PROPOSED NEW DISPOSAL AT SEA SITES

For Canpotex Potash Export Terminal, Ridley Island, Prince Rupert, BC

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EXECUTIVE SUMMARY

An assessment of the potential effects of disposal of dredged material at two proposed new disposal sites has been prepared to support the federal comprehensive study of the Canpotex Potash Export Terminal Project on Ridley Island, British Columbia. The comprehensive study is a joint assessment of the potash terminal and the Prince Rupert Port Authority's Road, Rail and Utility Corridor Project. Construction of the terminal's marine wharf will require a permit under the Disposal at Sea Regulations (subsection 127(1) of the *Canadian Environmental Protection Act* [*CEPA*]) for disposal of up to 840,000 m^3 of dredgeate.

Environment Canada (EC)'s designated disposal site in the Prince Rupert area is Brown Passage, which is approximately 30 km east of the Project site. Eight potential new disposal sites plus Brown Passage were identified for potential use for the Canpotex Project. All sites were compared from biological, physical, human use and economic perspectives. For the most part, biological and human use differences between sites are negligible. Based on economics (proximity of the dredge site) and physical differences (site capacity) only two of the sites, sites A and B, were deemed suitable. As a result, these were the only new sites carried forward in the assessment. Although it is less economical, Brown Passage was also assessed because it has been previously approved as a disposal site

The preferred disposal sites, sites A and B, are located within the boundaries of the Prince Rupert Port Authority. Site A is approximately 1 km west of the dredge site, offshore of Coast Island. Site B is approximately 6 km southwest of the dredge site, near the Kinahan Islands. Given the distance to EC's designated disposal site, identification of a site located closer to the Project would reduce the amount of vessel activity required, thus providing a more economical and environmentally-friendly option. Site A is sufficiently close to use a pipe network to transport the majority of material to the disposal site, thus almost eliminating the need for vessel transport, whereas the proximity of site B will result in an approximate five-fold decrease in the amount of vessel activity required.

Site A is approximately 195,715 m^2 with a range in depth of 30 to 68 m and a range in salinity of 26.8 to 31.5 parts per thousand (ppt). Site B is approximately 864,435 m^2 with a range in depth of 59 to 177 m and a range in salinity of 26.5 to 32.0 ppt. There are no utilities or other sub-sea infrastructure in close proximity to either of the proposed disposal sites and during benthic video surveys of each site, no archaeological resources were identified.

This assessment addresses potential concerns through a discussion of baseline conditions at the two proposed disposal sites, fate of the disposed material when it reaches the ocean floor, and potential effects on sediment, water quality, marine biota, and human uses (including First Nations, commercial, and recreational fishing). Existing baseline information was reviewed and sediment fate modeling was conducted to predict sediment accumulation, distribution and total suspended solid (TSS) levels during and after disposal.

Material to be disposed of at sea consists of subtidal dredged material from within the terminal's marine wharf and vessel berthing footprint. A sediment sampling program was conducted to assess physical and chemical sediment properties at both the disposal sites (November 2010) and the dredge site (December 2008 and June 2009). All sediment sampling procedures followed a protocol

developed to meet EC's guidelines for sample collection and quality control for the Disposal at Sea program. Sediment quality was assessed in relation to the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life, which include Interim Marine Sediment Quality Guidelines (ISQGs) and Probable Effects Levels (PELs). Concentrations below the ISQG values are not expected to be associated with any adverse biological effects, whereas concentrations above the PEL are expected to be frequently associated with adverse biological effects. The BC working sediment guideline based on the National Status and Trends Program Approach (NSTPA) was used for nickel.

Fifty six sediment samples were collected from 32 stations at the proposed dredge site. These samples are characterized by relatively low levels of most of the analyzed metals, with the exception of arsenic and copper, and to a lesser degree nickel. Concentrations of arsenic and copper exceeded the ISQG at all stations and at all depths; however, no value exceeded the guideline levels for PELs. Nickel concentrations were above the BC Working Guideline in 12 of 56 samples. The elevated levels of arsenic, copper and nickel noted in the dredge area were similar to those measured in disposal sites A and B and are suggestive of elevated background levels. Concentrations of arsenic and copper exceeded the ISQG at three stations at site A and six stations at site B, with all concentrations well below the guideline levels for PELs. Nickel concentrations were slightly above the BC Working Guideline at one station at site A and two stations at site B.

Two types of crab and a variety of shrimp species have the potential to occur at sites A and B. Important marine benthos habitat in the general vicinity include Dungeness crab (*Cancer magister*) habitat at both sites, tanner crab (*Chionoecetes* spp*.)* habitat at site A, and shrimp (*Pandalus* spp*.)* habitat at site B. Several fish species are present within Chatham Sound and although fish would occur at and around the disposal site, important fish habitat (as identified for the Pacific North Coast Integrated Management Area [PNCIMA]), has not been identified at either proposed disposal site. Sites A and B also ranked low in their overlap with important fish spawning habitat. The closest known herring spawning location is approximately 2.5 km from site A and 7.5 km from site B. In addition, the sites are more than 5 km from any rockfish conservation areas or eulachon spawning river.

Marine mammals are common in Chatham Sound. Harbour porpoises are found there year-round, particularly near Ridley and the Kinahan Islands. Humpback whales are also seen in the region throughout the year. Chatham Sound has been identified as potentially important for northern resident killer whales during the early summer (May to mid-July) when chinook salmon migrate to the Skeena and Nass rivers and chum salmon are present in the area. Northern resident killer whales are generally scarce after mid-July. Seabirds are also common throughout the area. There are no known important feeding areas nearby; however, two important bird colonies are present on the Kinahan Islands, approximately 2.5 km from both sites.

Ocean Ecology was retained to collect fish and benthic fauna composition data at both sites. Three surveys were conducted: a benthic macroinvertebrate sampling study in November 2010 (sites A and B), a towed benthic video survey in April 2011 (site A), and a drop camera video survey in July 2011 (site B). While the average number of individual benthic macroinvertebrates per sample did not show a statistically significant difference between the two sites, site B had statistically significant higher taxa richness and diversity indices than site A.

Sites A and B are both located directly in the plume of the Skeena River, resulting in normally high turbidity. The visibility at the sites seldom exceeded 1 m during the field surveys. Substrate at both sites is homogenously silt-mud, except for a small amount of rock seen in the northwest corner of site A. Significant currents were observed along the seafloor at site B (estimated to be as high as 1.5 m/s). Due to the depths, no flora was observed at either site. The most dominant fauna were unmounded holes at site A and krill and unmounded holes at site B (unmounded holes represent the observed surface disturbances caused by unidentified infauna such as burrowing polychaetes, some bivalve species, and mud shrimp).

Glass sponge reefs are not expected to occur at site A given that they are typically found at depths between 140 and 240 m. At one of the stations just outside site B, sediment collected during the macroinvertebrate survey was found to consist of approximately 25% dead Hexactinellid sponge fragments. Although no live sponges were found during either the video or macroinvertebrate surveys, the large amount of sponge debris suggests that living sponges must be occurring in close proximity to the outskirts of site B, or that strong, deep currents have transported sponge debris from an unknown location.

Both disposal sites overlap with commercial fisheries; specifically, shrimp trawling and crab trapping occur at both sites, and prawn trapping and red sea urchin catch occur at site B. There is no reported overlap with commercial geoduck catch, groundfish trawling, or outside groundfish hook and line catch. There is no known overlap with recreational fishing areas; however, both sites are adjacent to known recreational fishing sites.

Large commercial vessel traffic along the shipping routes to Prince Rupert is considered relatively light when compared to other ports along the coast. Within the next four years, one or two large ships per day, or approximately 387 to 524 per year, are projected to transit through port waters. These numbers are expected to increase to approximately 1,039 vessels by 2016, mainly as a result of planned expansion of the Fairview Terminal. Two cruise ship terminals service Prince Rupert and there are year-round ferry runs between Prince Rupert and both Port Hardy and the Queen Charlotte Islands, with increased service in the summer. There are also regularly scheduled ferry runs to and from Alaska.

There are three First Nations in the north coast with asserted traditional territories that encompass Prince Rupert Harbour and Chatham Sound: Lax Kw'alaams First Nation, Metlakatla First Nation, and Gitxaala Nation. All are Tsimshian peoples. No project-specific evaluation of First Nations' traditional use has yet been completed. However, First Nations have indicated that they are not in favour of Brown Passage as a disposal site and would prefer a site within the Prince Rupert Port Authority boundary. In addition, the Gitxaala Nation has indicated that it will produce a project-specific traditional use study that will encompass waters around both proposed disposal sites. Because of the location and depth below current sea levels of the proposed disposal at sea locations, potential First Nations traditional use of these locations expected to be limited to fishing. There is no known overlap with First Nations fisheries, with the exception of the First Nations halibut fishery which extends over the vast majority of Chatham Sound.

It is not anticipated that any archaeological sites, features, or deposits will be impacted as a direct result of offshore developments associated with the disposal at sea options discussed here. Sites A and B are 50 m and 100 m below modern sea level, respectively. Modelling of the sea level history in the Prince Rupert area indicates that in-situ archaeological materials related to terrestrial activity should not exist at depths greater than 3 m below present sea level.

The change in bathymetry resulting from disposal of sediment was modeled at each site. The modeling shows only limited dispersal of sediment beyond either disposal site and dispersal of sediment is limited to areas of deeper water depth (i.e., sediment does not disperse into shallower nearshore areas that would be highly productive fish habitat or habitat for species at risk). At site A, the disposal program is predicted to result in the overall addition of 1,200 mm to 5,192 mm within the 195,715 m^2 disposal site. Outside site A, sediment deposition greater than 1 mm will only occur to the north, where water depths exceed 30 m and near-bottom currents are relatively weak. The maximum distance of sediment dispersal out from the centre of the disposal site is 4.1 km. At site B, disposal is predicted to result in the overall addition of 200 mm to 1,155 mm within the 864,435 m2 disposal site. Outside site B, sediment deposition greater than 1 mm will only occur to the east and north, where water depths exceed 50 m and near-bottom currents are relatively weak. The maximum distance of sediment dispersal out from the centre of the disposal site is 5.3 km. Beyond the disposal site boundaries, the increase in thickness would range from 1 to 100 mm in most areas (with a small area immediately around site A receiving up to 3,000 mm). These increases in sediment depth would result in a slight change to the sites' bathymetry, but given water depth are not expected to affect navigation.

The changes in sediment thickness associated with disposal would occur primarily over a 45 to 140 day or 85 to 180 day period (site A and B, respectively) and would likely result in some burial, smothering and/or crushing of benthic organisms within the disposal site, especially where deposition is at its maximum. In cases where rate of sedimentation is not too great, organisms are able to migrate up through the deposited materials. Many benthic species are well adapted to the dynamic characteristics of soft bottom habitat and are able to dig out of deposited sediment, back to the surface. In cases where sedimentation rate exceeds the ability of organisms to survive burial, recolonization takes place primarily through immigration from adjacent areas and through larval recruitment. The sediment quality assessment for material to be dredged indicates the material will meet screening criteria of the *Disposal at Sea Regulation* and is not un-similar to levels found at the disposal sites; therefore, the addition of sediment to either proposed site is not expected to introduce contaminants to the marine environment at levels of concern. Changes in sediment thickness would not be expected to affect other marine organisms such as fish, crabs or shrimp, or commercial, recreational or First Nations fisheries.

Changes in water quality (increased TSS) were modelled for the periods during and immediately after disposal of materials. At site A, and just north of site A, provincial water quality guidelines would be exceeded only for the first few hours after each disposal event and would return to typical levels within six hours of completion of all disposal activities. At site B, and just southeast of site B, this level would only be exceeded for the first few hours after each disposal event and would return to typical levels within 7 hours of completion of all disposal activities. Movement of fish away from the area when there is elevated TSS may result in a minor and short-term reduction in fisheries catch in some areas, particularly within the disposal sites, during and immediately after disposal. Commercial, First Nations, and recreational fisheries are not expected to see a measurable long-term decrease in fish abundance due to TSS, either at the disposal sites, or further away.

At site A, the majority of material will be discharged as a slurry using a sub-surface pipe. Vessel use will be limited to the transport of large pieces of blasted rock for re-use in onshore development and trips by one to two tugs to relocate the barge supporting the pipeline to ensure even dispersal of the dredgeate across the disposal site. It is estimated that this vessel activity will result in up to 100 one-way trips (200 trips if two tugs are required). For site B, the material will be loaded onto a barge and then towed to the site. Assuming 2,000m^3 barges are used, it is estimated that barges will make a maximum of five return trips per day over 85 to 180 days, resulting in the addition of 850 one-way barge trips (425 return trips) between the loading site and site B. Barges will be towed by tugs and follow the most direct vessel route to the disposal site. Based on existing traffic, which is considered light, this increase in vessel traffic is not anticipated to interfere with navigation in the area. Research suggests that the probability of a vessel strike is positively correlated with a vessel's speed and that serious injuries to whales are rare at vessel speeds of less than 10 knots. Since speed during tow will be approximately 4 to 8 knots, strikes causing injury to marine mammals are not anticipated.

There are 11 *designatable units* listed at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that may occur near the proposed disposal sites. Of these, eight are listed in Schedule 1 of the *Species at Risk Act* (SARA): green sturgeon, marbled murrelet, grey whale, harbour porpoise, humpback whale, northern resident killer whale, transient killer whale, and Steller sea lion. Species at risk will be affected in a similar manner to organisms discussed above. Marine fish species at risk may temporarily move out of the area, but no long-term effects are expected. Fatal collisions to marine mammal species at risk as a result of increased vessel traffic are not expected at the proposed vessel speeds. Collisions with marine birds at risk would be few to none and would not affect local populations. There are no sensitive areas for species at risk within the area of impact of proposed disposal at sea activities.

A number of mitigations will be put in place to minimize effects on aquatic organisms, water quality and interference with vessel activity. These mitigations include reducing and reusing dredged material where possible, increasing the time between barge loads to provide organisms with time to unbury themselves and to decrease TSS concentrations, adherence to timing windows established through discussions with Fisheries and Oceans Canada (DFO), development of a Dredge Material Disposal Plan, capping vessel speeds at 8 knots and notifying the Prince Rupert Harbour Master of all barge activity.

Based on the analysis presented in this report both sites A and B have been identified as preferred disposal option over the current disposal site in Brown Passage. This determination is based primarily on the environmental and economic benefits associated with the use of sites A and B. Stantec respectfully requests that Environment Canada consider the designation of sites A and B as new disposal at sea sites.

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1 INTRODUCTION

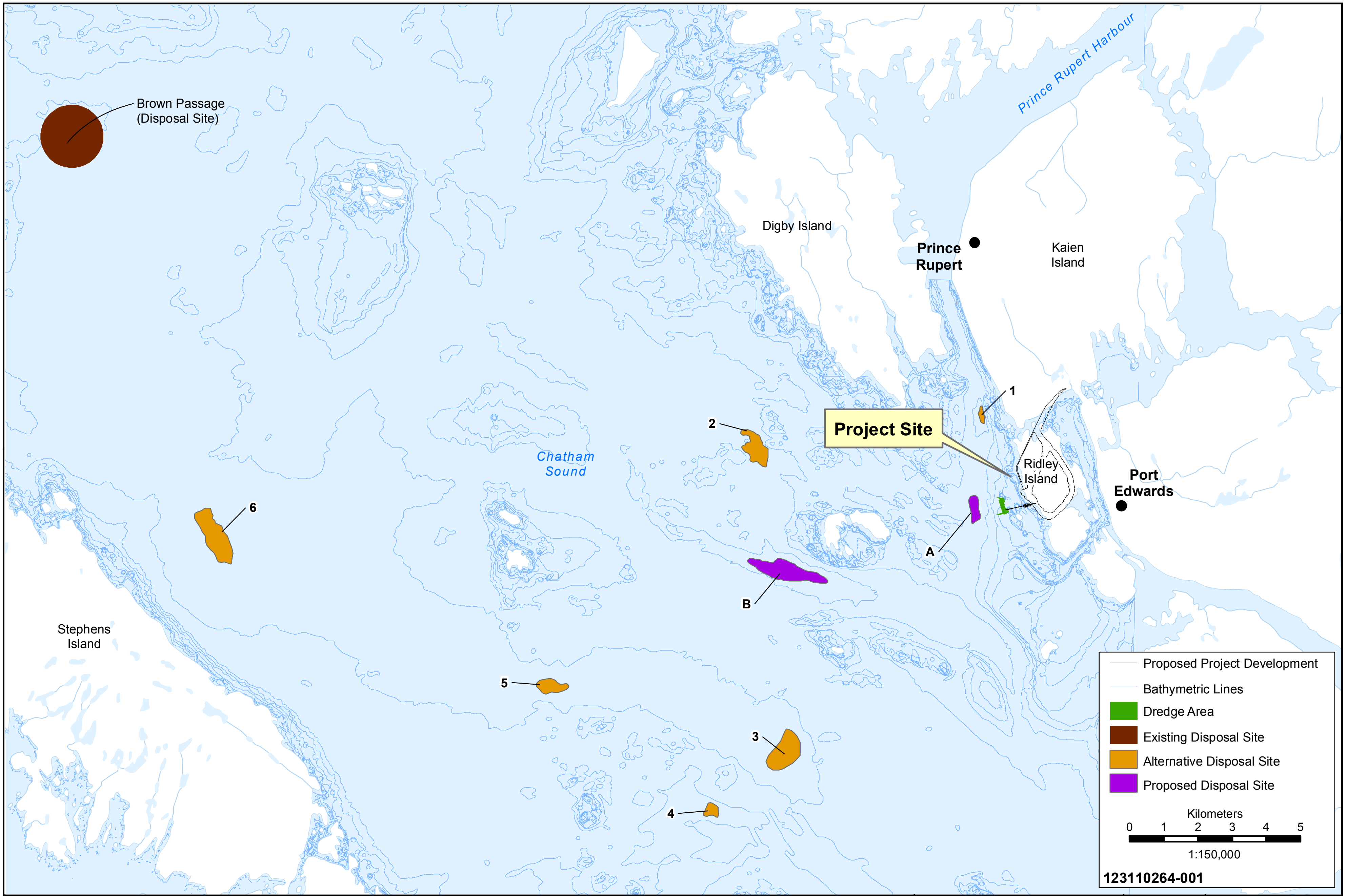
An assessment of the potential effects of disposal of dredged material at two proposed new disposal sites has been prepared to support the federal comprehensive study of the Canpotex Potash Export Terminal Project on Ridley Island, British Columbia (BC). The comprehensive study is a joint assessment of the potash terminal and the Prince Rupert Port Authority's Road, Rail and Utility Corridor Project. Construction of the terminal's marine wharf will require a permit under the Disposal at Sea Regulations (subsection 127(1) of the *Canadian Environmental Protection Act* [*CEPA*]) for disposal of up to 840,000 m^3 of dredgeate.

Environment Canada (EC)'s designated disposal site in the Prince Rupert area is Brown Passage located approximately 30 km east of the Project site (54°18.50 N, 130°45.50 W). Given the distance to Brown Passage, identification of a site located closer to the Project would reduce the amount of vessel activity required, thus providing a more economical and environmentally-friendly option. The proposed disposal sites, sites A and B, are located within the boundaries of the Prince Rupert Port Authority.

Site A is located offshore of Coast Island at 54.21601, -130.34928 and is approximately 195,715 m^2 with a range in depth of 30 to 68 m. Based on CTD (conductivity, temperature, depth) profiles taken in November 2010, salinity at site A ranged from 26.8 parts per thousand (ppt) at the surface to 31.5 ppt at depth. Site B is located southwest of the Kinahan Islands at 54.19872, -130.43417 and is approximately 864,435 m^2 with a range in depth of 59 to 177 m. Salinity at site B ranged from 26.5 ppt at the surface to 32.0 ppt at depth. Figure 1 shows the location of sites A and B relative to Prince Rupert, the terminal footprint and dredge site at Ridley Island, six alternative disposal sites and the Brown Passage disposal site.

This assessment addresses potential concerns through a discussion of how the two proposed disposal sites were selected, baseline conditions at the sites, fate of the disposed material when it reaches the ocean floor, and potential effects on sediment, water quality, marine biota, and human uses (including First Nations, commercial and recreational fishing). Existing information was reviewed and sediment fate modeling was used to predict sediment accumulation and distribution and total suspended solid (TSS) levels during and after disposal.

Material to be disposed of at sea consists of subtidal dredged material from within the terminal's marine wharf footprint. This material has been found to meet the screening criteria for contaminants described by CEPA (see Section 3.1.2).



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PROPOSED AND ALTERNATIVE DISPOSAL AT SEA SITE LOCATIONS
DISPOSAL AT SEA
RIDLEY ISLAND, BRITISH COLUMBIA

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2 CRITERIA FOR IDENTIFICATION OF NEW DISPOSAL AT SEA SITE(S)

2.1 Possible Alternative Disposal Sites

2.1.1 Screening Level Alternative Disposal Site Assessment

Eight possible new disposal sites plus Brown Passage were identified for potential use for the Canpotex Project (Table 1 and Figure 1). The sites were identified based on apparent suitability due to proximity, water depth and bathymetry (i.e., area available for disposal) and were compared from physical, human use, biological, and economic perspectives.

Water depth and bathymetry were a key consideration, as sufficient depth is needed to provide capacity for the volume to be disposed. Site one is the smallest and shallowest of the sites considered, with an approximate area of 60,500 m^2 and a depth of 60 m, and was not deemed suitable given the proposed dredge volume of 840,000 m^3.

Human use differences between sites are negligible apart from sites one and two, which are located close to the shipping lane. These sites may pose hazards to or interfere with navigation and would require further review to determine feasibility. As a result, they were dismissed from this assessment. The preferred site A is also located in the shipping lane but due to its proximity to the dredge site suction dredging would be used, which would significantly reduce vessel activity.

Ecological features were also an important consideration, especially with respect to highly productive habitat or habitat for species at risk. Sites four and five were dismissed for environmental reasons because the sediment plume resulting from disposal could affect nearby rockfish conservation areas (site four is within a rockfish conservation area and site five is between two).

Site six was dismissed as a result of its distance from the dredge site. At 23.8 km from Ridley Island, it is the furthest of the eight potential new sites and represents little economic advantage over the use of Brown Passage, especially considering the cost of assessing a new site.

Based on economics (proximity of the dredge site), site three was considered a less preferred option to sites A and B. As a result, sites A and B were the only new sites carried forward in the assessment. Though not economical, Brown Passage was also assessed because it has been previously approved as a disposal site.

2.2 Proposed New Disposal Sites

Sites A and B are both located within the Prince Rupert Port Authority boundaries; site A is located approximately 1 km west of the dredge site and site B is located approximately 6 km southwest of the dredge site near the Kinahan Islands (Figure 1). In contrast, Brown Passage is located approximately 30 km northwest of the dredge site. The proximity of site B will reduce the amount of vessel activity required to dispose of the dredgeate. Site A is sufficiently close to use a pipe network for transport of most dredgeate. The pipe would be suspended from a pontoon winched from a barge located over the disposal area. This setup would significantly reduce vessel transport needs as vessels would only be required for transport of blasted rock fragments that are too heavy or large for the pipe and for one or two tugs to adjust the pontoon to ensure homogenous distribution of dredgeate. Site A has the added benefit that use of a pipe will significantly reduce the sediment plume because the pipe outfall will be approximately 10 m above the seabed as opposed to upwards of 200 m when dumped from a barge.

Table 1: Comparison of Potential Disposal Sites

Characteristic	Site A	Site B	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Brown Passage
Description/location	Offshore Coast Island	Southwest Kinahan Islands	Offshore from Barrett Rock	Northwest Kinahan Islands	Southwest corner of port boundaries	North Porcher Island	Between Rachael Islands – Gull Rocks	Stephens Island	EC's designated disposal site
Travel distance from Ridley Island (km) (one way)	1	6	2.5	7.5	10.0	12.5	15	23.8	30
Maximum depth (m)	68	177	60	100	160	140	180	200	200
Approximate area (m^2)	195,715	864,435	60,500	491,754	744,242	132,456	284,079	911,000	2,692,475
Rock Fish Conservation Area	X	X	X	X	X	✓	✓	X	X
Important Crab Habitat	✓	✓	✓	✓	✓	✓	✓	✓	X
Important Shrimp Habitat	X	✓	X	✓	✓	✓	✓	✓	X
Commercial Fishing Area Overlap	✓	✓	✓	✓	✓	✓	✓	✓	✓
Comm. Shrimp Trawl Catch	✓	✓	✓	✓	✓	✓	✓	✓	✓
Comm. Prawn Trap Catch	X	✓	X	✓	X	X	✓	X	X
Outside Groundfish Hook and Line Catch	X	X	X	X	✓	✓	X	✓	✓
In First Nations Fishing Area	X	X	X	X	X	X	X	X	X
In Recreational Fishing Area	X	X	✓	X	X	X	X	X	X
Overlap with Shipping Route	✓	X	✓	✓	X	X	X	X	X

3 BASELINE CONDITIONS AND SETTING

Neither site A nor B has been used for disposal at sea in the past; therefore, no site-specific baseline data exists. To assess baseline sediment characteristics, a sediment sampling program was conducted to assess physical and chemical sediment properties at both the disposal and dredge sites. Where available, information in the general area of the sites was used to consider baseline conditions in terms of fisheries resources, First Nations and Traditional Uses, species at risk, utilities, navigation, archaeological and heritage resources, and other legitimate uses. Much of this information was obtained from government databases.

3.1 Sediment Chemistry and Quality

Environment Canada (EC) administers the *Disposal at Sea Regulation* under authority of the CEPA 1999, Part 7, Division 3, Disposal at Sea. All sediment sampling procedures followed a protocol developed to meet EC's guidelines for sample collection and quality control for the Disposal at Sea program (EC 2000). Sediment quality was assessed in relation to the Canadian Council of Ministers of the Environment (CCME 2002) guidelines for the protection of aquatic life, which include Interim Marine Sediment Quality Guidelines (ISQGs) and Probable Effects Levels (PELs). Concentrations below the ISQG values are not expected to be associated with any adverse biological effects, whereas concentrations above the PEL are expected to be frequently associated with adverse biological effects. Concentrations between the ISQG and the PEL represent the range in which effects are occasionally observed.

The BC working sediment guideline based on the National Status and Trends Program Approach (NSTPA) was used for nickel. Cadmium, mercury, PCB and total PAH levels were also assessed in relation to Disposal at Sea screening criteria, which are listed in Table 2. Sediment samples were analyzed by ALS Environmental Services for particle size, moisture content, total organic carbon, total metals (ICP-MS), PAHs and PCBs to determine if they meet criteria set by the *Disposal at Sea Regulation*. All samples collected were analyzed for total PAH (sum of 16 USEPA priority PAHs) and total PCB along with 17 individual PAH compounds and 9 PCB compounds.

Table 2: Disposal at Sea Screening Criteria

Parameter	Screening Limit
Cadmium	0.6 µg/g dry weight
Mercury	0.75 µg/g dry weight
Polycyclic Aromatic Hydrocarbons (PAHs)	2.5 µg/g dry weight (total PAH)
Polychlorinated biphenyls (PCBs)	0.1 µg/g

Source: Interim Contaminant Testing Guidelines (EC 2000)

3.1.1 Disposal Site

In November 2010, 59 sediment samples were collected from 49 stations (14 stations at site A, 35 stations at site B) in the proposed disposal sites to assess baseline sediment conditions. Ponar surface grab samples were composites of three individual grabs from the same general location. Sediment sampling protocol and results from the disposal sites A and B are provided in Appendix A and are summarized briefly below.

Particle Size

A total of five sediment particle size categories were identified at site A (grouped to compare with those used in the sediment disposal model): clay (0.004 mm, 29.7 %), fine silt (0.06 to 0.004 mm, 64.7 %), medium sand (2 to 0.063 mm, 3.2 %) and gravel (>2 mm, 0.3 %). Sediment particle sizes at site B were comparable: clay (0.004 mm, 28.9 %), fine silt (0.06 to 0.004 mm, 66.6 %), medium sand (2 to 0.063 mm, 4.1 %) and gravel (>2 mm, 0.5 %).

Total Organic Carbon (TOC)

Total organic carbon (TOC) provides a measure of how much organic matter occurs in sediments. TOC values in surface sediments at site A ranged from 1.39 to 2.09% with an average of 1.70%. TOC values in surface sediments at site B ranged from 1.33 to 1.84% with an average of 1.65%.

Metals

Overall, sediment samples from the samples at both disposal sites were characterized by relatively low levels of most of the analyzed metals, with the exception of arsenic and copper.

Concentrations of arsenic and copper exceeded the ISQG at three stations at site A and six stations at site B; however, all were well below the guideline levels for PELs. Nickel concentrations were slightly above the BC Working Guideline at one station at site A and two stations at site B. The highest cadmium and mercury concentrations at both disposal sites were well below the disposal at sea screening criteria (site A: four and six times lower, respectively; site B: three and eleven times lower, respectively) and all other analyzed metals were either below the detection limit or below the CCME ISQG or BC Working Guidelines.

Polycyclic Aromatic Hydrocarbons (PAH)

Total PAH levels at both disposal sites met the Disposal at Sea screening limit at all stations sampled. Total and individual PAH values were below analytical detection limits at all stations.

Polychlorinated Biphenyls (PCBs)

Total PCB and all PCB compounds were below analytical detection limits at all stations at both sites.

3.1.2 Dredge Site

In December 2008 and June 2009, 56 sediment samples were collected from 32 stations in the proposed dredge footprint to assess sediment conditions for disposal. Ponar surface grab samples

(20 stations) were composites of three individual grabs from the same general location. Sediment cores were also taken (12 stations), with three samples collected from each core at surface, 2 m and 5 m depths. Sediment sampling protocol and results from the dredge site are provided in Appendix B and are summarized briefly below.

Particle Size

Based on the sampling data, a total of five sediment particle size categories were identified and used in the sediment disposal model: clay (0.004 mm, 30.39%), fine silt (0.02 mm, 40.71%), coarse silt (0.05 mm, 21.18%), medium sand (0.2 mm, 6.5%) and gravel (30 mm, 0.17%).

Total organic carbon (TOC)

In surface sediment, TOC values ranged from 1.0 to 2.1% with an average of 1.4%. At 2 m depth, TOC values ranged from 0.78 to 0.94%, and at 5 m depth TOC values varied from 0.67 to 1.1%. These values are only slightly lower than those observed at the dredge site (average of 1.7% at site A and 1.65% at site B).

Metals

Overall, sediment samples from the 32 stations (surface, 2 m, and 5 m depths) were characterized by relatively low levels of most of the analyzed metals, with the exception of arsenic and copper, and to a lesser degree nickel.

Concentrations of arsenic exceeded the ISQG at all stations and at all depths; however, all were well below the guideline levels for probable biological effects. The ISQG for copper was exceeded at all stations and at all depths, but no copper value higher than the PEL was reported. Nickel concentrations were above the BC Working Guideline in four of 32 surface sediment samples, four of 12 samples collected from 2 m depth, and four of 12 samples collected at 5 m depth.

The highest cadmium and mercury concentrations were well below the screening criteria for dredged material (three and nine times lower, respectively) and only slightly higher than the values observed at the disposal sites. All other analyzed metals were below either the detection limit or the CCME ISQG or BC Working Guidelines.

The elevated levels of arsenic, copper and nickel noted in the dredge area were similar to those measured in the disposal sites and are suggestive of elevated background levels.

Polycyclic Aromatic Hydrocarbons (PAH)

Total PAH levels met the Disposal at Sea screening limit at all stations sampled. At most stations, all total and individual PAH values were below analytical detection limits. At eight stations, between one and four compounds showed detectable concentrations of PAHs with 2-methylnaphthalene and phenanthrene being the most frequently reported compounds in the monitored area. Fluoranthene and pyrene showed detectable levels at one station each. Only fluoranthene exceeded the ISQG in one surface sediment sample; however, the concentration was well below the PEL, and the fluoranthene concentration measured in a replicate sample collected at the same station met the ISQG.

Polychlorinated Biphenyls (PCBs)

Sediment samples at all stations were analyzed for nine PCB compounds. All compounds were below analytical detection limits and lower than the Disposal at Sea screening limit. As analytical detection limits for PCB compounds varied from 0.05 to 0.07 mg/kg, it was not possible to assess whether PCB-1254 and total PCB concentrations were below the CCME ISQGs (0.06 and 0.02 mg/kg, respectively) for all samples.

3.2 Fish and Other Aquatic Resources

3.2.1 Important Habitat

Data regarding important habitat for fish, crab, shellfish and other aquatic resources were obtained from a review of government databases including Coastal Resources Information Management Systems and Fisheries and Oceans Canada – Pacific (CRIMS 2010 Internet site; DFO 2010a Internet site) as well as Pacific North Coast Integrated Management Area (PNCIMA) data (Lucas *et al.* 2007).

Data obtained from government websites document important habitat for several marine species based on various studies and expert knowledge. Based on this data, important habitat for marine benthos and fish are summarized in Figures 2 and 3, respectively.

Two types of crab and a variety of shrimp species have the potential to occur at sites A and B. According to Figure 2, important marine benthos habitat in the general vicinity include Dungeness crab (*Cancer magister*) habitat at both sites, tanner crab (*Chionoecetes* spp.*)* habitat at site A, and shrimp (*Pandalus* spp.*)* habitat at site B.

Dungeness crabs are found from the intertidal zone down to depths greater than 180 m (DFO 2009a, internet site). They generally occur on sandy substrate with mature individuals found at greater depths, often buried just below the surface (Pauley *et al.*, 1986). Female crabs molt between May and August. Mating occurs after molting, before the new exoskeleton hardens. Eggs are fully developed, extruded and fertilized in fall (October or November) but remain attached to the female's abdomen until they hatch in late winter. During that time, females are often buried in the sand. Although both disposal sites are located within Dungeness crab habitat, most Dungeness crabs are found at depths of less than 50 m (DFO 2009a, internet site).

Three species of Tanner crab occur in the waters of British Columbia; two of these species (*Chionoecetes tanneri* and *Chionoecetes angulatus*) occur at depths of 500 to 3,000 m (DFO 2010b, internet site) and so are unlikely to occur at either of the proposed disposal sites. *Chionoecetes bairdi* is a nearshore, relatively shallow water species (0 to 400 m depth) that is found throughout BC, both in coastal inlets and offshore (DFO 2010b, internet site). The majority of adults migrate to water deeper than 100 m after reaching maturity (DFO 2009b, internet site). Adults tend to be found buried in mud-sand substrate; females are nocturnal and remain buried in the substrate during daylight hours (DFO 2009b, internet site). While *C. bairdi* has the potential to occur at both sites, it is more likely to occur in greater numbers at site B.

Six shrimp species occur on the British Columbia coast. These include: spiny pink shrimp (*Pandalus borealis*), humpback (king) shrimp (*Pandalus hypsinotus*), smooth (ocean) pink shrimp (*Pandalus jordani*), sidestripe (giant) shrimp (*Pandalopsis dispar*), coonstripe (dock) shrimp (*Pandalus danae*), and spot prawns (*Pandalus platyceros*) (DFO 2009c, internet site).

Spiny pink shrimp are typically found on muddy substrates from 20 to 900 m depth, with more frequent occurrence at 80 to 500 m (de Kluijver and Ingalsuo, internet site). This species was not seen during the site surveys; however, given their habitat preference they may occur at both sites A and B, perhaps more commonly at the deeper site B.

Humpback shrimp (also known as king shrimp) are typically found on smooth mud and sand bottoms, but may also occur on hard bottoms at depths ranging from 10 to 100 m (ADFG 2011a, internet site). This species is the main bycatch species for pink shrimp trawls at 54 to 90 m depth (DFO 2009c, internet site). Though not observed during the surveys, this species has the potential to occur at site A based on depth and substrate habitat preferences.

Smooth pink shrimp (also known as ocean pink shrimp) are generally found on green mud or mixed mud and sand bottoms, at a depth range of 36 to 457 m; however, they are usually found between 110 to 183 m depth. Males are found in shallower waters (75 to 128 m) than females during the first six months of the year, after which both sexes are generally mixed (Dahlstrom 1970). Though not observed during the site surveys, the potential exists for this species to occur at both sites A and B, perhaps more commonly at the deeper site B.

Sidestripe shrimp (also known as giant shrimp) are generally found on muddy bottoms at depths of 90 to 201 m (DFO 2009c, internet site), but can range from depths of 45 to 640 m (ADFG 2011b, internet site). Though not observed during the site surveys, the potential exists for this species to occur at both sites A and B, perhaps more commonly at the deeper site B.

Coonstripe shrimp (also known as dock shrimp) are typically found on sand or gravel bottoms where a rapid tidal current flows (DFO 2009c, internet site). This species can often be found around docks. Juveniles remain intertidal while adults range from subtidal to 185 m (Anon 2009, internet site). This species ranges over both depths at site A and B. Because it prefers habitats with sandy-gravel bottoms with rapid current, it is unlikely to occur at either of these sites.

Spot prawns are typically found in rocky crevices and under boulders (DFO 2009c, internet site) at depths from the intertidal to 487 m, however they are most commonly found from 198 to 234 m (Mormorunni, 2001). Considering their typical substrate and depth, this species is unlikely to be significantly affected at either site A or B.

Several fish species are present within Chatham Sound. Although fish would occur at and around the disposal site, important fish habitat, as identified for PNCIMA (Figure 3), has not been identified at either proposed disposal site. These areas also ranked low in overlap of important fish spawning habitat (Figure 3). Herring spawning generally occurs in late winter (February to as late as July) in BC, with the majority of spawning occurring in March from the high tide line down to 20 m depth (DFO and EC 1994). Spawning can occur as deep as 60 m. The closest known herring spawning location is approximately 2.5 km from site A and 7.5 km from site B. In addition, the sites are more than 5 km from any rockfish conservation areas or eulachon spawning rivers.

In addition to the above broad-scale important habitat characterization, Ocean Ecology conducted three site-specific field studies to characterize the baseline fish and benthic fauna composition of both sites: a benthic macroinvertebrate sampling study in November 2010 (sites A and B), a towed benthic video survey in April 2011(site A), and a drop camera video survey in July 2011 (site B). Results of these three surveys are presented in Appendices C, D and E, respectively, and are summarized briefly below.

3.2.2 Benthic Macroinvertebrate Survey

Benthic macroinvertebrate sampling was carried out at the two potential disposal sites using a standard Ponar grab equipped with sliders. A total of 10 benthic macroinvertebrate samples were collected (five at each of the two sites). Once separated from the sediment and fixed in solution, benthic organisms were identified using a ten times power magnifying lamp and a dissecting microscope.

Site A

A total of 490 individual organisms in 38 taxa were identified and enumerated from the five samples taken at site A. Four Phyla were represented - Mollusca (14 taxa), Annelida (Polychaeta – 21 taxa), Crustacea (two taxa), and Echinodermata (one taxon) (see Appendix C for details of species composition). While Phylum Annelida had the greatest number of taxa at the site, Phylum Mollusca had the greatest number of individuals (265). The average organism density was 1,875 organisms/m^2.Two diversity indices were calculated for each station at site A; the stations with the highest diversity tended to be on the landward side of site A, whereas the stations with lowest diversity tended to be on the seaward side.

Site B

A total of 302 individual organisms in 53 taxa were identified and enumerated from the five samples taken at site B. Five phyla were represented – Mollusca (18 taxa), Annelida (Polychaeta – 23 taxa), Crustacea (six taxa), Echinodermata (five taxa), and Chordata (one taxon; not actually an invertebrate, but included in the count for completeness) (see Appendix C for details of species composition). Phylum Annelida had both the greatest number of taxa and the greatest number of individuals (144) at the site. The average organism density was 1,156 organisms/m^2. According to the two diversity indices, diversity was highest in the northern region of the site, and decreased to the south.

Site Comparisons

While the average number of individual organisms per sample did not show a statistically significant difference between the two sites, site B had statistically significant higher taxa richness and diversity indices than site A (Appendix C). Species occurrence, composition, and abundance at each site were quite different, suggesting very different habitats between the two sites. Fourteen species were unique to site A and 29 were unique to site B. The dissimilarity of species composition between sites was found to be mostly the result of the presence of four species that were found predominantly at site A with only minimal occurrence at site B: *Nutricola tantilla* (a small bivalve), *Praxillella gracilis* (a bamboo worm), *Sternaspis fossor* (a dumbbell worm), and *Nuculana minuta* (another small bivalve).

3.2.3 Benthic Towed Video Survey (Site A)

A DGPS-positioned, towed video system was used to collect imagery of the seabed at Site A. The towed video system has two video cameras: one in a forward-looking orientation and one in a downward-looking orientation. These were towed approximately 1 m above the seabed at a speed of 0.7 knots. The survey design consisted of a grid survey pattern with a nominal shore-normal and shore-parallel transect line spacing of 120 m (see Appendix D, Figure 3). The field of view width of the camera was on average about 0.5 m across, resulting in an approximate area of 3,950 m^2 of visualized seafloor across site A. Raw video was reviewed and habitat classified using a substrate and biotic classification system that created a data record of substrate and biota classes for each second of video imagery.

Habitat Characteristics

Site A is located directly in the plume of the Skeena River, resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m. The site substrate was homogenously silt-mud, except for a small amount of rock seen in the northwest corner of the site. The majority of site A is flat and featureless. As such, anthropogenically-produced garbage, observed in small amounts, appeared to provide habitat complexity for organisms such as spot prawns, which aggregated in large numbers around the garbage.

Species Composition

Due to the depth of the site, no flora was observed.

The following commercial species were observed at site A:

- Spot prawns in high abundance
- Dungeness crabs in moderate abundance
- Tanner crabs in moderate abundance
- Flatfish in moderate abundance
- Longnose skates in low abundance.

The most dominant fauna at the site were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp. Unmounded holes were distributed more or less uniformly throughout the site. While not clearly identifiable, many clam species were probably present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.

As a group, fish were the most diverse organisms at the site. Northern ronquils were the second most abundant organism at site A. Also abundant were a variety of flatfish. Starry flounders and rock soles were found mainly in the northern half of the site, while northern ronquils and unidentified eelpout and sculpin species were observed throughout the site.

Spot prawns were the third most abundant fauna at the site, and were found mainly at depths below 50 m. Detailed analysis of video transects reported by Schlining (1999) showed that prawns were not usually associated with barren sediments, but appeared to actively seek out habitats that were more complex, including drift algae (loose kelp on the sea floor). Anthropogenically-produced garbage may also provide habitat complexity for these organisms. Male spot prawns are typically caught in bottom trawls on sandy or muddy bottoms, while females are rarely caught outside rocky habitat (Lowry, 2007; Berkeley, 1930); thus, the spot prawns observed at site A were most likely adult males.

Once they have settled and migrated to adult grounds, spot prawns appear to remain in a very restricted area throughout the rest of their life; probably limited by the size of the habitat patch they inhabit (Lowry, 2007). Tagging studies have shown that prawns were captured within 1.7 km of their release location over a period of several years (Kimker *et al.*, 1996). Observed spot prawns are probably a localized population, with limited migration out of the site into shallower areas with rockier substrate for feeding and during breeding.

Both Dungeness and tanner crabs were found in moderate abundance at site A. While their ranges overlap somewhat, Dungeness crabs tended to be found in shallower water than tanner crabs. As a result, the Dungeness crabs were located mainly around the “rim” of site A, whereas the tanner crabs were found in the “depression”.

Plumose anemones were found in association with the small amount of rock observed in the northwest corner of site A, whereas sea whips were found at both north and south ends, associated with silt-mud substrate. Both species occurred largely at depths shallower than 50 m, and thus were located in a “rim” around the site boundary.

In considering the entire site, fauna diversity is relatively low, with three species groups (i.e., unmounded holes, northern ronquils, and spot prawns) dominating the majority of the site. On a smaller scale perspective, 25% of the individual 30 m-width polygons considered showed no diversity (e.g., only one type of organism was observed within the polygon). It should be noted however, that since very small species (e.g., barnacles, small tube worms), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna often cannot be identified in the video footage, the actual fauna diversity of the site is probably higher than observed. Maximum species richness for the site occurred in the deeper regions of the site and towards the northern end of the site. In general, maximum diversity appears to be correlated with anything that increases habitat complexity, such as: (1) rocks in the northwest corner of the site; and (2) anthropogenically-derived garbage in the deeper northern parts of the site. Overall however, site A has a relative species richness that is only 37% of the maximum potential species richness observed in other sites around Prince Rupert (see Appendix D for details).

3.2.4 Benthic Drop Video Survey (Site B)

A DGPS-positioned, drop video camera system was used to collect imagery of the seabed at site B. Unlike the towed video system, the drop camera system was designed specifically for taking video in deep water, in this case down to 177 m. The drop video system has one video camera in a downward-looking orientation. The survey design consisted of 35 drops (36 were performed) with an approximate spacing of 200 m between drops (see Appendix E, Figure 3). The field of view of the camera was 0.25 m^2, resulting in a total 9 m^2 area of sampled seafloor across site B. Once dropped, the camera was left in position for 2 to 5 minutes. Raw video was reviewed and habitat classified using a substrate and biotic classification system that created a data record of substrate and biota classes for each second of video imagery.

Habitat Characteristics

Site B, like site A, is located directly in the plume of the Skeena River, resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m. The site substrate was homogenously silt-mud, with trace amounts of shell at most drop sites. In the deepest region of site B, a small amount of drift kelp was seen. Significant currents were observed along the seafloor, and at some drops were estimated to be as high as 1.5 m/s (5.4 km/h or 2.9 knots).

Species Composition

Due to the depth of the site, no flora was observed apart from a small amount of drift kelp. Spot prawns were the only commercial species observed at site B and this was near the northwest end of the site[1].

The most dominant fauna at the site in terms of number of observations were krill. Krill were most abundant at the northwest end of the site and formed dense aggregations just to the south of the central deep region.

The most dominant fauna in terms of area were unmounded holes. As discussed for the towed video survey of site A, unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp. Unmounded holes were present throughout most of the site, but were most abundant at the centre.

Chaetognaths (commonly known as arrow worms) were very abundant at the site, both in terms of number of observations and areal coverage. Unidentified bivalves were the third most abundant group in terms of areal coverage. They occurred throughout the site, but were also most abundant just to the south of the central deep region.

Larvaceans (free-swimming tunicates) and a small number of unidentified amphipods were distributed throughout the site. Sea whips and a single brittlestar were found in the northwest end of the site. A single unidentified seastar was observed near the centre.

As a result of the reduced area that was covered by the drop camera, fewer species will be observed relative to the towed camera system, and diversity indices calculated from the data produced by this methodology will tend to be lower. Therefore diversity indices for sites A and B cannot be compared. However, site B appears to have relatively little dominance of any one species and maximum species richness occurred towards the northwest end of the site, and in the deeper regions.

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[1] While relatively few spot prawns were seen using the drop camera, spot prawns are highly mobile and will rapidly leave an area when startled. Thus, it is expected that the population of spot prawns is higher than recorded by the drop camera.

3.2.5 Other Aquatic Resources

Glass sponge reefs are not expected to occur at site A given that they are typically found at depths between 140 and 240 m (Whitney *et al.* 2005). At one of the stations just outside site B, sediment collected during the macroinvertebrate survey was found to consist of approximately 25% dead Hexactinellid sponge fragments, a sample of which was later identified in the laboratory as *Aphrocallistes vastus*. Although no live sponges were found during either the video or macroinvertebrate surveys, the large amount of sponge debris suggests that living sponges must be occurring in close proximity to the grab station at the outskirts of site B, or that strong, deep currents have transported sponge debris from an unknown, upstream location. Deep sea corals could also occur at site B as they mostly occur between 100 and 200 m (Stone 2006); however, none have been documented at the site.

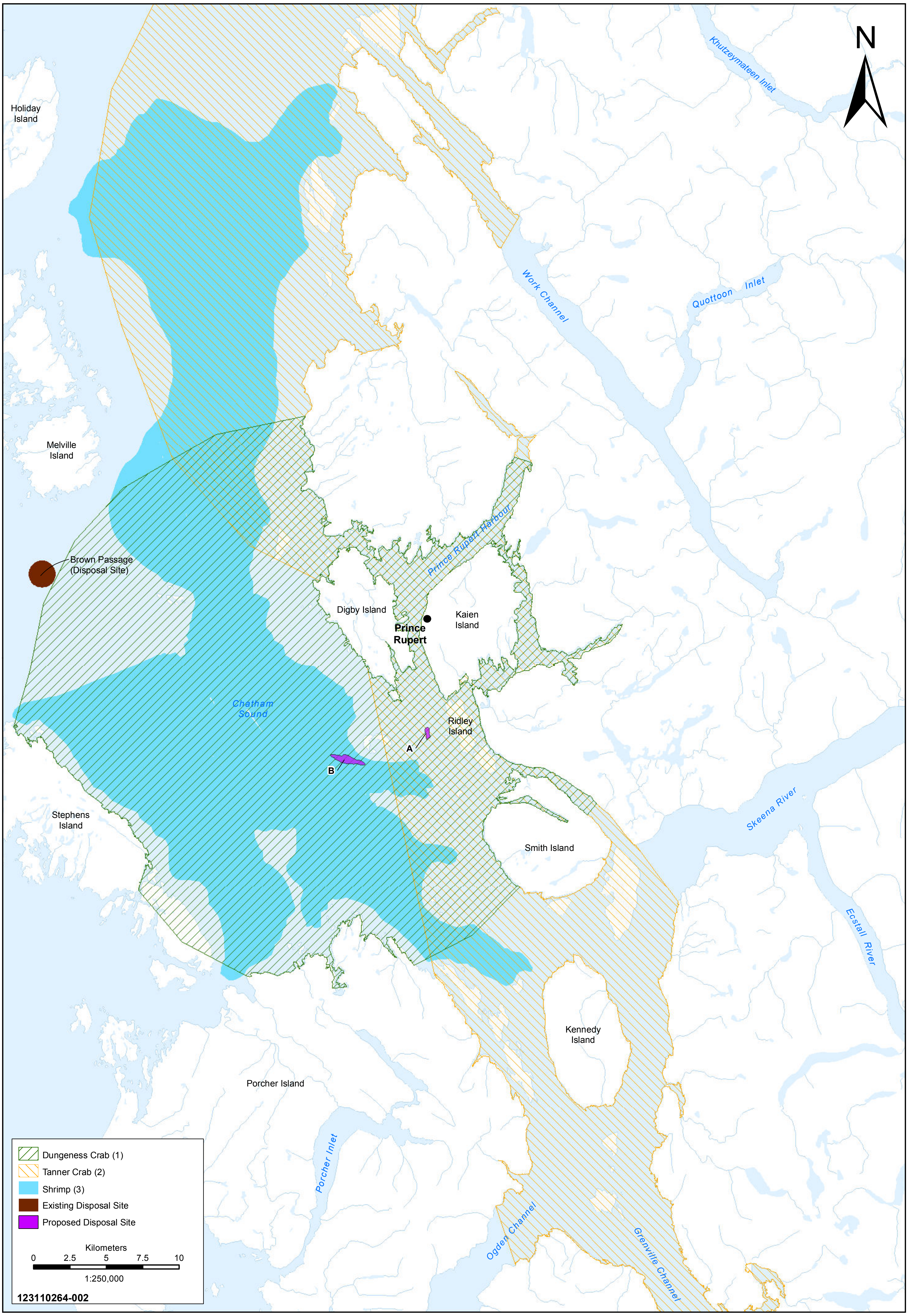
Marine mammals are common in Chatham Sound. Harbour porpoises are found there year-round, particularly near Ridley and the Kinahan Islands. Humpback whales are also seen throughout the year. Chatham Sound has been identified as potentially important for northern resident killer whales during the early summer (May to mid-July) when chinook salmon migrate to the Skeena and Nass rivers and chum salmon are present in the area. Northern resident killer whales are generally scarce after mid-July (Ford 2006). Seabirds are also common throughout the area. As a result, marine birds may be found at the surface. There are no known important feeding areas nearby; however, two important bird colonies are present on the Kinahan Islands, approximately 2.5 km from both sites.

3.3 Species at Risk

The purpose of the *Species at Risk Act* (SARA) is to:

- Prevent Canadian indigenous species, subspecies and distinct populations of wildlife from being extirpated or becoming extinct
- Provide for the recovery of wildlife species that are extirpated, endangered, or threatened as a result of human activity
- Manage species of special concern to prevent them from becoming further endangered or threatened.

If a species is listed under Schedule 1 of SARA as *Extirpated, Endangered* or *Threatened*, that species has legal protection related to the species' residence and critical habitats as well as recovery planning. For species of *Special Concern*, there is no similar legal prohibition per se; however, recovery planning is likely to include the development of a management plan specific to that species.



* NOTES: Numbers in parentheses correspond to references provided in Appendix F.

Client:

Canpotex

PRINCE RUPERT PORT AUTHORITY

IMPORTANT AREAS FOR MARINE BENTHOS
DISPOSAL AT SEA
RIDLEY ISLAND, BRITISH COLUMBIA

Job No.:	123110264
Scale:	1:250,000
Date:	13-Sep-11
Dwn. By:	NP
App'd By:	SW

Fig. No.:
2

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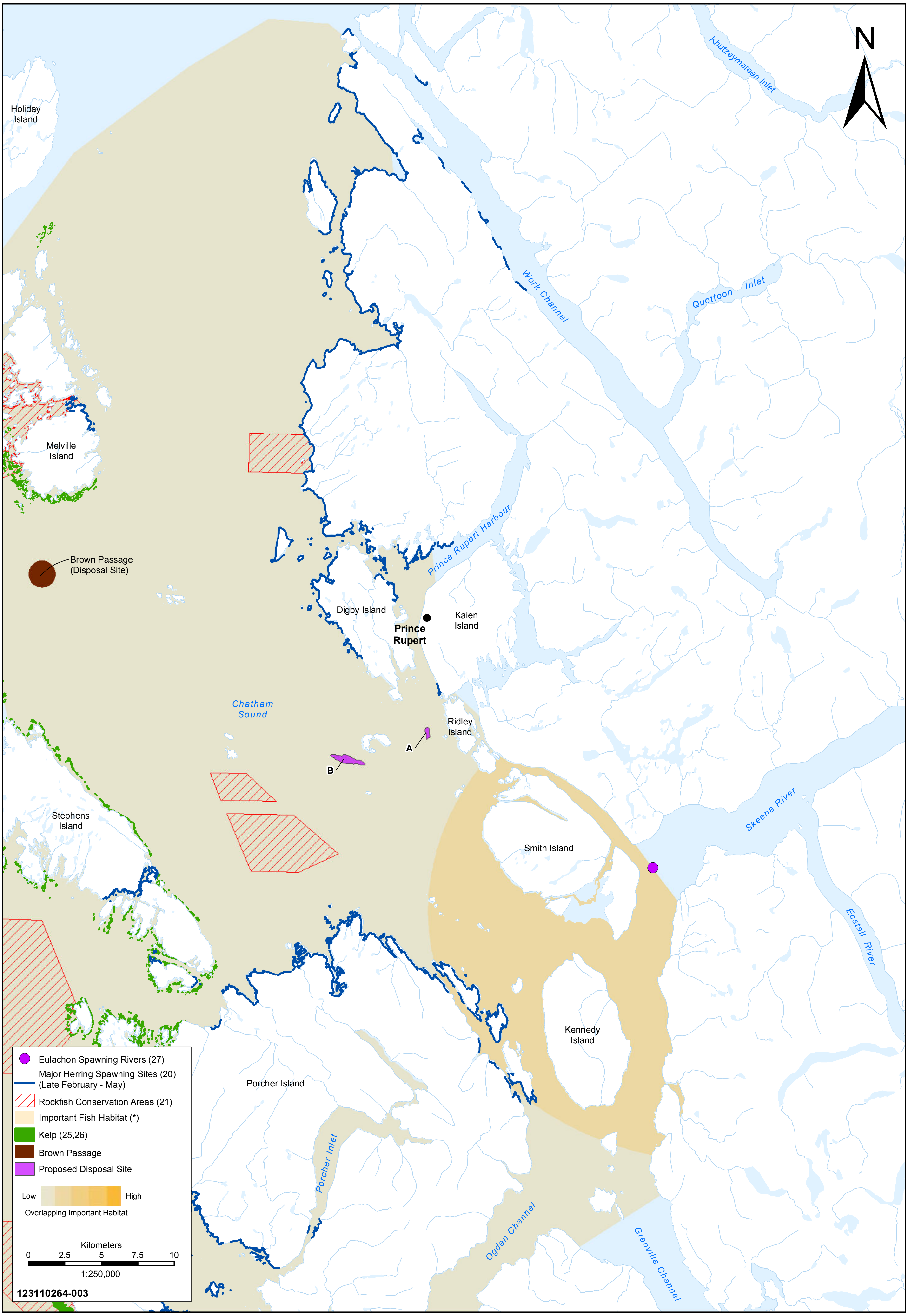

* REFERENCES: 17, 20, 27, 28. Numbers correspond to references provided in Appendix F.

Client:

Canpotex

PRINCE RUPERT
PORT AUTHORITY

IMPORTANT FISH HABITAT AREAS
DISPOSAL AT SEA
RIDLEY ISLAND, BRITISH COLUMBIA

Job No.: 123110264
Scale: 1:250,000
Date: 13-Sep-11
Dwn. By: NP
App'd By: SW

Fig. No.:
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Table 3 lists marine species that may occur either at or en route to the two proposed disposal sites and that have been identified as *Endangered*, *Threatened*, or *Special Concern* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Table 3 also provides their federal status under the *Species at Risk Act* (SARA) and their provincial status according to the BC Conservation Data Centre (CDC). Species listed on the CDC red or blue lists that are not listed by either COSEWIC or SARA were not included.

There are 11 *designatable units*[2] listed at risk by COSEWIC that may occur near the proposed disposal sites. Of these, eight are listed in Schedule 1 of SARA. The presence of listed species was identified based on range and distribution reported in COSEWIC status reports and expert opinion. Although other species-at-risk may be encountered in the area on rare occasions, those listed below are considered to be the most likely.

Table 3: Marine Species of Conservation Concern Most Likely to occur Near Proposed Disposal Sites A or B

Common Name	Scientific Name	COSEWIC Status	SARA Schedule[1]	British Columbia Status
Fish				
Eulachon (Nass/Skeena Rivers population)	Thaleichthys pacificus	Threatened	No schedule, No status	Blue
Green sturgeon	Acipenser medirostris	Special Concern	Schedule 1	Red
Quillback rockfish	Sebastes maliger	Threatened	No schedule, No status	No status
Yelloweye rockfish (outside waters population)	Sebastes ruberrimus	Special Concern	No schedule, No status	No status
Marine Birds				
Marbled murrelet	Brachyramphus marmoratus	Threatened	Schedule 1	Blue
Marine Mammals				
Grey whale	Eschrichtius robustus	Special Concern	Schedule 1	Blue
Harbour porpoise	Phocoena phocoena	Special Concern	Schedule 1	Blue
Humpback whale	Megaptera novaeangliae	Special Concern	Schedule 1 (threatened)	Blue
Killer whale (northern resident)	Orcinus orca	Threatened	Schedule 1	Red
Killer whale (transient)	Orcinus orca	Threatened	Schedule 1	Red
Steller sea lion	Eumetopias jubatus	Special Concern	Schedule 1	Blue

NOTES:

[1] Status under the SARA is the same as COSEWIC status unless otherwise stated.

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[2] This grouping includes species that have been broken down into separate populations, stocks, or ecotypes, and are listed as such (i.e., an individual species may have more than a single listing).

3.4 Human Uses

3.4.1 Fisheries and Other Marine Uses

Information on fisheries and other human uses within the area was obtained from government websites (CRIMS 2010 Internet site; DFO 2010a Internet site) and traditional use studies (MacDonald 2009; Menzies 2008), and is shown on Figures 4 and 5. References for information used on the figures and individual maps of fisheries by catch type are found in Appendix F. Areas shown include:

- Commercial and recreational fishing areas
- First Nations band locations and fisheries
- Industry sites, aquaculture sites
- Parks and protected areas
- Indian reserves, anchorage, boat launches and marinas
- Vessel routes.

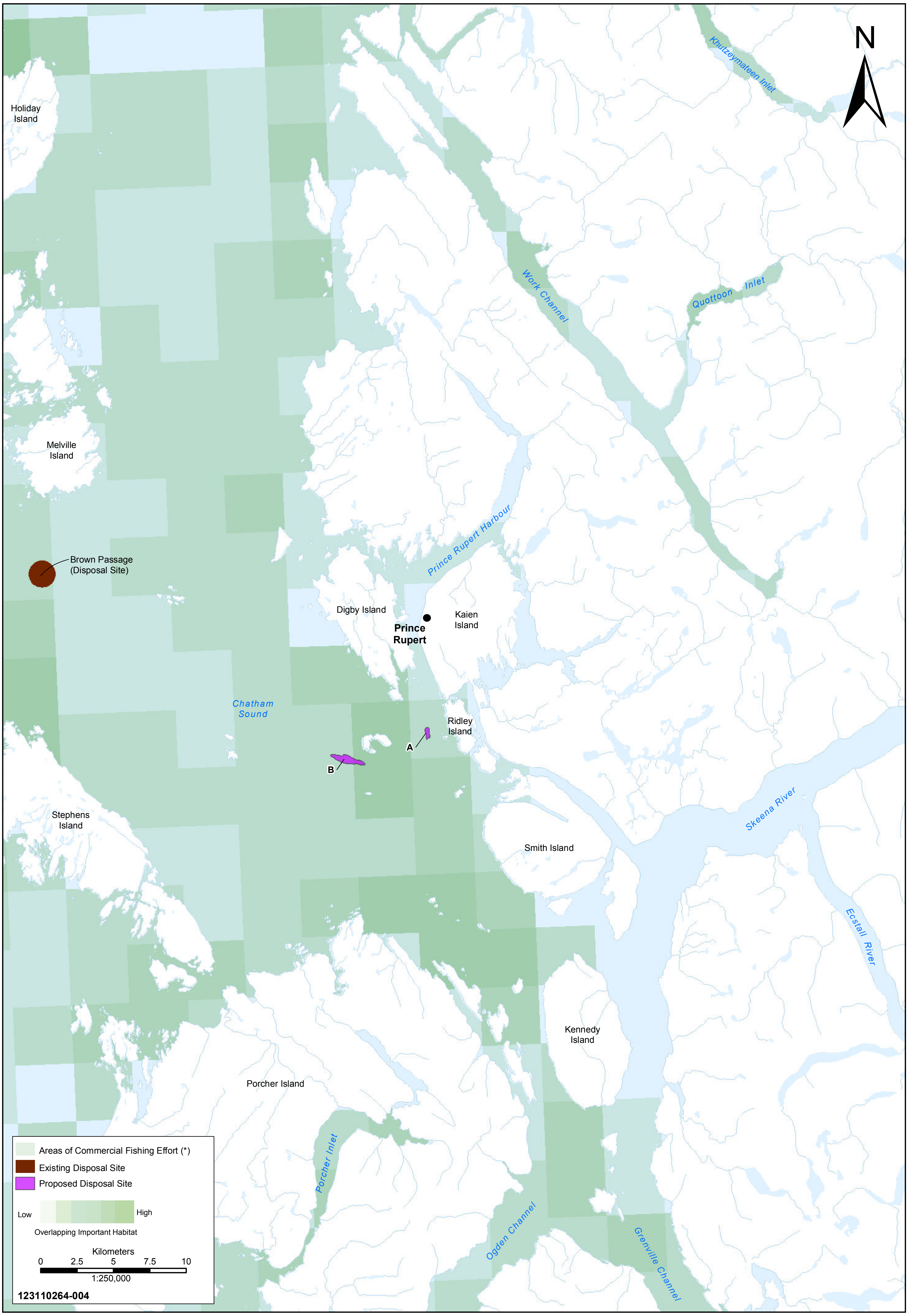
Both proposed sites overlap with some commercial fisheries (Figure 4). Specifically, shrimp trawling and crab trapping occur at both sites, and prawn trapping and red sea urchin catch occur at site B (Figures F-1, F-2, F-3 and F-7; Appendix F). There is no reported overlap with commercial geoduck catch, groundfish trawling, or outside groundfish hook and line catch (Figures F-4, F-5, F-6; see Appendix F). There is no known overlap with First Nations fisheries, with the exception of the halibut fishery which extends over the vast majority of Chatham Sound (Figure 5).

There is no known overlap with recreational fishing areas; however, both sites are adjacent to known recreational fishing sites (Figure 5).

3.4.2 Vessel Traffic and Navigation

The Port of Prince Rupert is located along the Pacific Great Circle Route between Asia and the west coast of North America, making it the first inbound and last outbound port of call. The port handles commodities produced throughout Western Canada including lumber, pulp, grains and coal destined for export markets. It also handles imports of steel and wax destined for manufacturing plants in Alberta. Major shipping routes to and from the Port of Prince Rupert are shown in Figure 5.

The Prince Rupert port boundaries comprise more than 350 km of coastline. Several marinas, docks, jetties, wharves and terminals are located within the Prince Rupert port boundaries. Baseline navigational use within the Prince Rupert port boundaries was determined through a review of available literature, government websites and databases, and consultation with various stakeholders.



* REFERENCES: 4, 5, 6, 7, 9, 10, 11, 12, 13. Numbers correspond to references provided in Appendix F.

Client:

Canpotex

PRINCE RUPERT
PORT AUTHORITY

AREAS OF OVERLAPPING COMMERCIAL FISHING
DISPOSAL AT SEA
RIDLEY ISLAND, BRITISH COLUMBIA

Job No.:	123110264
Scale:	1:250,000
Date:	13-Sep-11
Dwn. By:	NP
App'd By:	SW

Fig. No.:
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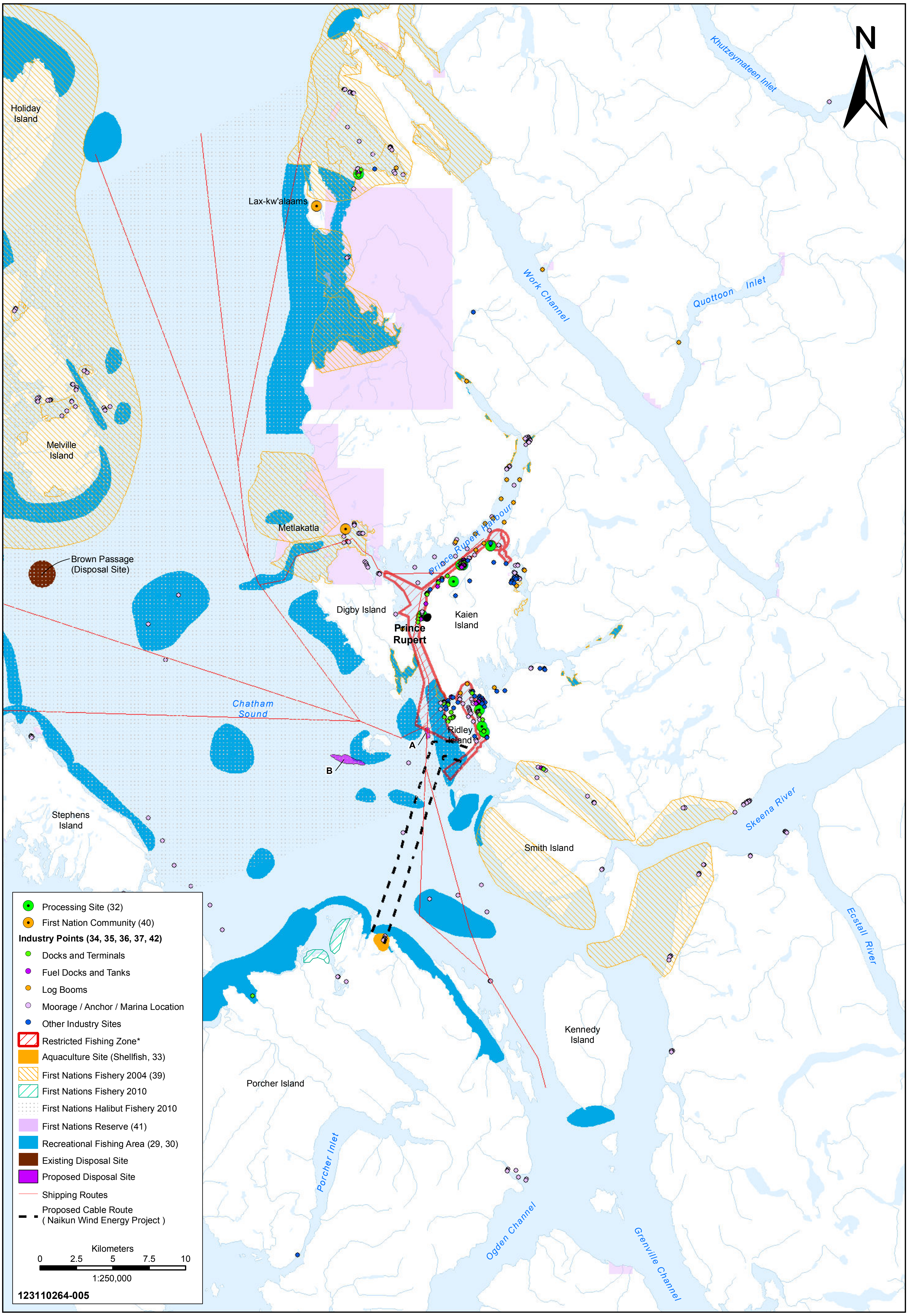

* NOTES: Fishing is permitted unless fishing gear creates obstacles or safety hazards to shipping and/or anchorage; regulated by Prince Rupert Port Authority. Numbers in parentheses correspond to references provided in Appendix F.

Client:

Canpotex

PRINCE RUPERT
PORT AUTHORITY

Job No.: 123110264
Scale: 1:250,000
Date: 13-Sep-11
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Fig. No.:
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Stantec

HUMAN USE AREAS
DISPOSAL AT SEA
RIDLEY ISLAND, BRITISH COLUMBIA

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Large commercial vessel traffic along the shipping routes to Prince Rupert is considered relatively light when compared to other ports along the coast. Traffic generally includes coal, grain, pellet, wood chip and wax carriers, container ships, cruise ships, logs and tankers. Within the next four years, one or two large ships per day, or approximately 387 to 524 per year, are projected to transit through port waters. These numbers are expected to increase to approximately 1,039 vessels per year by 2016, mainly as a result of planned expansion of the Fairview Terminal.

In addition, two cruise ship terminals service Prince Rupert and there are year-round ferry runs between Prince Rupert and both Port Hardy and the Queen Charlotte Islands, with increased service in the summer. There are also regularly scheduled ferry runs to and from Alaska.

Statistics on the number of small to medium-sized vessels are not available for the area. Numbers of clients using the local small craft harbours were obtained from the Small Craft Harbour Authority for 2009. Commercial fishing vessels make up about half of the client records at the local harbours. Total visits recorded at all three harbours average 217 per month and 2,600 annually.

3.4.3 First Nations/Traditional Use

There are three First Nations in the north coast with asserted traditional territories that encompass Prince Rupert Harbour and Chatham Sound: Lax Kw'alaams First Nation, Metlakatla First Nation, and Gitxaala Nation. All are Tsimshian peoples.

No project-specific evaluation of First Nations' traditional use has yet been completed. However, First Nations have indicated that they are not in favour of Brown Passage as a disposal site and would prefer a site within the Prince Rupert Port Authority boundary. In addition, the Gitxaala Nation have indicated that they will produce a project-specific traditional use study that will provide more detailed information on their traditional use of waters within port boundaries.

Because of the location and depth below current sea levels of the proposed disposal at sea locations, potential First Nations traditional use of these locations is limited to the watercraft-based fishing activities. The proposed disposal sites do not overlap with any known important First Nations fishing areas, with the exception of the First Nations halibut fishery which extends over the vast majority of Chatham Sound (Figure 5).

3.4.4 Archaeological and Heritage Resources

3.4.4.1 Regional Sea Level History

The differential effects of glacio-eustatic, isostatic, and tectonic change have resulted in a complicated relative sea level history for the north coast of British Columbia. The Hecate Strait area has been the focus of much recent research aimed at refining our knowledge of this history. A general model of sea level change for the Prince Rupert "outer mainland coast" area has been developed through the analysis of isolation basins, ancient beaches and archaeological sites (Fedje *et al.* 2005).

The model indicates that by 12,500 B.P. the sea level was 50 m higher than at present. Following 12,500 B.P., sea levels fell rapidly until about 12,000 B.P. Thereafter, sea levels continued to fall gradually until approaching present-day shoreline elevations by about 8,000 B.P. Sea levels appear to have continued to fall until reaching a low point of about 3 m below present level sometime between 8,000 B.P. and 5,000 B.P. Following this low-stand, the relative sea level has gradually risen to modern levels (Figure 6).

3.4.4.2 Implications for Archaeological Site Locations

According to the model, archaeological sites pre-dating 8,000 B.P. should be located at elevations above the present shoreline. Similarly, sites post-dating about 5,000 B.P. should be expected at or very near modern shoreline elevations. Sub-tidal sites are only predicted for the period between 8,000 B.P. and 5,000 B.P. Further, sub-tidal sites are not expected to be located at depths greater than about 3 m.

This model fits well with known archaeological site location data for the Prince Rupert Harbour area. No archaeological sites on the northern mainland coast are known to predate 5,000 B.P. despite similarly ancient sites in Alaska, Haida Gwaii and on the Central Coast. A possible exception exists at Bish Cove near Kitimat where a site has been recently identified in association with a raised palaeo-shoreline and is indirectly dated to 9,500 B.P. (Streeter 2005). One interpretation for this lack of data, despite relatively thorough survey in the area, is that many older sites are located either on raised beaches, on difficult to access hill slopes, or they are submerged (Fladmark *et al.* 1990). Several archaeological sites in the Prince Rupert Harbour area are partially submerged and are therefore thought to possibly date to the 8,000 to 5,000 B.P. period (Ames and Maschner 1999).

3.4.4.3 Offshore Archaeological Potential

Proposed disposal at sea locations A and B are 100 m and 50 m below modern sea level, respectively. No in-situ archaeological materials related to terrestrial activity are expected to exist at a depth of greater than 3 m below present sea level according to the area sea level history detailed above. A previous archaeological impact assessment conducted for Naikun Wind Farm Development had an underwater archaeology component which assessed areas covering the proposed disposal at sea locations footprint as having low archaeological potential (Eldridge *et al.* 2009).

It is not anticipated that any archaeological sites, features, or deposits will be impacted as a direct result of the disposal at sea options discussed here.

3.4.4.4 Potential for Ship and Aircraft Wreckage

Charles Moore (2009) conducted archival research regarding potential for encountering ship and aircraft wreckage sites for Naikun Wind Farm Development project, which included coverage of the project footprint for the proposed disposal at sea locations A and B. This study identified a very high density of protected wreckage sites in the Chatham Sound area, with an average of 5.84 sites/100 km^2 (Moore 2009:38).

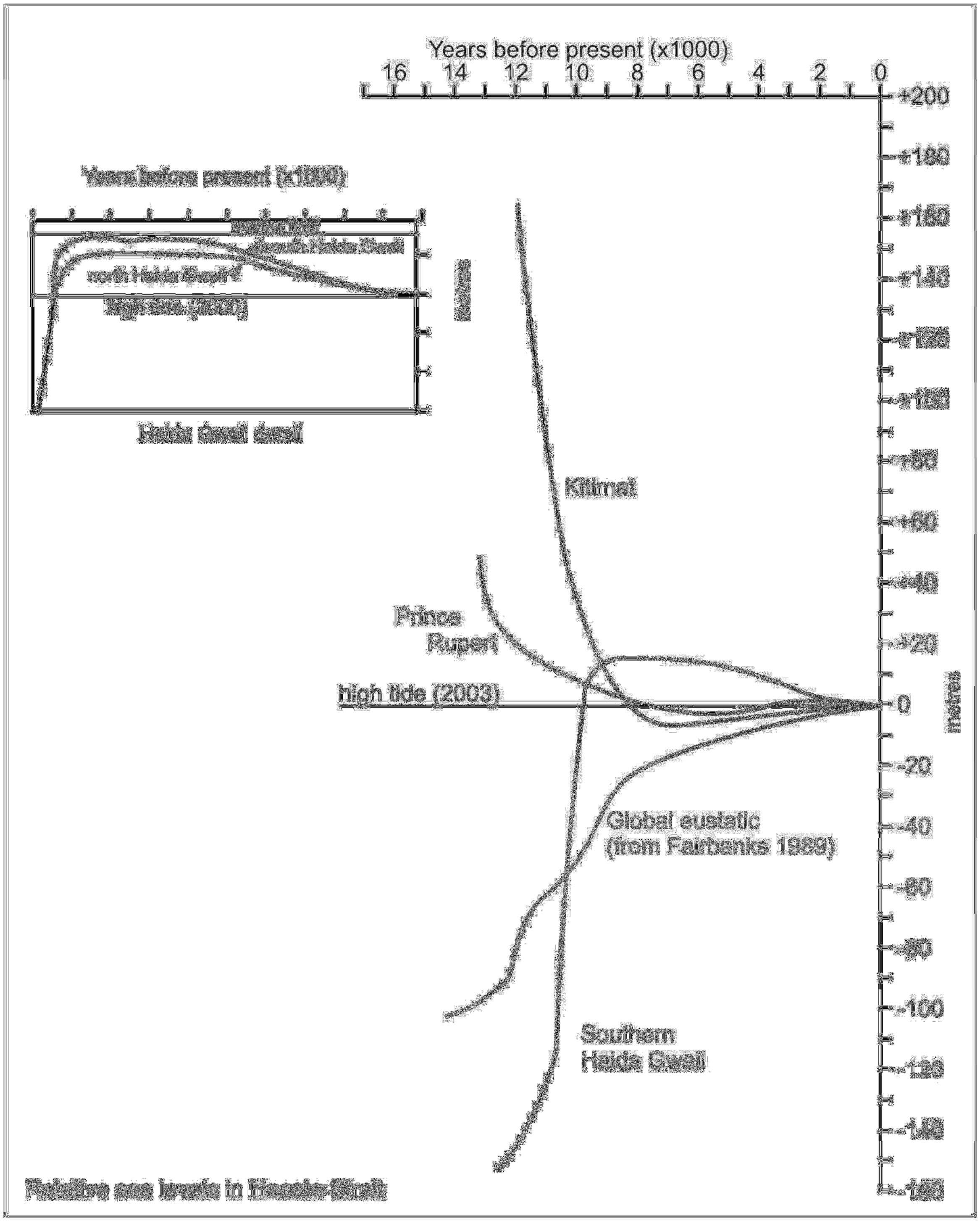

Figure 6: **Relative Sea Levels in Hecate Strait (from Fedje *et al.* 2005)**

Two ship wrecks, the Rosina B. and Newcastle 4, were recorded as being lost within close vicinity to proposed disposal at sea location B. However, these wrecks were deemed unlikely to still be preserved due to their material composition, size and time passed since the wreckage (Moore 2009: 38).

One shipwreck, the Kingwood, was recorded as being lost in proximity to, but outside of, proposed disposal at sea location A. While it was a small vessel, it was made of steel and lost recently in 1996. Moore also discussed wreck significance based on potential for human remains and historical significance. The Kingwood was not listed among wrecks deemed to be significant (Moore 2009:38).

4 ASSESSMENT OF CURRENT FLOWS AND SEDIMENT TRANSPORTATION CHARACTERISTICS

The major oceanographic processes that will determine the deposition, dispersion and transport of the discharged sediments are the tidal, river and wind driven currents. Historical ocean current data was collected by the Institute of Ocean Sciences (IOS) and DFO's Canadian Hydrographic Service (CHS), at two ocean currents mooring sites near the potential disposal sites, one to the south of Kinahan Island (instrument depth 16 m and measurement period of May to September, 1982) and the other off the west coast of Ridley Island (instrument depth 17 and 31 m, and measurement period of May to September, 1993) (see Figure 1 of Appendix G). These data were used by ASL Environmental Sciences (ASL) in their sediment transport model calibration and verification, which involved tidal forcing, river input, and wind forcing.

At 16 m depth at the mooring site, ocean current speeds measured in June 1982 ranged from approximately 0 to 0.5 m/s. Peak ebb and flood flows for this period, measured at 2.5 m below chart datum are presented in Figure 4 of Appendix G.

5 EFFECTS ASSESSMENT

Dredging during the construction phase will generate materials that will be suitable for disposal at sea. Only material deemed suitable for disposal at a designated site in accordance with the *Canadian Environmental Protection Act* will be considered. Dredging itself is not addressed here, as it was assessed in the Environmental Assessment. Project activities with the potential to result in effects on the environment are: (1) disposal of the material at the designated disposal site; and (2) vessel traffic required for the transport of material.

Based on these project activities, three potential effects on the environment are assessed:

- Change in sediment quality and quantity – potential impacts on fish, fish habitat, species at risk and human use
- Change in water quality – potential impacts on fish, fish habitat, species at risk and human use

- Increases in vessel traffic – potential impacts on navigation, fish and human use.

5.1 Project Activities

Development of the proposed potash export terminal on Ridley Island will include construction of a marine wharf and a berthing pocket. It is not feasible to construct the wharf to completely avoid dredging. The sediment depths and undulations in the bedrock offshore of Ridley Island limit where the wharf and access trestle can be constructed. As a result, it is necessary to dredge a berthing pocket to create the water depth needed for safe vessel movement and berthing at the berth face. The estimated dredge volume is approximately 810,000 m^3 of sediment and 40,000 m^3 of rock material. Rock will be used as infill where possible; rock not used as infill will be disposed of at sea. These values were used in sediment disposal modelling (see Section 5.2.1 below).

