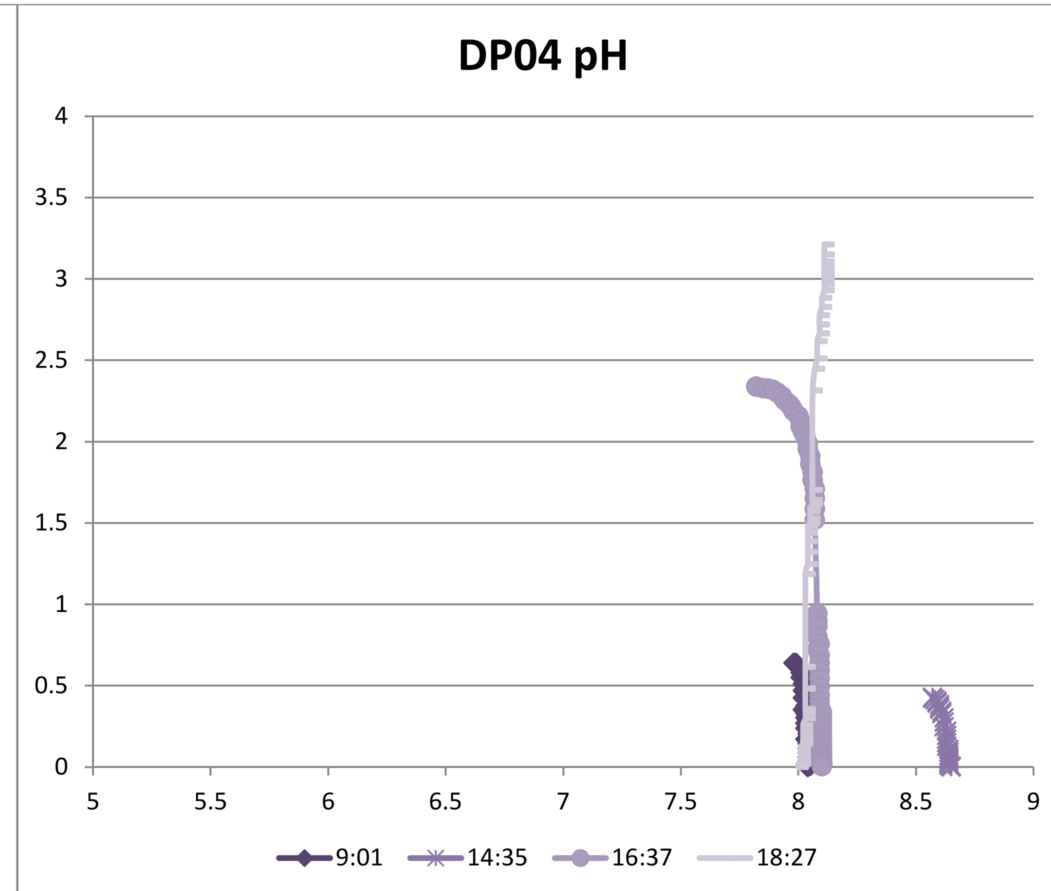

DP09 pH
0 0.5 1 1.5 2 2.5 3 3.5 4
5 5.5 6 6.5 7 7.5 8 8.5 9
9:28 14:20 16:17 17:38 18:44

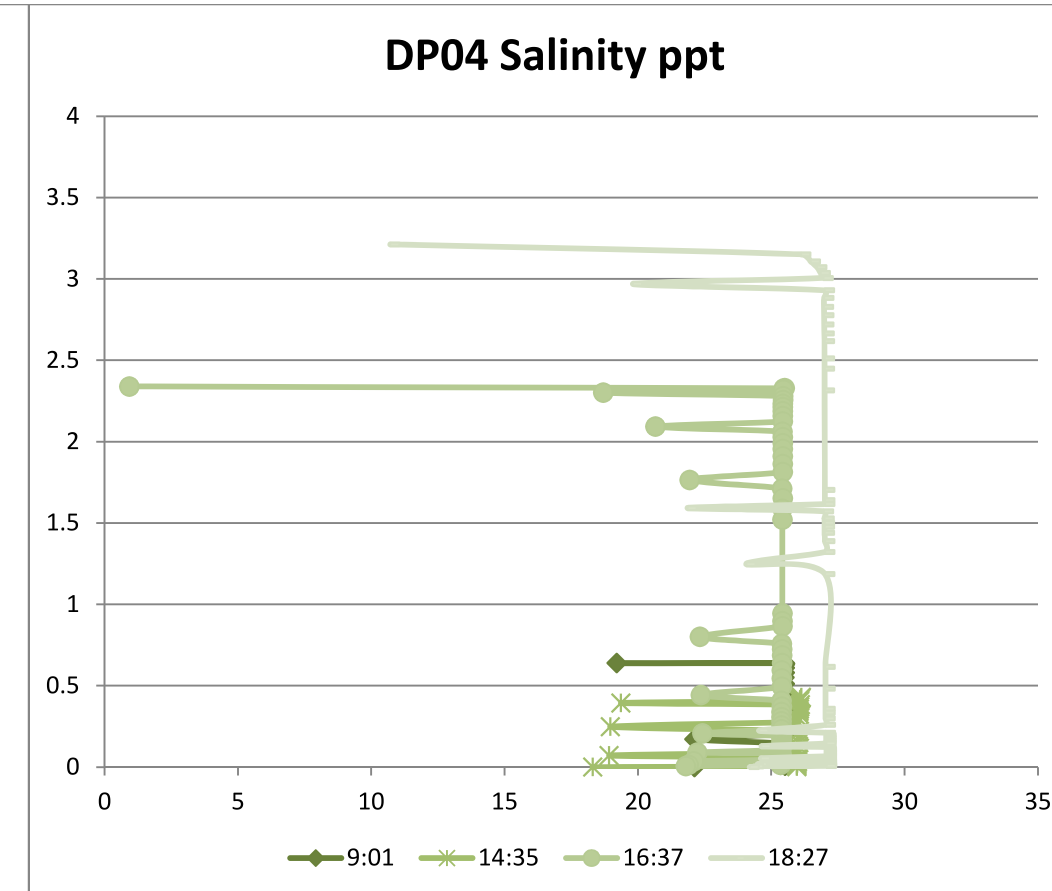

DP09 Salinity ppt
0 0.5 1 1.5 2 2.5 3 3.5 4
0 5 10 15 20 25 30 35
9:28 14:20 16:17 17:38 18:44

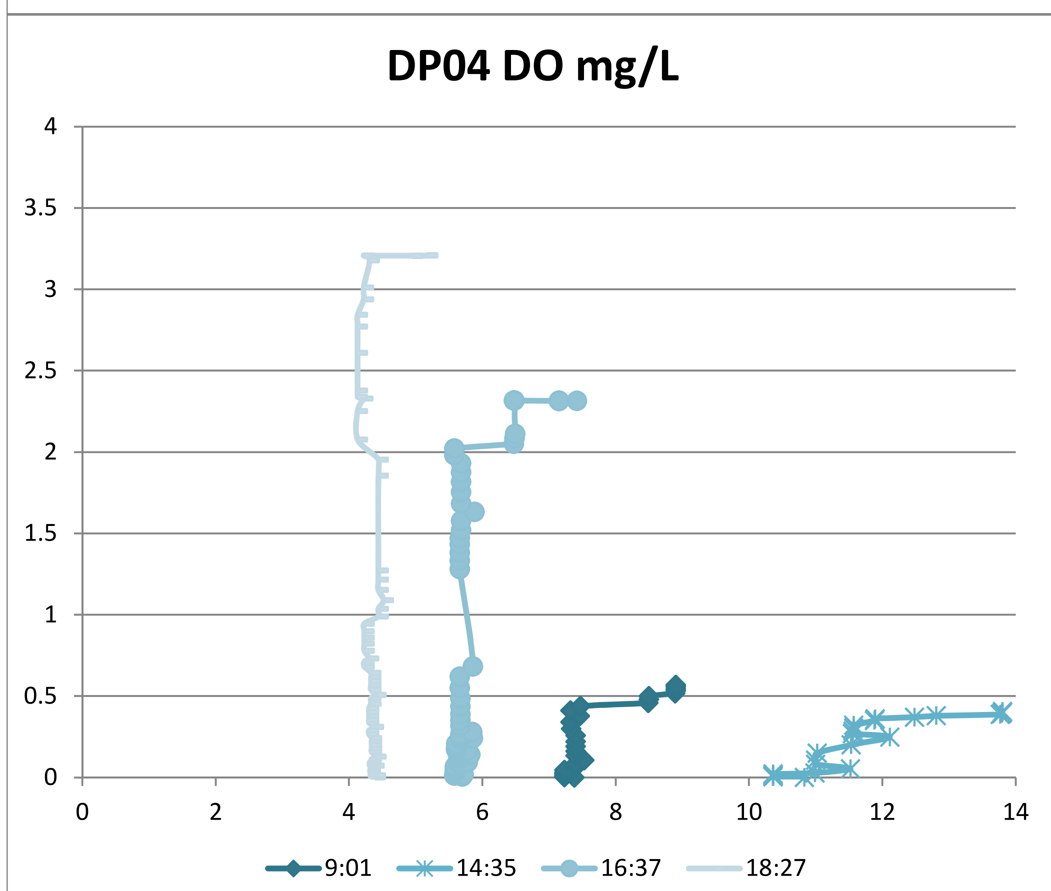

DP09 DO mg/L
0 0.5 1 1.5 2 2.5 3 3.5 4
0 2 4 6 8 10 12 14
9:28 14:20 16:17 17:38 18:44

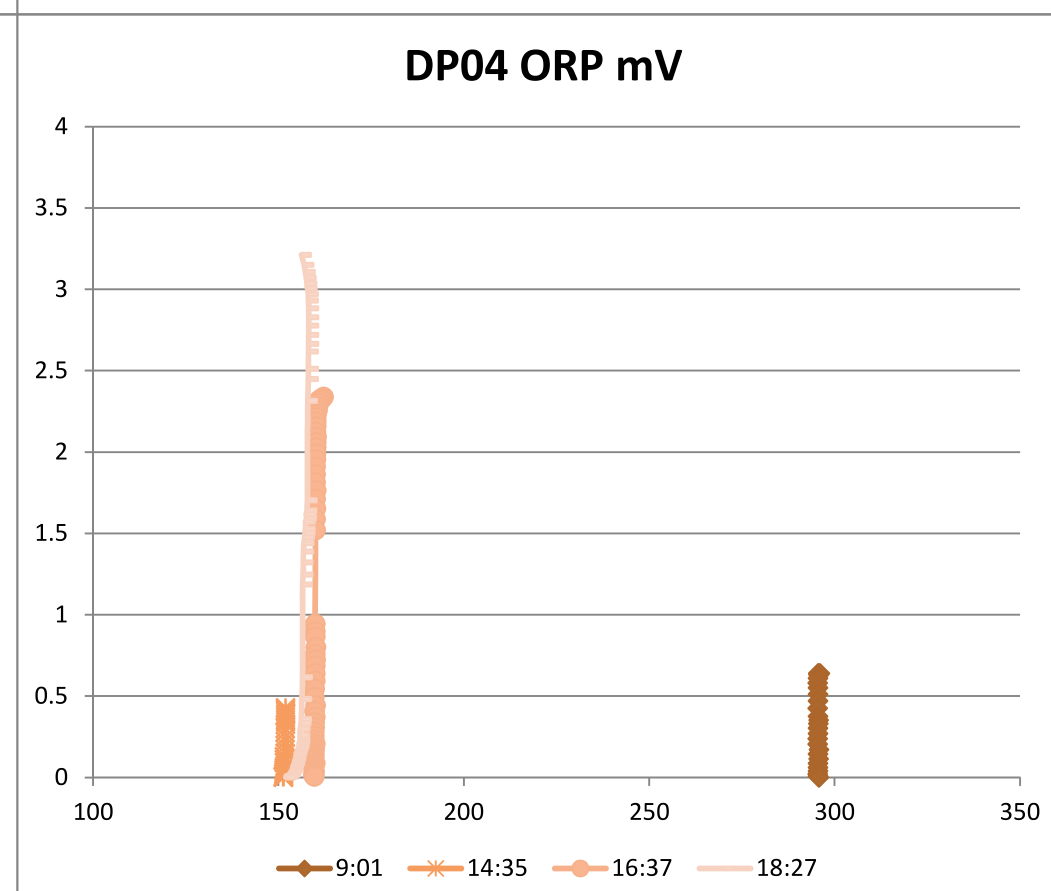

DP09 ORP mV
0 0.5 1 1.5 2 2.5 3 3.5 4
100 150 200 250 300 350
9:28 14:20 16:17 17:38 18:44

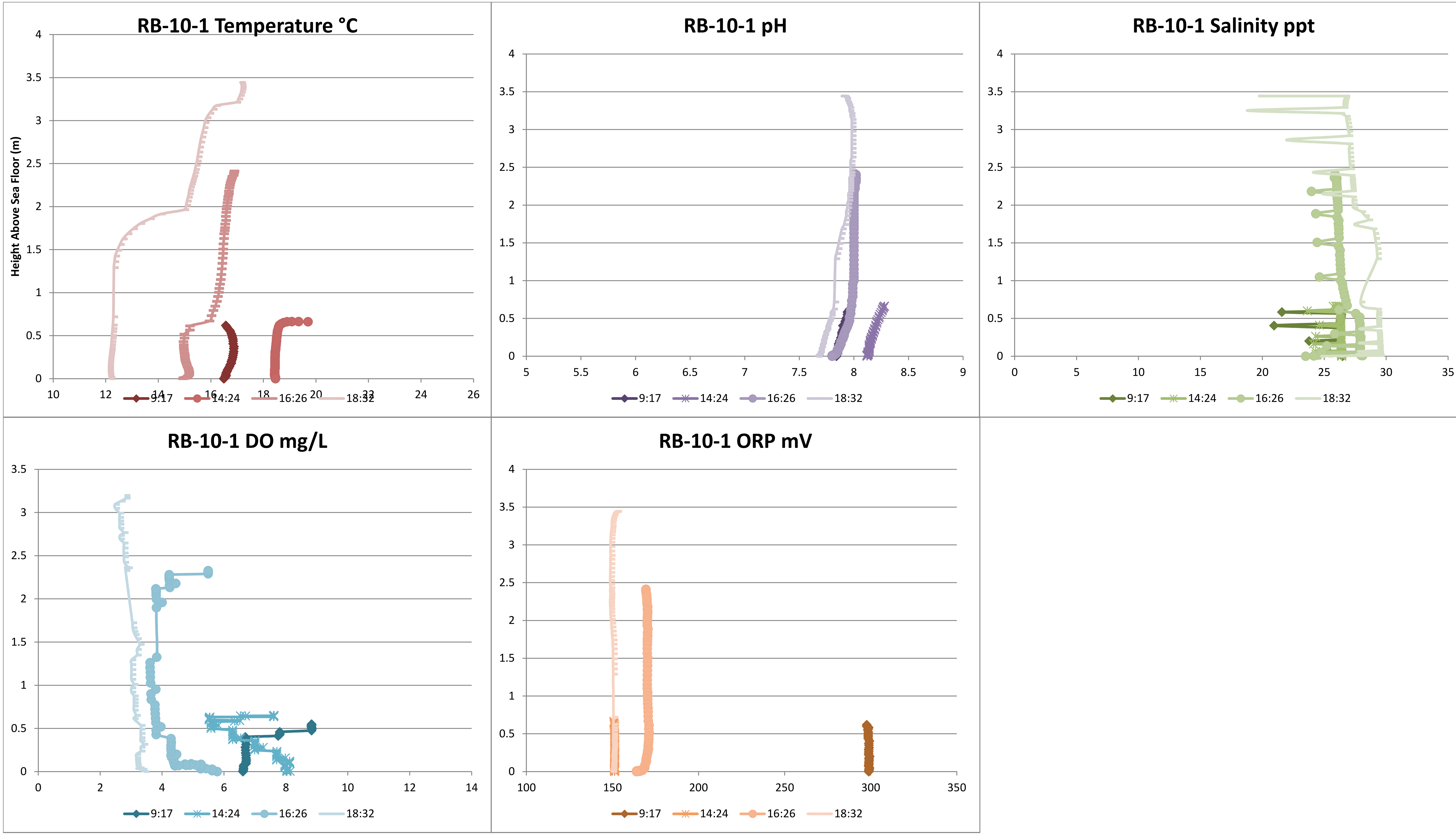

DP04 Temperature °C
Height Above Sea Floor (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
10
12
14
16
18
20
22
24
26
9:01
14:35
16:37
18:27


DP04 pH
0
0.5
1
1.5
2
2.5
3
3.5
4
5
5.5
6
6.5
7
7.5
8
8.5
9
9:01
14:35
16:37
18:27

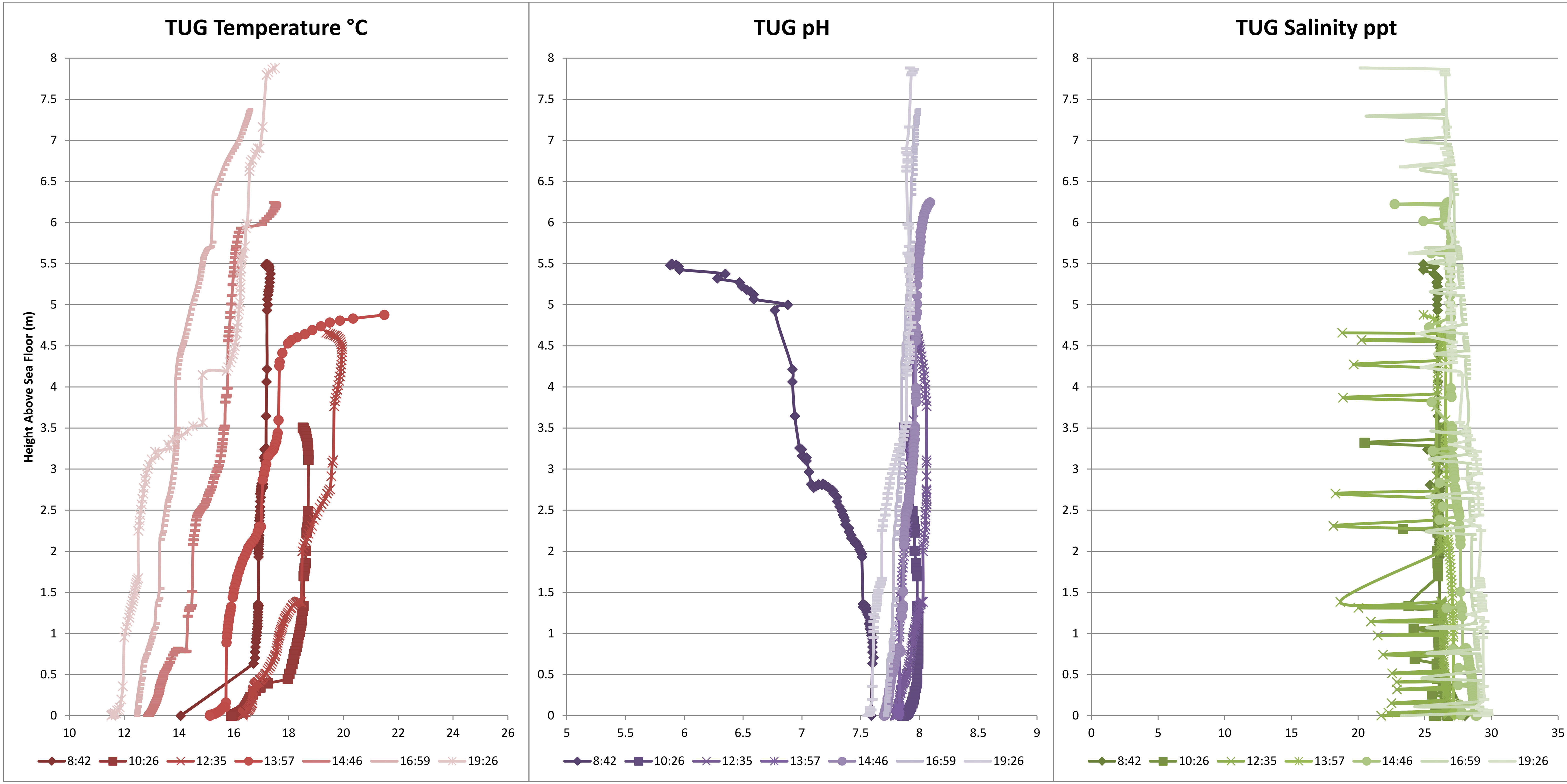

DP04 Salinity ppt
0
0.5
1
1.5
2
2.5
3
3.5
4
0
5
10
15
20
25
30
35
9:01
14:35
16:37
18:27


DP04 DO mg/L
0
0.5
1
1.5
2
2.5
3
3.5
4
0
2
4
6
8
10
12
14
9:01
14:35
16:37
18:27

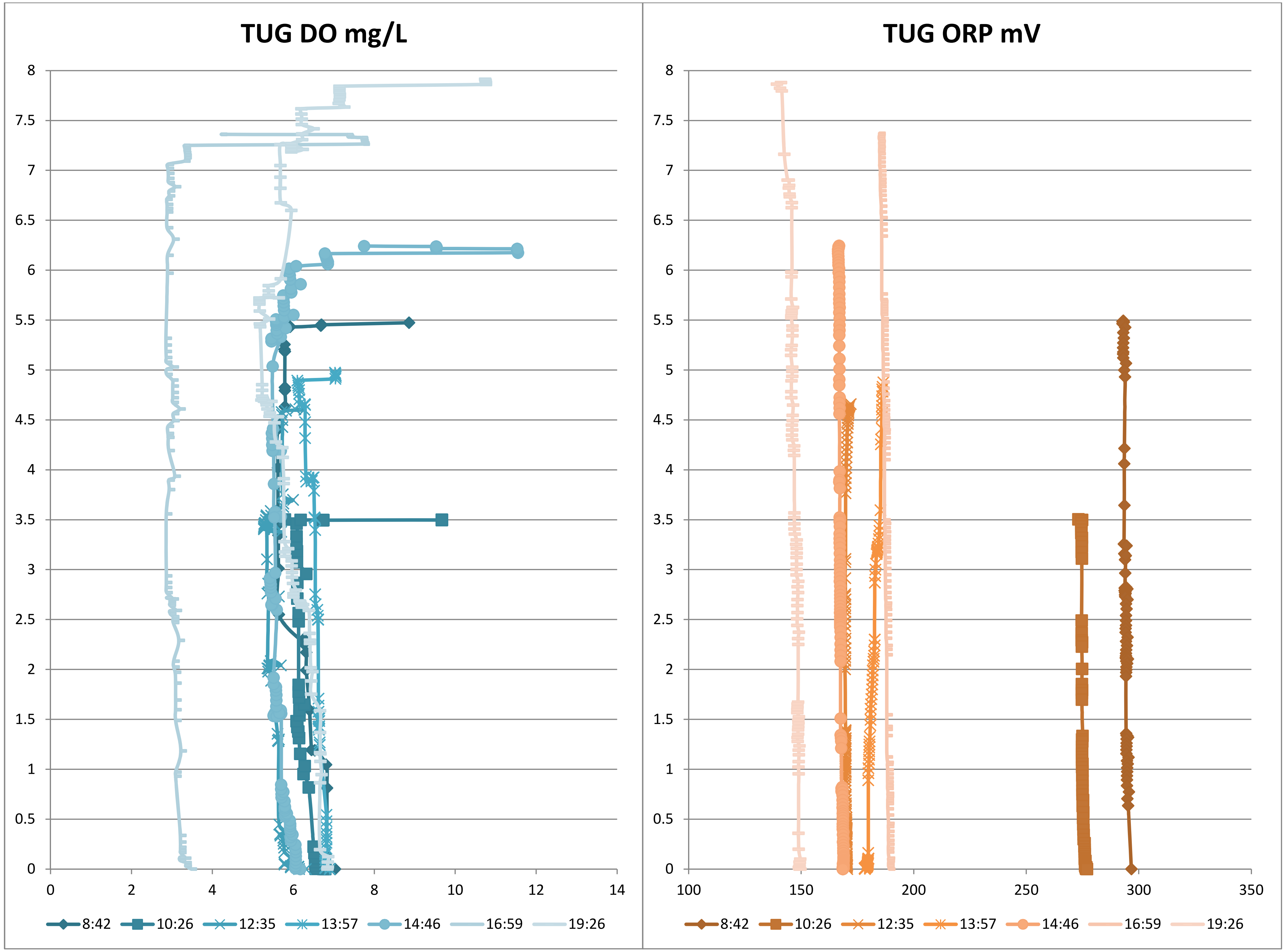

DP04 ORP mV
0
0.5
1
1.5
2
2.5
3
3.5
4
100
150
200
250
300
350
9:01
14:35
16:37
18:27



RB-10-1 Temperature °C
Height Above Sea Floor (m)
0
0.5
1
1.5
2
2.5
3
3.5
4
10
12
14
16
18
20
22
24
26
9:17
14:24
16:26
18:32
RB-10-1 pH
5
5.5
6
6.5
7
7.5
8
8.5
9
9:17
14:24
16:26
18:32
RB-10-1 Salinity ppt
0
5
10
15
20
25
30
35
9:17
14:24
16:26
18:32
RB-10-1 DO mg/L
0
2
4
6
8
10
12
14
9:17
14:24
16:26
18:32
RB-10-1 ORP mV
100
150
200
250
300
350
9:17
14:24
16:26
18:32

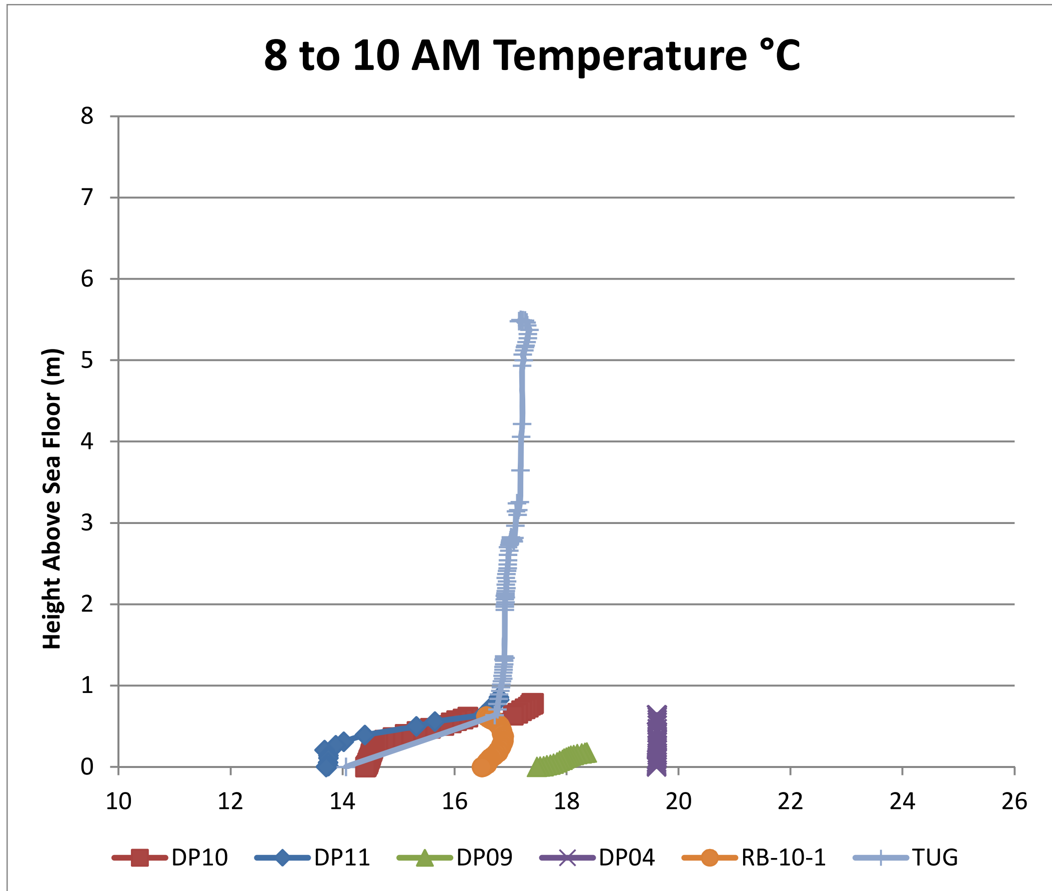


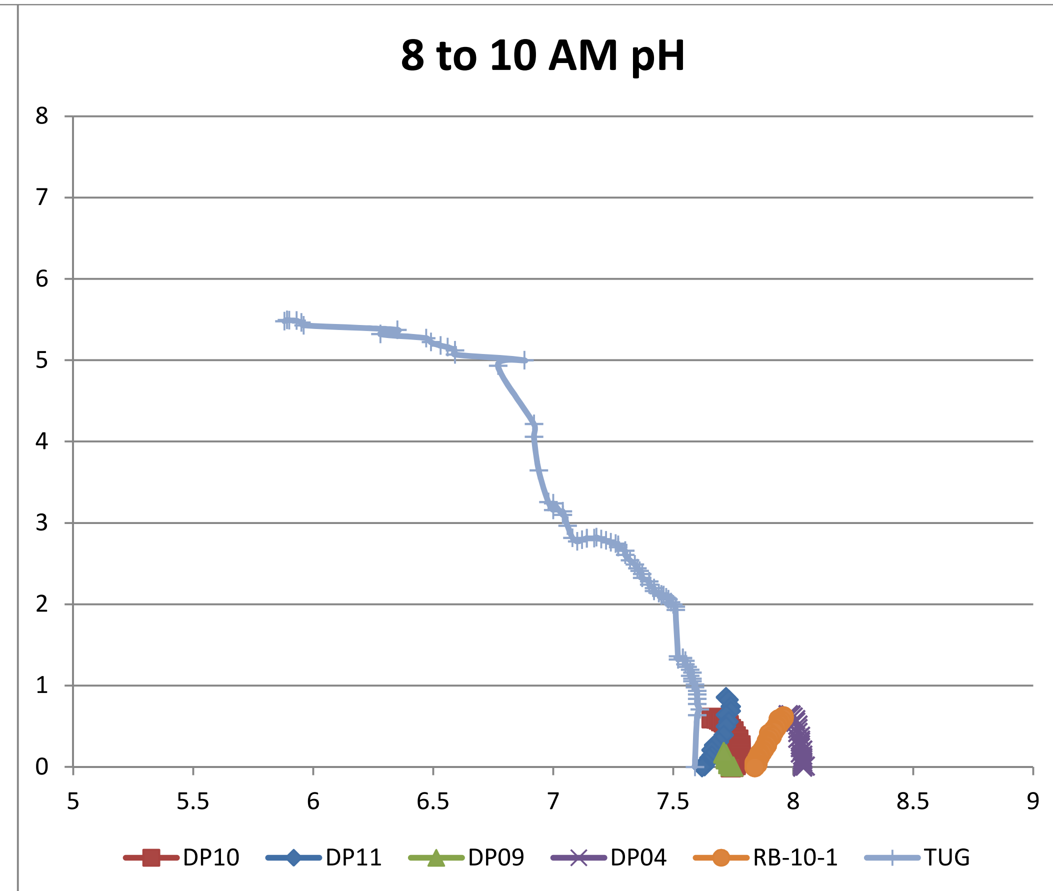
TUG Temperature °C
TUG pH
TUG Salinity ppt
Height Above Sea Floor (m)
8:42
10:26
12:35
13:57
14:46
16:59
19:26

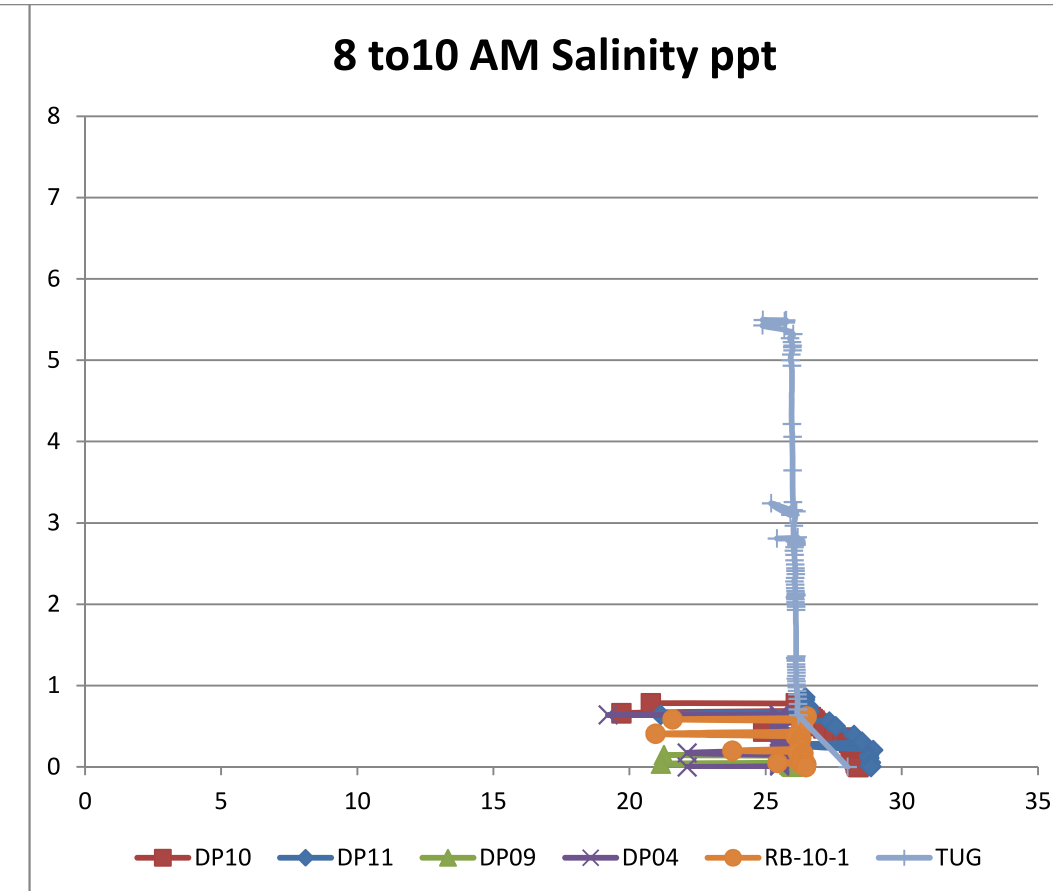

TUG DO mg/L
TUG ORP mV
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0 2 4 6 8 10 12 14
100 150 200 250 300 350
8:42
10:26
12:35
13:57
14:46
16:59
19:26

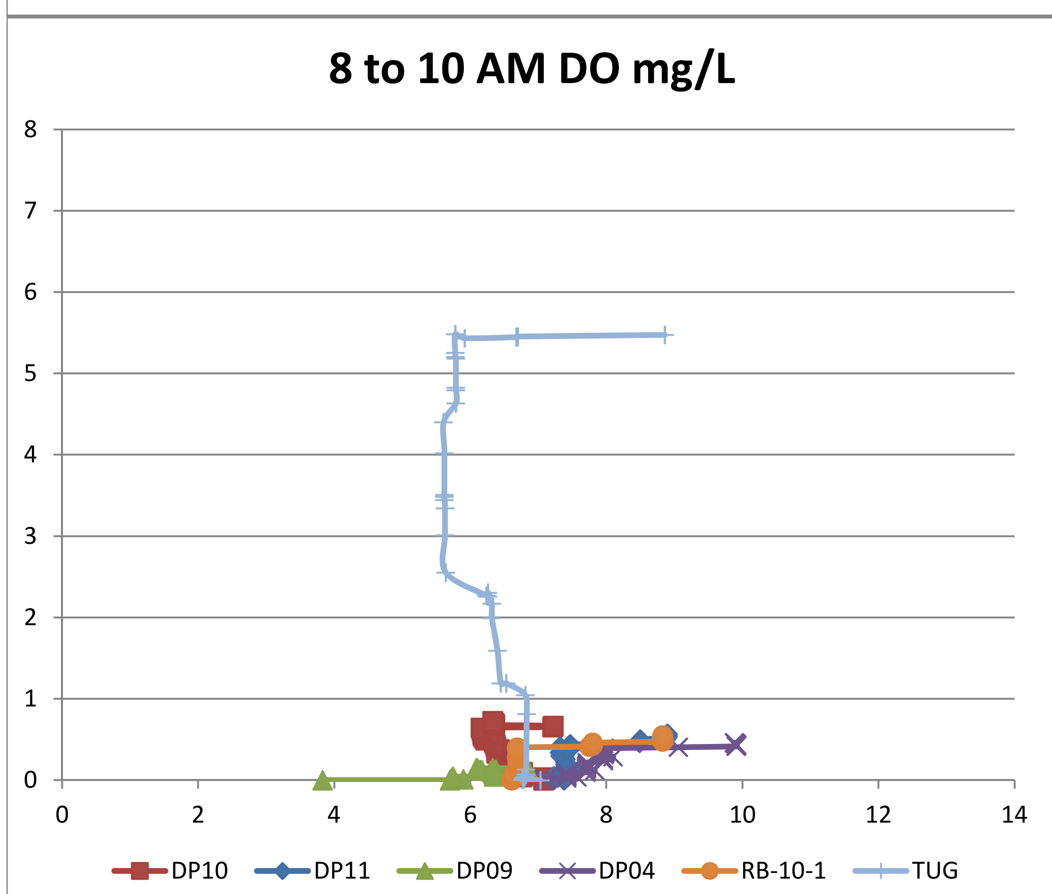
ATTACHMENT #2

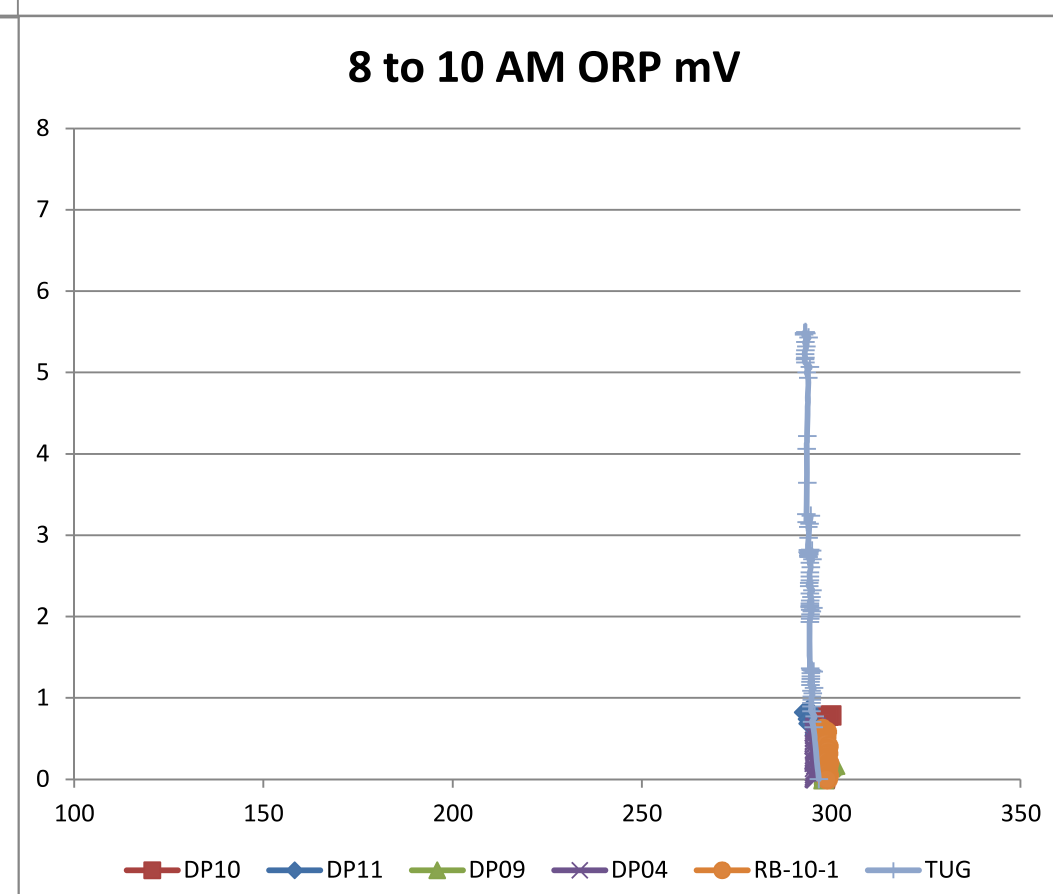
July 22nd Water Profiles by time

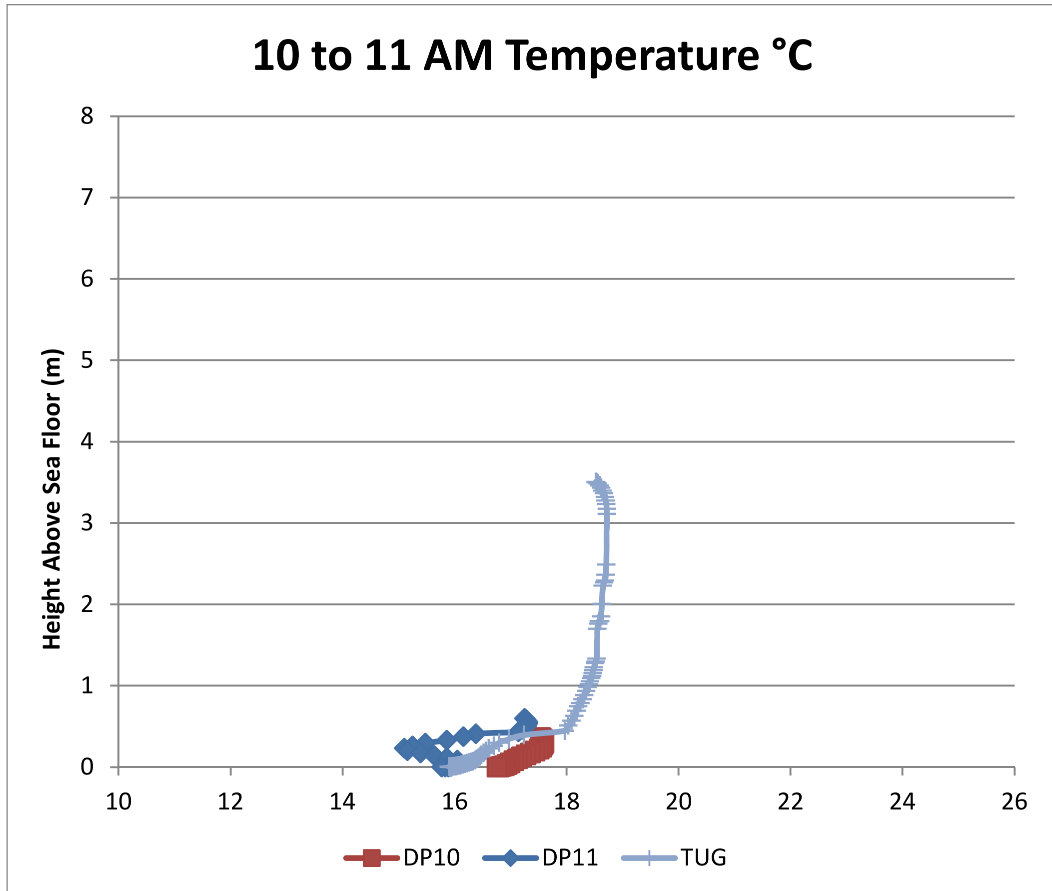

8 to 10 AM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10 DP11 DP09 DP04 RB-10-1 TUG

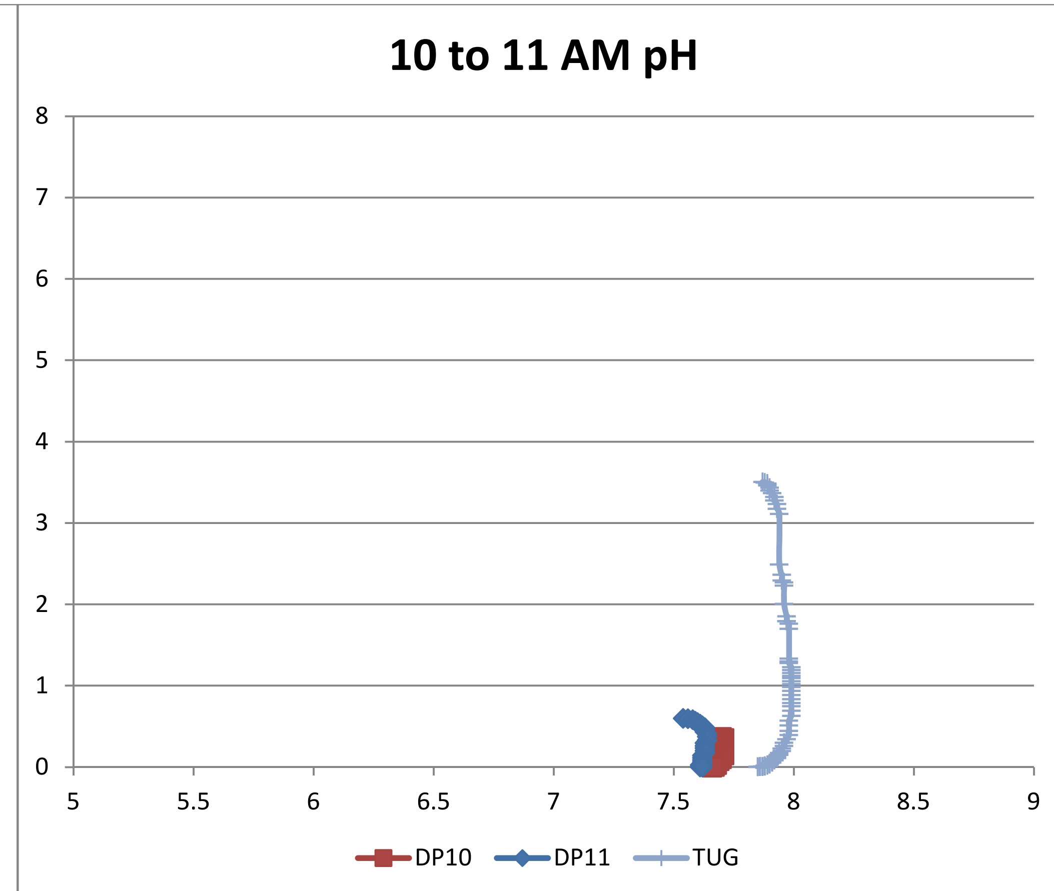

8 to 10 AM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10 DP11 DP09 DP04 RB-10-1 TUG

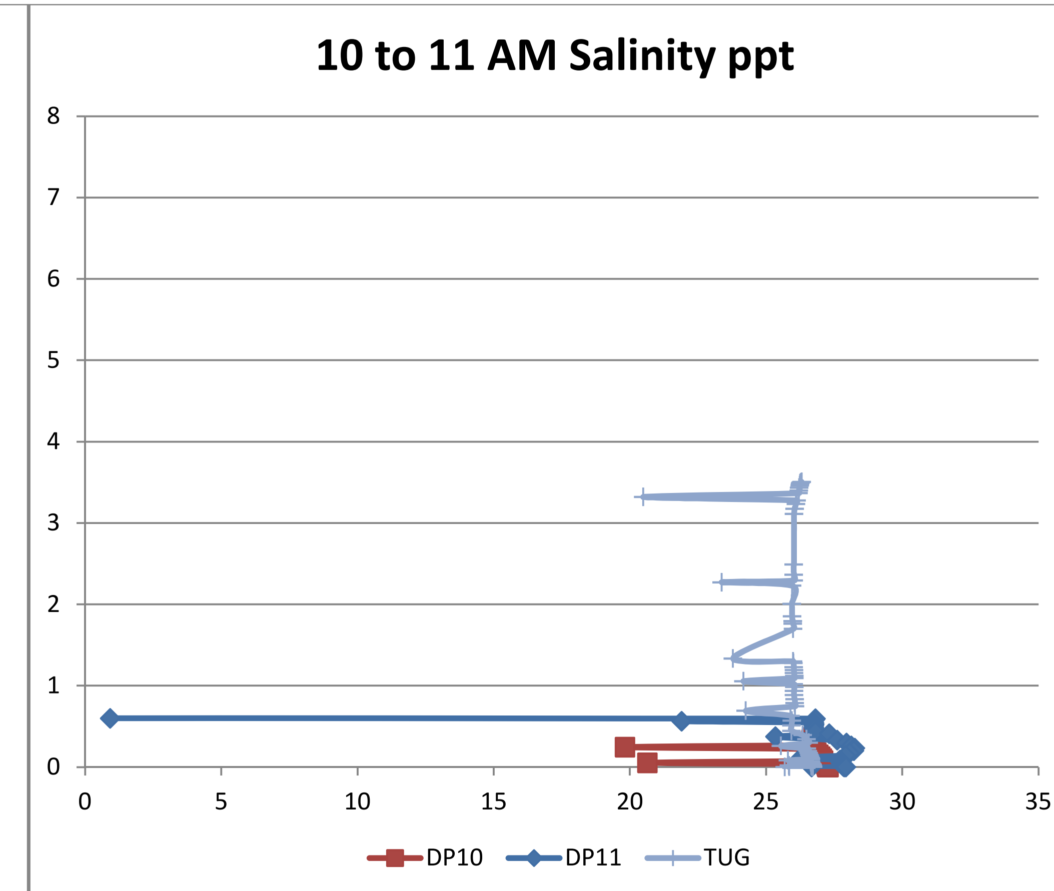

8 to10 AM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10 DP11 DP09 DP04 RB-10-1 TUG

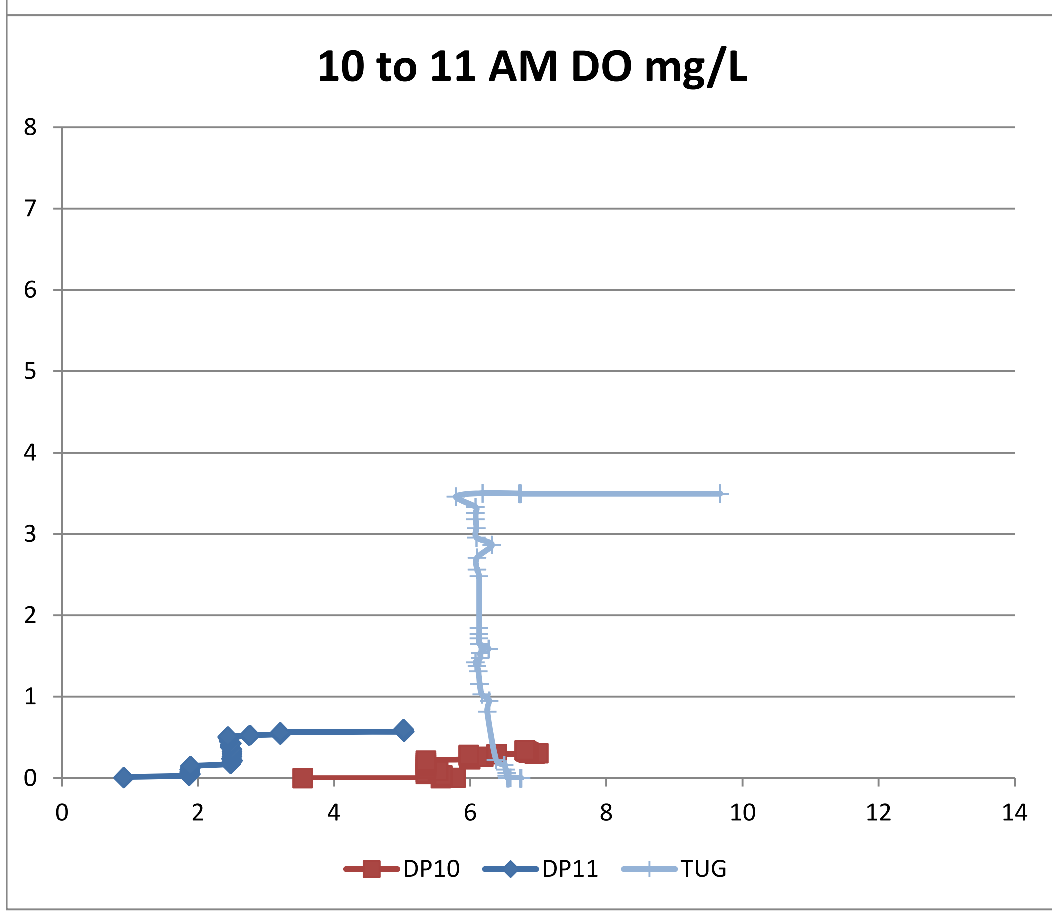

8 to 10 AM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10 DP11 DP09 DP04 RB-10-1 TUG

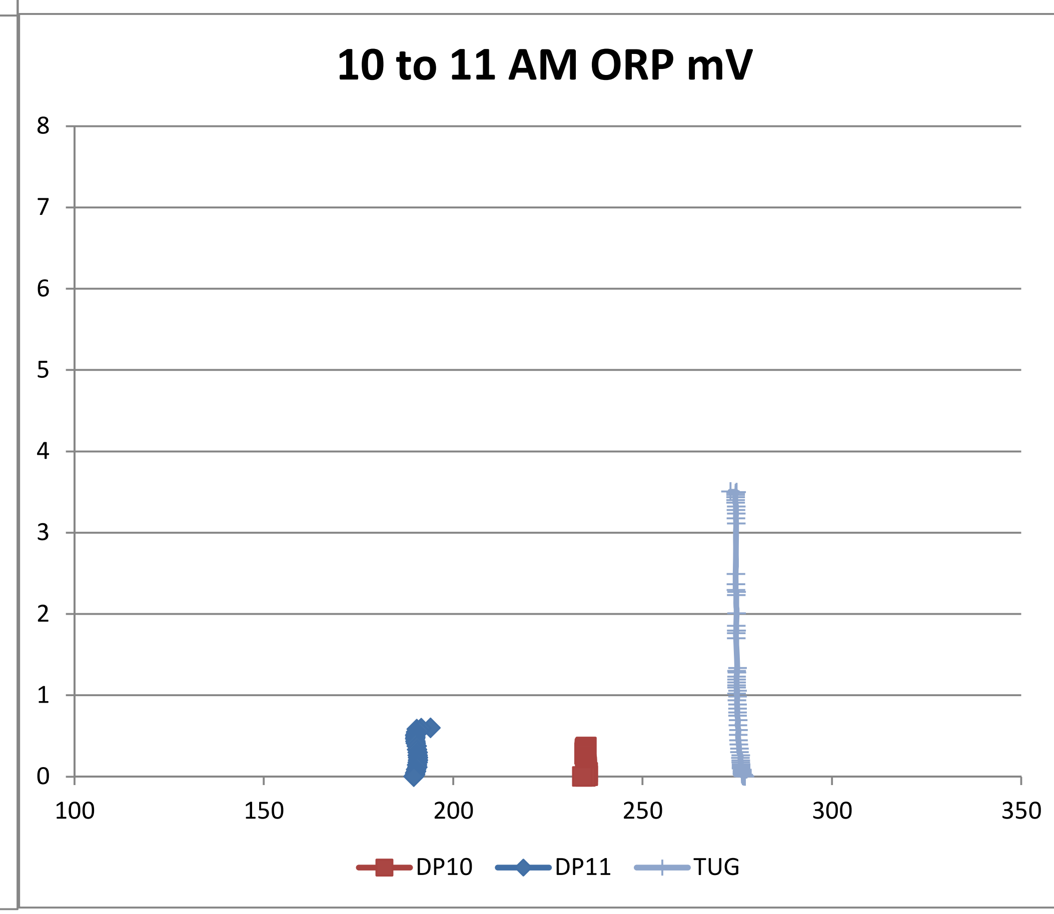

8 to 10 AM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10 DP11 DP09 DP04 RB-10-1 TUG

