Submarine Pipeline Crossings – Capital Regional District Wastewater Program – Alignment Evaluation

Report Context

The CRD has been planning wastewater treatment for the Core Area for over 30 years. During this time a significant number of reports have been prepared and/or reviewed to assess options and provide information to further planning.

In May 2016 a Project Board was established to define and implement wastewater treatment for the Core Area. The Project Board heard delegations and presentations from the public, industry professionals, and a CRD Director. The Project Board Chair and Vice Chair also met with staff from the CRD, all of the Core Area municipalities, and with Esquimalt and Songhees Nations representatives. The Project Board reviewed the previous technical work and extensive public commentary and developed a methodology to review and evaluate all options. This methodology included evaluation of a large number of options to identify a short list that best addressed the Project goals.

In September 2016 the Project Board presented its recommendation for wastewater treatment and on September 14, 2016 the CRD Board approved the Wastewater Treatment Project (the Project).

A significant number of the reports that have been prepared and/or reviewed still serve as useful background information, but not all of the reports are applicable to the Project. To respond to several recent public inquiries regarding topics of interest, the CRD has prepared a synopsis of reports along with a summary of the applicability of the report to the Project. The document summary is available here: https://www.crd.bc.ca/docs/default-source/wastewater-planning-2014/2017-05-30-summary-of-documents-related-to-topics-of-interest.pdf. The document summary does not provide a comprehensive list of reports completed as part of wastewater treatment planning for the Core Area, it is a compilation of a number of reports related to key topics of interest: odour; seabed pipeline; bluffs and shoreline; geotechnical; and noise.

Purpose of this Report

Early in wastewater treatment planning an option was identified for a regional plant located on the West Shore in south Colwood. Stantec was asked to evaluate options to take sewage flows to the West Shore for treatment. The initial concepts included evaluation of tunnel and seabed options to take flows from Saxe Point to Colwood. The dredged seabed option was found to be less expensive than a tunnel option.

Applicability to Project

This report is not applicable to the Project because it was prepared to compare a tunnel option to a seabed option for transporting flows from Saxe Point to Colwood. This report is no longer applicable because none of the options it assessed are part of the Project.

SUB-MARINE PIPELINE CROSSINGS CRD WASTEWATER TREATMENT PROGRAM

Alignment Evaluation

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Stantec

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1 INTRODUCTION

Stantec Consulting Ltd. (Stantec) has completed an engineering evaluation of alignment options pertaining to sub-marine pipeline crossings associated with the proposed Core Area Wastewater Treatment Program. The scope of work was detailed in our work task of July 27, 2010 and generally comprised:

- A desk top study to assess sub-surface conditions at the subject areas;
- A geophysical survey to supplement the above desk top study, and
- An evaluation of cost and schedule issues pertaining to sub-marine pipeline crossings options.

The results of the above tasks are presented in the following sections of this report.

Stantec was retained by the Capital Regional District (CRD) to assist in planning the proposed wastewater treatment facilities required for the Core Area of Greater Victoria for the provision of secondary sewage treatment. The CRD has requested additional analysis of the sub-marine crossings for Victoria Harbour and for a wastewater treatment configuration option that included a centralized treatment facility in South Colwood.

In order to convey screened sewage from the Clover Point outfall to the proposed wastewater treatment facility location at McLoughlin Point, a sub-marine pipeline across the mouth of Victoria Harbour between Victoria and Esquimalt (~ 750 m long) is required.

Locating the wastewater treatment plant on the West Shore at a site in South Colwood is also being investigated. This would require a second sub-marine crossing to convey screened wastewater between Esquimalt and the West Shore (almost 4,000 m long). The areas for these two marine pipeline crossings are shown on Figure 1, included in Appendix B, as Area 1 and Area 2, respectively. At this very early stage of the project, it is understood that the pipeline across Victoria Harbour would have a diameter of 1.2 m and the crossing to the West Shore would have a diameter of 1.8 m. For the West Shore crossing, it is also possible that a small diameter pipe of 0.25 m or 0.3 m diameter could be installed to convey sludge from the liquid plant at McLoughlin Point to a biosolids facility in South Colwood and a second pipe to return the centrate to the McLoughlin Plant.

2 DESKTOP STUDY

The desktop study was initiated by reviewing information about the geology of the subject region. The information reviewed included maps published by the Geological Survey of Canada, as well as information presented on the CRD's website about marine features. Relevant journal papers were also reviewed that described the geology of the area. Additional information about the subsurface conditions in the study area was obtained from the Government of British Columbia's Water Resources Atlas web site, which contains logs of water wells completed in the subject region.

The two proposed sub-marine crossings are located in the eastern part of the Juan de Fuca Strait, which geologically is part of the tectonically active Cascadian subduction zone near the southern and western terminus of the late Wisconsinan glaciations (also known as the Fraser Glaciations, which occurred some 15,000 to 25,000 years ago).

The seafloor in Royal Roads has a series of terraces between the depths of -15 m to -65 m. The continuity of these terraces can be traced westward, but give way to a more gradual and continuous seafloor slope south of the entrance to Esquimalt Harbour.

The lithological units in the subject regions comprise:

1) Holocene sediments;
2) Glacial-marine sediments;
3) Glacial diamict (till), over
4) Bedrock

Unit 1 is the youngest material and deposited in the last 10,000 years. Throughout much of the region, the Holocene soil unit is divided into a lower post-glacial deposit and an upper post-glacial deposit. Geophysical survey data indicates a complex stratigraphy of these units with the layers dipping in a variety of orientations.

The glacial-marine sediments were deposited as the ice retreated, approximately 10,000 to 15,000 years ago, when the sea level was up to 75 m above its present level. These deposits contain variable amounts of sand, gravel, silt and clay size particles with a composition similar to glacial diamict (till). Cobbles and boulders could also be encountered within this material.

More specific information about the soil stratigraphy was provided on the water well logs and nearby boreholes completed by Stantec, which indicated Holocene deposits (silt/sand deposits overlying marine silt and clay) underlain by glacial and glaciomarine sediments (till-like soil) over bedrock. No information was provided on the water well logs that could be used for interpretation of the properties/parameters of the encountered materials.

A summary of the geology and anticipated soil stratigraphy including on-shore bedrock formation is presented on Figure 1, which also presents anticipated water depths for the two crossing areas.

3 GEOPHYSICAL SURVEY

Planning and permitting for an underwater geophysical survey was completed by Stantec in August 2010. Subsequently, the geophysical survey was completed in the period between September 8 and 24, 2010, by Frontier Geoscience Inc. (Frontier) of North Vancouver, BC. The objective of this survey was to provide bathymetric and sub-bottom information to aid in the feasibility evaluation of the sub-marine pipeline alignments. Details of the geophysical survey are presented in Frontier's report enclosed in **Appendix A** and summarized in the following.

The survey was carried out in a 9.5 m (31 foot long) vessel traversing the two subject areas with survey equipment towed in the water approximately 15 m behind the vessel. The survey was completed in a grid pattern with a maximum spacing of about 20 m by 20 m. The survey equipment included a transmitter (using low energy signals well below the 170 dB rms per 1 mPa level stipulated for marine life environmental compliance) and several recorders, which were towed behind the vessel.

Compilation, processing and interpretation of the survey data was completed by Frontier. The processed survey data was used to determine the depths to material interfaces reflecting the transmitted signal. The depths to the seafloor and the bedrock are typically conclusive from the interpretation of the geophysical data, and it may also be possible on occasion to delineate interfaces between other geological formations, depending on their material properties.

The results of the interpretations of the two areas (Area 1: Victoria Harbour; Area 2: Royal Roads are shown on Figures 2 through 7, included in Appendix B. The depth to the seafloor (bathymetry data), the depth to interpreted bedrock from sea level and the thickness of sediments above the bedrock are shown for each of the two areas. The main observations pertaining to the two areas are summarized in the following sections.

3.1 Victoria Harbour

The bathymetry data on Figure 2 shows the depth to the seafloor increases from the shorelines towards the middle of the water body to a maximum depth of approximately 12 m to 14 m. The seafloor in this area is generally gently sloping with the steepest grade being about 7H:1V. Steeper slopes may occur along the shoreline areas with rock outcrops. No slope instability is anticipated for soil and bedrock seafloors in this area.

The soil sediment thickness above the bedrock increases significantly away from the shoreline towards the middle of the water body as shown on Figure 4. Visible rock outcroppings at both shorelines suggest there are negligible soil sediments along most of the shoreline on both sides of the harbour. The soil sediment thickness increases to a maximum of approximately 60 m in the middle of the channel, but the sediment thickness decreases to less than 20 m towards the north of this area.

The depth to bedrock from sea level is nominal along the shorelines, but increases to a maximum of about 70 m as shown on Figure 3. Towards the north end of the subject area, the maximum depth to bedrock is slightly less than 30 m.

3.2 Royal Roads

The seafloor terraces identified in the desktop study (see Section 2) were also observed in the recorded geophysical survey data completed for this assignment. This resulted in a somewhat irregular seafloor profile at depths of approximately 15 m below sea level as shown on Figure 5. The maximum slope of the seafloor indicated by the geophysical data is approximately 5H:1V. In general, the seafloor is very gently sloping with a maximum water depth in the order of 16 m except along the shoreline of Esquimalt where the maximum water depth is in the order of almost 40 m and along the south end of the Coburg Peninsula. The underwater slope along the Coburg peninsula is exposed to high wave action from southeast storms. This wave action could generate marine sediment movements to considerable depths. This should be investigated further at the preliminary design stage

The irregular seafloor profile and visible rock outcropping along the shoreline of Esquimalt influence the sediment thickness above the bedrock. As shown on Figure 7, the sediment thickness is variable with negligible thickness along the shoreline of Esquimalt increasing significantly towards the south and away from the Coburg Peninsula. The maximum sediment thickness was interpreted to be near the centre of the subject area with a total thickness of more than 120 m.

The depth to bedrock varies from negligible along the shoreline of Esquimalt to as much as 140 m near the centre of the subject area as shown on Figure 6. The depth to bedrock is even significant along the Coburg Peninsula, where it increases southwards from approximately 40 m to more than 80 m.

4 CONSTRUCTION METHODOLOGY

Conceptually, three different construction methods were considered for the two sub-marine pipeline crossings: tunneling, horizontal directional drilling (HDD), and dredge trenching. General issues associated with these construction methods are discussed in the following sub-sections. A discussion about environmental issues pertaining to these construction methodologies is presented in Section 4.5.

4.1 Tunneling

The preliminary geotechnical information available from the desktop study and geophysical survey suggests that a tunnel installation is possible for both areas. A detailed geotechnical investigation with offshore boreholes advanced along the proposed alignment should be completed in subsequent phases of the project to confirm that the fine sand deposits (Holocene Unit) and underlying silty clay formations under the ocean floor are adequate to allow a conventional tunnel installation using a Tunnel Boring Machine (TBM).

A tunnel installation for the sub-marine pipelines would most likely involve a two pass operation with a primary liner installed behind the TBM, followed by pressure rated pipe installed inside the primary liner, and grouted in place. For purposes of the alignment evaluation, it has been assumed that the carrier pipe will be welded steel, but other pipe material options should also be evaluated during the detailed design phase of the project.

For the Victoria Harbour crossing, a 1.2 m internal diameter (ID) carrier pipe will require a TBM with a 1.8 m to 2.4 m outside diameter. Similarly for the Royal Roads crossing, a TBM with an outside diameter of 2.1 m to 3.0 m would be required for a 1.8 m ID carrier pipe.

A tunnel installation will require a working shaft and a reception shaft. Suitable surface space/area for these shafts and the adjacent staging areas will be required at each end of the tunnel. Determination of which side of the crossing should be designated as the working shaft should include a review of access routes for delivery of the construction materials, including longer length carrier pipe, as well as hauling out the excavated material.

The working shaft for tunnel requirements would be in the 6 m to 8 m diameter range to accommodate the installation of the TBM. The working shaft may be expanded to a rectangular section in the 6 to 8 m by 15 m range to accommodate installation of longer (13 m) lengths of the steel carrier pipe to reduce the number of welds. The reception shaft needs to be in the 5 m diameter range to allow recovery and removal of the TBM once the tunnel is completed.

The tunnel design should be at a slight grade with the TBM going uphill, to allow any water infiltration to be collected in the working shaft and disposed of. Therefore, the shafts need to be deep enough to get to competent material for tunneling (i.e. no settlement of the tunneling machine). Harder rock outcrops may be handled if they are not extremely hard and are relatively short. Boulders or cobbles, if encountered can cause problems for tunneling, depending on their size and hardness. Based on the available preliminary geotechnical information, the tunnel alignment could be as much as 40 m to 50 m below sea level, depending on the competency of the material above the bedrock.

For the shorter, Victoria Harbour crossing (Area 1), a potential alternative to conventional TBM construction would be to use a microtunnel boring machine (MTBM). A microtunnel machine differs from a conventional TBM in that it is remotely operated without the need for an operator at the tunnel face. Appropriate pipe selection could also potentially eliminate the need for a primary liner and carrier pipe, if the carrier pipe is used directly with the MTBM system. Potential pipe materials could include fiber reinforced polymer, welded steel or polymer concrete with a pressure rated joint. The MTBM machine could potentially be a 1,200 mm machine if a steel pipe is used. Alternatively, a 1,350 mm or 1,500 mm machine would be required, if a thicker walled pipe is used, to achieve a 1,200 mm ID. An 800 m long crossing is typically beyond the range of a MTBM. However with the addition of a tail jack station and/or inter-jack stations, it may be possible to achieve this length if ground conditions are favorable. Much more detailed geotechnical information is required before this decision can be determined. The main savings in cost would be the elimination of the primary liner and grouting requirements (although some grouting may be required if the overcut gets excessive). Production rate of the MTBM is expected to be slightly better than a TBM, but the appreciable time savings would be in eliminating the additional time necessary to install the carrier pipe inside the primary liner.

Some of the benefits associated with a tunnel installation include:

- Limited excavated material to dispose of. No matter what depth the tunnel is to be installed at, the volume of excavated material is limited to the cross-section area of the tunnel multiplied by its length. Typically, the additional volume of material excavated for deeper shaft installations is negligible compared to the volume of excavation from the tunnel.
- Construction impacts are limited to the portal areas with the greater impact at the working shaft location.
- With the relatively small footprint of the portal areas, housekeeping and site security are easily implemented.

Limitations and drawbacks for tunneling installations include:

- Limited number of contractors with tunneling capabilities.
- Expensive.
- Some ability to follow a large radius curved alignment but typically would follow a straight alignment.
- Risks associated with the variability in soils and bedrock conditions.

4.2 Horizontal Directional Drilling (HDD)

As for the tunneling option, the preliminary geotechnical information also suggests that Horizontal Directional Drilling (HDD) could be used to install the forcemain across Victoria Harbour (Area 1). The combination of longer length and large diameter for the Royal Roads (Area 2) crossing location precludes the use of HDD for installation of the Area 2 crossing. If an alternative, shorter alignment and/or utilizing smaller diameter pipe(s) such as a 250 mm or 300 mm sludge line could be developed, HDD may also be a viable installation methodology for the Area 2 crossing as well. Again, a detailed geotechnical investigation would be required to confirm the subsurface conditions as being acceptable for HDD.

A HDD installation would involve drilling a pilot hole along a predetermined drill path, and then enlarging the pilot hole to a size sufficient to install the forcemain. The pilot hole would be in the 250 mm to 300 mm diameter range, and there would likely be about five reaming passes required to enlarge the pilot hole to a diameter approximately 300 mm larger than the forcemain OD. Preferred pipe material would be welded steel. Although there is the potential to use HDPE instead of steel, this would require the final reamed hole to be larger to accommodate the HDPE wall thickness.

The HDD rig footprint at the drill entry side is likely to be similar to the area required for a conventional tunneling installation. However, on the drill exit side where the pipe will be assembled for pull back to the HDD rig, an extended length equivalent to the length of the drill path is required to assemble the pipe into one string to allow for a continuous pull back operation. This is preferred, but not necessarily essential depending on the ground conditions. It is possible that the pipe could be assembled into two or three shorter sections with the sections joined together during the pull back operation. This is often achieved by closing a road or one lane of a multi-lane road to assemble the pipes. Cross roads could be left open until shortly before the pull back operation, when the sections would need to be joined together. This could be coordinated to occur over a weekend to reduce the impacts to traffic and any local businesses and residents.

Another requirement for a HDD installation of this magnitude is the ability to work 24/7 once drilling is underway and until pull back is completed. This reduces the risk "of losing the hole" during any down time.

Limitations on HDD capabilities are determined by a combination of diameter, length and geotechnical conditions. In good soil conditions, drill lengths of 3,000 m to 4,000 m for smaller diameter pipes (less than 0.5 m diameter) are possible. As the pipe diameter increases, the feasible length of the drill decreases. For the largest pipe sizes (1.5 m to 1.8 m diameter) that are currently able to be installed by HDD methods, the length of the drill may be limited to 1,000 m to 1,500 m. These limitations are general rules that continuously increase as a function of experience and technology. The actual limitations are closely tied to the geotechnical conditions to be drilled through and each potential HDD location should be reviewed with as much geotechnical information as possible. Detailed geotechnical investigations including boreholes should be carried out in order to determine if there are cobbles and boulders in the soil unit through which HDD would be carried out. If there are significant boulders and cobbles, it may be necessary to drill deeper into the bedrock in order to avoid the soil unit. Also the detailed boreholes would provide information on the hardness and integrity of the rock.

Prior to selecting HDD as an option for a trenchless crossing method, detailed geotechnical investigations with boreholes and consultation with an experienced contractor on the latest capabilities of the technology is warranted.

4.3 Dredge Trenching

This construction option pertains to dredging a trench followed by installation of the pipeline. Dredging is an excavation activity or operation usually carried out at least partly underwater, in shallow seas or fresh water areas with the purpose of gathering up bottom sediments and disposing of them. Removal of the sediments can be via suction, air-lifting or excavation using a grab/bucket mounted onto a ship or barge. It is anticipated that stable temporary excavation slopes for the dredged trench would be no steeper than approximately 4H:1V. Dredging can create disturbance in aquatic ecosystems, often with adverse impacts as discussed in sub-section 4.5.3.

A soil cover is needed to protect the pipeline against damage from anchoring vessels. At this very early stage of the project, the required soil cover is estimated to be in the order of 3 m. A soil cover, albeit thinner, will also be required in areas with no anchoring vessel for erosion protection.

Depending on the profile of the seafloor and the proposed sub-marine pipeline profile, it may be possible to reduce the amount of dredging by installing some sections of the pipeline directly on the seabed with a rock fill cover for protection. This will require a settlement evaluation to be completed in the design phase to confirm settlements induced by the rock fill will be within tolerable limits of the pipeline.

Dredging, installation of the pipeline and placement of soil cover could occur almost concurrently within a limited length of the alignment at a rate of about 16 m per day per barge.

A large volume of excavated spoil will be associated with the dredge trenching construction method (it is estimated it could be up towards 90 m^3 per metre of pipeline). It may be possible to use some of this excavated material as backfill though erosion resistant material (for example, rock fill) will be needed to provide the protective soil cover. Side-casting excavated material and temporarily stock-piling it on the seafloor would be possible prior to re-using as backfill. However, a large amount of excavated material will still need to be disposed of. The potential for the presence of contaminated soils in the surplus excavated spoil could impact this construction methodology.

4.4 Portals

Depending on the construction methodology used to construct the sub-marine crossings, some form of portals will be required where the forcemain transitions from an on-shore trenched installation to a below sea bottom installation. In the case of either a HDD installation or a dredge trench installation, this transition will be very straight forward and just involve connecting the two sections of pipe together and backfilling the trench as appropriate.

For a tunneled installation, the portals at each end of the crossings will be converted from the working and receiving shafts. As the on-shore portion of the forcemain will be at shallow trenching depths and the tunnel elevation could be 30 m or more below sea level, the vertical transition will need to occur in the access shafts.

Construction of the shafts may be one of several methods. Due to the proximity of the ocean and the depth of the shafts, it is expected that the shaft construction will likely occur in the wet and the shaft will need to be made water tight following completion. This will likely result in either a caisson type of shaft construction or possibly the use of a soldier pile system (piles are installed to the proper depth and the center is excavated out following the pile installation). Once the excavation is complete for either instance, the bottom of the shaft would be sealed with a tremie pour and then the water pumped out.

Following completion of the tunnel/carrier pipe installation, the vertical transition from the tunnel to the trenched installation would be assembled in the shaft and grouted in place.

The shafts would typically be constructed on land though it is possible to construct a shaft off-shore if needed depending on the combination of below sea pipe installation methods that may be used.

4.5 Environmental Considerations

4.5.1 General Permitting & Approval Issues

A review of the permitting and approvals process for the marine construction methods is provided here. This review did not focus on the overarching permitting and approvals process for the entire project (including treatment facilities, etc.). Similarly, effects to human uses of the areas under consideration are not included here (e.g., commercial fishing, anchorage, etc.). Trenchless construction methodology likely reduces the applicability of the permitting and approval requirements.

The dredge trenching options (including pipeline directly laid on seafloor) will require work in or near the marine environment, and as such are subject to federal environmental approvals and permitting. The following definitions have been provided for information purposes:

- The Fisheries Act (Section 34) defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes."
- The Fisheries Act (Section 2) defines fish as "shellfish, crustaceans, marine animals, the eggs, sperm, spawn, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals."

A review of relevant approvals and permits suggests:

1. The proposed work (under all three construction methodologies) will likely trigger an environmental assessment under Section 5(1)(d) of the Canadian Environmental Protection Act (CEPA). Section 5(1)(d) states that an environmental assessment is required where a federal authority issues a permit or license, grants any approval or takes any other action for the purpose of enabling the project to be carried out in whole or in part (Law List Trigger). The proposed work would likely require authorizations under the federal Fisheries Act (Section 35(2)) (Fisheries and Oceans Canada; DFO) and Section 5 of the Navigable Waters Protection Act (NWPA).
    a. It is expected that the proposed works will result in habitat alteration, disruption or destruction (HADD), and that habitat compensation will be required in order to offset

these losses or alterations. Habitat compensation is typically negotiated with DFO during the environmental assessment process, but is not finalized until the environmental assessment is completed and DFO is in a position to issue an authorization under Section 35(2) of the Fisheries Act.

b. It is expected that the proposed works will require approval under Section 5 of the NWPA. The NWPA minimizes the interference of navigation on navigable waters throughout Canada. It ensures a balance between the public right to navigate and the need to build works such as bridges, dams or docks in navigable waters. With this goal in mind, the NWPA prohibits construction in navigable waters; regulates the removal of wreck and other obstacles to navigation; and prohibits the throwing or depositing of any material into navigable waters *unless* a proponent has gone through the Approval process and the Minister of Transport has approved the work, the site and the plans, or unless the work or the water qualifies as a minor work or water. Once the environmental assessment is complete, Transport Canada is in a position to issue a permit under Section 5 of the NWPA.

