APPENDIX O

Sediment Modeling of Dredging off Lelu Island, Prince Rupert, BC Canada, and Disposal of Dredgate at Brown Passage

Pacific NorthWest LNG

Stantec

Sediment Modeling of Dredging off Lelu Island, Prince Rupert, BC Canada, and Disposal of Dredgate at Brown Passage

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TABLE OF CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

ASL Environmental Sciences Inc. carried out a 3D numerical modeling study for the estimation of potential environmental effects in support of the regulatory approval process for the proposed Pacific Northwest LNG project located at Lelu Island, British Columbia, Canada. The ASL highly-integrated circulation and sediment transport model COCIRM-SED was used for estimating total suspended solids (TSS) and deposition of sediments in Porpoise Channel and off the coast of Lelu Island resulting from dredging operations at the materials offloading facility (MOF, Figures 1 and 2). A separate COCIRM-SED model was developed and applied for studying the transport and fate of the marine dredging disposal in Brown Passage (Figure 3).

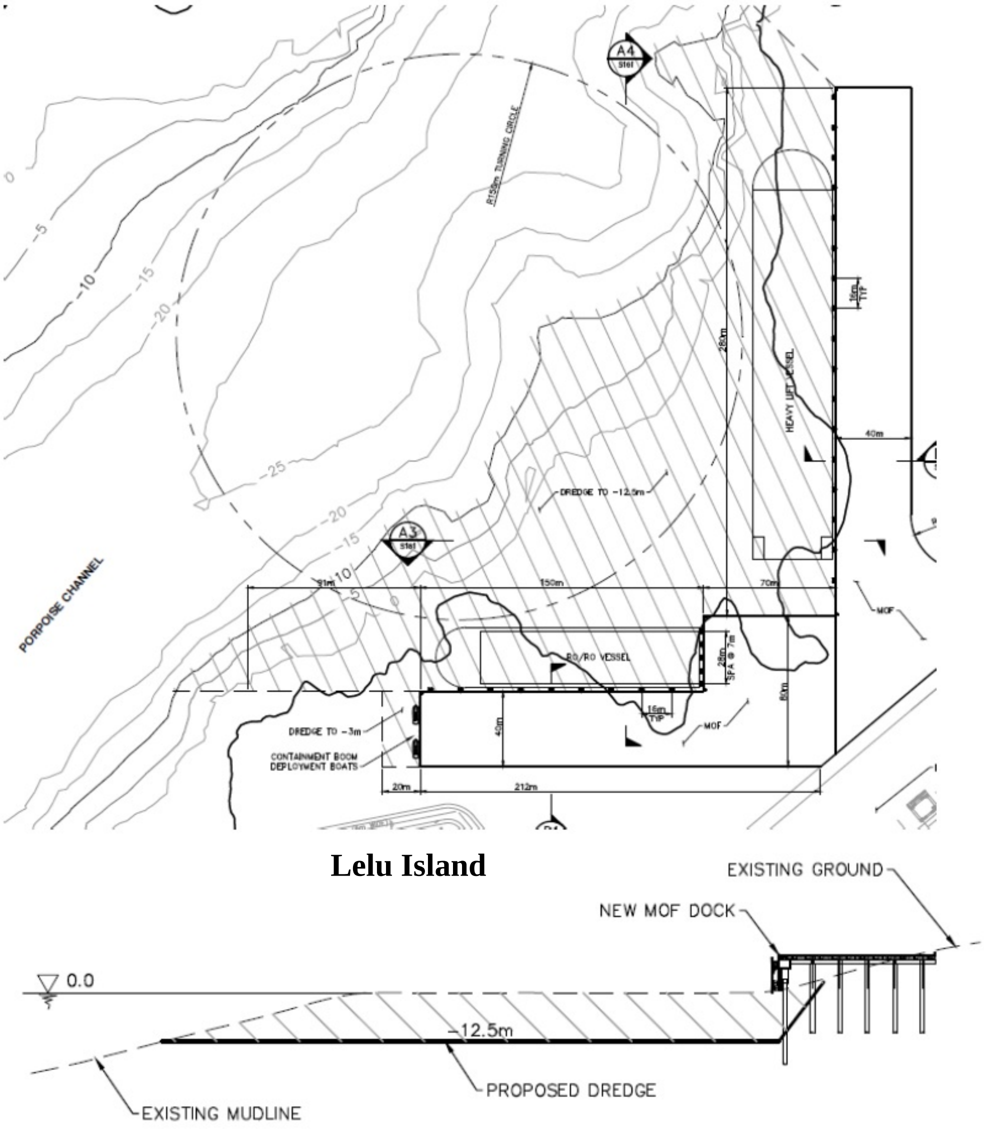


Figure 1: Dredge footprint for the material offloading facility (MOF).

Table 1: Summary of sediment input parameters.

Parameter	Values						
Sediment category	Clay	Fine silt	Coarse silt	Fine sand	Mid sand	Coarse sand	Gravel
	<0.004 mm	0.004-0.0312 mm	0.0312-0.063 mm	0.063-0.125 mm	0.125-0.5 mm	0.5-2 mm	>2 mm
	16.6%	22.6%	14.0%	11.8%	21.0%	8.7%	5.3%
Total volume	615,000 m^3						
Modeling period	Jan. 1, 2015 – Jun. 25, 2015 (1 day for spin up, 153 days for dredging and disposal, 20 days for post-disposal)						
Dredging Operations							
Dredging production rate	400 m^3 /hour			Release Rate		1%	
Disposal Operations							
Total trips	205			Interval		Every 18 hours	
Barge capacity	3,000 m^3			Duration of dump		3 minutes	
Bulk density	1,650 kg/m^3 (on barge)			Dry density		1,015 kg/m^3 (on barge)	

There were two types of numerical modeling studies conducted:

(1) Modeling the release, transport and fate of sediments during dredging operations in the shallow base on the southeast side of Porpoise Channel. The model domain includes the southern portion of Chatham Sound, Arthur Passage, Telegraph Passage, Edye Passage, Skeena River, and the narrow channel network surrounding Lelu Island (Figure 2)

(2) Modeling the release, transport and fate of sediments in the disposal operations within the Environment Canada designated ocean disposal site in Brown Passage in eastern Dixon Entrance (Figure 3)

The model input parameters of the dredged marine sediments are summarized in Table 1. The total volume of the disposal material is 615,000 m^3. According to sediment sampling data collected during May-July 2013, a total of 7 sediment categories were identified, respectively clay (16.6%), fine silt (22.6%), coarse silt (14.0%), fine sand (11.8%), medium sand (21.0%), coarse sand (8.7%) and gravel (5.3%). These data were provided by Stantec, obtained from sediment samples taken at 30 locations at the surface and at a variety of different depths representing the horizontal and vertical profiles of the dredge area. Data were averaged from all sample locations and depths. The fine-grained/cohesive sediment content (clay and silt) in the dredge material is 53.2%.

