Deltaport Third Berth Project
Adaptive Management Strategy

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BCEAA/CEAA Harmonized Environmental Assessment Process

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1.0 INTRODUCTION

The following document has been prepared to facilitate the identification, management, prevention and mitigation of effects resulting directly or indirectly from construction of a third berth at the Vancouver Port Authority (VPA) Deltaport container facility located in Delta, British Columbia. The primary objective of this work was to, in consultation with Environment Canada, develop an Adaptive Management Strategy (AMS) for the Deltaport Third Berth (DP3) Project that will provide early detection of changes in the inter-causeway ecosystem such that any significant negative environmental trends attributable to the DP3 project can be prevented or mitigated. This AMS enables Environment Canada to conclude the *Canadian Environmental Assessment Act* (CEAA) assessment of DP3 effects on migratory birds.

1.1 DP3 PROJECT DESCRIPTION SUMMARY

The Vancouver Port Authority (VPA) is proposing to expand the Deltaport Container Terminal (Deltaport) at Roberts Bank in Delta, British Columbia. The VPA plans to construct an additional berth and storage yard at its existing Deltaport two-berth container terminal. The proposed third berth, known as the Deltaport Third Berth Project (the Project or DP3), is in response to industry projections that indicate that container traffic at all major container ports on the west coast of North America will double in the next ten years, and triple in the next twenty years.

The Project, located within the Roberts Bank inter-causeway area, consists of construction of a wharf to accommodate an additional berth, and approximately 20 hectares (50 acres) of land for an expanded container storage yard. It will also include dredging to deepen the existing ship channel and create a tug moorage area adjacent to the terminal (**Figure 1**).

The Project is subject to both the provincial *Environmental Assessment Act* (BCEAA) and the federal *Canadian Environmental Assessment Act* (CEAA). When both Acts apply, a cooperative environmental assessment is conducted in accordance with the *Canada-British Columbia Agreement for Environmental Assessment Cooperation* (2004).

The Environmental Assessment Application for the Deltaport Third Berth Project (DP3) was submitted for provincial and federal review in January 2005 (Vancouver Port Authority, 2005. *Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC.)*. During the environmental assessment review, Environment Canada raised concerns that the proposed expansion to the Deltaport facility could have an impact on the existing habitat within the Roberts Bank inter-causeway area, particularly with respect to the potential for future marine eutrophic events and dendritic channelization leading to erosion. Environment Canada identified that Roberts Bank ecosystem changes unrelated to the DP3 project continue to occur, and that the current level of scientific understanding of Roberts Bank was insufficient to verify the accuracy of predictions that the proposed DP3 project will not cause significant adverse environmental effects in the inter-causeway area ecosystem. Initial review comments by Environment Canada led to a recommendation that an adaptive management strategy (AMS) be developed for the Roberts Bank inter-causeway area to (1) provide practical advance warning of any potential emerging negative ecosystem trends during project construction and operation, and (2) to establish actions that VPA would undertake to prevent or mitigate negative trends which are linked to DP3 and found to exceed applicable thresholds. This document outlines the AMS for the Deltaport Third Berth Project.

1.2 MARINE EUTROPHICATION BACKGROUND

In recent years the definition of eutrophication has shifted from being based primarily on nutrient input to a more ecosystem based definition (Cognetti 2001, Flynn 2005). The definition supplied by Cognetti (2001) is, "an environmental adverse perturbation caused by an excess rate of supply of organic matter, including excess primary production."

Examples of some of the potential undesirable effects associated with marine eutrophication include (Wu 1999, Meyer-Reil and Köster 2000):

- Shifts in relative abundance of diatoms and dinoflagellates or flagellates;
- Increase in 'red-tide' occurrence;
- Decrease in water transparency;

- Increase in sedimentation of organic matter;
- Plankton, fish, or benthos kills;
- Food web shifts resulting from balance of zooplankton versus phytoplankton.

Because of the complexities of the nitrogen-cycle and factors that contribute to eutrophication, prediction that a eutrophication event could occur is challenging. Still, there have been many papers written on the topic of marine eutrophication and there are several key factors that have been identified as being important in its prediction:

- Nitrogen availability (in marine ecosystems)
- Chlorophyll presence (measure of primary production)
- Oceanography (system flushing and renewal)

One of the measures considered most useful for the prediction of eutrophication is the relationship between phytoplankton biomass (as evaluated by chlorophyll measurements) and nitrogen supply (Edwards *et al.* 2003). Other investigators such as Dell'Anno *et al.* (2002) have relied heavily on chlorophyll measurements for characterizing trophic state and predicting eutrophication events.

It is important to consider that eutrophication occurs most commonly in the summer months when there are longer days that enhance the photosynthetic period. There have been a variety of numerical modeling approaches developed for coastal and semi-enclosed marine embayments that relate chlorophyll, nitrogen levels, system renewal, and silicon information as predictors of eutrophication, but typically on scales much larger than the relatively small inter-causeway area (Arhonditsis *et al.* 2003, Edelvang *et al.* 2005, Flynn 2005, Wirtz and Wiltshire 2005).

According to Tett *et al.* (2003), water exchange rate is of critical importance with respect to the potential for an area to go eutrophic. Previous geomorphology/oceanography studies at Deltaport have indicated that there is complete renewal of the seawater in the inter-causeway area each tidal cycle.

Some of the more common sources of nutrient input to marine systems are non-point sources such as:

- Agricultural release of ammonia;
- Acid rain from fossil fuel burning (dilute nitric acid dissociates to give nitrate);
- Upwelling
- Decomposition of algae
- Bird and wildlife excreta.

Examples of point sources of nutrient input to marine systems include:

- Waste water discharge
- Septic system discharge

The major source of nutrients from the existing Deltaport operation is treated sewage effluent. The Deltaport sanitary sewage treatment plant was constructed as part of the initial Deltaport container terminal development in 1997 and provides secondary treatment of sewage prior to discharge. The sewage treatment plant is permitted under BC Ministry of Environment effluent permit PE-14865 to discharge treated effluent into the Deltaport ship berth at a depth of 12 metres below mean low water.

The Deltaport terminal sanitary sewer collects domestic and industrial wastewater generated in building facilities and wash-down areas. The proposed increase in sewage output from the DP3 project is minimal and will fall within the current operating requirements of the existing Deltaport sanitary sewage treatment plant. Although disinfection of the effluent is not required at this time, the Deltaport sewage treatment plant has been designed to accommodate disinfection facilities in the future, if necessary.

Storm water from the Deltaport Third Berth terminal will pass through an oil interceptor and sedimentation tank to collect possible contaminants prior to discharge of storm water effluent to the ocean. The eight existing storm outfalls that discharge into the embayed intertidal area, located along the northern perimeter of Deltaport, will be decommissioned and replaced by new storm outfalls that will direct storm water into the berth face and discharge subtidally. In addition the new storm outfalls will be fitted with shut-off valves to terminate flow from the area should a sizeable spill occur on the terminal and enter the storm water system.

Within the inter-causeway area there is an abundance of eelgrass, including the native species of *Zostera marina* but also the introduced species *Zostera japonica*. Eelgrass, as it decomposes, is in itself a potential source of nutrients to the inter-causeway ecosystem and sediments. Concerns have been identified by Environment Canada that the potential for eutrophication/anoxia to occur within the sediments in the inter-causeway ecosystem could trigger a switch from the eelgrass-dominated system. The postulated mechanism for such euthrophication is overloading of the ecosystem capacity to aerobically decompose eelgrass biomass between the causeways, coupled with inadequate transport from the inter-causeway of the nutrient products of decomposition, with subsequent excess deposition in and on the intertidal sediment. This scenario could occur regardless of DP3.

1.3 Dendritic Channel Background

In 2003 VPA retained coastal geomorphology experts to undertake an assessment of the Roberts Bank coastal zone processes and the DP3 Project (NHC-Triton 2004). One of the key tasks of this study was to describe the long-term physical response of the Roberts Bank tidal flats to past port developments there. This would provide a thorough understanding of the physical processes occurring there, and verify that potential impacts can be predicted and, if necessary, mitigated (NHC-Triton 2004a). Based on past experience at Roberts Bank, one of the key potential issues related to DP3 expansion concerns the initiation of tidal drainage channels, often referred to as dendritic channels. These channels have caused concern with regard to erosion of the tidal flats, loss of eelgrass habitat, and the long-term stability of the tidal flat environment. The scientific and engineering consulting team used a number of different methods to assess channel formation, including field observations and data collection, interpretive historical studies using available charts and air photos, analytical studies to assess hydraulic and sediment transport processes, and numerical model investigations.

There are two main factors that have triggered drainage channel formation on Roberts Bank in the past:

1. dredging into the tidal flats above the low tide line lowered the base level for water draining off the tidal flats and initiated shoreward headcutting;
2. expansion of eelgrass beds and resulting changes to flow resistance and water storage on the tidal flats affected runoff patterns and promoted channelization.

Based on studies of seven different tidal channels on Roberts Bank and Boundary Bay, the geomorphology consultant was able to produce a simplified model of tidal channel development. The stages include:

1. Initial general bed lowering on the flats due to headcutting
2. Channel incision due to flow concentration from upland runoff
3. Shoreward channel progression
4. Channel bifurcation at the head of the trunk channel
5. Establishment of final dynamic equilibrium

Initial channel formation and headcutting processes occur primarily during ebbing tides. However, as the channel extends landward, it commonly bifurcates, splitting into two or more branches. Sediment may be deposited in the zone of flow divergence at the bifurcation point near the head of the channel. Local gradients and sediment transport become very high when it is flooded, and the bar surface becomes mobilized as a "sand sheet". As a result, eelgrass is not able to survive in this region. The trunk channel will extend landward until reaching an ultimate equilibrium position. This will occur when the discharge intensity is reduced sufficiently that a stable channel can be achieved. The stable point will be governed by the elevation of the surrounding tidal flats, since this level controls the volume of water draining into the channel.

The coastal geomorphology study showed that tidal channel dimensions could be predicted approximately using "regime" equations that relate hydraulic geometry to the discharge magnitude generated by the tidal exchange on the flats and sediment transport properties. This provides a means for assessing the approximate equilibrium channel conditions that will develop in response to future dredging works.

