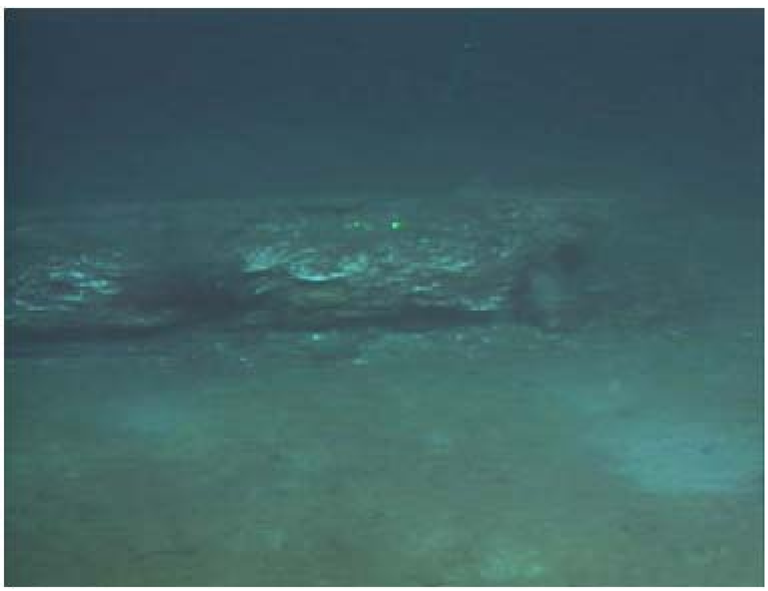
Compendium of Monitoring Activities at Disposal at Sea Sites in 2004-2005

Client Edition



Disposal at Sea Program
Environmental Protection Service
Environment Canada

March 2006

Cover: Submersible ROPOS image from Point Grey, British Columbia disposal site

Summary

Canada is a maritime nation whose 243,790 km of coastline is the longest of any nation in the world. The Canadian maritime environment is relatively uncontaminated, but does have some problems. One of the measures in place to protect Canada's marine environment and meet our international obligations under the *London Convention 1972* and its *1996 Protocol*, is the regulation of disposal at sea through a permit system under the *Canadian Environmental Protection Act, 1999* (CEPA).

Each year, as required by CEPA, Environment Canada conducts representative monitoring at disposal at sea sites. This National Compendium of Monitoring Activities provides a technical summary of the monitoring activities conducted in 2004 at a total of 12 disposal sites. This compendium is produced annually to meet national and international reporting obligations.

In the Atlantic Region, three disposal sites were examined. The first was Great Mosquito Cove Newfoundland which was used for disposal once in 1994. A complete recovery of the benthic community at the disposal site was anticipated since that time. Significant recovery was observed in the benthic community although full recovery was not found. Because the disposal site is not actively used, and blasting activities may have occurred in the area after 1994 that further affected benthic biota, the level of recovery is acceptable. Future monitoring at this site could be conducted to gauge any further potential for recovery. The second Atlantic site studied was the Strait of Canso, Nova Scotia which is a common-user disposal site. Monitoring was triggered by an excess of 100,000 cubic metres of material being disposed. Monitoring was conducted to verify that deposited sediments are not being dispersed outside the disposal site boundaries, and to confirm that disposal is not leading to adverse effects on biota. Multibeam imagery indicated that most of the dredged material was deposited within the disposal site boundaries. Laboratory bioassays of sediment samples showed biological responses, but evidence of adverse effects was not observed in an in-situ benthic community study. No further management action is deemed necessary at this site. The third Atlantic site monitored was in the Miramichi River, New Brunswick where dredged material with elevated cadmium levels was deposited and capped in the early 1980s. Monitoring was conducted to determine whether capping effectively confined cadmium contaminated sediments and that the integrity of the cap was maintained. Multibeam and backscatter images revealed that dredged material forming the cap on the seafloor is largely confined to the immediate area surrounding the disposal site. Analysis of Miramichi sediment chemistry data is ongoing and will be presented upon completion to determine the efficacy of the cap and the management action taken.

The settling of sediment at six disposal sites in the Gaspé Peninsula was examined in the Quebec region. Using the STFATE modelling system, it was shown that the majority of disposed sediments settle at the centre of the authorized disposal area. A small fraction of these sediments may be carried large distances depending on the current conditions. Monitoring to investigate the potential effects of this dispersal is to commence in 2006. Results from an analysis of the physical, chemical, and biological effects of dredged material at a Pointe-Basse Harbour disposal site in the Magdalen Islands will be presented in the 2005 compendium.

Preliminary monitoring data are presented from the Pacific and Yukon Region. Studies were conducted at five routinely used sites and looked at all or a combination of the following in accordance with National Disposal Site Monitoring Guidelines: sediment dispersal, trace contaminant levels, and biological effects. These studies are intended to provide information about the trends at each disposal site, and to verify that use continues to be appropriate and protective of

the marine environment. Results and conclusions from these studies are pending analysis of the collected data.

Results and conclusions from data collected at six Pacific and Yukon disposal sites in 2003 are also presented. Four of the sites require no further management, while varied responses in biological tests prompted recommendations for further study at both Porlier Pass and Five Finger Island.

Comments

Comments may be sent to:

Linda Porebski
Marine Protection Programs
Environmental Assessment Division
Environmental Protection Operations Directorate
Environmental Stewardship Branch
Environment Canada
Ottawa, Ontario
K1A 0H3

Tel.: 819-953-4341
Fax: 819-953-0913
Email: Linda.Porebski@ec.gc.ca
Web site: www.ec.gc.ca/seadisposal

Table of Contents

Introduction

Canada is a maritime nation. It possesses 243,790 km of coastline, the longest of any nation in the world, and has a vital interest in preserving a healthy marine environment. Though by world standards the Canadian maritime environment is relatively uncontaminated, Canada's territorial waters do have some problems, especially in harbours, estuaries and near shore areas.

Canada regulates disposal at sea through a permit system under the Canadian Environmental Protection Act, 1999 (CEPA). This is one of the measures in place to protect Canada's marine environment and meet our international obligations under the London Convention 1972 and its 1996 Protocol on preventing marine pollution by controlling the disposal of wastes at sea.

CEPA requires Environment Canada to monitor representative disposal at sea sites each year. This is conducted in accordance with national monitoring guidelines and dependant on available resources from the disposal fees collected. In order to respond to Canada's national and international reporting obligations, this National Compendium of Monitoring Activities, based on regional reports, is produced annually.

Role of monitoring

Disposal site monitoring allows permittees continued access to suitable disposal sites by helping to ensure that the permit conditions were met and the use of the site has not caused unacceptable or unpredicted impacts. It verifies that assumptions made during the permit review and site selection process were correct and sufficient to protect the marine environment and human health. Monitoring allows Environment Canada to gather information and take appropriate action to manage the sites in an environmentally sound manner.

Monitoring also plays a critical role in reviewing the overall adequacy of controls. Information compiled nationally and regionally, over time, provides the basis to assess whether the disposal at sea regulatory controls, guidelines and permit conditions are adequate to protect the marine environment and human health.

Experience gained with monitoring may also point to the need for research to develop better monitoring tools, or to refine the monitoring program, on specific environmental, health or public concerns. It is also expected that monitoring will uncover gaps in our understanding of impacts, particularly in the area of cause and effect relationships.

In order to increase the level of involvement of stakeholders, annual meetings with clients and other interested parties provide additional comments on past monitoring and better indication of Regional priorities for future assessments. The annual meetings also ensure Environment Canada’s decisions concerning monitoring activities are carried out in an open and transparent manner.

Finally, Environment Canada’s disposal site monitoring, reporting and communication with stakeholders are activities critical to fulfilling the federal and international obligation to apply the Precautionary Principle in administering CEPA.

Conducting monitoring studies

Monitoring at disposal at sea sites is conducted according to national guidelines. Activities carried out in a given year are based on available resources and can involve an assessment of the physical, chemical and biological features of sites under review. The impact hypotheses generated by permit reviews form the basis of this monitoring.

Physical monitoring relates to the collection of relevant geological information for determining the area of deposition, delineating the disposal site boundaries, studying the accumulation of dredged material within the area of deposition, and documenting evidence of sediment transport from the disposal site.

Biological and chemical assessments are undertaken concurrently in many cases, and the monitoring design for these parameters takes into account the size and dispersal characteristics of the site. Chemical monitoring is aimed at measuring the levels of chemicals in sediments and comparing them to lower action levels set out by the Disposal at Sea Regulations or other national screening levels for additional parameters of concern.

CEPA Lower Action Levels.

Lower Action Levels for chemicals in sediments
(*Disposal at Sea Regulations*)
(mg/kg, dry weight)

Chemical	Current Level
Cadmium	0.6
Mercury	0.75
total PCBs	0.1
total PAHs	2.5

Biological monitoring is primarily centred on biological testing in the laboratory and benthic community surveys. The biological test methods currently used for sediment assessment include:

- an acute toxicity test using marine or estuarine amphipods (the end point is lethality);
- a fertilization assay using echinoids (the endpoint is significant reduction in fertilization);
- a toxicity test using a photoluminescent bacteria, the Microtox® solid-phase test (the end point is significant reduction in bioluminescence);
- a bedded sediment bioaccumulation test using bivalves (the end point is significant bioaccumulation).

Integrative assessment

If sediments are below the lower action levels, and other national screening levels, for contaminants and pass all biological tests, no further action is required. However, if levels of contaminants or biological test results demonstrate a cause for concern then the first step is to verify compliance with the terms of the permits issued since the site was last monitored.

The second step will generally involve checking potential sources of pollutants and conducting further site characterization. After considering this information, the following hierarchy of interpretative guidance can be applied to the concurrent chemical and toxicological data:
if sediments at the disposal site contain substances in excess of national screening levels (including lower action levels), pass the acute toxicity test, but fail one sublethal or bioaccumulation test: consideration could be given to modifying further use of the site and investigating the long term stability of the material onsite;

- if the sediments contain substances below the national screening levels, yet fail any of the biological tests, then further investigation would be required to determine if this is the result of either a confounding factor such as laboratory anomaly, or the presence of a contaminant not included in the chemical screening; or

- if the sediments contain substances in excess of the national screening levels and either fail the acute test or fail two (or more) additional tests including the sublethal tests and the bioaccumulation test: further monitoring, site closure or remediation could be considered.

As well, cursory benthic community surveys can be used as a general sediment quality indicator. The overall assessment of the disposal site considers all available information from physical, chemical and biological monitoring.

Intensity of monitoring

Monitoring at every disposal site is not considered necessary, as current knowledge of impacts related to disposal of dredged material from routine dredging allows for good assessments to be drawn from representative disposal sites. In addition, the program attempts to ensure that the major sites (>100,000 m3 of dredged materials/year) are monitored on at least a five year cycle. The monitoring of other sites is determined by triggers set out in the national monitoring guidelines which are based on volume, proximity to sensitive areas, or level of concern. The number of sites monitored in a year and the parameters measured at each site depend on the available resources through the collection of fees from permittees.

Reporting

Canada’s Disposal at Sea Program is administered through regional offices which are largely responsible for the permit review process, as well as for planning, conducting and reporting on monitoring studies undertaken in their administrative areas. This compendium, based on regional detailed reports, is now produced annually to respond to Canada's national and international reporting obligations. Readers may request detailed information on any of the monitoring activities in this compendium, from the appropriate regional office.

Atlantic Region: Great Mosquito Cove, Newfoundland

Background

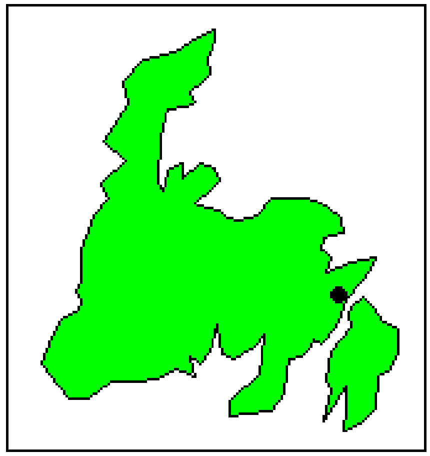


Figure 1. Map showing the location of Mosquito Cove,Newfoundland

Great Mosquito Cove, Bull Arm, Trinity Bay is located on the east shore of Newfoundland. An earth berm was placed on the sea floor in the area to allow the construction of a gravity-based structure (GBS) that enabled access to the Hibernia oil field. Upon completion of the GBS, the berm was removed by dredging that took place between March 1st and July 1st 1994. In excess of 450,000 cubic metres were removed for disposal in a small underwater gorge located within Mosquito Cove. The material removed from the first cut of the berm was used to build an underwater containment berm intended to prevent till from migrating out of the containment area. When the 1994 permit for this activity was issued, Environment Canada concluded that any negative environmental effects of the project could be mitigated and that disposal would have no long-term effect on the area. The Mosquito Cove disposal site was triggered for inclusion in the 2004/2005 monitoring program because more than 100,000 cubic metres were disposed of in a single year.

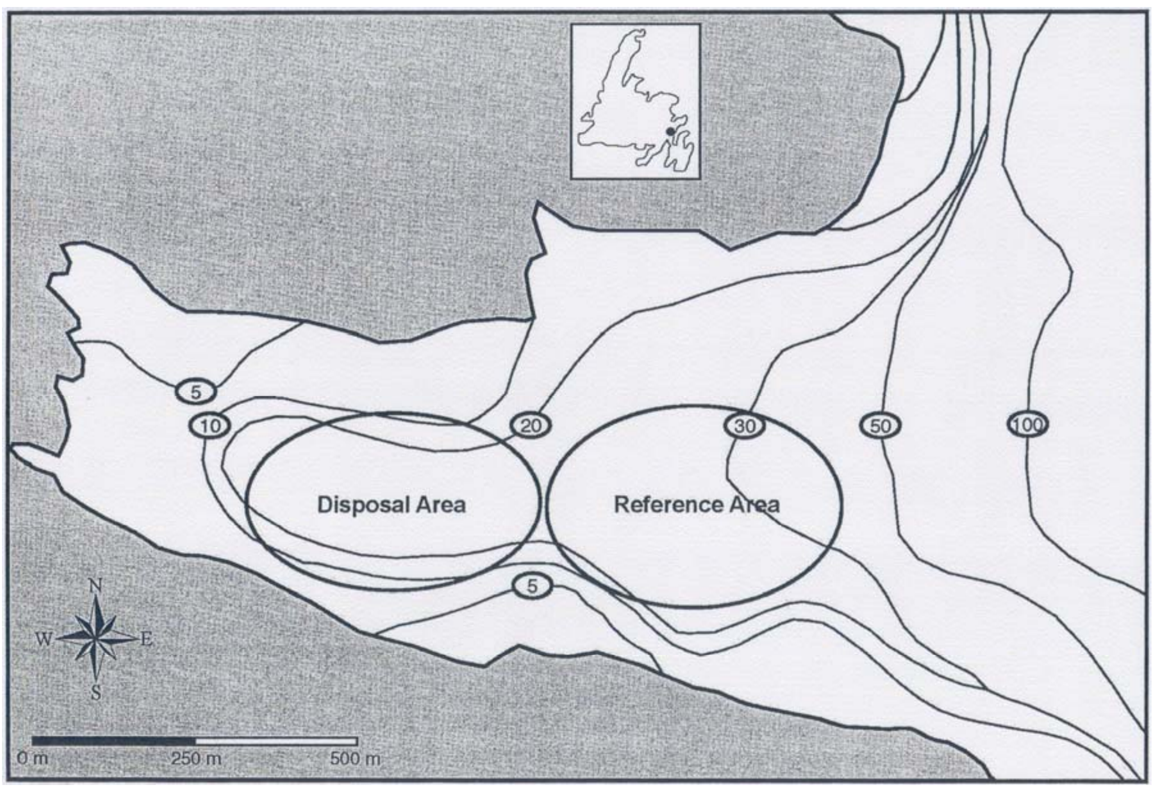


Figure 2. Monitoring Locations, Mosquito Cove, Newfoundland.

Impact Hypothesis

In the 10 years following disposal activities the benthic community at the disposal site has undergone a complete recovery.

Monitoring Conducted

The monitoring work at Mosquito Cove was conducted in February of 2005 by AMEC Earth and Environmental (AMEC). Data collected included multibeam bathymetry, towed video and dropped camera footage, and benthic grab sampling. Monitoring was conducted at the former Great Mosquito Cove disposal site and at a representative reference site within Mosquito Cove (see Figure 2). Video footage in the Mosquito Cove area was collected in 1993 and 1995 by Polaris Marine Services Ltd., but direct comparisons with these observations were not possible as the precise location of their collection is not known.

Results and Conclusions

Verification and Delineation of Disposal Site Boundaries

The bathymetric survey centered on disposal area coordinates provided by Environment Canada. Survey efforts were concentrated over a 200 m^2 grid established around these coordinates. Depths within the survey area ranged from 15 to 55m, and were more variable in the reference area than in the disposal area. The survey identified bottom features that indicated a possible disposal area and the probable location of the containment berm constructed at the time disposal occurred (see Figure 3).

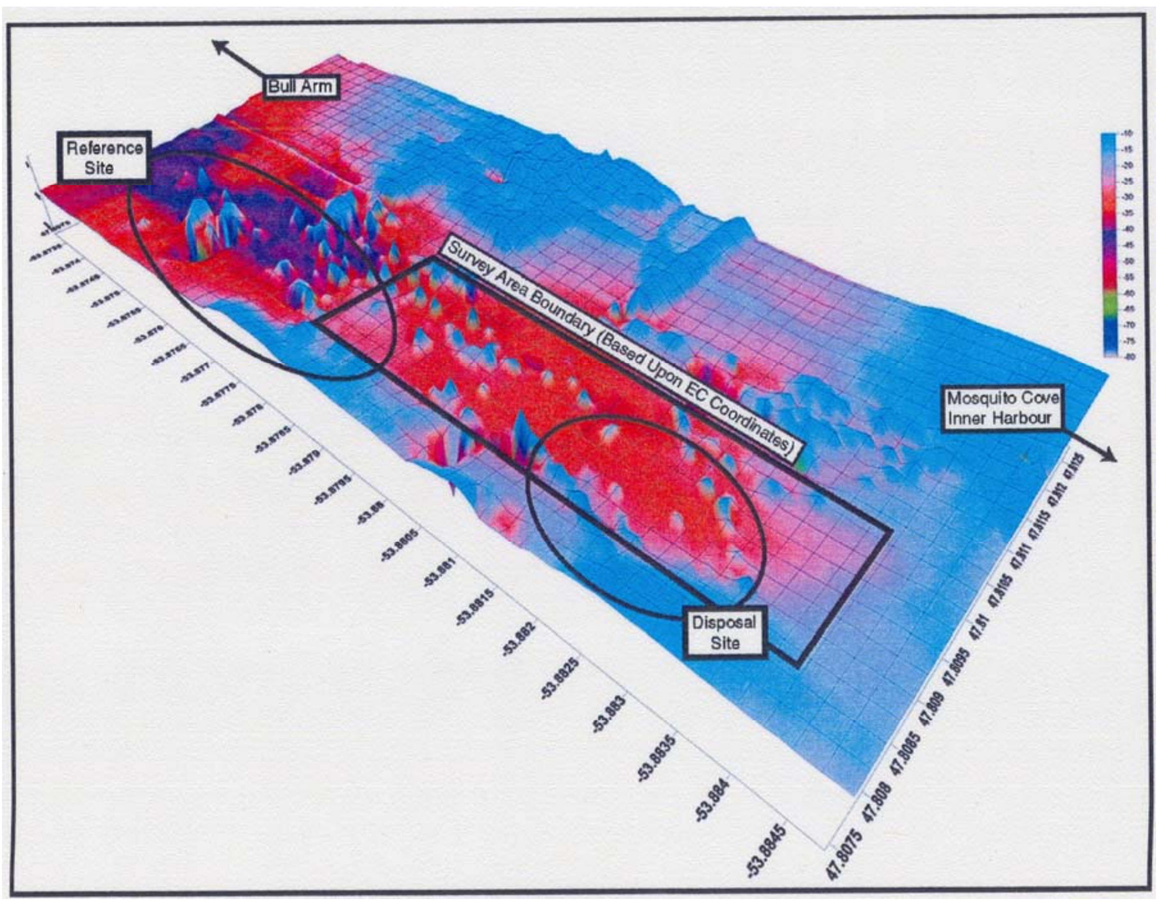


Figure 3. Approximate Boundaries of Disposal Site and Reference Areas.