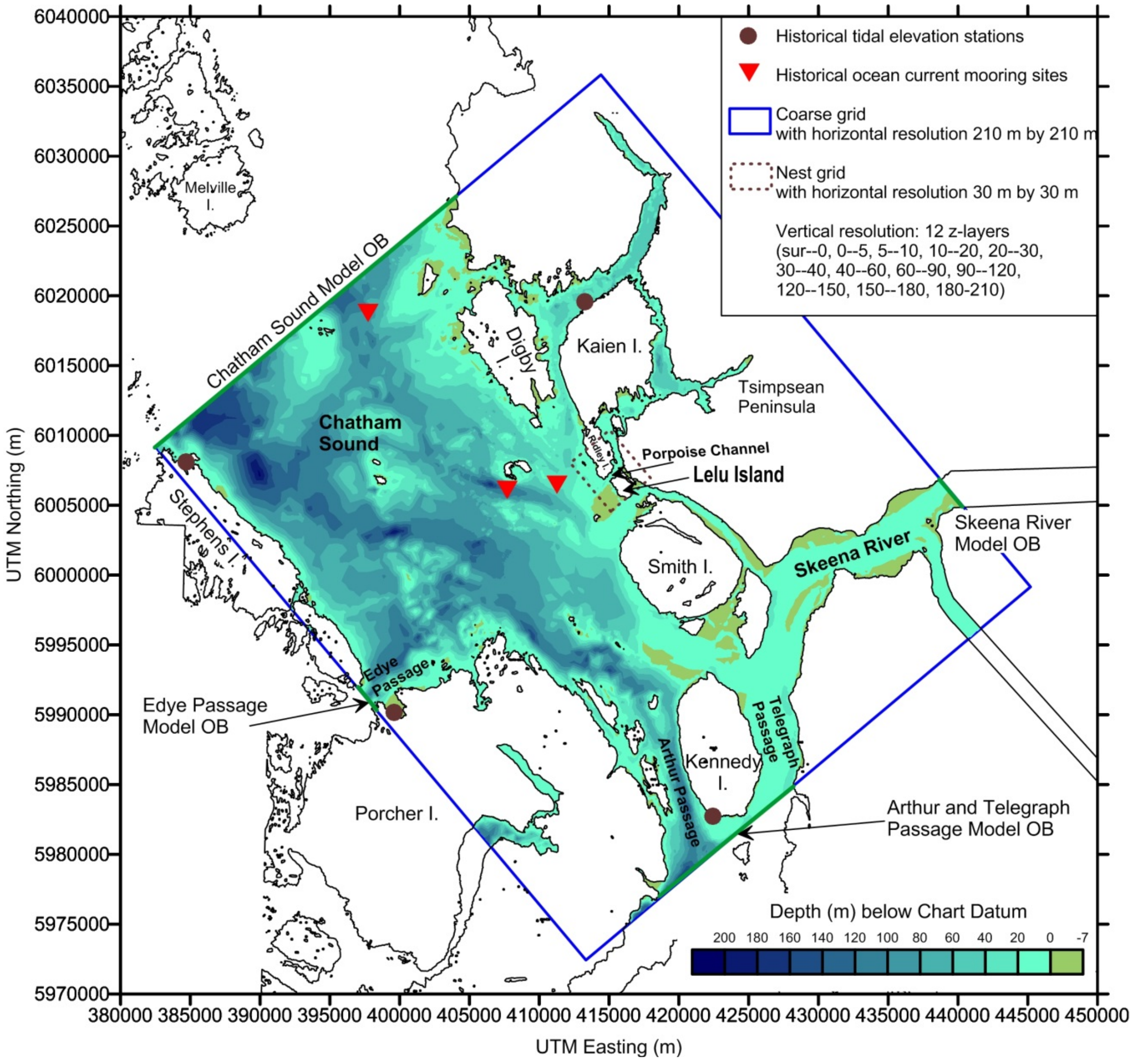
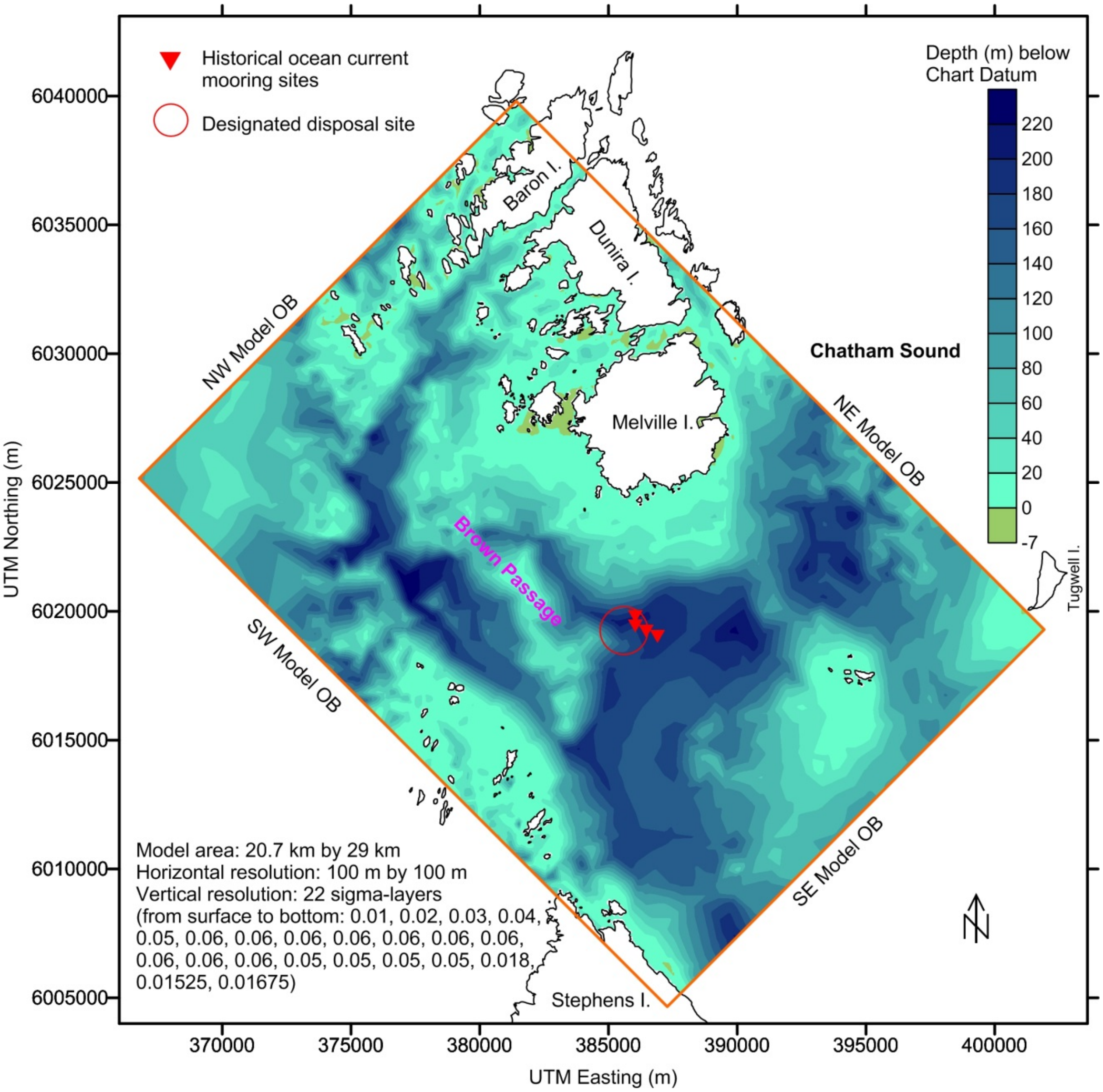