In 1981 a crest protection structure consisting of placed rock rip rap was constructed in the inter-causeway area to limit the headcutting processes by artificially maintaining the original base level. Based on the coastal geomorphology study (NHC-Triton 2004) the structure appears to have effectively limited the growth of at least two channels. However, the large channel near the centre of the inter-causeway area has partially by-passed the structure by flowing along its inside edge. As a result, this channel is continuing to expand in both the seaward and landward directions. It is expected that the trunk channel will continue to expand shoreward before eventually stabilizing. A small channel that developed near the Tsawwassen Ferry terminal was also observed during the study to have by-passed a riprap control structure. These channels will continue to expand independent of the DP3 project.

The conclusions of the geomorphology study are that the construction of the Deltaport Third Berth Project is not expected to initiate any new tidal channels. This is because all of the excavation that is planned will be in deep water, well below the low tide line. As a result, base lowering or triggering of head cutting is not predicted. Furthermore, the main structures associated with the DP3 Project are not expected to affect tidal current patterns or waves sufficiently to initiate scour or erosion.

1.4 PREVIOUS STUDIES

A series of biophysical, social and economic components of the environment at Roberts Bank was studied over a one year period from 2003 to 2004. The spatial boundaries of the study area for the assessment varied according to the individual studies undertaken. For some studies only the footprint of the proposed DP3 was considered; for others it was the immediate area around the causeway and existing Roberts Bank Port terminal. The wider Roberts Bank area was also considered in studies such as those for the marine habitat and coastal geomorphology studies, and wider areas still, including parts of the Strait of Georgia and the Delta portion of the Lower

Mainland were considered in the air quality and marine mammals studies. The temporal scope consisted of two main time-related phases of the Project: short-term construction phase (approximately three years); and long-term operation phase into the foreseeable future. For each of the studies the VPA prepared a draft workplan that was reviewed by the harmonized federal-provincial working group.

The following studies were conducted for the DP3 Environmental Assessment Application and are available in their entirety as Technical Volumes on the VPA website. The studies are also summarized in the various chapters of the Application, which can also be found on the VPA website. Applicable studies were summarized and presented at the workshops as part of the information sharing and gap analysis of the AMS planning phase.

Environmental Assessment Application:

http://www.portvancouver.com/container_expansion/deltaport/index.html#EA_application

Supporting Technical Volumes

http://www.portvancouver.com/container_expansion/deltaport/index.html#tech_volumes

Table 1 - Deltaport Third Berth Project Supporting Studies

Subject	Report Title	Application Chapter	Technical Volume Reference #
Coastal Geomorphology	Roberts Bank Container Expansion – Coastal Geomorphology Study (2004)	Chapter 7	#2
Water Quality	Water Quality Report Roberts Bank Expansion Project (2004)	Chapter 8	#3
Sediment Sampling	Deltaport Third Berth Sediment Sampling Program (2004)	Chapter 9	#4
Marine Resources	Deltaport Third Berth Project Marine Resources Impact Assessment (2004)	Chapter 10	#5
Coastal Seabird and Waterfowl	Deltaport Third Berth Project Coastal Seabird and Waterfowl Resources Impact Assessment (2004)	Chapter 11	#6
Wildlife and Vegetation	Deltaport Third Berth Project Terrestrial Wildlife and Vegetation Assessment (2004)	Chapter 12	#7
Air Quality and	Roberts Bank Container Expansion	Chapter 13	#8

Human Health	Project Air Quality and Human Health Assessment (2004)		
Noise	Roberts Bank Container Expansion Project Environmental Noise Assessment (2004)	Chapter 14	#9
Visual and Lighting	Visual and Lighting Assessment of the Roberts Bank Container Expansion - Deltaport Third Berth Project (2004)	Chapter 15 and 16	#10
Socio-Economic	Roberts Bank Socio-Community and Economic Impact Assessment (2004)	Chapter 17	#11
Archaeology	Roberts Bank Archaeological Overview Assessment and Archaeological Impact Assessment Permit 2004 – 11 (2004)	Chapter 18	#12
Road Traffic	Deltaport Third Berth Road Systems Impact Assessment (2004)	Chapter 2 (Section 2.9.4)	#1
Rail Traffic	Deltaport Third Berth Rail Operations	Chapter 2 (Section 2.9.3)	No Technical Volume
Ship Traffic	Deltaport Third Berth Marine (Ship Traffic) Operations	Chapter 2 (Section 2.9.5)	No Technical Volume

The DP3 environmental assessment prepared for VPA concluded that no significant adverse environmental effects would occur as a result of the DP3 project, as long as recommended mitigation measures identified in the Application were implemented. Initial review comments by Environment Canada led to a recommendation that the VPA develop an Adaptive Management Strategy to provide practical advance warning of any potential emerging negative ecosystem trends during project construction and operation and to establish actions that VPA would undertake to stabilize or mitigate negative trends in marine eutrophication or coastal zone processes which are the result of DP3 and found to exceed applicable thresholds.

The Fraser River Estuary and Roberts Bank (including the inter-causeway area) is an ecologically significant area which provides critical habitat for migratory birds. As noted during the environmental assessment, Environment Canada raised concerns that the proposed expansion to the Deltaport facility could have an impact on the usefulness of that habitat for wildlife, particularly with respect to the potential for future marine eutrophic events and dendritic channelization leading to erosion. Environment Canada identified that ongoing ecosystem changes unrelated to the DP3 project are occurring in the Roberts Bank area and the current level of scientific understanding of Roberts Bank was insufficient to verify the accuracy of predictions that the proposed DP3 project will not cause significant adverse environmental effects in the inter-causeway area ecosystem.

The VPA, in acknowledging the ecological significance of Roberts Bank, has made a commitment to sustainable port development. As part of that commitment, the VPA has agreed to develop a rigorous science based adaptive management strategy, in consultation with Environment Canada, that will provide practical advance warning of any potential emerging negative ecosystem trends during DP3 construction and operation.

1.5 AMS OBJECTIVE

The objective of the DP3 Adaptive Management Strategy is to undertake a science-based systematic approach to monitoring and managing the Roberts Bank inter-causeway ecosystem. The specific goal of the AMS is to reduce scientific uncertainty and to assess the potential for the occurrence of marine eutrophic events and dendritic channelization leading to erosion that could result in significant negative trends in the ecosystem. Further the AMS details the commitments that VPA would undertake to evaluate, prevent or mitigate those negative trends attributable to the DP3 project.

1.6 AMS DEVELOPMENT PROCESS

The VPA developed the DP3 AMS by bringing together regulatory and science-based agencies, and technical experts to identify shared environmental issues and concerns relevant to the DP3 project. Based on a review of the information collected for the Application, two consultative workshops with scientists and regulators, and a detailed literature review of applicable adaptive management processes, the VPA has produced the DP3 AMS to:

- Plan, monitor, and evaluate the parameters identified for the shared environmental concerns and issues;

- Establish appropriate thresholds for action;
- Establish potential strategy adaptations; and,
- Identify possible mitigation steps to address issues if, and when, they develop.

1.7 DETAILED AMS WORKPLAN

Prior to initiation of DP3 construction monitoring and the AMS monitoring studies described herein, the VPA will have prepared, in consultation with regulatory and scientific agencies, a Detailed AMS Workplan outlining:

- Specific parameters (e.g., nutrients, dissolved oxygen, chlorophyll *a*, etc.);
- Data quality objectives (e.g., detection limits, analytical precision, accuracy, and completeness);
- Sampling locations (characterization and reference locations);
- Sampling methodologies (e.g., Ponar sediment sampling, Van Dorn water sampling, etc.); and,
- Sampling and reporting schedules.

2.0 ADAPTIVE MANAGEMENT STRATEGY

The fundamental principle behind an AMS is the concept of learning by doing. This approach to management was developed as a means to overcome the limitations of static environmental assessment and management (Holling 1978). Since its inception in the late 1960s, adaptive management has evolved considerably and is now applied in a wide variety of situations where there is the need to manage highly complex systems. Conservation of natural resources such as those found at Roberts Bank necessarily involves living systems and the environments that sustain them. However, by its very complexity, the network of biological, environmental, physical and social components that influence living systems provides a challenge to understand changes and manage those systems effectively (Marzluff and Sallabanks 1998). Therefore there are several benefits of adaptive management. First, uncertainty is recognized as a factor in assessing management options and is factored into the objectives of management. Second, acquisition of data is incorporated directly into the goals of management, and used to guide decision making (Byron 2003). Thus, monitoring programs are planned, designed and redesigned to facilitate the reduction of uncertainty in monitoring rather than monitoring for its own sake (Holling 1995).

The underlying phases of any effective AMS include the following four components (Bormann *et al.* 1995):

- Planning
- Monitoring
- Evaluation
- Action

A schematic flow diagram of the DP3 AMS showing the links between monitoring, review, evaluation and action, which could be adaptation or mitigation is presented in Diagram 1.