2. If any of the proposed options require the disposal of dredge material at sea, issuance of a permit by Environment Canada pursuant to subsection 127(1) of CEPA (Disposal at Sea Regulations) would likely be required. Issuance of this permit is also a Law List Trigger. A sampling program must be agreed to with Environment Canada, and in order to obtain the permit, the proponent must be able to demonstrate the sediments analyzed meet Environment Canada's screening criteria for disposal at sea. The screening criteria include sampling for cadmium, mercury, polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and chlorophenols, at a minimum.

3. There is the potential that some or all of the seabed material will have levels of contaminants that do not meet Environment Canada's screening criteria for disposal at sea. In this case, once sediment is dredged and brought to land, it is classified as a soil and would be regulated under the BC Environmental Management Act, Contaminated Soils Regulations. Further analysis would likely then be required, in accordance with the technical guidance published by the Province of BC, and an appropriate disposal location selected. It is unlikely that a disposal permit would be required. Depending on the levels of the contaminants in the soil, the material may not have to go to a landfill; however, as the dredged material is from the marine environment, there is the potential for concerns with sodium and chloride levels, and disposal on land.

DFO's "Policy for the Management of Fish Habitat" describes in detail the objectives for administering the habitat provisions of the Fisheries Act, the goals of the policy and the principles which guide the interpretation of the policy. It is important to note that approvals, permits and/or monitoring requirements may be influenced by the proposed construction methods and according to interpretation by the relevant agencies.

Stantec notes that the conduct (or not) of an environmental assessment under CEPA is also contingent on:

- Land ownership
- Federal funding of the Project
- Jurisdiction and mandates of local harbour authorities (e.g., the Esquimalt Harbour, administered by the Department of National Defense, or the Victoria Harbour Authority)

4.5.2 Trenchless Construction Methodology

Given that the trenchless construction methodology would not interact with the water column, aquatic environmental effects are considered unlikely. Depending on the depth of the pipeline alignment, some benthic invertebrates (mostly polychaete worms) may be affected. Effects to such invertebrates are unlikely to invoke permitting (e.g., not a HADD under the Fisheries Act) or study requirements by DFO.

Note is made however, that the Department of Fisheries and Oceans Canada (DFO) is familiar with trenchless construction methodology and the possibilities of 'fracking-out'. Should this construction option be developed further, Stantec recommends that the possibility/risk/effect of this accidental event be addressed in materials submitted to DFO.

4.5.3 Dredge Trenching

Dredging of the seafloor to install a wastewater pipe will interact with the aquatic environment. The following overview is based on our understanding that the majority of the underwater dredging will occur at depths greater than 15 m. Effects relating to the marine environment are largely contingent on the construction method (e.g., water jetting, bucket dredge, etc.) but typically include:

- Sediment suspension (which may affect fish and fish habitat)
- Temporary habitat loss (until rock and sediment are replaced)
- Direct mortality of sessile benthic invertebrates (e.g., sponges, sea fans, sea whips, etc.).
- Underwater noise from dredge operation which may interact with fish and/or mammals

Studies will likely be required to adequately describe the temporal and spatial extent of such effects. Similarly, the benthic invertebrate and fish community will also require characterization. This construction option will likely constitute a HADD under the Fisheries Act and therefore will require approval, and studies, for DFO.

According to DFO, the summer work window (of least risk to the environment) in this region is from July 1 to October 1. The winter window is from December 1 to February 15. Near-shore and low-risk activities in this area may be conducted within these windows.

Some best practice mitigation measures may minimize effects to the marine environment (e.g., closed dredge bucket, noise abatement procedures, timing of dredging). Environmental constraint analyses are a good example of such planning. This will minimize permitting, cost and schedule risk to the Project.

Approval by DFO will require input on habitat compensation associated with this construction method. From our experience this compensation would be focused primarily on temporary habitat loss and will be heavily contingent on the areal extent and temporal duration of the dredging operation.

4.5.4 Pipe on Seafloor with Rock Cover

In areas where the risk of damage by anchors is low such as areas near the shore, islands or reefs, the pipe could be placed directly on the seafloor and covered with a rock cover. The primary environmental effects associated with this option are predicted as:

- Habitat change (existing sub-tidal habitat will be covered by rock habitat; see below)
- Direct mortality of sessile benthic invertebrates (e.g., sponges, sea fans, sea whips, etc.)
- Underwater noise from dredge operation, which may interact with fish and/or mammals

This construction method would not manipulate marine sediment. Therefore, effects on fish and fish habitat from sediment suspension in the water column are not anticipated.

Mitigation measures and timing windows for this construction method are similar to those pertaining to dredge trenching (see Section 4.5.3).

In the marine environment, biological growth is often limited by lack of hard substrate. The construction method described in this sub-section essentially entails the construction of a linear rock reef. Biological abundance and productivity in relation to this reef (pipe burial) will likely exceed that of the neighboring environment in one to two growing seasons. Therefore, our position with DFO would be that no additional habitat compensation measures are warranted.

5 ALIGNMENT EVALUATION

5.1 Victoria Harbour Crossing

It is expected that the sub-marine crossing of Victoria Harbour would be almost 800 m long with an internal pipe diameter of 1,200 mm.

There are numerous constraints that could impact the feasibility of the different construction methods for the pipeline crossing of Victoria Harbour. Many of these constraints are associated with the dredge trenching construction methodology. In the Victoria Harbour area, it is our understanding that there is a contaminated soil issue that would have to be addressed for this construction method. Also, there is considerable marine traffic in this area. For primarily these two reasons, the dredge trenching construction method is not recommended in this area.

This crossing could be completed using trenchless technology either as a tunnel installation or utilizing horizontal directional drill (HDD) technology.

Advantages of a trenchless crossing for Victoria Harbour are:

- The pipe is installed well below the potential anchor zone;
- The potential to encounter contaminated material is greatly reduced compared to working directly on the sea bottom;
- Limited risk of disturbing/disrupting marine habitat, and
- No impact on navigation.

Disadvantages of a trenchless crossing include:

- Potential unforeseen costs due to unexpected geotechnical conditions including the presence of boulders in the sediments;
- Safety concerns for personnel entry systems for tunneling (this would not be a concern for an HDD or micro tunnel installation), and
- Risk of getting "stuck" necessitating the need for a "rescue" operation to recover the trenchless equipment.

Two alignment options were investigated and are shown on Figures 8 and 12. This figure also shows the profiles of the bedrock, the overlying weaker reflectors (soils units) identified by the geophysical interpretation and the proposed pipeline profile for the two options. An evaluation of the two options for this crossing is presented in the following two sub-sections.

5.1.1 Tunneling

This option includes a portal in the parking area in the vicinity of the Heliport site at Ogden Point and another portal at McLoughlin Point with a tunnel constructed between these two locations. Either location could be used as the working shaft. The Ogden Point site and adjacent neighbourhood may have easier access for bringing in a high voltage power service, but would be more disruptive to the harbour activities. The McLoughlin Point site would likely be less disruptive to the surrounding area but depending on the timing, there may be other facilities being constructed at this location at the same time as tunnel construction.

As indicated on Figure 8, it is proposed to drill the tunnel primarily through the soil material in order to limit shaft depth. Drilling the tunnel entirely through bedrock would require access shafts in excess of 50 to 65 metres.

Assuming no unforeseen issues would be encountered, the expected construction sequence for a tunnel would be as follows:

- Mobilization – This includes getting power service to site, ordering materials, transporting the tunnel boring machine to the site and security fencing.
- Shaft construction – The Contractor could utilize two shaft construction crews, or alternatively the working shaft construction crew could move over and construct the reception shaft once the working shaft is completed and the tunneling is underway. Shaft construction may be initiated while most of the mobilization is ongoing.
- Tunnel excavation and primary liner installation – A typical production rates for a TBM in reasonable ground conditions would be +/- 1 m/hr which would be approximately 800 hours of actual tunneling time for this crossing. The potential depth of this tunnel will add time as the lowering of construction materials and the removal of excavated materials will add to the time with the extended lift heights. Also water control has potential to be a significant task. These and other issues could increase the actual tunneling time by a factor of 2 to 3.
- Carrier pipe installation – This operation includes the installation of one 13 m (40 ft) length per shift.
- Riser pipes in shafts and connections to onshore piping – A period of 2 months is allowed at each shaft, although work could be ongoing simultaneously with two crews.

A conservative estimate of the construction schedule from award of contract based on working a 10 hour day, five days per week would be a period of two years. Assuming no unforeseen issues are encountered, an approximate construction schedule would be as follows:

- Mobilization – 3 months;
- Shaft construction – 3 months;
- Tunnel excavation and primary liner installation – 10 months;
- Carrier pipe installation – 4 months, and
- Riser pipes in shafts and connections to onshore piping – 2 months at each shaft.

Based on existing information obtained from the geophysical survey, the preliminary cost estimate for a tunnel across Victoria Harbour is in the range of $20 million $24 million. The assumptions in the cost estimate include:

- Because of the preliminary nature of the conceptual design, the cost should be considered accurate within a range of +/- 25%;
- Cost is in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing;

- No allowance has been included for handling and disposal of contaminated materials if encountered, and
- A disposal site for excavated material is available within 10 km of access shafts.

5.1.2 Horizontal Directional Drilling

For the HDD alternative, the drill rig could be set up on either side of the crossing, although positioning the drill rig on the McLoughlin Point side would probably be preferred for several reasons. It is expected that once drilling will be initiated, the operation will advance on a continuous basis, 24 hours a day and seven days a week. This continuous operation is expected to have less impact at McLoughlin Point than at the Ogden Point location. The Ogden Point site also has possible laydown and pipe assembly locations along either Niagara Street or Dallas Road, depending on the orientation of the crossing.

Assuming no unforeseen issues are encountered, the total construction schedule based on working 24 hours a day and 7 days a week during the drilling and pull back period would be up to one year. The expected construction sequence would be as follows:

- Mobilization and equipment set up;
- Drilling and reaming of the bore hole – The time required will depend on hardness of the rock and the material encountered but is estimated to be two to four months;
- Pipe assembly – Concurrent with drilling operations;
- Pipe installation, and
- Connections to on shore piping – on each side of crossing, although work could be ongoing simultaneously with two crews.

The preliminary cost estimate for an HDD installation across Victoria Harbour and based on existing information is $9.3 million. The assumptions on the cost estimate include:

- Because of the preliminary nature of the conceptual design, these costs should be considered accurate within a range of +/- 25%;
- The soils and bedrock conditions are favourable to carry out HDD along the profile shown on Figure 8;
- Costs are in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing;
- No allowance has been included for handling and disposal of contaminated materials if encountered, and
- A disposal site for excavated material is available within 10 km of access shafts.

Significant cost savings could be achieved by crossing Victoria Harbour using HDD instead of tunneling.

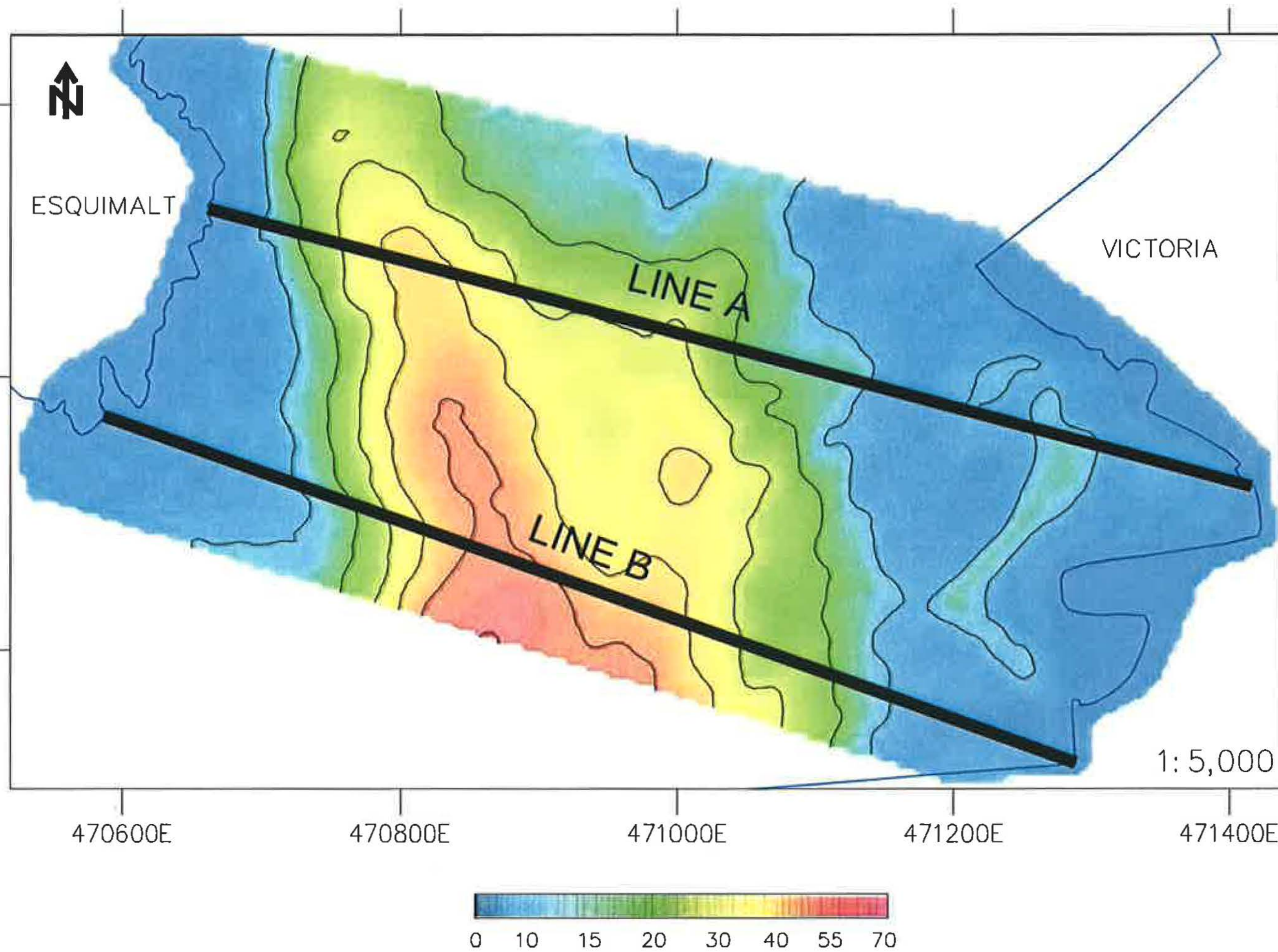

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Figure No.
Figure 12

Title
ALIGNMENT 1a (Tunnel) + 1b (HDD)

5.2 Royal Roads Crossing

The major constraints associated with the alignment of the Royal Roads crossing pertain to the Department of National Defense (DND) properties. It is our understanding that it is not possible to secure long term tenure (> 5 years) to construct a portion of the alignment within the DND property in order to reduce the length of the sub-marine pipeline crossing. As a result, all potential routes have to avoid DND-owned properties located in Esquimalt and Colwood. Several routes were evaluated for this 1.8 m diameter pipeline crossing including:

- Crossing between Saxe Point and the south end of the Coburg Peninsula. With this option, the sub-marine crossing will have a total length of 3,800 m.
- Crossing between Saxe Point and north end of the Coburg Peninsula. At 3,000 m, this is the shortest length of the sub-marine pipeline. This would require an on-shore pipeline segment within the Coburg Peninsula. However, the presence of a large amount of First Nation artifacts within the Coburg Peninsula and the beach erosion problems present significant constraints for the installation of an on-shore pipeline.
- Another option would be to follow the shoreline between Saxe Point and the south end of the Coburg Peninsula. This would increase the total length of the crossing to 4,600 metres.

5.2.1 Options for Construction Method

<u>Horizontal Directional Drilling</u>

As indicted in Section 4, the main restriction pertaining to horizontal directional drilling as a construction method for the Royal Roads crossing is the maximum length of about 1,000 m to 1,500 m for the large diameter pipe being considered (i.e. 1.8 m diameter). Interim off-shore shafts would be required for the HDD construction method (with today's capacity limitations) over such a significant length, which eliminates this option from further consideration. This crossing exceeds the current capabilities of today's HDD technology for this length and diameter combination. This is also well beyond the capabilities of today's microtunneling limits, even with the inclusion of tail jack or inter-jack stations.

<u>Tunneling</u>

Because of length and diameter combination, conventional tunneling is the only viable trenchless construction method available today for crossing Royal Roads. Similar to the Victoria Harbour crossing, advantages of a trenchless crossing include:

- The pipe is installed well below the potential anchor zone;
- The potential to encounter contaminated material is greatly reduced compared to working directly on the sea bottom;
- Limited risk of disturbing/disrupting marine habitat, and
- No impact on navigation.

Disadvantages of a trenchless crossing include:

- Potential unforeseen costs due to unexpected geotechnical conditions;
- Safety concerns for personnel entry systems;
- Risk of getting "stuck" necessitating the need for a "rescue" operation to recover the trenchless equipment, and
- Long construction period.

Tunneling would be feasible in the Royal Roads area and would have the least number of issues that need to be addressed in subsequent phases of the project. Environmental impacts would be negligible except at the portal locations. Tunneling could be combined with less expensive construction methods (i.e. dredge trenching) to reduce the overall cost of the crossing.

It is assumed that the soil formations under the ocean floor are suitable to allow for tunneling (i.e. no settlements of TBM) and that no measures are required to strengthen the soils before drilling. The estimated cost for a tunnel is based on tunneling through these deposits at depths below the sea floor in the range of 5 to 10 times the diameter of the tunnel (12 m to 24 m below sea floor). In order to confirm this assumption, drilling boreholes would be required.

<u>Dredging</u>

Dredge trenching to a depth of approximately 5 m below the sea bed in order to provide a pipe cover of 3 m as protection from damage by anchoring is an alternative to tunneling for this crossing. This construction methodology can be combined with placement of the pipeline directly on the seafloor with a rock fill cover. Any dredge trenching option for the Royal Road crossing would have to follow the shoreline in order to avoid the two deeper marine areas south of Saxe Point and adjacent to the south portion of the Coburg peninsula (see Figure 5). This would increase the length of the crossing to approximately 4.6 km. Two potential routes for dredging were investigated. The first route follows the Esquimalt shoreline north of Brothers Islands to Scroggs Rocks, crosses the entrance of Esquimalt Harbour approximately 250 metres south of Fisgard Lighthouse and then follows the shoreline on the West Shore to the south end of the Coburg Peninsula. The second route follows the Esquimalt shoreline along an alignment located south of Brothers Islands in order to avoid the shallow rocky areas at Scroggs Rocks and between Brothers Island and Esquimalt. Rocky areas generally have high biodiversity and ecological value. In the absence of detailed environmental information, the route south of Brothers Island was tentatively selected for the preliminary evaluation of the dredging option as shown on Figure 11 and 15. The exact route of a marine pipeline installed by dredging would have to be confirmed following environmental investigations.

Though a dredge trenching solution for the Royal Roads crossing or portions thereof would result in a large quantity of excavated spoil to dispose of, it is our understanding that the potential for encountering contaminated soil in this area is limited. Significant environmental impacts are generally associated with the dredge trenching construction method. As a result, habitat compensation and mitigation measures are likely to be required in accordance with DFO requirements (placement of rock fill may be considered habitat compensation as discussed in Section 4.5.4). Additional environmental investigations should be completed in the subsequent project phases to identify impacts as well as the need and extent of compensation and mitigation measures.

A dredge trench construction method could be used in conjunction with a shorter tunnel section such as a tunnel to the north tip of the Coburg Peninsula or a tunnel across the entrance to Esquimalt Harbour.

5.2.2 Options for Royal Roads Crossings

Based on the information presented in the previous sections, the following four options were identified for crossing Royal Roads (see Figures 9 through 11 and 13 to 15). These figures also show the profiles of the bedrock, the overlying weaker reflectors identified by the geophysical interpretation (soil units) and the profile of the proposed pipeline.

Option 1 – Long Tunnel from Saxe Point to South End of Coburg Peninsula

This option is shown on Figures 9 and 13 and includes portals at Saxe Point and at the south end of the Coburg Peninsula. With this option, a 3.8 km long tunnel is constructed between these two points. The portal at Saxe Point Park would be located within the paved parking area and would not affect the landscaped portion of the park. The portal on the West Shore would be located south of the existing sewage pumping station near the intersection of Lagoon Drive and Ocean Boulevard.

A conservative estimate of the construction schedule from award of contract would be five to six years based on working a 10 hour a day, five days a week with one tunnel boring machine. A shorter construction period could be achieved with two shifts per day but at a higher cost. The use of two tunnel boring machines to save time would result in the two machines meeting at mid point under the ocean which could lead to complications related to the removal of the boring machine and drainage during construction. Assuming no unforeseen issues are encountered, the expected construction sequence would be as follows:

- Mobilization – 6 months;
- Shaft construction – 3 months per shaft;
- Tunnel excavation and primary liner installation – 48 months.
  Typical production rates for a TBM in reasonable ground conditions would be +/- 1 m/hr which would be approximately 3,800 hours of actual tunneling time for this crossing. The potential depth (50 m) of this tunnel will add time as the lowering of construction materials and the removal of excavated materials will add to the time with the extended lift heights. Also water control has potential to be a significant task. These and other issues could increase the actual tunneling time by a factor of 2 to 3. Using 2.5 as the average, tunnel excavation could take as long as 9,500 hrs, or 950 – 10 hr shifts.
- Carrier pipe installation – 15 months.
  Allowing for installation of one 13 m (40 ft) length per shift would equal 292 shifts. If allowing the grouting to follow on a two week lag, this would increase to 302 shifts.
- Riser pipes in shafts and connections to on shore piping – 2 months at each shaft.

Based on the available information, a preliminary cost estimate for this option would be in the range of $121 million to $145 million. The assumptions in the cost estimate presented herein include:

- Because of the preliminary nature of the conceptual design, these costs should be considered accurate within a range of +/- 25%;
- The soils and bedrock conditions are favourable to carry out tunneling along the profile shown on Figure 9;
- Cost is in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing;
- No allowance has been included for handling and disposal of contaminated materials if encountered, and
- A disposal site for excavated material is available within 10 km of access shafts.