Figure 2: Dredging modeling study area including the model domain, bathymetry, historical tidal elevation stations and ocean currents mooring sites.



Model area: 20.7 km by 29 km
Horizontal resolution: 100 m by 100 m
Vertical resolution: 22 sigma-layers
(from surface to bottom: 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.06, 0.06, 0.06, 0.06, 0.06, 0.06, 0.06, 0.06, 0.06, 0.05, 0.05, 0.05, 0.05, 0.018, 0.01525, 0.01675)

Figure 3: Disposal modeling study area including the model domain, bathymetry, designated disposal site and historical ocean currents mooring sites.

2.0 DREDGING MODELING

In this section, we present the model approaches and results of the numerical modeling simulations of TSS as well as the estimated levels of deposition of the sediments back to the seabed during the dredging periods.

2.1 Model Setup and Description

The nested-grid COCIRM-SED model for the sediment dredging modeling offshore of Lelu Island operated on two different spatial scales: the full and near-field scales. The full scale model is required to capture the length and time scales of the basic forcing mechanisms of tides, winds and the large inflow from the Skeena River. The full scale model area has a size of 42 km by 48.3 km, including the southern portion of Chatham Sound, Arthur Passage, Telegraph Passage, Edye Passage, Skeena River, and the narrow channel network surrounding Lelu Island and Prince Rupert Harbour (Figure 2), and is resolved using a horizontal grid size of 210 m by 210 m.

The near-field scale model is required to realistically resolve initial dilution of the disposal sediment and include the topography of the narrow Porpoise Channel. The horizontal resolution in the near-field is reduced to 30 m (Figure 2). In the vertical, both full and near-field scale models used 12 z-layers with a higher resolution near the surface to account for salinity and temperature stratification effects. The 210 m and 30 m model grids are coupled at interfaces and solved together every time step with a single modeling procedure using the two-way, dynamic nested grid scheme in COCIRM-SED.

ASL digitized the bathymetric data as shown in Canadian Hydrographic Service (CHS) nautical charts #3955, #3957, #3958, #3959 and #3964 within the model domain, and also purchased CHS vector digital charts #3717 #3773 and #3927. The digital bathymetric data set, in the format of UTM Easting, UTM Northing and seabed elevation relative to chart datum, was gridded to provide suitable representation of the water depths in the model.

The model was forced at tidal height elevations spanning three open boundaries and by Skeena River input and surface winds. The three model open boundaries include Chatham Sound to the north, Edye Passage to the west and Arthur and Telegraph Passages to the south (Figure 2). Tidal elevations at these three open boundaries were derived from 7 major tidal height constituents (O1, P1, K1, N2, M2, S2, K2) using the Department of Fisheries and Oceans (DFO) standard tidal prediction program. The tidal constituents for the reference port of Prince Rupert and the secondary ports of Qlawdzeet Anchorage, Refuge Bay and Seabreeze Point were obtained from CHS. In the COCIRM-SED model, geostrophically balanced elevations due to Coriolis force at each open boundary are calculated and superimposed on tidal components at every time step. The Skeena River discharge data were obtained from Canadian Hydrological Database, archived by Environment Canada. The wind data were obtained from the Prince Rupert airport weather station, operated by Environment Canada. The initial water properties (temperatures, salinities and densities) within the model domain and at the boundaries were derived using historical CTD/bottle data from the on-line DFO database for BC coastal waters.

The model was validated through model calibration and verification runs using historical ocean current data collected by Institute of Ocean Science (IOS) and CHS, at two current mooring sites near Lelu Island (Figure 2), one to the south of Kinahan Island (instrument depth 16 m and measurement period May-Sep, 1982) and the other off the west coast of Ridley Island (instrument depth 17 and 31 m, and measurement period May-Sep, 1993). Both calibration and verification runs involved tidal forcing, river input and wind forcing, and model results are in reasonably good agreement with observations (Jiang, J. and D. Fissel, 2011b).

2.2 Dredging Activities and Assumptions

The modeled dredging would be conducted within the 153-day period from January 2 to June 4, 2015. For the purpose of modeling simulations of the fate of the sediments released in dredging, the 3-D numerical model was operated for 4 separated model runs associated with different forcing regimes (strong, medium, and weak winds, non-freshet and freshet seasons) as summarized in Table 2. By simulating the representative scenarios, if there is any change in the work schedule the associated model results can be selected and combined to make a new estimate.

Dredging will take place at the MOF and turning basin in Porpoise Channel at the northwest coast of Lelu Island (Figures 1, 2). The area of the dredging is approximately 0.054 km^2 to a depth of 12.5 m. The duration of dredging operations is estimated to be 7 days a week, on a 24 hour per day operation. Dredging will be conducted with clamshell buckets that capture the dredged materials from the bottom, raising the closed bucket through the water column and then depositing the materials into a dredge barge for disposal at the Brown Passage disposal site. The disposal of the dredged materials is dealt with in section 3.

Dredging will be carried out to minimize the release of sediments to the water column. The potential release effects include (Schroeder and Ziegler, 2004): the bottom wake arising from capturing the sediment in the clamshell bucket and expulsion during closing, stripping of sediments from the shovel while rising through the water column, draining during slewing and washing from descent through the water column. It is also possible that loads can be lost due to debris.