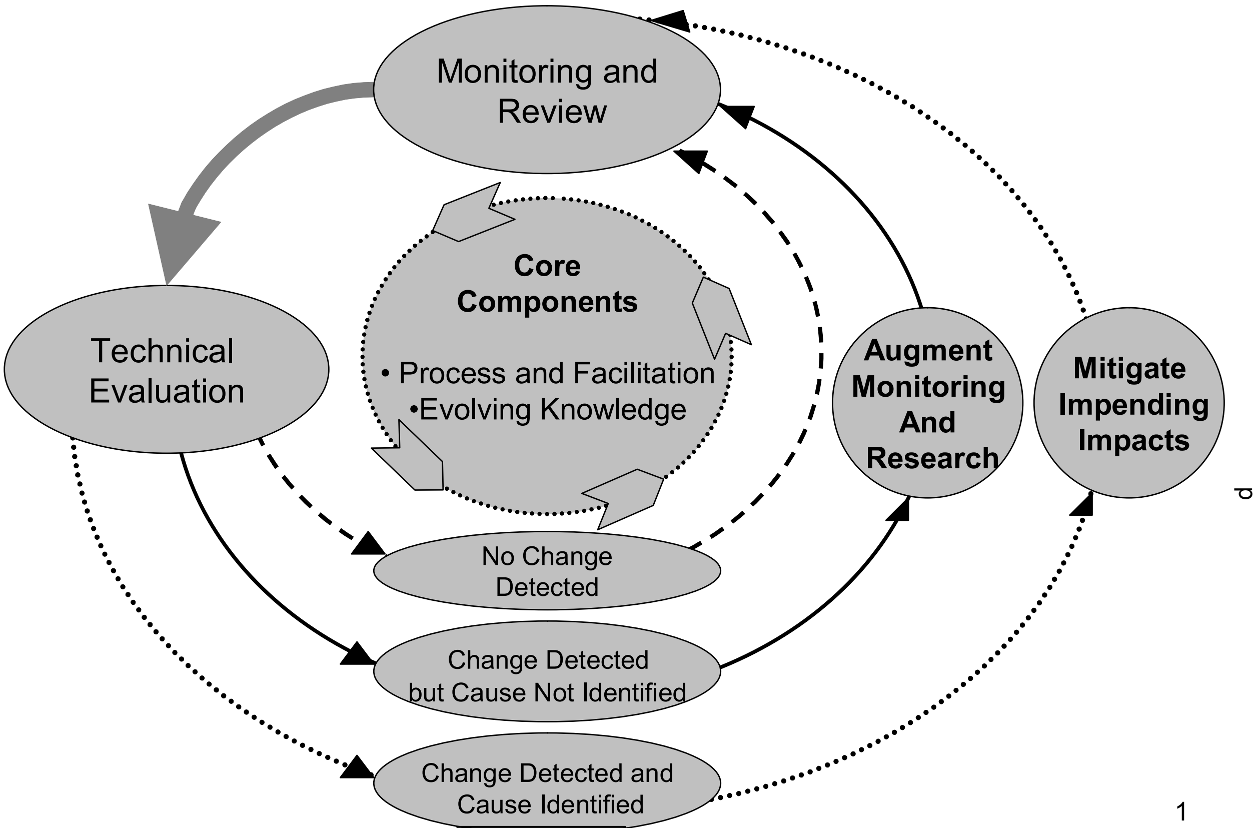


Diagram 1[1] Adaptive Management Strategy Process

2.1 PLANNING

The initial planning component of the AMS presented herein has involved representatives from the following regulatory and scientific agencies:

- Vancouver Port Authority
- Environment Canada
- Fisheries and Oceans Canada

[1] Elner, B. 2005 Canadian Wildlife Service – Presentation to FREMP Management Committee October 2005

- Canadian Environmental Assessment Agency
- Geological Survey of Canada
- Hemmera Envirochem Inc.
- Precision Identification Biological Consultants
- Northwest Hydraulic Consultants

The planning component involved a shared review of the environmental information collected by VPA for Deltaport Third Berth summarized in detail in Section 3, as well as information from the regulatory agencies generated through their independent research efforts. The planning component also reviewed areas of uncertainty in the inter-causeway area including the key areas of concern identified by Environment Canada. The shared review identified five key components for monitoring that either provide indication of negative trends in the ecosystem such as eutrophication and coastal erosion processes, or improve the level of understanding of the inter-causeway ecosystem to reduce uncertainty. The planning component also identified the ability to collect complementary monitoring data that when incorporated into the AMS has the potential to provide a greater understanding of the inter-causeway ecosystem again reducing the level of uncertainty.

The five key areas identified for consideration in the AMS include:

1. Geomorphology/Oceanography – an indicator in potential changes from DP3 or other causes to coastal zone processes that would increase erosion (dendritic channels) or reduce flushing contributing to potential eutrophication in the inter-causeway area.
2. Surface Water Quality – an indicator in potential changes from DP3 or other causes to potential eutrophication in the inter-causeway area.
3. Sediment Quality - an indicator in potential changes from DP3 or other causes to potential eutrophication and to coastal zone processes (sediment transport).

4. Eelgrass - an indicator in potential changes from DP3 or other causes to potential eutrophication and to the overall ecosystem health in the inter-causeway area.

5. Other Biota – an indicator of ecosystem health when compared to the other key areas of monitoring.

The state of knowledge for each area of monitoring is summarized in the sections describing the specific monitoring programs detailed in Sections 3, 4, 5, 6 and 7, respectively.

The planning component includes the preparation of the Detailed AMS Workplan described in Section 1.4. As noted, this workplan will be prepared prior to initiation of DP3 construction monitoring and the AMS monitoring studies described herein, and will be reviewed with the regulatory and scientific agencies prior to implementation. Over the course of the AMS the Detailed AMS Workplan is subject to modification based on advice from the Scientific Advisory Committee (see Section 2.3).

The AMS focuses on the "inter-causeway area," (or study area) shown on **Figure 2**; however, reference stations located outside of the study area will be monitored for comparison purposes.

2.2 MONITORING

VPA will implement the AMS, with the first monitoring event occurring prior to initiation of DP3 construction activities and extending for five years following substantial completion of DP3. Some of the monitoring activities proposed in the planning workshops relate specifically to construction monitoring and would be complementary to the monitoring that would indicate negative trends in the environment due to eutrophication or changes to coastal zone processes. Other key monitoring activities would start prior to construction, continue through construction and extend into operation of the facility. Again, a component of the ongoing monitoring program will be complementary and is intended to provide for a better understanding of the inter-causeway ecosystem to reduce uncertainty. It bears repeating that AMS monitoring program is 'adaptable' as needed to facilitate the reduction of uncertainty in monitoring and provide a basis for evaluation so that negative change can be detected and appropriate management action undertaken (Holling 1995).

2.3 Evaluation

Under the AMS, VPA will present monitoring data and an interpretation of its significance with respect to any ecosystem trends to the Scientific Advisory Committee (SAC) within 30 days of sampling being completed and processed. The SAC will review the data and interpretations, then make a recommendation of any future actions. The SAC may also consider community knowledge and aboriginal traditional knowledge when reviewing the AMS monitoring data. Additionally, the adaptive evaluation component of the AMS will include an annual program review whereby each year's monitoring results will be tabulated, reviewed, and compared against the thresholds identified in the following sections. The VPA will communicate the year's results in an annual AMS report (Annual Report) submitted, along with recommendations for any actions or changes to the Detailed AMS Workplan, to the SAC for review and comment. Once accepted by the SAC, the completed Annual Report will be made available to the public and First Nations on the VPA website (http://www.portvancouver.com/) or by request.

The SAC will consist of one scientific representative each chosen by Environment Canada and the VPA, a third scientist chosen jointly by EC and the VPA, and other supporting independent scientists appointed from time to time by Environment Canada and the VPA, who have specialist expertise in the key environmental, ecosystem, and engineering components being monitored. The VPA will serve as secretariat to the SAC at its own costs.

The AMS study design is based on the concept of weight-of-evidence and evolving knowledge. A considerable number of parameters has been proposed for monitoring, but the decisions to adapt the plan or trigger mitigation measures will be based on consideration of multiple lines-of-evidence indicating negative trends towards eutrophication or changes to coastal zone processes. This approach is important as it improves the decision-making process and reduces uncertainty potentially resulting from an incomplete understanding of the processes that occur naturally in the marine environment.

2.3.1 Evaluation Thresholds

As detailed in the relevant sections that follow, existing national, provincial or regional standards for monitored parameters will serve as action thresholds for the AMS. For those monitoring parameters that do not have national, provincial or regional objectives or standards, a 20 percent effect level or 20 percent change over background has been selected as the preliminary AMS threshold.

The basis for using a 20 percent effect level originates from standardized toxicity testing protocols where 20 percent is considered the minimum level at which effects could be resolved. For example, in amphipod tests where 5 individuals are evaluated with respect to survival in sediment, if one died that would constitute a 20 percent effect. There is considerable variability in nature and as such effects of less than 20 percent become increasingly difficult to resolve with respect to the precise origin of the effect and whether it is due to anthropogenic or natural causes. Effects 20 percent or greater are typically more clear with respect to the source of the effect, such that 20% is considered a reasonable a preliminary threshold of evidence for an effect.

The British Columbia Ministry of Environment, in their guidance document for completion of ecological risk assessments, suggests the use of an EC20 (*Concentration causing a 20 percent effect in the test species*) for identification of adverse effects to aquatic ecological receptors, and an EC50 (*Concentration causing a 50 percent effect in the test species*) for identification of adverse effects to terrestrial ecological receptors, or for assessment of ecological risk at industrial sites (BC MOE 1998). Because of the ecological importance of the inter-causeway and Roberts Bank area, it is deemed appropriate to follow the more conservative 20 percent effect threshold.

As the AMS proceeds and data is collected, analyzed and trends in the inter-causeway ecosystem are identified the preliminary 20 percent effect level threshold may change, based on consultation with the SAC, to further reduce uncertainty and refine detection of trends.

2.4 ACTION

On advice of the SAC, the VPA will develop an action plan (Action Assessment Report) based on consultation between the VPA and the SAC. Possible actions could range from 'adaptation' of the monitoring plan for the subsequent year to further reduce uncertainty in the monitoring, to the identification of concerns requiring immediate attention and/or mitigation by the VPA, or in the case the impact is not attributed to DP3, informing the parties responsible, if they can be identified.

Once having received the monitoring data from the VPA, the SAC will notify the VPA within 30 days if the monitoring results show any evidence of, or otherwise indicate, the development of a negative ecosystem or environmental trend in the inter-causeway area. Notwithstanding such notice, if VPA obtains evidence or suspicion of a negative trend in the inter-causeway area through the monitoring program or any other means, it will notify the SAC within 30 days.

If the SAC determines that the negative ecosystem trend is significant and attributable to DP3, VPA commits to immediately initiate engineering studies and subsequent physical works to mitigate or reverse the negative ecosystem trend. Within 90 days after a negative ecosystem trend is identified during the course of the AMS, VPA will provide an Action Assessment Report to the SAC that includes recommendations for possible 'actions' to mitigate or reverse the trend. The results of an Action Assessment Report, if required, will be included in the Annual Report for that year and will be made available to the public for review.

Some of the Detailed AMS Workplan components may be expanded upon during the course of the AMS, while other components may be removed in consultation with the SAC. The results of this process will also be made available to the public on the VPA website (http://www.portvancouver.com/) or by request.

At the conclusion of the AMS, five years following substantial completion of DP3, the cumulative results will be compiled into a final report summarizing the monitoring, adaptations and mitigation, including what was learned over the duration of the DP3 AMS. It is possible that the DP3 AMS monitoring duration (monitoring will commence prior to construction, estimated to take 3 years, and run for a further five years after substantial completion of DP3) may be only part way through establishing a significant negative ecosystem trend attributable to DP3. In this case the VPA, in consultation with the SAC, would extend the monitoring program for a suitable period of time to confirm or refute the ecosystem trend.