Option 2 – Tunnel to North Tip of Peninsula and Dredging Along the Coburg Peninsula

This option shown on Figure 10 and 14 includes a tunnel from Saxe Point to the north end of Coburg Peninsula, and then a dredge trenching installation parallel to the Coburg Peninsula. With this option, a 3 km long tunnel is required followed by a pipeline installed by dredging over a distance of 1.9 km along the Coburg Peninsula in order to avoid problems associated with the installation of an on-shore pipeline on the Coburg Peninsula. The dredge trenching portion along the Coburg peninsula could be constructed at the same time as the tunnel. Based on the productivity rates indicated above, it is estimated that the construction period for a 3 km tunnel would be 4 to 5 years. A reduced construction period could be achieved by working two shifts per day but at a high cost

Based on available information, the preliminary cost estimate for this option is as follows:

- Tunnel section: $91 million to $109 million
- Dredged section: $27 million
- Total estimated cost: $118 to $136 million

The assumptions in the cost estimate presented herein include:

- Because of the preliminary nature of the conceptual design, these costs should be considered accurate within a range of +/- 25%;
- Construction with one 10-hour shift per day;
- The soils and bedrock conditions are favourable to carry out tunneling along the profile shown on Figure 10;
- Cost is in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing;
- No allowance has been included for handling and disposal of contaminated materials if encountered, and
- A disposal site for excavated material is available within 10 km of access shafts.

Option 3 – Dredging from Saxe Point to South End of Coburg Peninsula

This option shown on Figure 11 and 15 includes dredge trenching from Saxe Point to the south end of the Coburg Peninsula. As mentioned earlier, this route would follow the shoreline along Esquimalt and Colwood and would be located south of Brothers Islands. This route would avoid extensive underwater rock excavation. A careful installation will be required to ensure there are no high points in the pipeline. Entrained air would accumulate in high points and restrict the cross-section available for the flow of liquid. When pipelines are constructed on land, air release valves can be installed at high points to purge the entrained air. This arrangement is not possible in marine installations and a sloped pipeline is required to avoid high points.

As shown on Figures 5, there is high point in the sea floor south of the entrance to Esquimalt Harbour. Hence, a direct route between Saxe Point and the Coburg Peninsula would result in a high point in the pipeline. The preliminary pipeline alignment was selected to avoid the two deep areas south of Saxe Point and near the south tip of Coburg Peninsula. The resulting pipeline route is a long arc that avoids the deep areas as well as the shallow rock area near Brothers Islands. This results in a pipeline alignment that generally follows the bathymetric contour of 14 m. In order to prevent the accumulation of entrained air in high points, the pipeline would be installed with a low point in the centre of the crossing and an upward slope towards the two ends of the crossings.

The Royal Roads area is designated as a controlled access zone on navigation charts. Further discussions will be required with the Department of National Defense on restrictions that may apply to this area and on the presence of any cables on the seafloor.

It is anticipated that dredging would progress at a rate of 80 metres per week per barge and that two barges would be used concurrently resulting in a construction period of approximately 8 months. The preliminary cost estimate for dredging is $70 million. The assumptions in the cost estimate include:

- An allowance of $3.7 million was included for potential environmental considerations, mitigation measures and habitat compensation;
- An allowance of $5.2 million was added for possible rock excavation along the portion of pipe alignment south of Brothers Island in order to provide a positive slope;
- No allowance was included for handling and disposal of contaminated materials if encountered;
- Dredged material can be disposed at sea and land disposal of dredged material is not required;
- Cost is in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing, and
- Because of the preliminary nature of the conceptual design, these costs should be considered accurate within a range of +/- 25%;

Option 4 – Short Tunnel across Esquimalt Harbour and Dredging Along Shoreline

The alignment for this option is similar to Option 3 shown on Figures 14 with the following changes

- Dredge trenching from Saxe Point to Scroggs Rocks (1.3 km)
- Tunnel from Scroggs Rocks to the north end of Coburg Peninsula with an access shaft in the shallow waters of Scroggs Rock and another access shaft at the tip of the Coburg peninsula (1.7 k)

- Dredge trenching along the Coburg Peninsula (1.9 m).

Based on available information, the preliminary cost estimate for this option is as follows:

- Tunnel section: $52 million to $62 million
- Dredged section: $48 million
- Total estimated cost: $100 to $110 million

The assumptions in the cost estimate presented herein include:

- Because of the preliminary nature of the conceptual design, these costs should be considered accurate within a range of +/- 25%;
- The soils and bedrock conditions are favourable to carry out tunneling;
- Cost is in 2014 Canadian dollars;
- The cost estimate includes contingencies, professional fees and interim financing;
- No allowance has been included for handling and disposal of contaminated materials if encountered, and
- A disposal site for excavated material is available within 10 km of access shafts.

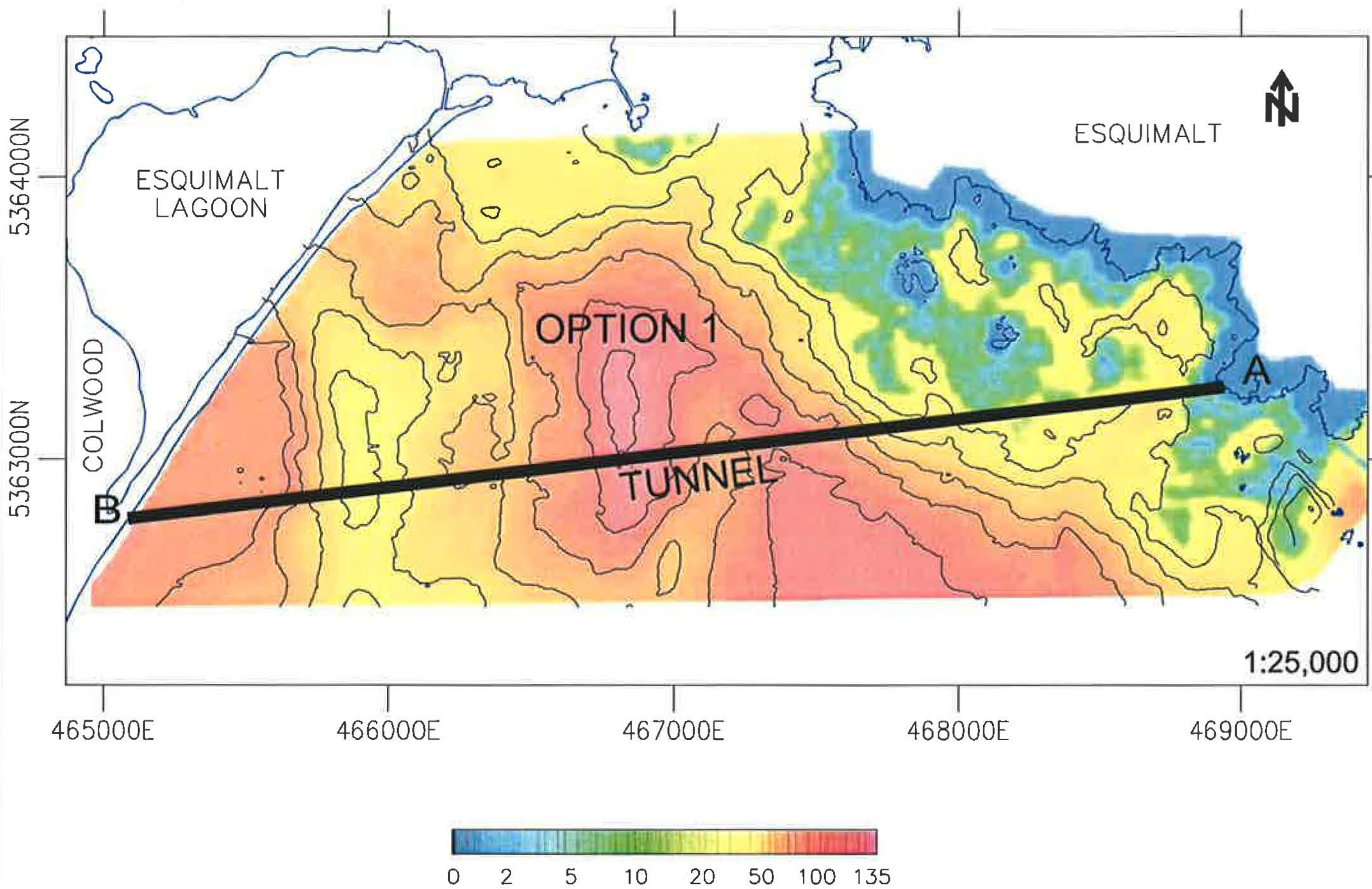

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Figure No.
Figure 13

Title
Option 2: Tunnel

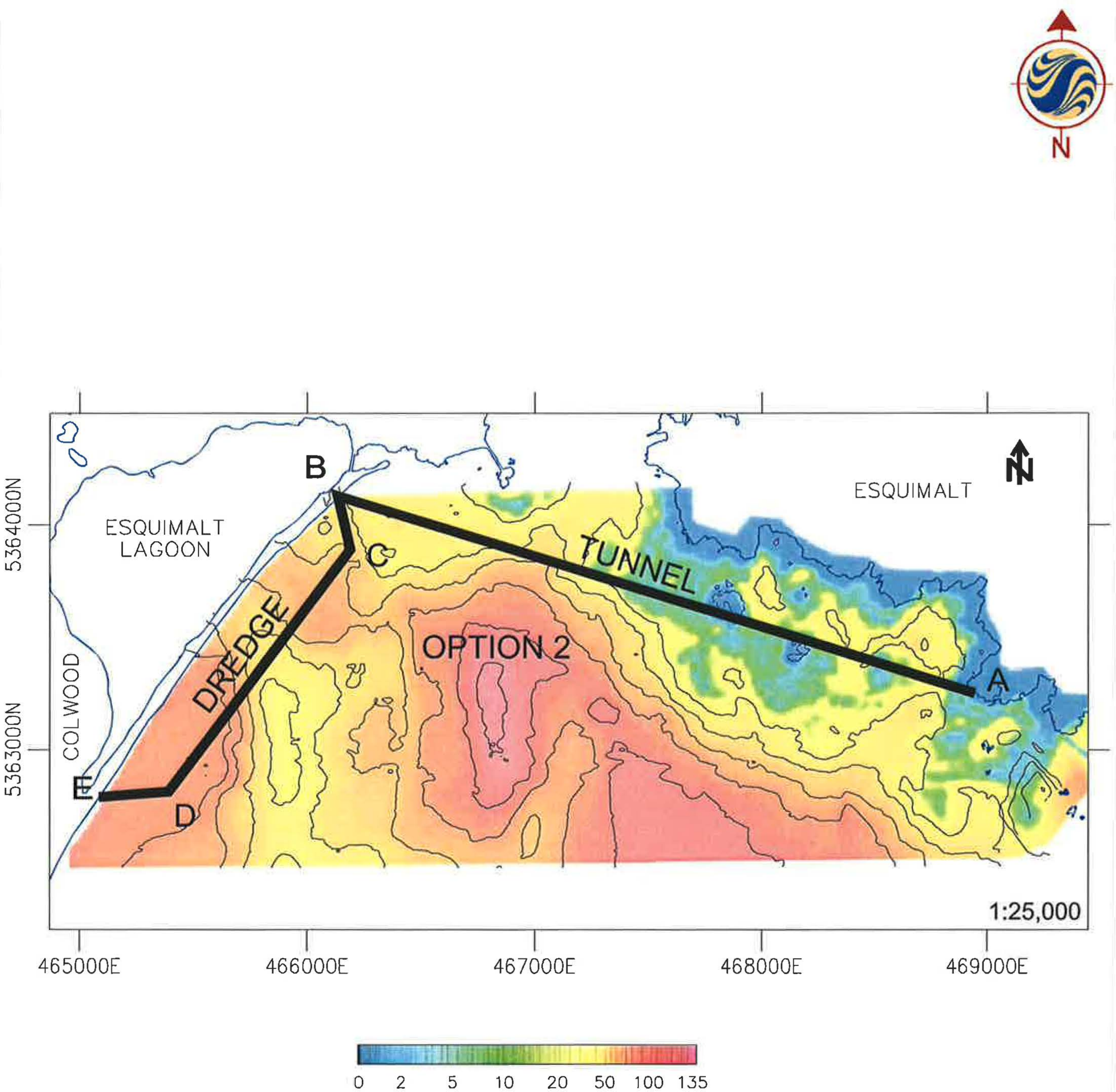

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Figure No.
Figure 14

Title
Option 3: Short Tunnel and Dredge

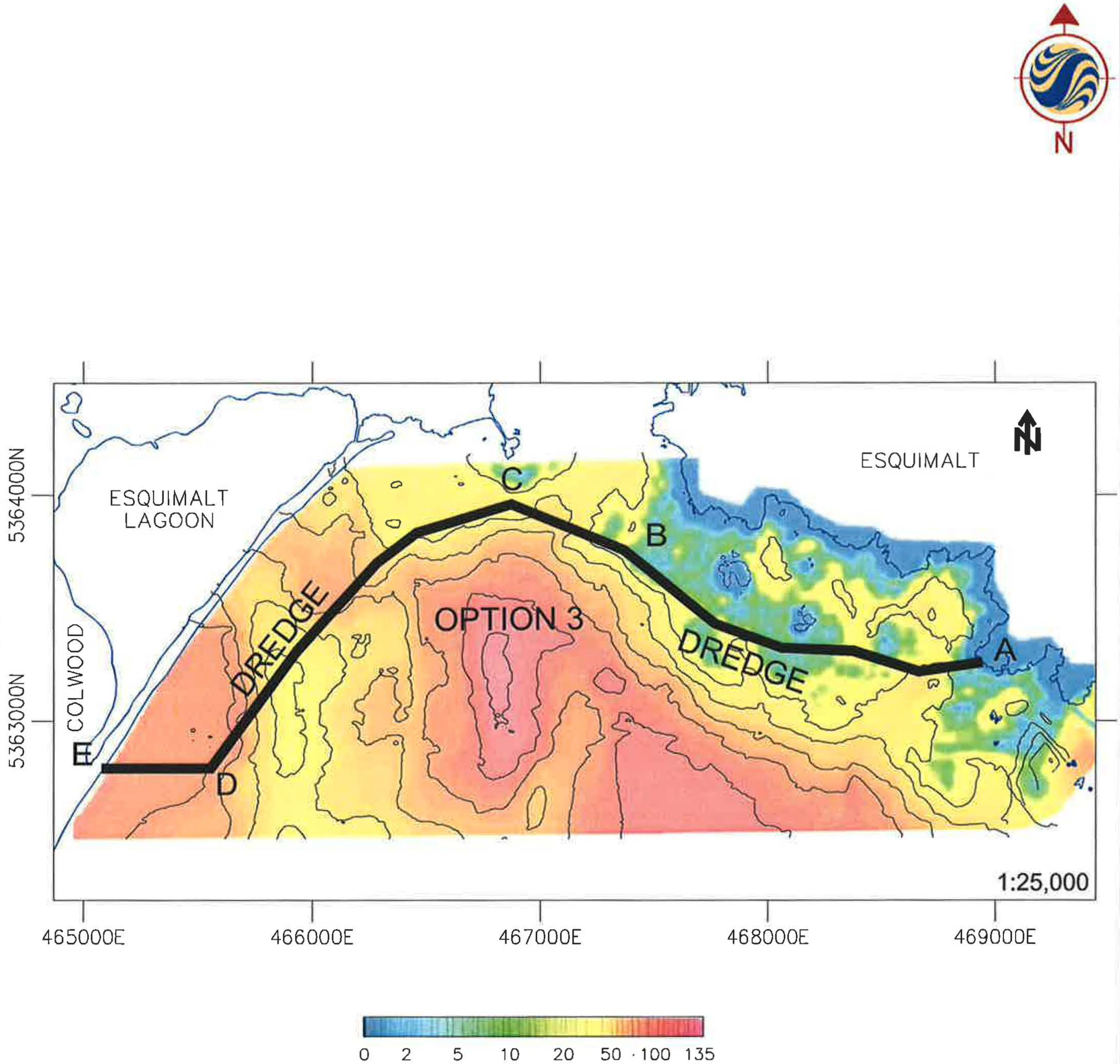

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Figure No.
Figure 15
Title
Option 3: Dredge

6 IMPACT ON WASTEWATER TREATMENT COST

6.1.1 Crossing of Victoria Harbour

This section summarizes the cost information of the various options as presented in Section 5 and their impact on the cost of the wastewater treatment program.

The preliminary cost estimate for a tunnel across Victoria Harbour, based on the information obtained with the underwater geophysical survey, is in the range of $20 million to $24 million. This estimate is in the same order of magnitude assimilar to the sum of $26.3 million already included for the tunnel in the project cost estimate for Option 1A $^{Prime 2}$ prepared in June 2010.

The preliminary cost estimate for horizontal directional drilling across Victoria Harbour is $9.3 million. As a result of the significant cost savings of HDD over tunneling, this option should be pursued and examined in more detail following the completion of additional geotechnical investigations that include the drilling of boreholes along the proposed alignment. The underwater geophysical survey has provided a very detailed profile of the bedrock and overlying soil units. Information on the hardness and integrity of the bedrock and on the presence/absence of cobbles and boulders in the soil units are required to complete a more detailed assessment of HDD. In order to provide redundancy, consideration could be given to drilling two pipelines for the forcemain crossing of Victoria Harbour.

6.1.2 Crossing of Royal Roads

The cost estimates for the Royal Roads crossing options presented in Section 5 are summarized in Table 6.1

Table 6.1 – Summary of Cost Estimates for Crossing of Royal Roads

	Option 1 – Long Tunnel	Option 2 – Tunnel to North Tip of Coburg Peninsula & Dredging	Option 3 – Dredging Only	Option 4 – Short Tunnel & Dredging
Length of Tunnel	3.8 km	3 km	0	1.7 km
Length of Dredging	0	1.9 km	4.6 km	3.2 km
Estimated Cost of Tunnel	$121 to $145 million	$91 to $109 million	0	$52 to $62 million
Estimated Cost of Dredging	0	$26 million	$70 million	$49 million
Total Estimated Cost	$121 to $145 million	$117 to $135 million	$70 million	$101 to $111 million

A sum of $124 million was included for the cost of a tunnel to the West Shore in the project cost estimate for the wastewater treatment program Option 1B $^{\text{Revised 2}}$ prepared in June 2010. This earlier cost estimate of $124 million is within the range of the updated cost estimates for a tunnel crossing to the West Shore.

At a preliminary cost estimate for Option 3 (dredging) of $70 million, this option using a pipe installed by dredging would result in significant cost savings compared with the budget of $124 million for tunneling.

Option 1B $^{\text{Revised 2}}$ prepared in June 2010 included provision of a biological aerated filter secondary treatment plant at a site in South Colwood, a 3.8 km long tunnel crossing to the West Shore and a 2.8 km long outfall pipe. The June 2010 cost estimate for Option 1B $^{\text{Revised2}}$ was $868 million and does not include the HST which came in effect in July 2010.

In conjunction with modeling work associated with the McLoughlin outfall, preliminary modeling was carried out to determine the length of outfall for a West Shore plant. Preliminary modeling has indicated that the outfall should be extended by approximately 700 m. This would extend the length of the outfall from 2,800 m to 3,500 m. Adding the HST and extending the outfall would increase the cost of Option 1B$^{\text{Revised 2}}$ by approximately $19 million to $887 million.

The impact of dredging on the estimated cost of the wastewater treatment program is outlined in Table 6.2. The cost estimate for Option 1B revised on the basis of crossing Royal Roads with a dredge pipeline instead of a tunnel is $835 million (Option 1B $^{\text{Revised 3}}$).

Table 6.2 – Revised Cost Estimates for Option 1B

Description	Estimated Cost	Remarks
Option 1B **Revised 2** – June 2010	$868 million	• Includes $124 million for tunnel to the West Shore • Includes 2.8 km long outfall
Option 1B **Revised 2** – November 2010	$887 million	• Modified to include HST • Includes $124 million for tunnel to the West Shore • Modified for a 3.5 km long outfall
Option 1B **Revised 3** – November 2010	$835 million	• Modified to included HST • Updated to include $70 million for dredged crossing to the West Shore • Modified for a 3.5 km long outfall

6.1.3 Mitigation of Financial Risks

The underwater geophysical survey has provided bathymetric information with elevation of the sea bed and bedrock profile that are sufficiently detailed for preliminary route selection and profile for the crossings of Victoria Harbour and Royal Roads, and for the preparation of preliminary cost estimates. However, there are other factors that will affect cost estimates. In the case of the Victoria Harbour crossing, geotechnical considerations will have a significant impact on horizontal directional drilling or tunneling. In the case of the dredge pipeline crossing of Royal Roads, environmental factors and possible mitigation measures have not been identified and these could significantly affect the cost estimates.

Victoria Harbour Crossing

As discussed in Section 5.1.3, the preliminary cost estimate for the horizontal direction drilling or tunneling under Victoria Harbour are based on the assumption that soils and bedrock conditions are favourable to carry out HDD or tunneling along the profiles shown on Figure 8. It appears there are significant cost savings if HDD is used to cross Victoria Harbour instead of tunneling. In order to confirm the preliminary cost estimate for HDD, additional geotechnical investigations should be carried out. These would include boreholes to determine if there are cobbles and boulders in the soil unit through which HDD would be carried out. If there are significant boulders and cobbles, it would be necessary to drill deeper into the bedrock in order to avoid the soil unit. Also the detailed boreholes would provide information on the hardness and integrity of the rock.

Royal Roads Crossing

As indicated in Section 3.2, it is possible that the underwater sloping face along the Coburg peninsula could be subject to marine sediment movements induced by wave actions during high storms. In order to protect the pipe from erosion, it is proposed to install the dredge pipeline with a 3 metre cover of rock. Should the option of installing a dredge pipe across Royal Roads be preferable, it is recommended to retain the service a specialist to carry out a detailed study on marine sediment movement in Royal Roads at the time of preliminary design.

To minimize potential cost and environmental approval risk associated with the marine portions of the project, a phased approach in proceeding with additional investigations is recommended. All elements described in the following phased approach will be required for an environmental assessment (once the project is better defined); hence this strategic approach is also cost effective:

- Regulatory Strategy. As outlined in Section 4.5.1, the marine in-water works will likely require permits from two or three Federal agencies. Issuance of such permits also invokes the need to conduct an environmental assessment (and potentially consultation with First Nations). It is recommended that all aspects pertaining to the project (at large, including up-land facilities), all potential permits, approvals, and regulators (or governance bodies) be analyzed as early as possible. This regulatory strategy would be used by senior project directors to guide consultations with pertinent regulatory bodies, First Nations and other stakeholders. This strategy would outline an environmental assessment process optimized for schedule and risk reduction.