Schroeder and Ziegler (2004) provide a range of loss rates of 0.2 to 3% for closed mechanical dredges. Hayes et al. (2007) suggest that the rate and mass of sediment resuspended during dredging varied from 0.16 to 0.88% based on their 5 field studies for estuarine and freshwater river environments. In this simulation, the loss rate was taken to be 1% to be on the conservative side based on more recent studies by Hayes et al. (2007). We further assume that one-half of the total loss will occur within 5 m of the bottom due to a combination of: capturing the sediment; expulsion of sediments when closing the bucket; and during the initial raising of the bucket through the water column. The remaining 50% of the losses are assumed to be evenly distributed through the upper water column. These parameters and approaches are the same as Fissel et al. (2006).

The sediment size distribution is shown in Table 1. Since any released coarse-grained sediment will sink near the dredging area and be removed by later dredging operations, only the fine-grained sediment (clay and silt) was simulated in the sediment transport model. To be conservative, the sediment was modeled as being released at a representative dredging site near the middle of the channel where currents are relatively stronger (so that sediment can be suspended and transported out of the MOF easily).

The release rate is computed as 1% of 400 m^3/hour (a rate of 96 m^3/day or 0.0011 m^3/s). Taking the sediment density (on barge) as 1650 kg/m^3, the mass release rate is 1.8 kg/s. Among them, the fine-grained sediment (clay and silt) amount is 53.2%, i.e. 1.0 kg/s. Since the computations are made over a duration of months, the release rate is taken to be continuous in time, rather than episodic over periods of minutes.

2.3 Forcing Design and Model Runs

Tidal elevations at open boundaries in 2015 were predicted based on known tidal height constituents. Surface winds and Skeena River discharges are not predictable. A representative year forcing was selected from the past 5 years (2008 – 2012). Specifically, winter and spring winds in 2009 and Skeena River discharges in 2008 were used to drive the model (Figure 4).

As summarized in Table 2, the 3-D numerical model was operated for 4 separated model runs associated with different forcing regimes (strong, medium, and weak winds, non-freshet and freshet seasons).

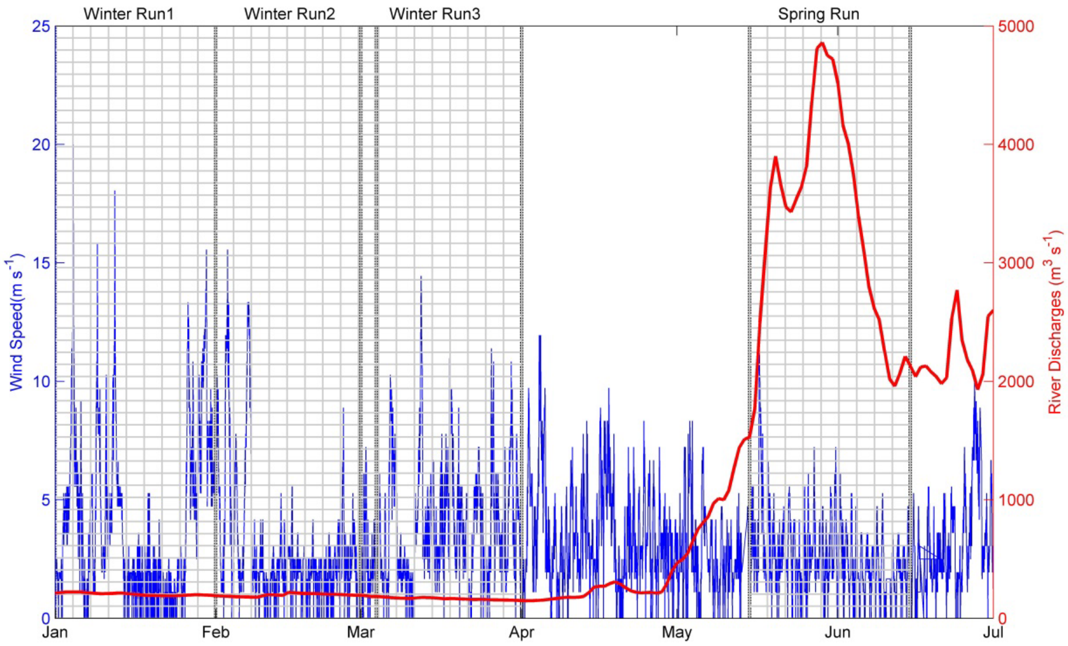


Figure 4: Dredging model runs and associated forcing regimes.

Table 2: Summary of dredging simulations.

Model Runs	Period	Wind	Skeena River Discharges
Winter Run1	Jan 1 – Jan 31	Strong	Non-freshet
Winter Run2	Feb 1 – Mar 3	Weak	Non-freshet
Winter Run3	Mar 1 – Mar 31	Medium	Non-freshet
Spring Run2	May 15 – Jun 14	Weak	Freshet

Table 3: Summary of surface velocities at UTM Easting 415200 m.

Model Runs	Max Flood Flow (m/s)	Max Ebb Flow (m/s)	Difference (m/s)
Winter Run1	1.78	-1.87	-0.09
Winter Run2	1.89	-1.87	0.01
Winter Run3	1.88	-1.90	-0.02
Spring Run	1.70	-1.81	-0.11

Each model run covers a period of 31 full days including 1 day spin-up and 30 days of continuous releasing. Total released fine-grained sediment is about 2.6×10^6 kg in each model run.

2.4 Model Results

2.4.1 Currents in Porpoise Channel

The modeled surface currents in Porpoise Channel along the transect at UTM Easting 415200 were saved in each model run (Table 3). The modeled flow in the channel is dominated by tides, which are relatively weak during the Spring Run. The wind and freshet effects on the currents in Porpoise Channel are apparently minor for these cases.

2.4.2 TSS from Dredging

Based on the Water Quality Guideline (WQG) in BC, the correct criteria to use for “clear flows or in clear waters” (which is the situation we are dealing with) is that an increase of 25 mg/L is allowable if the duration of the increased TSS is 24 hours or less. If the duration of the increased TSS is 30 days (presumably from 24 hours to 30 days or more), then the allowable increase in TSS from background levels is 5 mg/L.

Model-derived TSS distribution patterns during a typical tide cycle are shown in Figures 5-6. The model output data are also provided as ancillary results to this report. For the dredging operations, the maximum TSS values in the water column are always less than 5 mg/L above background in areas away from the dredging area, and generally less than 1 mg/L above background.