As noted, the five key areas identified for consideration in the AMS include:

- Geomorphology/Oceanography
- Surface Water Quality
- Sediment Quality
- Eelgrass
- Other Biota

These five key areas and the associated adaptive management strategy for each are discussed in the following sections.

3.0 COASTAL GEOMORPHOLOGY / OCEANOGRAPHY

The initial construction of the BC Ferries terminal and causeway in 1958 and the subsequent development of the Roberts Bank port facilities, starting in 1968 with the port causeway and coal terminal, altered the Roberts Bank coastal geomorphology processes.

In order to meet the requirements of the environmental assessment process, the VPA retained coastal geomorphology experts to undertake a study (NHC-Triton 2004) to assess the potential coastal impacts to Roberts Bank as the result of the DP3 project. This study assessed how ocean waves, river and tidal currents may be altered by the proposed DP3 and how in turn those impacts may alter the coastal processes and physical environment of Roberts Bank. Of particular concern was the formation, and ongoing development, of dendritic channels within the inter-causeway area and the potential for DP3 to reduce coastal zone flushing, thereby exacerbating or contributing to marine eutrophication.

The extent of the investigation area was defined by the Steveston Jetty to the north, Point Roberts to the south, the 100 m water depth contour to the west and the top of the bank along the eastern Roberts Bank shoreline. The geomorphic investigations used three general methods to assess the physical response to the proposed development: (1) interpretive geomorphic studies using historical data, site observations, and measurements; (2) analytical computations using empirical or theoretical relations that describe sediment transport, erosion and deposition processes; and (3) numerical modeling of waves and tidal currents.

The model development was carried out in three phases. A "Wide Area Model" of the Strait of Georgia, Juan de Fuca Strait, and around Vancouver Island was used to develop boundary conditions in the vicinity of Roberts Bank. A "Base Model" was then developed to simulate hydrodynamic conditions in the Fraser Estuary, Roberts Bank tidal flats, and adjacent portions of the Strait of Georgia. This model was used to assess general flow patterns in the area of interest and to identify the potential extent of impacts from various alternative project developments. Finally, a "Detailed Model" was developed specifically for the DP3 project to assess local flow conditions in the inter-causeway area between the BC Ferry and Deltaport causeways. This Detailed Model was particularly useful for assessing shallow flows on the tidal flats and in eelgrass covered areas, as well as for assessing flow effects induced by structures such as the proposed wharf extension at DP3 and the existing crest protection weir on the tidal flats. The computational mesh for the Detailed Model had a resolution of between 5 to 10 meters in critical areas near the proposed developments in order to model small changes in local flow patterns caused by the proposed DP3 structures. The Detailed Model was verified with a series of current velocity measurements made in the inter-causeway area in April and May 2004. Comparisons between predicted and measured velocities showed excellent agreement.

The results from the coastal geomorphology study for DP3 and Roberts Bank concluded:

1. No wide-scale morphological impacts on Roberts Bank;

2. New tidal drainage (dendritic) channels will not form in response to planned dredging;

3. Impacts to tidal currents and waves are confined to the local flow field around the wharf extension and the dredged channel;

4. The magnitude of the velocities in the impact zone is well below the threshold for sediment transport; and

5. No changes to coastal zone flushing of the inter-causeway area.

The coastal geomorphology study also identified that the existing dendritic channels are still evolving independent of DP3 and are dependent upon a number of factors.

- Channel evolution is closely interrelated with eelgrass expansion (eelgrass governs resistance on tidal flats, stores and releases water during drainage, modifies flow paths); and

- Channels are governed by fluvial processes not waves. Drainage paths and topography control the amount of water carried by tidal channels.

The monitoring plan has been prepared to detect changes/trends in the coastal zone processes that were not or could not be identified in the coastal geomorphology study. The plan is designed such that any significant negative trends attributable to DP3 that would contribute to marine eutrophication and increased erosion can be detected early enough to allow VPA to undertake adaptation or mitigation.

3.1 MONITORING PLAN

The monitoring parameters and frequency of monitoring for the coastal geomorphology/oceanographic processes are presented in **Table 2**.

The key monitoring program component is the deployment of an Acoustic Wave and Current (AWAC) meter in the area of the proposed Third Berth. The Nortek AWAC is a combined directional wave gauge and current profiler. The three ‘current’ acoustic beams, slanted 25 degrees from vertical, operate like other Doppler current profiler systems. However the AWAC also has a vertical beam that measures the wave height directly. This beam provides an actual time-series of wave height, and is not a computation based on linear wave theory. Thus it is capable of measuring non-linear waves such as those starting to break on the edge of a bank, and transient waves generated by local ship traffic. The AWAC can also measure current profiles every 10 minutes, and a wave burst every hour with current measurements every metre in the vertical. Analysis of depth profiles will be selected based on tidal currents of concern. The field results will be compared to the coastal geomorphology model to confirm whether changes are occurring.

In addition, quarterly field investigations will be undertaken of the crest protection to assess ongoing effectiveness and the early detection of incise of dendritic channels. Orthorectified photography or remote sensing techniques will be conducted on an annual basis and LIDAR or bathymetry mapping will be done ever three to four years to track the dendritic channelization process and potential tidal current impacts such as scour and erosion.

The coastal geomorphology monitoring plan will be reviewed on an annual basis for adaptation opportunities.

3.1.1 Deployment Location

Precise deployment location will be determined in consultation with the Coastal Geomorphology consultant, Environment Canada and NRCan. For general reference the AWAC will be located in close proximity to the Third Berth project.

3.1.2 Deployment Methodology

The AWAC instrument will have a custom fabricated bottom frame that will be serviced by divers. A transponder will be attached to the instrument frame to assist with re-location. A 30 metre ground line will also be laid on the bottom to assist the divers and which could be dragged up if necessary.

The AWAC will be deployed in Summer 2006 well in advance of DP3 construction. Data will be collected over a three-month period and the instrument collected and the data transferred to computer for processing. The data from the AWAC and other interpretive coastal geomorphology/oceanography parameters will be analyzed on the schedule frequencies outlined in **Table 2** and an annual report prepared.

Table 2 Coastal Geomorphology/Oceanography Monitoring Parameters and Purposes

Parameter	Monitoring Frequency	Assessment Use
Wave/Current Meter (AWAC - acoustic wave and current profiler)	Continual	Tidal current impacts, scour, erosion
Orthorectified photography/remote sensing	Annual	Dendritic channelization, tidal current impacts, scour, erosion
Total Suspended Sediment (OBS (optical backscatter sensors /manual water sampling)	Continual/Quarterly	Siltation
Crest Protection Monitoring	Quarterly	Incise of dendritic channels
PEEP (Photo-Electronic Erosion Pin) monitoring (sediment accumulation/erosion)	Continual	Siltation
Grain size	Semiannual	Siltation
LIDAR (LIght Detection And Ranging) or Bathymetry	Once per 3-4 yr	Dendritic channelization, erosion, siltation

3.1.3 Evaluation Thresholds

The following parameters will be evaluated over the course of each sampling year for trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the results of the coastal geomorphology model as well as appropriate reference stations elsewhere along Roberts Bank. Specific action levels are as follows:

- Reduced tidal flushing - 20 percent reduction in flushing rates vs. modeled background
- Increased scour and erosion – 20 percent difference in measured sedimentation rates vs. modeled accretion and deposition
- Dendritic channelization – initiation of any knickpoint for incise of additional dendritic channels in the inter-causeway area
- Increased siltation during construction - When background is less than or equal to 8 nephelometric turbidity units (NTU), induced turbidity should not exceed 8 NTU above the background value NTU in 24 hours; or should not exceed by more than a mean of 2 NTU in 30 days when background is less than or equal to 8.

When background is between 8 and 80 NTU, induced turbidity should not exceed the background value by more than 8 NTU. Above 80 NTU induced turbidity should not exceed 10% of the background value (BC MOE 2001a).

3.2 POSSIBLE ADAPTATION/MITIGATION

As noted above, the results of the coastal geomorphology study will be evaluated over the course of each sampling year for trends and for impacts. This evaluation will follow the reporting and action protocols outlined in Section 2.4 (Action) above.

Based on the detailed assessment of the coastal geomorphology, unacceptable impacts are not anticipated. However, if negative changes to the coastal geomorphology are detected and are attributed to the VPA's DP3 project, VPA commits to design and construct the following mitigation measures:

- Dendritic channelization – VPA would immediately design and construct "crest protection" to arrest dendritic channel processes.
- Reduced tidal flushing leading to marine eutrophication - VPA commits to constructing a drainage channel or other appropriate engineered mitigation measure by first developing a physical model with the goal to design increased flushing of the inter-causeway area if the coastal geomorphology monitoring results, in combination with the water quality, sediment quality and biota monitoring, indicate a negative trend towards marine eutrophication.
- Increased scour and erosion – VPA would immediately initiate an assessment of the localized habitat impacts, in consultation with the SAC, and undertake to design and implement engineered scour and erosion protection to mitigate for impacts as required.
- Increased siltation during construction – During construction, VPA will deploy silt curtains and booms to contain sediment plumes. During operation, VPA will work with the terminal operators to reduce ongoing sediment discharges.

4.0 SURFACE WATER QUALITY

Surface water quality is a critical factor in the maintenance of a healthy aquatic ecosystem. Surface water supports an extensive network of biological organisms covering multiple trophic levels from phytoplankton, zooplankton, marine algae, juvenile salmon, up to large carnivores such as seals and sea lions. As such, the maintenance of surface water quality in the inter-causeway area and in the vicinity of VPA's Deltaport facility is considered to be of significant environmental, social, and economic importance.

A baseline water quality sampling program was conducted over a one year period (EVS-Golder 2004) for the DP3 Environmental Application to characterize the pre-project water quality conditions, such that post-project impacts on water quality can be predicted and monitored. The water quality sampling program assessed the following questions regarding baseline water quality conditions in the Roberts Bank surface water:

- What is the pre-project range of values for water quality parameters in the surface waters around the Roberts Bank terminal, relative to the range of values at reference sites remote from the terminal?
- How do the values for water quality parameters vary spatially and temporally (i.e., seasonally) in the waters of the study area and at reference sites?
- How do the values for water quality parameters at the study and reference sites compare with established water quality guidelines (WQG)?