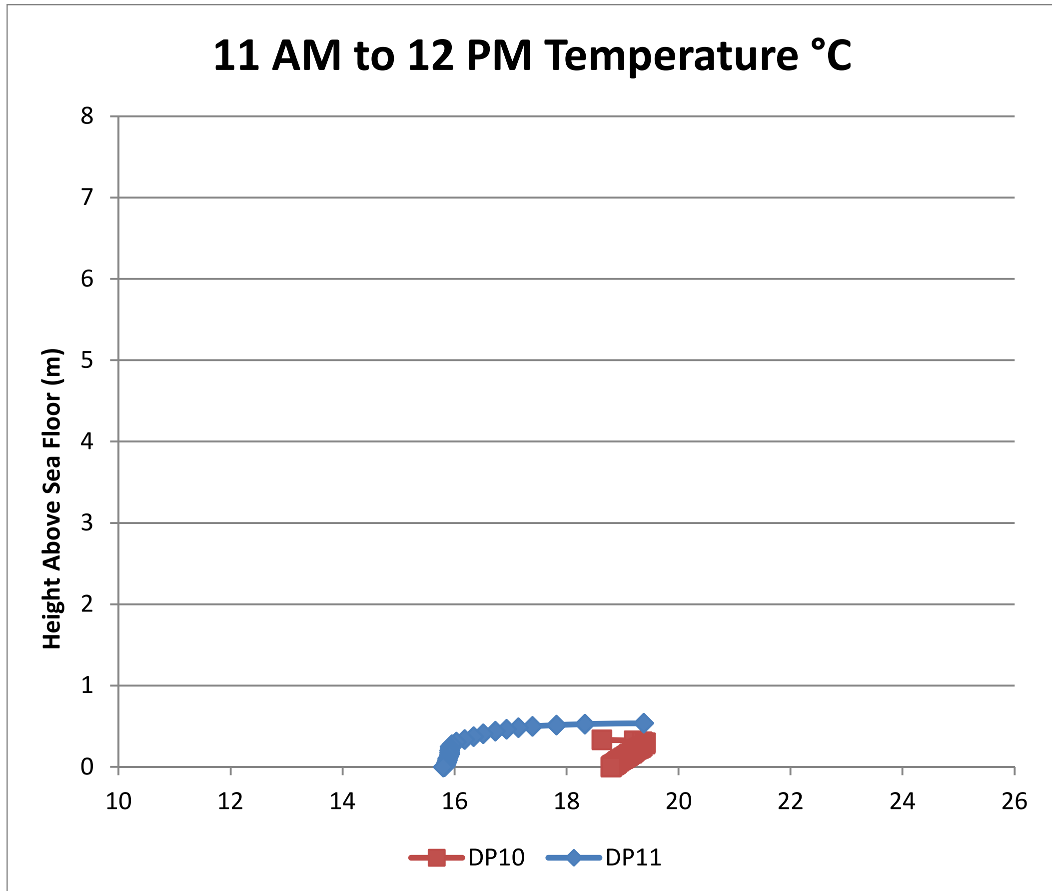

10 to 11 AM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10 DP11 TUG

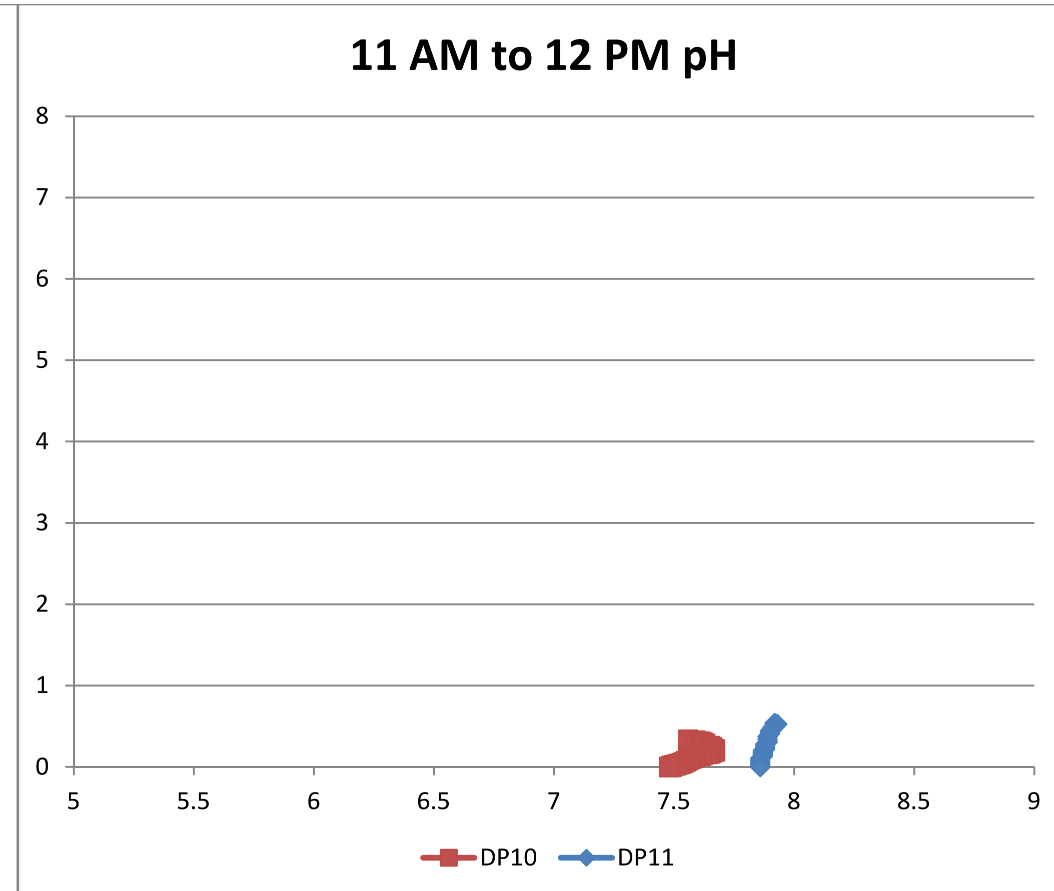

10 to 11 AM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10 DP11 TUG

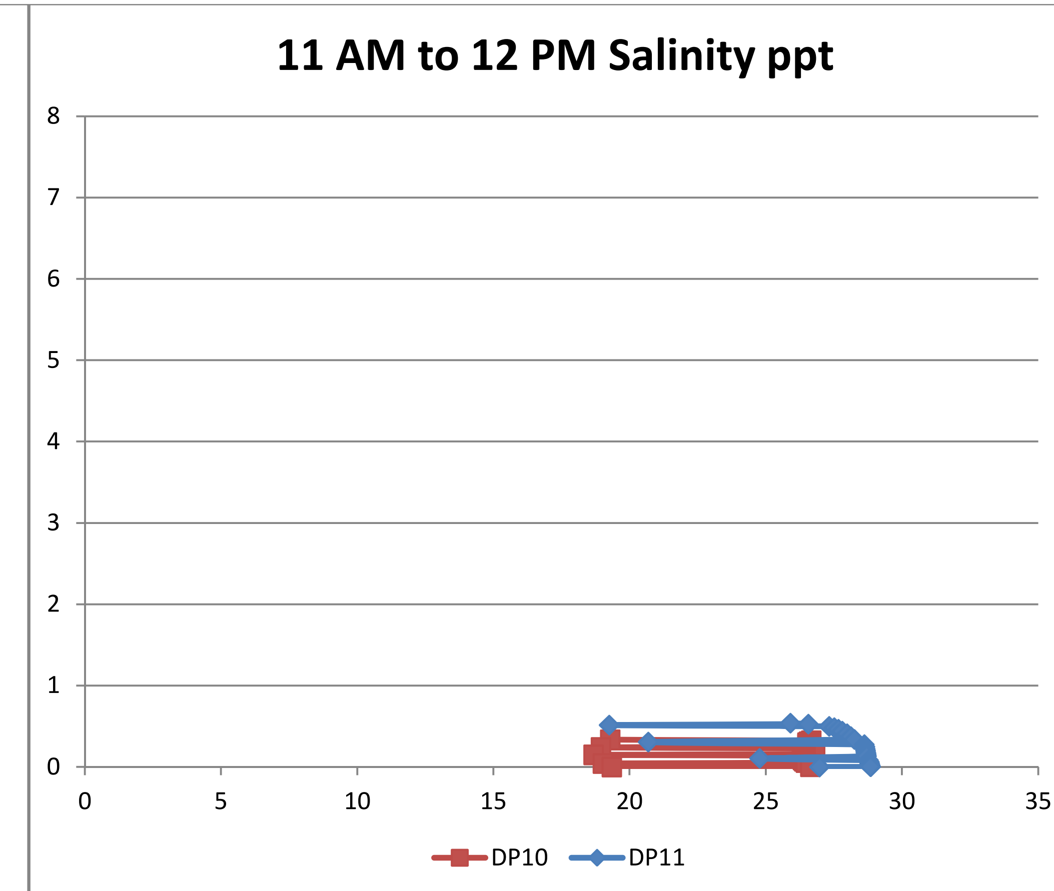

10 to 11 AM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10 DP11 TUG

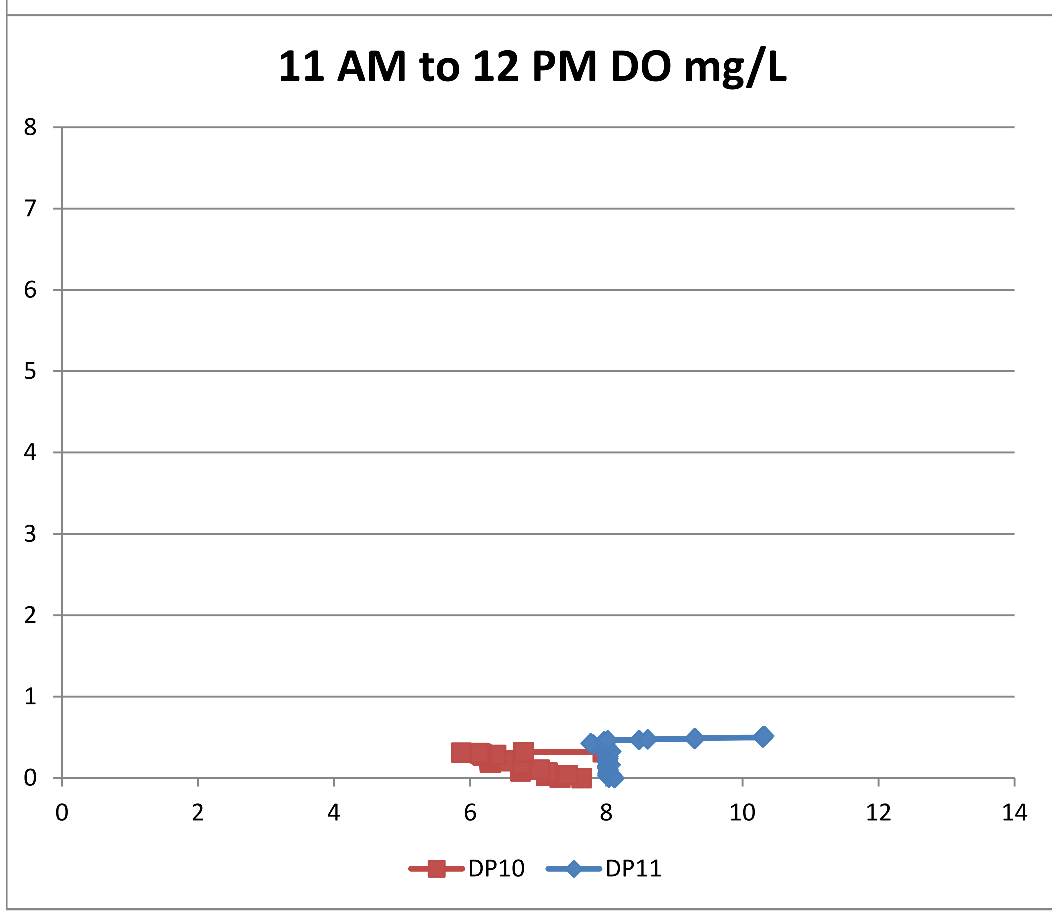

10 to 11 AM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10 DP11 TUG

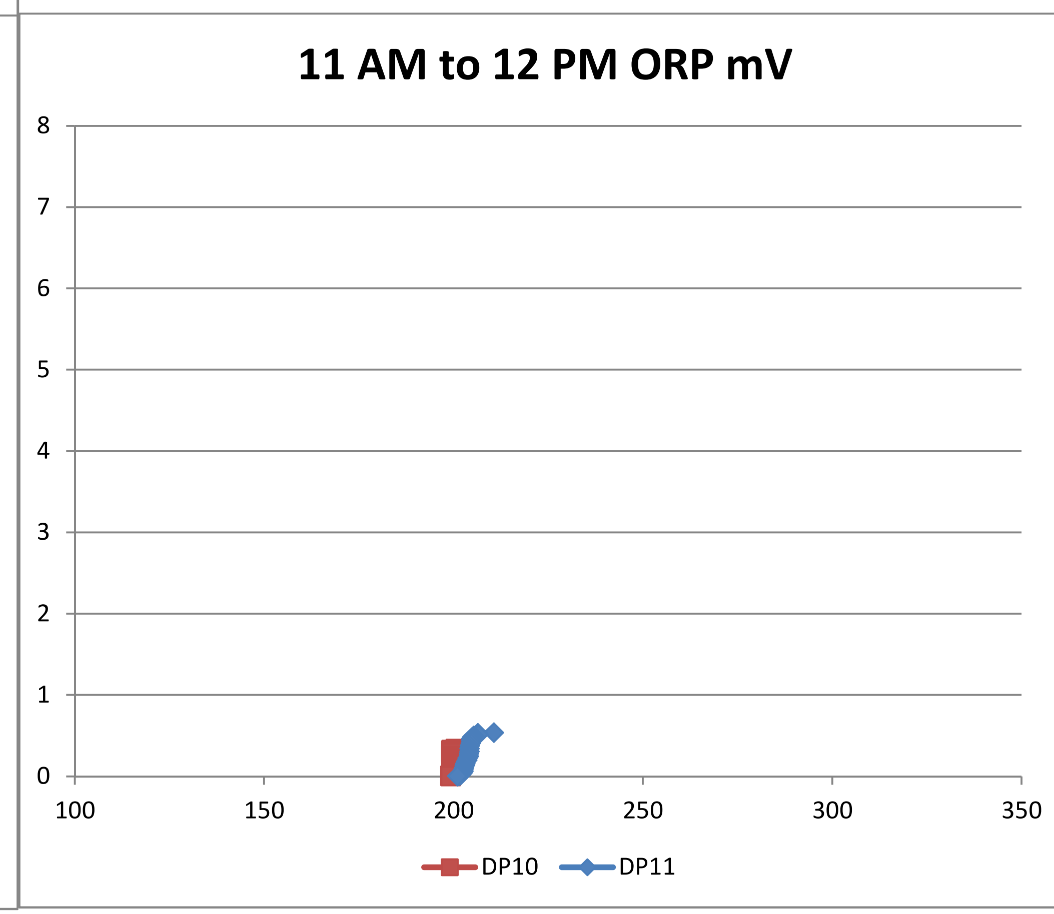

10 to 11 AM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10 DP11 TUG

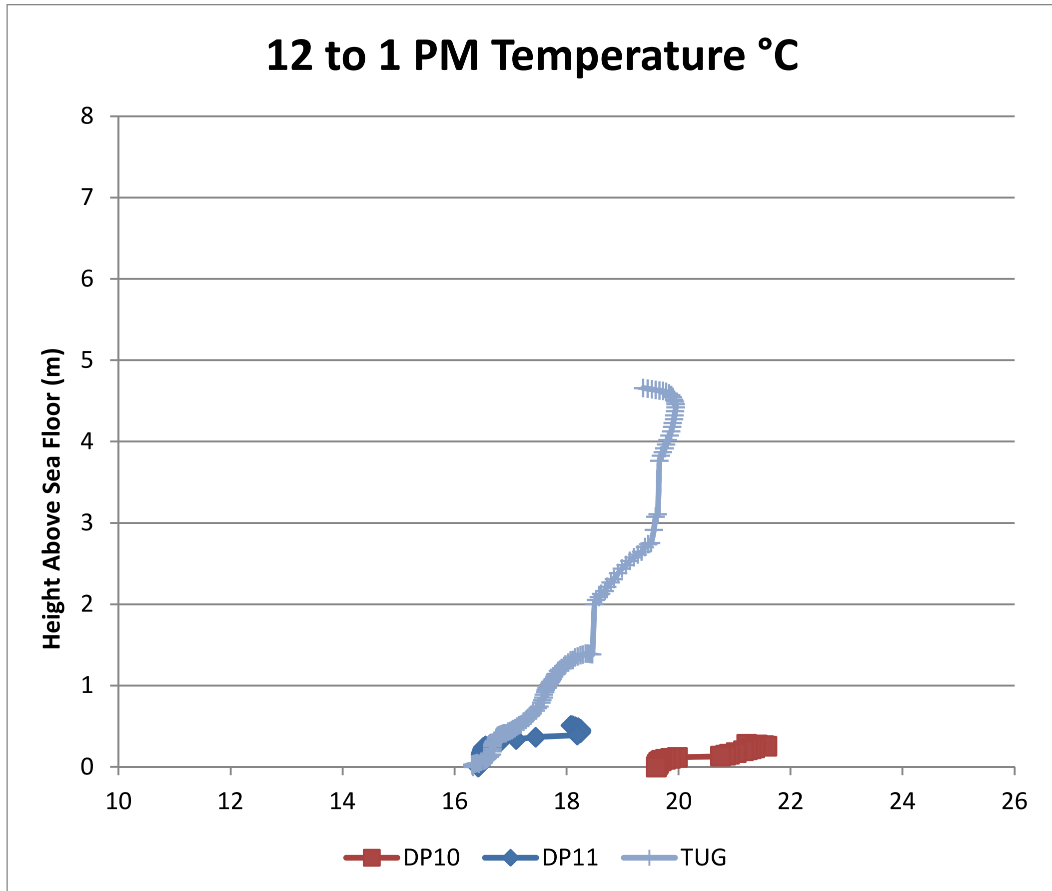

11 AM to 12 PM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10
DP11

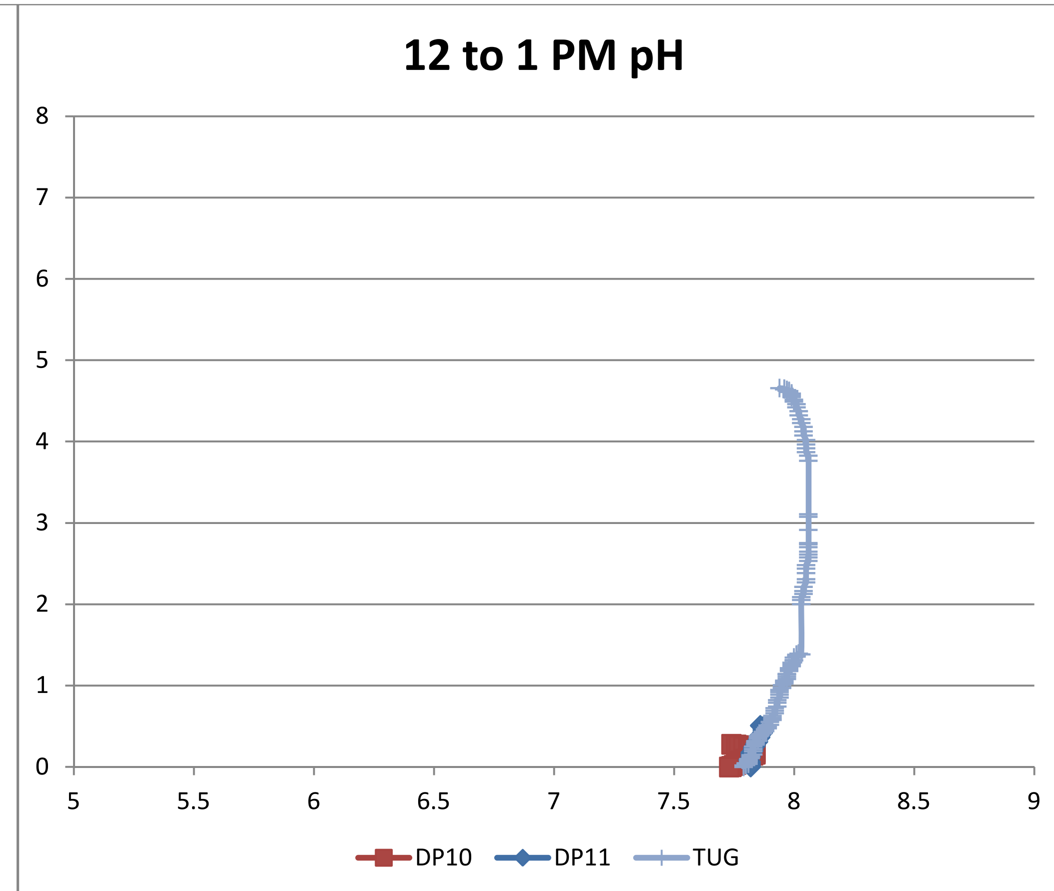

11 AM to 12 PM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10
DP11

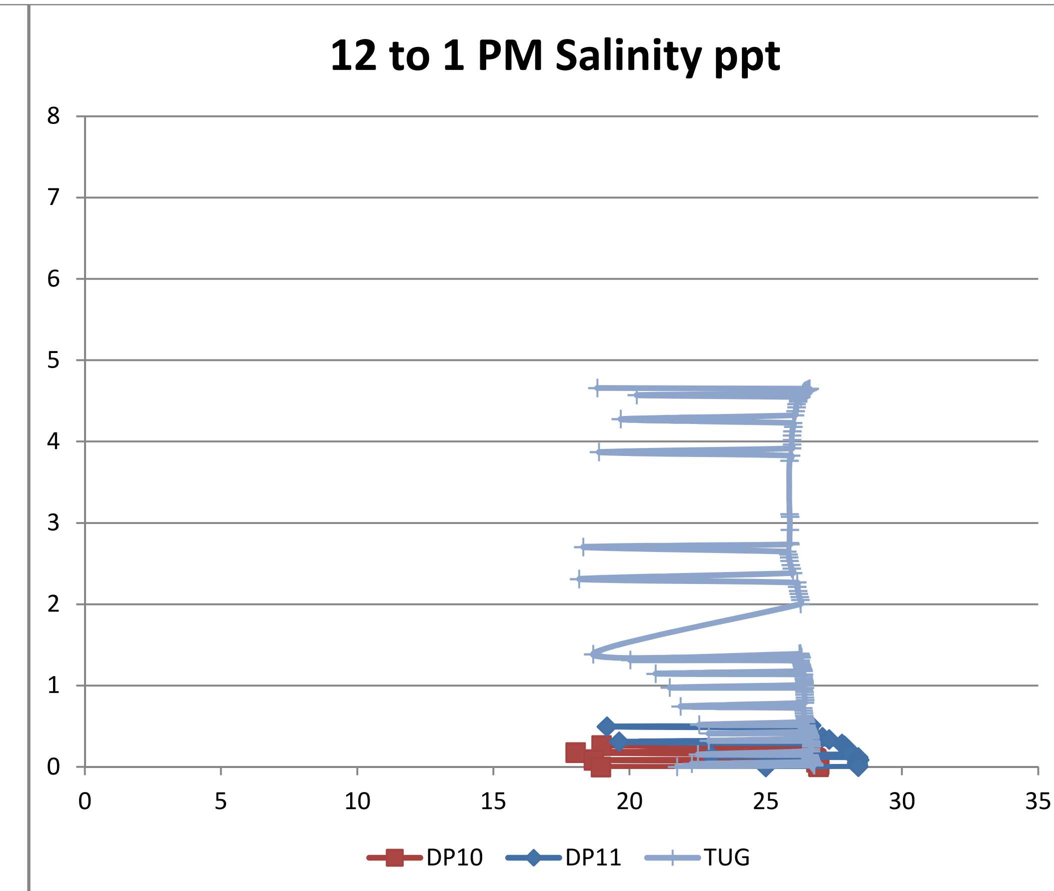

11 AM to 12 PM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10
DP11

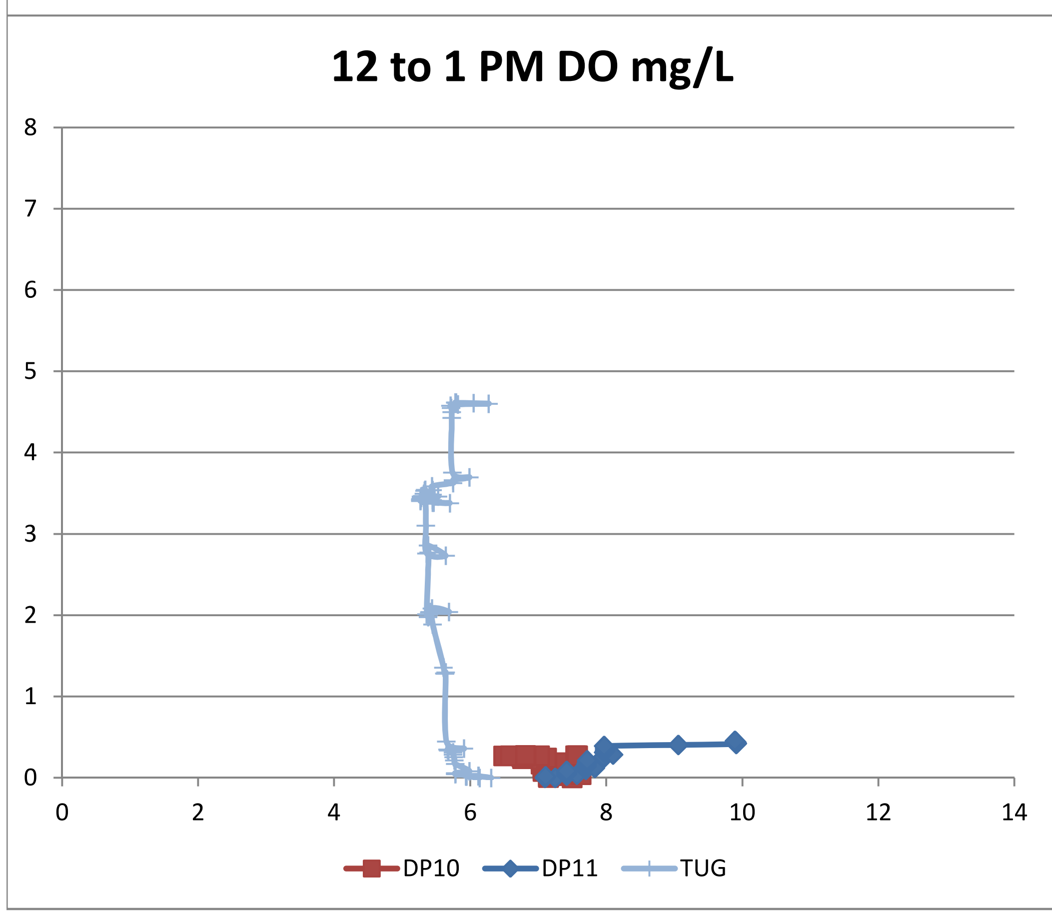

11 AM to 12 PM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10
DP11

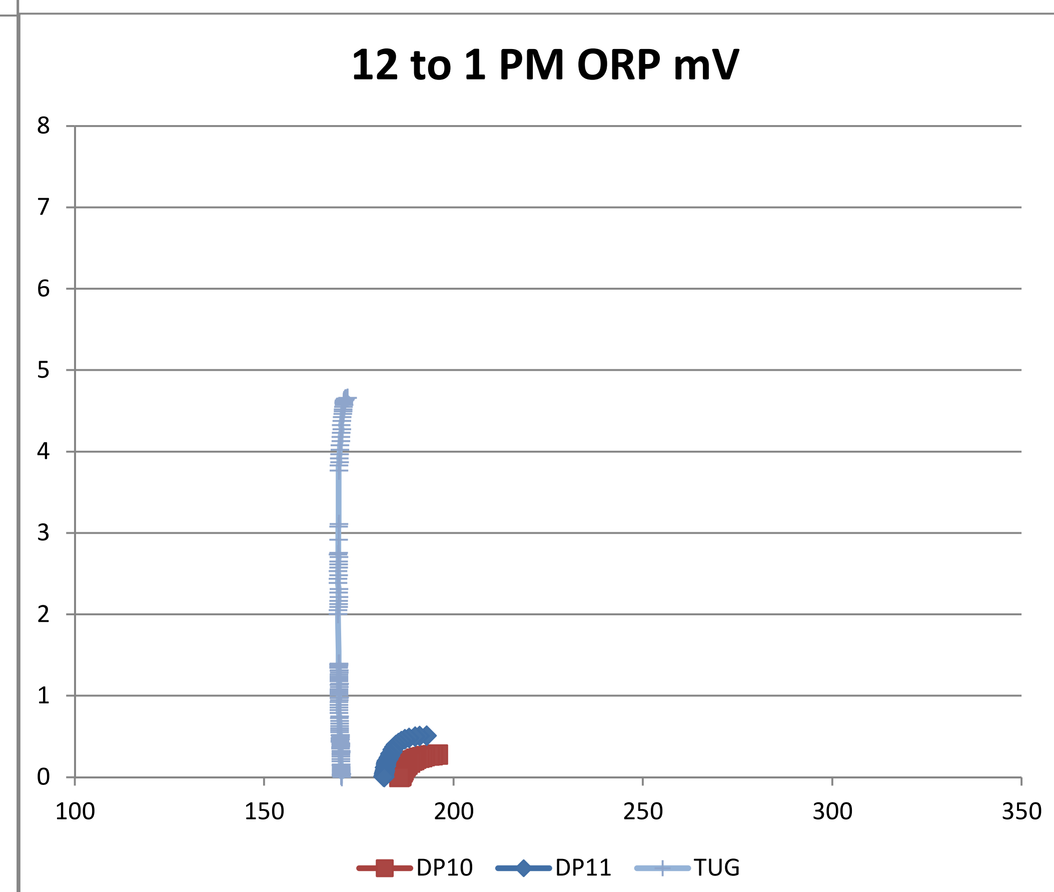

11 AM to 12 PM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10
DP11

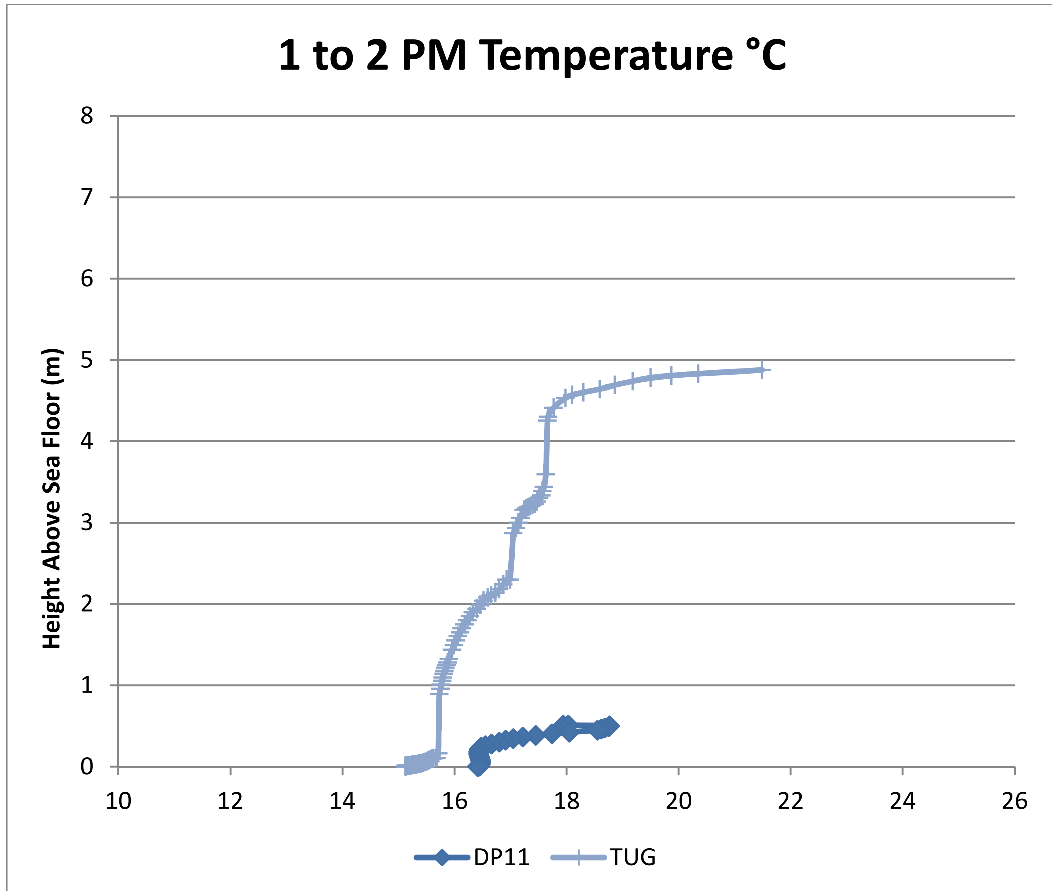

12 to 1 PM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10 DP11 TUG

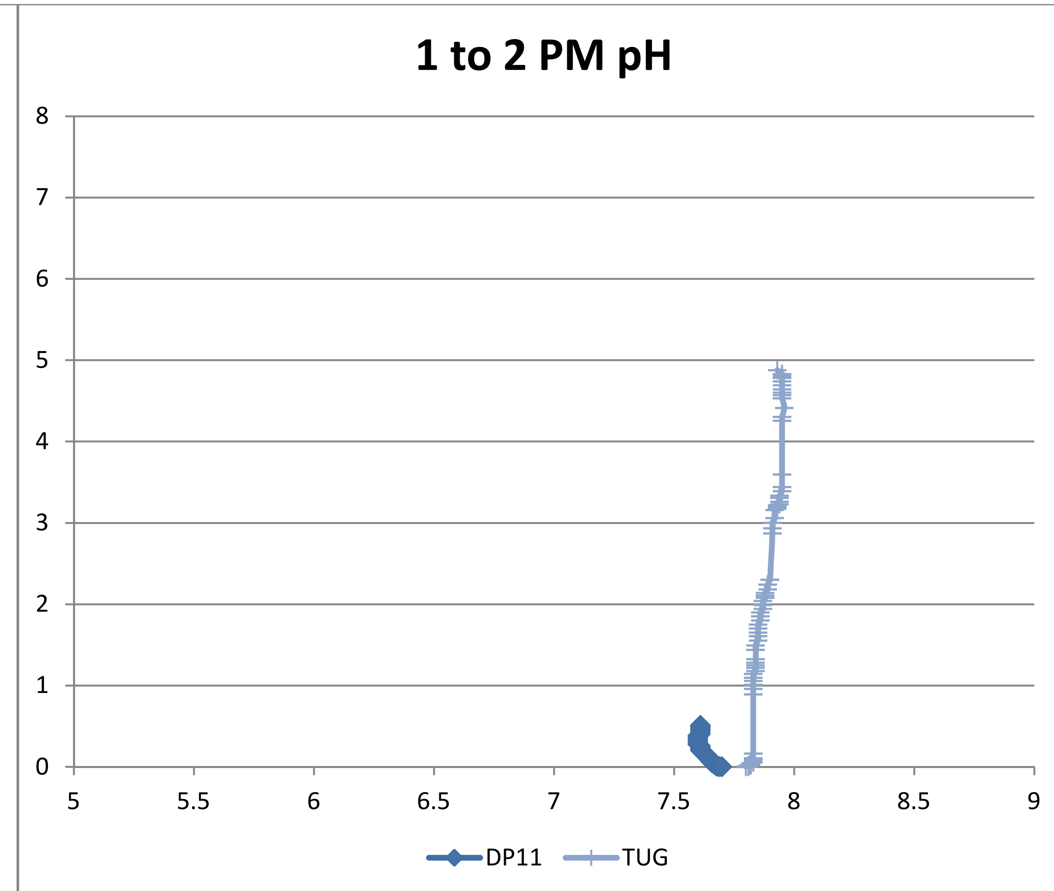

12 to 1 PM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10 DP11 TUG

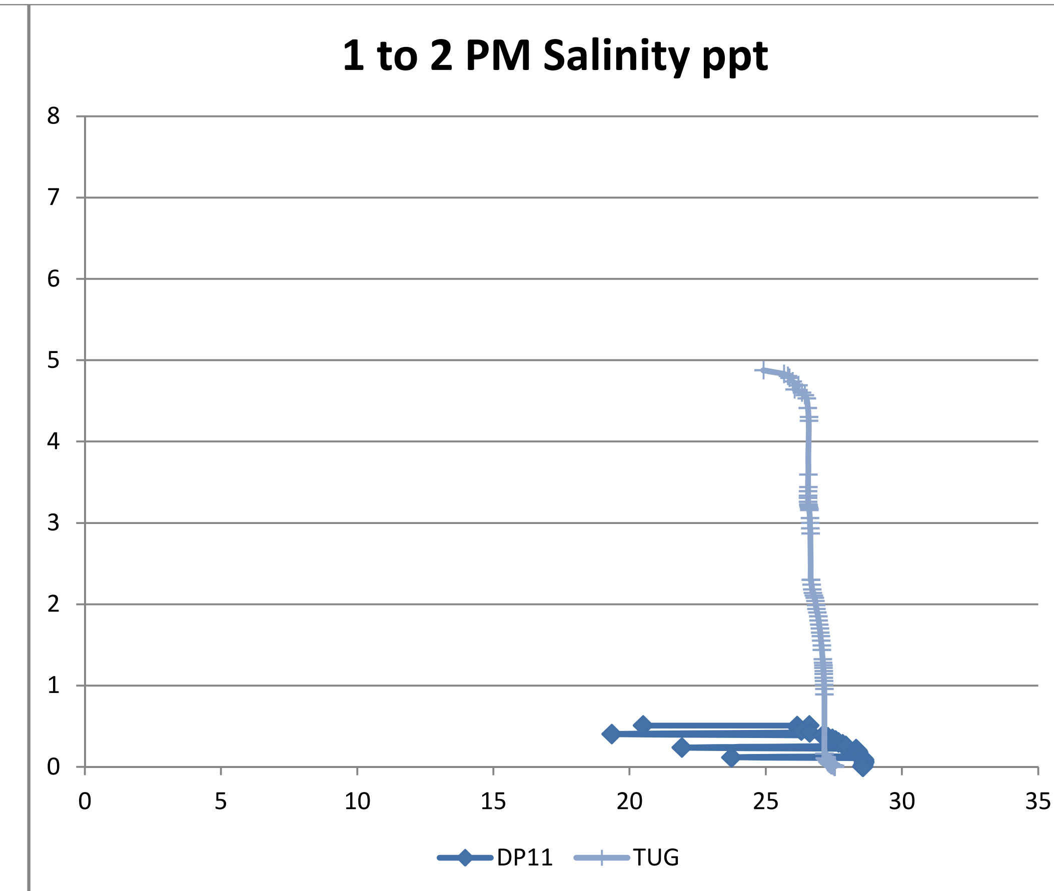

12 to 1 PM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10 DP11 TUG

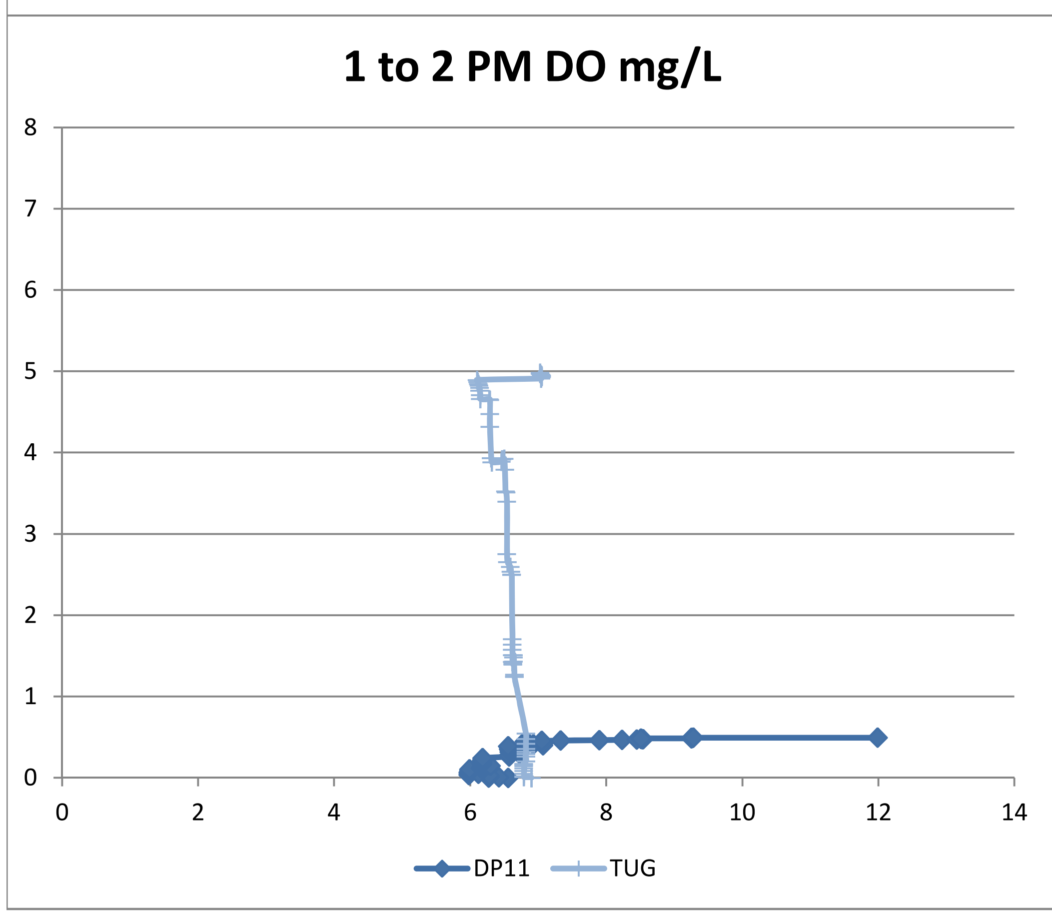

12 to 1 PM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10 DP11 TUG

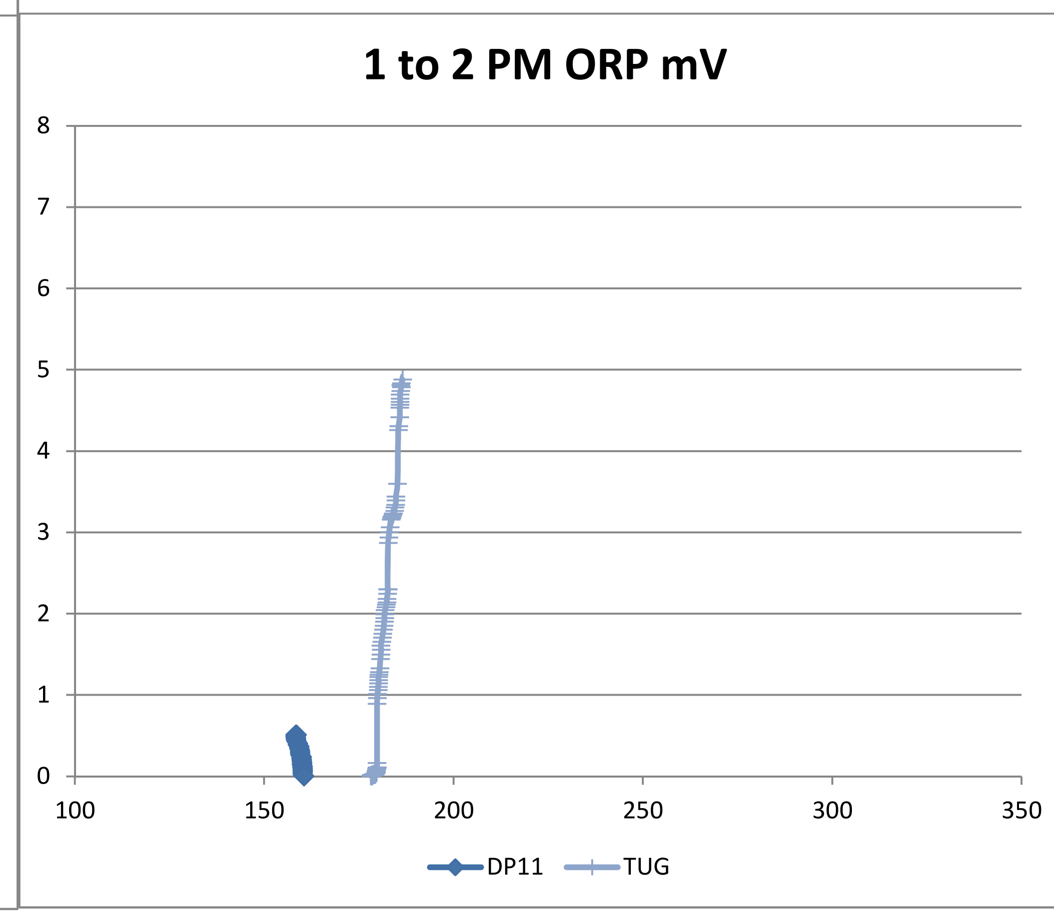

12 to 1 PM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10 DP11 TUG

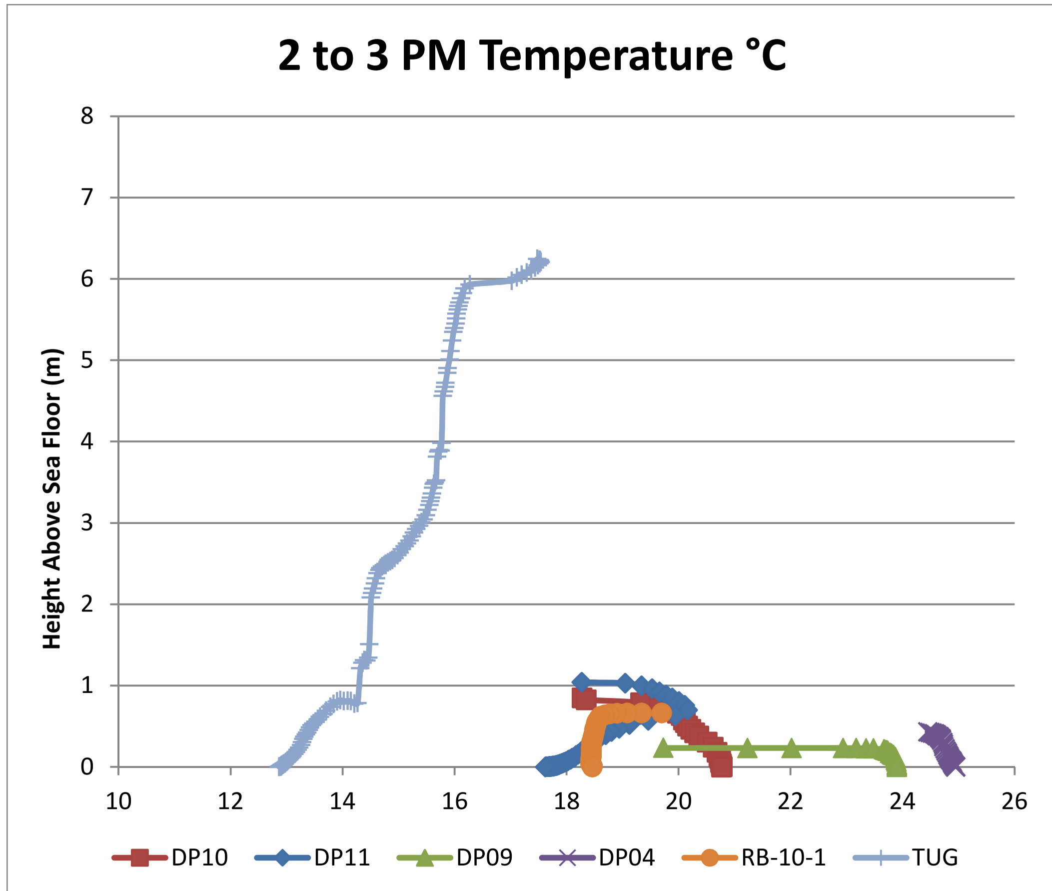

1 to 2 PM Temperature °C
Height Above Sea Floor (m)
0
1
2
3
4
5
6
7
8
10
12
14
16
18
20
22
24
26
DP11
TUG

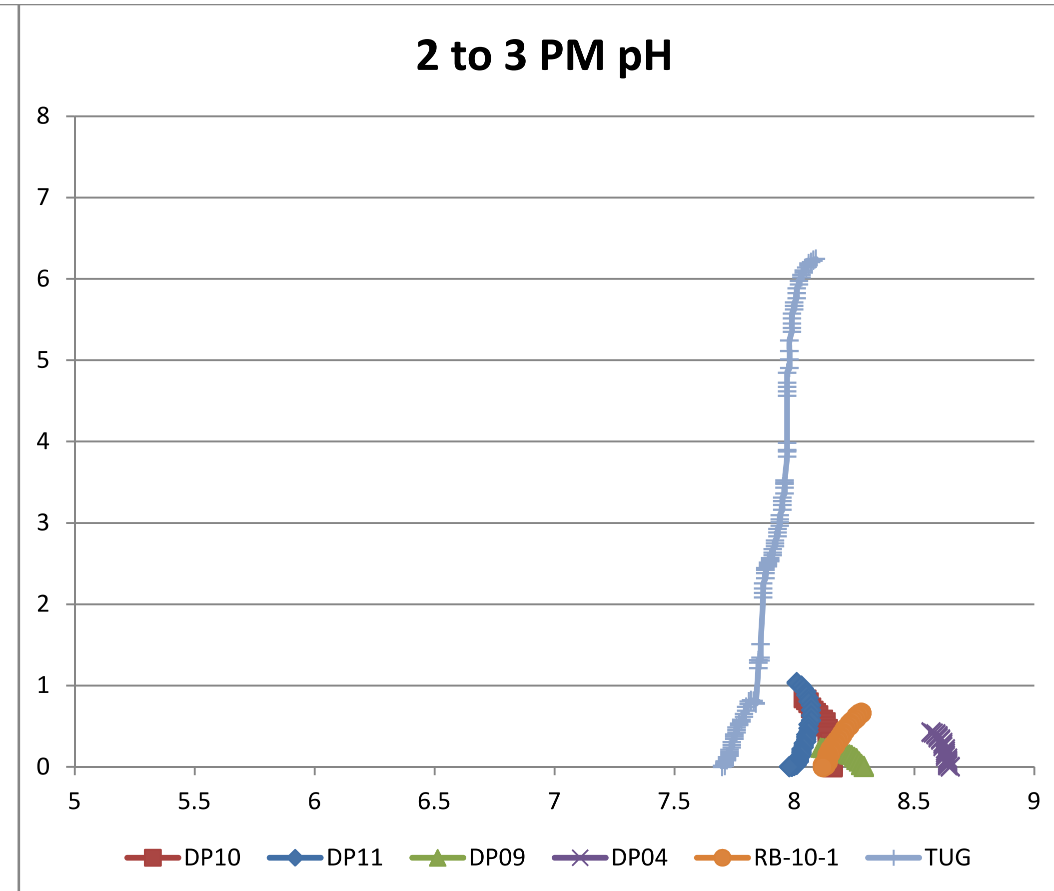

1 to 2 PM pH
0
1
2
3
4
5
6
7
8
5
5.5
6
6.5
7
7.5
8
8.5
9
DP11
TUG

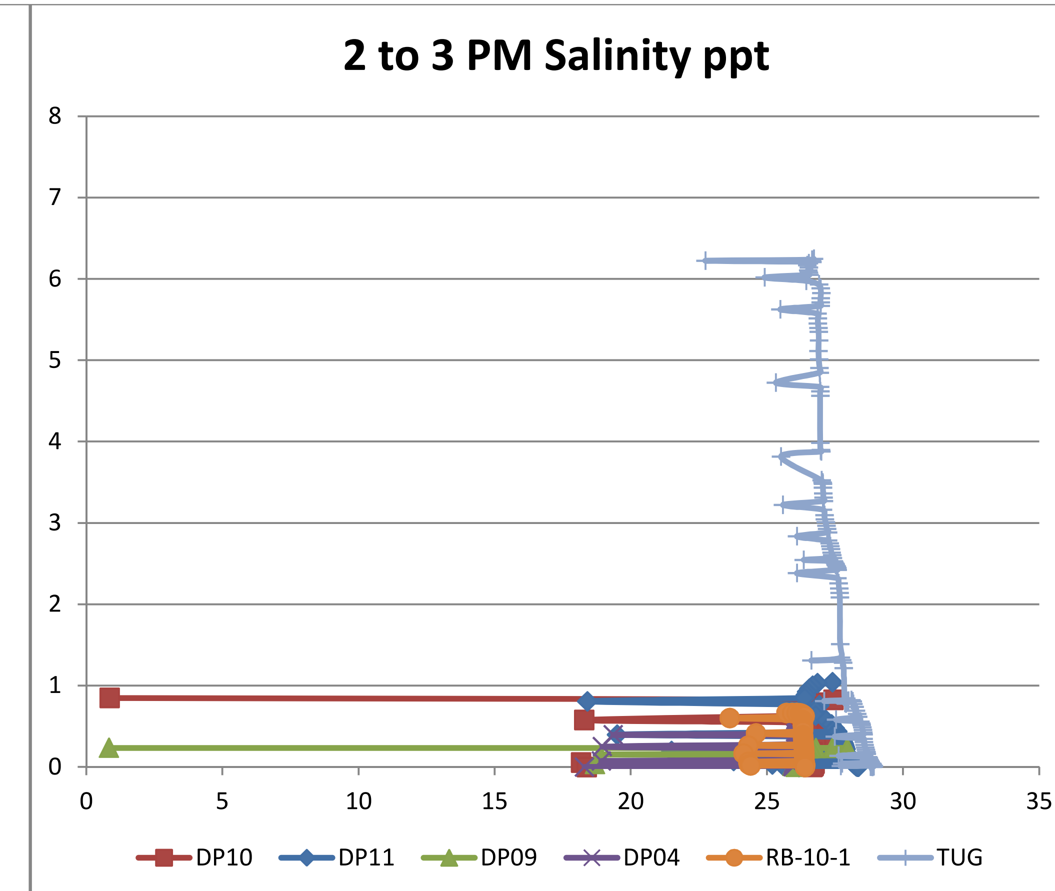

1 to 2 PM Salinity ppt
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
DP11
TUG

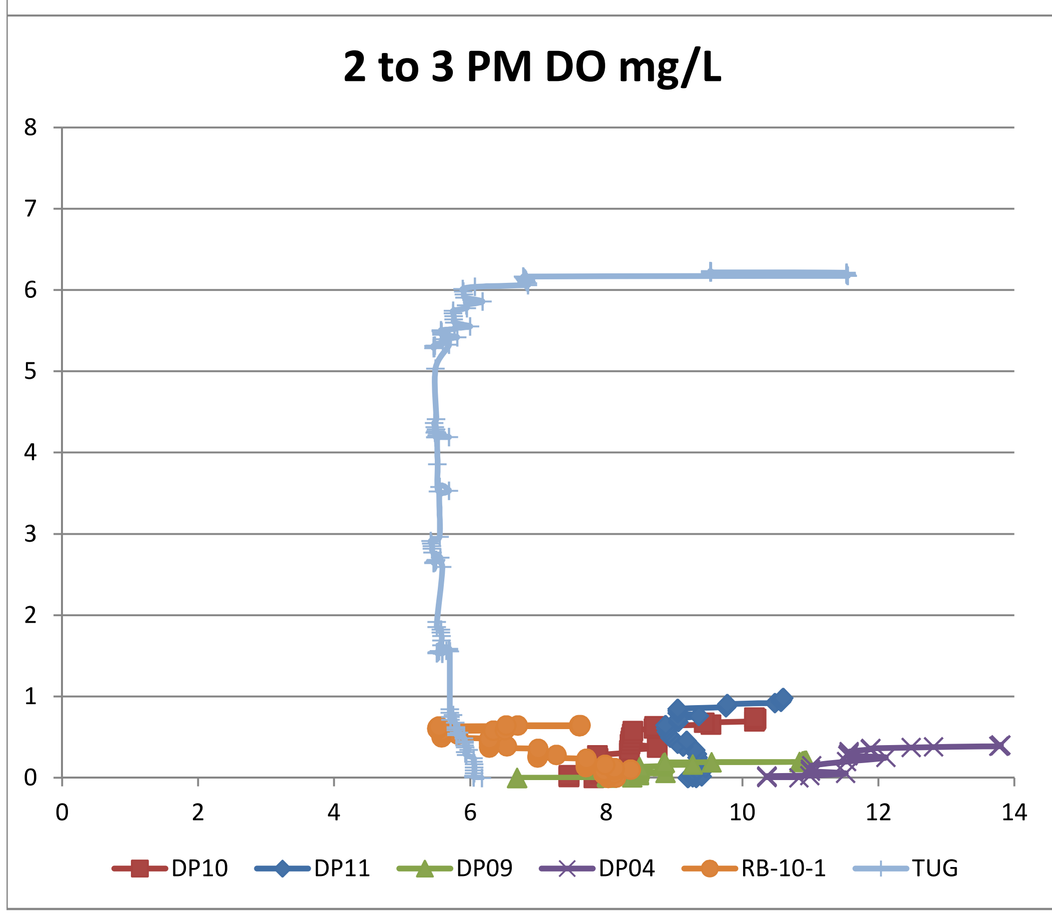

1 to 2 PM DO mg/L
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
DP11
TUG

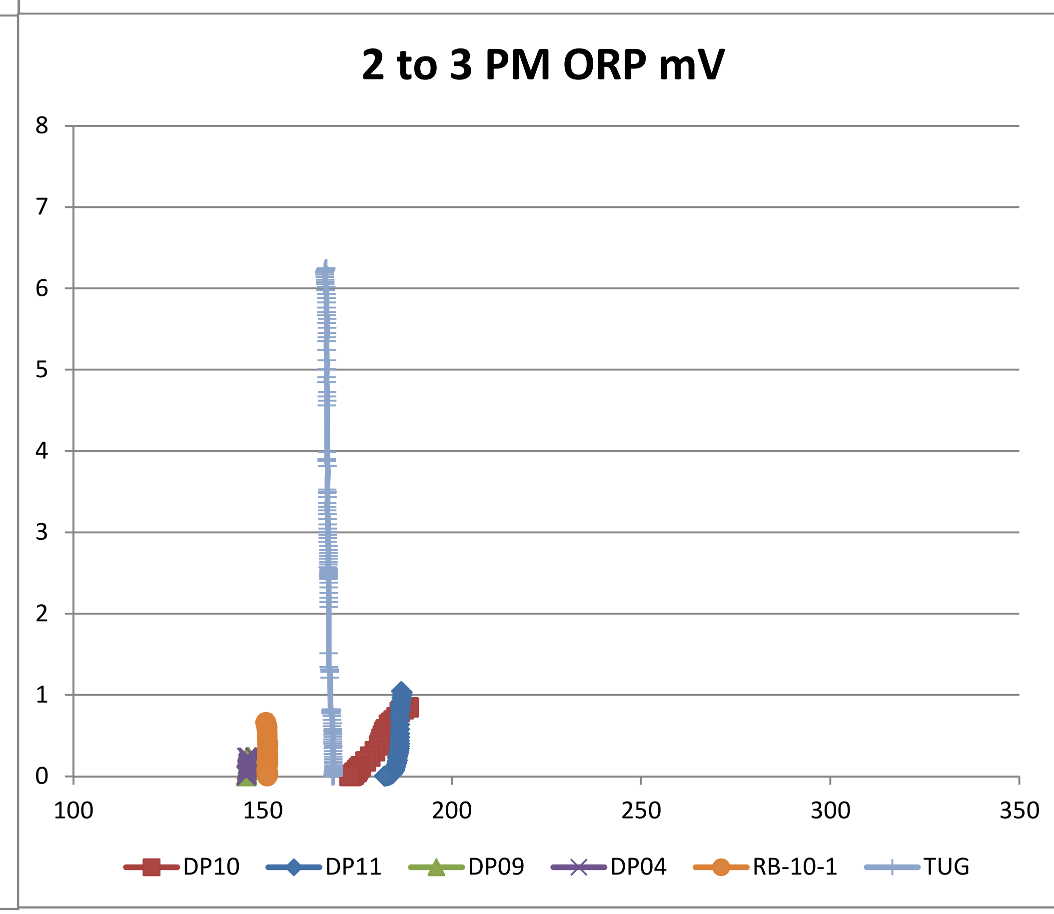

1 to 2 PM ORP mV
0
1
2
3
4
5
6
7
8
100
150
200
250
300
350
DP11
TUG

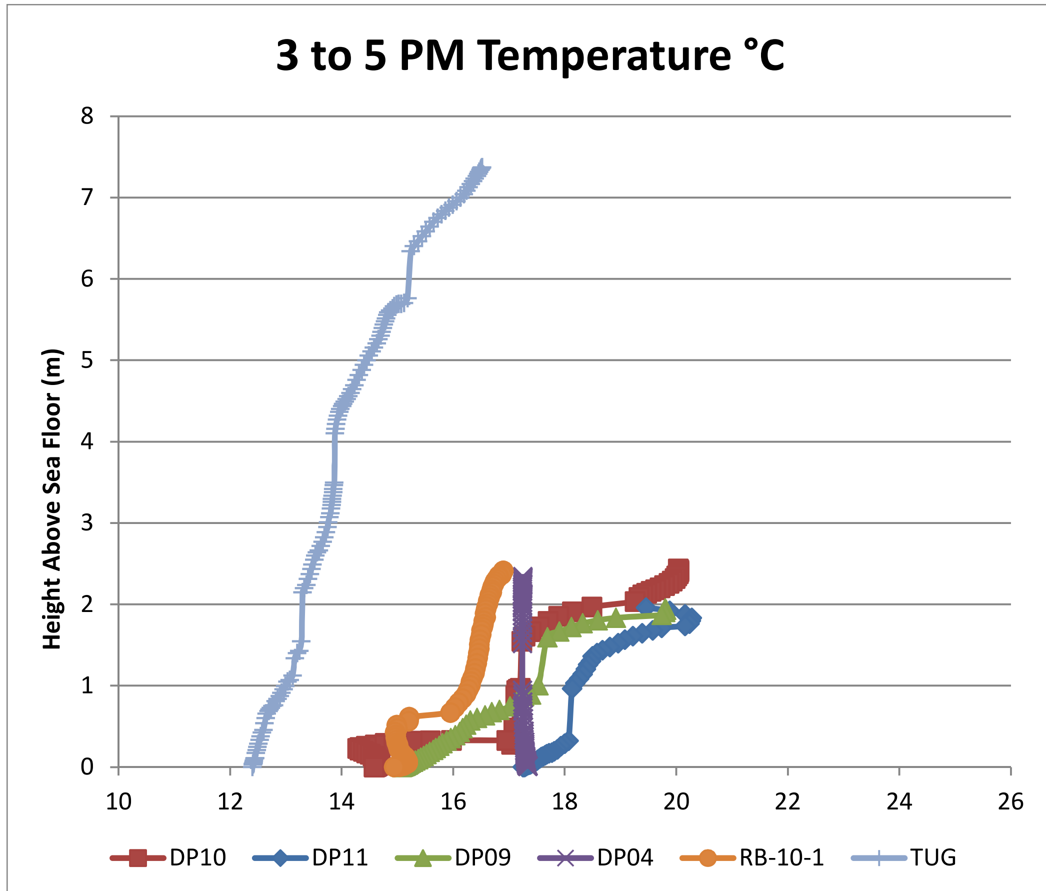

2 to 3 PM Temperature °C
Height Above Sea Floor (m)
0
1
2
3
4
5
6
7
8
10
12
14
16
18
20
22
24
26
DP10
DP11
DP09
DP04
RB-10-1
TUG

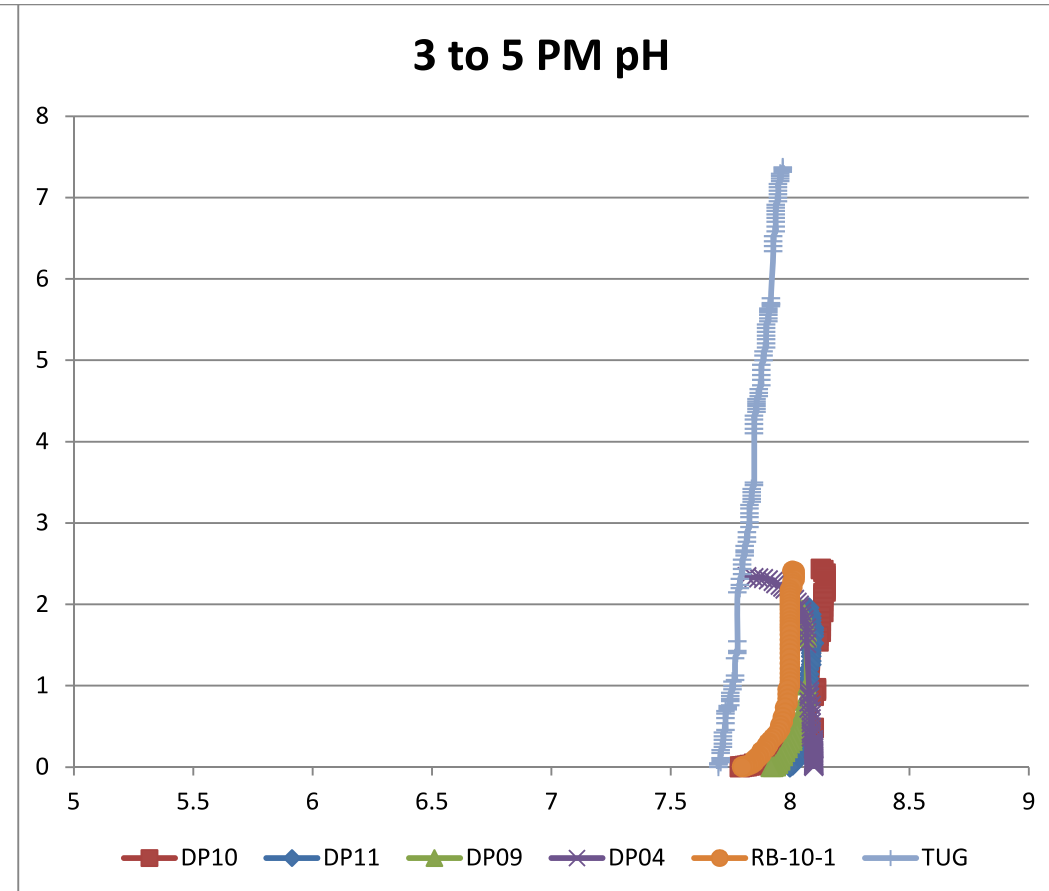

2 to 3 PM pH
0
1
2
3
4
5
6
7
8
5
5.5
6
6.5
7
7.5
8
8.5
9
DP10
DP11
DP09
DP04
RB-10-1
TUG

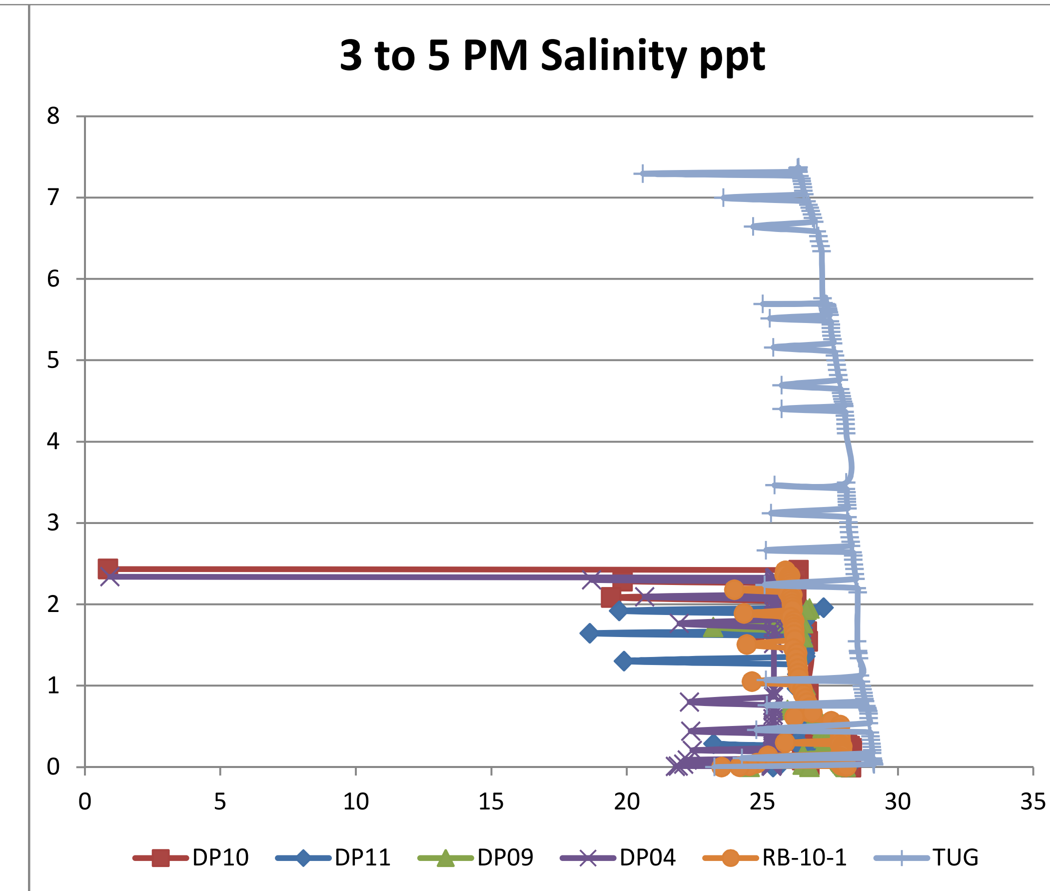

2 to 3 PM Salinity ppt
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
DP10
DP11
DP09
DP04
RB-10-1
TUG

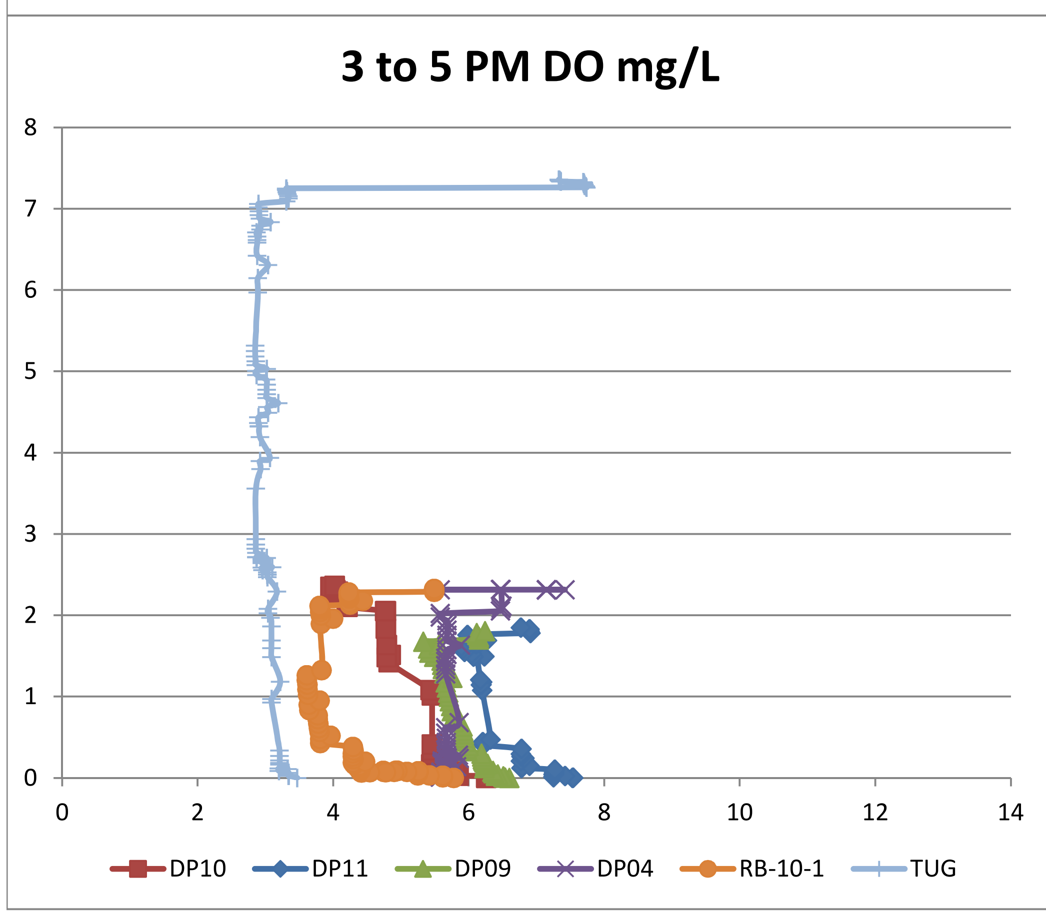

2 to 3 PM DO mg/L
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
DP10
DP11
DP09
DP04
RB-10-1
TUG