Characterization of Substrate and Benthic Communities

Video and dropped camera footage collected in 2005 revealed that, compared to 1993, epifauna occurred less frequently, and fine introduced sediments were dominant. The 2005 substrate was comparable to the substrate observed in 1995 in that the amounts of visible coarse substrate were similar, and substrate characteristics were consistent.

Invertebrate samples collected in 2005 (see Figure 4 for locations) indicated that the reference site community is richer and more robust than the community at the disposal site. The reference site values for richness (total species) and the Shannon-Weiner Diversity Index were higher than the disposal site values, and these results were statistically significant. The reference site values for abundance (total individuals) and evenness were also higher, but these results were not statistically significant. There is some uncertainty as to the cause of the differences between the disposal and reference sites since data collected prior to berm removal is lacking.

Particle size analysis of samples from the disposal and reference areas in Mosquito Cove suggest that sediment profiles in both areas are similar, and that a substantial layer of sand/fines has been deposited in the Mosquito Cove area since berm construction and removal.

Based on monitoring work conducted in Mosquito Cove in 2005 and comparisons to previous work conducted in 1995 and 1993, it is concluded that the disposal site has undergone significant recovery since the berm was removed in 1994, but the benthic community is not as rich or diverse as it was before that time. The impact hypothesis is therefore rejected.

There is anecdotal evidence that the seabed in Mosquito Cove was subjected to blasting and levelling activity not associated with the disposal operation. Some of this activity may have occurred after the disposal and could have affected both the disposal site and the reference site. This factor, together with the lack of baseline benthic data, makes it difficult to assess the recovery potential of the altered habitat.

At this time, there is no indication that this site will ever be used again for disposal of dredged material. However, it is still a matter of interest whether any further recovery of the benthic community will occur. It is possible that the site will be investigated again in 10-15 years.

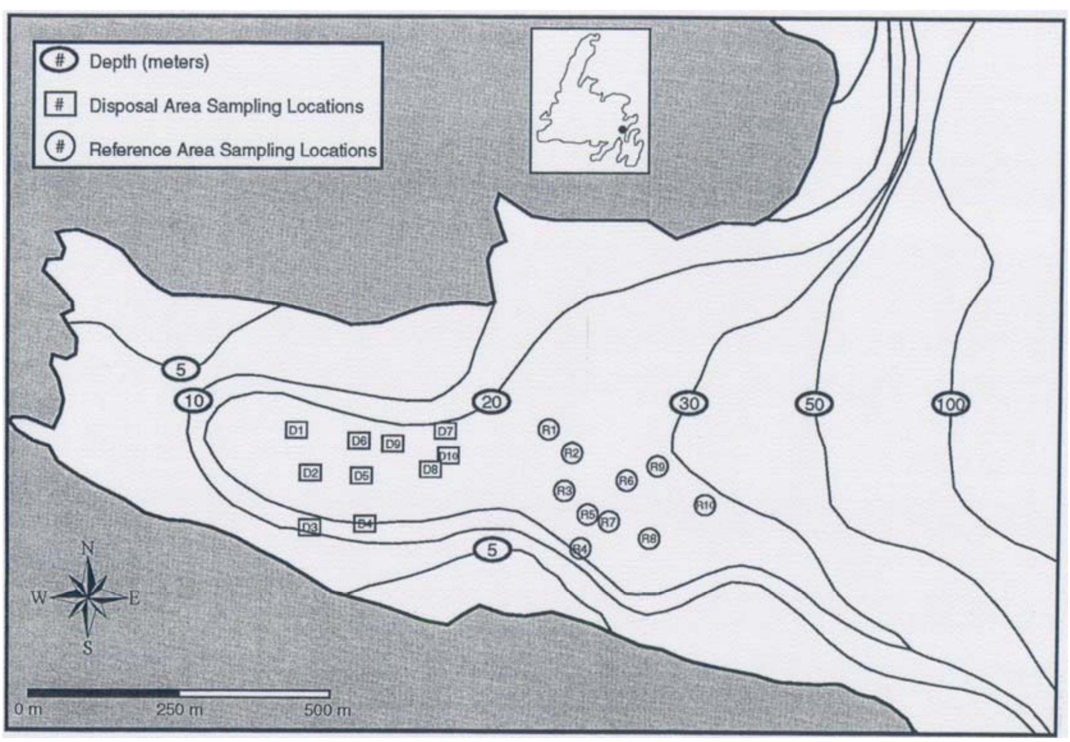


Figure 4. Mosquito Cove disposal and reference area benthic grab sampling locations.

Atlantic Region: Strait of Canso, Nova Scotia

Background

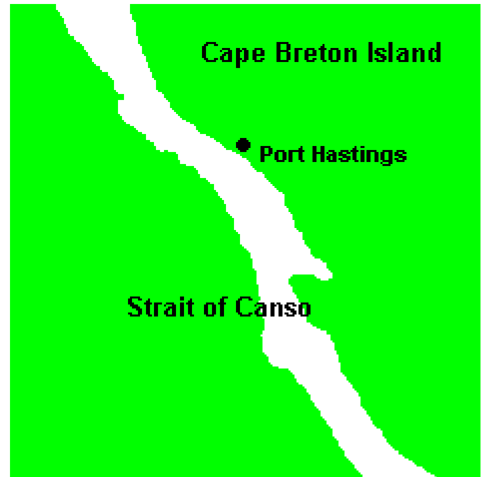


Figure 5. Map of Strait of Canso, Nova Scotia

The Strait of Canso is a narrow body of water separating Cape Breton Island from mainland Nova Scotia. Construction of a causeway across the Strait was completed in 1955, restricting tidal flow and seawater exchange through the Strait. The restricted current regime changed the Strait from an erosional environment which saw the development of sandwaves and erosional flutes, to a depositional environment where there is an accumulation of fine-grained sediments.

The development of an ice-free port on the eastern side of the causeway led to an increase in shipping traffic and a corresponding need for dredging to facilitate vessel access. In 1983 a common-user ocean disposal site was established to accommodate material originating from dredging operations within the Strait. The site is delineated by a natural depression approximately 650 metres long and 200 metres wide with depths ranging between 55 metres to 64 metres. It was selected as a stable environment from which dredge spoils were not expected to be transported. To date, three Disposal at Sea Permits have been issued for the site, with a total recorded disposal volume of 177,000 cubic metres of dredged material.

Monitoring at the Strait of Canso disposal site was triggered in 2004 because more than 100,000 cubic metres were disposed there.

Impact Hypotheses

i. *Dredged material deposited at the disposal site is not scattering beyond the boundaries of the disposal site.*
ii. *Dredged material disposal at the Strait of Canso common-user ocean disposal site has not resulted in significant adverse effects on the chemical or biological characteristics of the disposal site sediments*.

Monitoring Conducted

During the period of April 27 – May 14, 2004, the Geological Survey of Canada – Atlantic (GSC - Atlantic) collected data at the disposal site and surrounding area including multibeam bathymetry, side-scan sonar, seafloor samples, underwater video and photographs, and sub-bottom profiler data.

Further work was completed in late July 2004 when a sediment sampling program was carried out by Envirosphere Consultants Ltd. and Environment Canada to assess the sediment chemistry, biological effects, and the biological communities at the disposal site and nearfield areas.

Results and Conclusions

The monitoring data indicates that disposal activities have not resulted in an alteration of the chemical characteristics of the disposal site sediments. However, toxicity tests show that some of the disposal site sediments cause biological responses in laboratory toxicity tests using sensitive marine species. However, evidence of adverse effects on biota was not observed in an in-situ benthic community study. It is likely that the toxicity test results were confounded by the presence of high levels of ammonia and sulphide in the sediments.

The results of this study indicate that dredged material disposal at the Strait of Canso common-user ocean disposal site has not resulted in significant adverse effects on the chemical or biological characteristics of the disposal site. Further monitoring at this site would not be required within the next 3 to 5 year unless the site is used again.

Determination of Physical Site Characteristics

Geophysical data collected by the GSC – Atlantic indicates that accumulation of sediments in the Strait is presently continuing. A thin veneer of fine sediments originating from a combination of locally occurring natural processes (e.g., eroding shorelines, small drainage systems) and anthropogenic sources (e.g., urban and industrial waste) has been deposited in the deeper portions of the Strait. This can be compared to sub-bottom profiler data which indicates an accumulation of approximately 1 metre of recent sediment at the disposal site, likely related to recent dredged material disposal.

Multibeam imagery (see Figure 6) shows that most of the dredged material was deposited within the boundaries of the disposal site, with lesser amounts of dredged material visible in several areas to the east of the site. Areas of high backscatter were found within the disposal site and may be related to the disposal of coarse material. The presence of coarse material at the disposal site and its vicinity was confirmed with seafloor video and photographs which showed the occurrence of boulders, cobble, and gravel, along with assorted debris including tires, trees, wood, and a trailer. Surficial coverage of gravel at the disposal site is higher than elsewhere in the strait.

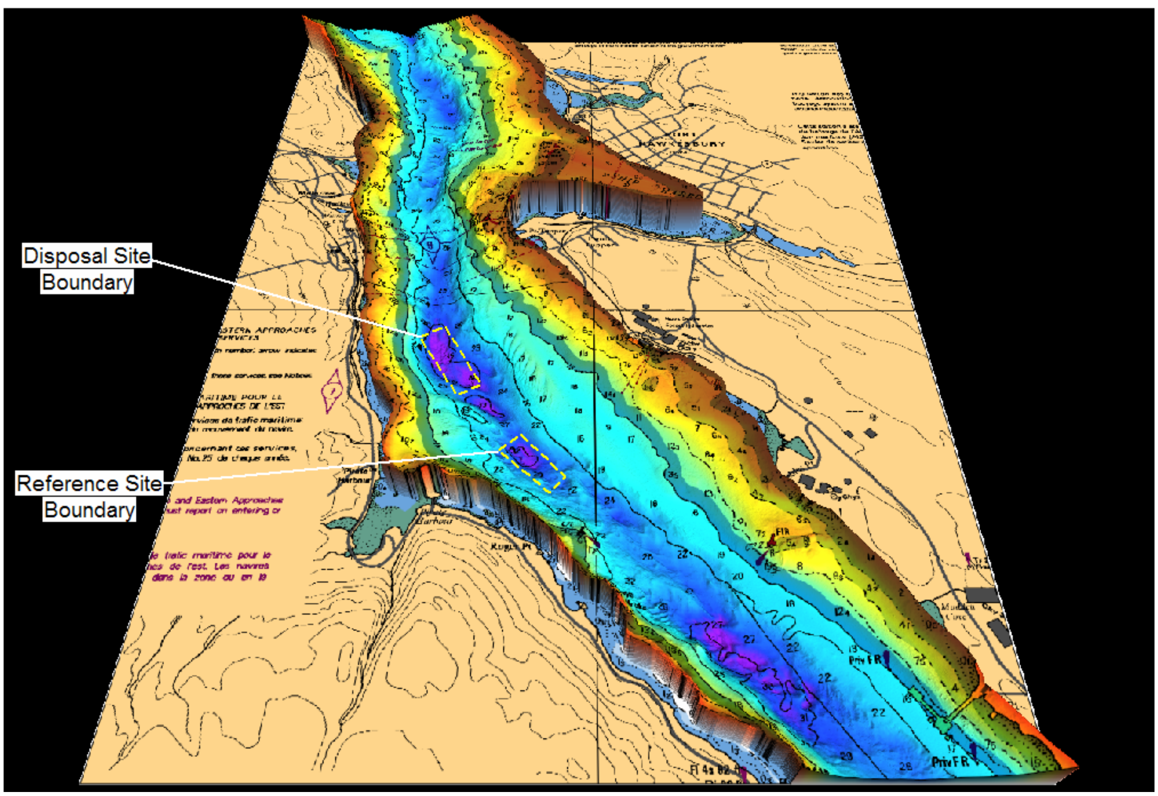


Figure 6. Strait of Canso Multibeam Bathymetry, 2004

Benthic Community Analysis

A total of 18 benthic biota samples were collected and analyzed to determine community composition, distribution, and abundance; 6 samples were taken at the disposal site, 6 samples at a nearfield station, and 6 samples at a reference site. The disposal site and nearfield site were dominated in terms of numbers by polychaete worms with the occasional occurrence of brittle stars, bivalves, gastropods, nemerteans, amphipods and cumateans. Overall, there was lower species richness in 2004 when compared with a benthic community study conducted in 1987. Biomass; however, was not significantly different ($p < 0.05$) between 1987 and 2004.

Community measures including abundance, species richness, Shannon Weiner Diversity, Pielou's Evenness and biomass were not significantly different between the disposal site and nearfield stations. Abundance biomass curves were also similar between the disposal site and nearfield stations, showing a balance of distribution of biomass and abundance among species and suggesting communities are not stressed as would occur in situations involving organic loading.

The communities at both disposal site and nearfield areas are not particularly diverse or abundant, possibly reflecting the slowness for communities to establish in the area after the construction of the causeway half a century ago. The absence of major differences (with the exception of species richness) between the spatial (disposal site vs. adjacent areas) and temporal (2004 data vs. 1987 data) scales is an indication of the lack of adverse effects and/or recovery of the disposal site from ocean disposal activities.

Analysis of Sediment Chemistry

Chemical analyses that were conducted on sediment samples in 1985 showed that concentrations of cadmium, zinc, copper and lead were higher in the disposal site sediments than those measured before disposal; however, with the exception of copper, these differences were not statistically significant. High levels of polychlorinated biphenyls (PCBs) (up to 1 mg/kg) were found at the disposal site in 1985 and subsequent surveys in 1987 showed a wider distribution of PCBs in the Strait beyond the disposal site. The highest PCB concentrations were found along the eastern shoreline of the Strait in front of the Nova Scotia Forest Industrial Plant (2.6 mg/kg).

Results from sampling conducted in 2004 indicate that PCBs remain distributed in a similar pattern to that found in 1987; however, total concentrations have lessened. Higher PCBs concentrations (up to 0.53 mg/kg) were found along the eastern shoreline of the strait with a general decrease in magnitude as distance from the eastern shoreline increased toward the centre of the strait (with the exception of one sample found at the reference site at 0.57 mg/kg). PCBs were found to be present within the boundaries of the disposal site but were low (< 0.1 mg/kg) as compared to the reference site and nearfield stations (0.06 – 0.57 mg/kg). Cadmium, zinc, copper, lead, and mercury levels at the disposal site were not found to be higher at the disposal site compared to the reference site and nearfield stations.

Sediment Biological Tests

Biological testing was conducted on six sediment samples from each of the disposal, reference, and near-field sites. Tests conducted were amphipod survival, polychaete survival and growth, echinoid fertilization, and light inhibition in a marine bacterium. The results for the echinoid fertilization tests consistently showed signs of toxicity in sediments from all three sites; one of the reference site sediment samples is considered toxic based on the light inhibition test and Environment Canada's interpretation criteria; one of the disposal sites sediment failed the amphipod survival test; and the polychaete test results indicated evidence of toxicity in three disposal site samples and three reference site samples. However, because no significant difference was observed in benthic biota data between the disposal and reference sites, and because of the absence of high levels of contaminants in the test sediments, it is highly likely that the toxic effects observed in the laboratory were caused by the high levels of ammonia and sulphides in the test sediments.

Acknowledgements
Environment Canada would like to thank Russell Parrott of the Geological Survey of Canada and Pat Stewart of Envirosphere Consultants Ltd. for their work on this project.

Atlantic Region: Miramichi, New Brunswick

Background

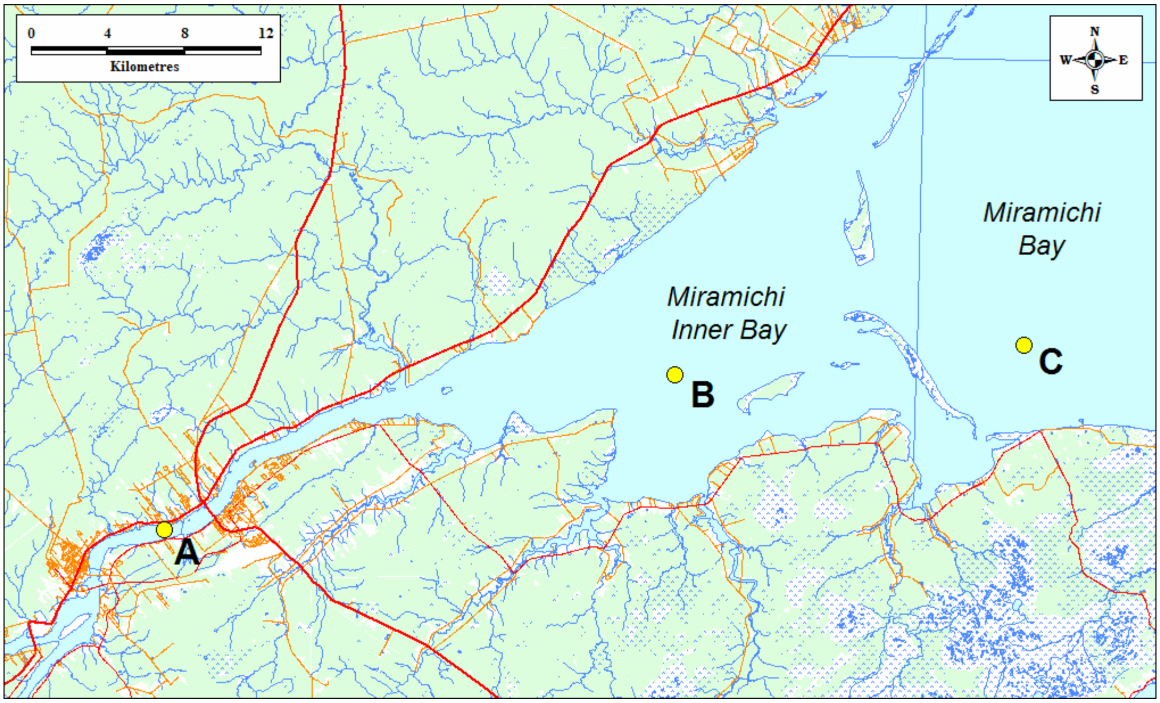


Figure 7. Disposal Site Locations, Miramichi, NB

The Miramichi River is situated on the eastern shore of northern New Brunswick. Shipping on the Miramichi River historically occurred via a five metre deep channel that was largely natural and required little maintenance. Due to increased commercial demands, a major dredging operation was conducted from 1981 to 1983 to widen and deepen the channel to accommodate a vessel draft of 7.6 metres. Over six million cubic metres of material was removed from the channel and disposed of at three designated disposal sites. Dredged material with elevated cadmium levels was disposed of and capped with clean sediment at site A, located farthest upriver. The other two sites, B (Miramichi Inner Bay) and C (Miramichi Bay) received the remainder of the dredged material. Between 1989 and 1994, disposal sites B and C received an additional 550,000 cubic metres and 106,300 cubic metres respectively from maintenance dredging operations. Depths at the disposal sites vary from 3 to10 metres.

Impact Hypothesis

i. Disposal was conducted within the boundary of the designated disposal site and has created a disposal area that is stable in the local dynamic physical marine environment.
ii. The management action has effectively capped cadmium at the disposal site.

Monitoring Conducted

In 2003/2004, Environment Canada, in cooperation with Natural Resources Canada and Fisheries and Oceans Canada, jointly funded a sampling program as part of a larger study into the long term effects of dredging. The sampling program was carried out by Fisheries and Oceans Canada scientists with the goal to characterize the hydrodynamics in the vicinity of site B and look for evidence of changes in the sediment dynamics of Miramichi Inner Bay which might have resulted from the 1981 to 1983 dredging project. In addition to the sampling program, Natural Resources Canada conducted multibeam and backscatter surveys of disposal sites A and B. Apart from a few small studies, this represents the first major Miramichi Inner Bay monitoring effort since a three-year monitoring program was conducted following the dredging operations of 1981 to 1983.