Prior to initiating baseline water quality monitoring program a literature review was undertaken to assist with determining appropriate water quality parameters and to determine historical data trends (Triton 2001, Swain *et al.* 1998).

Monthly water samples were taken at eight "monitoring" sites between Canoe Passage and the BC Ferries Terminal Causeway, and two "reference" sites off Westham Island, remote from the Roberts Bank terminal. The ten sampling stations were arranged in five pairs, each consisting of a "nearshore" station, on the landward side of the 5-m depth contour at the edge of Roberts

Bank, and a "farshore" station on the open water side of the 5-m depth contour. At each station, one water sample was collected from immediately below the water surface ("surface" samples), and one sample was taken from a location 2 m above the bottom ("deep" samples). In October 2004 two locations were sampled in order to obtain additional data regarding nutrient inputs into the area between the BC Ferries and Roberts Bank port causeways. One sample was obtained at the outlet of an agricultural drainage ditch near the base of the BC Ferries causeway, and another sample was obtained from within the ditch itself.

Specific water quality parameters considered for the DP3 water quality study were as follows:

- dissolved oxygen (DO) concentration,
- pH,
- water temperature,
- turbidity salinity,
- total suspended solids (TSS),
- ammonia nitrogen (NH_4-N),
- nitrate nitrogen (NO_3-N),
- nitrite nitrogen (NO_2-N),
- dissolved ortho-phosphorus (ortho-P),
- chlorophyll *a*; and
- polycyclic aromatic hydrocarbons (PAHs) were also included as a parameter for the October 2004 monitoring cycle.

A quantitative assessment of parameters that either were indicators or contributors to marine eutrophication (e.g. dissolved oxygen – DO, phytoplankton biomass – chlorophyll *a*, and nutrients such as ammonia - NH_4-N) was conducted for the DP3 assessment. Other parameters such as pH, temperature, and salinity provided baseline information. PAHs were included in the monitoring program at the request of Fisheries and Oceans Canada. Polycyclic aromatic hydrocarbons (PAHs) from all sample locations were recorded at levels below laboratory detection limits.

Water quality objectives (WQO) or water quality guidelines existed for several of the parameters measured during the DP3 water sampling program. Twenty-four of the 99 DO measurements were below the chronic WQO of 8.0 mg/L (mean of 5 samples collected within a 30-d period) set by Swain *et al.* (1998), but none of the measurements was below the instantaneous minimum of 5.0 mg/L. All of the low DO measurements were taken from deep samples. Based on these measurements, harm to DO-sensitive species (e.g., salmonids) is not expected.

For water temperatures of 15°C, salinity of 20 ppt, and pH of 8.0, the maximum allowable ammonia concentration is 9.8 mg/L and the allowable 30-d average concentration is 1.5 mg/L (BC MWLAP 1998). All measured ammonia-N concentrations were non-detectable or below half of the 30-day average guideline. Therefore, ammonia related toxicity is not expected.

Based on the information collected to date there is no indication of pervasive marine eutrophication occurring in the inter-causeway area.

4.1 MONITORING PLAN

Although considerable water quality monitoring has already taken place within the inter-causeway area and vicinity of Deltaport, VPA proposes establishing 'fixed' water quality monitoring stations adjacent to the Deltaport facility, within the 'inter-causeway area' and at several 'far-field' locations along Roberts Bank for use throughout the duration of the AMS. In addition, one or more reference locations offering similar habitat and speciation as Roberts Bank and the inter-causeway area, will benefit the interpretation of information attained. Some of the water quality parameters will be indicators of marine eutrophication while others will provide complementary water quality information. Contaminant parameters (PAHs, heavy metals, chlorine) are included to assess potential toxicity in the inter-causeway area even though DP3 is not discharging or increasing the levels of these parameters. This monitoring would also be considered complementary.

As with other aspects of the DP3 AMS, the surface water quality monitoring plan would be evaluated on an annual basis for opportunities to adapt the plan before moving forward.

The following parameters will be measured using either a field deployed multi-meter (e.g., YSI 6820 Sonde) or via sample collection using a vertical point sampler (e.g., Van Dorn sampler). Specific details pertaining to the sample stations, sample collection methodologies, analytical requirements, and data quality objectives will be outlined in the Detailed AMS Workplan prepared prior to the field work commencing.

4.1.1 Parameters

The water quality parameters identified for monitoring within the first year of the AMS are presented in **Table 3**.

Table 3. Surface Water Quality Parameters, Frequency, and Purpose

Parameters	Monitoring Frequency	Assessment Use
Temperature, pH, DO, salinity	Continuous (data logger)	eutrophication
Salinity	Quarterly	interpretation
pH	Quarterly	interpretation
Hardness	Quarterly	bioavailability
Turbidity	Quarterly	eutrophication
Total Suspended Solids (TSS)	Quarterly	eutrophication
Clarity (secchi disk)	Quarterly Sampling or Data Logger	eutrophication, siltation
Total Nitrogen (Nitrate and Nitrite, Total Kjeldahl Nitrogen)	Quarterly	eutrophication
Nitrate	Quarterly	eutrophication
Ammonia	Quarterly	eutrophication
Total Phosphorous	Quarterly	eutrophication
Total Dissolved Phosphate	Quarterly	eutrophication
Silicon/Silicate	Quarterly	eutrophication
Dissolved Inorganic Nitrogen (DIN)	Quarterly	eutrophication
Chlorophyll *a* (w/ filtration)	Quarterly Sampling or Data Logger	eutrophication
Total metals	Quarterly	toxicity
PAHs	Quarterly	toxicity
Chlorine	Quarterly	toxicity

4.1.2 Evaluation Thresholds

A number of the monitored parameters are for data interpretation purposes only and therefore do not require evaluation thresholds. These include parameters such as:

- Temperature
- pH
- Salinity
- Hardness

Parameters collected as indicators of potential toxicity to marine organisms however, will be compared against the applicable provincial and federal water quality screening levels:

- Canadian Council of Ministers of the Environment (CCME) water quality guidelines (CCME 2004);
- British Columbia Approved Water Quality Guidelines (Criteria), 1998 Edition (BC MOE 2001a); and where applicable,
- A Compendium of Working Water Quality Guidelines for British Columbia, 2001 Update (BC MOE 2001b).

The parameters being analyzed to assess the presence/absence of toxicants include:

- Metals
- Polycyclic aromatic hydrocarbon scan (PAHs)
- Chlorine

Several of the water quality parameters will also be considered for their value in prediction of marine eutrophication events and/or construction impacts:

- Turbidity, TSS, Clarity
- Nutrients
- Chlorophyll *a*

These parameters will be evaluated over the course of each sampling year for trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the results from reference stations elsewhere along Roberts Bank and at distant reference locations. A 20 percent difference from elsewhere along Roberts Bank will be used as an indicator of a potential for impact and result in its mandatory consideration in each of the annual data reviews.

4.2 POSSIBLE ADAPTATION/MITIGATION

The results of the surface water quality study will be evaluated over the course of each sampling year for trends and for effects. If nutrient, chlorophyll *a* or dissolved oxygen levels are found to indicate a trend toward marine eutrophication in the inter-causeway area, and the indication from the water quality monitoring, in combination with the coastal geomorphology, sediment quality and biota monitoring is that DP3 has reduced coastal flushing, VPA commits to constructing a drainage channel or other appropriate engineered mitigation measure by immediately developing a physical model to inform the physical works. The intent of the physical model is to design for increased flushing of the inter-causeway area to reverse a negative trend towards marine eutrophication. This evaluation will follow the reporting and action protocols outlined in Section 2.4 (Action) above.

If the AMS provides evidence that marine eutrophication is occurring, or has the potential to occur, as a result of increased nutrient loading to the inter-causeway area from sources other than DP3 the VPA will refer this information to the authorities responsible for those negative ecosystem trends, if they can be identified.

Although DP3 is not anticipated to introduce additional contaminants, discharges of toxics will be used to trigger an assessment of the source. If a discharge is the result of the DP3 project, VPA commits to stopping the discharge. If the discharge is not attributable to DP3, the issue will be referred by VPA to the authorities responsible, if they can be identified.

Identification of toxicants would result in their continued monitoring for the duration of the AMS. However, if the noted toxicants are not identified in the first year of monitoring, these could be removed from future monitoring events.

5.0 SEDIMENT QUALITY

Sediment quality, like surface water quality, is also critical in the maintenance of healthy aquatic ecosystems, particularly at a local scale. Often overlooked by the casual observer, marine sediments provide important habitat for numerous infaunal and epifaunal organisms from invertebrates to demersal fish such as Starry Flounder. The intertidal and nearshore subtidal sediments also represent critical forage potential for many birds that feed on the algae and invertebrates that reside there. As such, the maintenance of clean, healthy sediment in the vicinity of VPA's Deltaport facility is also considered to be of significant environmental, social, and economic importance.

In 2004 a sediment sampling program and sampling methodology was developed in consultation with Environment Canada through its review of the draft sediment sampling workplan. The purpose of the sediment sampling program was to determine whether the marine sediments that required removal for the construction of DP3 were clean enough for ocean disposal. Sediment samples, which consisted of both core and surface grab samples, were collected from the study area by barge and by boat. Sediment sampling locations were coordinated with the geotechnical drilling program that involved six cone penetration tests in the wharf and terminal area and 10 boreholes. (Hemmera 2004).

A total of 45 sediment samples was collected (25 core samples and 20 surface grab samples).

At the time of collection the following sediment sample characteristics were recorded:

- sediment texture (*e.g.*, sandy silt);
- colour and odour;
- anthropogenic and non-anthropogenic sediment sample characteristics; and
- visual evidence of contamination.

As per Environment Canada's *Disposal at Sea Regulations, 2001* and *Interim Contaminant Testing Guidelines,* each sample was analyzed in the laboratory for:

- total organic carbon (TOC);

- PAHs;
- cadmium and mercury; and
- grain size.

All of the surface and sub-surface sediment samples were below the maximum allowable levels for cadmium, mercury and PAHs specified in the *Disposal at Sea Regulations, 2001*.

In addition to the *Disposal at Sea* required parameters, fifteen samples were analyzed for total sulphur and total sulphides to assist with material characterization in support of proposed sediment use for habitat compensation features. There are no criteria for total sulphur and sulphide levels in marine sediments. These results will be used in conjunction with other sediment analyses, including particle size and TOC, to determine salt marsh and eelgrass "bed" preparation requirements as part of the detailed design of the habitat compensation features, in the event that this material is used for beneficial purposes.