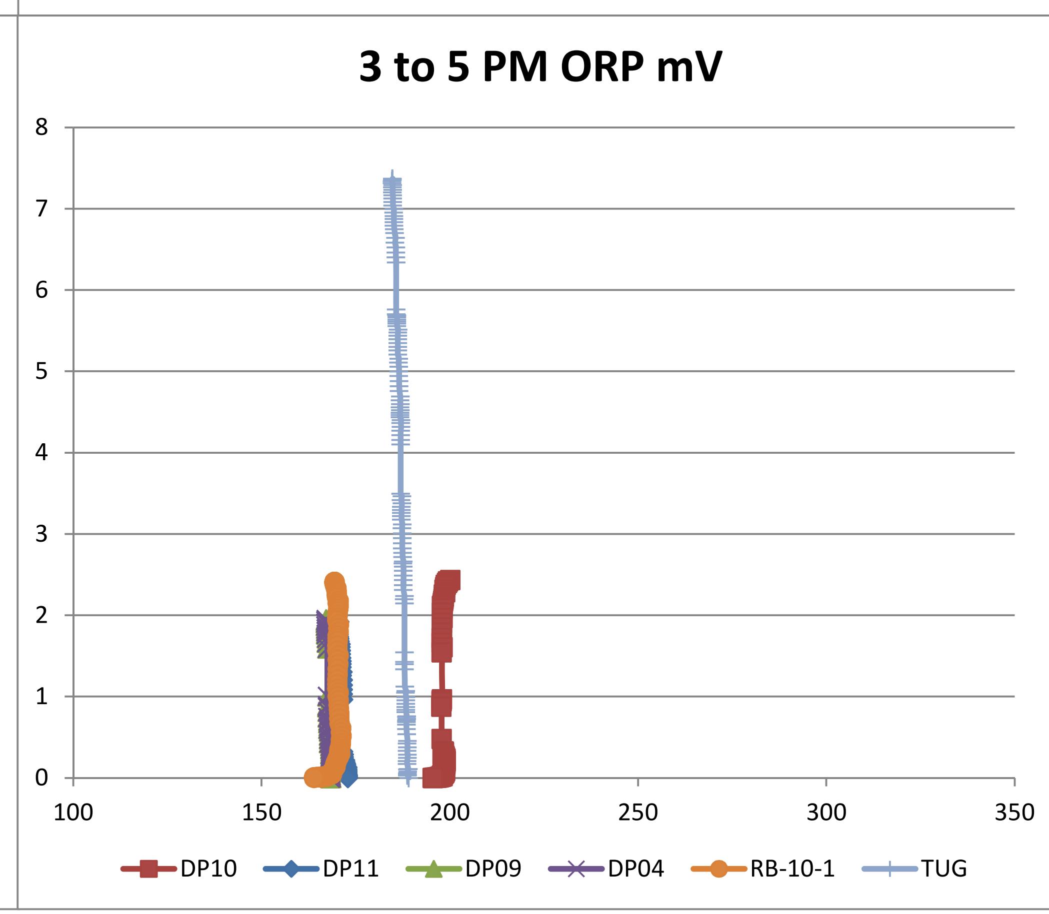

2 to 3 PM ORP mV
0
1
2
3
4
5
6
7
8
100
150
200
250
300
350
DP10
DP11
DP09
DP04
RB-10-1
TUG

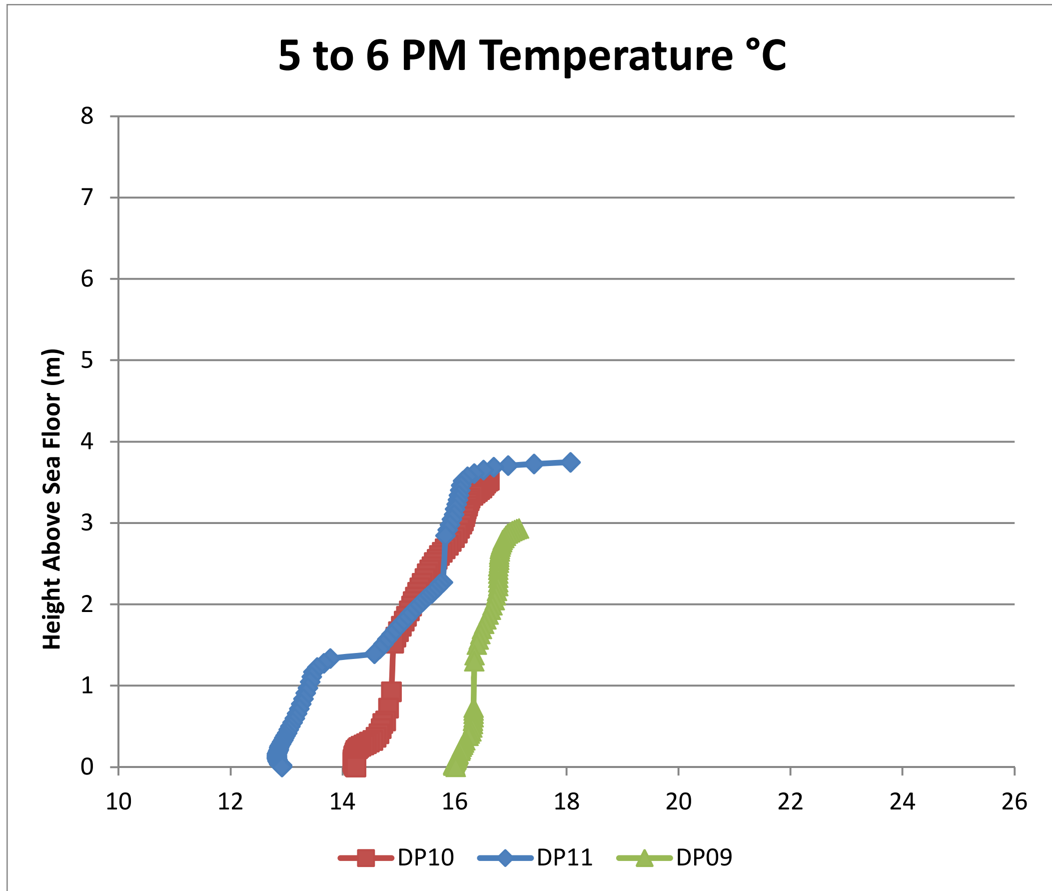

3 to 5 PM Temperature °C
Height Above Sea Floor (m)
0
1
2
3
4
5
6
7
8
10
12
14
16
18
20
22
24
26
DP10
DP11
DP09
DP04
RB-10-1
TUG

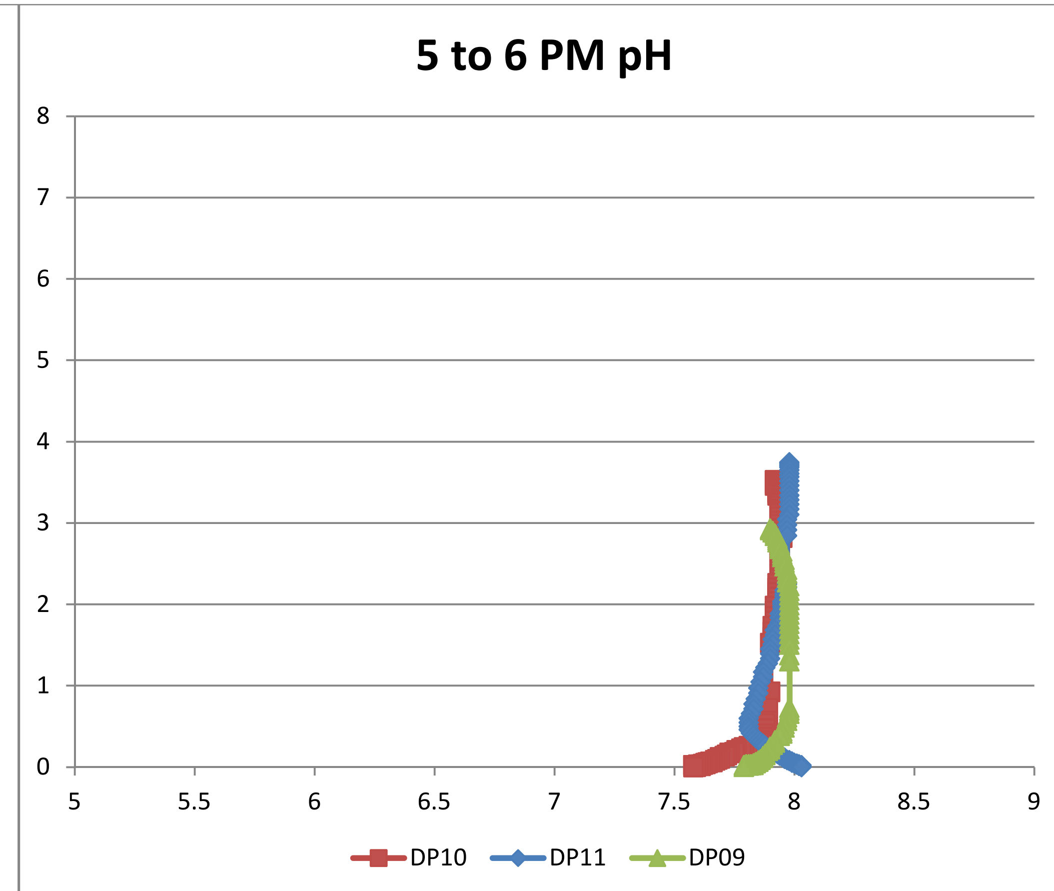

3 to 5 PM pH
0
1
2
3
4
5
6
7
8
5
5.5
6
6.5
7
7.5
8
8.5
9
DP10
DP11
DP09
DP04
RB-10-1
TUG

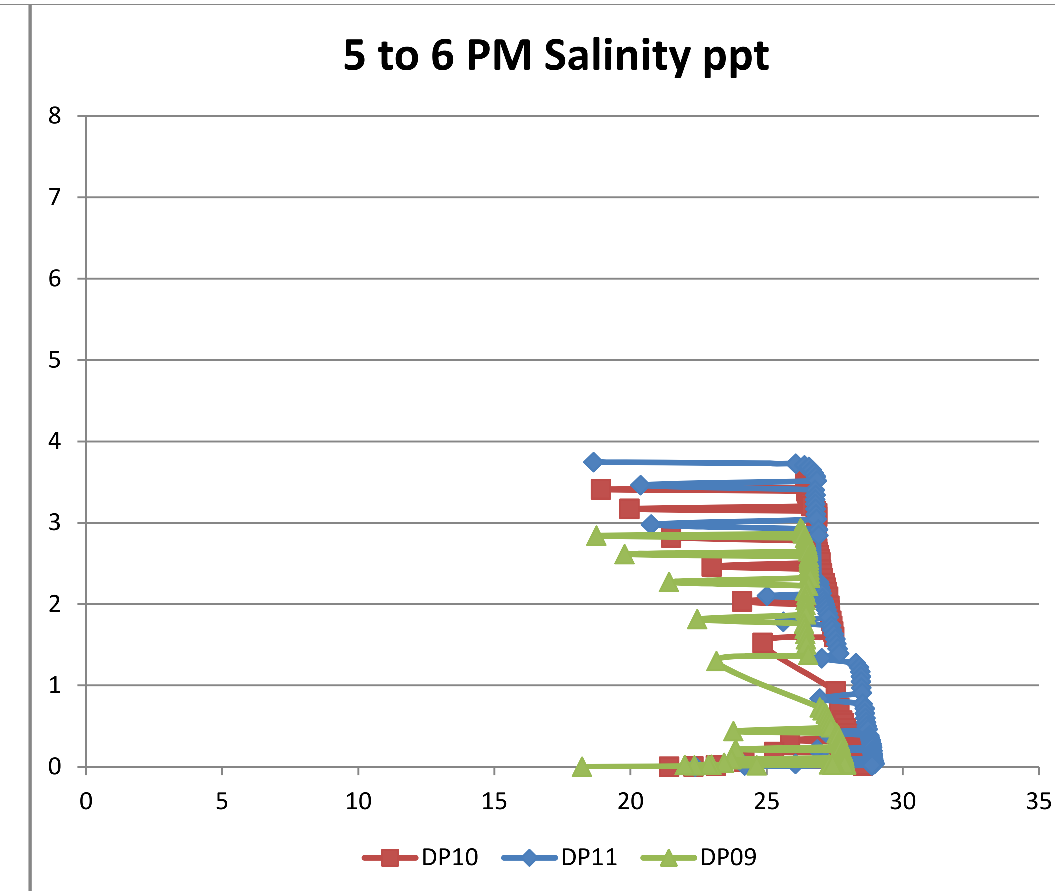

3 to 5 PM Salinity ppt
0
1
2
3
4
5
6
7
8
0
5
10
15
20
25
30
35
DP10
DP11
DP09
DP04
RB-10-1
TUG

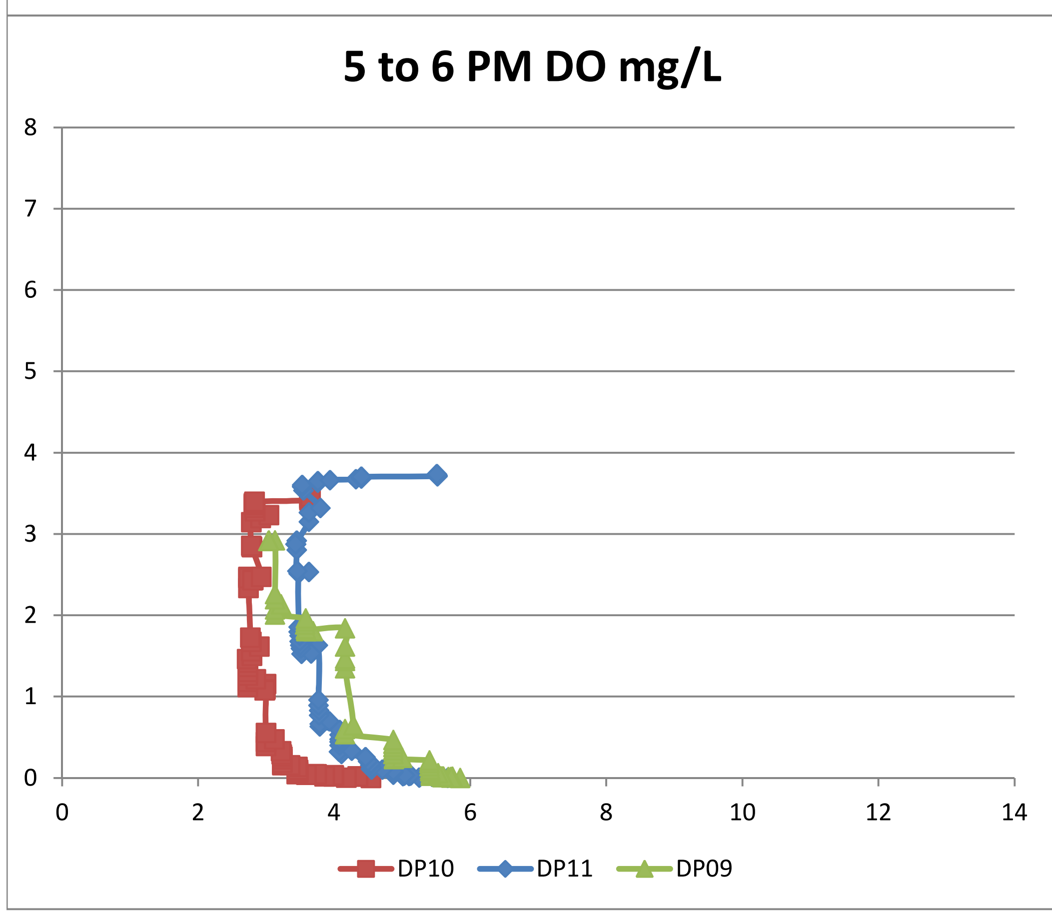

3 to 5 PM DO mg/L
0
1
2
3
4
5
6
7
8
0
2
4
6
8
10
12
14
DP10
DP11
DP09
DP04
RB-10-1
TUG

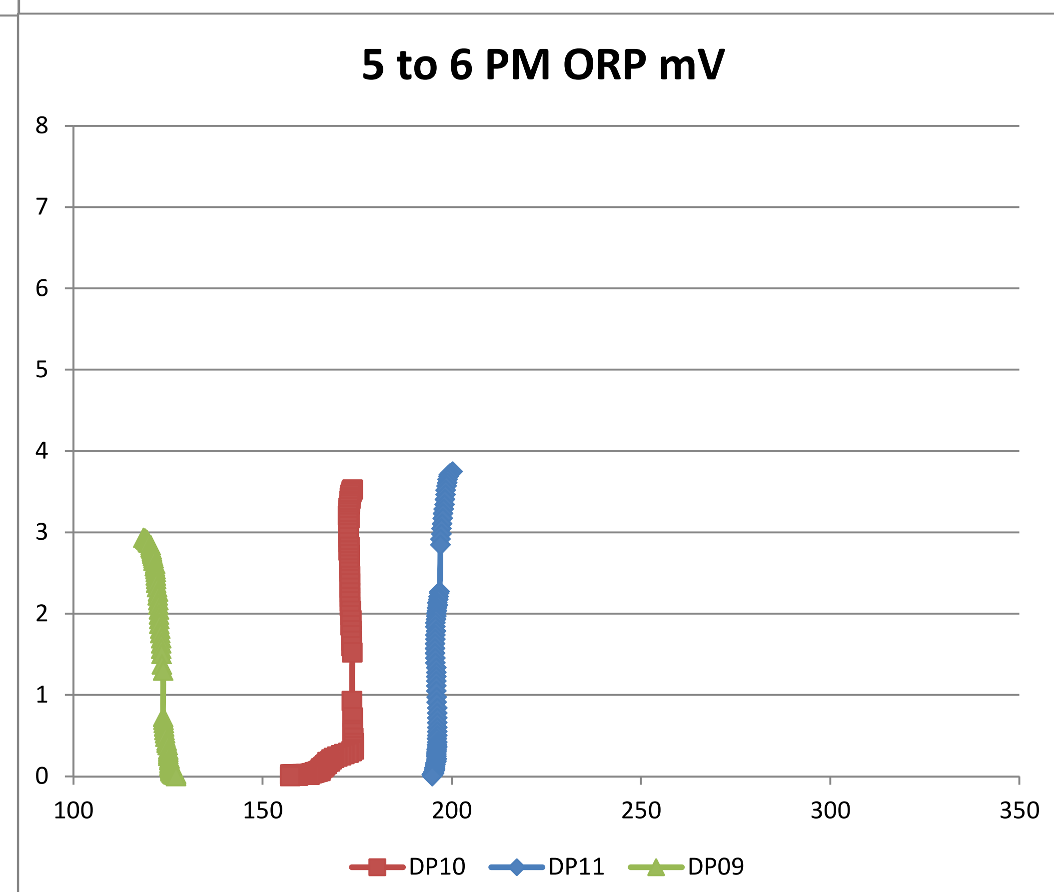

3 to 5 PM ORP mV
0
1
2
3
4
5
6
7
8
100
150
200
250
300
350
DP10
DP11
DP09
DP04
RB-10-1
TUG

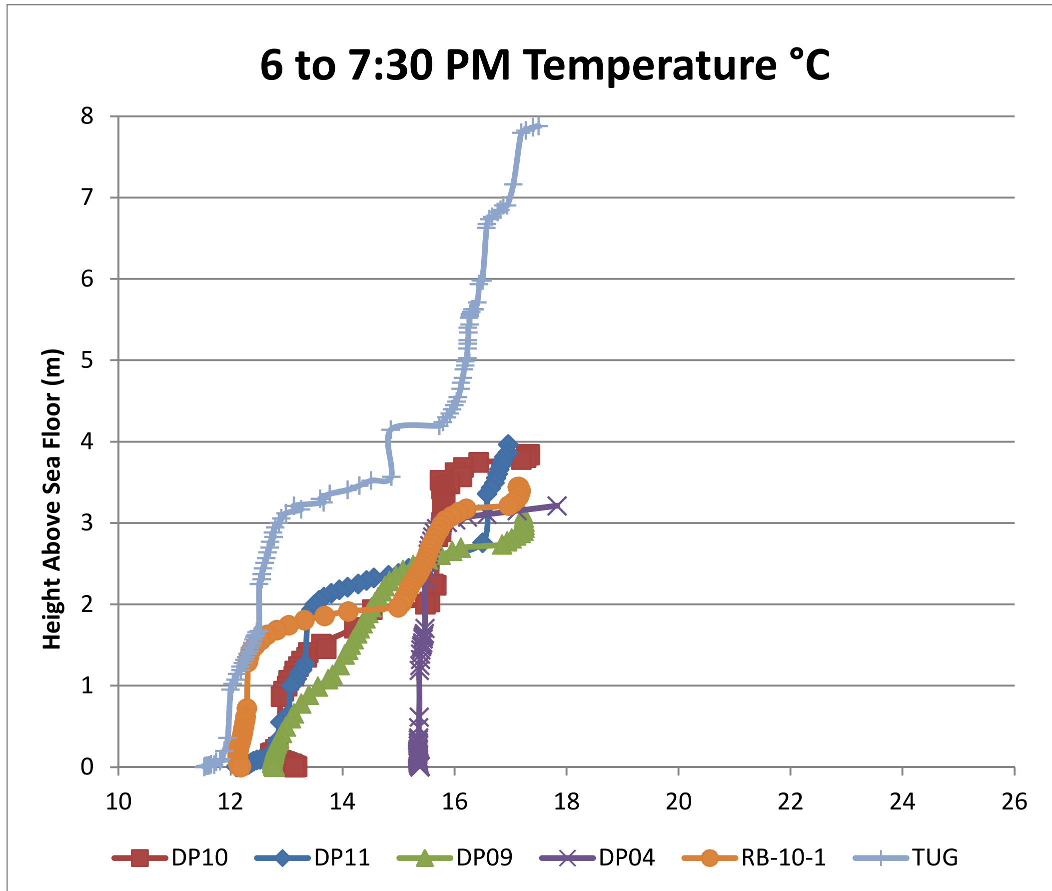

5 to 6 PM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10
DP11
DP09

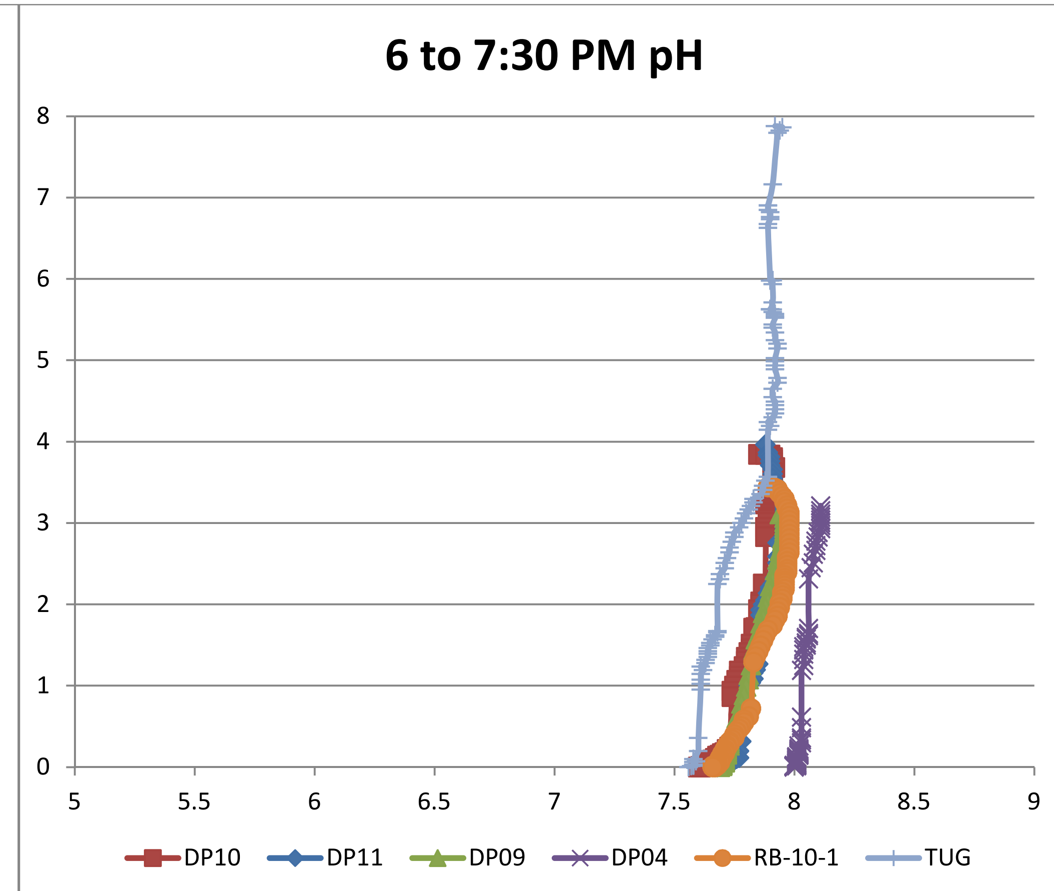

5 to 6 PM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10
DP11
DP09

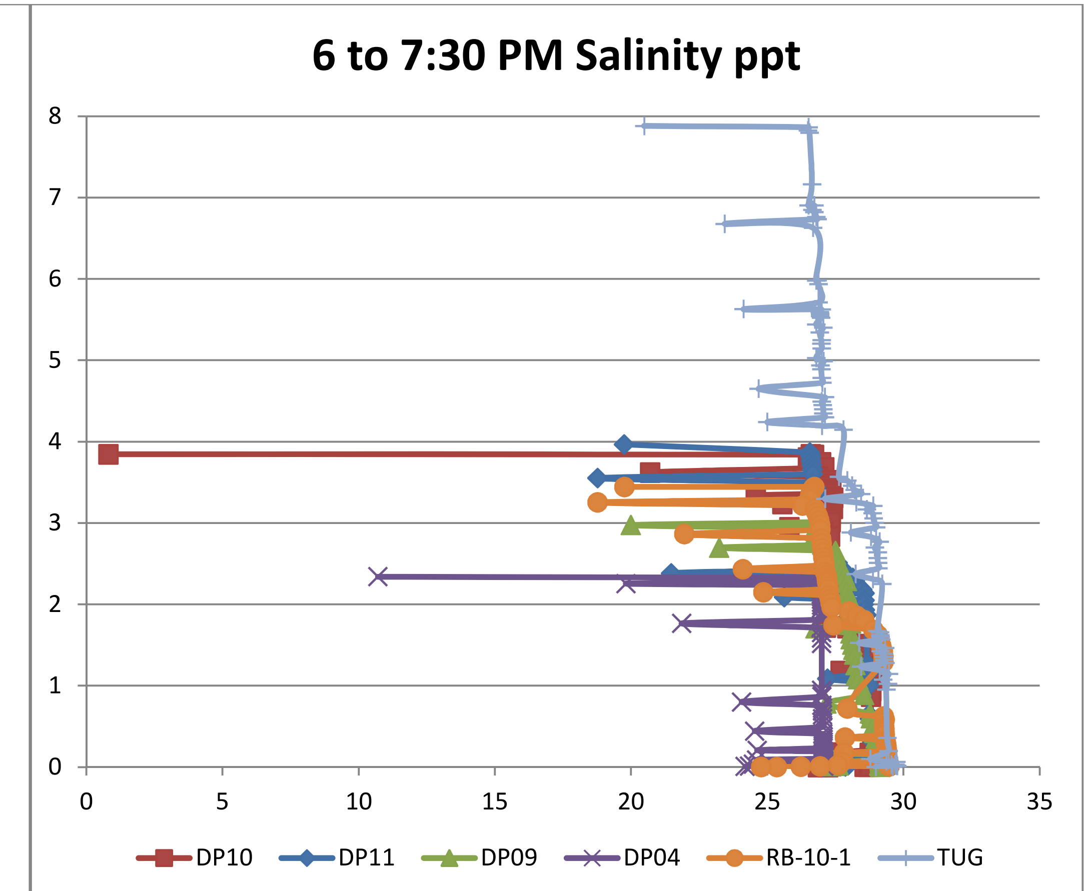

5 to 6 PM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10
DP11
DP09

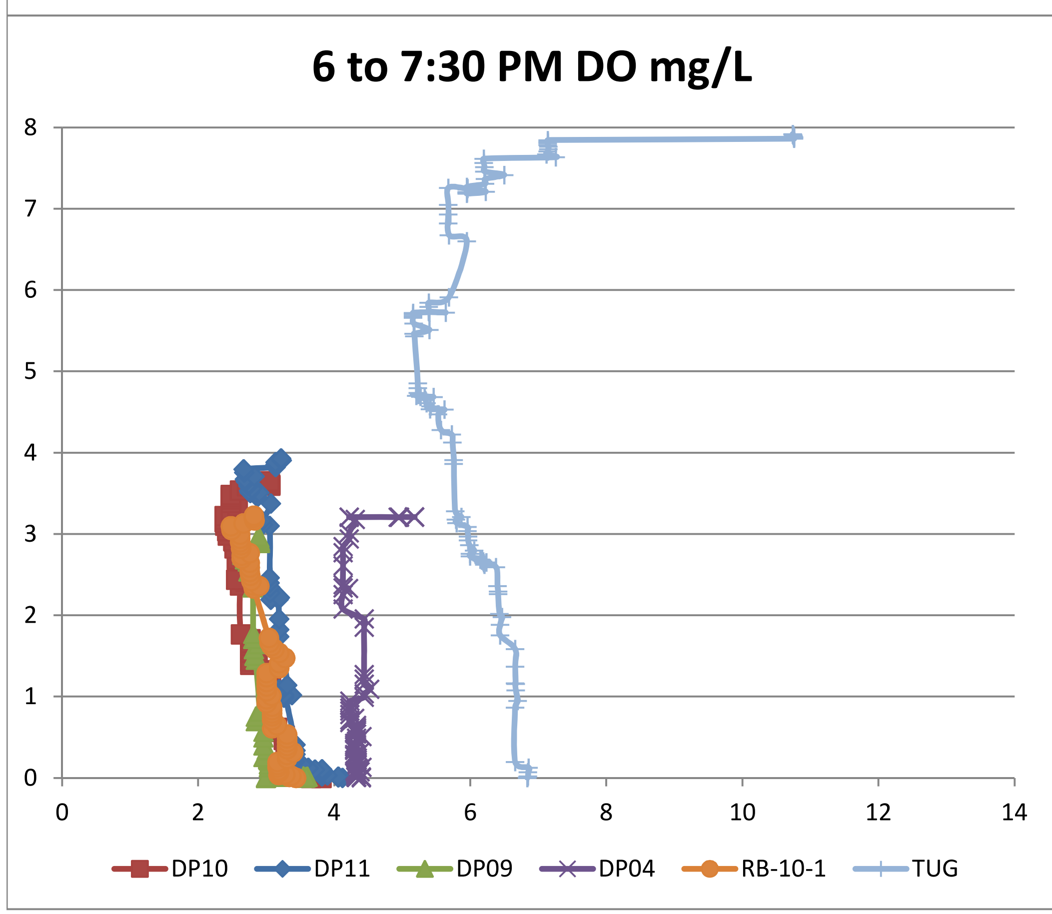

5 to 6 PM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10
DP11
DP09

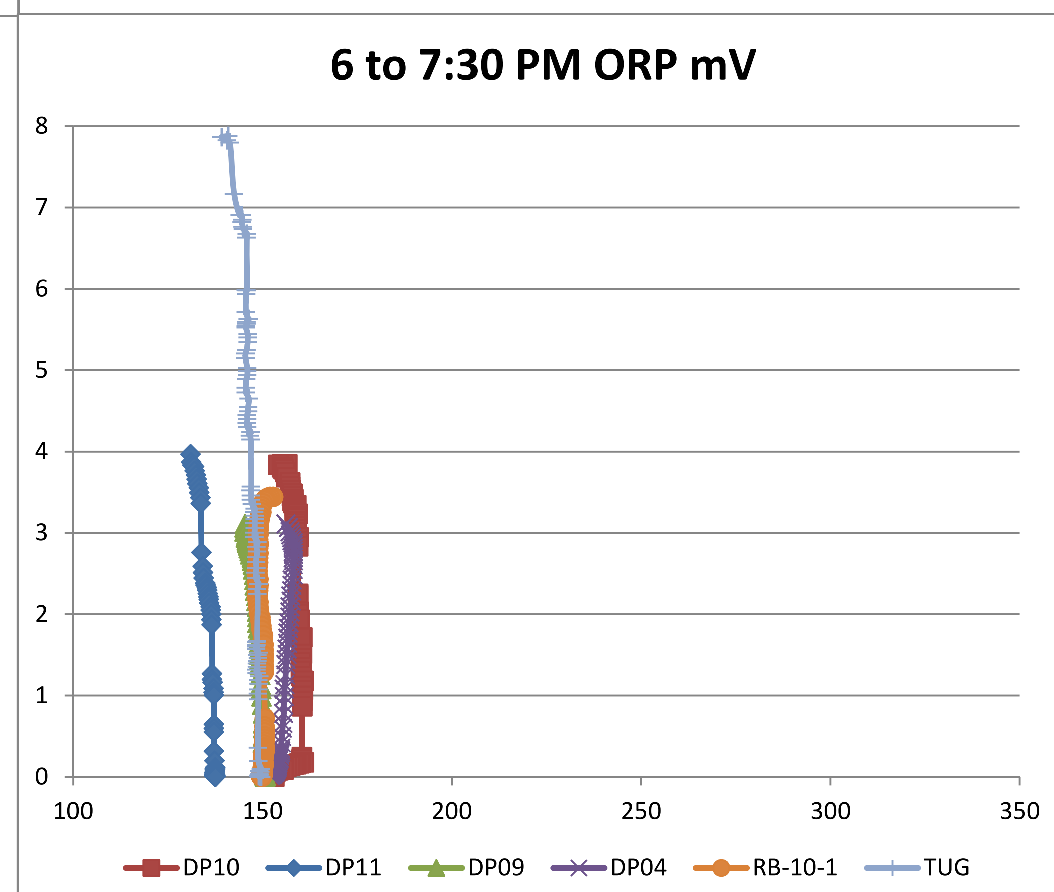

5 to 6 PM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10
DP11
DP09


6 to 7:30 PM Temperature °C
Height Above Sea Floor (m)
0 1 2 3 4 5 6 7 8
10 12 14 16 18 20 22 24 26
DP10 DP11 DP09 DP04 RB-10-1 TUG


6 to 7:30 PM pH
0 1 2 3 4 5 6 7 8
5 5.5 6 6.5 7 7.5 8 8.5 9
DP10 DP11 DP09 DP04 RB-10-1 TUG


6 to 7:30 PM Salinity ppt
0 1 2 3 4 5 6 7 8
0 5 10 15 20 25 30 35
DP10 DP11 DP09 DP04 RB-10-1 TUG


6 to 7:30 PM DO mg/L
0 1 2 3 4 5 6 7 8
0 2 4 6 8 10 12 14
DP10 DP11 DP09 DP04 RB-10-1 TUG


6 to 7:30 PM ORP mV
0 1 2 3 4 5 6 7 8
100 150 200 250 300 350
DP10 DP11 DP09 DP04 RB-10-1 TUG

ATTACHMENT #3

Certificate of Analysis

HEMMERA ENVIROCHEM INC.
ATTN: Bonnie Marks
250 - 1380 Burrard Street
Vancouver BC V6Z 2H3

Date Received: 04-JUN-13
Report Date: 14-JUN-13 11:23 (MT)
Version: FINAL

Client Phone: 604-669-0424

Certificate of Analysis

Lab Work Order #: L1311740

Project P.O. #: NOT SUBMITTED
Job Reference: 499-002.19
C of C Numbers: 1, 2
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1311740-1	L1311740-2	L1311740-3	L1311740-4	L1311740-5
	Description	Other	Other	Other	Other	Other
	Sampled Date	04-JUN-13	04-JUN-13	04-JUN-13	04-JUN-13	04-JUN-13
	Sampled Time					
	Client ID	SWDP09A-26	SWDP10A-26	SWDP11A-26	SWRB-10-1A-26	SWDP09B-26
Grouping	**Analyte**					
SEAWATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	4020	4220	4190	4240	4340
	pH (pH)	8.09	8.26	8.16	8.17	8.31
	Salinity (psu)	22.8	24.6	24.2	24.5	24.2
	Total Suspended Solids (mg/L)	3.2	2.4	2.6	5.8	39.4
	Turbidity (NTU)	2.70	2.14	2.24	3.32	4.17
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0118	0.0142	0.0199	0.0111	0.0179
	Nitrate (as N) (mg/L)	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM	0.12
	Total Kjeldahl Nitrogen (mg/L)	0.162	0.173	0.215	0.201	0.211
	Total Nitrogen (mg/L)	<0.51	<0.51	<0.51	<0.51	<0.51
	Total Organic Nitrogen (mg/L)	0.150	0.158	0.195	0.190	0.193
	Orthophosphate-Dissolved (as P) (mg/L)	0.0269	0.0360	0.0369	0.0314	0.0356
	Phosphorus (P)-Total Dissolved (mg/L)	0.0309	0.0428	0.0349	0.0343	0.0354
	Phosphorus (P)-Total (mg/L)	0.0398	0.0495	0.0553	0.0497	0.0760
	Silicate (as SiO2) (mg/L)	1.43	1.28	1.32	1.09	1.11
Total Metals	Boron (B)-Total (mg/L)	2.8	3.0	3.0	3.0	3.1
	Calcium (Ca)-Total (mg/L)	256	267	264	269	286
	Magnesium (Mg)-Total (mg/L)	820	863	856	867	880
	Potassium (K)-Total (mg/L)	245	258	251	255	261
	Sodium (Na)-Total (mg/L)	7170	7480	7360	7430	7540
Plant Pigments	Chlorophyll a (ug/L)	1.43	0.691	1.76	4.15	4.31

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1311740-6	L1311740-7	L1311740-8	L1311740-14	
	Description	Other	Other	Other	Other	
	Sampled Date	04-JUN-13	04-JUN-13	04-JUN-13	04-JUN-13	
	Sampled Time					
	Client ID	SWDP10B-26	SWDP11B-26	SWRB-10-1B-26	SWDP101-26	
Grouping	**Analyte**					
SEAWATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	5040	4920	4350	3990	
	pH (pH)	7.77	7.95	8.12	8.22	
	Salinity (psu)	28.8	28.7	24.6	22.8	
	Total Suspended Solids (mg/L)	72.2	16.0	66.6	4.4	
	Turbidity (NTU)	20.0	3.03	17.5	2.55	
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0226	0.0247	0.0107	0.0121	
	Nitrate (as N) (mg/L)	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM	
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM	
	Total Kjeldahl Nitrogen (mg/L)	0.494	0.202	0.371	0.158	
	Total Nitrogen (mg/L)	<0.51	<0.51	<0.51	<0.51	
	Total Organic Nitrogen (mg/L)	0.471	0.178	0.360	0.145	
	Orthophosphate-Dissolved (as P) (mg/L)	0.0460	0.0564	0.0218	0.0304	
	Phosphorus (P)-Total Dissolved (mg/L)	0.0454	0.0558	0.0300	0.0300	
	Phosphorus (P)-Total (mg/L)	0.213	0.0891	0.180	0.0408	
	Silicate (as SiO2) (mg/L)	1.67	1.65	0.56	1.48	
Total Metals	Boron (B)-Total (mg/L)	3.5	3.4	3.1	2.8	
	Calcium (Ca)-Total (mg/L)	336	319	290	253	
	Magnesium (Mg)-Total (mg/L)	1020	1000	880	816	
	Potassium (K)-Total (mg/L)	307	295	262	239	
	Sodium (Na)-Total (mg/L)	8830	8470	7540	6440	
Plant Pigments	Chlorophyll a (ug/L)	24.7	8.03	12.5	2.03	

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1311740-9	L1311740-10	L1311740-11	L1311740-12	L1311740-13
	Description	Sediment	Sediment	Sediment	Sediment	Sediment
	Sampled Date	04-JUN-13	04-JUN-13	04-JUN-13	04-JUN-13	04-JUN-13
	Sampled Time					
	Client ID	SDDP09-26	SDDP10-26	SDDP11-26	SDRB-10-1-26	SDDP101-26
SOIL						
Physical Tests	Moisture (%)	34.7	65.4	55.1	53.8	37.1
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.075	0.212	0.140	0.163	0.073
	Total Organic Nitrogen (%)	0.075	0.212	0.139	0.162	0.072
	Sulphide as S (mg/kg)	9.4	388	239	249	6.8
Anions and Nutrients	Total Nitrogen by LECO (%)	0.101	0.212	0.149	0.167	0.078
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.90	1.95	1.40	1.58	0.85
Plant Available Nutrients	Available Ammonium-N (mg/kg)	3.2	7.9	5.9	10.5	3.5
	Available Phosphate-P (mg/kg)	6.6	<2.0	3.1	2.2	6.2
Saturated Paste Extractables	Oxidation-Reduction Potential (ORP) (mV)	-192	-168	-178	-318	-260
Metals	Phosphorus (P) (mg/kg)	709	1020	901	674	805

* 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)
Duplicate	Nitrite (as N)	DLM	L1311740-1, -14, -2, -3, -4, -5, -6, -7, -8
Duplicate	Nitrate (as N)	DLM	L1311740-1, -14, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-C-NO2-IC-VA	Seawater	Nitrite in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-C-NO3-IC-VA	Seawater	Nitrate in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

C-TOT-ORG-LECO-SK	Soil	Organic Carbon by combustion method	SSSA (1996) p. 973

Total Organic Carbon (C-TOT-ORG-LECO-SK, C-TOT-ORG-SK)

Total C and inorganic C are determined on separate samples. The total C is determined by combustion and thermal conductivity detection, while inorganic C is determined by weight lass after addition of hydrochloric acid. Organic C is calculated by the difference between these two determinations.

Reference for Total C:
Nelson, D.W. and Sommers, L.E. 1996. Total Carbon, organic carbon and organic matter. P. 961-1010 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

Reference for Inorganic C:
Loeppert, R.H. and Suarez, D.L. 1996. Gravimetric Method for Loss of Carbon Dioxide. P. 455-456 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

CHLOROA-C-VA	Seawater	Chlorophyll a by Fluorometer (seawater)	APHA 10200 H. Chlorophyll and EPA 445

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

ETL-N-TOTORG-CALC-SK	Soil	Nitrogen, Total Organic - calculation	APHA 4500 Norg-Calculated as TKN - NH3-N
HARDNESS-CALC-VA	Seawater	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

MET-T-L-HRMS-VA	Seawater	Tot. Metals in Seawater by HR-ICPMS	EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve preliminary sample treatment by acid digestion based on APHA Method 3030E.

MET-TOT-C-ICP-VA	Seawater	Total Metals in Seawater by ICPOES	PUGET SOUND PROTOCOLS, EPA 6010B

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

N-ORGANIC-CALC-VA	Seawater	Total Organic Nitrogen (Calculation)	APHA 4500-NORG (TKN)/NH3-NITROGEN (NH3)

Reference Information

Total Organic Nitrogen is a calculated parameter. Total Organic Nitrogen = Total Kjeldahl Nitrogen - Ammonia.

N-TOT-LECO-SK	Soil	Total Nitrogen by combustion method	SSSA (1996) P. 973-974

The sample is ignited in a combustion analyzer where nitrogen in the reduced nitrous oxide gas is determined using a thermal conductivity detector.

N-TOTKJ-COL-SK	Soil	Total Kjeldahl Nitrogen	CSSS (1993) 22.2.3

The soil is digested with sulfuric acid in the presence of $CuSO_4$ and K_2SO_4 catalysts. Ammonia in the soil extract is determined colrimetrically at 660 nm.

NH3-F-VA	Seawater	Ammonia in Seawater by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH4-AVAIL-SK	Soil	Available Ammonium-N	CSSS(1993) 4.2/COMM SOIL SCI 19(6)

Ammonium (NH4-N) is extracted from the soil using 2 N KCl. Ammonium in the extract is mixed with hypochlorite and salicylate to form indophenol blue, which is determined colorimetrically by auto analysis at 660 nm.

ORP-PASTE-VA	Soil	Oxidation reduction potential of Soil	SOIL SAMPLING AND METHODS OF ANALYSIS

This analysis is carried out using procedures adapted from ASTM G57-95a (2001) "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method". In summary, 200 to 500 grams of sample is mixed with deionized water as required to create a saturated paste. The sample is then measured as is (i.e. the paste) for Oxidation Reduction Potential.

P-T-COL-VA	Seawater	Total P in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA	Seawater	Total Dissolved P in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorous is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-C-PCT-VA	Seawater	pH by Meter (Automated) (seawater)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PO4-AVAIL-SK	Soil	Available Phosphate-P	Comm. Soil Sci. Plant Anal. 25 (5&6)

Plant available phosphorus is extracted from the soil using Modified Kelowna solution. Phosphorous in the soil extract is determined colorimetrically at 880 nm.

PO4-DO-COL-VA	Seawater	D-Orthophosphate in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

S2-NAOH-VA	Soil	Sediment Sulphide (NaOH leach) by Colour	ALSEV IN-HOUSE METHOD

This analysis is carried out on a leachable basis. The procedure involves shaking a subsample for 20 minutes with a sodium hydroxide solution in a one to seven ratio. The leachate is filtered and Zinc acetate is added to an aliquot of filtrate and analyzed colorimetrically using methylene blue.

SALINITY-C-EC-VA	Seawater	Salinity by calc. using EC (seawater)	APHA 2520 B

Salinity is determined by the APHA 2520B Electrical Conductivity Method. Salinity is a unitless parameter that is roughly equivalent to grams per Litre. ALS applies the unit of psu (practical salinity unit) to indicate that salinity values are derived from the Practical Salinity Scale

SILICATE-C-COL-VA	Seawater	Silicate by Colourimetric (seawater)	APHA 4500-SiO2 E.

This analysis is carried out using procedures adapted from APHA Method 4500-SiO2 E. "Silica". Silicate (molybdate-reactive silica) is determined by the molybdosilicate-heteropoly blue colourimetric method.

TKN-C-F-VA	Seawater	TKN in Seawater by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Seawater	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-C-VA	Seawater	Total Suspended Solids by Gravimetric	APHA 2540 D. / PSWQA TSS

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a 0.45um membrane filter (Puget Sound Water Quality Authority TSS Method, May 1991), TSS is determined by drying the filter at 104 degrees celsius.

		Turbidity by Meter in Seawater	APHA 2130 Turbidity

Reference Information

TURBIDITY-C-VA Seawater

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** 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
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

1	2

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.

Short Holding Time

Rush Processing

ALS Analytical
Environmental Division

L1311740-COFC

COC #

Report to:	
Company:	HEMMERA
Contact:	Bonnie Marks
Address:	250-1380 Burrard St, Vancouver V5Z 2H3
Phone:	604-669-0424 Fax: 604-669-0430
Invoice To:	☑ Same as Report
Company:	
Contact:	
Address:	
Sample	
Phone:	Fax:
Lab Work Order # (lab use only)	L1311740

Report Format / Distribution

☑ Standard ☐ Other
☑ PDF ☑ Excel ☐ Fax
Email 1: bmarks@hemmera.com, dclegg@hemmera.com
Email 2: lmclaren@hemmera.com

Indicate Bottles: Filtered / Preserved (F/P)

Client / Project Information:

Job #: ~~[illegible]~~ 499-002-19
PO/AFE:
Legal Site Description:
Quote #: Q23052
ALS Contact: Brent Mack
Sampler (Initials):

Service Requested:

☑ Regular Service (Default)
☐ Rush Service (2-3 Days)
☐ Priority Service (1 Day or ASAP)
☐ Emergency Service (<1 Day / Wkend) - Contact ALS

Analysis Request

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	pH, Turbidity, Salinity, TSS	SiO3 (Silicate)	PO4 (Tot, Dis, and Ortho)	Ammonia and TKN	NO2, NO3 by IC	TN-CALC-VA, N-ORG-CALC-	Chlorophyll-a	~~SL2-C-TOTAL-VA (Chlorine)~~	~~Major cations and anions~~ select metals	Hazardous?	Highly Contaminated?	Number of Containers
	SWDP09A-26	04-JUN-13		Other	X	X	X	X	X	X	X		X			4
	SWDP10A-26	↓		Other	X	X	X	X	X	X	X		X			4
	SWDP11A-26	↓		Other	X	X	X	X	X	X	X		X			4
	SWRB-10-1A-26	↓		Other	X	X	X	X	X	X	X		X			4
	SWDP09B-26	↓		Other	X	X	X	X	X	X	X		X			4
	SWDP10B-26	↓		Other	X	X	X	X	X	X	X		X			4
	SWDP11B-26	↓		Other	X	X	X	X	X	X	X		X			4
	SW RB-10-1B-26	↓		Other	X	X	X	X	X	X	X		X			4
				Other												
				Other												

Guidelines / Regulations	Special Instructions / Hazardous Details
	Samples are SEAWATER

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:		Date & Time:		Received By:	Elise	Date & Time:	June 4 19:40	Sample Condition (lab use only) Temperature #1 11.7 #2 15.6	Samples Received in Good Condition? Y / N (if no provided details)
Relinquished By:		Date & Time:		Received By:		Date & Time:			

select metals are: calcium, boron, magnesium, potassium, sodium (report these only)

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Page 2 of 2

Report to:	Report Format / Distribution	Service Requested:
Company: HEMMERA	☑ Standard ☐ Other	☑ Regular Service (Default)
Contact: Bonnie Marks	☑ PDF ☑ Excel ☐ Fax	☐ Rush Service (2-3 Days)
Address: Vancouver	Email 1: bmarks@hemmera.com, dclegg@hemmera.com	☐ Priority Service (1 Day or ASAP)
	Email 2: lmclaren@hemmera.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone: 604-669-0424 Fax:		Analysis Request
Invoice To: ☑ Same as Report	Indicate Bottles: Filtered / Preserved (F/P) →	
Company:	Client / Project Information:	
Contact:	Job #: ~~499-00224~~ 499-002.19	
Address:	PO/AFE:	
Sample	Legal Site Description:	
Phone: Fax:	Quote #: Q23052	
Lab Work Order # (lab use only) L1311740	ALS Contact: Brent Mack / Sampler (Initials):	

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	MET-200.2-CCMS-1-VA	(REP) VA-P-200.2-MS	PO4-AVAIL-SK, NH4-AVAIL-S	N-TOTKJ-SK	N-TOT-LECO-SK	ETL-N-TOTORG-CALC-SK	C-TOT-ORG-LECO-SK		S2-NAOH-VA (rush)	ORP-PASTE-VA	Hazardous?	Highly Contaminated?	Number of Containers
	SDDP09-26	04-JUN-13		Sediment	X	X	X	X	X	X	X		X	X			3
	SDDP10-26	↓		Sediment	X	X	X	X	X	X	X		X	X			3
	SDDP11-26	↓		Sediment	X	X	X	X	X	X	X		X	X			3
	~~SDDP~~ SDRB-10-1-26	↓		Sediment	X	X	X	X	X	X	X		X	X			3
				Sediment													
				Sediment													
				Sediment													
				Sediment													
				Sediment													
				Sediment													

Guidelines / Regulations	Special Instructions / Hazardous Details
	SULFIDE needs RUSH extraction

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:		Date & Time:		Received By:	Elise	Date & Time:	June 4 19:40	Sample Condition (lab use only) Temperature #1 11.7 #2 15.6	Samples Received in Good Condition? Y / N (if no provided details)
Relinquished By:		Date & Time:		Received By:		Date & Time:			

L1311740-COFC

HEMMERA ENVIROCHEM INC.
ATTN: Bonnie Marks
250 - 1380 Burrard Street
Vancouver BC V6Z 2H3

Date Received: 02-OCT-13
Report Date: 11-OCT-13 11:26 (MT)
Version: FINAL

Client Phone: 604-669-0424

Certificate of Analysis

Lab Work Order #: **L1372395**

Project P.O. #: NOT SUBMITTED
Job Reference: 499-002.19
C of C Numbers: 10-345859
Legal Site Desc:

Brent Mack
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1372395-1	L1372395-2	L1372395-3	L1372395-4	L1372395-5
	Description	Seawater	Seawater	Seawater	Seawater	Seawater
	Sampled Date	02-OCT-13	02-OCT-13	02-OCT-13	02-OCT-13	02-OCT-13
	Sampled Time					
	Client ID	SWDP09A-27	SWDP09B-27	SWDP10A-27	SWDP10B-27	SWDP11A-27
Grouping	**Analyte**					
SEAWATER						
Physical Tests	pH (pH)	7.81	7.86	7.88	7.87	7.88
	Salinity (psu)	26.1	28.0	26.2	28.1	27.1
	Total Suspended Solids (mg/L)	10.7	149	8.9	5.4	5.4
	Turbidity (NTU)	5.02	39.8	4.74	2.45	3.10
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0684	0.0398	0.0622	0.0348	0.0575
	Nitrate (as N) (mg/L)	DLM <0.50	0.58	0.64	DLM <0.50	DLM <0.50
	Nitrite (as N) (mg/L)	DLM <0.10	DLM <0.10	DLM <0.10	DLM <0.10	DLM <0.10
	Total Kjeldahl Nitrogen (mg/L)	0.278	1.88	0.235	0.190	0.207
	Total Nitrogen (mg/L)	<0.51	2.47	0.87	<0.51	<0.51
	Total Organic Nitrogen (mg/L)	0.209	1.84	0.173	0.155	0.150
	Orthophosphate-Dissolved (as P) (mg/L)	0.0545	0.0474	0.0538	0.0565	0.0547
	Phosphorus (P)-Total Dissolved (mg/L)	0.0575	0.0492	0.0568	0.0580	0.0597
	Phosphorus (P)-Total (mg/L)	0.0856	0.243	0.0828	0.0722	0.0738
	Silicate (as SiO2) (mg/L)	1.96	1.92	2.26	1.78	1.90
Total Metals	Boron (B)-Total (mg/L)	3.05	3.45	3.19	3.31	3.41
	Calcium (Ca)-Total (mg/L)	304	319	296	316	315
	Magnesium (Mg)-Total (mg/L)	915	982	912	956	968
	Potassium (K)-Total (mg/L)	281	300	279	295	295
	Sodium (Na)-Total (mg/L)	7690	8150	7570	8040	7980
Plant Pigments	Chlorophyll a (ug/L)	2.48	2.92	2.19	4.18	1.00

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1372395-6	L1372395-7	L1372395-8	L1372395-9
	Description	Seawater	Seawater	Seawater	Seawater
	Sampled Date	02-OCT-13	02-OCT-13	02-OCT-13	02-OCT-13
	Sampled Time				
	Client ID	SWDP11B-27	SWRB-10-1A-27	SWRB-10-1B-27	SWDP100-27
Grouping	**Analyte**				
SEAWATER					
Physical Tests	pH (pH)	7.87	7.90	7.67	7.79
	Salinity (psu)	28.3	26.5	28.0	26.6
	Total Suspended Solids (mg/L)	42.9	4.9	38.2	5.5
	Turbidity (NTU)	12.5	3.18	10.6	3.20
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0421	0.0692	0.0284	0.0702
	Nitrate (as N) (mg/L)	0.55	0.54	<0.50 DLM	0.52
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM
	Total Kjeldahl Nitrogen (mg/L)	0.396	0.260	0.387	0.248
	Total Nitrogen (mg/L)	0.94	0.80	<0.51	0.77
	Total Organic Nitrogen (mg/L)	0.354	0.191	0.359	0.178
	Orthophosphate-Dissolved (as P) (mg/L)	0.0584	0.0615	0.0582	0.0613
	Phosphorus (P)-Total Dissolved (mg/L)	0.0568	0.0656	0.0577	0.0614
	Phosphorus (P)-Total (mg/L)	0.129	0.0795	0.142	0.0786
	Silicate (as SiO2) (mg/L)	1.86	2.06	1.70	2.06
Total Metals	Boron (B)-Total (mg/L)	3.56	3.31	3.52	3.39
	Calcium (Ca)-Total (mg/L)	320	308	322	307
	Magnesium (Mg)-Total (mg/L)	988	938	994	933
	Potassium (K)-Total (mg/L)	301	290	305	290
	Sodium (Na)-Total (mg/L)	8080	7780	8120	7730
Plant Pigments	Chlorophyll a (ug/L)	7.44	0.425	7.09	0.859

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

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted due to sample matrix effects.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-C-NO2-IC-VA	Seawater	Nitrite in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-C-NO3-IC-VA	Seawater	Nitrate in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

CHLOROA-C-VA	Seawater	Chlorophyll a by Fluorometer (seawater)	APHA 10200 H. Chlorophyll and EPA 445

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

MET-TOT-C-ICP-VA	Seawater	Total Metals in Seawater by ICPOES	PUGET SOUND PROTOCOLS, EPA 6010B

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-TOT-C-LOW-MS-VA	Seawater	Total Metals in Seawater by ICPMS	PUGET SOUND PROTOCOLS, EPA 6020A

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005A). Instrumental analysis is by atomic inductively coupled plasma - mass spectrometry (EPA Method 6020A).

N-ORGANIC-CALC-VA	Seawater	Total Organic Nitrogen (Calculation)	APHA 4500-NORG (TKN)/NH3-NITROGEN (NH3)

Total Organic Nitrogen is a calculated parameter. Total Organic Nitrogen = Total Kjeldahl Nitrogen - Ammonia.

NH3-F-VA	Seawater	Ammonia in Seawater by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Seawater	Total P in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA	Seawater	Total Dissolved P in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorous is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-C-PCT-VA	Seawater	pH by Meter (Automated) (seawater)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Seawater	D-Orthophosphate in Seawater by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SALINITY-C-EC-VA	Seawater	Salinity by calc. using EC (seawater)	APHA 2520 B

Salinity is determined by the APHA 2520B Electrical Conductivity Method. Salinity is a unitless parameter that is roughly equivalent to grams per Litre. ALS applies the unit of psu (practical salinity unit) to indicate that salinity values are derived from the Practical Salinity Scale

SILICATE-C-COL-VA	Seawater	Silicate by Colourimetric (seawater)	APHA 4500-SiO2 E.

This analysis is carried out using procedures adapted from APHA Method 4500-SiO2 E. "Silica". Silicate (molybdate-reactive silica) is determined by the molybdosilicate-heteropoly blue colourimetric method.

TKN-C-F-VA	Seawater	TKN in Seawater by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Seawater	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-C-VA	Seawater	Total Suspended Solids by Gravimetric	APHA 2540 D. / PSWQA TSS

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a 0.45um membrane filter (Puget Sound Water Quality Authority TSS Method, May 1991), TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-C-VA Seawater Turbidity by Meter in Seawater APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** 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, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-345859

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.

10-345859

Short Holding Time

Rush Processing

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page 1 of 1

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	HEMMERA	Standard: ✓ Other (specify):		✓ Regular (Standard Turnaround Times - Business Days)
Contact:	BONNIE MARKS	Select: PDF ✓ Excel ✓ Digital Fax		Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	250-1380 BURRARD ST	Email 1:	BMARKS@HEMMERA.COM	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	VAN/BC V5Z 2H3	Email 2:	DCLEGG@HEMMERA.COM	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: 604 669 0424	Fax: 604 669 0430		LMCLAREN@HEMMERA.COM	Analysis Request

Invoice To Same as Report? (circle) (Yes) or No (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No

Company:	
Contact:	
Address:	
Phone:	Fax:

Client / Project Information
Job #: 499-002.19
PO / AFE:
LSD:
Quote #: Q23052

Lab Work Order # (lab use only): L1372395
ALS Contact: B. MACK
Sampler: D CLEGG

(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, TURBIDITY, SALINITY, TSS	SiO2 (SILICATE)	PO4 (TOT/DIS/ORTHO)	AMMONIA / TKN	NO2, NO3 by IC	TN-CAL-VA, N-ORG-CAL	CHLOROPHYLL A	SELECT METALS (P)	Number of Containers
	SWDP09A-27	02 OCT 13		SEAWATER	X	X	X	X	X	X	X	X	4
	SWDP09B-27	"		"	X	X	X	X	X	X	X	X	4
	SWDP10A-27	"		"	X	X	X	X	X	X	X	X	4
	SWDP10B-27	"		"	X	X	X	X	X	X	X	X	4
	SWDP11A-27	"		"	X	X	X	X	X	X	X	X	4
	SWDP11B-27	"		"	X	X	X	X	X	X	X	X	4
	SWRB-10-1A-27	"		"	X	X	X	X	X	X	X	X	4
	SWRB-10-1B-27	"		"	X	X	X	X	X	X	X	X	4
	SWDP100-27	"		"	X	X	X	X	X	X	X	X	4

L1372395-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

SAMPLES ARE SEAWATER
SELECT METALS ARE (ONLY REPORT THESE) CALCIUM/BORON/MAGNESIUM/POTASSIUM/SODIUM

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: [signature]	Date: OCT 2/13	Time:	Received by: Jaye	Date: Oct 2	Time: 22:00	Temperature: 10.1 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

HEMMERA ENVIROCHEM INC.
ATTN: Bonnie Marks
250 - 1380 Burrard Street
Vancouver BC V6Z 2H3

Date Received: 25-SEP-13
Report Date: 04-OCT-13 13:42 (MT)
Version: FINAL

Client Phone: 604-669-0424

Certificate of Analysis

Lab Work Order #: L1368351

Project P.O. #: NOT SUBMITTED
Job Reference: 449-002.19
C of C Numbers: 1, 2
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1368351-5	L1368351-6	L1368351-7	L1368351-8	
	Description	sediment	sediment	sediment	sediment	
	Sampled Date	24-SEP-13	24-SEP-13	24-SEP-13	24-SEP-13	
	Sampled Time					
	Client ID	SDDP09-27	SDDP10-27	SDDP11-27	SDRB10-11-27	
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	38.6	63.6	52.8	51.8	
Leachable Anions & Nutrients	Total Kjeldahl Nitrogen (%)	0.087	0.251	0.151	0.134	
	Total Organic Nitrogen (%)	0.087	0.250	0.150	0.134	
	Sulphide as S (mg/kg)	12.0 DLM	518 DLM	304 DLM	219 DLM	
Anions and Nutrients	Total Nitrogen by LECO (%)	0.100	0.252	0.167	0.151	
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.04	2.20	1.50	1.44	
Plant Available Nutrients	Available Ammonium-N (mg/kg)	2.8	10.1 DLM	4.5	4.3	
	Available Phosphate-P (mg/kg)	4.6	2.7	4.0	3.2	
Saturated Paste Extractables	Oxidation-Reduction Potential (ORP) (mV)	-100	-106	-107	-146	
Metals	Phosphorus (P) (mg/kg)	606	710	630	582	

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

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
C-TOT-ORG-LECO-SK	Soil	Organic Carbon by combustion method	SSSA (1996) p. 973

Total Organic Carbon (C-TOT-ORG-LECO-SK, C-TOT-ORG-SK)

Total C and inorganic C are determined on separate samples. The total C is determined by combustion and thermal conductivity detection, while inorganic C is determined by weight lass after addition of hydrochloric acid. Organic C is calculated by the difference between these two determinations.