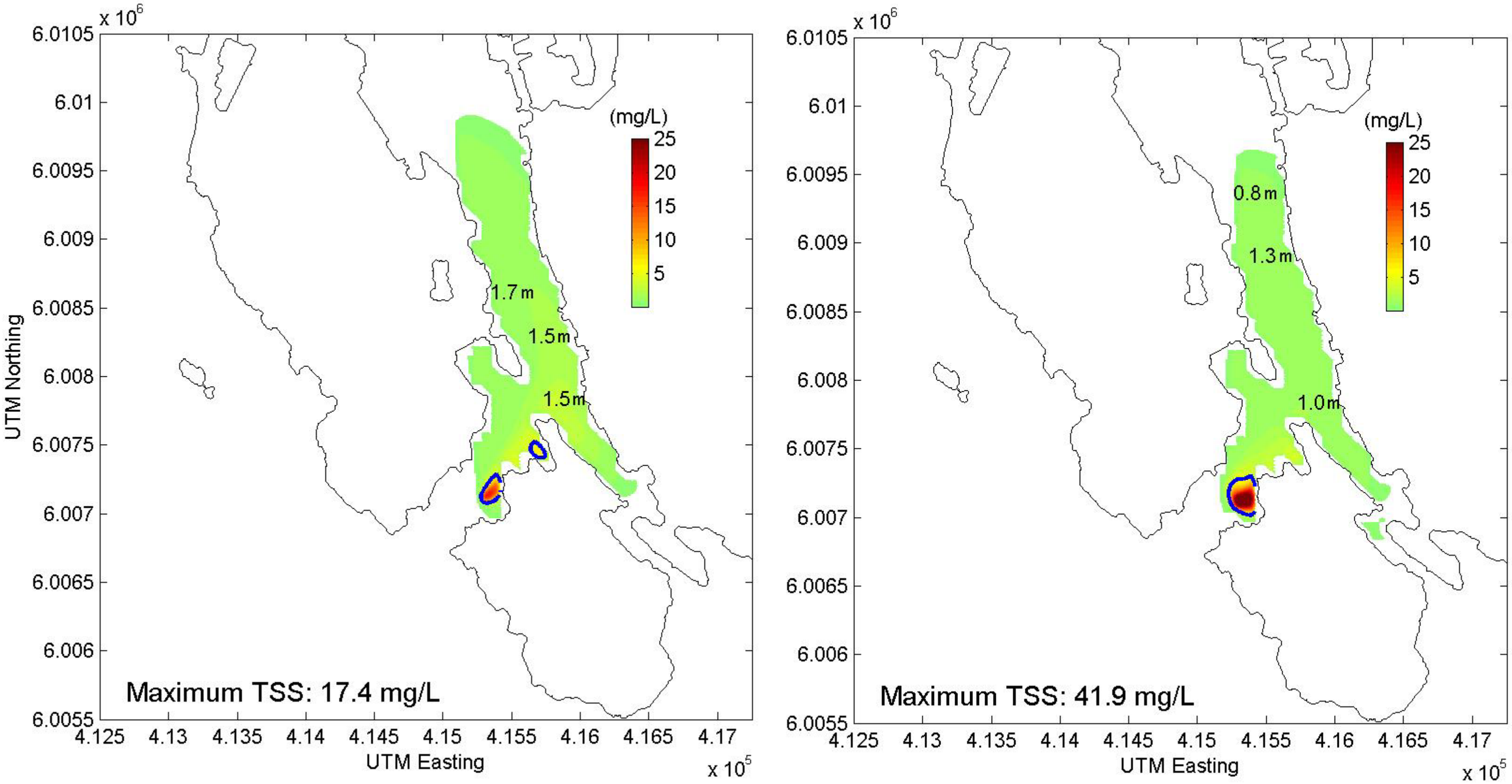


Figure 5: Model-derived TSS (mg/L above background, maximum value in the water column) at flood flow (left panel, 15:00 January 12, 2015) and flood slack (right panel, 18:00 January 12, 2015). Numbers mark depths (above seabed) of maximum values in vertical column. Blue contours present the areas of TSS greater than 5 mg/L.