5.1 MONITORING PLAN

The most recent assessment of sediment quality in the vicinity of the Deltaport facility did not reveal the presence of elevated metal or PAH concentrations; however the VPA proposes establishing 'fixed' sediment quality monitoring stations both within the inter-causeway area and at reference locations for use throughout the duration of the AMS. As with the surface water quality, sediment reference locations will be used for comparison to stations closer to Deltaport to evaluate larger scale trends and to facilitate data interpretation activities.

As part of the sediment quality monitoring program, a representative core sample of the inter-causeway sediments will be collected for analysis using radioactive dating methods (Pb-210). The procedure involves collecting a core of the sediments and analyzing samples at various depth intervals. The distribution of natural or artificial radioactive species, in this case Pb-210, can be interpreted to produce a chronological history of the sediments and their associated quality, including the presence of contaminants or eutrophic events. The core sampling and analysis program will be prepared in consultation with Environment Canada and Natural Resources Canada.

The sediment quality monitoring plan, like the water quality plan, would be reviewed on an annual basis for adaptation opportunities. Specific details pertaining to the sample collection methodologies, analytical requirements, and data quality objectives will be outlined in a Detailed AMS Workplan prepared prior to the field work.

5.1.1 Parameters

Parameters to be monitored in sediment are identified in **Table 4**.

5.1.2 Evaluation Thresholds

As with the surface water quality monitoring plan, a number of the monitored parameters are intended for data interpretation purposes only and do not require action levels. These include parameters such as:

- pH
- Hydrogen sulphide
- Salinity
- Grain Size
- Total Organic Carbon (TOC)

Other complementary parameters collected as indicators of potential toxicity to marine organisms will be compared against the BC Contaminated Sites Regulation, Schedule 9 Generic Numerical Sediment Criteria for 'sensitive' marine and estuarine sediments (SedQCscs) (BC 1997). Though provincial standards, these represent the most recent sediment screening levels available and were developed in consultation with Environment Canada and Fisheries and Oceans Canada. In the absence of a federal or provincial sediment screening level for tributyltin

(TBT), the Puget Sound Dredge Disposal Analysis (PSDDA) criteria (73 µg TBT/kg) will be adopted for screening purposes (WDEQ and ACE 1996).

As with the surface water quality program, eutrophication parameters noted in **Table 4** will be evaluated over the course of each sampling year for trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the sediment results from reference stations elsewhere along Roberts Bank and at distant reference locations. A 20 percent difference from elsewhere along Roberts Bank will be used as an indicator of a potential for eutrophication impacts in sediment. For each of the potential ecosystem effects of concern, multiple measurement parameters will be considered to arrive at an overall conclusion regarding threshold exceedance.

Table 4. Sediment Quality Parameters, Frequency, and Purpose

Parameters	Frequency	Purpose
pH	Quarterly	Interpretation
Hydrogen sulphide	Quarterly	Interpretation
Salinity	Quarterly	Interpretation
Grain size	Annual	Interpretation
Total Nitrogen (TN)	Quarterly	Eutrophication
Ammonia	Quarterly	Eutrophication
Nutrients (dissolved inorganic nitrogen (DIN), total inorganic phosphates (TIP), filterable reactive phosphate)	Quarterly	Eutrophication
Total organic carbon (TOC)	Quarterly	Interpretation
Metals	Semi-annual	Toxicity
Organotin: Tributyltin	Semi-annual	Toxicity / Imposex
Eh, H_2S probe	Quarterly	Eutrophication
Core Sampling (Pb-210 Radioactive Dating)	Pre-DP3 Construction	Historical baseline

5.2 POSSIBLE ADAPTATION/MITIGATION

The results of the sediment quality study will be evaluated over the course of each sampling year for trends and for effects. If nutrient, Eh or H_2S levels in the sediments indicate a trend toward marine eutrophication in the inter-causeway area, and the indication from the coastal geomorphology, water quality and biota monitoring is that DP3 has reduced coastal flushing, VPA commits to constructing a drainage channel or other appropriate engineered mitigation measure by immediately developing a physical model to inform the physical works. The purpose of the model is to design for increased flushing of the inter-causeway area to reverse a negative trend towards marine eutrophication. This evaluation will follow the reporting and action protocols outlined in Section 2.4 (Action) above.

If the AMS determines that marine eutrophication is occurring, or has the potential to occur, as a result of increased nutrient loading to the inter-causeway area from sources other than DP3 the VPA will refer this information to the authorities responsible for those negative ecosystem trends, if they can be identified.

Although DP3 is not anticipated to introduce additional contaminants, discharges of toxics will be used to trigger an assessment of the source. If a discharge is a result of the DP3 project, the VPA commits to stopping the discharge. If the discharge is not attributable to DP3, the issue will be referred by VPA to the authorities responsible.

Identification of toxicants would also result in their continued monitoring for the duration of the AMS. However, if the noted toxicants are not identified in the first year of monitoring, these could be removed from future monitoring events after consultation with the appropriate agencies and the SAC.

5.3 EELGRASS

Eelgrass beds provide refuge for many species of fishes and invertebrates and feeding areas for many species of waterfowl. A widespread loss of eelgrass/seagrass habitat has been documented throughout the world, including both the Atlantic and Pacific coastal areas of the United States of

America. Eelgrass beds are also likely diminishing in BC. The eelgrass beds at Roberts Bank have not followed this trend. Based on a current assessment of eelgrass (*Zostera marina)* in the Roberts Bank inter-causeway area, eelgrass has expanded by approximately 33% from 377 hectares in 1967 to 500 hectares in 2003 (Triton 2004).

The Tarbotton and Harrison Report (1996) prepared for the Roberts Bank Environmental Review Committee (RBERC) estimated the area of eelgrass at Roberts Bank in 1967 to be 496 hectares, 348 hectares of which were located in the inter-causeway area and north bed. Subsequent development of the Roberts Bank port facilities, commencing in 1968 and the expansion in 1981 led to losses of eelgrass over a short term. Based on the marine habitat surveys conducted in 2003 (Triton 2004), the inter-causeway *Zostera marina* bed had expanded to 500 hectares. This was likely due to many factors including diversion of the Fraser plume by the Roberts Bank causeway (which improved water clarity in the inter-causeway area), drainage at low tide impeded by the causeways, sediment escape from coal port development raising bed elevations near the coal port, and the ferry causeway, initially constructed in 1958, sheltering the area from southeasterly storms. The combined eelgrass area of the inter-causeway and eelgrass bed located north of the port causeway totalled 724 hectares in 2003 (Triton 2004), an increase of 228 ha from 1967.

One of the reasons for concern that marine eutrophication could occur within the inter-causeway area is the large biomass of eelgrass, including both the native species *Zostera marina* and also the introduced species *Zostera japonica*. Eelgrass in itself is a potential source of nutrients to the inter-causeway ecosystem system in that eelgrass decomposition without adequate coastal flushing could lead to marine eutrophication.

The eelgrass monitoring program will assess the health and growth of eelgrass in the inter-causeway area relative to reference sites on the west side of the causeway as well as in Boundary Bay.

The eelgrass monitoring plan will be reviewed on an annual basis for adaptation opportunities.

5.4 Monitoring Plan

5.4.1 Parameters

- **Remote Sensing**: Annual remote sensing (satellite imagery/aerial photography) (e.g., Air photos/2005 images prepared by Hatfield and the European Space Agency (Hatfield 2004));
- **Ground Truthing**: Annual checks of eelgrass stations established for the Deltaport Third Berth EA: Four inter-causeway stations, four west of the Roberts Bank VPA facility, and three reference stations in Boundary Bay.

  Monitoring Parameters:

  - Shoot density (Leaf Area Indices (LAI) = (mean shoot length) x (mean shoot width) x (mean density of shoot/m^2)).
  - Description of percent coverage at monitoring stations:
    - *Zostera marina*: patchy = clustered in small islands; continuous = eelgrass shoots are distributed throughout the area; absent = densities below 1 shoot/m.
    - *Zostera japonica*: <1% present; <40% sparse; 41-75% moderate; > 75% dense.
  - Presence/absence of epiphytes. (possible indicator of eutrophication)
  - Presence/absence of *Beggiatoa* sp. (possible indicator of eutrophication)
- **SIMS survey**: Every third year use underwater video to confirm the lower limits of eelgrass within the inter-causeway study area.

5.4.2 Evaluation Thresholds

A 20 percent difference from elsewhere along Roberts Bank will be used as an indicator of a potential impact on eelgrass in the inter-causeway area. Based on the annual review of the AMS, the evaluation threshold level for eelgrass may be modified to reflect specific conditions in the inter-causeway area. It is important to note that differences greater than 20 percent could be the result of natural conditions. An exceedance of this threshold results in the mandatory consideration of the parameter during the annual data and program review process.

5.5 POSSIBLE ADAPTATION/MITIGATION

The results of the eelgrass study will be evaluated over the course of each sampling year for trends and for effects. If reduced tidal flushing, in combination with the coastal geomorphology, water quality, and eelgrass monitoring results, are found to indicate a trend toward marine eutrophication, VPA commits to constructing a drainage channel or other appropriate engineered mitigation measure by first developing a physical model to inform the physical works. The intent of the physical model is to design for increased flushing of the inter-causeway area to reverse a negative trend towards marine eutrophication.. This evaluation will follow the reporting and action protocols outlined in Section 2.4 (Action) above.

If changes to coastal zone processes impact on eelgrass beds as a result of increased scour and erosion, VPA commits to immediately initiate an assessment of the localized habitat impacts and, in consultation with the Environment Canada and Fisheries and Oceans Canada, design and implement engineered scour and erosion protection to mitigate impacts, as required, including replanting of eelgrass areas that have been impacted by the construction and operation of Deltaport Third Berth project.

6.0 OTHER BIOTA

Other biota, such as benthic communities, birds and fish are indicators of a healthy ecosystem, particularly given the high bird usage in the Roberts Bank area. Given their position in the ecosystem food web, benthic communities are often used as indicators of the health of an ecosystem. Many fish and bird species feed on benthic infauna and epifauna that reside in the intertidal and nearshore subtidal habitats at Roberts Bank.