Reference for Total C:
Nelson, D.W. and Sommers, L.E. 1996. Total Carbon, organic carbon and organic matter. P. 961-1010 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

Reference for Inorganic C:
Loeppert, R.H. and Suarez, D.L. 1996. Gravimetric Method for Loss of Carbon Dioxide. P. 455-456 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

ALS Test Code	Matrix	Test Description	Method Reference**
ETL-N-TOTORG-CALC-SK	Soil	Nitrogen, Total Organic - calculation	APHA 4500 Norg-Calculated as TKN - NH3-N
MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
N-TOT-LECO-SK	Soil	Total Nitrogen by combustion method	SSSA (1996) P. 973-974

The sample is ignited in a combustion analyzer where nitrogen in the reduced nitrous oxide gas is determined using a thermal conductivity detector.

ALS Test Code	Matrix	Test Description	Method Reference**
N-TOTKJ-COL-SK	Soil	Total Kjeldahl Nitrogen	CSSS (1993) 22.2.3

The soil is digested with sulfuric acid in the presence of CuSO4 and K2SO4 catalysts. Ammonia in the soil extract is determined colrimetrically at 660 nm.

ALS Test Code	Matrix	Test Description	Method Reference**
NH4-AVAIL-SK	Soil	Available Ammonium-N	CSSS(1993) 4.2/COMM SOIL SCI 19(6)

Ammonium (NH4-N) is extracted from the soil using 2 N KCl. Ammonium in the extract is mixed with hypochlorite and salicylate to form indophenol blue, which is determined colorimetrically by auto analysis at 660 nm.

ALS Test Code	Matrix	Test Description	Method Reference**
ORP-PASTE-VA	Soil	Oxidation reduction potential of Soil	SOIL SAMPLING AND METHODS OF ANALYSIS

This analysis is carried out using procedures adapted from ASTM G57-95a (2001) "Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method". In summary, 200 to 500 grams of sample is mixed with deionized water as required to create a saturated paste. The sample is then measured as is (i.e. the paste) for Oxidation Reduction Potential.

ALS Test Code	Matrix	Test Description	Method Reference**
PO4-AVAIL-SK	Soil	Available Phosphate-P	Comm. Soil Sci. Plant Anal. 25 (5&6)

Plant available phosphorus is extracted from the soil using Modified Kelowna solution. Phosphorous in the soil extract is determined colorimetrically at 880 nm.

ALS Test Code	Matrix	Test Description	Method Reference**
S2-NAOH-VA	Soil	Sediment Sulphide (NaOH leach) by Colour	ALSEV IN-HOUSE METHOD

This analysis is carried out on a leachable basis. The procedure involves shaking a subsample for 20 minutes with a sodium hydroxide solution in a one to seven ratio. The leachate is filtered and Zinc acetate is added to an aliquot of filtrate and analyzed colorimetrically using methylene blue.

** 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

Reference Information

SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

1	2

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.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

L1368351-COFC

COC #

Report to:		Report Format / Distribution		Service Requested:
Company:	HEMMERA	☑ Standard ☐ Other		☑ Regular Service (Default)
Contact:	Bonnie Marks Laura McLaren	☑ PDF ☑ Excel ☐ Fax		☐ Rush Service (2-3 Days)
Address:	250-1380 Burrard St, Vancouver V5Z 2H3	Email 1:	bmarks@hemmera.com	☐ Priority Service (1 Day or ASAP)
		Email 2:	lmclaren@hemmera.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone: 604-669-0424	Fax: 604-669-0430			Analysis Request
Invoice To:	☑ Same as Report		Indicate Bottles: Filtered / Preserved (F/P) →	
Company:		Client / Project Information:		
Contact:		Job #:	~~400-002.24~~ 499-002.19	
Address:		PO/AFE:		
Sample		Legal Site Description:		
Phone:	Fax:	Quote #:	Q23052	
Lab Work Order # (lab use only)		ALS Contact: Brent Mack	Sampler (Initials):	

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	pH, Turbidity, Salinity, TSS	SiO3 (Silicate)	PO4 (Tot, Dis, and Ortho)	Ammonia and TKN	NO2, NO3 by IC	TN-CALC-VA, N-ORG-CALC-VA	Chlorohyll-a	~~CL2-O-TOTAL-VA (Chlorine)~~	~~MET-T-ICP+HRMS-VA~~	SELECT METALS	Hazardous?	Highly Contaminated?	Number of Containers
1	SWDP09A-27	24-SEP-13		Water	X	X	X	X	X	X	X			X			4
2	SWDP10A-27	〃		Water	X	X	X	X	X	X	X			X			4
3	SWDP11A-27	〃		Water	X	X	X	X	X	X	X			X			4
4	SWRB10-1A-27	〃		Water	X	X	X	X	X	X	X			X			4
				Water													
				Water													
				Water													
				Water													
				Water													
				Water													

Short Holding Time

Rush Processing

...tions

Special Instructions / Hazardous Details

Samples are SEAWATERS

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:	Date & Time:	Received By:	Date & Time:	Sample Condition (lab use only)	
[signature]		Jaye	Sep 24	Temperature	Samples Received in Good Condition? Y / N (if no provided details)
Relinquished By:	Date & Time:	Received By:	Date & Time: ~~1~~ 21:25	13.8	

SELECT METALS ARE
Calcium, boron, magnesium, potassium, sodium
report these only

L1368351-COFC

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

CCC #

Report to:		Report Format / Distribution		Service Requested:
Company:	HEMMERA	☑ Standard ☐ Other		☑ Regular Service (Default)
Contact:	Bonnie Marks	☑ PDF ☑ Excel ☐ Fax		☐ Rush Service (2-3 Days)
Address:	Vancouver	Email 1:	bmarks@hemmera.com, cclegg@hemmera.com	☐ Priority Service (1 Day or ASAP)
		Email 2:	rmclaren@hemmera.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone:	604-669-0424 Fax:			Analysis Request
Invoice To:	☑ Same as Report	Indicate Bottles: Filtered / Preserved (F/P) →		
Company:		Client / Project Information:		
Contact:		Job #:	~~[illegible]~~ 999-002.19	
Address:		PO/AFE:		
Sample		Legal Site Description:		
Phone:	Fax:	Quote #:	Q23052	
Lab Work Order # (lab use only)		ALS Contact:	Brent Mack	Sampler (Initials):

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	MET-200.2-CCMS-1-VA	(RFP) VA-P-200.2-MS	PO4-AVAIL-SK, NH4-AVAIL-S	N-TOTKJ-SK	N-TOT-LECO-SK	ETL-N-TOTORG-CALC-SK	C-TOT-ORG-LECO-SK		S2-NAOH-VA (rush)	ORP-PASTE-VA	Hazardous?	Highly Contaminated?	Number of Containers
5	SRDP09-27	24 SEPT 13		Sediment	X	X	X	X	X	X	X		X	X			3
6	SRDP10-27	"		Sediment	X	X	X	X	X	X	X		X	X			3
7	SRDP11-27	"		Sediment	X	X	X	X	X	X	X		X	X			3
8	SRRB10-11-27	"		Sediment	X	X	X	X	X	X	X		X	X			3
				Sediment													
				Sediment													
				Sediment													
				Sediment													
				Sediment													
				Sediment													

Guidelines / Regulations	Special Instructions / Hazardous Details
	SULFIDE needs RUSH extraction

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:	[signature]	Date & Time		Received By:	Jaye	Date & Time	Sep 24	Sample Condition (lab use only)	
Relinquished By:		Date & Time		Received By:		Date & Time	21:25	Temperature 13.8	Samples Received in Good Condition? Y / N (if no provided details)

HEMMERA ENVIROCHEM INC.
ATTN: Bonnie Marks
250 - 1380 Burrard Street
Vancouver BC V6Z 2H3

Date Received: 23-JUL-13
Report Date: 13-AUG-13 12:16 (MT)
Version: FINAL

Client Phone: 604-669-0424

Certificate of Analysis

Lab Work Order #: L1336806

Project P.O. #: NOT SUBMITTED
Job Reference: 499-002.24
C of C Numbers: 1, 2
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1336806-1	L1336806-2	L1336806-3	L1336806-4	L1336806-5
	Description	seawater	seawater	seawater	seawater	seawater
	Sampled Date	22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13
	Sampled Time					
	Client ID	DP10-9	DP11-9	RB-10-1-9	DP11-13	DP11-16
Grouping	**Analyte**					
SEAWATER						
Physical Tests	Hardness (as CaCO3) (mg/L)					
	pH (pH)	7.97	7.93	8.07	7.92	8.11
	Salinity (psu)	25.4	25.8	25.2	25.0	25.6
	Total Suspended Solids (mg/L)	4.5	3.2	5.4	8.8	8.4
	Turbidity (NTU)	0.84	1.07	0.93	1.11	1.64
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0136	0.114	0.0259	0.0467	0.0351
	Nitrate (as N) (mg/L)	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM
	Total Kjeldahl Nitrogen (mg/L)	0.256	0.314	0.305	0.234	0.304
	Total Nitrogen (mg/L)	<0.51	<0.51	<0.51	<0.51	<0.51
	Total Organic Nitrogen (mg/L)	0.243	0.200	0.279	0.187	0.269
	Orthophosphate-Dissolved (as P) (mg/L)	0.0202	0.0519	0.0478	0.0699	0.0452
	Phosphorus (P)-Total Dissolved (mg/L)	0.0272	0.0561	0.0513	0.0767	0.0533
	Phosphorus (P)-Total (mg/L)	0.0484	0.0751	0.0725	0.0918	0.0720
Total Metals	Boron (B)-Total (mg/L)					
	Calcium (Ca)-Total (mg/L)					
	Magnesium (Mg)-Total (mg/L)					
	Potassium (K)-Total (mg/L)					
	Sodium (Na)-Total (mg/L)					
Plant Pigments	Chlorophyll a (ug/L)	7.42	2.09	5.11	0.818	5.28

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1336806-6	L1336806-7	L1336806-8	L1336806-9	L1336806-10
Description		seawater	seawater	seawater	seawater	seawater
Sampled Date		22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13
Sampled Time						
Client ID		DP10-16	DP09-16	RB10-1-16	DP11-19	DP10-18
Grouping	**Analyte**					
SEAWATER						
Physical Tests	Hardness (as CaCO3) (mg/L)				5040	4910
	pH (pH)	8.13	8.13	8.12	7.93	7.93
	Salinity (psu)	25.8	26.0	26.0	28.0	28.0
	Total Suspended Solids (mg/L)	9.8	13.4	5.0	12.8	6.9
	Turbidity (NTU)	1.63	1.39	1.50	1.36	1.02
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0308	0.0270	<0.0050	0.0075	0.0122
	Nitrate (as N) (mg/L)	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM
	Total Kjeldahl Nitrogen (mg/L)	0.318	0.277	0.207	0.189	0.179
	Total Nitrogen (mg/L)	<0.51	<0.51	<0.51	<0.51	<0.51
	Total Organic Nitrogen (mg/L)	0.287	0.250	0.207	0.182	0.167
	Orthophosphate-Dissolved (as P) (mg/L)	0.0410	0.0399	0.0166	0.0487	0.0473
	Phosphorus (P)-Total Dissolved (mg/L)	0.0471	0.0418	0.0222	0.0509	0.0526
	Phosphorus (P)-Total (mg/L)	0.0753	0.0797	0.0397	0.0787	0.0603
Total Metals	Boron (B)-Total (mg/L)				3.5	3.4
	Calcium (Ca)-Total (mg/L)				340	330
	Magnesium (Mg)-Total (mg/L)				1020	992
	Potassium (K)-Total (mg/L)				305	300
	Sodium (Na)-Total (mg/L)				8630	8460
Plant Pigments	Chlorophyll a (ug/L)	7.19	8.07	9.65	5.89	2.01

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

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1336806-11	L1336806-12	L1336806-13	L1336806-14	L1336806-19
	Description	seawater	seawater	seawater	seawater	seawater
	Sampled Date	22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13	22-JUL-13
	Sampled Time					
	Client ID	DP09-18	RB-10-1-18	DP09-9	DP04-9	DP04-16
Grouping	**Analyte**					
SEAWATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	4880	4910			
	pH (pH)	7.93	7.92	7.80	8.04	8.07
	Salinity (psu)	27.6	28.0	24.9	24.7	24.4
	Total Suspended Solids (mg/L)	15.2	97.2	13.2	4.8	6.6
	Turbidity (NTU)	1.94	22.3	1.59	1.10	2.19
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0079	0.0085	0.0149	0.0358	<0.0050
	Nitrate (as N) (mg/L)	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM	<0.50 DLM
	Nitrite (as N) (mg/L)	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM	<0.10 DLM
	Total Kjeldahl Nitrogen (mg/L)	0.215	0.415	0.278	0.288	0.223
	Total Nitrogen (mg/L)	<0.51	<0.51	<0.51	<0.51	<0.51
	Total Organic Nitrogen (mg/L)	0.207	0.406	0.263	0.253	0.223
	Orthophosphate-Dissolved (as P) (mg/L)	0.0446	0.0421	0.0975	0.0507	0.0078
	Phosphorus (P)-Total Dissolved (mg/L)	0.0487	0.0395	0.0980	0.0577	0.0136
	Phosphorus (P)-Total (mg/L)	0.0704	0.233	0.173	0.0733	0.0367
Total Metals	Boron (B)-Total (mg/L)	3.3	3.4			
	Calcium (Ca)-Total (mg/L)	335	329			
	Magnesium (Mg)-Total (mg/L)	983	993			
	Potassium (K)-Total (mg/L)	302	300			
	Sodium (Na)-Total (mg/L)	8500	8420			
Plant Pigments	Chlorophyll a (ug/L)	5.15	9.15	1.64	1.10	6.31

* 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)
Duplicate	Nitrite (as N)	DLM	L1336806-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Nitrate (as N)	DLM	L1336806-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Nitrite (as N)	DLM	L1336806-1, -10, -11, -12, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Nitrite (as N)	DLM	L1336806-13, -14, -19
Duplicate	Nitrate (as N)	DLM	L1336806-13, -14, -19
Duplicate	Nitrate (as N)	DLM	L1336806-13, -14, -19

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-C-NO2-IC-VA	Seawater	Nitrite in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ALS Test Code	Matrix	Test Description	Method Reference**
ANIONS-C-NO3-IC-VA	Seawater	Nitrate in Seawater by IC	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

CHLOROA-C-VA Seawater Chlorophyll a by Fluorometer (seawater) APHA 10200 H. Chlorophyll and EPA 445

This analysis is done using procedures modified from EPA Method 445.0. Chlorophyll-a is determined by a routine acetone extraction followed with analysis by fluorometry using the non-acidification procedure. This method is not subject to interferences from chlorophyll b.

HARDNESS-CALC-VA Seawater Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-T-L-HRMS-VA Seawater Tot. Metals in Seawater by HR-ICPMS EPA 200.8

Trace metals in seawater are analyzed by high resolution inductively coupled plasma mass spectrometry (HR-ICPMS) based on US EPA Method 200.8, (Revision 5.5). The procedures may involve preliminary sample treatment by acid digestion based on APHA Method 3030E.

MET-TOT-C-ICP-VA Seawater Total Metals in Seawater by ICPOES PUGET SOUND PROTOCOLS, EPA 6010B

This analysis is carried out using procedures adapted from "Recommended Guidelines for Measuring Metals in Puget Sound Marine Water, Sediment, and Tissue Samples" prepared for the United States Environmental Protection Agency and the Puget Sound Water Quality Authority, 1995. The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-ORGANIC-CALC-VA Seawater Total Organic Nitrogen (Calculation) APHA 4500-NORG (TKN)/NH3-NITROGEN (NH3)

Total Organic Nitrogen is a calculated parameter. Total Organic Nitrogen = Total Kjeldahl Nitrogen - Ammonia.

NH3-F-VA Seawater Ammonia in Seawater by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA Seawater Total P in Seawater by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

P-TD-COL-VA Seawater Total Dissolved P in Seawater by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Dissolved Phosphorous is determined colourimetrically after persulphate digestion of a sample that has been lab or field filtered through a 0.45 micron membrane filter.

PH-C-PCT-VA Seawater pH by Meter (Automated) (seawater) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Seawater D-Orthophosphate in Seawater by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SALINITY-C-EC-VA Seawater Salinity by calc. using EC (seawater) APHA 2520 B

Salinity is determined by the APHA 2520B Electrical Conductivity Method. Salinity is a unitless parameter that is roughly equivalent to grams per Litre. ALS applies the unit of psu (practical salinity unit) to indicate that salinity values are derived from the Practical Salinity Scale

Reference Information

TKN-C-F-VA Seawater TKN in Seawater by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA Seawater Total Nitrogen (Calculation) BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-C-VA Seawater Total Suspended Solids by Gravimetric APHA 2540 D. / PSWQA TSS

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a 0.45um membrane filter (Puget Sound Water Quality Authority TSS Method, May 1991), TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-C-VA Seawater Turbidity by Meter in Seawater APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** 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, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

1 2

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.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # ______

Page 1 of 2

Report to:		Report Format / Distribution		Service Requested:
Company:	HEMMERA	☑ Standard ☐ Other		☑ Regular Service (Default)
Contact:	Bonnie Marks	☑ PDF ☑ Excel ☐ Fax		☐ Rush Service (2-3 Days)
Address:	250-1380 Burrard St, Vancouver V5Z 2H3	Email 1:	bmarks@hemmera.com, dclegg@hemmera.com	☐ Priority Service (1 Day or ASAP)
		Email 2:	lmclaren@hemmera.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone:	604-669-0424 Fax: 604-669-0430			Analysis Request
Invoice To:	☑ Same as Report	Indicate Bottles: Filtered / Preserved (F/P) →		
Company:		Client / Project Information:		
Contact:		Job #:	499-002.24	
Address:		PO/AFE:		
Sample		Legal Site Description:		
Phone:		Quote #:	Q23052	
Lab Work Order # (lab use only)	L1336806-COFC	ALS Contact: Brent Mack	Sampler (Initials):	

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	pH, Turbidity, Salinity, TSS	PO4 (Tot, Dis, and Ortho)	Ammonia and TKN	NO2, NO3 by IC	TN-CALC-VA, N-ORG-CALC-VA	Chlorohyll-a	select metals. See instructions	HOLD				Hazardous?	Highly Contaminated?	Number of Containers
	DP10-9	22-Jul-13		Other	X	X	X	X	X	X								
	DP11-9	22-Jul-13		Other	X	X	X	X	X	X								
	RB-10-1-9	22-Jul-13		Other	X	X	X	X	X	X								
	DP11-13	22-Jul-13		Other	X	X	X	X	X	X								
	DP11-16	22-Jul-13		Other	X	X	X	X	X	X								
	DP10-16	22-Jul-13		Other	X	X	X	X	X	X								
	DP09-16	22-Jul-13		Other	X	X	X	X	X	X								
	RB10-1-16	22-Jul-13		Other	X	X	X	X	X	X								
	DP11-19	22-Jul-13		Other	X	X	X	X	X	X	X							
	DP10-18	22-Jul-13		Other	X	X	X	X	X	X	X							

Guidelines / Regulations	Special Instructions / Hazardous Details
	Samples are SEAWATER. Select metals are: calcium, boron, magnesium, potasium, sodium reported only

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:	Date & Time:	Received By:	Date & Time:	Sample Condition (lab use only)	
[signature]	July 23 3:00pm			Temperature	Samples Received in Good Condition? Y / N (if no provided details)
Relinquished By:	Date & Time:	Received By: Elise	Date & Time: July 23 16:23	6.2	

7.4
9.9

Short Holding Time

Rush Processing

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # ______________

Report to:		**Report Format / Distribution**		**Service Requested:**
Company:	HEMMERA			Regular Service (Default)
Contact:	Bonnie Marks			Rush Service (2-3 Days)
Address:	250-1380 Burrard St, Vancouver V5Z 2H3	Email 1:	bmarks@hemmera.com, dclegg@hemmera.com	Priority Service (1 Day or ASAP)
		Email 2:	lmclaren@hemmera.com	Emergency Service (<1 Day / Wkend) - Contact ALS
Phone:	604-669-0424 Fax: 604-669-0430			**Analysis Request**
Invoice To:			Indicate Bottles: Filtered / Preserved (F/P) →	
Company:		**Client / Project Information:**		
Contact:		Job #:	499-002.24	
Address:		AFE:		
Sample		al Site Description:		
Phone:		te #:	Q23052	
Lab Wor (lab us		tact:	Brent Mack	Sampler (Initials):

L1336806-COFC

Sample #	(This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	pH, Turbidity, Salinity, TSS	PO4 (Tot, Dis, and Ortho)	Ammonia and TKN	NO2, NO3 by IC	TN-CALC-VA, N-ORG-CALC-	Chlorohyll-a	select metals. See instructions	HOLD			Hazardous?	Highly Contaminated?	Number of Containers
	DP09-18	22-Jul-13		Other	X	X	X	X	X	X	X						
	RB-10-1-18	22-Jul-13		Other	X	X	X	X	X	X	X						
	DP09-9	22-Jul-13		Other								X					
	DP04-9	22-Jul-13		Other								X					
	TUG-10	22-Jul-13		Other								X					
	DP10-12	22-Jul-13		Other								X					
	DP11-12	22-Jul-13		Other								X					
	TUG-16	22-Jul-13		Other								X					
	DP04-16	22-Jul-13		Other								X					
	TUG-19	22-Jul-13		Other								X					

Guidelines / Regulations	**Special Instructions / Hazardous Details**
	Samples are SEAWATER. Select metals are: calcium, boron, magnesium, potasium, sodium reported only

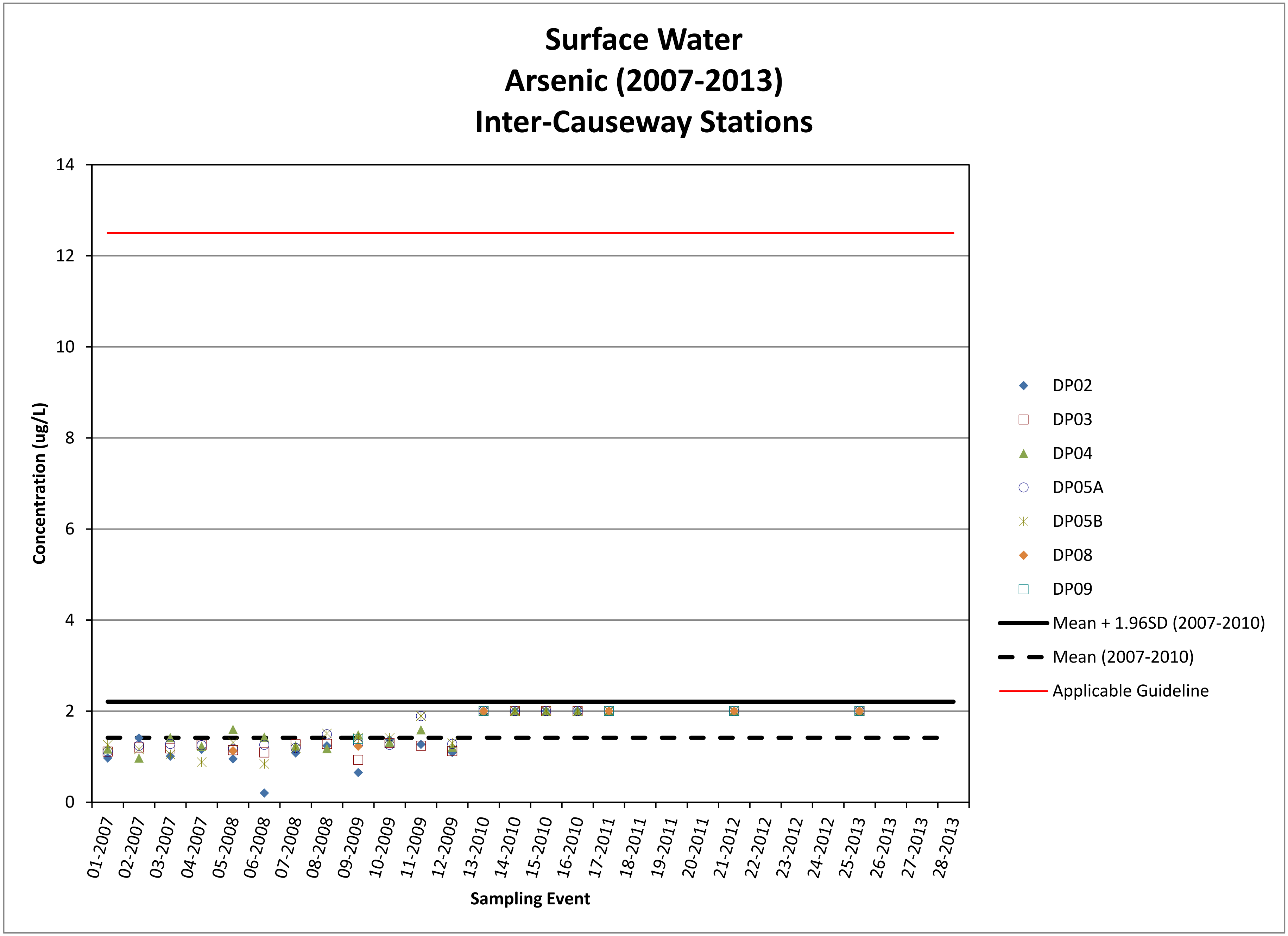
Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

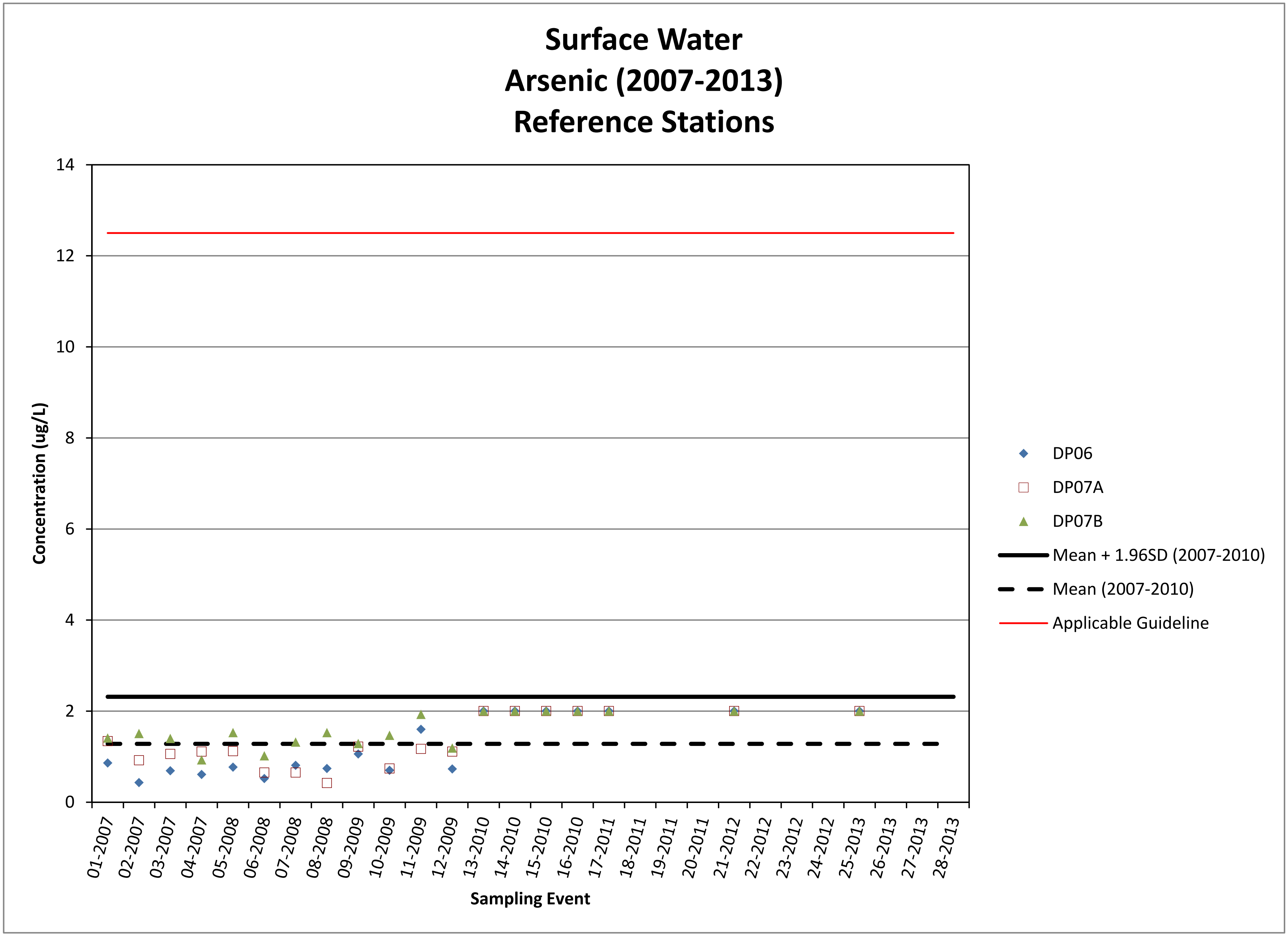
Relinquished By:	Date & Time:	Received By:	Date & Time:	Sample Condition (lab use only)	
[signature]	July 23 3:00pm			Temperature	Samples Received in Good Condition? Y / N (if no provided details)
Relinquished By:	Date & Time:	Received By: Elise	Date & Time: July23 16:23	6.2 7.4 9.9	

APPENDIX D

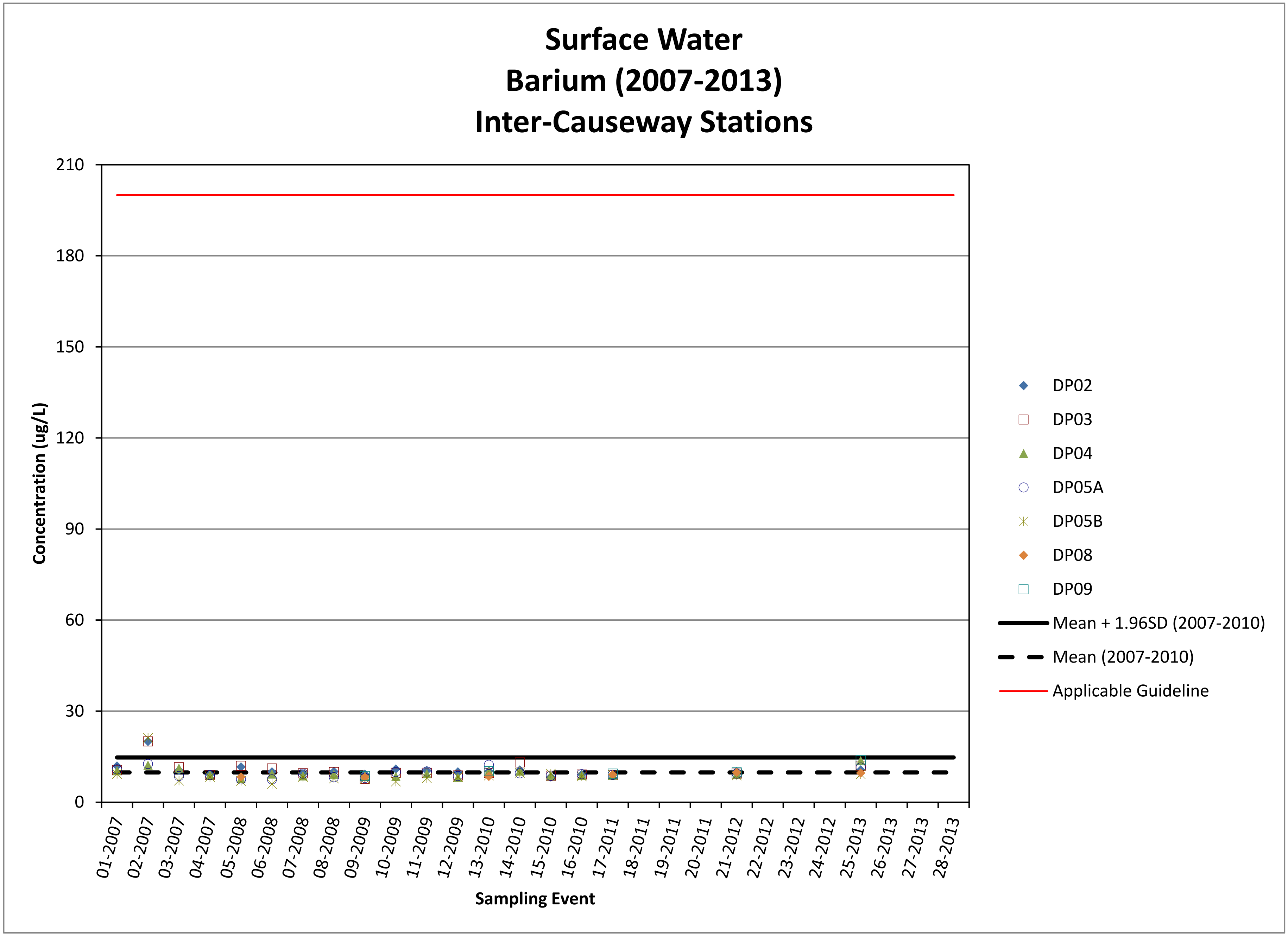
Trend Graphs for Surface Water and Sediment Chemistry – Metals



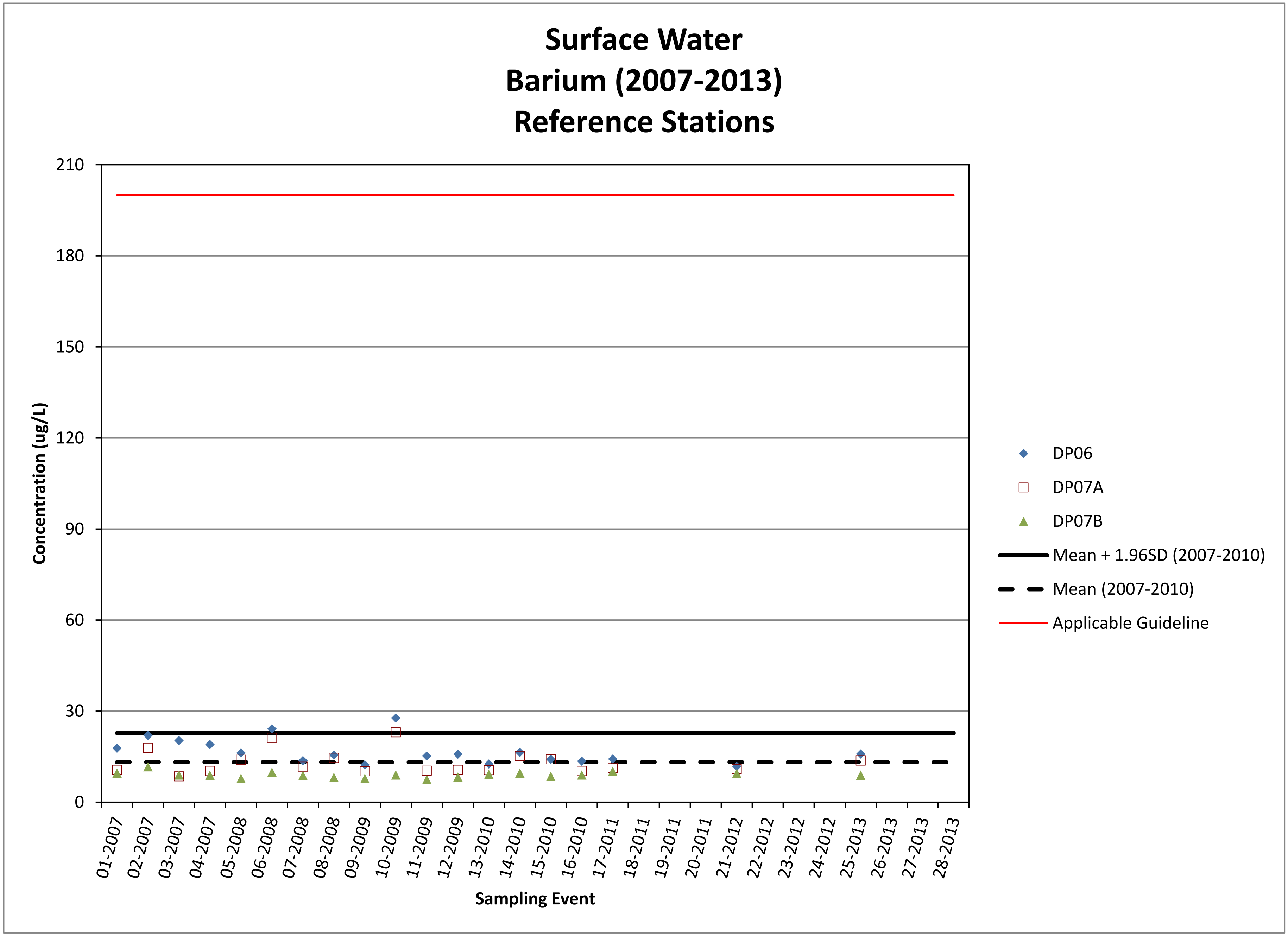
Surface Water
Arsenic (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



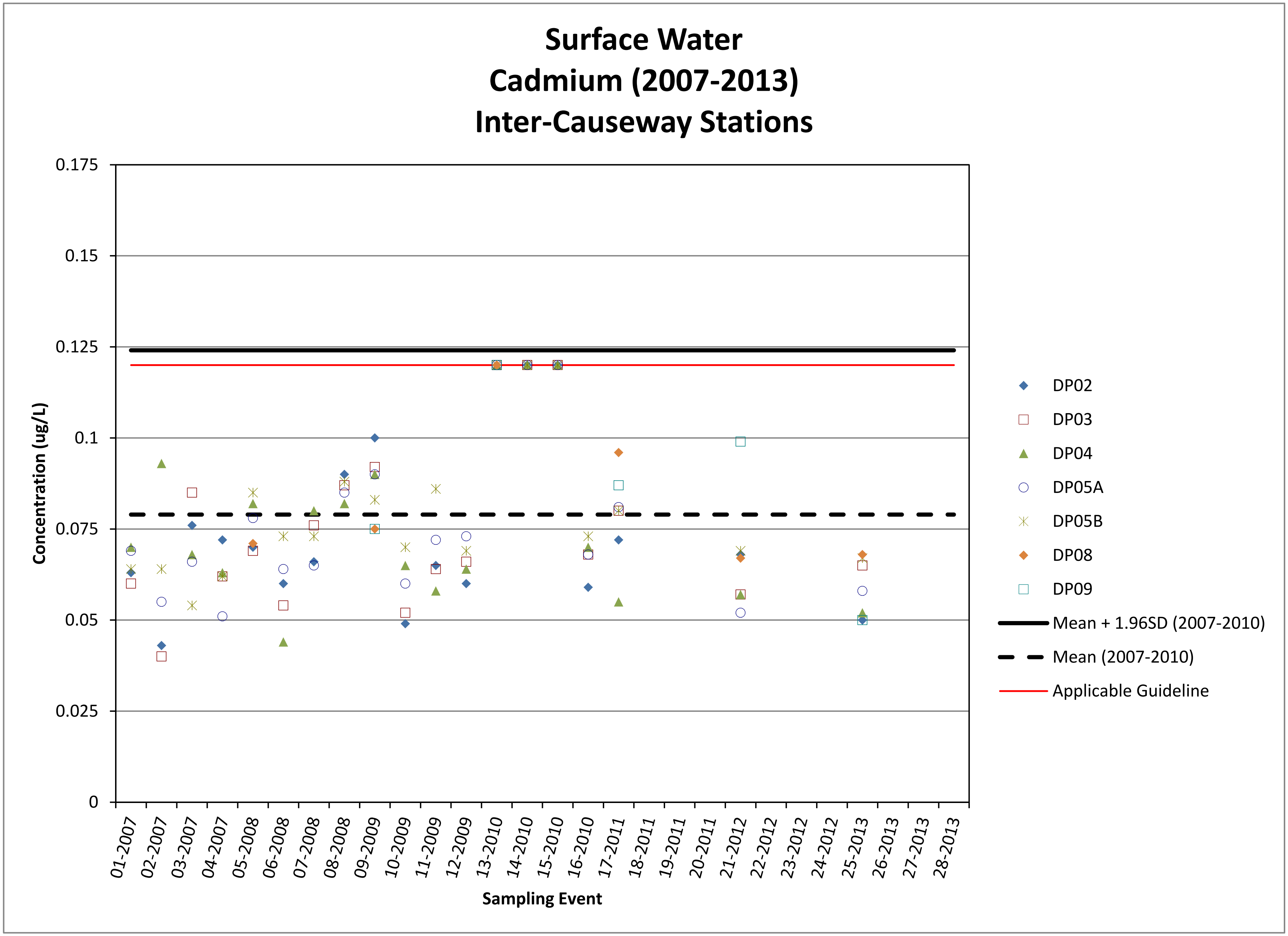
Surface Water
Arsenic (2007-2013)
Reference Stations
Concentration (ug/L)
14
12
10
8
6
4
2
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



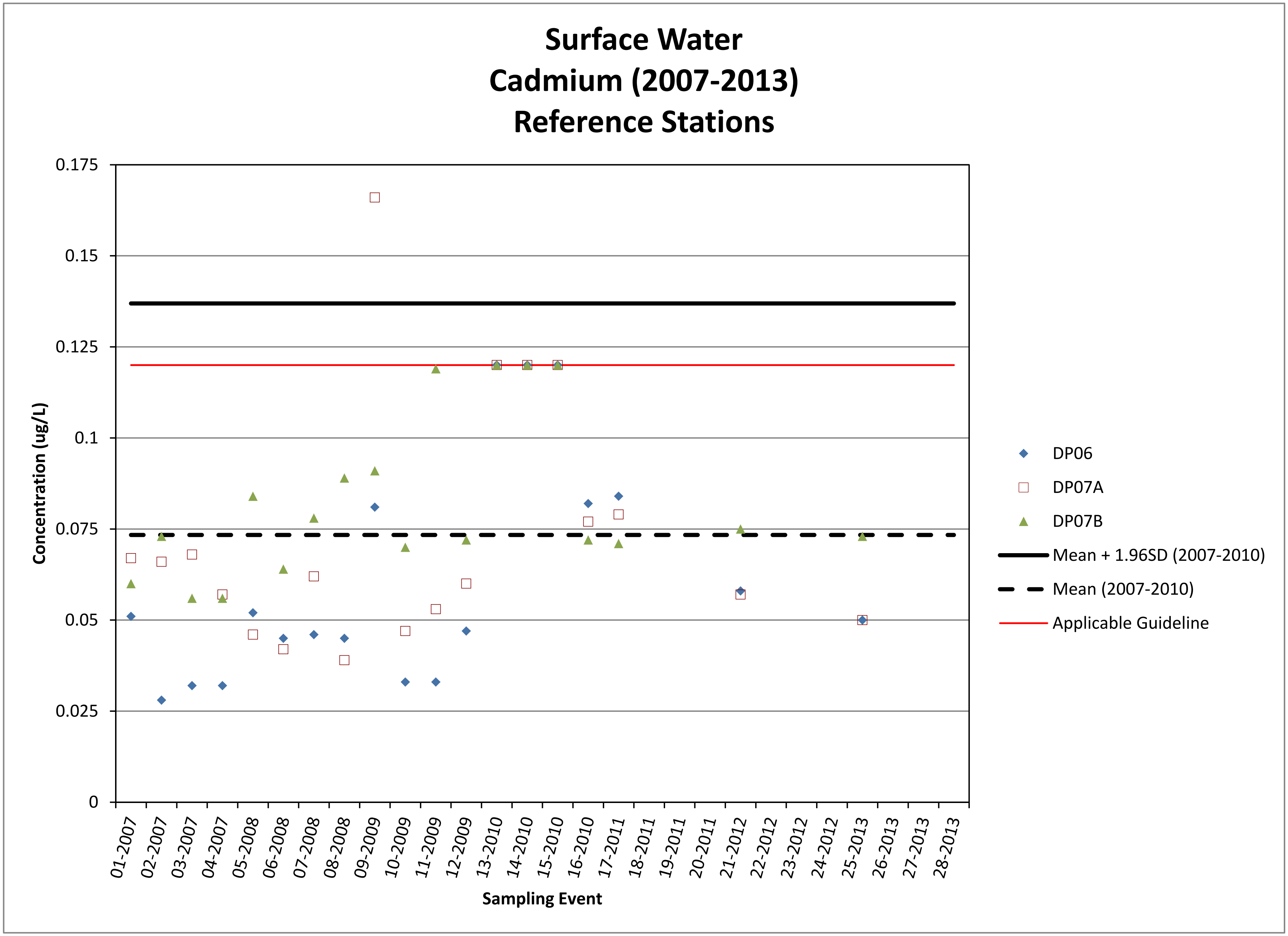
Surface Water
Barium (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
210
180
150
120
90
60
30
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



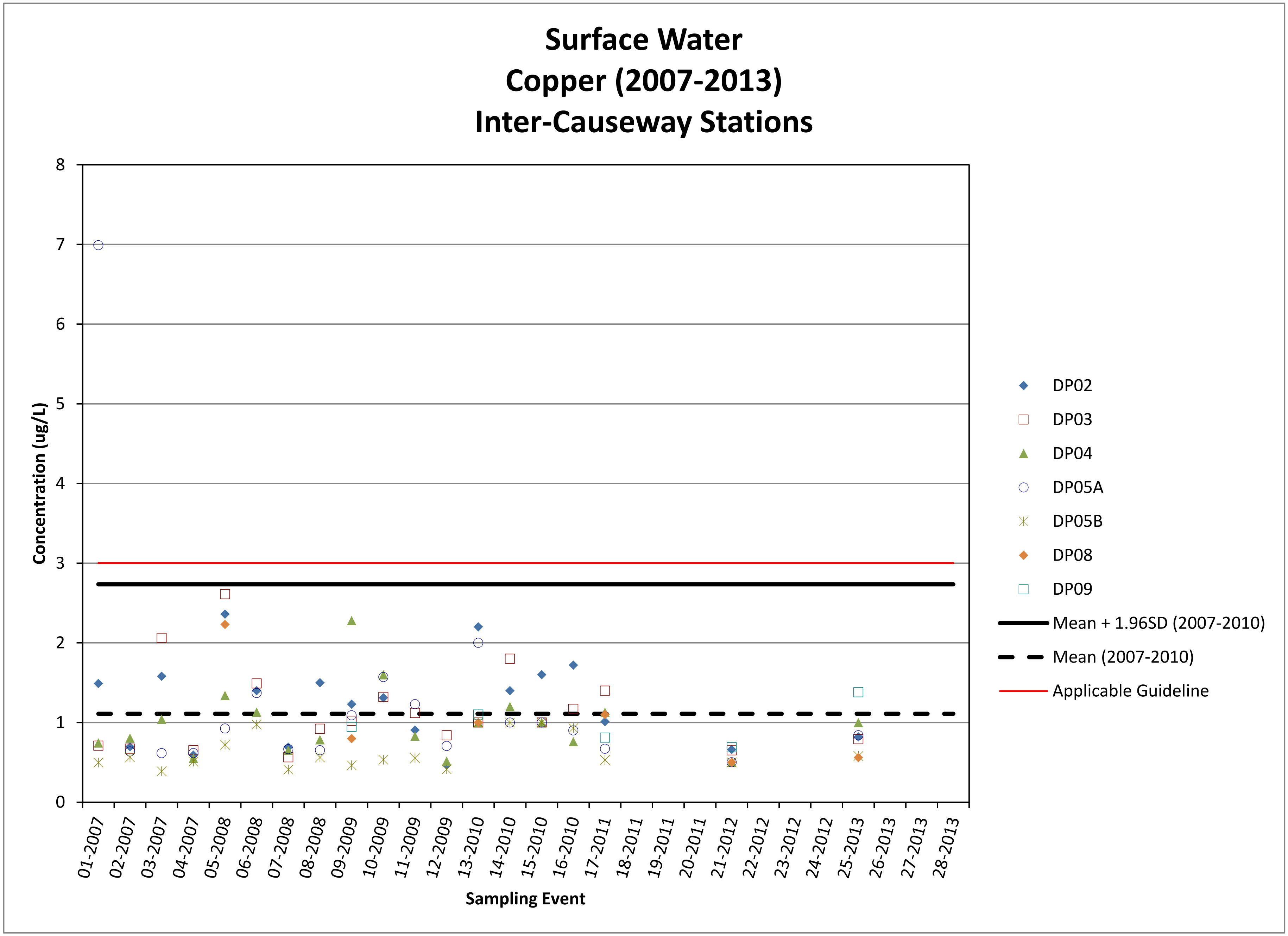
Surface Water
Barium (2007-2013)
Reference Stations
Concentration (ug/L)
0
30
60
90
120
150
180
210
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



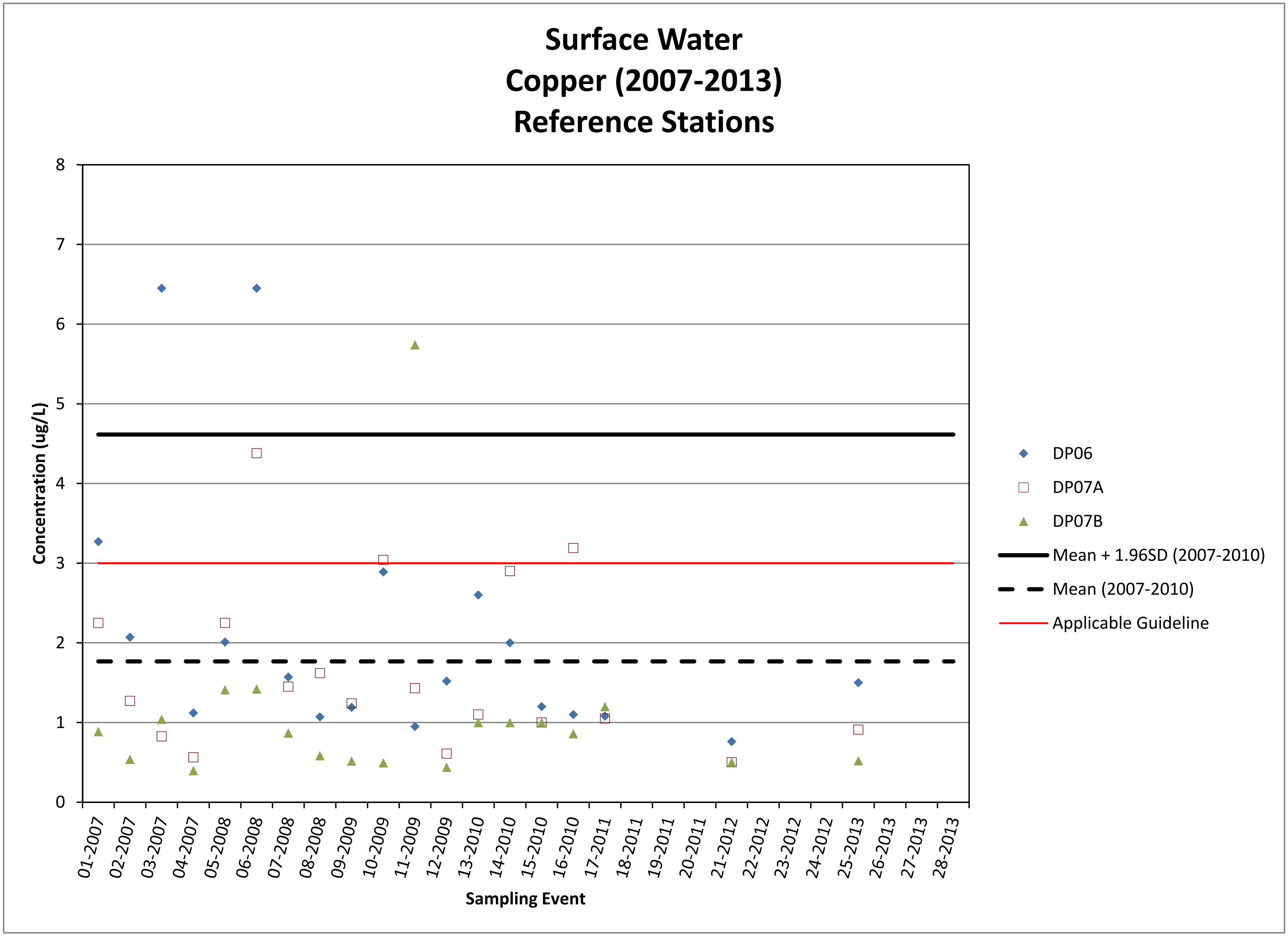
Surface Water
Cadmium (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

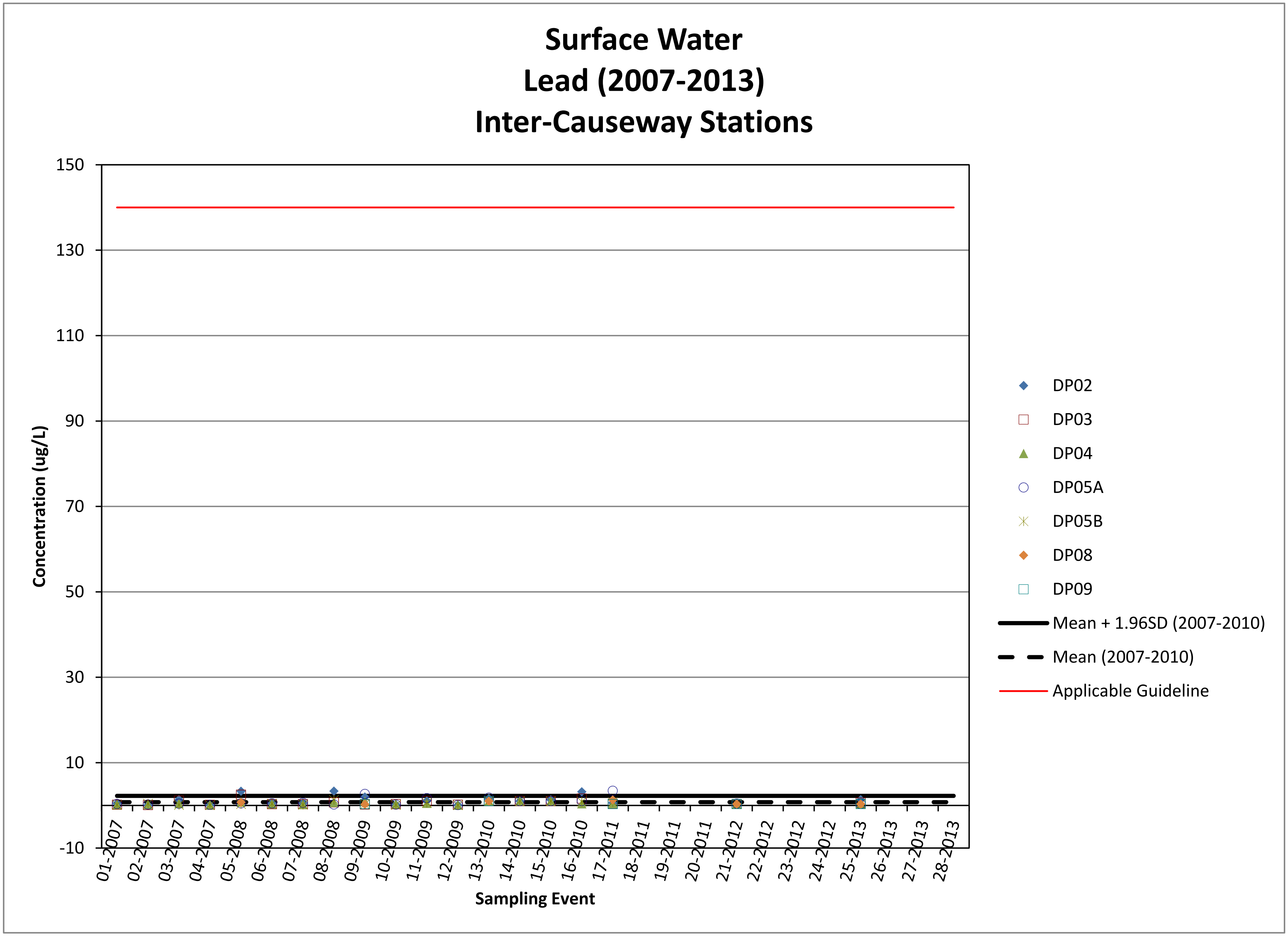


Surface Water
Cadmium (2007-2013)
Reference Stations
Concentration (ug/L)
0.175
0.15
0.125
0.1
0.075
0.05
0.025
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

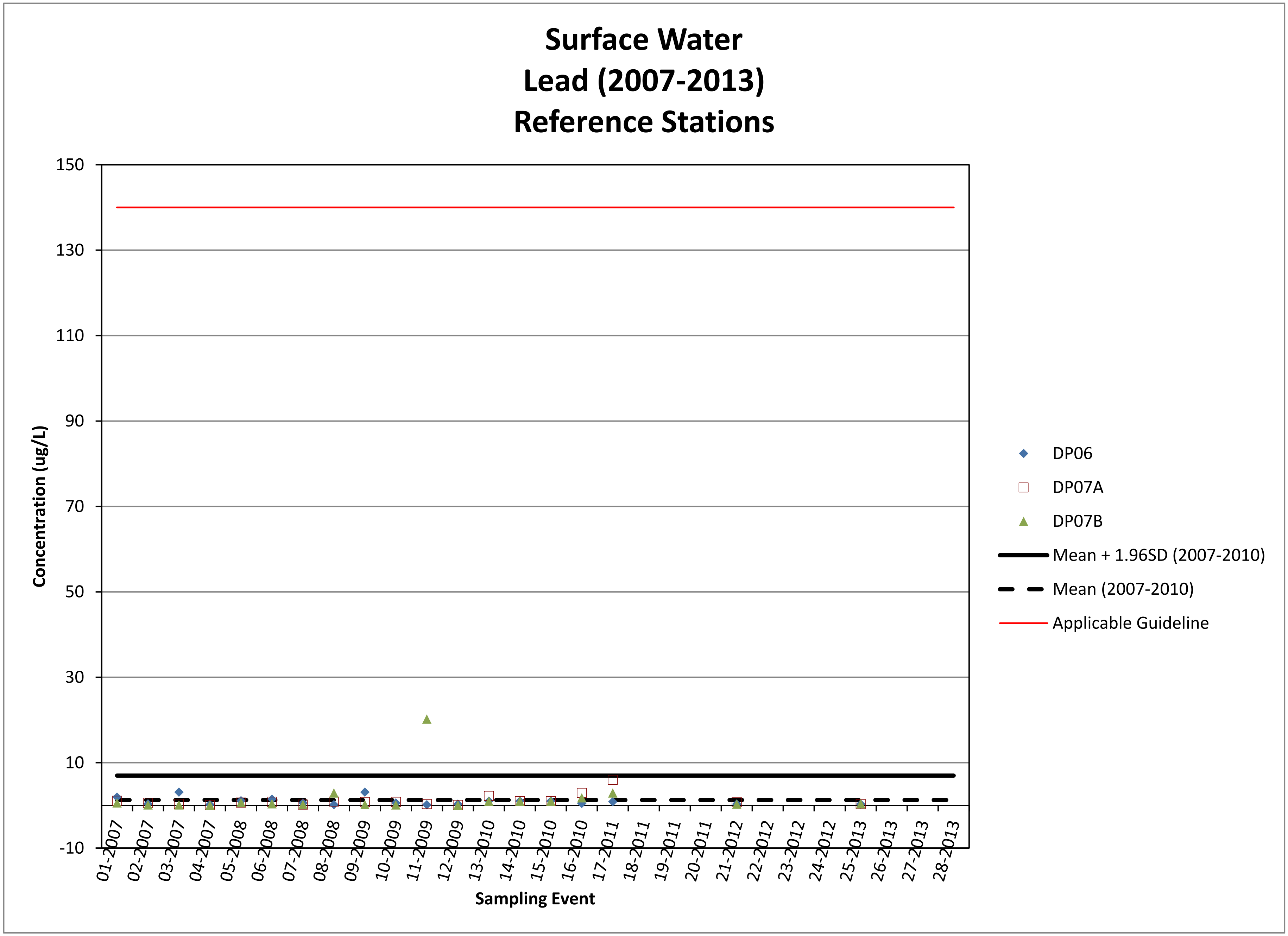


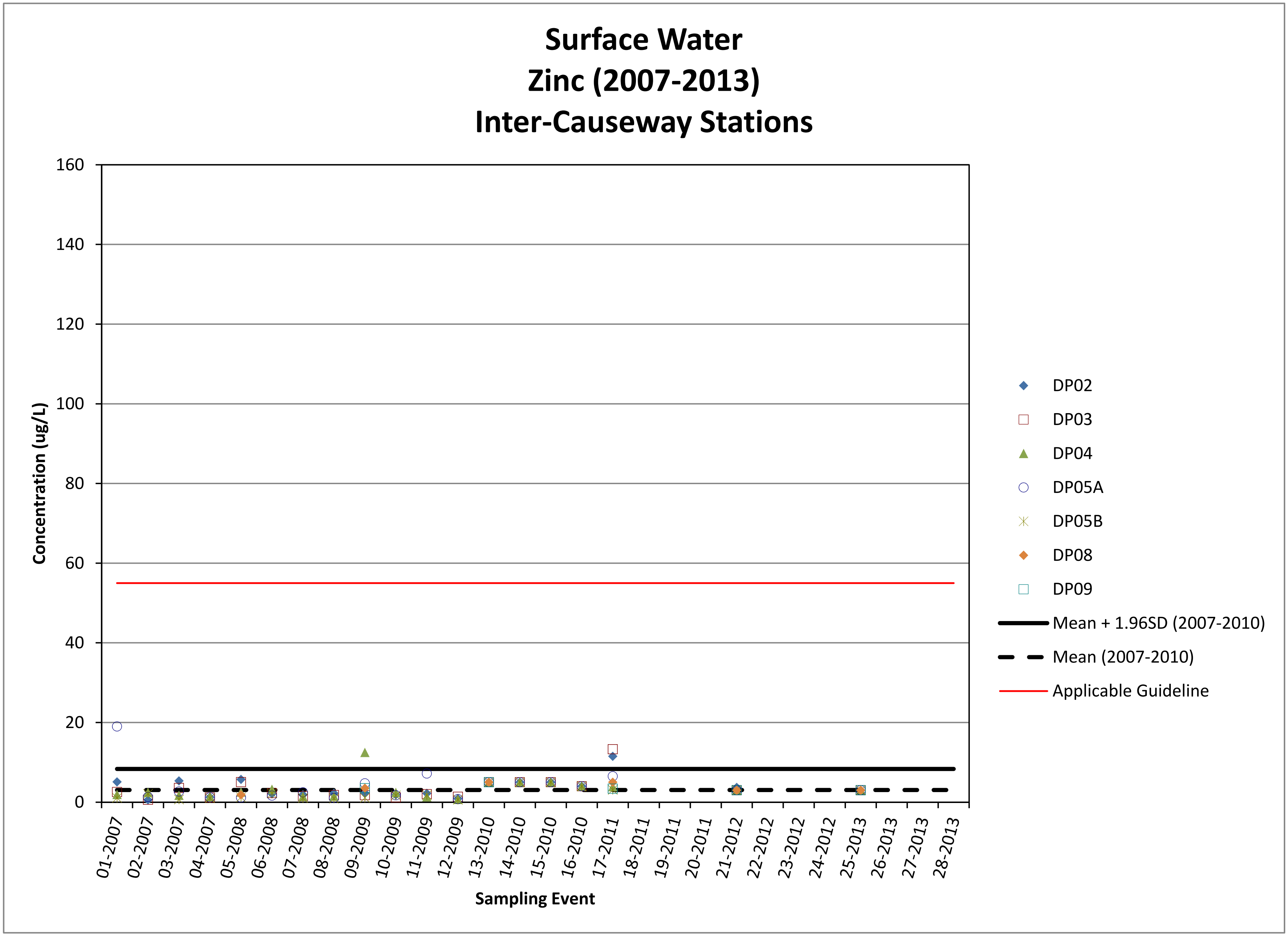
Surface Water
Copper (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
0
1
2
3
4
5
6
7
8
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline


Surface Water
Copper (2007-2013)
Reference Stations
Concentration (ug/L)
0
1
2
3
4
5
6
7
8
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

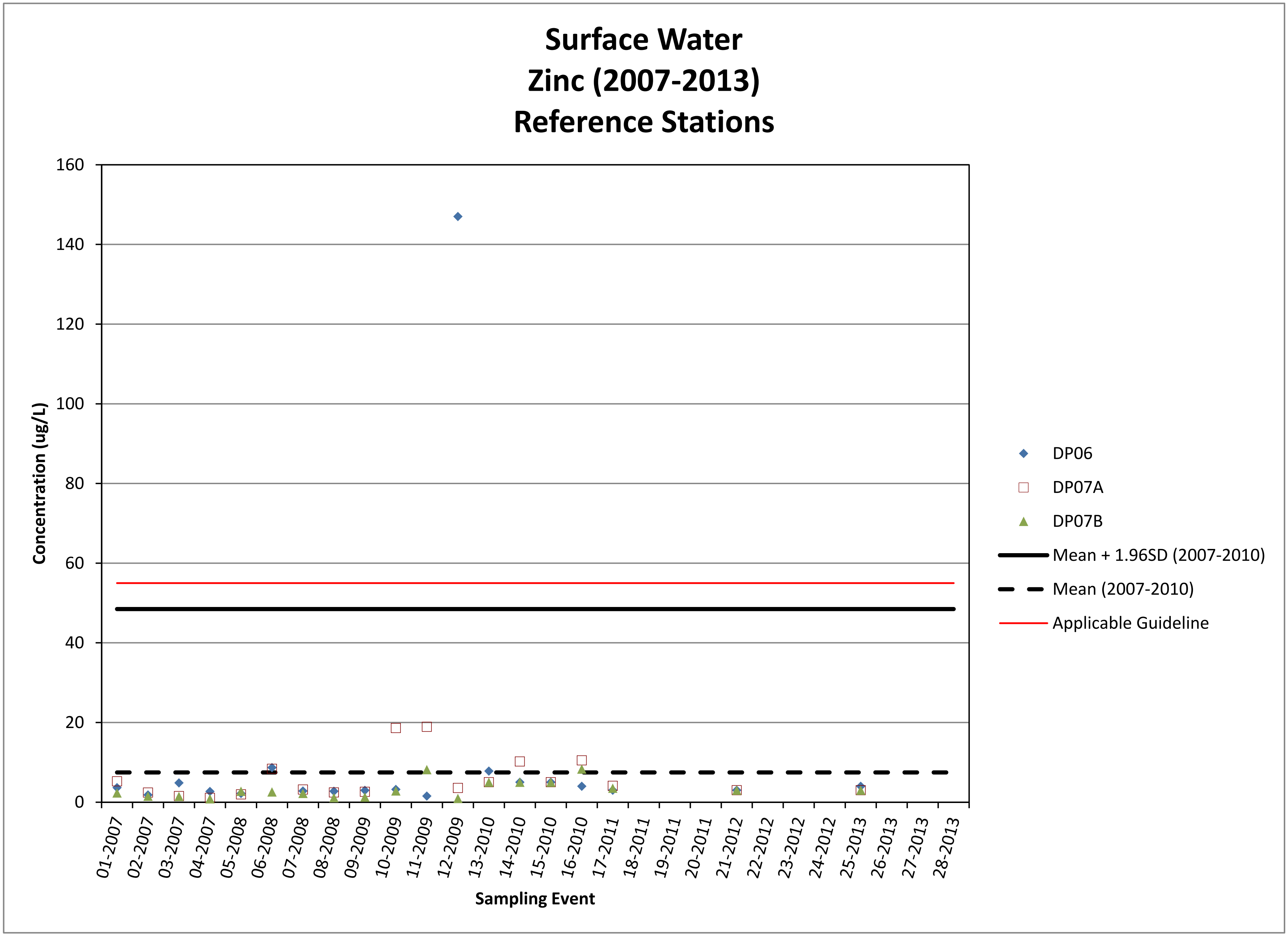


Surface Water
Lead (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
150
130
110
90
70
50
30
10
-10
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

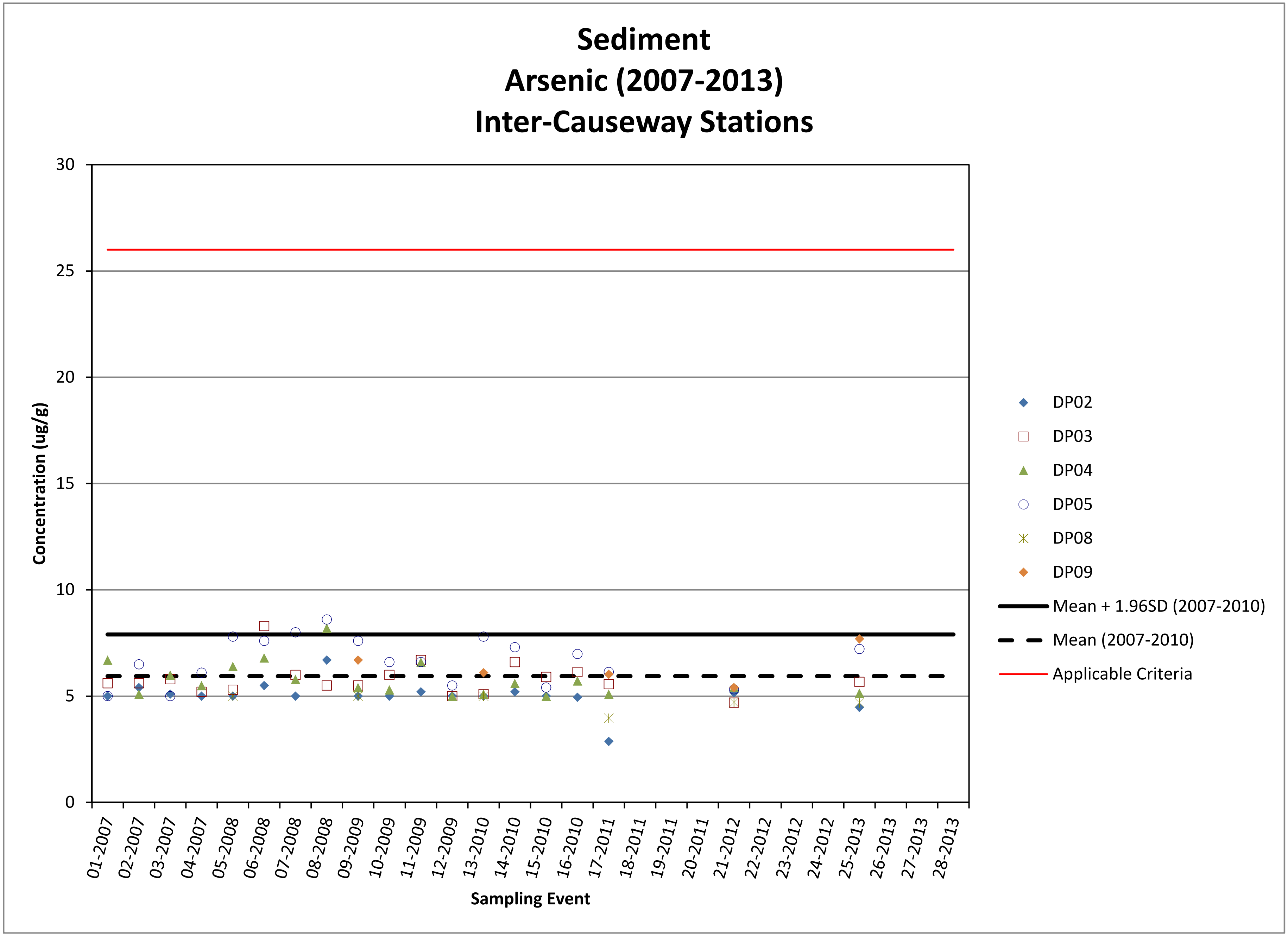

Surface Water
Lead (2007-2013)
Reference Stations
Concentration (ug/L)
150
130
110
90
70
50
30
10
-10
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



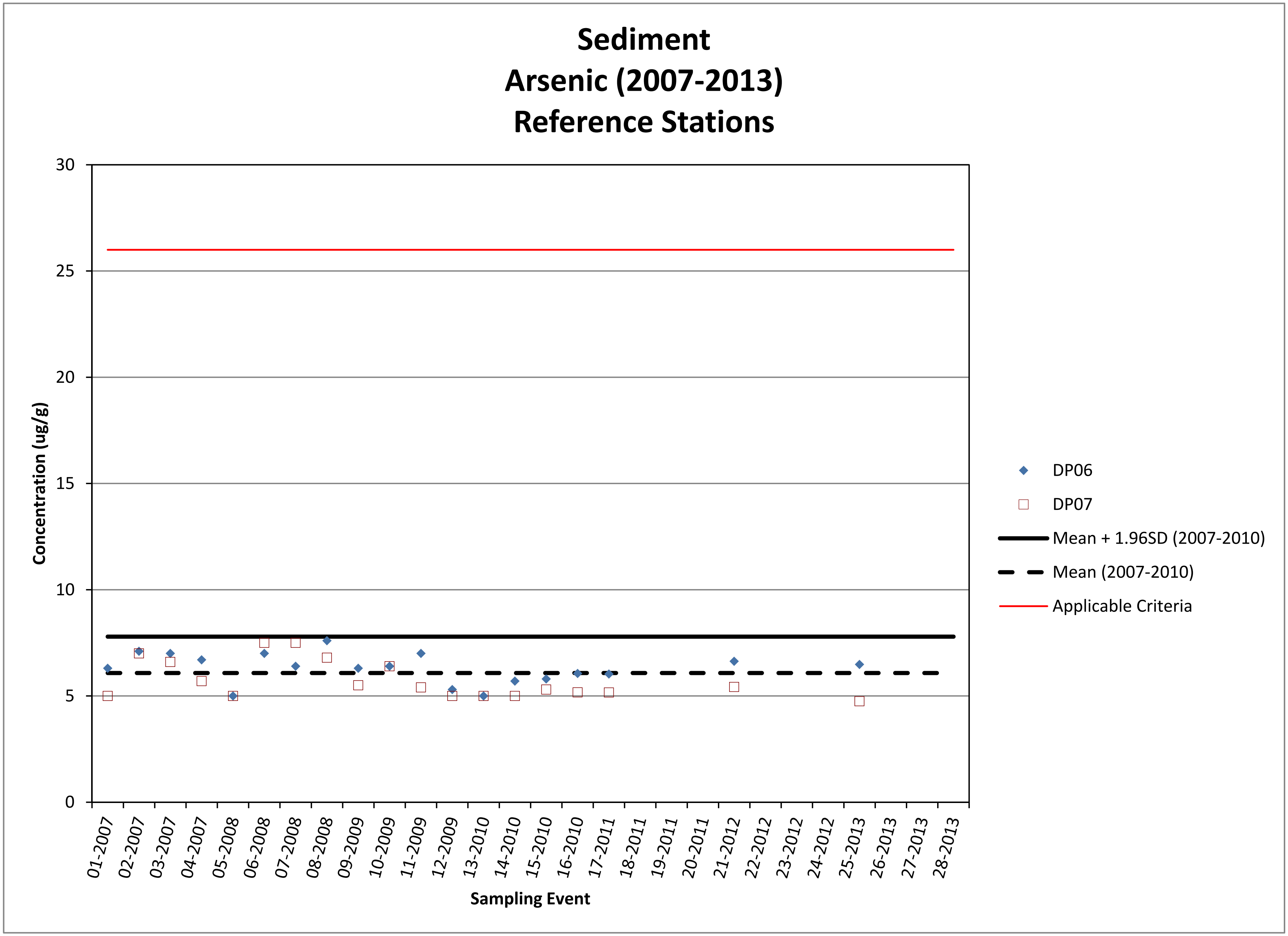
Surface Water
Zinc (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
0
20
40
60
80
100
120
140
160
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline



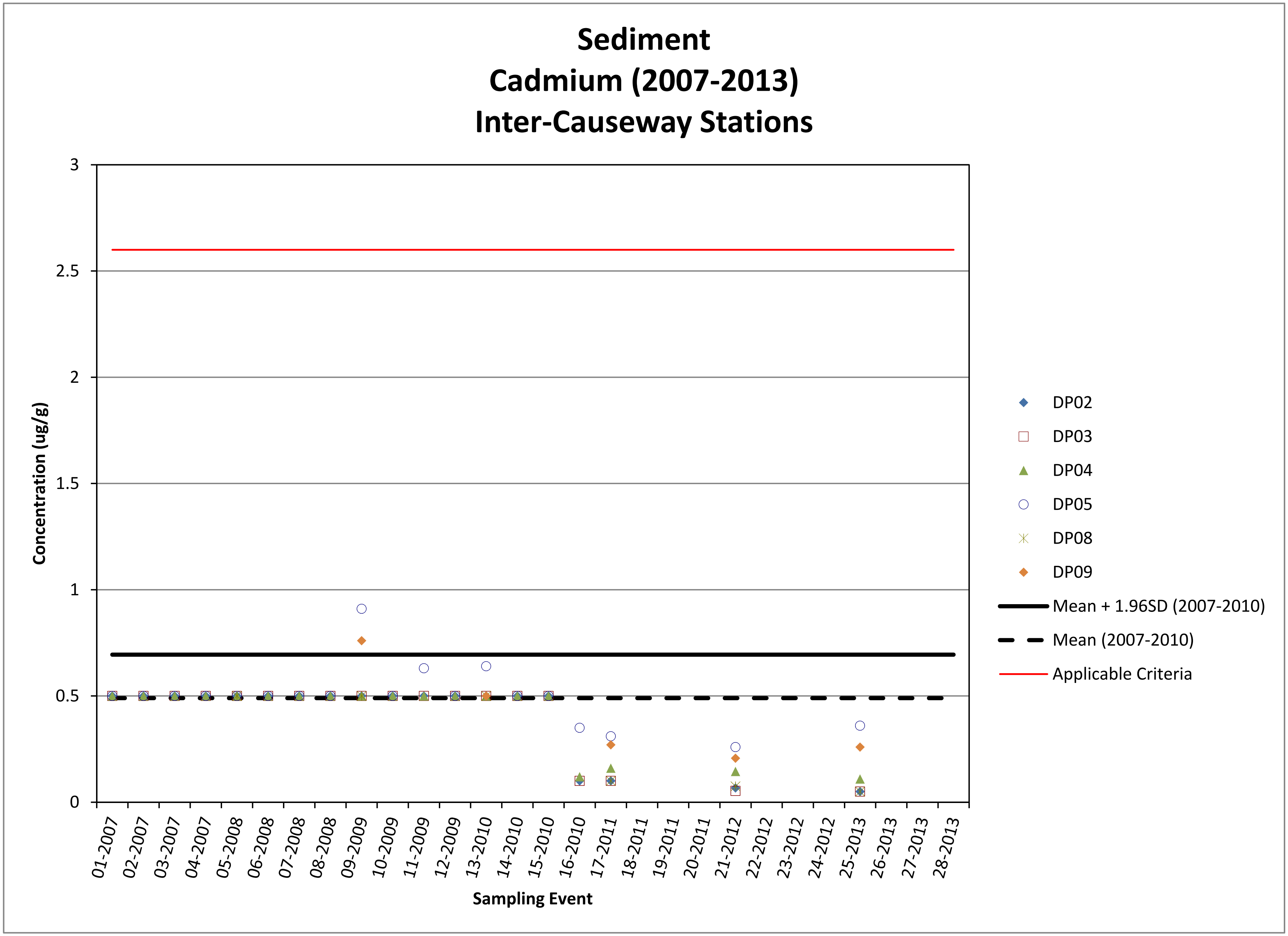
Surface Water
Zinc (2007-2013)
Reference Stations
Concentration (ug/L)
160
140
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

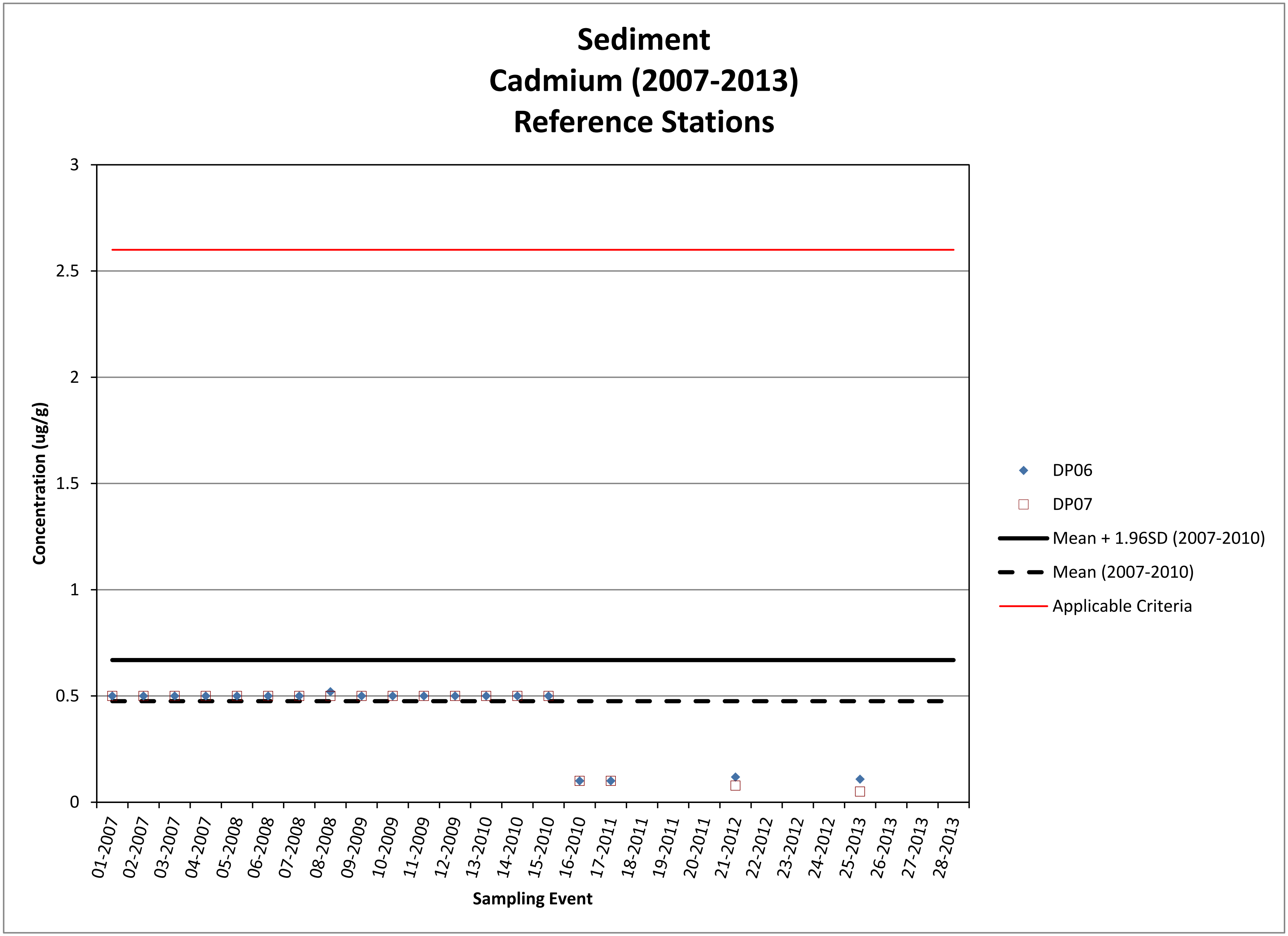


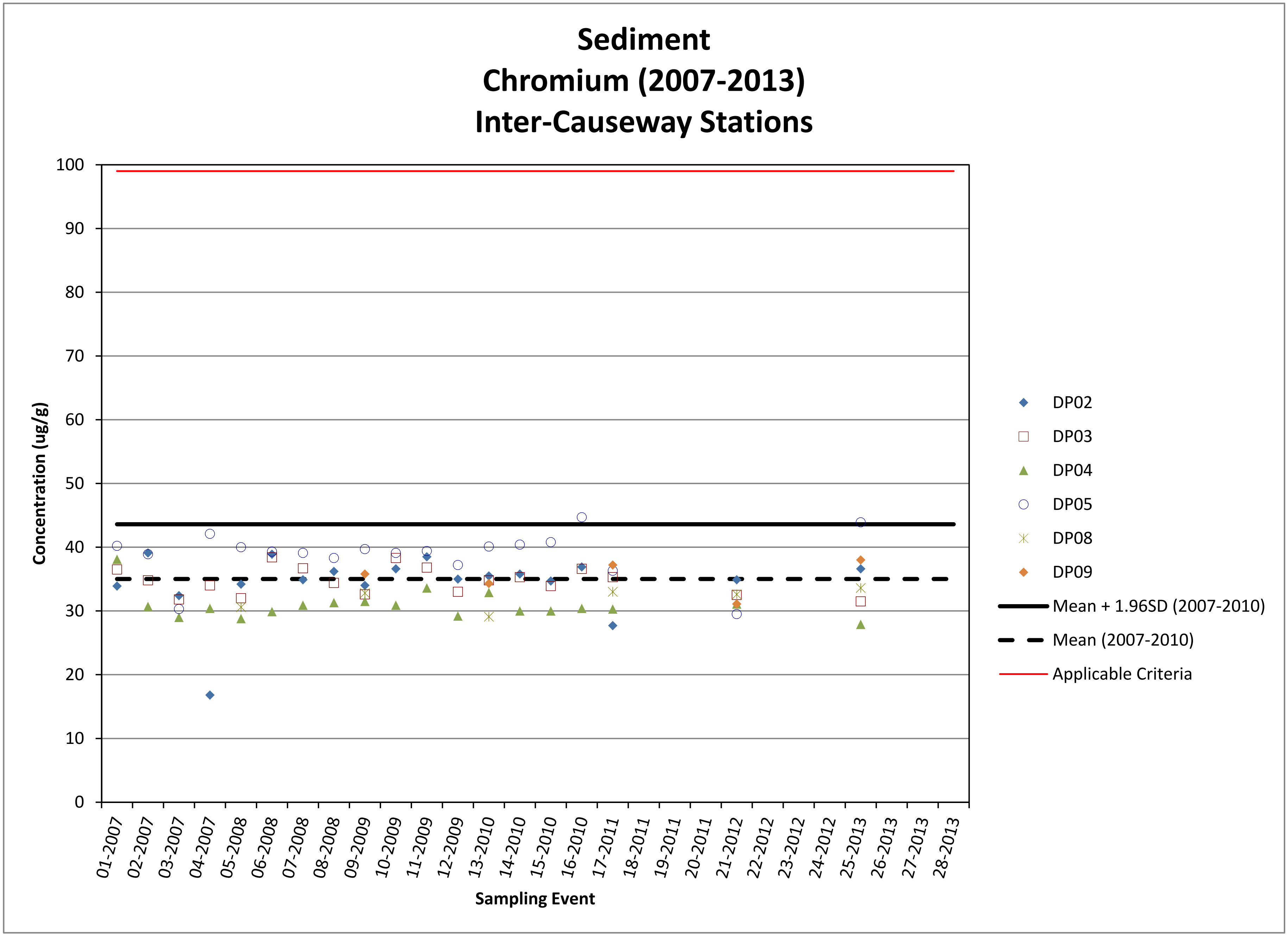
Sediment
Arsenic (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
5
10
15
20
25
30
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

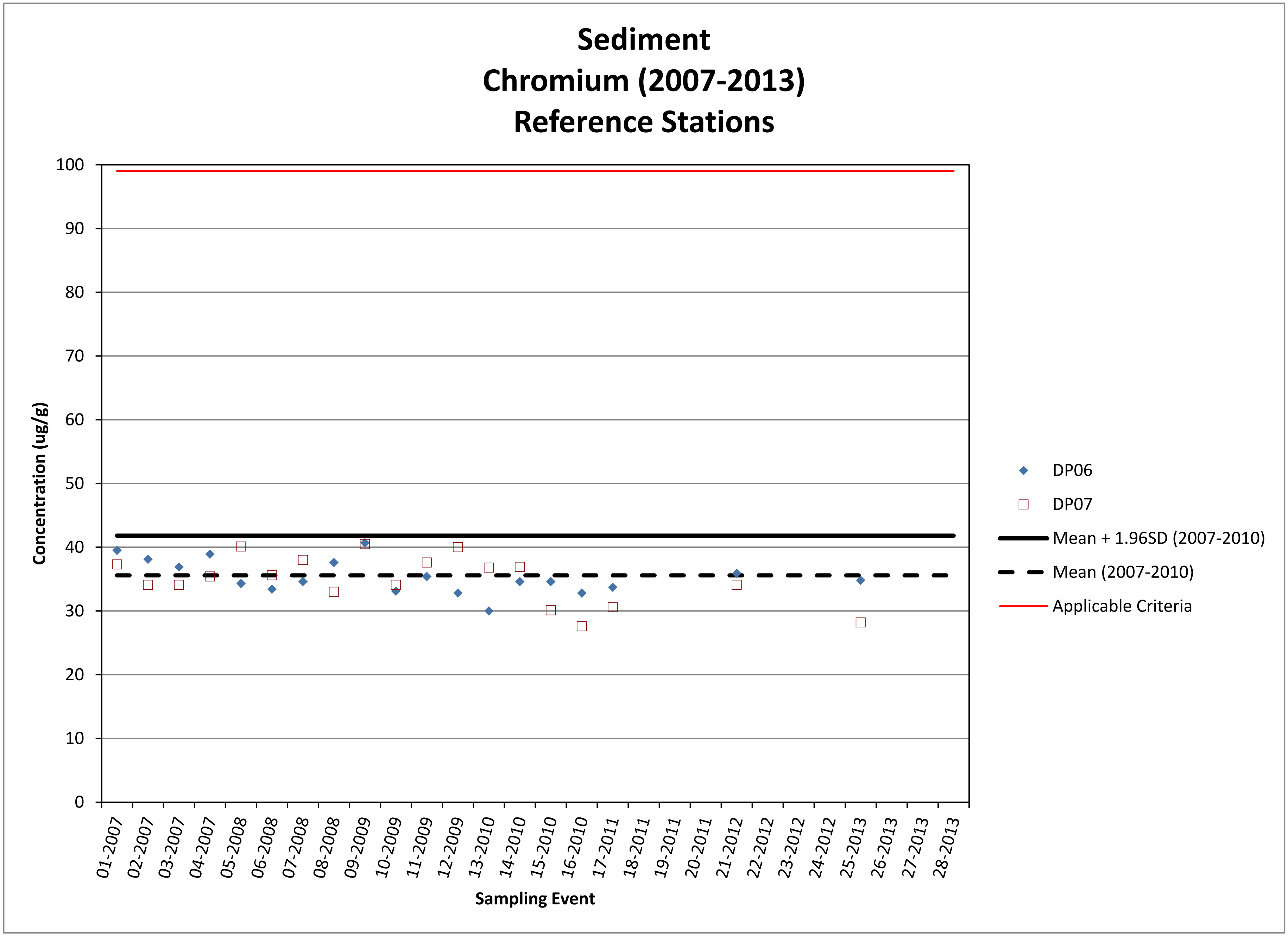


Sediment
Arsenic (2007-2013)
Reference Stations
Concentration (ug/g)
0
5
10
15
20
25
30
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

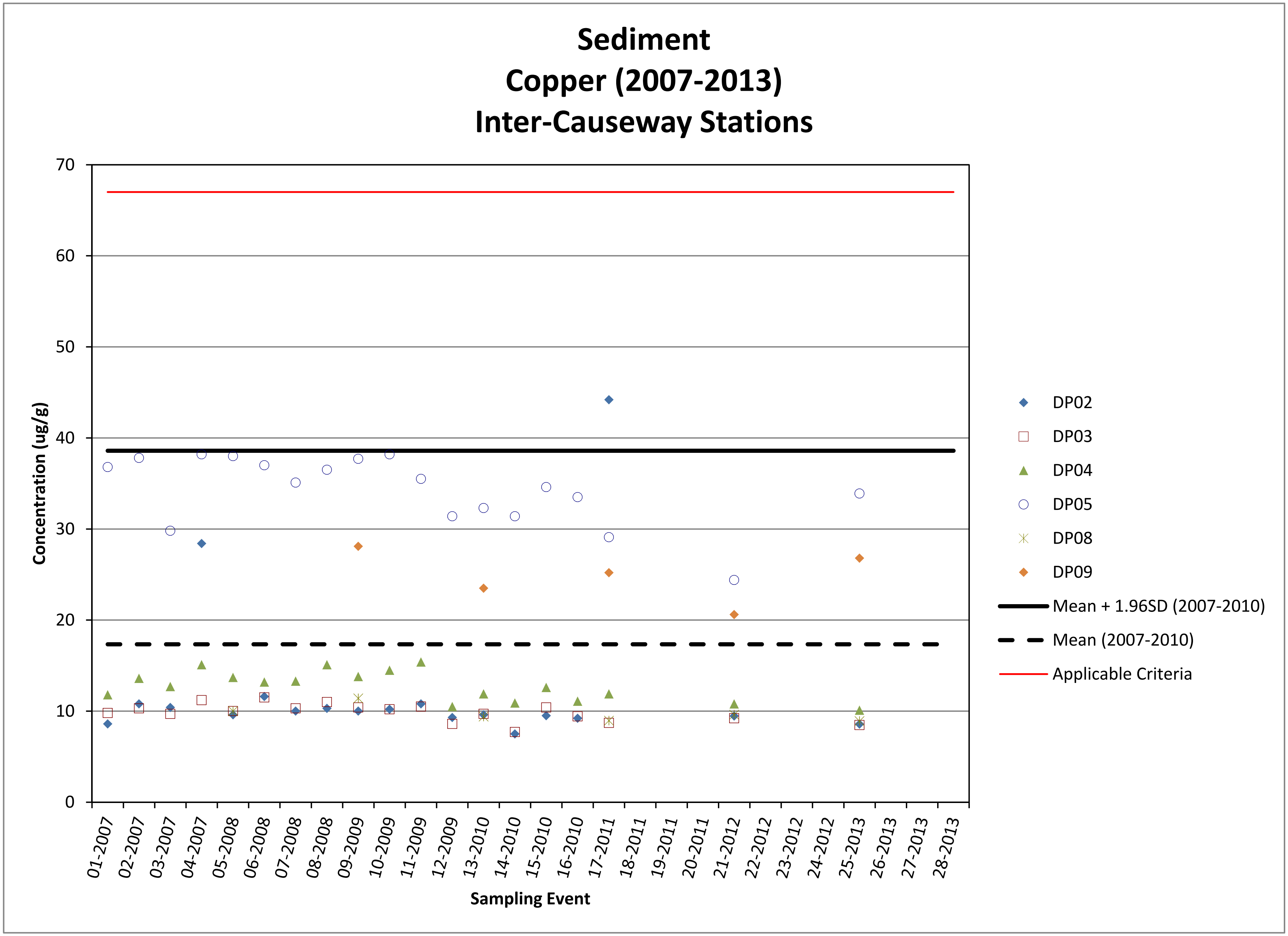

Sediment
Cadmium (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
0.5
1
1.5
2
2.5
3
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Cadmium (2007-2013)
Reference Stations
Concentration (ug/g)
0
0.5
1
1.5
2
2.5
3
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

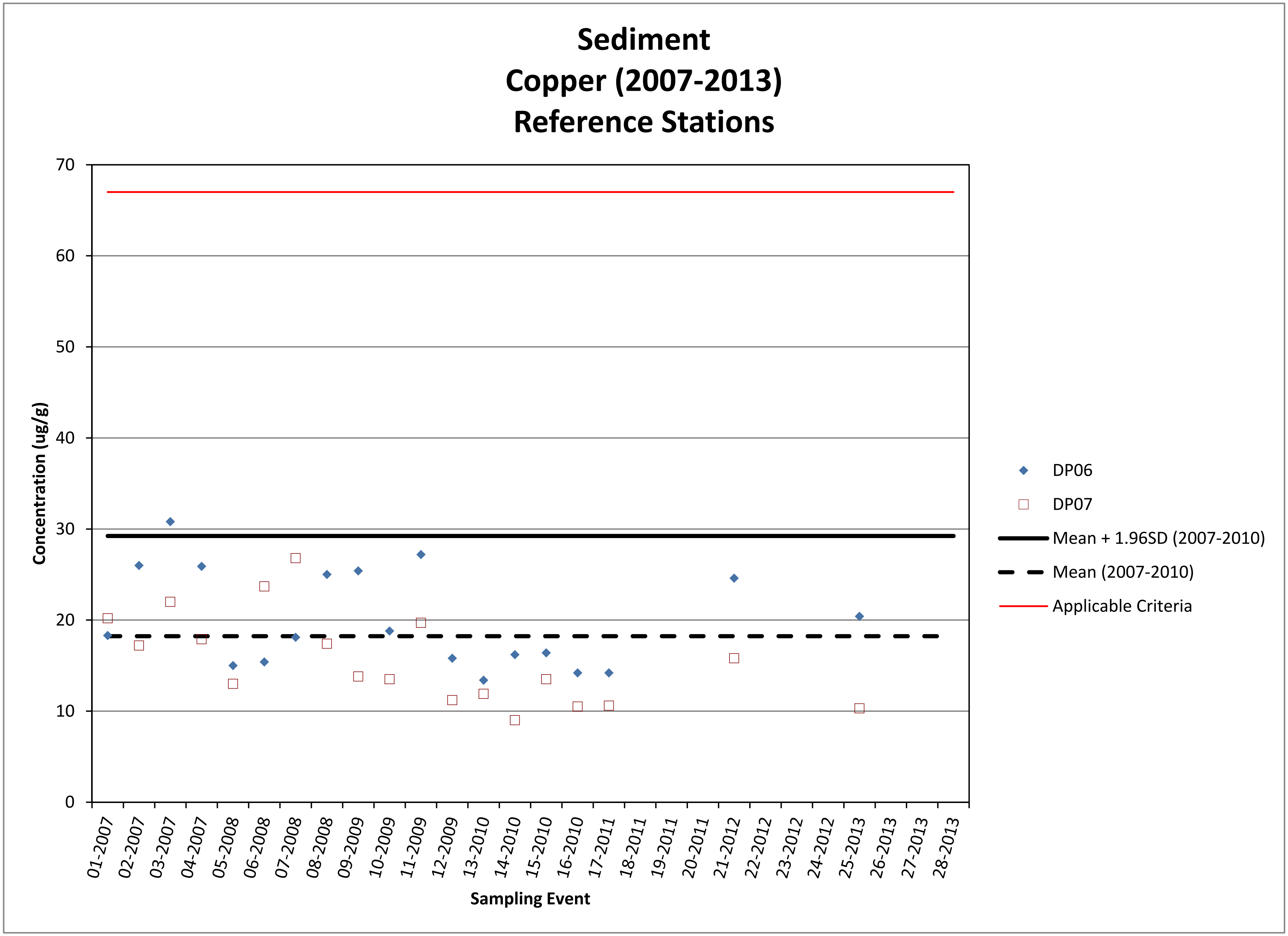

Sediment
Chromium (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
80
90
100
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



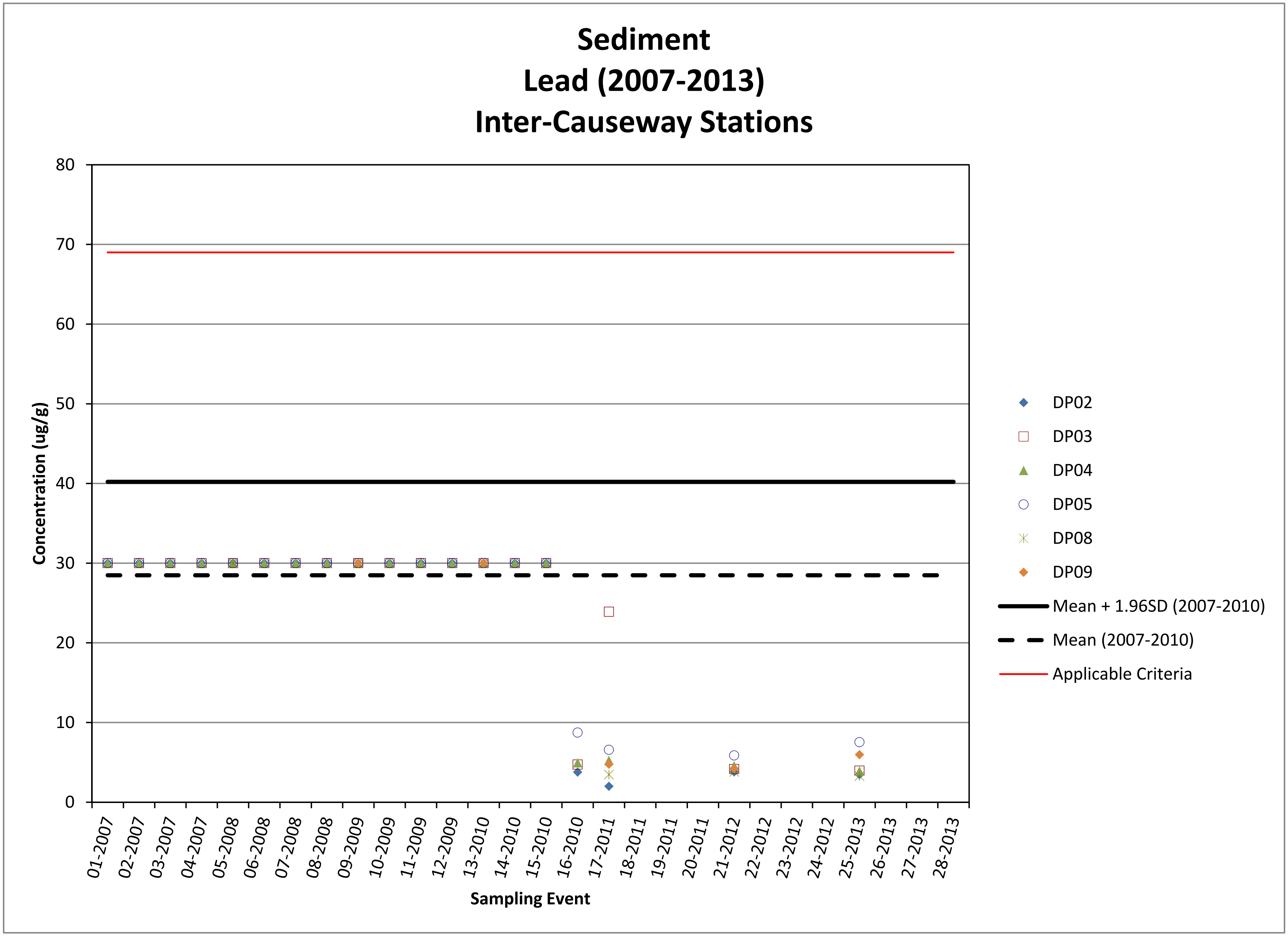
Sediment
Chromium (2007-2013)
Reference Stations
Concentration (ug/g)
100
90
80
70
60
50
40
30
20
10
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



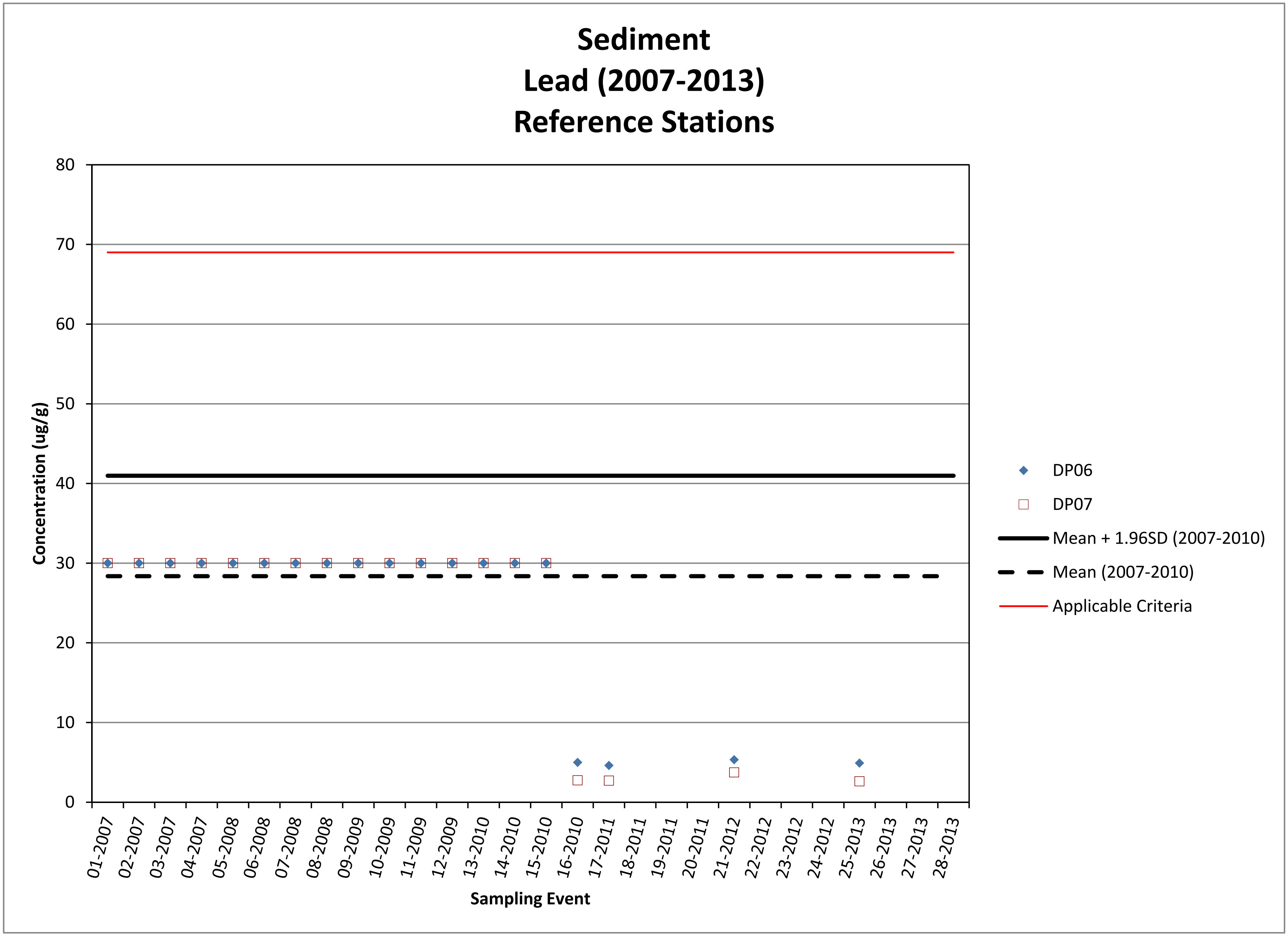
Sediment
Copper (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

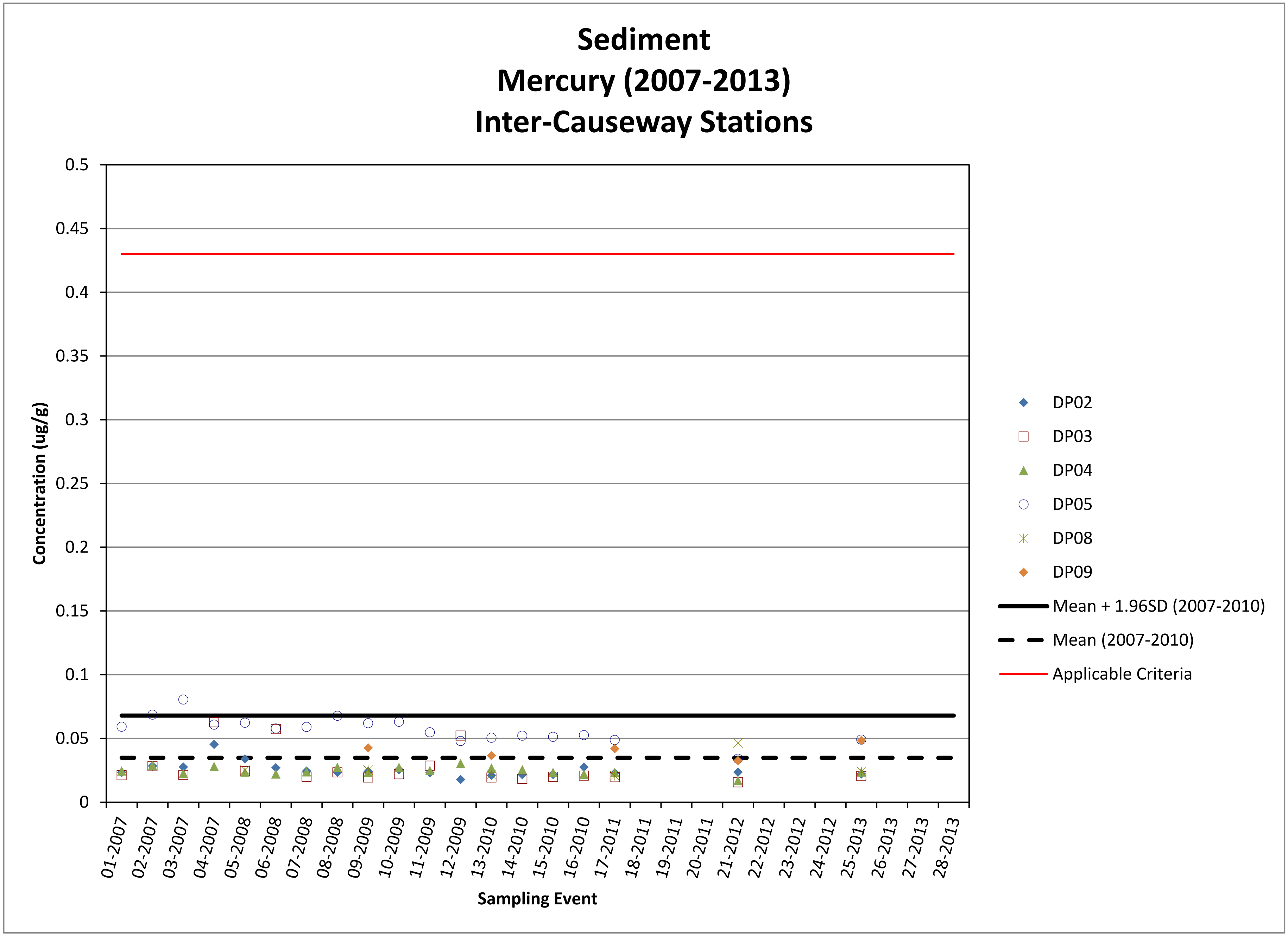


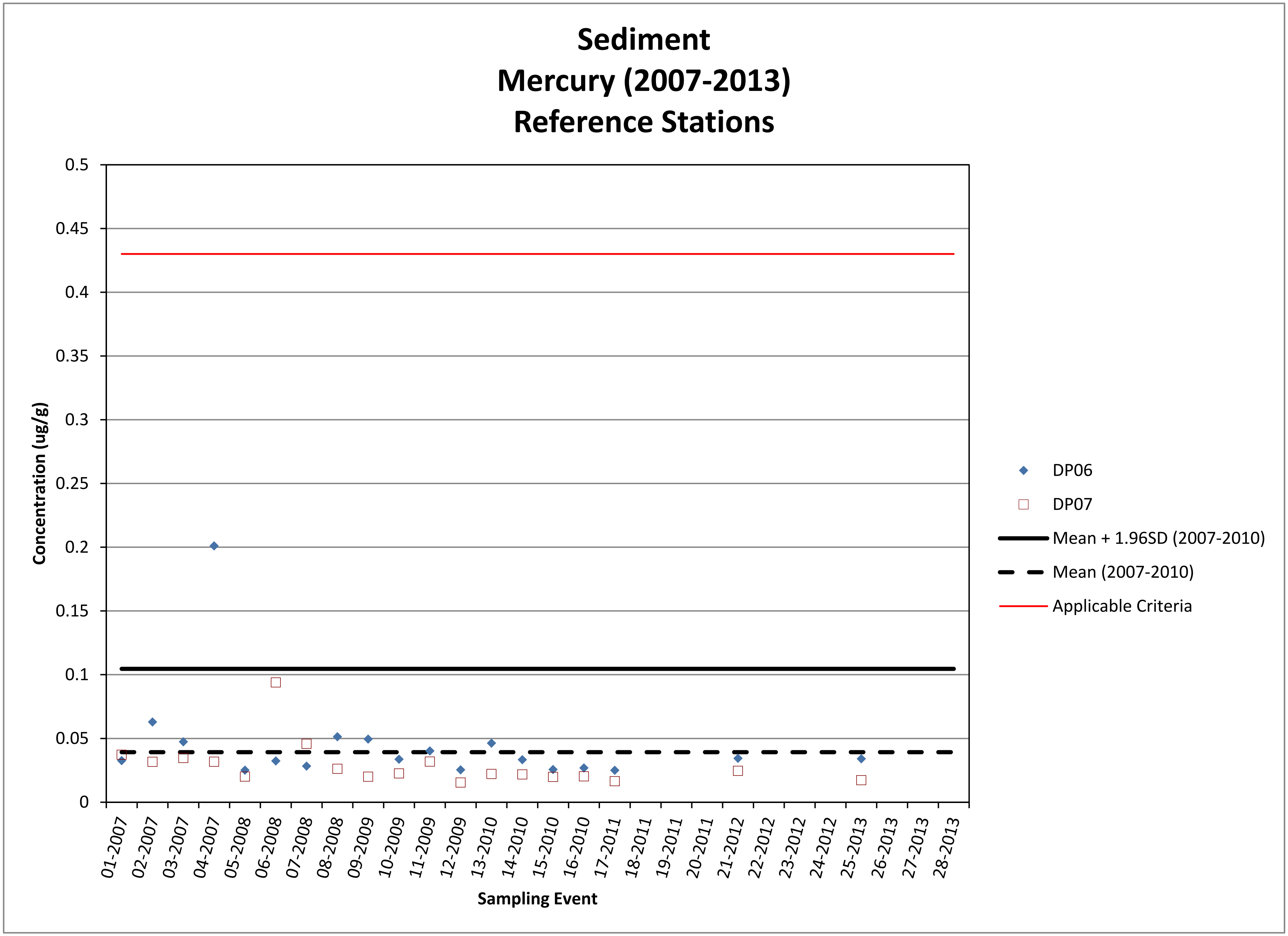
Sediment
Copper (2007-2013)
Reference Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



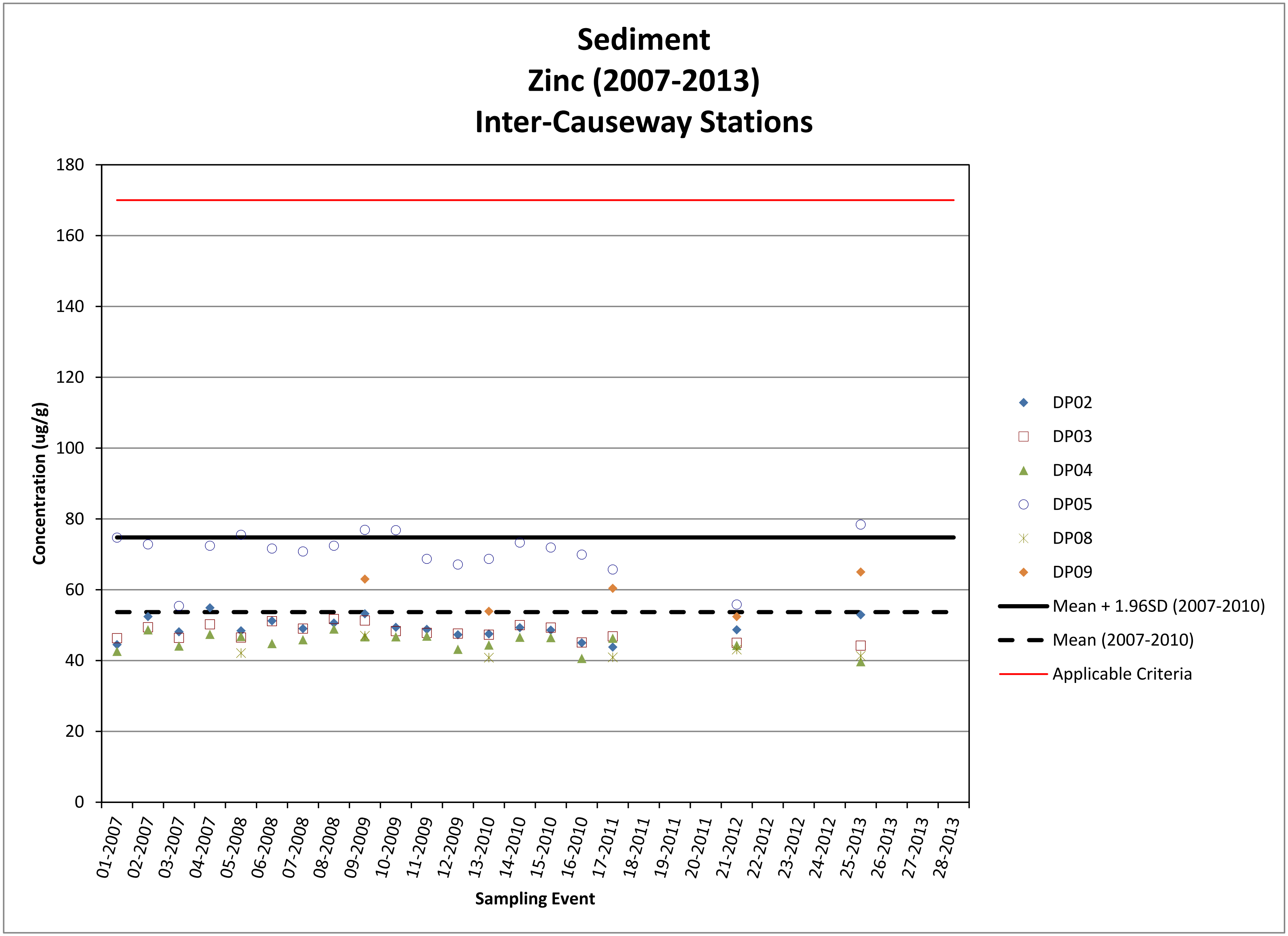
Sediment
Lead (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
80
70
60
50
40
30
20
10
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria


Sediment
Lead (2007-2013)
Reference Stations
Concentration (ug/g)
0
10
20
30
40
50
60
70
80
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

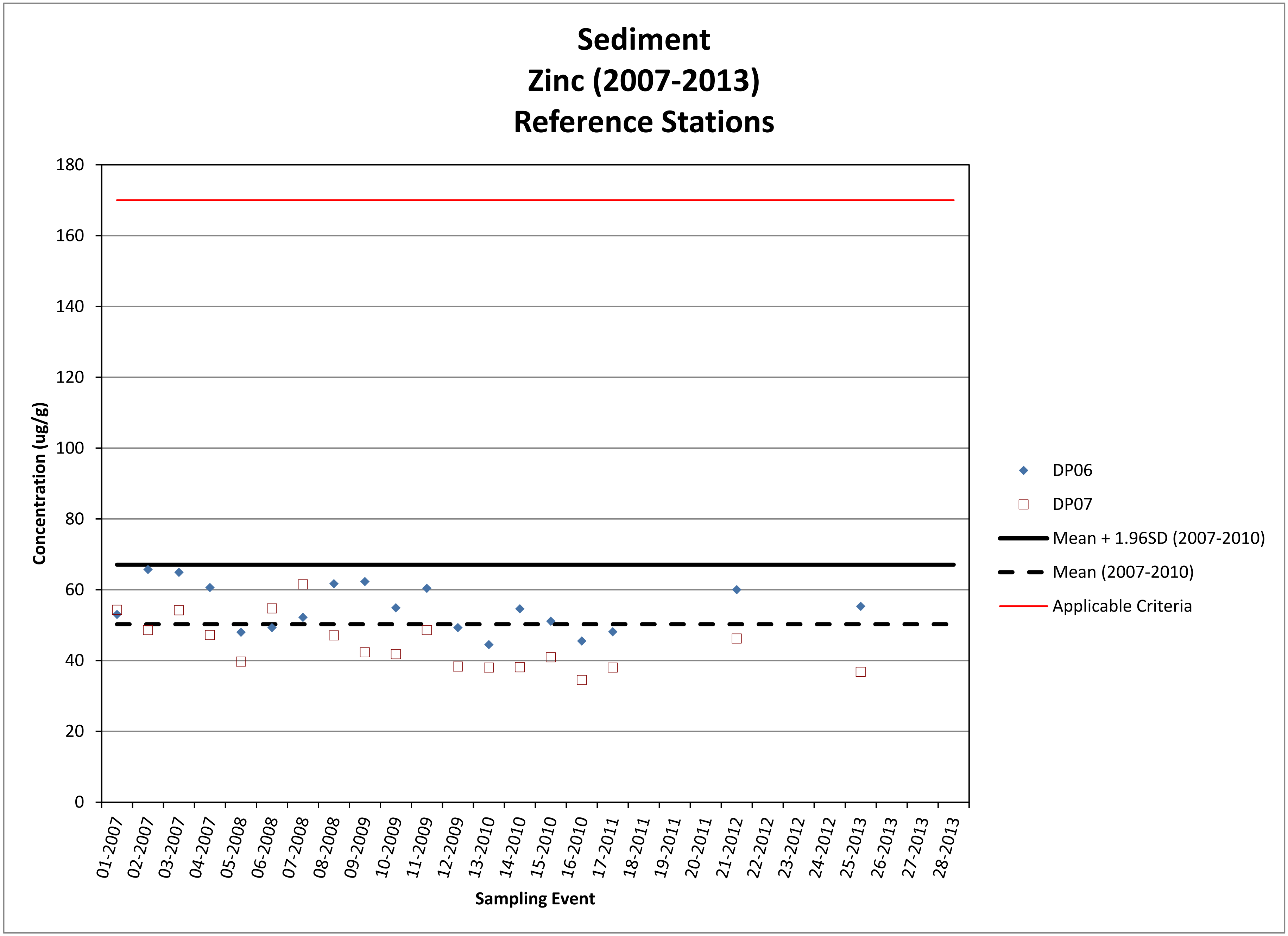

Sediment
Mercury (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria



Sediment
Mercury (2007-2013)
Reference Stations
Concentration (ug/g)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

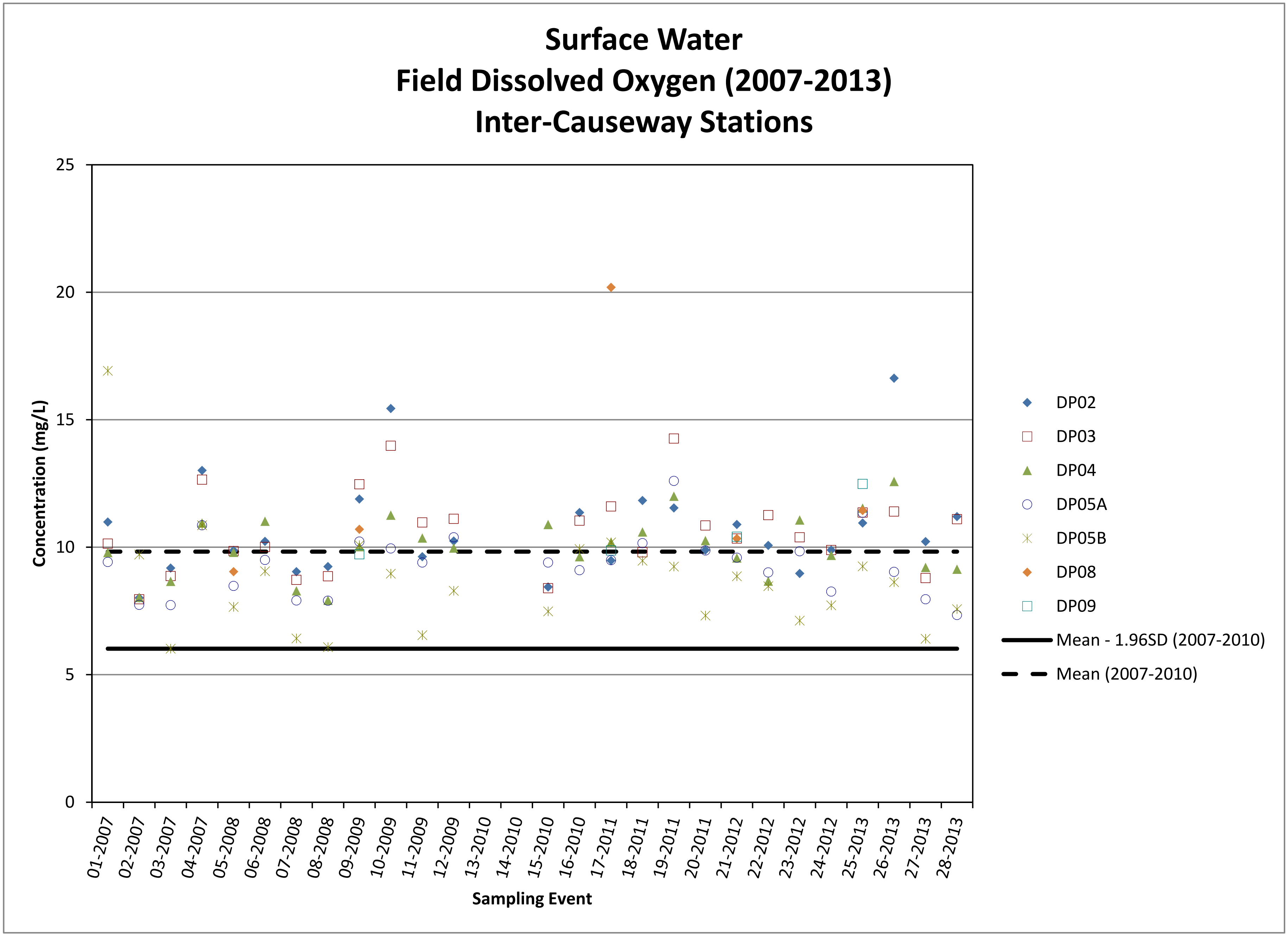


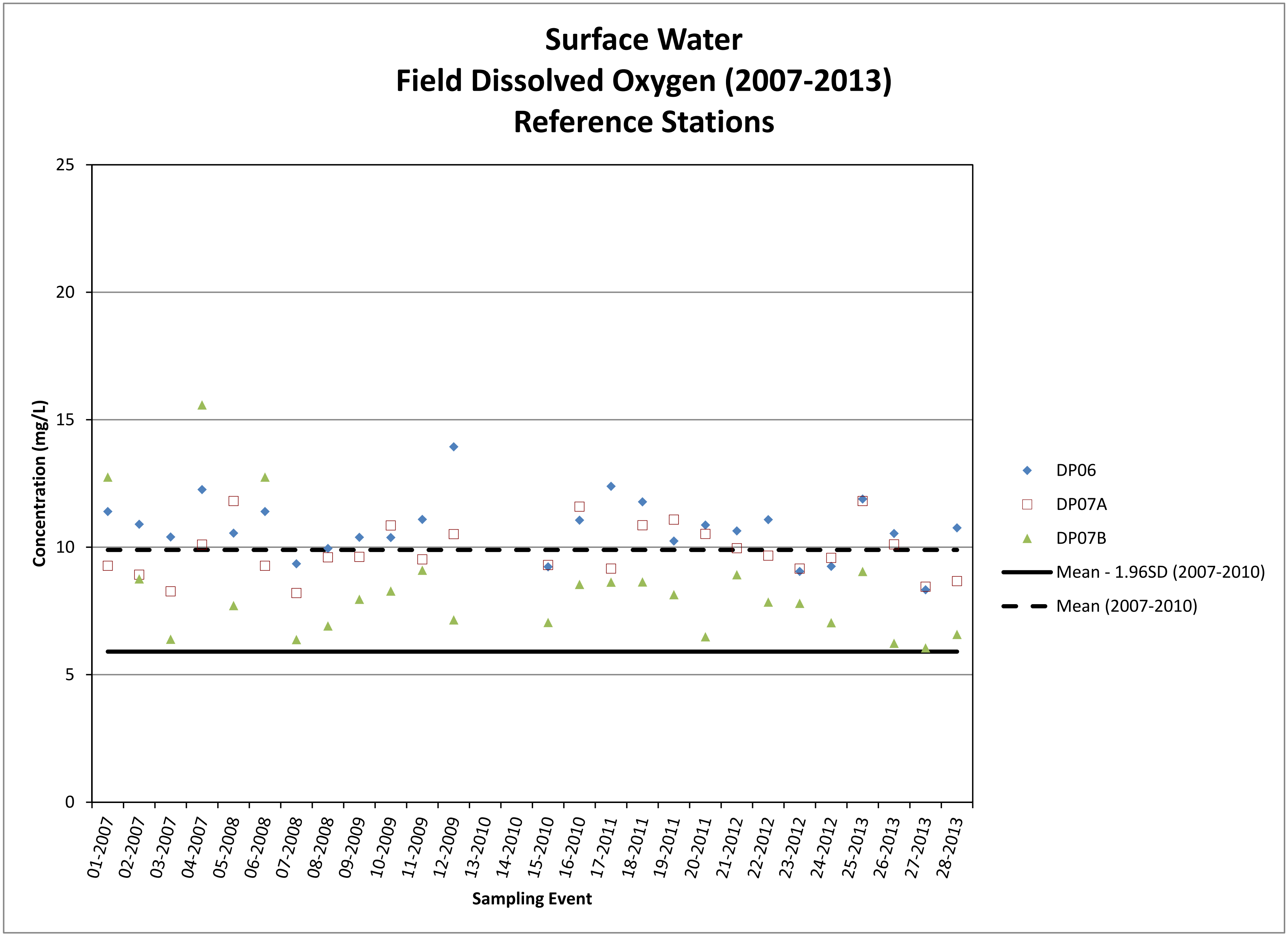
Sediment
Zinc (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
180
160
140
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