Monitoring work at the Miramichi disposal sites is ongoing. Sediment sampling at site A was conducted in October 2005 by Environment Canada and Natural Resources Canada. The sediment samples collected will be analyzed for sediment chemistry, grain size, toxicity and benthic community parameters. Data and conclusions from these analyses will be forthcoming.

Results and Conclusions

Results from the Miramichi monitoring program are incomplete pending synthesis of the most recent data. Preliminary results from sediment core sampling conducted by Fisheries and Oceans Canada (Milligan et al. 2005), however, provide some insight into the possible influences the large-scale dredging project have had on sediment dynamics in Miramichi Inner Bay.

During the channel deepening project of the early 1980's large volumes of fine-grained sediment were released from the cutter suction dredge operation. An unknown amount of erosion of dredged material from the disposal sites also contributed to the amount of fine grained material released to the bay. Milligan et al. (2005) used cored samples to analyze the disaggregated inorganic grain size (DIGS) distribution of bottom sediments. The DIGS of bottom sediments preserve the record of physical transport processes responsible for their formation. Fine-grained sediment is deposited as either single grains or in agglomerations of many particles, called flocs. Parameterization of the DIGS near the inner mouth of Miramichi Bay indicated that there was a period of increased floc deposition prior to a period of rapid sedimentation. Radionuclide dating of sediment core samples indicated that there was a rapid deposition of sediment (>10 centimetres) near the region of the turbidity maximum (near Bartibog; the inner mouth of the Miramichi River) around 1980 ± 5 years. While it cannot be conclusively proven that this rapid sediment deposition was a result of dredging, the evidence suggests that fine sediment dynamics in the Miramichi Bay were affected by increased sediment concentrations due to dredging. Considering the amount of material released as a result of dredging, it is likely that much of this material made its way to the turbidity maximum or the deepened channel. In order to fully resolve this issue, analysis of a larger number of cores would be required.

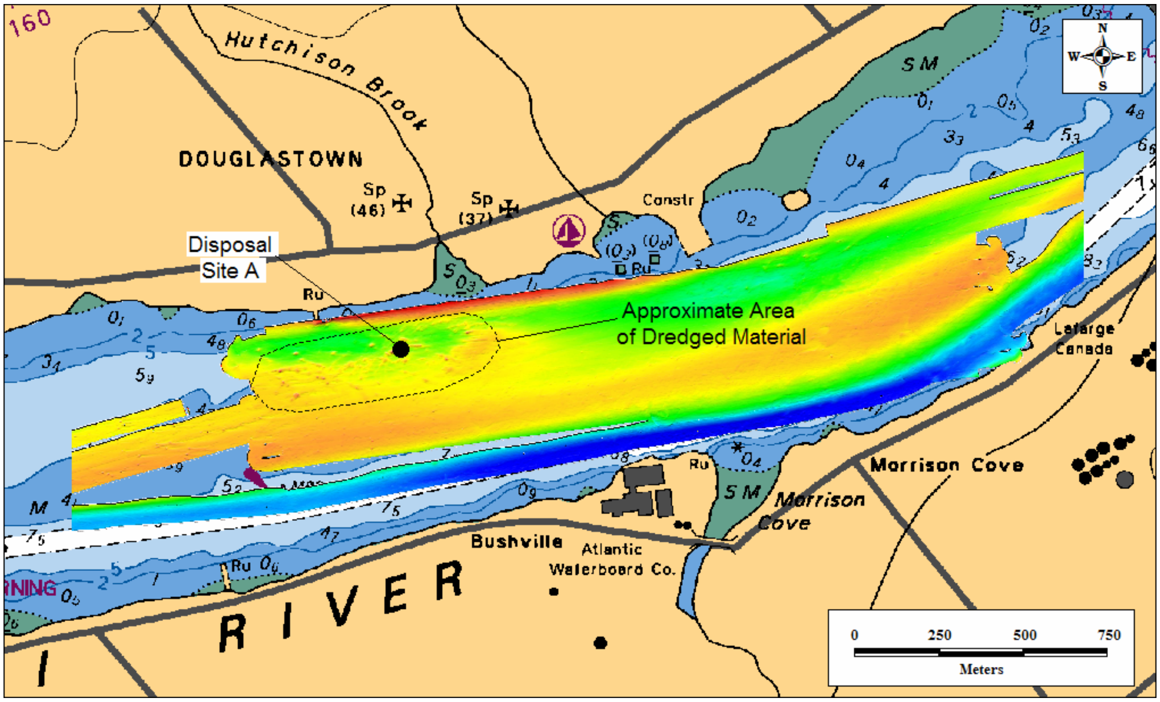


Figure 8. Multibeam Imagery, Disposal Site A

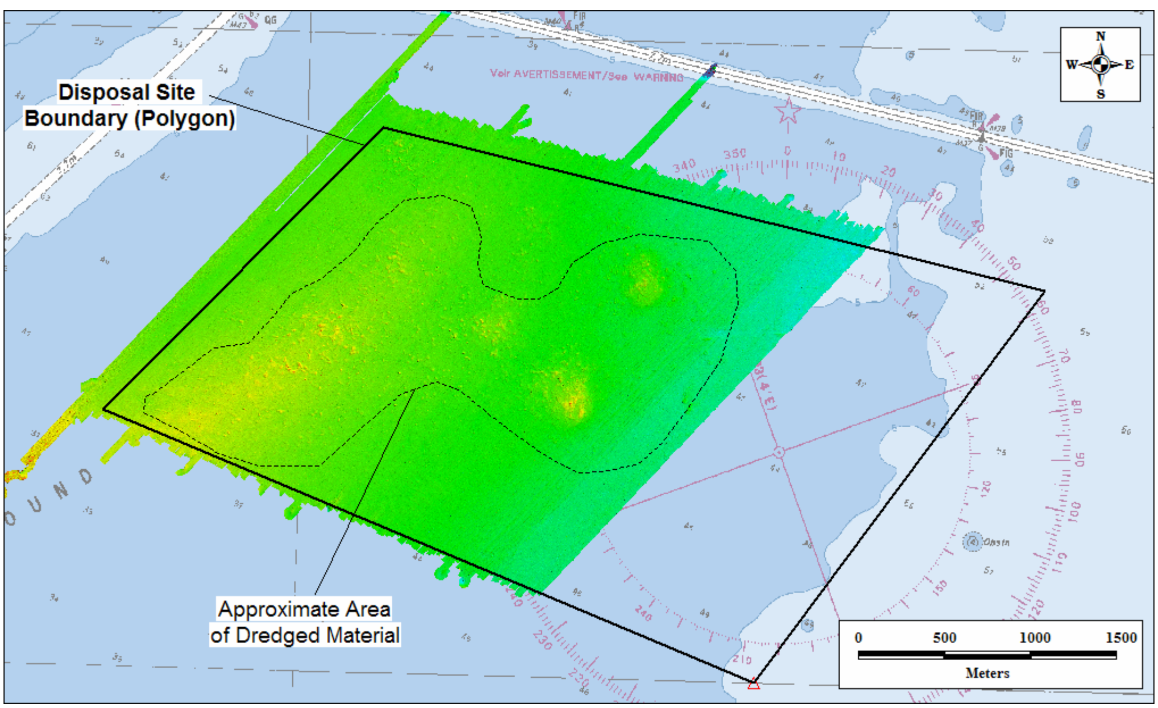


Figure 9: Multibeam Imagery, Disposal Site B

Multibeam and backscatter images collected by Natural Resources Canada at disposal sites A (Figure 8) and B (Figure 9) show the clear presence of dredge material on the seafloor. The dredged material is largely confined to the immediate area surrounding disposal site A (defined by a point) and within the boundaries of disposal site B (defined by a polygon). Sediment samples collected in the footprint of disposal site A are currently being analyzed for sediment chemistry, toxicity to marine organisms, and benthic community assemblage data. These results will be compared with data collected at two nearby reference sites to help identify what influence, if any, disposal activities have had on the sediment quality and benthic communities at dumpsite A.

Further results from the recent monitoring work will be forthcoming following analysis of the data, and will enable a conclusion to be reached about the effectiveness of capping to contain cadmium contamination.

Acknowledgements

Environment Canada would like to thank Russell Parrott, Natural Resources Canada and Tim Milligan, Fisheries and Oceans Canada for their work on this monitoring project.

References

Milligan, T.G., Budgen, B., Law, B., and Smith, J.N. Miramichi River Estuary Dredging Impact Study. June 28, 2005.

Pacific and Yukon Region Preliminary Results

Malcolm Island, British Columbia

Background

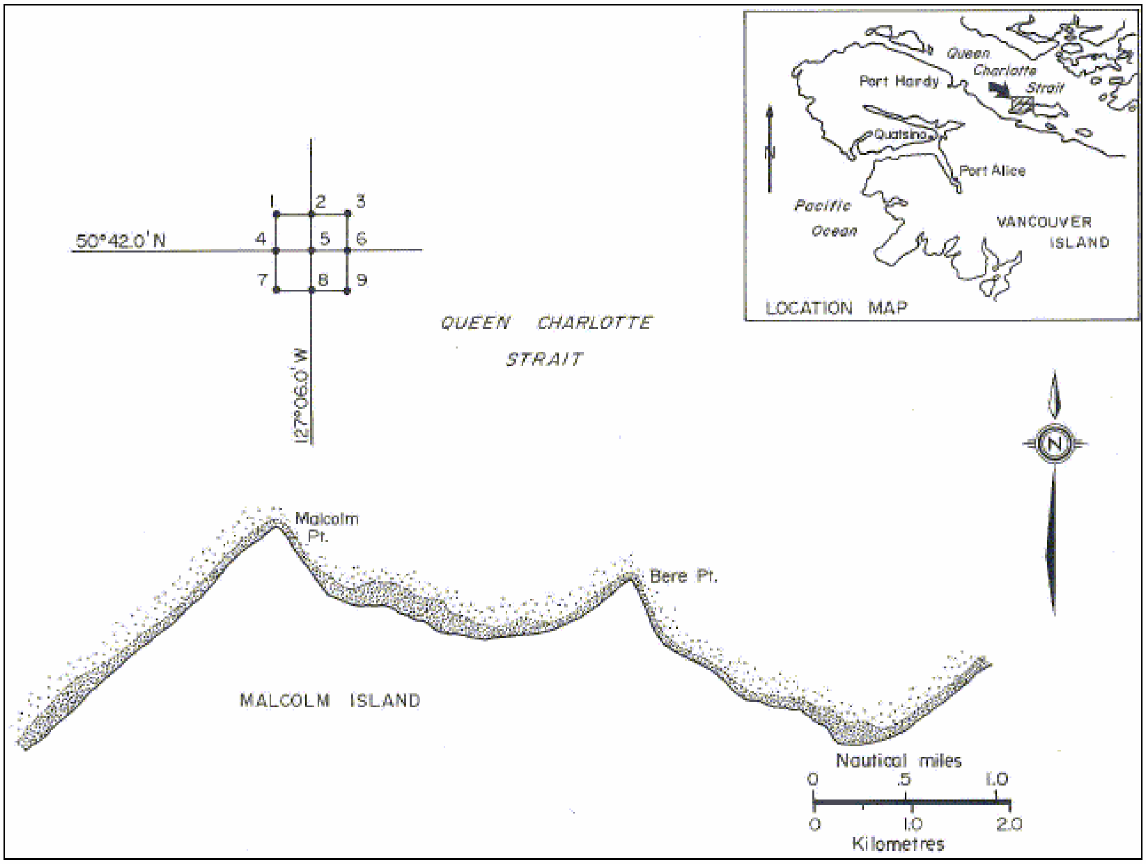


Figure 10. Map showing the location of Malcolm Island, British Columbia

The Malcolm Island ocean disposal site was designated in 1984. To date, the total volume of dredged material disposed of at the site is approximately 102,960 cubic metres. The site is located in 180 metres of water depth. The majority of the material disposed of at the site results from maintenance dredging at log handling facilities on northern Vancouver Island.

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Impact Hypothesis

i. Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.
ii. The bioavailabilty of contaminants at designated sites is low.
iii. The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.

Monitoring Conducted

In June 2004, sediment chemistry samples were collected with a Smith-McIntyre grab sampler at pre-determined station locations. Samples were analyzed for trace metal concentrations, organics, particle size distribution, TOC and AVS/SEM (see Figures 11 through 13).

The sediment chemistry data has been added to the monitoring database and will be compared with survey results from November 1998. Sediment chemistry, particle size and TOC will also be used to monitor the distribution of material disposed of at the site and the surrounding areas.

AVS/SEM will be used to evaluate the potential for bioavailability of trace metal contaminants in the sediment at the disposal site.

Composite sediment samples were collected at pre-determined station locations and prepared for biological testing. Bioassays using the amphipods *Eohaustorius estuaries* (see Table 1), the Microtox® solid phase test, and the echinoid fertilization test were conducted. Results were evaluated against current pass/fail criteria. All sediments from Malcolm Island that were tested passed the criteria.

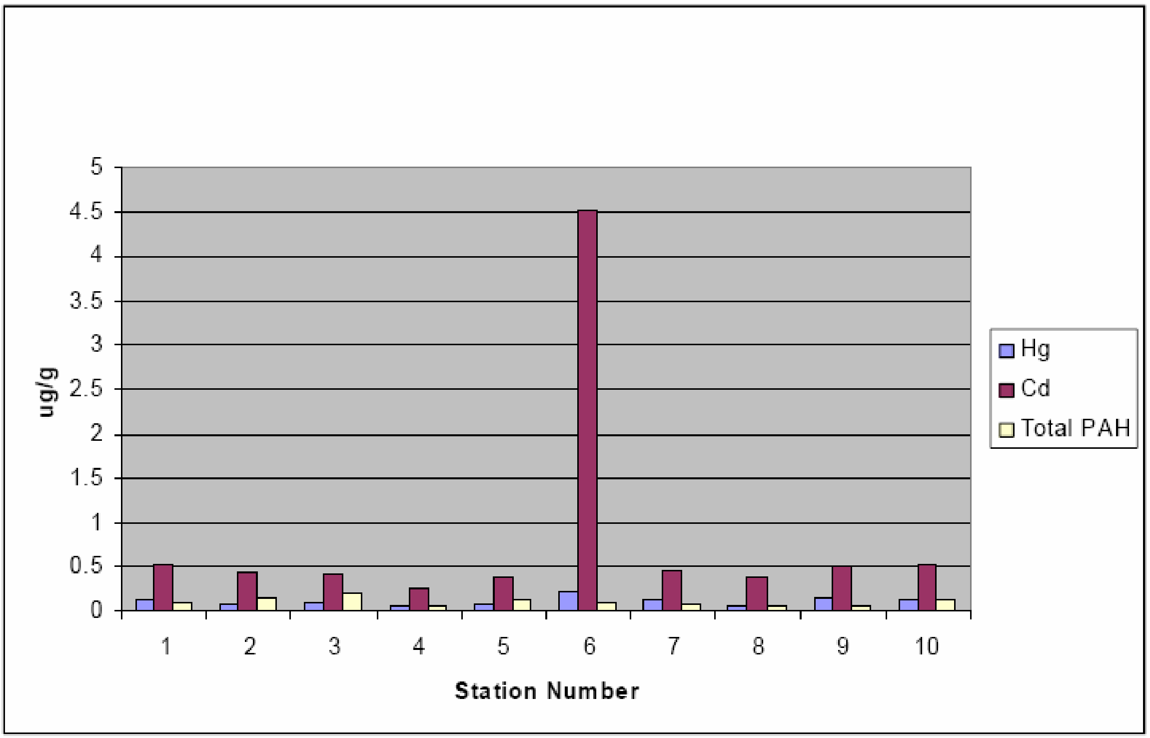


Figure 11. Mean Trace Metal Concentrations and Total PAH Data from Malcolm Island Monitoring Survey, 2004

Site	**Station Number**	**% Survival Replicates**					**Mean**	**+/- SD**	**Significant Difference**
		A	**B**	**C**	**D**	**E**			
Control	-	95	100	100	95	85	95	6.12	-
Malcolm Island	5	95	95	100	90	75	91	9.62	No

Table 1. Amphipod Euhaustorius estuaries *sediment bioassay Day 10 Survival data for Malcolm Island*

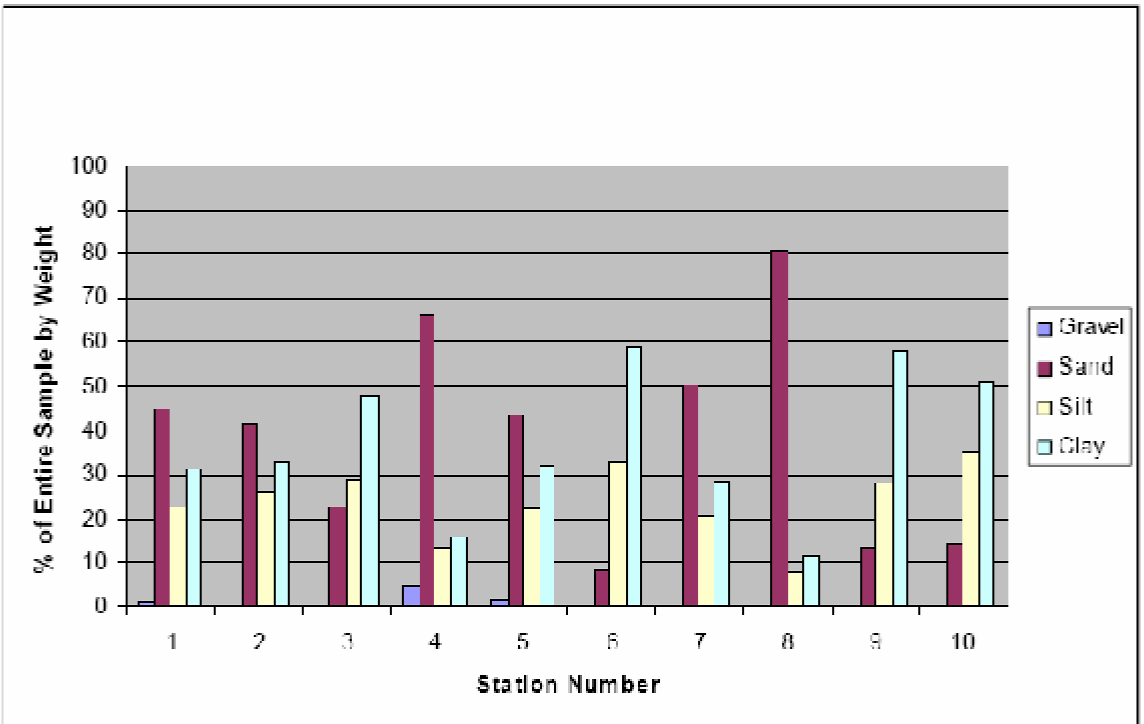


Figure 12. Mean Particle Size Data from Malcolm Island Monitoring Survey, 2004

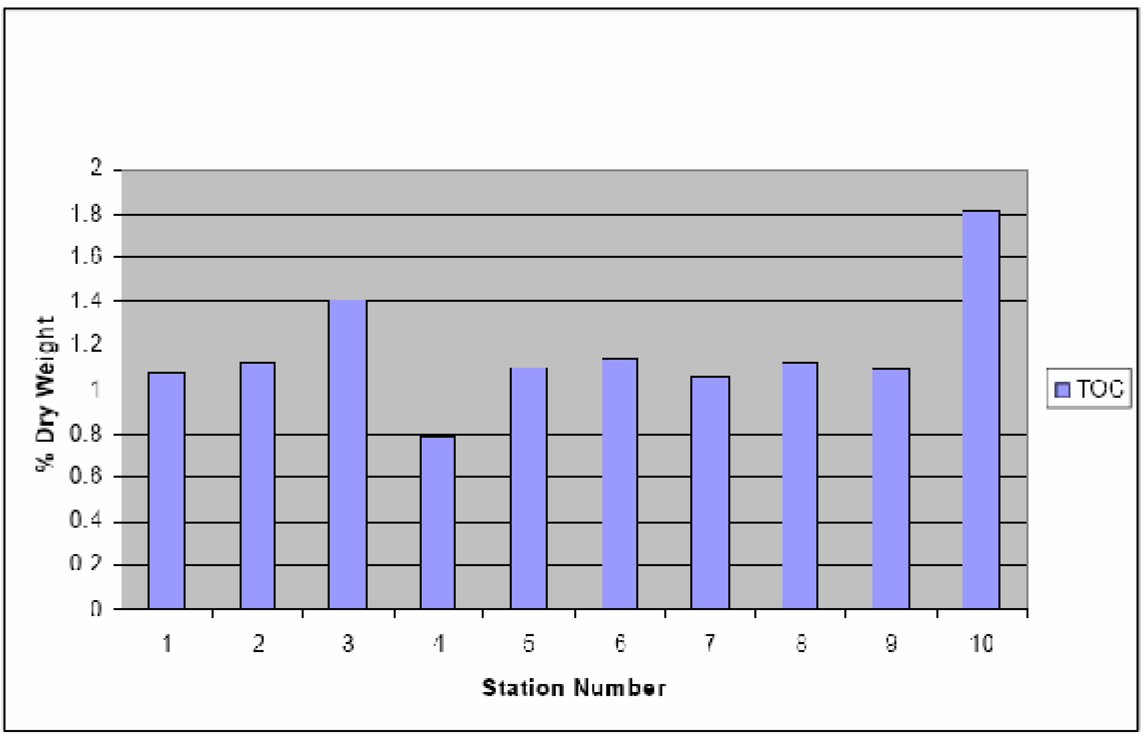


Figure 13. Mean TOC Data from Malcolm Island Monitoring Survey, 2004

Pacific and Yukon Region Preliminary Results

Johnstone Strait – Hanson Island, British Columbia

Background

The Johnstone Strait – Hanson Island ocean disposal site was designated in 1980. To date, the total volume of dredged material disposed of at the site is approximately 225,853 cubic metres. The site is located in 470 metres of water. The majority of the material disposed of at the site results from maintenance dredging at log handling facilities on northern Vancouver Island.