The most recent assessment of benthic community health, bird usage and fish usage in the vicinity of the Deltaport facility did not reveal any significant adverse effects; however VPA proposes establishing monitoring stations both within the inter-causeway area and at reference locations for use during construction. As with the previous monitoring plans, reference locations will be used for comparison to stations closer to Deltaport to evaluate larger scale trends and to facilitate data interpretation activities.

The "other biota" monitoring plan is complementary to answering the concern about potential marine eutrophication and changes to coastal erosion processes and will reduce uncertainty. However, like the previous monitoring plans, the "other biota" would be reviewed on an annual basis for adaptation opportunities.

6.1.1 Parameters

Parameters to be monitored for other biota are identified in **Table 5**.

Table 5. Other Biota Parameters, Frequency, and Purpose

Parameters	Monitoring Frequency	Purpose
Benthic community infauna (richness and abundance)	Pre and Post DP3 Construction	Benthic community, food source for higher trophic levels
Benthic community epifauna (richness and abundance)	Pre and Post DP3 Construction	Benthic community, food source for higher trophic levels
Heron density	Annual (June-Aug)	Bird Populations
Brant density	Annual (Feb-Mar)	Bird Populations
Coastal Seabird Survey	Twice/month during DP3 Construction	Bird Populations
Fish	*Subject to DFO authorization*	Fish Populations

Benthic community:

The main objectives of the benthic community (infauna and epifauna) sampling plan will be to:

- Determine composition and distribution in the intertidal and subtidal zones in the inter-causeway area and a reference site.
- Compare the results with previous studies (Triton 2004, 2001) and DFO studies (where applicable).
- Track, assess, and contribute to the efforts to control *Spartina anglica* in the inter-causeway area.

Bird Studies:

The main objectives of the bird studies (Brant geese, Great Blue Heron and coastal sea and shorebirds) will be based on a follow up monitoring program to:

- Determine whether there are impacts on the Brant geese and Great Blue Heron usage of the inter-causeway during key timing windows during construction and operation (timing windows shown in Table 4); and

- Determine whether there are impacts on coastal seabird usage of the inter-causeway during construction.

The bird study monitoring will follow similar methodology used by VPA and Environment Canada's Canadian Wildlife Service (CWS) for the DP3 supporting studies. Bird observers collected bird sighting data using standard survey sheets to record species and behavior once every two weeks during high tide and low tide daily, within a three-day window of survey opportunity.

Since 2003, CWS has collected bird survey data along the shoreline from Brunswick Point to the tip of the Tsawwassen ferry causeway. This data was collected from 100 m inland to >500 m (max distance 1 km) out from the shoreline. VPA added to this database by collecting bird survey data along both sides of the Roberts Bank causeway and around the tip of the Roberts Bank Port Facility from September 2003 to August 2004. For the AMS monitoring program the VPA would re-initiate the bird studies along the Roberts Bank causeway during construction and operation.

Prior to any field work, data collection methods will be developed in consultation with Environment Canada.

Fish Studies:

The main objectives of the fish studies and associated sampling plan will be to ensure that the monitoring commitments associated with the *Fisheries Act* Authorization are met during construction and operation. A *Fisheries Act* Authorization is required prior to project construction and will contain the VPA commitments, including monitoring, mitigation and compensation, for fish and fish habitat.

6.1.2 Evaluation Thresholds

Benthic Communities

As with the surface water and sediment quality programs, benthic community results will be evaluated over the course of the AMS for trends. The data collected within the inter-causeway area will be tabulated, graphed, and statistically compared with the benthic results from reference stations elsewhere along Roberts Bank. A 20 percent difference from elsewhere along Roberts Bank will be used as an indicator of a potential for benthic community impacts.

Benthic community health is linked to sediment quality and water quality; therefore, it is expected that if significant changes are seen in benthic community health, effects would also be observed in water quality and/or sediment quality (see Sections 5 and 6).

Birds

Adverse impacts resulting from the DP3 project, if any, would be anticipated to affect physical conditions and/or lower trophic level groups of wildlife before they were to affect birds in the area. As a result, no specific thresholds for interpretation/evaluation of the proposed bird studies have been identified at this time. However, it is possible over the time that changes to the ecosystem can be linked to key species and the use of the resources such as Herons, Brant, Western Sandpiper and Dunlin. Again, the intent of the AMS study design including oceanography/geomorphology, surface water quality, sediment quality, and eelgrass monitoring programs, is to facilitate prediction/identification of ecosystem changes primarily related to marine eutrophication and coastal zones processes prior to the occurrence of serious adverse effects on the ecosystem.

Fish

The action levels for monitoring and management for fish and fish habitat will be outlined in the *Fisheries Act* Authorization.

6.2 POSSIBLE ADAPTATION/MITIGATION

Though not anticipated, if unacceptable levels of "other biota" parameters are identified during construction, VPA commits to undertaking the mitigation measures described in the Construction Environmental Management Plan (EMP) (Vancouver Port Authority 2005). Mitigation measures could include altering construction methods or avoiding construction altogether during key bird or fish migration or feeding times.

7.0 REFERENCES

Arhonditsis G, Eleftheriadou M, Karydis M, Tsirtsis G. 2003. Eutrophication risk assessment in coastal embayments using simple statistical models. *Marin Poll Bull*. V46 (9): 1174-8.

British Columbia (BC). 1997. *Contaminated Sites Regulation*. BC Reg. 375/96 (includes amendments up to BC Reg. 76/2005, March 7, 2005).

British Columbia Ministry of Environment (BC MOE). 1998. Recommended guidance and checklist for Tier 1 ecological risk assessment of contaminated sites in British Columbia. Victoria, BC.

British Columbia Ministry of Environment (BC MOE). 2001a. British Columbia Approved Water Quality Guidelines (Criteria) 1998 Edition. [Online Resource] Updated August 24, 2001. Available at URL: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/approved.html.

BC MOE. 2001b. A Compendium or Working Water Quality Guidelines for British Columbia. [Online Resource] Updated August 23, 2001. Available at URL: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/working.html.

Bormann BT, Martin JR, Wagner FH, Wood G, Alegria J, Cunningham PG, Brookes MH, Friesema P, Berg J, Henshaw J. 1995. *Adaptive management: common ground where managers, scientists, and citizens can try to learn to meet society's needs and wants while maintaining ecological capacity*. Chapter T-27 in: Ecological stewardship book. US Forest Service, Pacific Northwest Research Station, Corvallis, Oregon.

Byron, W.K., 2003. *Policy, research, and adaptive management in avian conservation*. The Auk

Canadian Council of Ministers of the Environment (CCME). 2004. *Canadian Environmental Quality Guidelines, Update 4.0, December 2004*.

Cognetti G. 2001. Marine Eutrophication: The Need for a New Indicator System. *Marin Poll Bul*, V42 (3): 163-4.

Dell'Anno ML, Mei A, Pusceddu, Danovaro R. 2002. Assessing the trophic state and eutrophication of coastal marine systems: a new approach based on the biochemical composition of sediment organic matter. *Marin Poll Bull*. V44 (7): 611-22.

Edwards VR, Tett P, Jones KJ. 2003. Changes in the yield of chlorophyll a from dissolved available inorganic nitrogen after an enrichment event-applications for predicting eutrophication in coastal waters. *Continental Shelf Research*. V23 (17-19): 1771-85.

Edelvang K, Kaas H, Erichsen AC, Alvarez-Berastegui D, Bundgaard K, Jørgensen PV. 2005. Numerical modelling of phytoplankton biomass in coastal waters. *Journal of Marine Systems*. In Press, Corrected Proof. Available May 2005

Environment Canada, 2005. *Environmental Assessment Application – Deltaport Third Berth Addendum to Environment Canada's Wildlife Comments.* Letter from P. Kluckner, Environment Canada – Canadian Wildlife Service to D. Carter, CEAA, date July 26, 2005.

EVS Environment Consultants –Golder Associates Ltd. 2004. *Report on Water Quality Roberts Bank Container Expansion Project.* Report prepared for Vancouver Port Authority.

Flynn KJ. 2005. Modelling marine phytoplankton growth under eutrophic conditions. *Journal of Sea Research*. V52: 92-103.

Hemmera Envirochem Inc 2004, *Deltaport Third Berth Sediment Sampling Program (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC.* prepared for Vancouver Port Authority

Holling CS (ed). 1978. *Adaptive Environmental Assessment and Management*. International Institute for Applied Systems Analysis.

Holling, C.S. 1995. *What barriers? What bridges?* Pages 3-24 in *Barriers and Bridges to the Renewal of Ecosystems and Institutions* (L. H. Gunderson, C. S. Holling, and S. S. Light, Eds.), Columbia University Press, New York

Marzluff, J.M., and R. Sallabanks (Eds). 1998. Avian Conservation: Research and Management. Island Press, Washington, D.C.

McAllister, M.K. and R.M. Peterman. 1992. *Experimental design in the management of fisheries: a review*. North American Journal of Fisheries Management 12:1–18.

Meyer-Reil LA, Köster M. 2000. Eutrophication of Marine Waters: Effects on Benthic Microbial Communities. *Marin Poll Bull*. V41 (1-6): 255-63.

Northwest Hydraulic Consultants – Triton Consultants Ltd., 2004. *Roberts Bank Container Expansion Coastal Geomorphology Study.* Report prepared for Vancouver Port Authority.

Northwest Hydraulic Consultants , Triton Consultants Ltd 2004a. *Roberts Bank Container Expansion Coastal Geomorphology Study Appendix C* Report prepared for Vancouver Port Authority.

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

Tarbotton, M. and Harrison. P., 1996. *A Review of the Recent Physical and Biological Development of the Southern Roberts Bank Seagrass System, 1950-1994*. Report prepared for Roberts Bank Environmental Review Committee, June 1996.

Taylor, B., Kremsater L, and Ellis, R. 1997 - *Adaptive management of forests in British Columbia* prepared for B.C. Ministry of Forests, Forest Practices Branch, Strategic Policy Section

Tett P, Gilpin L, Svendsen H, Erlandsson CP, Larsson U, Kratzer S, Fouilland E, Janzen C, Lee JY, Grenz Cl. 2003. Eutrophication and some European waters of restricted exchange. *Continental Shelf Research*. V23 (17-19): 1635-71.

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

Triton Environmental Consultants Ltd. 2001 – *Marine inventory of Roberts Bank - Jacques Whitford Environment Ltd. 2001. Roberts Bank Cumulative Environmental Effects Study. Report* prepared for the Vancouver Port Authority.