The method for disposal of dredged material will depend on the proximity of the selected site. For site A, the majority of the material will be discharged as a slurry at about 10 m above the seafloor using a sub-surface pipe. The blasted rock will be transported by vessel for use in on-shore developments where possible. For site B, all material will be loaded onto a barge and then towed to the site.

Before release into water, the disposal material has a density of 1,280 kg/m^3 (or dry density about 420 kg/m^3) for site A in the pipe, and 1,340 kg/m^3 (or dry density about 513 kg/m^3) for site B on the barge. When placed under water, the volume of the disposal material would increase by a factor up to 1.4. The upper limit bulking factor of 1.4 was used in the modelling to be conservative in the sense of estimating the maximum volumes of sediment discharges.

The disposal pipe at site A will have a diameter of about 1 m and be positioned about 10 m off the seabed. The pipe will move at a speed of about 100 m/h with a slurry discharge rate of about 2,750 m^3/h. The slurry pipe was assumed to operate 7 times per day over the course of 45 days, with each operation lasting 1 hour. For the purpose of modelling site B, the capacity of the disposal barge was taken to be 2,000 m^3, with a length, width and draft taken as 80 m, 11.4 m and 4.5 m respectively. Dumping duration was taken as 2 minutes, with five trips per day for 85 days. Both the disposal pipe at site A and barge operations at site B were assumed to run 24 hours a day with a constant time interval between each operation. However, operations would be delayed in the event of adverse weather conditions or coming into contact with rock that requires drilling and/or blasting. As a result it is expected that the operations window will in fact be upward of 140 and 180 days at Sites A and B respectively. It should be noted that the disposal scenario used in the numerical sediment modeling is considered conservative because by not including blasting setbacks and weather delays disposal will tend to result in the highest concentrations of suspended sediments per unit time.

A Dredge Material Disposal Plan will be developed following issuance of a permit and will include procedures to accurately measure or estimate quantities of dredged material disposed of at the disposal site, vessel and barge tracking, and a schedule for use of the disposal site. The Dredge Material Disposal Plan will also outline position-fixing procedures, which will be followed to ensure disposal occurs at the designated disposal site.

5.2 Change in Sediment Quality and Quantity

5.2.1 Project Effects

Disposal will lead to an increase in the thickness of benthic sediment at the selected site. Deposition of sediment could lead to changes in the bathymetry of the area, transport of sediment outside the disposal area, and burial, smothering or crushing of benthic organisms. These could further lead to a reduction in number, density or biomass of species at the site. Time for recovery will depend on several factors including depth of sediment deposition and proximity of organisms capable of recolonizing the area.

The approach taken to address these potential effects was to collect and analyze sediment from the dredge area and to model the short-term fate and near-field distribution of the disposed material using the US Army Corps of Engineers' STFATE (Short-Term Fate of Dredged Material) and the COCIRM-SED three-dimensional model, selected in consultation with EC and conducted by ASL Environmental Sciences (ASL).

Thickness of sediment following disposal of dredged material at the proposed disposal sites was modeled by ASL using site-specific information about tidal, river and wind-driven currents, bathymetry, and soil and sediment grain size. Appendix G provides ASL's technical memo.

In brief, the modeling shows only limited dispersal of sediment beyond either disposal site and dispersal of sediment is limited to areas of deeper water depth (i.e., sediment does not disperse into shallower nearshore areas that would be highly productive fish habitat or habitat for species at risk; Figures 7 and 8). Highlights of the ASL report include the following:

Site A:

During initial 45 minutes of each pipe disposal operation:

- All gravel and sand settles out on the seabed, while about half of the clay and silt remains suspended in the water column, with a total deposition of 57.24% and the remainder in suspension.

15 days following completion of deposition (Figure 7):

- All suspended disposal sediments have settled out and are located on the seabed.
- Total change in sediment thickness within the disposal site would be an addition of 1,200 mm to 5,192 mm (5.192 m), accounting for 58.43% of the total dredging material.
- Outside site A, the only area that will receive total sediment deposition greater than 1 mm is north of the disposal site, where water depths are greater than 30 m and near-bottom ocean currents are relatively weak, usually less than 0.2 to 0.3 m/s.
- The maximum distance of sediment dispersal out from the centre of the disposal site is 4.1 km.

Site B

During initial 25 minutes of each barge disposal trip:

- All gravel and most of the sand settles out on the seabed, while about 60% of the clay and silt remains suspended in the water column, with a total deposition of 41.69% and the remainder in suspension.

15 days following completion of deposition (Figure 8):

- All suspended disposal sediments have settled out and are located on the seabed.
- Total change in sediment thickness within the disposal site would be an addition of 200 mm to 1,155 mm (1.155 m), accounting for 51.65% of the total dredging material.
- Outside site B, the only areas that will receive total sediment deposition greater than 1 mm is to the east and to the north of the disposal site, where water depths are greater than 50 m and near-bottom ocean currents are relatively weak, usually less than 0.2 to 0.3 m/s.
- The maximum distance of sediment dispersal out from the centre of the disposal site is 5.3 km.

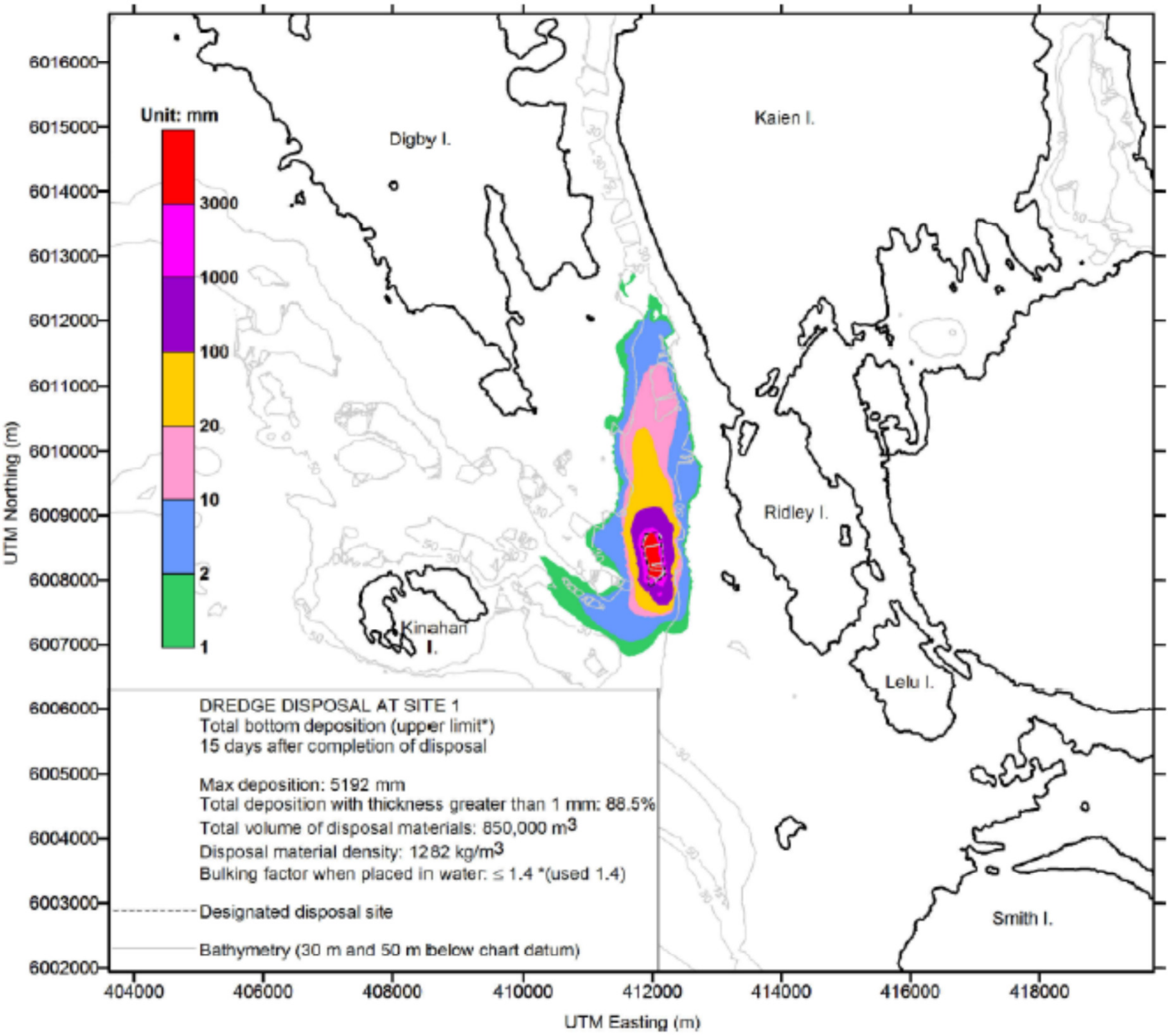

Figure 7: **Modeled Change in Sediment Thickness at Site A 15-days after Completion of Disposal of Dredged Material**

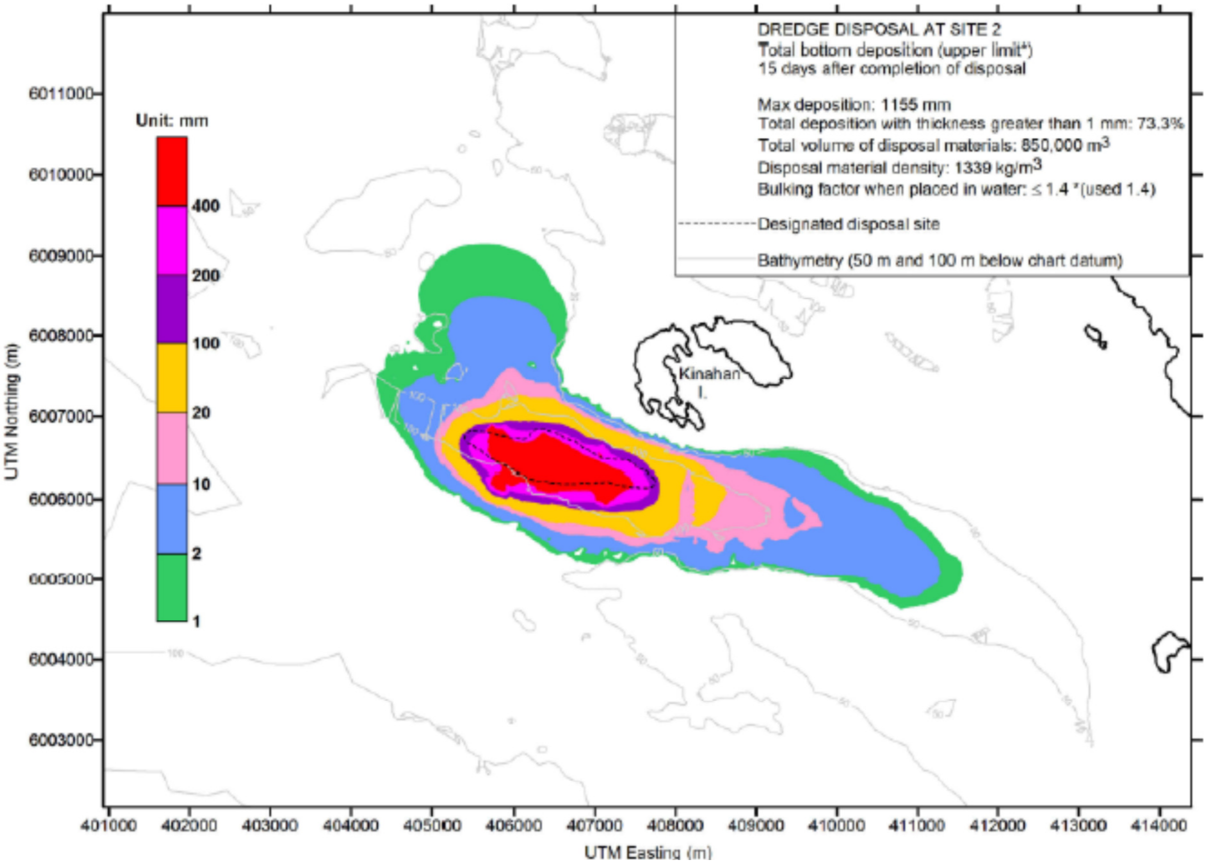

Figure 8: **Modeled Change in Sediment Thickness at Site B 15-days after Completion of Disposal of Dredged Material**

The changes in sediment thickness associated with disposal would primarily occur over a 45 to 140 day or 85 to 180 day period (site A and B, respectively; assuming use of a 2,000m^3 barge at site B) and would likely result in some burial, smothering and/or crushing of benthic organisms within the disposal site, especially where deposition is at its maximum. Most benthic invertebrates live in the top 100 mm of sediment and need to maintain connection with the water-sediment interface to ventilate and feed, which makes them susceptible to disposed material (Miller, *et al.* 2002). In cases where sedimentation is not too great, organisms are able to migrate up through the deposited materials. Many benthic species are well adapted to the dynamic characteristics of soft bottom habitat and are able to dig out of deposited sediment, back to the surface. Maurer and Keck (1978) tested a number of species from several taxonomic groups and found that many species were able to migrate vertically back to the surface. In cases where sedimentation exceeds the ability of organisms to survive burial, recolonization takes place primarily through immigration from adjacent areas and through larval recruitment.

Several monitoring studies have shown recovery of benthic communities over one to four years, depending on the environment, with deeper sites recovering in two or more years (Newell, *et al.* 1998; Bolam and Rees 2003). Benthic communities in stable environments, such as deeper areas with constant salinity, tend to take longer to recover from disturbance than do communities more regularly exposed to environmental stress, such as estuaries (Bolam and Rees 2003).

Productive conditions can be maintained by timing the disturbance (disposal) at specific intervals, such as during periods of low recruitment (winter). Repeating disposal each year could maintain the population in an exponential phase of growth (Bolam and Rees 2003). Recovery will be fastest where disposal sediment thickness is relatively small (200 to 300 mm; Essink 1999), so organisms can migrate upward, which is possible where sediments are dispersed over a wide area.

The sediment quality assessment for material to be dredged indicates the material will meet screening criteria of the Disposal at Sea Regulation (Section 3.1.2), and is not un-similar to levels found at the disposal sites (Section 3.1.1). Therefore, the addition of sediment to either proposed site is not expected to introduce contaminants to the marine environment at levels of concern.

5.2.2 Mitigation

Proposed mitigation for reducing the effects on sediment quality and quantity are as follows:

- Reduce and reuse dredgeate to the greatest extent possible so as to reduce the thickness of sediment accumulation. Blasted rock will be used for onshore construction wherever possible.
- Reduce effects on aquatic organisms by establishing timing windows through discussions with DFO

No mitigations are considered necessary to address sediment quality, as sediment sampling within the dredge footprint indicates the material would meet the screening criteria in the Disposal at Sea Regulation (Section 3.1.2).

5.2.3 Residual Effects

The total maximum increase in sediment thickness attributable to disposal of sediment is 5,192 mm at site A (range: 1,200 to 5,192 mm) and 1,155 mm at site B (range: 200 to 1,155 mm). Beyond the disposal site boundaries, the increase in thickness would range from 1 to 100 mm in most areas (with a small area immediately around site A receiving up to 3,000 mm). These increases in sediment depth would result in a slight change to the sites' bathymetry, but are not expected to affect navigation.

Based on a gradual increase in sediment depth (to a maximum thickness of 5,192 mm and 1,155 mm at sites A and B respectively) in the disposal area, no irreversible or long term effects are predicted for benthic organisms during or following disposal. This is because the total thickness would develop over time (some invertebrates will be able to migrate up through the sediment as it is deposited) and colonization and recovery would occur through vertical and horizontal migration into the area. Effects on benthic organisms outside the disposal area would be negligible, given the predicted increase of 1 to 3,000 mm sediment depth. As a result, no effects to sediment quality and quantity are expected.

5.3 Change in Water Quality

5.3.1 Project Effects

Disposal of material at sites A and B will introduce sediment in the water column, which could: (1) reduce the amount of light available for photosynthesis by phytoplankton; or (2) introduce irritants to sensitive organisms. Either of these results could potentially lead to an adverse effect on the health of aquatic organisms (i.e., reducing biological productivity) or the availability of aquatic organisms for human uses (i.e., fisheries).

The approach to addressing these potential effects was to model total suspended sediment (TSS) levels in surface and deep water during and after disposal. The modeling was conducted by ASL using STFATE and the COCIRM-SED three-dimensional model, selected in consultation with EC. Near bottom and near surface TSS predictions were compared with the BC water quality guideline of an increase over baseline of less than or equal to 25 mg/L TSS (Ministry of Environment [MOE] 2006 Internet site). Other changes in water quality, related to introduction of contaminants, were not considered, as the disposed material would meet the screening criteria for the Disposal at Sea Regulations (Section 3.1.2).

The TSS levels in surface and deep water following disposal were modeled considering site-specific information about tidal, river and wind-driven currents, bathymetry, and soil and sediment grain size. Figure 9 shows the TSS plume at depths of 45, 35, and 25 m, 6 minutes and 6 hours after completion of all dredging disposal at site A. Figure 10 shows the TSS plume at depths of 105, 55, and 25 m, 1.1 hours and 7.1 hours after completion of all dredging disposal at site B. Appendix G provides the modelling details in ASL's technical memo.

In brief, the modeling shows the following:

Site A:

During initial 45 minutes of each pipe disposal operation:

- All gravel and sand settles out on the seabed, while about half of the clay and silt remains suspended in the water column, with a total deposition of 57.24% and the remainder in suspension.
- Suspended sediment is mostly concentrated within 10 m of the bottom, with maximum near-bottom TSS values equivalent to about 7,200 mg/L above background and the initial suspended sediments spreading into an area of about 200 m in diameter.

Within two hours after each disposal event:

- High initial near-bottom TSS values are reduced quickly, to a maximum near-bottom TSS value of less than 30 mg/L, due to sediment settling and strong dilution.

15 days following completion of deposition:

- All suspended disposal sediments have settled out and are located on the seabed.
- Resuspension is very marginal, with a total of about 120 m^3 of re-suspended sediment, or 1.3 mm of sediment deposition over a 15 day period post-disposal modelling.

Site B

During initial 25 minutes of each barge disposal trip:

- All gravel and most of the sand settles out on the seabed, while about 60% of the clay and silt remains suspended in the water column, with a total deposition of 41.69% and the remainder in suspension.
- Suspended sediment is mostly concentrated in the water column below 50 m water depth, with maximum near-bottom TSS values of about 900 mg/L above background (at 125 m depth) and the initial suspended sediments spreading into an area of about 700 m in diameter.

Within two hours after each disposal event:

- High initial near-bottom TSS values are reduced quickly, to a maximum near-bottom TSS value of less than 60 mg/L, due to sediment settling and strong dilution.

15 days following completion of deposition:

- All suspended disposal sediments have settled out and are located on the seabed.
- Resuspension is very marginal, with a total of about 120 m^3 of re-suspended sediment, or 1.3 mm of sediment deposition over a 15 day period post-disposal modelling.
- Resuspension is minor, with a total of about 2,500 m^3 of re-suspended sediment, or 7 mm of sediment deposition over a 15 day period post-disposal modelling.

Predicted near-bottom TSS levels were considerably higher than near-surface TSS in and around both disposal sites (Figures 9 and 10).

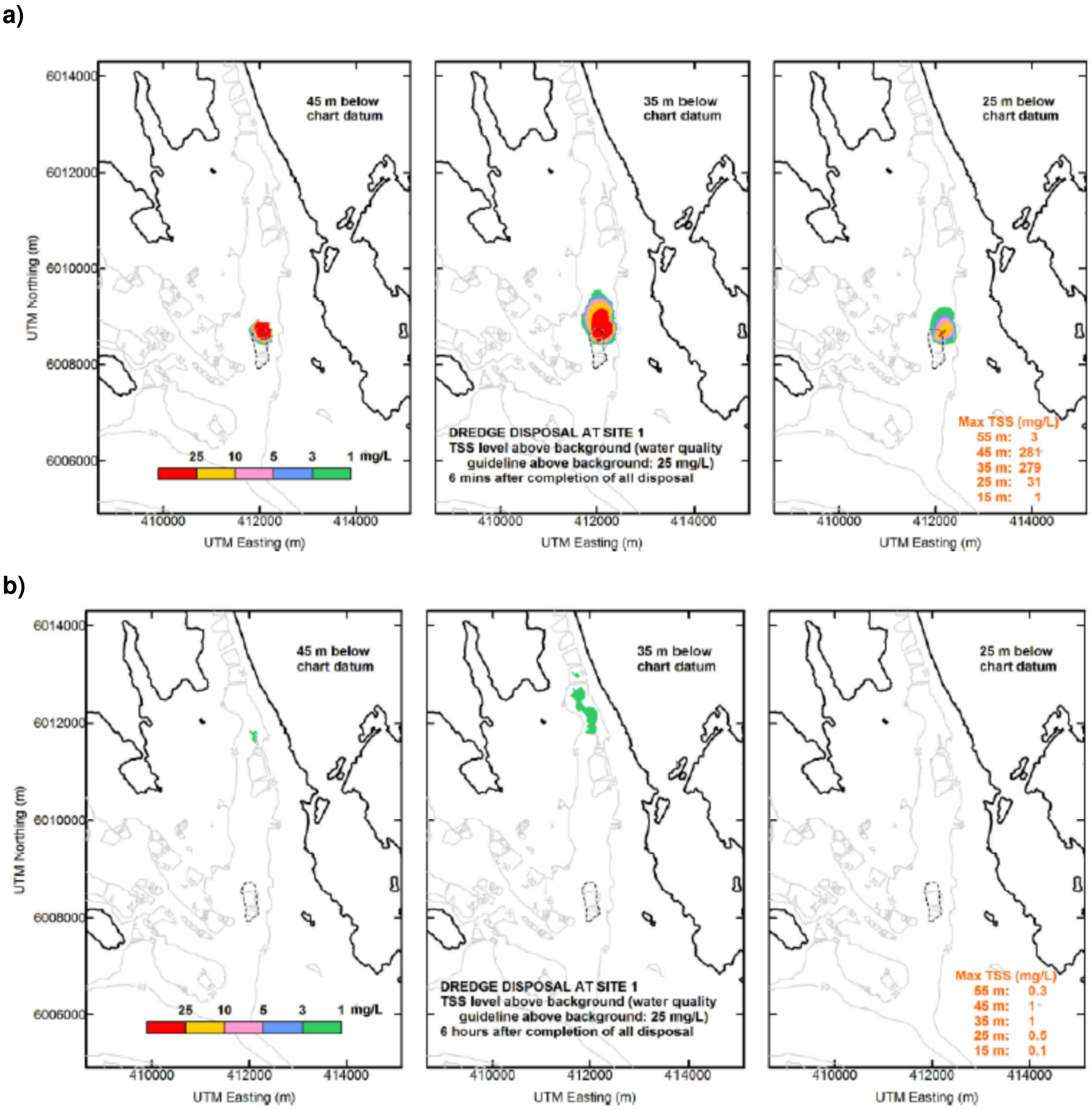

Figure 9: **Modeled Total Suspended Solids (TSS) Plume at 45 m, 35 m, and 25 m Below Chart Datum, (a) 6 minutes, and (b) 6 hours after Completion of all Disposal at Site A**

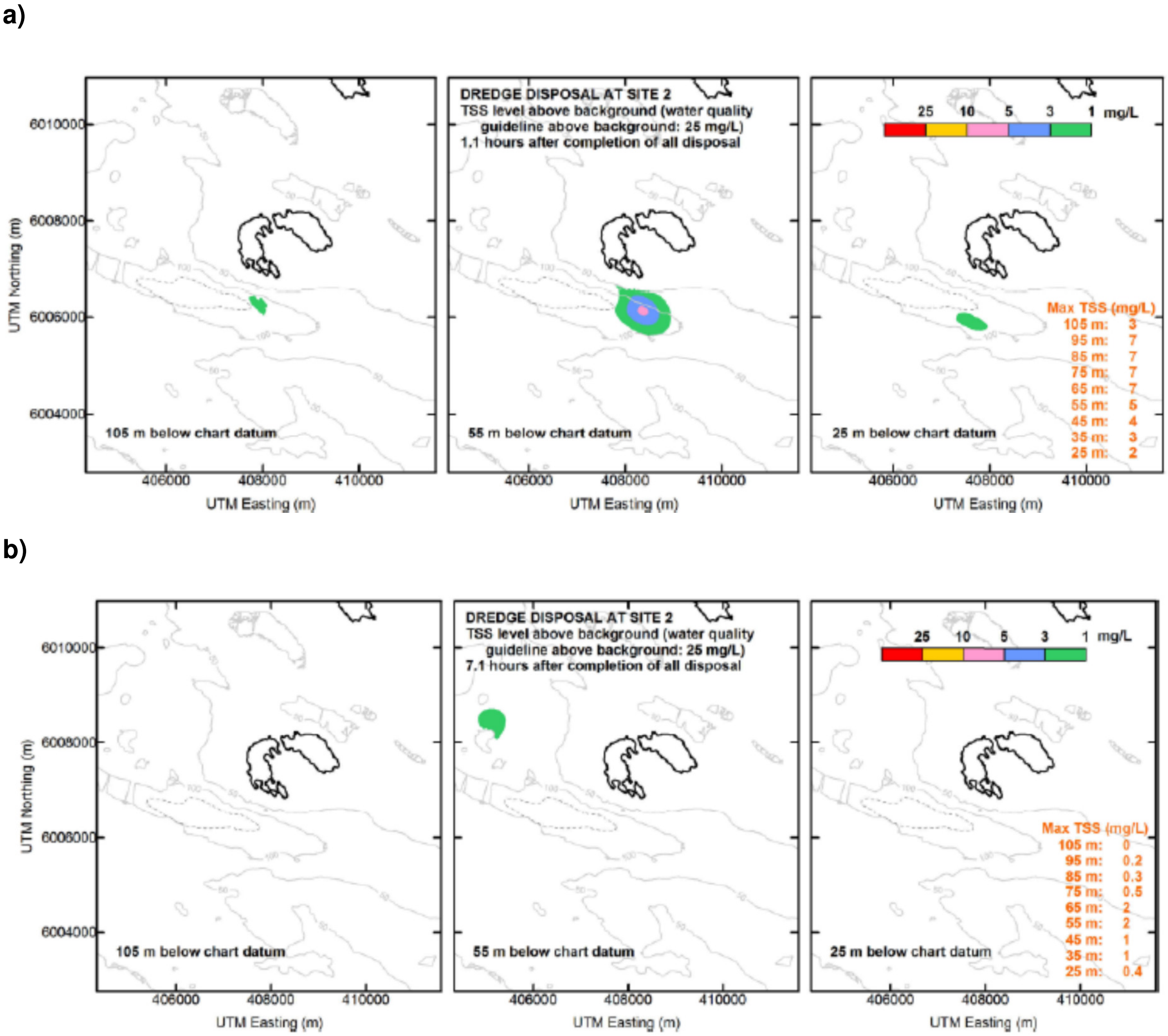

Figure 10: Modeled Total Suspended Solids (TSS) Plume at 105 m, 55 m, and 25 m Below Chart Datum, (a) 1.1 hours, and (b) 7.1 hours after Completion of all Disposal at Site B

Photosynthesis can occur in the water column to a depth of where light intensity is 1% of that at the surface. This photic zone is typically less than 100 m in deep coastal areas due to nutrient and sediment input and primary productivity (phytoplankton) affecting light penetration (Thurman 1994). Increased TSS in the water column from disposal may reduce the depth of the photic zone and the overall depth available for phytoplankton to photosynthesize. This effect will be more important if disposal takes place during spring and summer, when productivity is greater.

Benthic invertebrates that filter feed are the most sensitive species to TSS (Newell, *et al.* 1998) as they may experience fouling of feeding structures at elevated TSS levels, particularly at the disposal site. However, that effect is considered to be small compared to likely burial from sediment deposition, addressed in the previous section. Marine biota that live at depths most affected by elevated TSS (>150 m) include mid-depth fish that are adapted to low light intensity (large eyes). These fish are highly mobile so are likely to cope with temporary reductions in light levels due to TSS or to move away from the area. Movement of fish away from the area when there is elevated TSS may result in a minor and short-term reduction in fisheries catch in some areas, particularly within the disposal sites, during and immediately after disposal. Commercial, First Nations and recreational fisheries are not expected to see a measurable long-term decrease in fish abundance due to TSS, either within the disposal sites, or further away.

Increased TSS is expected to have limited effects on marine mammals and seabirds, as these are also highly mobile and can easily avoid the area during and after disposal if TSS affects their ability to feed. The total area affected by elevated TSS represents only a small portion of the available habitat for these species in the area (<0.026% of Chatham Sound).

5.3.2 Mitigation

Recommended mitigation for water quality include:

- Reducing TSS at the disposal sites by:
    - using suction dredging as opposed to barges where possible
    - reducing dredgeate volume to the greatest extent possible (i.e., reusing blasted rock for onshore construction works wherever possible).
- Reduce effects of TSS on aquatic organisms by working during timing windows established through discussion with DFO

No mitigations are considered necessary to address water quality related to introduction of contaminants, as the disposed material would meet the screening criteria for the Disposal at Sea Regulations (Section 3.1.2).

5.3.3 Residual Effects

The water quality guideline of an increase of 25 mg/L above background was established by MOE to protect the most sensitive species from adverse effects of suspended sediment. At site A, and just north of site A, this level would only be exceeded for the first few hours after each disposal event and would return to typical levels within six hours of completion of all disposal activities (Figure 9). At site B, and just southeast of site B, this level would only be exceeded for the first few hours after each disposal event and would return to typical levels within seven hours of completion of all disposal activities (Figure 10). Commercial fisheries catch at the disposal site may be reduced for a short period of time if fishing takes place during or shortly after the disposal period at the disposal site but no residual effect on First Nations and recreational fisheries taking place further away, where TSS levels are predicted to be below guidelines, are expected.

5.4 Increased Vessel Traffic

5.4.1 Project Effects

At site A, the majority of material will be discharged as a slurry using a sub-surface pipe. The pipe will be suspended from a pontoon winched from a barge located over the disposal area. The barge will be anchored in place. Vessel activity from one or two tugs will be required to relocate the pipe outflow to ensure even dispersal across the disposal site. Vessels may also be required to transport large pieces of blasted rock for re-use in shore construction. It is estimated that this vessel activity will not exceed 100 one-way trips (200 trips if two tugs are required).

For site B, the material will be loaded onto a barge and then towed to the site. It is estimated that barges will make between 2.4 and 5.0 return trips per day to transport the material during the disposal period, based on a barge capacity of 2,000 m^3 and continuous (24-hr) operations over 85 to 180 days. This will result in the addition of 850 one-way barge trips (425 return trips) between the loading site and site B. Barges will be towed by tugs and follow the most direct vessel route to the disposal site. Speed during tow will be approximately 4 to 8 knots.

Increased vessel traffic will result in an increase in emissions and has the potential to interfere with existing vessel use along shipping routes. There is also potential for an increased likelihood of collisions between vessels and marine mammals, including species at risk.

Emission levels will vary both with distance traveled and number of trips (Table 4). Site A would result in the lowest emission levels because it would require the fewest trips over the shortest distance (<2 km). Site B and Brown Passage both require the same number of trips but the proximity of site B to the dredge site would result in significantly fewer emissions than would transits to Brown Passage (Table 4).

Table 4: Estimated Vessel Emissions per Disposal Site

Emissions (kg)			
Disposal Site	**Brown Passage**	**Site B**	**Site A**
Distance from Dredge Site	**30 km**	**6 km**	**1 km**
Number of One-way Trips	**850**	**850**	**200***
SO_2	72.90	14.58	0.58
NOx	14,425.46	2,885.09	113.14
CO	1,202.12	240.42	9.42
PM_{10}	786.84	157.37	6.18
$PM_{2.5}$	629.47	125.89	4.94
VOCs	0.26	0.05	0.0020

*Assumes two tugs to maneuver the pontoon

Several vessels currently use the waters near Prince Rupert into the harbour. Ship traffic is monitored by Marine Communication and Traffic Services (MCTS), operated by the Canadian Coast Guard. The number of vessel trips planned for disposal at site A (maximum of one per day) and site B (maximum of five per day) is relatively small and the duration of these activities is short term (between 45 and 140 days at site A and between 85 and 180 days at site B; assuming use of a 2,000 m3 barge at site B). Based on existing traffic, which is considered light (see Section 3.4.2), vessel interference is not anticipated.

Current research suggests that the probability of a vessel strike is positively correlated with a vessel's speed (Kite-Powell *et al.* 2007). Based on Kite-Powell *et al.*'s model, a large vessel travelling at 25 knots has a 50% probability of striking a whale travelling in its path, while at a speed of 10 knots, that likelihood is reduced to 30%. Depending on the severity of the injuries sustained, a marine mammal may or may not recover from a vessel strike. However, research also suggests that the severity of the strike is positively correlated with vessel speed (Vanderlaan and Taggart 2007). Vanderlaan and Taggart (2007) modelled the probability of lethal injury to a whale based on vessel speed and found that the probability of lethal injury decreases from 79% at 15 knots, to 31% at 10 knots and 21% at 8.6 knots. Laist *et al.* (2001) similarly concluded that serious injuries to whales are infrequent at vessel speeds of less than 14 knots, and are rare at vessel speeds of less than 10 knots.

Because barges will be towed by tug boats with expected speeds of only 4 to 8 knots, the risk of collision with marine mammals from increased vessel traffic is expected to be minimal, and serious injuries resulting from any such collision are not expected.

While small numbers of marine birds might be killed from collisions with the superstructure of vessels, this risk is considered to be greater at night when birds might be attracted to lighting on the vessels. To reduce the effects of light "dark sky" shielded luminaires will be used where possible and numbers of lights used will be reduced to the greatest extent possible without sacrificing safety. Given proposed mitigation the number of individuals affected is predicted to be small (e.g., tens of birds) and the risk to birds will be of short duration (i.e., between 45 and 140 days at Site A and between 85 and 180 days at Site B).

5.4.2 Mitigation

Traffic interference as a result of increased vessel activity will be mitigated through the following:

- Development of a Dredge Material Disposal Plan that requires vessels to adhere to the most direct and established shipping routes nearest to the disposal site, proper containment procedures, communications, and schedules as defined in the Dredge Material Disposal Plan
- Details on the location and movement envelope of barges will be provided to the Prince Rupert Port Authority Harbour Master who will then issue a Notice to Mariners
- Maximum vessel speeds of 4 to 8 knots for tow boats and barges to reduce or eliminate the potential for serious collisions with marine mammals
- Minimizing light emissions to the greatest extent possible to reduce the risk of collision for marine birds
- Reduce emissions by reducing distance travelled and number of vessel trips where possible

5.4.3 Residual Effects

The magnitude of effects of increased vessel traffic will be low and limited to the planned route to disposal site B and a few vessels to site A. Vessel traffic is not likely to interfere with the limited existing traffic or disrupt any fishing activity in the Chatham Sound area, is short-term in duration (i.e., between 45 and 140 days at site A and between 85 and 180 days at site B), occurs only once for the life of the project and is reversible. In addition, this traffic will occur in an area already used by vessels on a regular basis.

5.5 Species at Risk

Species at risk will be affected in a similar manner to organisms discussed in Sections 5.2 to 5.4. Some burial, smothering and/or crushing of benthic organisms within the disposal site is expected; however, there are no benthic invertebrate species at risk in the immediate area. Marine fish species at risk may temporarily move out of the area, but no long term effects are expected. Fatal collisions to marine mammals at risk as a result of increased vessel traffic are not expected at the proposed vessel speeds. Collisions with marine birds at risk would be limited to no more than a few individuals and would not affect local populations. There are no sensitive areas for species at risk within the area of impact of proposed disposal at sea activities. The closest Rockfish Conservation Area is approximately 9,700 m from site A and approximately 5,200 m from site B (Figure 3).

5.6 Human Uses

5.6.1 First Nations/Traditional Use

As discussed in Sections 5.2 to 5.4, First Nations fisheries are not expected to see a measurable decrease in fish abundance due to disposal activities and no other effects to First Nations or Traditional Use are expected.

5.6.2 Archaeology and Heritage Resources

No impacts to archaeological or heritage resources are expected to occur as a result of the dredging or disposal at sea programs. An archaeological overview assessment completed for Ridley Island (Brunsden and Eldridge 2008) and an overview of the potential for sub-tidal archaeological resources off the west side of Ridley Island (Streeter 2006) have concluded that the potential for the existence of sub-tidal or intertidal archaeological sites is very low. Furthermore, an archaeological impact assessment specific to the terrestrial and intertidal portions of Canpotex's potash terminal project footprint (Hutchcroft 2011) identified no archaeological sites in these areas and concluded that the potential for their existence is low. Lastly, no archaeological materials or evidence of archaeological deposits were identified in core samples extracted from submarine contexts off the west coast of Ridley Island in the summer of 2009.

The most recent, relevant relative sea level data indicate that relative sea levels were never more than 3.5 m below present in the area since the last glaciation (Eldridge and Parker 2007; Eldridge *et al*. 2008; McLaren 2008). Sites A and B are located at depths of 50 m and 100 m below modern sea levels, respectively. As a result, the potential for submerged, previously terrestrial archaeological sites to be present within the project footprint is considered to be extremely low. Three shipwrecks have been reported to be within close vicinity of the project footprint only one of which, the Kingwood, is likely to still be preserved. Both proposed disposal locations were subject to Benthic Video Survey and no evidence of shipwrecks was reported.

It is not anticipated that any archaeological or heritage resources will be impacted by the proposed project.

5.6.3 Utilities

Conversations in August, 2010 with representatives from BC Hydro, Pacific Northern Gas and CityWest (phone/cable) confirm there are no utilities or sub-sea cables in close proximity to either of the proposed disposal sites.

5.6.4 Other Legitimate Uses

Other legitimate uses of the two proposed disposal sites include tourism, recreation, and sport fishing, as evidenced by the large number of docks, moorages, and marinas in the area (Figure 5). Disposal activities will occur over a short period (i.e., between 45 and 140 days at site A and between 85 and 180 days at site B, assuming use of a 2,000 m^3 barge) and are unlikely to alter fish distributions permanently, if at all, thus recreational fishing is unlikely to be affected. Furthermore, the limited addition of slow-moving vessel traffic is not likely to interfere with the existing recreational traffic in the Chatham Sound area.

6 ALTERNATIVES

6.1 Strategies to Reduce Volume to be Disposed

The volume of material discussed in this assessment represents the maximum possible volume. It may not be necessary to dispose of all of this material at sea, as portions may be re-used elsewhere for the Project. The disposal volume will be confirmed closer to the time that the Disposal at Sea Permit application is prepared. However, alternatives to disposal at sea are limited within the Prince Rupert region.

6.2 Comparison of Preferred Disposal Site Options

A comparison of sites A, B and Brown Passage reveals minimal ecological and physical differences given the amount of dredgeate being disposed. However, there are economic and human use differences. In contrast to Brown Passage, which is located approximately 30 km east of the Project site, sites A and B are located 1 km and 6 km from the dredge site, respectively. The closer proximity of sites A and B will result in reduced travel time between sites and an associated reduction in emissions, costs, and risk of collision or interference with other vessels. Travel time and emissions would be further reduced at site A, which is sufficiently close to use a suction dredge (instead of a barge) to transport the majority of material to the disposal site. Use of the suction dredge will also result in reduced TSS because the disposal pipe would be approximately 10 m above the ocean floor as opposed to at the ocean surface. Differences in current speed will also affect dispersal of TSS. Currents are stronger at Brown Passage which will result in greater dispersal of TSS.

As a result, site A is the preferred option. Relative to Brown Passage, the proximity of site B will result in an approximate five-fold decrease in the amount of vessel activity required; therefore, site B is the second preferred option.

Table 5 Comparison of Preferred Disposal Site Options

	Site A	Site B	Brown Passage
Travel Distance (one-way)	1 km	6 km	30 km
Number of one-way trips	200*	850	850
Number of barge loads per day	0	5	5
Number of disposal days	45	85	85
Total SO_2 emissions (kg)	0.58	14.58	72.9
Total NO_x emissions(kg)	113.14	2,885.09	14,425.46
Typical current speed (m/s)	0.05 - 0.2	0.1 – 0.5	0.05 - 0.8
Ranking of preferred disposal site options	**1st**	**2nd**	**3rd**

*Assumes two tugs

7 CONCLUSION

This report was prepared in support of the federal comprehensive study of the Canpotex Potash Export Terminal Project on Ridley Island, British Columbia. The primary objectives of the report were to assess the potential effects of disposal of dredged material at two proposed new disposal sites, sites A and B, contrast these new sites with EC's designated disposal site in Brown Passage, and recommend the preferred disposal site(s). Based on the information presented in this report, site A, located approximately 1 km west of the dredge site, is the recommended option. The primary reasons in support of site A as a new disposal at sea site are summarized below:

- Location will allow use of a suction dredge instead of transportation by barge
- Minimize TSS plume
- Minimize emissions
- Minimize interference with vessel activity
- Dredged sediment meets CEPA standards
- Material is stable over the long term
- Expect rapid recovery where sediments <1cm and rapid recolonization where sediments are deeper

Selection of site B would result in increased vessel traffic relative to site A; however, relative to Brown Passage, site B will reduce vessel traffic approximately five-fold. Site B would therefore be the preferred second choice. Though site A is preferred to site B, we request that both sites be considered for approval. It is unlikely that Canpotex would submit disposal at sea permit applications for both sites; however, depending on final project design (i.e., amount of dredgeate) one site may be preferred to the other.

8 CLOSURE

Based on the analysis presented in this report both sites A and B have been identified as preferred disposal options over the current disposal site in Brown Passage. This determination is based primarily on the environmental and economic benefits associated with the use of sites A and B and considering First Nations preference to have a disposal site located within the PRPA harbor boundaries. Stantec respectfully requests that Environment Canada consider the designation of sites A and B as new disposal at sea sites.

The information provided in this report was compiled from existing documents and data. This report represents the best professional judgment of Stantec's personnel at the time of its preparation. If you have any questions or concerns about this report, please do not hesitate to contact the undersigned.

Respectfully submitted,

Stantec Consulting Ltd.

	Reviewed by:
Andrea Ahrens, M.Sc., R.P.Bio.	Sandra Webster, Ph.D., R.P.Bio.
Marine Biologist	Senior Biologist

AA/SW/TE/WP/pf

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APPENDIX A

Sediment Sampling Protocol and Results for Disposal Sites A and B

STANTEC CONSULTING LTD.
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Phone: 604-436-3014

Date Received: 19-NOV-10
Report Date: 07-DEC-10 09:22 (MT)
Version: FINAL REV. 2

Certificate of Analysis

Lab Work Order #: L955807
Project P.O. #: NOT SUBMITTED
Job Reference: CANPOTEX (123110264 / 500.018)
Legal Site Desc:
C of C Numbers: 1, 2, 3, 4, 5

Comments: ADDITIONAL 02-DEC-10 08:40
ADDITIONAL 02-DEC-10 08:40

07-DEC-10: This revised report contains detailed particle size analysis that the client required for certain samples reported in the following data tables.

Heather Easton
Account Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L955807-1	L955807-2	L955807-3	L955807-4	L955807-5
	Description					
	Sampled Date	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10
	Sampled Time	10:30	10:16	10:03	09:16	09:31
	Client ID	S1 OUTSIDE - 1	S1-2	S1-3	S1-4	S1-5
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	58.6	56.2	57.8	58.1	55.7
	pH (pH)	7.35				
Particle Size	% Gravel (>2mm) (%)	1.71	0.66	<0.10	0.16	<0.10
	% Sand (2.0mm - 0.063mm) (%)	2.81	1.98	3.08	2.77	4.39
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)	63.1	66.6	67.2	65.3	66.0
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)	32.4	30.8	29.7	31.8	29.6
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.84	1.77	1.68	1.78	1.58
Metals	Antimony (Sb) (mg/kg)	0.57				
	Arsenic (As) (mg/kg)	14.0				
	Barium (Ba) (mg/kg)	91.0				
	Beryllium (Be) (mg/kg)	0.35				
	Cadmium (Cd) (mg/kg)	0.13	0.14	0.12	0.14	0.13
	Chromium (Cr) (mg/kg)	27.3				
	Cobalt (Co) (mg/kg)	11.8				
	Copper (Cu) (mg/kg)	33.7				
	Lead (Pb) (mg/kg)	8.25	8.32	8.06	7.99	7.87
	Mercury (Hg) (mg/kg)	0.0631	0.0621	0.120	0.0646	0.0623
	Molybdenum (Mo) (mg/kg)	0.99				
	Nickel (Ni) (mg/kg)	26.8				
	Selenium (Se) (mg/kg)	0.42				
	Silver (Ag) (mg/kg)	0.14				
	Thallium (Tl) (mg/kg)	0.086				
	Tin (Sn) (mg/kg)	<2.0				
	Uranium (U) (mg/kg)	0.669				
	Vanadium (V) (mg/kg)	72.5				
	Zinc (Zn) (mg/kg)	89.6				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L955807-6	L955807-7	L955807-8	L955807-9	L955807-10
	Description					
	Sampled Date	16-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	09:50	14:48	15:05	15:23	14:33
	Client ID	S1 OUTSIDE - 6	S1-7A	S1-7B	S1-7C	S1-8
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	54.4	58.7	60.6	63.8	55.6
	pH (pH)					7.58
Particle Size	% Gravel (>2mm) (%)	<0.10	<0.10	<0.10	0.56	<0.10
	% Sand (2.0mm - 0.063mm) (%)	4.79	2.25	2.31	1.83	3.64
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)	66.8	63.0	63.0	63.5	65.1
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)	28.5	34.7	34.7	34.1	31.2
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.65	1.88	1.90	1.87	2.09
Metals	Antimony (Sb) (mg/kg)					0.55
	Arsenic (As) (mg/kg)					12.6
	Barium (Ba) (mg/kg)					87.9
	Beryllium (Be) (mg/kg)					0.39
	Cadmium (Cd) (mg/kg)	0.12	0.14	0.13	0.14	0.12
	Chromium (Cr) (mg/kg)					27.4
	Cobalt (Co) (mg/kg)					12.0
	Copper (Cu) (mg/kg)					33.9
	Lead (Pb) (mg/kg)	7.67	8.47	8.07	8.08	7.94
	Mercury (Hg) (mg/kg)	0.0621	0.0647	0.0607	0.0574	0.0616
	Molybdenum (Mo) (mg/kg)					1.09
	Nickel (Ni) (mg/kg)					27.1
	Selenium (Se) (mg/kg)					0.38
	Silver (Ag) (mg/kg)					0.14
	Thallium (Tl) (mg/kg)					0.080
	Tin (Sn) (mg/kg)					<2.0
	Uranium (U) (mg/kg)					0.628
	Vanadium (V) (mg/kg)					71.3
	Zinc (Zn) (mg/kg)					89.6
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

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

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L955807-11	L955807-12	L955807-13	L955807-14	L955807-15
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	14:04	14:18	13:46	13:33	12:56
	Client ID	S1-9	S1-10	S1 OUTSIDE - 11	S1-12	S1-13
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	56.6	51.0	58.5	52.7	55.2
	pH (pH)					7.39
Particle Size	% Gravel (>2mm) (%)	<0.10	<0.10	<0.10	<0.10	<0.10
	% Sand (2.0mm - 0.063mm) (%)	3.21	4.37	2.91	3.98	3.09
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)	66.5	65.3	64.9	62.6	64.9
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)	30.3	30.3	32.2	33.4	32.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.59	1.39	1.82	1.50	1.68
Metals	Antimony (Sb) (mg/kg)					0.71
	Arsenic (As) (mg/kg)					17.3
	Barium (Ba) (mg/kg)					107
	Beryllium (Be) (mg/kg)					0.40
	Cadmium (Cd) (mg/kg)	0.12	0.12	0.12	0.12	0.14
	Chromium (Cr) (mg/kg)					32.5
	Cobalt (Co) (mg/kg)					13.2
	Copper (Cu) (mg/kg)					40.7
	Lead (Pb) (mg/kg)	8.03	7.54	7.70	7.94	9.88
	Mercury (Hg) (mg/kg)	0.0613	0.0593	0.0628	0.0580	0.0680
	Molybdenum (Mo) (mg/kg)					1.22
	Nickel (Ni) (mg/kg)					31.2
	Selenium (Se) (mg/kg)					0.44
	Silver (Ag) (mg/kg)					0.15
	Thallium (Tl) (mg/kg)					0.089
	Tin (Sn) (mg/kg)					<2.0
	Uranium (U) (mg/kg)					0.753
	Vanadium (V) (mg/kg)					82.0
	Zinc (Zn) (mg/kg)					101
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

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

	Sample ID	L955807-16	L955807-17	L955807-18	L955807-19	L955807-20
	Description					
	Sampled Date	15-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10
	Sampled Time	13:18	10:44	10:56	11:10	11:24
	Client ID	S1 OUTSIDE - 14	S3-1	S3-2	S3-3	S3-4
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	55.5				
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)	<0.10	<0.10	0.15	0.11	1.56
	% Sand (2.0mm - 0.063mm) (%)	3.27				
	% Sand (2.00mm - 1.00mm) (%)		<0.10	<0.10	<0.10	<0.10
	% Sand (1.00mm - 0.50mm) (%)		<0.10	0.10	0.10	0.28
	% Sand (0.50mm - 0.25mm) (%)		0.21	0.17	0.14	0.24
	% Sand (0.25mm - 0.125mm) (%)		0.36	0.36	0.30	0.39
	% Sand (0.125mm - 0.063mm) (%)		4.65	5.09	6.72	8.49
	% Silt (0.063mm - 4um) (%)	61.7				
	% Silt (0.063mm - 0.0312mm) (%)		26.6	22.4	22.9	23.1
	% Silt (0.0312mm - 0.004mm) (%)		44.9	46.2	46.4	45.9
	% Clay (<4um) (%)	35.0	23.2	25.5	23.3	20.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.57				
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.15				
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	9.43				
	Mercury (Hg) (mg/kg)	0.0642				
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050				
	Acenaphthylene (mg/kg)	<0.050				
	Anthracene (mg/kg)	<0.050				

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

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Grouping	Analyte	L955807-21	L955807-22	L955807-23	L955807-24	L955807-25
	Description					
	Sampled Date	16-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	11:38	10:32	10:14	09:53	10:47
	Client ID	S3-5	S2 OUTSIDE - 1	S2 OUTSIDE - 4	S2 OUTSIDE - 6	S2-7
SOIL						
Physical Tests	Moisture (%)		61.2	57.5	60.6	60.2
	pH (pH)				7.65	
Particle Size	% Gravel (>2mm) (%)	<0.10	0.15	<0.10	<0.10	<0.10
	% Sand (2.0mm - 0.063mm) (%)		3.40	4.17	1.23	6.93
	% Sand (2.00mm - 1.00mm) (%)	<0.10				
	% Sand (1.00mm - 0.50mm) (%)	0.10				
	% Sand (0.50mm - 0.25mm) (%)	0.17				
	% Sand (0.25mm - 0.125mm) (%)	0.29				
	% Sand (0.125mm - 0.063mm) (%)	6.32				
	% Silt (0.063mm - 4um) (%)		56.0	56.6	55.8	56.3
	% Silt (0.063mm - 0.0312mm) (%)	24.7				
	% Silt (0.0312mm - 0.004mm) (%)	46.6				
	% Clay (<4um) (%)	21.8	40.5	39.2	43.0	36.7
Organic / Inorganic Carbon	Total Organic Carbon (%)		1.78	1.68	1.73	1.63
Metals	Antimony (Sb) (mg/kg)				0.62	
	Arsenic (As) (mg/kg)				10.8	
	Barium (Ba) (mg/kg)				96.5	
	Beryllium (Be) (mg/kg)				0.41	
	Cadmium (Cd) (mg/kg)		0.14	0.17	0.15	0.15
	Chromium (Cr) (mg/kg)				33.2	
	Cobalt (Co) (mg/kg)				11.9	
	Copper (Cu) (mg/kg)				34.9	
	Lead (Pb) (mg/kg)		9.01	9.31	9.70	8.93
	Mercury (Hg) (mg/kg)		0.0653	0.0665	0.0677	0.0600
	Molybdenum (Mo) (mg/kg)				1.27	
	Nickel (Ni) (mg/kg)				31.1	
	Selenium (Se) (mg/kg)				0.64	
	Silver (Ag) (mg/kg)				0.14	
	Thallium (Tl) (mg/kg)				0.087	
	Tin (Sn) (mg/kg)				<2.0	
	Uranium (U) (mg/kg)				0.799	
	Vanadium (V) (mg/kg)				75.6	
	Zinc (Zn) (mg/kg)				97.8	
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)		<0.050	<0.050	<0.050	<0.050

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

	Sample ID	L955807-26	L955807-27	L955807-28	L955807-29	L955807-30
	Description					
	Sampled Date	15-NOV-10	16-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10
	Sampled Time	11:38	13:00	11:04	13:19	13:33
	Client ID	S2-8	S2-9	S2 OUTSIDE - 14	S2-15-A	S1-12 METALS QC1-1
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	56.7	56.4	62.2	55.5	
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)	0.39	1.29	<0.10	0.25	
	% Sand (2.0mm - 0.063mm) (%)	9.36	12.3	1.75	11.9	
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)	52.0	50.1	53.1	48.3	
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)	38.3	36.4	45.2	39.6	
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.41	1.38	1.73	1.43	
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.15	0.16	0.15	0.14	0.13
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	8.55	7.88	9.58	8.55	7.69
	Mercury (Hg) (mg/kg)	0.0595	0.0566	0.0643	0.0564	0.0580
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	

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

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	Sample ID	L955807-31	L955807-32	L955807-33	L955807-34	L955807-35
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	13:33	13:33	13:33	10:47	10:47
	Client ID	S1-12 METALS QC1-2	S1-12 METALS QC1-3	S1-12 METALS QC1-4	S2-7 METALS QC2-1	S2-7 METALS QC2-2
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)					
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.12	0.13	0.12	0.14	0.14
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	7.65	8.02	7.80	8.32	8.43
	Mercury (Hg) (mg/kg)	0.0630	0.0583	0.0608	0.0573	0.0581
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)					
	Acenaphthylene (mg/kg)					
	Anthracene (mg/kg)					

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

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	Sample ID	L955807-36	L955807-37	L955807-38	L955807-39	L955807-40
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	10:47	10:47	09:31	15:23	13:18
	Client ID	S2-7 METALS QC2-3	S2-7 METALS QC2-4	S1-5 PAH QC1	S1-7C PAH QC2	S1 OUTSIDE - 14 PAH QC3
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)			57.0	62.3	57.1
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.13	0.14			
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	8.27	8.33			
	Mercury (Hg) (mg/kg)	0.0603	0.0629			
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)			<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)			<0.050	<0.050	<0.050
	Anthracene (mg/kg)			<0.050	<0.050	<0.050

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

	Sample ID	L955807-41	L955807-42	L955807-43	L955807-44	L955807-45
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	10:14	11:04	09:50	14:18	10:32
	Client ID	S2 OUTSIDE - 4 PAH QC4	S2 OUTSIDE - 14 PAH QC5	S1 OUTSIDE - 6 PCB QC1	S1-10 PCB QC2	S2 OUTSIDE - 1 PCB QC3
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	56.4	62.0	59.4	53.2	59.9
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)					
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)					
	Mercury (Hg) (mg/kg)					
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050			
	Acenaphthylene (mg/kg)	<0.050	<0.050			
	Anthracene (mg/kg)	<0.050	<0.050			

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

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	Sample ID	L955807-46	L955807-47			
	Description					
	Sampled Date	16-NOV-10	16-NOV-10			
	Sampled Time	13:00	13:19			
	Client ID	S2-9 PCB QC4	S2-15-A PCB QC5			
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	56.0	57.4			
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Sand (2.00mm - 1.00mm) (%)					
	% Sand (1.00mm - 0.50mm) (%)					
	% Sand (0.50mm - 0.25mm) (%)					
	% Sand (0.25mm - 0.125mm) (%)					
	% Sand (0.125mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Silt (0.063mm - 0.0312mm) (%)					
	% Silt (0.0312mm - 0.004mm) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)					
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)					
	Mercury (Hg) (mg/kg)					
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)					
	Acenaphthylene (mg/kg)					
	Anthracene (mg/kg)					

	Sample ID	L955807-1	L955807-2	L955807-3	L955807-4	L955807-5
	Description					
	Sampled Date	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10
	Sampled Time	10:30	10:16	10:03	09:16	09:31
	Client ID	S1 OUTSIDE - 1	S1-2	S1-3	S1-4	S1-5
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12	<0.12	<0.12	<0.12	<0.12
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Total PAHs (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	98	90	89	96	90
	Surrogate: d12-Chrysene (SS) (%)	83	76	72	80	74
	Surrogate: d8-Naphthalene (SS) (%)	90	83	82	92	85
	Surrogate: d10-Phenanthrene (SS) (%)	102	88	87	93	88
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1221 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1232 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1242 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1248 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1254 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1260 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1262 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1268 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	Total Polychlorinated Biphenyls (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040

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	Sample ID	L955807-6	L955807-7	L955807-8	L955807-9	L955807-10
	Description					
	Sampled Date	16-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	09:50	14:48	15:05	15:23	14:33
	Client ID	S1 OUTSIDE - 6	S1-7A	S1-7B	S1-7C	S1-8
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12	<0.12	<0.12	<0.12	<0.12
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Total PAHs (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	96	86	96	92	92
	Surrogate: d12-Chrysene (SS) (%)	79	74	84	83	79
	Surrogate: d8-Naphthalene (SS) (%)	85	81	89	83	90
	Surrogate: d10-Phenanthrene (SS) (%)	93	82	93	89	93
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1221 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1232 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1242 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1248 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1254 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1260 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1262 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1268 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	Total Polychlorinated Biphenyls (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040

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

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L955807-11	L955807-12	L955807-13	L955807-14	L955807-15
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	14:04	14:18	13:46	13:33	12:56
	Client ID	S1-9	S1-10	S1 OUTSIDE - 11	S1-12	S1-13
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12	<0.12	<0.12	<0.12	<0.12
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Total PAHs (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	93	95	98	88	70
	Surrogate: d12-Chrysene (SS) (%)	79	82	84	71	52
	Surrogate: d8-Naphthalene (SS) (%)	89	89	93	80	65
	Surrogate: d10-Phenanthrene (SS) (%)	90	97	90	82	60
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1221 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1232 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1242 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1248 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1254 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1260 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1262 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	PCB-1268 (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	Total Polychlorinated Biphenyls (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L955807-16	L955807-17	L955807-18	L955807-19	L955807-20
	Description					
	Sampled Date	15-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10	16-NOV-10
	Sampled Time	13:18	10:44	10:56	11:10	11:24
	Client ID	S1 OUTSIDE - 14	S3-1	S3-2	S3-3	S3-4
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050				
	Benzo(a)pyrene (mg/kg)	<0.050				
	Benzo(b)fluoranthene (mg/kg)	<0.050				
	Benzo(g,h,i)perylene (mg/kg)	<0.050				
	Benzo(k)fluoranthene (mg/kg)	<0.050				
	Chrysene (mg/kg)	<0.050				
	Dibenz(a,h)anthracene (mg/kg)	<0.050				
	Fluoranthene (mg/kg)	<0.050				
	Fluorene (mg/kg)	<0.050				
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050				
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12				
	Naphthalene (mg/kg)	<0.050				
	Total PAHs (mg/kg)	<0.20				
	Phenanthrene (mg/kg)	<0.050				
	Pyrene (mg/kg)	<0.050				
	Surrogate: d10-Acenaphthene (SS) (%)	73				
	Surrogate: d12-Chrysene (SS) (%)	53				
	Surrogate: d8-Naphthalene (SS) (%)	67				
	Surrogate: d10-Phenanthrene (SS) (%)	63				
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040				
	PCB-1221 (mg/kg)	<0.040				
	PCB-1232 (mg/kg)	<0.040				
	PCB-1242 (mg/kg)	<0.040				
	PCB-1248 (mg/kg)	<0.040				
	PCB-1254 (mg/kg)	<0.040				
	PCB-1260 (mg/kg)	<0.040				
	PCB-1262 (mg/kg)	<0.040				
	PCB-1268 (mg/kg)	<0.040				
	Total Polychlorinated Biphenyls (mg/kg)	<0.040				

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

	Sample ID	L955807-21	L955807-22	L955807-23	L955807-24	L955807-25
	Description					
	Sampled Date	16-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	11:38	10:32	10:14	09:53	10:47
	Client ID	S3-5	S2 OUTSIDE - 1	S2 OUTSIDE - 4	S2 OUTSIDE - 6	S2-7
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Heavy Molecular Wt. Pah Sum (mg/kg)		<0.20	<0.20	<0.20	<0.20
	Indeno(1,2,3-c,d)pyrene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Light Molecular Wt. Pah Sum (mg/kg)		<0.12	<0.12	<0.12	<0.12
	Naphthalene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Total PAHs (mg/kg)		<0.20	<0.20	<0.20	<0.20
	Phenanthrene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)		<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)		77	68	82	86
	Surrogate: d12-Chrysene (SS) (%)		61	47	62	64
	Surrogate: d8-Naphthalene (SS) (%)		75	63	75	83
	Surrogate: d10-Phenanthrene (SS) (%)		72	59	68	72
Polychlorinated Biphenyls	PCB-1016 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1221 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1232 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1242 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1248 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1254 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1260 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1262 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	PCB-1268 (mg/kg)		<0.040	<0.040	<0.040	<0.040
	Total Polychlorinated Biphenyls (mg/kg)		<0.040	<0.040	<0.040	<0.040

	Sample ID	L955807-26	L955807-27	L955807-28	L955807-29	L955807-30
	Description					
	Sampled Date	15-NOV-10	16-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10
	Sampled Time	11:38	13:00	11:04	13:19	13:33
	Client ID	S2-8	S2-9	S2 OUTSIDE - 14	S2-15-A	S1-12 METALS QC1-1
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20	<0.20	<0.20	<0.20	
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12	<0.12	<0.12	<0.12	
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Total PAHs (mg/kg)	<0.20	<0.20	<0.20	<0.20	
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	
	Surrogate: d10-Acenaphthene (SS) (%)	84	78	80	74	
	Surrogate: d12-Chrysene (SS) (%)	61	SURR-ND 58	SURR-ND 59	SURR-ND 53	
	Surrogate: d8-Naphthalene (SS) (%)	76	72	74	70	
	Surrogate: d10-Phenanthrene (SS) (%)	73	66	67	63	
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1221 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1232 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1242 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1248 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1254 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1260 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1262 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	PCB-1268 (mg/kg)	<0.040	<0.040	<0.040	<0.040	
	Total Polychlorinated Biphenyls (mg/kg)	<0.040	<0.040	<0.040	<0.040	

	Sample ID	L955807-31	L955807-32	L955807-33	L955807-34	L955807-35
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	13:33	13:33	13:33	10:47	10:47
	Client ID	S1-12 METALS QC1-2	S1-12 METALS QC1-3	S1-12 METALS QC1-4	S2-7 METALS QC2-1	S2-7 METALS QC2-2
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)					
	Benzo(a)pyrene (mg/kg)					
	Benzo(b)fluoranthene (mg/kg)					
	Benzo(g,h,i)perylene (mg/kg)					
	Benzo(k)fluoranthene (mg/kg)					
	Chrysene (mg/kg)					
	Dibenz(a,h)anthracene (mg/kg)					
	Fluoranthene (mg/kg)					
	Fluorene (mg/kg)					
	Heavy Molecular Wt. Pah Sum (mg/kg)					
	Indeno(1,2,3-c,d)pyrene (mg/kg)					
	Light Molecular Wt. Pah Sum (mg/kg)					
	Naphthalene (mg/kg)					
	Total PAHs (mg/kg)					
	Phenanthrene (mg/kg)					
	Pyrene (mg/kg)					
	Surrogate: d10-Acenaphthene (SS) (%)					
	Surrogate: d12-Chrysene (SS) (%)					
	Surrogate: d8-Naphthalene (SS) (%)					
	Surrogate: d10-Phenanthrene (SS) (%)					
Polychlorinated Biphenyls	PCB-1016 (mg/kg)					
	PCB-1221 (mg/kg)					
	PCB-1232 (mg/kg)					
	PCB-1242 (mg/kg)					
	PCB-1248 (mg/kg)					
	PCB-1254 (mg/kg)					
	PCB-1260 (mg/kg)					
	PCB-1262 (mg/kg)					
	PCB-1268 (mg/kg)					
	Total Polychlorinated Biphenyls (mg/kg)					

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

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	Sample ID	L955807-36	L955807-37	L955807-38	L955807-39	L955807-40
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	10:47	10:47	09:31	15:23	13:18
	Client ID	S2-7 METALS QC2-3	S2-7 METALS QC2-4	S1-5 PAH QC1	S1-7C PAH QC2	S1 OUTSIDE - 14 PAH QC3
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)			<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)			<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)			<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)			<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)			<0.050	<0.050	<0.050
	Chrysene (mg/kg)			<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)			<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)			<0.050	<0.050	<0.050
	Fluorene (mg/kg)			<0.050	<0.050	<0.050
	Heavy Molecular Wt. Pah Sum (mg/kg)			<0.20	<0.20	<0.20
	Indeno(1,2,3-c,d)pyrene (mg/kg)			<0.050	<0.050	<0.050
	Light Molecular Wt. Pah Sum (mg/kg)			<0.12	<0.12	<0.12
	Naphthalene (mg/kg)			<0.050	<0.050	<0.050
	Total PAHs (mg/kg)			<0.20	<0.20	<0.20
	Phenanthrene (mg/kg)			<0.050	<0.050	<0.050
	Pyrene (mg/kg)			<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)			100	93	75
	Surrogate: d12-Chrysene (SS) (%)			77	80	SURR-ND 53
	Surrogate: d8-Naphthalene (SS) (%)			88	87	68
	Surrogate: d10-Phenanthrene (SS) (%)			96	91	62
Polychlorinated Biphenyls	PCB-1016 (mg/kg)					
	PCB-1221 (mg/kg)					
	PCB-1232 (mg/kg)					
	PCB-1242 (mg/kg)					
	PCB-1248 (mg/kg)					
	PCB-1254 (mg/kg)					
	PCB-1260 (mg/kg)					
	PCB-1262 (mg/kg)					
	PCB-1268 (mg/kg)					
	Total Polychlorinated Biphenyls (mg/kg)					

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	Sample ID	L955807-41	L955807-42	L955807-43	L955807-44	L955807-45
	Description					
	Sampled Date	15-NOV-10	15-NOV-10	16-NOV-10	15-NOV-10	15-NOV-10
	Sampled Time	10:14	11:04	09:50	14:18	10:32
	Client ID	S2 OUTSIDE - 4 PAH QC4	S2 OUTSIDE - 14 PAH QC5	S1 OUTSIDE - 6 PCB QC1	S1-10 PCB QC2	S2 OUTSIDE - 1 PCB QC3
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)	<0.050	<0.050			
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050			
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050			
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050			
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050			
	Chrysene (mg/kg)	<0.050	<0.050			
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050			
	Fluoranthene (mg/kg)	<0.050	<0.050			
	Fluorene (mg/kg)	<0.050	<0.050			
	Heavy Molecular Wt. Pah Sum (mg/kg)	<0.20	<0.20			
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050			
	Light Molecular Wt. Pah Sum (mg/kg)	<0.12	<0.12			
	Naphthalene (mg/kg)	<0.050	<0.050			
	Total PAHs (mg/kg)	<0.20	<0.20			
	Phenanthrene (mg/kg)	<0.050	<0.050			
	Pyrene (mg/kg)	<0.050	<0.050			
	Surrogate: d10-Acenaphthene (SS) (%)	77	86			
	Surrogate: d12-Chrysene (SS) (%)	51 SURR-ND	60			
	Surrogate: d8-Naphthalene (SS) (%)	69	79			
	Surrogate: d10-Phenanthrene (SS) (%)	65	70			
Polychlorinated Biphenyls	PCB-1016 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1221 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1232 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1242 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1248 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1254 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1260 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1262 (mg/kg)			<0.040	<0.040	<0.040
	PCB-1268 (mg/kg)			<0.040	<0.040	<0.040
	Total Polychlorinated Biphenyls (mg/kg)			<0.040	<0.040	<0.040

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

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	Sample ID	L955807-46	L955807-47			
	Description					
	Sampled Date	16-NOV-10	16-NOV-10			
	Sampled Time	13:00	13:19			
	Client ID	S2-9 PCB QC4	S2-15-A PCB QC5			
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Benz(a)anthracene (mg/kg)					
	Benzo(a)pyrene (mg/kg)					
	Benzo(b)fluoranthene (mg/kg)					
	Benzo(g,h,i)perylene (mg/kg)					
	Benzo(k)fluoranthene (mg/kg)					
	Chrysene (mg/kg)					
	Dibenz(a,h)anthracene (mg/kg)					
	Fluoranthene (mg/kg)					
	Fluorene (mg/kg)					
	Heavy Molecular Wt. Pah Sum (mg/kg)					
	Indeno(1,2,3-c,d)pyrene (mg/kg)					
	Light Molecular Wt. Pah Sum (mg/kg)					
	Naphthalene (mg/kg)					
	Total PAHs (mg/kg)					
	Phenanthrene (mg/kg)					
	Pyrene (mg/kg)					
	Surrogate: d10-Acenaphthene (SS) (%)					
	Surrogate: d12-Chrysene (SS) (%)					
	Surrogate: d8-Naphthalene (SS) (%)					
	Surrogate: d10-Phenanthrene (SS) (%)					
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.040	<0.040			
	PCB-1221 (mg/kg)	<0.040	<0.040			
	PCB-1232 (mg/kg)	<0.040	<0.040			
	PCB-1242 (mg/kg)	<0.040	<0.040			
	PCB-1248 (mg/kg)	<0.040	<0.040			
	PCB-1254 (mg/kg)	<0.040	<0.040			
	PCB-1260 (mg/kg)	<0.040	<0.040			
	PCB-1262 (mg/kg)	<0.040	<0.040			
	PCB-1268 (mg/kg)	<0.040	<0.040			
	Total Polychlorinated Biphenyls (mg/kg)	<0.040	<0.040			

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

Reference Information

Qualifiers for Individual Parameters Listed:

Qualifier	Description
SURR-ND	Surrogate recovery was slightly outside ALS DQO. Reported non-detect results for associated samples were unaffected.

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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	BCMELP CSR SALM METHOD 8/EPA 245.7

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). 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 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-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 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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-HIGHLOW-CALC-VA	Soil	Sum of low,high PAH’s	CALCULATION

The concentrations of individual PAH compounds are added together, based on molecular size; 2 and 3 ring PAHs constitute low-weight PAHs, 4 to 6 ring PAHs are the high-weight compounds.

PAH-SUM-CALC-VA	Soil	Sum of PAH’s	CALCULATION

Total PAH represents the sum of all PAH analytes reported for a given sample. Note that regulatory agencies and criteria differ in their definitions of Total PAH in terms of the individual PAH analytes to be included.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
PAH-TUMB-H/A-MS-VA	Soil	PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil
This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is

Reference Information

analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-ENONE-SK	Soil	Special Particle Size - ENONE Hydrometer	Forestry Canada (1991) p.42-45.
PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

PSA-PIPET-DETAIL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the silt and clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatments may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

** 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 LABORATORY GROUP - VANCOUVER, BC, CANADA
SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

Chain of Custody Numbers:

1	2	3	4	5

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 receieved 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.

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COC #

Page 1 of 5

Report To	
Company:	STANTEC
Contact:	Karen Munro
Address:	4370 Dominion St, 5th Floor, Burnaby, BC V5G 4L7
Phone:	604-436-3014 Fax: 604-436-3752
Invoice To	Same as Report ? ☑ Yes ☐ No
Company:	Stantec Consulting Ltd.
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L955807

Report Format / Distribution

☑ Standard ☐ Other

☑ PDF ☑ Excel ☐ Digital ☐ Fax

Email 1: Karen.Munro@stantec.com

Email 2: Kelsey.Miller@stantec.com

Client / Project Information

Job #: Canpotex (123110264 / 500.018)

PO / AFE:

LSD:

Quote #: Q26938

ALS Contact: Can Dang **Sampler:** JB

Service Requested (Rush for routine analysis subject to availability)

● Regular (Default)

○ Priority (Specify Date Required → →) Surcharges apply

○ Emergency (1 Business Day) - 100% Surcharge

○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-TOT-ORG-LECO-SK	MET-CCME-VA	MET-OD-200.2-DREG-VA	MOISTURE-VA	OD-PAH-VA	PCB-SE-ECD-VA	Particle size-sieve & pipette						Number of Containers
	S1 Outside - 1	15/01/2010	10:30	Sediment	x	x	x	x	x	x	x						2
	S1-2	16/01/2010	10:16	Sediment	x		x	x	x	x	x						2
	S1-3	16/01/2010	10:03	Sediment	x		x	x	x	x	x						2
	S1-4	16/01/2010	9:16	Sediment	x		x	x	x	x	x						2
	S1-5	16/01/2010	9:31	Sediment	x		x	x	x	x	x						2
	S1 Outside - 6	16/01/2010	9:50	Sediment	x		x	x	x	x	x						2
	S1-7A	15/01/2010	14:48	Sediment	x		x	x	x	x	x						2
	S1-7B	15/01/2010	15:05	Sediment	x		x	x	x	x	x						2
	S1-7C	15/01/2010	15:23	Sediment	x		x	x	x	x	x						2
	S1-8	15/01/2010	14:33	Sediment	x	x	x	x	x	x	x						2
	S1-9	15/01/2010	14:04	Sediment	x		x	x	x	x	x						2
	S1-10	15/01/2010	14:18	Sediment	x		x	x	x	x	x						2

Special Instructions / Regulations / Hazardous Details

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 provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
J.Beckett	17/11/2010	13:30.	SH	19 Nov	12:20	3.8 °C				

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OC #

Page 2 of ~~4~~5

Report To
Company: STANTEC
Contact: Karen Munro
Address: 4370 Dominion St, 5th Floor, Burnaby, BC V5G 4L7
Phone: 604-436-3014 Fax: 604-436-3752

Report Format / Distribution
☑ Standard ☐ Other
☑ PDF ☑ Excel ☐ Digital ☐ Fax
Email 1: Karen.Munro@stantec.com
Email 2: Kelsey.Miller@stantec.com

Service Requested (Rush for routine analysis subject to availability)
● Regular (Default)
○ Priority (Specify Date Required → →) Surcharges apply
○ Emergency (1 Business Day) - 100% Surcharge
○ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Invoice To Same as Report ? ☑ Yes ☐ No
Company: Stantec Consulting Ltd.
Contact:
Address:
Phone: Fax:

Client / Project Information
Job #: Canpotex (123110264 / 500.018)
PO / AFE:
LSD:
Quote #: Q26938

Lab Work Order # (lab use only)

ALS Contact: Can Dang **Sampler:** JB

Analysis Request
Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-TOT-ORG-LECO-SK	MET-CCME-VA	MET-OD-200.2-DREG-VA	MOISTURE-VA	OD-PAH-VA	PCB-SE-ECD-VA	Particle size-sieve & pipette						Number of Containers
	S1 Outside - 11	15/01/2010	13:46	Sediment	x		x	x	x	x	x						2
	S1-12	15/01/2010	13:33	Sediment	x		x	x	x	x	x						2
	S1-13	15/01/2010	12:56	Sediment	x	x	x	x	x	x	x						2
	S1 Outside - 14	15/01/2010	13:18	Sediment	x		x	x	x	x	x						2

Special Instructions / Regulations / Hazardous Details

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
J. Beckett	17/11/2010	13:30	S H	19 Nov	17:20	3.8 °C				

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Page 3 of 5

Report To		**Report Format / Distribution**	
Company:	STANTEC	☑ Standard ☐ Other	
Contact:	Karen Munro	☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Address:	4370 Dominion St, 5th Floor, Burnaby, BC V5G 4L7	Email 1:	Karen.Munro@stantec.com
		Email 2:	Kelsey.Miller@stantec.com
Phone:	604-436-3014 Fax: 604-436-3752		
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	
Company:	Stantec Consulting Ltd.	Job #:	Canpotex (123110264 / 500.018)
Contact:		PO / AFE:	
Address:		LSD:	
Phone:	Fax:	Quote #:	Q26938
Lab Work Order # (lab use only)		ALS Contact: Can Dang	Sampler: JB

Service Requested (Rush for routine analysis subject to availability)

● Regular (Default)
○ Priority (Specify Date Required → →) Surcharges apply
○ Emergency (1 Business Day) - 100% Surcharge
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Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Special part size - hydromete												Number of Containers
	S3 - 1	16/11/2010	10:44	Sediment	x												2
	S3 - 2	16/11/2010	10:56	Sediment	x												2
	S3 - 3	16/11/2010	11:10	Sediment	x												2
	S3 - 4	16/11/2010	11:24	Sediment	x												2
	S3 - 5	16/11/2010	11:38	Sediment	x												2

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: J.Beckett	Date (dd-mmm-yy) 17/11/2010	Time (hh-mm) 13:30	Received by: SH	Date: 19 Nov	Time: 12:20	Temperature: 3.8 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

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Report To	
Company:	STANTEC
Contact:	Karen Munro
Address:	4370 Dominion St, 5th Floor, Burnaby, BC V5G 4L7
Phone:	604-436-3014 Fax: 604-436-3752
Invoice To	Same as Report ? ☑ Yes ☐ No
Company:	Stantec Consulting Ltd.
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	

Report Format / Distribution
☑ Standard ☐ Other
☑ PDF ☑ Excel ☐ Digital ☐ Fax
Email 1: Karen.Munro@stantec.com
Email 2: Kelsey.Miller@stantec.com

Client / Project Information
Job #: Canpotex (123110264 / 500.018)
PO / AFE:
LSD:
Quote #: Q26938
ALS Contact: Can Dang
Sampler: JB

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Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-TOT-ORG-LECO-SK	MET-CCME-VA	MET-OD-200.2-DREG-VA	MOISTURE-VA	OD-PAH-VA	PCB-SE-ECD-VA	Particle size-sieve & pipette						Number of Containers
	S2 Outside - 1	15/01/2010	10:32	Sediment	x		x	x	x	x	x						2
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	S2 Outside - 4	15/01/2010	10:14	Sediment	x		x	x	x	x	x						2
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	S2 Outside - 6	15/01/2010	9:53	Sediment	x	x	x	x	x	x	x						2
	S2-7	15/01/2010	10:47	Sediment	x		x	x	x	x	x						2
	S2-8	15/01/2010	11:38	Sediment	x		x	x	x	x	x						2
	S2-9	16/11/2010	13:00	Sediment	x		x	x	x	x	x						2
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

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Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
J. Beckett	17/11/2010	13:30	SH	19 Nov	12:20	3.8 °C				

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Page 5 of 5

Report To		**Report Format / Distribution**	
Company:	STANTEC	☑ Standard ☐ Other	
Contact:	Karen Munro	☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Address:	4370 Dominion St, 5th Floor, Burnaby, BC V5G 4L7	Email 1:	Karen.Munro@stantec.com
		Email 2:	Kelsey.Miller@stantec.com
Phone:	604-436-3014 Fax: 604-436-3752		
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	
Company:	Stantec Consulting Ltd.	Job #:	Canpotex (123110264 / 500.018)
Contact:		PO / AFE:	
Address:		LSD:	
Phone:	Fax:	Quote #:	Q26938
Lab Work Order # (lab use only)		ALS Contact: Can Dang	Sampler: JB

Service Requested (Rush for routine analysis subject to availability)
● Regular (Default)
○ Priority (Specify Date Required → →) Surcharges apply
○ Emergency (1 Business Day) - 100% Surcharge
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Analysis Request
Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	C-TOT-ORG-LECO-SK	MET-CCME-VA	MET-OD-200.2-DREG-VA	MOISTURE-VA	OD-PAH-VA	PCB-SE-ECD-VA	Particle size-sieve & pipette						Number of Containers
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	S2 Outside - 14	15/01/2010	11:04	Sediment	x		x	x	x	x	x						2
	~~S2 Outside - 15A~~ S2-15-A	16/11/2010	13:19	Sediment	x		x	x	x	x	x						2
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Special Instructions / Regulations / Hazardous Details

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 provided on a separate Excel tab.
Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
J.Beckett	17/11/2010	13:30	SH	19 Nov	12:20	3.8 °C				

APPENDIX B

Sediment Sampling Protocol and Results for the Dredge Site

Sediment Sampling Protocol

Chemical characterization of sediment at the proposed disposal sites was completed on November 16 and 26, 2010. Specific guidelines detailing minimum sample sizes required to characterize chemistry of proposed disposal sites were unavailable at the time of the study. As a result, professional expertise were relied to design a sampling program that provides a representative characterization of the sites while taking into account that the sites are in remote areas where contamination is unlikely. Based on these criteria, 14 samples were collected at Site A and 35 samples were collected at Site B. Sampling sites were distributed throughout the site in a grid-like fashion to ensure an appropriate spatial characterization of sediment constituents..

Samples were collected using a Ponar grab from which the top 7 to 8 cm of sediment were removed. Removed sediment was placed in a stainless steel bowl, homogenized, then placed into sterilized jars, sealed, and stored on ice until delivery to the laboratory facility (ALS Laboratories). Only samples containing fine sediments were accepted; if gravel or sand was collected in a grab, additional sampling was done until fines were obtained. Between sites, the grab and all sampling equipment were cleaned with site water and de-ionized water.

Samples were analyzed for all sediment parameters required for disposal at sea (mercury, cadmium, arsenic, chromium, copper, lead and zinc for disposal at sea package, total metals, % moisture, PAHs, PCBs, total organic carbon, and particle size distribution). Supporting information about the sediment samples was also recorded (colour, sheen, odour, presence of invertebrates and particle size components and layers) and the samples were photographed before being placed into sample jars.