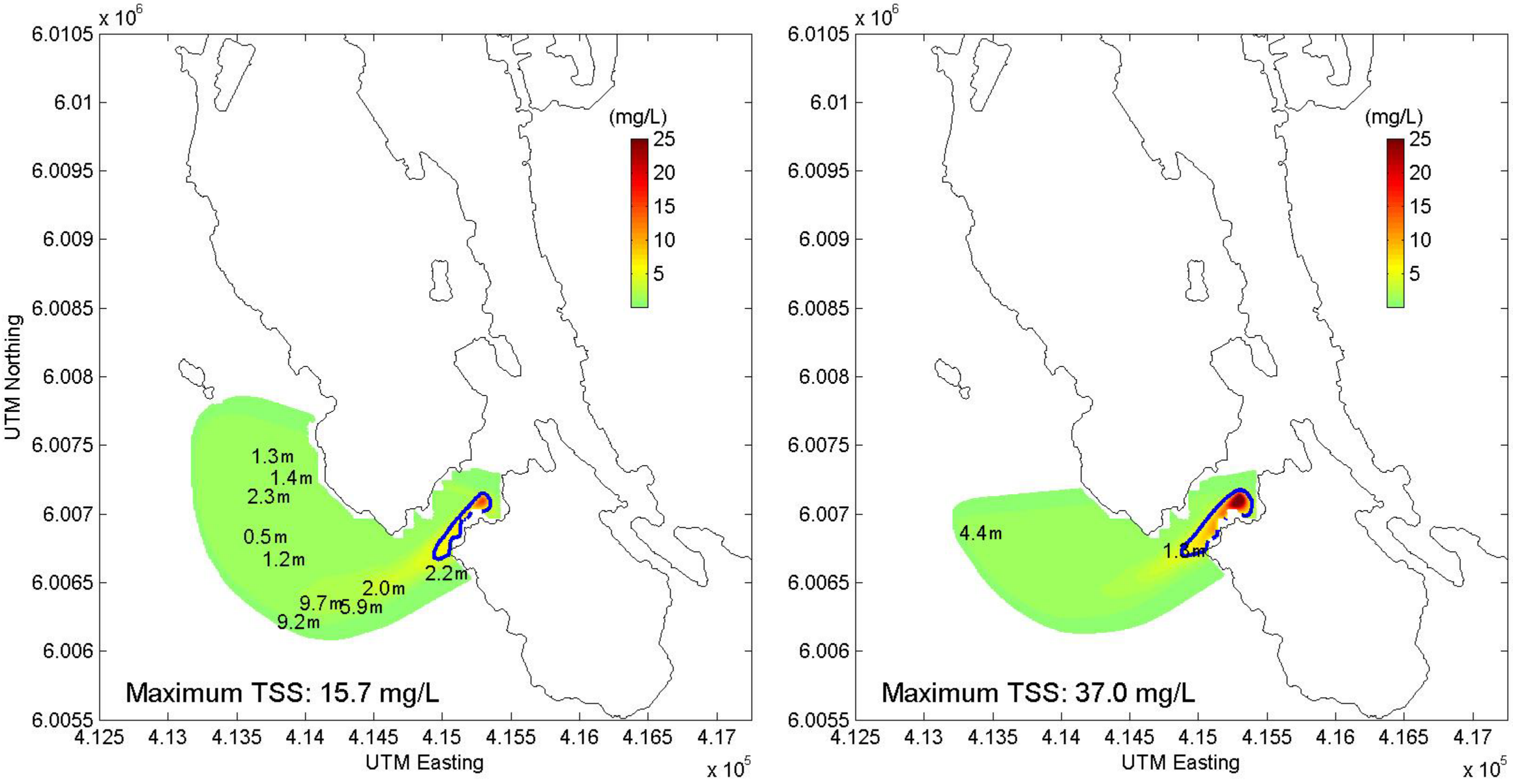


Figure 6: Model-derived TSS (mg/L above background, maximum value in the water column) at ebb flow (left panel, 21:00 January 12, 2015) and ebb slack (right panel, 00:00 January 13, 2015). Numbers mark depths (above seabed) of maximum values in vertical column. Blue contours present the areas of TSS greater than 5 mg/L.

During tidal flood (Figure 5, left panel), the water flows northeastward in Porpoise Channel. The sediment concentration at the dredging site is well diluted due to the strong advection, with a maximum value of 17.4 mg/L at the dredging site. The suspended sediment mainly affects the cove further north to the MOF as marked by the 5 mg/L contours in Figure 5 (left panel). In the next scenario during flood slack, water flow is weak in Porpoise Channel before reversed to ebb flow. The sediment release is concentrated near the dredging site with a maximum TSS about 41.9 mg/L (Figure 5, right panel). During these periods, the suspended sediment drifts to shallower coastal areas and channels, depths of the maximum TSS are close to the bottom (less than 1.7 m) as marked on Figure 5.

During the tidal ebb as shown in Figure 6 (left panel), the water flows southwestward in Porpoise Channel. The current speeds are generally larger than the flood flow (Table 3), consequently the maximum sediment concentration (at the dredging site) is only 15.7 mg/L. The sediment plume extends inland of Porpoise Channel on the flood tide and offshore of Porpoise Channel to within a few kilometers of the coastline in Chatham Sound (Figure 6, left panel). During the ebb slack, water flow is weak and the sediment release is concentrated near the dredging site and the southwest area (Figure 6, right panel). During these periods, the suspended sediment drifts to deeper offshore areas where the maximum TSS can be 9.7 meters above the deep seabed as marked in Figure 6. Suspended sediment can persist longer because of the deep water depths, which enlarge the area of its influence (as marked by the 5 mg/L contours in Figure 6).

2.4.3 Deposited Sediments from Dredging

The predicted deposition of the fine-grained sediment during the four periods is presented in Figures 7-10. The maximum thickness of deposited sediments is 11.3 mm, 10.3 mm, 11.0 mm, and 6.9 mm separately. These peak values are all located near the dredging area at the MOF, where the deposition is assumed to be removed by subsequent dredging operations. Outside of this disturbed area, major sediment deposition locations are largely confined to the northwest coast of Lelu Island, the conjunction zone of channels at the northeast to Lelu Island, and along the southwest coast of Port Edward (Figures 7-10). Overall, sediment deposition levels in these areas are very low: most of them are less than 2 mm, except in the Spring Run, where there is a maximum value of 3 mm deposition at the southwest end of Porpoise Channel (Figure 10).

The predicted deposition also extends to the offshore area, where the maximum amount of deposition is generally less than 1 mm in the areas shown in Figures 7 to 10 inclusive. The sediment is widely dispersed over an extended offshore area in windy conditions (Winter Run 1 and Winter Run 3), up to 3 km to the west of Lelu Island (Figures 7 and 9).

The four one-month study periods cover most of the potential forcing regimes (tides, winds, and river discharges) that would occur from January to June~~,~~ 2015. The distribution patterns are very similar in all cases, especially for the major deposition areas. The final deposition pattern for the full dredging period was calculated in association and shown in Figure 11.

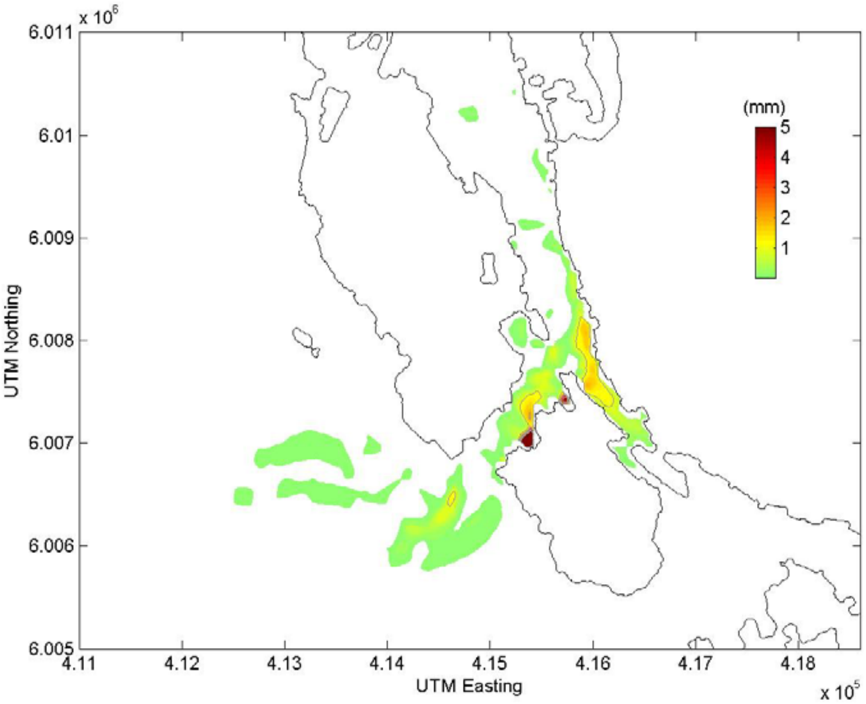


Figure 7: Estimated deposition after 30 days of dredging activity in Winter Run1.