Impact Hypothesis

i. Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.

ii. The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.

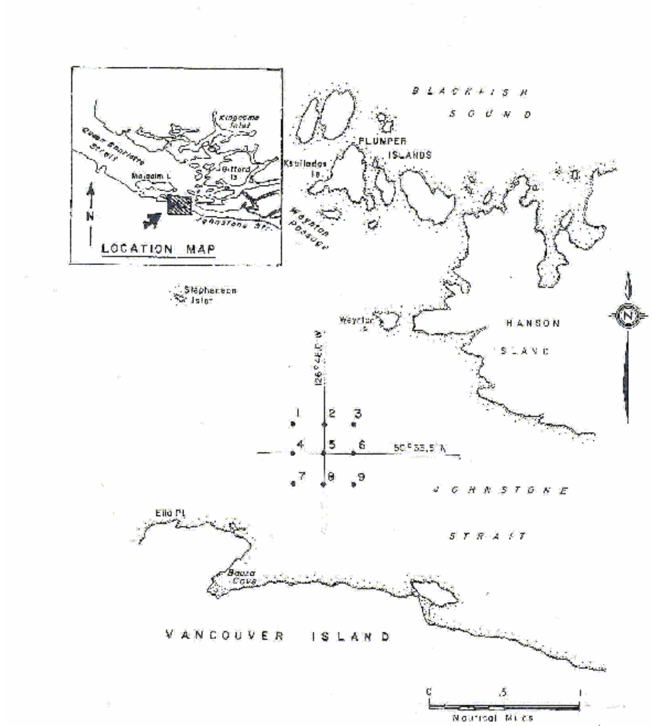


Figure14. Map showing the location of Johnstone Strait - Hanson Island, British Columbia

Monitoring Conducted

In June 2004, attempts to collect sediment samples at the disposal site were unsuccessful. The bottom is known to be composed of rocks, coarse gravel and hard sediment. A collection of hydroids, cnidarians, urchins and barnacles were collected during the sampling attempts indicating the disposal site experiences significant currents.

Pacific and Yukon Region Preliminary Results

Johnstone Strait – Hickey Point, British Columbia

Background

The Johnstone Strait ocean disposal site was designated in 1980. To date, the total volume of dredged material disposed of at the site is approximately 183,694 cubic metres. The site is located in 270 metres of water. The majority of the material disposed of at the site results from maintenance dredging at forest industry sites and is comprised of wood waste, silt, clay, sand, and gravel.

Impact Hypothesis

i. *Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.*
ii. *The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.*

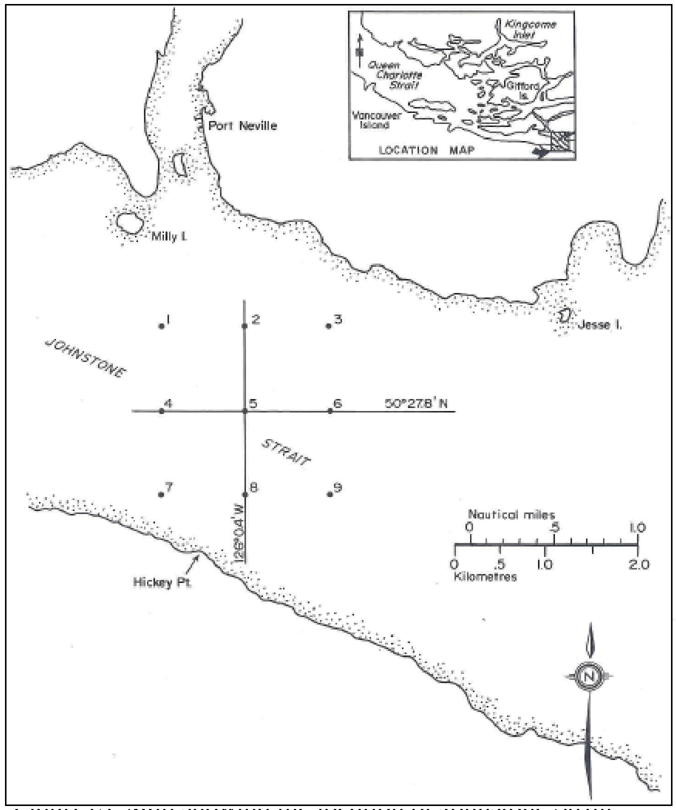


Figure15: Map showing the location of Johnstone Strait – Hickey Point, British Columbia

Monitoring Conducted

In June 2004, sediment chemistry samples were collected with a Smith-McIntyre grab sampler at pre-determined station locations and analysed for trace metal concentrations, organics, particle size distribution, TOC, and AVS/SEM (see figures 16 - 18).

The sediment chemistry data has been added to the monitoring database and will be compared with survey results from November 1998. Sediment chemistry, particle size and TOC will also be used to monitor the distribution of material disposed of at the site and the surrounding areas. AVS/SEM will be used to evaluate the potential for bioavailability of trace metal contaminants in the sediment at the disposal site.

Composite sediment samples were collected at pre-determined station locations and prepared for biological testing. Bioassays using the amphipods *Eohaustorius estuaries* (see Table 2), the Microtox® solid phase test and the echinoid fertilization test were conducted. Results will be evaluated against current pass/fail criteria. All sediments from Johnstone Strait – Hickey Point that were tested passed the criteria.

Site	Station Number	% Survival Replicates					Mean	+/- SD	Significant Difference
		A	B	C	D	E			
Control	-	95	100	100	95	85	95	6.12	-
Johnstone Strait Hickey Point	5	75	95	95	95	95	91	8.94	No

Table 2. Amphipod Euhaustorius estuaries *sediment bioassay Day 10 Survival data for Hickey Point*

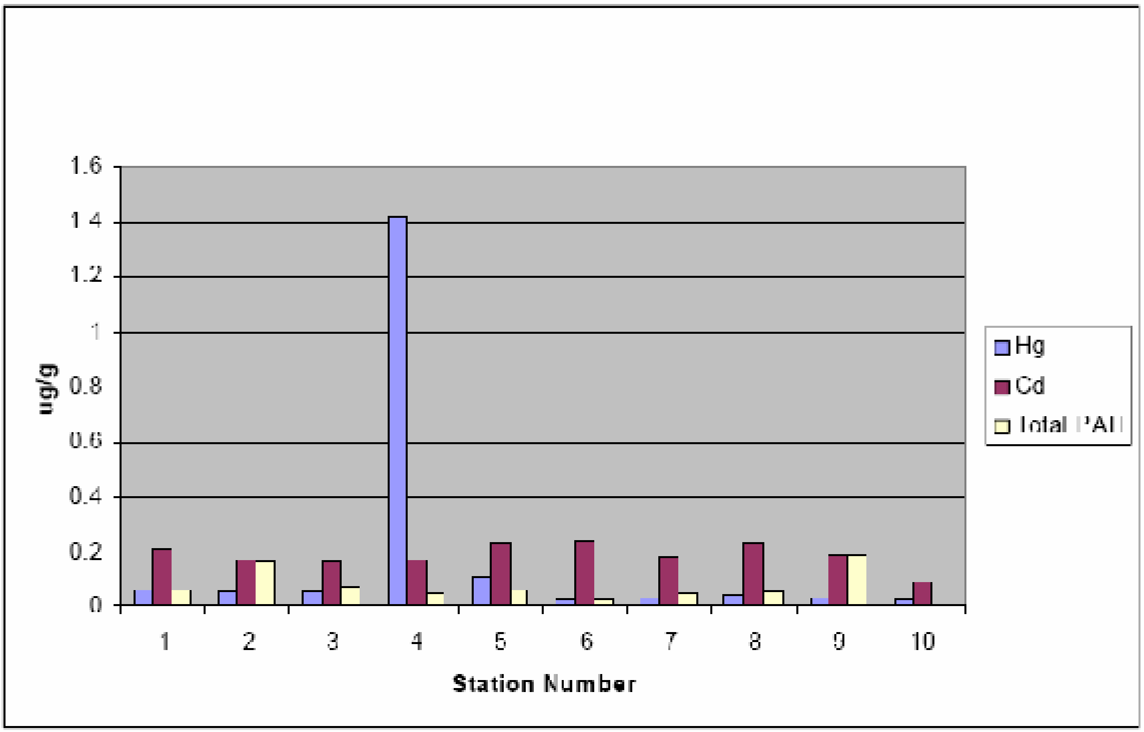


Figure 16. Mean Trace Metal Concentrations and Total PAH Data from Johnstone Strait / Hickey Point Monitoring Survey, 2004

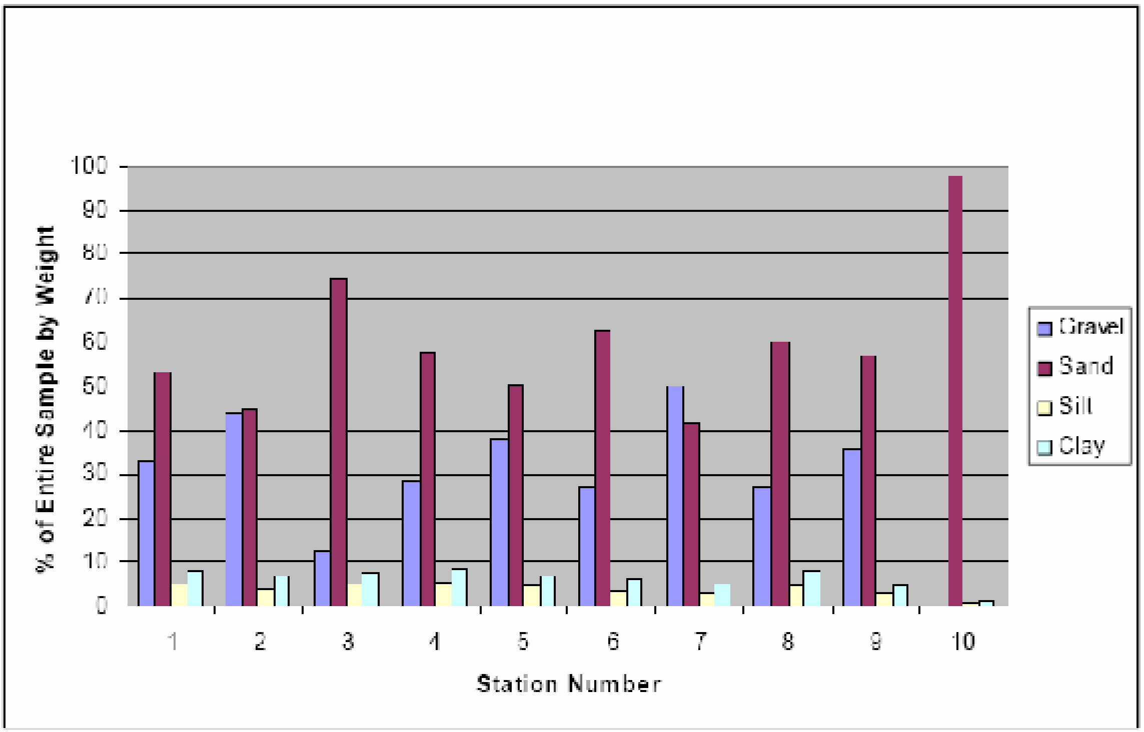


Figure 17. Mean Particle Size Data from Johnstone Strait / Hickey Point Monitoring Survey, 2004

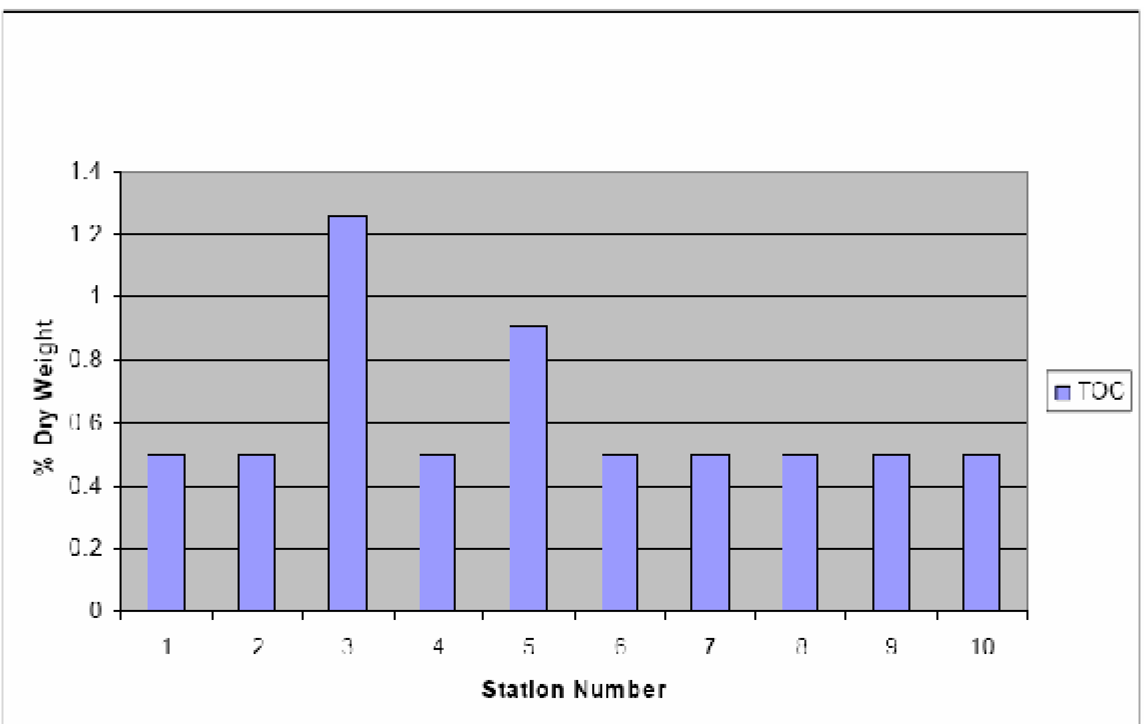


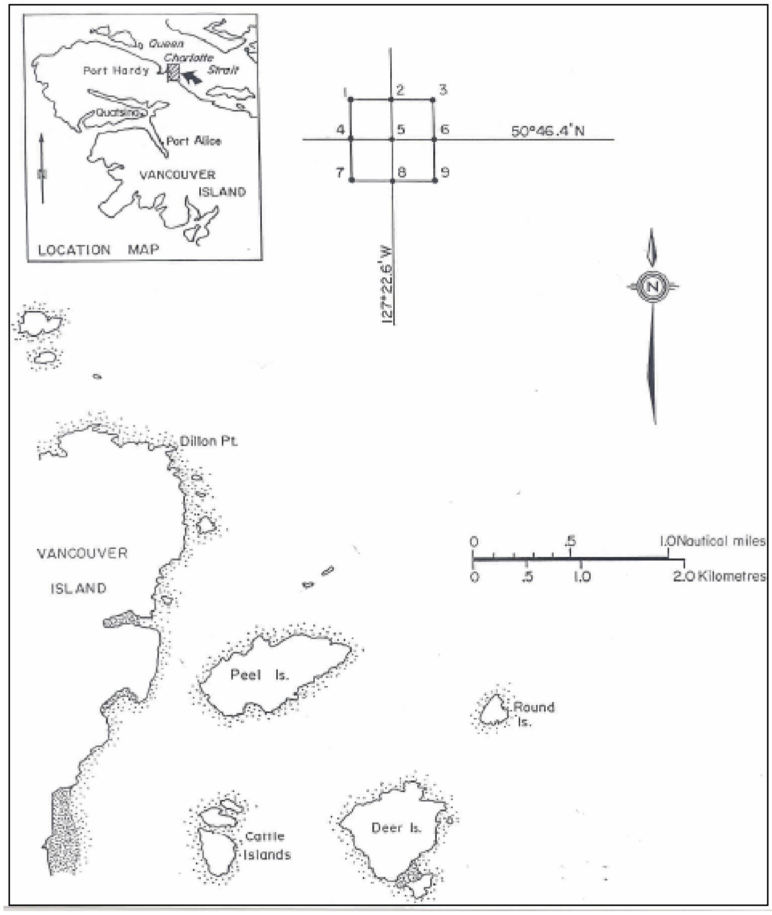
Figure 18. Mean TOC Data from Johnstone Strait / Hickey Point Monitoring Survey, 2004

Pacific and Yukon Region Preliminary Results

Queen Charlotte Strait, British Columbia

Background

The Queen Charlotte Strait ocean disposal site was designated in 1984. To date, the total volume of dredged material disposed of at the site is approximately 20,613 cubic metres. The site is located in 390 metres of water depth. The majority of the material disposed of at the site results from maintenance dredging at log handling facilities on northern Vancouver Island.



Impact Hypothesis

i. *Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.*
ii. *The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing*

.

Monitoring Conducted

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler at pre-determined station locations. Samples were analysed for trace metal concentrations, organics, TOC, AVS/SEM, and particle size distribution (see Figures 20 -22).

The sediment chemistry data will be added to the monitoring database and compared with survey results from November 1998. Sediment chemistry, particle size, and TOC will also be used to monitor the distribution of material disposed of at the site and the surrounding areas. AVS/SEM will be used to evaluate the potential for bioavailability of trace metal contaminants in the sediment at the disposal site.

Composite sediment samples were collected at pre-determined station locations and prepared for biological testing. Bioassays using the amphipods *Eohaustorius estuaries* (See Table 3), the Microtox® solid phase test, and the echinoid fertilization test were conducted. Results will be evaluated against current pass/fail criteria.