Analytical results were compared to the disposal at sea screening criteria and to Canadian Council of Ministers of the Environment 2006 sediment quality guidelines for the protection of marine aquatic life, which includes Interim Marine Sediment Quality Guidelines and Probable Effects Levels.

Quality Assurance/Quality Control (QA/QC)

The following QA/QC criteria were used to ensure adherence to the minimum requirements for dredged materials in the Pacific and Yukon Region:

- Each sample will be processed wearing clean nitrile gloves and all stainless steel equipment will be thoroughly cleaned using site water then de-ionized water between samples to avoid cross-contamination. In addition to these measures, bilge pump activity, smoking, and other sources of contamination will not be permitted while sampling is being performed.
- Where possible, winches will be lubricated with vegetable oil to avoid contamination of samples. Where petroleum-based lubricants are unavoidable, all steps will be taken to have the operator prepare a clean work area and to minimize sources of sample contamination.

Certificate of Analysis

JACQUES WHITFORD

ATTN: CRAIG LOSOS

4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Report Date: 15-JUL-09 17:52 (MT)
Version: FINAL REV. 2

Lab Work Order #: **L780781**
Date Received: **19-JUN-09**

Project P.O. #:
Job Reference: 1048843.01
Legal Site Desc:
CofC Numbers: 09-027610

Other Information:

Comments: The certain Polychlorinated Biphenyls detection limits have been increased for some of the samples due to the interferences encountered during the analysis.
.

Lindsay Jones

LINDSAY JONES
Account Manager

	Sample ID	L780781-1	L780781-2	L780781-3	L780781-4	L780781-5
	Description					
	Sampled Date	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	VC23 (SURFACE)	VC23 (2M)	VC23 (5M)	VC26 (SURFACE)	VC26 (2M)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	39.2	34.9	32.3	36.4	32.5
	pH (pH)	7.72	8.07	8.18	7.47	8.26
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	<1.0	1.0
	% Sand (2.0mm - 0.063mm) (%)	2.0	9.0	10.0	4.0	3.0
	% Silt (0.063mm - 4um) (%)	66.0	63.0	59.0	68.0	62.0
	% Clay (<4um) (%)	31.0	29.0	32.0	29.0	34.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.22	0.94	0.81	1.09	0.78
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.7	10.8	12.0	8.2	10.9
	Barium (Ba) (mg/kg)	112	118	95.8	106	108
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.19	0.15	0.17	0.17	0.15
	Chromium (Cr) (mg/kg)	31.1	31.0	30.1	33.4	31.4
	Cobalt (Co) (mg/kg)	13.8	13.6	14.1	13.9	14.1
	Copper (Cu) (mg/kg)	48.5	43.2	45.6	47.5	45.4
	Lead (Pb) (mg/kg)	13.2	9.0	9.7	10.8	10.2
	Mercury (Hg) (mg/kg)	0.0783	0.0542	0.0819	0.0658	0.0544
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	29.0	28.2	30.1	29.1	29.4
	Selenium (Se) (mg/kg)	<0.50	<3.0	<2.0	<2.0	<0.50
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	81.4	81.6	77.6	80.8	80.4
	Zinc (Zn) (mg/kg)	104	97.8	99.8	100	101
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

	Sample ID	L780781-6	L780781-7	L780781-8	L780781-9	L780781-10
	Description					
	Sampled Date	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	VC26 (5M)	VC13 (SURFACE)	VC13 (2M)	VC13 (5M)	PONAR 1
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	32.9	37.0	34.2	33.6	44.5
	pH (pH)	8.07	7.73	8.11	8.39	7.41
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	<1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)	13.0	5.0	4.0	5.0	10.0
	% Silt (0.063mm - 4um) (%)	59.0	62.0	64.0	64.0	62.0
	% Clay (<4um) (%)	28.0	33.0	33.0	31.0	28.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.07	0.98	0.85	0.86	1.64
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.3	9.4	12.0	11.1	12.8
	Barium (Ba) (mg/kg)	109	113	113	98.1	95.7
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.17	0.16	0.15	0.17	0.14
	Chromium (Cr) (mg/kg)	31.3	31.7	32.1	31.0	30.6
	Cobalt (Co) (mg/kg)	13.5	13.7	14.3	14.0	13.0
	Copper (Cu) (mg/kg)	43.6	46.5	45.1	44.9	43.0
	Lead (Pb) (mg/kg)	9.4	11.1	10.4	10.8	10.4
	Mercury (Hg) (mg/kg)	0.0530	0.0584	0.0676	0.0600	0.0641
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	28.8	28.8	29.2	30.3	27.2
	Selenium (Se) (mg/kg)	<3.0	<2.0	<0.50	<0.50	<0.50
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	80.6	81.8	81.3	79.6	76.8
	Zinc (Zn) (mg/kg)	98.2	101	101	100	93.5
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

	Sample ID	L780781-11	L780781-12			
	Description					
	Sampled Date	15-JUN-09	17-JUN-09			
	Sampled Time					
	Client ID	PONAR 2	REPLICATE 10			
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	43.3	44.7			
	pH (pH)	7.41				
Particle Size	% Gravel (>2mm) (%)	<1.0				
	% Sand (2.0mm - 0.063mm) (%)	7.0				
	% Silt (0.063mm - 4um) (%)	64.0				
	% Clay (<4um) (%)	29.0				
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.56				
Metals	Antimony (Sb) (mg/kg)	<10				
	Arsenic (As) (mg/kg)	11.6				
	Barium (Ba) (mg/kg)	96.4				
	Beryllium (Be) (mg/kg)	<0.50				
	Cadmium (Cd) (mg/kg)	0.15				
	Chromium (Cr) (mg/kg)	31.4				
	Cobalt (Co) (mg/kg)	13.2				
	Copper (Cu) (mg/kg)	45.0				
	Lead (Pb) (mg/kg)	10.3				
	Mercury (Hg) (mg/kg)	0.0625				
	Molybdenum (Mo) (mg/kg)	<4.0				
	Nickel (Ni) (mg/kg)	27.6				
	Selenium (Se) (mg/kg)	<2.0				
	Silver (Ag) (mg/kg)	<2.0				
	Thallium (Tl) (mg/kg)	<1.0				
	Tin (Sn) (mg/kg)	<5.0				
	Vanadium (V) (mg/kg)	79.2				
	Zinc (Zn) (mg/kg)	96.3				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050			
	Acenaphthylene (mg/kg)	<0.050	<0.050			
	Anthracene (mg/kg)	<0.050	<0.050			
	Benz(a)anthracene (mg/kg)	<0.050	<0.050			
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050			
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050			
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050			
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050			
	Chrysene (mg/kg)	<0.050	<0.050			
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050			
	Fluoranthene (mg/kg)	<0.050	<0.050			
	Fluorene (mg/kg)	<0.050	<0.050			
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050			
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050			

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780781-1	L780781-2	L780781-3	L780781-4	L780781-5
	Description					
	Sampled Date	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	VC23 (SURFACE)	VC23 (2M)	VC23 (5M)	VC26 (SURFACE)	VC26 (2M)
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	107	103	106	96	106
	Surrogate: d12-Chrysene (SS) (%)	104	102	95	96	105
	Surrogate: d8-Naphthalene (SS) (%)	103	99	104	93	102
	Surrogate: d10-Phenanthrene (SS) (%)	107	104	108	97	107
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1221 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1232 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1242 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1248 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1254 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1260 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1262 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	PCB-1268 (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070
	Total Polychlorinated Biphenyls (mg/kg)	<0.060	<0.060	<0.060	<0.070	<0.070

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID **Description** **Sampled Date** **Sampled Time** **Client ID**	L780781-6 15-JUN-09 VC26 (5M)	L780781-7 15-JUN-09 VC13 (SURFACE)	L780781-8 15-JUN-09 VC13 (2M)	L780781-9 15-JUN-09 VC13 (5M)	L780781-10 15-JUN-09 PONAR 1
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	102	104	95	105	106
	Surrogate: d12-Chrysene (SS) (%)	101	102	96	104	105
	Surrogate: d8-Naphthalene (SS) (%)	97	100	90	101	102
	Surrogate: d10-Phenanthrene (SS) (%)	102	105	97	106	108
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1221 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1232 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1242 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1248 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1254 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1260 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1262 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	PCB-1268 (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060
	Total Polychlorinated Biphenyls (mg/kg)	<0.060	<0.070	<0.060	<0.060	<0.060

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780781-11	L780781-12			
	Description					
	Sampled Date	15-JUN-09	17-JUN-09			
	Sampled Time					
	Client ID	PONAR 2	REPLICATE 10			
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050			
	Phenanthrene (mg/kg)	<0.050	<0.050			
	Pyrene (mg/kg)	<0.050	<0.050			
	Surrogate: d10-Acenaphthene (SS) (%)	103	96			
	Surrogate: d12-Chrysene (SS) (%)	95	88			
	Surrogate: d8-Naphthalene (SS) (%)	102	95			
	Surrogate: d10-Phenanthrene (SS) (%)	103	97			
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.070				
	PCB-1221 (mg/kg)	<0.070				
	PCB-1232 (mg/kg)	<0.070				
	PCB-1242 (mg/kg)	<0.070				
	PCB-1248 (mg/kg)	<0.070				
	PCB-1254 (mg/kg)	<0.070				
	PCB-1260 (mg/kg)	<0.070				
	PCB-1262 (mg/kg)	<0.070				
	PCB-1268 (mg/kg)	<0.070				
	Total Polychlorinated Biphenyls (mg/kg)	<0.070				

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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-CSR-MS-VA	Soil	Metals in Soil by ICPMS (CSR SALM)	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
		PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PAH-TUMB-H/A-MS-VA	Soil		

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
SE-SALM-HVAF-VA	Soil	Se in Soil by HVAFS (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Water Quality - Determination of As/Se/Sb, Part 1 - Hydride Generation Atomic Fluorescence Spectrometry (HG-AFS)", by the International Organization for Standardization (ISO). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry.

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	Analytical Method Reference(Based On)
TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA	SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

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 # **09 - 027610**
Page 1 of 1

Report To CRAIG LOSOS
Company: STANTEC
Contact:
Address: 4370 DOMINION ST
BURNABY BC V5Z 1B8
Phone: 604-436-3014 Fax: 604-436-3752

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:

Lab Work Order # (lab use only) L780781

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF___ Excel___ Digital___ Fax___
Email 1: craig.losos@stantec.com
Email 2: karen.munro@stantec.com

Client / Project Information
Job #: 1648843.01
PO / AFE:
LSD:
Quote #:
ALS Contact: CAN DANG
Sampler: M. VAUGHAN T. HICKS

Service Requested: (Rush subject to availability)
☒ Regular (Standard Turnaround Times))
☐ Priority, Date Req'd: ________ (Surcharges apply)
☐ Emergency (1 Business Day) - 100% Surcharge
☐ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request
(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	PARTICLE SIZE	TOTAL ORGANIC CARBON	METALS (CCME pkg.)	PAHS	PCBS								Number of Containers
	VC 23	15-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC 23			CORE	✓	✓	✓	✓	✓								3
	VC 23			CORE	✓	✓	✓	✓	✓								3
	VC 26			CORE	✓	✓	✓	✓	✓								3
	VC 26			CORE	✓	✓	✓	✓	✓								3
	VC 26			CORE	✓	✓	✓	✓	✓								3
	VC 13			CORE	✓	✓	✓	✓	✓								3
	VC 13			CORE	✓	✓	✓	✓	✓								3
	VC 13	↓		CORE	✓	✓	✓	✓	✓								3
	PONAR 1	15-JUN-09		PONAR GRAB	✓	✓	✓	✓	✓								3
	PONAR 2	15 JUN 09		PONAR GRAB	✓	✓	✓	✓	✓								3
	REPLICATE 10	17-JUN-09		PONAR GRAB				✓									3

Special Instructions / Regulations / Hazardous Details

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:	Date:	Time:	Received by: HD	Date: 09/06/19	Time: 10:45	Temperature: 2 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

GENF 18.01 Front

- Precision will be assessed based on replicate subsamples. A replicate subsample (three jars) will be taken at 10% of the sampling sites to verify precision of CCME metals and total PAHs.
- All samples will be stored in 250 mL glass jars and kept in a cooler at ~4°C until they are shipped to the analytical laboratory in Vancouver within 48 to 72 hours of collection.

Certificate of Analysis

JACQUES WHITFORD

ATTN: CRAIG LOSOS

4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Reported On: 02-JAN-09 12:39 PM

Lab Work Order #: **L717954**

Date Received: **13-DEC-08**

Project P.O. #:

Job Reference: 1044383

Legal Site Desc:

CofC Numbers: 08-028154

Other Information:

Comments: The detection limits for some PCB parameters have been increased for the samples reported due to interferences encountered during analysis.

Bryan Mark
Account Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L717954-1	L717954-2	L717954-3	L717954-4	L717954-5
	Description					
	Sampled Date	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08
	Sampled Time					
	Client ID	SDT 1 (COMPOSITE)	SDT 2 (COMPOSITE)	SDT 3 (COMPOSITE)	SDT 4 (COMPOSITE)	SDT 5 (COMPOSITE)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	47.4	48.8	49.5	46.4	48.4
	pH (pH)	7.36	7.44	7.41	7.44	7.45
Particle Size	% Gravel (>2mm) (%)	<1	<1	<1	<1	<1
	% Sand (2.0mm - 0.063mm) (%)	4	7	4	5	5
	% Silt (0.063mm - 4um) (%)	67	66	67	66	68
	% Clay (<4um) (%)	29	27	29	29	27
Organic / Inorganic Carbon	Total Organic Carbon (%)	2.1	1.7	1.7	1.5	1.6
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	12.9	13.5	13.1	13.5	15.2
	Barium (Ba) (mg/kg)	104	101	102	101	101
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Chromium (Cr) (mg/kg)	30.9	29.9	30.4	30.4	30.0
	Cobalt (Co) (mg/kg)	13.3	13.0	13.1	12.9	13.0
	Copper (Cu) (mg/kg)	43.5	42.2	41.7	41.5	41.8
	Lead (Pb) (mg/kg)	<30	<30	<30	<30	<30
	Mercury (Hg) (mg/kg)	0.0678	0.0633	0.0642	0.0619	0.0601
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	28.6	28.3	28.2	27.6	27.6
	Selenium (Se) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	82.1	81.1	80.6	79.9	80.2
	Zinc (Zn) (mg/kg)	101	98.1	98.1	97.8	96.6
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L717954-6	L717954-7	L717954-8	L717954-9	L717954-10
	Description					
	Sampled Date	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08
	Sampled Time					
	Client ID	SDT 6 (COMPOSITE)	SDT 7 (COMPOSITE)	SDT 8 (COMPOSITE)	SDT 9 (COMPOSITE)	SDT 10 (COMPOSITE)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	46.3	45.6	47.6	47.5	44.9
	pH (pH)	7.44	7.50	7.48	7.43	7.23
Particle Size	% Gravel (>2mm) (%)	<1	<1	<1	<1	<1
	% Sand (2.0mm - 0.063mm) (%)	6	6	6	5	4
	% Silt (0.063mm - 4um) (%)	69	66	68	67	71
	% Clay (<4um) (%)	25	28	26	28	24
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.7	1.5	1.4	2.2	1.7
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	12.2	12.9	13.5	13.0	11.9
	Barium (Ba) (mg/kg)	102	105	102	99.8	105
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Chromium (Cr) (mg/kg)	29.8	30.7	30.2	30.2	29.8
	Cobalt (Co) (mg/kg)	13.1	13.6	13.5	13.2	13.3
	Copper (Cu) (mg/kg)	41.3	42.5	42.0	43.0	42.9
	Lead (Pb) (mg/kg)	<30	<30	<30	<30	<30
	Mercury (Hg) (mg/kg)	0.0610	0.0618	0.0657	0.0765	0.101
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	27.6	28.2	28.0	28.2	27.7
	Selenium (Se) (mg/kg)	<2.0	<2.0	<3.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	80.4	82.2	80.2	80.4	81.3
	Zinc (Zn) (mg/kg)	96.2	101	98.1	99.3	101
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.040	<0.040	<0.040	<0.040	<0.040
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L717954-11	L717954-12			
	Description					
	Sampled Date	12-DEC-08	12-DEC-08			
	Sampled Time					
	Client ID	SDT 11 (COMPOSITE)	SDT 12 (COMPOSITE)			
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	43.1	45.5			
	pH (pH)	7.71	7.37			
Particle Size	% Gravel (>2mm) (%)	4	<1			
	% Sand (2.0mm - 0.063mm) (%)	10	4			
	% Silt (0.063mm - 4um) (%)	57	69			
	% Clay (<4um) (%)	29	27			
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.7	1.6			
Metals	Antimony (Sb) (mg/kg)	<10	<10			
	Arsenic (As) (mg/kg)	9.2	12.5			
	Barium (Ba) (mg/kg)	102	109			
	Beryllium (Be) (mg/kg)	<0.50	<0.50			
	Cadmium (Cd) (mg/kg)	<0.50	<0.50			
	Chromium (Cr) (mg/kg)	29.2	30.5			
	Cobalt (Co) (mg/kg)	12.8	13.3			
	Copper (Cu) (mg/kg)	41.4	42.7			
	Lead (Pb) (mg/kg)	<30	<30			
	Mercury (Hg) (mg/kg)	0.0617	0.0592			
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0			
	Nickel (Ni) (mg/kg)	27.0	28.5			
	Selenium (Se) (mg/kg)	<2.0	<2.0			
	Silver (Ag) (mg/kg)	<2.0	<2.0			
	Thallium (Tl) (mg/kg)	<1.0	<1.0			
	Tin (Sn) (mg/kg)	<5.0	<5.0			
	Vanadium (V) (mg/kg)	78.8	84.0			
	Zinc (Zn) (mg/kg)	95.8	101			
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.040	<0.040			
	Acenaphthylene (mg/kg)	<0.050	<0.050			
	Anthracene (mg/kg)	<0.050	<0.050			
	Benz(a)anthracene (mg/kg)	<0.050	<0.050			
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050			
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050			
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050			
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050			
	Chrysene (mg/kg)	<0.050	<0.050			
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050			
	Fluoranthene (mg/kg)	<0.050	<0.050			
	Fluorene (mg/kg)	<0.050	<0.050			
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050			

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L717954-1	L717954-2	L717954-3	L717954-4	L717954-5
	Sample ID	L717954-1	L717954-2	L717954-3	L717954-4	L717954-5
	Description					
	Sampled Date	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08
	Sampled Time					
	Client ID	SDT 1 (COMPOSITE)	SDT 2 (COMPOSITE)	SDT 3 (COMPOSITE)	SDT 4 (COMPOSITE)	SDT 5 (COMPOSITE)
SOIL						
Polycyclic Aromatic Hydrocarbons	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	0.052	<0.050	0.056	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	91	102	98	101	101
	Surrogate: d12-Chrysene (SS) (%)	88	104	99	101	101
	Surrogate: d8-Naphthalene (SS) (%)	93	105	100	103	103
	Surrogate: d10-Phenanthrene (SS) (%)	92	103	100	102	104
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1221 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1232 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1242 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1248 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1254 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1260 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1262 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	PCB-1268 (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060
	Total Polychlorinated Biphenyls (mg/kg)	<0.060	<0.060	<0.060	<0.060	<0.060

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L717954-6	L717954-7	L717954-8	L717954-9	L717954-10
	Description					
	Sampled Date	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08	12-DEC-08
	Sampled Time					
	Client ID	SDT 6 (COMPOSITE)	SDT 7 (COMPOSITE)	SDT 8 (COMPOSITE)	SDT 9 (COMPOSITE)	SDT 10 (COMPOSITE)
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	0.085	0.110	0.074
	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	0.052	<0.050	0.059	0.079	0.058
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	101	100	95	98	93
	Surrogate: d12-Chrysene (SS) (%)	103	100	97	98	93
	Surrogate: d8-Naphthalene (SS) (%)	103	101	97	100	96
	Surrogate: d10-Phenanthrene (SS) (%)	104	102	98	102	96
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1221 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1232 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1242 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1248 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1254 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1260 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1262 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	PCB-1268 (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050
	Total Polychlorinated Biphenyls (mg/kg)	<0.050	<0.060	<0.060	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L717954-11	L717954-12			
	Description					
	Sampled Date	12-DEC-08	12-DEC-08			
	Sampled Time					
	Client ID	SDT 11 (COMPOSITE)	SDT 12 (COMPOSITE)			
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	2-Methylnaphthalene (mg/kg)	0.058	0.070			
	Naphthalene (mg/kg)	<0.050	<0.050			
	Phenanthrene (mg/kg)	<0.050	0.056			
	Pyrene (mg/kg)	<0.050	<0.050			
	Surrogate: d10-Acenaphthene (SS) (%)	97	99			
	Surrogate: d12-Chrysene (SS) (%)	98	99			
	Surrogate: d8-Naphthalene (SS) (%)	99	100			
	Surrogate: d10-Phenanthrene (SS) (%)	99	102			
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.050	<0.050			
	PCB-1221 (mg/kg)	<0.050	<0.050			
	PCB-1232 (mg/kg)	<0.050	<0.050			
	PCB-1242 (mg/kg)	<0.050	<0.050			
	PCB-1248 (mg/kg)	<0.050	<0.050			
	PCB-1254 (mg/kg)	<0.050	<0.050			
	PCB-1260 (mg/kg)	<0.050	<0.050			
	PCB-1262 (mg/kg)	<0.050	<0.050			
	PCB-1268 (mg/kg)	<0.050	<0.050			
	Total Polychlorinated Biphenyls (mg/kg)	<0.050	<0.050			

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2794-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

MOISTURE-VA	Soil		ASTM METHOD D2794-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-TUMB-H/A-MS-VA	Soil	PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil
This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (10 mesh /2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA	VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

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 # **08-028154**

Page 1 of 1

Report to: CRAIG LOSOS
Company: JACQUES WHITFORD AXYS
Contact:
Address: 4370 DOMINION ST.
BURNABY BC
Phone: 604 436 3014 Fax:

Invoice To: Same as Report ? [✓ Yes] / No ?
Company:
Contact:
Address:
Phone: Fax:

Lab Work Order # (lab use only) L717954

Report Format / Distribution
Standard: ✓ Other:
Select: PDF ___ Excel ___ Digital ___
Email 1: craig.losos@jacqueswhitford.com
Email 2: ward.prystay@jacqueswhitford.com

Client / Project Information:
Job #: 1044383
PO / AFE:
Legal Site Description:
Quote #:

ALS Contact: NATASHA Sampler: C. LOSOS

Service Requested: (rush - subject to availability)
✓ Regular (Default)
Priority (2-3 Business Days) - 50% Surcharge
Emergency (1 Business Day) - 100% Surcharge
For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request
(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date	Time	Sample Type	PARTICLE SIZE	TOTAL ORGANIC CARBON	TOTAL METALS (CCME)	PAHs	PCBs								Number of Containers
	SDT 1 (COMPOSITE)	DEC 12 08		SOIL	↓	↓	↓	↓	↓								3
	SDT 2 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 3 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 4 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 5 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 6 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 7 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 8 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 9 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 10 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 11 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3
	SDT 12 (COMPOSITE)	↓		↓	↓	↓	↓	↓	↓								3

Special Instructions / Regulations / Hazardous Details

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:	Date & Time:	Received by:	Date: 08/12/13	Time: 15:36	Temperature: 2 °C	Verified by:	Date & Time:	Observations: Yes / No ? If Yes attach SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Certificate of Analysis

JACQUES WHITFORD
ATTN: CRAIG LOSOS

4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Report Date: 15-JUL-09 17:18 (MT)
Version: FINAL

Lab Work Order #: **L780788**
Date Received: **19-JUN-09**

Project P.O. #:
Job Reference: 1048843.01
Legal Site Desc:
CofC Numbers: 09-027609

Other Information:

Comments: Please note that some of the PCBs detection limits have been increased due to low dry sample weight.

Lindsay Jones
LINDSAY JONES
Account Manager

	Sample ID	L780788-1	L780788-2	L780788-3	L780788-4	L780788-5
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	VC 21 (SURFACE)	VC 21 (2M)	VC 21 (5M)	VC 25 (SURFACE)	VC 25 (2M)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	39.8	34.5	31.5	37.7	35.4
	pH (pH)	7.48	7.85	8.01	7.40	8.23
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	<1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)	3.0	4.0	17.0	9.0	5.0
	% Silt (0.063mm - 4um) (%)	64.0	65.0	54.0	60.0	64.0
	% Clay (<4um) (%)	33.0	31.0	28.0	31.0	31.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.20	0.83	0.67	1.14	0.83
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	11.2	9.3	9.3	9.8	10.7
	Barium (Ba) (mg/kg)	111	102	98.6	104	111
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.20	0.22	0.19	0.19	0.16
	Chromium (Cr) (mg/kg)	32.8	29.1	29.8	30.3	30.8
	Cobalt (Co) (mg/kg)	13.9	14.0	13.9	13.4	13.4
	Copper (Cu) (mg/kg)	48.9	43.3	40.1	46.1	43.7
	Lead (Pb) (mg/kg)	13.5	10.9	10.5	12.5	9.0
	Mercury (Hg) (mg/kg)	0.0689	0.0513	0.0490	0.0687	0.0490
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	29.5	29.3	28.4	29.3	28.5
	Selenium (Se) (mg/kg)	<2.0	<2.0	<3.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	86.2	81.4	79.3	81.9	81.1
	Zinc (Zn) (mg/kg)	107	102	101	104	99.8
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780788-6	L780788-7	L780788-8	L780788-9	L780788-10
	Description					
	Sampled Date	16-JUN-09	17-JUN-09	17-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	VC 25 (5M)	PONAR 11	PONAR 12	REPLICATE 1	REPLICATE 2
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	34.1	43.3	46.9	42.9	45.2
	pH (pH)	8.11	7.45	7.30	7.28	7.20
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0		
	% Sand (2.0mm - 0.063mm) (%)	6.0	10.0	20.0		
	% Silt (0.063mm - 4um) (%)	63.0	64.0	55.0		
	% Clay (<4um) (%)	31.0	25.0	26.0		
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.85	1.09	1.36		
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.9	10.5	11.7	13.5	13.0
	Barium (Ba) (mg/kg)	103	104	99.8	102	102
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.17	0.18	0.16	0.15	0.15
	Chromium (Cr) (mg/kg)	30.8	30.0	29.1	30.6	30.4
	Cobalt (Co) (mg/kg)	14.0	13.2	12.9	12.8	13.2
	Copper (Cu) (mg/kg)	43.8	41.4	41.1	42.4	43.2
	Lead (Pb) (mg/kg)	9.7	9.7	10.6	10.3	10.7
	Mercury (Hg) (mg/kg)	0.0539	0.0551	0.0623	0.0618	0.0627
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	29.7	27.9	27.6	28.0	28.4
	Selenium (Se) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	82.2	80.9	79.1	81.1	82.3
	Zinc (Zn) (mg/kg)	103	98.9	97.4	98.5	102
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

	Sample ID	L780788-11	L780788-12	L780788-15	L780788-16	L780788-17
	Description					
	Sampled Date	15-JUN-09	17-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	REPLICATE 3	REPLICATE 9	REPLICATE 1 METALS QC1	REPLICATE 1 METALS QC2	REPLICATE 1 METALS QC3
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	43.4	44.0	47.7	46.9	47.5
	pH (pH)	7.17				
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)	<10				
	Arsenic (As) (mg/kg)	12.7				
	Barium (Ba) (mg/kg)	111				
	Beryllium (Be) (mg/kg)	<0.50				
	Cadmium (Cd) (mg/kg)	0.14		0.17	0.16	0.16
	Chromium (Cr) (mg/kg)	33.7				
	Cobalt (Co) (mg/kg)	13.4				
	Copper (Cu) (mg/kg)	43.9				
	Lead (Pb) (mg/kg)	9.8		12.2	10.8	11.1
	Mercury (Hg) (mg/kg)	0.0620		0.074	0.065	0.068
	Molybdenum (Mo) (mg/kg)	<4.0				
	Nickel (Ni) (mg/kg)	29.2				
	Selenium (Se) (mg/kg)	<3.0				
	Silver (Ag) (mg/kg)	<2.0				
	Thallium (Tl) (mg/kg)	<1.0				
	Tin (Sn) (mg/kg)	<5.0				
	Vanadium (V) (mg/kg)	82.8				
	Zinc (Zn) (mg/kg)	100				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050			
	Acenaphthylene (mg/kg)	<0.050	<0.050			
	Anthracene (mg/kg)	<0.050	<0.050			
	Benz(a)anthracene (mg/kg)	<0.050	<0.050			
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050			
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050			
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050			
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050			
	Chrysene (mg/kg)	<0.050	<0.050			
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050			
	Fluoranthene (mg/kg)	<0.050	<0.050			
	Fluorene (mg/kg)	<0.050	<0.050			
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050			
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050			

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L780788-19 15-JUN-09 REPLICATE 2 METALS QC1	L780788-20 15-JUN-09 REPLICATE 2 METALS QC2	L780788-21 15-JUN-09 REPLICATE 2 METALS QC3	L780788-23 15-JUN-09 REPLICATE 3 METALS QC1	L780788-24 15-JUN-09 REPLICATE 3 METALS QC2
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	45.4	45.6	47.9	46.0	46.2
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.16	0.15	0.16	0.16	0.17
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	11.2	10.4	10.9	11.0	11.3
	Mercury (Hg) (mg/kg)	0.064	0.062	0.061	0.065	0.066
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)					
	Acenaphthylene (mg/kg)					
	Anthracene (mg/kg)					
	Benz(a)anthracene (mg/kg)					
	Benzo(a)pyrene (mg/kg)					
	Benzo(b)fluoranthene (mg/kg)					
	Benzo(g,h,i)perylene (mg/kg)					
	Benzo(k)fluoranthene (mg/kg)					
	Chrysene (mg/kg)					
	Dibenz(a,h)anthracene (mg/kg)					
	Fluoranthene (mg/kg)					
	Fluorene (mg/kg)					
	Indeno(1,2,3-c,d)pyrene (mg/kg)					
	2-Methylnaphthalene (mg/kg)					

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780788-25				
	Description					
	Sampled Date	15-JUN-09				
	Sampled Time					
	Client ID	REPLICATE 3 METALS QC3				
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	47.0				
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.16				
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	11.1				
	Mercury (Hg) (mg/kg)	0.069				
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)					
	Acenaphthylene (mg/kg)					
	Anthracene (mg/kg)					
	Benz(a)anthracene (mg/kg)					
	Benzo(a)pyrene (mg/kg)					
	Benzo(b)fluoranthene (mg/kg)					
	Benzo(g,h,i)perylene (mg/kg)					
	Benzo(k)fluoranthene (mg/kg)					
	Chrysene (mg/kg)					
	Dibenz(a,h)anthracene (mg/kg)					
	Fluoranthene (mg/kg)					
	Fluorene (mg/kg)					
	Indeno(1,2,3-c,d)pyrene (mg/kg)					
	2-Methylnaphthalene (mg/kg)					

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L780788-1 16-JUN-09 VC 21 (SURFACE)	L780788-2 16-JUN-09 VC 21 (2M)	L780788-3 16-JUN-09 VC 21 (5M)	L780788-4 16-JUN-09 VC 25 (SURFACE)	L780788-5 16-JUN-09 VC 25 (2M)
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	100	107	110	114	99
	Surrogate: d12-Chrysene (SS) (%)	90	94	97	101	86
	Surrogate: d8-Naphthalene (SS) (%)	97	104	107	111	96
	Surrogate: d10-Phenanthrene (SS) (%)	101	110	112	115	98
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1221 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1232 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1242 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1248 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1254 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1260 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1262 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	PCB-1268 (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060
	Total Polychlorinated Biphenyls (mg/kg)	<0.070	<0.060	<0.060	<0.070	<0.060

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L780788-6	L780788-7	L780788-8	L780788-9	L780788-10
	Sample ID	L780788-6	L780788-7	L780788-8	L780788-9	L780788-10
	Description					
	Sampled Date	16-JUN-09	17-JUN-09	17-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	VC 25 (5M)	PONAR 11	PONAR 12	REPLICATE 1	REPLICATE 2
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	0.052	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	100	107	103	99	107
	Surrogate: d12-Chrysene (SS) (%)	87	99	93	105	97
	Surrogate: d8-Naphthalene (SS) (%)	98	105	102	95	107
	Surrogate: d10-Phenanthrene (SS) (%)	101	108	104	105	109
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1221 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1232 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1242 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1248 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1254 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1260 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1262 (mg/kg)	<0.070	<0.070	<0.070		
	PCB-1268 (mg/kg)	<0.070	<0.070	<0.070		
	Total Polychlorinated Biphenyls (mg/kg)	<0.070	<0.070	<0.070		

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L780788-11	L780788-12	L780788-15	L780788-16	L780788-17
	Description					
	Sampled Date	15-JUN-09	17-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	REPLICATE 3	REPLICATE 9	REPLICATE 1 METALS QC1	REPLICATE 1 METALS QC2	REPLICATE 1 METALS QC3
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050			
	Phenanthrene (mg/kg)	<0.050	<0.050			
	Pyrene (mg/kg)	<0.050	<0.050			
	Surrogate: d10-Acenaphthene (SS) (%)	99	96			
	Surrogate: d12-Chrysene (SS) (%)	92	89			
	Surrogate: d8-Naphthalene (SS) (%)	97	93			
	Surrogate: d10-Phenanthrene (SS) (%)	104	98			
Polychlorinated Biphenyls	PCB-1016 (mg/kg)					
	PCB-1221 (mg/kg)					
	PCB-1232 (mg/kg)					
	PCB-1242 (mg/kg)					
	PCB-1248 (mg/kg)					
	PCB-1254 (mg/kg)					
	PCB-1260 (mg/kg)					
	PCB-1262 (mg/kg)					
	PCB-1268 (mg/kg)					
	Total Polychlorinated Biphenyls (mg/kg)					

	Sample ID	L780788-19	L780788-20	L780788-21	L780788-23	L780788-24
	Description					
	Sampled Date	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	REPLICATE 2 METALS QC1	REPLICATE 2 METALS QC2	REPLICATE 2 METALS QC3	REPLICATE 3 METALS QC1	REPLICATE 3 METALS QC2
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)					
	Phenanthrene (mg/kg)					
	Pyrene (mg/kg)					
	Surrogate: d10-Acenaphthene (SS) (%)					
	Surrogate: d12-Chrysene (SS) (%)					
	Surrogate: d8-Naphthalene (SS) (%)					
	Surrogate: d10-Phenanthrene (SS) (%)					
Polychlorinated Biphenyls	PCB-1016 (mg/kg)					
	PCB-1221 (mg/kg)					
	PCB-1232 (mg/kg)					
	PCB-1242 (mg/kg)					
	PCB-1248 (mg/kg)					
	PCB-1254 (mg/kg)					
	PCB-1260 (mg/kg)					
	PCB-1262 (mg/kg)					
	PCB-1268 (mg/kg)					
	Total Polychlorinated Biphenyls (mg/kg)					

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780788-25
	Description	
	Sampled Date	15-JUN-09
	Sampled Time	
	Client ID	REPLICATE 3 METALS QC3
Grouping	**Analyte**	
SOIL		
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	
	Phenanthrene (mg/kg)	
	Pyrene (mg/kg)	
	Surrogate: d10-Acenaphthene (SS) (%)	
	Surrogate: d12-Chrysene (SS) (%)	
	Surrogate: d8-Naphthalene (SS) (%)	
	Surrogate: d10-Phenanthrene (SS) (%)	
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	
	PCB-1221 (mg/kg)	
	PCB-1232 (mg/kg)	
	PCB-1242 (mg/kg)	
	PCB-1248 (mg/kg)	
	PCB-1254 (mg/kg)	
	PCB-1260 (mg/kg)	
	PCB-1262 (mg/kg)	
	PCB-1268 (mg/kg)	
	Total Polychlorinated Biphenyls (mg/kg)	

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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.

HG-CSR-CVAFS-VA	Soil	CVAFS Hg in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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-CSR-MS-VA	Soil	Metals in Soil by ICPMS (CSR SALM)	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
PAH-TUMB-H/A-MS-VA	Soil	PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil
This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA	SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

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 # **09 - 027609**

Page 1 of 1

Report To CRAIG LOSOS
Company: STANTEC
Contact:
Address: 4370 DOMINION ST.
BURNABY BC V5Z 1B8
Phone: 604-436-3014 Fax: 604-436-3752

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF ___ Excel ___ Digital ___ Fax ___
Email 1: craig.losos@stantec.com
Email 2: karen.munro@stantec.com

Service Requested: (Rush subject to availability)
☒ Regular (Standard Turnaround Times))
☐ Priority, Date Req'd: ______ (Surcharges apply)
☐ Emergency (1 Business Day) - 100% Surcharge
☐ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

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 #: 1048843.01
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only) L780788

ALS Contact: CAN DANG

Sampler: M. VAUGHAN T. HICKS

Analysis Request
(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	PARTICLE SIZE	TOTAL ORGANIC CARBON	METALS (CCME PKG)	PAHS	PCBS								Number of Containers
	VC 21 - SURFACE	16·JUN·09		CORE	✓	✓	✓	✓	✓								3
	VC 21 - 2m	16·JUN·09		CORE	✓	✓	✓	✓	✓								3
	VC 21 - 5m	16·JUN·09		CORE	✓	✓	✓	✓	✓								3
	VC 25 - SURFACE	16-JUN·09		CORE	✓	✓	✓	✓	✓								3
	VC 25 - 2m	16-JUN·09		CORE	✓	✓	✓	✓	✓								3
	VC 25 - 5m	16·JUN·09		CORE	✓	✓	✓	✓	✓								3
	PONAR 11	17·JUN·09		PONAR GRAB	✓	✓	✓	✓	✓								3
	PONAR 12	17·JUN·09		PONAR GRAB	✓	✓	✓	✓	✓								3
	REPLICATE 1	15·JUN·09		PONAR GRAB			✓	✓									3
	REPLICATE 2	15·JUN·09		PONAR GRAB			✓	✓									3
	REPLICATE 3	15·JUN·09		PONAR GRAB			✓	✓									3
	REPLICATE 9	17·JUN·09		PONAR GRAB				✓									3

Special Instructions / Regulations / Hazardous Details

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:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
			HD	09/06/19	10:44	2 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

GENF 18.01 Front

Certificate of Analysis

JACQUES WHITFORD

ATTN: CRAIG LOSOS

4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Report Date: 15-JUL-09 17:14 (MT)
Version: FINAL REV. 2

Lab Work Order #: **L780790**
Date Received: **19-JUN-09**

Project P.O. #:
Job Reference: 1048843.01
Legal Site Desc:
CofC Numbers:

Other Information:

Comments: The certain Polychlorinated Biphenyls detection limits have been increased for some of the samples due to the interferences encountered during the analysis.
.

Lindsay Jones
LINDSAY JONES
Account Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780790-1	L780790-2	L780790-3	L780790-4	L780790-5
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	15-JUN-09	15-JUN-09	17-JUN-09
	Sampled Time					
	Client ID	VC24-SURFACE	VC10-SURFACE	VC17-SURFACE	PONAR 3	PONAR 6
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	41.3	40.3	41.2	46.7	47.7
	pH (pH)	7.30	7.13	7.40	7.16	7.35
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	<1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)	3.0	4.0	6.0	15.0	7.0
	% Silt (0.063mm - 4um) (%)	65.0	63.0	63.0	58.0	66.0
	% Clay (<4um) (%)	32.0	33.0	31.0	27.0	27.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.21	1.40	1.38	1.78	1.44
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.3	11.0	11.5	12.5	12.0
	Barium (Ba) (mg/kg)	106	115	111	108	107
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.17	0.17	0.18	0.13	0.14
	Chromium (Cr) (mg/kg)	31.4	33.7	32.4	31.7	30.7
	Cobalt (Co) (mg/kg)	14.0	14.1	13.4	13.3	13.0
	Copper (Cu) (mg/kg)	47.0	47.6	45.6	41.8	40.4
	Lead (Pb) (mg/kg)	10.9	11.8	11.4	9.4	9.9
	Mercury (Hg) (mg/kg)	0.0614	0.0630	0.0611	0.0602	0.0565
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	30.6	31.0	28.9	28.8	28.6
	Selenium (Se) (mg/kg)	<2.0	<3.0	<3.0	<2.0	<3.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	83.8	86.3	84.3	82.8	81.8
	Zinc (Zn) (mg/kg)	106	108	103	98.4	97.0
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	0.122
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	0.056

	Sample ID	L780790-6	L780790-7	L780790-8	L780790-9	L780790-10
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	15-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	VC24-2M	VC10-2M	VC17-2M	VC24-5M	VC10-5M
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	34.5	35.6	35.5	34.1	36.0
	pH (pH)	8.00	7.94	8.33	7.89	8.26
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	<1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)	4.0	5.0	5.0	15.0	13.0
	% Silt (0.063mm - 4um) (%)	66.0	64.0	64.0	58.0	55.0
	% Clay (<4um) (%)	30.0	32.0	31.0	27.0	33.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.79	0.88	0.94	0.95	0.88
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.4	11.8	11.3	9.4	9.7
	Barium (Ba) (mg/kg)	116	118	126	105	110
	Beryllium (Be) (mg/kg)	<0.50	0.50	<0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.16	0.18	0.13	0.15	0.16
	Chromium (Cr) (mg/kg)	30.6	31.7	31.7	31.4	31.0
	Cobalt (Co) (mg/kg)	14.2	14.6	13.9	13.2	14.8
	Copper (Cu) (mg/kg)	43.9	46.5	43.3	41.7	44.0
	Lead (Pb) (mg/kg)	10.0	10.7	8.4	8.5	9.3
	Mercury (Hg) (mg/kg)	0.0485	0.0499	0.0439	0.0436	0.0605
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	29.6	30.3	29.8	29.1	31.1
	Selenium (Se) (mg/kg)	<2.0	<3.0	<2.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	84.5	84.3	84.6	82.0	83.2
	Zinc (Zn) (mg/kg)	102	106	104	98.6	105
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780790-11				
	Description					
	Sampled Date	15-JUN-09				
	Sampled Time					
	Client ID	VC17-5M				
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	35.9				
	pH (pH)	8.06				
Particle Size	% Gravel (>2mm) (%)	<1.0				
	% Sand (2.0mm - 0.063mm) (%)	6.0				
	% Silt (0.063mm - 4um) (%)	58.0				
	% Clay (<4um) (%)	35.0				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.86				
Metals	Antimony (Sb) (mg/kg)	<10				
	Arsenic (As) (mg/kg)	10.0				
	Barium (Ba) (mg/kg)	119				
	Beryllium (Be) (mg/kg)	0.54				
	Cadmium (Cd) (mg/kg)	0.16				
	Chromium (Cr) (mg/kg)	33.1				
	Cobalt (Co) (mg/kg)	15.2				
	Copper (Cu) (mg/kg)	46.0				
	Lead (Pb) (mg/kg)	10.1				
	Mercury (Hg) (mg/kg)	0.0450				
	Molybdenum (Mo) (mg/kg)	<4.0				
	Nickel (Ni) (mg/kg)	31.9				
	Selenium (Se) (mg/kg)	<3.0				
	Silver (Ag) (mg/kg)	<2.0				
	Thallium (Tl) (mg/kg)	<1.0				
	Tin (Sn) (mg/kg)	<5.0				
	Vanadium (V) (mg/kg)	88.8				
	Zinc (Zn) (mg/kg)	108				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050				
	Acenaphthylene (mg/kg)	<0.050				
	Anthracene (mg/kg)	<0.050				
	Benz(a)anthracene (mg/kg)	<0.050				
	Benzo(a)pyrene (mg/kg)	<0.050				
	Benzo(b)fluoranthene (mg/kg)	<0.050				
	Benzo(g,h,i)perylene (mg/kg)	<0.050				
	Benzo(k)fluoranthene (mg/kg)	<0.050				
	Chrysene (mg/kg)	<0.050				
	Dibenz(a,h)anthracene (mg/kg)	<0.050				
	Fluoranthene (mg/kg)	<0.050				
	Fluorene (mg/kg)	<0.050				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050				
	2-Methylnaphthalene (mg/kg)	<0.050				

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L780790-1	L780790-2	L780790-3	L780790-4	L780790-5
	Sample ID	L780790-1	L780790-2	L780790-3	L780790-4	L780790-5
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	15-JUN-09	15-JUN-09	17-JUN-09
	Sampled Time					
	Client ID	VC24-SURFACE	VC10-SURFACE	VC17-SURFACE	PONAR 3	PONAR 6
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	0.083
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	0.067
	Surrogate: d10-Acenaphthene (SS) (%)	96	99	98	103	96
	Surrogate: d12-Chrysene (SS) (%)	89	90	88	95	88
	Surrogate: d8-Naphthalene (SS) (%)	94	95	97	101	93
	Surrogate: d10-Phenanthrene (SS) (%)	99	99	99	107	99
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1221 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1232 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1242 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1248 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1254 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1260 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1262 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	PCB-1268 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080
	Total Polychlorinated Biphenyls (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.080

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L780790-6	L780790-7	L780790-8	L780790-9	L780790-10
	Sample ID	L780790-6	L780790-7	L780790-8	L780790-9	L780790-10
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	15-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	VC24-2M	VC10-2M	VC17-2M	VC24-5M	VC10-5M
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	106	102	108	98	110
	Surrogate: d12-Chrysene (SS) (%)	93	93	96	87	97
	Surrogate: d8-Naphthalene (SS) (%)	103	100	105	96	107
	Surrogate: d10-Phenanthrene (SS) (%)	106	104	108	98	110
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1221 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1232 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1242 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1248 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1254 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1260 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1262 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	PCB-1268 (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070
	Total Polychlorinated Biphenyls (mg/kg)	<0.060	<0.060	<0.070	<0.070	<0.070

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780790-11				
	Description					
	Sampled Date	15-JUN-09				
	Sampled Time					
	Client ID	VC17-5M				
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050				
	Phenanthrene (mg/kg)	<0.050				
	Pyrene (mg/kg)	<0.050				
	Surrogate: d10-Acenaphthene (SS) (%)	114				
	Surrogate: d12-Chrysene (SS) (%)	100				
	Surrogate: d8-Naphthalene (SS) (%)	111				
	Surrogate: d10-Phenanthrene (SS) (%)	113				
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060				
	PCB-1221 (mg/kg)	<0.060				
	PCB-1232 (mg/kg)	<0.060				
	PCB-1242 (mg/kg)	<0.060				
	PCB-1248 (mg/kg)	<0.060				
	PCB-1254 (mg/kg)	<0.060				
	PCB-1260 (mg/kg)	<0.060				
	PCB-1262 (mg/kg)	<0.060				
	PCB-1268 (mg/kg)	<0.060				
	Total Polychlorinated Biphenyls (mg/kg)	<0.060				

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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-CSR-MS-VA	Soil	Metals in Soil by ICPMS (CSR SALM)	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
		PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PAH-TUMB-H/A-MS-VA	Soil		

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA	SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

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 # **09 - 027614**

Page ____ of ____

Report To CRAIG LOSOS
Company: STANTEC
Contact:
Address: 4370 DOMINION ST
BURNABY, BC V5G 1B8
Phone: 604-436-3014 Fax: 604-436-3752

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:

Lab Work Order # (lab use only) L780790

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF____ Excel____ Digital____ Fax____
Email 1: craig.losos@stantec.com
Email 2: karen.munro@stantec.com

Client / Project Information
Job #: 1048843.01
PO / AFE:
LSD:
Quote #:

ALS Contact: CAN DANG
Sampler: M VAUGHAN T HICKS

Service Requested: (Rush subject to availability)
☒ Regular (Standard Turnaround Times))
☐ Priority, Date Req'd: ____________ (Surcharges apply)
☐ Emergency (1 Business Day) - 100% Surcharge
☐ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request
(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	PARTICLE SIZE	TOTAL ORGANIC CARBON	METALS (CCME PKG)	PAH S	PCBS	Number of Containers
	VC 24 - SURFACE	16-JUN-09		CORE	✓	✓	✓	✓	✓	3
	VC 10 - SURFACE	16-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 17 - SURFACE	15-JUN-09		CORE	↓	↓	↓	↓	↓	3
	PONAR 3	15-JUN-09		PONAR GRAB	↓	↓	↓	↓	↓	3
	PONAR 6	17-JUN-09		PONAR GRAB	↓	↓	↓	↓	↓	3
	VC 24 - 2m	16-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 10 - 2m	16-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 17 - 2m	15-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 24 - 5m	16-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 10 - 5m	16-JUN-09		CORE	↓	↓	↓	↓	↓	3
	VC 17 - 5m	15-JUN-09		CORE	↓	↓	↓	↓	↓	3

Special Instructions / Regulations / Hazardous Details

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)
Released by: Date: Time:

SHIPMENT RECEPTION (lab use only)
Received by: HD Date: 09/06/19 Time: 10:43 Temperature: 1 °C

SHIPMENT VERIFICATION (lab use only)
Verified by: Date: Time: Observations: Yes / No ? If Yes add SIF

Certificate of Analysis

JACQUES WHITFORD
ATTN: CRAIG LOSOS

4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Report Date: 15-JUL-09 17:21 (MT)
Version: FINAL

Lab Work Order #: **L780801**

Date Received: **19-JUN-09**

Project P.O. #:
Job Reference: 1048843.01
Legal Site Desc:
CofC Numbers: 09-027607

Other Information:

Comments: Please note that some of the PCB detection limits have been increased due to low dry sample weight.

Lindsay Jones
LINDSAY JONES
Account Manager

	Sample ID	L780801-1	L780801-2	L780801-3	L780801-4	L780801-5
	Description					
	Sampled Date	17-JUN-09	16-JUN-09	16-JUN-09	17-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	REPLICATE 5	VC14 (SURFACE)	VC11 (SURFACE)	REPLICATE 4	VC16 (SURFACE)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	46.3	40.3	40.8	46.0	39.5
	pH (pH)	7.49	7.61	7.78	7.39	7.54
Particle Size	% Gravel (>2mm) (%)		<1.0	1.0		<1.0
	% Sand (2.0mm - 0.063mm) (%)		17.0	4.0		9.0
	% Silt (0.063mm - 4um) (%)		57.0	63.0		60.0
	% Clay (<4um) (%)		26.0	32.0		30.0
Organic / Inorganic Carbon	Total Organic Carbon (%)		1.61	1.50		1.25
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	12.1	9.8	11.0	12.0	10.9
	Barium (Ba) (mg/kg)	104	111	113	98.9	104
	Beryllium (Be) (mg/kg)	<0.50	<0.50	0.50	<0.50	<0.50
	Cadmium (Cd) (mg/kg)	0.13	0.13	0.18	0.13	0.14
	Chromium (Cr) (mg/kg)	31.0	32.4	31.6	28.8	30.7
	Cobalt (Co) (mg/kg)	13.3	13.7	14.1	13.1	13.5
	Copper (Cu) (mg/kg)	41.2	42.9	50.1	40.9	45.0
	Lead (Pb) (mg/kg)	9.2	8.4	11.3	9.0	9.2
	Mercury (Hg) (mg/kg)	0.0612	0.0537	0.0611	0.0524	0.0541
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	29.1	30.2	31.0	28.6	29.4
	Selenium (Se) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<3.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	81.9	84.6	84.5	79.0	81.0
	Zinc (Zn) (mg/kg)	98.5	104	108	97.9	105
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

	Sample ID	L780801-6	L780801-7	L780801-8	L780801-9	L780801-10
	Description					
	Sampled Date	17-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	REPLICATE 6	VC14 (2M)	VC14 (5M)	VC11 (2M)	VC11 (5M)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	44.7	37.7	36.6	37.7	39.2
	pH (pH)		8.50	8.18	8.31	8.20
Particle Size	% Gravel (>2mm) (%)		<1.0	<1.0	<1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)		7.0	8.0	4.0	3.0
	% Silt (0.063mm - 4um) (%)		60.0	61.0	61.0	54.0
	% Clay (<4um) (%)		33.0	31.0	35.0	43.0
Organic / Inorganic Carbon	Total Organic Carbon (%)		0.91	0.98	0.93	0.93
Metals	Antimony (Sb) (mg/kg)		<10	<10	<10	<10
	Arsenic (As) (mg/kg)		9.1	13.4	9.4	12.5
	Barium (Ba) (mg/kg)		126	124	133	123
	Beryllium (Be) (mg/kg)		<0.50	0.51	0.50	0.56
	Cadmium (Cd) (mg/kg)		0.15	0.16	0.16	0.21
	Chromium (Cr) (mg/kg)		31.7	31.8	32.3	32.4
	Cobalt (Co) (mg/kg)		13.8	14.4	14.2	16.0
	Copper (Cu) (mg/kg)		43.0	44.4	44.1	54.4
	Lead (Pb) (mg/kg)		9.0	8.9	9.3	11.6
	Mercury (Hg) (mg/kg)		0.0468	0.0470	0.0499	0.0525
	Molybdenum (Mo) (mg/kg)		<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)		30.3	30.1	30.6	31.8
	Selenium (Se) (mg/kg)		<2.0	<2.0	<2.0	<2.0
	Silver (Ag) (mg/kg)		<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)		<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)		<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)		85.3	86.7	87.3	85.1
	Zinc (Zn) (mg/kg)		104	104	107	113
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780801-11	L780801-12	L780801-15	L780801-16	L780801-17
	Description					
	Sampled Date	16-JUN-09	16-JUN-09	17-JUN-09	17-JUN-09	17-JUN-09
	Sampled Time					
	Client ID	VC16 (2M)	VC16 (5M)	REPLICATE 5 METALS QC1	REPLICATE 5 METALS QC2	REPLICATE 5 METALS QC3
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	37.4	35.8	40.6	40.4	40.9
	pH (pH)	8.36	8.25			
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0			
	% Sand (2.0mm - 0.063mm) (%)	6.0	11.0			
	% Silt (0.063mm - 4um) (%)	59.0	58.0			
	% Clay (<4um) (%)	35.0	32.0			
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.87	0.91			
Metals	Antimony (Sb) (mg/kg)	<10	<10			
	Arsenic (As) (mg/kg)	10.6	9.8			
	Barium (Ba) (mg/kg)	119	108			
	Beryllium (Be) (mg/kg)	0.51	<0.50			
	Cadmium (Cd) (mg/kg)	0.14	0.15	0.15	0.15	0.13
	Chromium (Cr) (mg/kg)	31.3	31.4			
	Cobalt (Co) (mg/kg)	14.8	14.5			
	Copper (Cu) (mg/kg)	45.4	43.5			
	Lead (Pb) (mg/kg)	8.6	9.3	10.5	10.4	10.0
	Mercury (Hg) (mg/kg)	0.0491	0.0461	0.062	0.063	0.062
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0			
	Nickel (Ni) (mg/kg)	29.7	29.4			
	Selenium (Se) (mg/kg)	<2.0	<2.0			
	Silver (Ag) (mg/kg)	<2.0	<2.0			
	Thallium (Tl) (mg/kg)	<1.0	<1.0			
	Tin (Sn) (mg/kg)	<5.0	<5.0			
	Vanadium (V) (mg/kg)	86.0	83.3			
	Zinc (Zn) (mg/kg)	104	102			
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050			
	Acenaphthylene (mg/kg)	<0.050	<0.050			
	Anthracene (mg/kg)	<0.050	<0.050			
	Benz(a)anthracene (mg/kg)	<0.050	<0.050			
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050			
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050			
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050			
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050			
	Chrysene (mg/kg)	<0.050	<0.050			
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050			
	Fluoranthene (mg/kg)	<0.050	<0.050			
	Fluorene (mg/kg)	<0.050	<0.050			
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050			
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050			

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780801-19	L780801-20	L780801-21		
	Description					
	Sampled Date	17-JUN-09	17-JUN-09	17-JUN-09		
	Sampled Time					
	Client ID	REPLICATE 4 METALS QC1	REPLICATE 4 METALS QC2	REPLICATE 4 METALS QC3		
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	48.7	25.0	25.5		
	pH (pH)					
Particle Size	% Gravel (>2mm) (%)					
	% Sand (2.0mm - 0.063mm) (%)					
	% Silt (0.063mm - 4um) (%)					
	% Clay (<4um) (%)					
Organic / Inorganic Carbon	Total Organic Carbon (%)					
Metals	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Cadmium (Cd) (mg/kg)	0.16	0.16	0.16		
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Lead (Pb) (mg/kg)	10.7	10.7	10.6		
	Mercury (Hg) (mg/kg)	0.060	0.069	0.067		
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)					
	Acenaphthylene (mg/kg)					
	Anthracene (mg/kg)					
	Benz(a)anthracene (mg/kg)					
	Benzo(a)pyrene (mg/kg)					
	Benzo(b)fluoranthene (mg/kg)					
	Benzo(g,h,i)perylene (mg/kg)					
	Benzo(k)fluoranthene (mg/kg)					
	Chrysene (mg/kg)					
	Dibenz(a,h)anthracene (mg/kg)					
	Fluoranthene (mg/kg)					
	Fluorene (mg/kg)					
	Indeno(1,2,3-c,d)pyrene (mg/kg)					
	2-Methylnaphthalene (mg/kg)					

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L780801-1	L780801-2	L780801-3	L780801-4	L780801-5
	Description					
	Sampled Date	17-JUN-09	16-JUN-09	16-JUN-09	17-JUN-09	15-JUN-09
	Sampled Time					
	Client ID	REPLICATE 5	VC14 (SURFACE)	VC11 (SURFACE)	REPLICATE 4	VC16 (SURFACE)
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	106	103	108	108	95
	Surrogate: d12-Chrysene (SS) (%)	97	96	99	97	91
	Surrogate: d8-Naphthalene (SS) (%)	105	101	106	107	95
	Surrogate: d10-Phenanthrene (SS) (%)	107	104	110	109	94
Polychlorinated Biphenyls	PCB-1016 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1221 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1232 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1242 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1248 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1254 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1260 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1262 (mg/kg)		<0.070	<0.070		<0.070
	PCB-1268 (mg/kg)		<0.070	<0.070		<0.070
	Total Polychlorinated Biphenyls (mg/kg)		<0.070	<0.070		<0.070

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780801-6	L780801-7	L780801-8	L780801-9	L780801-10
	Description					
	Sampled Date	17-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	REPLICATE 6	VC14 (2M)	VC14 (5M)	VC11 (2M)	VC11 (5M)
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	97	98	93	96	98
	Surrogate: d12-Chrysene (SS) (%)	96	93	94	98	93
	Surrogate: d8-Naphthalene (SS) (%)	97	96	94	97	96
	Surrogate: d10-Phenanthrene (SS) (%)	98	94	94	98	95
Polychlorinated Biphenyls	PCB-1016 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1221 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1232 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1242 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1248 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1254 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1260 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1262 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	PCB-1268 (mg/kg)		<0.070	<0.070	<0.070	<0.060
	Total Polychlorinated Biphenyls (mg/kg)		<0.070	<0.070	<0.070	<0.060

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L780801-11 16-JUN-09 VC16 (2M)	L780801-12 16-JUN-09 VC16 (5M)	L780801-15 17-JUN-09 REPLICATE 5 METALS QC1	L780801-16 17-JUN-09 REPLICATE 5 METALS QC2	L780801-17 17-JUN-09 REPLICATE 5 METALS QC3
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050			
	Phenanthrene (mg/kg)	<0.050	<0.050			
	Pyrene (mg/kg)	<0.050	<0.050			
	Surrogate: d10-Acenaphthene (SS) (%)	93	94			
	Surrogate: d12-Chrysene (SS) (%)	92	92			
	Surrogate: d8-Naphthalene (SS) (%)	94	94			
	Surrogate: d10-Phenanthrene (SS) (%)	93	94			
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060	<0.060			
	PCB-1221 (mg/kg)	<0.060	<0.060			
	PCB-1232 (mg/kg)	<0.060	<0.060			
	PCB-1242 (mg/kg)	<0.060	<0.060			
	PCB-1248 (mg/kg)	<0.060	<0.060			
	PCB-1254 (mg/kg)	<0.060	<0.060			
	PCB-1260 (mg/kg)	<0.060	<0.060			
	PCB-1262 (mg/kg)	<0.060	<0.060			
	PCB-1268 (mg/kg)	<0.060	<0.060			
	Total Polychlorinated Biphenyls (mg/kg)	<0.060	<0.060			

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780801-19	L780801-20	L780801-21		
	Description					
	Sampled Date	17-JUN-09	17-JUN-09	17-JUN-09		
	Sampled Time					
	Client ID	REPLICATE 4 METALS QC1	REPLICATE 4 METALS QC2	REPLICATE 4 METALS QC3		
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)					
	Phenanthrene (mg/kg)					
	Pyrene (mg/kg)					
	Surrogate: d10-Acenaphthene (SS) (%)					
	Surrogate: d12-Chrysene (SS) (%)					
	Surrogate: d8-Naphthalene (SS) (%)					
	Surrogate: d10-Phenanthrene (SS) (%)					
Polychlorinated Biphenyls	PCB-1016 (mg/kg)					
	PCB-1221 (mg/kg)					
	PCB-1232 (mg/kg)					
	PCB-1242 (mg/kg)					
	PCB-1248 (mg/kg)					
	PCB-1254 (mg/kg)					
	PCB-1260 (mg/kg)					
	PCB-1262 (mg/kg)					
	PCB-1268 (mg/kg)					
	Total Polychlorinated Biphenyls (mg/kg)					

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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.

HG-CSR-CVAFS-VA	Soil	CVAFS Hg in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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-CSR-MS-VA	Soil	Metals in Soil by ICPMS (CSR SALM)	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
PAH-TUMB-H/A-MS-VA	Soil	PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil
This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA	SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

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Canada Toll Free: 1 800 668 9878
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COC # **09 - 027607**

Page 1 of 1

Report To CRAIG LOSOS
Company: STANTEC
Contact:
Address: 4370 DOMINION ST
BURNABY BC V5Z 1B8
Phone: 604-436-3014 Fax: 604-436-3752

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF ___ Excel ___ Digital ___ Fax ___
Email 1: craig.losos@stantec.com
Email 2: raven.munro@stantec.com

Service Requested: (Rush subject to availability)
☒ Regular (Standard Turnaround Times))
☐ Priority, Date Req'd: ______ (Surcharges apply)
☐ Emergency (1 Business Day) - 100% Surcharge
☐ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

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 #: 1048843.01
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only) L780801

ALS Contact: CAN DANG
Sampler: M. VAUGHAN T. HICKS

Analysis Request
(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	PARTICLE SIZE	TOTAL ORGANIC CARBON	METALS (CMEPKL)	PAHS	PCBs								Number of Containers
	Replicate 5	17-JUN-09		PONAR GRAB			✓	✓									3
	VC-14 -SURFACE	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-11 -SURFACE	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	Replicate 4	17-JUN-09		PONAR GRAB			✓	✓									3
	VC-16 -SURFACE	15-JUN-09		CORE	✓	✓	✓	✓	✓								3
	Replicate 6	17-JUN-09		PONAR GRAB				✓									3
	VC-14 2m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-14 5m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-11 2m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-11 5m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-16 2m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC-16 5m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3

Special Instructions / Regulations / Hazardous Details

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:	Date:	Time:	Received by: HD	Date: 09/06/19	Time: 10:44	Temperature: 1° °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

Certificate of Analysis

JACQUES WHITFORD
ATTN: CRAIG LOSOS
4370 DOMINION STREET, 5TH FLOOR
PO BOX 21
BURNABY BC V5G 4L7

Report Date: 15-JUL-09 17:05 (MT)
Version: FINAL

Lab Work Order #: **L780809**
Date Received: **19-JUN-09**

Project P.O. #:
Job Reference: 1048843.01
Legal Site Desc:
CofC Numbers: 09-027608

Other Information:

Comments: Please note that some of the PCBs have increased detection limits due to low dry sample weight.

Lindsay Jones
LINDSAY JONES
Account Manager

Grouping	Analyte					
	Sample ID	L780809-1	L780809-2	L780809-3	L780809-4	L780809-5
	Description					
	Sampled Date	17-JUN-09	17-JUN-09	17-JUN-09	17-JUN-09	17-JUN-09
	Sampled Time					
	Client ID	PONAR 5	PONAR 4	REPLICATE 8	REPLICATE 7	PONAR 7
SOIL						
Physical Tests	% Moisture (%)	49.9	46.1	47.1	49.9	46.4
	pH (pH)	7.42	7.54			7.54
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0			1.0
	% Sand (2.0mm - 0.063mm) (%)	6.0	5.0			7.0
	% Silt (0.063mm - 4um) (%)	65.0	68.0			65.0
	% Clay (<4um) (%)	28.0	27.0			27.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.43	1.46			1.40
Metals	Antimony (Sb) (mg/kg)	<10	<10			<10
	Arsenic (As) (mg/kg)	12.7	10.3			12.7
	Barium (Ba) (mg/kg)	94.0	96.0			100
	Beryllium (Be) (mg/kg)	<0.50	<0.50			<0.50
	Cadmium (Cd) (mg/kg)	0.13	0.12			0.10
	Chromium (Cr) (mg/kg)	29.8	30.2			28.9
	Cobalt (Co) (mg/kg)	12.8	13.2			12.7
	Copper (Cu) (mg/kg)	40.1	41.3			40.2
	Lead (Pb) (mg/kg)	9.1	8.5			7.6
	Mercury (Hg) (mg/kg)	0.0547	0.0555			0.0539
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0			<4.0
	Nickel (Ni) (mg/kg)	28.0	27.9			28.0
	Selenium (Se) (mg/kg)	<2.0	<2.0			<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0			<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0			<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0			<5.0
	Vanadium (V) (mg/kg)	78.2	78.7			79.4
	Zinc (Zn) (mg/kg)	95.8	96.6			95.7
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	0.059	0.060	<0.050	0.078	0.055

	Sample ID	L780809-6	L780809-7	L780809-8	L780809-9	L780809-10
	Description					
	Sampled Date	17-JUN-09	17-JUN-09	17-JUN-09	16-JUN-09	16-JUN-09
	Sampled Time					
	Client ID	PONAR 8	PONAR 9	PONAR 10	VC29 (SURFACE)	VC29 (2M)
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	45.2	46.6	46.4	40.1	33.6
	pH (pH)	7.51	7.48	7.45	7.64	8.58
Particle Size	% Gravel (>2mm) (%)	<1.0	<1.0	<1.0	1.0	<1.0
	% Sand (2.0mm - 0.063mm) (%)	5.0	17.0	19.0	5.0	4.0
	% Silt (0.063mm - 4um) (%)	67.0	55.0	53.0	65.0	63.0
	% Clay (<4um) (%)	29.0	28.0	28.0	29.0	33.0
Organic / Inorganic Carbon	Total Organic Carbon (%)	1.32	1.26	1.23	1.09	0.81
Metals	Antimony (Sb) (mg/kg)	<10	<10	<10	<10	<10
	Arsenic (As) (mg/kg)	10.9	12.0	9.6	8.9	10.8
	Barium (Ba) (mg/kg)	101	103	97.4	101	110
	Beryllium (Be) (mg/kg)	<0.50	<0.50	<0.50	<0.50	0.53
	Cadmium (Cd) (mg/kg)	0.14	0.16	0.15	0.17	0.16
	Chromium (Cr) (mg/kg)	29.7	31.6	28.8	30.6	31.8
	Cobalt (Co) (mg/kg)	13.0	13.0	12.5	13.1	14.8
	Copper (Cu) (mg/kg)	41.1	42.6	39.9	43.6	46.9
	Lead (Pb) (mg/kg)	9.1	10.1	9.9	12.3	10.0
	Mercury (Hg) (mg/kg)	0.0563	0.0821	0.0514	0.0535	0.0397
	Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
	Nickel (Ni) (mg/kg)	28.5	29.0	27.7	28.7	31.8
	Selenium (Se) (mg/kg)	<2.0	<3.0	<2.0	<2.0	<2.0
	Silver (Ag) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
	Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	<5.0
	Vanadium (V) (mg/kg)	80.7	81.6	78.2	80.9	85.5
	Zinc (Zn) (mg/kg)	98.8	101	95.2	102	107
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID **Description** **Sampled Date** **Sampled Time** **Client ID**	L780809-11 16-JUN-09 VC29 (5M)				
Grouping	**Analyte**					
SOIL						
Physical Tests	% Moisture (%)	34.5				
	pH (pH)	8.30				
Particle Size	% Gravel (>2mm) (%)	<1.0				
	% Sand (2.0mm - 0.063mm) (%)	8.0				
	% Silt (0.063mm - 4um) (%)	60.0				
	% Clay (<4um) (%)	32.0				
Organic / Inorganic Carbon	Total Organic Carbon (%)	0.89				
Metals	Antimony (Sb) (mg/kg)	<10				
	Arsenic (As) (mg/kg)	10.1				
	Barium (Ba) (mg/kg)	101				
	Beryllium (Be) (mg/kg)	<0.50				
	Cadmium (Cd) (mg/kg)	0.16				
	Chromium (Cr) (mg/kg)	30.0				
	Cobalt (Co) (mg/kg)	13.8				
	Copper (Cu) (mg/kg)	42.7				
	Lead (Pb) (mg/kg)	9.3				
	Mercury (Hg) (mg/kg)	0.0388				
	Molybdenum (Mo) (mg/kg)	<4.0				
	Nickel (Ni) (mg/kg)	29.7				
	Selenium (Se) (mg/kg)	<2.0				
	Silver (Ag) (mg/kg)	<2.0				
	Thallium (Tl) (mg/kg)	<1.0				
	Tin (Sn) (mg/kg)	<5.0				
	Vanadium (V) (mg/kg)	82.9				
	Zinc (Zn) (mg/kg)	102				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050				
	Acenaphthylene (mg/kg)	<0.050				
	Anthracene (mg/kg)	<0.050				
	Benz(a)anthracene (mg/kg)	<0.050				
	Benzo(a)pyrene (mg/kg)	<0.050				
	Benzo(b)fluoranthene (mg/kg)	<0.050				
	Benzo(g,h,i)perylene (mg/kg)	<0.050				
	Benzo(k)fluoranthene (mg/kg)	<0.050				
	Chrysene (mg/kg)	<0.050				
	Dibenz(a,h)anthracene (mg/kg)	<0.050				
	Fluoranthene (mg/kg)	<0.050				
	Fluorene (mg/kg)	<0.050				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050				
	2-Methylnaphthalene (mg/kg)	<0.050				

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780809-1	L780809-2	L780809-3	L780809-4	L780809-5
	Description					
	Sampled Date	17-JUN-09	17-JUN-09	17-JUN-09	17-JUN-09	17-JUN-09
	Sampled Time					
	Client ID	PONAR 5	PONAR 4	REPLICATE 8	REPLICATE 7	PONAR 7
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	0.061	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	90	96	95	93	93
	Surrogate: d12-Chrysene (SS) (%)	87	93	95	92	88
	Surrogate: d8-Naphthalene (SS) (%)	90	96	96	93	94
	Surrogate: d10-Phenanthrene (SS) (%)	90	96	96	94	91
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1221 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1232 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1242 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1248 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1254 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1260 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1262 (mg/kg)	<0.080	<0.060			<0.080
	PCB-1268 (mg/kg)	<0.080	<0.060			<0.080
	Total Polychlorinated Biphenyls (mg/kg)	<0.080	<0.060			<0.080

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID **Description** **Sampled Date** **Sampled Time** **Client ID**	L780809-6 17-JUN-09 PONAR 8	L780809-7 17-JUN-09 PONAR 9	L780809-8 17-JUN-09 PONAR 10	L780809-9 16-JUN-09 VC29 (SURFACE)	L780809-10 16-JUN-09 VC29 (2M)
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)	90	96	94	100	97
	Surrogate: d12-Chrysene (SS) (%)	86	91	84	93	86
	Surrogate: d8-Naphthalene (SS) (%)	88	94	93	97	95
	Surrogate: d10-Phenanthrene (SS) (%)	93	98	94	102	98
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1221 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1232 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1242 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1248 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1254 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1260 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1262 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	PCB-1268 (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060
	Total Polychlorinated Biphenyls (mg/kg)	<0.070	<0.070	<0.070	<0.070	<0.060

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L780809-11				
	Description					
	Sampled Date	16-JUN-09				
	Sampled Time					
	Client ID	VC29 (5M)				
Grouping	**Analyte**					
SOIL						
Polycyclic Aromatic Hydrocarbons	Naphthalene (mg/kg)	<0.050				
	Phenanthrene (mg/kg)	<0.050				
	Pyrene (mg/kg)	<0.050				
	Surrogate: d10-Acenaphthene (SS) (%)	94				
	Surrogate: d12-Chrysene (SS) (%)	84				
	Surrogate: d8-Naphthalene (SS) (%)	92				
	Surrogate: d10-Phenanthrene (SS) (%)	95				
Polychlorinated Biphenyls	PCB-1016 (mg/kg)	<0.060				
	PCB-1221 (mg/kg)	<0.060				
	PCB-1232 (mg/kg)	<0.060				
	PCB-1242 (mg/kg)	<0.060				
	PCB-1248 (mg/kg)	<0.060				
	PCB-1254 (mg/kg)	<0.060				
	PCB-1260 (mg/kg)	<0.060				
	PCB-1262 (mg/kg)	<0.060				
	PCB-1268 (mg/kg)	<0.060				
	Total Polychlorinated Biphenyls (mg/kg)	<0.060				

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
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

HG-CCME-CVAFS-VA	Soil	CVAFS Hg in Soil (CCME)	CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

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-CSR-FULL-ICP-VA	Soil	Metals in Soil by ICPOES (CSR SALM)	BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

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-CSR-MS-VA	Soil	Metals in Soil by ICPMS (CSR SALM)	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
		PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PAH-TUMB-H/A-MS-VA	Soil		

Polycyclic Aromatic Hydrocarbons in Sediment/Soil

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PCB-SE-ECD-VA	Soil	PCB by Extraction with GCECD	EPA 3630/8082 GCECD

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3500, 3620, 3630, 3660, 3665 & 8082, published by the United States Environmental Protection Agency (EPA). The procedure involves a solid-liquid extraction of a subsample of the sediment/soil using a mixture of hexane and acetone. Water is added to the extract and the resulting hexane extract undergoes one or more of the following clean-up procedures (if required): florisil clean-up, silica gel clean-up, sulphur clean-up and/or sulphuric acid clean-up. The final extract is analysed by capillary column gas chromatography with electron capture detection (GC/ECD).

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
PSA-PIPET+GRAVEL-SK	Soil	Particle size - Sieve and Pipette	FORESTRY CANADA (1991) P. 46-48 MOD

Particle size analysis involves the measurement of the proportions of the various primary soil particle sizes (ie. clay < 0.004 mm, silt 0.004-0.063 mm, sand 0.063-2.0 mm and gravel > 2.0 mm). In this method, the gravel and sand portions are determined by sieving, while the clay portion is determined by sedimentation using Stokes Law, which relates the radius of the particles to the velocity of the sedimentation in water. Silt is calculated as 100% - (sand% + clay%)
Pretreatment of the soil with Calgon (sodium hexametaphosphate) is used to ensure the complete dispersion of the primary soil particles. Additional pretreatment may be necessary to remove cementing materials such as CaCO3 and organic matter.

Reference
Y.P. Kalra, and D.G. Maynard, 1991. Methods Manual For Forest Soil and Plant Analysis,Northwest Region. Forestry Canada (modified sand, silt and clay size ranges)

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (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.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA	SK	ALS LABORATORY GROUP - SASKATOON, SASKATCHEWAN, CANADA

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
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.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

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COC # **09 - 027608**
Page 1 of 1

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Address: 4370 DOMINION ST
BURNABY BC V5Z 1B8
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Invoice To Same as Report ? (circle) Yes or No (if No, provide details)
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Client / Project Information
Job #: 1048843.01
PO / AFE:
LSD:
Quote #:

ALS Contact: CAN DANG
Sampler: M. VAUGHAN ~~T.~~ HICKS

Service Requested: (Rush subject to availability)
☒ Regular (Standard Turnaround Times))
☐ Priority, Date Req'd: ____ (Surcharges apply)
☐ Emergency (1 Business Day) - 100% Surcharge
☐ For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Analysis Request
(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**	PARTICLE SIZE	TOTAL ORGANIC CARBON	METALS (CCME PG)	PAHs	PCBs								Number of Containers
	PONAR 5	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	PONAR 4	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	REPLICATE 8	17-JUN-09		PONARGRAB				✓		PAH only							3
	REPLICATE 7	17-JUN-09		PONARGRAB				✓		PAH only							3
	PONAR 7	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	PONAR 8	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	PONAR 9	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	PONAR 10	17-JUN-09		PONARGRAB	✓	✓	✓	✓	✓								3
	VC 29 SURFACE	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC 29 2m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3
	VC 29 5m	16-JUN-09		CORE	✓	✓	✓	✓	✓								3

Special Instructions / Regulations / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by: HD	Date: 09/06/19	Time: 10.42	Temperature: 1 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

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APPENDIX C

Ocean Ecology Macroinvertebrate Survey of Sites A and B

Macroinvertebrate Baseline Study for the Canpotex Potash Terminal Project Disposal at Sea Application

January 2011

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Table of Contents

1. Benthic Macroinvertebrate Survey Methodology

Canpotex and the Prince Rupert Port Authority (PRPA) are proposing to dispose of ~724,000 m^3 of dredgate at one or two new disposal sites within the PRPA harbour boundaries. Baseline information is required for the environmental assessment (EA) of this project, and by Environment Canada as part of the permit application process for disposal at a new site.

As a part of the baseline study for the project, the benthic fauna in the area was characterized. Benthic macroinvertebrate sampling was carried out at the two potential disposal sites using a standard Ponar grab equipped with sliders. A total of 10 benthic macroinvertebrate samples were collected (5 at each of the two sites). The sample stations at which the benthic samples were collected are shown in Figure 1 and Figure 2.

Once the sample was collected using the Ponar grab, the volume of the sediment was measured and recorded, and observations regarding the sediment particle size, odor, color, and other physical features were made. The entire sample was then screened by diluting the sample with seawater and pouring the slurry gradually through a 4 mm mesh sieve into a bucket. At this stage, invertebrates which were too large to pass through the screen were collected and placed in a glass sample container. The sample in the bucket was concentrated by sieving it through a 0.5 mm mesh sieve. Macroinvertebrates were then carefully picked from the screened material and transferred into the sample container.

Samples were fixed in a 10% buffered formalin seawater solution. Samples remained in the formalin-seawater solution for 6 days to allow proper fixation. Subsequently, the samples were transferred to 70% isopropanol.

Organisms were identified using a 10 x power magnifying lamp and a dissecting microscope. Organisms were enumerated and identified to the species level whenever possible.

2. Survey Results

2.1 Site 1

A total of 490 individual organisms in 81 taxa were identified and enumerated from the five samples taken at Site 1 (see Table 1 below). Four phyla were represented - Mollusca (14 taxa), Annelida (Polychaeta - 21 taxa), Crustacea (2 taxa), and Echinodermata (1 taxa) (see Table 2 below). While Phylum Annelida had the greatest number of taxa at the site, Phylum Mollusca had the greatest number of individuals (265).

Table 1. Diversity of benthic macroinvertebrates from Site 1.

Station	Total number of taxa	Total Number of Individuals	Shannon's diversity index	Simpson's diversity index
1-1	17	81	3.32	8.00
1-2	11	46	3.10	8.63
1-3	15	52	3.39	9.54
1-4	22	112	3.76	10.19
1-5	16	199	3.02	6.56
Totals	**81**	**490**	**--**	**--**

Two diversity indices were calculated for each station at Site 1 - Shannon's diversity index and Simpson's diversity index. The Shannon's diversity index is based on information theory and measures the order observed in a particular system. As the number of individuals observed for each taxon in a sample increases, the order of the system increases, and the Shannon's diversity index is larger. The Simpson's diversity index accounts for both the richness and proportion (percent) of each taxon in a sample. While the Shannon's diversity index is the most widely used diversity index, the Simpson's diversity index is much less sensitive to changes in sample size, and is thus more accurate under conditions where sample size is variable.

Shannon's diversity index ranged from a low of 3.02 at station 1-5 to a high of 3.76 at station 1-4. Likewise, Simpson's diversity index was also lowest at station 1-5, with a value of 6.56, and highest at station 1-4, with a value of 10.19. Figure 1 shows the positions of the stations and their Shannon's diversity indices. The stations with highest diversity tend to be on the landward side of Site 1, whereas the stations with lowest diversity tend to be on the seaward side of Site 1.

The total volume of all samples collected for Site 1 was 21 L. The average organism density was 23 organisms/L or 2.3 x 10^4 organisms/m^3. Since most organisms live in the upper surface of the sediment, this can also be expressed as organisms per unit area. The total area sampled for Site 1 was 0.26 m^2. Thus, the average organism density was 1875 organisms/m^2.

Table 2. Species list for Site 1.