- The information presented in the report on potential off-shore environmental considerations was based primarily on professional knowledge of the region. To better inform further discussions on routing of the pipeline, and minimize regulatory and cost risk, it is recommended that a desktop literature review and site visit be conducted (by boat). Identification of biological 'hot spots' (e.g., kelp, eelgrass habitat) earlier in the design phase of the project is advantageous.
- The permitting process can be a schedule risk if not managed or included in planning. Issuance of the permits (Section. 4.5.1) will require in-water field studies, which are sometimes seasonally dependant (and therefore a potential schedule risk). It is therefore recommended that field and desktop studies necessary to support permit applications be conducted as early as possible. Other factors typically governing field study execution include: probabilities of routing change, construction techniques (e.g., blasting), input on study design from regulators (Disposal At Sea, Environment Canada) and weather/environmental conditions (waves, water clarity, growth season).

7 SUMMARY AND RECOMMENDATIONS

The underwater geophysical survey has provided detailed information on the bathymetry of the sea bed, the depth to the interpreted bedrock and the overall thickness of soil and sediments deposits over the bedrock. The geophysical survey has also identified the thickness of the various soil and sediment units. However, no boreholes were drilled and the characteristics of the bedrock and soil types are inferred from information obtained in adjacent boreholes carried out on land.

Victoria Harbour

Preliminary alignment and profiles were prepared for crossing Victoria Harbour using horizontal directional drilling and tunneling. Marine sediments in Victoria Harbour are likely to be contaminated. Therefore, the trenchless construction methods or placement of pipeline directly on the seafloor are the preferred construction options for Victoria Harbour.

The preliminary cost estimate for a tunnel across Victoria Harbour is in the range of $20 million to $24 million. This estimate is in the same order of magnitude as the sum of $26.3 million already included for the tunnel in the project cost estimate for Option 1A $^{\text{Prime 2}}$ prepared in June 2010. The preliminary cost estimate based for horizontal directional drilling across Victoria Harbour is $9.3 million. It appears there are significant cost savings if HDD is used to cross Victoria Harbour instead of tunneling. In order to confirm the preliminary cost estimate for HDD, additional geotechnical investigations should be carried out. These would include boreholes to determine the possibility of encountering cobbles and boulders in the soil units that the HDD will advance through. Also the detailed boreholes would provide information on the hardness and integrity of the rock.

Royal Roads

The combination of length and pipe diameter for the Royal Roads crossing exceeds the capability of today's horizontal directional drilling. Two construction methods were examined for this crossing: tunneling and pipeline installation by dredging. Four combinations of alignments and construction methods were identified for this crossing and are summarized in the following table.

	Option 1 – Long Tunnel	**Option 2 – Tunnel to North Tip of Coburg Peninsula & Dredging**	**Option 3 – Dredging Only**	**Option 4 – Short Tunnel & Dredging**
Length of Tunnel	3.8 km	3 km	0	1.7 km
Length of Dredging	0	1.9	4.6	3.2
Estimated Cost of Tunnel	$121 to $145 million	$91 to $109 million	N/A	$52 to $62 million
Estimated Cost of Dredging	0	$26 million	$70 million	$49 million
Total Estimated Cost	$121 to $145 million	$117 to $135 million	$70 million	$101 to $111 million

The sum of $124 million was included for the cost of a tunnel to West Shore in the project cost estimate for the wastewater treatment program Option 1B $^{Revised\ 2}$ prepared in June 2010. This earlier cost estimate of $124 million is within the range of updated cost estimates for a tunnel crossing to the West Shore as per Options 1 and 2. The preliminary cost estimate for Option 3 (dredging) is $70 million, which is approximately 45% lower than the amount budgeted for a tunnel crossing to the West Shore. The crossing of Royal Roads using a pipe installed by dredging would result in cost savings compared with tunneling.

To minimize potential cost and environmental approval risk associated with the marine portions of the project, a phased approach in proceeding with additional investigations is recommended. This includes the preparation of a regulatory strategy, a desk top literature review and a site visit conducted by boat to identify key habitats and early input from regulators regarding construction techniques and disposal of dredged material.

Also, a study on marine sediment movement should be carried out in order to confirm the pipeline alignment and determine the depth of burial of the dredge pipeline along the Coburg peninsula.

The estimated cost for the wastewater treatment program Option 1B ^{Revised3} based on a dredged pipeline crossing and including the HST and provisions to extend the outfall to ensure adequate dispersion and mixing of the effluent is $835 million. This option is $44 million more than Option 1A $^{Prime\ 2}$ which is estimated at $791 million including the HST.

8 CLOSURE

This report was prepared for the exclusive use of Capital Regional District and their agents. The material in it reflects Stantec's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

If you have any questions, please contact the undersigned.

Respectfully submitted,

Stantec Consulting Ltd.

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Senior Associate, Geotechnical

Gilbert Cote, P.Eng.
Senior Project Management, Environmental Infrastructure

Dave Krywiak, P.Eng
Senior Associate, Linear Infrastructure

APPENDIX A

Geophysical Survey Report

STANTEC

REPORT ON

BATHYMETRIC AND ACOUSTIC

SUB-BOTTOM SURVEY

VICTORIA AND ESQUIMALT

PIPELINE PROJECT

VICTORIA, B.C.

by

Pierre Foicik, M.Sc.

Cliff Candy, P.Geo.

September, 2010 **PROJECT FGI-1154**

Frontier Geosciences Inc. 237 St. Georges Avenue, North Vancouver, B.C., Canada V7L 4T4
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CONTENTS

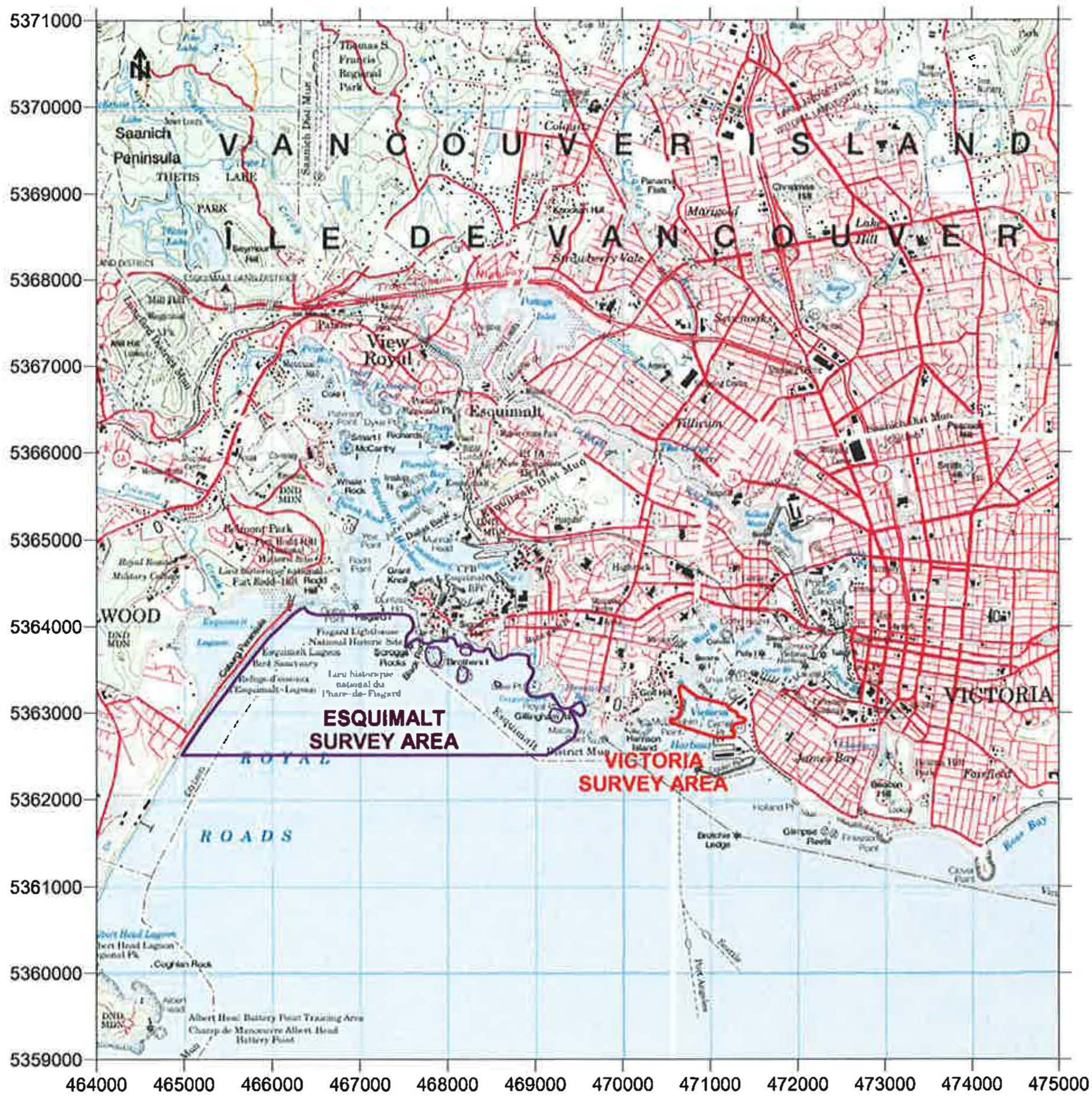
ILLUSTRATIONS

1. INTRODUCTION

In the period Sept. 8 to Sept. 24, 2010, Frontier Geosciences Inc. carried out an overwater geophysical survey for Stantec at the entrance to Victoria harbour and at Royal Roads near the entrance to Esquimalt harbour. The purpose of the survey was to determine ocean bottom contours, thicknesses of overburden materials and the depths to and configuration of the bedrock surface. This information will aid in planning the route of proposed pipelines and assist in deciding the appropriate emplacement technology.

The survey work at Royal Roads extends from Fleming Bay on the east to the south end of the Coburg Peninsula on the west and covers an area of approximately 3600 metres by 1600 metres. The Victoria harbour overwater survey encompassed an area at the entrance to Victoria harbour of approximately 650 metres by 300 metres.

A Survey Location Plan of the survey areas is illustrated at a scale of 1: 75,000 in Figure 1.



0 750 1500 2250 3000

METRES

STANTEC ESQUIMALT AND VICTORIA HARBOURS		
OVERWATER ACOUSTIC PROFILING SURVEY		
SURVEY LOCATION PLAN		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010	SCALE 1:75,000	FIG. 1

2. THE OVERWATER BATHYMETRY SURVEY

2.1 Equipment

The overwater bathymetric survey was completed with a Marinetek, PCS-200 Sounder. The system was calibrated with respect to water temperature and water salinity and used a broadband output with a 200 kHz centre frequency. Power for the field computer and Marinetek Sounder was provided by the survey vessel through an inverter. The work was carried out from a 31 foot Camano Trawler survey vessel.

2.2 Survey Procedure and Positioning

The bathymetric transducer was placed in the water at a depth of 0.30 metres at the stern of the vessel. The transducer location was carefully determined to facilitate the best operating environment for the transmission and reception of sound pulses. In operation, the source transducer pulsed twice every second with a sounding frequency of 200 kHz. The pulses emitted from the transducer were reflected by the ocean bottom and then digitally recorded and visually reviewed in real time on the high resolution display of a notebook computer. The digital record of the reflected signal was stored in the notebook hard drive and played back to interpret the water depth.

Data collected on the Marinetek PCS-200 Sounder was correlated with a differential Ray Marine GPS so that each pulse position could be contoured for final data presentation and interpretation. The positioning accuracy of the differential GPS was 0.5 metres to 1 metre. The positioning datum of NAD83 in UTM grid coordinates was used on all plans.

As some parts of survey were carried out in high traffic areas, all operations were co-ordinated with the Harbourmaster, for the Victoria site, and with the Fleet Manager, for the Esquimalt Naval Base. The survey was carried out in good conditions, and the continuity and quality of the data was excellent.

3. THE SUB-BOTTOM ACOUSTIC PROFILING SURVEY

3.1 Equipment

The overwater acoustic profiling was completed with an electric pulser source. The pulser system was used with a multi-element hydrophone receiver array. The system was calibrated in milliseconds and has a broad band output with a 250 Hz centre frequency. Reflected signals were amplified for viewing and recorded in a field computer. The field computer recorded a seismogram of 200 milliseconds two-way time duration approximately twice per second. Power for the seismic system was also provided from the power inverter.

The pulser source was placed in the water, 5 metres astern of the vessel with the midpoint of the receiver hydrophone "eel," 15 metres behind the source. In operation, pulses from the source were reflected from the bottom and sub-bottom objects or horizons and were summed in the eel hydrophone elements and transferred to the recording amplifiers.

3.2 Data Processing and Interpretation Procedure

The sub-bottom acoustic profiling data was processed into SEG-2 format and imported into the Seismic Unix reflection processing package. The positioning information was processed to account for the lay-back of the source and receiver from the GPS transducer. The data was then converted to SEG-Y format and together with the GPS position information, was imported into the Seismic Micro Technologies (SMT) 2D/3D seismic interpretation package. This software is a comprehensive 2D/3D seismic interpretation program that provides interpretive and horizon picking tools integrated into a map and section database, data management and display system. As well, the bathymetry data was imported as a horizon into the SMT package for interpretation and to allow full handling of the time to depth conversion.

The first stage in the analysis was the use of the horizon picking tools to identify the bedrock reflector and reflectors present within the sediment column. The software shows time markers at the intersection of lines and tie-lines, facilitating the picking of a consistent event throughout the map area. The data was then converted to depth, and the surfaces were plotted in colour contour format.

4. GEOPHYSICAL RESULTS

4.1 General

The results of the overwater bathymetry survey are displayed in map and profile format in the Appendix. These include contour plans of the bathymetry, interpreted bedrock depth, isopachs of the sediment thickness, and depth sections along the proposed alignments. The Esquimalt data is displayed at a scale of 1:12,500 and the Victoria data is displayed at a scale of a 1:2500. The depths shown on the bathymetric plan were referenced to the Canadian Hydrographic Survey Tide and Chart Datum.

An example of acoustic profiling data illustrating key sub-bottom reflectors is illustrated in Dwg. ESQ-EX. The interpreted bedrock reflector is shown in green. The shallow, yellow line is the sea floor reflector, which is consistent with bathymetric depths acquired from the sounder system.

4.2 Discussion

4.2.1 Esquimalt Harbour Area

The bathymetric survey for the Royal Roads area is displayed in Dwg. ESQ-BAT. The eastern shores are predominantly rock controlled, consistent with the numerous islands in the area. In the east-central segment of the coverage area, a series of terraced depressions are evident at depths ranging from 28 to 40 metres. These features are described by Mosher and Hewitt (Ref. 1) as either primary depositional features, or possibly post-depositional structures produced from a rotational slide failure.

The central and western shores area of the survey coverage show very uniform variations in water depths, extending to a maximum of approximately 22 metres at the southwestern survey boundary.

The eastern shoreline of the bedrock depth map Dwg. ESQ-BED shows numerous bedrock highs and troughs between Gillingham Islands and Scroggs Rocks. The central area of the survey coverage shows two depressions in bedrock that are approximately 140 metres deep. A very prominent feature in the bedrock topography is present in the western area of the survey, near the Coburg Peninsula. This north-northwesterly trending bedrock ridge rises to approximately 30 metres depth at its shallowest point. East of this ridge, bedrock depths of up to 90 metres are extant, indicating thick sediment cover shoreward into the Esquimalt Lagoon area.

An interpreted sediment isopach plan was prepared by contouring the thicknesses of sediments overlying bedrock. This plot displayed on Dwg. ESQ-SED, is particularly pertinent in the area of the eastern shoreline, where it clearly shows the areas of thinner sediment cover over the complex bedrock surface.

Stantec determined three possible alignments for the pipeline routes to Colwood. These routes were used to interrogate the bathymetry and interpreted bedrock surfaces, and profiles were derived to plot the depths of these surfaces along the chosen alignment. Displayed on Dwg, ESQ-DR-DR, ESQ-DR-01, and ESQ-DS-02, these plots show the proposed dredge emplacement alignment, and tunnel alignments Options 1 and 2, respectively. These profiles employ a 10 to 1 vertical scale exaggeration.

The seismic data show a number of reflectors within the overall sediment column. Mosher and Hewitt indicate that three main lithologic units overlie bedrock in the region (from the top down): modern (Holocene) sediment, glacial-marine sediment, and a glacial diamict. Three main horizons were also interpreted from the seismic data. These horizons are referred to as the first, second and third intermediate sediment layer on Dwg. ESQ-DR-01; the section exhibiting the thickest sediment. While correlation of the second and third horizon with lithology would have to be determined by drilling, some information is available within the survey area to provide correlation for the first interpreted horizon.

Mosher and Hewitt describe sea floor drilling that was carried out south of Brothers Island. This work showed the presence of post-glacial (Holocene) sediments consisting of fine Sand to coarse Sand/Pebbles in the materials overlying the first intermediate sediment horizon. Below this horizon, the boreholes showed the presence of Silty-Clays that are interpreted by Mosher and Hewitt to be glacial-marine sediment.

4.2.2 Victoria Harbour Area

The bathymetric depth contours in Dwg, VIC-BAT display the ocean bottom configuration in the survey area. The western area of the bathymetric plan shows a steeper gradient and is fairly irregular, as the shoreline is controlled by complex, shallow bedrock. The more central channel area is a uniform sediment surface varying between 6 and 14 metres depth. The eastern area, near Ogden Point, is shallow and irregular, indicative of the thinner sediment cover over bedrock.

The bedrock surface shown on Dwg. VIC-BED is dominated by a north-northwest trending, steep-walled trough with the greatest depths of approximately 70 metres at the southern survey boundary. A second bedrock low is observed east of this main feature that is present at a depth of approximately 50 metres. A number complex of bedrock troughs and ridges are evident in the eastern survey area. The variations in sediment thickness are illustrated in Dwg. VIC-SED.

Two proposed pipeline alignments were provided by Stantec. The profile information associated with these alignments is displayed on Dwg. VIC-DS. As was the case with the profiles for the Esquimalt area, a distinct reflector is present approximately 15 metres below the sea floor in the central part of the channel. No drillholes are present within the survey area, but the depth and character of the reflector strongly suggests that it corresponds to the boundary between the post-glacial (Holocene) sediments and the glacial-marine sediment.

5. LIMITATIONS

The depths to subsurface boundaries derived from overwater seismic acoustic profiling surveys are generally accepted as accurate to within ten percent of the true depths to the boundaries. In practice, the seismic velocity of sub-bottom materials is not determined in the course of an overwater acoustic profiling investigation. Errors may arise from application of an assumed velocity for saturated materials to determine the depths to sub-surface horizons when only the travel time to the horizon is known. An underestimate of the velocity function would produce depths that are too shallow, and the reverse occurring with an overestimate of velocity. True depths may be established by carrying out overwater seismic refraction surveying or by determining velocities with known borehole intersections. Small errors may also occur in data gridding. In this survey, a compressional wave velocity of 1442 m/s was utilized for conversion of travel times for the water column into depth. The sediment column was converted using a estimated velocity of 1560 m/s.

In addition, the nature and composition of sub-bottom objects and layers identified in acoustic profiling surveys cannot be determined by inspection of the data. Several indicators such as reflector strength, diffraction patterns, lack of internal reflectors, multiple thin-bed reflectors, depth position, smoothness of reflectors and reflector relief may provide insight into subsurface features. The geology of horizons identified in an overwater acoustic profiling investigation would have to be established by borehole intersections.

The information in this report is based upon acoustic measurements and field procedures and our interpretation of the data. The geological information is based upon our estimate of subsurface conditions considering the acoustic data and all other information available to us. The results are interpretive in nature and are considered to be a reasonably accurate presentation of existing lake bottom and subsurface conditions within the limitations of the acoustic profiling method.

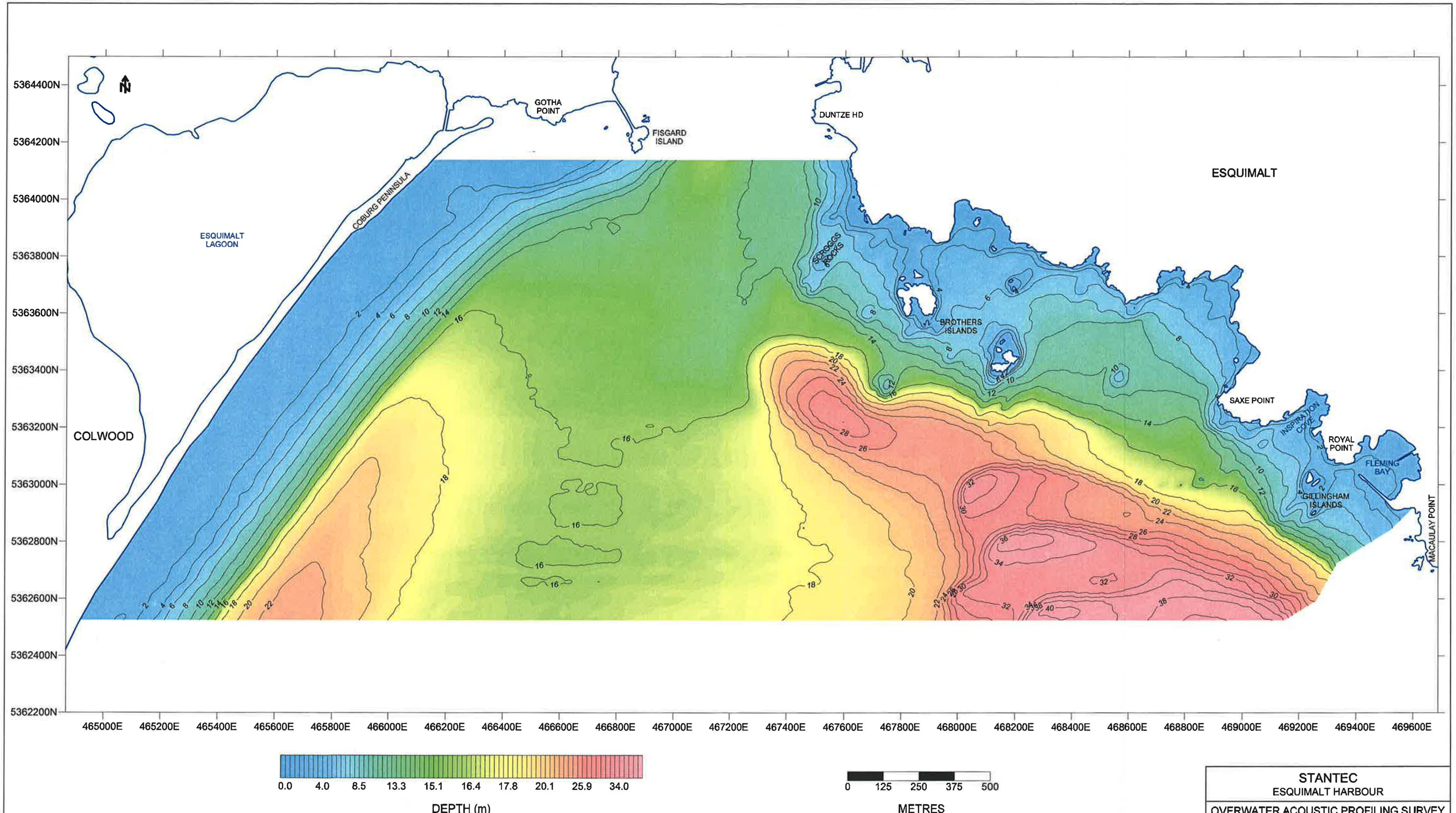
For: Frontier Geosciences Inc.