Site	Station Number	% Survival Replicates					Mean	+/- SD	Significant Difference
		A	B	C	D	E			
Control	-	95	100	100	95	85	95	6.12	-
Queen Charlotte Strait	5	100	95	95	100	90	96	4.18	No

Table 3; Amphipod Euhaustorius estuaries *sediment bioassay Day 10 Survival data for Queen Charlotte Strait*

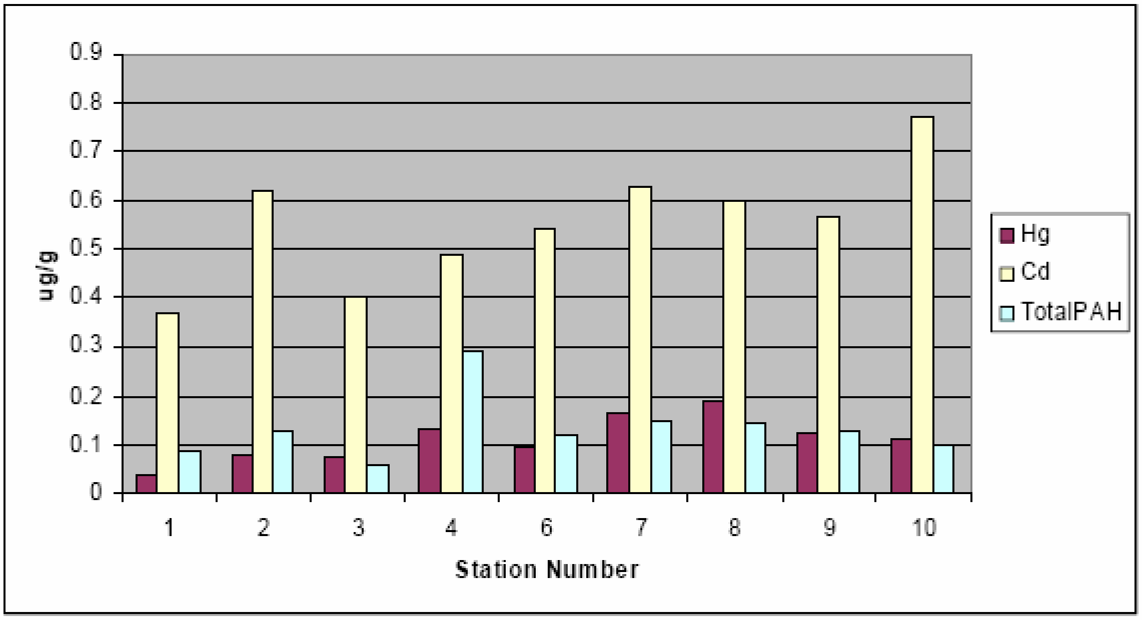


Figure 20. Trace Metal Concentrations and PAH Data from Queen Charlotte Strait Monitoring Survey, 2004

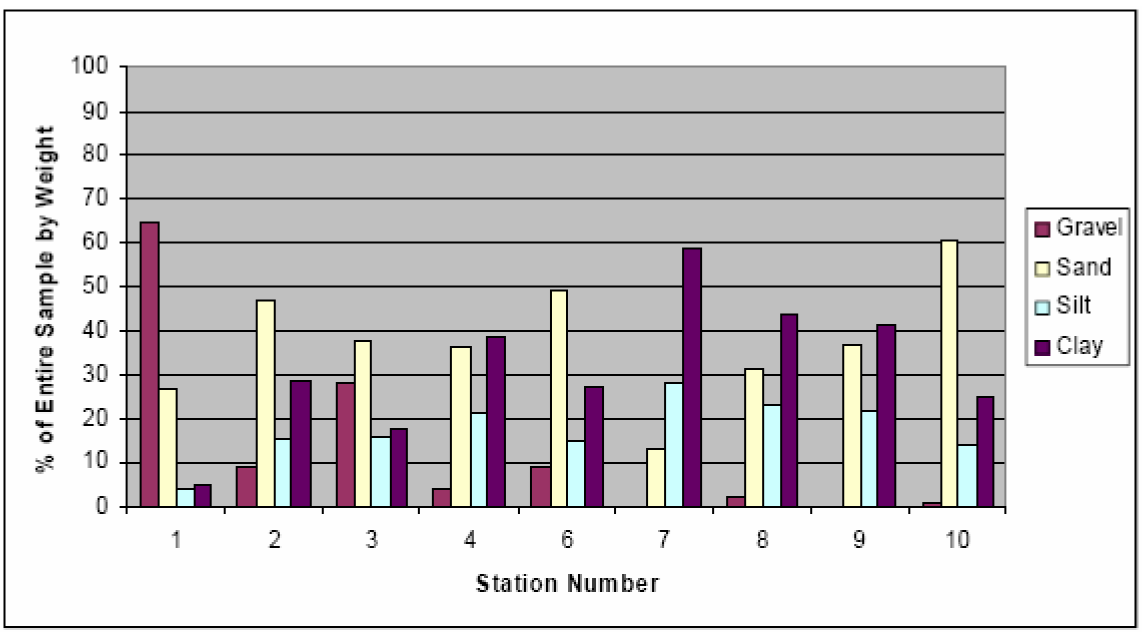


Figure 21. Particle Size Data from Queen Charlotte Strait Monitoring Survey, 2004

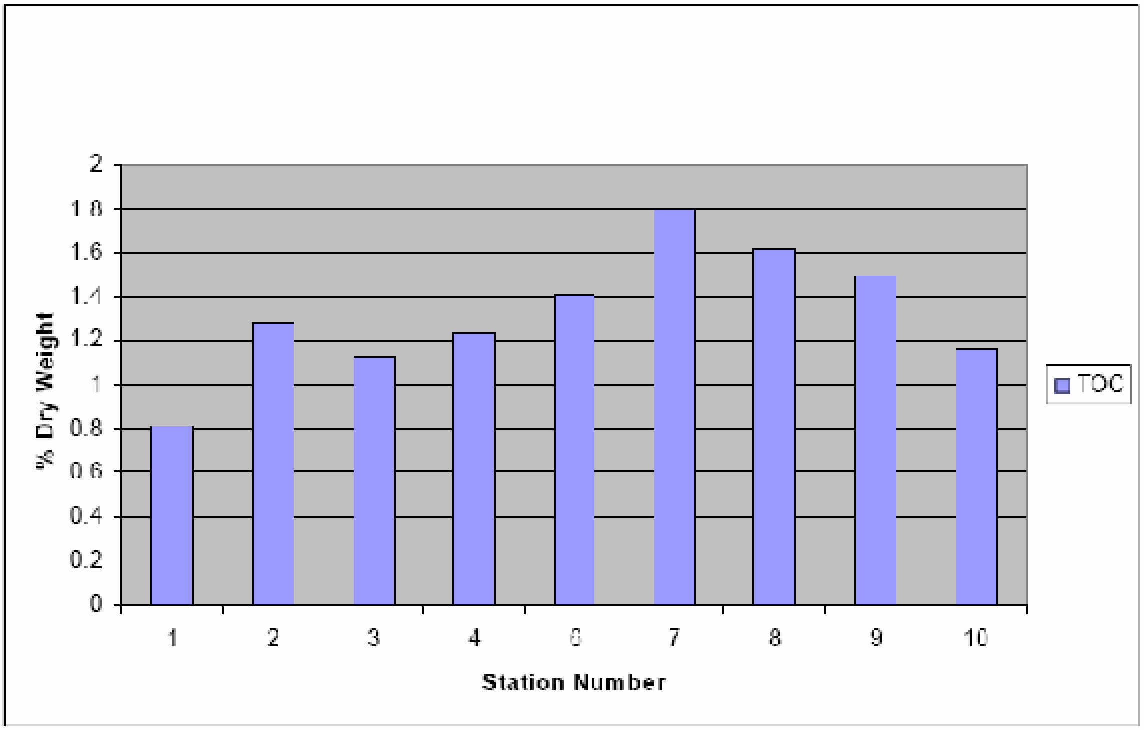


Figure 22. TOC Data from Queen Charlotte Strait Monitoring Survey, 2004

Pacific and Yukon Region Preliminary Results

Sand Heads, British Columbia

Background

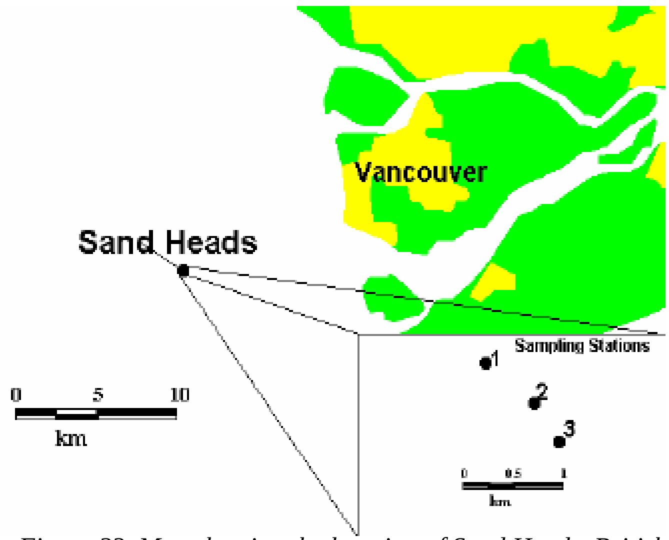


Figure 23. Map showing the location of Sand Heads, British Columbia

The Sand Heads, British Columbia disposal site is located at 49°06.00'N, 123°19.5'W in 70 m of water, and has been in active use since 1974. Site boundaries were delineated to allow position fixing on the navigation aids at the mouth of the main arm of the Fraser River Delta. Material disposed of at the site is comprised almost exclusively of sand and silt from annual maintenance dredging in the navigation channels located in the main arm of the Fraser River conducted by the Fraser River Port Authority. The location is in a highly dynamic zone subject to significant freshwater flow, tidal action and the marine weather conditions of the Strait of Georgia. The foreslope of the Fraser Delta is also subject to frequent sloughing into the Georgia Basin.

Impact Hypothesis

Disposal activities do not result in a significant dispersal of material beyond the boundaries of the disposal site.

Monitoring Conducted

In October 2004, the Depatment of Fisheries and Oceans remotely operated submersible ROPOS was used to conduct physical monitoring work in the vicinity of the disposal site at approximately 200 metres. The survey was designed to provide real-time records of the benthic conditions at a location where the Fraser slope is known to slough. Bathymetric data indicates the material from the disposal site and natural discharges from the river accumulate at the site tested. The transect lines were georeferenced to allow future surveys to be carried out for comparative purposes. Video records are used to record conditions (i.e. biological and geophysical changes and any currents related effects) at the site and the surrounding area. These records are currently being processed. Still digital camera images and Interactive-Realtime-Logging images were collected, and are also being processed.

Pacific and Yukon Region: *Thormanby Island, British Columbia*

Background

The Thormanby Island ocean disposal site was designated in 1980. The total volume of dredged material disposed of at the site is approximately 13,585 cubic metres. The site is located in 384 metres of water in the south portion of Malaspina Strait. The majority of the material disposed of at the site results from maintenance dredging at marinas as well as gravel loading facilities on the Sunshine Coast.

Impact Hypothesis

Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.

Monitoring Conducted

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler and a Benthos gravity core at pre-determined station locations. Samples were analyzed for trace metal concentrations, organics, TOC, and particle size distribution.

Results and Conclusions

The results show marginally elevated cadmium levels at a single station (Station 7 – see Table 4) and in the core sample; however, the levels are not of concern and no further management of the disposal site is proposed at this time. All levels of other metals and TPAH are within acceptable levels for disposal at sea. Particle size distribution analysis indicates sediment with >95% silts and clays within the disposal site and reference location.

The sediment chemistry data will be added to the regional monitoring database to be used in long-term monitoring profiles of the disposal site.

Station	Cd	Hg	Sediment Chemistry[1] Cu	Pb	Zn	TPAH	TOC	Gravel	% Particle Size Sand	Silt	Clay
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.42	0.12	35.10	15.00	97.10	0.28	1.25	0.00	1.70	30.50	67.80
2	0.46	0.12	41.60	14.00	112.00	0.30	1.38	0.00	2.80	27.10	70.10
3	0.47	0.12	51.20	37.00	135.00	0.50	1.40	0.00	5.50	28.00	66.50
4	0.51	0.12	46.20	21.00	128.00	0.35	1.20	0.00	4.60	30.40	65.00
5	0.49	0.12	58.50	27.00	130.00	0.33	1.29	0.00	1.10	31.10	67.80
6	0.43	0.12	41.30	21.00	124.00	0.27	1.30	0.00	0.60	27.25	72.15
7	0.71*	0.13	37.50	13.00	104.00	0.24	1.30	0.00	1.10	33.20	65.70
8	0.56	0.12	41.50	22.00	127.00	0.23	1.40	0.00	1.00	28.60	70.40
9	0.44	0.12	41.50	22.00	127.00	0.27	1.33	0.00	0.70	32.00	67.30
10	0.43	0.13	46.50	23.00	135.00	0.35	1.33	0.00	0.50	21.70	77.80
Stn. 5: Core											
0-5 cm	0.89*	0.07	70.20	21.00	168.00			0.00	0.40	23.90	75.70
10-20 cm	0.53	0.06	37.90	11.00	94.80			0.00	0.50	20.40	79.10
30-40 cm	0.44	0.05	29.00	9.00	117.00			0.00	0.20	19.00	80.80
60-70 cm	0.49	0.06	33.80	9.00	94.10			0.00	0.20	20.10	79.70
90-100 cm	0.65*	0.06	58.50	14.00	118.00			0.00	0.30	20.60	79.10
120-130 cm	0.57	0.06	38.70	9.00	95.00			0.00	0.30	18.70	81.00

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 4; Thormanby Island trace metal, organic and particle size distribution

Pacific and Yukon Region: *Comox, British Columbia*

Background

The Comox ocean disposal site was designated in 1977. To date, the total volume of dredged material disposed of at the site has been approximately 90,918 cubic metres. The site is located in 190 metres of water in the northern section of the Strait of Georgia. The majority of the material disposed of at the site results from maintenance dredging at sawmills and log handling facilities on the central section of Vancouver Island.

Impact Hypothesis

Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.

Monitoring Conducted

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler and a Benthos gravity core at pre-determined station locations. Samples were analysed for trace metal concentrations, organics, TOC, and particle size distribution.

Results and Conclusions

The results show the levels of trace metals and organics are not of concern and no further management of the disposal site is proposed at this time (see Table 5). Particle size distribution analysis indicates sediment with a relatively high sand content (19.6 - 49.7%) within the disposal site and reference location.

Station	Cd	Hg	Cu	Pb	Zn	TPAH	TOC	Gravel	Sand	Silt	Clay
	Sediment Chemistry[1]							% Particle Size			
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.20	0.07	36.90	N.D.	61.40	0.20	1.95	9.80	22.90	34.30	33.10
2	0.30	0.06	41.60	N.D.	65.30	0.45	1.63	30.80	19.60	22.60	27.00
3	0.19	0.07	44.00	N.D.	66.70	0.46	1.63	22.80	25.60	20.50	31.00
4	0.16	0.06	50.80	N.D.	79.70	0.47	3.19	15.70	26.80	30.30	27.10
5	0.22	0.07	42.60	N.D.	68.60	0.29	1.23	8.00	39.40	26.70	25.90
6	0.20	0.06	33.60	N.D.	62.50	0.52	2.84	27.60	25.20	21.40	25.70
7	0.24	0.05	35.10	N.D.	61.30	0.26	1.50	0.00	49.70	25.50	24.80
8	0.37	0.06	43.00	N.D.	68.40	0.37	2.13	20.30	25.00	29.40	25.20
9	0.38	0.06	41.60	N.D.	65.90	0.61	3.12	0.00	28.50	38.70	32.80
10	0.18	0.07	41.90	N.D.	67.00	0.21	1.81	6.80	23.50	29.90	39.80
Stn. 5: Core											
0-5 cm	0.35	0.08	52.60	N.D.	80.70			2.40	27.70	36.90	33.00
10-20 cm	0.24	0.04	25.40	N.D.	58.40			1.50	17.20	40.40	41.00
30-40 cm	0.16	0.03	16.90	N.D.	50.20			0.00	12.90	40.40	46.70
50-60 cm	0.30	0.03	23.30	N.D.	48.70			0.00	6.70	42.10	51.20

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 5; Comox (Cape Lazo) trace metal, organic and particle size distribution

Pacific and Yukon Region: *Victoria, British Columbia*

Background

The Victoria ocean disposal site has been in use since 1970 when it was designated for use by the provincial Ministry of Transport in British Columbia. To date, the total volume of dredged and excavated material disposed of at the site is approximately 296 544 cubic metres. The site is located in 90 metres of water south of the city of Victoria. The majority of the material disposed of at the site results from maintenance dredging at marinas and commercial properties near Victoria.

Impact Hypothesis

i. *Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.*
ii. *Disposal activities do not result in a significant dispersal of material beyond the boundaries of the disposal site.*

Monitoring Conducted

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler at pre-determined station locations. Samples were analyzed for trace metal concentrations, organics, TOC, and particle size distribution.

The Department of Fisheries and Oceans remotely operated submersible ROPOS was scheduled to be deployed at the site in October 2003. The survey was cancelled due to time constraints and poor weather conditions and will be rescheduled at the next available opportunity.

Results and Conclusions

The results show the levels of trace metals and organics are not of concern and no further management of the disposal site is proposed at this time (see Table 6). Particle size distribution analysis indicates sediment with high gravel and sand content within the disposal site and reference location which is suggestive of a dispersive benthic environment.

	Sediment Chemistry[1]							% Particle Size			
Station	**Cd**	**Hg**	**Cu**	**Pb**	**Zn**	**TPAH**	**TOC**	**Gravel**	**Sand**	**Silt**	**Clay**
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 Mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.16	0.16	19.10	N.D.	61.90	0.17	-0.5	43.50	39.30	9.70	7.60
2	0.24	0.05	19.40	10.00	72.60	0.18	-0.5	30.40	53.50	8.80	7.20
3	0.40	0.05	294.00	11.00	87.50	0.09	-0.5	16.50	68.80	8.50	6.30
4	0.24	0.05	21.00	N.D.	65.10	0.07	-0.5	34.10	47.50	8.80	9.50
5	0.26	0.04	17.90	N.D.	59.30	0.10	-0.5	43.00	45.70	4.60	6.70
6	0.41	0.05	63.20	N.D.	74.20	0.13	-0.5	21.30	67.90	6.10	4.60
7	0.21	0.04	12.30	10.00	47.90	0.09	-0.5	20.40	68.20	6.20	5.20
8	0.34	0.04	21.50	N.D.	60.70	0.08	-0.5	14.10	73.90	7.60	4.60
9	0.33	0.04	17.40	N.D.	58.20	0.05	-0.5	23.70	70.00	3.70	2.50
10	0.20	0.02	10.90	N.D.	52.30	0.08	-0.5	6.00	81.60	6.40	6.00

[1] Total metals results are expressed in dry weight

Table 6; Victoria trace metal, organic and particle size distribution.

Pacific and Yukon Region: *Porlier Pass, British Columbia*

Background

The Porlier Pass ocean disposal site was designated in 1978. To date, the total volume of dredged material disposed of at the site is approximately 197,074 cubic metres. The site is located in 176 metres of water in the Strait of Georgia. The majority of the material disposed of at the site results from maintenance dredging at sawmills and log handling facilities on southern Vancouver Island.