Molluscsa (Number of taxa = 14; Number of individuals = 265)
Acila castrensis
Acteocina eximia
Astyris gausapata
Dentalium rectius
Diplodonta orbella
Euspira lewisii
Lacuna vincta
Nuculana minuta
Nutricola lordi
Nutricola tantilla
Saxidomus gigantea
Tellina carpenteri
Tellina modesta
Yoldia scissurata
Polychaeta (Number of taxa = 21; Number of individuals = 222)
Abarenicola pacifica
Amage anops
Aricidea sp.
Ceratonereis paucidentata
Cossura pygodactylata
Diplocirrus sp.
Eteone longa
Glycera capitata
Micropodarke dubia
Nephtys cornuta
Nephtys ferruginea
Nereis vexillosa
Nereis zonata
Ophelina acuminata
Polycirrus sp.
Praxillella gracilis
Protula pacifica
Scoloplos acmeceps
Sternaspis fossor
Tomopteris cavalli
Travisia pupa
Crustacea (Number of taxa = 2; Number of individuals = 2)
Diastylis sp.
Lysianassidae
Echinodermata (Number of taxa= 1; Number of individuals = 1)
Ophiura leptoctenia

2.2 Site 2

A total of 302 individual organisms in 29 taxa were identified and enumerated from the five samples taken at Site 2 (see Table 3 below). Five phyla were represented - Mollusca (18 taxa), Annelida (Polychaeta - 23 taxa), Crustacea (6 taxa), Echinodermata (5 taxa), and Chordata (1 taxa; not actually an invertebrate, but included in the count for completeness) (see Table 4 below). Phylum Annelida had both the greatest number of taxa and the greatest number of individuals (144) at the site.

Table 3. Diversity of benthic macroinvertebrates from Site 2.

Station	Total number of taxa	Total Number of Individuals	Shannon's diversity index	Simpson's diversity index
2-1	25	58	4.04	12.62
2-2	20	34	4.00	19.34
2-3	27	56	4.43	25.25
2-4	31	102	4.28	14.76
2-5	26	52	4.44	28.21
Totals	**129**	**302**	**--**	**--**

As with Site 1, two diversity indices were calculated for each station at Site 2 - Shannon’s diversity index and Simpson’s diversity index.

Shannon’s diversity index ranged from a low of 4.00 at station 2-2 to a high of 4.44 at station 2-5. In this case, however, the Simpson’s diversity index did not agree completely with the Shannon’s diversity index. The Simpson’s diversity index was lowest at station 2-1, with a value of 12.62, and highest at station 2-5, with a value of 28.21. Both indices agreed that maximum diversity occurred at station 2-5. Figure 2 shows the positions of the stations and their Shannon’s diversity indices. Diversity is highest in the northern region of the site, and decreases southward.

The total volume of all samples collected for Site 2 was 26 L. The average organism density was 12 organisms/L or 1.2 x 10^4 organisms/m^3. The total area sampled for Site 2 was 0.26 m^2. Thus, the average organism density was 1156 organisms/m^2.

Table 4. Species list for Site 2.

Molluscsa (Number of taxa = 18; Number of individuals = 76)
Acila castrensis
Acteocina eximia
Astyris gausapata
Bittium munitum
Cyclocardia ventricosa
Dentalium pretiosum
Dentalium rectius
Diplodonta orbella
Euspira lewisii
Megayoldia thraciaeformis
Nuculana minuta
Nutricola tantilla
Olivella baetica
Opalia borealis
Saxidomus gigantea
Tellina carpenteri
Tellina modesta
Yoldia scissurata
Polychaeta (Number of taxa = 23; Number of individuals = 144)
Amage anops
Amphisamytha bioculata
Arabella iricolor
Dodecaceria concharum
Drilonereis falcata
Eteone longa
Euclymene zonalis
Glycera capitata
Lumbrineris luti
Neoamphitrite robusta
Nephtys ferruginea
Nereis zonata
Pectinaria granulata
Pholoe caeca
Platynereis bicanaliculata
Polycirrus sp.
Praxillella gracilis
Scalibregma inflatum
Scoloplos acmeceps
Sigalion sp.
Sternaspis fossor
Tomopteris cavalli
Travisia pupa

Table 4. Continued.

Crustacea (Number of taxa = 6; Number of individuals = 12)
Cyphocaris challengeri
Diastylis sp.
Holmesiella anomala
Munida quadrispina
Pinnixa occidentalis
Rocinela belliceps
Echinodermata (Number of taxa= 5; Number of individuals = 69)
Amphiodia periercta
Amphiodia urtica
Amphioplus strongyloplax
Molpadia intermedia
Ophiura luetkeni
Chordata (Number of taxa= 1; Number of individuals = 1)
Synchirus gilli

2.3 Site Comparisons

2.3.1 ANOVA

Using Excel, a series of single-factor ANOVA analyses were performed to compare the various attributes of the two sites.

i. Total number of taxa

Null hypothesis: The station averages of the total number of taxa at Site 1 and Site 2 are the same.

ANOVA results:

Alpha = 0.05

F = 14.68

F-crit = 5.32

P-value = 0.01

Interpretation: Null hypothesis is rejected - Site 2 has a significantly greater total number of taxa per station (25.8) than Site 1 (16.2).

ii. Total number of individuals

Null hypothesis: The station averages of the total number of individuals at Site 1 and Site 2 are the same.

ANOVA results:

Alpha = 0.05

F = 1.57

F-crit = 5.32

P-value = 0.25

Interpretation: Null hypothesis is accepted - the station averages of the total number of individuals at Site 1 (98) and Site 2 (60.4) are statistically the same.

iii. Shannon's diversity index

Null hypothesis: The station averages of the Shannon's diversity index at Site 1 and Site 2 are the same.

ANOVA results:

Alpha = 0.05

F = 33.27

F-crit = 5.32

P-value = 0.0004

Interpretation: Null hypothesis is rejected - Site 2 has a significantly greater Shannon's diversity index (4.24) per station than Site 1 (3.32).

iv. Simpson's diversity index

Null hypothesis: The station averages of the Simpson's diversity index at Site 1 and Site 2 are the same.

Alpha = 0.05

F = 14.16

F-crit = 5.32

P-value = 0.0055

Interpretation: Null hypothesis is rejected - Site 2 has a significantly greater Simpson's diversity index (20.0) per station than Site 1 (8.58).

In conclusion, while the number of individual organisms per sample was not significantly different between the two sites, Site 2 had significantly higher taxa richness and diversity indices than Site 1.

2.3.2 ANOSIM

Using the statistical software Past, an analysis of the similarity in the occurrence and abundance of species at each site was performed. An analysis of similarity (ANOSIM) routine was used to test the significance between the taxon groupings at each site. The results of the ANOSIM were as follows:

Alpha = 0.05

Permutation Number = 10,000

Distance measure = Bray-Curtis

R = 0.952

P-value = 0.0071

The Bray-Curtis distance measure is used when abundance data is available, as in this case. It is good for community data because it doesn't give too much weight to unobserved taxa. In ANOSIM, large positive R values (up to 1) signify dissimilarity between groups. Thus, the interpretation for this statistical result is that the taxon groups at Sites 1 and 2 are very dissimilar (R is nearly 1) at a high level of statistical significance (P-value is 0.0071). It is most likely that the habitats at the two sites are quite different.

2.3.3 Multi-dimensional Scaling Plot

A multi-dimensional scaling (MDS) plot was generated using the statistical software Past to compare the biological communities at Sites 1 and 2. MDS plots are used to show the “closeness” of the species composition and abundance between samples. MDS plots are commonly either 2D or 3D plots. To determine how many dimensions are best for a given data set, a scree plot is used. This is a line plot of minimum stress (or “badness-of-fit” of the regression line) on the y-axis against number of dimensions on the x-axis. A sharp break in slope of the curve, beyond which further reductions in stress are small, suggests the dimensionality which should be used. Figure 3 shows the scree plot for the data from Sites 1 and 2. The sharpest break occurs at a dimensionality of 3, suggesting that this is the value that should be used for the MDS plot.

The MDS plot comparing data from Sites 1 and 2 is shown in Figure 4. As with the ANOSIM routine, the similarity measure used was the Bray-Curtis distance. Red crosses indicate stations from Site 1, whereas blue squares indicate stations from Site 2. Ellipses showing the 95% confidence level are draw for both Sites (a red ellipse for Site 1 and a blue ellipse for Site 2). Note that there is no overlap between the ellipses. This indicates the species composition and abundance is considered to be significantly different between the two sites at the 95% level.

A Shepard plot (scatter plot of the interpoint distances) was done to determine goodness-of-fit of the MDS solution (see Figure 5). If the fit is poor, then visualization could be misleading, because large (or small) distances between points might not correspond to large (or small) dissimilarities in the data. In the Shepard plot, a narrow scatter around a 1:1 line indicates a good fit of the distances to the dissimilarities, while a large scatter or a nonlinear pattern indicates a lack of fit. The Shepard plot in Figure 5 has a relatively narrow scatter around the 1:1 line, with an R^2 value of 0.7335 (an R^2 value of 1.0 is a straight line, whereas an R^2 value of 0 is a completely random scatter).

The degree of correspondence between the distances among points implied by the MDS map and the matrix input by the user is measured (inversely) by a stress function. The value generated by the stress function can be interpreted as follows:

< 0.05	**Excellent:** no prospect of misinterpretation (rarely achieved)
0.05 – 0.10	**Good:** little danger of drawing false inferences
0.10 – 0.20	**Fair:** useable, but some distances will be misleading
> 0.20	**Poor:** ordination may be dangerous to interpret

The stress value calculated for the Shepard plot in Figure 5 was 0.09135. This indicates that the goodness-of-fit of the MDS solution is good and that there is little danger of false inferences.

2.3.4 Dendogram Analysis

A dendrogram of similarity values among the benthic macroinvertebrate grab samples at Sites 1 and 2 is shown in Figure 6. In this diagram, “groups” of samples which cluster together by common branch points are more similar to each other than to adjacent “groups”. Again, the distance used for this calculation is the Bray-Curtis metric. The dendrogram in Figure 6 clearly shows all the grab samples from Site 2 clustered on a single branch, indicating that these samples have very similar species composition and abundances. The samples from Site 1 are somewhat less clustered, suggesting that there may have been a wider range in species compositions and abundances across that site than at Site 2.

2.3.5 SIMPER

The SIMPER (Similarity Percentage) routine is a simple method for assessing which taxa are primarily responsible for an observed difference between groups of samples. The Bray-Curtis similarity measure (multiplied by 100) is implicit to SIMPER.

Using Past, the SIMPER routine was run on the data from Sites 1 and 2. The overall average dissimilarity between the two sites was 80.51%. The main species contributing to this overall dissimilarity are listed in Table 5 below. The top four species, contributing to a total of 37.18% of the dissimilarity, were *Nutricola tantilla* (a small bivalve found predominantly at Site 1), *Praxillella gracilis* (a bamboo worm found predominantly at Site 1), *Sternaspis fossor* (a dumbbell worm found predominantly at Site 1), and *Nuculana minuta* (a small bivalve found predominantly at Site 1).

Table 5. Species with significant contributions to the dissimilarity of samples from Sites 1 and 2.

Taxon	Contribution	Cumulative %	Mean abundance at Site 1	Mean abundance at Site 2
Nutricola tantilla	13.26	16.47	23	0.6
Praxillella gracilis	5.865	23.76	11.8	3
Sternaspis fossor	5.523	30.62	11	2
Nuculana minuta	5.283	37.18	11	0.6
Acila castrensis	3.694	41.77	7.8	1.6
Ophiura luetkeni	3.337	45.91	0	5.6
Nereis zonata	3.097	49.76	6.4	2
Polycirrus sp.	2.866	53.32	3.6	5.2
Amphioplus strongyloplax	2.376	56.27	0	3.4
Dentalium rectius	2.37	59.21	0.2	3.2
Euclymene zonalis	2.277	62.04	0	3.2
Amphiodia urtica	2.176	64.74	0	3.2
Nephtys ferruginea	2.17	67.44	3.2	1.2
Platynereis bicanaliculata	1.568	69.39	0	2.2
Saxidomus gigantea	1.479	71.22	1.8	0.2
Tellina carpenteri	1.46	73.04	3.2	0.8
Scoloplos acmeceps	1.46	74.85	2	1.4
Nutricola lordi	1.269	76.43	2.2	0
Yoldia scissurata	1.201	77.92	1.4	2.2
Dentalium pretiosum	1.081	79.26	0	1.8
Molpadia intermedia	0.9434	80.43	0	1.4

A number of species were unique to either Site 1 or Site 2. These species are listed in Table 6 below. Fourteen species were unique to Site 1 and 29 species were unique to Site 2.

Table 6. Species found uniquely at only one site.

Taxon	Unique Location
Nutricola lordi	Site 1
Abarenicola pacifica	Site 1
Nephtys cornuta	Site 1
Diastylis sp.	Site 1
Nereis vexillosa	Site 1
Ceratonereis paucidentata	Site 1
Aricidea sp.	Site 1
Micropodarke dubia	Site 1
Ophelina acuminata	Site 1
Cossura pygodactylata	Site 1
Lysianassidae	Site 1
Ophiura leptoctenia	Site 1
Lacuna vincta	Site 1
Protula pacifica	Site 1
Ophiura luetkeni	Site 2
Amphioplus strongyloplax	Site 2
Euclymene zonalis	Site 2
Amphiodia urtica	Site 2
Platynereis bicanaliculata	Site 2
Dentalium pretiosum	Site 2
Molpadia intermedia	Site 2
Amphisamytha bioculata	Site 2
Scalibregma inflatum	Site 2
Arabella iricolor	Site 2
Cyphocaris challengeri	Site 2
Pholoe caeca	Site 2
Neoamphitrite robusta	Site 2
Pinnixa occidentalis	Site 2
Megayoldia thraciaeformis	Site 2
Drilonereis falcata	Site 2
Holmesiella anomala	Site 2
Lumbrineris luti	Site 2
Bittium munitum	Site 2
Olivella baetica	Site 2
Dodecaceria concharum	Site 2
Munida quadrispina	Site 2
Synchirus gilli	Site 2
Sigalion sp.	Site 2
Pectinaria granulata	Site 2
Opalia borealis	Site 2
Cyclocardia ventricosa	Site 2
Rocinela belliceps	Site 2
Amphiodia periercta	Site 2

2.4 Other Observations

While not part of the formal macroinvertebrate baseline study, several macroinvertebrates not included in the species lists for Sites 1 and 2 were observed during the grab sampling for chemistry samples at Site 2.

i. *Aphrocallistes vastus*

At station S2-outside (see Figure 7), the sediment in the grab sample consisted of approximatey 25% dead Hexactinellid sponge fragments. A sample of this material was taken and later identified in the laboratory as *Aphrocallistes vastus*. While no living sponge was collected by the grab, the large amount of sponge debris suggests that living sponges must be occurring in close proximity to the grab station.

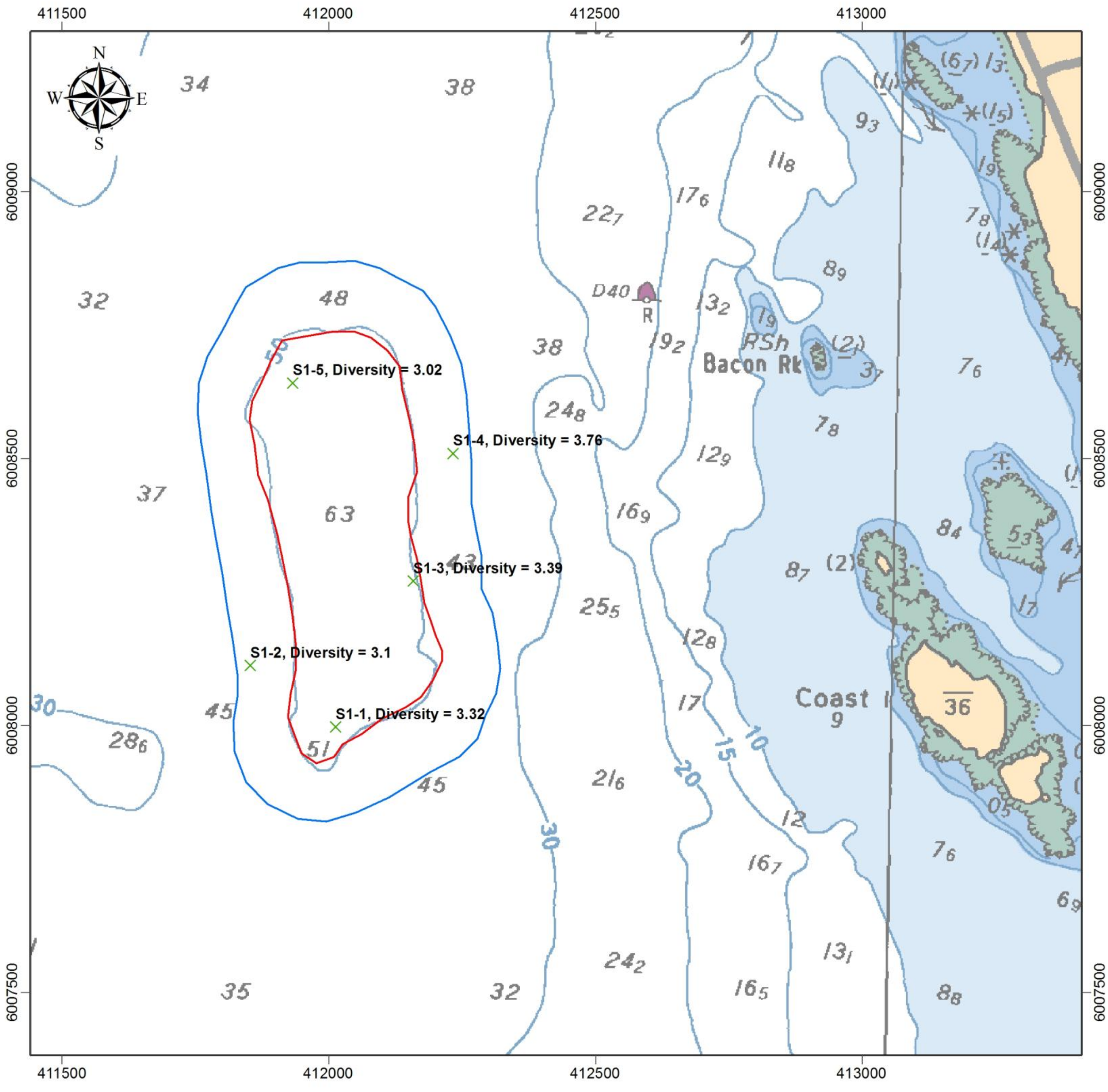
ii. *Brisaster latifrons*

At station S2-16 (see Figure 7), a heart urchin (*Brisaster latifrons*) was collected by the Ponar grab (see image below).

iii. ***Pagurus sp*.**

At station S2outside-23 (see Figure 7), a hermit crab, possibly *Pagurus dalli*, was brought up with the sediment sample (see image below).

3. Figures



Canpotex Disposal Site

Figure 1.
Benthic macroinvertebrate sampling stations at Site 1.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:10,000

Legend

- 🟥 Site 1 boundary
- 🟦 Site 1 adjacent areas
- × Sampling stations

0 125 250 500 Meters

OCEAN ECOLOGY

Canpotex Disposal Site

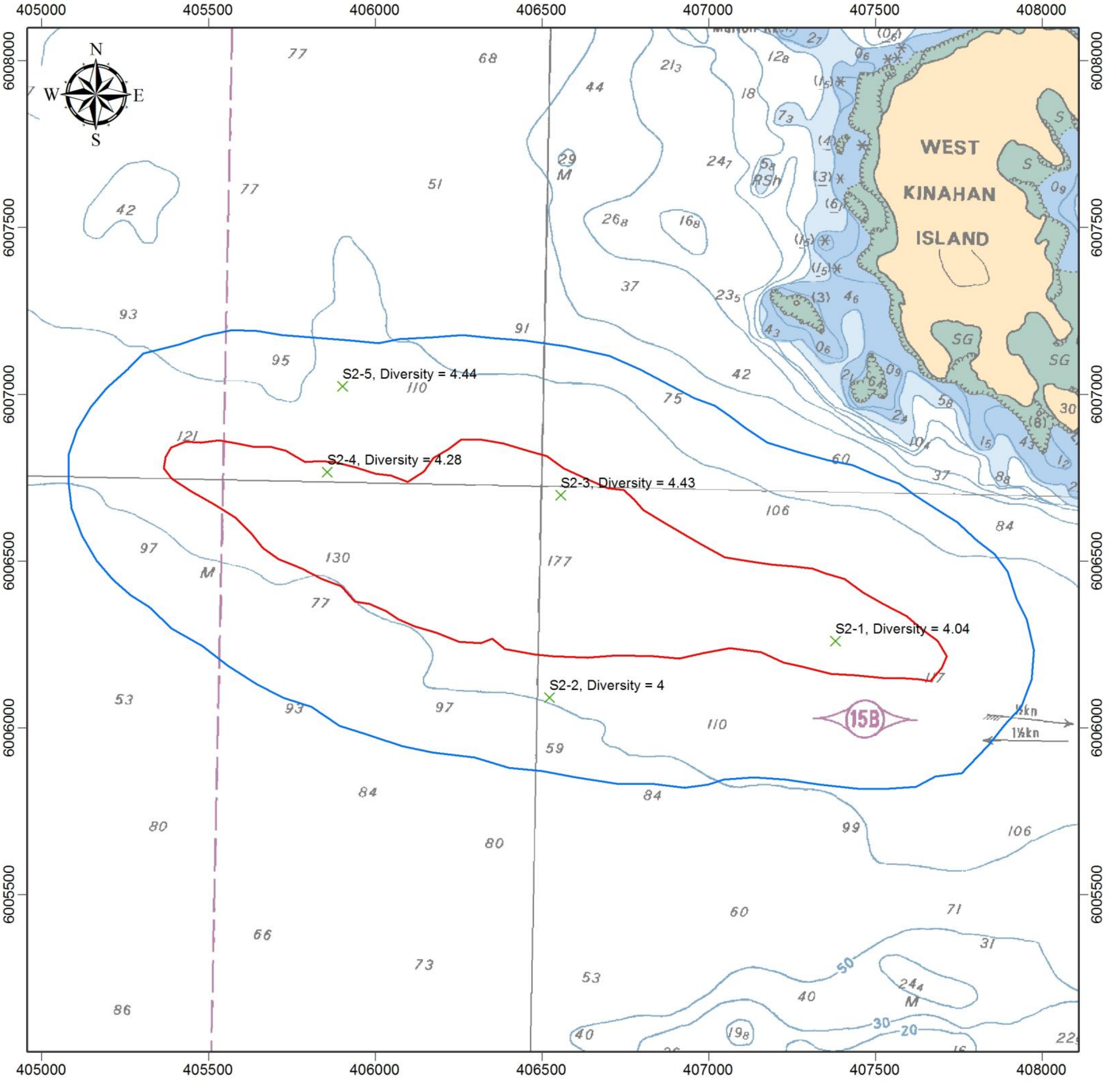


Figure 2.
Benthic macroinvertebrate sampling stations at Site 2.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:16,000

Legend

- 🟥 Site 2 boundary
- 🟦 Site 2 adjacent areas
- × Sampling stations

0 125 250 500 Meters

OCEAN ECOLOGY

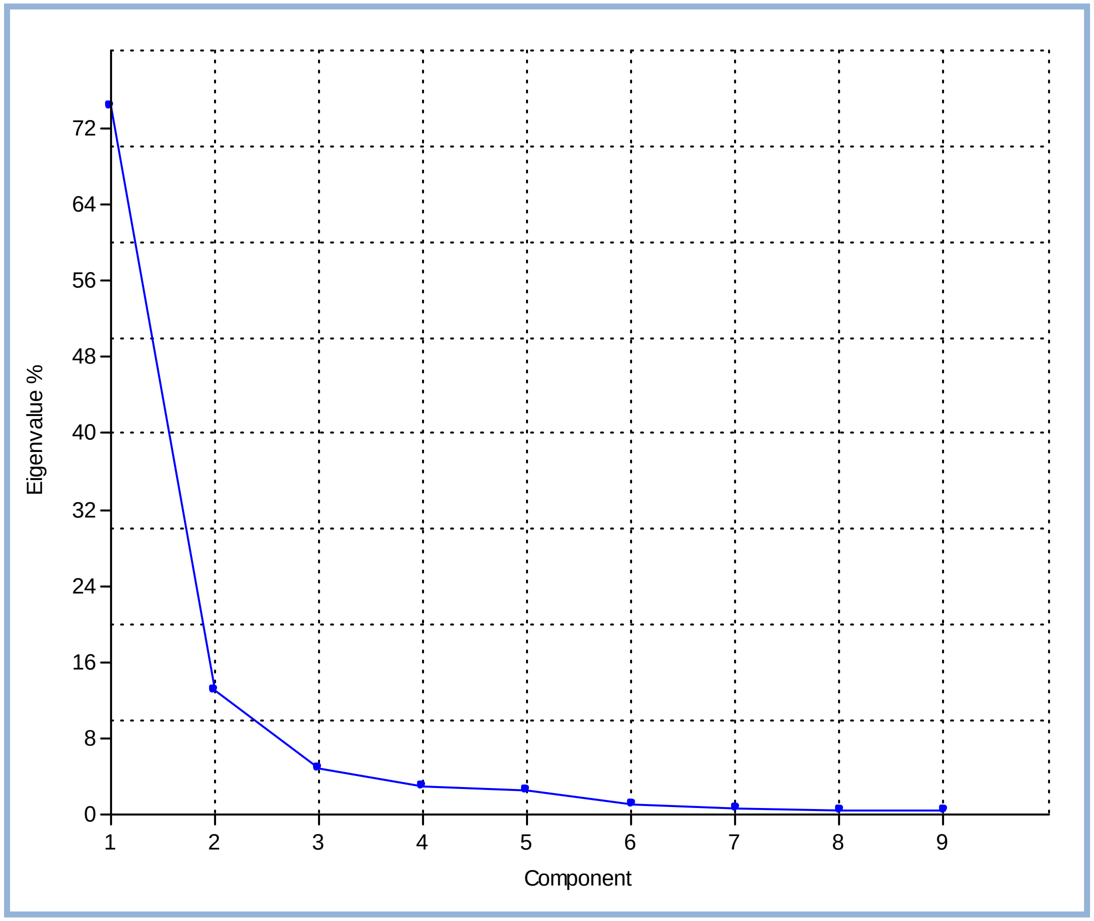


Figure 3. Scree plot.

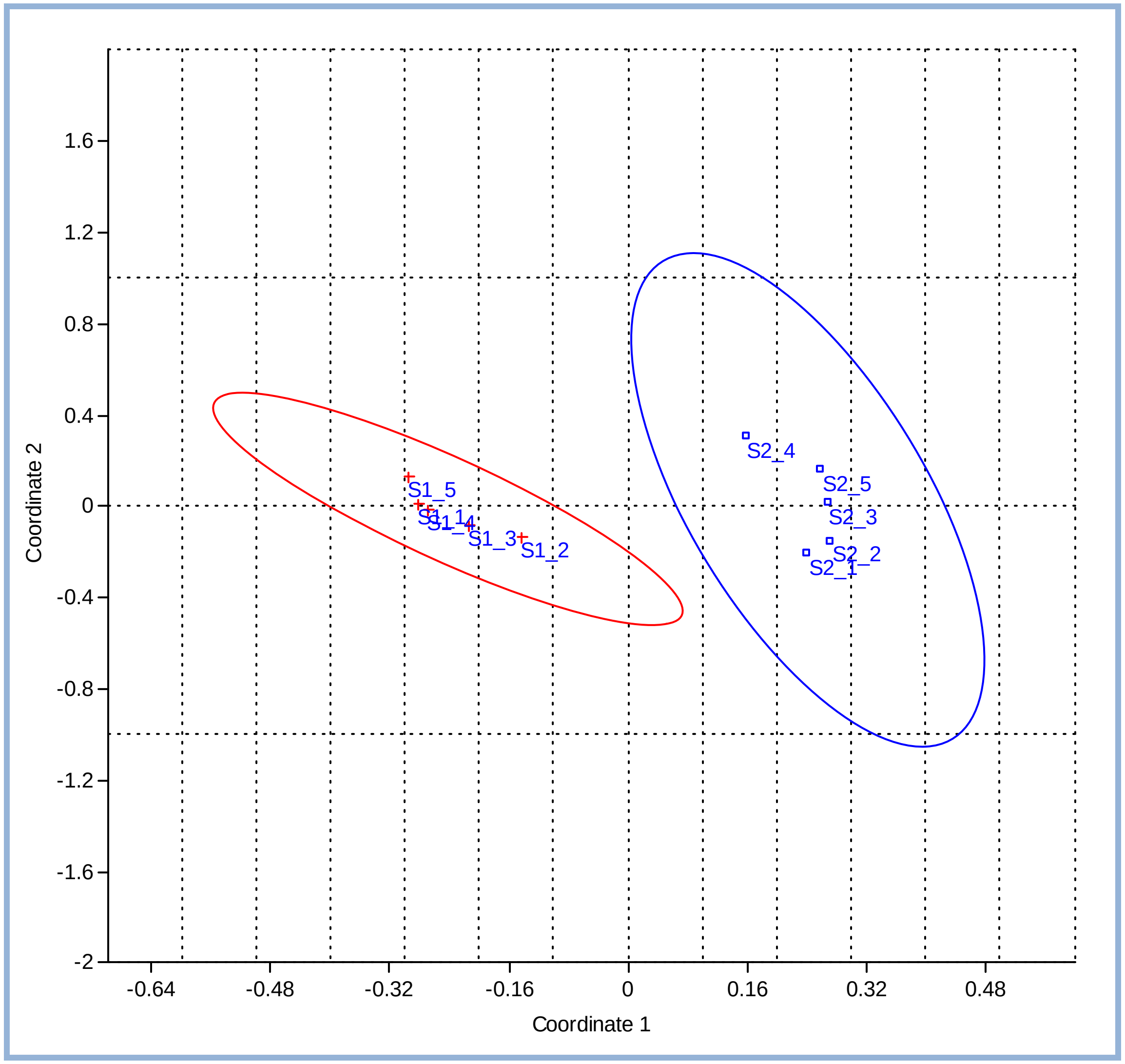


Figure 4. Multidimensional scaling plot.

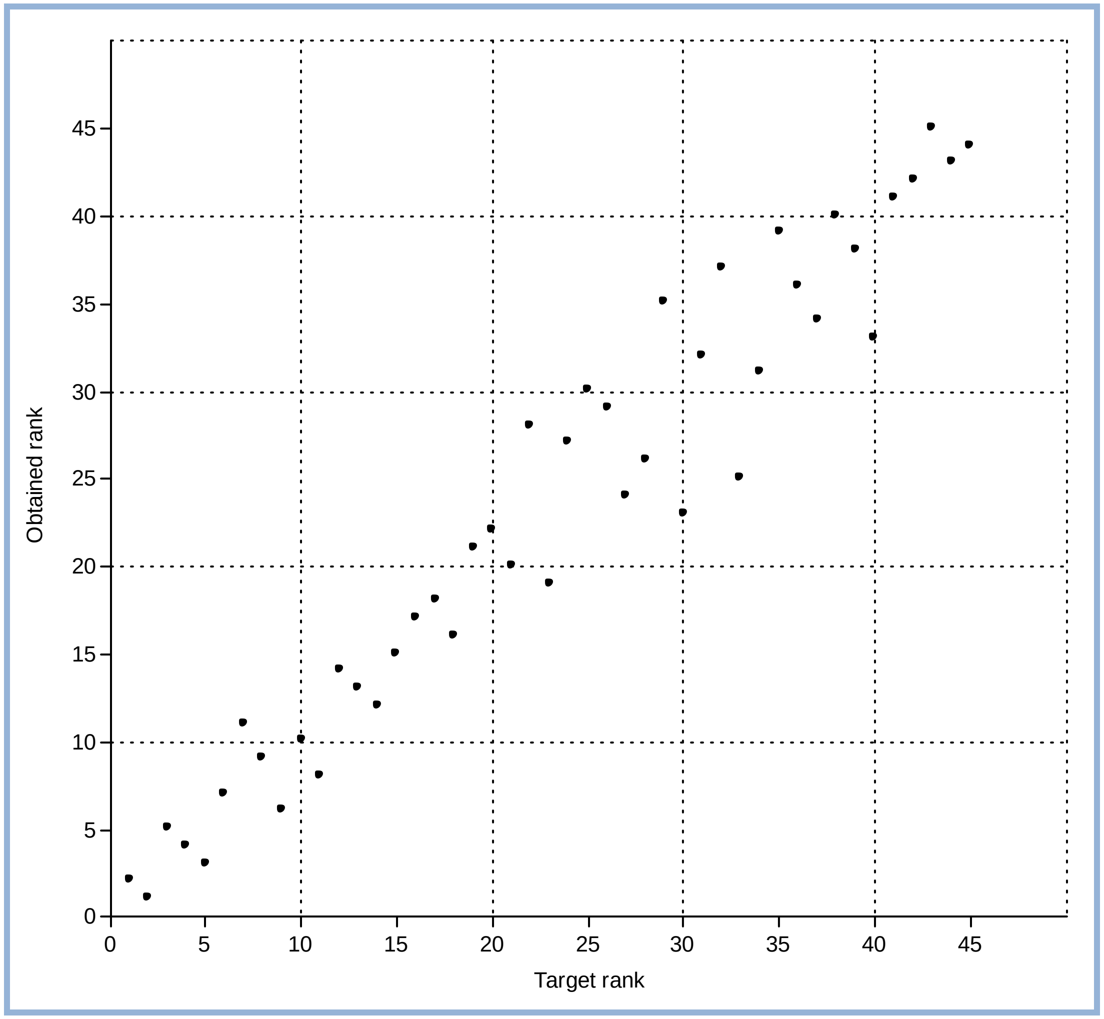


Figure 5. Shepard plot.

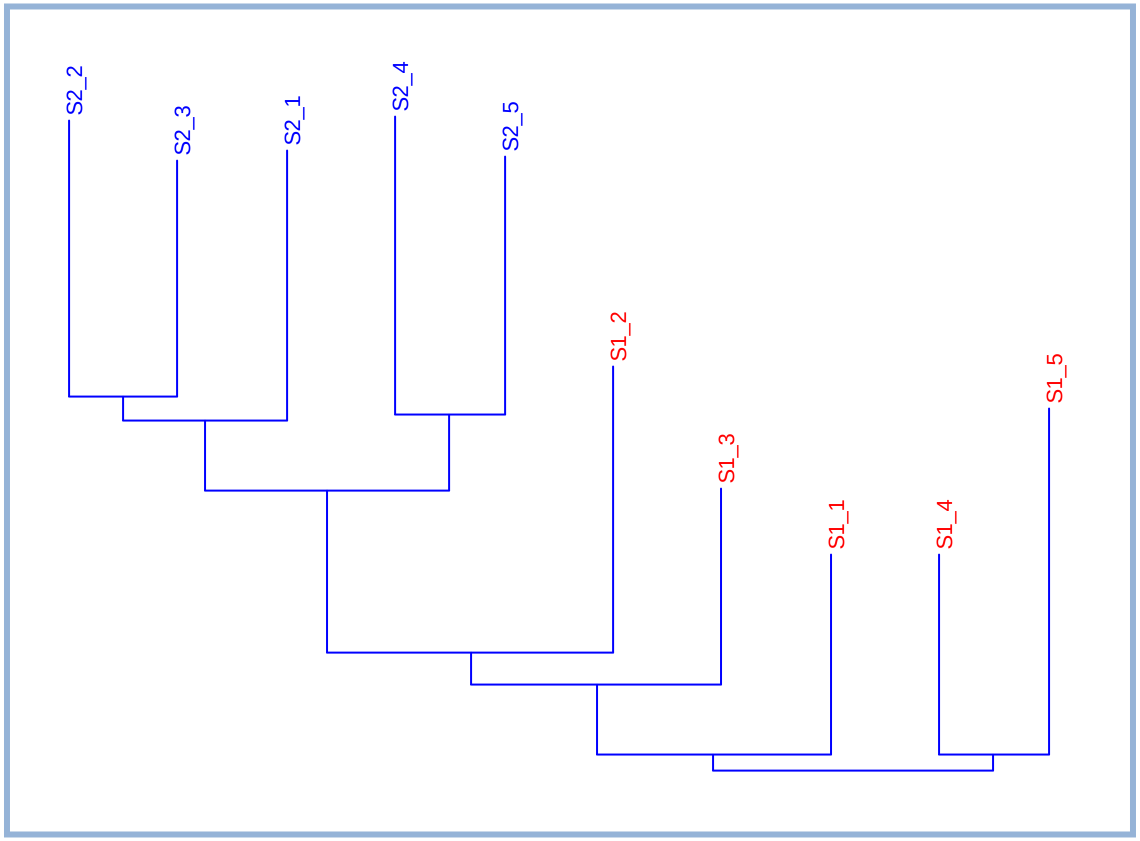
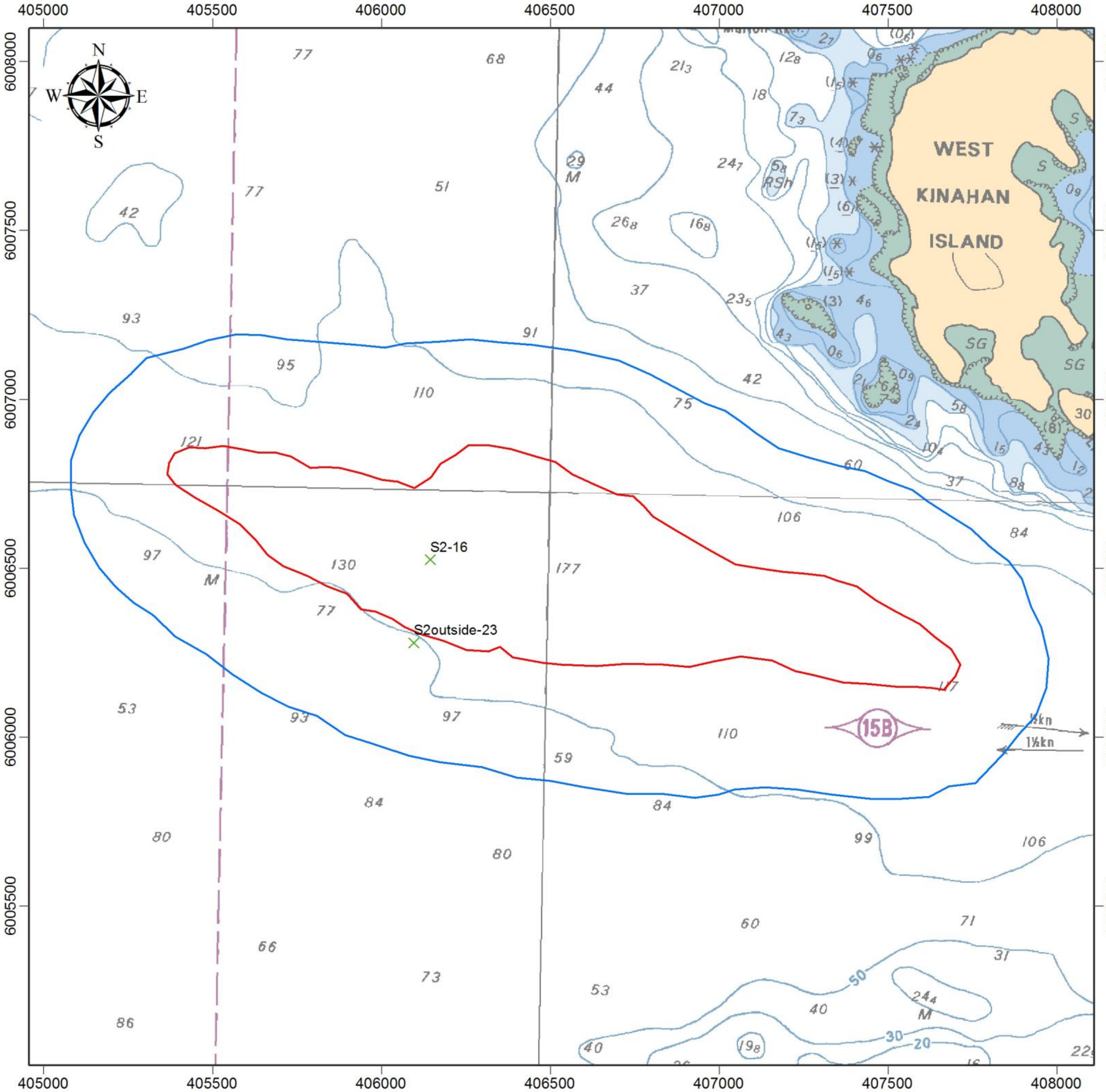


Figure 6. Dendrogram of similarity values for macroinvertebrates.



Canpotex Disposal Site

Figure 7.
Observations of macroinvertebrates during chemistry sampling at Site 2.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:16,000

Legend

- 🟥 Site 2 boundary
- 🟦 Site 2 adjacent areas
- × Other observations

0 125 250 500 Meters

OCEAN ECOLOGY

4. Disclaimer

The findings presented in this report are based upon data collected during the day November 21st, 2010 using the methodology described in the Survey Methodology section of this report. Ocean Ecology has exercised reasonable skill, care, and diligence to collect and interpret the data, but makes no guarantees or warranties as to the accuracy or completeness of this data.

This report has been prepared solely for the use of Stantec pursuant to the agreement between Ocean Ecology and Stantec. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Ocean Ecology accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

Any questions concerning the information or its interpretation should be directed to the undersigned.

Prepared By:	Reviewed By:
Barb Faggetter	Kennard D Hall
Barb Faggetter, Ph.D Oceanographer, R.P.Biol.	Kennard Hall, Captain Partner, Ocean Ecology

Appendix 1 - Raw Data

Sample Date:	21/11/2010
Sample Time:	10:03
Sample No.:	S1-1
Location Name:	Canpotex Site 1, inside
Latitude:	54.21242
Longitude:	-130.3492133
Weather conditions:	Clear, light wind, 2' swell
Sample Type:	2
Depth from sounder (m):	56
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	2
Depth of RPD (if present) (nearest 0.5 cm):	14.0
Anoxic layer (black):	2
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	4 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mullusca	0	*Polychaete*	0	*Echinoderm*	0	*Crustacea*	0		0		0		0		0
Nuculana minuta	8	*Sternaspis fossor*	12	*Ophiura leptoctenia*	1	*Lysianassidae*	1		0		0		0		0
Nutricola tantilla	20	*Polycirrus sp.*	2		0		0		0		0		0		0
Diplodonta orbella	1	*Abarenicola pacifica*	4		0		0		0		0		0		0
Tellina modesta	4	*Praxillella gracilis*	14		0		0		0		0		0		0
Tellina carpenteri	1	*Ceratonereis paucidentata*	2		0		0		0		0		0		0
Acila castrensis	1	*Nereis zonata*	6		0		0		0		0		0		0
Euspira lewisii	1		0		0		0		0		0		0		0
Astyris gausapata	1		0		0		0		0		0		0		0
Nutricola lordi	2		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	39	*Total*	40	*Total*	1	*Total*	1		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	17														
Shannon's diversity index:	3.3242														
Simpson's diversity index	8.0000														

Sample Date:	21/11/2010
Sample Time:	10:22
Sample No.:	S1-2
Location Name:	Canpotex Site 1, outside
Latitude:	54.21343
Longitude:	-130.3516983
Weather conditions:	Clear, light wind, 2' swell
Sample Type:	2
Depth from sounder (m):	
Characteristics of surficial sediment:	48
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	2
Depth of RPD (if present) (nearest 0.5 cm):	13.0
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	13.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	4 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0		0		0		0		0		0		0
Nuculana minuta	1	*Sternaspis fossor*	6		0		0		0		0		0		0
Nutricola tantilla	9	*Nephtys ferruginea*	4		0		0		0		0		0		0
Saxidomus gigantea	5	*Micropodarke dubia*	1		0		0		0		0		0		0
	0	*Aricidea sp.*	1		0		0		0		0		0		0
	0	*Nereis vexillosa*	2		0		0		0		0		0		0
	0	*Nereis zonata*	2		0		0		0		0		0		0
	0	*Polycirrus sp.*	9		0		0		0		0		0		0
	0	*Praxillella gracilis*	6		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	15	*Total*	31		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	11														
Shannon's diversity index:	3.0956														
Simpson's diversity index	8.6250														

Sample Date:	21/11/2010
Sample Time:	10:37
Sample No.:	S1-3
Location Name:	Canpotex Site 1, inside
Latitude:	54.21490667
Longitude:	-130.3470517
Weather conditions:	Clear, light wind, 1' swell
Sample Type:	2
Depth from sounder (m):	55
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	2
Depth of RPD (if present) (nearest 0.5 cm):	15.0
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	4 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0		0		0		0		0		0		0
Nuculana minuta	5	*Sternaspis fossor*	7		0		0		0		0		0		0
Nutricola tantilla	12	*Polycirrus sp.*	2		0		0		0		0		0		0
Saxidomus gigantea	1	*Praxillella gracilis*	6		0		0		0		0		0		0
Tellina carpenteri	2	*Nereis zonata*	7		0		0		0		0		0		0
Yoldia scissurata	2	*Ophelina acuminata*	1		0		0		0		0		0		0
Acteocina eximia	1	*Nephtys cornuta*	3		0		0		0		0		0		0
Dentalium rectius	1	*Glycera capitata*	1		0		0		0		0		0		0
	0	*Travisia pupa*	1		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	24	*Total*	28		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	15														
Shannon's diversity index:	3.3890														
Simpson's diversity index	9.5396														

Sample Date:	21/11/2010
Sample Time:	10:52
Sample No.:	S1-4
Location Name:	Canpotex Site 1, outside
Latitude:	54.21706667
Longitude:	-130.3459867
Weather conditions:	Clear, light wind, 1' swell
Sample Type:	2
Depth from sounder (m):	51
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	2
Depth of RPD (if present) (nearest 0.5 cm):	14.0
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	14.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	4 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0		0		0		0		0		0
Nuculana minuta	4	*Sternaspis fossor*	13	*Diastylis sp.*	1		0		0		0		0		0
Nutricola tantilla	27	*Nephtys ferruginea*	11		0		0		0		0		0		0
Saxidomus gigantea	3	*Amage anops*	2		0		0		0		0		0		0
Nutricola lordi	7	*Praxillella gracilis*	6		0		0		0		0		0		0
Tellina carpenteri	5	*Eteone longa*	4		0		0		0		0		0		0
Yoldia scissurata	1	*Polycirrus sp.*	4		0		0		0		0		0		0
Acteocina eximia	1	*Nereis zonata*	10		0		0		0		0		0		0
Euspira lewisii	1	*Scoloplos acmeceps*	5		0		0		0		0		0		0
Astyris gausapata	1	*Travisia pupa*	1		0		0		0		0		0		0
Lacuna vincta	1	*Protula pacifica*	1		0		0		0		0		0		0
	0	*Diplocirrus sp.*	3		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	51	*Total*	60	*Total*	1		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	22														
Shannon's diversity index:	3.7569														
Simpson's diversity index	10.1902														

Sample Date:	21/11/2010
Sample Time:	11:11
Sample No.:	S1-5
Location Name:	Canpotex Site 1, inside
Latitude:	54.21820167
Longitude:	-130.3506267
Weather conditions:	Clear, light wind, 1' swell
Sample Type:	2
Depth from sounder (m):	60
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	2
Depth of RPD (if present) (nearest 0.5 cm):	15.0
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	5 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0		0		0		0		0		0		0
Nuculana minuta	37	*Sternaspis fossor*	17		0		0		0		0		0		0
Nutricola tantilla	47	*Nephtys ferruginea*	1		0		0		0		0		0		0
Nutricola lordi	2	*Praxillella gracilis*	27		0		0		0		0		0		0
Tellina carpenteri	8	*Nereis zonata*	7		0		0		0		0		0		0
Yoldia scissurata	4	*Polycirrus sp.*	1		0		0		0		0		0		0
Acila castrensis	38	*Scoloplos acmeceps*	5		0		0		0		0		0		0
	0	*Tomopteris cavalli*	1		0		0		0		0		0		0
	0	*Cossura pygodactylata*	2		0		0		0		0		0		0
	0	*Eteone longa*	1		0		0		0		0		0		0
	0	*Diplocirrus sp.*	1		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	136	*Total*	63		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	16														
Shannon's diversity index:	3.0217														
Simpson's diversity index	6.5583														

Sample Date:	21/11/2010
Sample Time:	11:54
Sample No.:	S2-1
Location Name:	Canpotex Site 2, inside
Latitude:	
Longitude:	
Weather conditions:	Clear, light wind, 3' swell
Sample Type:	2
Depth from sounder (m):	
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	1
Depth of RPD (if present) (nearest 0.5 cm):	
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	6 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0	*Echinoderm*	0	*Chordate*	0		0		0		0
Nutricola tantilla	1	*Sternaspis fossor*	6	*Diastylis sp.*	1	*Molpadia intermedia*	2	*Synchirus gilli*	1		0		0		0
Yoldia scissurata	4	*Pectinaria granulata*	1	*Cyphocaris challengeri*	1	*Ophiura luetkeni*	2		0		0		0		0
Tellina modesta	1	*Neoamphitrite robusta*	2		0	*Amphioplus strongyloplax*	1		0		0		0		0
Dentalium rectius	3	*Amphisamytha bioculata*	1		0		0		0		0		0		0
Opalia borealis	1	*Arabella iricolor*	1		0		0		0		0		0		0
	0	*Scalibregma inflatum*	2		0		0		0		0		0		0
	0	*Euclymene zonalis*	5		0		0		0		0		0		0
	0	*Polycirrus sp.*	14		0		0		0		0		0		0
	0	*Scoloplos acmeceps*	2		0		0		0		0		0		0
	0	*Eteone longa*	1		0		0		0		0		0		0
	0	*Tomopteris cavalli*	1		0		0		0		0		0		0
	0	*Travisia pupa*	2		0		0		0		0		0		0
	0	*Nereis zonata*	1		0		0		0		0		0		0
	0	*Sigalion sp.*	1		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	10	*Total*	40	*Total*	2	*Total*	5	*Total*	1		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	25												
Shannon's diversity index:	4.0446												
Simpson's diversity index	12.6183												

Sample Date:	21/11/2010
Sample Time:	12:13
Sample No.:	S2-2
Location Name:	Canpotex Site 2, outside
Latitude:	
Longitude:	
Weather conditions:	Clear, light wind, 3' swell
Sample Type:	2
Depth from sounder (m):	
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	1
Depth of RPD (if present) (nearest 0.5 cm):	
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	14.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	4 L sample

	Definitions	
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0	*Echinoderm*	0		0		0		0		0
Yoldia scissurata	1	*Sternaspis fossor*	3	*Holmesiella anomala*	1	*Amphioplus strongyloplax*	4		0		0		0		0
Tellina carpenteri	1	*Euclymene zonalis*	1		0	*Amphiodia urtica*	2		0		0		0		0
Nuculana minuta	1	*Travisia pupa*	1		0	*Ophiura luetkeni*	1		0		0		0		0
Dentalium rectius	6	*Platynereis bicanaliculata*	1		0		0		0		0		0		0
Olivella baetica	1	*Arabella iricolor*	1		0		0		0		0		0		0
	0	*Nereis zonata*	1		0		0		0		0		0		0
	0	*Scalibregma inflatum*	2		0		0		0		0		0		0
	0	*Polycirrus sp.*	3		0		0		0		0		0		0
	0	*Amphisamytha bioculata*	1		0		0		0		0		0		0
	0	*Tomopteris cavalli*	1		0		0		0		0		0		0
	0	*Scoloplos acmeceps*	1		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	10	*Total*	16	*Total*	1	*Total*	7		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	20														
Shannon's diversity index:	3.9987														
Simpson's diversity index	19.3448														

Sample Date:	21/11/20010
Sample Time:	13:08
Sample No.:	S2-3
Location Name:	Canpotex Site 2, inside
Latitude:	
Longitude:	
Weather conditions:	Clear, light wind, 3' swell
Sample Type:	2
Depth from sounder (m):	
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	1
Depth of RPD (if present) (nearest 0.5 cm):	
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	2
Analyst:	Barb Faggetter
Comments:	
	Grab completely full; may have been some extrusion from screens; 6L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0	*Echinoderm*	0		0		0		0		0
Yoldia scissurata	3	*Sternaspis fossor*	1	*Munida quadrispina*	1	*Molpadia intermedia*	1		0		0		0		0
Nutricola tantilla	2	*Amphisamytha bioculata*	1	*Cyphocaris challengeri*	1	*Amphioplus strongyloplax*	2		0		0		0		0
Dentalium pretiosum	2	*Platynereis bicanaliculata*	4		0	*Amphiodia urtica*	3		0		0		0		0
Dentalium rectius	6	*Nephtys ferruginea*	1		0	*Ophiura luetkeni*	2		0		0		0		0
Tellina carpenteri	1	*Scoloplos acmeceps*	3		0		0		0		0		0		0
Tellina modesta	1	*Neoamphitrite robusta*	1		0		0		0		0		0		0
Megayoldia thraciaeformis	2	*Amage anops*	1		0		0		0		0		0		0
Euspira lewisii	1	*Euclymene zonalis*	5		0		0		0		0		0		0
	0	*Nereis zonata*	6		0		0		0		0		0		0
	0	*Arabella incolor*	1		0		0		0		0		0		0
	0	*Tomopteris cavalli*	1		0		0		0		0		0		0
	0	*Polycirrus sp.*	2		0		0		0		0		0		0
	0	*Dodecaceria concharum*	1		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	18	*Total*	28	*Total*	2	*Total*	8		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	27														
Shannon's diversity index:	4.4343														
Simpson's diversity index	25.2459														

Sample Date:	21/11/2010
Sample Time:	13:44
Sample No.:	S2-4
Location Name:	Canpotex Site 2, inside
Latitude:	
Longitude:	
Weather conditions:	Clear, light wind, 3' swell
Sample Type:	2
Depth from sounder (m):	
Characteristics of surficial sediment:	
Sediment type:	1
Sediment color:	1
Biological structures:	4
Debris:	1
Oily sheen:	1
Odor:	1
Characteristics of vertical profile:	
Oxic layer (brown):	2
Redox potential discontinuity (RPD) layer (grey):	1
Depth of RPD (if present) (nearest 0.5 cm):	
Anoxic layer (black):	1
Maximum penetration depth (nearest 0.5 cm):	15.0
Sample quality:	1
Analyst:	Barb Faggetter
Comments:	5 L sample

Definitions		
Sampl		
1	Petit Ponar grab	
2	Standard Ponar grab	
3	K-B corer	
Sedim		
1	Silt/clay	
2	Complex sediment, predominantly fine	
3	Sand	
4	Complex sediment, predominantly sand/gravel	
5	Gravel	
6	Shell hash	
Sedim		
1	Brown	
2	Black	
3	Red	
4	Green	
5	Yellow	
Biolog		
1	None	
2	Shells	
3	Tubes	
4	Worm holes	
5	Macrophytes	
6	Diatom mat	
7	Bacterial mat	
Debris:		
1	None	
2	Macrophytes	
3	Bark	
4	Wood chips	
5	Wood fibers	
6	Anthropogenic debris	
Oily		
1	Absent	
2	Present	
Odor:		
1	None	
2	Sulfide	odor of rotten eggs
3	Oily	odor of petroleum tar
4	Humic	musty, organic odor
Oxic l		
1	Absent	
2	Present	
RPD		
1	Absent	
2	Present	
Anoxi		
1	Absent	
2	Present	
Sampl		
1	Good	
2	Sediment extruded through upper surface of grab	
3	Leakage	
4	Surface canted	
5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0	*Echinoderm*	0		0		0		0		0
Yoldia scissurata	2	*Scalibregma inflatum*	1	*Pinnixa occidentalis*	1	*Molpadia intermedia*	2		0		0		0		0
Dentalium pretiosum	6	*Praxillella gracilis*	10	*Rocinela belliceps*	1	*Amphioplus strongyloplax*	6		0		0		0		0
Nuculana minuta	2	*Euclymene zonalis*	2	*Cyphocaris challengeri*	1	*Amphiodia urtica*	6		0		0		0		0
Acila castrensis	8	*Amphisamytha bioculata*	2		0	*Ophiura luetkeni*	20		0		0		0		0
Astyris gausapata	6	*Arabella iricolor*	1		0	*Amphiodia periercta*	1		0		0		0		0
Saxidomus gigantea	1	*Drilonereis falcata*	2		0		0		0		0		0		0
Megayoldia thraciaeformis	1	*Polycirrus sp.*	5		0		0		0		0		0		0
Tellina carpenteri	1	*Nephtys ferruginea*	3		0		0		0		0		0		0
Tellina modesta	1	*Amage anops*	1		0		0		0		0		0		0
Bittium munitum	1	*Glycera capitata*	1		0		0		0		0		0		0
Cyclocardia ventricosa	1	*Platynereis bicanaliculata*	2		0		0		0		0		0		0
	0	*Travisia pupa*	4		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	30	*Total*	34	*Total*	3	*Total*	35		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
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	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	31														
Shannon's diversity index:	4.2797														
Simpson's diversity index	14.7593														

Sample Date:	21/11/2010		**Definitions**		
Sample Time:	14:11		**Sampl**		
Sample No.:	S2-5		1	Petit Ponar grab	
Location Name:	Canpotex Site 2, outside		2	Standard Ponar grab	
Latitude:			3	K-B corer	
Longitude:					
Weather conditions:	Clear, light wind, 3' swell		**Sedim**		
Sample Type:	2		1	Silt/clay	
Depth from sounder (m):			2	Complex sediment, predominantly fine	
Characteristics of surficial sediment:			3	Sand	
Sediment type:	1		4	Complex sediment, predominantly sand/gravel	
Sediment color:	1		5	Gravel	
Biological structures:	4		6	Shell hash	
Debris:	1		**Sedim**		
Oily sheen:	1		1	Brown	
Odor:	1		2	Black	
Characteristics of vertical profile:			3	Red	
Oxic layer (brown):	2		4	Green	
Redox potential discontinuity (RPD) layer (grey):	1		5	Yellow	
Depth of RPD (if present) (nearest 0.5 cm):			**Biolog**		
Anoxic layer (black):	1		1	None	
Maximum penetration depth (nearest 0.5 cm):	15.0		2	Shells	
Sample quality:	1		3	Tubes	
Analyst:	Barb Faggetter		4	Worm holes	
Comments:	5 L sample		5	Macrophytes	
			6	Diatom mat	
			7	Bacterial mat	
			Debris:		
			1	None	
			2	Macrophytes	
			3	Bark	
			4	Wood chips	
			5	Wood fibers	
			6	Anthropogenic debris	
			Oily		
			1	Absent	
			2	Present	
			Odor:		
			1	None	
			2	Sulfide	odor of rotten eggs
			3	Oily	odor of petroleum tar
			4	Humic	musty, organic odor
			Oxic l		
			1	Absent	
			2	Present	
			RPD		
			1	Absent	
			2	Present	
			Anoxi		
			1	Absent	
			2	Present	
			Sampl		
			1	Good	
			2	Sediment extruded through upper surface of grab	
			3	Leakage	
			4	Surface canted	
			5	Sediment washed or winnowed	

Mollusca	0	*Polychaete*	0	*Crustacean*	0	*Echinoderm*	0		0		0		0		0
Yoldia scissurata	1	*Praxillella gracilis*	5	*Pinnixa occidentalis*	2	*Molpadia intermedia*	2		0		0		0		0
Dentalium pretiosum	1	*Euclymene zonalis*	3	*Holmesiella anomala*	1	*Amphioplus strongyloplax*	4		0		0		0		0
Dentalium rectius	1	*Nephtys ferruginea*	2	*Cyphocaris challengeri*	1	*Amphiodia urtica*	5		0		0		0		0
Tellina carpenteri	1	*Amphisamytha bioculata*	1		0	*Ophiura luetkeni*	3		0		0		0		0
Astyris gausapata	1	*Platynereis bicanaliculata*	4		0		0		0		0		0		0
Acteocina eximia	1	*Scoloplos acmeceps*	1		0		0		0		0		0		0
Diplodonta orbella	1	*Drilonereis falcata*	1		0		0		0		0		0		0
Bittium munitum	1	*Pholoe caeca*	3		0		0		0		0		0		0
	0	*Lumbrineris luti*	2		0		0		0		0		0		0
	0	*Nereis zonata*	2		0		0		0		0		0		0
	0	*Polycirrus sp.*	2		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total	8	*Total*	26	*Total*	4	*Total*	14		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
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	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
	0		0		0		0		0		0		0		0
Total number of species:	26														
Shannon's diversity index:	4.4411														
Simpson's diversity index	28.2128														

APPENDIX D

Ocean Ecology Benthic Towed Video Survey of Site A

Towed Benthic Video Survey of Site 1 for the Canpotex Potash Terminal Project Disposal at Sea Application

August 2, 2011

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Towed Benthic Video Survey of Site 1 for the Canpotex Potash Terminal Project Disposal at Sea Application

Prepared for: Sandra Webster, PhD, R.P.Bio.
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Prepared by: Ocean Ecology

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Executive Summary

A DGPS-positioned, towed video camera system was used to collect imagery of the seabed. Nominal shore-normal and shore-parallel transect line spacing was 120 m. Cross-over points between the shore-normal and shore-parallel transect lines were used to determine the confidence levels in the interpretation of the image data. Surveys were carried out in waters up to 63 m depth.

A data record of substrate and biota classes was produced for each second of video imagery using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO).

All classification data was entered into a relational database. Maps of observed species distribution and estimated species ranges were produced using ArcGIS. A library of linked and searchable video annotations was produced.

The overall confidence level of the survey was 100%. This was not surprising given the homogeneity of the site substrate and the ubiquitous nature of “unmounded hole” fauna.

The following substrate and biota features were observed:

1. The site is located directly in the plume of the Skeena River, resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m.
2. Based on video observations, the site substrate was homogenously silt-mud, except for a small amount of rock seen in northwest corner of the site.
3. Anthropogenically-produced garbage was observed in small amounts at the site. This garbage appeared to provide habitat complexity for organisms such as spot prawns, which aggregated in large numbers around the garbage.
4. Due to the depth of the site, no flora was observed.
5. The most dominant fauna at the site were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp. Unmounded holes were distributed more or less uniformly throughout the site. While not clearly identifiable, many clam species were probably present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.
6. As a group, fish were the most diverse organisms at the site.
7. Plumose anemones were found in association with the small amount of rock observed at the site, whereas sea whips were found associated with silt-mud substrate. Both species occurred largely at depths shallower than 50 m, and thus were located in a “rim” around the site boundary.
8. Both Dungeness and tanner crabs were found in moderate abundance at the site. While their ranges overlap somewhat, Dungeness crabs tended to be found in shallower water than tanner crabs. As a result, the Dungeness crabs were located mainly around the “rim” of Site 1, whereas the tanner crabs were found in the “depression” of Site 1.
9. Spot prawns were very abundant at the site, and were found mainly at depths below 50 m. Based on life stage depth and substrate preferences, the spot prawns observed at Site 1 were most likely adult males. They are probably a localized population, with limited migration out of the site into shallower areas with rockier substrate for feeding and during breeding.
10. Northern ronquils were very abundant at the site, as well as a variety of flatfish. Starry flounders and rock soles were found mainly in the northern regions of the site. Northern ronquils and unidentified eelpout and sculpin species were observed throughout the site.

11. The following commercial species were observed at the site:
    a. spot prawns in high abundance
    b. Dungeness crabs in moderate abundance
    c. tanner crabs in moderate abundance
    d. flatfish in moderate abundance
    e. longnose skates in low abundance
12. The overall Shannon's diversity index for the site was 2.629, and the species richness was 22. By comparison with other local sites, the diversity for this site is quite low.
13. Maximum species richness for the site occurred in the deeper regions of the site and towards the northern end of the site. In general, maximum diversity appears to be correlated with anything that increases habitat complexity, such as (1) rocks in the northwest corner of the site; and (2) anthropogenically-derived garbage in the deeper northern parts of the site

1 Introduction

Canpotex and the Prince Rupert Port Authority (PRPA) are proposing to dispose of ~724,000 m^3 of dredgate at one or two new disposal sites within the PRPA harbour boundaries. Baseline information is required for the environmental assessment (EA) of this project, and by Environment Canada as part of the permit application process for disposal at a new site.

As a part of the baseline study for the project, a towed benthic video survey was carried out at the smaller and shallower of the two proposed disposal sites, referred to as Site 1 (see Figure 1).

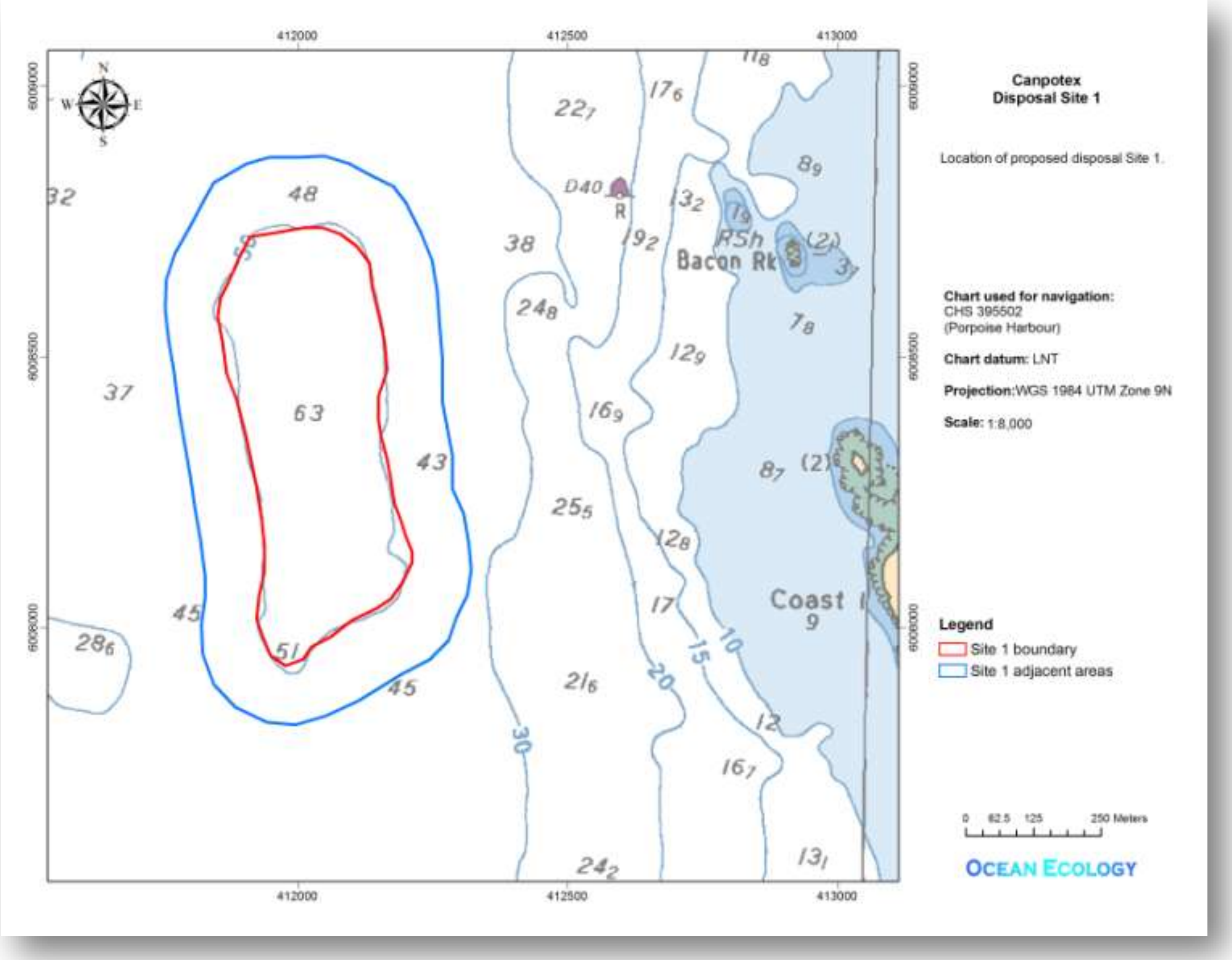


Figure 1. Location of proposed disposal Site 1.

2 Canpotex Disposal Site 1 Survey Methodology

2.1 Towed Benthic Video Survey

2.1.1 Towed Video System

A DGPS-positioned, towed video system was used to collect imagery of the seabed (similar to the Seabed Imaging and Mapping System [SIMS] used by CORI). This system was a custom-built model (e.g., not commercially available) designed for use in the steep, rugged terrain characteristic of British Columbia fjords (see Figure 2). Typical tow speed for the system was 0.7 knots. The towed video system has two video cameras - one in a forward-looking orientation and one in a downward-looking orientation. Both cameras have a Sony 1/3" super HAD color CCD with 480 lines horizontal resolution (768 x 494 pixels) and 0.5 lux @ F 2.0. These cameras provided composite video signals to an overlay unit that stamped the DGPS position data (latitude/longitude), together with date and time, on each video frame. The video signal was also displayed in real-time on the vessel, where it was used to adapt the survey to particular features that were seen while underway. High intensity white LEDs were mounted on the camera to provide additional illumination when it was required. The downward-looking camera was also equipped with a pair of scaling lasers with a center-to-center distance of 4 cm.

The altitude of the underwater camera was controlled using a hydraulic winch which was operated from the bridge while monitoring the real-time video feed from the camera. Typically, the camera was towed approximately 1 m above the seabed.

Figure 2. Towed video camera system about to be deployed.

2.1.2 Video Recording System

The dual analog camera signals were recorded using a digital video recorder directly onto a hard drive. After the survey was completed, the raw video data was copied onto DVDs. As the digital video recorder creates video files in a proprietary format, software to view and convert the video data into other formats was also provided on each raw video DVD.

2.1.3 Survey Design

The benthic video survey of Site 1 was carried out on April 16th and 17th, 2011. The survey design consisted of a grid survey pattern with a nominal shore-normal and shore-parallel transect line spacing of 120 m (see Figure 3). Surveys were carried out in waters up to approximately 63 m depth.

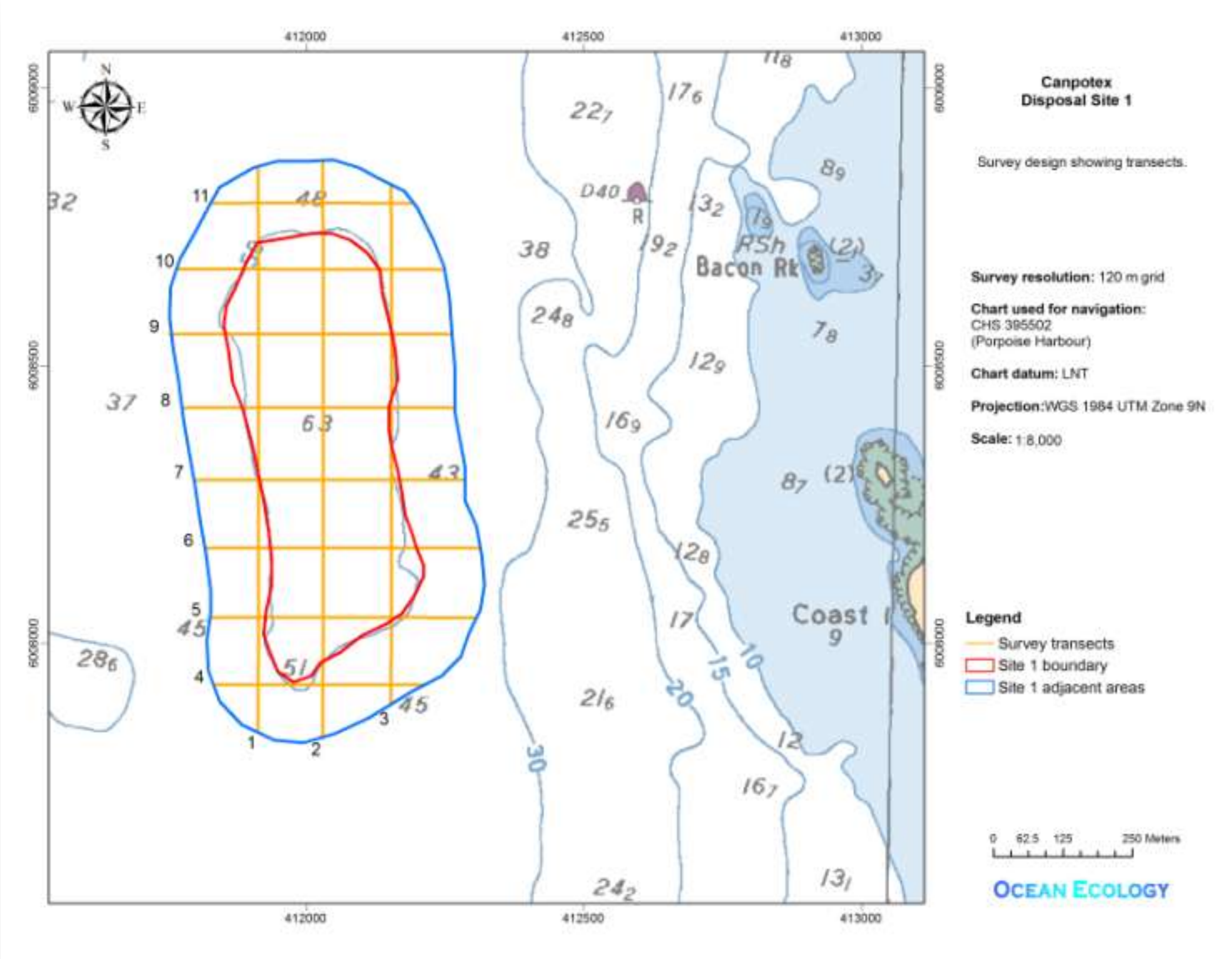


Figure 3. Survey design showing transects.

2.2 Classification and Mapping

2.2.1 Database of Species and Substrate Classifications

Raw video of the transects was reviewed and classified using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO). A data record of substrate and biota classes was produced for each second of video imagery.

The geology database contains information on substrate type (Table 3 in the Appendix) and percentage substrate cover (Table 5 in the Appendix). Anthropogenic features were mapped as part of the geological inventory.

The biological database captured detail on seabed biota within two general categories, vegetation (Table 6 in the Appendix) and fauna (Table 8 in the Appendix). Up to three faunal and floral types were evaluated for each second of video and given distribution codes. Vegetation coverage classes (Table 7 in the Appendix) and faunal distribution classes (Table 9 in the Appendix) were also recorded. Note that very small species (e.g., barnacles, small tube worms, small algal species), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) were often not identified in the video footage, and were therefore not included in the database.

Video annotation created a linked, random-access database of all the video data which can be readily searched using keywords from the classification scheme. Additionally, the provided “Transect Player” software links video and GPS data, allowing simultaneous viewing of the camera’s geographical position on a map and the video images captured by the camera at that location.

All classification data was also entered into a relational Access database, which was then used to generate the data for mapping. This database contains a “Filter by Video” function which allows the user to browse through the data for each transect as a series of data recording forms.

2.2.2 ArcGIS Mapping

Maps of observed species distribution and estimated species ranges were produced using ArcGIS. These maps have been provided as an ArcGIS project which can be viewed using the supplied ArcReader.

2.2.3 Survey Confidence Levels

All transect cross-over points were used to determine the confidence levels in the interpretation of the image data. All the data records within a 5.0 m radius (the maximum positional error of a DGPS signal) of the location where two transect lines crossed were analyzed for similarities. The number of times that data records from both transect lines had the same values for each classification category (e.g., substrate, fauna) was recorded and used to generate percentage confidence.

2.2.4 Range Maps

Range maps for fauna were generated using the fixed kernel density estimation procedure. Fauna observations were weighted by distribution (see Table 9 in the Appendix). In order to allow overlap of polygons between transects, the search radius (a.k.a. the smoothing factor) was set to the distance between transects (e.g., 120 m). For each organism, a 95% volume contour was generated. This consisted of a polygon covering a geographical area in which 95% of the estimated population was expected to be found.

2.2.5 Dominant Species Maps

Species observations for fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 30 m) was overlaid on the observation points. Each polygon was assigned a species code based on the most abundant species within that polygon, weighted by distribution. Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

2.2.6 Minor Species Maps

Species observations for fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 30 m) was overlaid on the observation points. Each polygon was assigned a species code based on the code of least abundant species within that polygon, weighted by distribution. Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

2.2.7 Diversity Analysis Using Range Maps

Calculations of Shannon's diversity index, Shannon's evenness, and Simpson's dominance index were carried out in ArcMap using the range map polygons. Note that the diversity values generated from the range map data should be considered minimum values for the site, as very small species (e.g., barnacles, small tube worms), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) are often not identified in the video footage, and are therefore may not included in the diversity calculations.

2.2.8 Species Richness Maps

A hexagonal grid (composed of hexagonal polygons with widths of 30 m) was overlaid on a shape file containing the fauna range map polygons. Using polygon in polygon analysis, each hexagonal polygon was assigned a number equal to the number of range map polygons with which it overlapped. This assigned number was equal to the species richness in a given hexagonal polygon, since each range map polygon represented a different species. The coded hexagonal polygons were used to generate a species richness map.

3 Canpotex Disposal Site 1 Survey Results

3.1 Benthic Video Survey

The transect lines for the survey as carried out are shown in Figure 4. Coverage for the site was excellent, with good extension of the transects to the edges of the proposed disposal site boundary. Other factors which had an effect on the survey quality and resolution were:

1. ***Turbid water*** – the site is located directly in the plume of the Skeena River (see Figure 5), resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m. High intensity LEDs were used to provide light during the video runs; however back-scattering of light from the silt particles often created a “halo effect”, causing additional visibility issues. This reduced the resolution of the video camera, producing a grainy image quality. In spite of these problems, the image quality was deemed sufficient for organism identification. Due to the limited visibility, the camera was often towed less than 1 m above the bottom, resulting in a relatively small field of view and a low towing speed (less than 0.5 knots).
2. ***Strong currents*** – strong currents occasionally made course-holding difficult on a few of the transects.
3. ***Loss of DGPS signal*** – occasionally during the survey, the high accuracy DGPS signal was lost, and a lower accuracy GPS signal had to be used, thus increasing positional error. Overall, a DGPS quality signal was received for 91% of the video survey.
4. ***Video interference*** - on April 16th, 2011, significant electromagnetic interference occurred in the video signal during the survey at Site 1. This interference did not occur during equipment set-up at Rushbrook dock, was not observed at the site on April 17th, 2011, and did not occur again during video surveys at other sites the following week. It appears that some equipment at Ridley Island, or on the ships loading at the terminals, was generating an electromagnetic signal with sufficient power at a frequency which resulted in video interference.

Five DVDs of raw video data were generated from the survey. Processing and annotation of the video data produced five DVDs containing the clipped and converted videos and viewers to visualize the data.

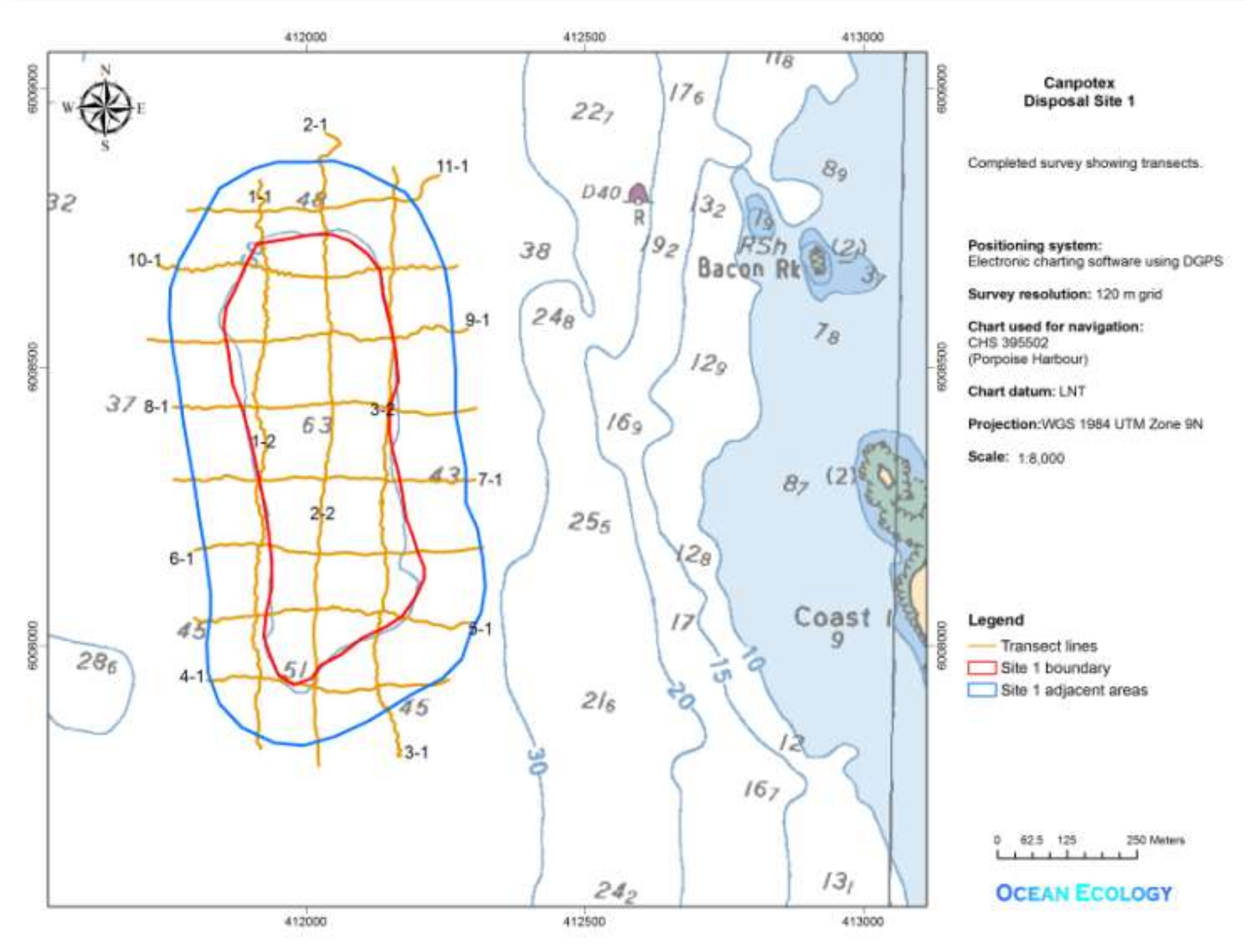


Figure 4. Completed survey showing transects.