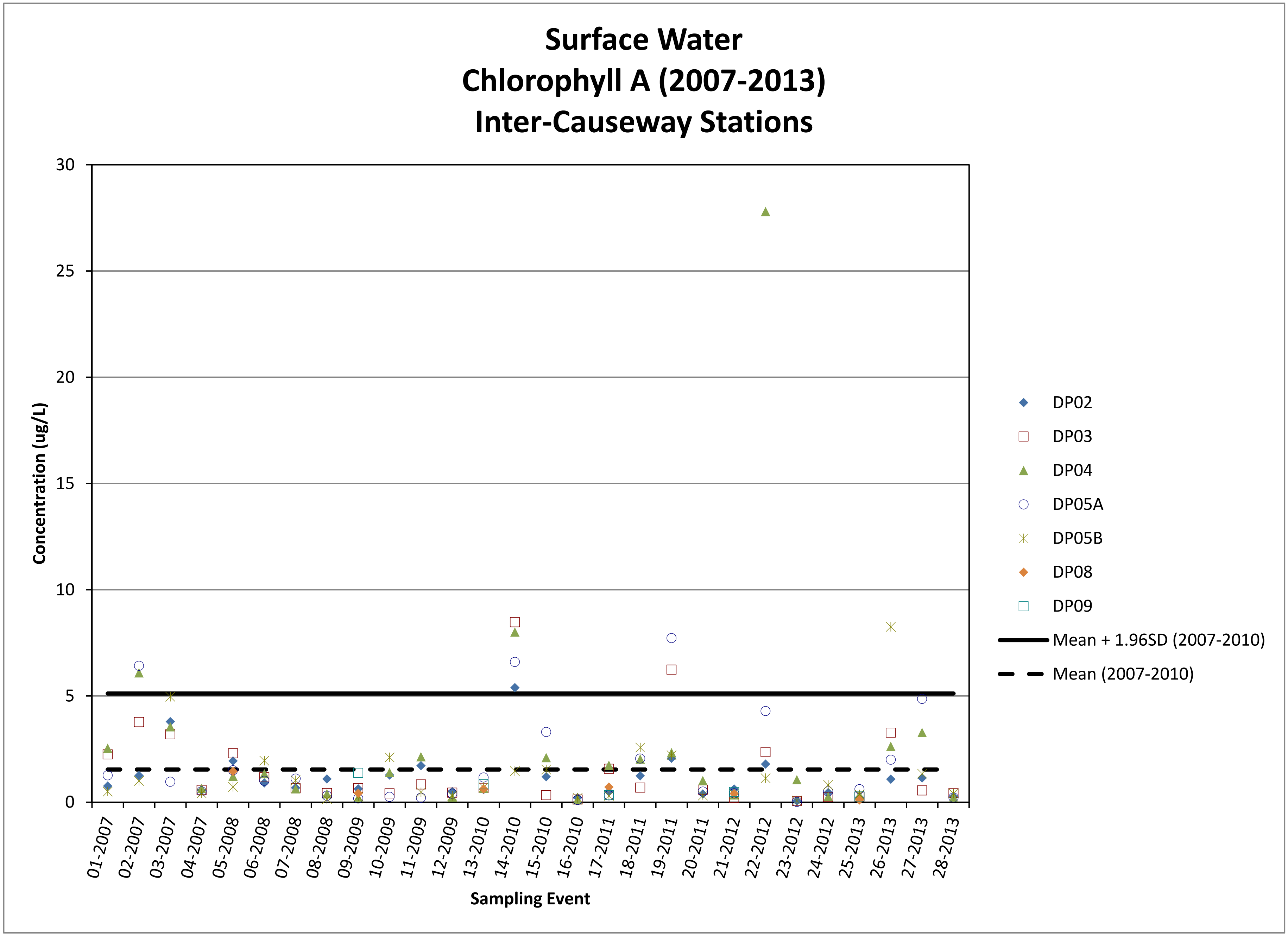

Sediment
Zinc (2007-2013)
Reference Stations
Concentration (ug/g)
0
20
40
60
80
100
120
140
160
180
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Criteria

APPENDIX E

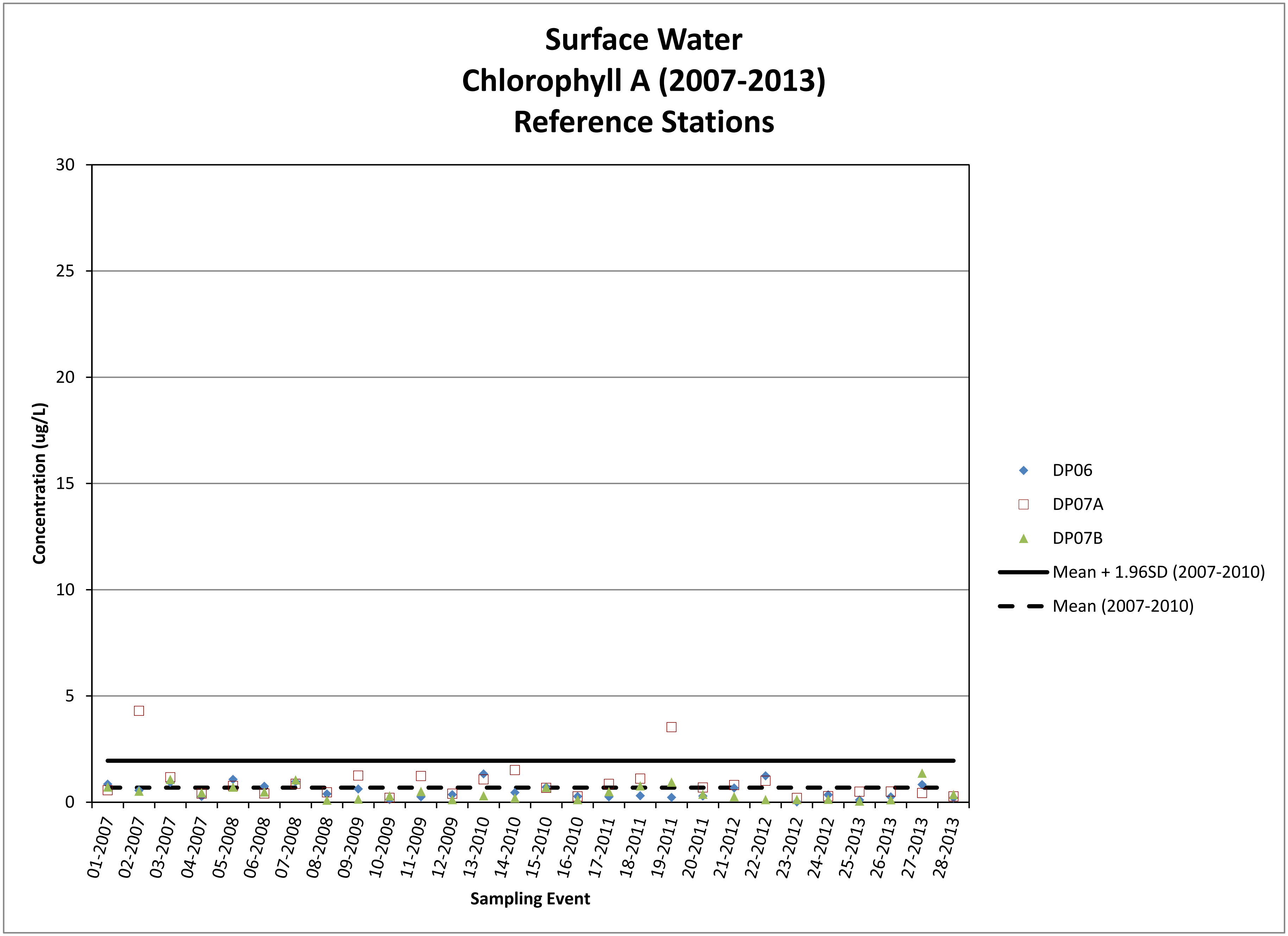
Trend Graphs for Surface Water and Sediment Chemistry – Eutrophication Parameters


Surface Water
Field Dissolved Oxygen (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean - 1.96SD (2007-2010)
Mean (2007-2010)

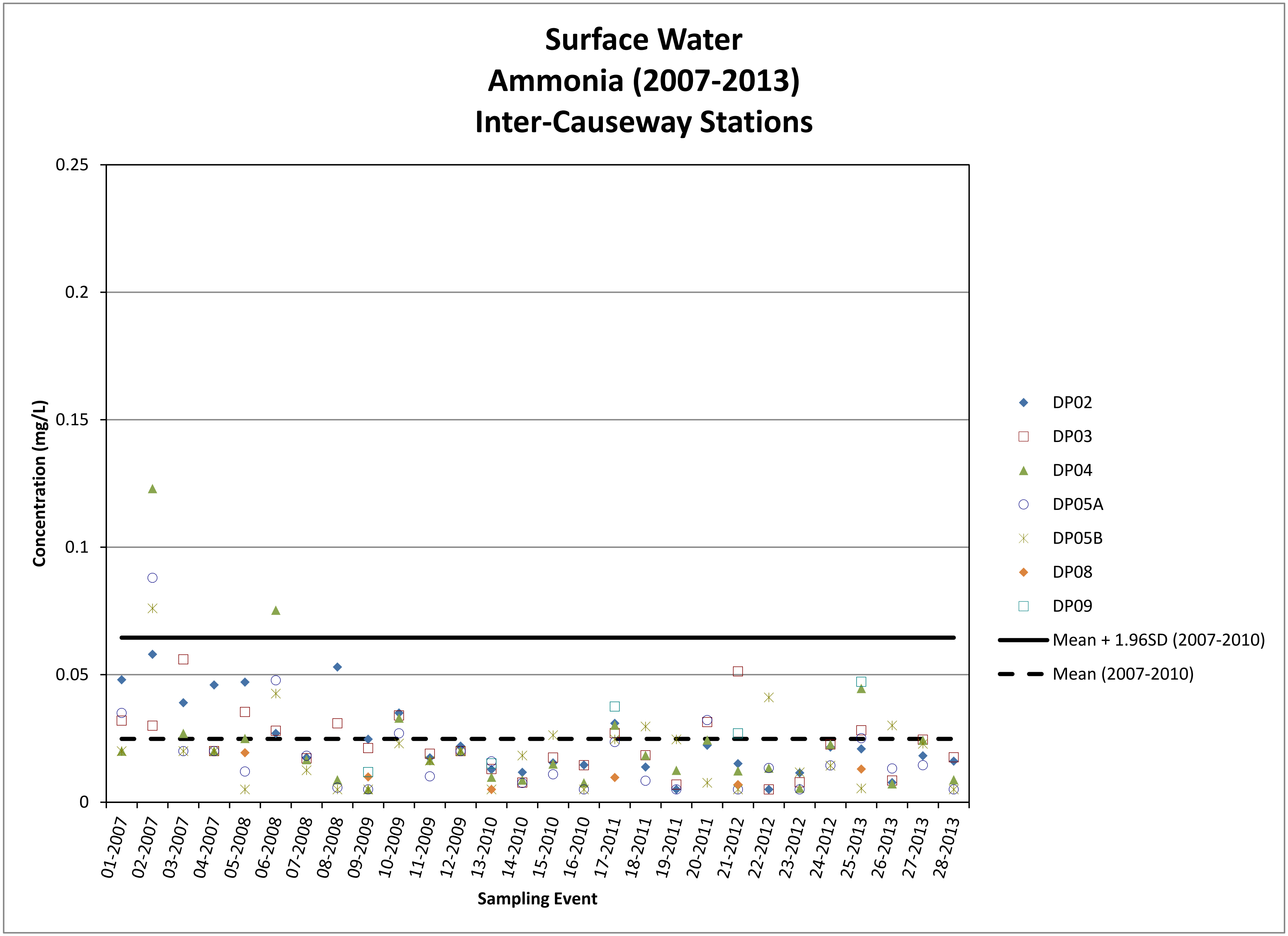

Surface Water
Field Dissolved Oxygen (2007-2013)
Reference Stations
Concentration (mg/L)
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean - 1.96SD (2007-2010)
Mean (2007-2010)

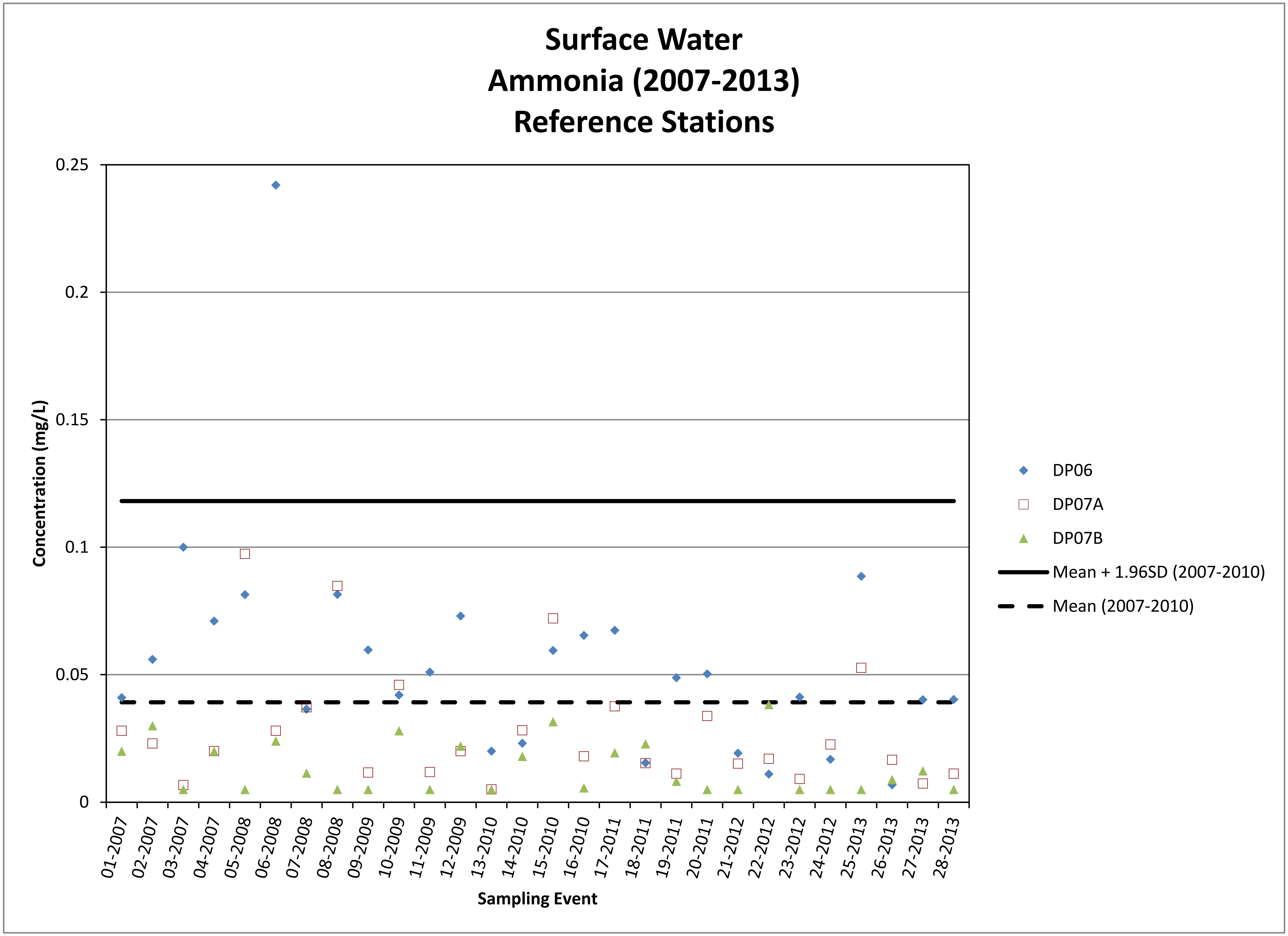


Surface Water
Chlorophyll A (2007-2013)
Inter-Causeway Stations
Concentration (ug/L)
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

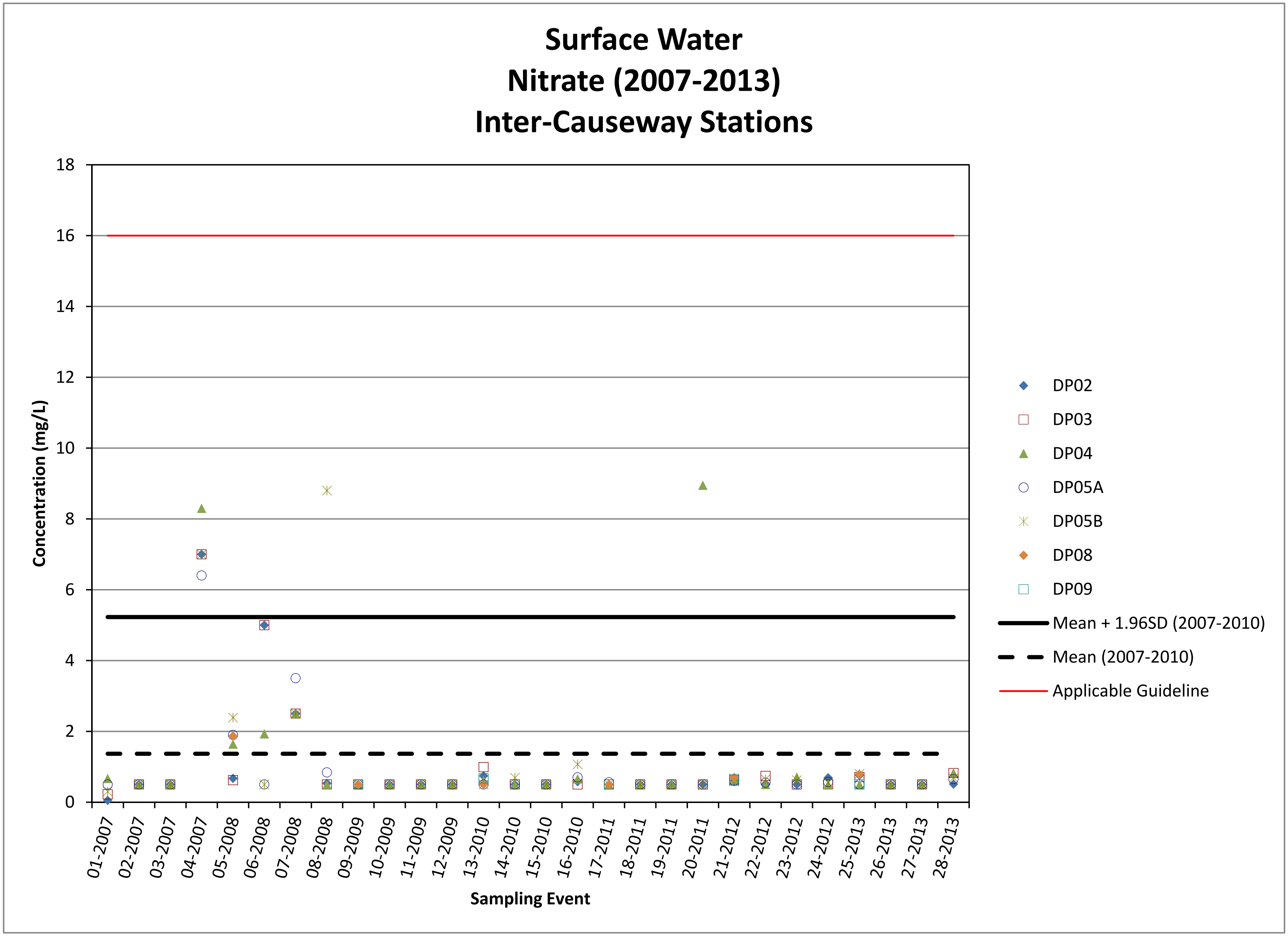


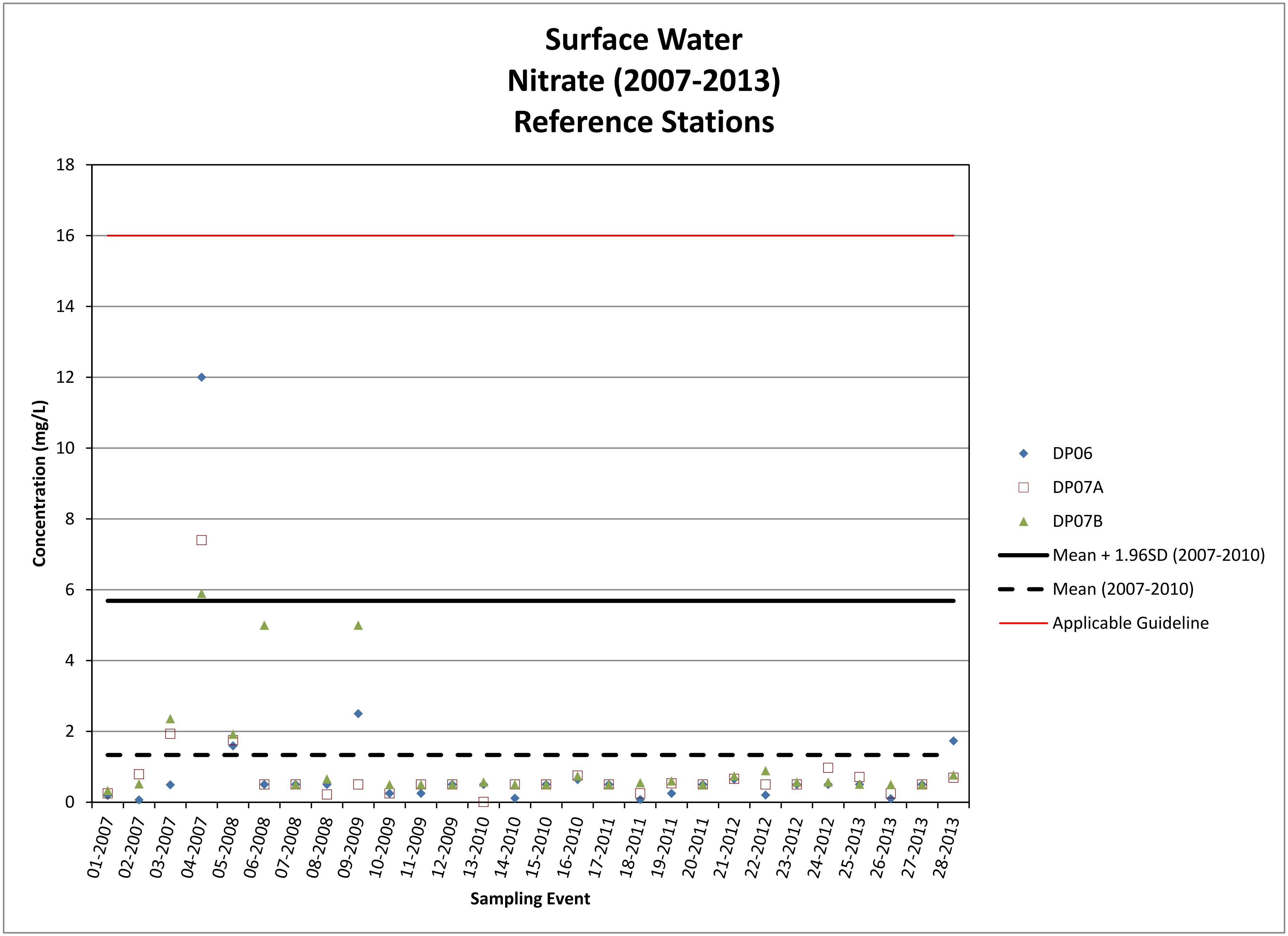
Surface Water
Chlorophyll A (2007-2013)
Reference Stations
Concentration (ug/L)
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Ammonia (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

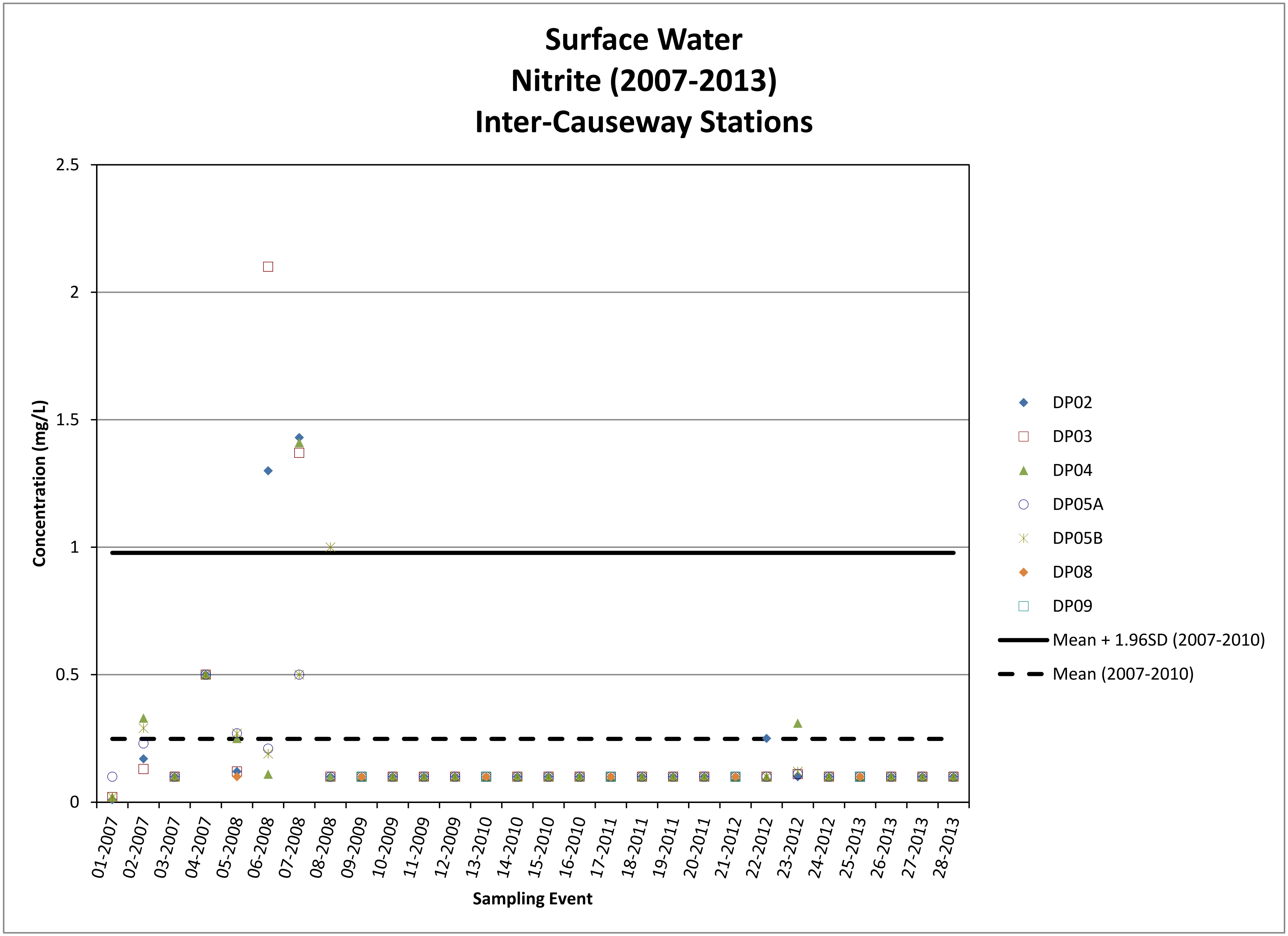


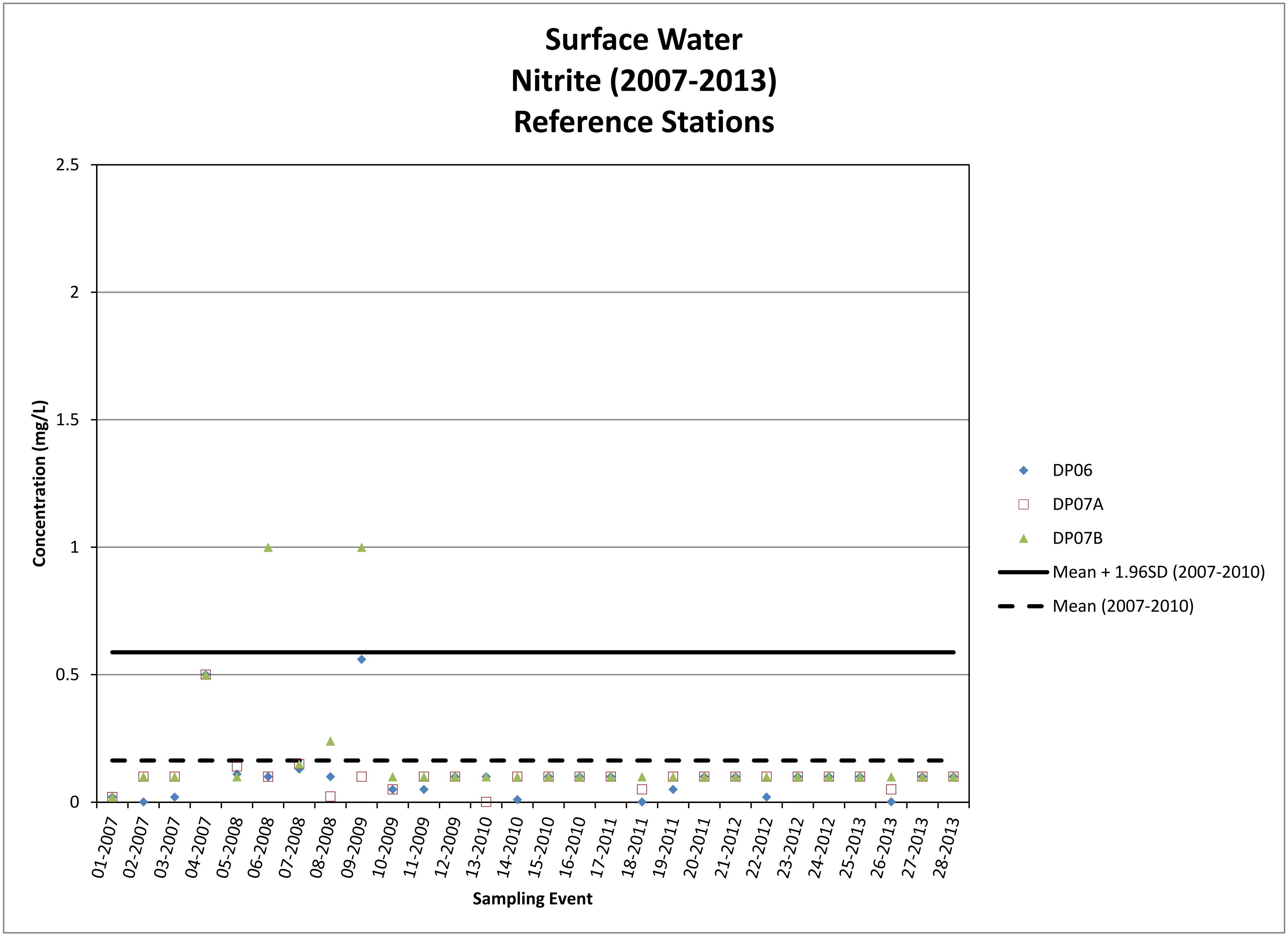
Surface Water
Ammonia (2007-2013)
Reference Stations
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Nitrate (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

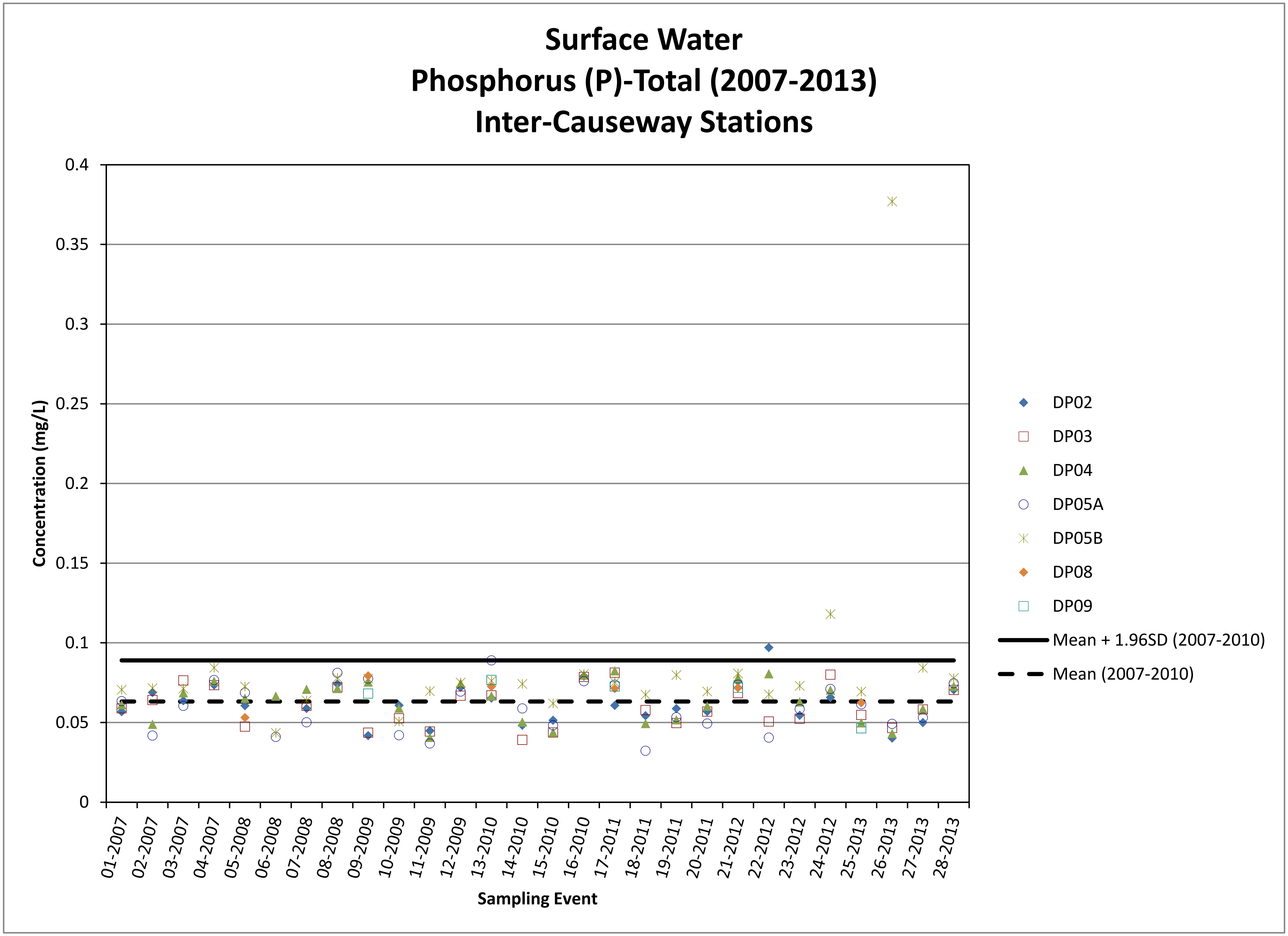


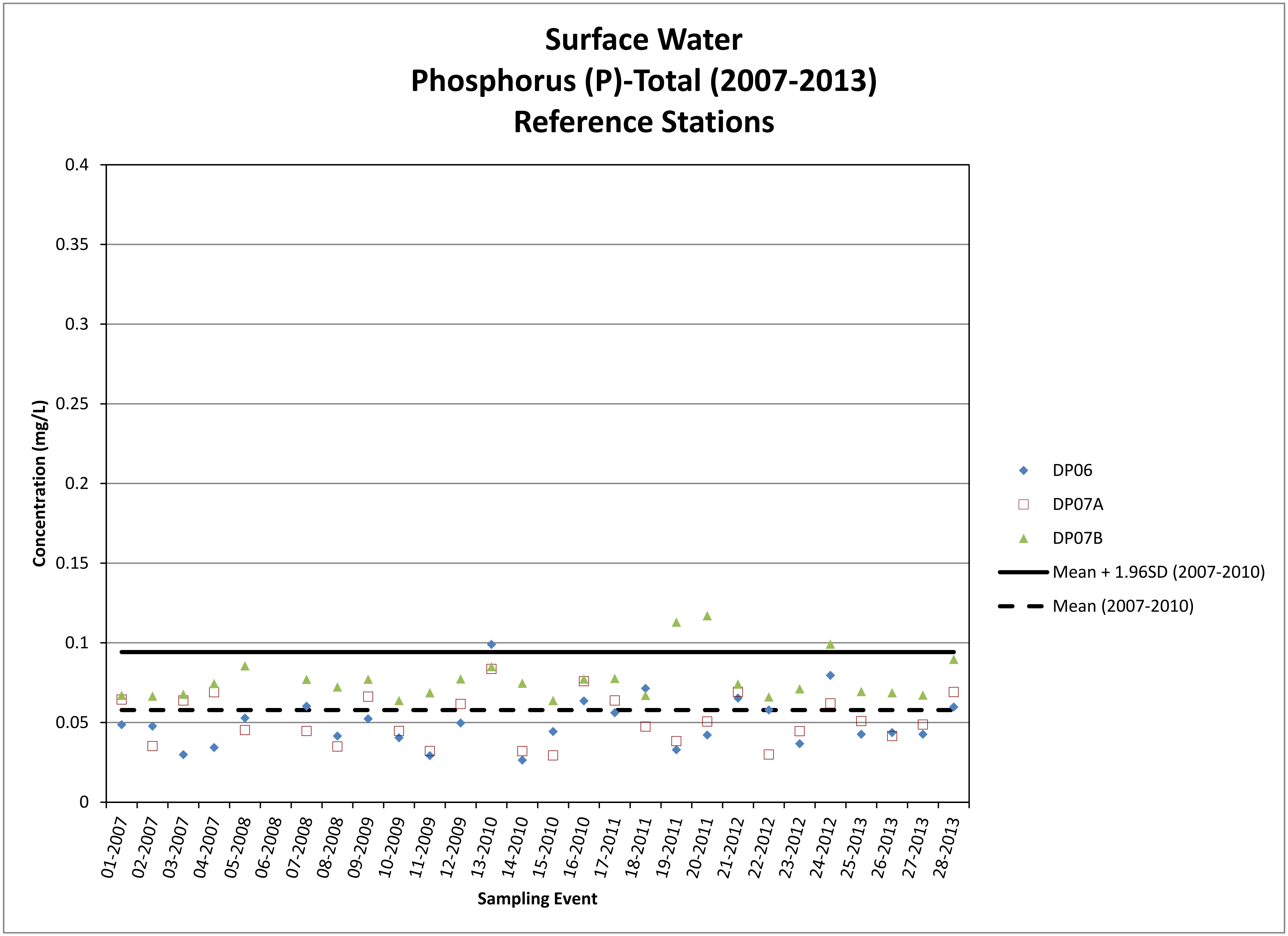
Surface Water
Nitrate (2007-2013)
Reference Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)
Applicable Guideline

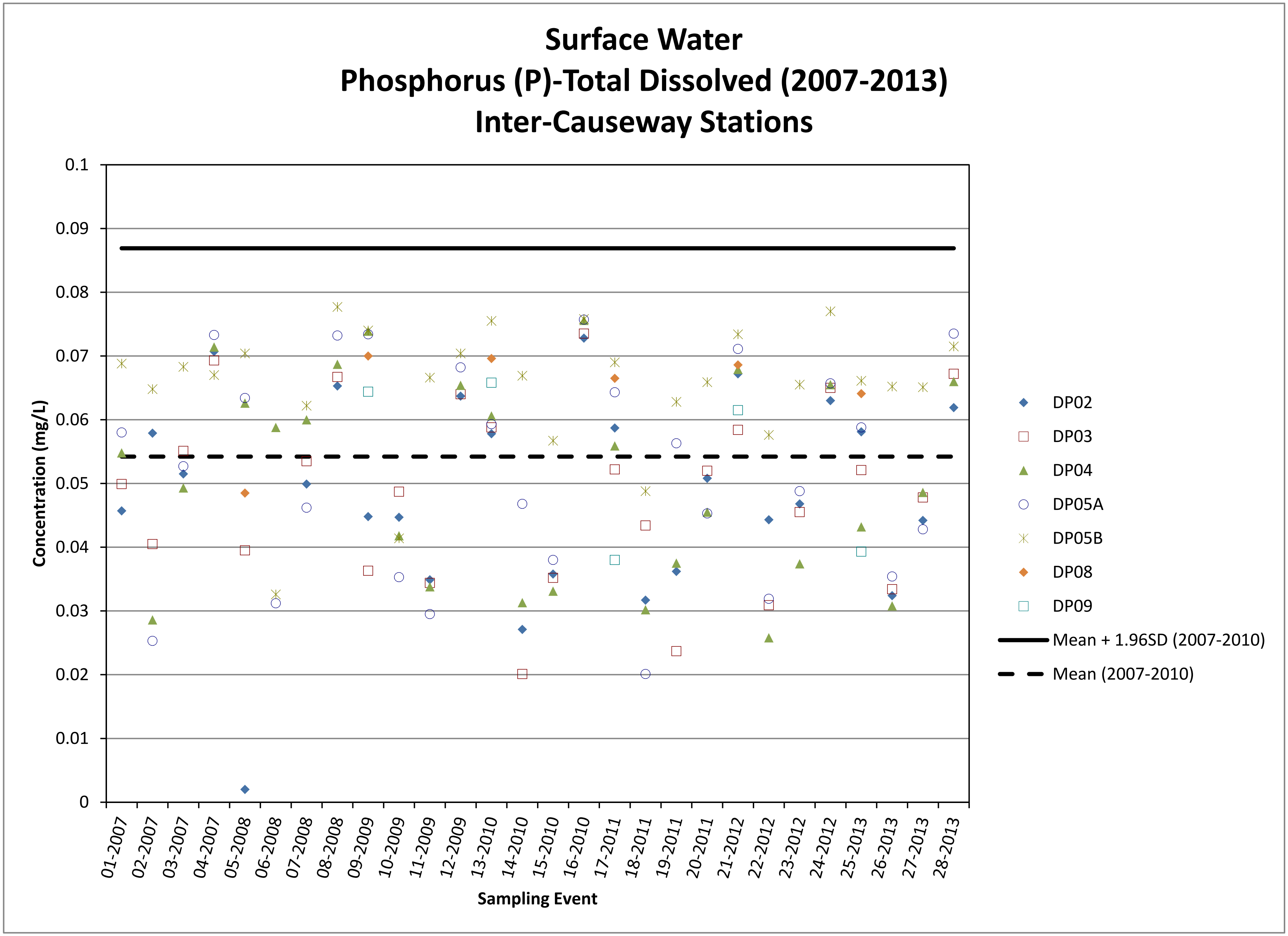

Surface Water
Nitrite (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



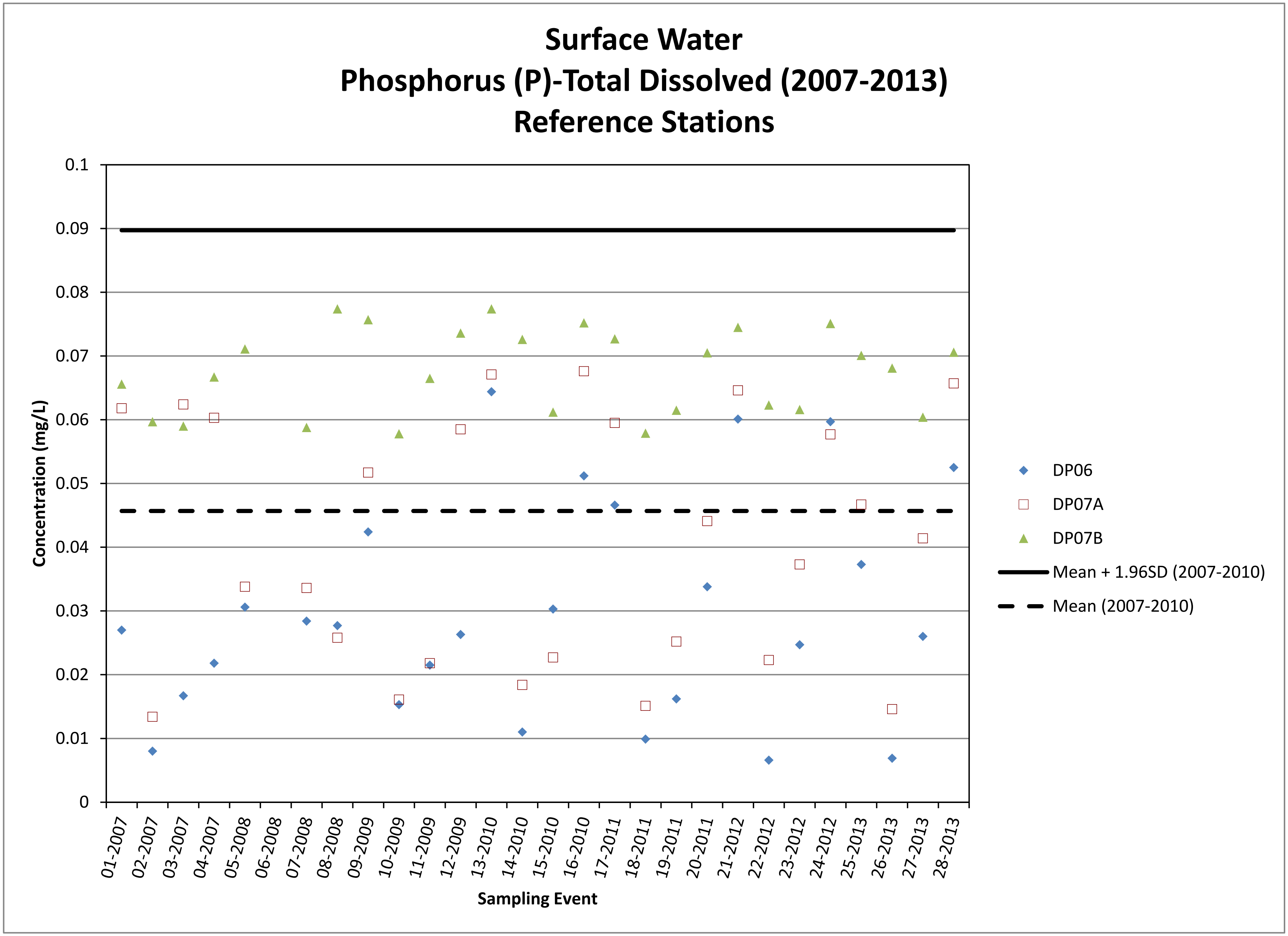
Surface Water
Nitrite (2007-2013)
Reference Stations
Concentration (mg/L)
2.5
2
1.5
1
0.5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Surface Water
Phosphorus (P)-Total (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

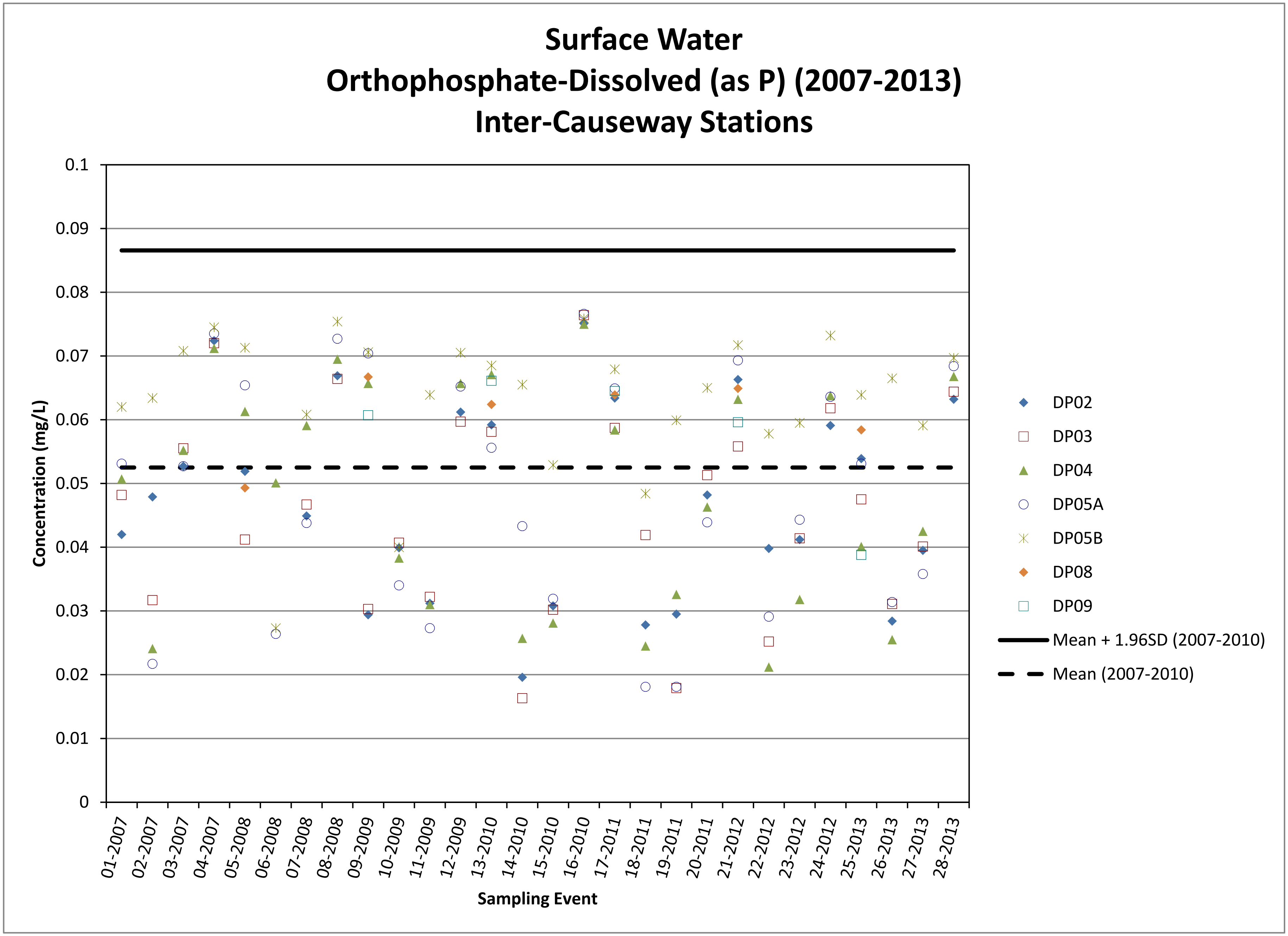

Surface Water
Phosphorus (P)-Total (2007-2013)
Reference Stations
Concentration (mg/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



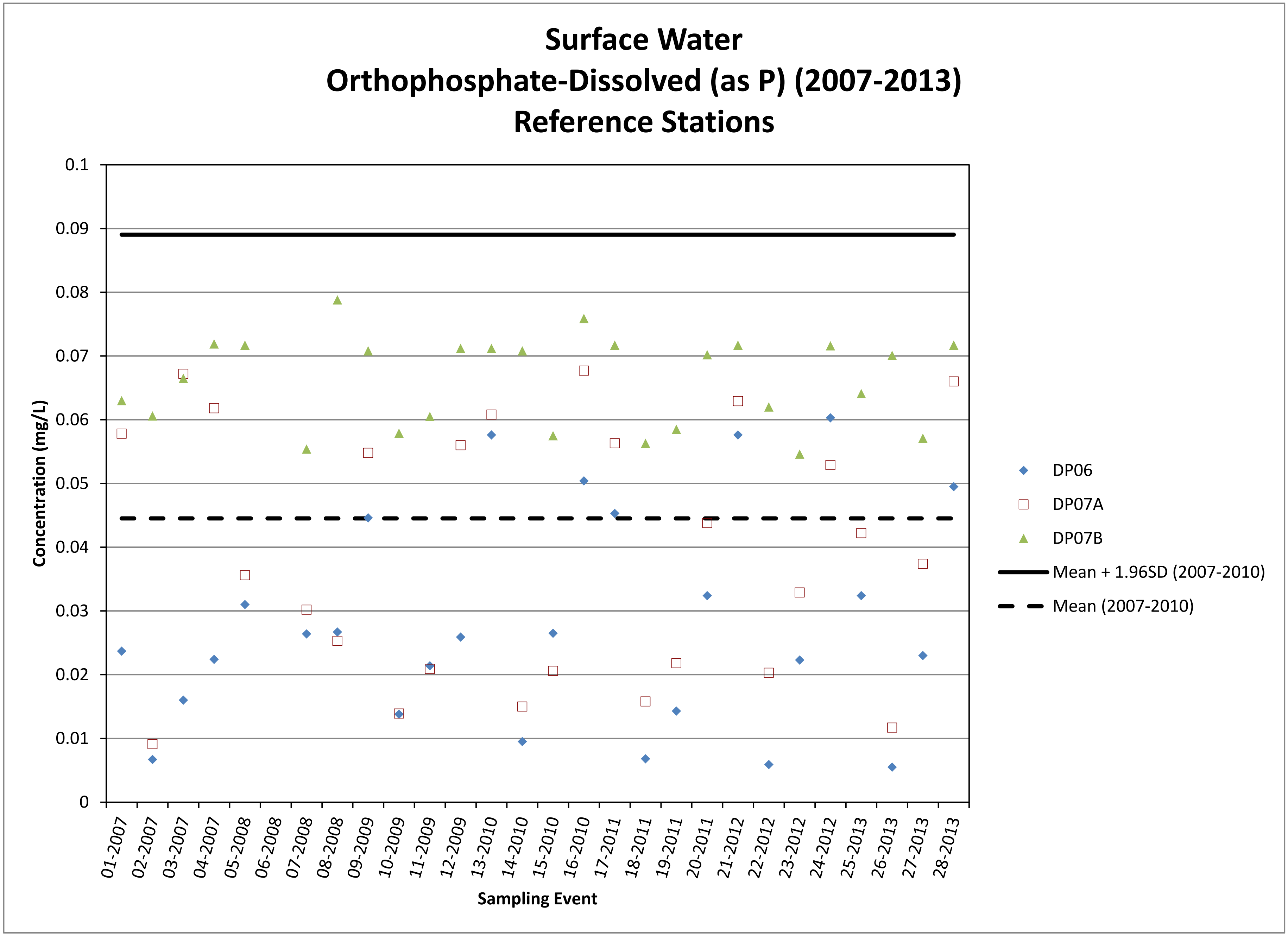
Surface Water
Phosphorus (P)-Total Dissolved (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



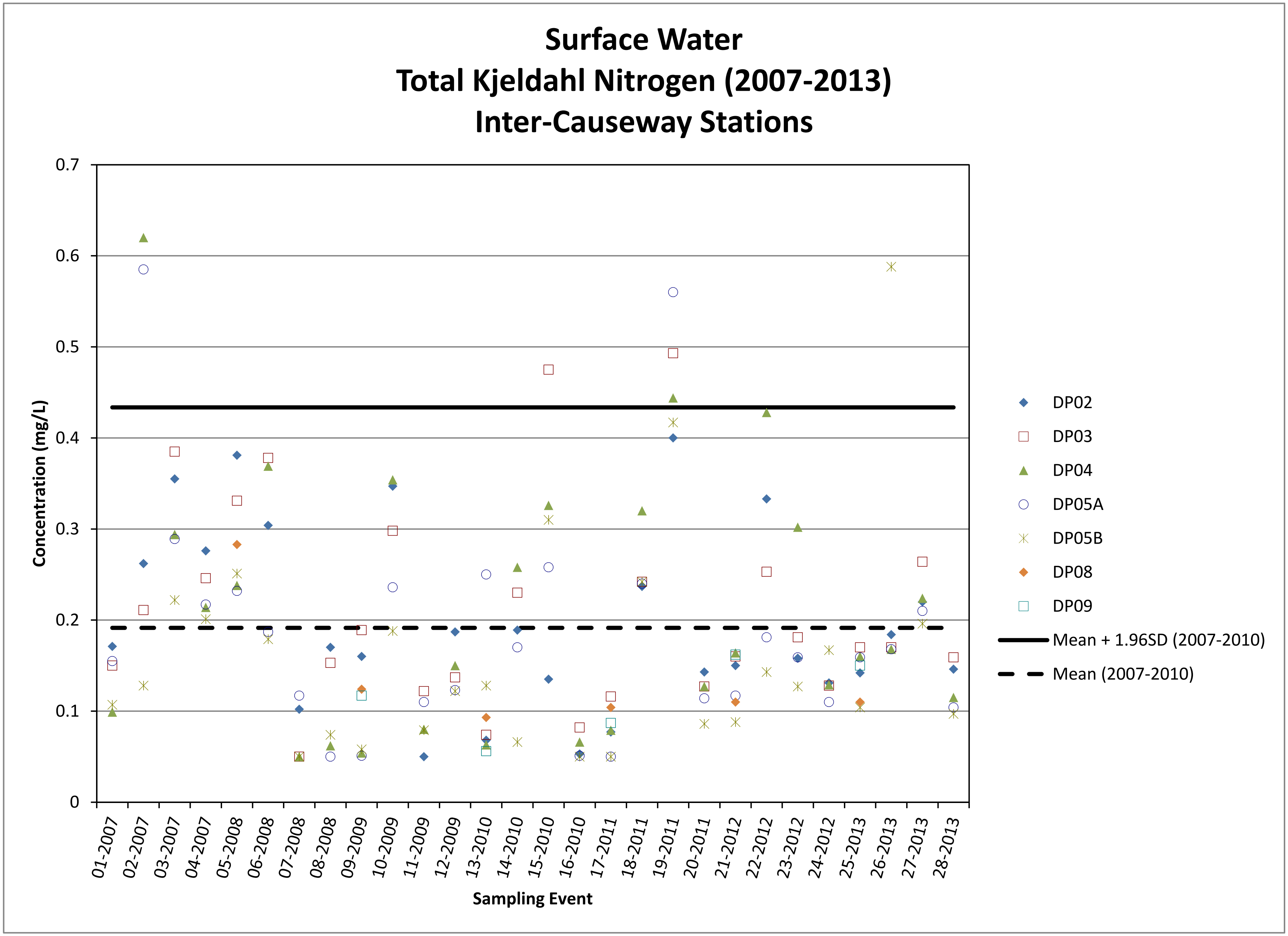
Surface Water
Phosphorus (P)-Total Dissolved (2007-2013)
Reference Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



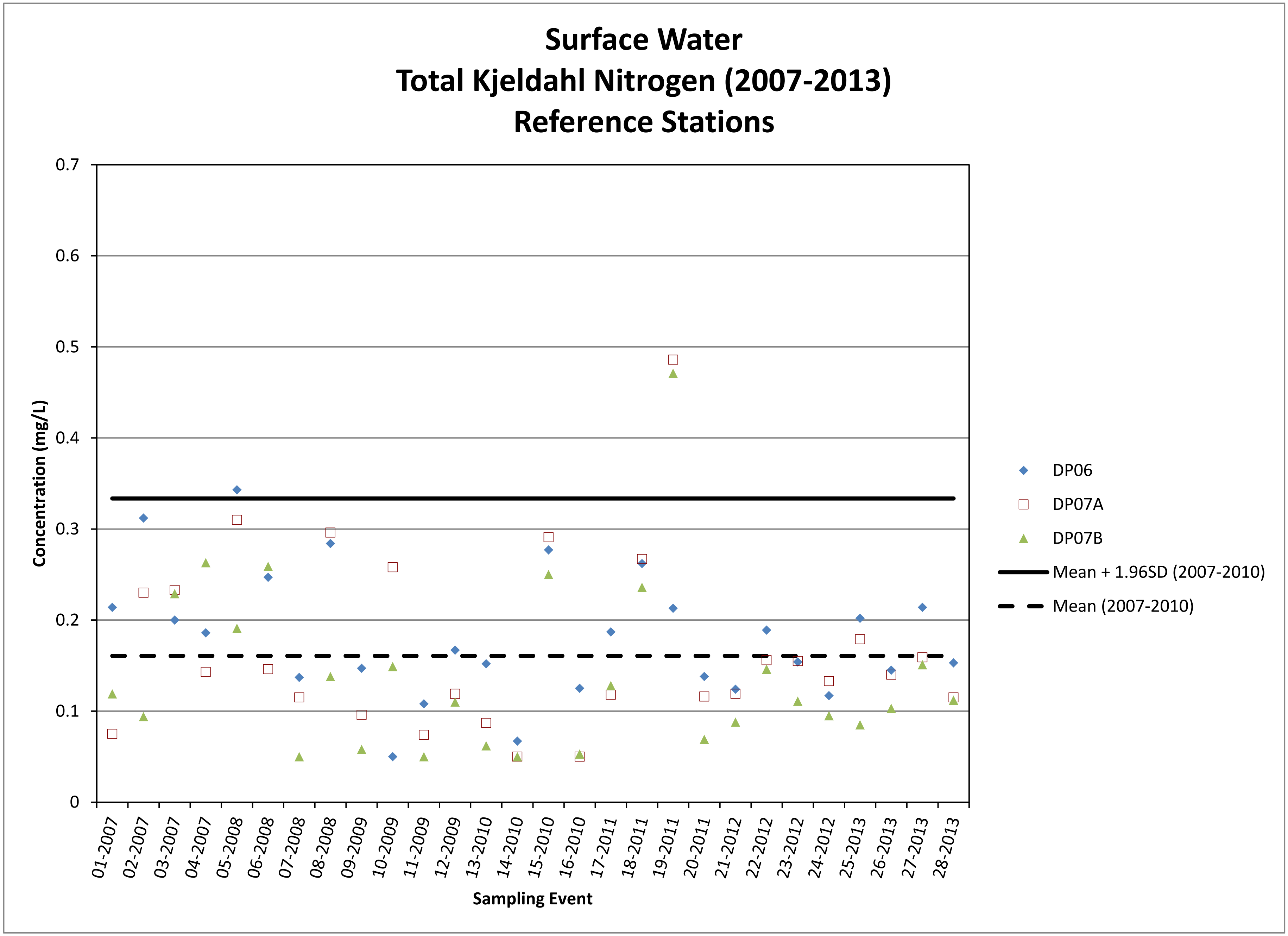
Surface Water
Orthophosphate-Dissolved (as P) (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