Vancouver Port Authority, 2005. *Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC.*

Vancouver Port Authority, 2005. *Roberts Bank Container Expansion – Coastal Geomorphology Study (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC. (Based on Northwest Hydraulic Consultants –Triton report, 2004).*

Vancouver Port Authority, 2005. *Water Quality Report Roberts Bank Expansion Project (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC. (Based on EVS/Golder report, 2004).*

Vancouver Port Authority, 2005. *Deltaport Third Berth Sediment Sampling Program (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC. (Based on Hemmera Envirochem Inc.'s report, 2004).*

Vancouver Port Authority, 2005. *Deltaport Third Berth Project Marine Resources Impact Assessment (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC. (Based on Triton Environmental Consultants report, 2004).*

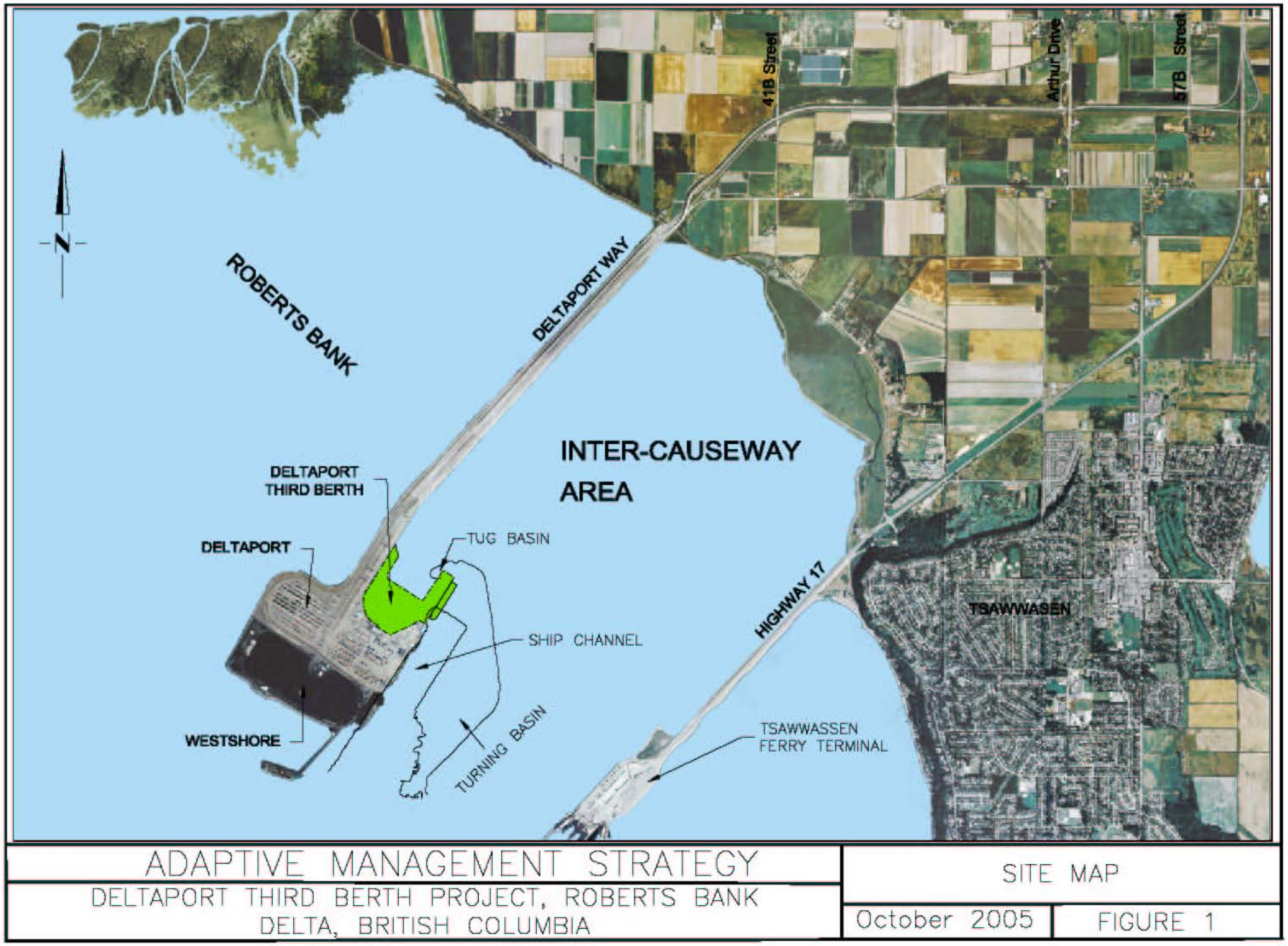
Vancouver Port Authority, 2005. *Deltaport Third Berth Project Coastal Seabird and Waterfowl Resources Impact Assessment (2004) In Support of the Environmental Assessment Application for the Deltaport Third Berth Project, Roberts Bank, Delta, BC. (Based on ECL Envirowest Environmental Consultants report, 2004).*

Washington Department of Environmental Quality (WDEQ) and Army Corps of Engineers (ACE). 1996. *PSDDA Issue Paper 10/96, SMS Technical Information Memorandum: Testing, Reporting, and Evaluation of Tributyltin Data in PSDDA and SMS Programs*

Wirtz KW, Wiltshire K. 2005. Long-term shifts in marine ecosystem functioning detected by inverse modeling of the Helgoland Roads time-series. *Journal of Marine Systems*. V56 (3-4): 262-82.

Wu RSS. 1999. Eutrophication, Water Borne Pathogens and Xenobiotic Compounds: Environmental Risks and Challenges. *Marin Poll Bull*. V39 (1-12): 11-22.

Figures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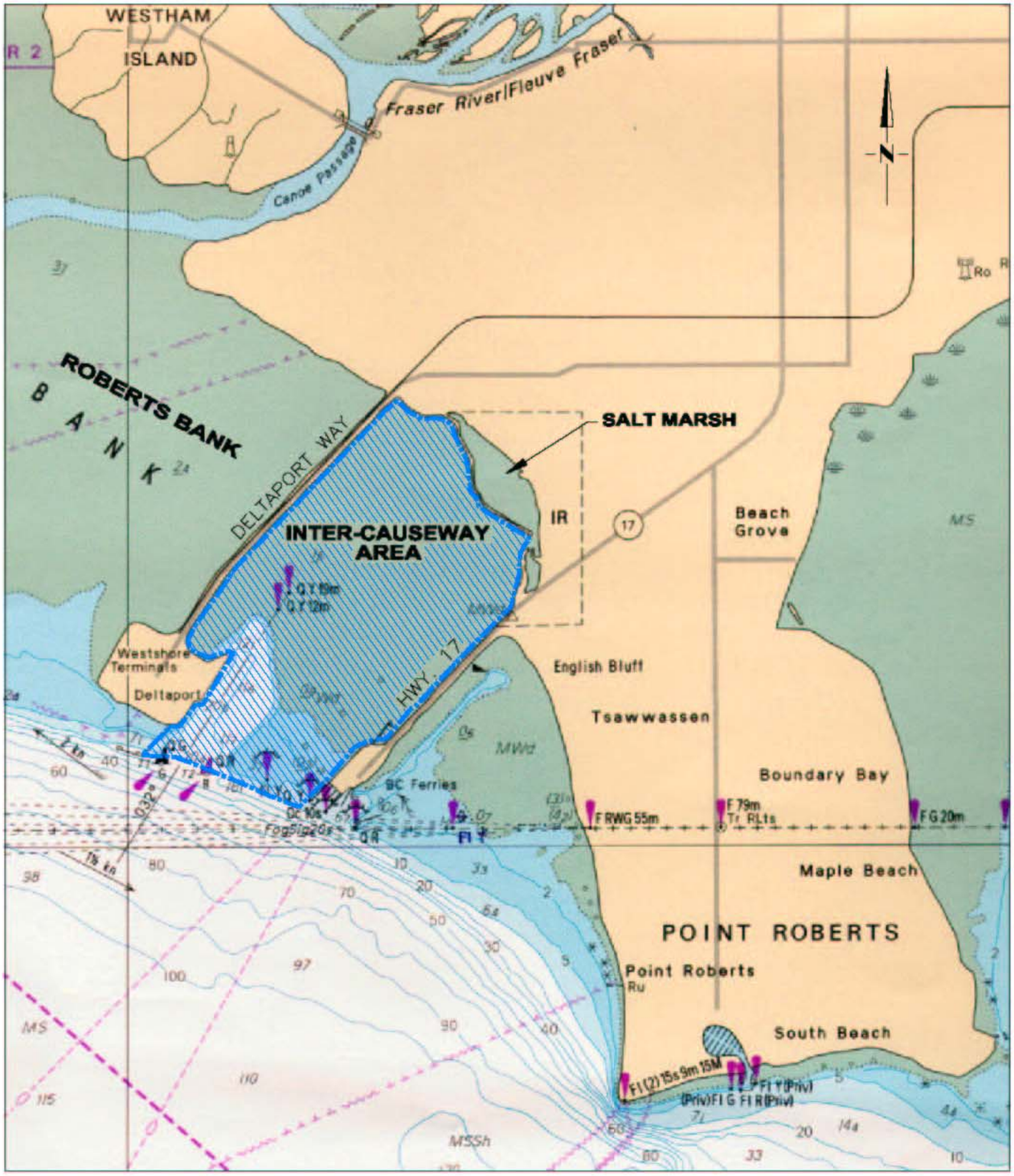
ROBERTS BANK
DELTAPORT WAY
41B Street
Arthur Drive
57B Street
INTER-CAUSEWAY AREA
DELTAPORT THIRD BERTH
DELTAPORT
TUG BASIN
SHIP CHANNEL
HIGHWAY 17
TSAWWASEN
WESTSHORE
TURNING BASIN
TSAWWASSEN FERRY TERMINAL
ADAPTIVE MANAGEMENT STRATEGY
DELTAPORT THIRD BERTH PROJECT, ROBERTS BANK
DELTA, BRITISH COLUMBIA
SITE MAP
October 2005
FIGURE 1



ADAPTIVE MANAGEMENT STRATEGY	INTER–CAUSEWAY AREA	
DELTAPORT THIRD BERTH PROJECT, ROBERTS BANK DELTA, BRITISH COLUMBIA	October 2005	FIGURE 2

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