Figure 5. Aerial photograph of the Skeena River plume in relation to the boundaries of Site 1.

3.2 Survey Confidence Levels

A total of 24 cross-over points were used to determine the survey confidence levels (refer to the "Cross over analysis" layer in the attached ArcGIS project). Each pair of records was compared for:

1. substrate
2. fauna

The results of this analysis are given in Table 1.

Table 1. Confidence levels in data interpretation.

Category	**# Points Compared**	**# Points in Agreement**	**% Confidence**
Substrate	24	24	100
Fauna	24	24	100
Overall	**48**	**48**	**100**

The overall confidence level of 100% is not surprising given the homogeneity of the site substrate and the ubiquitous nature of "unmounded hole" fauna.

3.3 Substrate

Based on video observations, the site substrate was homogenously silt-mud, except for a small amount of rock seen in northwest corner of the site. Figure 6 shows the locations of the 30 m diameter polygons in which rock was observed from the video survey.

Anthropogenically-produced garbage was observed in small amounts at the site. Figure 7 shows the locations of the 30 m diameter polygons in which garbage was observed from the video survey. Interestingly, in the flat and featureless benthic environment of Site 1, these "garbage dumps" formed regions where certain organisms, such as spot prawns, aggregated in large numbers. Detailed analysis of video transects reported by Schlining (1999) showed that prawns were not usually associated with barren sediments, but appeared to actively seek out habitats that were more complex, including drift algae (loose kelp on the sea floor). Anthropogenically-produced garbage may also provide habitat complexity for these organisms.

3.4 Flora

Due to the depth of the site, no flora was observed.

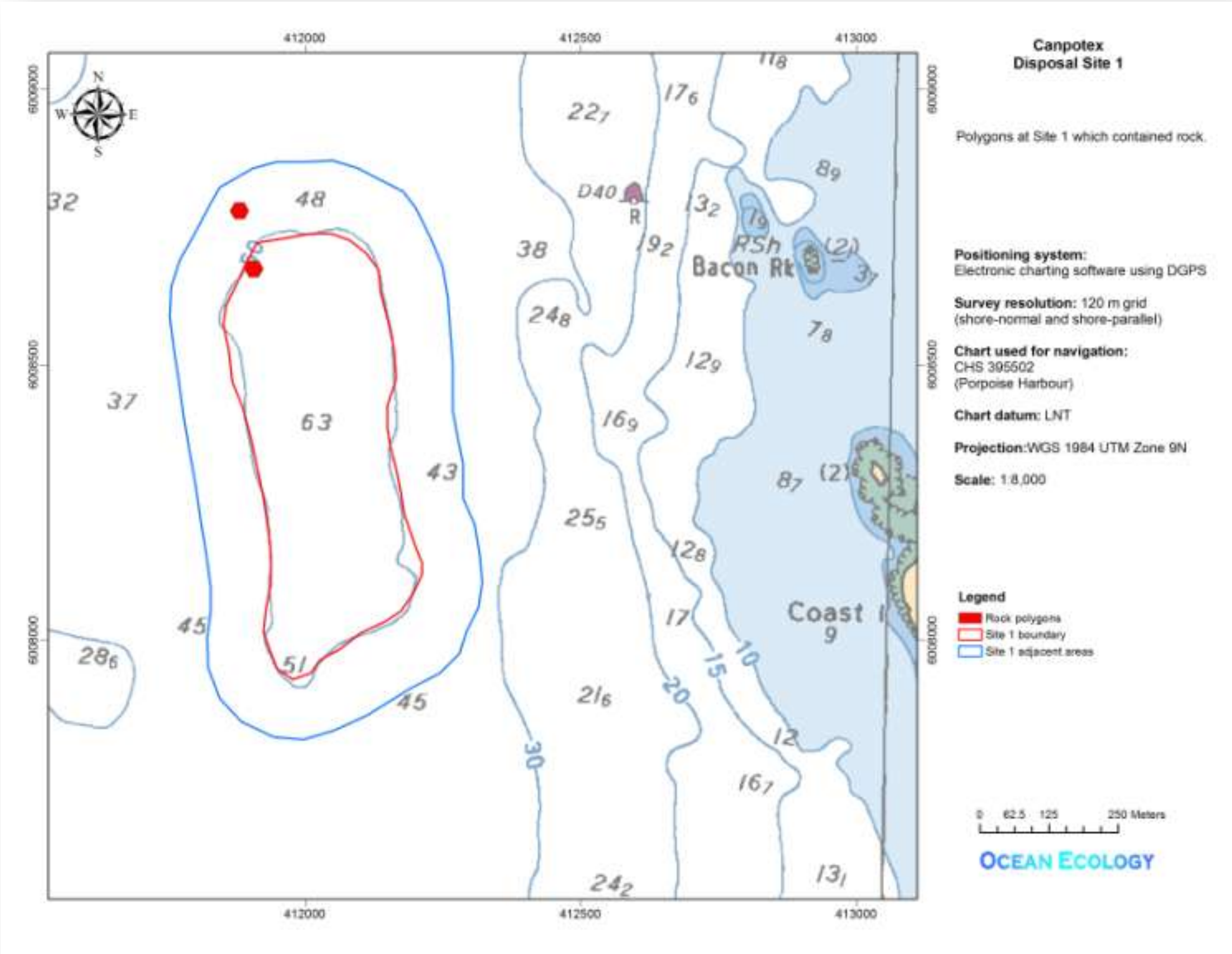


Figure 6. Polygons at Site 1 which contained rock.

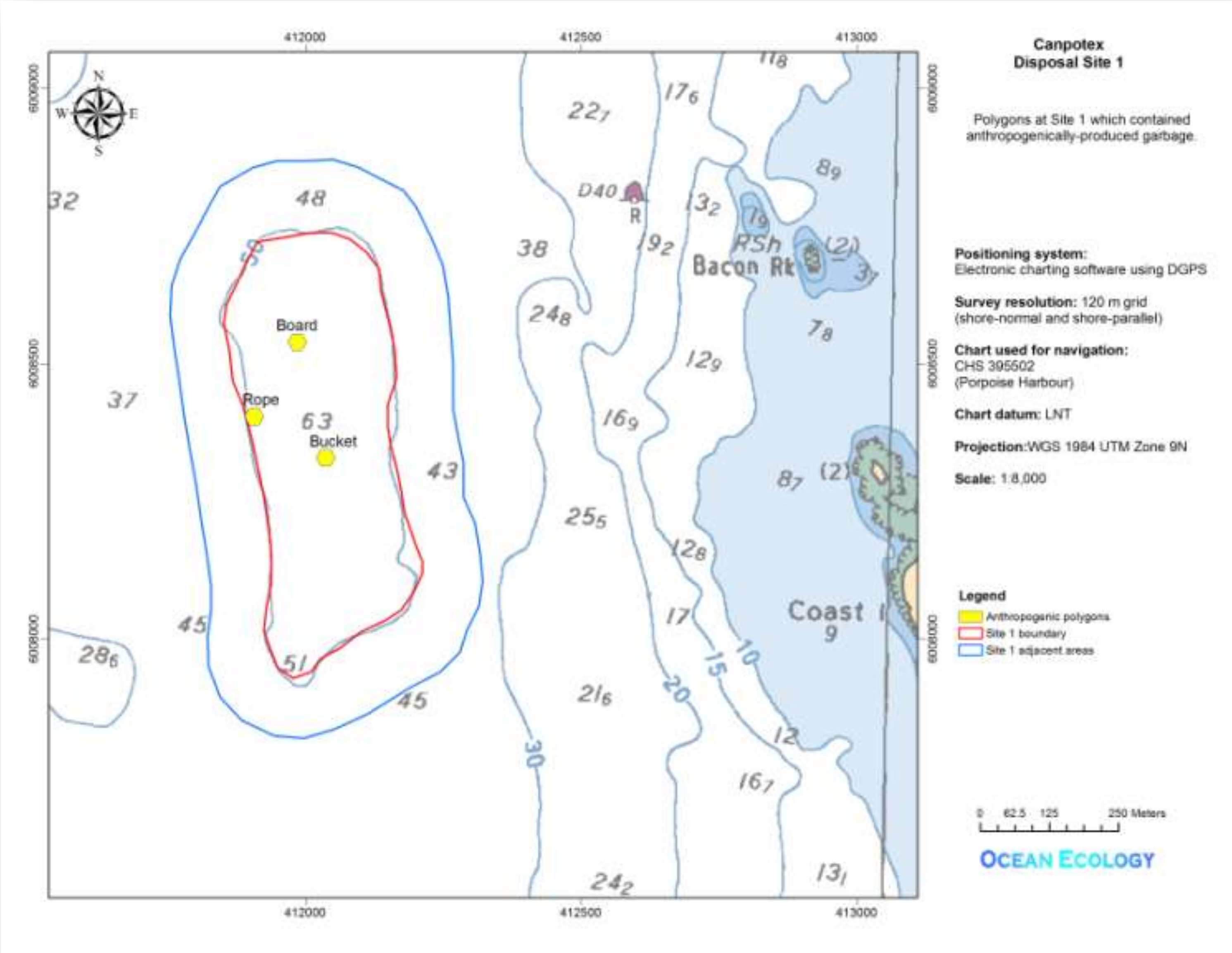


Figure 7. Polygons at Site 1 which contained anthropogenically-produced garbage.

3.5 Fauna

Table 2 lists the various groups of fauna identified at the site, and their abundances in terms of both total number of observations and percentage of total fauna abundance by area based on the range maps for each group.

Table 2. Abundances of various fauna groups.

Fauna identification	Number of Observations	% of Total Fauna Abundance by Area
Unmounded hole	20178	15.57
Northern ronquil	506	14.67
Spot prawn	393	6.65
Unidentified flatfish	57	12.16
Unidentified eelpout	46	10.70
Dungeness crab	25	7.69
Tanner crab	23	6.18
Plumose anemone	19	1.61
Rock sole	15	4.50
Starry flounder	9	2.88
Unidentified sculpin	9	3.34
Sea whip	8	3.24
Unidentified fish	8	2.41
Big skate	2	0.84
Moon jellyfish	2	0.84
Mounded hole	2	0.84
Orange sea pen	2	1.66
Ratfish	2	0.84
Sunflower seastar	2	0.84
Pacific snake prickleback	1	0.84
Snake lock anemone	1	0.84
Striped nudibranch	1	0.84

Some observations regarding fauna at Site 1 are:

1. The most dominant fauna in terms of both number of observations and area were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp. Unmounded holes were distributed more or less uniformly throughout the site.
2. As a group, fish were the most diverse organisms at the site.

3. The following distribution patterns were observed for organisms for which there were more than 4 sitings:

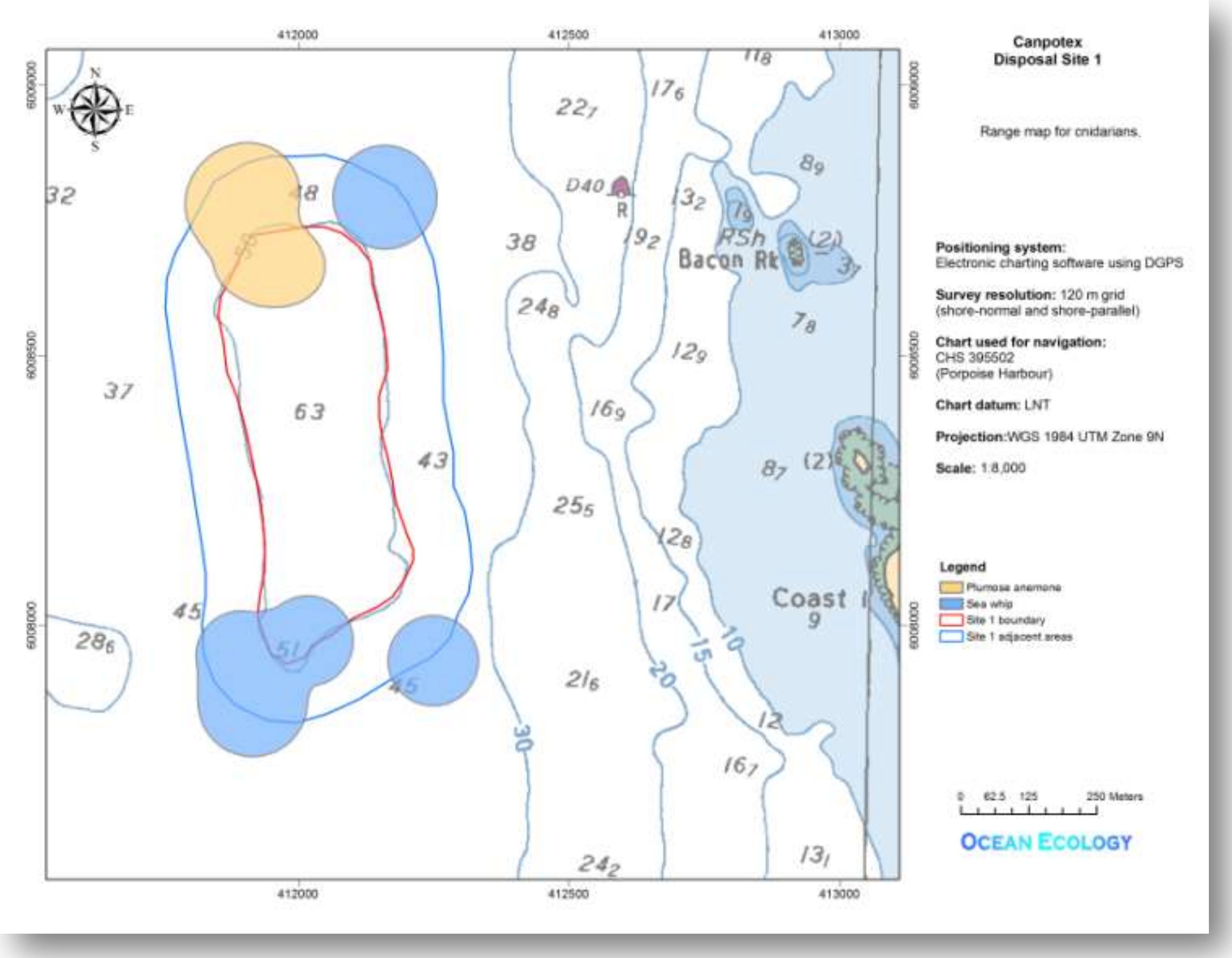
    a. Plumose anemones were found at the northwest corner of the site in association with the small amount of rock observed in this region (see Figure 8). Sea whips were found at both the north and south ends of the site associated with silt-mud substrate (see Figure 8). Both species occurred largely at depths shallower than 50 m, and thus were located in a "rim" around the site boundary.

    b. Spot prawns were the third most abundant organism at the site, and were found mainly at depths below 50 m. Mature adult spot prawns are found on bottom types ranging from soft to rocky. In the northern part of their range (Alaska and northern British Columbia), they are most abundant between 45 - 140 m. Males are typically caught in bottom trawls on sandy or muddy bottoms, while females are rarely caught outside rocky habitat (Lowry, 2007; Berkeley, 1930). Thus, the spot prawns observed at Site 1 were most likely adult males. Once they have settled and migrated to adult grounds, spot prawns appear to remain in a very restricted area throughout the rest of their life; probably limited by the size of the habitat patch they inhabit (Lowry, 2007). Tagging studies have shown that prawns were captured within 1.7 km of their release location over a period of several years (Kimker *et al*., 1996). The spot prawns at Site 1 are probably a localized population, with limited migration out of the site into shallower areas with rockier substrate for feeding and during breeding.

    c. Both Dungeness and tanner crabs were found in moderate abundance at Site 1 (see Figure 10). While their ranges overlap somewhat, Dungeness crabs tended to be found in shallower water than tanner crabs. As a result, the Dungeness crabs were located mainly around the "rim" of Site 1, whereas the tanner crabs were found in the "depression" of Site 1.

    d. Northern ronquils were the second most abundant organism at the site, and were distributed fairly evenly throughout the site. Also abundant were a variety of flatfish, mostly unidentifiable in the video footage (see Figure 11). The larger, and thus more easily identifiable, starry flounders and rock soles were found mainly in the northern regions of the site. Unidentified eelpout and sculpin species were observed throughout the site (see Figure 12).

    e. Unmounded holes were the most abundant group of organisms at the site, and were distributed uniformly throughout the site. These holes probably represented a variety of infaunal organisms; however most cannot be accurately identified from video images. While not clearly identifiable, many clam species were probably present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.



Canpotex
Disposal Site 1

Range map for cnidarians.

Positioning system:
Electronic charting software using DGPS

Survey resolution: 120 m grid
(shore-normal and shore-parallel)

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:8,000

Legend

- 🟧 Plumose anemone
- 🟦 Sea whip
- 🟥 Site 1 boundary
- 🟦 Site 1 adjacent areas

Figure 8. Range map for cnidarians.

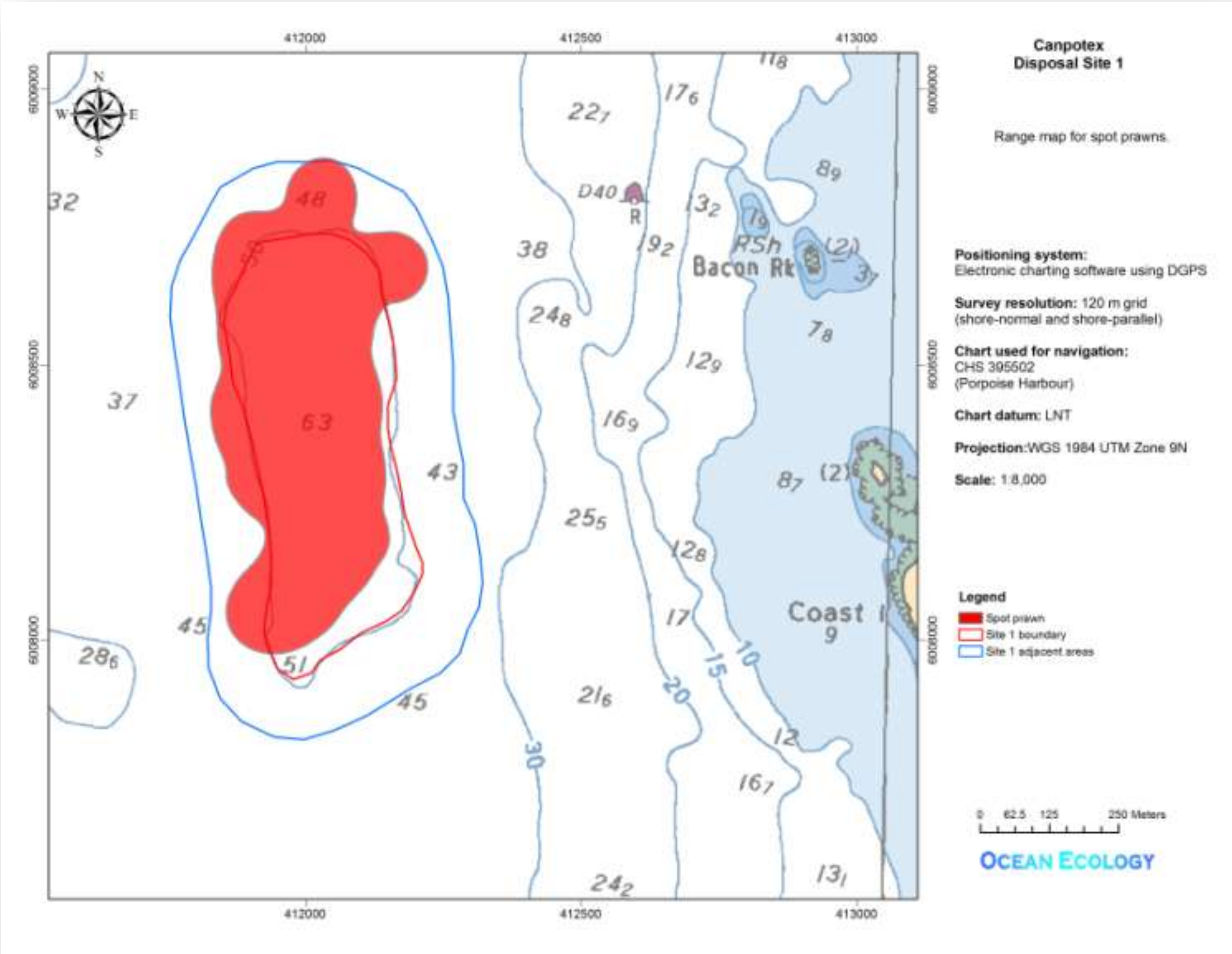


Figure 9. Range map for spot prawns.

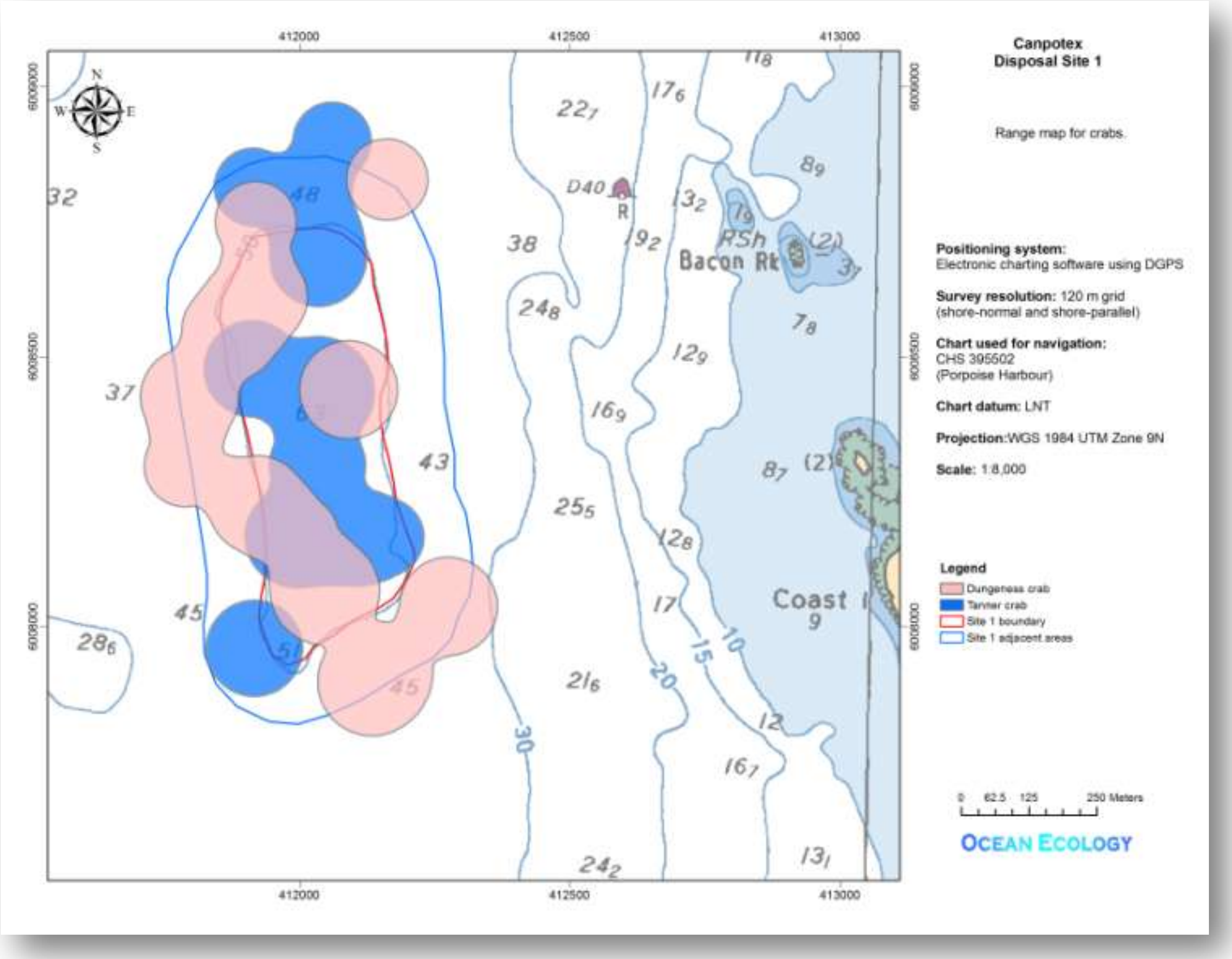


Figure 10. Range map for crabs.

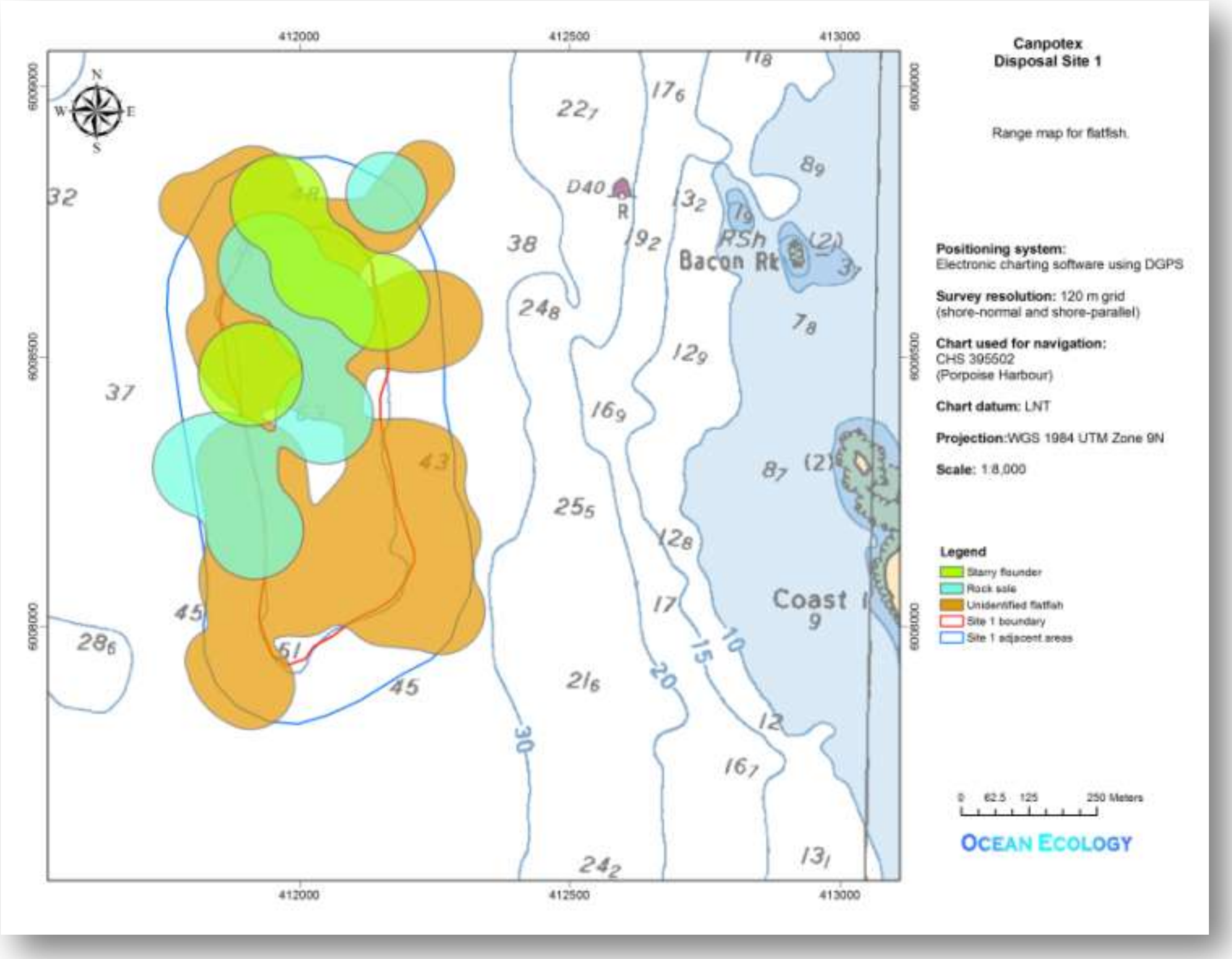


Figure 11. Range map for flatfish.

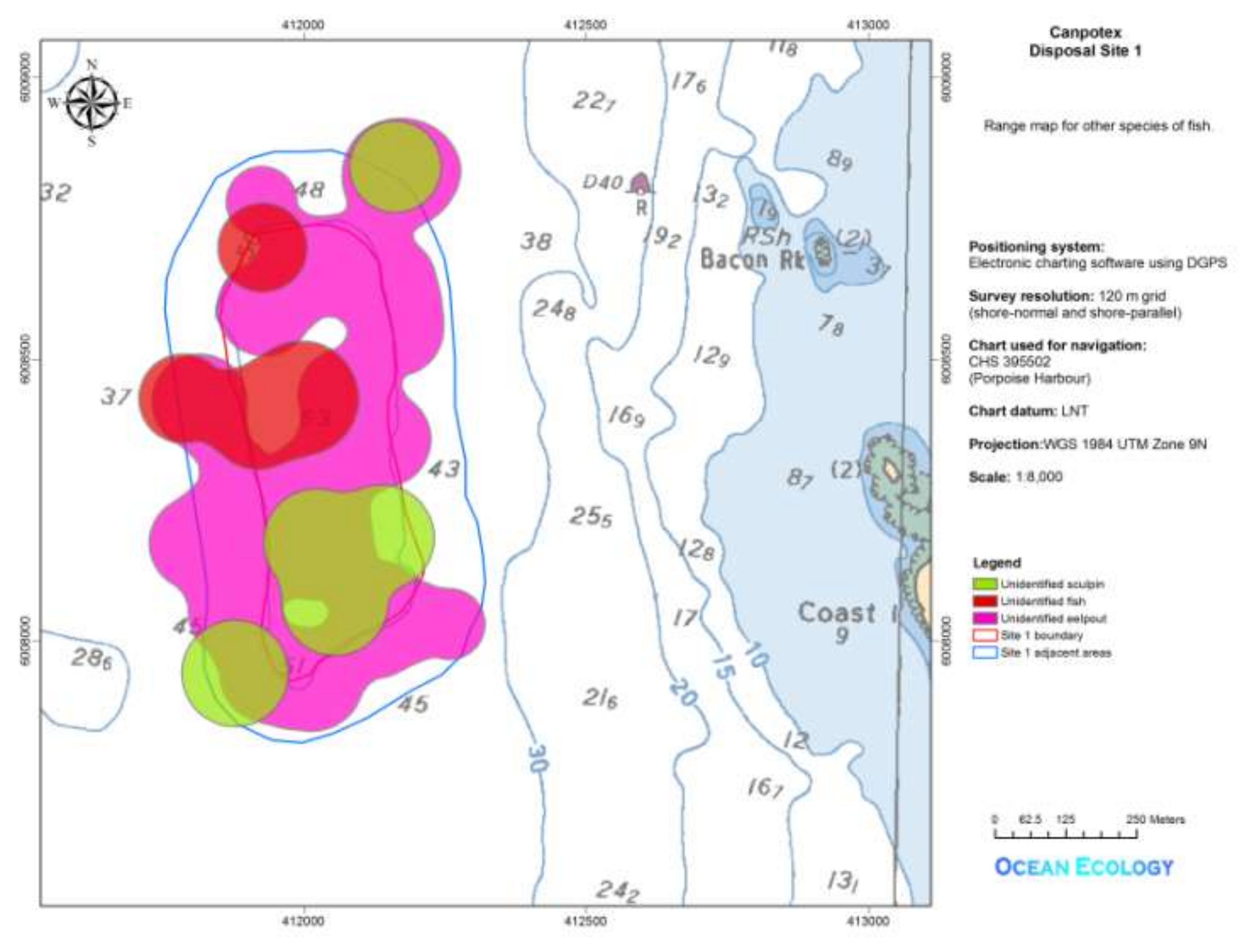


Figure 12. Range map for other species of fish.

4. The following commercial species were observed at the site:
    a. spot prawns in high abundance
    b. Dungeness crabs in moderate abundance
    c. tanner crabs in moderate abundance
    d. flatfish in moderate abundance
    e. longnose skates in low abundance

3.6 Diversity Analyses

3.6.1 Dominant and Minor Fauna Analyses

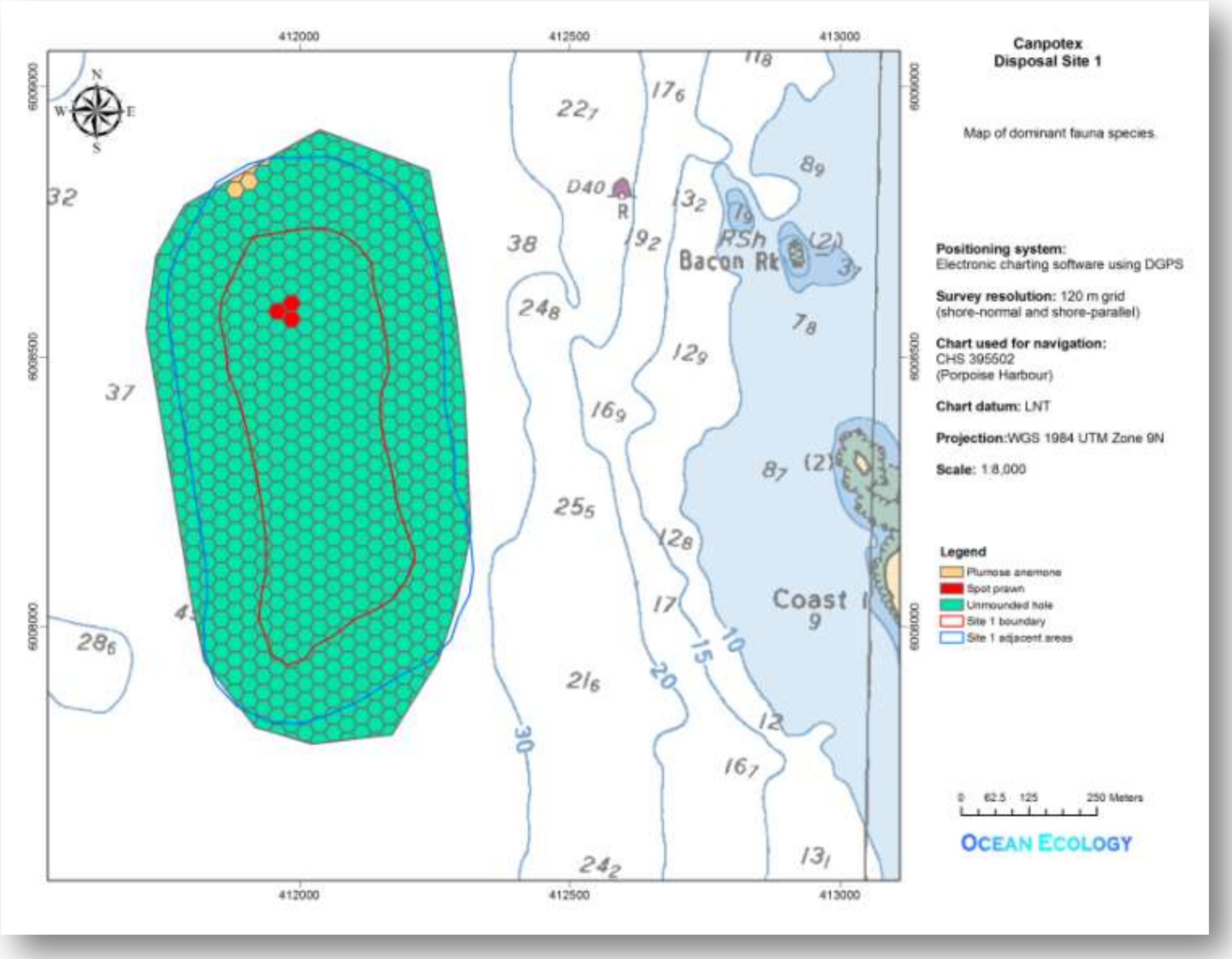
Analysis of fauna species dominance shows that unmounded holes are clearly the most dominant fauna overall (see Figure 13). Only in two small locations are other organisms more dominant: (1) in the northwest corner of the site where a small amount of rock is present and plumose anemones become dominant, and (2) at one small spot in the middle of the site where an anthropogenically-derived “board” increases habitat complexity for spot prawns, thus increasing their abundance and dominance.

In considering the entire site, fauna diversity is relatively low, as shown in the map of minor species (see Figure 14). Three species groups - unmounded holes, northern ronquils, and spot prawns - dominated the majority of the polygons. On a smaller scale perspective, 25% of the individual polygons showed no diversity (e.g., only one type of organism was observed within the polygon). Again, very small species (e.g., barnacles, small tube worms), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) often cannot be identified in the video footage, and thus the actual fauna diversity of the site is probably higher than observed.

3.6.2 Diversity Indices

The overall Shannon’s diversity index for the site was 2.629, and the species richness was 22. This is much lower than that at the nearby Canpotex site, which had an overall Shannon’s diversity index of 3.734 and a species richness of 57. If all organisms at Site 1 were completely evenly distributed (which would generate a maximum value for Shannon’s diversity index), the maximum possible diversity for the site would be 3.091. This suggests that the particular complement of species at this site is fairly close to reaching their maximum diversity. The Shannon’s evenness value of 0.850 also indicates that the species are relatively evenly distributed throughout the site (a value of 1.0 would indicate a completely even distribution).

To determine how the diversity of this site ranks with other sites in the area, we need to have some comparative values for species richness. Dr. Shannon Bard has provided information on species richness for a number of sites in the Prince Rupert area on her website (http://www.ecotoxicology.ca/csi/Prince%20Rupert.html). Her data indicates that recent values for species richness (2003) range from approximately 38 to approximately 60. Using these two values of species richness, we can calculate a range for the maximum value of Shannon’s diversity index for the area from 3.638 to 4.094. By comparison, the value of 2.629 for Site 1 is very low (i.e., it has a relative richness of 37% using a maximum potential species richness of 60).



Positioning system: Electronic charting software using DGPS

Survey resolution: 120 m grid (shore-normal and shore-parallel)

Chart used for navigation: CHS 395502 (Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:8,000

Figure 13. Map of dominant fauna species.

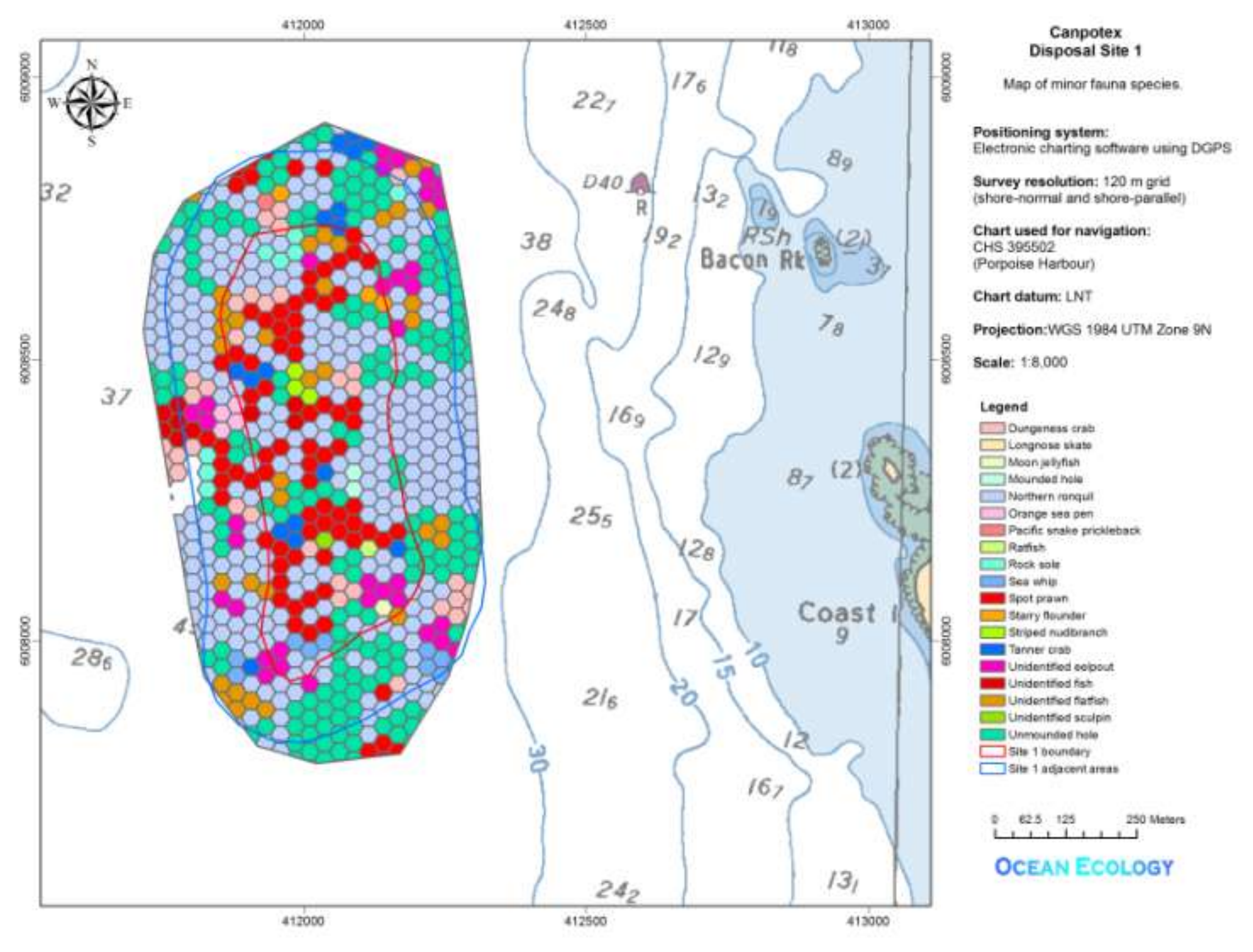


Figure 14. Map of minor fauna species.

The site has a Simpson's dominance index of 0.462. The Simpson's dominance index approaches 1.0 as one particular species dominates the site. A value of 0.462 suggests that there is some dominance by organisms (particularly unmounded holes, northern ronquils, and spot prawns) at the site, but only limited areas of extreme dominance (e.g., 25% of the site where only one species is found).

Figure 15 shows the species richness map for the site. Species richness in each hexagonal polygon ranges from 0 to 13 (as compared to a species richness range of 0 to 35 for the Canpotex site). Maximum species richness for the site occurs in the deeper regions of the site and towards the northern end of the site. In general, maximum diversity appears to be correlated with anything that increases habitat complexity, such as (1) rocks in the northwest corner of the site; and (2) anthropogenically-derived garbage in the deeper northern parts of the site.

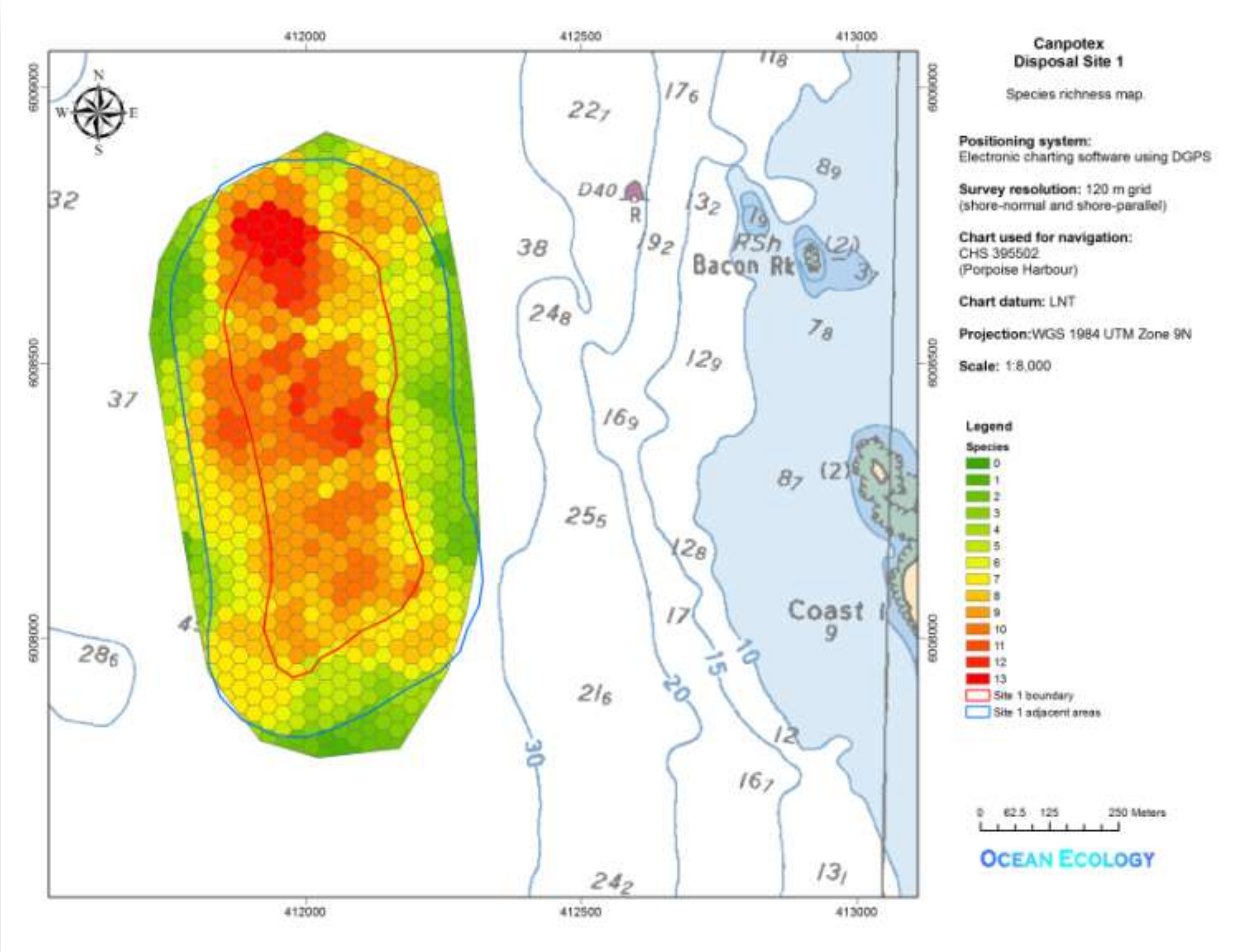


Figure 15. Species richness map.

4 Project Deliverables

In addition to this report, the following materials have also been provided from the subtidal survey:

1. Five DVDs containing raw georeferenced seabed video imagery* (overlaid with time, latitude, and longitude) of the survey site.
2. Five DVDs containing:
    a. java-based software which links video* and GPS data, allowing simultaneous viewing of the camera's geographical position on a map and the video images captured by the camera at that location.
    b. a library of video* annotations
3. One DVD containing:
    a. a georeferenced, classified Access database* for biological and physical features of the seabed.
    b. an electronic ArcGIS project* containing maps of analyzed video data.
    c. a report describing and explaining the results of the video survey.

*Note: time on the video imagery, in the database, and in the ArcGIS project is given in PST (Pacific Standard Time).

5 References Cited

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Schlining, K. L. 1999. The spot prawn (*Pandalus platyceros* Brandt 1851) resource in Carmel submarine canyon, California: Aspects of fisheries and habitat associations. Moss Landing Marine Laboratories. Stanislaus, California State University. M.Sc.: 54 pp.

6 Appendix

Table 3. Substrate type codes.

Substrate Composition	Class	Subclass	Description
Rock (R)			Bedrock outcrop; may be partially covered with a veneer of sediment.
Veneer over bedrock (vR)			Intermittently visible bedrock covered with a thin veneer of clastic sediments.
Clastic (C)			Seabed comprised of mineral grains of gravel-, sand- or mud-sized material.
	Gravel (G)	Boulder (B)	Percentage boulder (>25.6 cm in size) on seabed.
		Cobble (CO)	Percentage cobble (6.4 to 25.6 cm in size) on seabed.
		Pebble (P)	Percentage pebble (4 mm to 6.4 cm in size) on seabed.
		Granules (GR)	Percentage granules (2-4 mm in size) on seabed.
	Sand (S)	Sand (S)	Percentage sand (0.062 to 2 mm in size) on seabed.
	Silt-mud (M)	Silt-mud (M)	Percentage silt-mud (<0.62 mm in size) on seabed.
Biogenic (B)			Surface of seabed comprised of material of biogenic origin, such as vegetation.
	Organics (O)	Shell (SH)	Percentage coarse (> 2 mm in size) shell debris on seabed.
		Organic debris (OD)	Percentage organic debris on seabed.
		Wood debris (WD)	Percentage wood debris on seabed.
Anthropogenic (A)			Features of man-made origin, such as trawl marks, anchor drag marks, or cable drag marks.

Table 4. Average particle size values.

Substrate Class/Subclass	Average Size (mm)
Rock	10000
Veneer over bedrock	10000
Boulder	512
Cobble	256
Pebble	64
Granules	4
Sand	2
Silt-mud	0.62
Shell	--
Organic debris	--
Wood debris	--
Anthropogenic	--

Table 5. Percentage substrate cover codes.

Class Code	Percentage Cover
1	T-5%
2	5-30%
3	30-50%
4	50-80%
5	>80%

Table 6. Vegetation codes.

Algal Class	**Subclass**	**Code**	**Description**
Green Algae (GRA)	Foliose greens	FOG	Primarily *Ulva*, but also including *Enteromorpha* and *Monostroma.*
	Filamentous greens	FIG	The various filamentous green/red assemblages (*Spongomorpha/Cladophora* types).
Brown Algae (BA)	Fucus	FUC	*Fucus* and *Pelvetiopsis* species groups.
	Sargassum	SAR	*Sargassum* is the dominant and primary algal species.
	Nemalion	NEM	Filamentous *Nemalion* sp. is the dominant species.
	Soft brown kelps	BKS	Large laminarian bladed kelps, including *L. saccharina* and *groenlandica*, *Costaria costata, Cymathere triplicata.*
	Seersucker kelp	SEE	*Costaria costata.*
	Split kelp	SPL	*Laminaria setchellii.*
	Sugar wrack kelp	SWK	*Laminaria saccharina.*
	Suction-cup kelp	SUC	*Laminaria yezoensis*.
	Dark brown kelps	BKD	The LUCO chocolate brown group,. *L. setchelli, Pterygophora, Lessoniopis. Alaria* and *Egregia* may also be present. Generally more exposed than soft browns.
	Alaria	ALA	*Alaria* sp.
	Agarum	AGR	*Agarum* is the dominant species, but other laminarians may also occur. Generally found deeper than Laminarian subgroup.
	Fringed sea colander kelp	FSC	*Agarum fimbriatum*.
	Three-ribbed kelp	TRK	*Cymathere triplicata*.
	Stringy acid weed	STW	*Desmarestia viridis.*
	Broad acid weed	BRW	*Desmarestia lingulata.*
	Macrocystis	MAC	Beds of canopy forming giant kelp.
	Nereocystis	NER	Beds of canopy forming bull kelp.

Algal Class	**Subclass**	**Code**	**Description**
Red Algae (RED)	Foliose reds	FOR	A diverse species mix of foliose red algae (*Gigartina*, *Iridea, Rhodymenia, Constantinia*) which may be found from the lower intertidal to depths of 10 m primarily on rocky substrate.
	Filamentous reds	FIR1	A diverse species mix of filamentous red algae (including *Gastroclonium, Odonthalia, Prionitis*) which may be found from the lower intertidal to depths of 10 m, often co-occurring with the foliose red group described above.
	Filamentous reds	FIR2	A mix of red algae (primarily *Neoagardhiella*and *Gracilaria*) which grow on "submerged" cobble and pebble in fine sand and silt bottoms.
	Coralline reds	COR	Rocky areas with growths of encrusting and foliose forms of coralline algae.
	Halosaccion	HAL	*Halosaccion glandiforme.*
	Red fringe	RFR	*Smithora.naiadum*
Seagrasses (SGR)	Eelgrass	ZOS	Eelgrass beds.
	Surfgrass	PHY	Areas of surfgrasses (*Phyllospadix*), which may co-occur with subgroup BKS or BKD above.
No Vegetation		NOV	No vegetation observed.
Cannot Classify		X	Vegetation present by cannot be identified. Imagery is not clear, classification not possible.

Table 7. Vegetation coverage codes.

Code	**Class**	**Abundance**
1	Sparse	Less than 5% cover.
2	Low	5 to 25% cover.
3	Moderate	26 to 75% cover.
4	Dense	>75% cover.

Table 8. Fauna codes.

Species or Species Complex	**Code**	**Description**
Bacterial mat	BCM	Unidentified bacterial mat; sulfuretum.
Sponges	USP	Unidentified sponge.
	CLD	Cloud sponge (*Aphrocallistes vastus*).
	SBS	Sharp lipped boot sponge (*Rhabdocalyptus dawsoni*).
	RSB	Round lipped boot sponge (*Staurocalyptus dowlingi*).
	SVS	Stalked vase sponge (*Leucilla nuttingi*).
	BRS	Breast sponge (*Eumastia sitiens*).
Jellyfish	MJF	Moon jellyfish (*Aurelia labiata*).
	CYC	Lion’s mane jellyfish (*Cyanea capillata*).
Hydroids	HYD	Unidentified hydroids.
	HYM	Hydromedusa sp.
Anemones	PAF	Tube-dwelling anemone (*Pachycerianthes fimbriatus)*.
	MET	Plumose anemone (*Metridium* sp.).
	URT	Sea anemone (*Urticina* sp.).
	XAN	Giant green anemone (*Anthopleura xanthogrammica*).
	CRI	Snake lock anemone (*Cribrinopsis* sp.).
	ANT	Sea anemone (*Anthopleura* sp.).
	STR	Strawberry anemone (*Corynactis californica*).
Corals/Hydrocorals	SPO	Orange sea pen (*Ptilosarcus gurneyi*).
	SPW	White sea pen (*Virgularia* sp.).
	CUP	Orange cup coral (*Balanophyllia elegans*).
	SWP	Sea whip (*Balticina septentrionalis*).
	STY	Pink hydrocoral (*Stylaster* sp.).
Worms	TUB	Parchment tube dwelling polychaete worms.
	TUC	Calcareous tube dwelling polychaete worms.
	LUG	Pacific lugworm (*Abarenicola pacifica*).

Species or Species Complex	**Code**	**Description**
Crabs	CRB	Unidentified crab.
	CAN	*Cancer* sp.
	DUN	Dungeness crab (*Cancer magister*).
	TAN	Tanner crab (*Chionoecetes* sp.).
	KCR	Kelp crab (*Pugettia* sp.).
	BXC	Box crab (*Lopholithodes foraminatus*).
	BXC	Box crab (*Lopholithodes foraminatus*).
	HEC	Helmet crab (*Telmessus cheiragonus*).
	SQT	Squat lobster (*Munida quadraspina*).
Shrimps (Pandalid)	PAN	Unidentified pandalid.
	PRN	Spot prawn (*Pandalus platyceros*).
	PNB	Spiny pink shrimp (*Pandalus borealis*).
	PNH	Humpback shrimp (*Pandulus hypsinotus*).
Ghost and mud shrimps	GHS	Ghost shrimp (*Callianassa californiensis*).
	MDS	Mud shrimp (*Upogebia pugettensis*).
Gastropods	WHK	Unidentified whelk.
	ELI	Eelgrass limpet (*Lottia alveus paralella*).
	NUC	Dogwinkle (*Nucella* sp.).
	CDV	Carinate dovesnail (*Alia carinata*)
	TBI	Threaded bittium (*Bittium eschrichtii*)
	MOO	Moon snail (*Euspira lewisii*).
	WLN	White-lined nudibranch (*Dirona albolineata*).
	TOT	Orange-peel nudibranch (*Tochuina tetraquetra*).
	SNU	Striped nudibranch (*Armina californica*)
Bivalves	MUS	Mussel bed (*Mytilus trossulus*).
	GCL	Geoduck clam (*Panopea abrupta*).
	HCL	Horseclam (*Tresus* sp.).
	PCL	Piddock clam.
	BCL	Butter clam (*Saxidomas gigantea*).
	COC	Nuttall’s cockle (*Clinocardium nuttallii*).
	SFC	Softshell clam (*Mya* sp.).
	OYS	Oyster.
	OCL	Other clam species.
	SCA	Scallop (*Chlamys* sp.)
	TER	Teredo worm (*Bankia setacea*).
Octopus	OCT	Pacific octopus (*Octopus*).
Bryozoan Complex	BRY	Bryozoans, ascidians, sponges - generally on rock substrate.
Brachiopods	BRA	Unidentified brachiopod.
	LAM	California lamp shell (*Laqueus californicus*).

Species or Species Complex	**Code**	**Description**
Seastars	BRE	Short-spined seastar (*Pisaster brevispinus*).
	EVA	False ochre seastar (*Evasterias troschelli*).
	PYC	Sunflower seastar (*Pycnopodia helianthoides*).
	POR	Ochre seastar (*Pisaster ochraceus*).
	DER	Leather star (*Dermasterias imbricata*).
	GEP	Gunpowder star (*Gephyreaster swifti*).
	WRS	Wrinkled star (*Pteraster militaris*).
	PTT	Slime star (*Pteraster tesselatus*).
	VER	Vermilion star (*Mediaster aequalis*).
	HEN	Seastar (*Henricia* sp.).
	SOL	Seastar (*Solaster* sp.).
	COO	Cookie star (*Ceremaster patagonius*).
	PLS	Pale star (*Leptychaster pacificus*).
	SMS	Spiny mudstar (*Luidia foliolata*).
	ORT	Painted star (*Orthasterias koehleri*).
	STF	Long ray star (*Stylasteria forreri*).
	SIX	Six-armed star (*Leptasterias* sp.).
	ROS	Rose star (*Crossaster papposus*).
	STR	Unidentified seastar.
Brittle Stars	BRT	Unidentified brittle star.
	GYB	Gray brittle star (*Ophiura lütkeni*).
Basket Stars	BSK	Basket star (*Gorgonocephalus* sp.).
Feather Stars	FST	Feather star (*Florometra serratissima*).
Sand Dollars	SDD	Sand dollar (*Dendraster excentricus*).
Sea Urchins	RSU	Red sea urchin (*Strongylocentrotus franciscanus*).
	GSU	Green sea urchin (*Strongylocentrotus droebachiensis*).
	WSU	White sea urchin (*Strongylocentrotus pallidus*).
	PSU	Purple sea urchin (*Strongylocentrotus purpuratus*).
Sea Cucumbers	RCU	Rea sea cucumber (*Cucumaria miniata*).
	WCU	White sea cucumber (*Psolus squamatus*).
	PAR	California sea cucumber (*Parastichopus californicus*).
	ASC	Aggregating sea cucumber (*Pseudocnus* sp.).
Tunicates	TUN	Unidentified tunicate.
	CIO	Tunicate (*Ciona* sp.).
	PEA	Pacific sea peach (*Halocynthia aurantium*)
In fauna "holes"	HLM	Mounded worm, clam or crustacean hole, but species or species group cannot be distinguished.
	HLF	Unmounded (flat) worm or clam hole, but species or species group cannot be distinguished.

Species or Species Complex	**Code**	**Description**
Fish	FSH	Unidentified fish.
	SAL	Unidentified salmonid.
	ELP	Unidentified eelpout (Zoarcidae).
	POA	Unidentified poacher.
	PSP	Pacific snake prickleback (*Lumpenus sagitta*)
	TUS	Tubesnout (*Aulorhynchus flavidus*).
	GBE	Black-eyed goby (*Coryphoterus nicholsi*).
	PLP	Pile perch (*Rhacochilus vacca*).
	PST	Striped perch (*Embiotica lateralis*).
	SHP	Shiner perch (*Cymatogaster aggregata*).
	FTF	Unidentified flatfish.
	STF	Starry flounder (*Platichthys stellatus*).
	RKS	Rock sole (*Lepidopsetta bilineata*)
	RFS	Unidentified rockfish.
	BRF	Black rockfish (*Sebastes melanops*).
	NRK	China rockfish (*Sebastes nebulosus*).
	CRK	Copper rockfish (*Sebastes caurinus*).
	QRF	Quillback rockfish (*Sebastes maliger*).
	TRF	Tiger rockfish (*Sebastes nigrocinctus*).
	YRF	Yelloweye rockfish (*Sebastes ruberrimus*).
	GLG	Unidentified greenling (Hexagrammid).
	KGR	Kelp greenling (*Hexagrammos decagrammus*).
	LNG	Lingcod (*Ophiodon elongatus*).
	SCU	Unidentified sculpin (Cottidae).
	NRN	Northern ronquil (*Ronquilus jordani*).
	RAT	Ratfish (*Hydrolagus colliei*).
	BSK	Big skate (*Raja binoculata*)
	LSK	Longnose skate (*Raja rhina*)
Unknown	UNK	Macro fauna visible but cannot be identified.
No Fauna	**NOF**	No fauna observed.

Table 9. Faunal distribution classes.

Code	Descriptor	Distribution
1	Few	Rare (single) or a few sporadic individuals.
2	Patchy	A single patch, several individuals or a few patches.
3	Uniform	Continuous uniform occurrence.
4	Continuous	Continuous occurrence with a few gaps.
5	Dense	Continuous dense occurrence.
6		Code specific for school of fish.

7 Disclaimer

The findings presented in this report are based upon data collected during the days April16th and April 17th, 2011 using the methodology described in the Survey Methodology section of this report. Ocean Ecology has exercised reasonable skill, care, and diligence to collect and interpret the data, but makes no guarantees or warranties as to the accuracy or completeness of this data.

This report has been prepared solely for the use of the Stantec, pursuant to the agreement between Ocean Ecology and Stantec. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Ocean Ecology accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

Any questions concerning the information or its interpretation should be directed to the undersigned.

Prepared By:	Reviewed By:
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APPENDIX E

Ocean Ecology Benthic Drop Camera Video Survey of Site B

Drop Camera Video Survey of Site 2 for the Canpotex Potash Terminal Project Disposal at Sea Application

August 1, 2011

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Drop Camera Video Survey of Site 2 for the Canpotex Potash Terminal Project Disposal at Sea Application

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Executive Summary

A DGPS-positioned, drop video camera system was used to collect imagery of the seabed. The survey design consisted of 35 drops with an approximate spacing of 200 m between drops. Surveys were carried out in waters up to approximately 177 m depth.

A data record of substrate and biota classes was produced for each second of video imagery using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO).

All classification data was entered into a relational database. Maps of observed species distribution and estimated species ranges were produced using ArcGIS. A library of linked and searchable video annotations was produced.

The following substrate and biota features were observed:

1. Coverage for the site was excellent, with 36 successful drops.
2. Based on the drop camera observations, the site substrate was homogenously silt-mud with trace amounts of shell.
3. Significant currents were observed along the sea floor at the majority of the camera drops. Fine-grained sediments and plankton were often in continuous motion across the camera's field of view. Based on the movement of particles across the camera's field of view, it was estimated that at some drops the velocity of the bottom current was as high as 1.5 m/s (5.4 km/h or 2.9 knots). Examination of the local topography around Site 2 showed that there is a well-defined trough leading from outside the Rachael Islands to the mouth of Inverness Passage. This trough probably forms a conduit for deep water movement from offshore to replenish losses due to estuarine entrainment, and also acts as a funnel, thus increasing the velocity of bottom currents along the route. Site 2 is located directly along this potential path of deep water flow, and this is most likely the explanation for the strong currents observed by the drop camera survey.
4. Due to the depth of the site, no flora was observed.
5. The most dominant fauna in terms of number of observations were krill. The most dominant fauna in terms of area were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp.
6. Krill were more abundant at the northwest end of the site than at the southeast end of the site, and formed very dense aggregations just to the south of the central deep region of the site. Krill are an important prey item for north Pacific Humpback whales. During the period November 15th to November 28th, 2010, Ocean Ecology observed a large number of humpback whales feeding in the area around both Site 1 and Site 2. The presence of humpback whales in this area is not an uncommon phenomenon. Local whale watching tours often take clients out to this region to view feeding humpback whales. Ford *et al.* (2009) have photo-identifications of whales in the vicinity of Site 2 from data collected during 1984-2007. It seems likely that the dense krill population at Site 2 may make this region a good feeding area for humpback whales. The humpback whale (Pacific population) was designated Threatened in Schedule 1 of SARA; however, in May 2011, this status was downgraded to a designation of Special Concern by COSEWIC.

7. Spot prawns were located in a region near the northwest end of the site. While relatively few spot prawns were seen using the drop camera, this was not unexpected, as spot prawns are highly mobile and will rapidly leave an area when startled. The camera will only record those prawns which do not become started when the lander impacts the sea floor. Thus, it is likely that the population of spot prawns was much higher than recorded by the drop camera. The only commercial species observed at the site was spot prawns. Statistical data can be obtained from DFO regarding the aggregated prawn catch and effort for the years 2001 to 2004 in the region around Site 2. The DFO data show that Site 2 is located in an area with the highest prawn catch and effort data values north of Banks Island.
8. Sea whips were only found at the northwest end of the site. However, from the camera footage, it was clear that there was a large field of sea whips in the region of drop 2-1. Thus, it is possible that sea whips may have a fairly extensive areal coverage at this end of the site.
9. The overall Shannon's diversity index for the site was 1.979, and the species richness was 10. Due to differences in methodology, these diversity indices are not comparable with those produced by analysis of data from the towed benthic video camera survey.
10. Maximum species richness for the site occurred towards the northwest end of the site, and in the deeper regions of the site. Most likely these are the areas where the current flow is strongest and plankton abundance is greatest.
11. The greatest overall organism abundance occurred near the center of the site, just to the south of the central deep region.

1 Introduction

Canpotex and the Prince Rupert Port Authority (PRPA) are proposing to dispose of ~724,000 m^3 of dredgate at one or two new disposal sites within the PRPA harbour boundaries. Baseline information is required for the environmental assessment (EA) of this project, and by Environment Canada as part of the permit application process for disposal at a new site.

As a part of the baseline study for the project, a drop camera video survey was carried out at the larger and deeper of the two proposed disposal sites, referred to as Site 2 (see Figure 1).

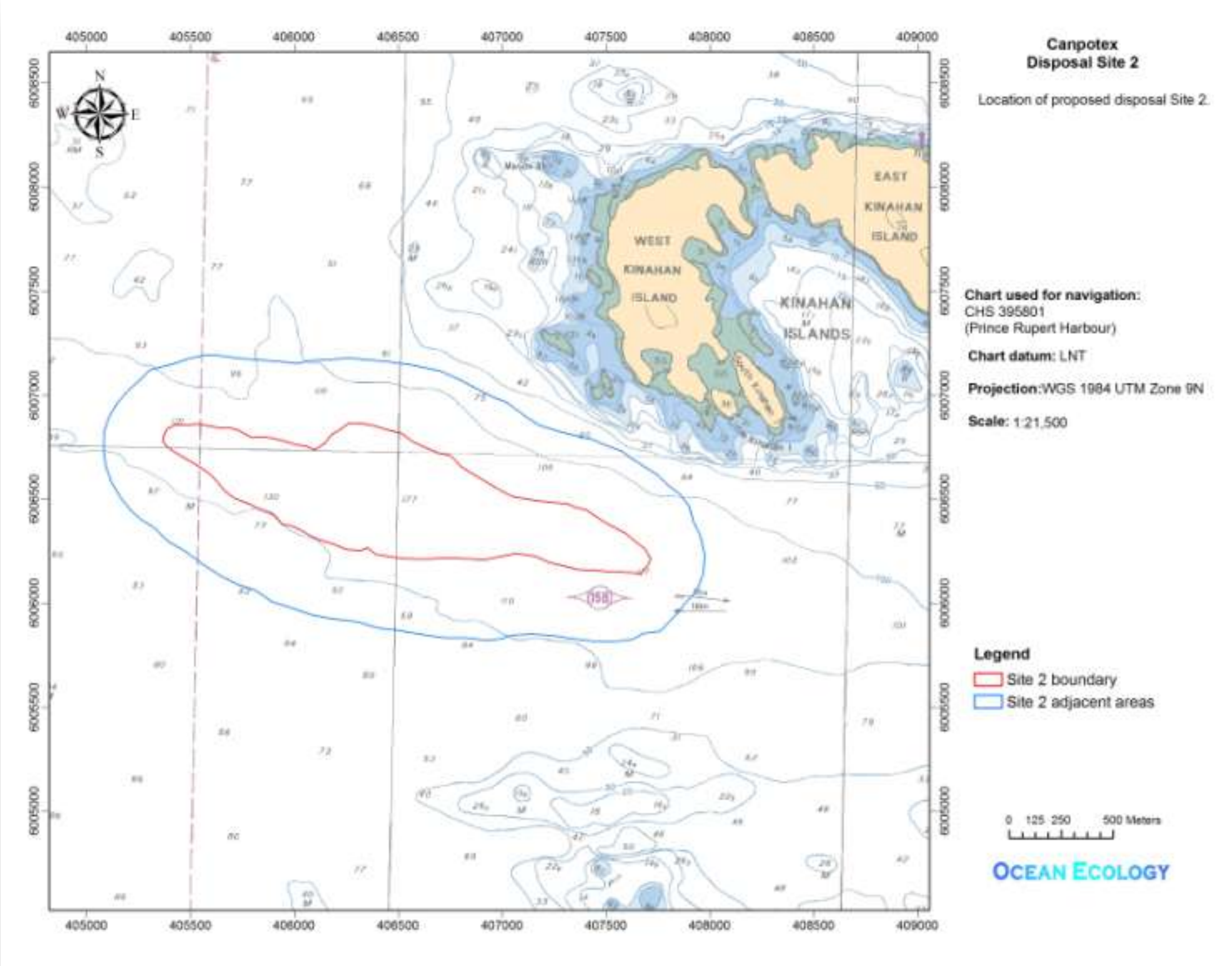


Figure 1. Location of proposed disposal Site 2.

2 Canpotex Disposal Site 2 Survey Methodology

2.1 Drop Camera Video Survey

2.1.1 Drop Camera System

A DGPS-positioned, drop video camera system was used to collect imagery of the seabed. This system was a custom-built model (e.g., not commercially available) designed specifically for taking video footage of the seafloor in deep water environments of up to 600 m depth (see Figure 2). The drop video camera system consisted of a single video camera with a downward-looking orientation in a water tight housing mounted in a “lander” frame. The lander frame was designed to hold the camera at a specific elevation above the sea floor with a known field of view, and to minimize movement of the camera system so that blurring of the video was reduced. The lander frame had a 0.25 m^2 base footprint, which matches the standard quadrat size used by many shore survey protocols. The height of the camera was adjusted in the frame such that the field of view of the camera matched the lander footprint, and was thus also 0.25 m^2. The camera had a Sony 1/3" super HAD color CCD with 480 lines horizontal resolution (768 x 494 pixels) and 0.003 lux low light performance. High intensity white LEDs were mounted on the camera to provide additional illumination.

The drop camera system was lowered from the vessel’s A-frame using a hydraulic winch until it contacted the sea floor. Depending on the drift speed of the vessel, the drop camera was left in position for approximately 2 to 5 minutes, after which time it was brought back to the surface. The DGPS position of the drop was logged using ArcMap.

The camera was deployed for periods of 3 hours, after which time the system’s onboard batteries required recharging. During the recharging period, acquired video footage was checked for quality and success of the video drops.

Figure 2. Drop video camera system about to be deployed.

2.1.2 Video Recording System

The analog camera signal was recorded using an onboard digital video recorder (DVR) directly onto an SD card. The DVR placed a date and time stamp on the video during the recording process. After the survey was completed, the raw video data was copied onto DVDs.

2.1.3 Survey Design

The drop video survey of Site 2 was carried out on July 6th and 7th, 2011. The survey design consisted of 35 drops with an approximate spacing of 200 m between drops (see Figure 3). Surveys were carried out in waters up to approximately 177 m depth.

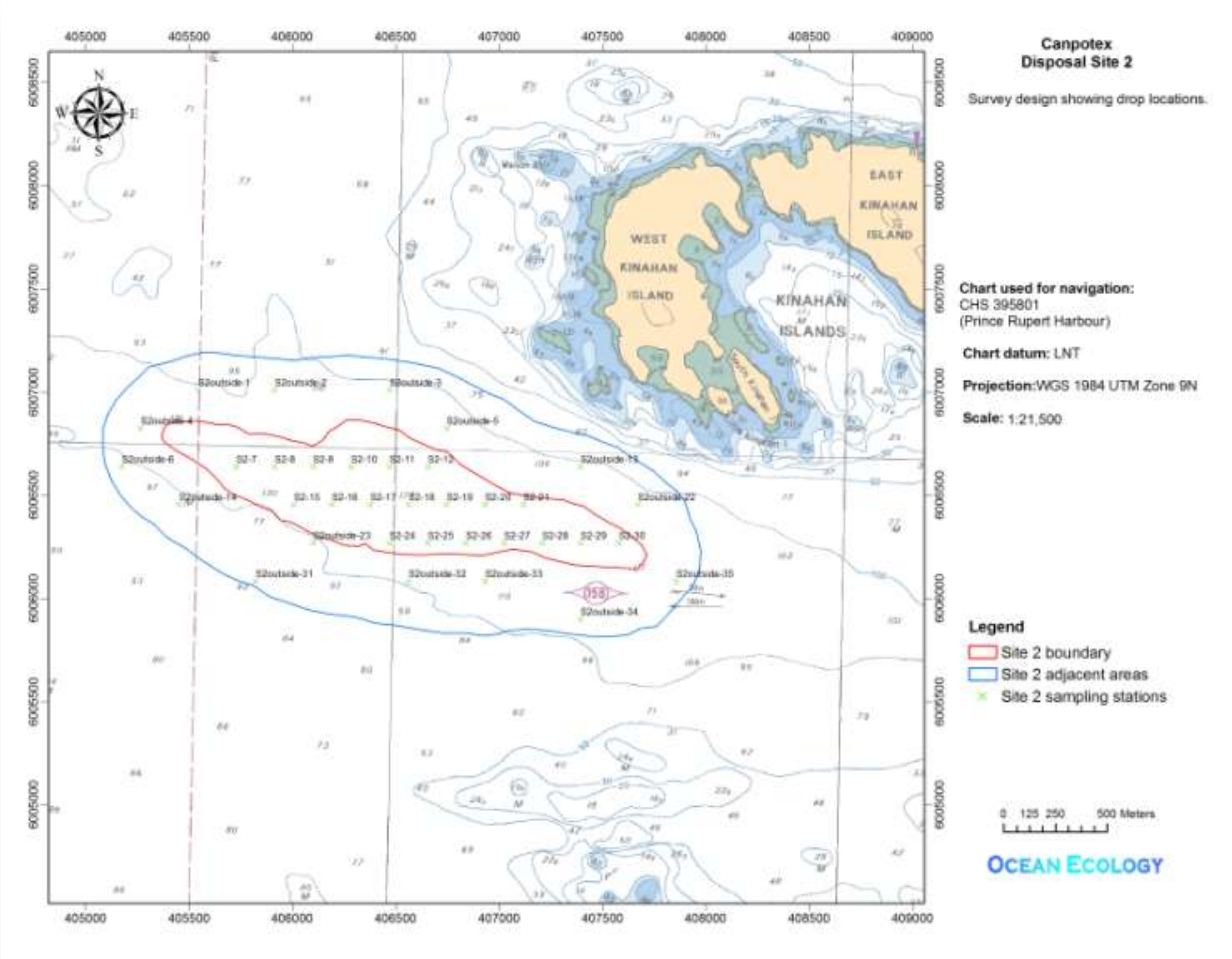


Figure 3. Survey design showing drop locatons.

2.2 Classification and Mapping

2.2.1 Database of Species and Substrate Classifications

Raw video of the drops was reviewed and classified using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO). A data record of substrate and biota classes was produced for each second of video imagery.

The geology database contains information on substrate type (Table 3 in the Appendix) and percentage substrate cover (Table 5 in the Appendix). Anthropogenic features were mapped as part of the geological inventory.

The biological database captured detail on seabed biota within two general categories, vegetation (Table 6 in the Appendix) and fauna (Table 8 in the Appendix). Up to three faunal and floral types were evaluated for each second of video and given distribution codes. Vegetation coverage classes (Table 7 in the Appendix) and faunal distribution classes (Table 9 in the Appendix) were also recorded. Note that very small species (e.g., barnacles, small tube worms, small algal species, plankton), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) were often not identified in the video footage, and were therefore not included in the database.

Video annotation created a linked, random-access database of all the video data which can be readily searched using keywords from the classification scheme. Additionally, the provided “Transect Player” software links video and GPS data, allowing simultaneous viewing of the camera’s geographical position on a map and the video images captured by the camera at that location.

All classification data was also entered into a relational Access database, which was then used to generate the data for mapping. This database contains a “Filter by Video” function which allows the user to browse through the data for each transect as a series of data recording forms.

2.2.2 ArcGIS Mapping

Maps of observed species distribution and estimated species ranges were produced using ArcGIS. These maps have been provided as an ArcGIS project which can be viewed using the supplied ArcReader.

2.2.3 Range Maps

Range maps for fauna were generated using the fixed kernel density estimation procedure. Fauna observations were weighted by distribution (see Table 9 in the Appendix). In order to allow overlap of polygons between drops, the search radius (a.k.a. the smoothing factor) was set to the distance between drops (e.g., 200 m). For each organism, a 50% and a 90% volume contour were generated. These consisted of polygons covering a geographical area in which either 50% or 90% of the estimated population was expected to be found. A density map showing the locations where the greatest population density occurred was also generated for each organism.

2.2.4 Diversity Analysis Using Range Maps

Calculations of Shannon's diversity index, Shannon's evenness, and Simpson's dominance index were carried out in ArcMap using the range map polygons. Note that the diversity values generated from the range map data should be considered minimum values for the site, as very small species (e.g., barnacles, small tube worms, plankton), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) are often not identified in the video footage, and are therefore may not included in the diversity calculations.

2.2.5 Species Richness Map

A hexagonal grid (composed of hexagonal polygons with widths of 50 m) was overlaid on a shape file containing the fauna range map polygons. Using polygon in polygon analysis, each hexagonal polygon was assigned a number equal to the number of range map polygons with which it overlapped. This assigned number was equal to the species richness in a given hexagonal polygon, since each range map polygon represented a different species. The coded hexagonal polygons were used to generate a species richness map.

2.2.6 Overall Organism Abundance Map

The population density map for each organism was cropped to the adjacent areas boundary of Site 2, and then normalized to the maximum fauna distribution code recorded for that organism. All the organism density maps were then summed together to form a single raster which represented the overall organism abundance observed at the site.

3 Canpotex Disposal Site 2 Survey Results

3.1 Benthic Video Survey

The camera drops for the survey as carried out are shown in Figure 4. Coverage for the site was excellent, with 36 successful drops. Other factors which had an effect on the survey quality and resolution were:

1. ***Turbid water*** – the site is affected by the plume of the Skeena River, resulting in relatively high turbidity. As a result, the visibility at the site seldom exceeded 1 m. High intensity LEDs were used to provide light during the video drops; however back-scattering of light from the silt particles and plankton often created a “halo effect”, causing additional visibility issues. This reduced the resolution of the video camera, producing a grainy image quality. In spite of these problems, the image quality was deemed sufficient for organism identification.
2. ***Strong currents*** – strong currents increased vessel drift speed during the camera drops, often resulting in reduced camera bottom time.
3. ***Fine-grained benthic sediments*** - very fine-grained benthic sediments were easily suspended by the impact of the lander frame on the sea floor. These sediments often took some time to settle and created drifting clouds of sediment which frequently obscured the camera’s view of the sea floor.
4. ***Limited battery time*** - unlike Ocean Ecology’s towed benthic video system, the camera, light ring, and DVR recorder of the drop camera system were not powered remotely using a POC (power over coaxial) system; rather they were powered by self-contained batteries. This limited the deployment time of the camera to approximately 3 hours.
5. ***Lack of real-time visualization*** - there was no real-time camera feed to the vessel’s bridge from the drop camera. Thus, all drops were made “blind”, and the effectiveness of the drops could only be determined after the camera had been retrieved and the data was viewed on a computer.
6. ***Limited amount of sea floor visualized*** - 36 camera drops, each with a footprint of 0.25 m^2, visualized approximately a total of 9 m^2 of the sea floor. By comparison, the towed video survey at Site 1 had 7.9 km of transects. Given an average field of view width of 0.5 m, this amounted to approximately 3,950 m^2 of sea floor visualized. Clearly, while the drop camera had the structural capacity to reach and visualize the deep sea floor, this ability came at the cost of reduced sea floor coverage.
7. ***Limited ability to visualize mobile organisms*** - mobile organisms tend to swim away from the drop camera as it is lowered. Once it has reached the sea floor, the camera’s limited field of view means that is unlikely to capture images of mobile organisms as they swim by. A longer soak time may have allowed curious organisms to approach the lander; however this was not possible in the strong currents at Site 2.
8. ***Attraction of plankton by the camera’s lights*** - the low-level blue-shifted LED lighting used by the camera does not tend to attract organisms over large distances. However, some attraction of plankton, particularly krill, did occur over short distances. Since these organisms are not strong swimmers, and since the camera had a very short soak time, it can be assumed that these organisms only traveled a small distance (e.g., a few meters) to reach the camera. Thus, the plankton attracted to the camera was probably a reasonable representation of the plankton at the drop location.

One DVD was generated containing both (1) raw video data generated from the survey; and (2) processed and annotated video data and viewers to visualize the data.