Pierre Foicik, M.Sc.

Cliff Candy, P.Geo.

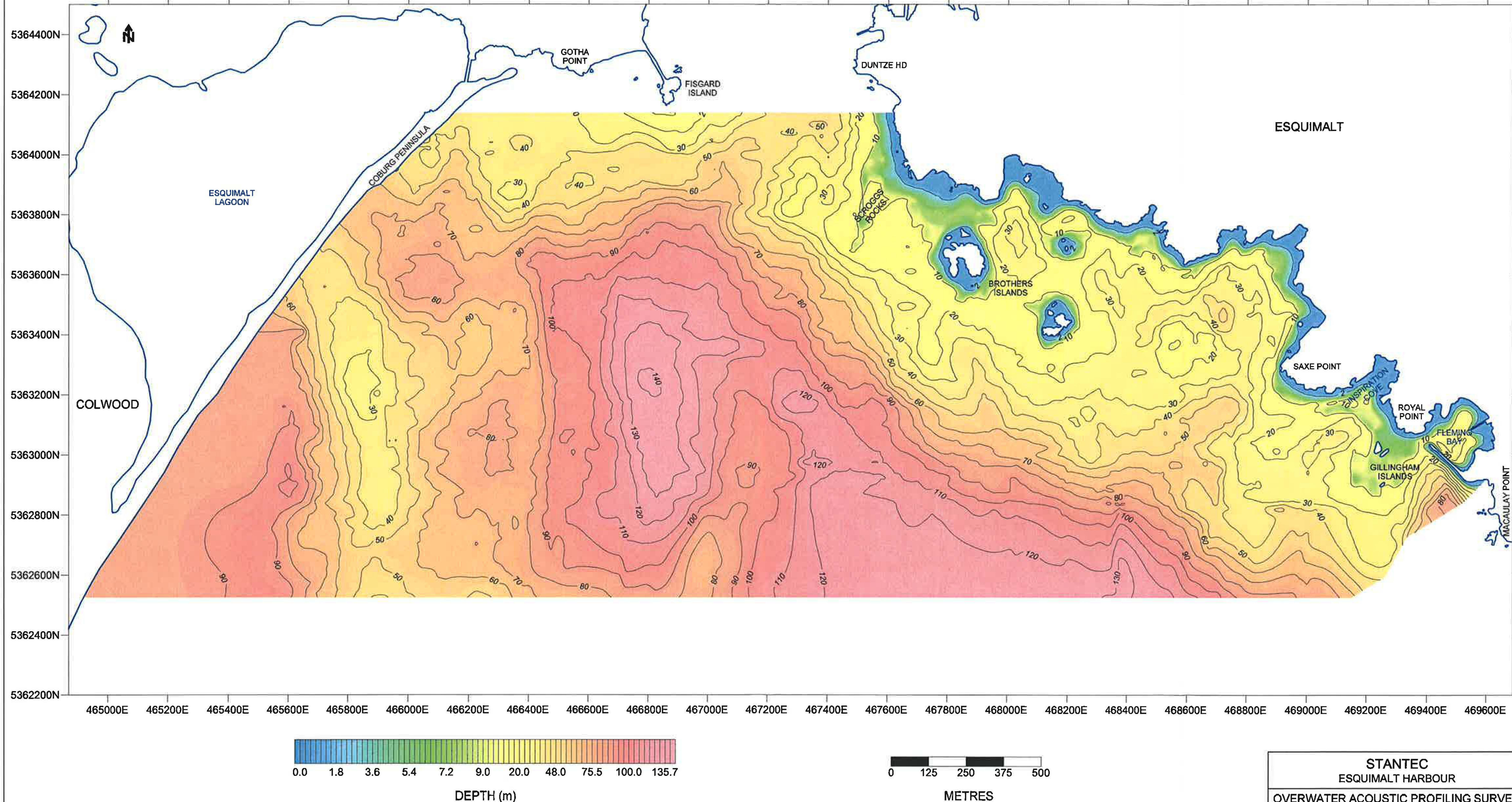
6. REFERENCES

Ref 1: Late Quaternary deglaciation and sea-level history of eastern Juan de Fuca Strait, Cascadia, David C. Moshera, Antony T. Hewitt, Quaternary International 121 (2004) 23–39



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

STANTEC ESQUIMALT HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
BATHYMETRIC CONTOUR PLAN		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010	SCALE 1:12,500	DWG: ESQ-BAT



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

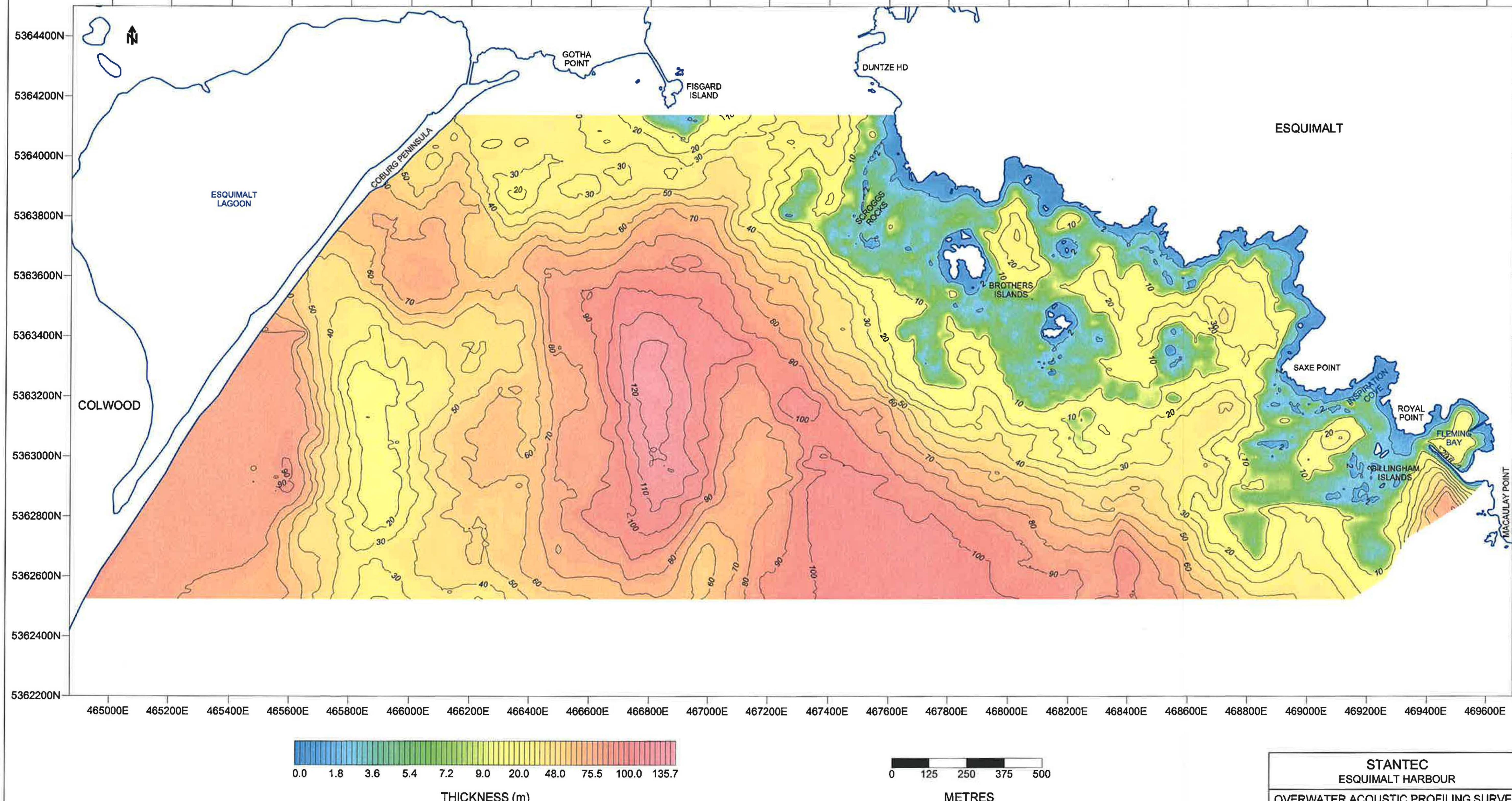
STANTEC
ESQUIMALT HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

INTERPRETED BEDROCK DEPTH CONTOUR PLAN

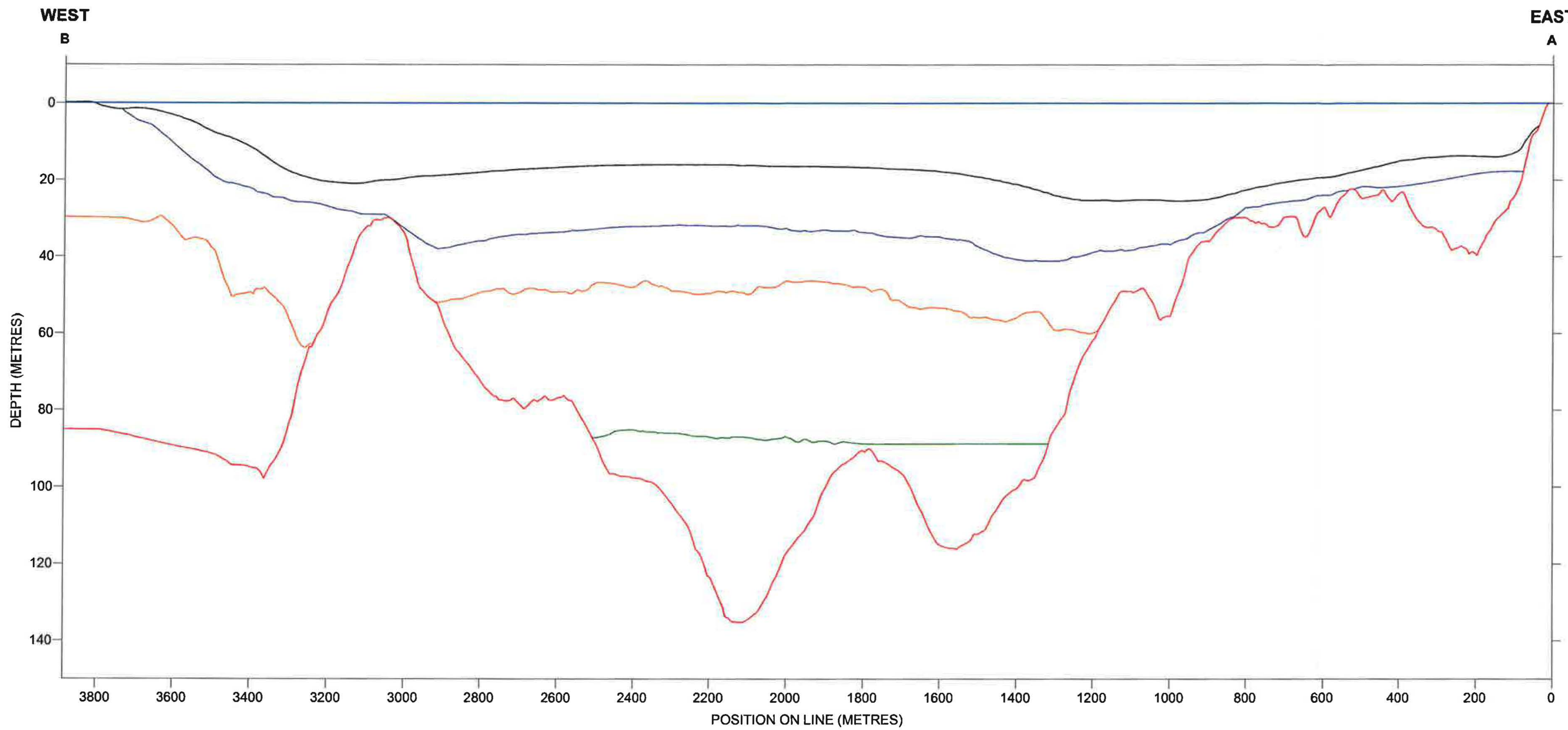
FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010	SCALE 1:12,500	DWG: ESQ-BED



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

STANTEC ESQUIMALT HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
INTERPRETED SEDIMENT THICKNESS ISOPACH PLAN		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010	SCALE 1:12,500	DWG: ESQ-SED



LEGEND

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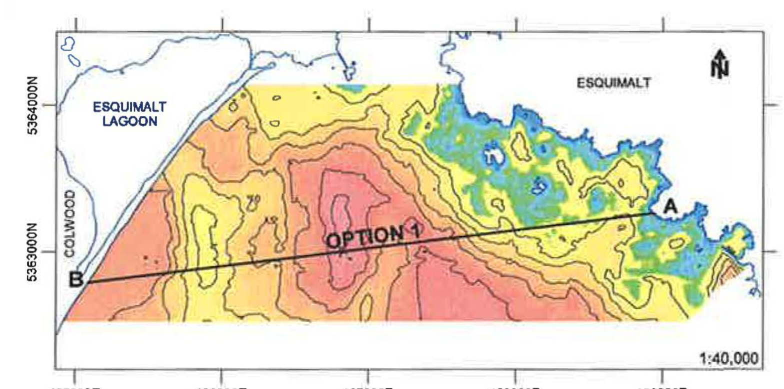
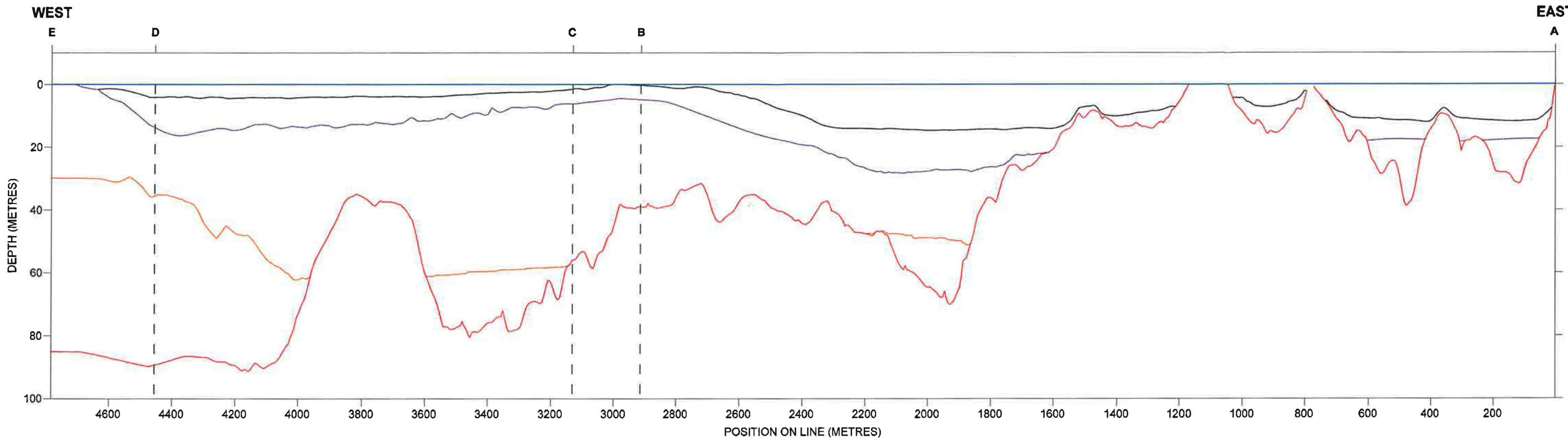
- BATHYMETRIC HORIZON
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- THIRD INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500

STANTEC ESQUIMALT HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
DEPTH SECTION ALIGNMENT: OPTION 1		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010		DWG: ESQ-DS-O1



LEGEND

- TIDE AND CHART LEVEL 0
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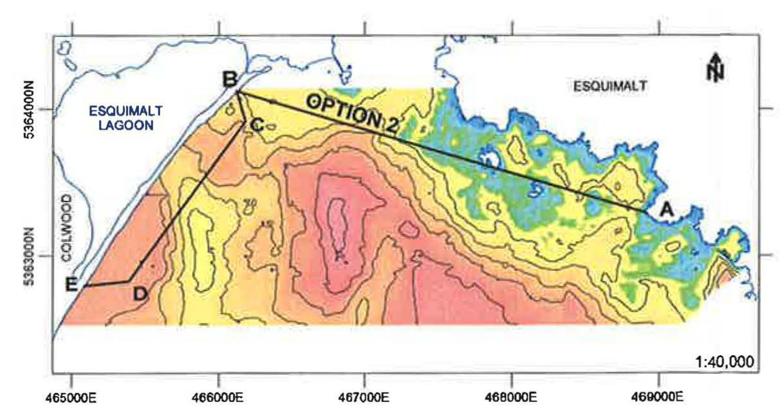
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON

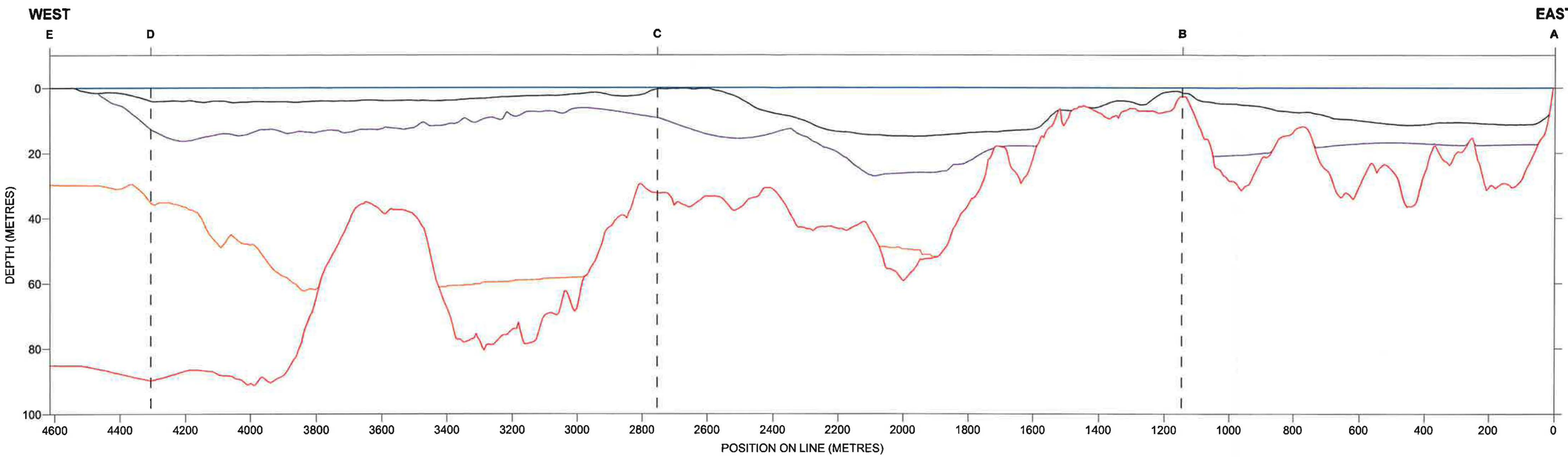


NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500

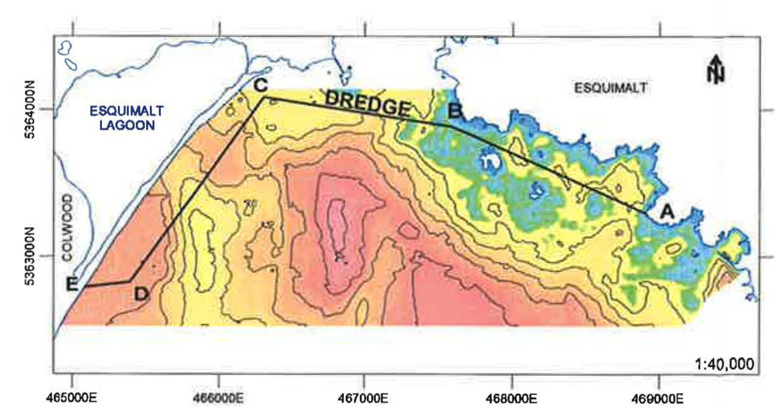
STANTEC ESQUIMALT HARBOUR
OVERWATER ACOUSTIC PROFILING SURVEY
DEPTH SECTION ALIGNMENT: OPTION 2
FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010		DWG: ESQ-DS-O2



LEGEND

- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON



NOTE: DATUM IS TIDE AND CHART
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VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500

STANTEC
ESQUIMALT HARBOUR

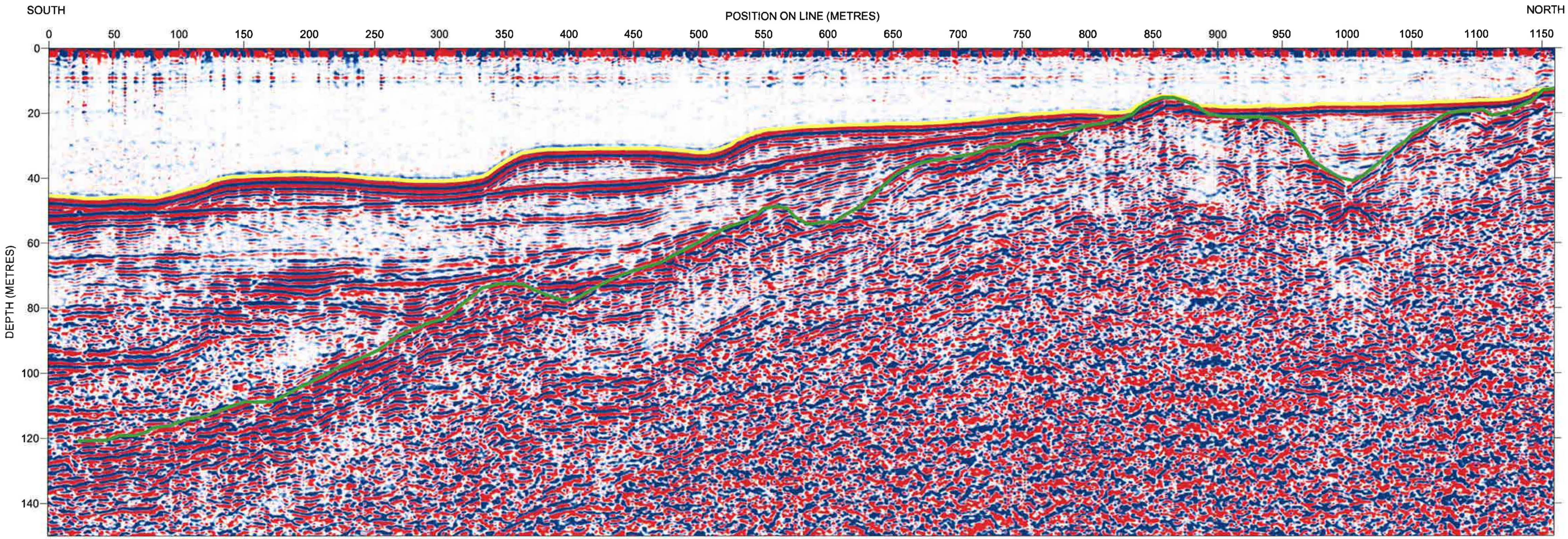
OVERWATER ACOUSTIC PROFILING SURVEY

DEPTH SECTION
ALIGNMENT: DREDGE

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010

DWG: ESQ-DS-DR



LEGEND

BATHYMETRY

INTERPRETED BEDROCK

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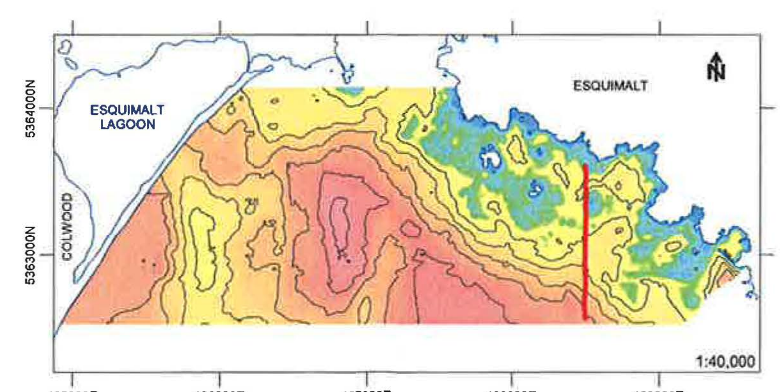
AMPLITUDE SCALE