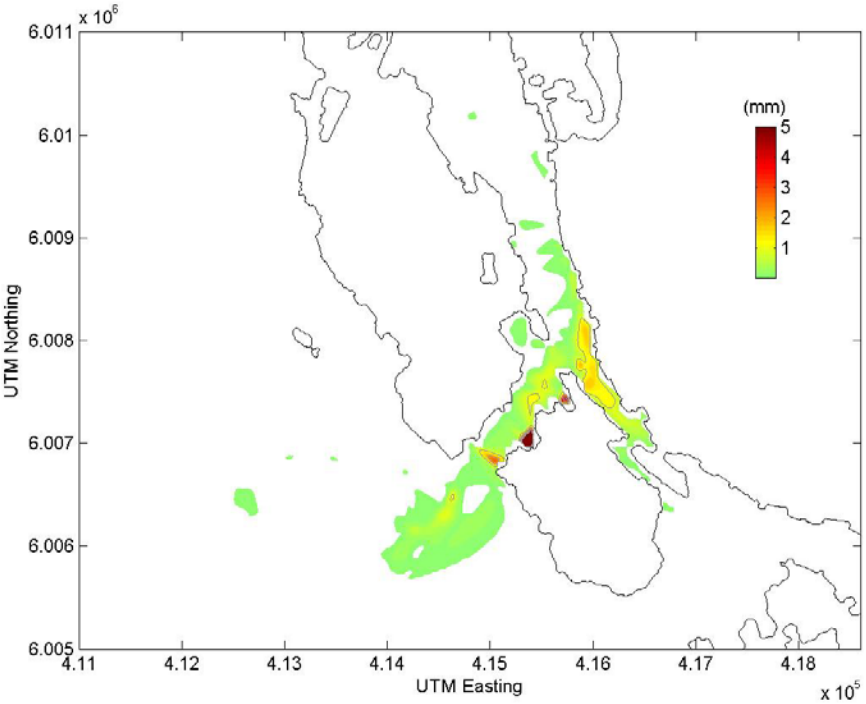


Figure 8: Estimated deposition after 30 days of dredging activity in Winter Run2.

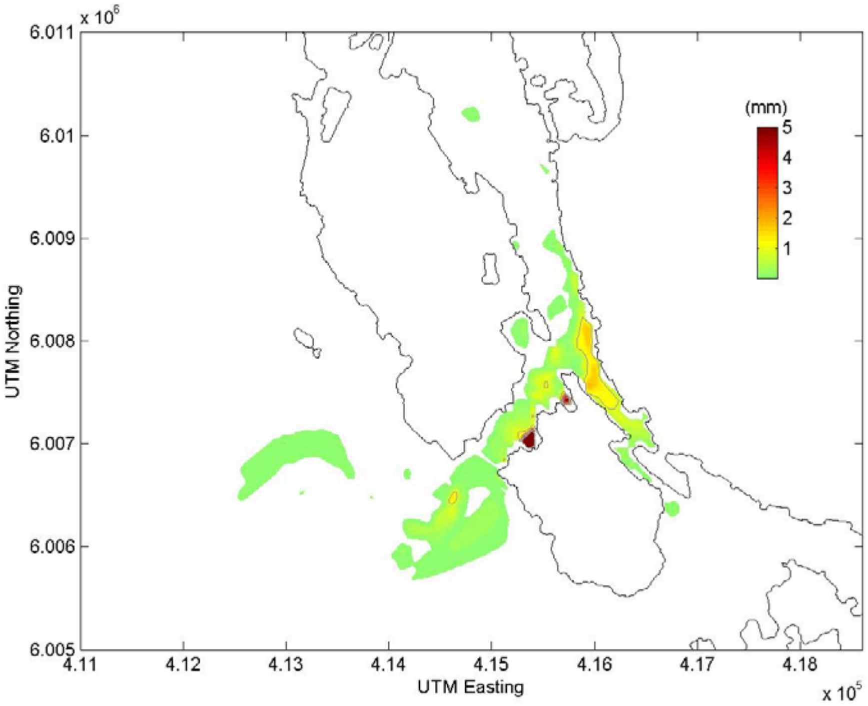


Figure 9: Estimated deposition after 30 days of dredging activity in Winter Run3.

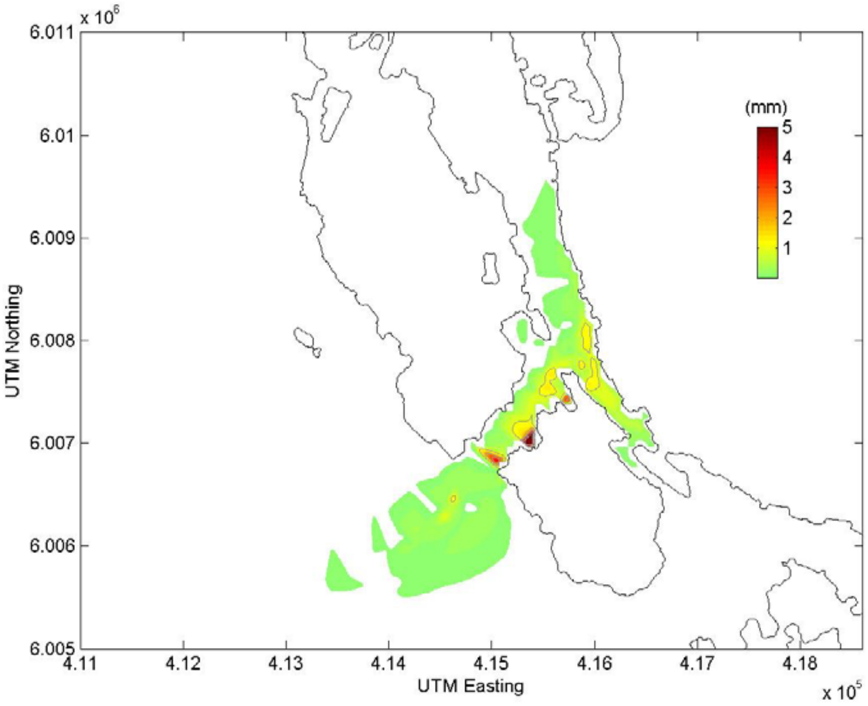


Figure 10: Estimated deposition after 30 days of dredging activity in Spring Run.