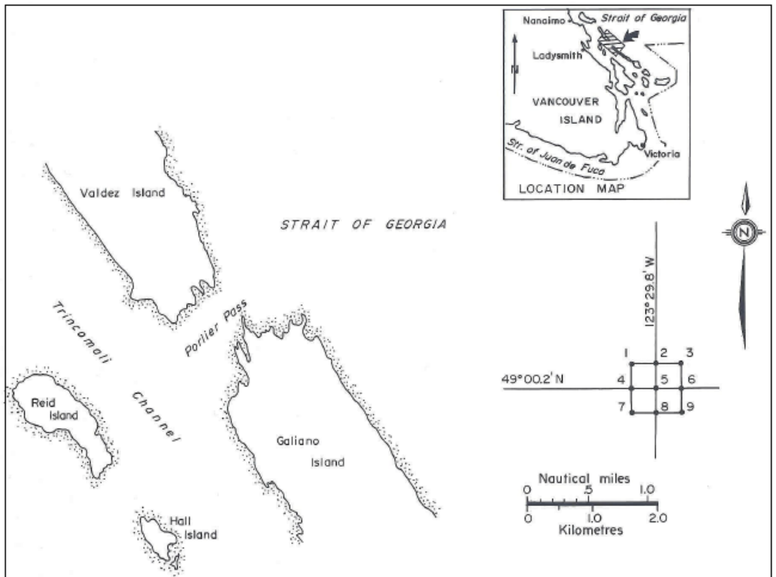


Figure 24. Map showing the location of Porlier Pass, British Columbia

Impact Hypothesis

i. Disposal activities do not result in a significant dispersal of material beyond the boundaries of disposal site.
ii. Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.
iii. The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.

Monitoring Conducted

In October 2003, the Department of Fisheries and Oceans remotely operated submersible ROPOS was used to conduct physical monitoring work at the site. Poor weather conditions at the time of the ROPOS dives limited the bottom time at this site and resulted in poor imaging and positioning. The survey will be rescheduled and conducted at the next available opportunity.

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler and a Benthos gravity core at pre-determined station locations. Samples were analysed for trace metal concentrations, organics, TOC, and particle size distribution. Composite samples of the sediment were also analysed for sulphides, ammonia and AVS/SEM.

Sediment toxicity was assessed using an acute amphipod test, a chronic echinoid fertilization test, and a Microtox® solid phase test.

Results and Conclusions

Sediment chemistry results indicate the levels of trace metals and organics are not of concern, with the exception of a very marginal exceedance in the surface portion of a core sample at the centre of the disposal site and a slightly elevated sample at Station 9 (see Table 7). Particle size distribution analysis indicates a non-dispersive benthic environment within the disposal site and reference location with sediments of high silt and clay content. This has been confirmed by visual records of the site on previous surveys using ROVs.

The ratio of acid volatile sulphides and simultaneously extracted metals was also assessed (see Table 8). When this ratio is greater than 1, potential bioavailability of trace metal contaminants in the sediment is indicated. Three stations have values greater than 1 which implies that free ion metals could potentially affect the resident benthic community.

Toxicity test results are presented in Table 9 below. The composite samples from Stations 7, 8 and 9 showed toxic responses in both the amphipod and echinoid fertilization tests. The amphipod response is marginally lower than the pass/fail criteria established for this bioassay. However, the response in the echinoid fertilization assay was significantly different than the control. According to the interpretative guidance used for the Microtox® solid phase assay, sediments from three stations within the disposal area triggered a toxic response.

In view of the varied responses in the biological tests, it is recommended that further study be undertaken at the disposal site and reference locations to more clearly understand any possible synergistic effects of the disposal activities.

Station	Cd	Hg	Cu	Pb	Zn	TPAH	TOC	Gravel	Sand	Silt	Clay
			Sediment Chemistry[1]						% Particle Size		
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.29	0.07	39.70	19.00	97.60	0.26	2.43	0.00	3.60	47.50	48.90
2	0.27	0.08	37.50	15.00	101.00	0.22	1.28	1.60	2.60	46.20	49.60
3	0.26	0.07	37.20	15.00	96.80	0.23	1.00	2.90	9.60	43.70	43.70
4	0.26	0.07	37.80	17.00	103.00	0.16	1.56	11.10	8.90	40.10	39.90
5	0.33	0.07	36.50	17.00	113.00	0.21	3.27	9.00	8.20	41.90	40.90
6	0.30	0.08	37.30	14.00	98.40	0.22	3.79	3.50	4.30	46.00	46.30
7	0.37	0.07	36.50	17.00	101.00	0.26	1.85	0.50	5.10	46.00	48.40
8	0.37	0.07	37.50	18.00	104.00	0.32	1.19	1.30	6.60	45.10	47.00
9	0.87*	0.07	36.10	17.00	101.00	0.24	1.23	0.00	6.20	47.70	46.10
10	0.28	0.06	31.90	18.00	96.83	0.12	0.97	3.80	13.90	31.00	51.30
Stn. 5: Core											
0-5 cm	0.62*	0.06	63.00	18.00	144.00			19.00	10.10	36.30	34.50
10-20 cm	0.33	0.09	40.60	21.00	111.00			0.00	2.50	48.30	49.20
30-40 cm	0.26	0.08	39.10	19.00	105.00			0.00	1.20	47.20	51.60
60-70 cm	0.43	0.05	31.90	15.00	93.90			0.00	1.70	47.20	51.10
90-100 cm	0.46	0.05	32.10	14.00	95.70			0.00	1.70	42.90	55.40
120-127 cm	0.28	0.05	33.20	15.00	96.50			0.00	1.00	43.90	55.10
Composite											
1,2,3	0.32	0.08	37.00	15.00	100.00	0.38	0.86	3.40	7.95	44.30	44.00
4,5,6	0.25	0.07	38.70	18.00	105.00	0.22	2.15	2.50	9.20	42.00	46.20
7,8,9	0.51	0.07	37.60	18.00	102.00	0.21	1.22	3.40	7.30	44.90	44.40
Reference 10	0.19	0.07	38.00	16.00	96.80	0.16	-0.50	12.30	11.70	31.20	44.80

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 7; Trace metal, organic and particle size distribution at Porlier Pass

Station	Sulphide µg/g	Ammonia µg/g	AVS µmol/g	SEM µmol/g	Ratio SEM/AVS
1	14.7	20.9	0.9	0.83	0.92
2	14.7	20.9	0.7	0.8	1.14
3	14.7	20.9	1.7	0.85	0.50
4	11.9	10.3	4.4	0.79	0.18
5	11.9	10.3	2.4	0.76	0.32
6	11.9	10.3	0.9	0.82	0.91
7	12.8	16.2	1.2	0.742	0.62
8	12.8	16.2	1.7	0.77	0.45
9	12.8	16.2	0.3	0.69	2.30
10	0.4	7.1	<0.27	0.648	2.40

"<" values indicate concentrations below the method detection limit.

* SEM/AVS > 1 indicates SEM metals may be bioavailable

Table 8; Additional chemical analyses at Porlier Pass

Station	Amphipod *Eohaustorius. estuarius* % survival	Echinoid *Dendraster excentricus* % fertilization	Microtox®+ solid phase 10 minute IC50 (mg/L)	 liquid phase 15 minute % decrease
Control	100.0 +/- 0.00	85.0 +/- 4.04		
1,2,3	72.0 +/- 4.47	68.0 +/- 7.94	854*	0
4,5,6	80.0 +/- 12.75	76.0 +/- 6.66	839*	2.63
7,8,9	70.0 +/- 7.91*	10.0 +/- 4.16*	736*	40.22
10	66.0 +/- 36.30	69.0 +/- 7.81	3351	2.07

*Toxic response

+ Microtox® results have been moisture corrected.

Table 9; Porlier Pass Toxicity Results

Pacific and Yukon Region: *Five Finger Island, British Columbia*

Background

The Five Finger Island ocean disposal site was designated in 1978. To date, the total volume of dredged material disposed of at the site is approximately 243,660 cubic metres. The site is located in 271 metres of water in the Strait of Georgia. The majority of the material disposed of at the site results from maintenance dredging at sawmills and log handling facilities on southern Vancouver Island.

Impact Hypothesis

i. *Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.*
ii. *The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.*

Monitoring Conducted

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler and a Benthos gravity core at pre-determined station locations. Samples were analysed for trace metal concentrations, organics, TOC, and particle size distribution.

Three replicate samples were collected at each station for bioassay purposes and were sub-sampled for analysis of trace metal concentrations, organics, TOC, and particle size distribution. Samples of the sediment were also analysed for sulphides, ammonia and AVS/SEM.

In October 2003, the Department of Fisheries and Oceans remotely operated submersible ROPOS was used to conduct physical monitoring work at the site. The survey was designed to provide real-time records of the benthic conditions at the disposal site. The transect lines are georeferenced to allow future surveys to be carried out for comparative purposes. The video records are used to record conditions (i.e. biological and geophysical changes and any currents related effects) of the disposal site and the surrounding area. Images of the benthic environment are available on the regional website.

Results and Conclusions

Chemistry results are presented in Table 10 below, and show a marginal exceedance of cadmium in the Station 5 sediment and in a portion of the core sample. TPAH levels above the regulated limit were noted at Station 2 and 5, and relatively higher levels than are observed at other disposal sites were noted at several other stations. This trend has been observed at the disposal site during previous surveys and is thought to be related to local geological conditions rather than disposal activities. The high percentage of material greater than 2mm in the particle size distribution can be attributed to woodwaste in the sediment and all stations have a significant percentage of sand, except the reference site.

Failures in the amphipod, echinoid and Microtox® (see Table 11) do not appear to correlate with the sediment chemistry profiles at the disposal site (see Table 12). The wide range of sediment types at stations on the disposal site and the reference location may have also affected the results of the bioassays.

A ratio of acid volatile sulphides to simultaneously extracted metals that is greater than 1 indicates the potential for bioavailability of trace metal contaminants in sediment. Four stations have values greater than 1 which means that free ion metals could potentially be available to the resident biota (see Table 13). Stations 1, 5 and 6 had elevated levels of ammonia and sulphide which could have the affected the fertilization success in the echinoid bioassay and the response in the Microtox® test. With the exception of a small exceedance of cadmium at Station 5 and TPAH at Stations 4 and 8, the trace metal and organic levels are not of concern.

In view of the varied responses in the biological tests, it is recommended that further study be undertaken at the disposal site and reference locations to more clearly understand any possible synergistic effects of the disposal activities.

	Sediment Chemistry[1]							% Particle Size			
Station	**Cd**	**Hg**	**Cu**	**Pb**	**Zn**	**TPAH**	**TOC**	**Gravel**	**Sand**	**Silt**	**Clay**
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.50	0.13	51.53	27.33	140.00	1.36	9.90	1.03	8.70	23.97	66.43
2	0.53	0.11	47.67	26.00	139.00	5.79*	3.26	4.00	18.07	21.43	56.47
3	0.51	0.10	45.50	23.67	139.33	0.42	5.14	8.10	26.03	18.63	47.20
4	0.46	0.11	44.37	24.00	123.00	0.84	3.27	24.07	22.70	13.43	39.80
5	0.66*	0.09	42.00	21.33	106.77	2.12	7.09	53.73	14.30	8.53	23.47
6	0.35	0.12	47.00	23.33	121.00	5.62*	7.71	14.00	29.20	14.10	42.70
7	0.46	0.12	46.80	21.33	114.67	1.66	2.33	3.73	16.83	18.67	60.73
8	0.34	0.11	56.07	19.00	109.67	2.38	-0.50	15.07	28.80	12.63	43.48
9	0.45	0.11	43.90	18.33	105.67	0.48	6.98	7.47	22.70	19.83	50.00
10	0.5	0.12	50.57	26.67	139.00	0.71	1.36	0.60	3.93	23.63	71.87
Stn. 5: Core											
0-5 cm	0.33	0.06	35.80	13.00	97.50			1.80	0.90	22.20	75.10
10-20 cm	0.28	0.06	33.70	13.00	117.00			0.00	1.10	22.90	76.00
30-40 cm	0.64*	0.05	38.50	13.00	122.00			0.00	1.20	22.30	76.50
60-70 cm	0.28	0.06	39.20	13.00	100.00			0.00	0.90	20.80	78.30
90-100 cm	0.49	0.06	34.90	13.00	100.00			0.00	0.90	21.50	77.60

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 10; Five Finger Island trace metal, organic and particle size distribution

Station	Amphipod *Eohaustorius. estuarius* % survival	Echinoid *Dendraster excentricus* % fertilization	Microtox®+ solid phase 10 minute IC50 (mg/L)	Microtox®+ liquid phase 15 minute % decrease
Control	100.0 +/- 0.00	86.0 +/- 2.65		
1	76.0 +/- 8.94	67.0 +/- 5.03	873*	0
2	91.0 +/- 4.18	75.0 +/- 5.51	1290	0
3	84.0 +/- 2.24	79.0 +/- 4.51	3858	1.29
4	82.0 +/- 9.08	74.0 +/- 8.33	1172	0
5	90.0 +/- 10.00	24.0 +/- 9.61*	320*	0.45
6	83.0 +/- 16.81	56.0 +/- 6.81*	738*	0
7	80.0 +/- 12.75	71.0 +/- 3.61	1865	1.73
8	68.0 +/- 16.81*	51.0 +/- 8.08*	3935	1.19
9	55.0 +/- 9.35*	20.0 +/- 5.29*	3184	5.08
10	66.0 +/- 23.02*	64.0 +/- 9.45	2571	0

*Toxic response

+ Microtox® results have been moisture corrected.

Table 11; Five Finger Island toxicity results

Station	Sediment Chemistry[1] Cd µg/g	Hg µg/g	Cu µg/g	Pb µg/g	Zn µg/g	TPAH µg/g	TOC %	% Particle Size Gravel > 2.0 mm	Sand 2 - 0.063 mm	Silt 0.063 - 0.004 mm	Clay < 0.004 mm
1	0.45	0.14	53.20	30.00	147.00	0.84	2.46	0.00	9.40	21.70	68.90
2	0.56	0.12	50.50	26.00	150.00	1.16	2.22	3.30	14.70	27.40	54.70
3	0.50	0.09	41.20	21.00	135.00	0.31	0.89	10.10	29.40	15.40	45.20
4	0.46	0.12	44.40	26.00	129.00	2.91*	6.21	19.00	18.40	15.10	47.50
5	0.67*	0.08	42.20	20.00	111.00	1.28	12.5	58.70	15.50	6.60	19.10
6	0.48	0.13	50.80	30.00	145.00	1.87	8.94	7.60	22.90	17.00	52.60
7	0.36	0.11	42.20	24.00	120.00	2.00	3.36	1.50	11.30	18.30	68.90
8	0.42	0.09	41.10	16.00	98.90	2.66*	2.05	8.10	30.60	14.20	47.00
9	0.54	0.16	41.90	19.00	114.00	1.89	3.35	3.50	23.50	19.10	53.90
10	0.33	0.13	51.40	26.00	143.00	0.44	1.76	0.00	2.70	24.10	73.20

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 12; Five Finger Island trace metal, organic and particle size distribution for bioassay samples

Station	Sulphide	Ammoni a	AVS	SEM	Ratio
	µg/g	µg/g	µmol/g	µmol/g	SEM/AVS
1	17.7	20.3	9	1.43	0.16
2	17.1	12.1	10.6	1.44	0.14
3	1.7	8.6	<0.6	0.95	1.58
4	21.4	9.7	6.5	0.98	0.15
5	92.8	40.1	17.4	0.8	0.05
6	22.7	29.5	13	0.94	0.07
7	10	7.1	0.7	1.14	1.63
8	n/a	n/a	<0.3	0.94	3.13
9	11	7	1.4	0.96	0.69
10	4.9	9.3	<0.8	1.51	1.89

"<" values indicate concentrations below the method detection limit.

* SEM/AVS > 1 indicates SEM metals may be bioavailable

Table 13; Five Finger Island additional chemical analysis

Pacific and Yukon Region: *Point Grey, British Columbia*

Background

Point Grey is the largest disposal site in Canada and receives over 450,000 cubic metres of material from several users each year. The site is located at 49o15.40’N, 123o22.10’W in 210 metres of water. Material disposed of at the site is comprised of woodwaste and river silt from channels in the Port of Vancouver and forest industry ports in the Fraser River.

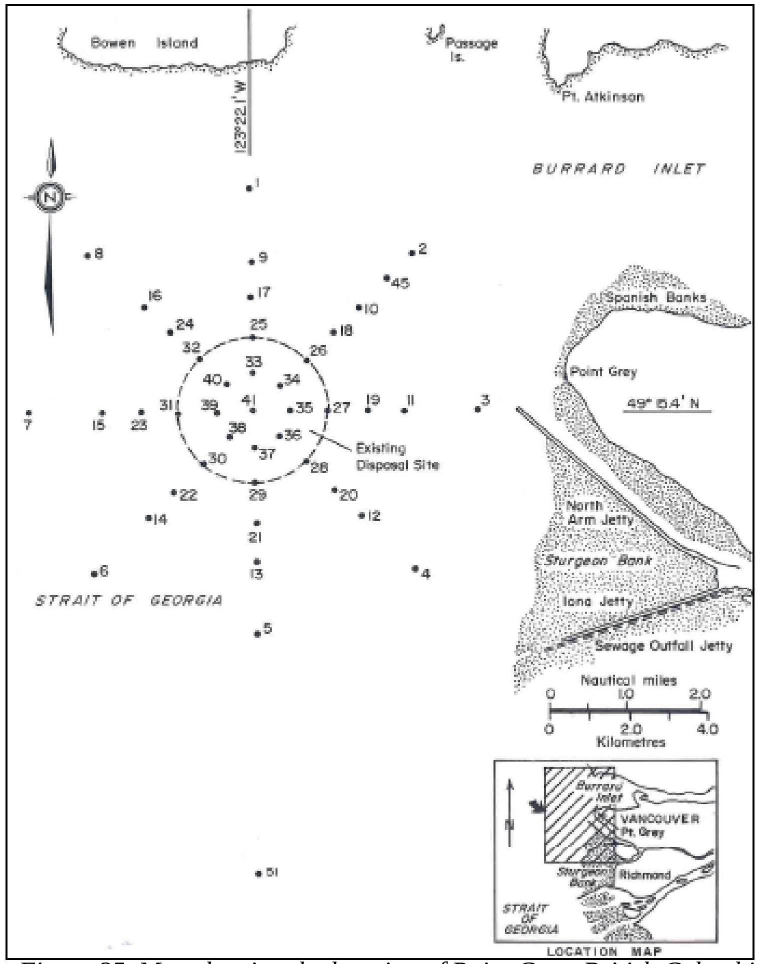


Figure 25. Map showing the location of Point Grey, British Columbia

Impact Hypothesis

i. *Disposal of dredged material does not result in a significant increase in trace contaminant levels in the sediments at designated sites.*
ii. *The disposed dredged material does not cause biological responses in sensitive marine organisms as determined by toxicity testing.*
iii. *Disposal activities do not result in a significant dispersal of material beyond the boundaries of the disposal site.*

Monitoring Conducted

The Point Grey disposal site was monitored in 2003 and 2004. Results and conclusions from 2003 have been analyzed and are reported here, while 2004 results are presented here in preliminary format only. Final conclusions from 2004 studies will be reported in the 2005/2006 compendium.

In June 2003, sediment chemistry samples were collected with a Smith-McIntyre grab sampler at pre-determined station locations. Samples were analysed for trace metal concentrations, organics, TOC, and particle size distribution.

In October 2004, sediment chemistry samples were collected with a Smith-McIntyre grab sampler from pre-determined disposal site station location. Samples were analysed for trace metal concentrations (see Figure 26), organics (not completed), TOC (not completed), and particle size distribution (see Figure 27). AVS/SEM was used to evaluate the potential for bioavailability of trace metal contaminants in the sediment at the disposal site (see Figure 28).
Composite sediment samples were collected and prepared for biological testing. Bioassays using the amphipods *Eohaustorius estuaries* (see Table 15), the Microtox® solid phase test, and the

echinoid fertilization test were conducted. Results will be evaluated against current pass/fail criteria.

In October 2004, the Department of Fisheries and Oceans remotely operated submersible ROPOS was used to conduct physical monitoring work at the site. The survey was designed to provide real-time records of the benthic conditions at the disposal site. The transect lines are georeferenced to allow future surveys to be carried out for comparative purposes. Video records are used to document conditions (i.e. biological and geophysical changes and any currents related effects) at the disposal site and the surrounding area. These records are currently being processed. Still digital camera images and Interactive-Realtime-Logging images were also collected, and are also being processed (see Figure 29).