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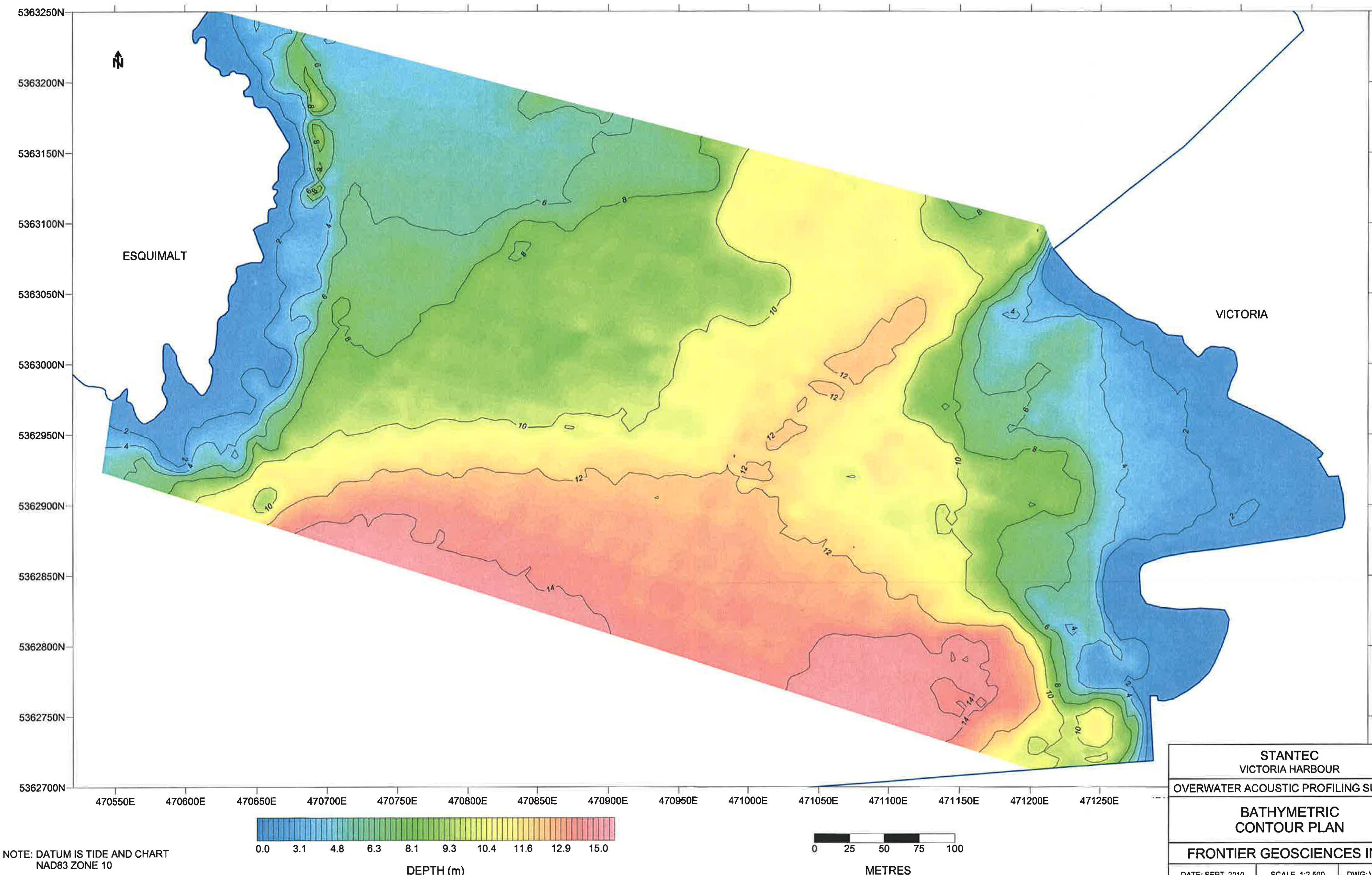
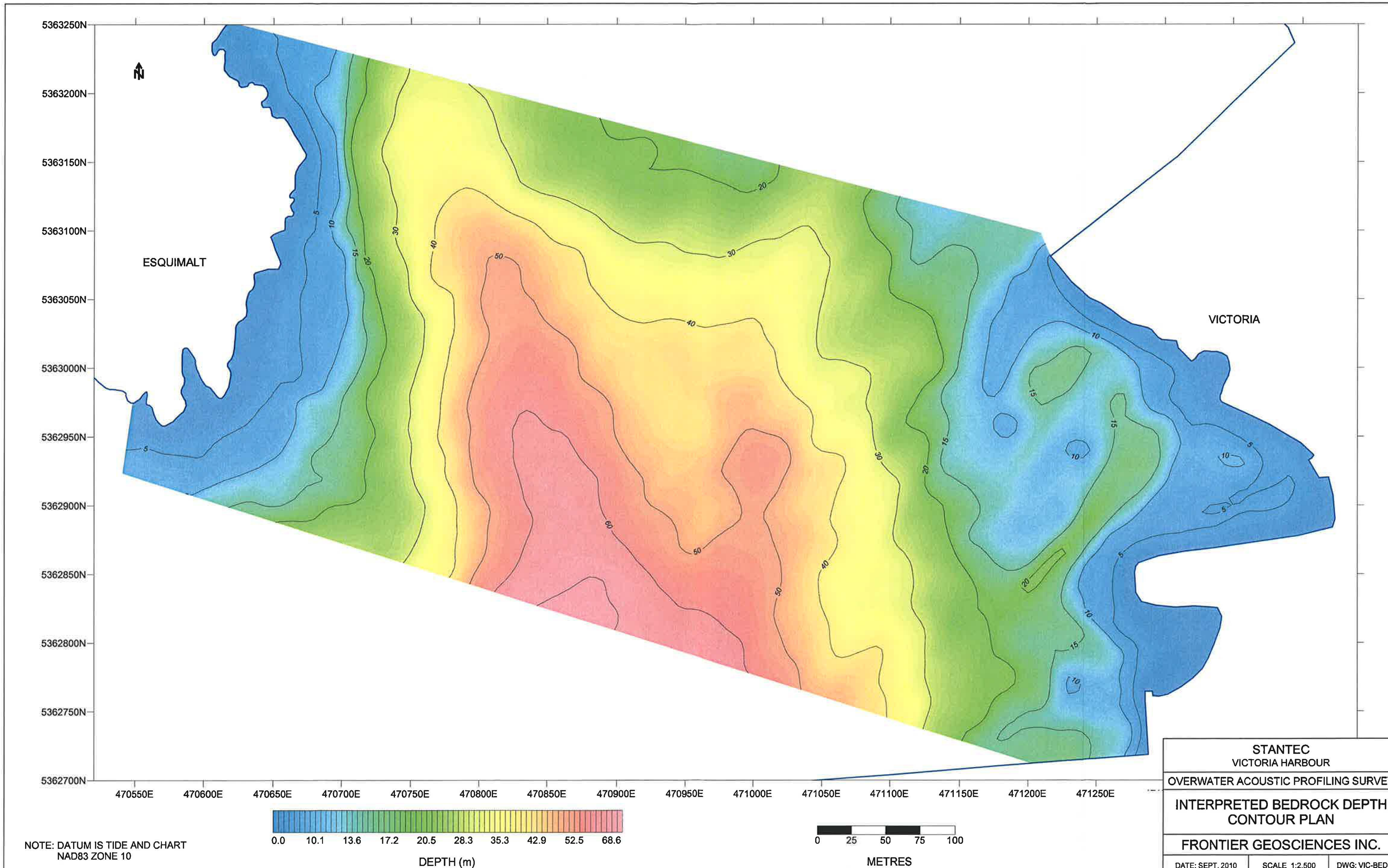
HORIZONTAL SCALE: 1:3,000

STANTEC ESQUIMALT HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
SEISMIC DEPTH SECTION N-S EXAMPLE LINE		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010		DWG: ESQ-EX



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

STANTEC VICTORIA HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
BATHYMETRIC CONTOUR PLAN		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010	SCALE 1:2,500	DWG: VIC-BAT



N
ESQUIMALT
VICTORIA
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470750E
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470850E
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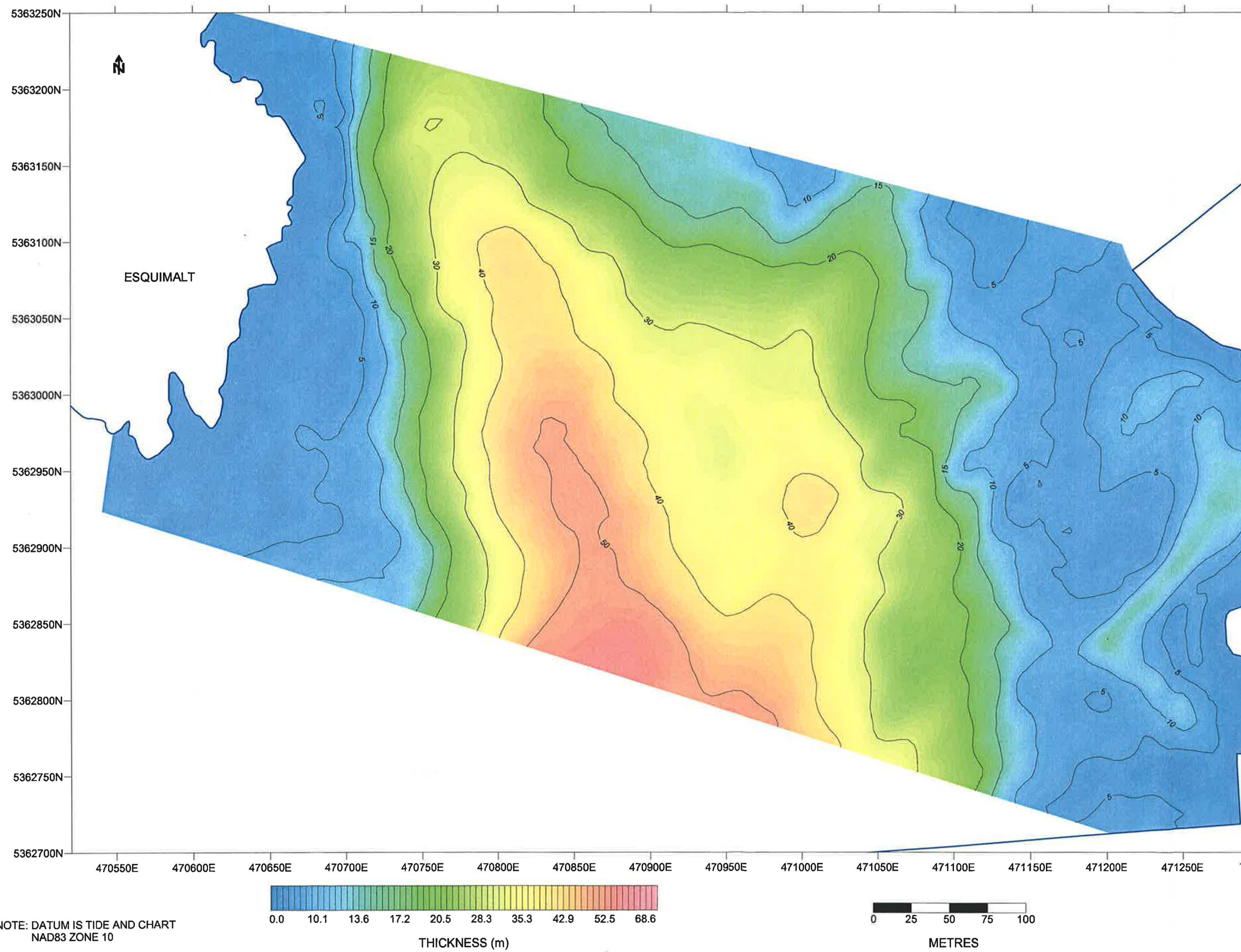
470950E
471000E
471050E
471100E
471150E
471200E
471250E
0.0 10.1 13.6 17.2 20.5 28.3 35.3 42.9 52.5 68.6
DEPTH (m)
0 25 50 75 100
METRES
NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10
STANTEC
VICTORIA HARBOUR
OVERWATER ACOUSTIC PROFILING SURVEY
INTERPRETED BEDROCK DEPTH CONTOUR PLAN
FRONTIER GEOSCIENCES INC.
DATE: SEPT. 2010
SCALE 1:2,500
DWG: VIC-BED



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

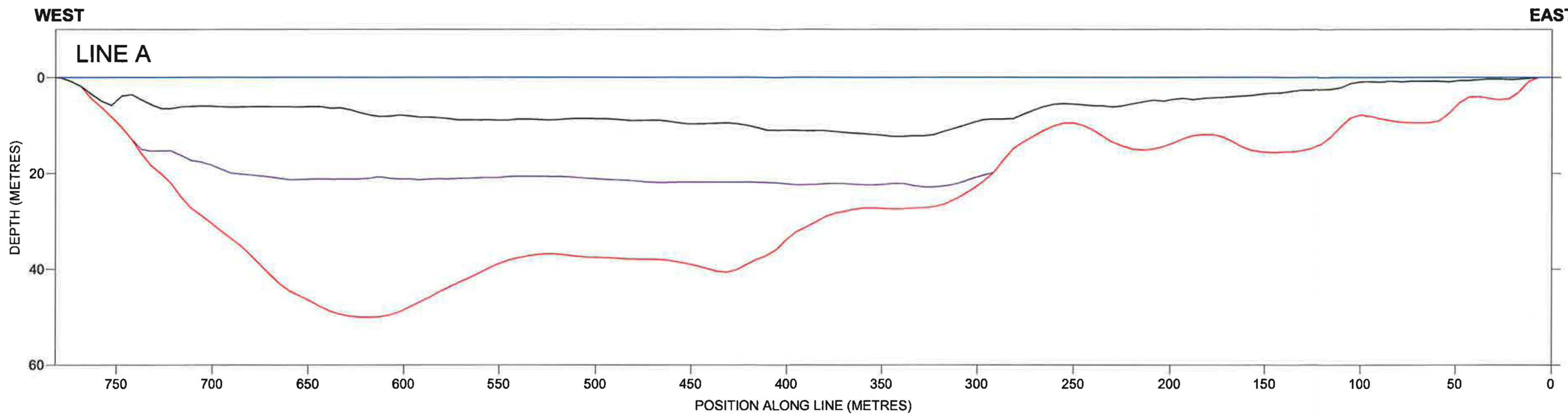
STANTEC
VICTORIA HARBOUR

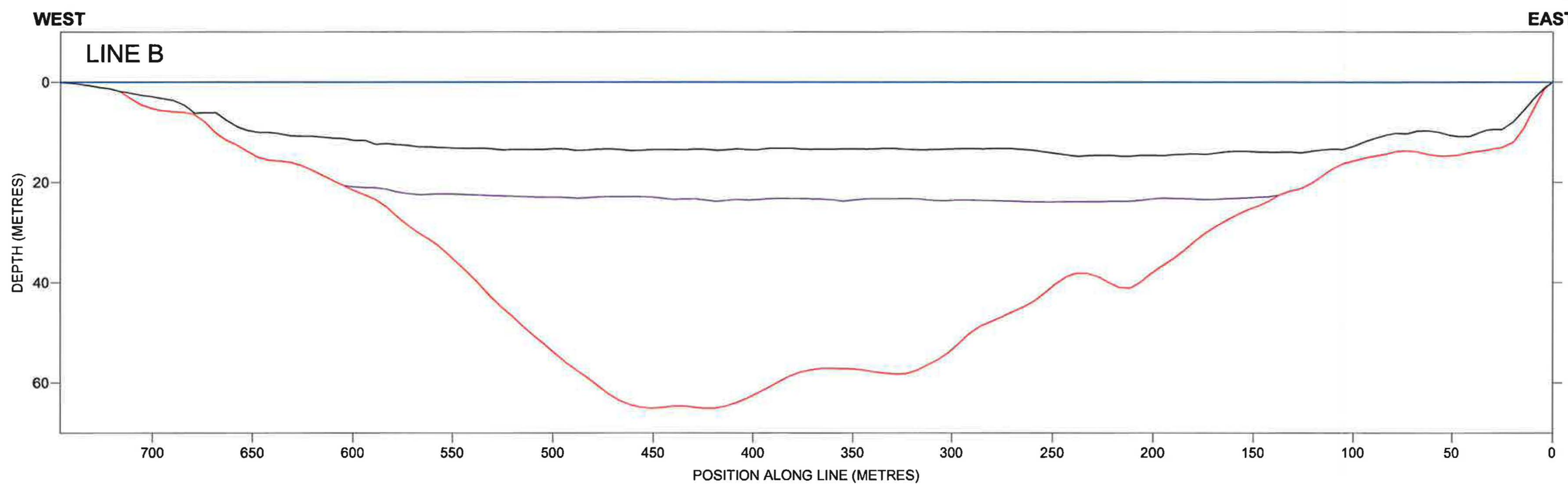
OVERWATER ACOUSTIC PROFILING SURVEY

INTERPRETED SEDIMENT THICKNESS ISOPACH PLAN

FRONTIER GEOSCIENCES INC.

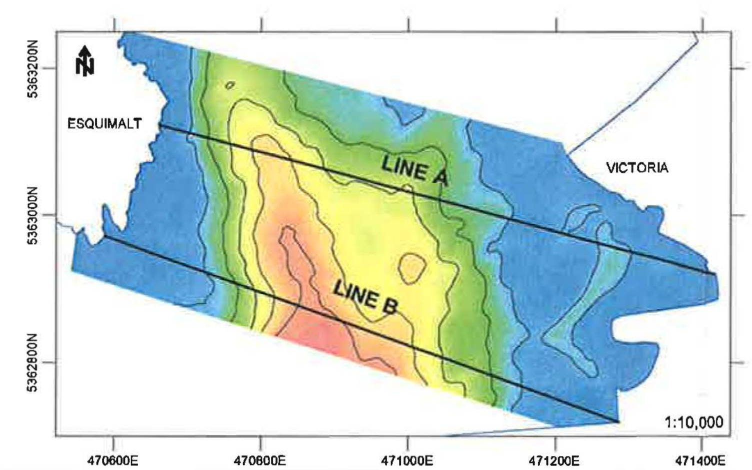
DATE: SEPT. 2010	SCALE 1:2,500	DWG: VIC-SED





LEGEND

- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON



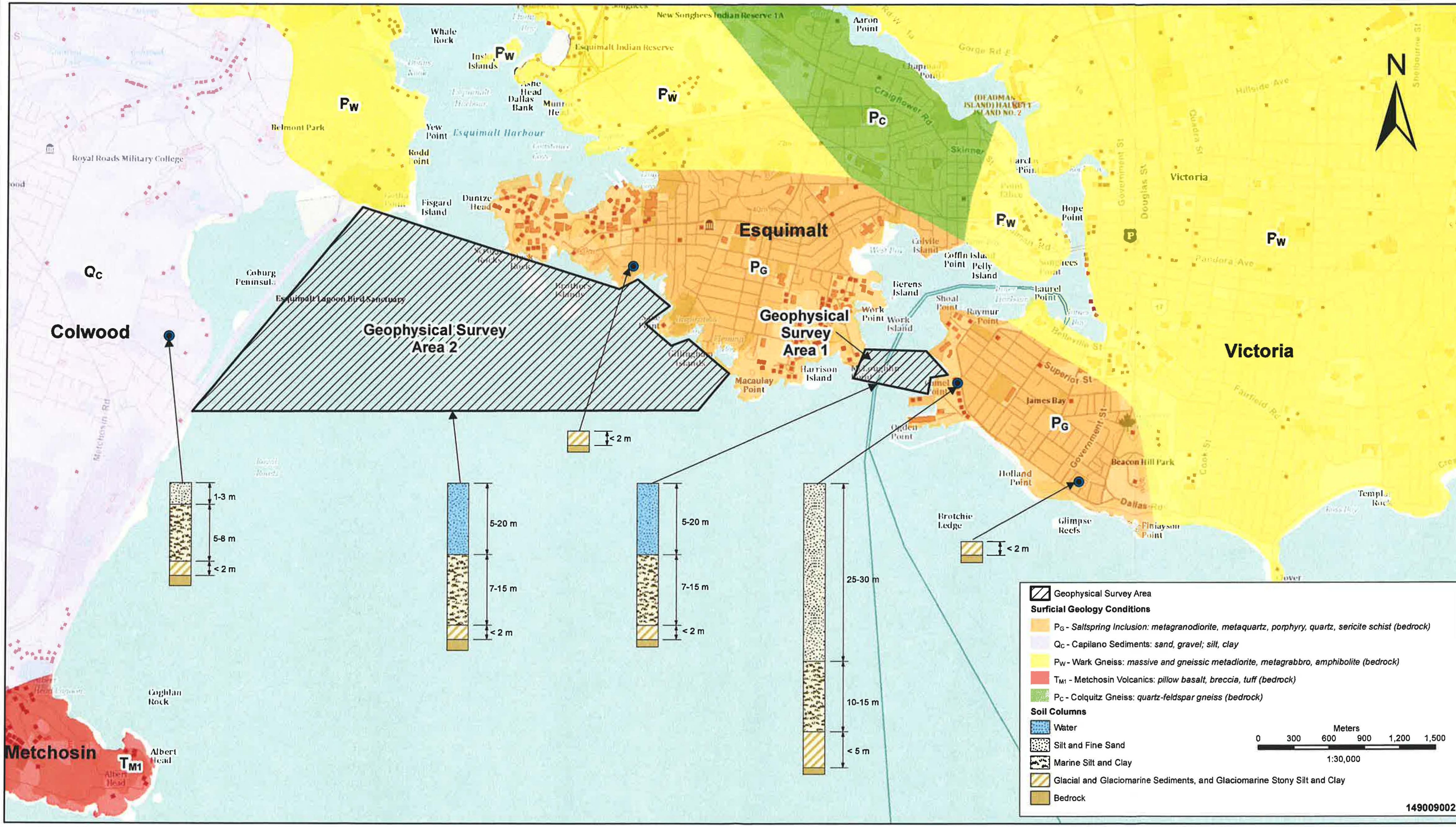
NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:250
HORIZONTAL SCALE: 1:1,000