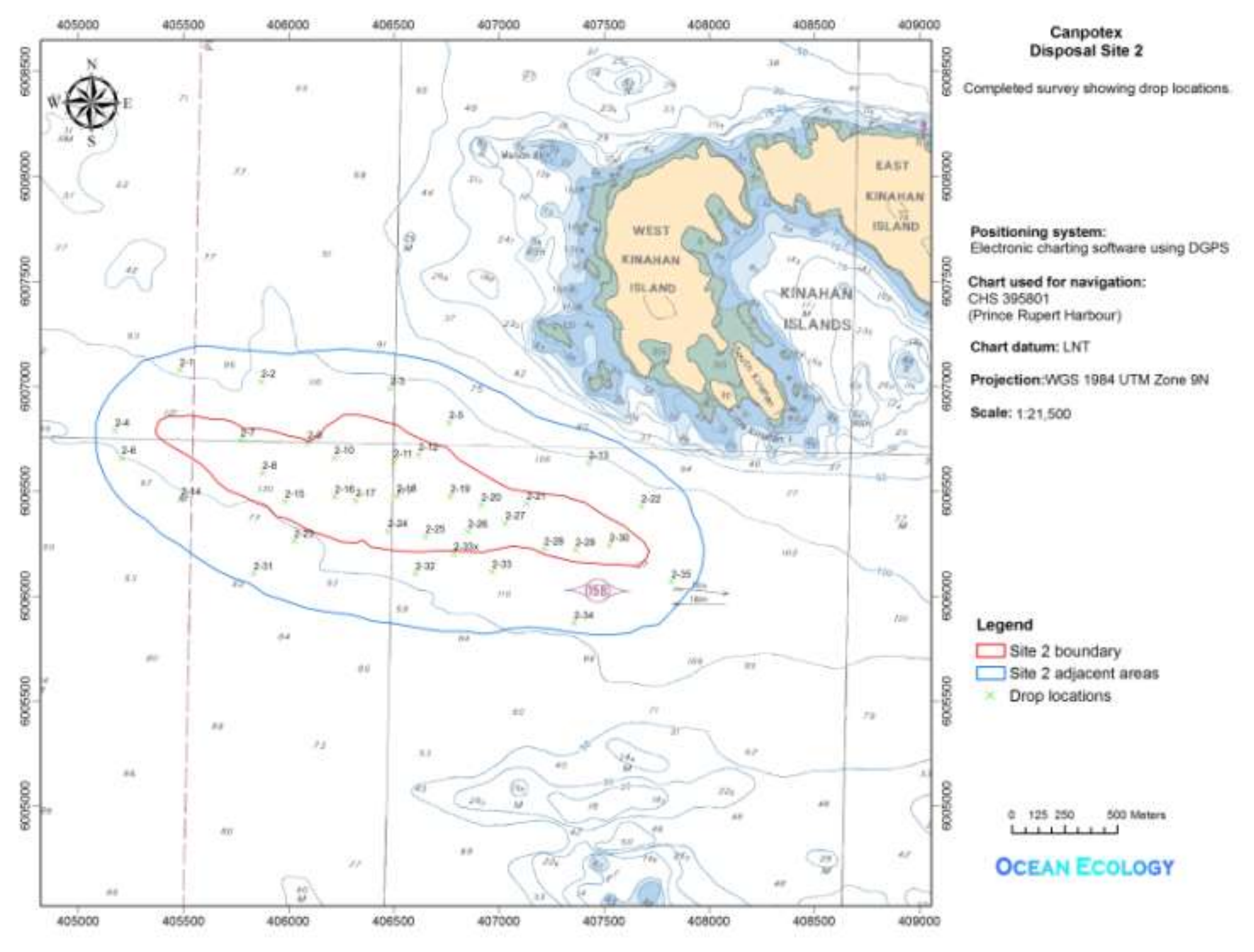


Figure 4. Completed survey showing drop locations.

3.2 Substrate

Based on the drop camera observations, the site substrate was homogenously silt-mud. Trace amounts of shell were observed at all but three of the drops (drops 2-13, 2-28, and 2-34 did not have any appreciable amounts of shell).

In the deepest region of Site 2, a small amount of drift kelp was seen. Figure 5 shows the locations of the 50 m diameter polygons in which drift kelp was observed from the drop camera survey. This kelp has been carried by currents from shallower nearshore regions and deposited in the depths of Site 2.

Significant currents were observed along the sea floor at the majority of the camera drops. Fine-grained sediments and plankton were often in continuous motion across the camera's field of view. Figure 6, which shows a sea whip bending in the currents at drop 2-9, gives a visual sense of the strength of the bottom currents. Based on the movement of particles across the camera's field of view, it was estimated that at some drops the velocity of the bottom current was as high as 1.5 m/s (5.4 km/h or 2.9 knots). The following description of current patterns in Chatham Sound explains how these deep water flows are generated.

Chatham Sound is influenced by fresh water from two large rivers, the Skeena and the Nass. The Nass River discharges into Portland Inlet, and fresh water flows from there into the northern end of Chatham Sound and eventually out through Dixon Entrance (Tera Planning Ltd., 1993). Water from the Skeena River enters Chatham Sound through a series of channels. Approximately 75% of the Skeena River flows equally through Marcus Passage (separating Smith and DeHorsey Islands from Kennedy Island) and Telegraph Passage, while the remaining 25% of the Skeena River flows through Inverness Passage (Trites, 1956).

As a result of the fresh water discharges of the Nass and Skeena Rivers, the whole of Chatham Sound is essentially a large estuary (Tera Planning Ltd., 1993). Figure 7 shows the regions in Chatham Sound affected by freshwater outflows from the Skeena and Nass Rivers. Generally, estuarine circulation occurs when a large volume of fresh water from a river flows out along the surface at the head of an inlet. As it moves seaward, this layer entrains saline water from the layer beneath it, and carries this entrained water seaward. The loss of water from the lower layer is replenished by a deep water flow which has a net landward movement (see Figure 8). However, as a result of the fresh water influx from two rivers, a highly irregular coastline, and a large horizontal extent, the circulation patterns in Chatham Sound are considerably more complex than most coastal BC inlets (Tera Planning Ltd., 1993).

Highest freshwater discharge (freshet) for the Skeena and Nass Rivers normally occurs from May through to June (Tera Planning Ltd., 1993). Although present throughout the year, estuarine circulation and the currents produced by this circulation are most pronounced during freshet. At this time of year, the amount of freshwater present in Chatham Sound can be 3 to 4 times the mean value (Cameron, 1948). During normal (non-freshet) river discharge conditions, approximately 70% of the Skeena River water moves northward past Tugwell Island, along the Tsimpsean Peninsula to merge with Nass River water (Trites, 1956). This water then exits Chatham Sound through Dundas Passage, with a smaller amount exiting through Hudson Bay Passage. Only a small proportion (30%) of the Skeena River discharge reaches Dixon Entrance and Hecate Strait through central and southern passages. This northward diversion of the Skeena River is due, in part, to the Coriolis effect, which diverts water to the right of the direction of flow in the northern hemisphere. Nass River water tends to be concentrated along the north shore of Chatham Sound, moving past Wales Island north of Dundas Island into Dixon Entrance. During freshet, fresh water flows through all the passages and channels exiting Chatham Sound is increased. Nass River water during freshet is thought to extend as far south as Melville Island, where it may interfere with the northern movement of Skeena River water past Dundas Island (Tera Planning Ltd., 1993; see Figure 9).

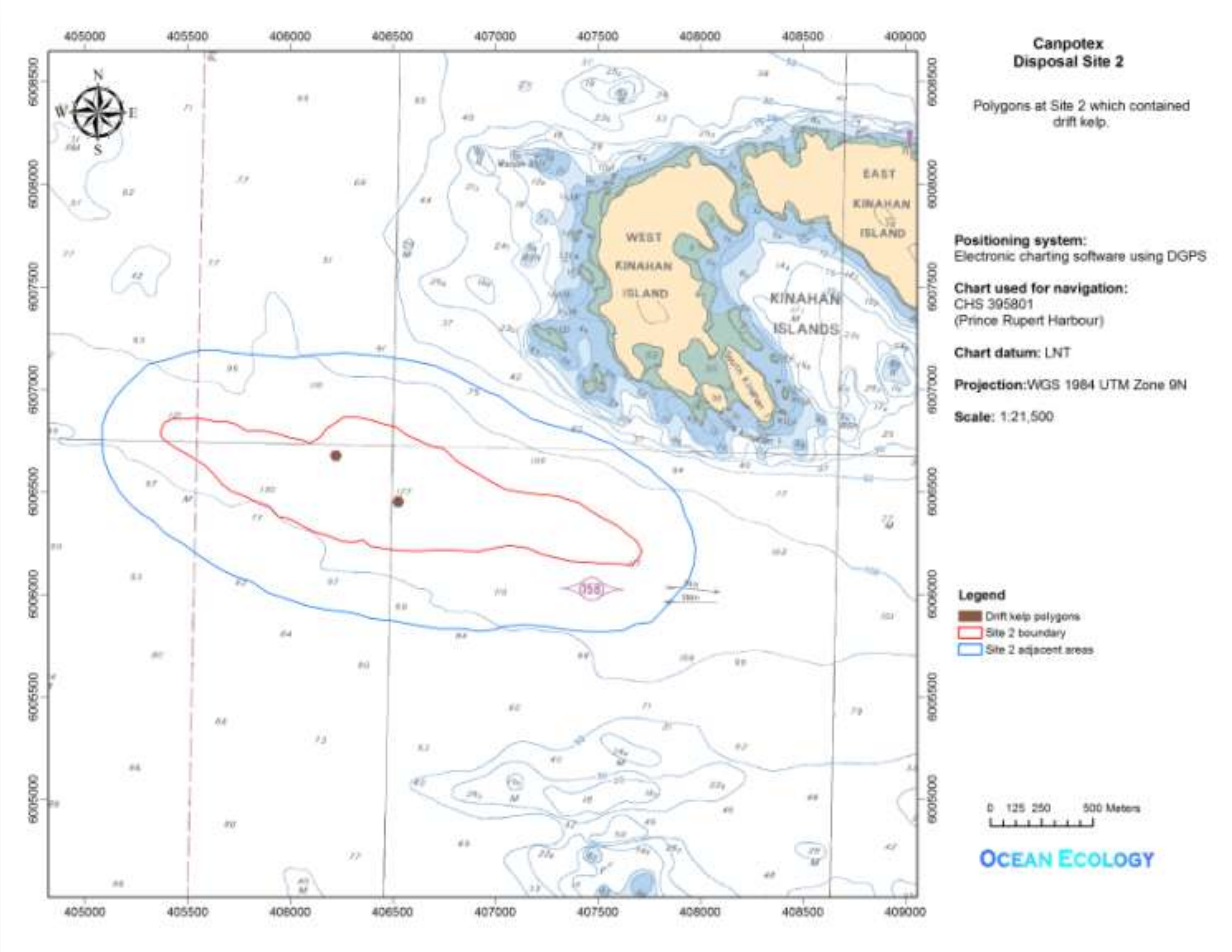
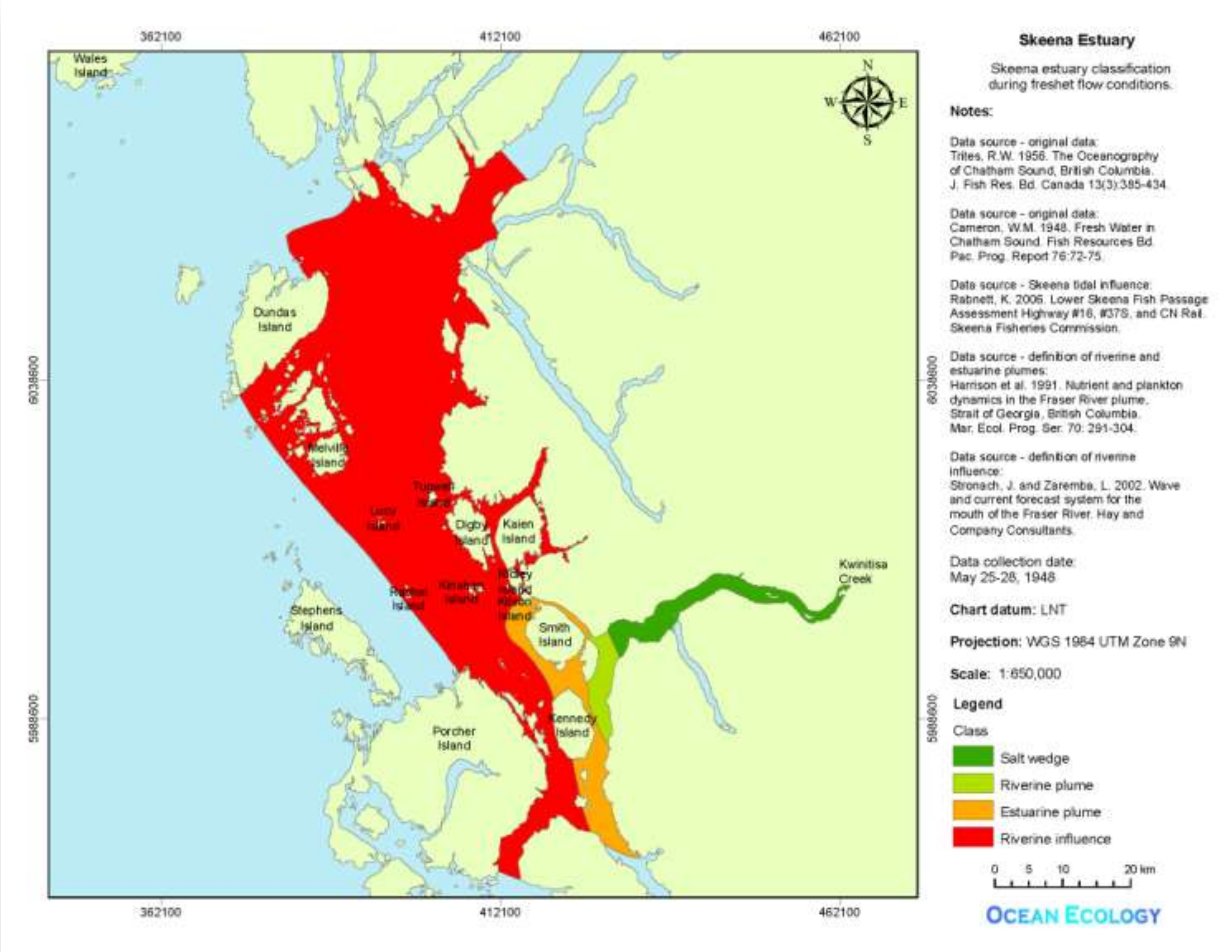


Figure 5. Polygons at Site 2 which contained drift kelp.

Figure 6. Sea whip bent over in strong currents at drop 2-9.

Based on the description of riverine inputs to Chatham Sound given above, it can be seen that the general pattern of surface flow in the sound around the area of Site 2 is a seaward flow in a more or less northwest direction. Thus, the corresponding landward deep water flow should occur in a general southeast direction. This deep water flow will be channeled and directed by local sea floor bathymetry, and will tend to be strongest in submarine canyons and troughs which have a northwest-southeast orientation.



Skeena Estuary

Skeena estuary classification during freshet flow conditions.

Notes:

Data source - original data:
Trites, R.W. 1956. The Oceanography of Chatham Sound, British Columbia. J. Fish Res. Bd. Canada 13(3):385-434.

Data source - original data:
Cameron, W.M. 1948. Fresh Water in Chatham Sound. Fish Resources Bd. Pac. Prog. Report 76:72-75.

Data source - Skeena tidal influence:
Rabnett, K. 2006. Lower Skeena Fish Passage Assessment Highway #16, #37S, and CN Rail. Skeena Fisheries Commission.

Data source - definition of riverine and estuarine plumes:
Harrison et al. 1991. Nutrient and plankton dynamics in the Fraser River plume. Strait of Georgia, British Columbia. Mar. Ecol. Prog. Ser. 70: 291-304.

Data source - definition of riverine influence:
Stronach, J. and Zaremba, L. 2002. Wave and current forecast system for the mouth of the Fraser River. Hay and Company Consultants.

Data collection date:
May 25-28, 1948

Chart datum: LNT

Projection: WGS 1984 UTM Zone 9N

Scale: 1:650,000

Legend

Class

🟩 Salt wedge
🟩 Riverine plume
🟧 Estuarine plume
🟥 Riverine influence

Figure 7. Skeena estuary classification during freshet flow conditions (Faggetter, 2011).

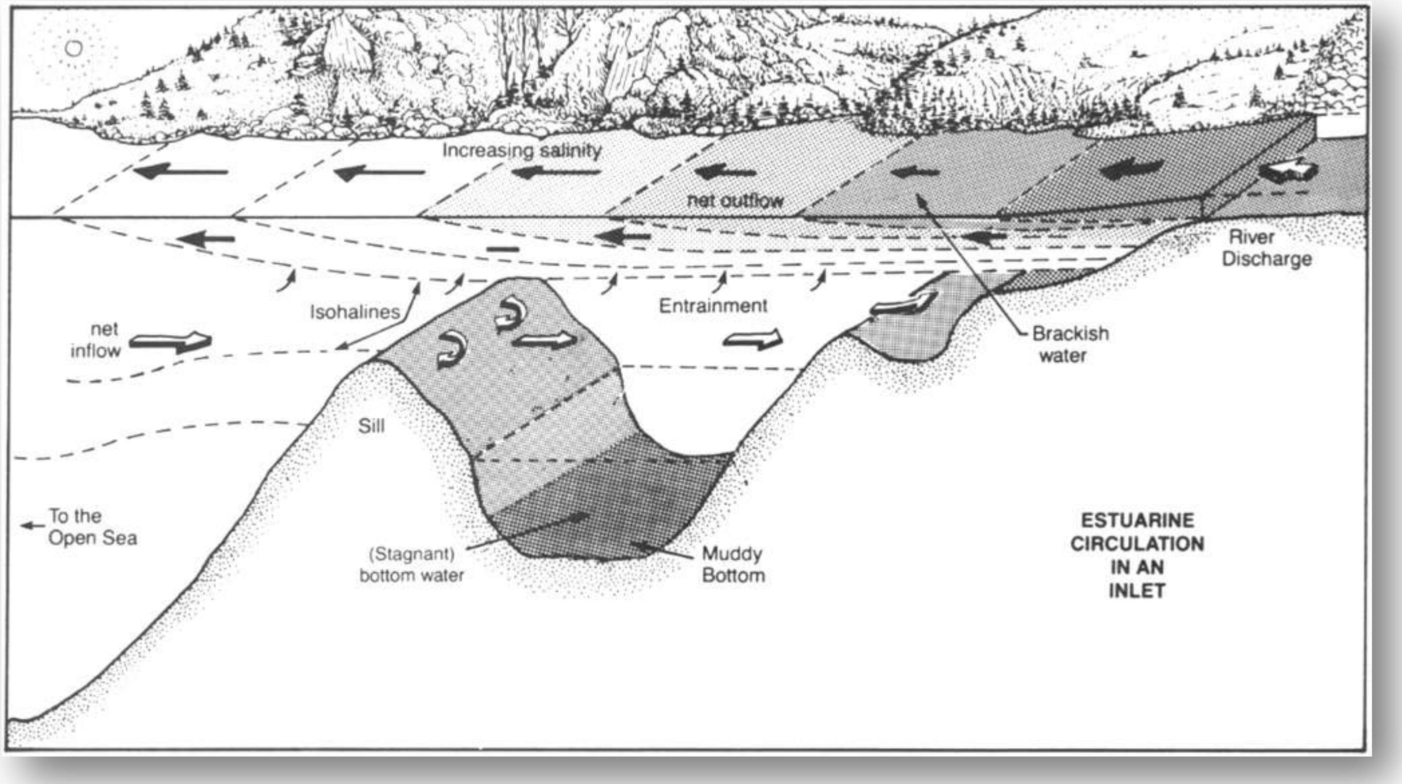


Figure 8. Estuarine circulation in a typical British Columbia inlet (Thomson, 1981).

While no detailed oceanographic models for the area around Site 2 currently exist, several larger domain models have been developed for the Hecate Strait/Chatham Sound region which confirm the general southeastward flow of deeper water in the area. Figure 10 shows the current patterns around Site 2 as predicted by three models

1. A model computed by Ballantyne *et al*. (1996) at a 3 m depth using forcing from tides and baroclinic pressure gradients calculated from a July 5th - August 18th, 1991 cruise.
2. A model computed by Jacques (1997) at a 10 m depth driven by tides, river runoff, and baroclinic pressure gradients calculated from the density field measured over the period June 24th - July 7th, 1991.
3. A model computed by DFO (Levings and Foreman, 2004) for average summer currents at 30 m.

All three models showed a general southeast current flow near Site 2, with current velocity decreasing with depth (note that the DFO model has a different scale for its current arrows than the other two models).

Examination of the local topography around Site 2 shows that there is a well-defined trough leading from outside the Rachael Islands to the mouth of Inverness Passage (see Figure 10). This trough probably forms a conduit for deep water movement from offshore to replenish losses due to estuarine entrainment, and also acts as a funnel, thus increasing the velocity of bottom currents along the route. Site 2 is located directly along this potential path of deep water flow, and this is most likely the explanation for the strong currents observed by the drop camera survey.

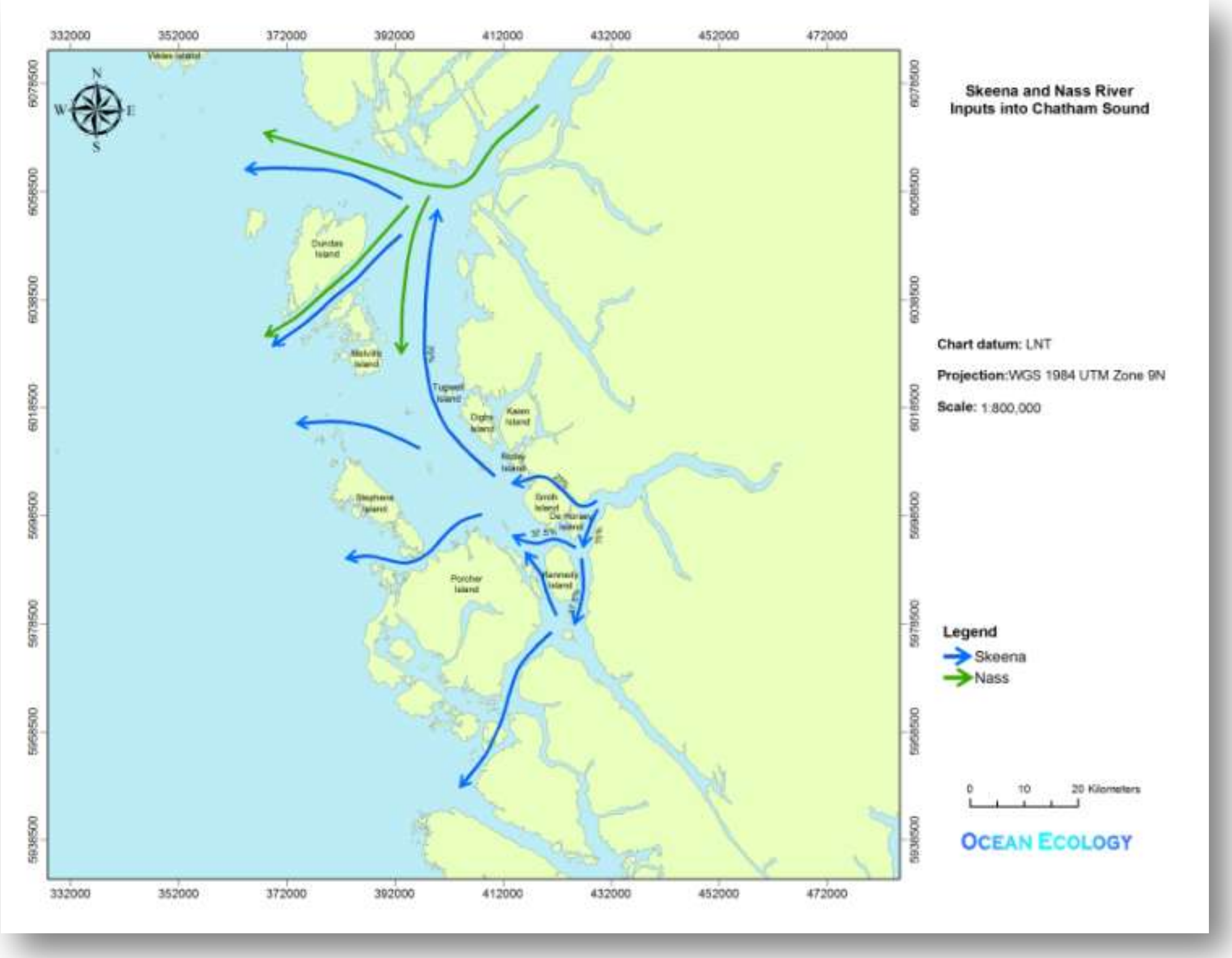


Figure 9. Skeena and Nass River inputs into Chatham Sound.

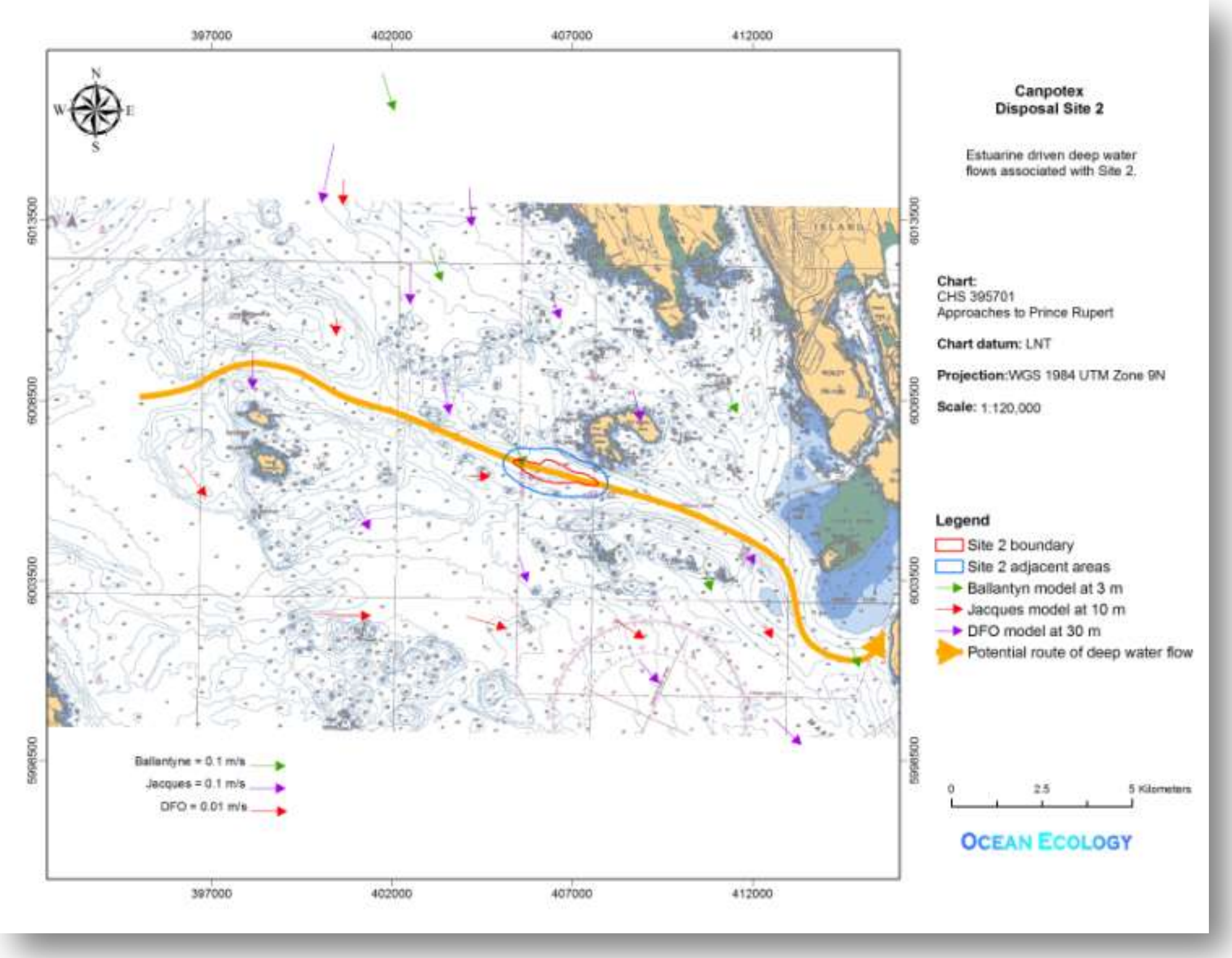


Figure 10. Estuarine driven deep water flows associated with Site 2.

3.1 Flora

Due to the depth of the site, no flora was observed.

3.2 Fauna

Table 1 lists the various groups of fauna identified at the site, and their abundances in terms of both total number of observations and percentage of total fauna abundance by area based on the range maps for each group. Note that since the drop camera is stationary, the value referred to by the term "*Number of Observations*" is calculated using a different formula than that used with the towed benthic video system. When using the towed video system, the Boolean value "*Species X presence*" is assigned either a 1 (present) or a 0 (absent) for each second of video footage. The term "*Number of Observations*" is then calculated as follows:

$$Number\ of\ Observations = \sum_{time=1}^{n} (Species\ X\ presence)$$

where *time* is in seconds. Since the camera is moving relatively rapidly over the sea floor, an organism is seldom in the camera's field of view for more than a second, and the numbers of "duplicate" counts for specific individuals are relatively few. However, the situation is quite different in the case of the drop camera system. Since the camera is not moving relative to the sea floor, if an organism did not move out of the camera's field of view, it would get counted for each second that it was present. As a result, stationary organisms would get counted many times. Thus, if the above formula were used, the value "*Number of Observations*" would be both an indication of the abundance of a particular species as well as how long individuals of that species were present in the camera's field of view. This would cause serious over-representation of sessile or non-moving organisms. For this reason, "*Number of Observations*" for the drop camera system was calculated as follows:

$$Number\ of\ Observations = \sum_{drops=1}^{n} (Species\ X\ presence)(Maximum\ value\ for\ Species\ X\ distribution\ code)$$

where *drops* refers to the number of camera drops, and the *Species X distribution code* is the faunal distribution class (Table 9 in the Appendix) for *Species X*. Thus, "*Number of Observations*" for the drop camera system is the number of drops in which a particular species was seen weighted by the relative abundance of that species in the drops where it occurred. As a result of the use of fauna distribution codes for weighting, it is important to note that "*Number of Observations*" is a relative value, and does not represent the total number of individuals present. For example, a fauna distribution code of 5 when applied to krill does not represent 5 individual krill, but rather a dense aggregation of krill which may contain over 100 individuals.

Table 1. Abundances of various fauna groups.

Fauna identification	Number of Observations	% of Total Fauna Abundance by Area
Krill	68	22.85
Unmounded hole	26	23.71
Chaetognath	22	10.38
Unidentified bivalve	13	15.27
Larvacean	10	11.75
Spot prawn	6	5.49
Sea whip	4	2.76
Unidentified amphipod	4	5.03
Unidentified brittlestar	1	1.38
Unidentified seastar	1	1.38

Some observations regarding fauna at Site 2 are:

1. The most dominant fauna in terms of number of observations were krill. The most dominant fauna in terms of area were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp.
2. The following distribution patterns were observed:
    a. Krill were more abundant at the northwest end of the site than at the southeast end of the site (see Figure 11). Krill formed very dense aggregations just to the south of the central deep region of Site 2 (see Figure 12).

    Krill (euphasiids) are an important prey item for north Pacific Humpback whales (*Megaptera novaeangliae*). Euphausiids were the most common prey reported in BC from stomach contents of humpback whales collected between 1949 and 1965 taken by commercial whalers (Nichol *et al.*, 2010). Of 287 stomachs that contained food remains, 263 (92%) contained only euphausiids, 12 (4%) contained only copepods, and 2 (0.7%) contained only fish. Two species of euphausiids were reported, *Euphausia pacifica* and *Thysanoessa spinifera*.

    During the period November 15th to November 28th, 2010, Ocean Ecology observed a large number of humpback whales feeding in the area around both Site 1 and Site 2. Up to 14 whales were observed simultaneously in three separate feeding groups. The actual number of whales present may have been even greater, as no attempt was made to individually track and identify each whale. The presence of humpback whales in this area is not an uncommon phenomenon. Local whale watching tours often take clients out to this region to view feeding humpback whales. Ford *et al.* (2009) have photo-identifications of whales in the vicinity of Site 2 from data collected during 1984-2007 (see Figure 13). Interestingly, one of these humpback whale siting locations was very close to Site 2 in the trough which may serve as a potential deep water conduit. It seems likely that the dense krill population at Site 2 may make this region a good feeding area for humpback whales.

    In 1985, the humpback whale (Pacific population) was designated Threatened in Schedule 1 of the Species at Risk Act (SARA; Species at Risk Public Registry, 2011). Under SARA it is prohibited to kill, harm, harass, capture or take an individual of this population and also to destroy any part of its critical habitat (DFO, 2009). In May 2011, COSEWIC (Committee on the Status of Endangered Wildlife in Canada) re-examined the status of this population of humpback whales and downgraded the designation to Special Concern (COSEWIC, 2011).

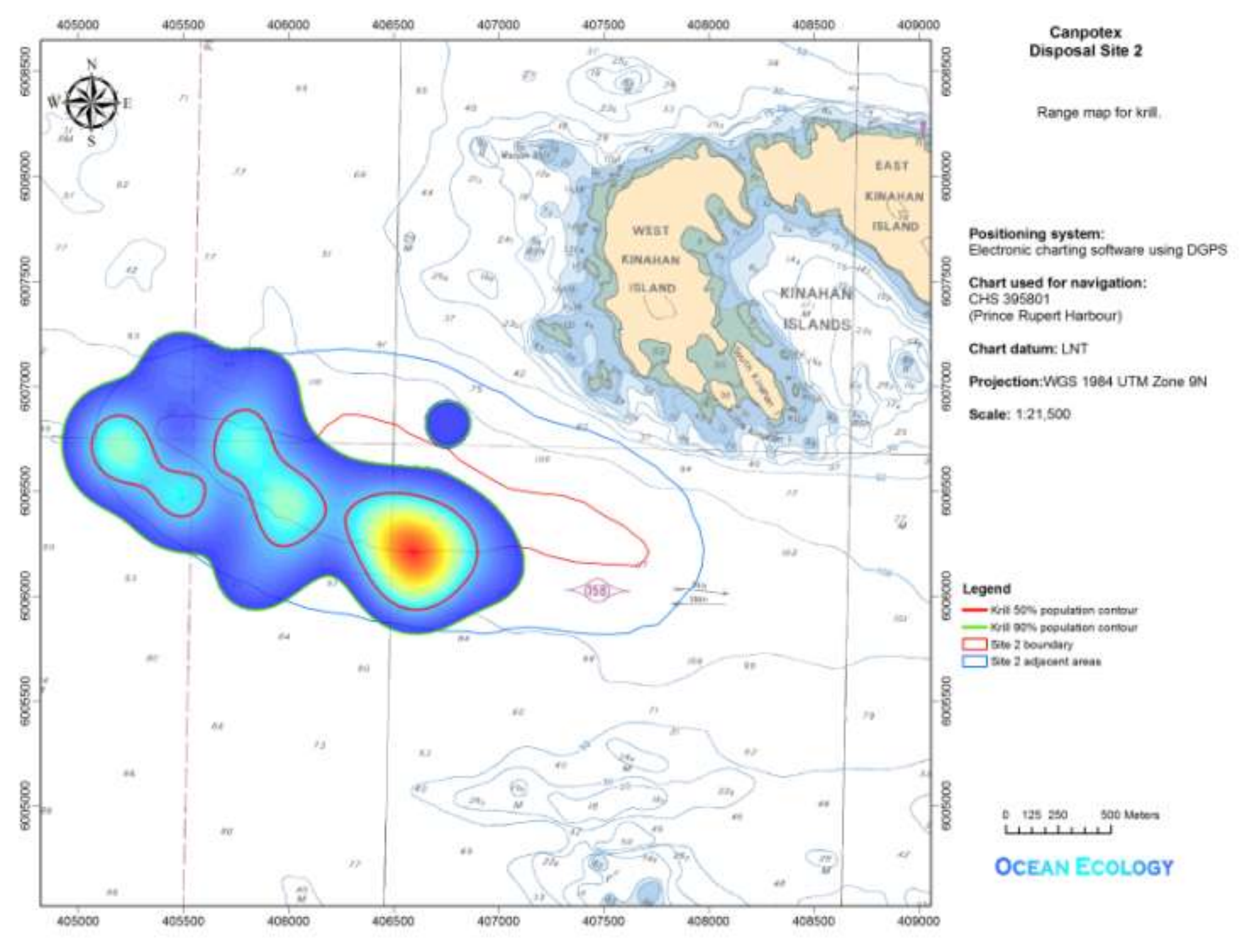


Figure 11. Range map for krill.

Figure 12. Dense aggregations of krill at drop 2-32.

b. Unmounded holes were present throughout most of the site, but were most abundant at the center of the site (see Figure 14). These holes probably represented a variety of infaunal organisms; however most cannot be accurately identified from video images. Based on the previous macroinvertebrate study done at the site during November 21st, 2010, some of the more conspicuous of these unmounded holes may be attributed to polychaete species such as fringed filament-worms (*Dodecaceria concharum*), robust sphaghetti-worms (*Neoamphitrite robusta*), small spaghetti worms (*Polycirrus* sp.), tusk coneworms (*Pectinaria granulate*), bamboo worms (*Praxillella gracilis*, *Euclymene zonalis*), and bristle worms (*Amage anops*, *Amphisamytha bioculata*), or infaunal sea cucumbers, such as the sweet potato sea cucumber (*Molpadia intermedia*).

c. Chaetognaths were very abundant at the site, both in terms of number of observations and areal coverage. Chaetognaths were more abundant at the southeast end of the site than at the northwest end of the site (see Figure 15). The high krill and the chaetognath populations were probably feeding on the abundant plankton observed in the water.

d. Unidentified bivalves were the third most abundant group in terms of areal coverage. They occurred throughout the site, but were most abundant just to the south of the central deep region of Site 2 (see Figure 16). Based on the previous macroinvertebrate study done at the site during November 21st, 2010, some of these bivalves may have been divaricate nutclams (*Acila castrensis*), stout cyclocardias (*Cyclocardia ventricosa*), round diplodons (*Diplodonta orbella*), broad yoldias (*Megayoldia thraciaeformis*), minute nutclams (*Nuculana minuta*), purple dwarf-venuses (*Nutricola tantilla*), butter clams (*Saxidomus gigantea*), Carpenter tellins (*Tellina carpenter*), plain tellins (*Tellina modesta*), or crisscrossed yoldias (*Yoldia scissurata*).

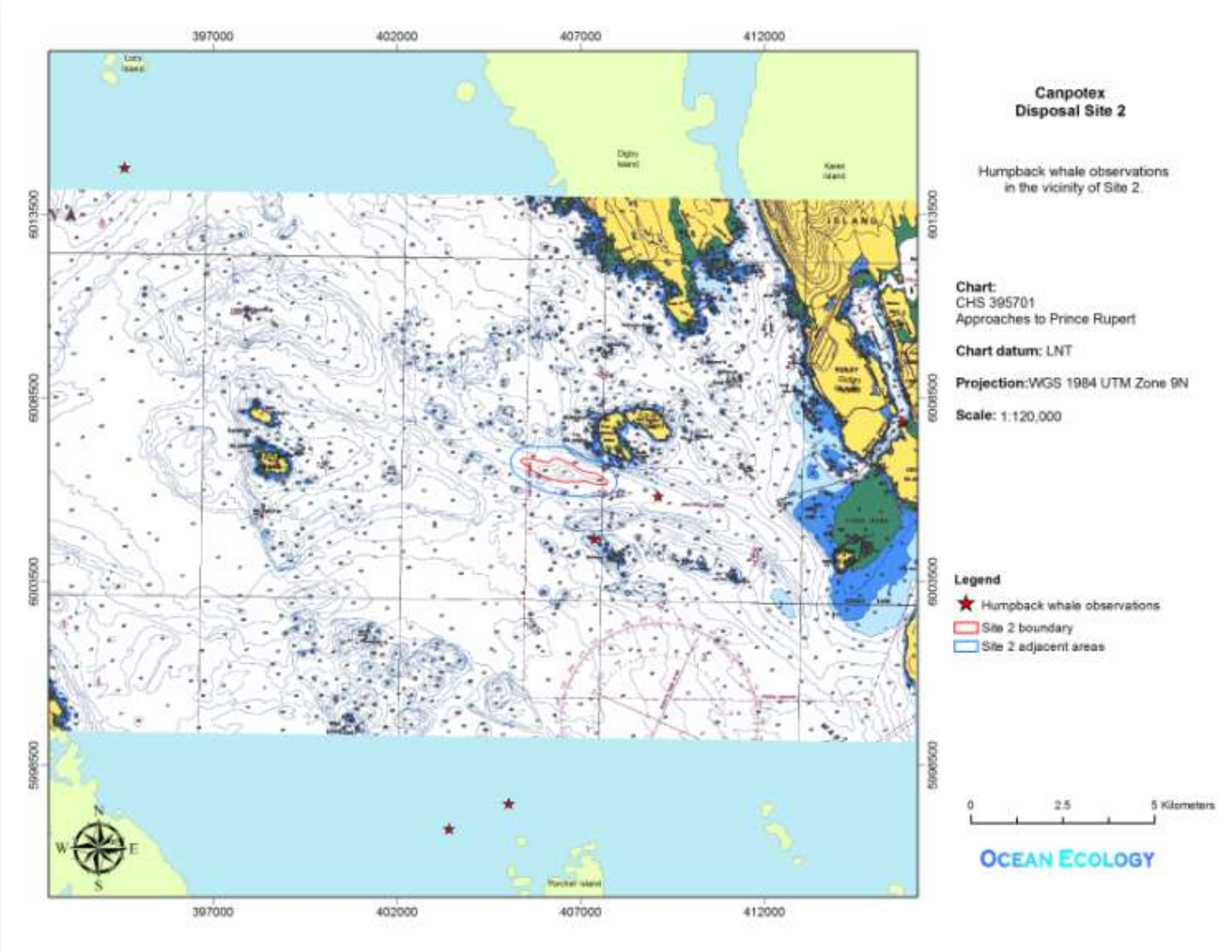


Figure 13. Humpback whale observations in the vicinity of Site 2 (Ford *et al.*, 2009).

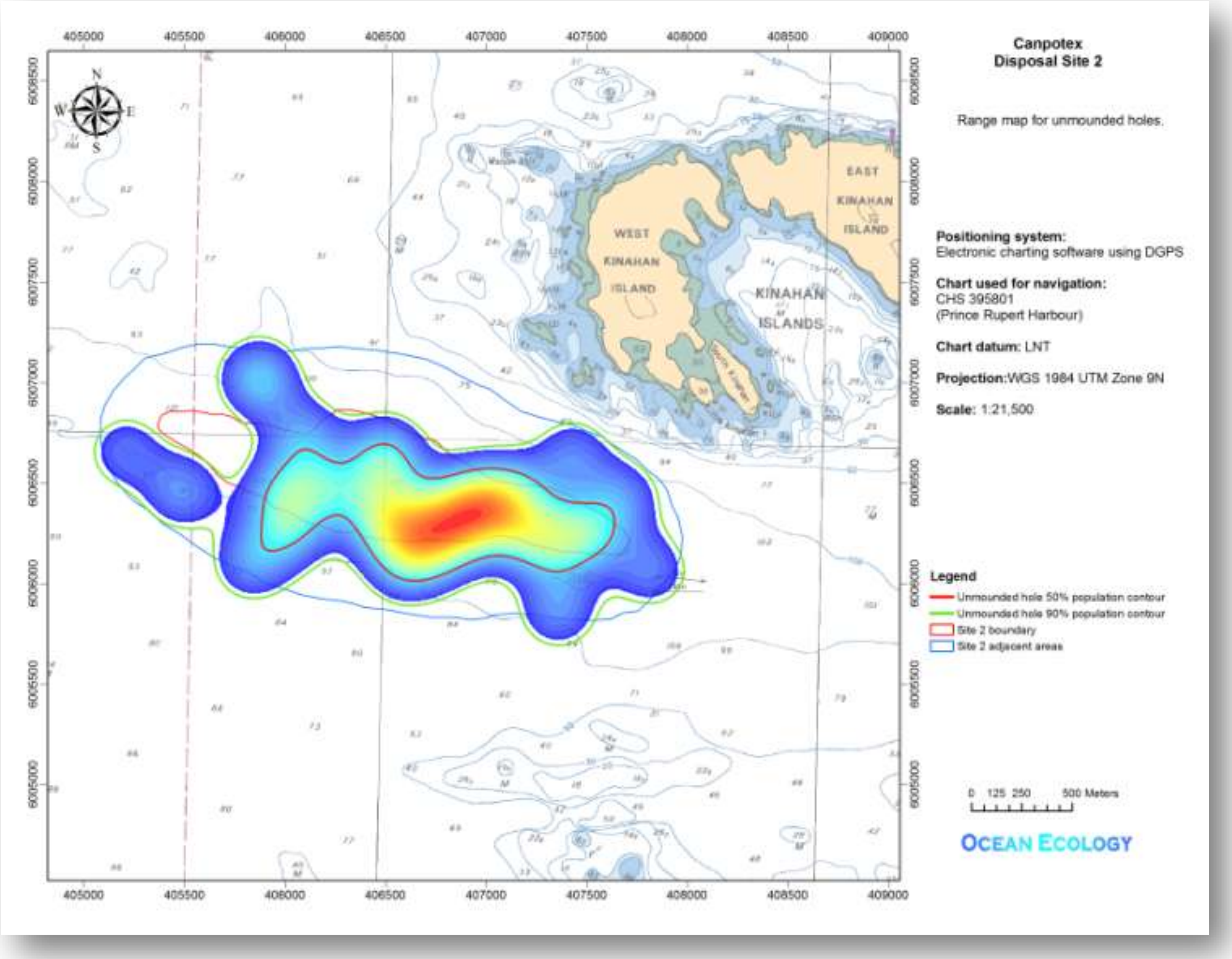
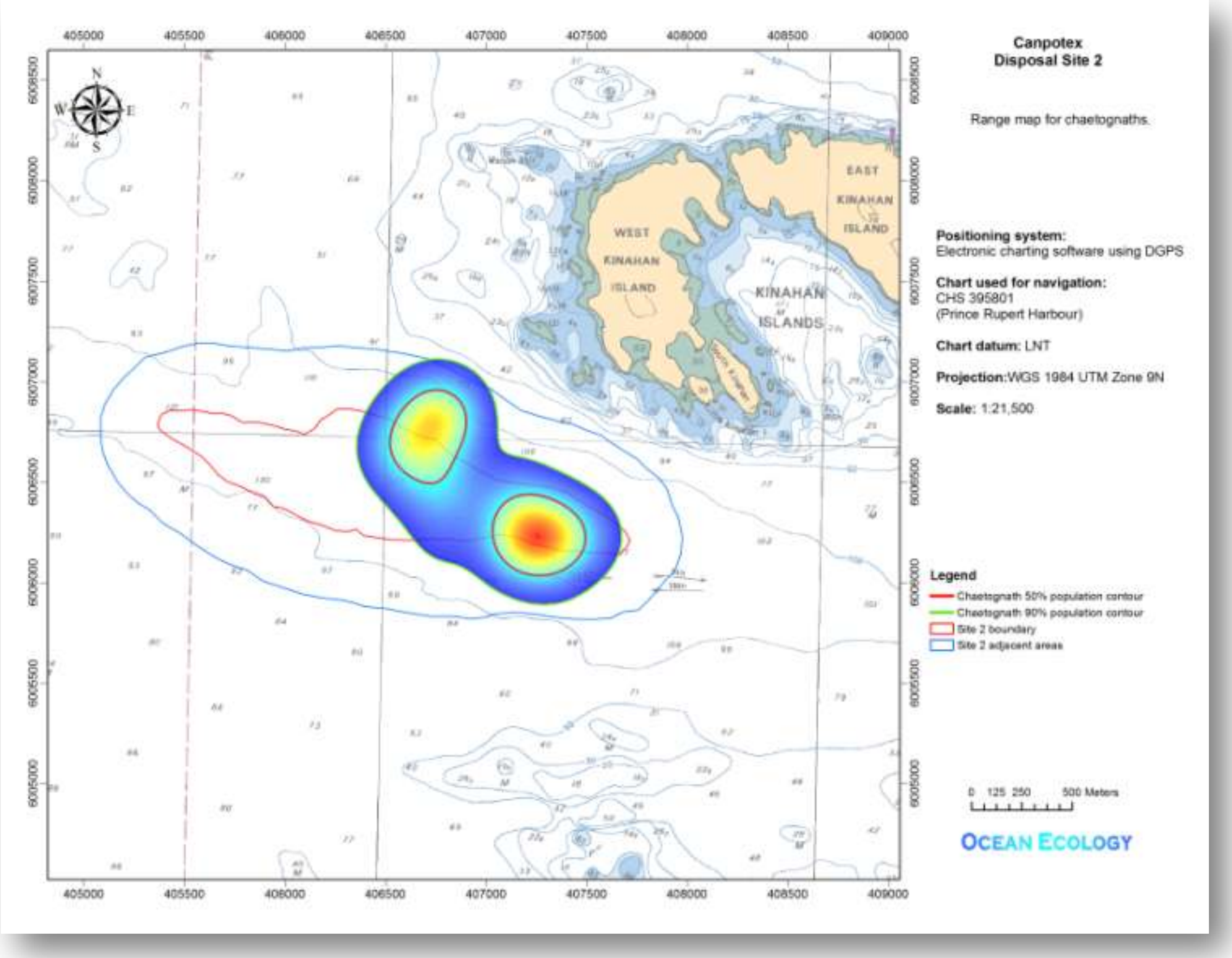


Figure 14. Range map for unmounded holes.



Canpotex Disposal Site 2

Range map for chaetognaths.

Positioning system: Electronic charting software using DGPS

Chart used for navigation: CHS 395801 (Prince Rupert Harbour)

Chart datum: LNT

Projection: WGS 1984 UTM Zone 9N

Scale: 1:21,500

Figure 15. Range map for chaetognaths.

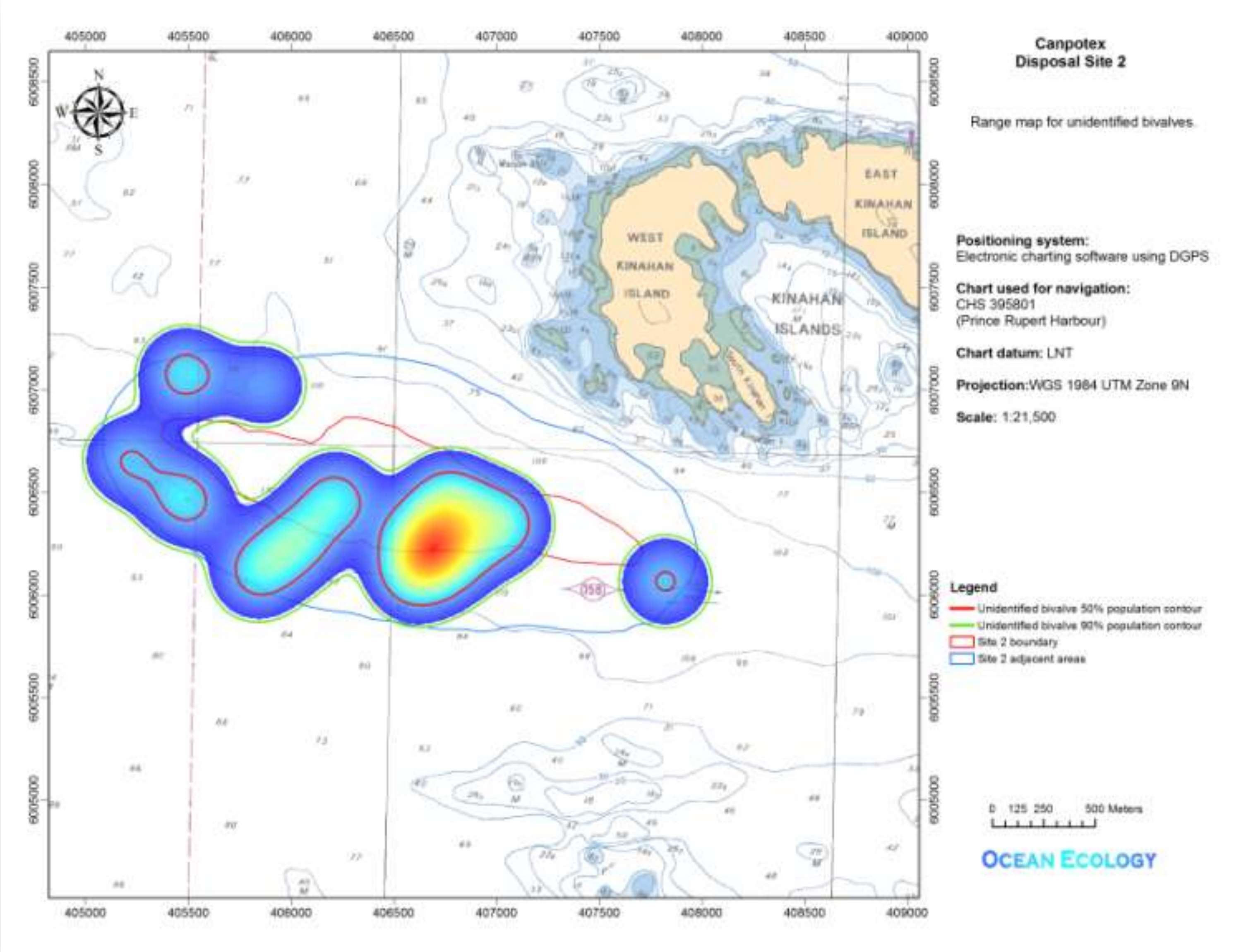


Figure 16. Range map for unidentified bivalves.

e. Larvaceans were distributed throughout the site. They were most abundant in the southeast region of the site (see Figure 17). Larvaceans filter feed on nanoplankton using a complex filter arrangement in a secreted, external mucous "house". The abundant plankton at Site 2 probably accounts for their presence at the site.

f. Spot prawns were located in a region near the northwest end of the site (see Figure 18). While relatively few spot prawns were seen using the drop camera, this was not unexpected, as spot prawns are highly mobile and will rapidly leave an area when startled. The camera will only record those prawns which do not become started when the lander impacts the sea floor. Thus, it is likely that the population of spot prawns was much higher than recorded by the drop camera.

g. Sea whips were only found at the northwest end of the site (see Figure 19). As the camera landed and lifted-off at drop 2-1, it was clear that the sea whip observed at this drop was part of a much larger field of sea whips. Thus, it is possible that sea whips may have a fairly extensive areal coverage at this end of the site.

h. A small number of unidentified amphipods were found throughout the site (see Figure 20). These crustaceans are relatively difficult to differentiate from krill when they are swimming rapidly, so it is quite likely that there were more of them than has been recorded.

i. A single unidentified brittlestar was observed towards the northwest end of the site (see Figure 21). Based on the previous macroinvertebrate study done at the site during November 21st, 2010, there is a good likelihood that this brittlestar belonged to the species *Amphiodia urtica*, *Amphioplus strongyloplax*, or *Ophiura luetkeni*.

j. A single unidentified seastar was observed near the center of Site 2 (see Figure 22).

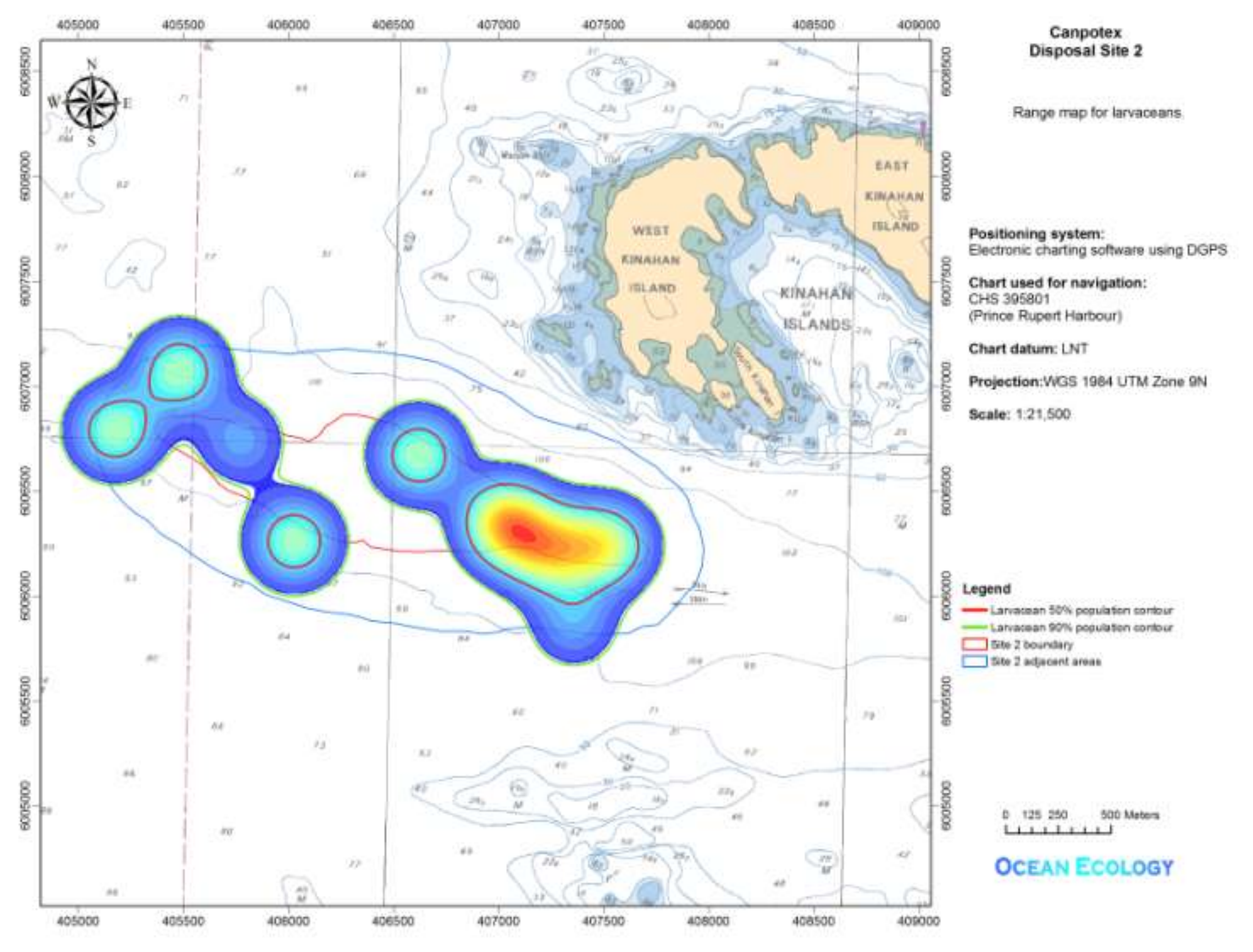


Figure 17. Range map for larvaceans.

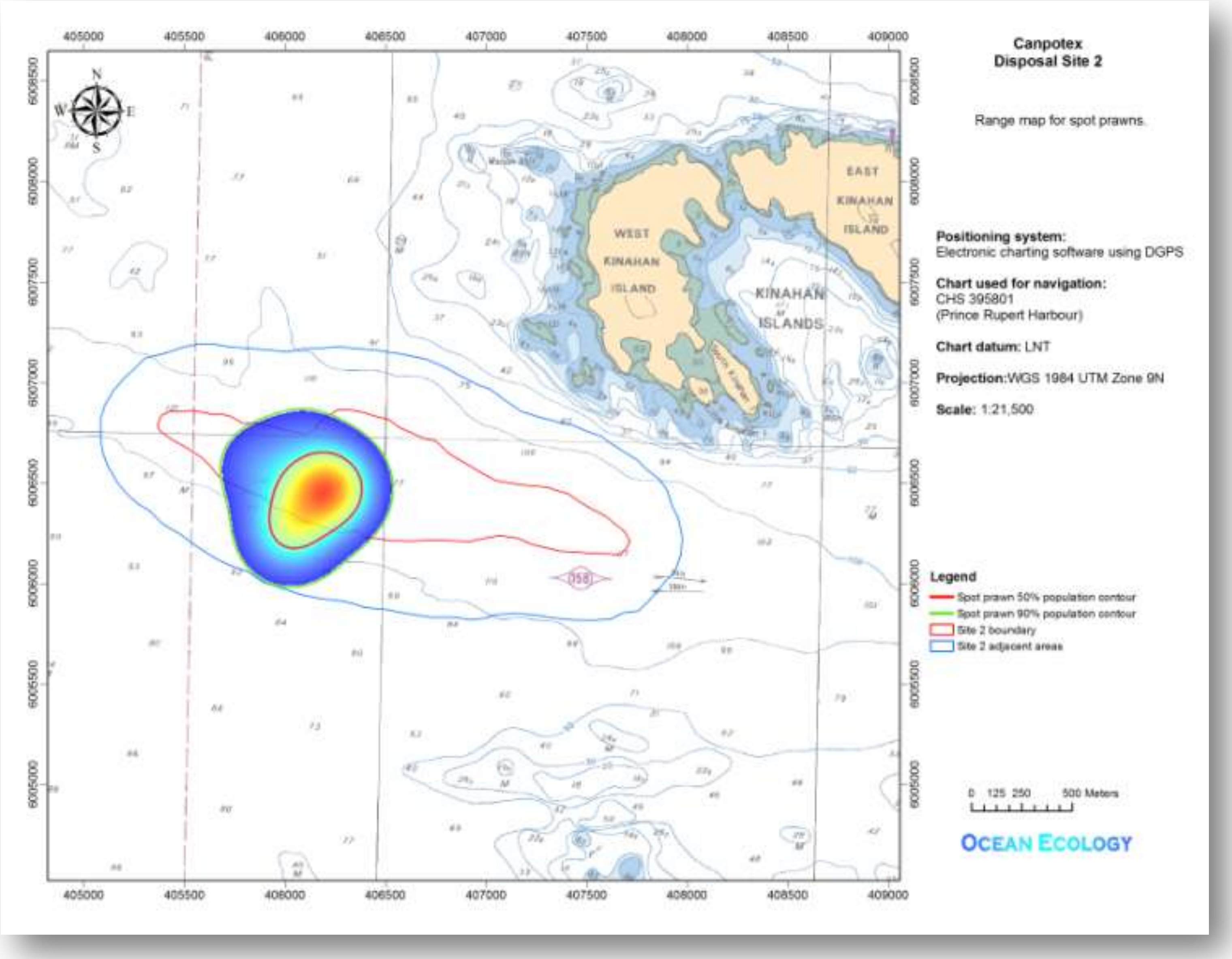


Figure 18. Range map for spot prawns.

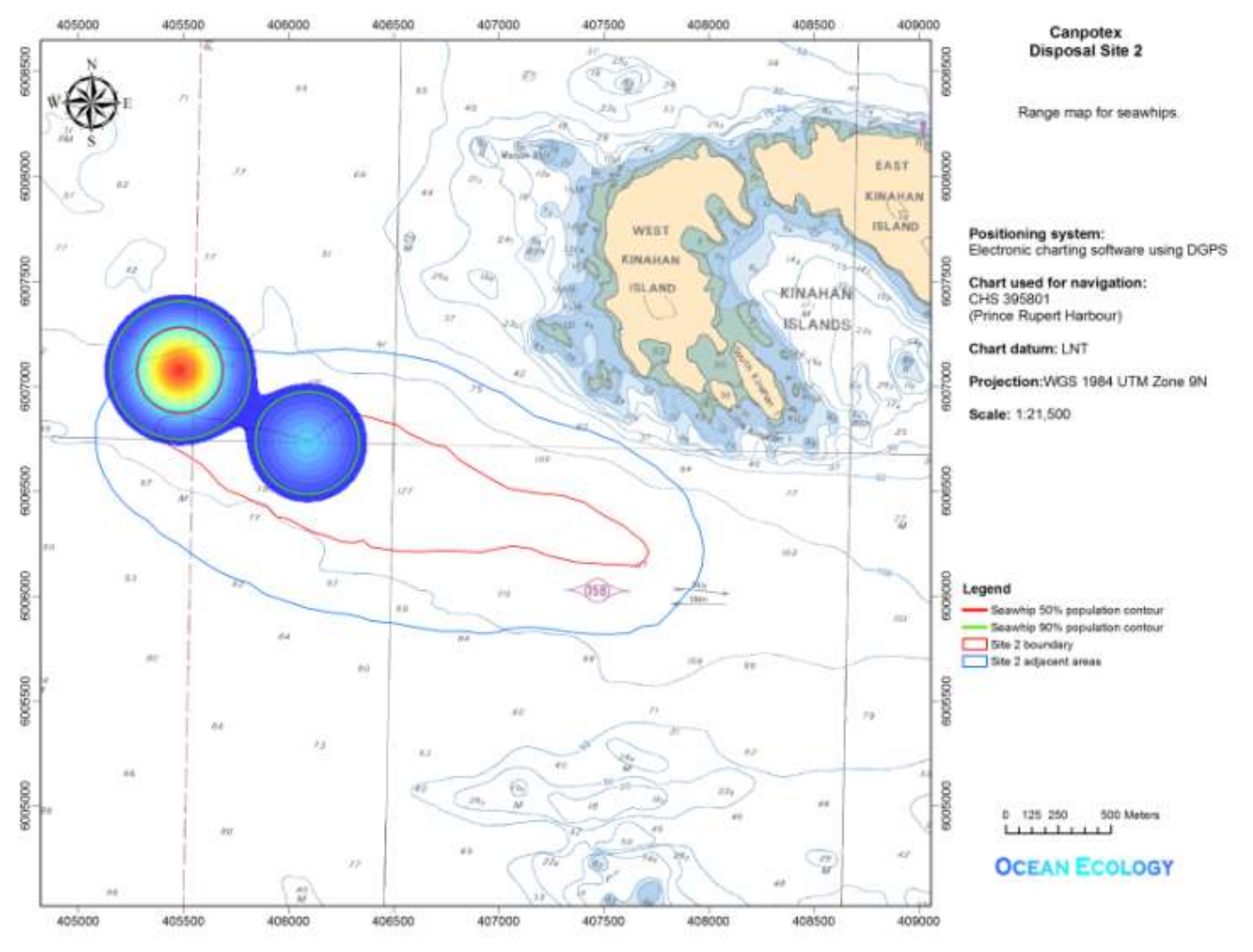


Figure 19. Range map for sea whips.

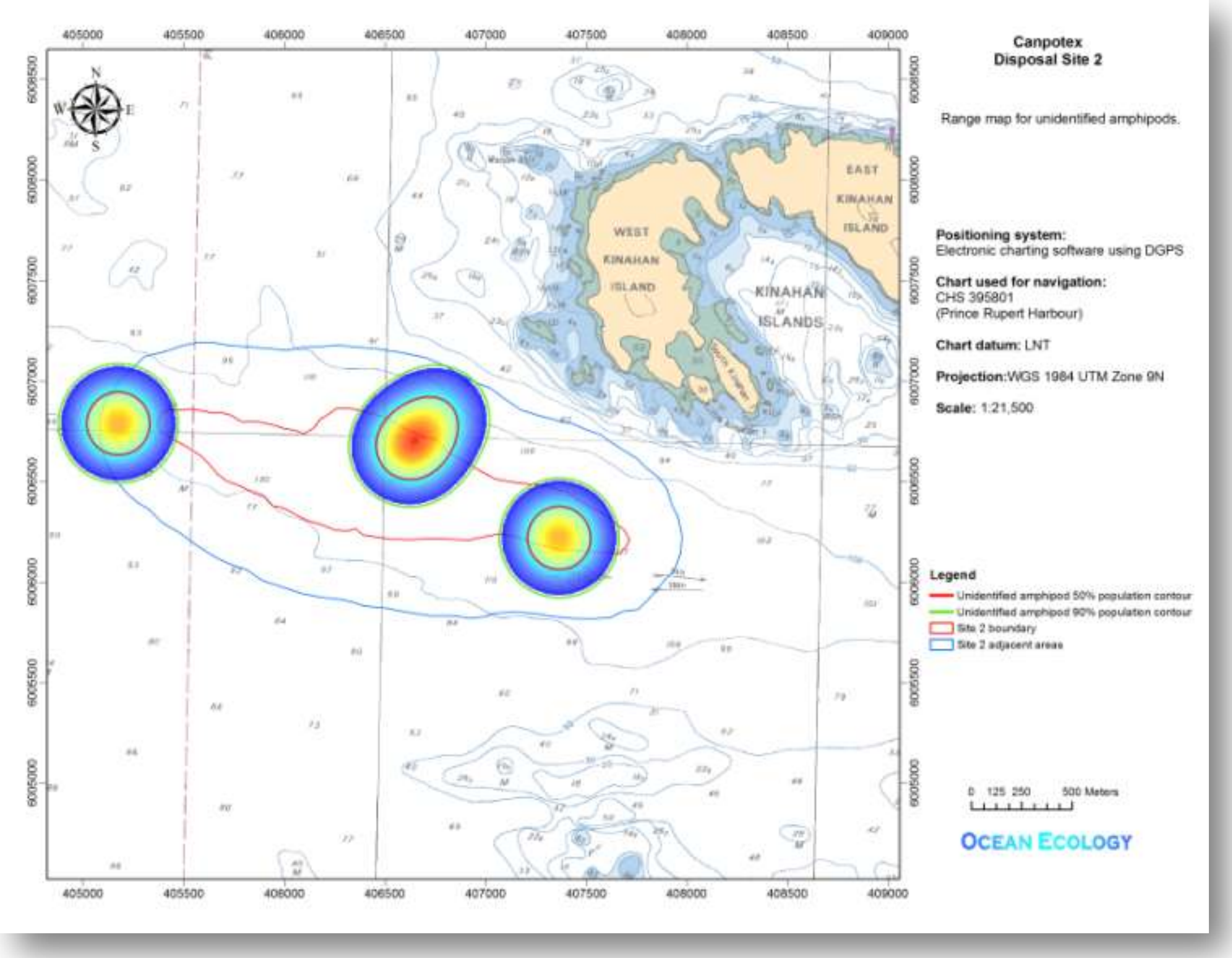


Figure 20. Range map for unidentified amphipods.

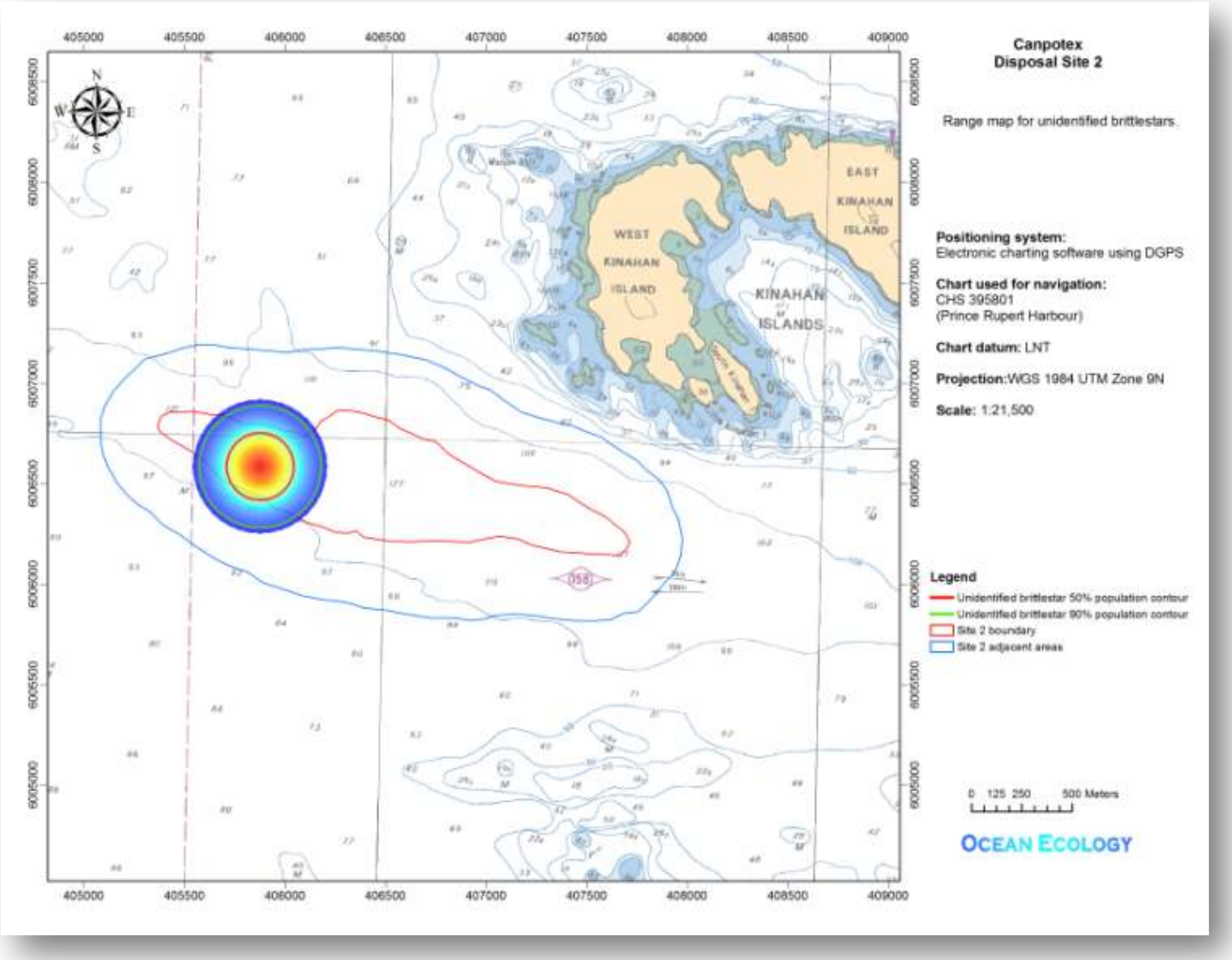


Figure 21. Range map for unidentified brittlestars.

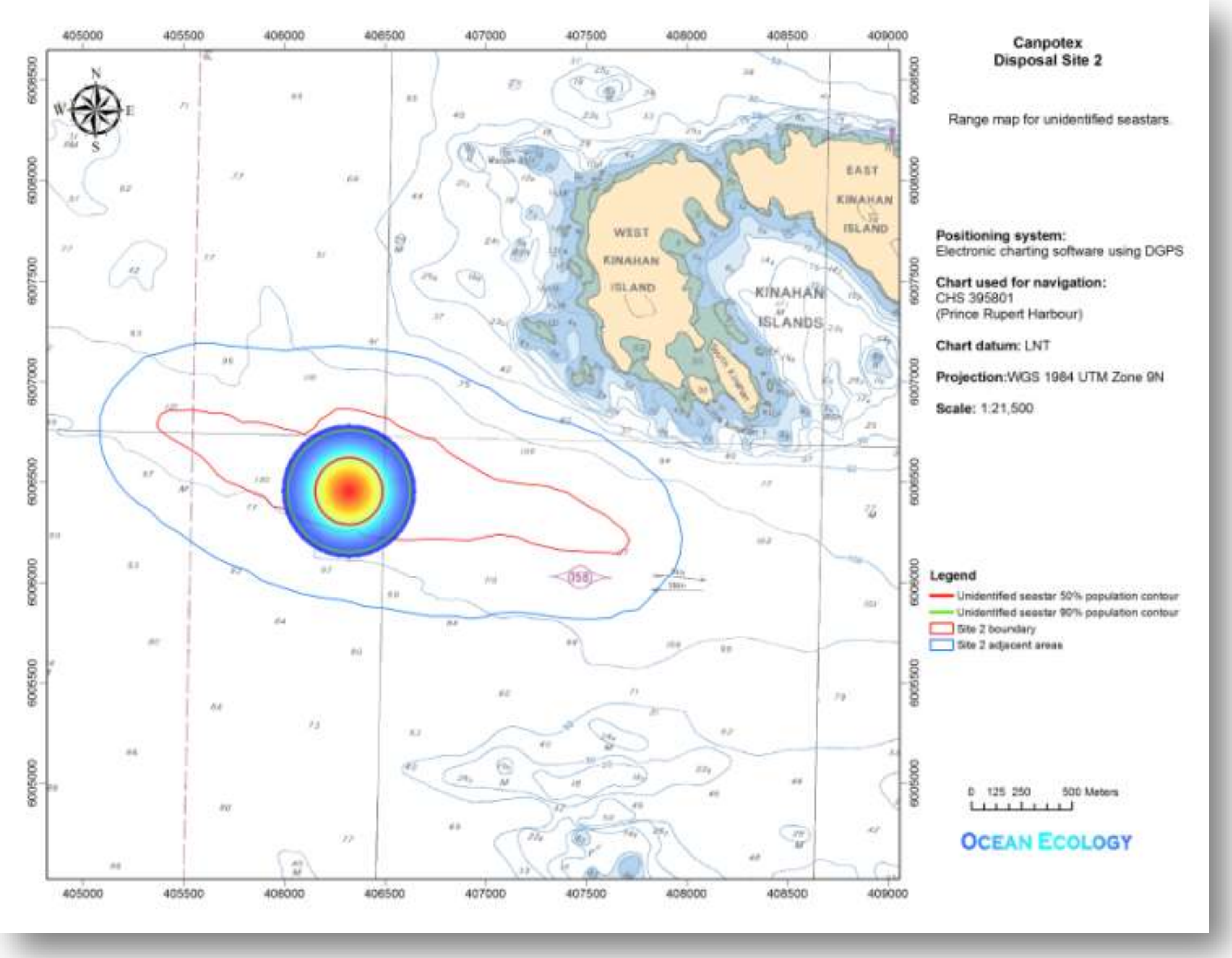


Figure 22. Range map for unidentified seastars.

3. The only commercial species observed at the site was spot prawns. Statistical data can be obtained from DFO regarding the aggregated prawn catch and effort for the years 2001 to 2004 in the region around Site 2. In order to prevent disclosure to a third party of confidential information that may prejudice the competitive position of a fisher, DFO used a 4 km x 4 km grid to protect exact fishing locations. The data for each grid cell was derived from a count of 3 or more vessels that were fishing within the same grid cell and within the same fishing season (DFO, 2011). The grid cells which are located in the vicinity of Site 2 are shown in Figure 23. The aggregated catch and effort values for these cells are given in Table 2.

   Table 2. Aggregated prawn catch and effort data in the vicinity of Site 2.

Grid Cell	Aggregated Prawn Catch (kg)	Aggregated Prawn Effort (hours soak time)
1	7674	6078
2	3786	2512
3	5440	4160
4	6330	3751

   The aggregated prawn catch and effort values in grid cell 1 are the highest values north of Banks Island.

3.3 Diversity Analyses

3.3.1 Diversity Indices

Due to the very large difference in areal coverage between the drop camera methodology (e.g., 9 m^2 at Site 2) and towed benthic video camera methodology (e.g., 3,950 m^2 at Site 1), the diversity indices from these two methodologies are not comparable. As a result of the reduced areal coverage of the drop camera system, fewer species will be observed, and diversity indices calculated from the data produced by this methodology will tend to be much lower than those calculated from data produced by the towed video system.

The overall Shannon’s diversity index for the site was 1.979, and the species richness was 10. If all organisms at Site 2 were completely evenly distributed (which would generate a maximum value for Shannon’s diversity index), the maximum possible diversity for the site would be 2.303. This suggests that the particular complement of species at this site is fairly close to reaching their maximum diversity. The Shannon’s evenness value of 0.860 also indicates that the species are relatively evenly distributed throughout the site (a value of 1.0 would indicate a completely even distribution).