Results and Conclusions (2003)

With the exception of very minor exceedances of cadmium at four stations (see Table 14), the sediment chemistry results are not of concern. Monitoring surveys of sediment chemistry conducted at the disposal site over the past 25 years indicate no cumulative effects resulting from disposal activities. No further management is recommended as a result of these findings.

Station	Cd	Hg	Cu	Pb	Zn	TPAH	TOC	Gravel	Sand	Silt	Clay
	Sediment Chemistry[1]							% Particle Size			
	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	%	> 2.0 mm	2 - 0.063 mm	0.063 - 0.004 mm	< 0.004 mm
1	0.34	0.08	37.10	16.00	97.90	0.33	0.88	0.00	4.60	49.50	45.90
2	0.23	0.10	44.00	19.00	102.00	0.31	0.78	0.00	1.80	54.40	43.80
3	0.31	0.06	32.40	12.00	83.80	0.28	0.59	0.00	30.60	52.40	17.00
4	0.21	0.08	36.80	16.00	96.80	0.23	1.11	0.00	1.50	53.90	44.60
5	0.35	0.07	33.00	12.00	93.10	0.20	0.83	0.00	1.40	51.20	47.40
6	0.31	0.08	34.00	13.00	96.10	0.21	0.90	1.40	0.80	49.40	48.50
7	0.37	0.08	37.10	14.00	102.00	0.33	0.65	0.10	2.50	43.40	54.10
8	0.31	0.09	42.40	21.00	110.00	0.27	0.91	0.00	2.90	43.20	53.90
9	0.32	0.07	33.50	16.00	93.00	0.37	2.17	0.00	12.30	46.00	41.70
10	0.41	0.08	38.70	18.00	97.40	0.30	0.79	0.00	3.80	51.70	44.50
11	0.29	0.08	39.80	17.00	104.00	0.25	0.94	0.00	1.40	54.70	43.90
12	0.46	0.07	35.40	15.00	98.40	0.23	0.82	0.00	1.20	54.20	44.60
13	0.33	0.08	34.40	12.00	97.30	0.23	0.99	0.00	1.00	54.00	45.00
14	0.26	0.08	34.40	13.00	95.60	0.23	0.89	0.00	1.40	50.00	48.60
15	0.31	0.08	35.60	14.00	97.40	0.40	0.81	0.00	7.30	42.20	50.50
16	0.33	0.09	40.50	20.00	107.00	0.34	0.81	0.00	4.60	43.70	51.70
17	0.40	0.07	33.00	15.00	91.10	0.35	1.10	0.00	18.20	43.40	38.40
18	0.23	0.08	38.70	20.00	104.00	0.61	1.37	0.00	6.80	48.60	44.60
19	0.26	0.07	38.30	17.00	97.50	0.28	1.10	0.00	2.40	48.90	48.70
20	0.47	0.08	33.60	15.00	96.00	0.31	0.90	0.00	2.20	51.10	46.70
21	0.58	0.08	33.30	10.00	93.00	0.23	0.76	0.00	2.70	52.15	45.15
22	0.24	0.08	34.60	13.00	96.00	0.29	0.81	0.00	5.50	46.20	48.30
23	0.38	0.08	34.60	14.00	92.40	0.38	1.26	1.30	15.10	37.70	45.90
24	0.64*	0.09	38.70	18.00	103.00	0.29	1.08	0.00	8.40	42.50	49.10
25	0.24	0.06	31.60	14.00	87.20	0.27	1.30	0.00	35.30	35.70	29.00
26	0.14	0.04	24.60	23.00	65.00	0.39	0.61	2.90	59.30	23.50	14.40
27	0.35	0.06	29.10	14.00	80.70	0.38	0.83	0.00	34.30	41.70	24.00
28	0.22	0.07	33.90	15.00	94.80	0.33	1.49	0.00	11.20	50.10	38.70
29	0.43	0.07	33.80	11.00	90.90	0.42	1.85	0.00	7.50	50.30	42.20
30	0.34	0.07	33.30	11.00	91.40	0.54	0.81	0.00	13.30	43.50	43.20
31	0.34	0.08	34.50	12.00	87.10	0.29	1.44	0.00	22.00	37.10	40.90
32	0.72*	0.07	40.10	15.00	100.00	0.24	1.36	0.00	22.00	41.90	36.10
33	0.64*	0.06	29.70	13.00	78.50	0.23	1.06	5.80	37.90	31.50	24.70
34	0.42	0.04	25.50	14.00	64.10	0.18	0.60	10.60	56.20	20.50	12.70
35	0.37	0.04	26.20	14.00	73.60	0.71	0.80	10.90	43.00	30.20	15.90
36	0.75*	0.05	30.30	13.00	83.60	0.36	1.83	21.90	36.25	25.15	16.80
37	0.52	0.06	39.50	18.00	110.00	0.54	3.01	0.00	22.00	50.60	27.40
38	0.32	0.06	33.70	10.00	84.20	0.38	2.03	0.70	27.70	38.90	32.70
39	0.22	0.06	29.40	10.00	82.30	0.33	2.30	11.70	30.20	31.60	26.50
40	0.22	0.06	31.20	15.00	88.00	0.28	1.11	0.00	33.20	37.30	29.50
41	0.33	0.07	33.10	11.00	84.50	0.29	1.40	2.80	36.80	36.30	24.10

[1] Total metals results are expressed in dry weight

* Indicates sample exceeded ICTG limit.

Table 14. Trace metal, organic and particle size distribution observed at Point Grey in 2003

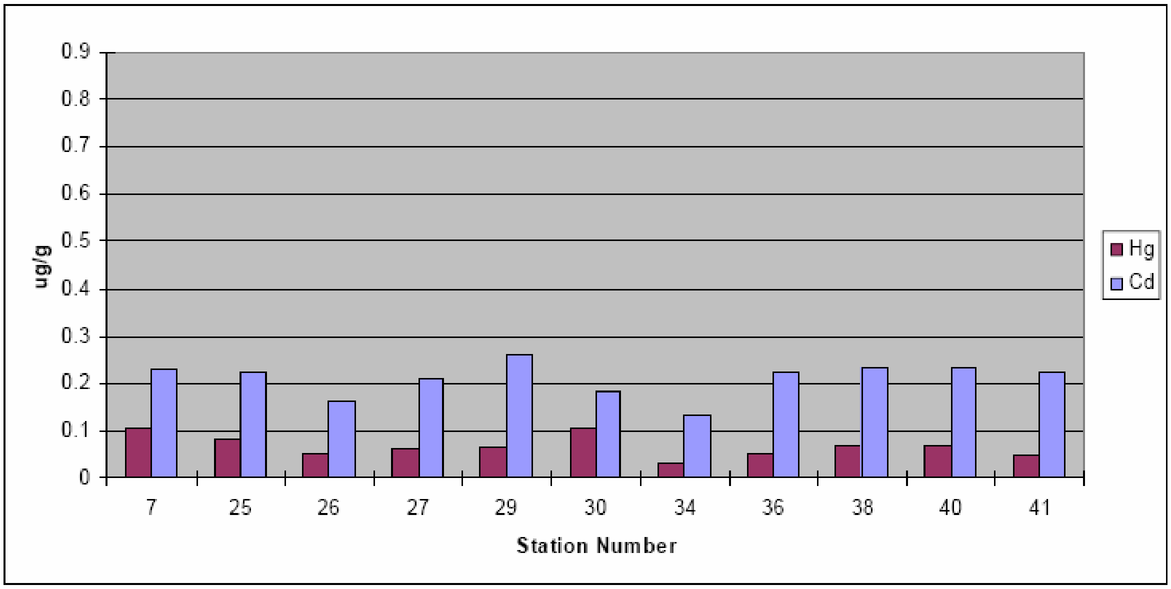


Figure 26. Mean Trace Metals Concentration Data from Point Grey Monitoring Survey, 2004

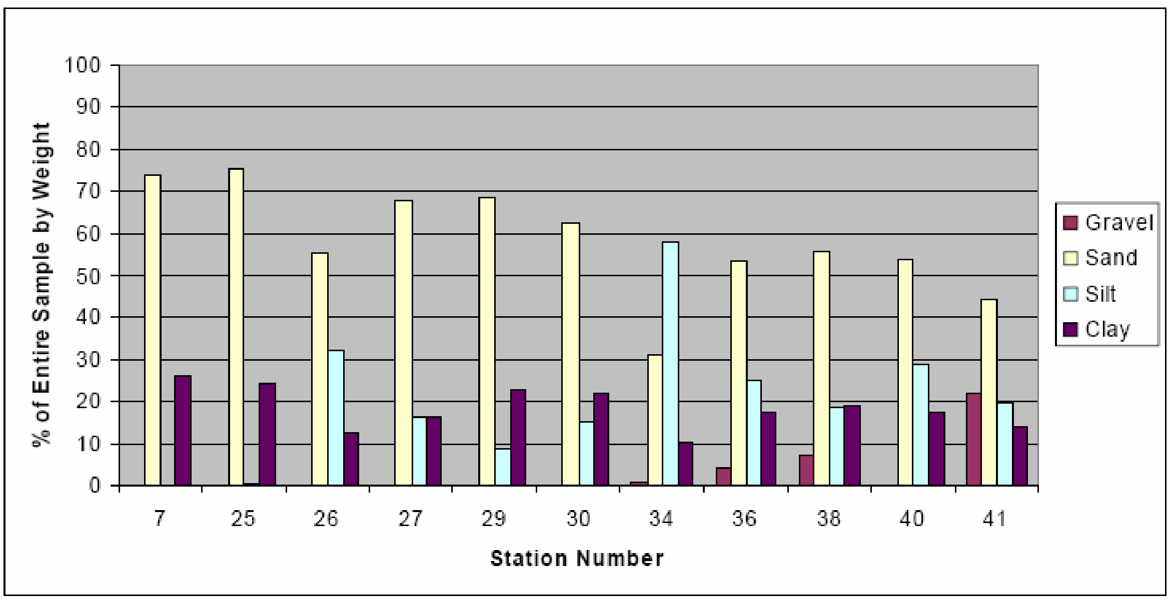


Figure 27. Mean Particle Size Data from Point Grey Monitoring Survey, 2004

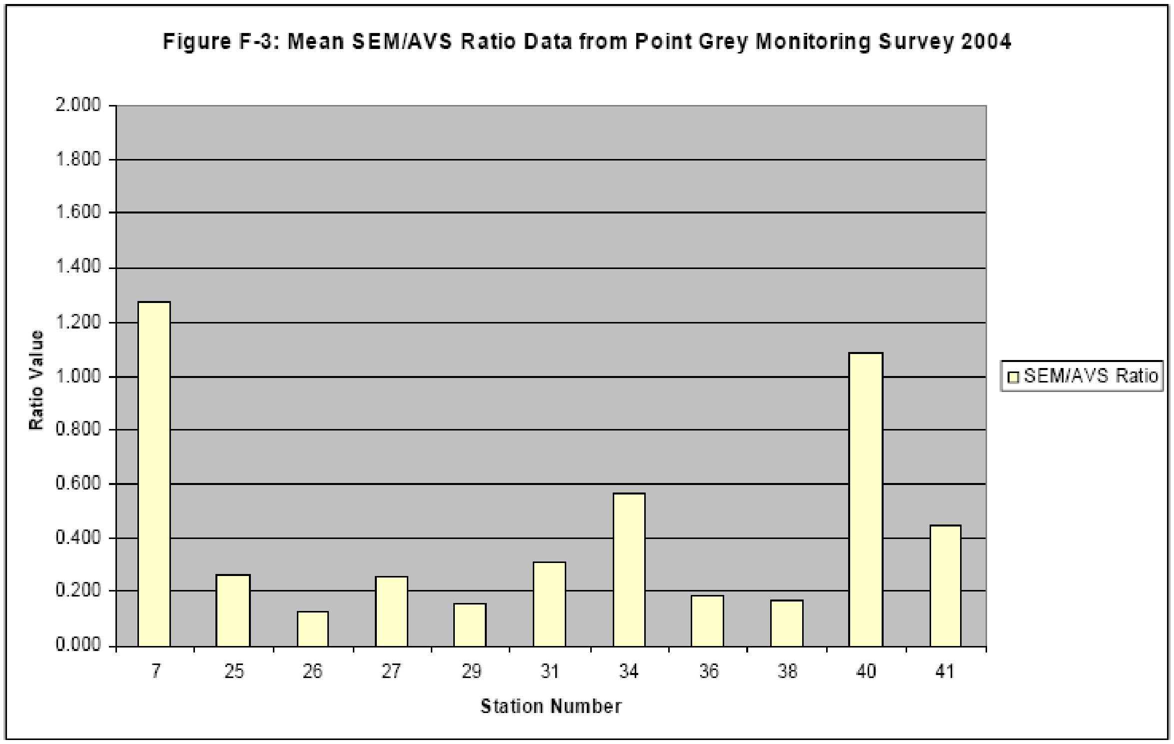


Figure 28. Mean SEM/AVS Ratio Data from Point Grey Monitoring Survey, 2004

Site	Station Number	% Survival Replicates					Mean	+/- SD	Significant Difference
		A	B	C	D	E			
Control	-	100	100	95	100	95	98	2.74	-
Point Grey	7	75	75	55	85	75	73	10.95	Statistically Only
Point Grey	25	90	90	85	90	95	90	3.54	Statistically Only
Point Grey	26	90	100	95	90	85	92	5.70	Statistically Only
Point Grey	27	70	85	85	85	85	82	6.71	Statistically Only
Point Grey	29	90	90	70	85	80	84	9.62	Statistically Only
Point Grey	31	100	100	95	100	90	97	4.47	No
Point Grey	34	100	100	90	100	95	97	4.47	No
Point Grey	36	100	95	90	100	90	95	5.00	No
Point Grey	38	95	100	90	95	100	96	4.18	No
Point Grey	40	95	100	100	100	100	99	2.24	No
Point Grey	41	100	90	80	95	90	91	7.42	Statistically Only

Table 15; Amphipod Euhaustorius estuaries *sediment bioassay Day 10 Survival data for Point Grey, 2004*

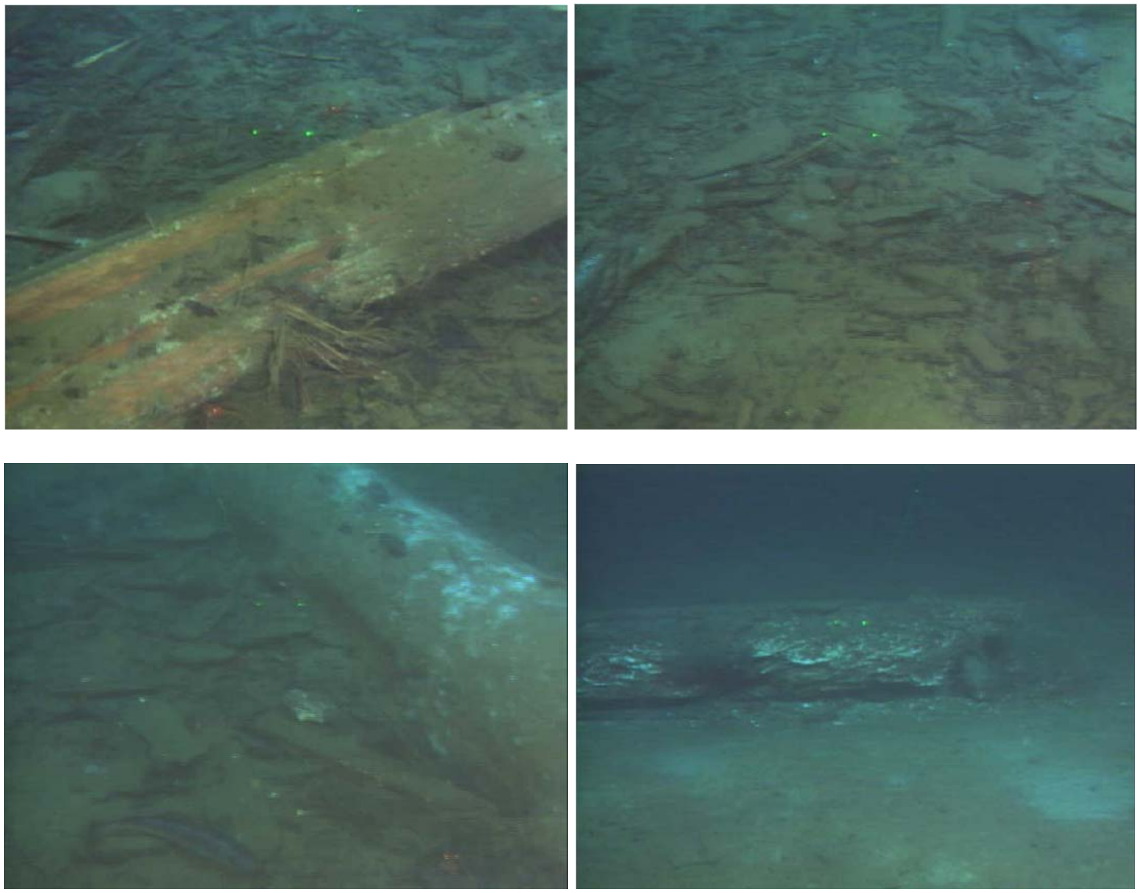


Figure 29; Sample submersible ROPOS images from the Point Grey, British Columbia disposal site, 2004

Quebec Region: Gaspé Peninsula

Background

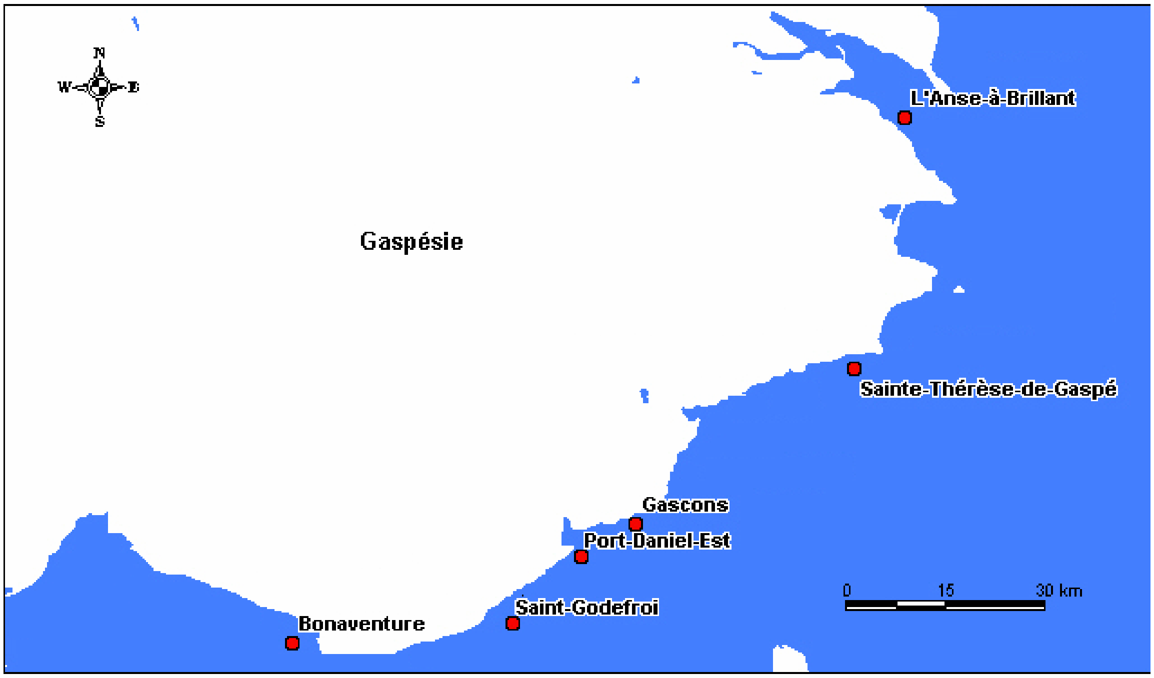


Figure 30. Location of the dredged material disposal sites studied

The coastal sediment dynamics of the Gaspé Peninsula are generally erosive and cause the resuspension of large sediment volumes, resulting in the silting of ports and harbours. Dredged material removed from these ports and harbours is disposed of at specific offshore sites chosen to stabilize the material, and prevent its resuspension near the coast or surrounding marine resources.