STANTEC VICTORIA HARBOUR		
OVERWATER ACOUSTIC PROFILING SURVEY		
DEPTH SECTION LINES A & B		
FRONTIER GEOSCIENCES INC.		
DATE: SEPT. 2010		DWG: VIC-DS

APPENDIX B

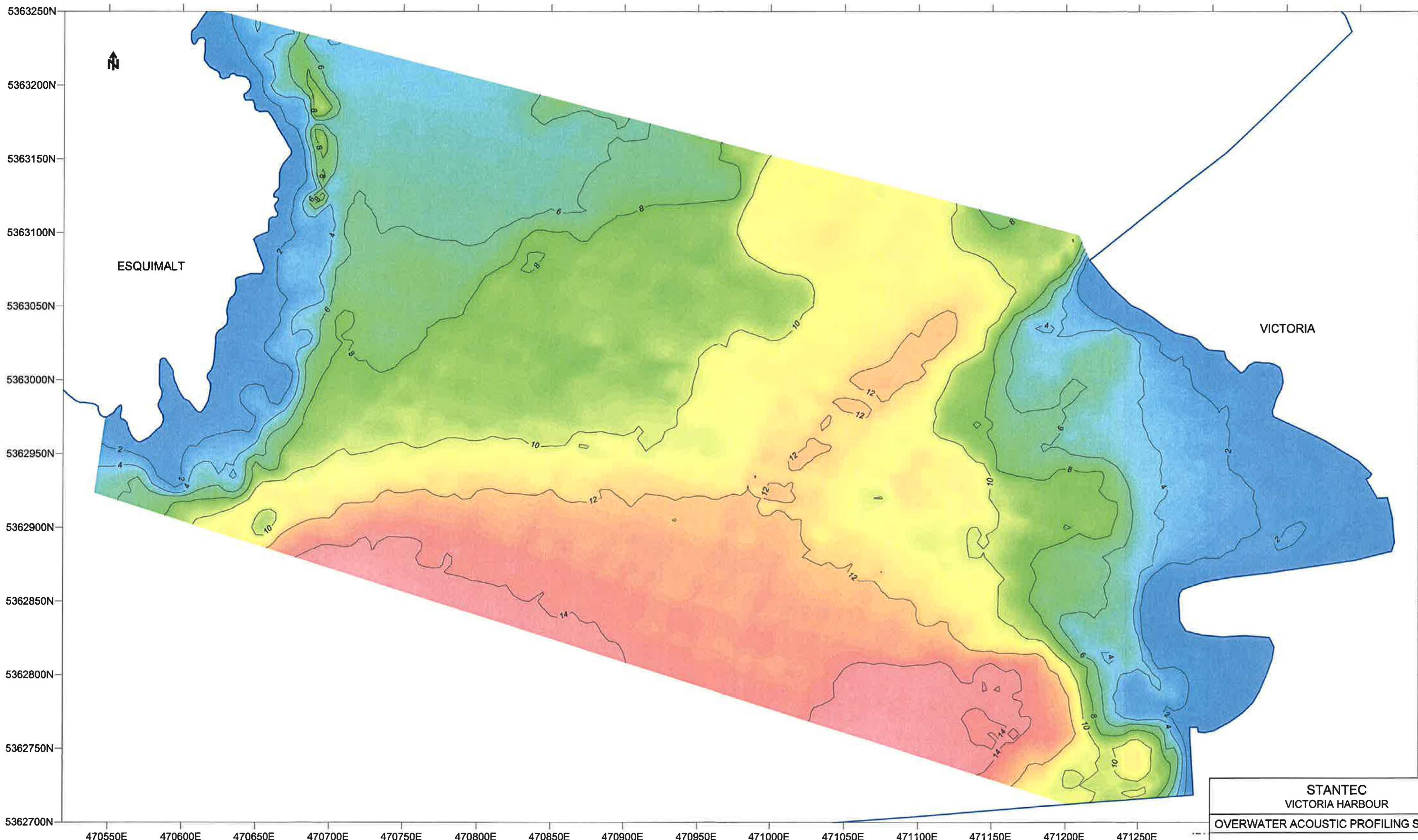
Figures 1 to 11



Source: ESRI Topo Map

Stantec 4370 Dominion Street Burnaby, British Columbia V5G 4L7 Tel. (604) 436 3014 Fax. (604) 436 3752	CAPITAL REGIONAL DISTRICT	**GENERAL SURFICIAL GEOLOGY CONDITIONS** CORE AREA WASTEWATER TREATMENT PROJECT WASTEWATER PIPELINES VICTORIA, BC	PROJECTION UTM - ZONE 10 DATUM NAD 83 DATE 30-Sep-10	DRAWN BY SS CHECKED BY HK FIGURE NO. 1

R:\2010\Stantec\149009002_CRD_Victoria\GIS\MXD\CoreAreaWastewaterTreatment\149009002 Fig 1_GeneralSurficialGeologyConditions.mxd



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

0.0 3.1 4.8 6.3 8.1 9.3 10.4 11.6 12.9 15.0

DEPTH (m)

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METRES

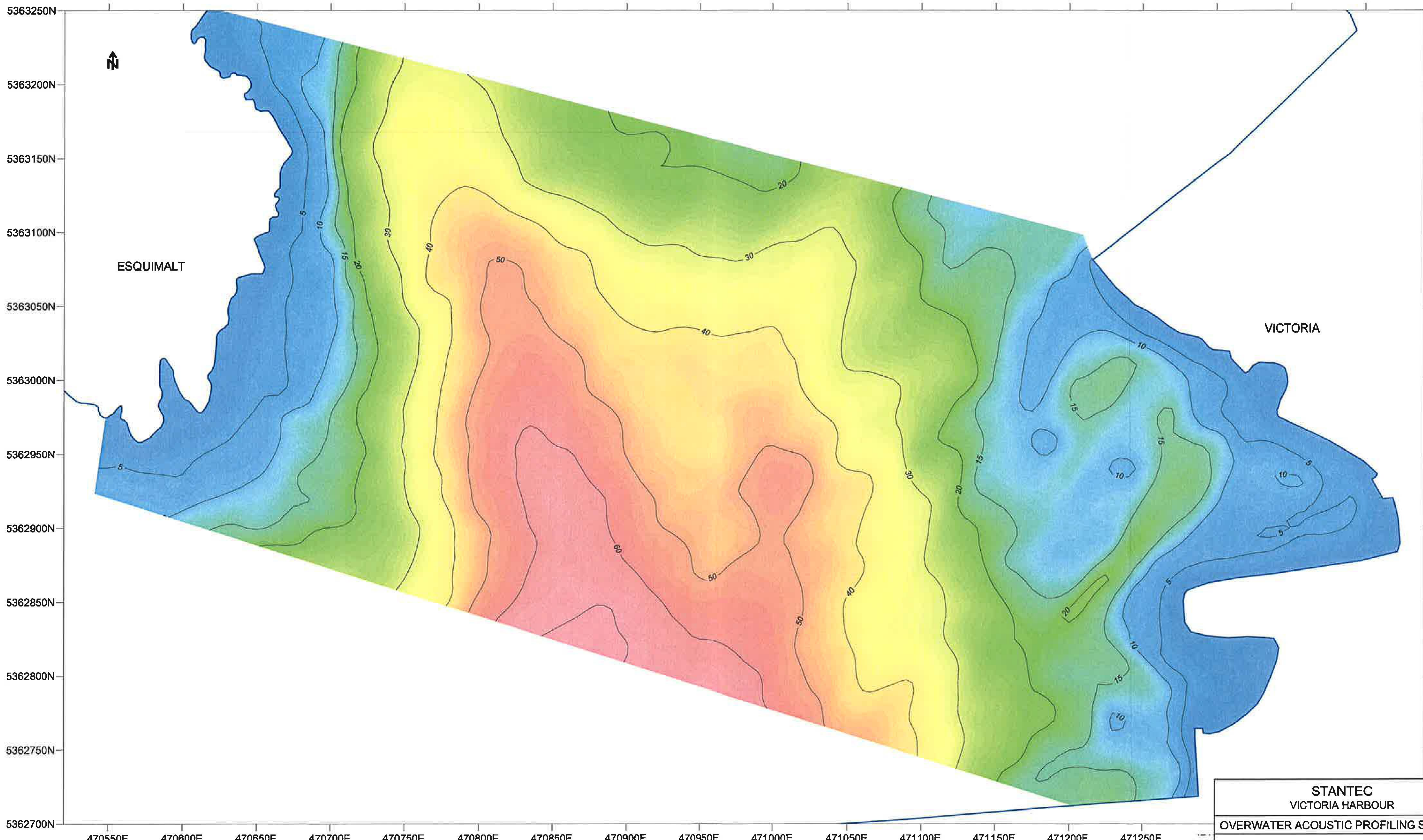
STANTEC
VICTORIA HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

BATHYMETRIC
CONTOUR PLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010	SCALE 1:2,500	Figure 2



0.0 10.1 13.6 17.2 20.5 28.3 35.3 42.9 52.5 68.6

DEPTH (m)

0 25 50 75 100

METRES

NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

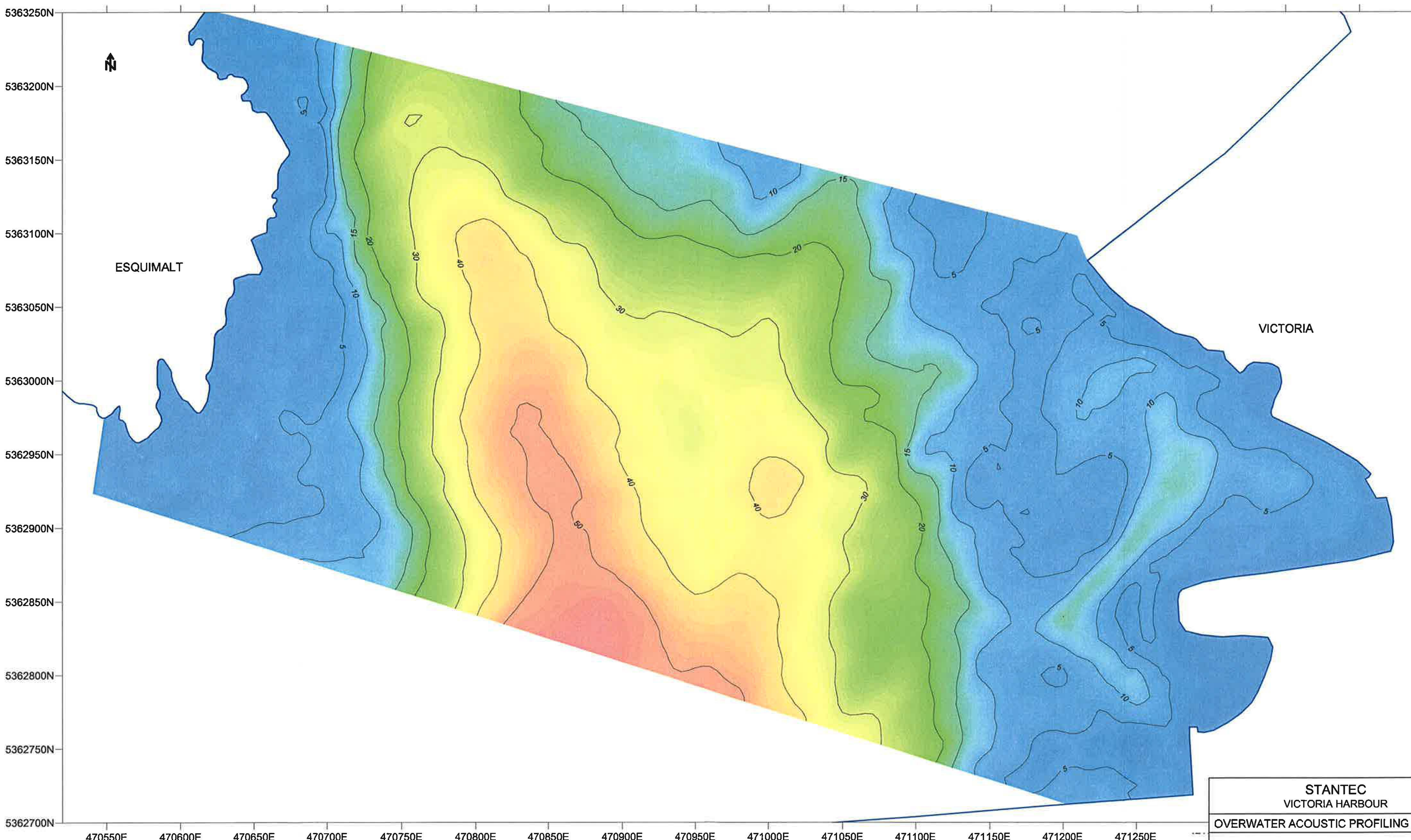
STANTEC
VICTORIA HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

INTERPRETED BEDROCK DEPTH CONTOUR PLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010	SCALE 1:2,500	Figure 3



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

0.0 10.1 13.6 17.2 20.5 28.3 35.3 42.9 52.5 68.6

THICKNESS (m)

0 25 50 75 100

METRES

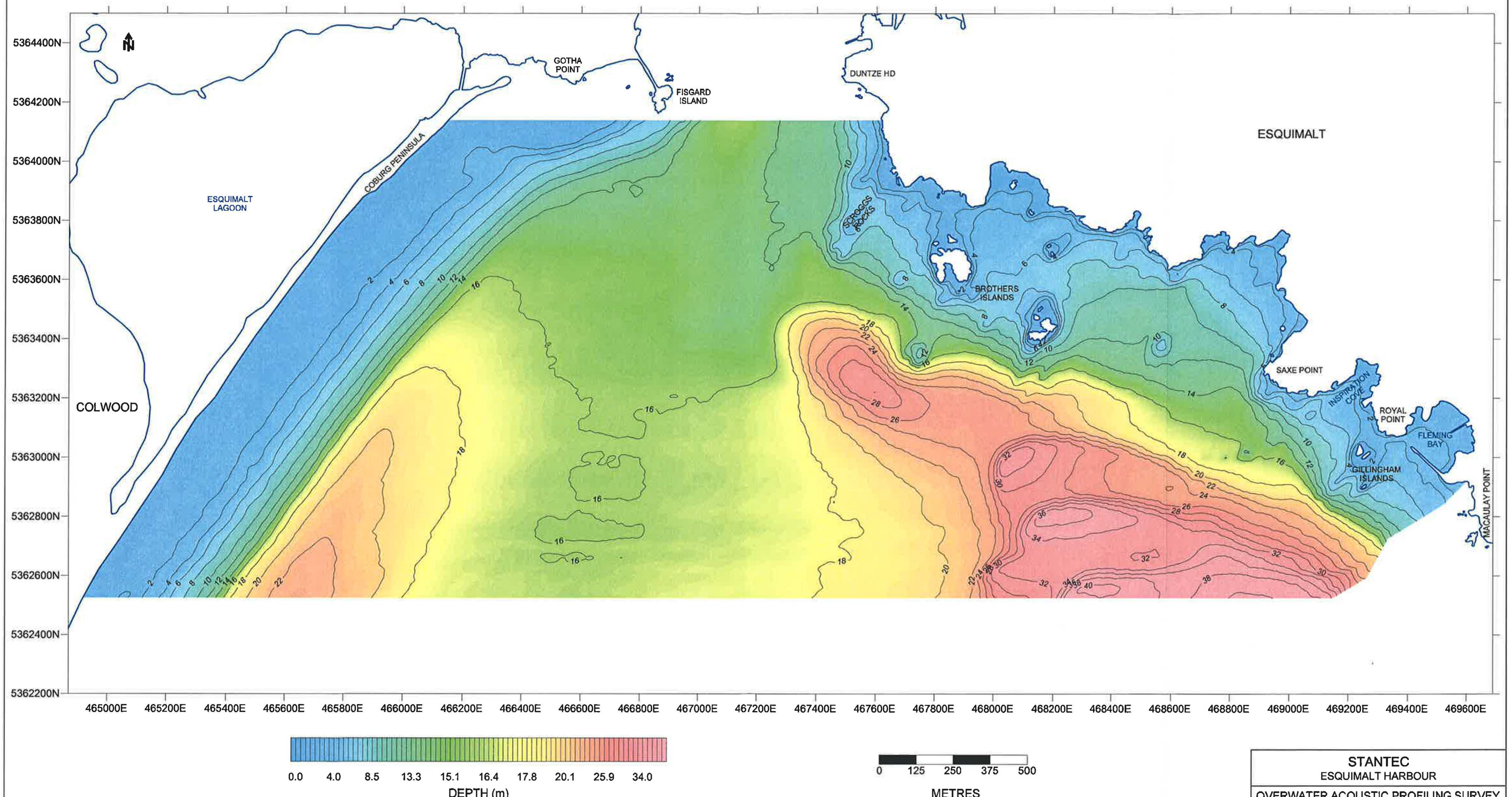
STANTEC
VICTORIA HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

INTERPRETED SEDIMENT THICKNESS ISOPACH PLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010	SCALE 1:2,500	Figure 4



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

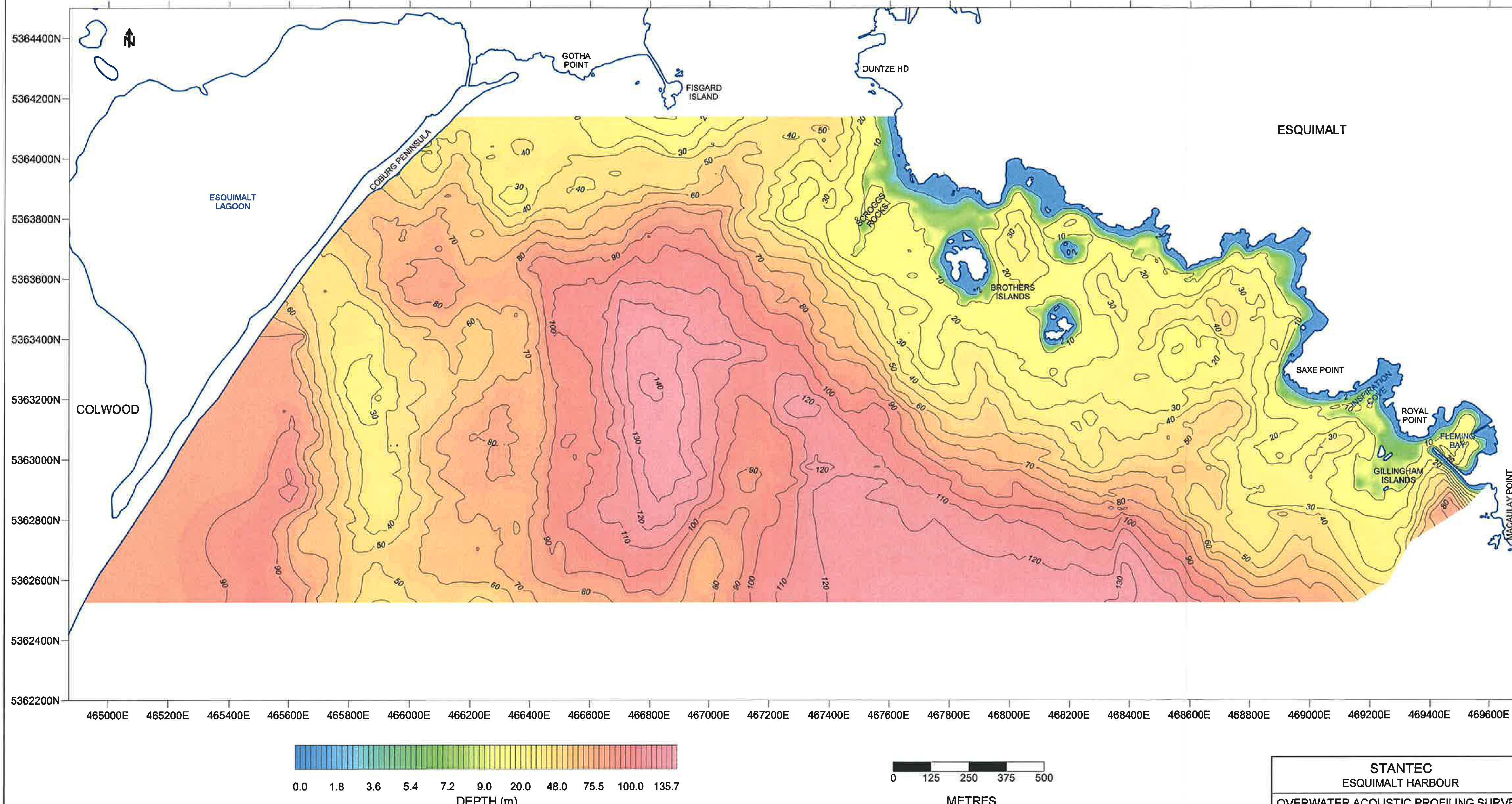
STANTEC
ESQUIMALT HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

BATHYMETRIC CONTOUR PLAN

FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010 | SCALE 1:12,500 | Figure 5