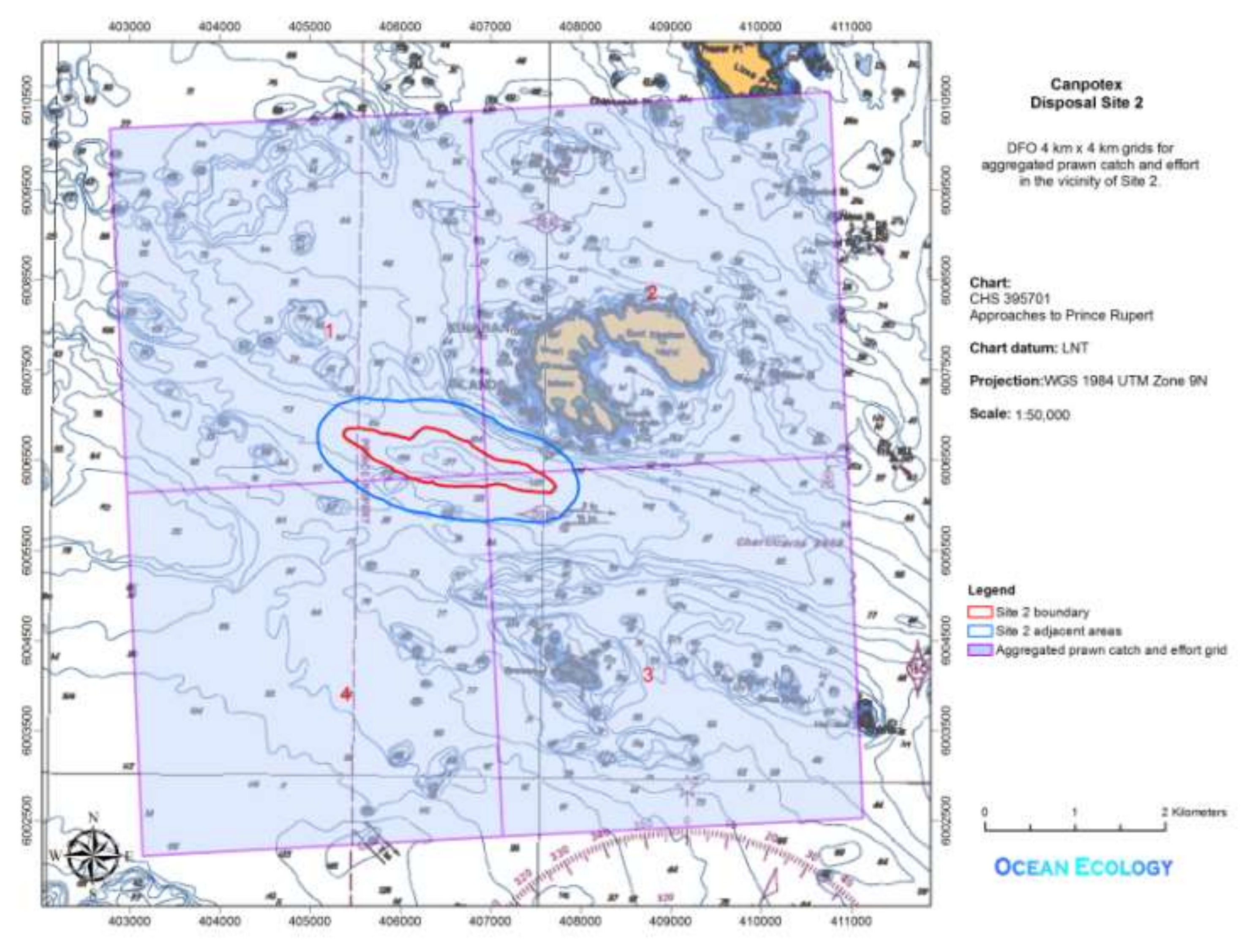


Figure 23. DFO 4 km x 4 km grids for aggregated prawn catch and effort in the vicinity of Site 2.

The site has a Simpson's dominance index of 0.323. The Simpson's dominance index approaches 1.0 as one particular species dominates the site. A value of 0.323 suggests that there is relatively little dominance by any species at the site.

Figure 24 shows the species richness map for the site. Species richness in each hexagonal polygon ranges from 0 to 7. Maximum species richness for the site occurred towards the northwest end of the site, and in the deeper regions of the site. Most likely these are the areas where the current flow is strongest and plankton abundance is greatest.

Figure 25 shows the overall organism abundance at the site. The greatest number of organisms occurred near the center of the site, just to the south of the central deep region.

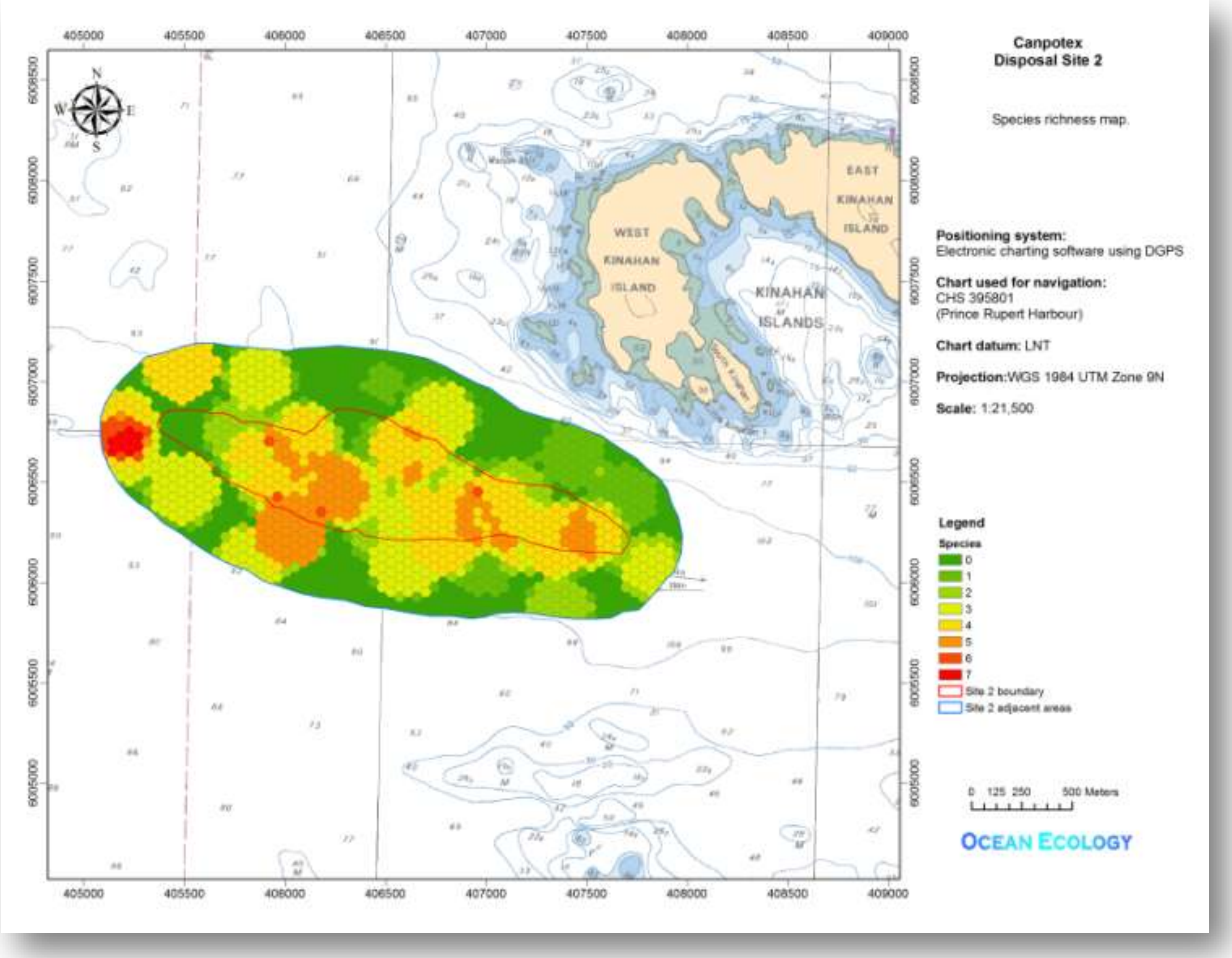


Figure 24. Species richness map.

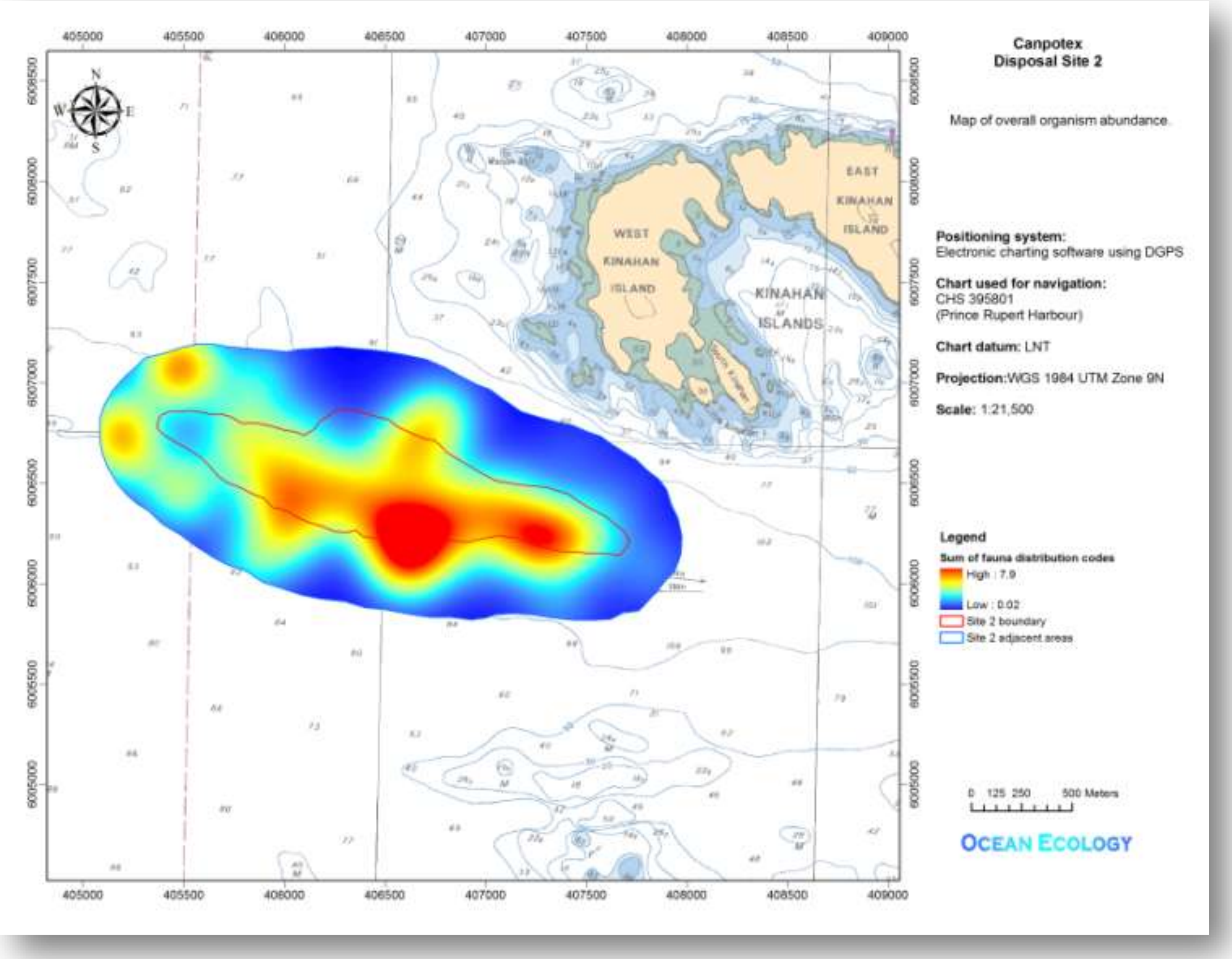


Figure 25. Map of overall organism abundance.

4 Project Deliverables

In addition to this report, the following materials have also been provided from the subtidal survey:

1. One DVD containing:.
    a. raw seabed video imagery* (overlaid with date and time) of the survey site.
    b. java-based software which links video* and GPS data, allowing simultaneous viewing of the camera’s geographical position on a map and the video images captured by the camera at that location.
    c. a library of video* annotations
    d. a georeferenced, classified Access database* for biological and physical features of the seabed.
    e. an electronic ArcGIS project* containing maps of analyzed video data.
    f. a report describing and explaining the results of the video survey.

*Note: time on the video imagery, in the database, and in the ArcGIS project is given in PDT (Pacific Daylight Time).

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6 Appendix

Table 3. Substrate type codes.

Substrate Composition	Class	Subclass	Description
Rock (R)			Bedrock outcrop; may be partially covered with a veneer of sediment.
Veneer over bedrock (vR)			Intermittently visible bedrock covered with a thin veneer of clastic sediments.
Clastic (C)			Seabed comprised of mineral grains of gravel-, sand- or mud-sized material.
	Gravel (G)	Boulder (B)	Percentage boulder (>25.6 cm in size) on seabed.
		Cobble (CO)	Percentage cobble (6.4 to 25.6 cm in size) on seabed.
		Pebble (P)	Percentage pebble (4 mm to 6.4 cm in size) on seabed.
		Granules (GR)	Percentage granules (2-4 mm in size) on seabed.
	Sand (S)	Sand (S)	Percentage sand (0.062 to 2 mm in size) on seabed.
	Silt-mud (M)	Silt-mud (M)	Percentage silt-mud (<0.62 mm in size) on seabed.
Biogenic (B)			Surface of seabed comprised of material of biogenic origin, such as vegetation.
	Organics (O)	Shell (SH)	Percentage coarse (> 2 mm in size) shell debris on seabed.
		Organic debris (OD)	Percentage organic debris on seabed.
		Wood debris (WD)	Percentage wood debris on seabed.
Anthropogenic (A)			Features of man-made origin, such as trawl marks, anchor drag marks, or cable drag marks.

Table 4. Average particle size values.

Substrate Class/Subclass	**Average Size (mm)**
Rock	10000
Veneer over bedrock	10000
Boulder	512
Cobble	256
Pebble	64
Granules	4
Sand	2
Silt-mud	0.62
Shell	--
Organic debris	--
Wood debris	--
Anthropogenic	--

Table 5. Percentage substrate cover codes.

Class Code	**Percentage Cover**
1	T-5%
2	5-30%
3	30-50%
4	50-80%
5	>80%

Table 6. Vegetation codes.

Algal Class	**Subclass**	**Code**	**Description**
Green Algae (GRA)	Foliose greens	FOG	Primarily *Ulva*, but also including *Enteromorpha* and *Monostroma.*
	Filamentous greens	FIG	The various filamentous green/red assemblages (*Spongomorpha/Cladophora* types).
Brown Algae (BA)	Fucus	FUC	*Fucus* and *Pelvetiopsis* species groups.
	Sargassum	SAR	*Sargassum* is the dominant and primary algal species.
	Nemalion	NEM	Filamentous *Nemalion* sp*.* is the dominant species*.*
	Soft brown kelps	BKS	Large laminarian bladed kelps, including *L. saccharina* and *groenlandica*, *Costaria costata, Cymathere triplicata.*
	Seersucker kelp	SEE	*Costaria costata.*
	Split kelp	SPL	*Laminaria setchellii.*
	Sugar wrack kelp	SWK	*Laminaria saccharina.*
	Suction-cup kelp	SUC	*Laminaria yezoensis*.
	Dark brown kelps	BKD	The LUCO chocolate brown group,. *L. setchelli, Pterygophora, Lessoniopis. Alaria* and *Egregia* may also be present. Generally more exposed than soft browns.
	Alaria	ALA	*Alaria* sp*.*
	Agarum	AGR	*Agarum* is the dominant species, but other laminarians may also occur. Generally found deeper than Laminarian subgroup.
	Fringed sea colander kelp	FSC	*Agarum fimbriatum*.
	Three-ribbed kelp	TRK	*Cymathere triplicata*.
	Stringy acid weed	STW	*Desmarestia viridis.*
	Broad acid weed	BRW	*Desmarestia lingulata.*
	Macrocystis	MAC	Beds of canopy forming giant kelp.
	Nereocystis	NER	Beds of canopy forming bull kelp.

Algal Class	**Subclass**	**Code**	**Description**
Red Algae (RED)	Foliose reds	FOR	A diverse species mix of foliose red algae (*Gigartina*, *Iridea, Rhodymenia, Constantinia*) which may be found from the lower intertidal to depths of 10 m primarily on rocky substrate.
	Filamentous reds	FIR1	A diverse species mix of filamentous red algae (including *Gastroclonium, Odonthalia, Prionitis*) which may be found from the lower intertidal to depths of 10 m, often co-occurring with the foliose red group described above.
	Filamentous reds	FIR2	A mix of red algae (primarily *Neoagardhiella*and *Gracilaria*) which grow on "submerged" cobble and pebble in fine sand and silt bottoms.
	Coralline reds	COR	Rocky areas with growths of encrusting and foliose forms of coralline algae.
	Halosaccion	HAL	*Halosaccion glandiforme.*
	Red fringe	RFR	*Smithora.naiadum*
Seagrasses (SGR)	Eelgrass	ZOS	Eelgrass beds.
	Surfgrass	PHY	Areas of surfgrasses (*Phyllospadix*), which may co-occur with subgroup BKS or BKD above.
No Vegetation		NOV	No vegetation observed.
Cannot Classify		X	Vegetation present by cannot be identified. Imagery is not clear, classification not possible.

Table 7. Vegetation coverage codes.

Code	**Class**	**Abundance**
1	Sparse	Less than 5% cover.
2	Low	5 to 25% cover.
3	Moderate	26 to 75% cover.
4	Dense	>75% cover.

Table 8. Fauna codes.

Species or Species Complex	**Code**	**Description**
Bacterial mat	BCM	Unidentified bacterial mat; sulfuretum.
Sponges	USP	Unidentified sponge.
	CLD	Cloud sponge (*Aphrocallistes vastus*).
	SBS	Sharp lipped boot sponge (*Rhabdocalyptus dawsoni*).
	RSB	Round lipped boot sponge (*Staurocalyptus dowlingi*).
	SVS	Stalked vase sponge (*Leucilla nuttingi*).
	BRS	Breast sponge (*Eumastia sitiens*).
Jellyfish	MJF	Moon jellyfish (*Aurelia labiata*).
	CYC	Lion's mane jellyfish (*Cyanea capillata*).
Hydroids	HYD	Unidentified hydroids.
	HYM	Hydromedusa sp.
Anemones	PAF	Tube-dwelling anemone (*Pachycerianthes fimbriatus)*.
	MET	Plumose anemone (*Metridium* sp.).
	URT	Sea anemone (*Urticina* sp.).
	XAN	Giant green anemone (*Anthopleura xanthogrammica*).
	CRI	Snake lock anemone (*Cribrinopsis* sp.).
	ANT	Sea anemone (*Anthopleura* sp.).
	STR	Strawberry anemone (*Corynactis californica*).
Corals/Hydrocorals	SPO	Orange sea pen (*Ptilosarcus gurneyi*).
	SPW	White sea pen (*Virgularia* sp.).
	CUP	Orange cup coral (*Balanophyllia elegans*).
	SWP	Sea whip (*Balticina septentrionalis*).
	STY	Pink hydrocoral (*Stylaster* sp.).
Worms	TUB	Parchment tube dwelling polychaete worms.
	TUC	Calcareous tube dwelling polychaete worms.
	LUG	Pacific lugworm (*Abarenicola pacifica*).

Species or Species Complex	**Code**	**Description**
Crabs	CRB	Unidentified crab.
	CAN	*Cancer* sp.
	DUN	Dungeness crab (*Cancer magister*).
	TAN	Tanner crab (*Chionoecetes* sp.).
	KCR	Kelp crab (*Pugettia* sp.).
	BXC	Box crab (*Lopholithodes foraminatus*).
	BXC	Box crab (*Lopholithodes foraminatus*).
	HEC	Helmet crab (*Telmessus cheiragonus*).
	SQT	Squat lobster (*Munida quadraspina*).
Shrimps (Pandalid)	PAN	Unidentified pandalid.
	PRN	Spot prawn (*Pandalus platyceros*).
	PNB	Spiny pink shrimp (*Pandalus borealis*).
	PNH	Humpback shrimp (*Pandulus hypsinotus*).
Ghost and mud shrimps	GHS	Ghost shrimp (*Callianassa californiensis*).
	MDS	Mud shrimp (*Upogebia pugettensis*).
Other crustaceans	EUP	Krill (*Euphasia pacifica*).
	AMP	Unidentified amphipod.
Gastropods	WHK	Unidentified whelk.
	ELI	Eelgrass limpet (*Lottia alveus paralella*).
	NUC	Dogwinkle (*Nucella* sp.).
	CDV	Carinate dovesnail (*Alia carinata*)
	TBI	Threaded bittium (*Bittium eschrichtii*)
	MOO	Moon snail (*Euspira lewisii*).
	WLN	White-lined nudibranch (*Dirona albolineata*).
	TOT	Orange-peel nudibranch (*Tochuina tetraquetra*).
	SNU	Striped nudibranch (*Armina californica*).
Bivalves	MUS	Mussel bed (*Mytilus trossulus*).
	GCL	Geoduck clam (*Panopea abrupta*).
	HCL	Horseclam (*Tresus* sp.).
	PCL	Piddock clam.
	BCL	Butter clam (*Saxidomas gigantea*).
	COC	Nuttall’s cockle (*Clinocardium nuttallii*).
	SFC	Softshell clam (*Mya* sp.).
	OYS	Oyster.
	OCL	Other clam species.
	SCA	Scallop (*Chlamys* sp.)
	TER	Teredo worm (*Bankia setacea*).
	BIV	Unidentified bivalve.
Octopus	OCT	Pacific octopus (*Octopus*).

Species or Species Complex	**Code**	**Description**
Bryozoan Complex	BRY	Bryozoans, ascidians, sponges - generally on rock substrate.
Brachiopods	BRA	Unidentified brachiopod.
	LAM	California lamp shell (*Laqueus californicus*).
Seastars	BRE	Short-spined seastar (*Pisaster brevispinus*).
	EVA	False ochre seastar (*Evasterias troschelli*).
	PYC	Sunflower seastar (*Pycnopodia helianthoides*).
	POR	Ochre seastar (*Pisaster ochraceus*).
	DER	Leather star (*Dermasterias imbricata*).
	GEP	Gunpowder star (*Gephyreaster swifti*).
	WRS	Wrinkled star (*Pteraster militaris*).
	PTT	Slime star (*Pteraster tesselatus*).
	VER	Vermilion star (*Mediaster aequalis*).
	HEN	Seastar (*Henricia* sp.).
	SOL	Seastar (*Solaster* sp.).
	COO	Cookie star (*Ceremaster patagonius*).
	PLS	Pale star (*Leptychaster pacificus*).
	SMS	Spiny mudstar (*Luidia foliolata*).
	ORT	Painted star (*Orthasterias koehleri*).
	STF	Long ray star (*Stylasteria forreri*).
	SIX	Six-armed star (*Leptasterias* sp.).
	ROS	Rose star (*Crossaster papposus*).
	STR	Unidentified seastar.
Brittle Stars	BRT	Unidentified brittle star.
	GYB	Gray brittle star (*Ophiura lütkeni*).
Basket Stars	BSK	Basket star (*Gorgonocephalus* sp.).
Feather Stars	FST	Feather star (*Florometra serratissima*).
Sand Dollars	SDD	Sand dollar (*Dendraster excentricus*).
Sea Urchins	RSU	Red sea urchin (*Strongylocentrotus franciscanus*).
	GSU	Green sea urchin (*Strongylocentrotus droebachiensis*).
	WSU	White sea urchin (*Strongylocentrotus pallidus*).
	PSU	Purple sea urchin (*Strongylocentrotus purpuratus*).
Sea Cucumbers	RCU	Rea sea cucumber (*Cucumaria miniata*).
	WCU	White sea cucumber (*Psolus squamatus*).
	PAR	California sea cucumber (*Parastichopus californicus*).
	ASC	Aggregating sea cucumber (*Pseudocnus* sp.).
Tunicates	TUN	Unidentified tunicate.
	CIO	Tunicate (*Ciona* sp.).
	PEA	Pacific sea peach (*Halocynthia aurantium*)
In fauna "holes"	HLM	Mounded worm, clam or crustacean hole, but species or species group cannot be distinguished.
	HLF	Unmounded (flat) worm or clam hole, but species or species group cannot be distinguished.

Species or Species Complex	Code	Description
Chaetognath	CGN	Chaetognath (*Sagitta* sp.).
Larvacean	LVN	Larvacean (*Oikopleura* sp.).
Fish	FSH	Unidentified fish.
	SAL	Unidentified salmonid.
	ELP	Unidentified eelpout (Zoarcidae).
	POA	Unidentified poacher.
	PSP	Pacific snake prickleback (*Lumpenus sagitta*).
	TUS	Tubesnout (*Aulorhynchus flavidus*).
	GBE	Black-eyed goby (*Coryphoterus nicholsi*).
	PLP	Pile perch (*Rhacochilus vacca*).
	PST	Striped perch (*Embiotica lateralis*).
	SHP	Shiner perch (*Cymatogaster aggregata*).
	FTF	Unidentified flatfish.
	STF	Starry flounder (*Platichthys stellatus*).
	RKS	Rock sole (*Lepidopsetta bilineata*).
	RFS	Unidentified rockfish.
	BRF	Black rockfish (*Sebastes melanops*).
	NRK	China rockfish (*Sebastes nebulosus*).
	CRK	Copper rockfish (*Sebastes caurinus*).
	QRF	Quillback rockfish (*Sebastes maliger*).
	TRF	Tiger rockfish (*Sebastes nigrocinctus*).
	YRF	Yelloweye rockfish (*Sebastes ruberrimus*).
	GLG	Unidentified greenling (Hexagrammid).
	KGR	Kelp greenling (*Hexagrammos decagrammus*).
	LNG	Lingcod (*Ophiodon elongatus*).
	SCU	Unidentified sculpin (Cottidae).
	NRN	Northern ronquil (*Ronquilus jordani*).
	RAT	Ratfish (*Hydrolagus colliei*).
	BSK	Big skate (*Raja binoculata*).
	LSK	Longnose skate (*Raja rhina*)
Unknown	UNK	Macro fauna visible but cannot be identified.
No Fauna	NOF	No fauna observed.

Table 9. Faunal distribution classes.

Code	Descriptor	Distribution
1	Few	Rare (single) or a few sporadic individuals.
2	Patchy	A single patch, several individuals or a few patches.
3	Uniform	Continuous uniform occurrence.
4	Continuous	Continuous occurrence with a few gaps.
5	Dense	Continuous dense occurrence.
6		Code specific for school of fish.

7 Disclaimer

The findings presented in this report are based upon data collected during the days July 6th and July 7th, 2011 using the methodology described in the Survey Methodology section of this report. Ocean Ecology has exercised reasonable skill, care, and diligence to collect and interpret the data, but makes no guarantees or warranties as to the accuracy or completeness of this data.

This report has been prepared solely for the use of the Stantec, pursuant to the agreement between Ocean Ecology and Stantec. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Ocean Ecology accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

Any questions concerning the information or its interpretation should be directed to the undersigned.

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Kennard Hall, Captain
Partner, Ocean Ecology

APPENDIX F

Fisheries by Catch Type in Chatham Sound

Table F-1: Reference Numbers and Data Sources Associated with Figures[1]

Important Areas (ISs) for Marine Benthos

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Shrimp	Important Areas	DFO PNCIMA	3	IAs were identified based on trawl industry log books and research trawl data, for aggregations and uniqueness
Tanner crab	Important Areas	DFO	2	The areas identified are based on research surveys done on the continental shelf. However information is limited at the moment and the area is subject to change
Dungeness crab	Important Areas	DFO	1	Identified IAs in the PNCIMA were identified important because of uniqueness, aggregations and fitness.

Important Fish Habitat Areas

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Areas of Important Fish Habitat	Rockfish Important Areas	DFO PNCIMA	28	Important habitat area as Identified in PNCIMA report
	Herring Important Areas	DFO PNCIMA	20	Important spawning, rearing and migration habitat areas
	Eulachon Important Areas	DFO PNCIMA	27	Important spawning and summer feeding habitat areas
	Rockfish Conservation Areas	DFO PNCIMA	21	Areas of important rockfish conservation closed to commercial and recreational fishing
	Kelp	DFO PNCIMA	25, 26	Kelp bed distribution areas

Human Use Areas

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Aquaculture Site	Shellfish farms, hatcheries, and aquaculture capability	CRIMS	33	Includes all the shellfish farms within the area.
Processing Sites	Aquaculture processing sites	CRIMS	32	Represents locations of aquaculture processing sites which incorporate raw materials into marketable commodities.
Recreational Fishing Area	NC Sport Fish	DFO	30	Recreational crab fishing data was included with overall recreational fishing layer because the sites were often close-to or on-top-of the sport/finfish fishing areas.
	NC Rec. Crab	DFO	29	
Moorage/Anchor/ Marina Location	Small Craft Harbours	DFO	31	Represent areas of use by recreational/pleasure crafts.
Industry Site	Anchorages	CRIMS	34	Represents various industries and all of the buildings associated with each industry. Additionally, it is not clear whether all industries are currently in operation. Thus, this data layer likely over-represents industrial operations in the study area
	Marinas	CRIMS	35	
	Moorage	CRIMS	37	
	Marine industries including: ▪ Docks and Terminals ▪ Fuel Docks and Tanks ▪ Log Booms	CRIMS CRIMS	36 42	
First Nation Communities	http://www.gov.bc.ca/arr/firstnation/maps/map_5.htm	Provincial	40	This layer was chosen to visually show the locations of First Nation Communities within the area thus the surrounding areas can be considered potential areas of use.
First Nations Fishery 2004	First Nations Food Fishery (layer name: fn_fishery)	MAPSTER (DFO)	39	This layer represents identified areas of First Nations Food Fisheries within the study area for 2004. Note that 2007 data did not show First Nation Fisheries within the study area. This information was compiled from interviews on Local Ecological Knowledge in the area by DFO and is updated about every 5 years. Information contained in traditional studies (Menzies 2008, MacDonald 2009) was also reviewed. Although discrete fishing areas were not identified in these reports, the confirm that fishing occurred traditionally in the Prince Rupert harbour, Skeena River and Nass River (north of the study area) and within coastal waters between the two rivers.
First Nations Reserve	CLAB_BC_2007_10_04	Provincial	41	This layer shows areas of First Nations Reserves as identified from the Province.

Areas of Overlapping Commercial Fishing

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Areas of Overlapping Commercial Fishing	Groundfish Trawl Catch/Effort	DFO PNCIMA	4	Displayed areas with groundfish trawl catch/effort
	Outside ZN Cumulative Hook and Line Catch/Effort	DFO PNCIMA	5	Displayed areas with outside rockfish hook and line catch/effort. Outside refers to fishing zones in outside waters. ZN is a fishing license category for rockfish.
	Groundfish Schedule II Cumulative Hook and Line Catch/Effort	DFO PNCIMA	6	Displayed areas with groundfish hook and line catch/effort for species listed under Schedule II (fishing licence category)
	Crab Cumulative Trap Catch/Effort	DFO PNCIMA	12	Displayed areas with crab fishery trap catch/effort
	Shrimp trawl catch/effort	DFO PNCIMA	10	Displayed areas with shrimp trawl catch/effort
	Red sea urchin catch/effort	DFO PNCIMA	13	Displayed areas with red sea urchin catch/effort
	Prawn trap catch/effort	DFO PNCIMA	11	Displayed areas with prawn trap catch/effort
	Geoduck catch/effort	DFO PNCIMA	9	Displayed areas with geoduck catch/effort
	Sablefish Cumulative Trap Catch/Effort	DFO PNCIMA	7	Sablefish trap fishery catch/effort

Commercial Crab Trap Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Crab Catch	Crab Cumulative Trap Catch	DFO PNCIMA	12	Crab fishery trap catch (lbs)

Commercial Shrimp Trawl Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Shrimp Catch	Shrimp trawl catch	DFO PNCIMA	10	Shrimp trawl catch (lbs)

Commercial Prawn Trap Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Prawn trap catch	Prawn trap catch/effort	DFO PNCIMA	11	Displayed areas with prawn trap catch (lbs)

Commercial Red Urchin Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Red Sea Urchin	Red Sea Urchin catch	DFO PNCIMA	13	Red sea urchin catch (lbs)

Commercial Geoduck Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Geoduck Catch	Geoduck catch	DFO PNCIMA	9	Geoduck catch (lbs)

Cumulative Commercial Fish Catch Outside Groundfish (ZN) Hook and Line

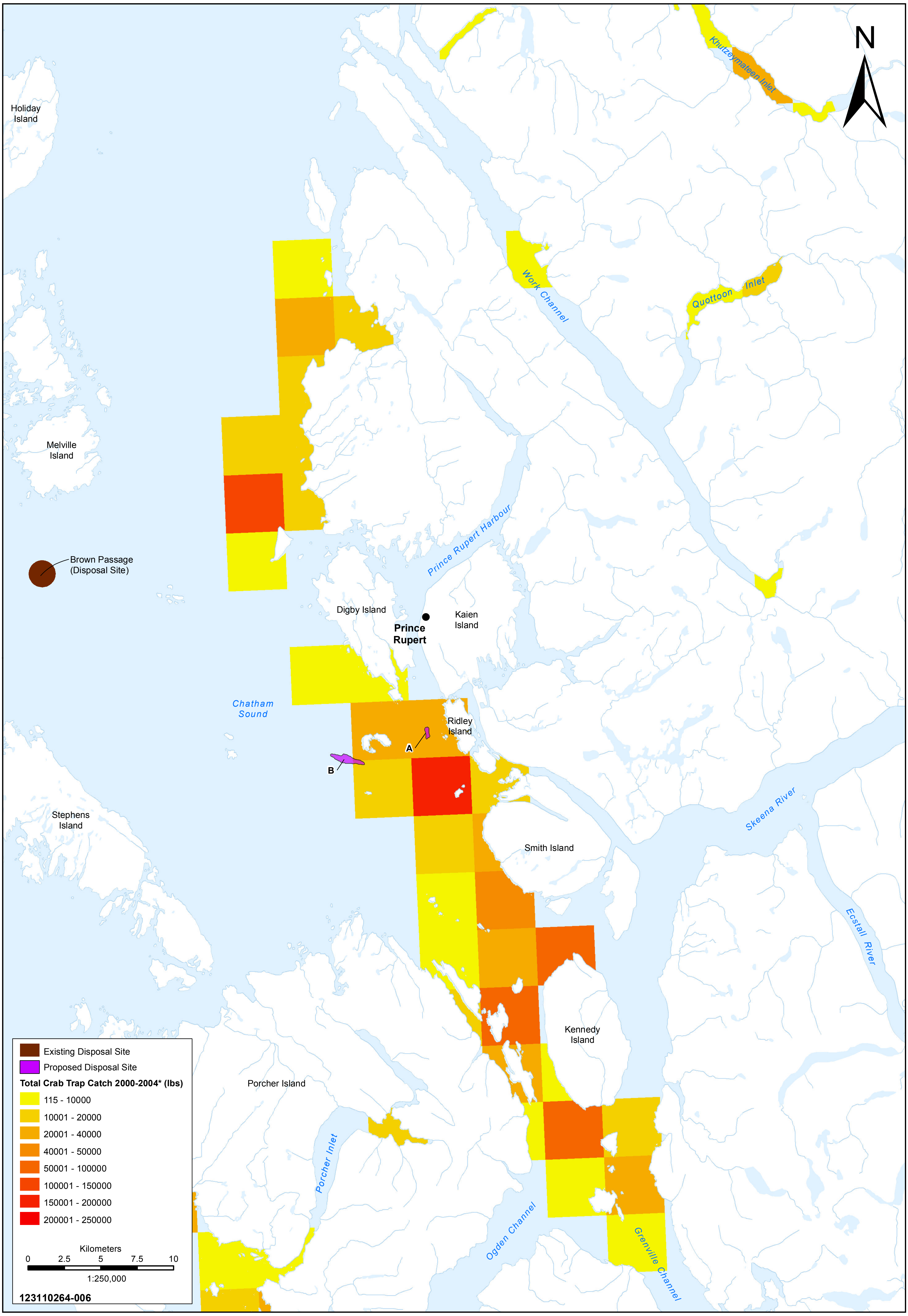
Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Cumulative Commercial Fish Catch outside groundfish (ZN) hook and line	Outside ZN cumulative hook and line catch	DFO PNCIMA	5	Outside ZN groundfish hook and line catch (kg). Outside refers to fishing zones in outside waters. ZN is a fishing license category for rockfish.

Commercial Groundfish Trawl Catch

Legend Title	Data Layers Included	Data Source	Reference Number	Comments
Commercial groundfish trawl	Groundfish trawl catch	DFO PNCIMA	4	Groundfish trawl catch (kg)

NOTE:

[1] Additional data on other organisms and human use were considered but did not show any overlap with the study area



* REFERENCES: 12. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

COMMERCIAL CRAB TRAP CATCH

PROJECTION
UTM - Zone 9

DRAWN BY
NP

DATUM
NAD 83

CHECKED BY

DATE
24-Aug-11

FIGURE NO.
F-1

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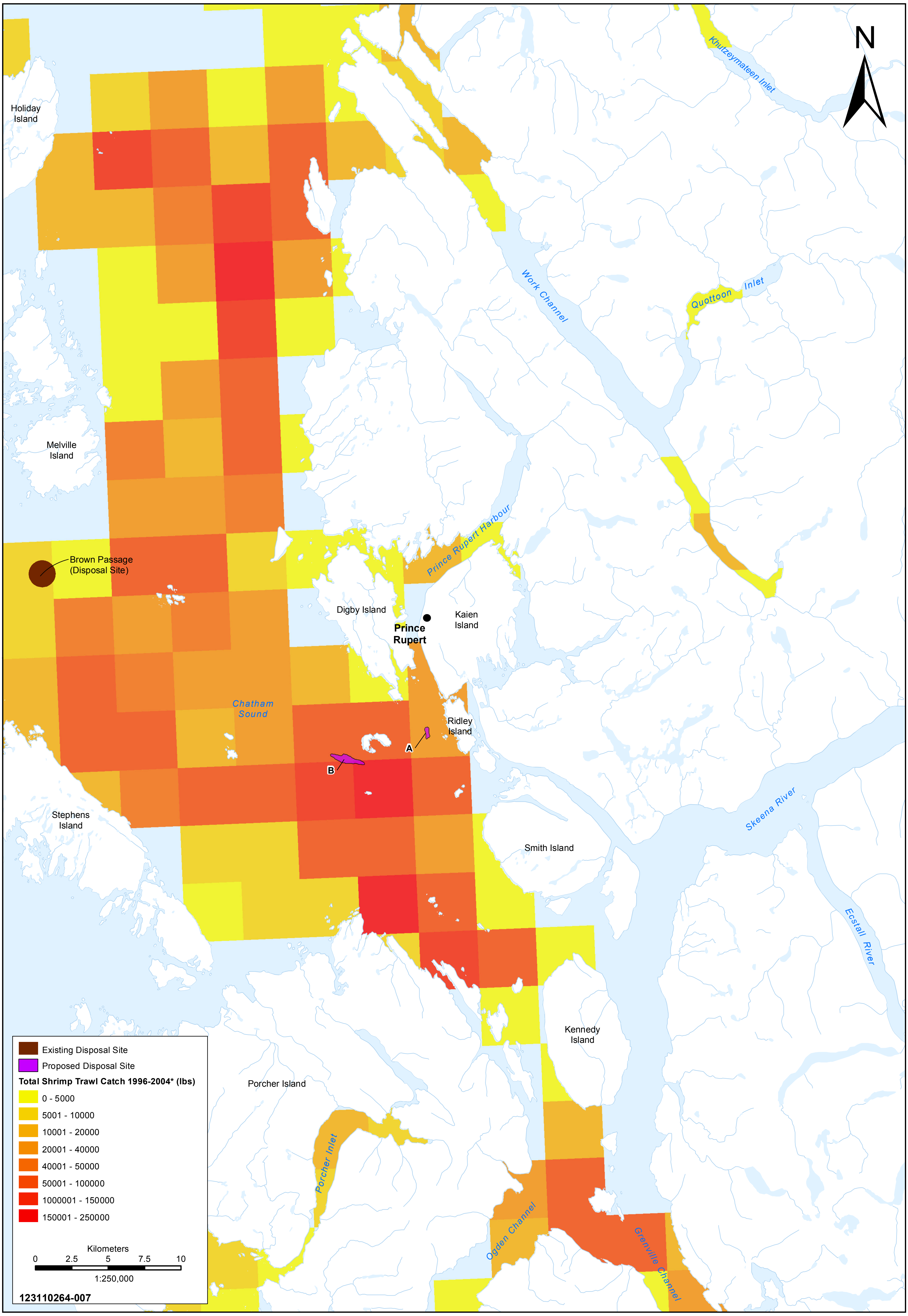

* REFERENCES: 10. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

COMMERCIAL SHRIMP TRAWL CATCH

PROJECTION	UTM - Zone 9	DRAWN BY	NP
DATUM	NAD 83	CHECKED BY	
DATE	24-Aug-11	FIGURE NO.	**F-2**

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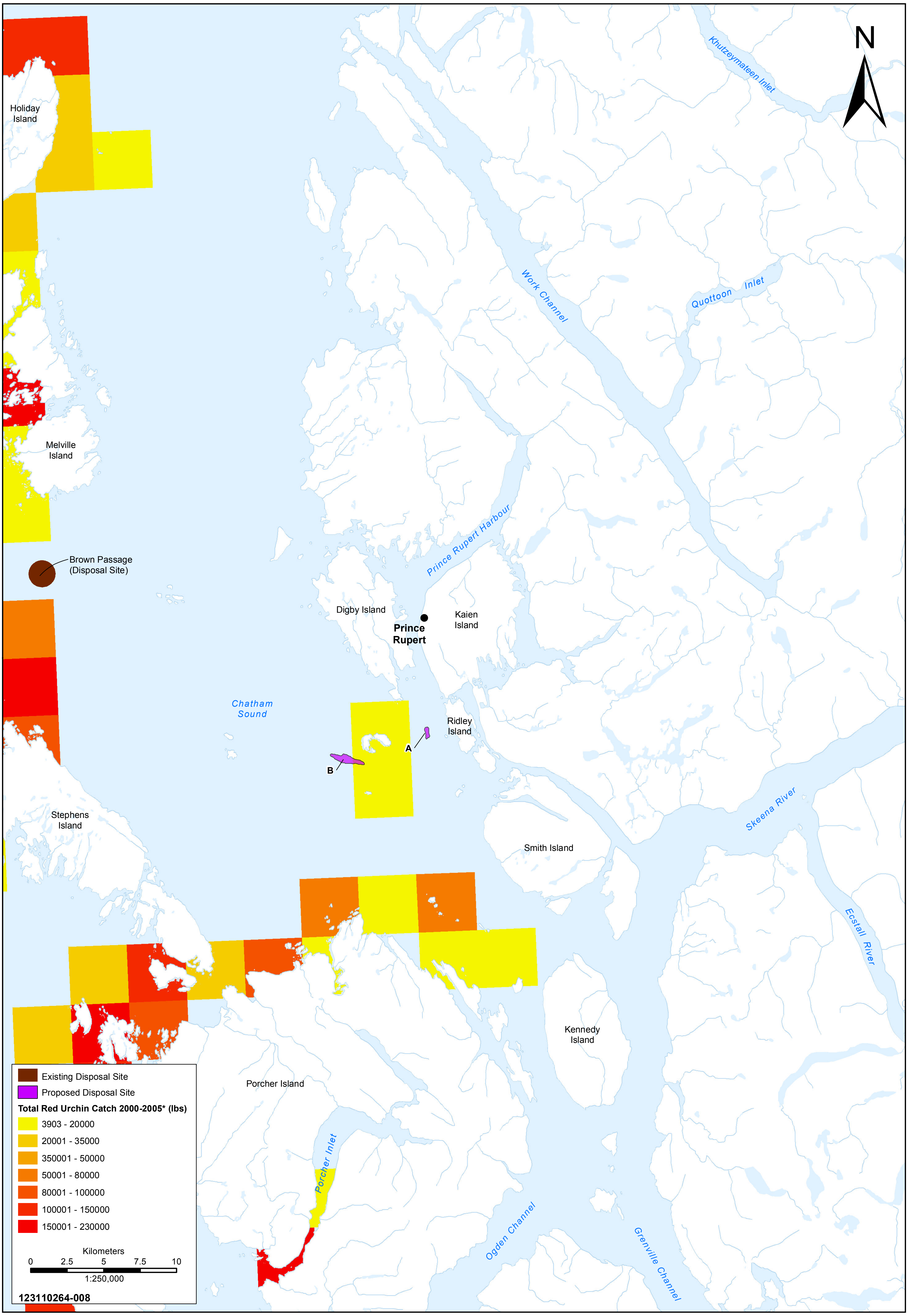

* REFERENCES: 13. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

COMMERCIAL RED SEA URCHIN CATCH

PROJECTION UTM - Zone 9	DRAWN BY NP
DATUM NAD 83	CHECKED BY
DATE 24-Aug-11	FIGURE NO. **F-3**

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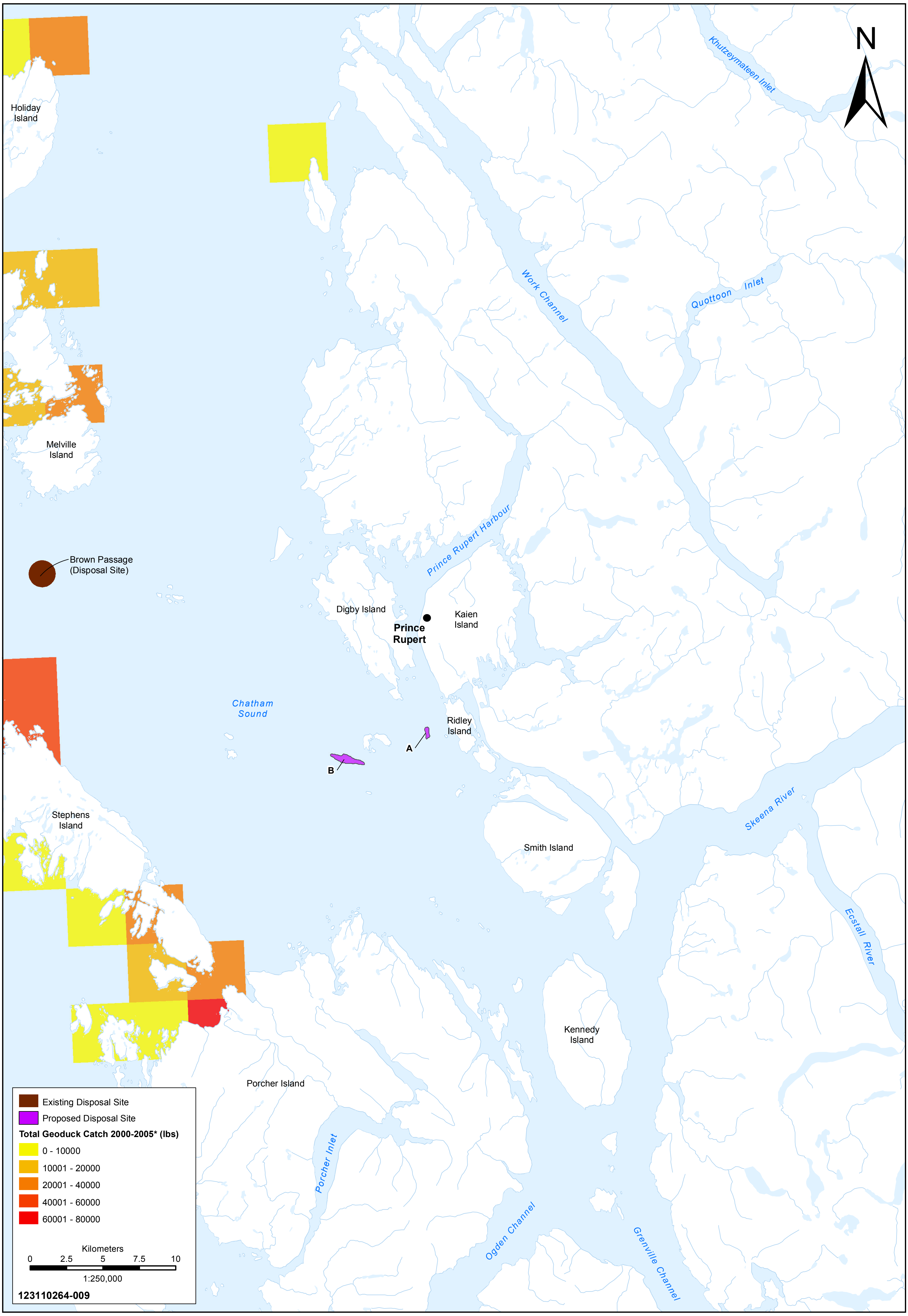

* REFERENCES: 9. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

COMMERCIAL GEODUCK CATCH

PROJECTION	UTM - Zone 9	DRAWN BY	NP
DATUM	NAD 83	CHECKED BY	
DATE	24-Aug-11	FIGURE NO.	**F-4**

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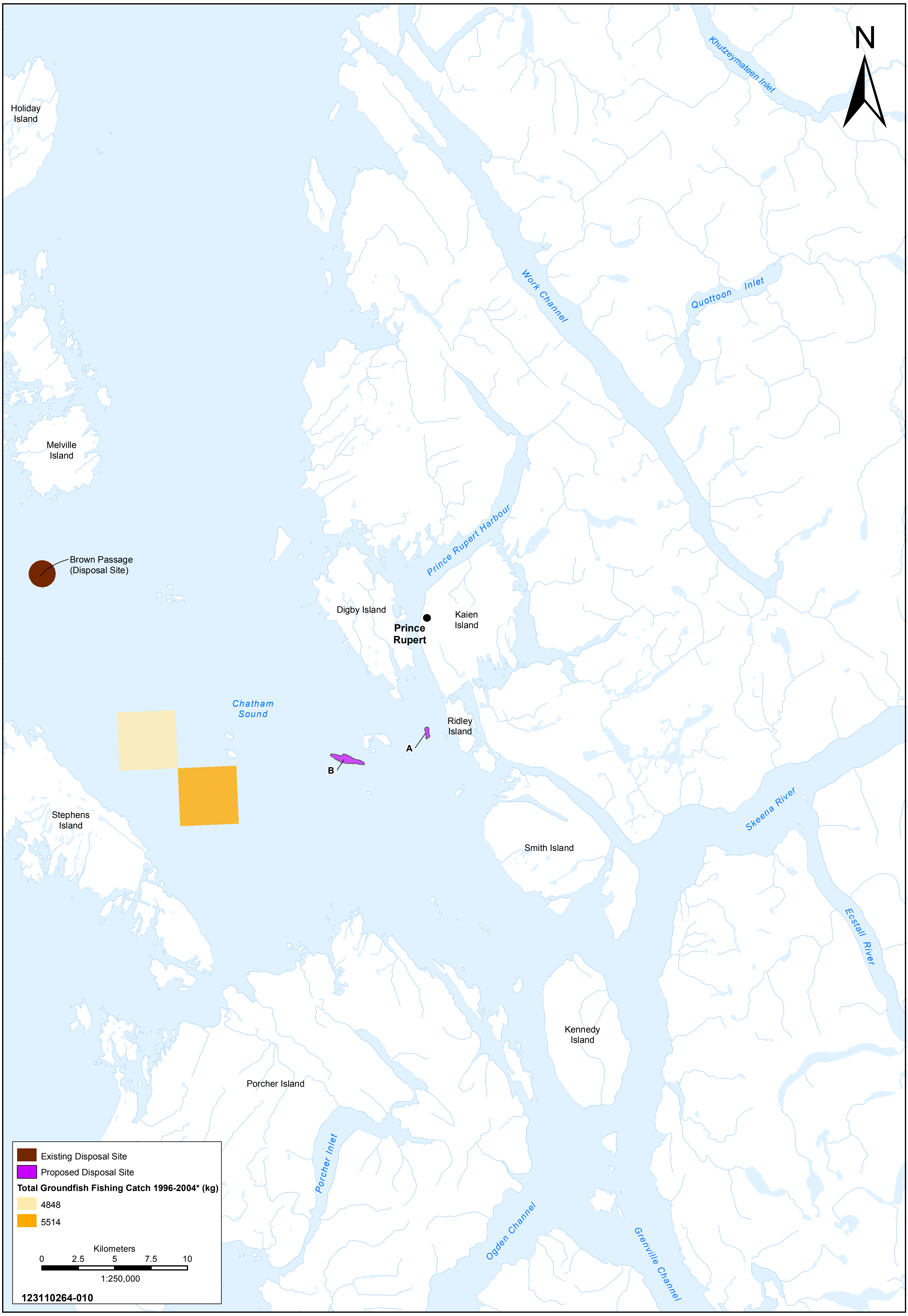

* REFERENCES: 4. Number corresponds to references provided in Appendix F.

COMMERCIAL GROUNDFISH TRAWL CATCH

PROJECTION UTM - Zone 9
DRAWN BY SS
DATUM NAD 83
CHECKED BY
DATE 24-Aug-11
FIGURE NO. F-5

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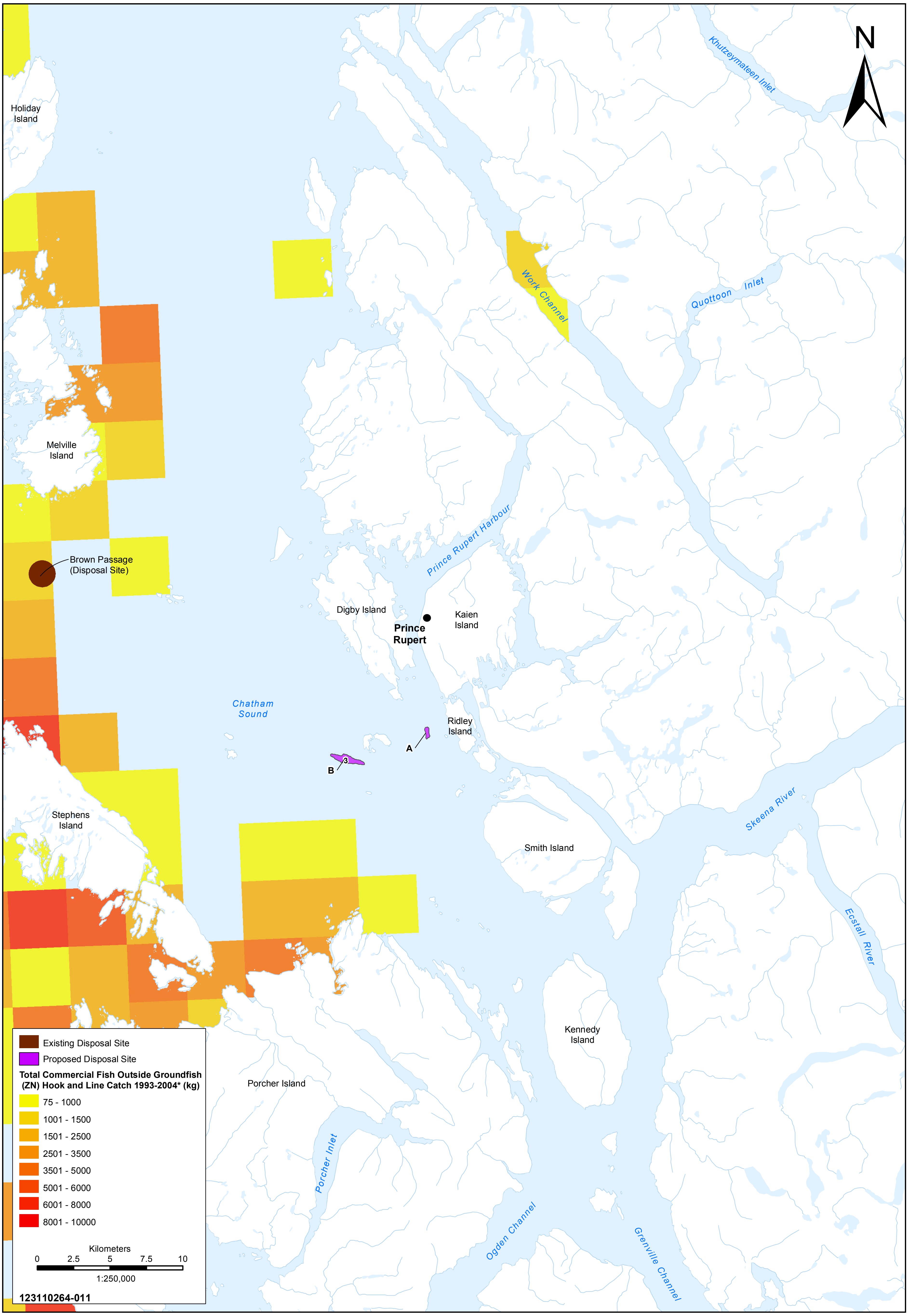

* REFERENCES: 5. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

CUMULATIVE COMMERCIAL FISH CATCH OUTSIDE GROUNDFISH (ZN) HOOK AND LINE

PROJECTION UTM - Zone 9	DRAWN BY NP
DATUM NAD 83	CHECKED BY
DATE 24-Aug-11	FIGURE NO. **F-6**

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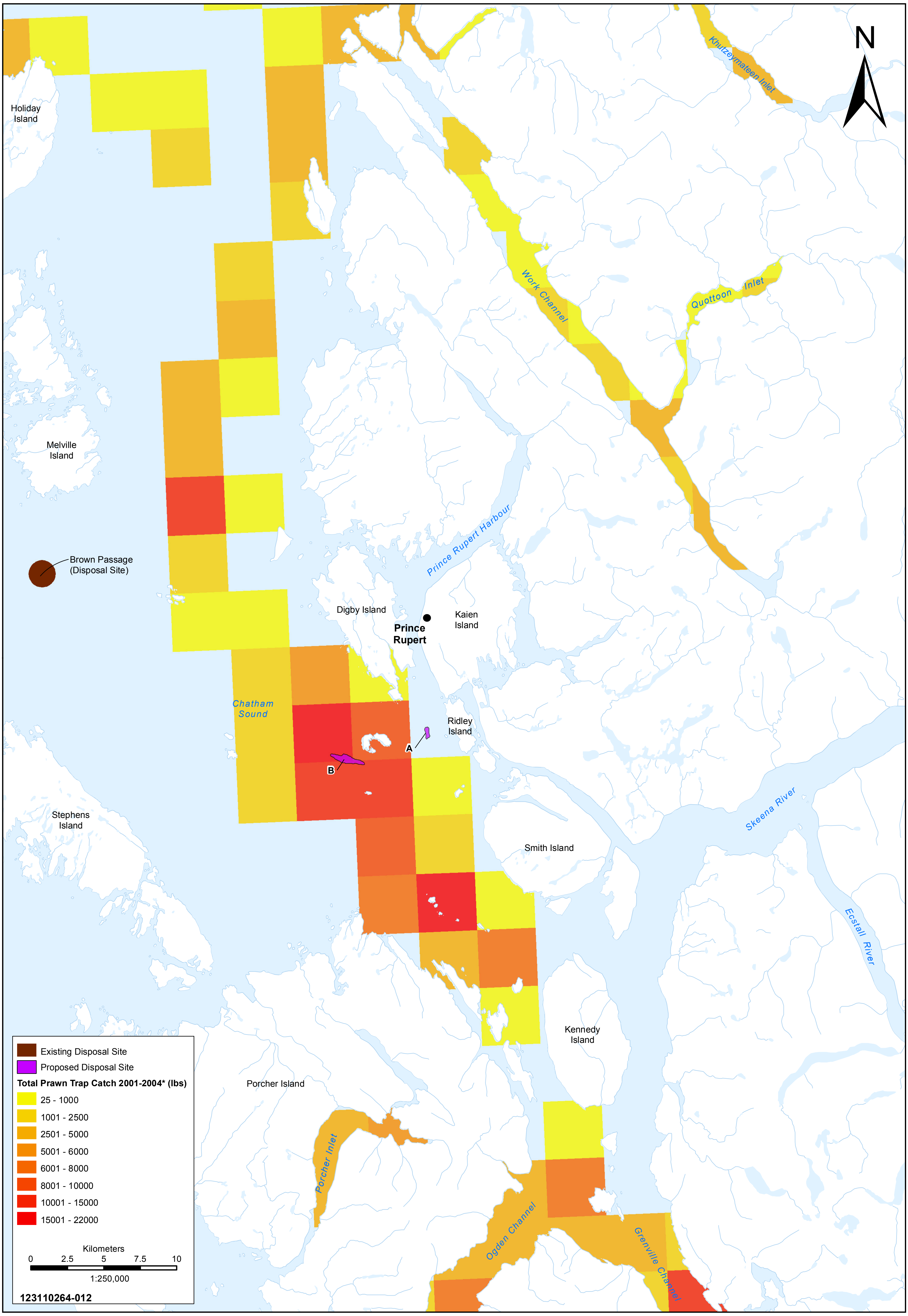

* REFERENCES: 11. Number corresponds to references provided in Appendix F.

Stantec

Canpotex

PRINCE RUPERT PORT AUTHORITY

CUMULATIVE COMMERCIAL PRAWN TRAP CATCH

PROJECTION UTM - Zone 9	DRAWN BY NP
DATUM NAD 83	CHECKED BY
DATE 24-Aug-11	FIGURE NO. F-7

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APPENDIX G

ASL Sediment Modeling Report

Draft

3D Numerical Modeling of Canpotex Dredge Disposal off Prince Rupert

Prepared for:
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ASL File: 90-710-F

January 18, 2011

ACKNOWLEDGEMENTS

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The correct citation for this report is:

Jiang, J. and D. Fissel, 2011. 3D Numerical Modeling of Canpotex Dredging disposal off Prince Rupert. Unpublished Report for Stantec Ltd., Burnaby B.C., by ASL Environmental Sciences Inc., Victoria, B.C., Canada, 40p.

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FIGURES

TABLES

1.0 INTRODUCTION

In support of assessing potential environmental effects of the sediment disposal offshore of Ridley Island in support of the environmental approval process, ASL Environmental Sciences Inc. has carried out a 3D numerical modeling study of the transport and fate of the disposal of dredged sediments. The sediment disposal is part of a port development plan for Canpotex in Prince Rupert, which will involve disposal of dredged sediment at one or both of two potential disposal sites offshore of the Ridley Island portion of the Prince Rupert Harbour (Figure 1). The modeling results will be used to address the potential impacts of the sediment disposal on the natural environment offshore of Ridley Island, especially for the benthic habitat. The 3D numerical model COCIRM-SED was adapted to determine the quantity and pattern of the short-term and long-term deposition of the disposal sediment and the Total Suspended Sediments (TSS) plume during and after the disposal operation. The major oceanographic processes determining the deposition, dispersion and transport of the discharged sediments are the tidal, river and wind driven currents.

The results of the numerical modeling, as described above, are presented. This report includes maps showing the distributions of deposition of the discharged sediments on the seabed and near-surface, mid-depth and near-bottom TSS concentrations, including time series of maximum TSS at various depths in the disposal sites. The report describes the model methods and the input data sources, including bathymetry, discharged sediment size distributions, and the tidal heights, river discharge and surface winds used to drive the model velocities. The model output data are also provided on a CD-ROM or through an on-line ftp site.

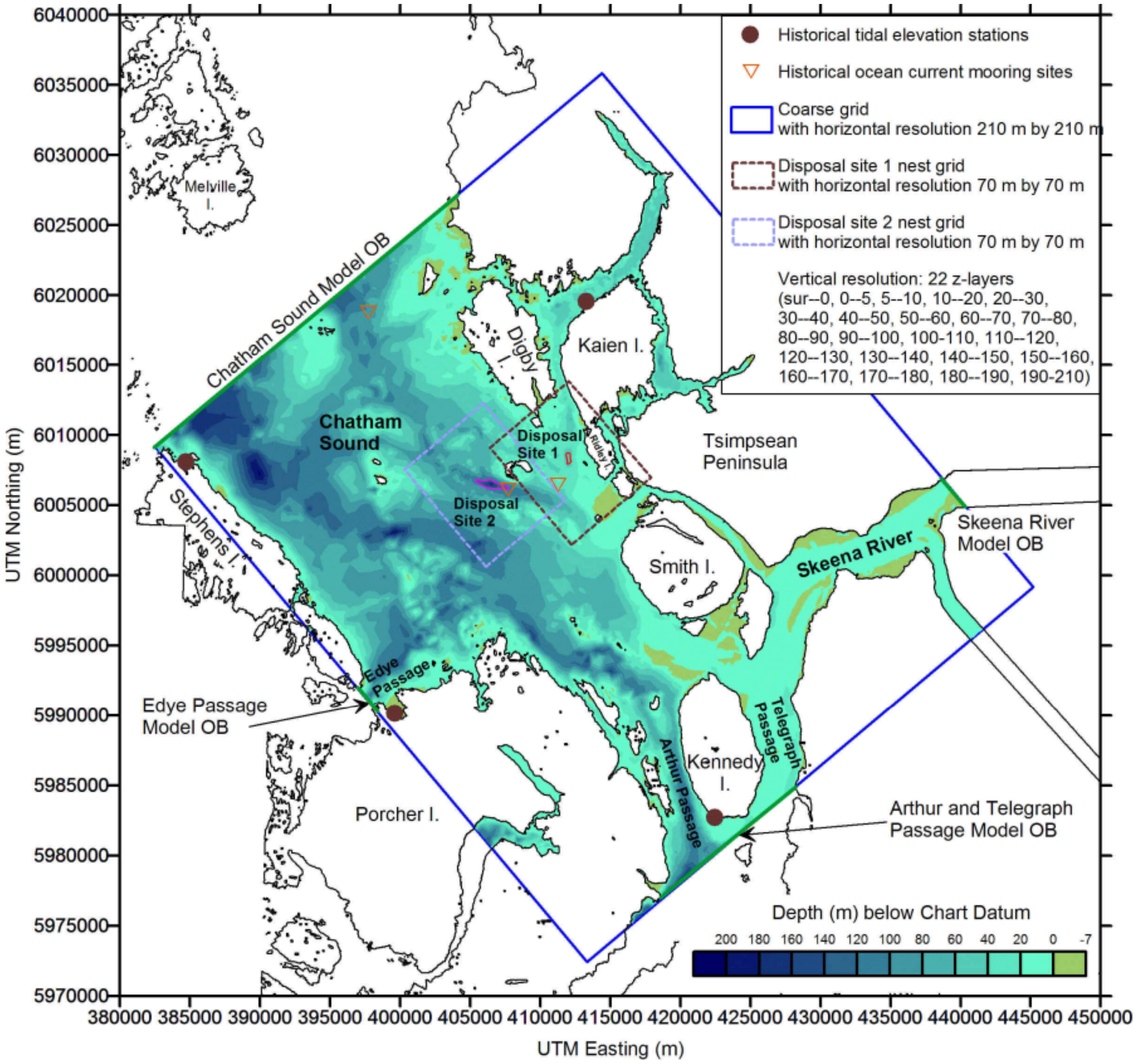

Figure 1: A map showing the study area including the model domain, bathymetry, potential disposal sites, historical tidal elevation stations and ocean currents mooring sites.

2.0 MODEL DEVELOPMENT AND SET-UP

2.1 Overview of COCIRM-SED

The 3D numerical model COCIRM-SED used in this study, represents a computational fluid dynamics, sediment transport and water quality modeling approach for river, estuarine and coastal applications (Jiang et al., 2003; Jiang et al., 2008; Jiang and Fissel, 2010). COCIRM-SED is a highly-integrated model, consisting of six sub-modules, including circulation, wave, multi-size sediment transport, morphodynamics, particle tracking and water quality (Figure 2). The model can be operated on either an integrated or an individual module basis. To run the model for sediment transport, inputs are required for the ocean currents, sediment grain size and percentage fraction for each sediment category, with total categories typically ranging from 5 to 20.

2.2 COCIRM-SED Implementation for Disposal Modeling

The COCIRM-SED model for the sediment disposal modeling offshore of Ridley Island operated on two different spatial scales: the full and near-field scales. The full scale model is required to capture the length and time scales of the basic forcing mechanisms of tides, winds and the large inflow from the Skeena River. The full scale model area has a size of 42 km by 48.3 km, including the southern portion of Chatham Sound, Arthur Passage, Telegraph Passage, Edye Passage, Skeena River, and the narrow channel network surrounding Ridley Island and Prince Rupert Harbour (Figure 1), and is resolved using a horizontal grid size of 210 m by 210 m. The near-field scale model is required to realistically resolve initial dilution of the disposal sediment and include the potential disposal sites 1 and 2 separately with an area of 7420 m by 9100 m. The horizontal resolution in the near-field is reduced to 70 m. In the vertical, both full and near-field scale models used 22 z-layers with a higher resolution near the surface to account for salinity and temperature stratification effects. The 210 m and 70 m model grids are coupled at interfaces and solved together every time step with a single modeling procedure using the two-way, dynamic nested grid scheme in COCIRM-SED.

ASL digitized the bathymetric data as shown in Canadian Hydrographic Service (CHS) nautical charts #3955, #3957, #3958, #3959 and #3964 within the model domain, and also purchased CHS vector digital charts #3717 #3773 and #3927. The digital bathymetric data set, in the format of UTM Easting, UTM Northing and seabed elevation relative to chart datum, was gridded to provide suitable representation of the water depths in the model.

The model was forced at tidal height elevations spanning three open boundaries and by Skeena River input and surface winds. The three model open boundaries include the Chatham Sound to the north, Edye Passage to the west and Arthur and Telegraph Passages to the south (Figure 1). Tidal elevations at these three open boundaries were derived from 7 major tidal height constituents (O1, P1, K1, N2, M2, S2, K2) using the Department of Fisheries and Oceans (DFO) standard tidal prediction program. The tidal constituents for the reference port of Prince Rupert and the secondary ports of Qlawdzeet Anchorage, Refuge Bay and Seabreeze Point were obtained from CHS. In the COCIRM-SED model, geostrophically balanced elevations due to Coriolis force at each open boundary are calculated and superimposed on tidal components at every time step. The Skeena River discharge data were obtained from Canadian Hydrological Database, archived by Environment Canada. The wind data were obtained from the Prince Rupert airport weather station, operated by Environment Canada. The initial water properties (temperatures, salinities and densities) within the model domain and at the boundaries were derived using historical CTD/bottle data from the on-line DFO database for BC coastal waters.

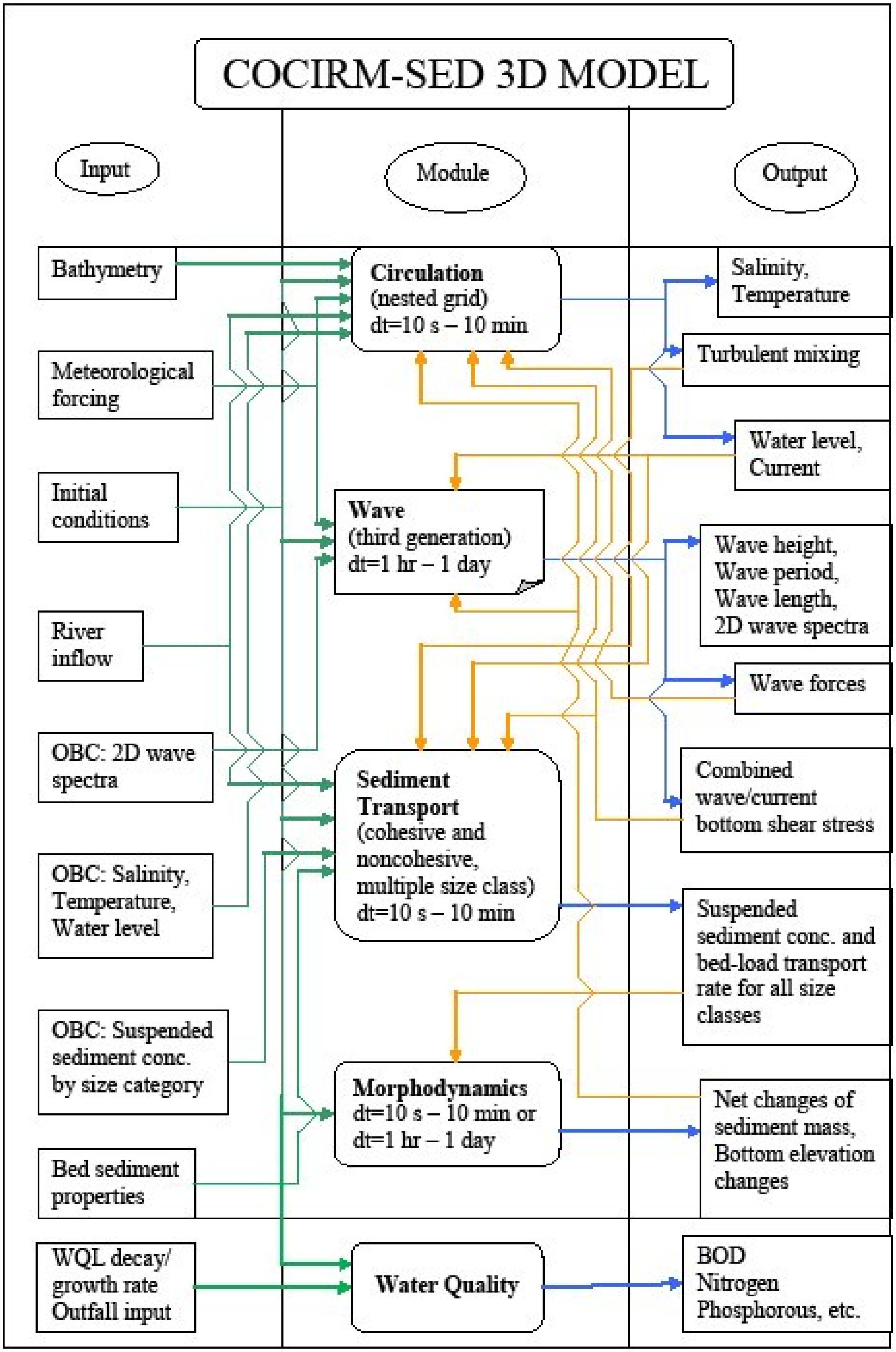

Figure 2: Schematic diagram of the COCIRM-SED numerical model.

3.0 MODEL CALIBRATION AND VERIFICATION

The model was first validated through model calibration and verification runs using historical ocean current data collected by Institute of Ocean Science (IOS) and Canadian Hydrographic Service (CHS), DFO, at two current mooring sites near the potential disposal sites 1 and 2 (Figure 1), one to the south of Kinahan Island (instrument depth 16 m and measurement period May-Sep, 1982) and the other off the west coast of Ridley Island (instrument depth 17 and 31 m, and measurement period May-Sep, 1993). The calibration case dealt with the 21 day long late spring period of June 1st – 22nd, 1982. The verification case dealt with a 25 day summer period of July 23rd – August 17th 1993. Both calibration and verification runs involved the tidal forcing, river input and wind forcing.

The model was initially tested and operated in the calibration run. Various physical parameters, mainly bottom drag coefficient and horizontal and vertical eddy diffusivity coefficients were repetitively adjusted to achieve optimal agreement with the observations and physically reasonable flow patterns in the model area. The vertical diffusivity for the model, as derived from the second order turbulence closure model (Mellor and Yamada, 1982), was found to be robust. Some adjustments of the horizontal diffusivity and bottom drag were made through the user-specified calibration parameter in Smagorinsky’s formula (Smagorinsky, 1963) and bottom effective roughness height.

The calibration results of modeled versus measured ocean current speed and direction for 16 m depth at the mooring site are shown in Figure 3. It is seen that the model results are in reasonably good agreement with observations. Figure 4 shows model peak ebb and flood flows at 15 m depth for a spring tide. It is seen that the modeled flow patterns in the model area are physically reasonable.

The model was next operated in validations runs using the previously optimized physical parameters, and compared with different observation data sets. The agreement between the model outputs and the observations is used to assess the capabilities of the model. The verification results (Figures 5 and 6) appear to be in reasonably good agreement with observations as well.

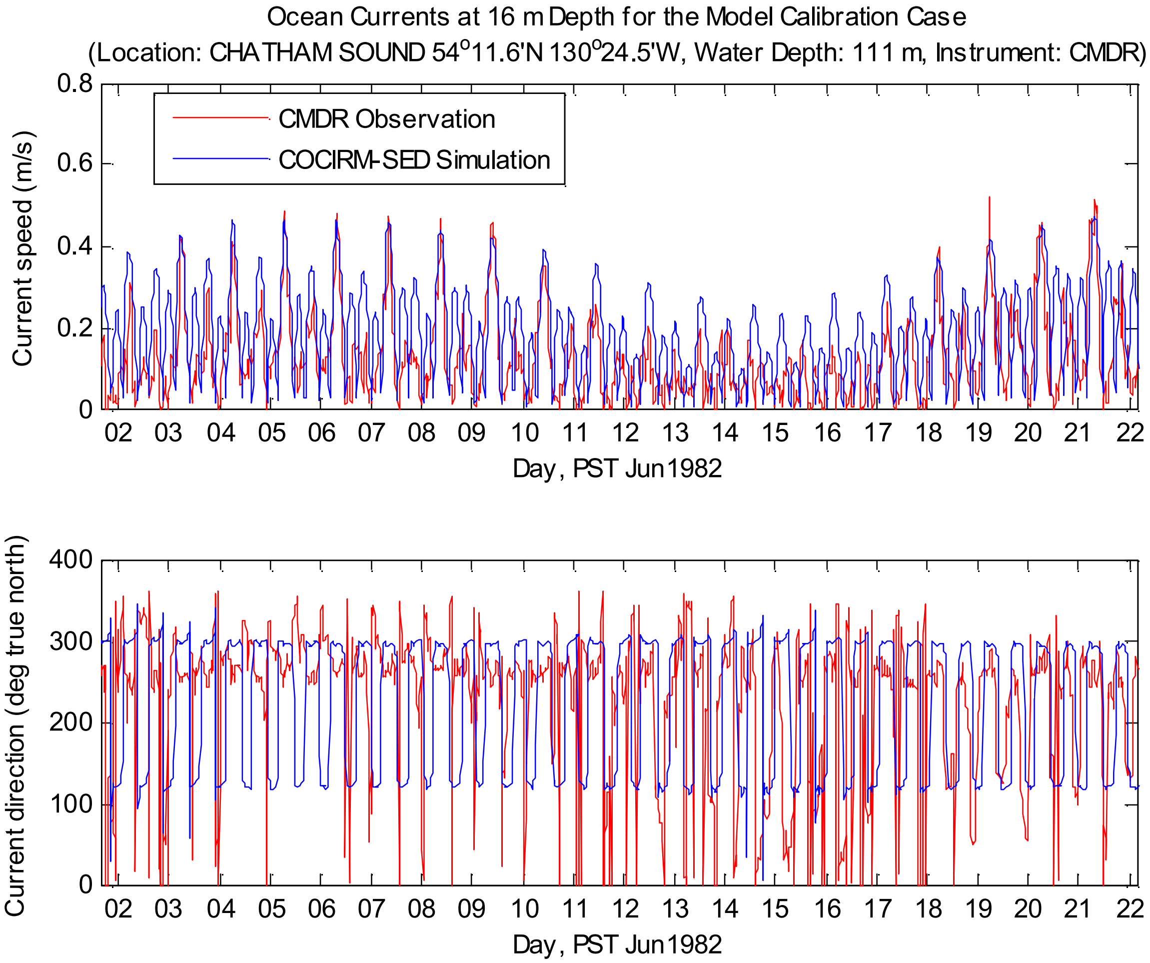

Figure 3: Calibration modeled and measured ocean currents at 15 m depth near disposal site 2.

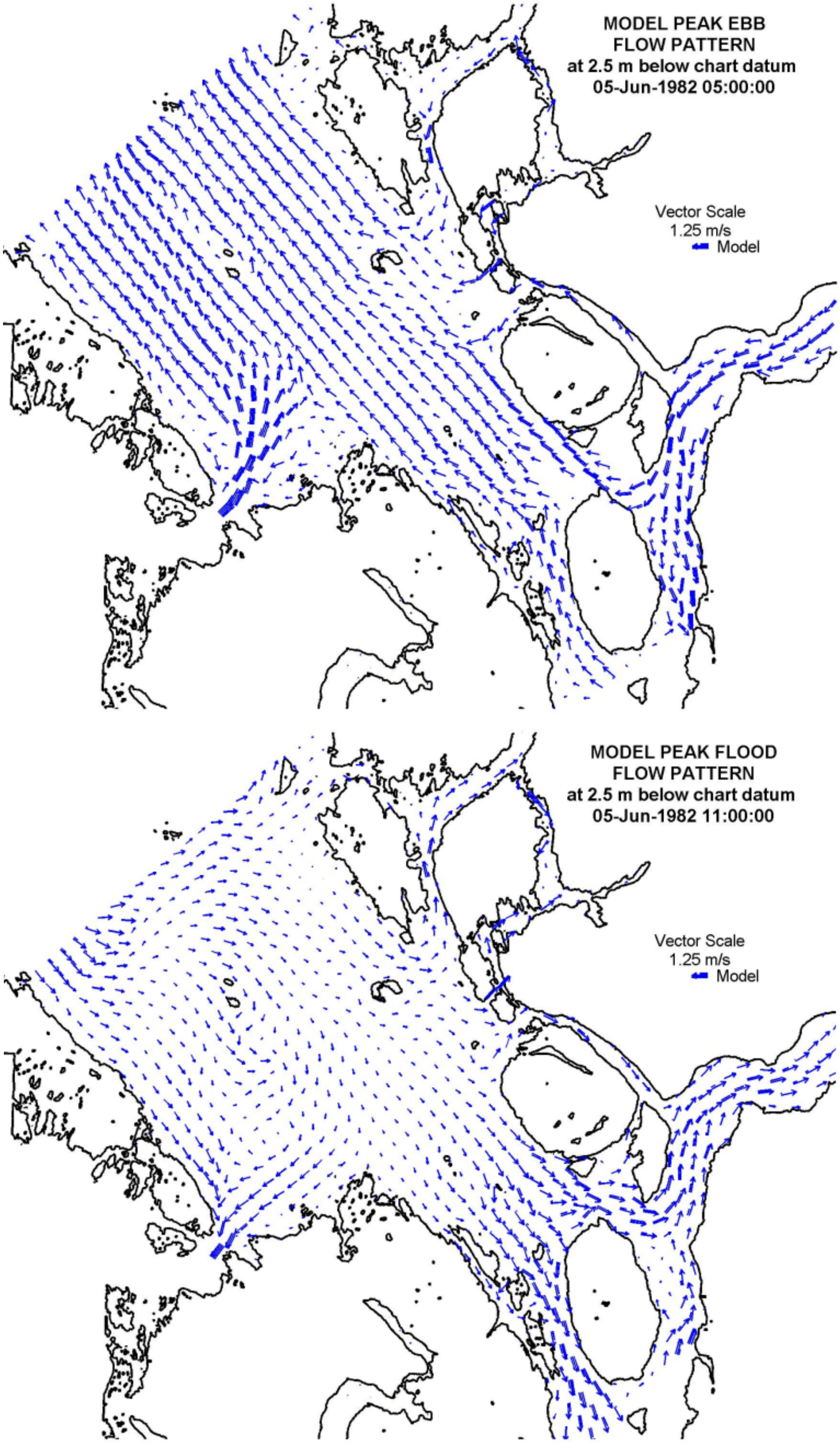

Figure 4: Calibration model results of the peak ebb (top panel) and flood (bottom panel) flows at 2.5 m below chart datum.