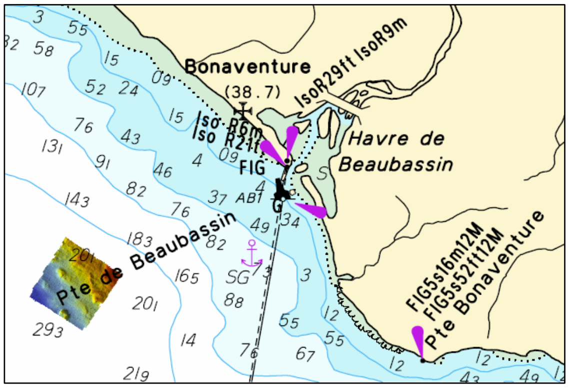
In November 1999, bathymetric surveys were conducted at six disposal sites in the Gaspé Peninsula in order to locate and delineate the sediment mounds (Figure 30). The surveys were conducted from a CHS vessel equipped with a SIMRAD EM-3000 multibeam sonar system and various other equipment, including a DGPS positioning system. Each area surveyed corresponded to a square measuring approximately 1 km x 1 km centered on the disposal site (Figure 31). Bathymetric and acoustic reflectivity data were obtained. The reflectivity images describe to some extent variations in the nature of sediments on the surface of the seabed. Combining the two types of data generally makes it possible to accurately locate and delineate the sediment mounds. Relief images were also produced on the basis of the surveys to visualize the variations in depth and the presence of ripple marks on the seabed (sediments versus rock).

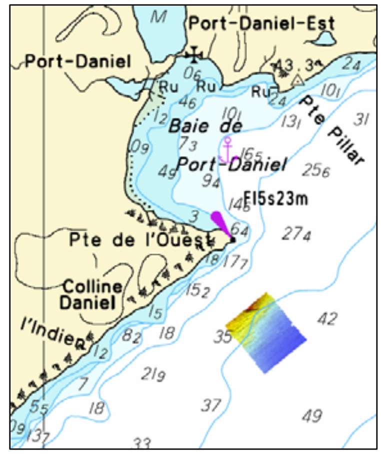
For the six sites in the Gaspé Peninsula, however, the sediment mounds could not be clearly identified in the images. The dredged material, which in some cases had been disposed of only a few weeks earlier (e.g., in the case of sites ABR-1, PD-6 and SG-2), did not form a clearly identifiable mound, in contrast to what had been observed in a similar project in the summer of 2001 at six disposal sites in the Magdalen Islands (Marceau and Ropars 2004).

As a result, in 2004-2005, Public Works and Government Services Canada, under contract to Environment Canada, evaluated the stability of the dredged material at the six disposal sites in the Gaspé Peninsula using modeling software.

Facts about the sites

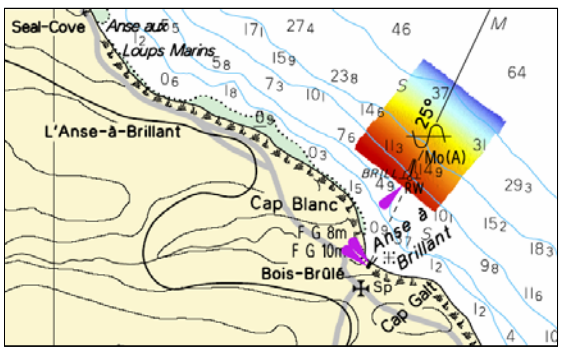
Location	ABR-1 (L'Anse-à-Brillant) 48°43.92' N, 64°16.92' W PD-6 (Port-Daniel-Est) 48°08.10' N, 64°56.50' W ST-4 (Sainte-Thérèse-de-Gaspé) 48°23.40' N, 64°23.20' W SG-2 (Saint-Godefroi) 48°02.70' N, 65°05.00' W G-5 (Gascons) 48°10.80' N, 64°50.00' W B-2 (Bonaventure) 48°01.00' N, 65°32.00' W
Depth	Varies depending on the site. See Table .
Material	Dredged material
Quantity	Varies depending on the site. See Table .
Status	Open.
Concerns	Has dredged material resuspension, erosion or transport occurred in sufficient quantities to have an impact on surrounding habitat, organisms present in the sector (e.g., migration, spawning or rearing of fish) or fisheries?

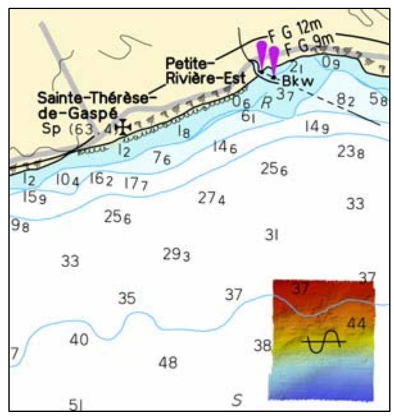




B-2 Bonaventure

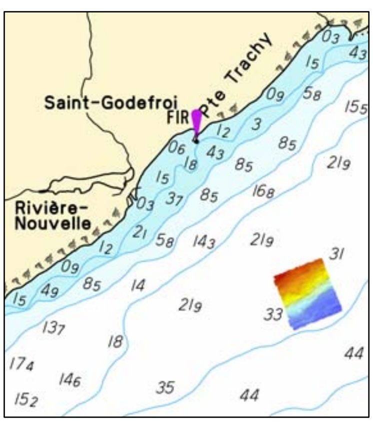
PD-6 Port-Daniel

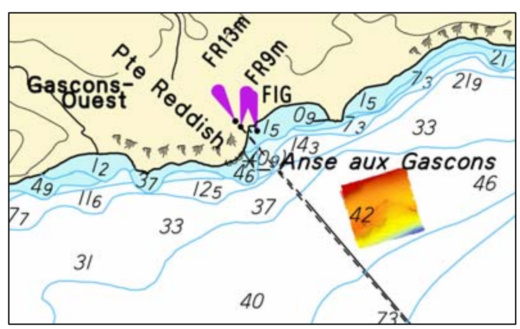




ABR-1 L'Anse-à-Brillant

ST-4 Sainte-Thérèse-de-Gaspé





SG-2 Saint-Godefroi

G-5 Gascons

Figure 31. Location of the areas surveyed using multibeam sonar in November 1999 (Source: Canadian Hydrographic Service, Fisheries and Oceans Canada)

Impact Hypotheses

All or part of the sediments discharged are found on the 1 km X 1 km surveyed area, but are spread over a large area.

Monitoring Conducted

Sediment behaviour at the six Gaspé Peninsula disposal sites was evaluated to determine whether the discharged sediments reached the bottom at the location specified, and under what conditions. This evaluation of the short-term behaviour of dredged material was carried out using the STFATE model (EPA and USACE 1995).

Parameters measured

Brief description of the STFATE model

The STFATE model is widely used throughout the world to evaluate the short-term fate of dredged material. Given its good performance, it is regularly used by Canadian and U.S. companies and the U.S. government. STFATE models the behaviour of sediment (from clay to rock) disposed of in aquatic environments. Figure 32 presents a simplified diagram of the various modeling phases of STFATE.

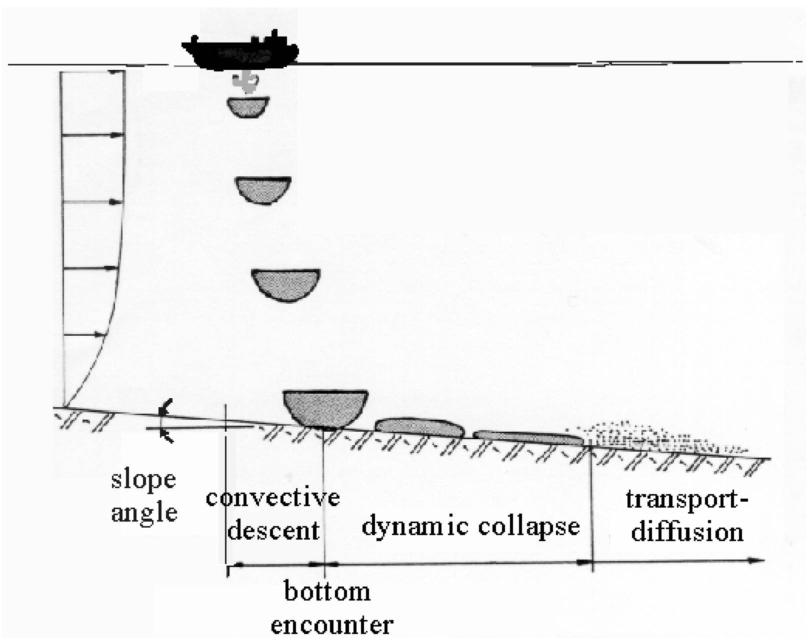


Figure 32. Simplified description of STFATE modeling stages (source: Technical Guidance for Physical Monitoring at Ocean Disposal Sites. (1998) Environment Canada, Marine Environment Division. 49 pp.)

Main parameters required for modeling with STFATE

Several parameters describing the disposal site, dredged material, and disposal conditions must be entered to perform the modeling. A large part of this information consists of dredging operations data provided by Environment Canada and concerns the percentage of each class of sediment and the volume deposited. Other necessary information comes from the web site of the St. Lawrence Observatory (e.g., current velocity) and bathymetric survey plans provided by Environment Canada (e.g., water depth at the site). The values used for these parameters are presented in Table 16.

For the modeling, the six sites in the Gaspé were divided into three homogeneous groups on the basis of their individual characteristics. Group 1 consists of PD-6, SG-2 and G-5, Group 2 consists of ABR-1 and B-2, and Group 3 consists of ST-4.

Group	*Disposal site*	*Average volume deposited per season (m^3)*	*% vol. clay-Volume (m^3)*	*% vol. silt-Volume (m^3)*	*% vol. sand-Volume (m^3)*	*Maximum current velocity (kt) **	*Average depth (m)*
1	***PD-6***	***3,480***	***6.25% 218 m^3***	***25.76% 897 m^3***	***54.52% 1,897 m^3***	***0.80***	***40.6***
1	***SG-2***	***2,270***	***12.16% 276 m^3***	***26.75% 607 m^3***	***56.37% 1,280 m^3***	***0.80***	***35.4***
1	***G-5***	***1,380***	***6.22% 86 m^3***	***28.92% 399 m^3***	***54.89% 758 m^3***	***0.80***	***43.1***
Average – Group 1		*2,377*	*8.21% 197 m^3*	*27.15% 650 m^3*	*55.26% 1,324 m^3*	*0.80*	*39.7*
2	***ABR-1***	***1,930***	***6.92% 134 m^3***	***24.29% 469 m^3***	***53.07% 1,024 m^3***	***0.40***	***24.9***
2	***B-2***	***2,860***	***8.77% 251 m^3***	***12.56% 359 m^3***	***52.92% 1,513 m^3***	***0.25***	***25.8***
Average – Group 2		*2,395*	*7.85% 188 m^3*	*8.43% 441 m^3*	*53.00% 1,269 m^3*	*0.33*	*25.4*
3	***ST-4***	***1,780***	***7.07% 126 m^3***	***8.16% 145 m^3***	***67.16% 1,195 m^3***	***1.00***	***46.4***
Average – Group 3		*1,780*	*7.07% 126 m^3*	*8.16% 145 m^3*	*67.16% 1,195 m^3*	*1.00*	*46.4*

* The values used correspond to the maximum velocities modeled for January 24 and 25, 2005.

Table 16. Characteristics of disposal sites and definition of homogeneous groups

The following modeling parameters are common to the three groups of disposal sites:

- the area modeled has 45 grid cells along the X axis and 45 grid cells along the Y axis
- square grid cells of 150 feet (for a total area of ~4.2 km²)
- total simulation duration: 3,600 s (1 hour)
- time-step duration: 60 s
- characteristics of the disposal equipment: multiple compartment tank barge
- sediment deposited in approximately the centre of the modeled area, i.e. at coordinates (3,000, 3,000) feet (grid cell [21,21])
- default coefficient values.

Validation of the STFATE model

To verify the accuracy of the STFATE model, predictions were compared to the characteristics of a known disposal site, PB-8 in the Magdalen Islands, for which the sediment mound is clearly defined and for which recent bathymetric data are available. Data from the multibeam sonar survey conducted in August 2001 by the Canadian Hydrographic Service were used. The results generated by STFATE for PB-8 were very consistent with the observations drawn from the survey, for both the thickness and extent of the mound.

Observations and results

The main results provided by STFATE are: (1) thickness of the material deposited on the bottom (identified by class of sediment or total volume); and (2) concentration of suspended sediment as a function of depth. Deposition thickness is of interest because it can be compared with available bathymetric surveys conducted at the disposal sites. The concentration of suspended sediment is also of interest because it can be used to monitor the location of the portion of sediments that remain in suspension during modeling. These two outputs, combined with the bathymetric surveys, can be used to evaluate the stability of sediments placed at the six sites in the Gaspé Peninsula.

The STFATE results are presented in the form of a distribution and show the thickness and volume of sediments in the modeled area as a function of the defined grid cells.

Thickness and extent of the sediment deposited on the bottom

Table 17 presents the maximum thickness of the sediment layer on the bottom at the end of the modeling and the approximate extent of the resulting mound. The extent of the mound was defined as the largest dimension of the mound where the sediment layer is at least 1/30 mm thick. According to the STFATE results, the maximum thickness of the sediment layer, all groups of sites and classes of sediment combined, is found almost at the centre of the disposal site (i.e. grid cell [21,21]). This means that the sediments settle quickly after discharge.

Modeling	*Class of sediment*	*Maximum thickness of sediments on the bottom (m)*	*Total maximum thickness of sediments on the bottom (m)*	*Approximate extent of the sediment mound (m)*
Group 1 PD-6, SG-2 and G-5	***Sand***	***0.530***	***1.660***	***500***
	Silt	***0.662***		
	Clay	***0.298***		
	Gravel	***0.171***		
Group 2 ABR-1 and B-2	***Sand***	***0.759***	***2.348***	***230***
	Silt	***0.759***		
	Clay	***0.485***		
	Gravel	***0.345***		
Group 3 ST-4	***Sand***	***0.436***	***0.965***	***450***
	Silt	***0.127***		
	Clay	***0.171***		
	Gravel	***0.230***		

Table 17. Maximum thickness of sediments deposited on the bottom and extent of the mound at the end of the modeling period

Concentration of material in suspension

The concentration of suspended sediment modeled by STFATE represents the sediment portion that remains in the water column and does not settle for the duration of the modeling period (3,600 s or 1 hour). For all modeling performed, only silts and clays remain partially suspended, whereas sands and gravels settle completely on the bottom.

The volumes of sediments that remain in suspension at the end of the modeling period can be extracted from STFATE results, and are presented in Table 18 alongside the volumes of sediment deposited on the bottom during the modeling. Silts and clays remaining suspended will eventually be transported further from the disposal site, or will settle on the bottom if current conditions change.

Modeling	*Class of sediments*	*Volume of material deposited on the bottom (m^3)*	*Volume of material in suspension (m^3)*	*% in suspension*
Group 1 PD-6, SG-2 and G-5	***Silt***	***593.4***	***49.1***	***8.3 %***
	Clay	***173.0***	***17.4***	***10.1 %***
Group 2 ABR-1 and B-2	***Silt***	***432.1***	***23.7***	***5.5 %***
	Clay	***179.2***	***12.8***	***7.1 %***
Group 3 ST-4	***Silt***	***127.0***	***15.6***	***12.3 %***
	Clay	***110.7***	***14.4***	***12.7 %***

Table 18. Volume of sediment deposited on the bottom and in suspension at the end of the modeling period

Conclusions

According to the STFATE model produced, the majority of the dredged material settles at the centre of the authorized disposal sites. The results indicated that the maximum thickness of the deposited sediments was located at the disposal site coordinates. Sediment mound thicknesses for sites PD-6, SG-2 and G-5 (Group 1), ABR-1 and B-2 (Group 2) and ST-4 (Group 3) were 1.7 m, 2.3 m and 1.0 m, respectively.

The deep water and fast-flowing currents at the disposal sites in the Gaspé Peninsula have a significant impact on the dispersion of dredged material and the extent of the sediment mounds. According to STFATE, the extent of the sediment mounds at the sites in groups 1 to 3 is approximately 500 m, 230 m and 450 m, respectively. The small thickness and large extent of the sediment mounds seem to provide a plausible explanation as to why the mounds do not show up in the bathymetric images. According to the STFATE results, the slopes of the mounds range from 0.2% to 1.0 %, whereas the natural slopes of the sites range from 0.8 % to 3.9%. In other words, it is possible that a sediment mound on the bottom blends in with the natural variation in the bathymetry of the disposal sites and that it does not show up in the bathymetric survey data.

The concentration of material in suspension modeled using STFATE shows that the majority of diffusive sediments (silts and clays) settle on the bottom despite their potential to remain in equilibrium in the water column. Sediment that remains in suspension is transported by currents and may potentially be deposited at large distances from the intended site, depending on the currents. Nonetheless, the proportion of the discharged sediment mass that remains in suspension is obviously highly dependent on the percentage of clay it contains.

Annex 1. Monitoring Expenditures

In March 1999, pursuant to Treasury Board policy on cost recovery, Environment Canada introduced a monitoring fee of $470 per 1000m^3 of dredged or excavated material. This fee is known as a "right or privilege" fee and is meant to provide Canadians with a fair return for use of public resources. Proceeds from this fee are used to cover the cost of disposal site monitoring, thus allowing environmentally sound management and allowing users continued access to their disposal sites.

Part of Environment Canada's commitment to the regulated community was to provide an annual summary of revenues and expenditures related to disposal site monitoring. The figures below represent the fifth year of cost recovery. In the 2004-2005 fiscal year, Environment Canada collected slightly less than the previous fiscal year, with revenues amounting to just over $1.2 million. The total net cost to the federal government was $413, 046. The net cost to Environment Canada was $91,547. This cost will be offset by surpluses carried over from previous years when revenues were high due to increased dredging activity.

Monitoring Expenditures 2004-2005	
Atlantic Region	$254,500
Quebec Region	$93,100
Prairie and Northern Region	$0
Pacific and Yukon Region	$458,500
Headquarters	$20,000
Environment Canada indirect expenditures	$479,700
Sub total expenditures for Environment Canada	$1,305,800
In-kind support from other federal departments	$321,500
Total expenditures for federal government	$1,627,300
Resources Recovered 2003-2004	
Monitoring Fees	$1,214,250
Net Expenditures 2003-2004	
Resources collected over federal government costs	-$413,047
Net Environment Canada costs	-$91,547

Annex 2. Offices for the Disposal at Sea Program

The Disposal at Sea Program Offices are located in the following Environment Canada offices.

Atlantic Region-Maritimes
Disposal at Sea Program
Environmental Protection Branch
Environment Canada
45 Alderney Drive, 4th Floor
Dartmouth, Nova Scotia
B2Y 2N6

Atlantic Region-Newfoundland and Labrador
Disposal at Sea Program
Environmental Protection Branch
Environment Canada
6 Bruce Street, Mount Pearl
Newfoundland and Labrador
A1N 4T3

Quebec Region
Disposal at Sea Program
Environmental Protection Branch
Environment Canada
105 McGill Street, 4th Floor
Montreal, Quebec
H2Y 2E7

Prairie and Northern Region
Disposal at Sea Program
Environmental Protection Branch
Environment Canada
5204 - 50th Avenue, Suite 301
Yellowknife, Northwest Territories
X1A 1E2

Pacific and Yukon Region
Disposal at Sea Program
Environmental Protection Branch
Environment Canada
201 - 401 Burrard Street
Vancouver, British Columbia
V6C 3S5

National Capital Region
Disposal at Sea Program
Environmental Protection Service
Environment Canada
351 St. Joseph Boulevard, 12th Floor
Hull, Quebec
K1A 0H3

Further details may be found on-line at the Program's web site www.ec.gc.ca/seadisposal/