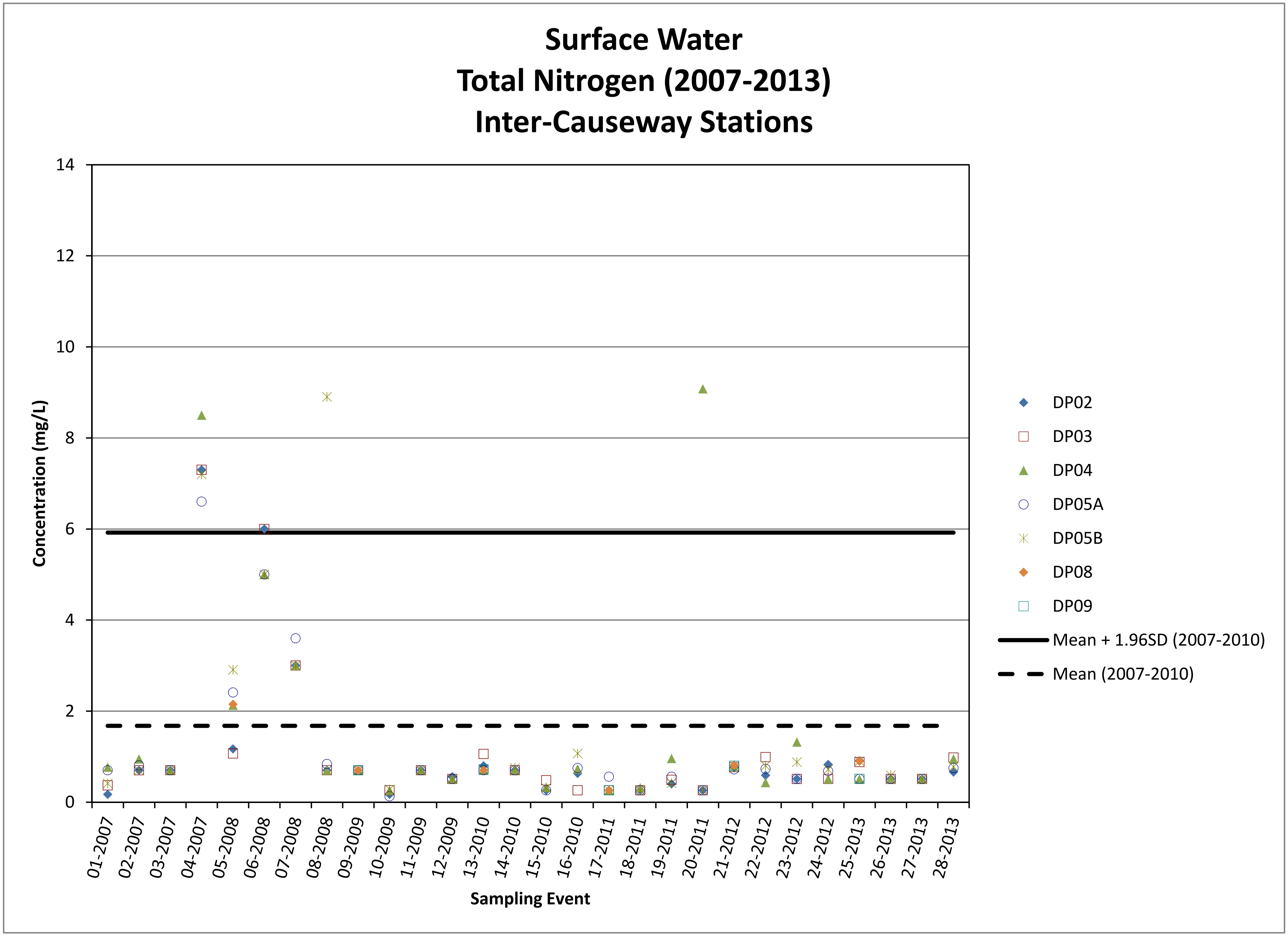
Surface Water
Orthophosphate-Dissolved (as P) (2007-2013)
Reference Stations
Concentration (mg/L)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



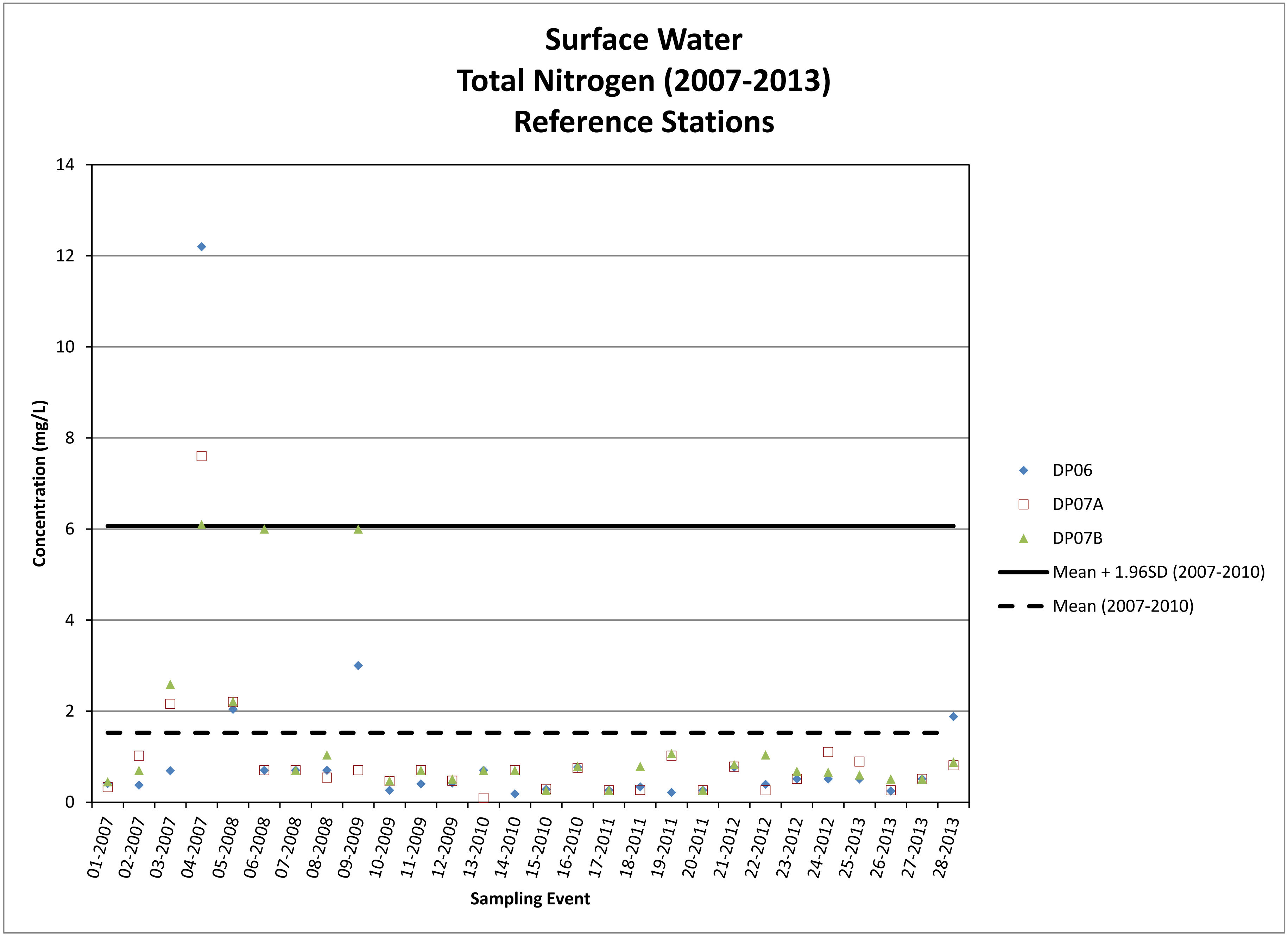
Surface Water
Total Kjeldahl Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

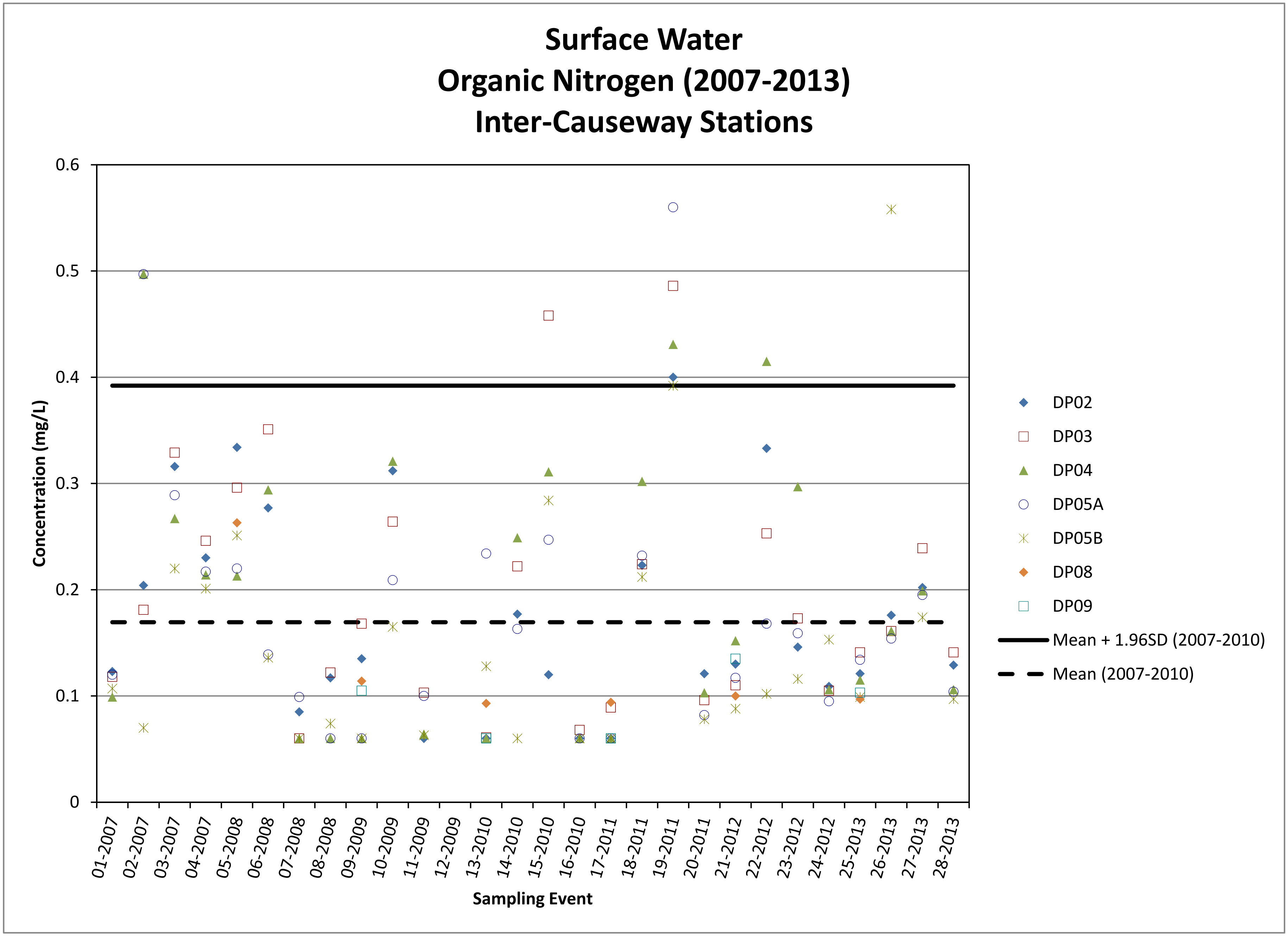


Surface Water
Total Kjeldahl Nitrogen (2007-2013)
Reference Stations
Concentration (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

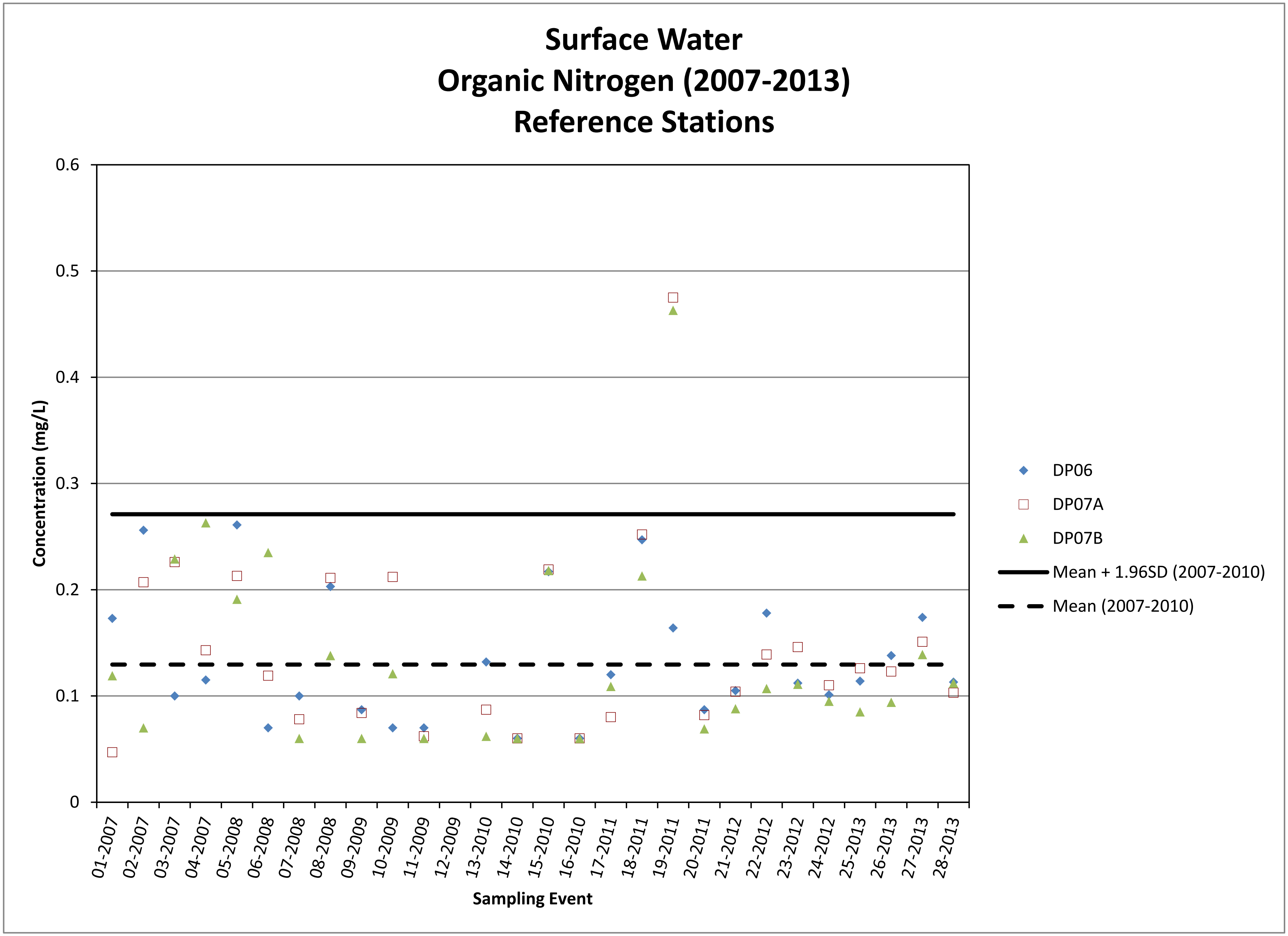


Surface Water
Total Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0
2
4
6
8
10
12
14
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

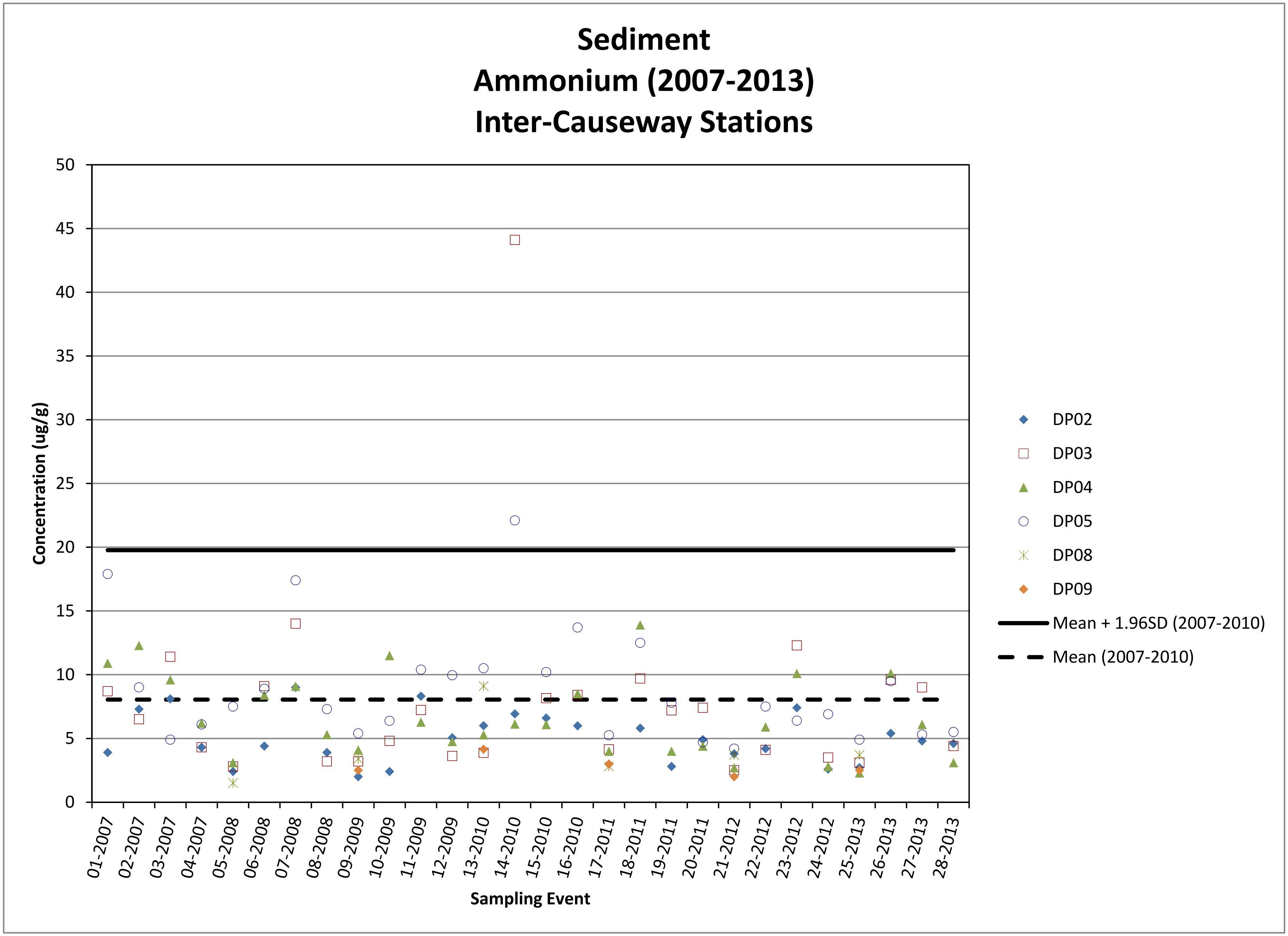

Surface Water
Total Nitrogen (2007-2013)
Reference Stations
Concentration (mg/L)
14
12
10
8
6
4
2
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

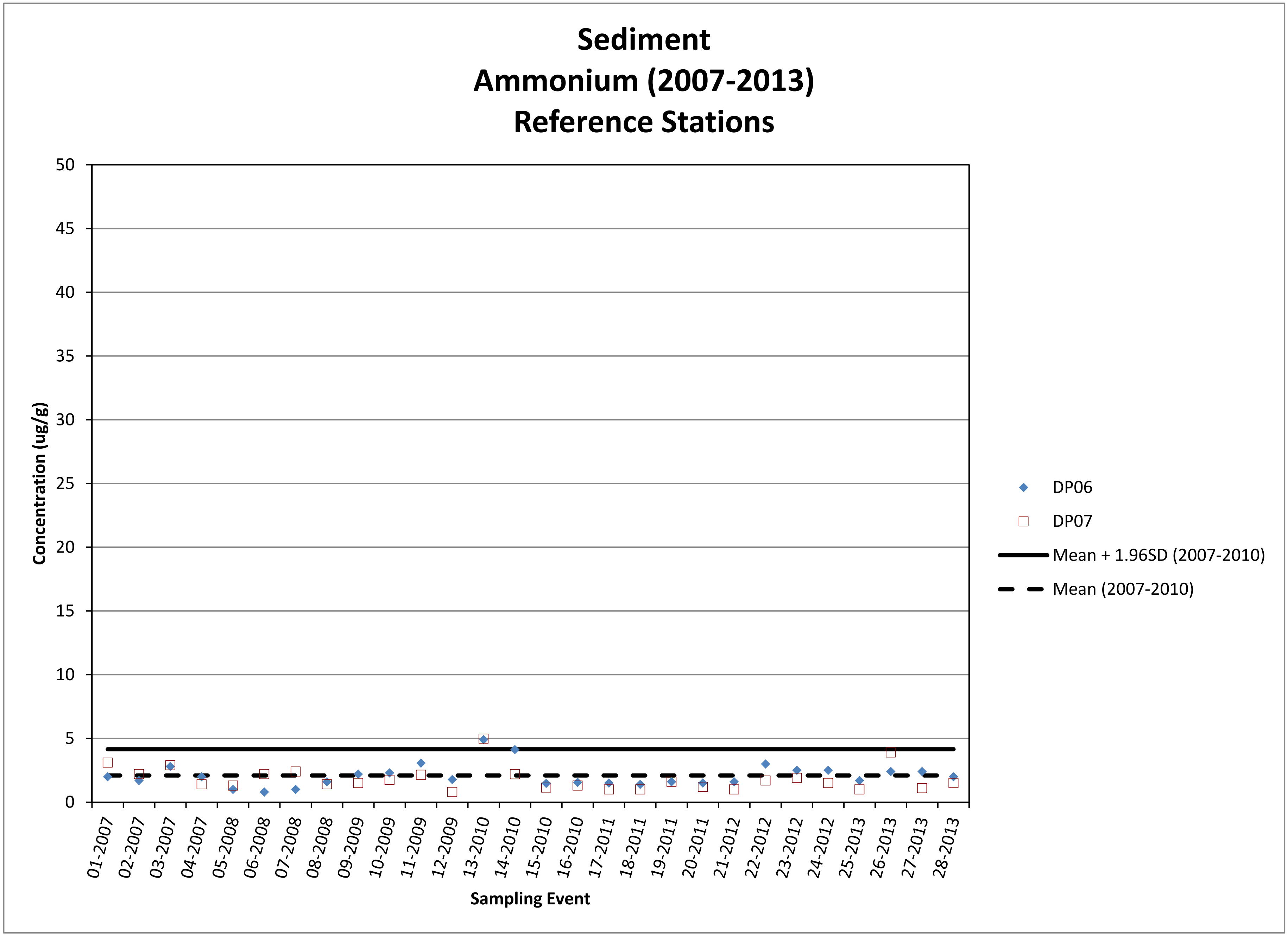


Surface Water
Organic Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

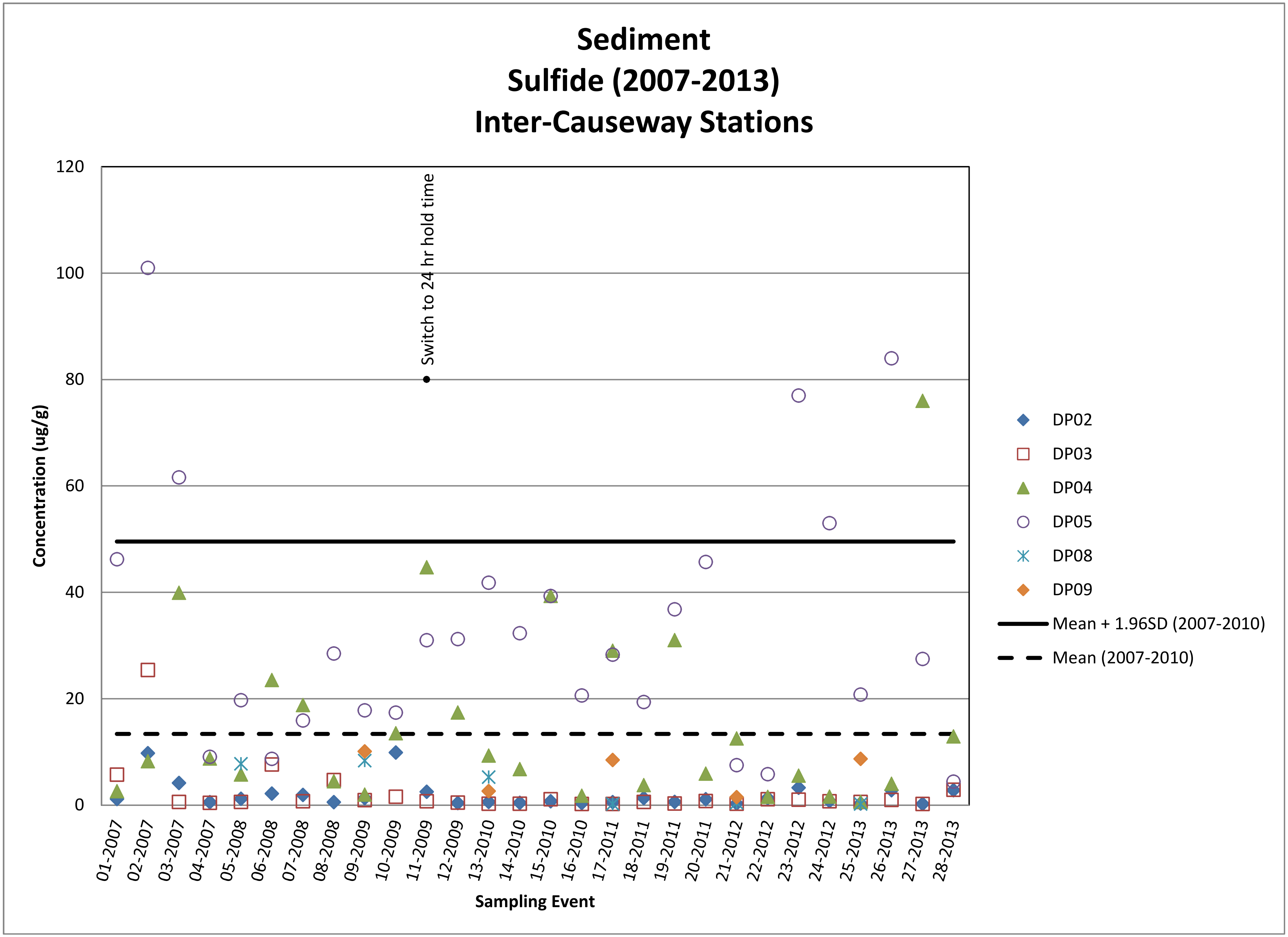


Surface Water
Organic Nitrogen (2007-2013)
Reference Stations
Concentration (mg/L)
0
0.1
0.2
0.3
0.4
0.5
0.6
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

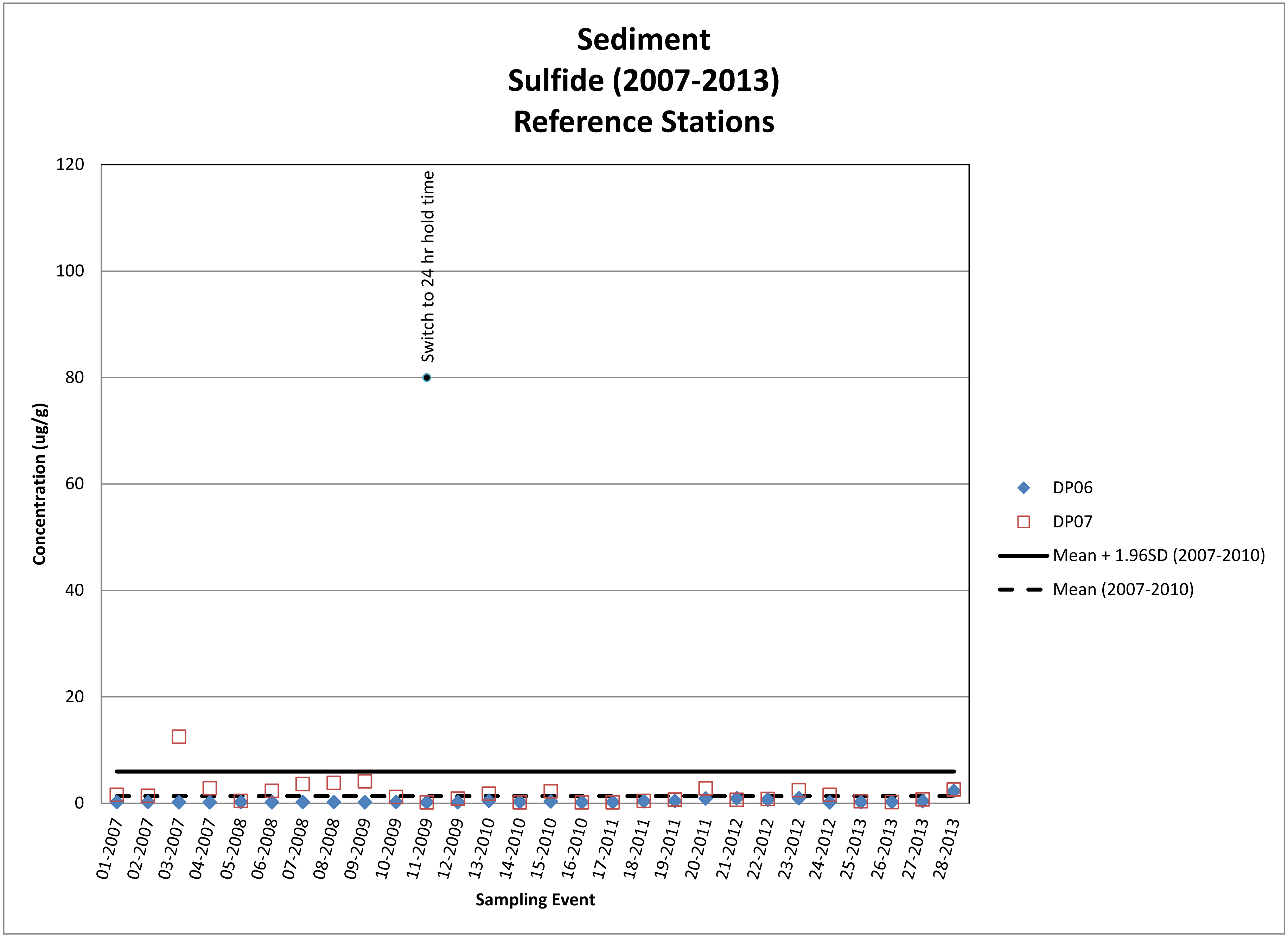

Sediment
Ammonium (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
5
10
15
20
25
30
35
40
45
50
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



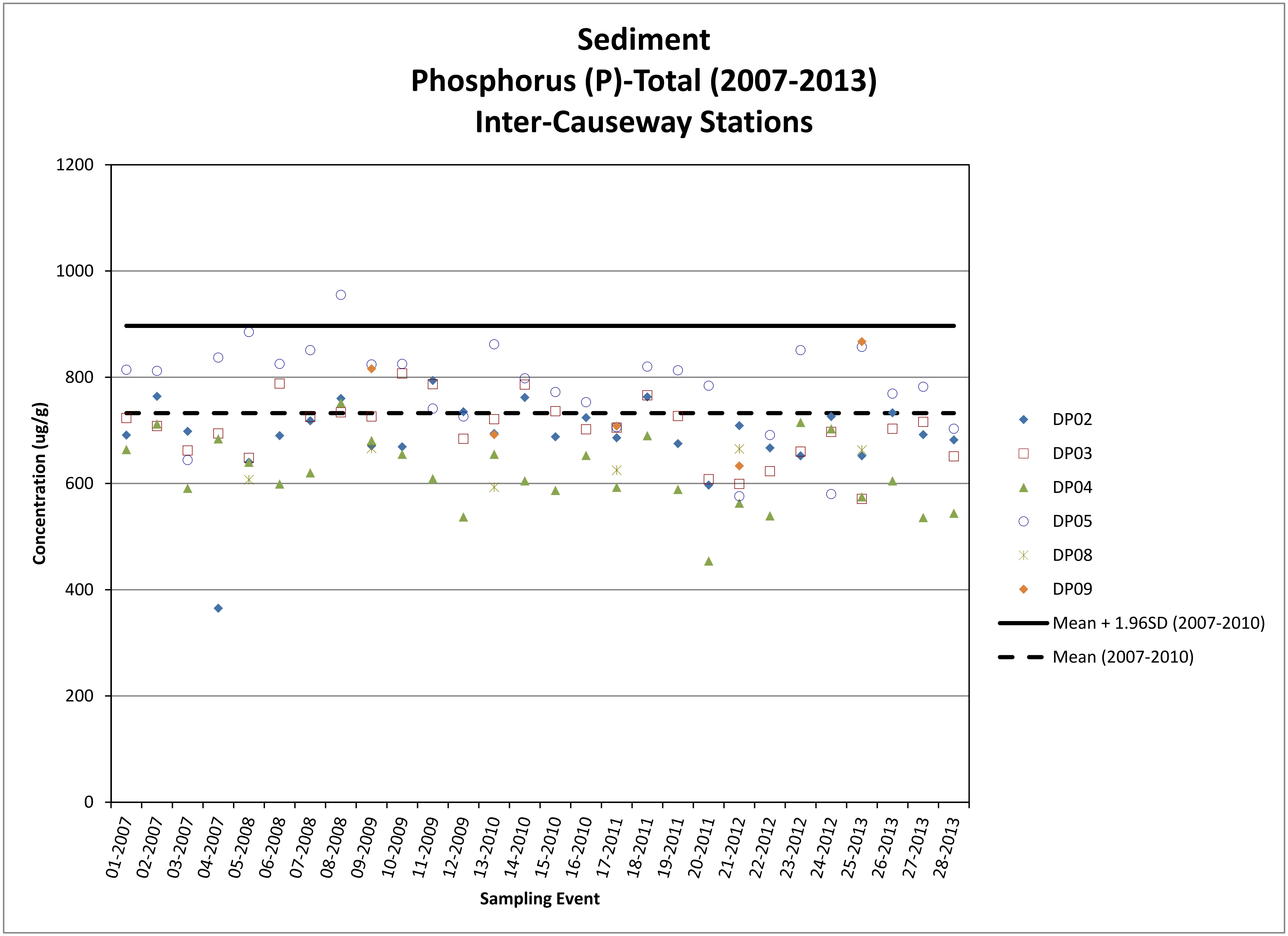
Sediment
Ammonium (2007-2013)
Reference Stations
Concentration (ug/g)
0
5
10
15
20
25
30
35
40
45
50
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

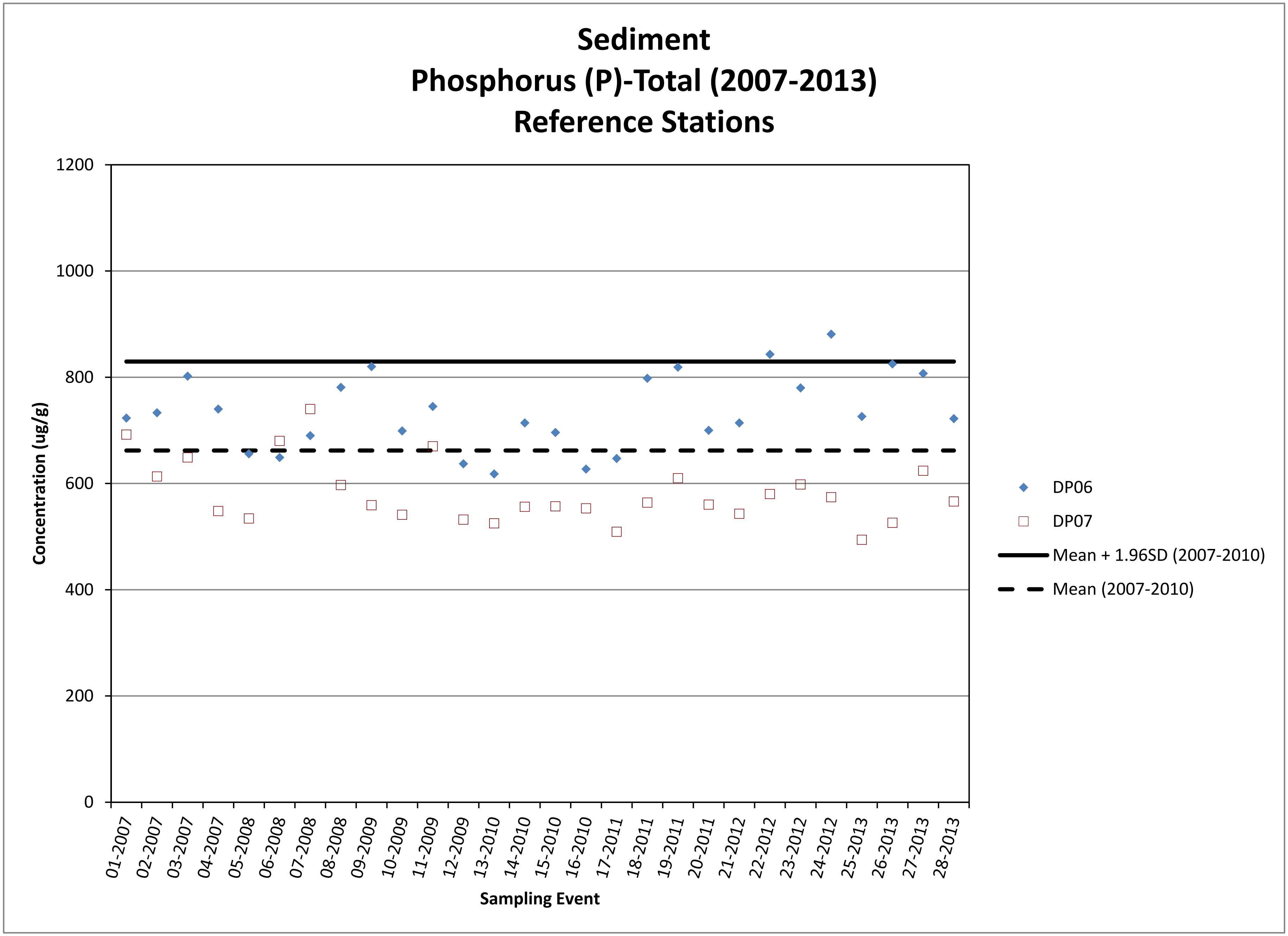


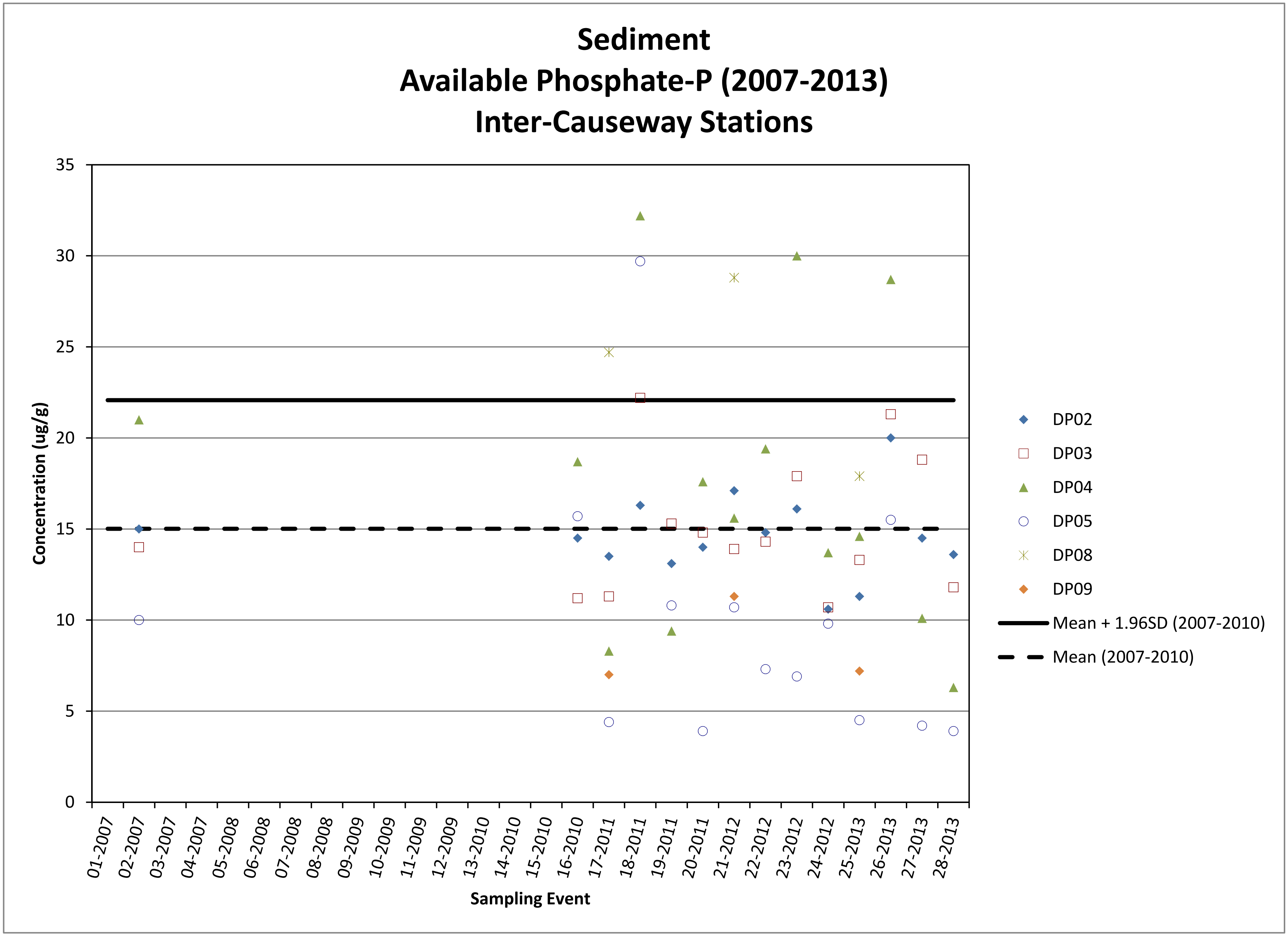
Sediment
Sulfide (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
20
40
60
80
100
120
Switch to 24 hr hold time
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



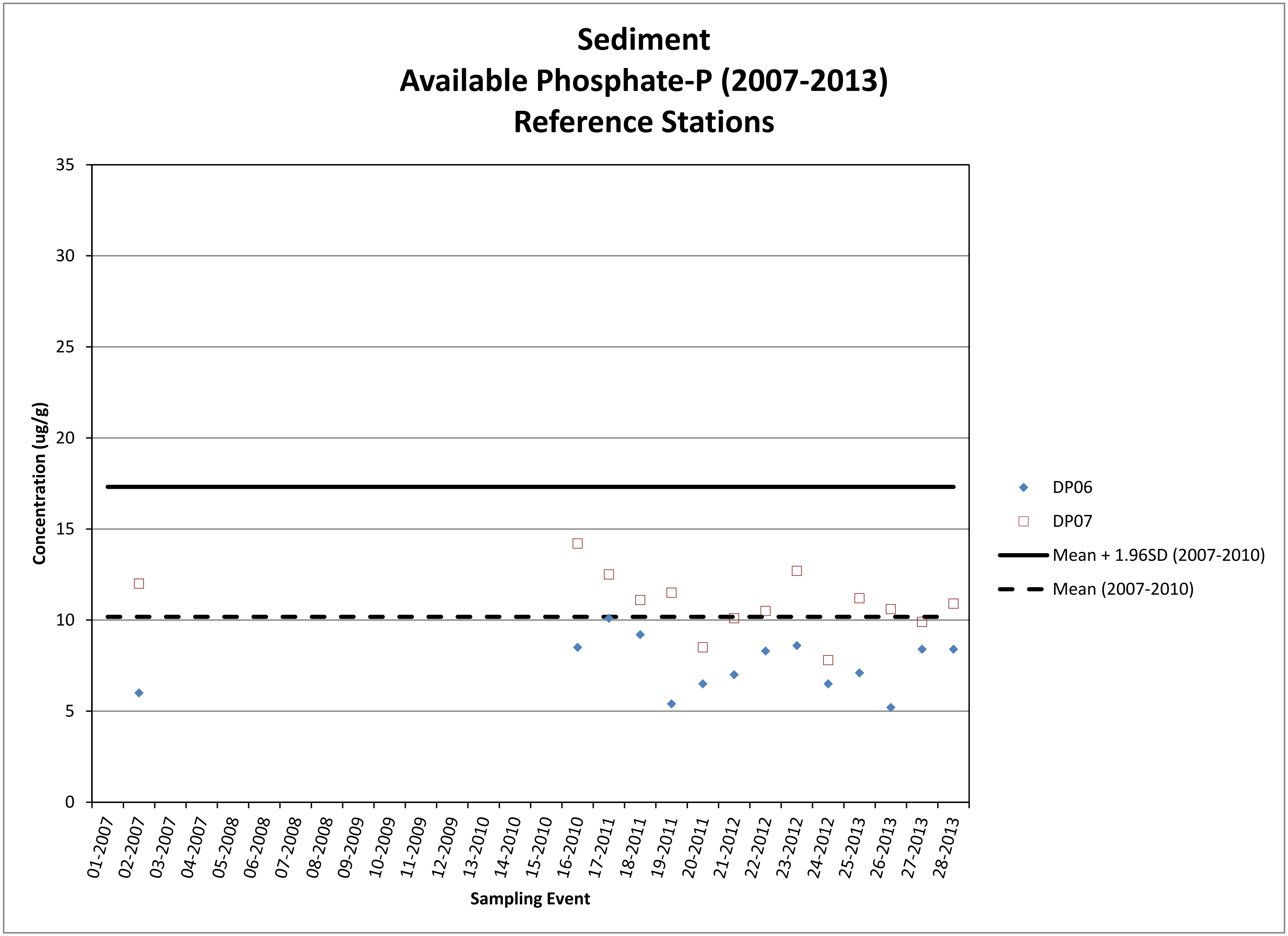
Sediment
Sulfide (2007-2013)
Reference Stations
Concentration (ug/g)
120
100
80
60
40
20
0
Switch to 24 hr hold time
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

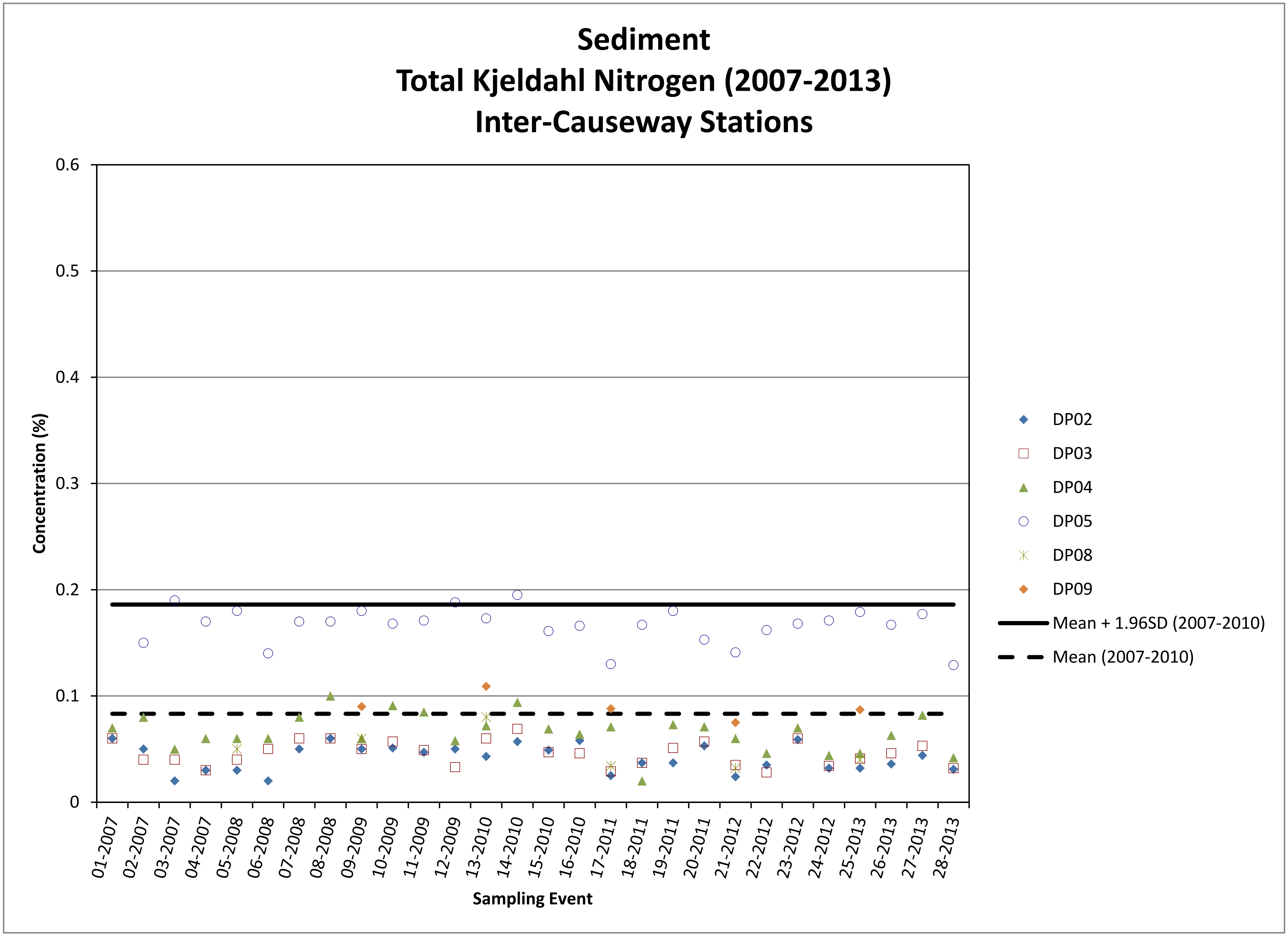

Sediment
Phosphorus (P)-Total (2007-2013)
Inter-Causeway Stations
1200
1000
800
600
400
200
0
Concentration (ug/g)
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Sediment
Phosphorus (P)-Total (2007-2013)
Reference Stations
1200
1000
800
600
400
200
0
Concentration (ug/g)
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

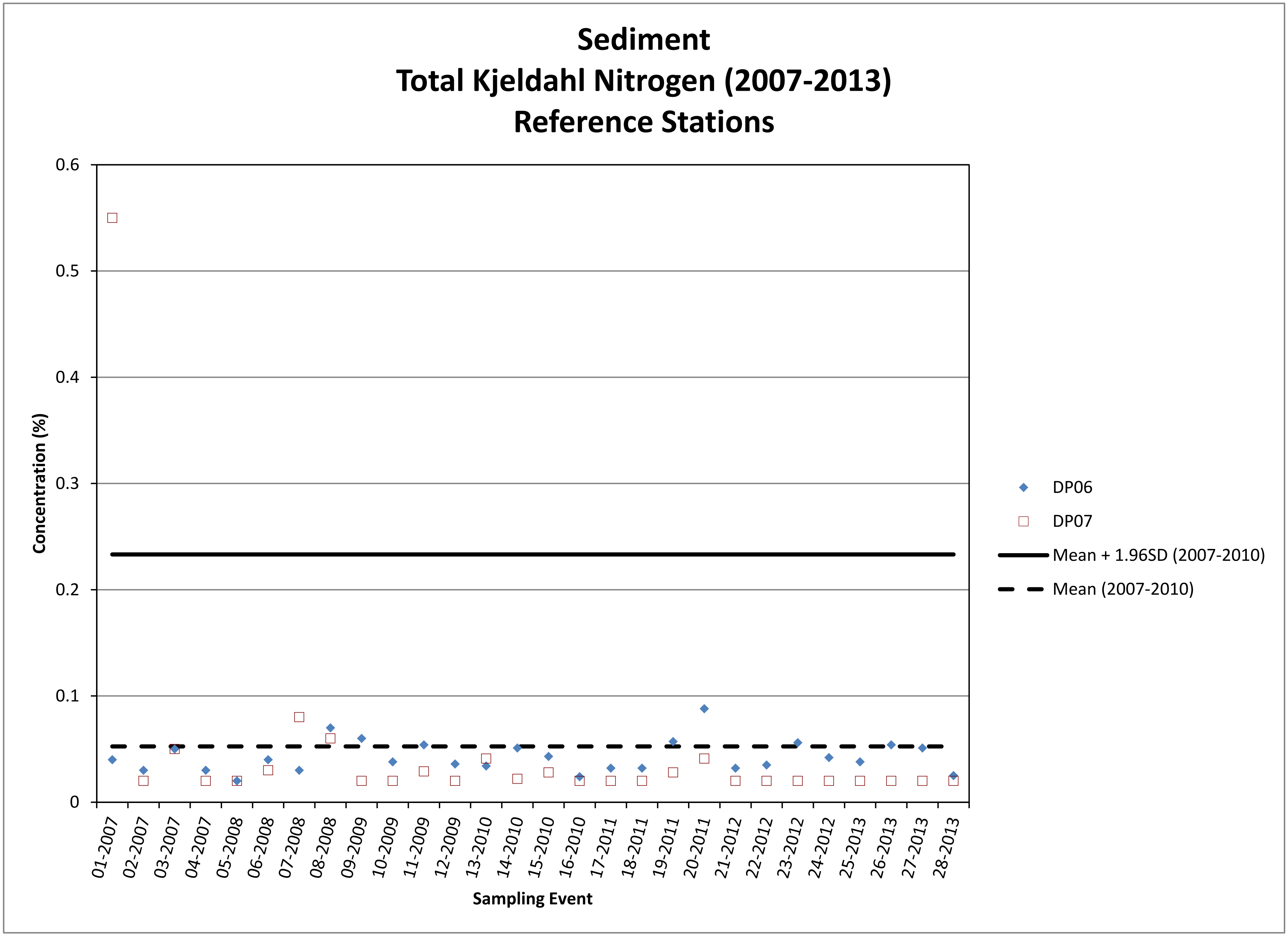


Sediment
Available Phosphate-P (2007-2013)
Inter-Causeway Stations
Concentration (ug/g)
0
5
10
15
20
25
30
35
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

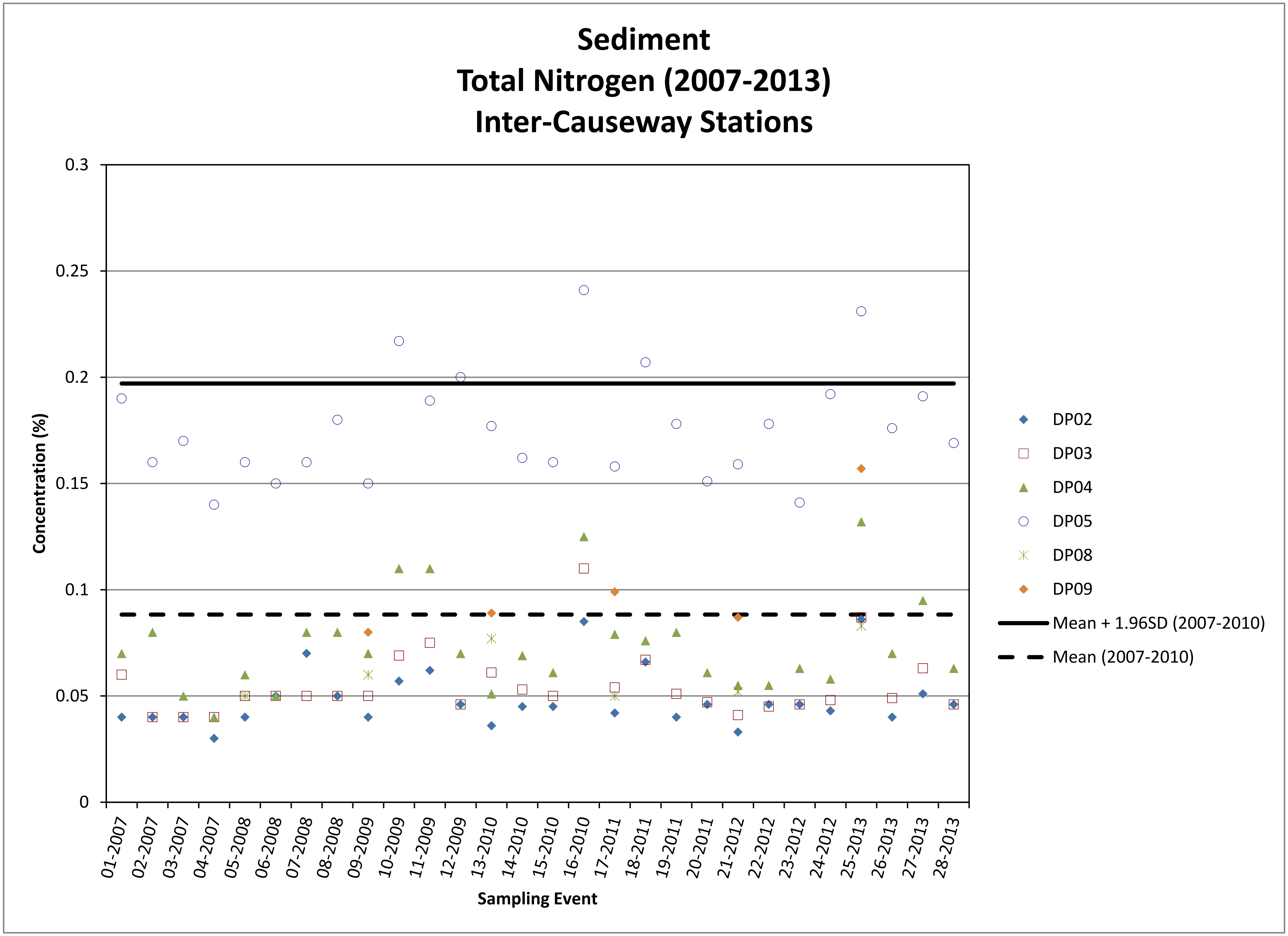

Sediment
Available Phosphate-P (2007-2013)
Reference Stations
Concentration (ug/g)
35
30
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



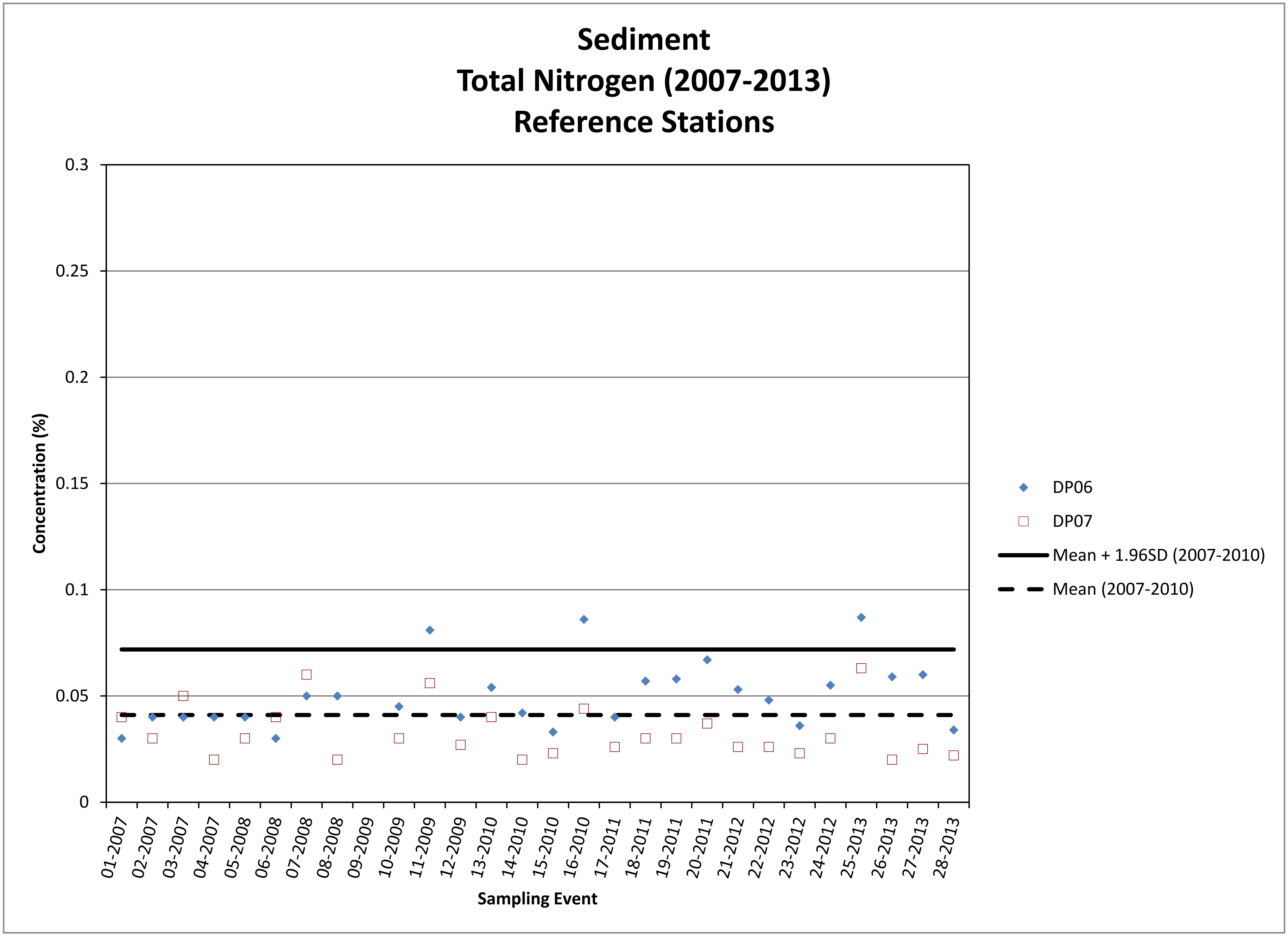
Sediment
Total Kjeldahl Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