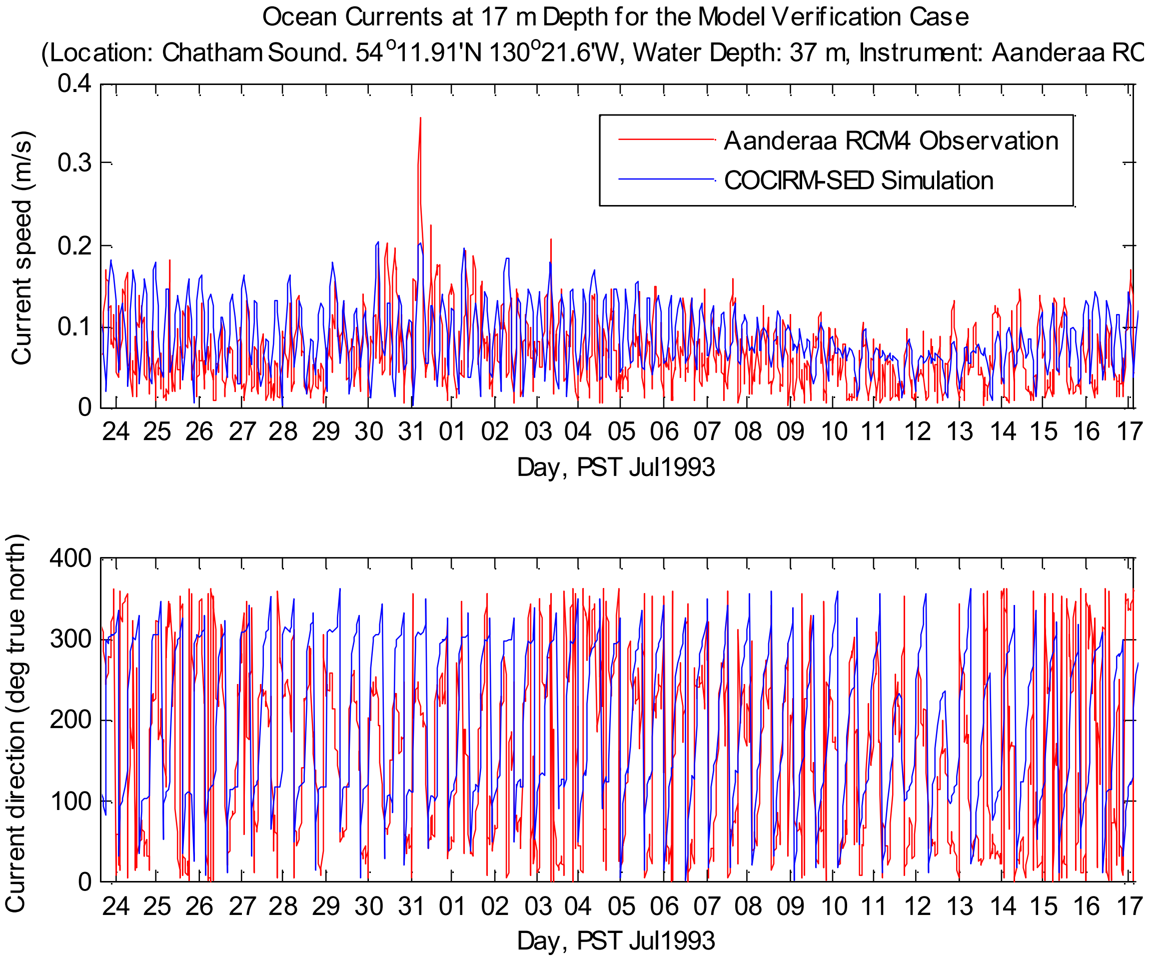

Figure 5: Verification modeled and measured ocean currents at 17 m depth near disposal site 1.

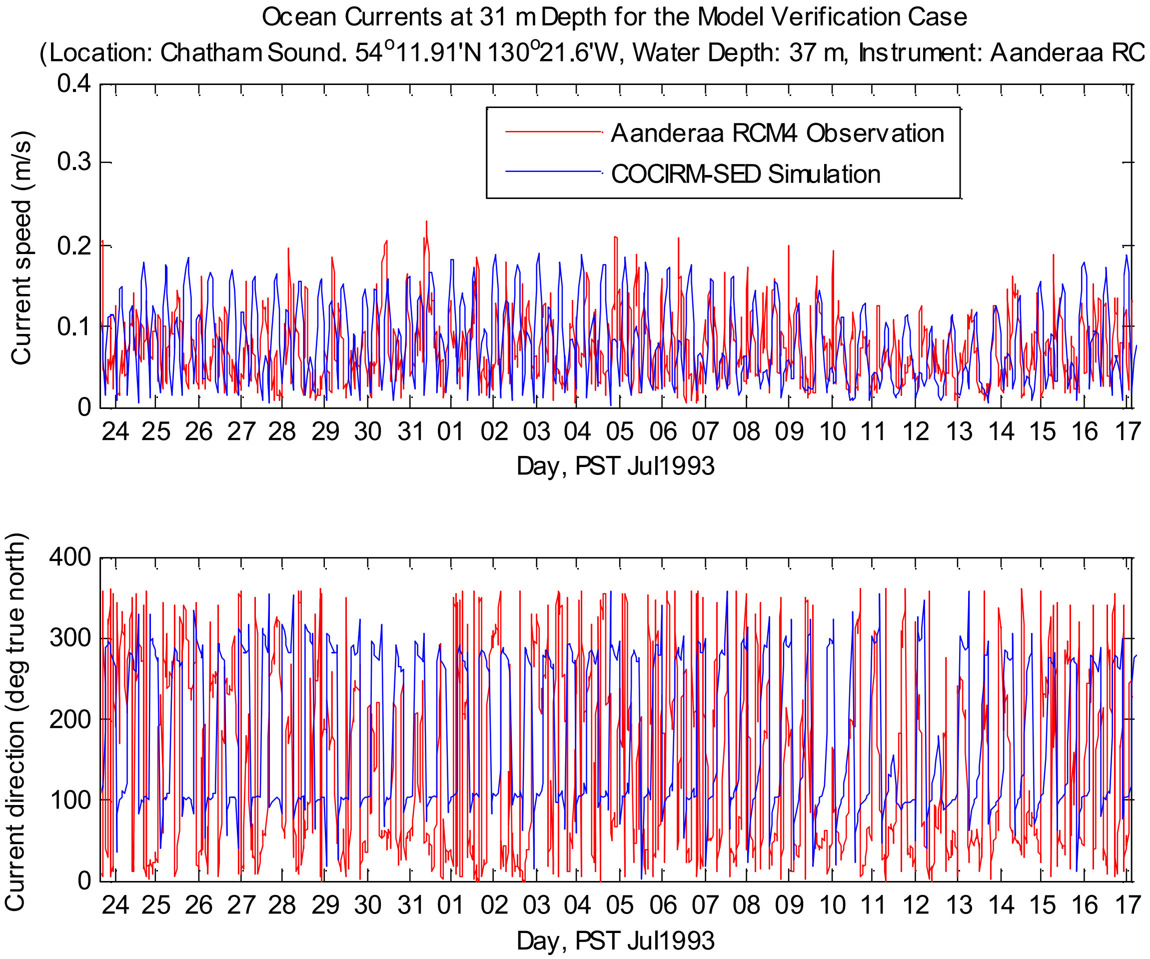

Figure 6: Verification modeled and measured ocean currents at 31 m depth near disposal site 1.

4.0 MODELING DREDGING DISPOSAL

4.1 Input Parameters of Disposal Sediment to Model

After the completion of model calibration and verification, the model was then used to simulate the transport and fate of the sediments released during and after the disposal operations at the two potential disposal sites (Figure 1). It is planned to release the dredging materials using different disposal approaches for these two sites. At the nearshore site off Ridley Island, namely site 1, the dredging material will be released into the water via pipe slurry discharge, while at the offshore site to the south of Kinahan Island, namely site 2, the traditional barge disposal will be used.

The input parameters of the disposal sediment for these two sites are summarized in Tables 1 and 2 respectively. Both sites has the same amount of disposal material with a total volume of 850,000 m^3 (810,000 m^3 sediment and 40,000 m^3 rock in situ), the same disposal material size distribution. According to sediment sampling data, a total of 5 sediment categories were identified in the model, respectively clay (0.004 mm, 30.39%), fine silt (0.02 mm, 40.71%), coarse silt (0.05 mm, 21.18%), medium sand (0.2 mm, 6.5%) and gravel (30 mm, 0.17%). It is seen that the fine-grained/cohesive sediment content (clay and silt) in the dredge material is over 90%. In saline water, suspended cohesive sediments with particle size less than 62 mm (clay – silt range) normally aggregate into stronger, denser and larger flocs. As a result, the settling velocity of cohesive sediment increases by a factor of 1 – 2 orders compared with the free settling velocity of the individual fine particles (Jiang 1999). Therefore, the flocculation settling will play very important role in the transport and fate of the dredging material disposal. Due to lack of flocculation experimental information, model sensitivity tests were conducted to select reasonable values of the flocculation settling velocities for clay, fine silt and coarse silt particles. After several trials, it was determined that the flocculation settling velocities as introduced in STFATE are very reasonable and can be used in this disposal modeling, which are 0.61 mm/s for clay, 2.2 mm/s for fine silt and 4.6 mm/s for coarse silt (Tables 1 and 2). These values are respectively about 44, 6 and 2 times of the individual clay, fine silt and coarse silt particle free settling velocities.

Before release into water, the disposal material has a density of 1,280 kg/m^3 (or dry density about 420 kg/m^3) for site 1 in the pipe, and 1,340 kg/m^3 (or dry density about 513 kg/m^3) for site 2 on the barge. When placed under water, the volume of the disposal material would increase by a factor up to 1.4. The upper limit bulking factor of 1.4 was used in this study in order to be conservative in the sense of estimating the maximum volumes of sediment discharges.

The disposal pipe at site 1 has a diameter of about 1 m and is 10 m off seabed. The pipe will move at a speed of about 100 m/hour with a slurry discharge rate of about 2,750 m^3/hour. The slurry pipe was assumed to operate 7 hours per day. Fore site 2, the capacity of the disposal barge was taken to be 2,000 m^3, with 5 trips per day. Both the disposal pipe at site 1 and barge operations at site 2 were simply assumed to run 24 hours a day with a constant time interval between each operation. However, adverse weather conditions may delay operations out to the disposal site during which time the disposal material would be accumulated near the project site, and then the disposal operations would continue when weather permits. It should be noted that the disposal scenario used in the numerical modeling studies is conservative in the sense that not including any weather delays will tend to result in the highest concentrations of suspended sediments per unit time.

Table 1: Summary of sediment input parameters for the pipe disposal at site 1.

Parameter	Value				
Sediment category	Clay 0.004 mm 30.39% 0.61 mm/s	Fine silt 0.02 mm 40.71% 2.2 mm/s	Coarse silt 0.05 mm 21.18% 4.6 mm/s	Medium sand 0.2 mm 6.5% Free settling	Gravel 30 mm 0.17% Free settling
Total volume	850,000 m^3				
Slurry density	Bulk density 1,280 kg/m^3 (in pipe)		Dry density 420.26 kg/m^3 (in pipe)		
Slurry discharge	2,750 m^3/hour				
Daily operation	7 hours (evenly split)				
Pipe size	1 m diameter				
Pipe height	10 m off seabed				
Bulking factor	≤ 1.4 (volume bulking factor of slurry discharge when placed under water)				
Modeling period	Nov. 21 – Jan. 21 (1 day for spin up, 45 days for disposal, 15 days for post-disposal)				

Table 2: Summary of sediment input parameters for the barge disposal at site 2.

Parameter	Value				
Sediment category (same as site 1)	Clay 0.004 mm 30.39% 0.61 mm/s	Fine silt 0.02 mm 40.71% 2.2 mm/s	Coarse silt 0.05 mm 21.18% 4.6 mm/s	Medium sand 0.2 mm 6.5% Free settling	Gravel 30 mm 0.17% Free settling
Total volume	850,000 m^3 (same as site 1)				
Sediment density	Bulk density 1,340 kg/m^3 (on barge)		Dry density 512.69 kg/m^3 (on barge)		
Barge capacity	2,000 m^3/hour				
Daily trip	5 (evenly split)				
Barge size	Overall length 80 m		Width 11.4 m		Draft 4.5 m
Duration of dump	2 minutes				
Bulking factor	≤ 1.4 (volume bulking factor of disposal material when placed under water)				
Modeling period	Nov. 21 – Mar. 02 (1 day for spin up, 85 days for disposal, 15 days for post-disposal)				

It was assumed that dredging and disposal activities would occur during fall and winter, to minimize levels of high turbidity that may be detrimental to marine life. Therefore, the disposal operation simulated in the modeling for both sites 1 and 2 began in late November until completion of all disposal operations. The total disposal modeling at site 1 lasted 61 days from late November to late January with 1 day for model spin-up, 45 days for the simulation of the disposal and 15 days for the simulation of post-disposal. The total disposal modeling at site 2 lasted 101 days from late November to early March with 1 day for model spin-up, 85 days for the simulation of the disposal and 15 days for the simulation of post-disposal.

Typical wind, river discharge and tidal forcing in the study area during the fall and winter seasons were used to drive the ocean currents in the model. Through an analysis of a 40 year wind data set recorded at Prince Rupert airport weather station, 80 year Skeena River discharge data and tidal elevations predicted using major tidal constituents, the winds, river discharges and tidal elevations over the period of late November 2009 to early March 2010 were used as the input of driving force to the model.

4.2 Modeling Short-term Fate of Disposal Sediment

For each disposal operation, the short-term fate and near-field distribution of the disposal material released from the pipe or barge were modeled using the U.S. Army Corps of Engineers' STFATE (Short-Term Fate of Dredged Material) which is accepted by the U.S. Environmental Protection Agency (EPA and USACE, 1995). This model provides detailed input information to COCIRM-SED, including deposition and suspended sediment concentrations and distributions by categories during the initial 15 – 45 minutes of disposal operation.

At site 1, the disposal operation was simulated in a fashion of being very similar with pipe releasing by reducing the STFATE barge horizontal dimensions and lowering the barge draft to about 10 m off seabed, and meanwhile increasing dumping duration to realistically simulate a continuous pipe slurry discharge, which releases 2,750 m^3 dredging material over a one hour period for each disposal operation. The barge length, width and draft were taken as 35 m, 10 m and 40 m respectively, and the dumping duration was taken as half hour. The STFATE output data of deposition and suspended sediment concentration distribution during the initial 45 minutes of disposal operation were input to COCIRM-SED for long-term fate simulation of the disposal sediment.

At site 2, the disposal barge length, width and draft were taken as 80 m, 11.4 m and 4.5 m respectively. And the dumping duration was taken as 2 minutes. The STFATE output data of deposition and suspended sediment concentration distribution during the initial 25 minutes of disposal operation were inputted to COCIRM-SED for long-term fate simulation of the disposal sediment.

Bathymetry data input for STFATE modeling was taken from three representative location L1 – L3 for both disposal sites 1 and 2 (Figure 7), and the ocean current information input was taken as average flood and ebb ambient currents at these two sites.

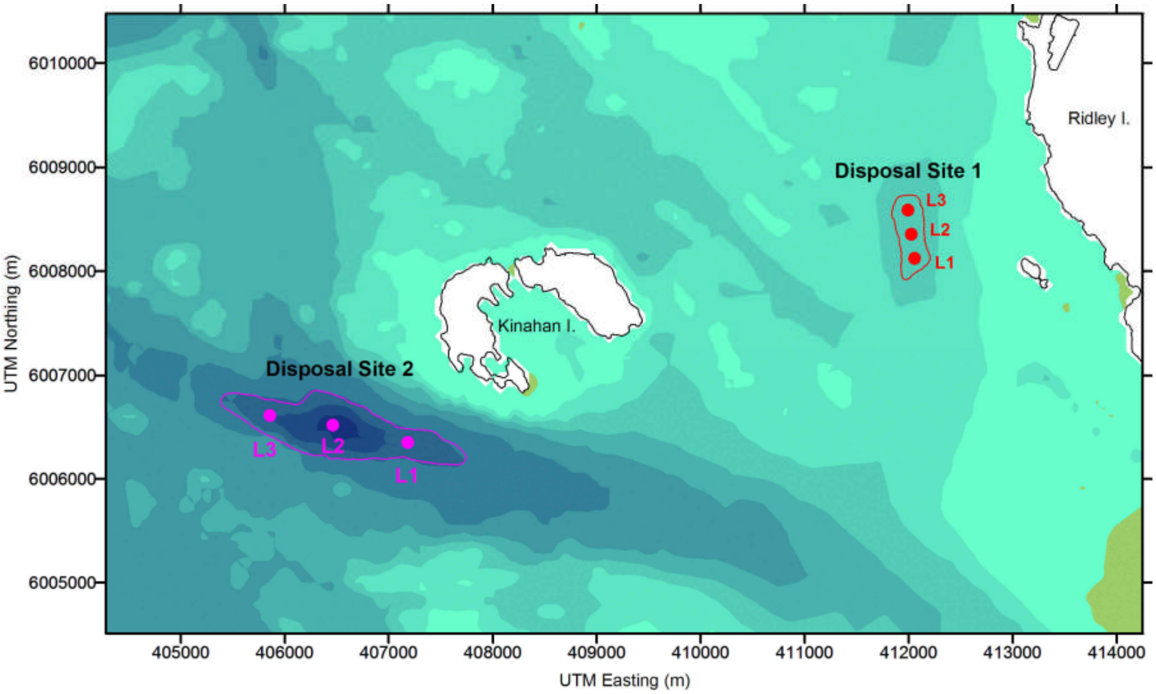

Figure 7: A map showing the three model pipe releasing locations (red dots) at disposal site 1 and the three model dumping locations (purple dots) at disposal site 2.

5.0 MODEL RESULTS AT SITE 1

The disposal operation via pipe at site 1 was initially simulated with STFATE, which ran over the initial 45 minutes of sediment disposal under average flood and ebb currents for three representative locations with a very long dumping duration of 30 minutes in order to realistically simulate the continuous pipe disposal, which releases a slurry discharge of 2,750 m^3 over one hour period for each disposal operation. The STFATE model results of the suspended sediment concentration (SSC) and initial deposition on the seabed were input to the COCIRM-SED model, which then simulated the transport and fate of all dredging materials over much larger spatial scales and longer periods of time. In COCIRM-SED, the initially suspended sediments were gradually released into COCIRM-SED grids over a half hour period, which is the remaining time of the one hour slurry discharge period for each pipe disposal operation.

The STFATE model results show that during initial 45 minutes of each pipe disposal operation, all gravel and sand settles out on the seabed, while about half of the clay and silt remains suspended in the water column, with a total deposition of 57.24% and the remainder in suspension. It is also seen that the suspended sediment is mostly concentrated within 10 m of the bottom, with maximum near-bottom TSS values equivalent to about 7200 mg/L above background (Figure 8), and the initial suspended sediments spreading into an area of about 200 m in diameter.

5.1 Model TSS Level

The COCIRM-SED model results of TSS plumes at 45 m, 35 m and 25 m below chart datum are presented both during and after the disposal (Figures 9 – 12). The time series of the model generated maximum TSS and velocity values in the disposal site are also presented (Figure 13). From the model results, it is found that maximum near-bottom TSS values at 45 m depth after each one hour pipe releasing operation is up to about 2,000 mg/L. The high near-bottom TSS clears up quickly due to sediment settling and strong dilution, with a maximum near-bottom TSS value of less than 30 mg/L within about 2 hours after each disposal event.

In the vertical, TSS values decrease towards the surface. The near-surface TSS level during disposal is mostly less than 1 mg/L at 15 m depth and less than 25 mg/L at 25 m depth. Higher TSS values of 25 – 50 mg/L at 25 m depth occur only at the center of the releasing level right after each disposal operation. Consequently, the minimum depth with TSS values greater than 25 mg/L (which reflect BC water quality guideline above background level) is always greater than 30 m over the entire disposal period.

After the completion of each marine dredging discharge event, TSS values gradually decrease as the suspended sediment settles out on the seabed and is further diluted (Figures 11 and 12). The model results show that maximum TSS levels in the study area are reduced to less than 1 mg/L within 7 hours after the completion of all dredging disposal.

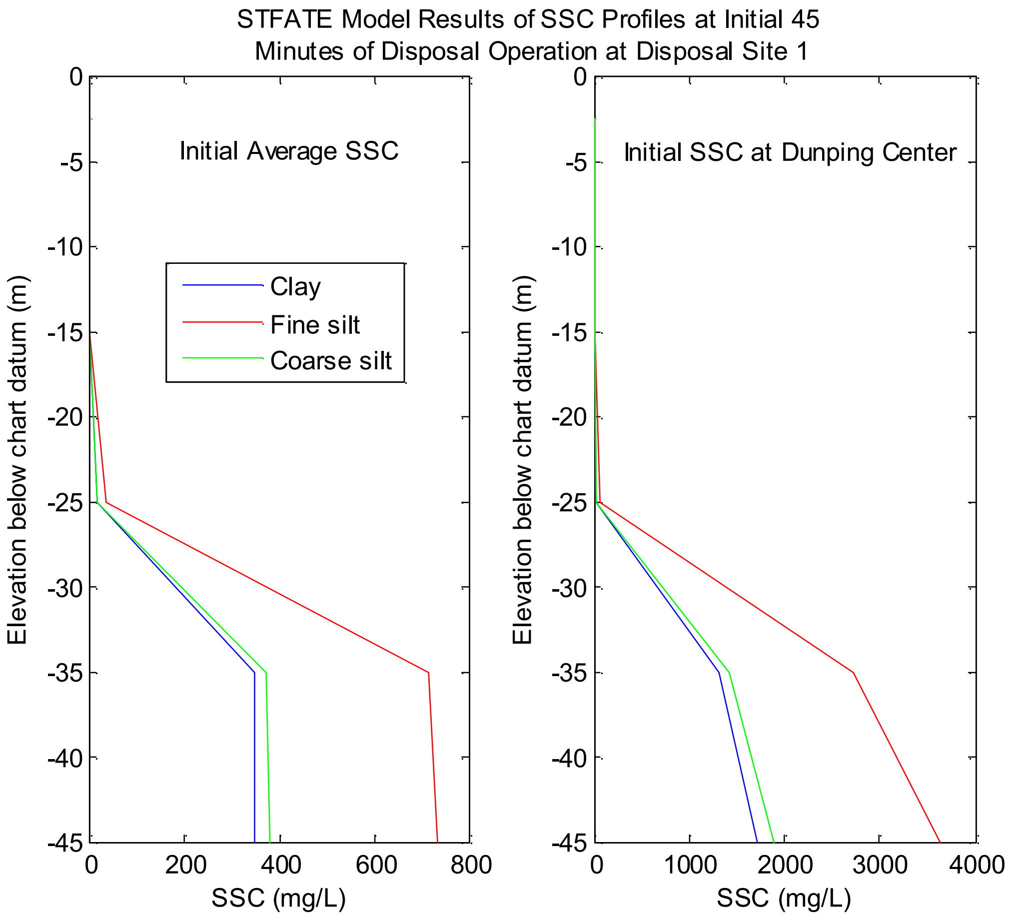

Figure 8: The STFATE model results of SSC profiles after the initial 45 minutes of site 1 disposal operations at the pipe releasing location L1 under average ebb currents.

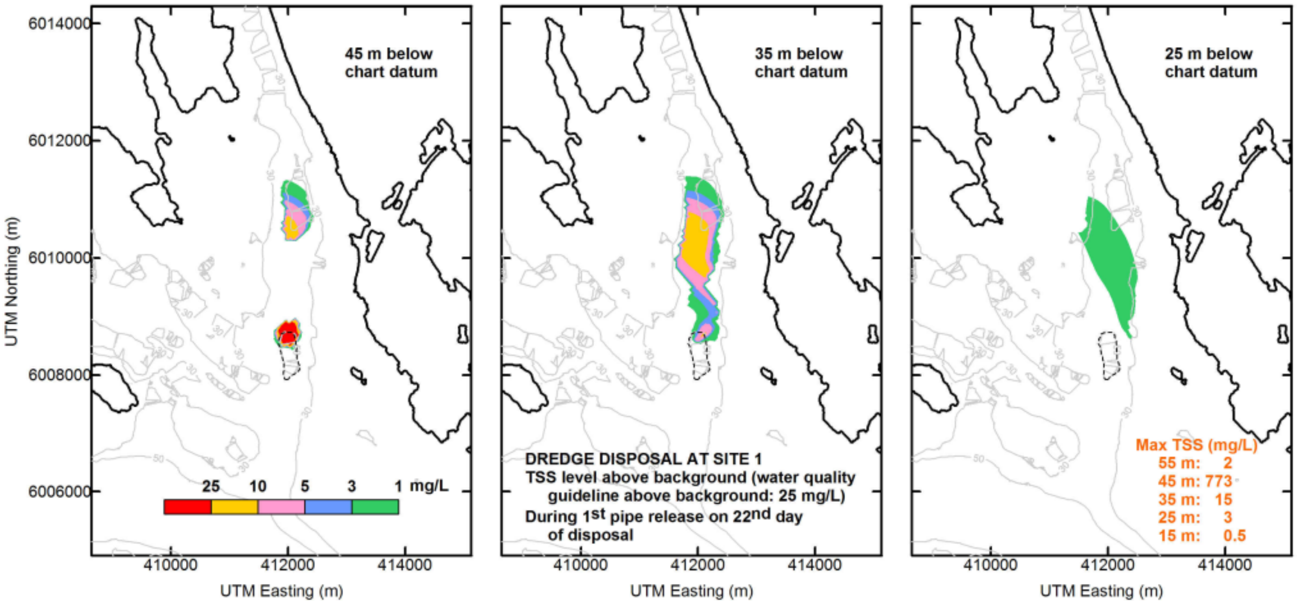

Figure 9: TSS plume at 45 m, 35 m and 25 m below chart datum during first pipe release on 22nd day of the dredging disposal at site 1.

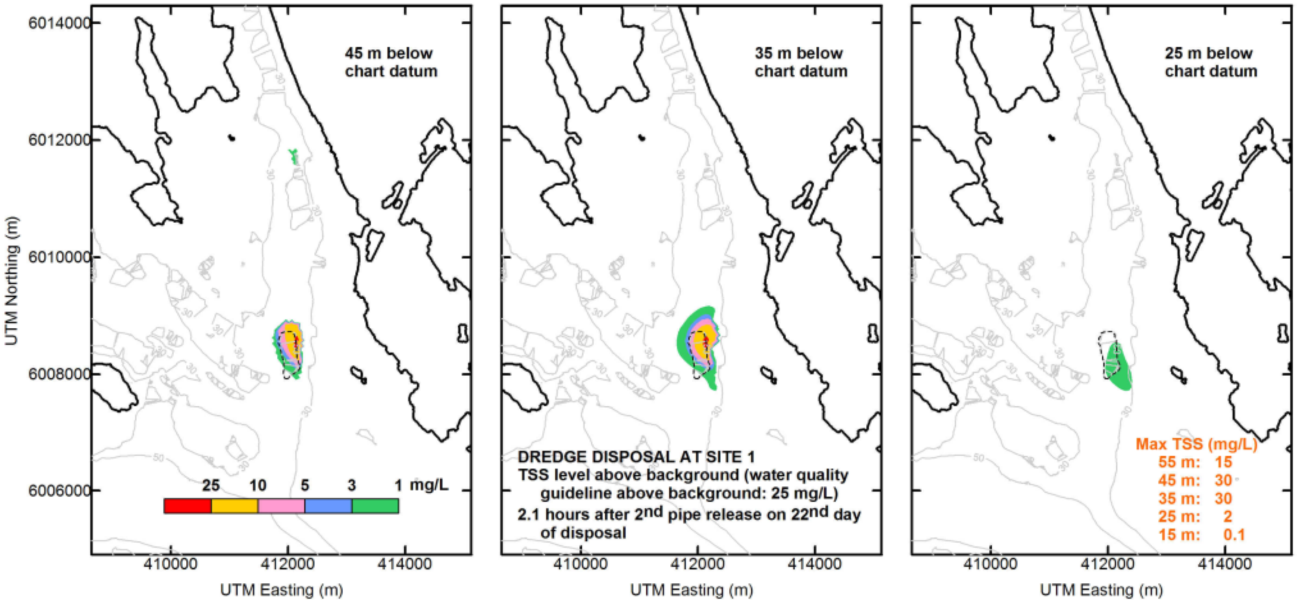

Figure 10: TSS plume at 45 m, 35 m and 25 m below chart datum 2.1 hours after 2nd pipe release on 22nd day of the dredging disposal at site 1.

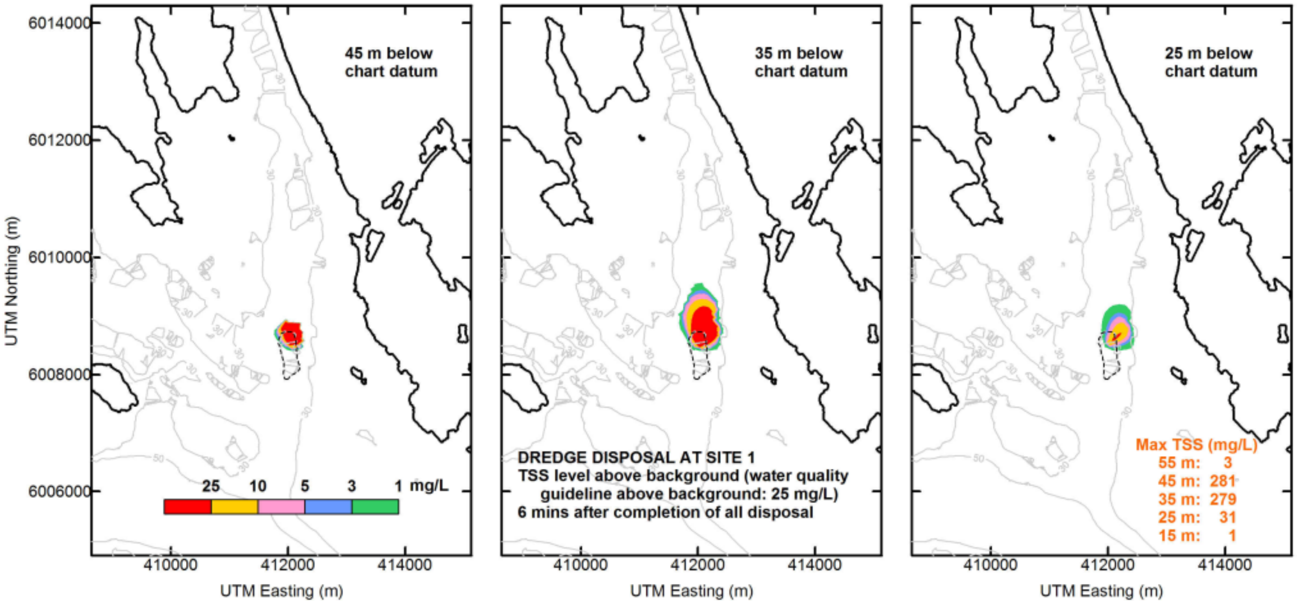

Figure 11: TSS plume at 45 m, 35 m and 25 m below chart datum 6 minutes after completion of all dredging disposal at site 1.

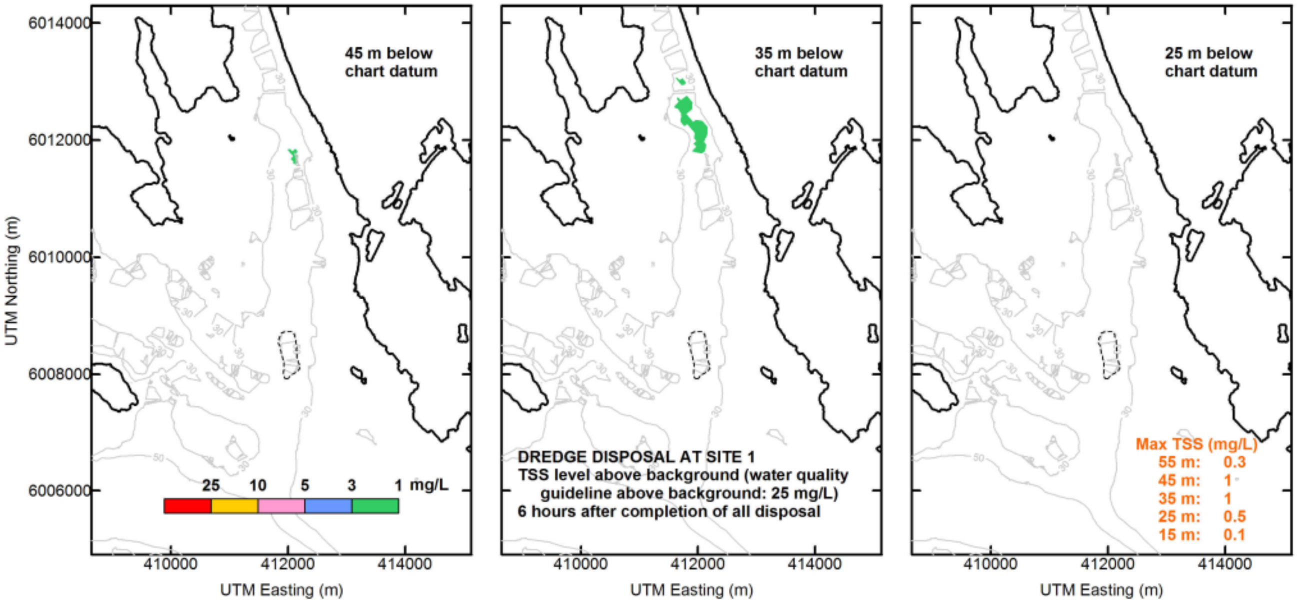

Figure 12: TSS plume at 45 m, 35 m and 25 m below chart datum 6 hours after completion of all dredging disposal at site 1.

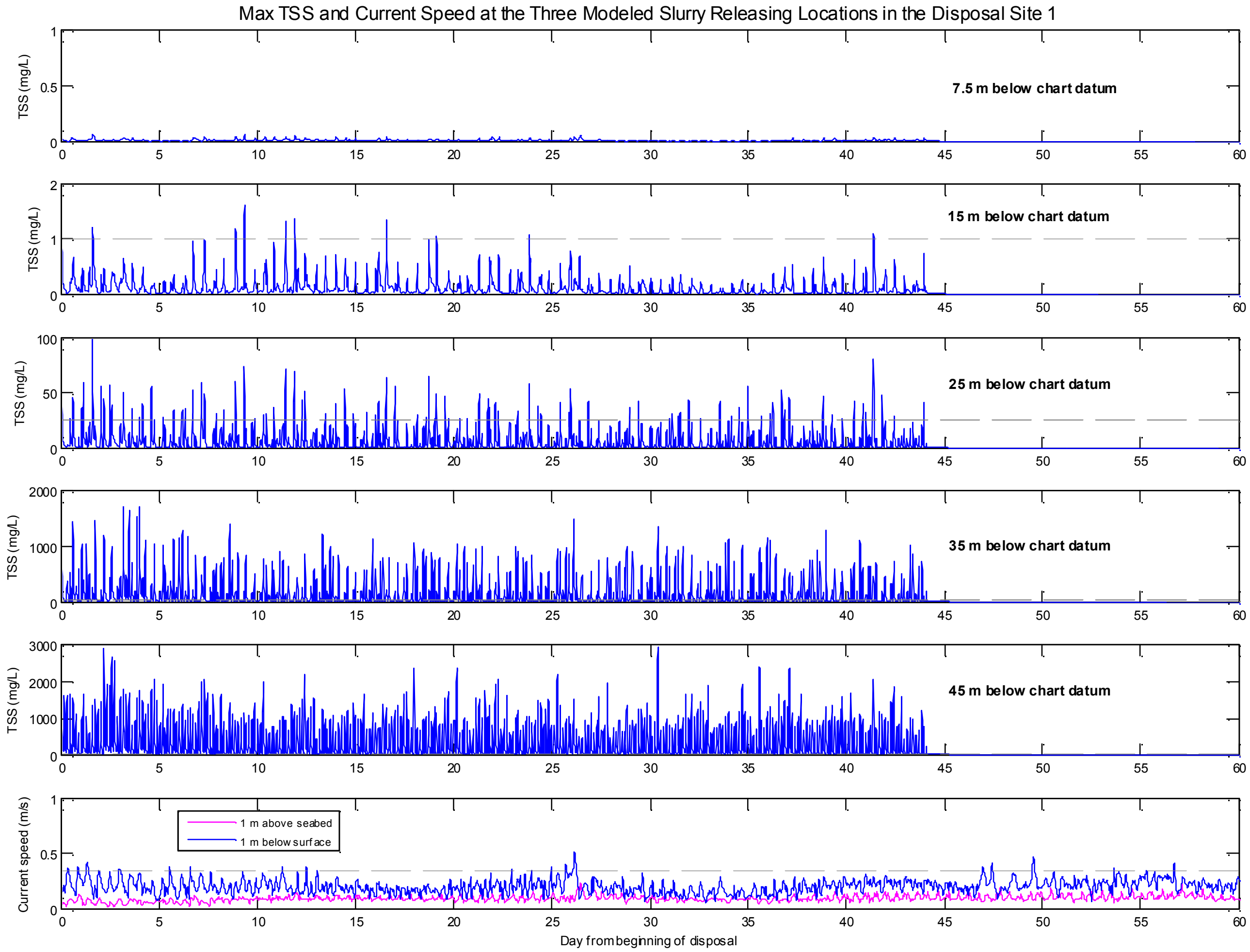

Figure 13: Time series of max TSS and current speed at the three modeled slurry releasing locations (L1 – L3) in the disposal site.

5.2 Model Bottom Accumulation

The total bottom deposition at 15 days following the completion of all dredging discharge is presented in Figure 14. By this time, all suspended disposal sediments have settled out and are located on the seabed. It was assumed that the volume of disposal material increases by an upper limit factor of 1.4 when placed under water. Therefore, the bottom accumulation shown in Figure 14 reflects very conservative values.

It is seen that most dredging materials are deposited in the deeper water to the north of the disposal site where water depths are greater than 30 m and where the near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. Total deposition within the disposal area occupies 58.43% of total dredging material, with a deposition thickness ranging from 1200 mm to 5192 mm. The area with total deposition greater than 1 mm is located in deeper water where water depths are greater than 30 m. The total deposition within this area occupies 88.5% of total dredging material.

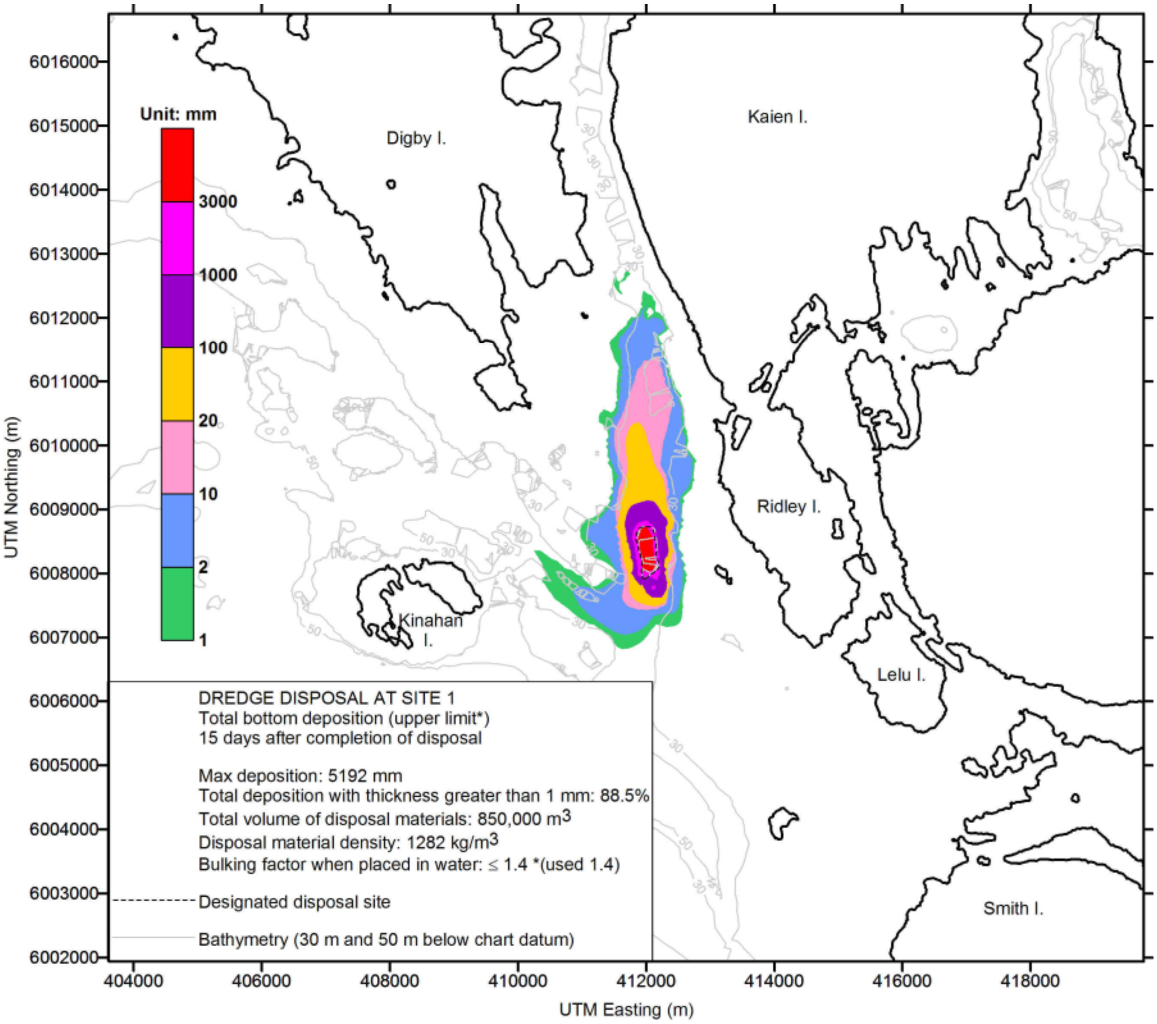

Figure 14: Total bottom deposition of dredge material 15 days after completion of all disposals at site 1.

5.3. Post-disposal Resuspension

After all disposal completed at site 1 and most of disposal sediment settled out on seabed with maximum TSS less than 1 mg/L, the model continued to simulate the sediment transport process for a 15 day period, including settling of the suspended sediment as well as the resuspension of the disposal sediment on seabed if near-bottom currents are strong enough for the incipient of the deposited sediment. The model results of the total resuspended amount of the disposal sediment on seabed (Figure 15) show that the resuspension in this area is very marginal, with a total resuspended sediment value of about 120 m^3 (underwater volume with bulking factor considered) over the 15 day post-disposal modeling period, which is about 3.1% of the pipe released sediment over one hour. It is also seen that the resuspension occurred only in the northern area where near-bottom currents are relatively stronger and the thickness of disposal sediment on seabed is less than 20 mm (Figure 16). The maximum resuspension over the 15 day model period is equivalent to about 1.3 mm of sediment deposition.

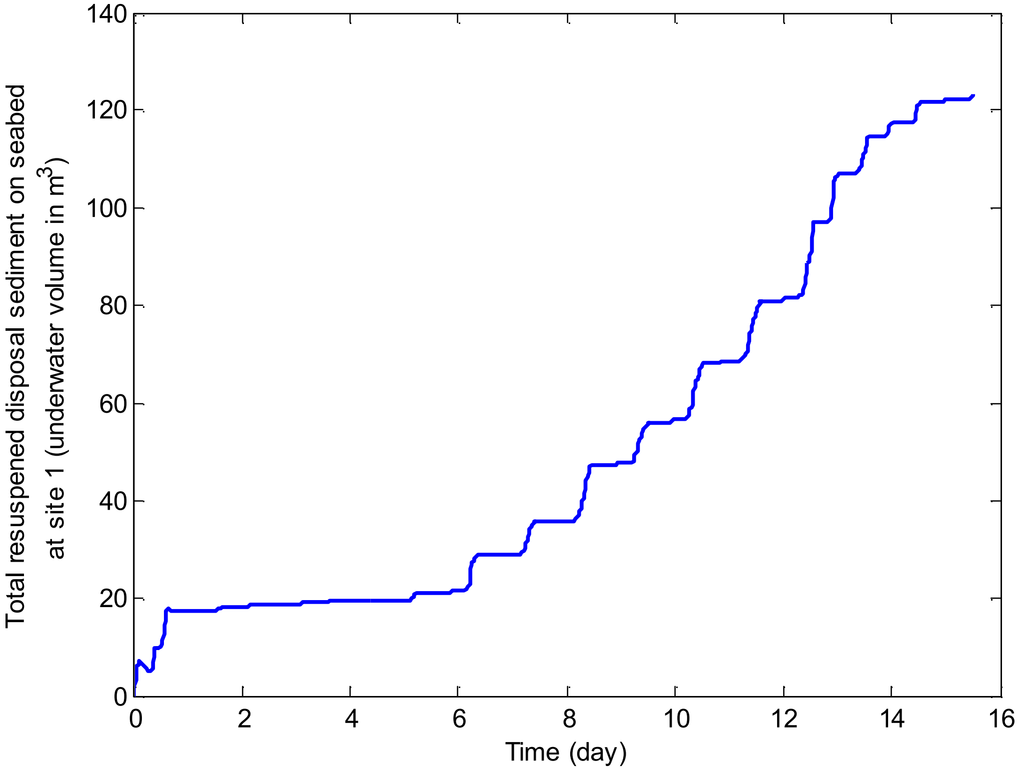

Figure 15: Time series of resuspension of the disposal sediment on seabed over a 15 day period after completion of all disposals at site 1.

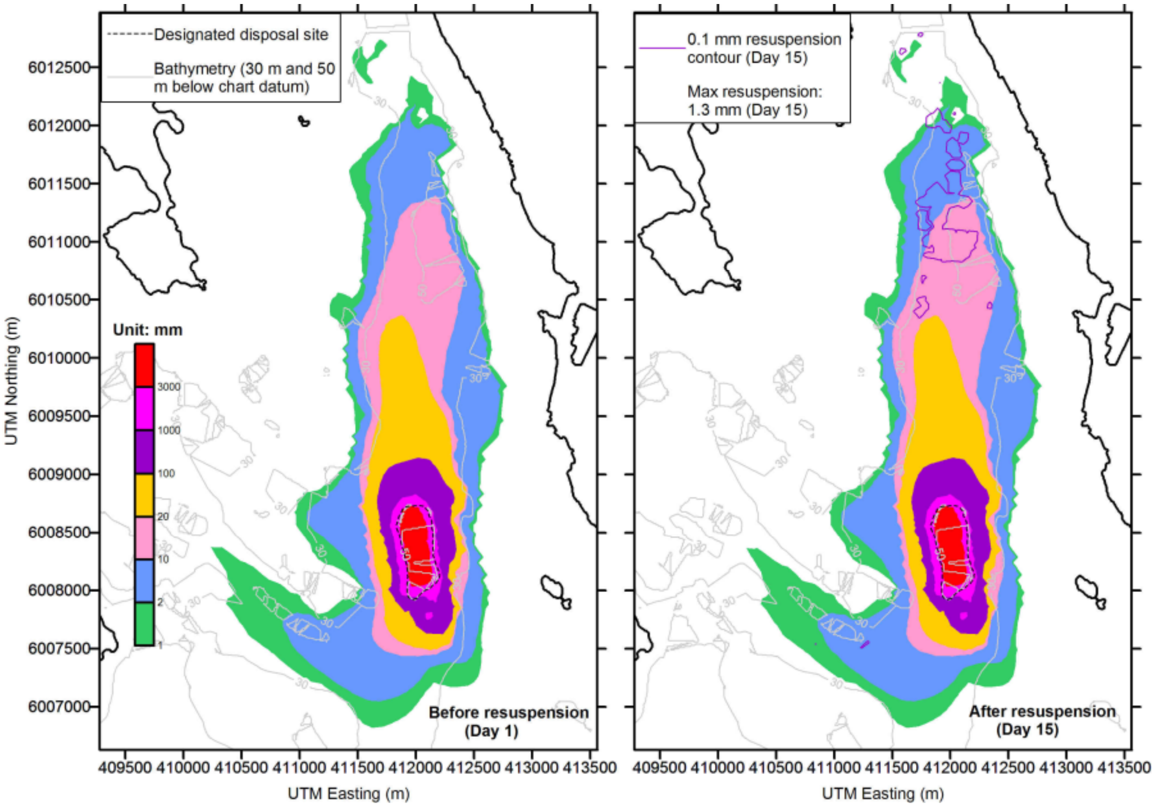

Figure 16: Disposal sediment on the seabed before (left) and after (right) resuspension over a 15 day period after completion of all disposal at site 1.

6.0 MODEL RESULTS AT SITE 2

The barge disposal operation at site 2 was initially simulated with STFATE, which ran over the initial 25 minutes of sediment disposal under average flood and ebb currents for three representative locations. The STFATE model results of the suspended sediment concentration and initial deposition on the seabed were input to the COCIRM-SED model, which then simulated the transport and fate of all dredging materials over much larger spatial scales and longer periods of time. The STFATE model results show that during the initial 25 minutes of each disposal trip, all gravel and most of sand settle out on the seabed, while about 60% of the clay and silt remains suspended in the water column, with a total deposition of 41.69% and the remainder in suspension. It is also seen that the suspended sediment is mostly concentrated in the water column below 50 m water depth, with maximum near-bottom (at 125 m depth) TSS values of up to about 900 mg/L (Figure 17), and the initial suspended sediments spreading into an area of about 700 m in diameter.

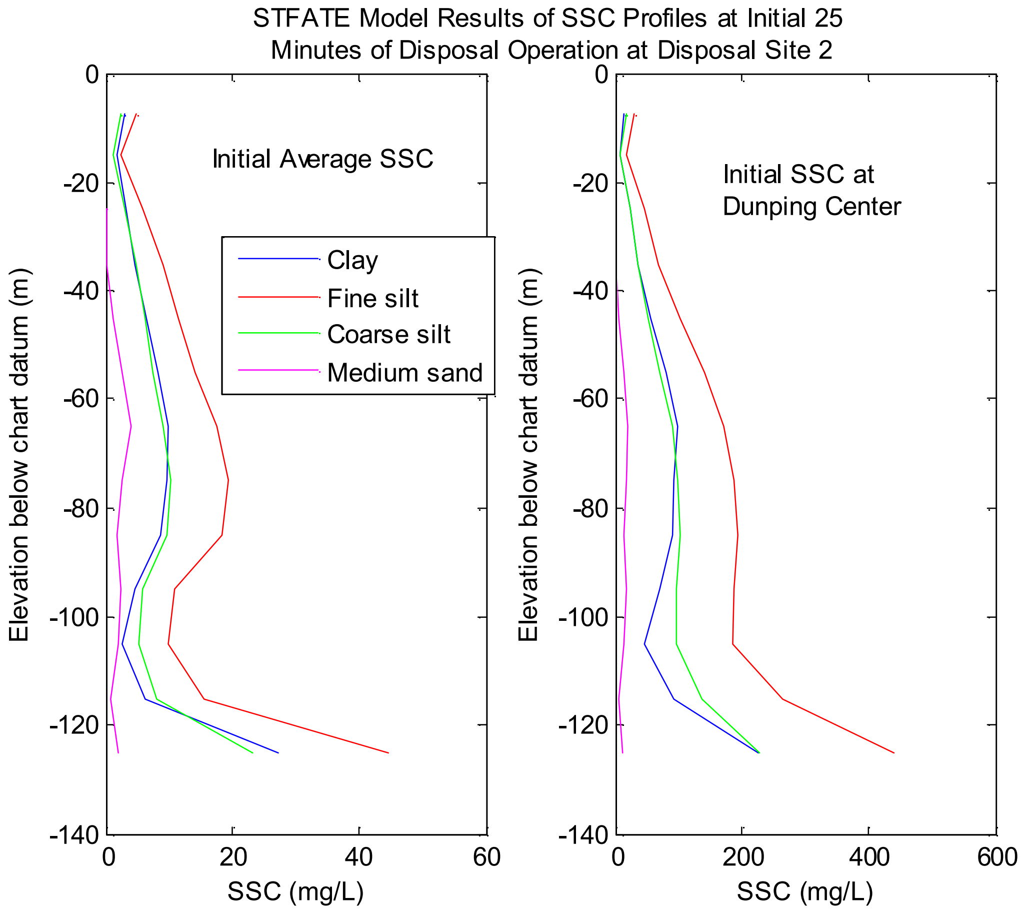

Figure 17: STFATE model results of SSC profiles at initial 25 minutes of site 2 disposal operation at dumping location L1 and under average ebb current.

6.1 Model TSS Level

The COCIRM-SED model results of the TSS plumes at 105 m, 55 m and 25 m depths are presented both during and after the dredging disposal (Figures 18 – 21). The time series of the model generated maximum TSS and velocity values in the disposal site are also presented (Figure 22). From the model results, it is found that maximum near-bottom (at 105 m depth) TSS values after each disposal trip is up to about 700 mg/L above background, which reflects the initial near-bottom TSS as derived from the STFATE model inputs. The high initial near-bottom TSS values are reduced quickly due to sediment settling and strong dilution, with a maximum near-bottom TSS value of less than 60 mg/L within about 2 hours after each disposal event.

In the vertical, TSS values decrease towards the surface. The TSS value during disposal is mostly less than 5 mg/L at 2.5 depth and less than 50 mg/L at 15 m depth. Higher near-surface TSS values greater than 25 mg/L (which reflects BC water quality guideline above background level) occur only at the center of the dumping site right after each disposal trip.

After the completion of each terrestrial overburden discharge event, TSS values gradually decrease as the suspended sediment settles out on the seabed and is further diluted (Figures 20 and 21). The model results show that maximum TSS levels in Chatham Sound are down to less than 1 mg/L within 10 hours after the disposal.

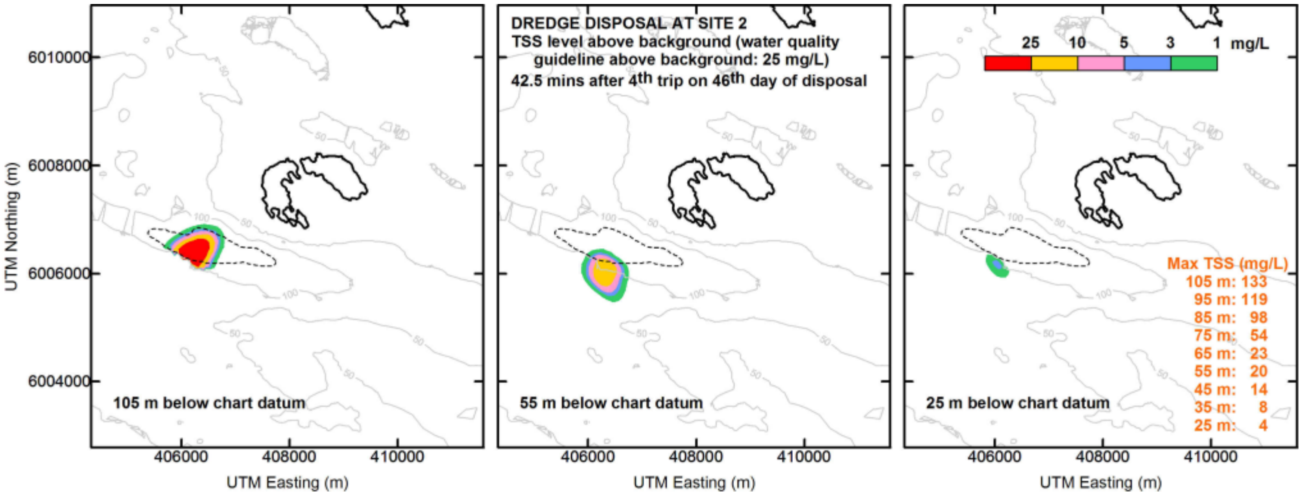

Figure 18: TSS plume at 105 m, 55 m and 25 m below chart datum 42.5 minutes after 4th disposal trip on 46th day of the dredging disposal at site 2.

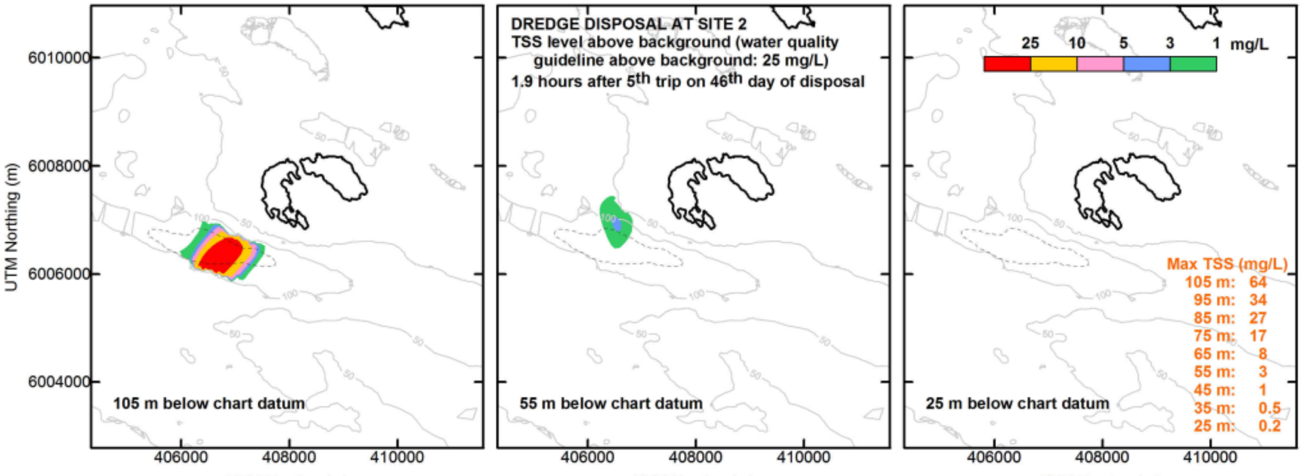

Figure 19: TSS plume at 105 m, 55 m and 25 m below chart datum 1.9 hours after 5th disposal trip on 46th day of the dredging disposal at site 2.

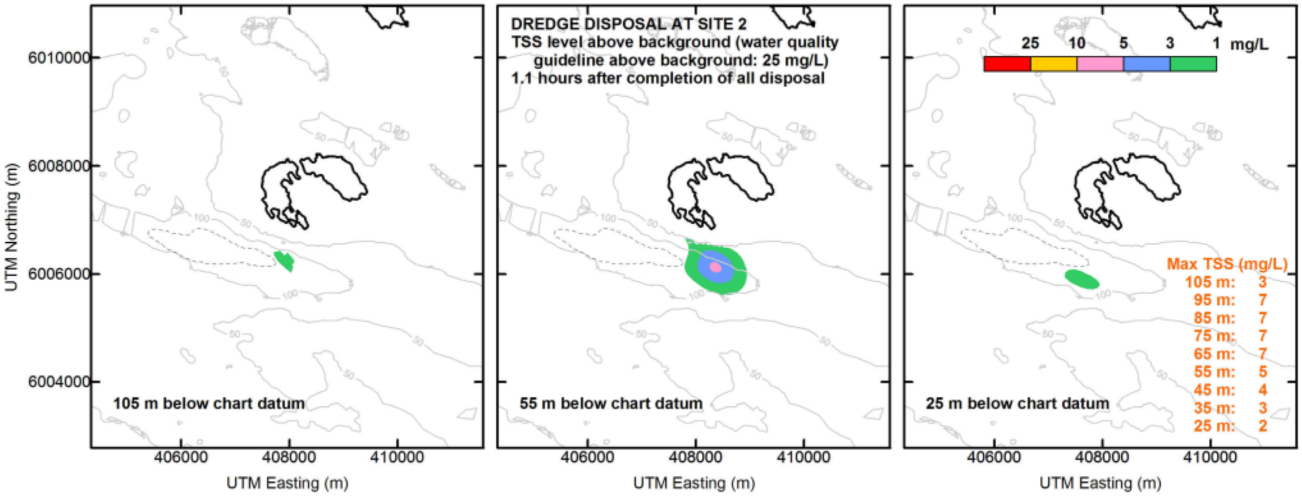

Figure 20: TSS plume at 105 m, 55 m and 25 m below chart datum 1.1 hours after completion of all dredging disposal at site 2.

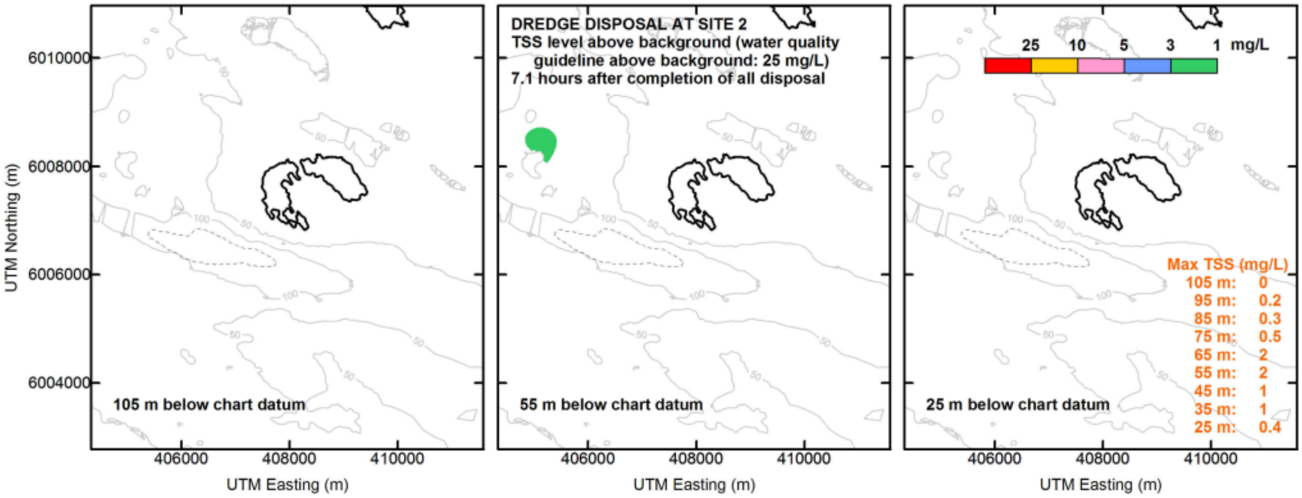

Figure 21: TSS plume at 105 m, 55 m and 25 m below chart datum 7.1 hours after completion of all dredging disposal at site 2.

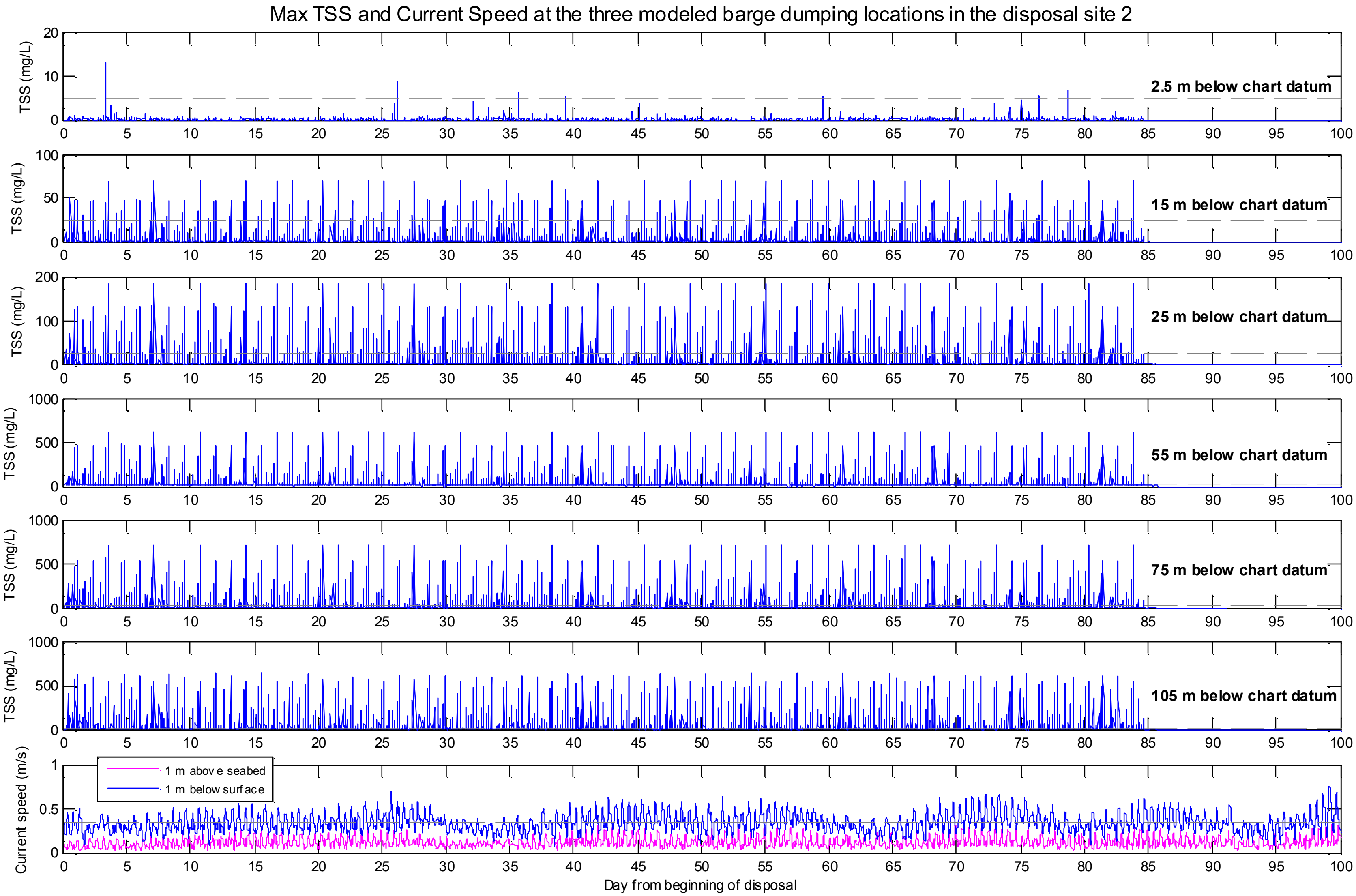

Figure 22: Time series of max TSS and current speed at the three modeled slurry releasing locations in the disposal site 2.

6.2 Model Bottom Accumulation

The total bottom deposition at 15 days after the completion of all dredging disposal is presented in Figure 23. By this time, all suspended disposal sediments have settled out and are located on the seabed. Again, it was assumed that the volume of disposal material increases by an upper limit factor of 1.4 when placed under water. Therefore, the bottom accumulation shown in Figure 23 reflects a very conservative level.

It is seen that most discharge materials are deposited in the deeper water to the ESE and N of the disposal site where water depths exceed 50 m and where near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. Total deposition within the disposal area accounts for 51.65% of the total dredging material, with a deposition thickness ranging from 200 mm to 1155 mm. The area with total deposition greater than 1 mm is located in areas of deeper water where water depths are greater than 50 m. The total deposition within this area accounts for 73.3% of the total terrestrial overburden material discharged to the ocean.

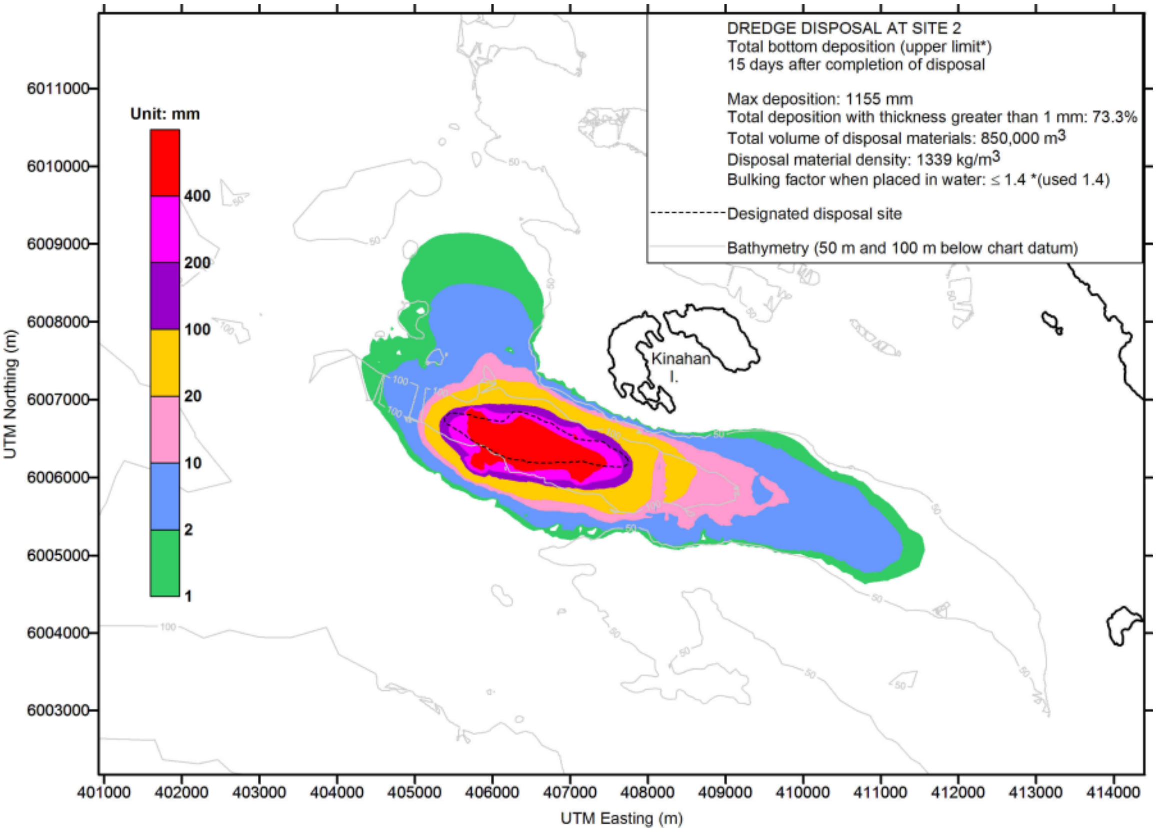

Figure 23: Total bottom deposition of the dredge material 15 days after completion of all disposals at site 2.

6.3. Post-disposal Resuspension

After all disposal completed at site 2 and most of disposal sediment has settled out on the seabed with maximum TSS less than 1 mg/L, the model continued to simulate the sediment transport process for a 15 day period, including settling of the suspended sediment as well as the resuspension of the disposal sediment if near-bottom currents are strong enough to resuspend the deposited sediment. The model results of the total resuspended amount of the disposal sediment on the seabed (Figure 24) show that the resuspension in this area is minor, with the total resuspended sediment of about 2,500 m^3 (underwater volume with bulking factor considered) over the 15 day post-disposal modeling period, which is about the same amount in one barge disposal trip which mostly occurred during the large spring tide in the end of the simulation (Figure 22). It is also seen that the resuspension mostly occurred in the area ESE of the disposal site where water depths are less than 100 – 120 m and the thickness of disposal sediment on seabed is mostly less than 100 mm (Figure 25). The maximum resuspension over the 15 day model period is about 7 mm.

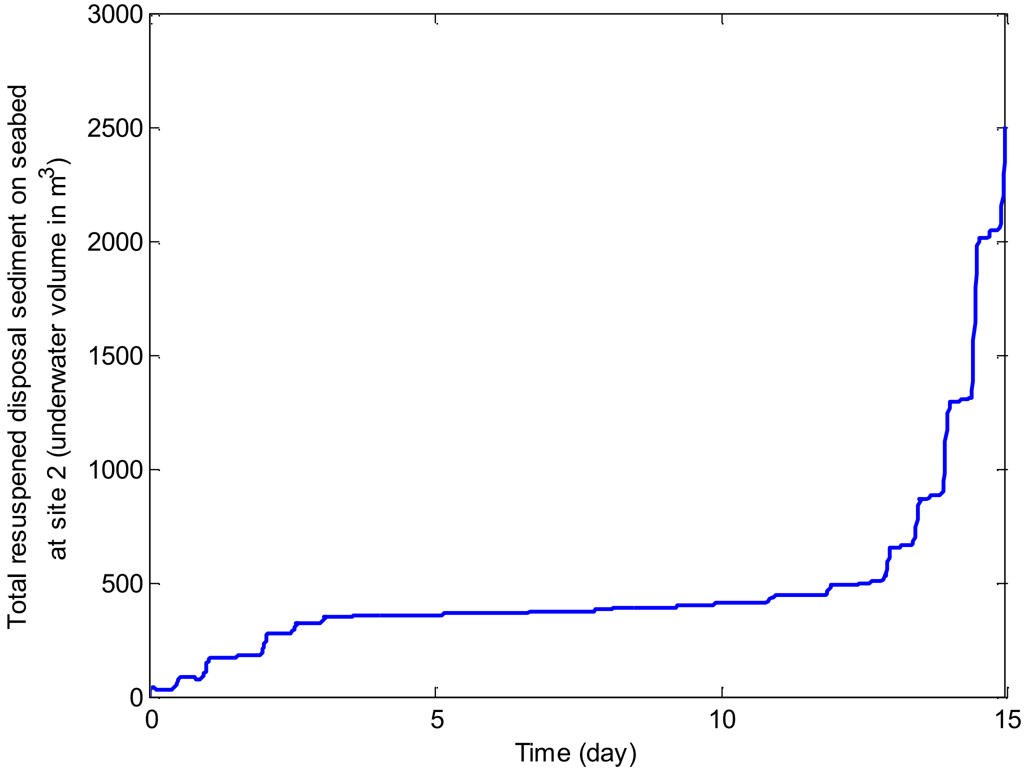

Figure 24: Time series of resuspension of the disposal sediment on seabed over a 15 day period after completion of all disposals at site 1.

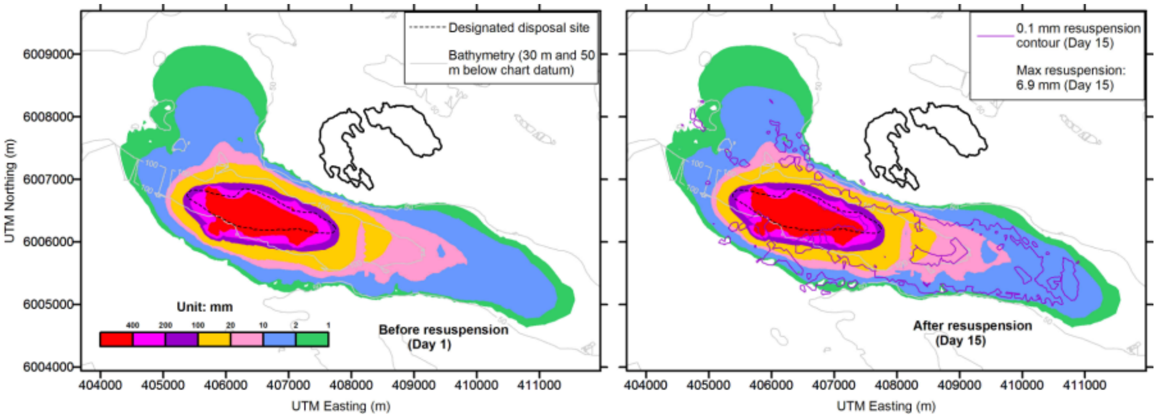

Figure 25: Disposal sediment on the seabed before (left) and after (right) resuspension over a 15 day period after completion of all disposal at site 2.

7.0 SUMMARY

In support of assessing potential environmental effects of the sediment disposal offshore of Ridley Island in support of the environmental approval process, ASL Environmental Sciences Inc. has carried out a numerical modeling study of the transport and fate of the sediment released during and after the disposal operations using the 3D numerical model COCIRM-SED. The sediment disposal is part of a port development plan for Canpotex in Prince Rupert, which will involve disposal of dredged sediments at one or both of two potential disposal sites offshore of the Ridley Island portion of the Prince Rupert Harbour. The 3D numerical model was adapted to determine the quantity and pattern of the disposal sediment deposition on seabed and the TSS plume during and after the sediment disposal. The major oceanographic processes determining the deposition, dispersion and transport of the discharged sediments are the tidal, Skeena River input and wind driven currents.

Before implementation, the model was validated using historical ocean current data at the mooring site near the two disposal sites. The model results of the ocean currents are generally in reasonable agreement with the observations over a 20 day period at 16 m measurement levels for the calibration case and at 17 m and 31 m measurement levels for the verification case. The model flow patterns in the study area were also determined to be physically reasonable.

The model involved the direct simulations of five sediment categories with size ranging from clay to gravel, which were identified from field sediment sampling data. The clay and silt have the content over 90% of total disposal sediment. It was found that the flocculation process of the fine clay and silt particles plays important role for the transport and fate of the disposal sediment. The flocculation settling velocities were examined through model sensitivity tests. The testing results show that the flocculation settling velocities introduced in STFATE are very reasonable and were thus used in the model.

The distribution of the discharged sediments was initially simulated with STFATE, which ran over the initial 45 minutes of sediment disposal for the pipe disposal operation at site 1, and over the initial 25 minutes of the sediment disposal for the barge disposal operation at site 2 under average flood and ebb currents and at three representative locations in the disposal sites. For site 1, STFATE operated in a realistic fashion to simulate an actual pipe slurry discharge by lowering the barge draft to 10 m off seabed and increasing dumping duration to half hour. The STFATE model results of the suspended sediment concentration and initial deposition on the seabed were then input to the COCIRM-SED model, which simulated the transport and fate of all dredging disposal over much larger spatial scales and longer periods of time. The STFATE model results show that initially, all or most of the coarse-grained disposal sediments (sand to gravel) settles out on the seabed, while most of fine-grained sediments (clay to silt) remains suspended in the water column, with a total initial bottom accumulation of about 42 – 57 percent and the remainder of the discharged sediments are still in suspension.

The COCIRM-SED model results show that the maximum near-bottom TSS values after each disposal operation is up to about 2,000 mg/L at site 1 and 700 mg/L at site 2. The high near-bottom TSS levels present after the discharge events are quickly reduced due to sediment settling and strong dilution, with a maximum near-bottom TSS value of less than 30 – 60 mg/L within about 2 hours after each disposal event for both disposal sites. In the vertical, TSS values decrease towards the surface. Near-surface TSS during disposal is mostly less than 5 – 10 mg/L above background. Higher near-surface TSS values greater than 25 mg/L above background (BC water quality guideline above background level) occur only at the center of the dumping site right after each disposal trip. After the completion of the disposal operations, TSS values gradually decrease as the suspended sediment settles out on the seabed and is further diluted, with the maximum TSS levels in the study area reduced to less than 1 mg/L within 7 – 10 hours after the discharge operations end.

At site 1, when all suspended sediments have settled out onto the seabed after completion of all project discharges, most disposal materials are deposited in the deeper water to the north of the disposal site where water depths are greater than 30 m and where the near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. Total deposition within the disposal area occupies 58.43% of total dredging material, with a deposition thickness ranging from 1200 mm to 5192 mm. The area with total deposition greater than 1 mm is located in deeper water where water depths are greater than 30 m. The total deposition within this area occupies 88.5% of total dredging material.

At site 2, when all suspended sediments have settled out onto the seabed after completion of all project discharges, most disposal materials are deposited in the deeper water to the ESE and N of the disposal site where water depths exceed 50 m and where near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. Total deposition within the disposal area accounts for 51.65% of the total dredging material, with a deposition thickness ranging from 200 mm to 1155 mm. The area with total deposition greater than 1 mm is located in areas of deeper water where water depths are greater than 50 m. The total deposition within this area accounts for 73.3% of the total terrestrial overburden material discharged to the ocean.

After all disposal completed at site 1 or 2 and most of disposal sediment settled out on seabed with maximum TSS less than 1 mg/L, the model continued to simulate the sediment transport process for a 15 day period, including settling of the suspended sediment as well as the resuspension of the disposal sediment on seabed if near-bottom currents are strong enough for the incipient of the deposited sediment. The model results the resuspension of the disposal sediment on seabed reflect the resuspension process under typical tidal and winter river and wind conditions. The post-disposal model results show that at site 1, the resuspension is very marginal, with a total resuspended sediment of about 120 m^3 over the 15 day post-disposal modeling period, and the resuspension only occurred in the northern area where near-bottom currents are relatively stronger and the thickness of disposal sediment on seabed is less than 20 mm. The maximum resuspension over the 15 day model period is about 1.3 mm.

At site 2, the total resuspended amount of the disposal sediment on seabed over the 15 day post-disposal period is about 2,500 m^3, which is about the same amount in one barge disposal trip and mostly occurred during the large spring tide in the end of the simulation. It is also seen that the resuspension mostly occurred in the area ESE of the disposal site where water depths are less than 100 – 120 m and the thickness of disposal sediment on seabed is mostly less than 100 mm. The maximum resuspension over the 15 day model period is about 7 mm.

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