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

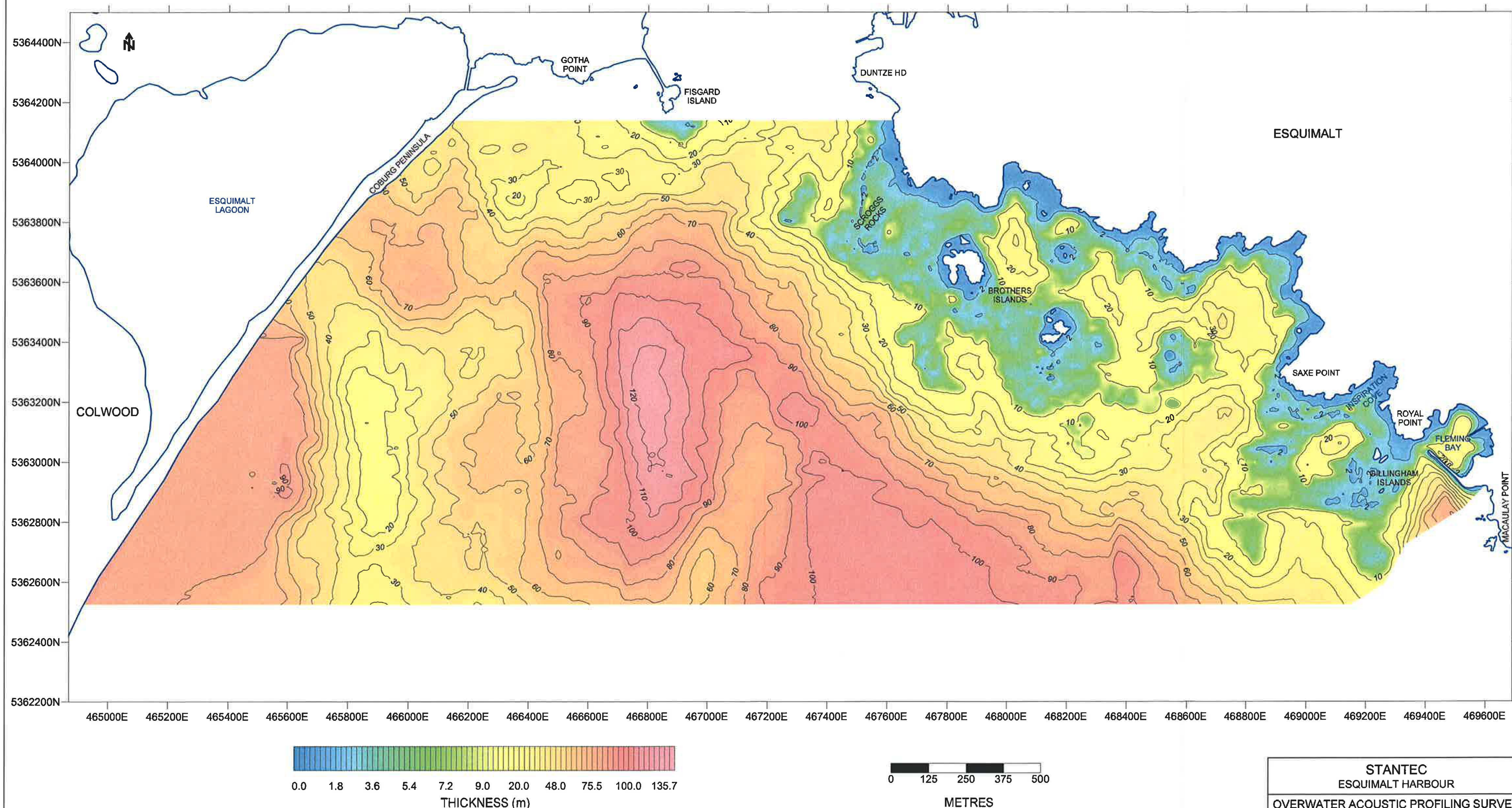
STANTEC
ESQUIMALT HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

INTERPRETED BEDROCK DEPTH CONTOUR PLAN

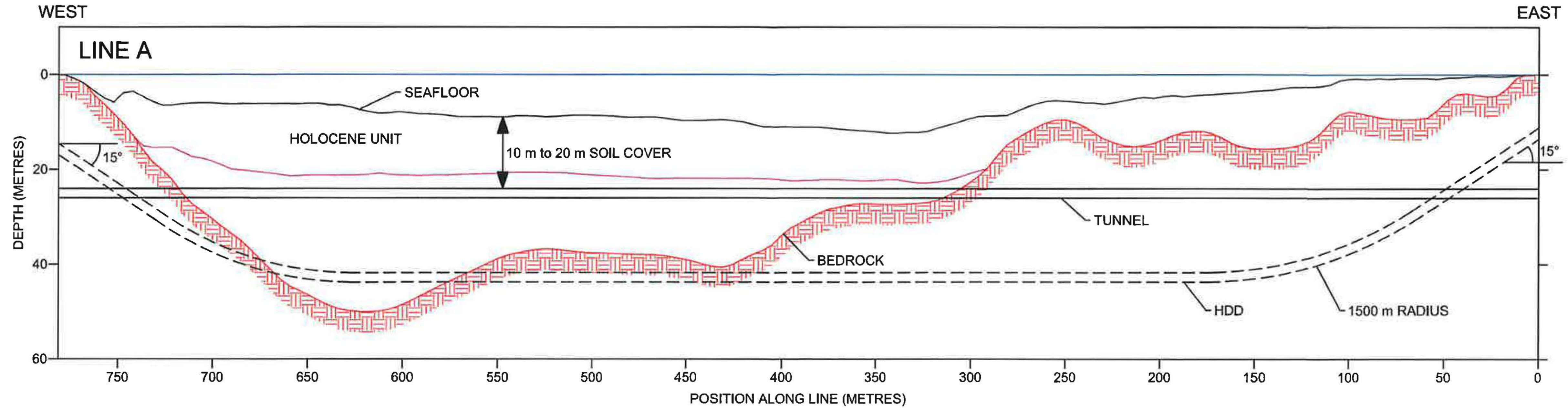
FRONTIER GEOSCIENCES INC.

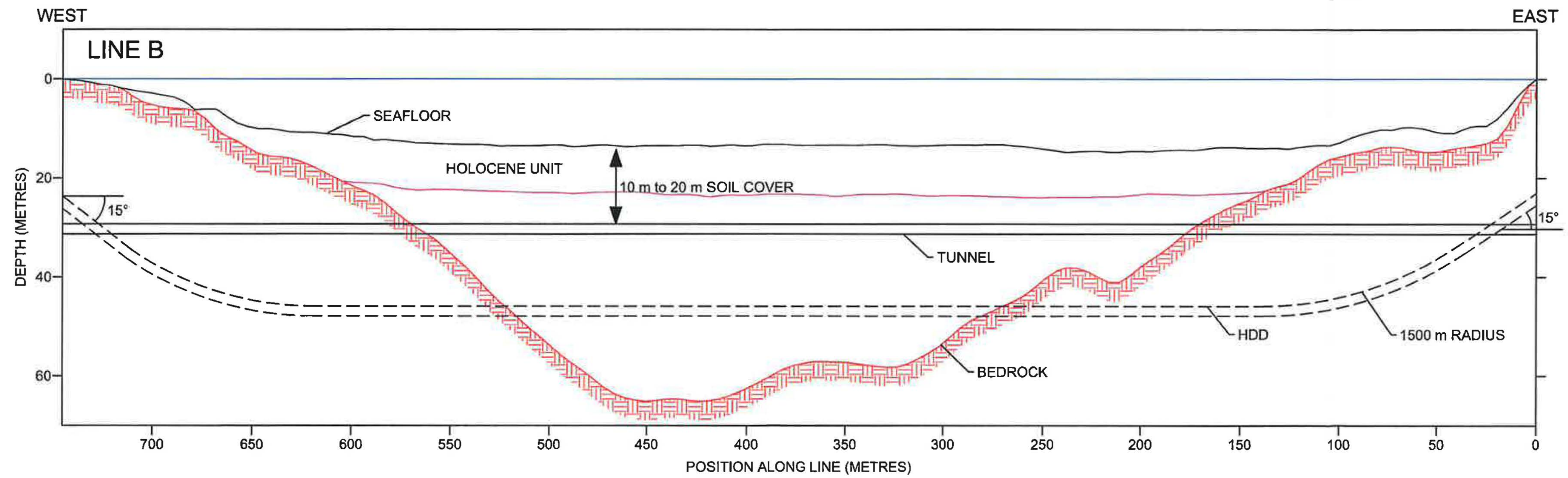
DATE: SEPT. 2010	SCALE 1:12,500	Figure 6



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

STANTEC ESQUIMALT HARBOUR	
OVERWATER ACOUSTIC PROFILING SURVEY	
INTERPRETED SEDIMENT THICKNESS ISOPACH PLAN	
FRONTIER GEOSCIENCES INC.	
DATE: SEPT. 2010	SCALE 1:12,500
Figure 7	



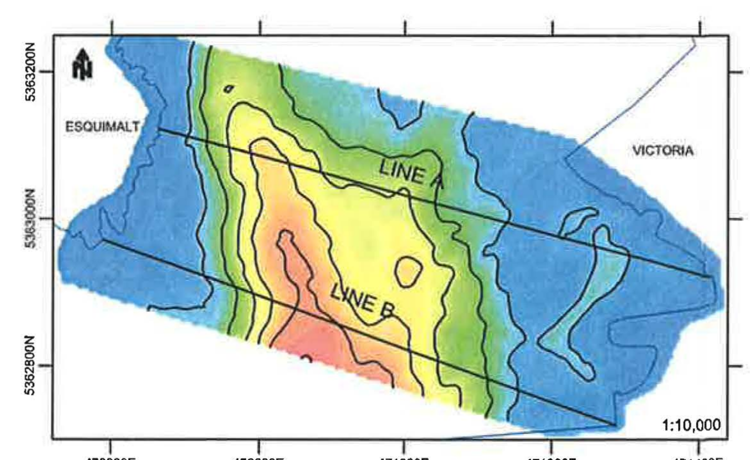


LEGEND

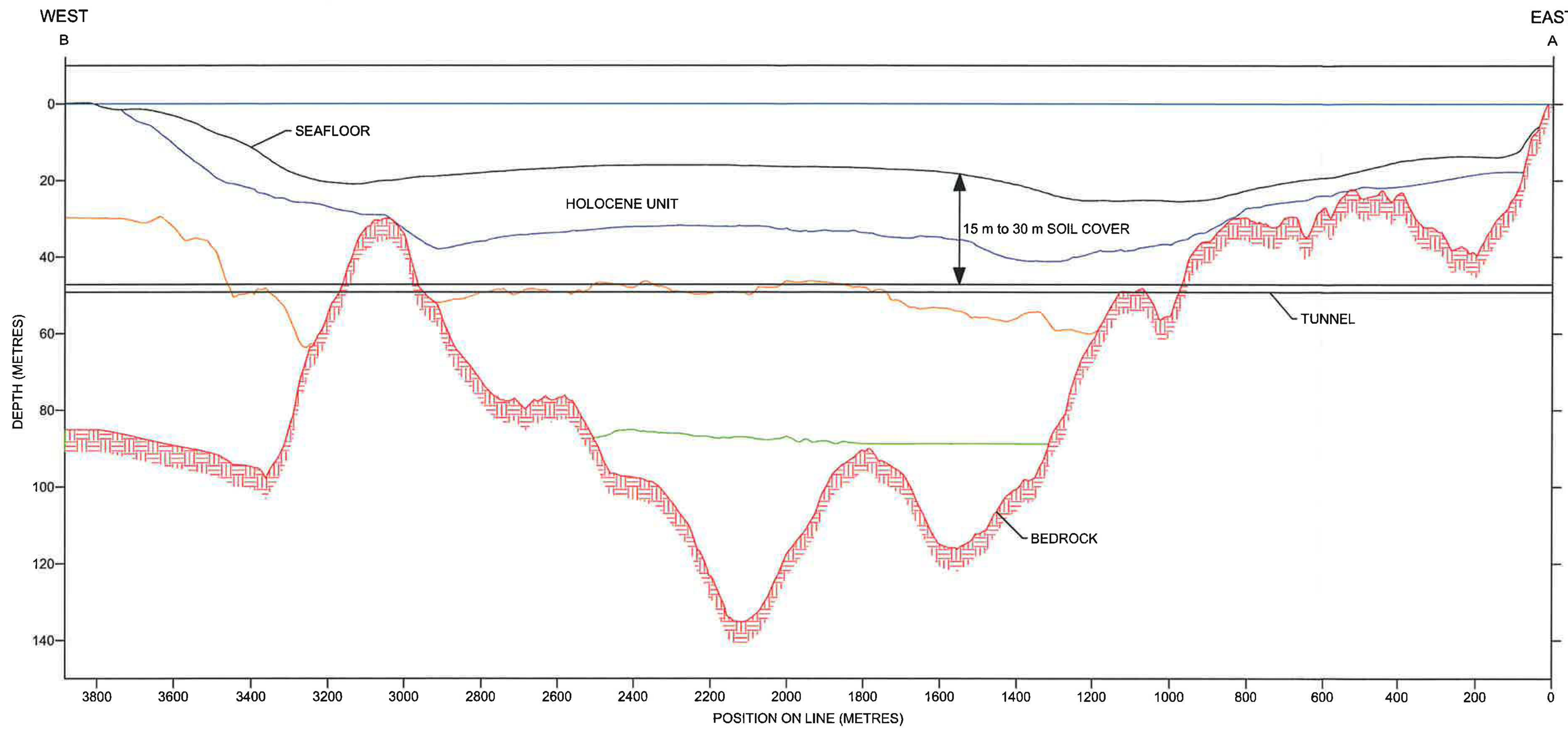
- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON
- TUNNEL
- HDD

NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:250
HORIZONTAL SCALE: 1:1,000



STANTEC VICTORIA HARBOUR
OVERWATER ACOUSTIC PROFILING SURVEY
DEPTH SECTION OPTION 1a (TUNNEL) + 1b (HDD)
FRONTIER GEOSCIENCES INC.
DATE: SEPT. 2010 | | FIGURE 8

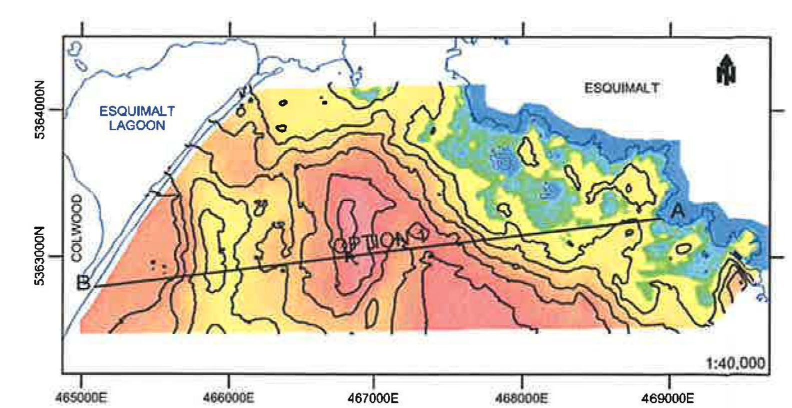


LEGEND

- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- THIRD INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON
- TUNNEL

NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500



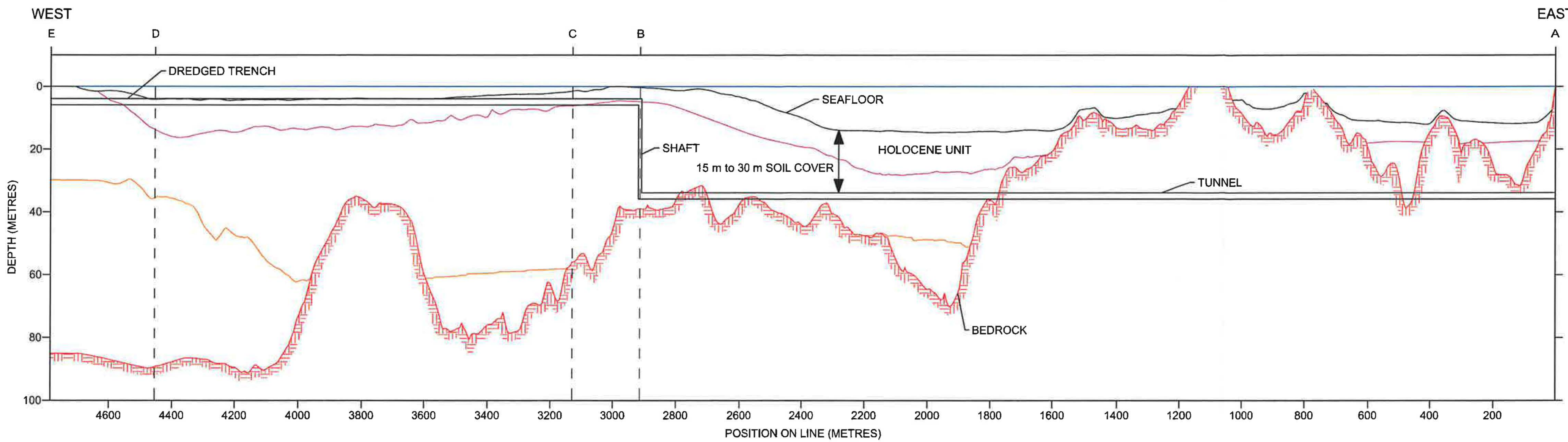
STANTEC
ESQUIMALT HARBOUR

OVERWATER ACOUSTIC PROFILING SURVEY

DEPTH SECTION
OPTION 2a: TUNNEL

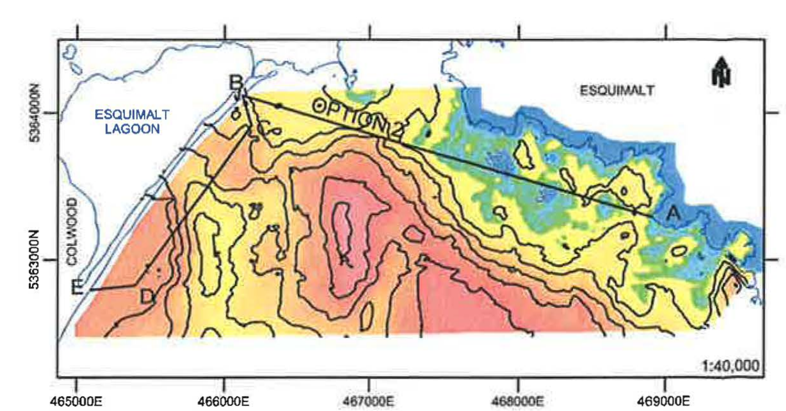
FRONTIER GEOSCIENCES INC.

DATE: SEPT. 2010		FIGURE 9



LEGEND

- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON
- TUNNEL



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500

STANTEC
ESQUIMALT HARBOUR

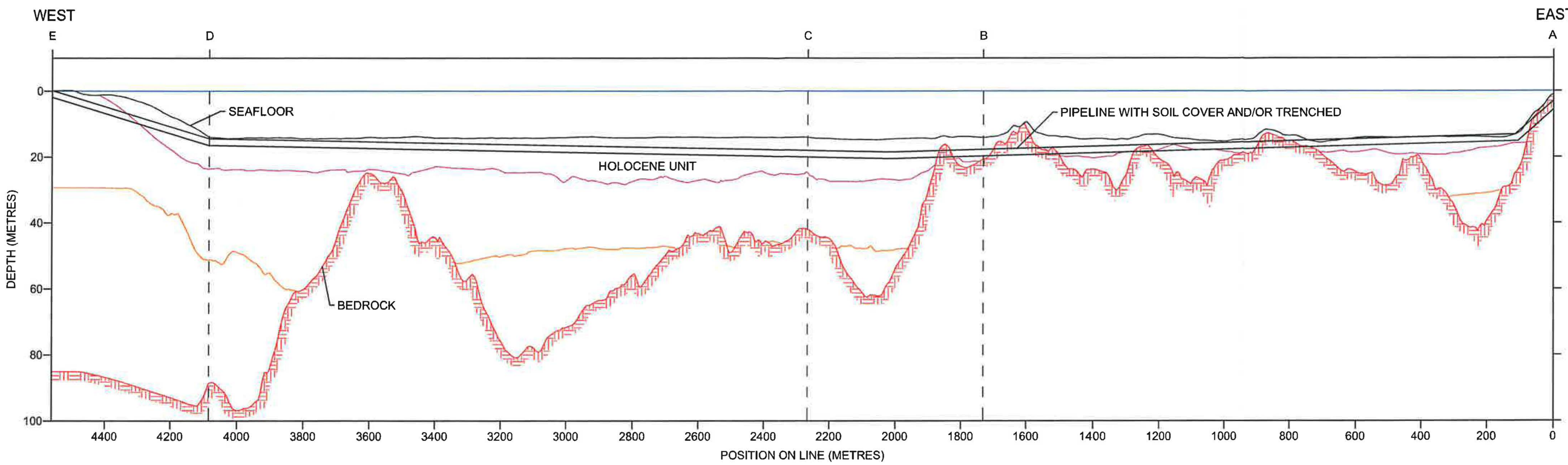
OVERWATER ACOUSTIC PROFILING SURVEY

DEPTH SECTION
OPTION 2b: TUNNEL & DREDGED TRENCH

FRONTIER GEOSCIENCES INC.

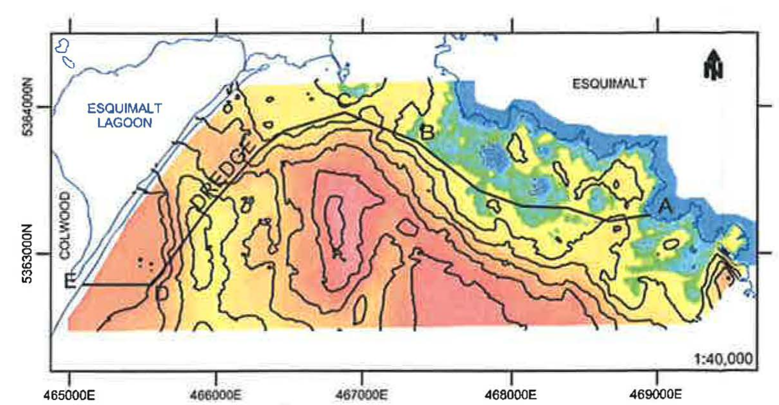
DATE: SEPT. 2010

FIGURE 10



LEGEND

- TIDE AND CHART LEVEL 0
- BATHYMETRIC HORIZON
- FIRST INTERMEDIATE SEDIMENTARY HORIZON
- SECOND INTERMEDIATE SEDIMENTARY HORIZON
- BEDROCK HORIZON
- PIPELINE



NOTE: DATUM IS TIDE AND CHART
NAD83 ZONE 10

VERTICAL SCALE: 1:1,250
HORIZONTAL SCALE: 1:12,500

STANTEC ESQUIMALT HARBOUR
OVERWATER ACOUSTIC PROFILING SURVEY
DEPTH SECTION OPTION 2c: DREDGE TRENCH
FRONTIER GEOSCIENCES INC.
DATE: SEPT. 2010 / FIGURE 11