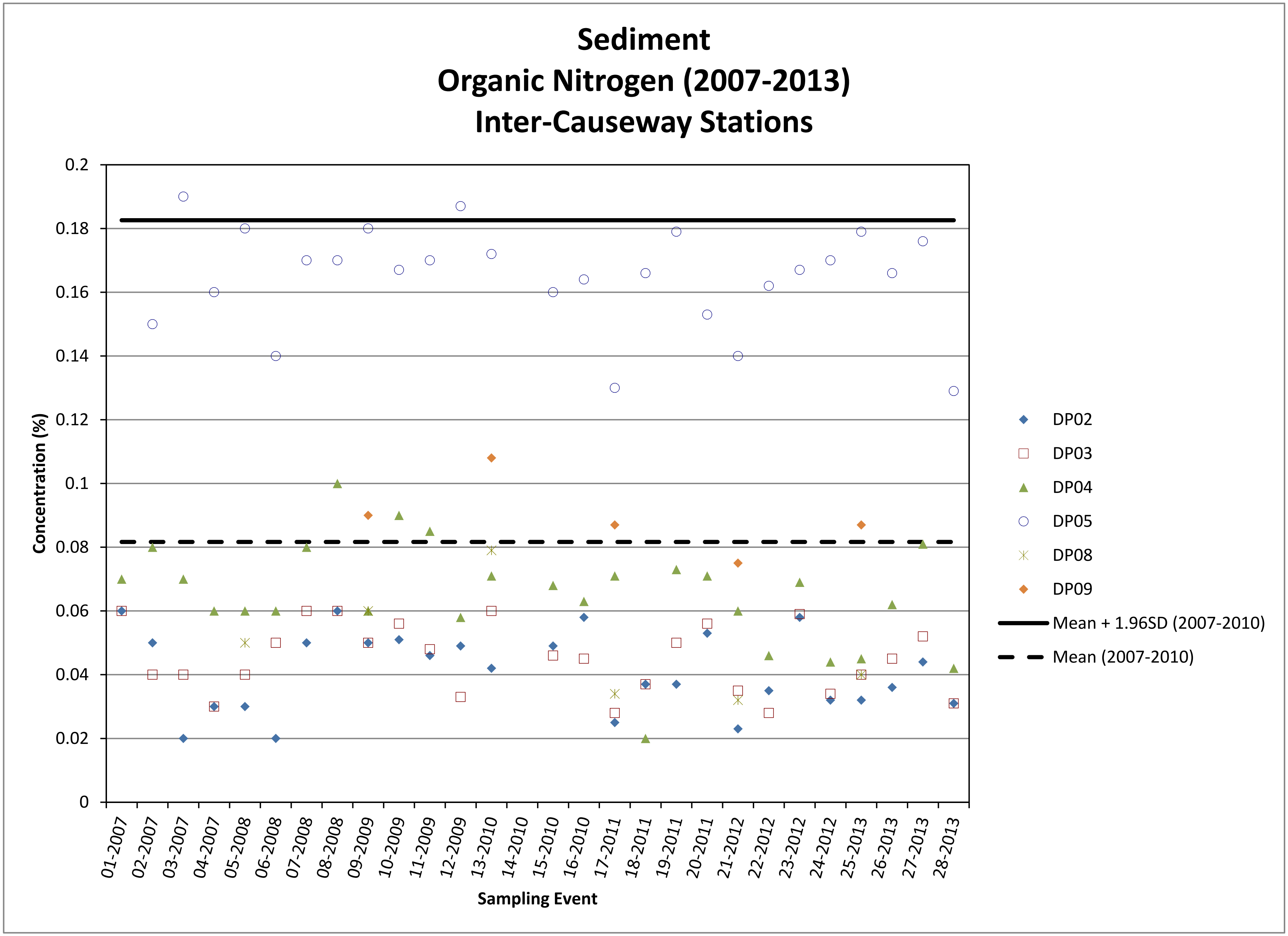
Sediment
Total Kjeldahl Nitrogen (2007-2013)
Reference Stations
Concentration (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



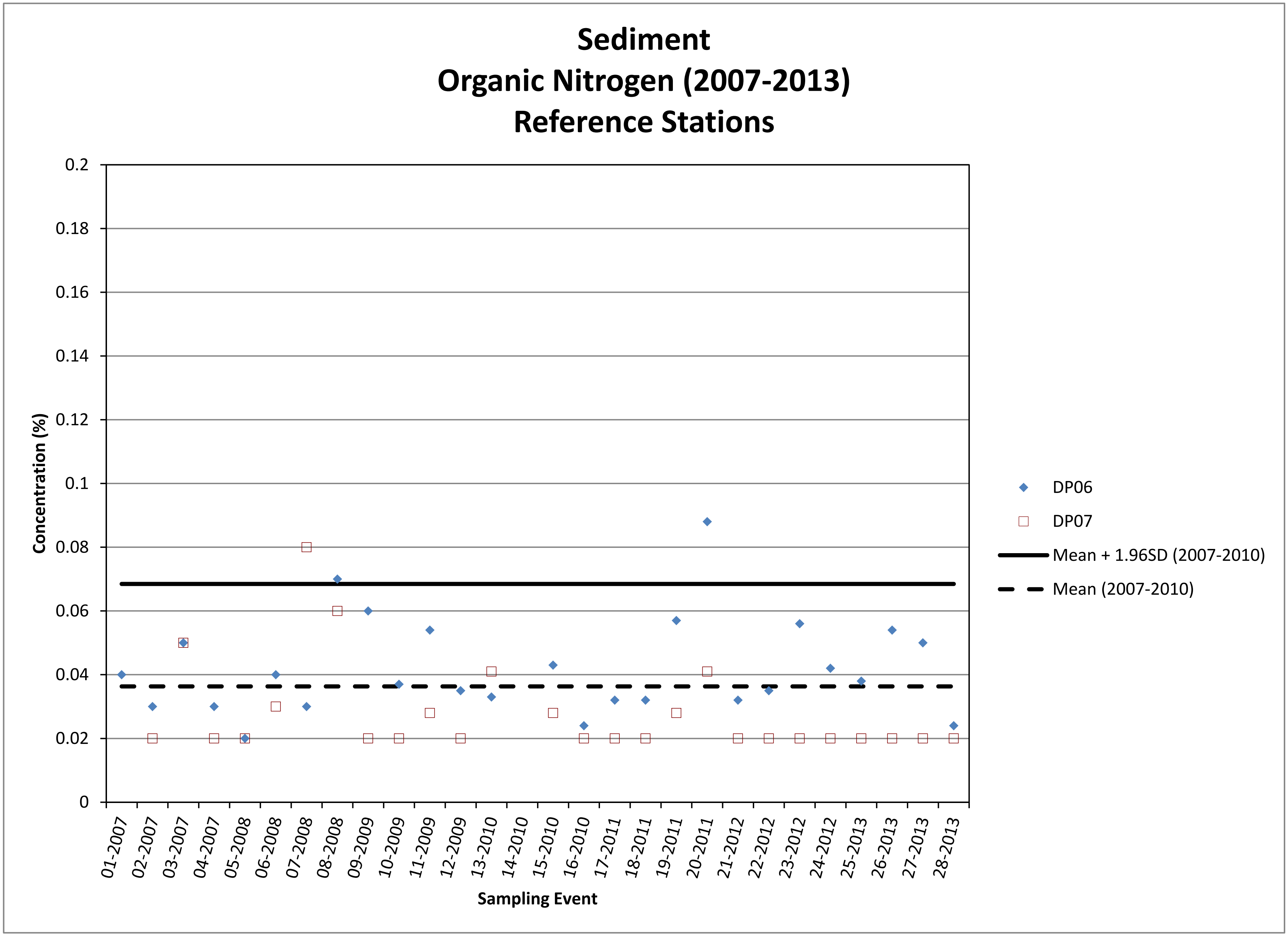
Sediment
Total Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



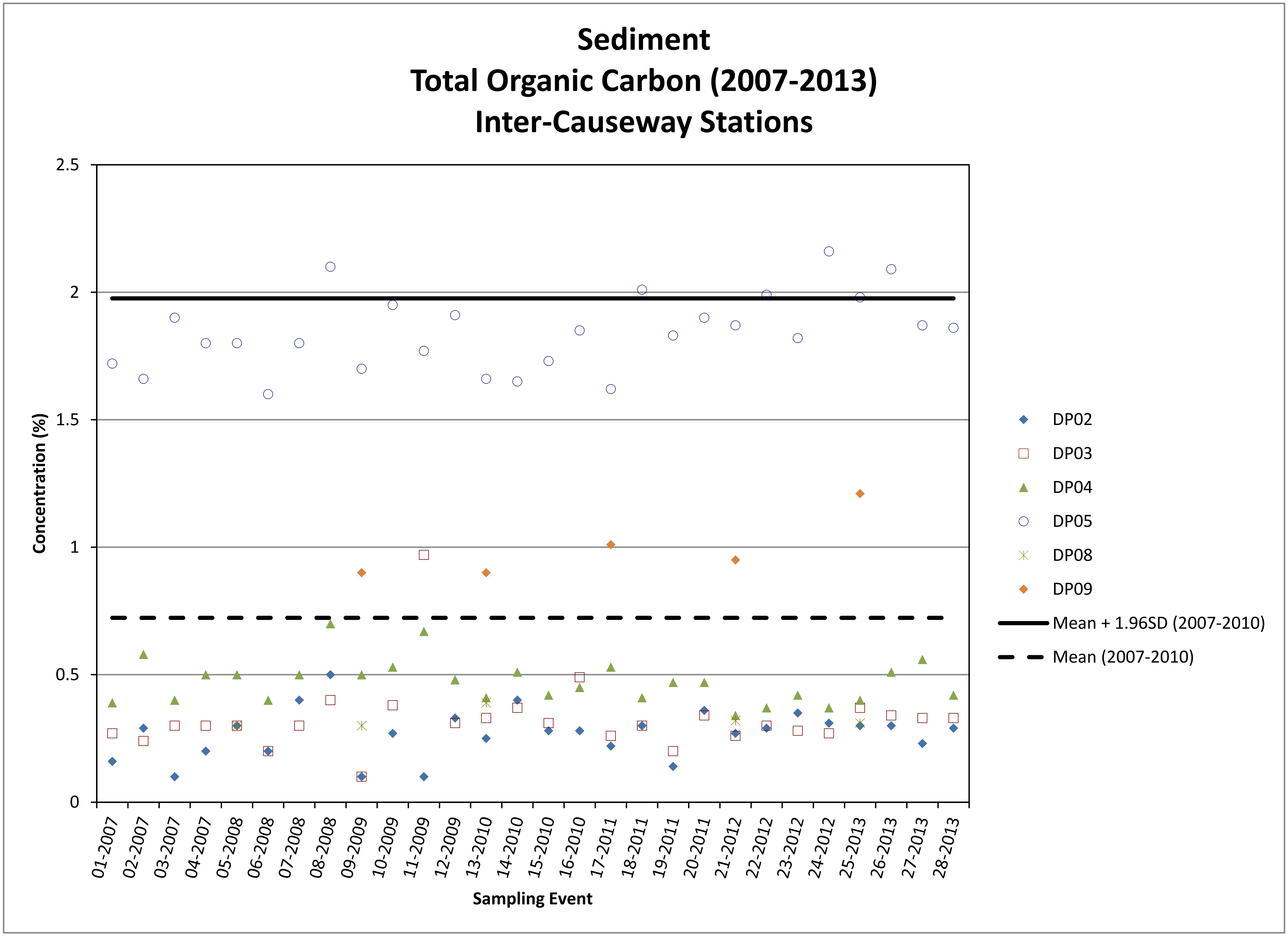
Sediment
Total Nitrogen (2007-2013)
Reference Stations
Concentration (%)
0.3
0.25
0.2
0.15
0.1
0.05
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

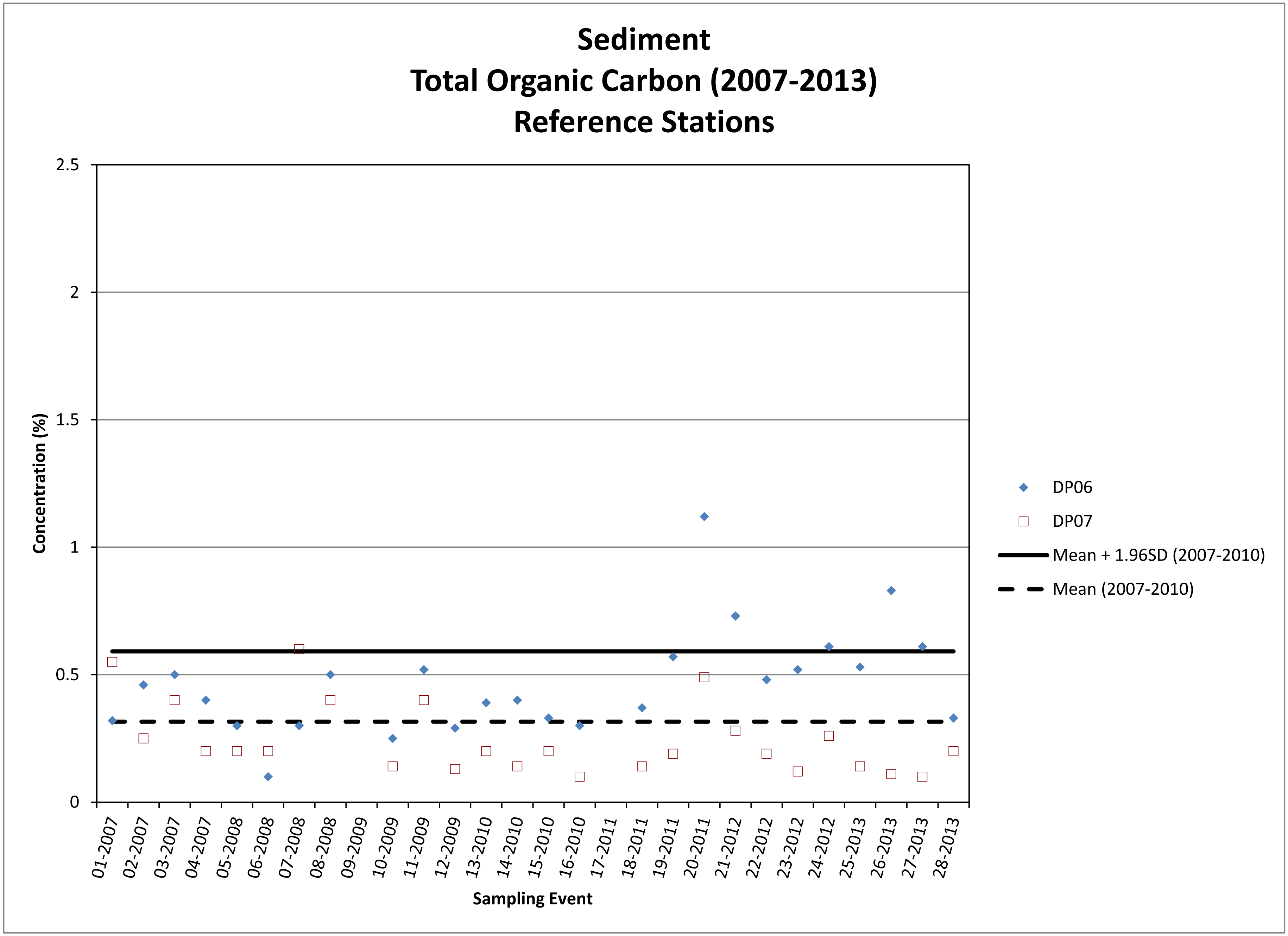


Sediment
Organic Nitrogen (2007-2013)
Inter-Causeway Stations
Concentration (%)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

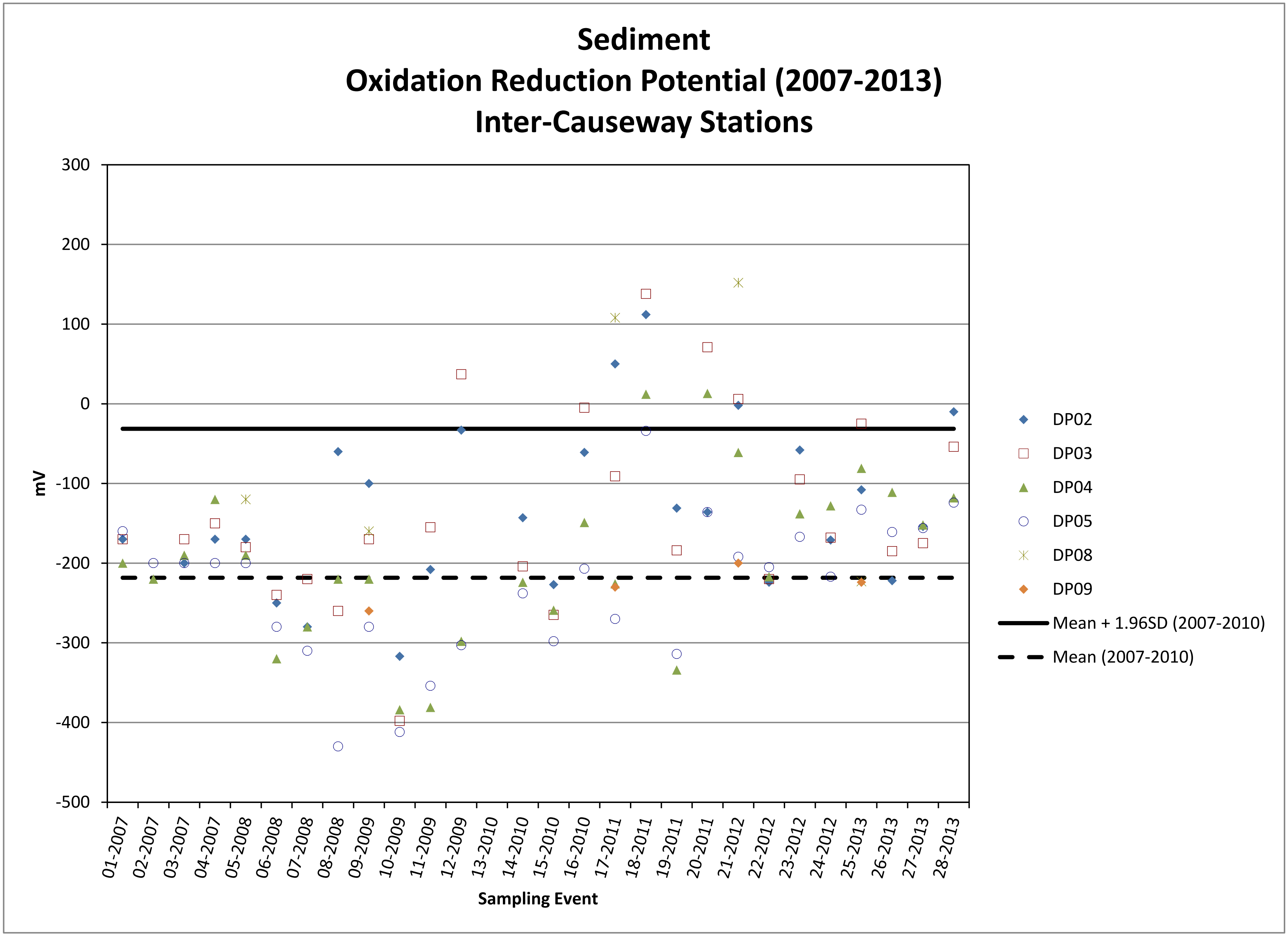


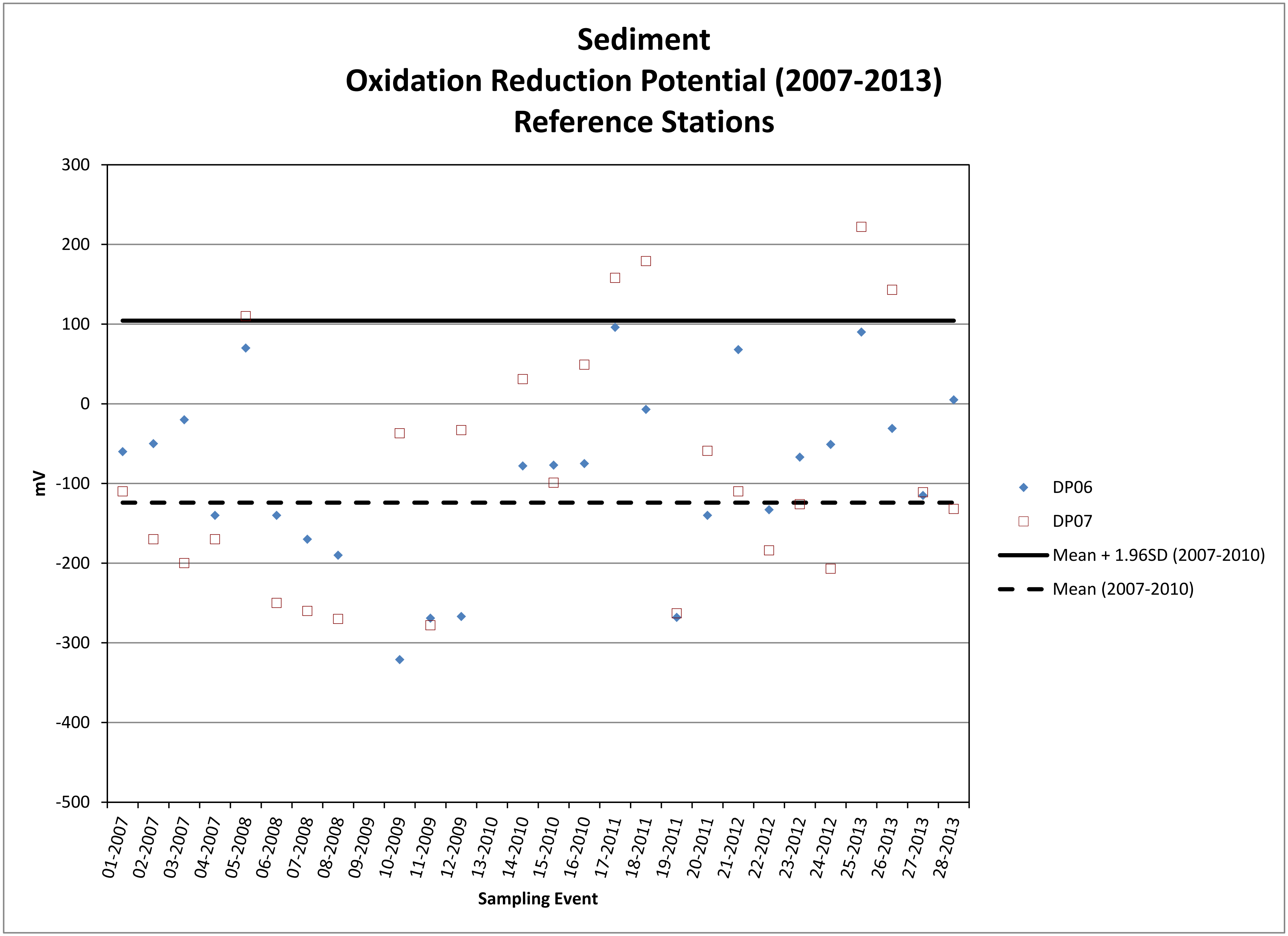
Sediment
Organic Nitrogen (2007-2013)
Reference Stations
Concentration (%)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)


Sediment
Total Organic Carbon (2007-2013)
Inter-Causeway Stations
Concentration (%)
0
0.5
1
1.5
2
2.5
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



Sediment
Total Organic Carbon (2007-2013)
Reference Stations
Concentration (%)
0
0.5
1
1.5
2
2.5
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

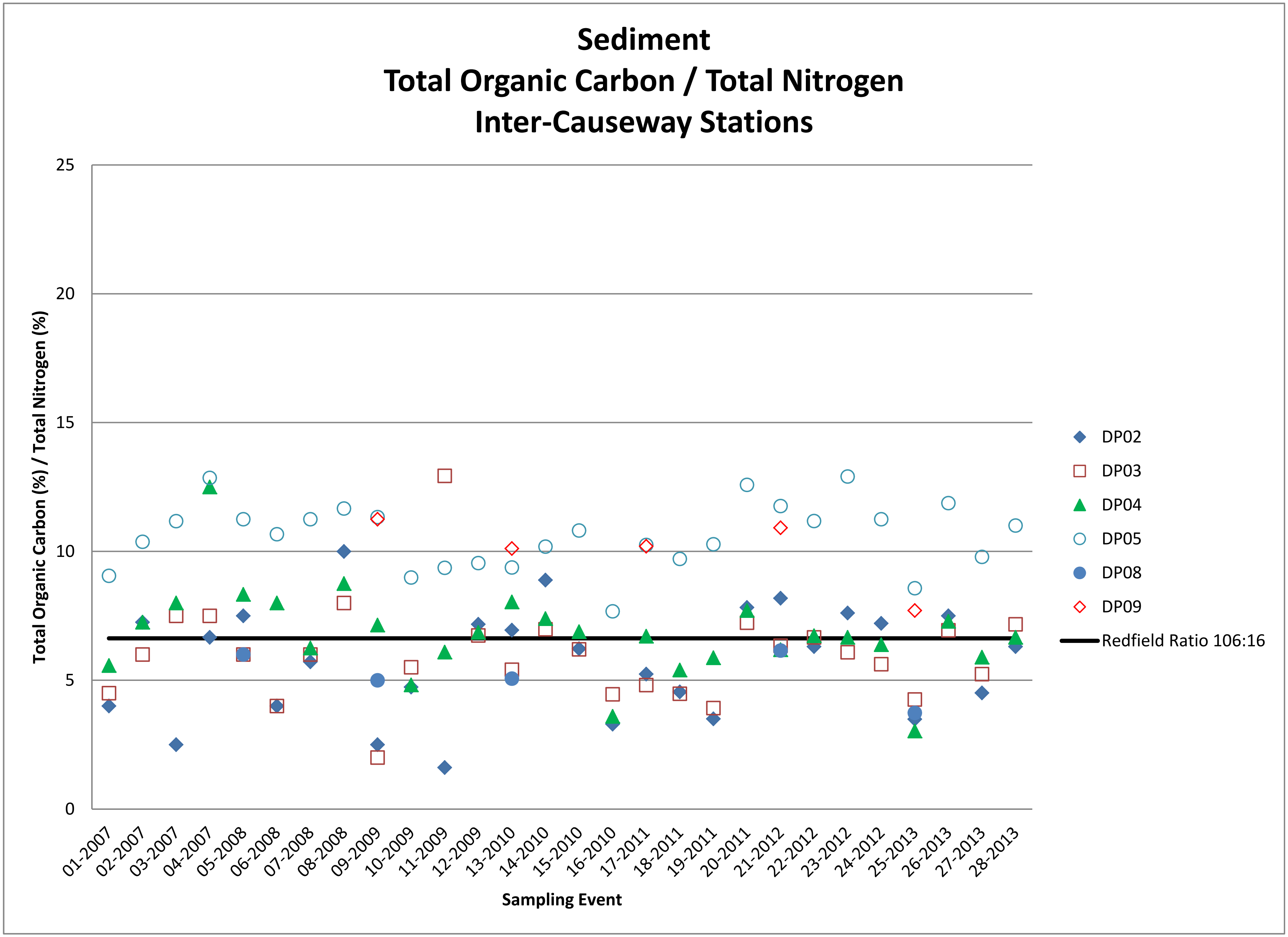

Sediment
Oxidation Reduction Potential (2007-2013)
Inter-Causeway Stations
300
200
100
0
-100
-200
-300
-400
-500
mV
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Mean + 1.96SD (2007-2010)
Mean (2007-2010)



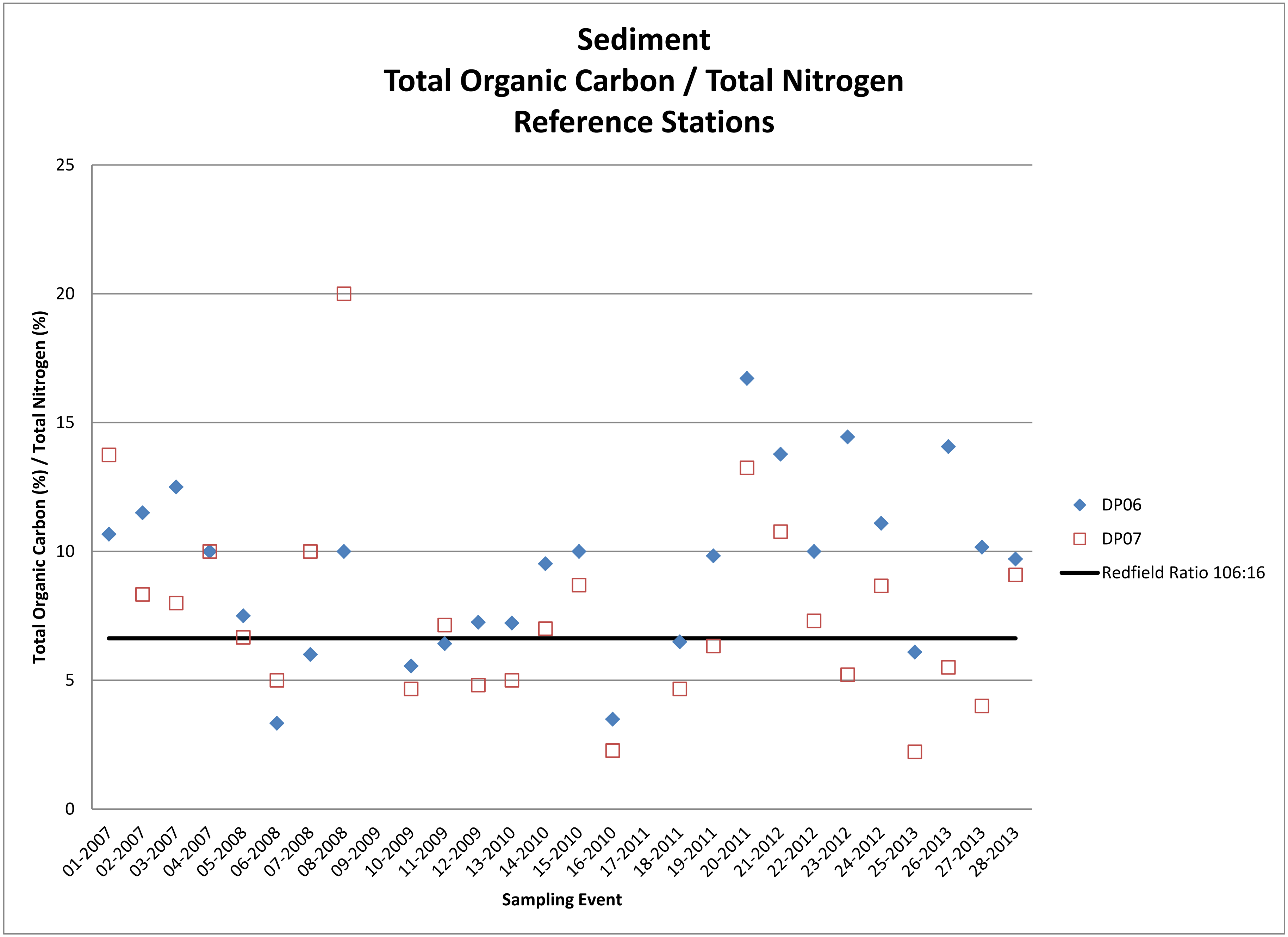
Sediment
Oxidation Reduction Potential (2007-2013)
Reference Stations
mV
300
200
100
0
-100
-200
-300
-400
-500
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Mean + 1.96SD (2007-2010)
Mean (2007-2010)

APPENDIX F

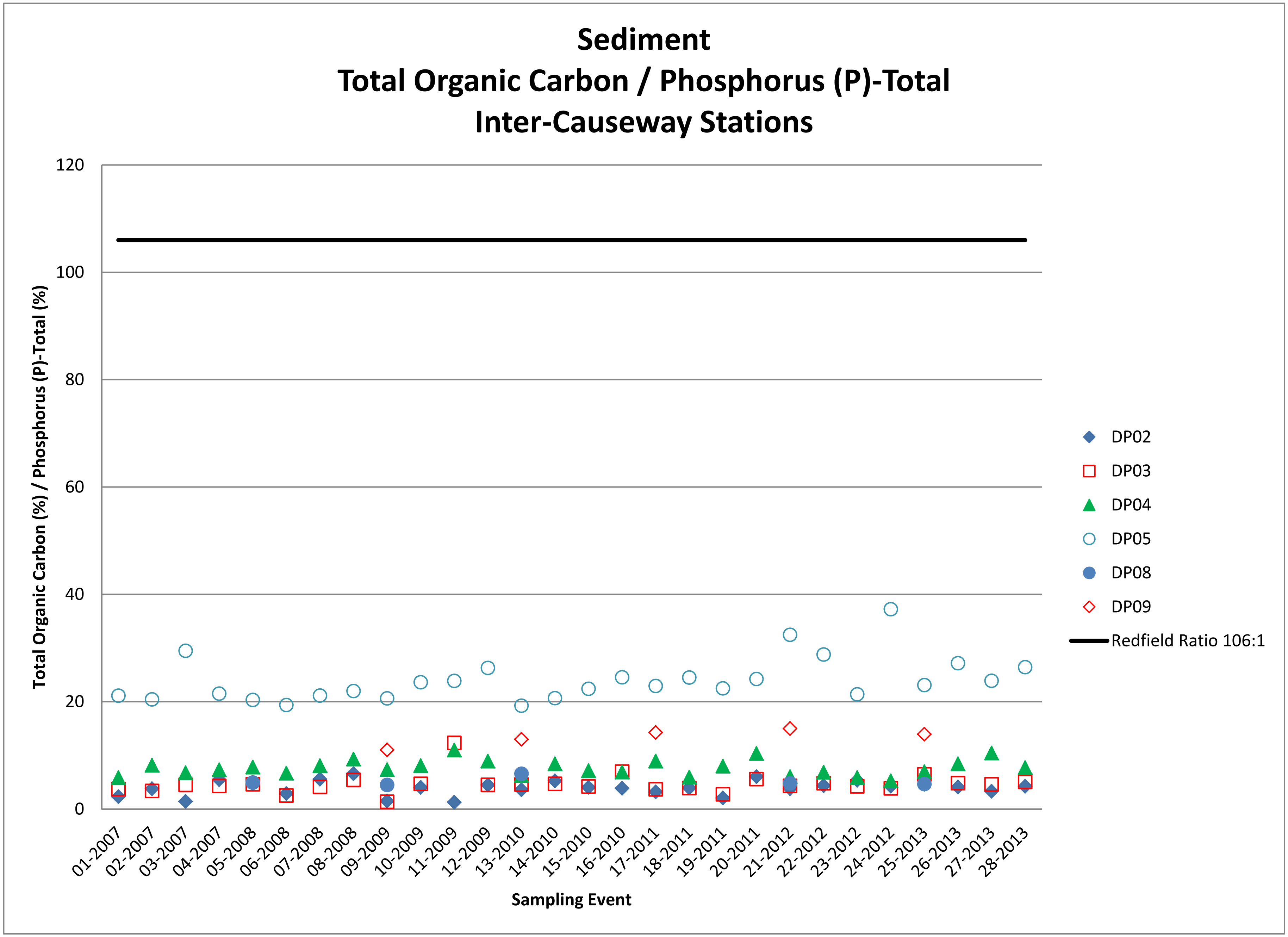
Trend Graphs for Surface Water and Sediment Chemistry – Eutrophication Ratios

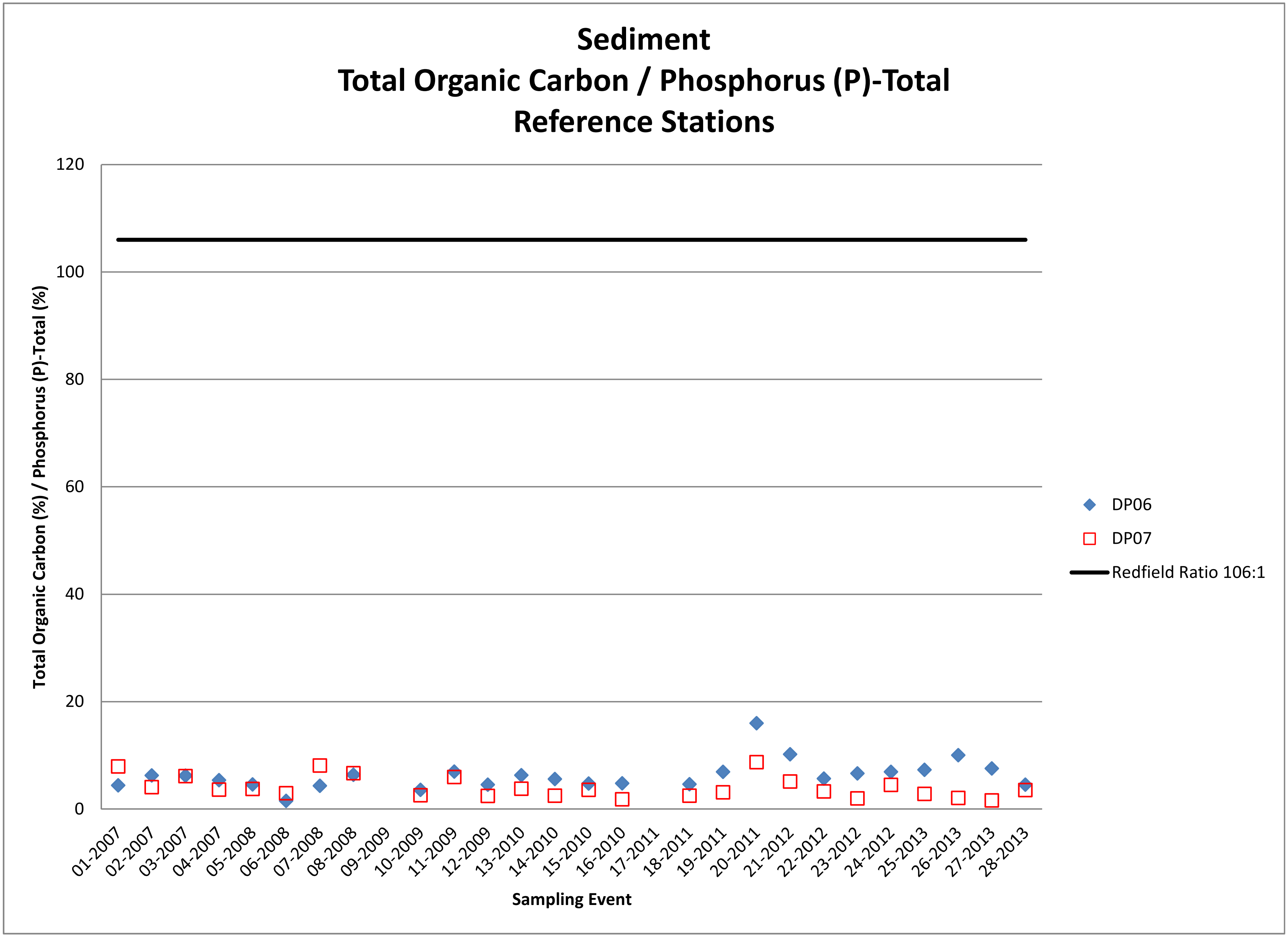


Sediment
Total Organic Carbon / Total Nitrogen
Inter-Causeway Stations
Total Organic Carbon (%) / Total Nitrogen (%)
25
20
15
10
5
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Redfield Ratio 106:16

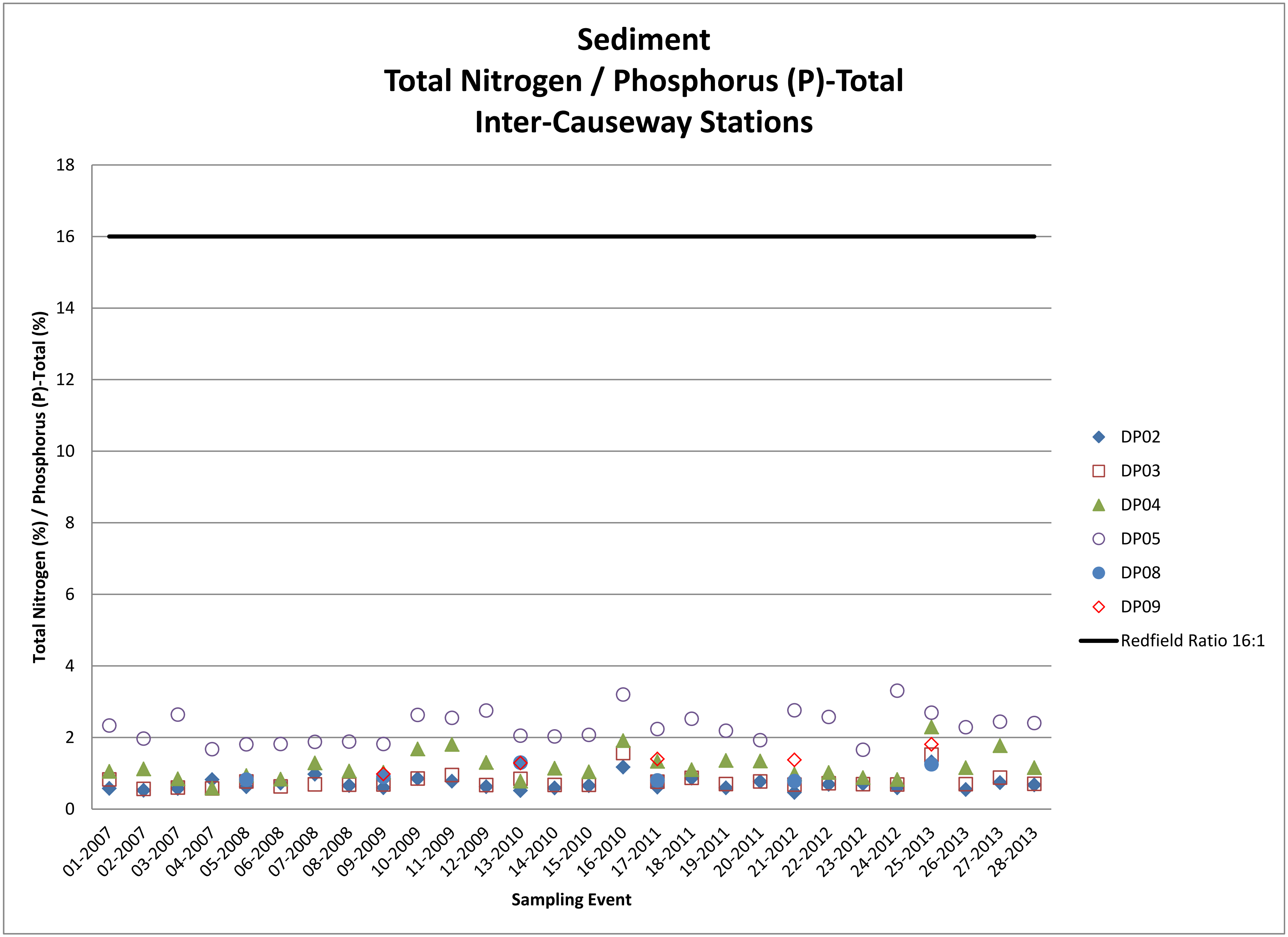


Sediment
Total Organic Carbon / Total Nitrogen
Reference Stations
Total Organic Carbon (%) / Total Nitrogen (%)
0
5
10
15
20
25
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Redfield Ratio 106:16

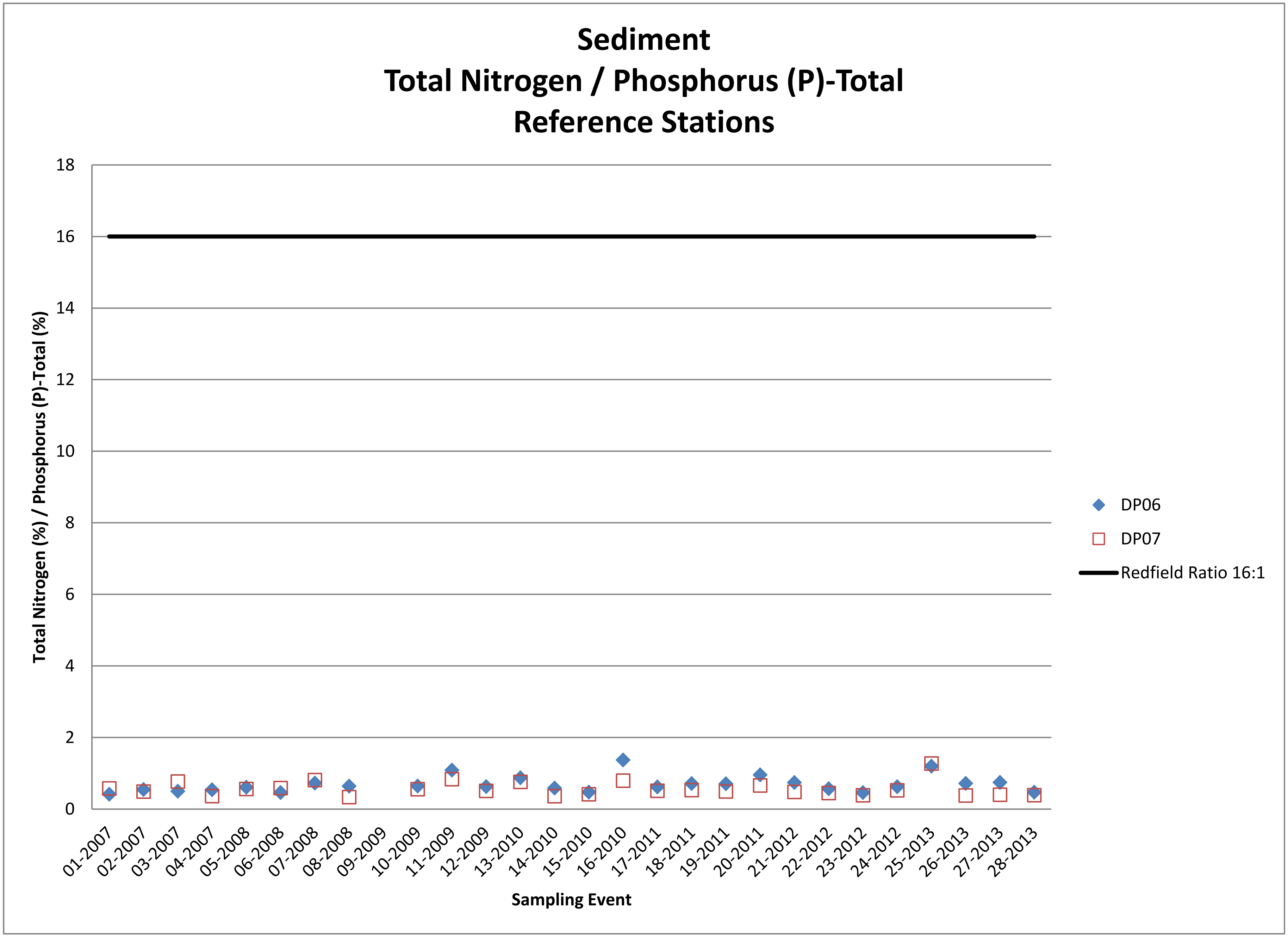

Sediment
Total Organic Carbon / Phosphorus (P)-Total
Inter-Causeway Stations
Total Organic Carbon (%) / Phosphorus (P)-Total (%)
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Redfield Ratio 106:1



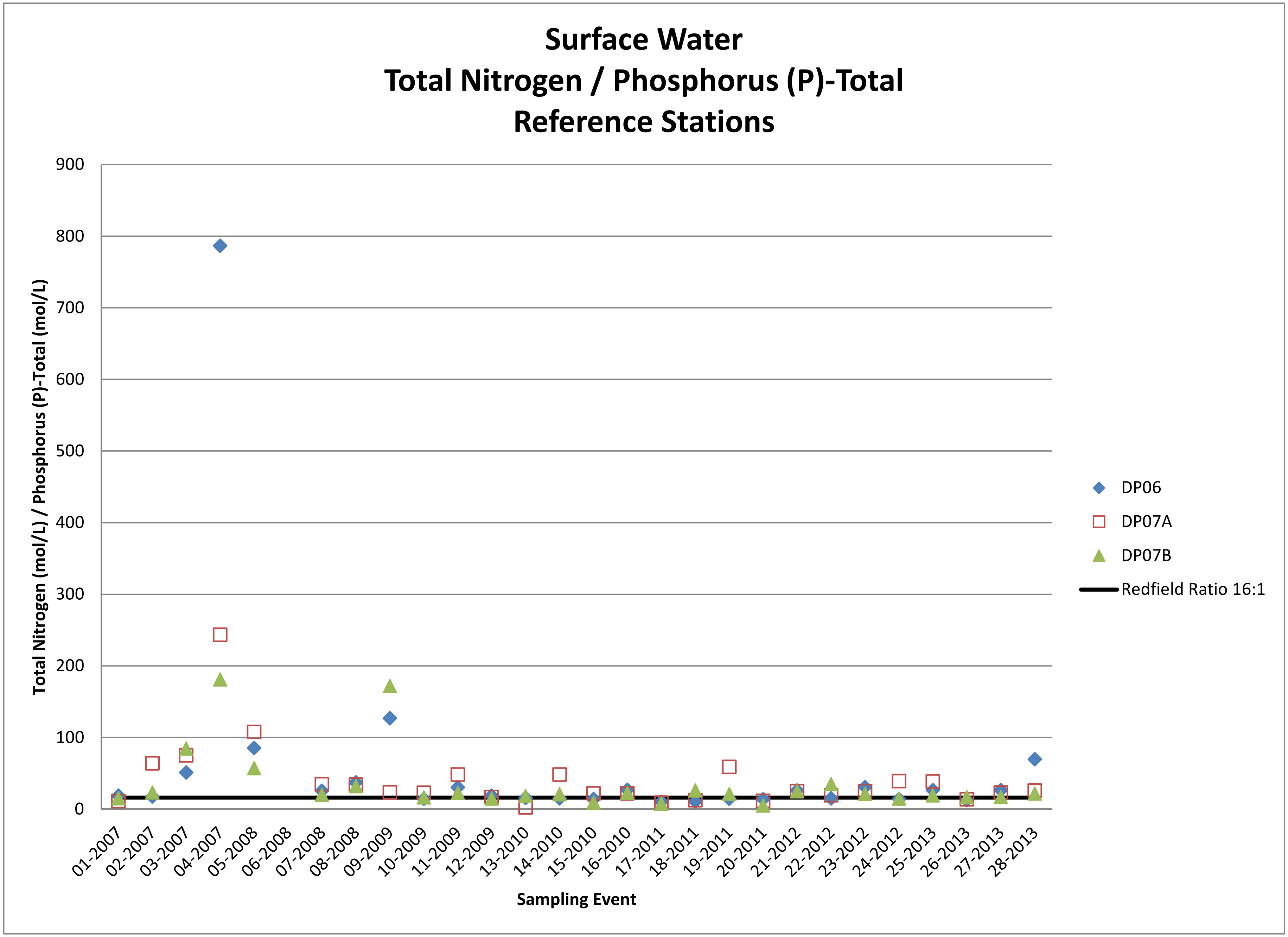
Sediment
Total Organic Carbon / Phosphorus (P)-Total
Reference Stations
Total Organic Carbon (%) / Phosphorus (P)-Total (%)
120
100
80
60
40
20
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Redfield Ratio 106:1



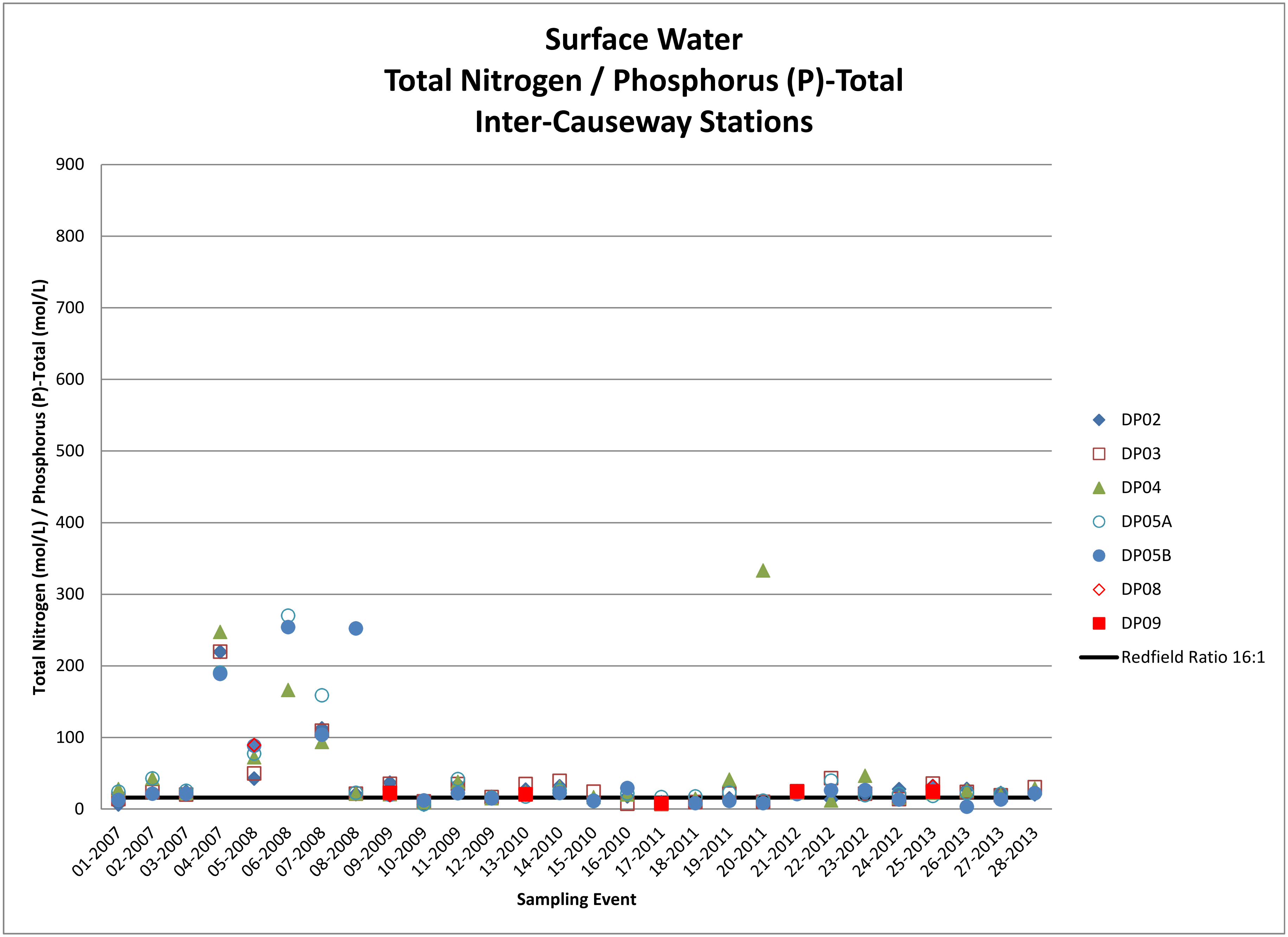
Sediment
Total Nitrogen / Phosphorus (P)-Total
Inter-Causeway Stations
Total Nitrogen (%) / Phosphorus (P)-Total (%)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05
DP08
DP09
Redfield Ratio 16:1

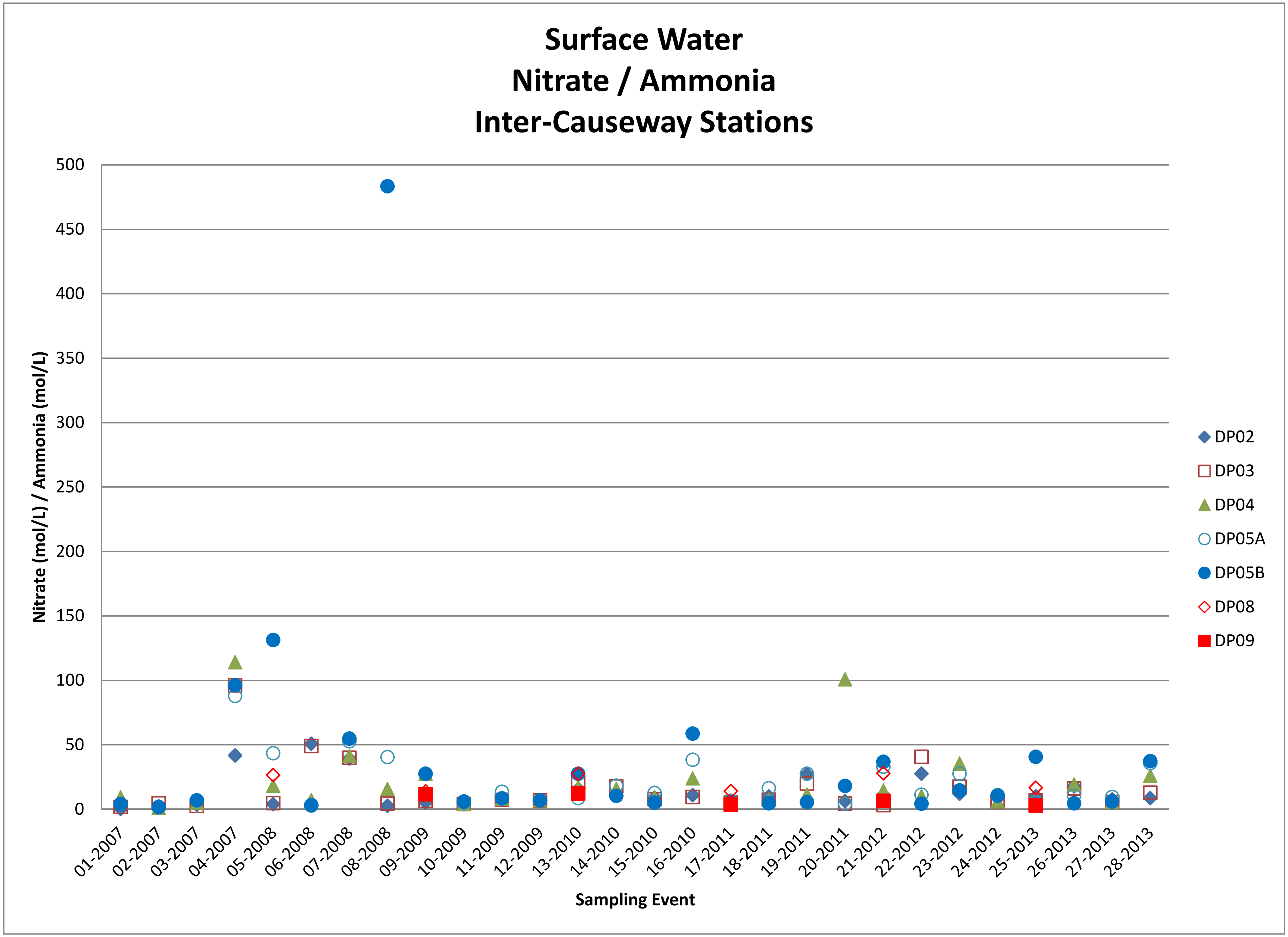


Sediment
Total Nitrogen / Phosphorus (P)-Total
Reference Stations
Total Nitrogen (%) / Phosphorus (P)-Total (%)
0
2
4
6
8
10
12
14
16
18
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07
Redfield Ratio 16:1

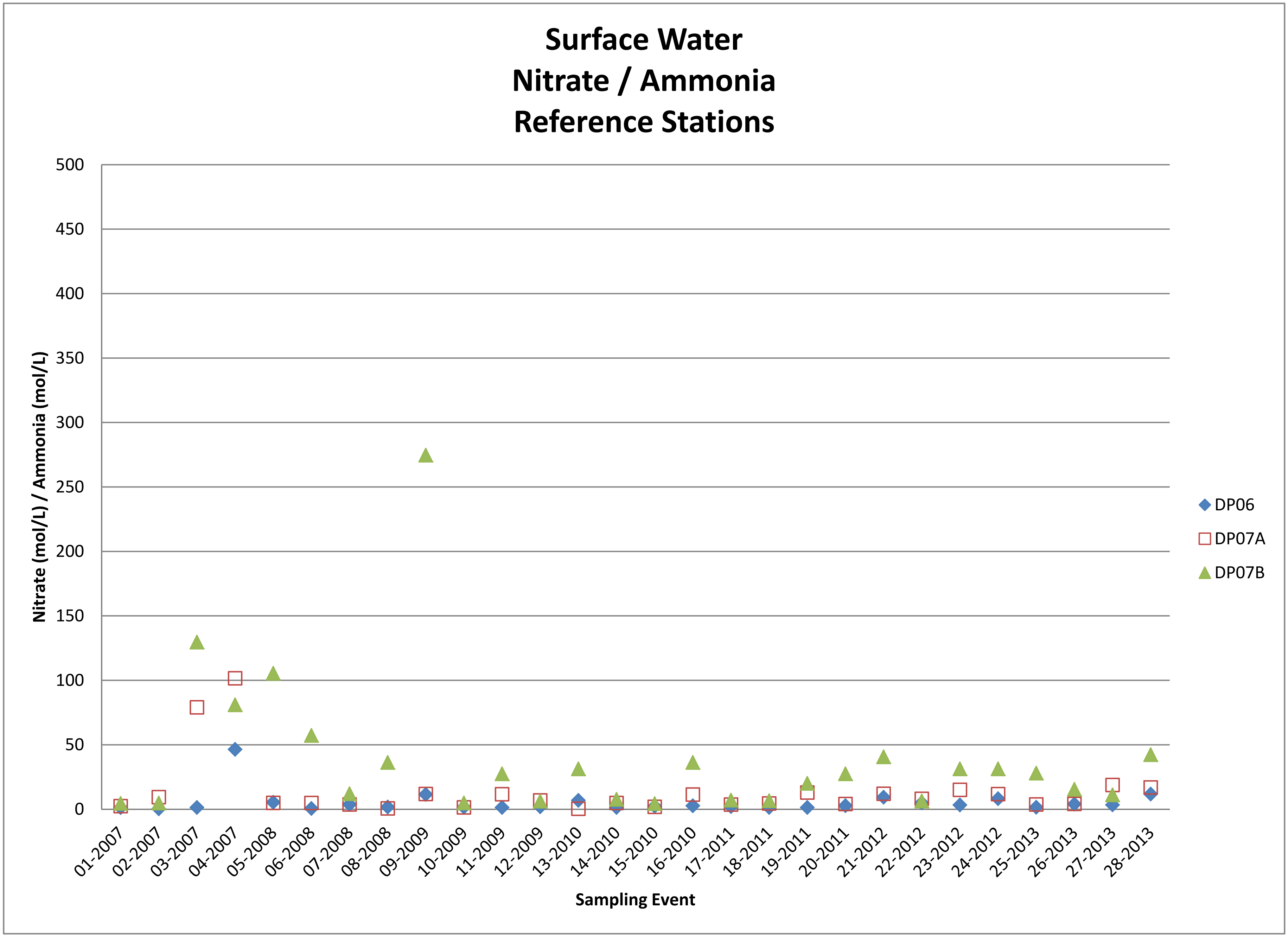


Surface Water
Total Nitrogen / Phosphorus (P)-Total
Reference Stations
Total Nitrogen (mol/L) / Phosphorus (P)-Total (mol/L)
900
800
700
600
500
400
300
200
100
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B
Redfield Ratio 16:1


Surface Water
Total Nitrogen / Phosphorus (P)-Total
Inter-Causeway Stations
Total Nitrogen (mol/L) / Phosphorus (P)-Total (mol/L)
0
100
200
300
400
500
600
700
800
900
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09
Redfield Ratio 16:1



Surface Water
Nitrate / Ammonia
Inter-Causeway Stations
Nitrate (mol/L) / Ammonia (mol/L)
500
450
400
350
300
250
200
150
100
50
0
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP02
DP03
DP04
DP05A
DP05B
DP08
DP09


Surface Water
Nitrate / Ammonia
Reference Stations
Nitrate (mol/L) / Ammonia (mol/L)
0
50
100
150
200
250
300
350
400
450
500
01-2007
02-2007
03-2007
04-2007
05-2008
06-2008
07-2008
08-2008
09-2009
10-2009
11-2009
12-2009
13-2010
14-2010
15-2010
16-2010
17-2011
18-2011
19-2011
20-2011
21-2012
22-2012
23-2012
24-2012
25-2013
26-2013
27-2013
28-2013
Sampling Event
DP06
DP07A
DP07B