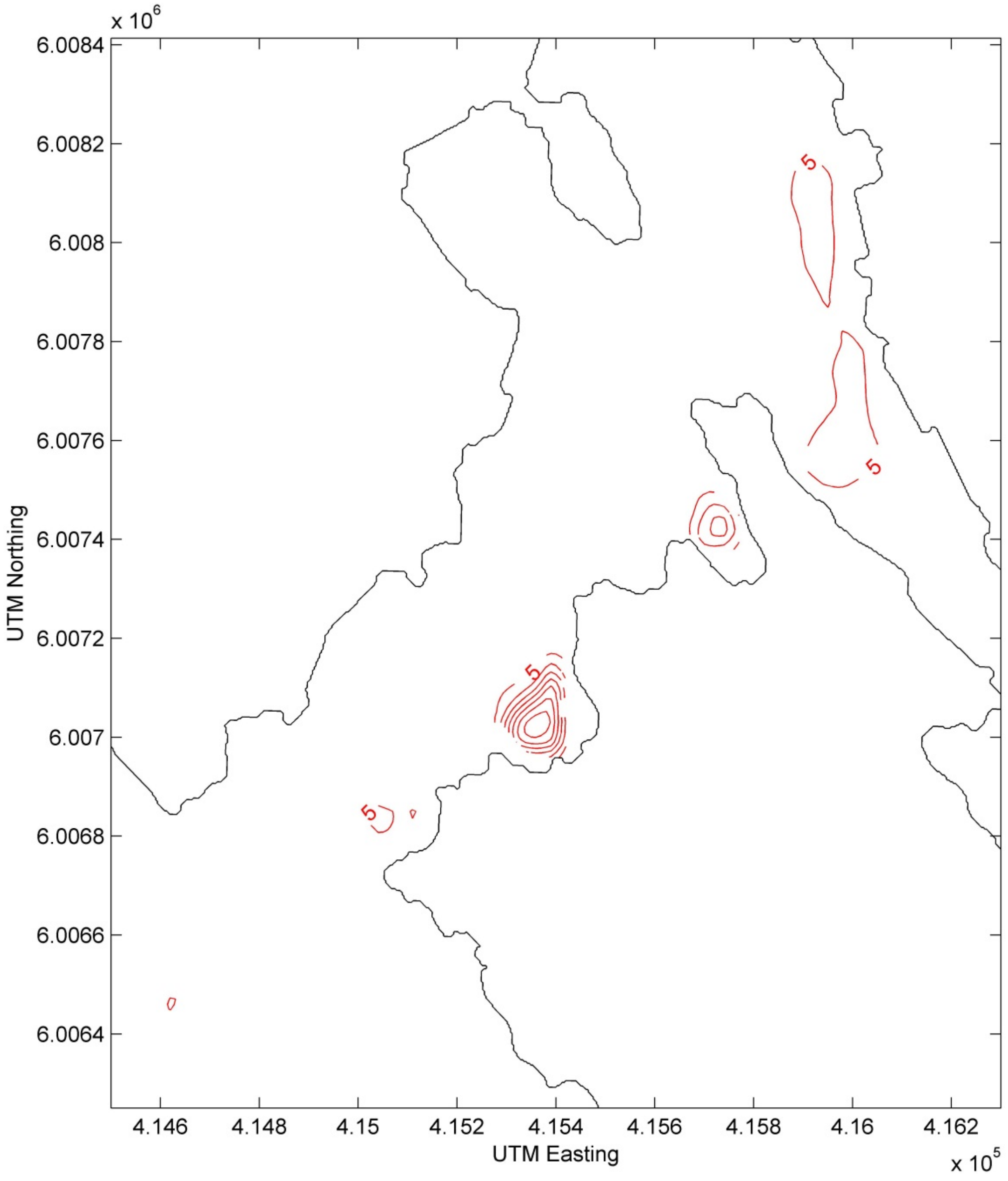


Figure 11: Estimated deposition (mm) after dredging completed. The interval between each contour line is 5 mm.

3.0 DISPOSAL MODELING

In this section, a separate disposal model simulation was adapted to quantify the short-term and long-term transport and fate of the sediments released during and after the disposal operations at the disposal site in Brown Passage. The major oceanographic processes determining the deposition, dispersion and transport of the discharged sediments are the tidal and wind driven currents.

3.1 Model Setup and Description

The COCIRM-SED model for the Brown Passage sediment modeling was set up and validated in the previous study (see details in Jiang and Fissel, 2010). The model was operated over a realistic numerical model domain for the full area of Brown Passage, with a total area of 20.7 km by 29 km (Figure 3). A horizontal grid size resolution of 100 m by 100 m was used for the model area. In the vertical, the model used 22 sigma layers with higher resolutions realized near the surface and bottom. The depths of model layers are computed as (Sigma-layer thickness) × (Total water depth) ($= \Delta\sigma H$). ASL digitized the bathymetric data as shown in Canadian Hydrographic Service nautical charts #3957 and #3959 within the model domain. The digital bathymetric data set, in the format of UTM Easting, UTM Northing and seabed elevation relative to chart datum, was gridded to provide suitable representation of the water depths in the model.

The model was forced at tidal height elevations spanning four open boundaries and by hourly surface winds. The four model open boundaries include the four adjoining sides of Brown Passage (Figure 3). Tidal elevations at these four open boundaries were derived from 7 major tidal height constituents (O1, P1, K1, N2, M2, S2, K2) using the DFO standard tidal prediction program. The tidal constituents for the reference port of Prince Rupert and the secondary port of Lawyer Islands were obtained from CHS. The wind data were obtained from the Prince Rupert airport weather station, operated by Environment Canada. In this study, tidal elevations at open boundaries in 2015 were predicted based on the tidal height constituents. Surface winds are selected in the same representative year of 2009 as in section 2.

The input parameters of the disposal sediment are shown in Table 1, including the disposal sediment categories and size, barge size and capacity, number of disposal trips, and dumping duration. A bulking factor of 1.4 was applied to the model results of deposition.

The dredging disposal will have a total of 205 trips for a duration of 153 days. After completion of all dredging, the model run was continued for another 20 days to let all disposed suspended sediment settle out on the seabed (Jiang and Fissel, 2010). Accordingly, the model simulated the marine dredging disposal from January to late June, 2015.

Immediately following each disposal operation, the short-term fate and near-field distribution of the material released from the barge were modeled using the U.S. Army Corps of Engineers' STFATE (Short-Term Fate of Disposal Material), which is accepted by the U.S. Environmental Protection Agency (EPA and USACE, 1995). The STFATE model operated on a constant bathymetry using an identical model mesh as that used in the 3D model COCIRM-SED, and ran over the initial 45 minutes of the sediment disposal under average flood and ebb currents. The STFATE output provided detailed input information, including deposition and suspended sediment concentrations (SSC) and distribution by categories during the initial disposal operation, to COCIRM-SED, which then simulated the transport and fate of all dredging materials over much larger spatial scales and longer periods of time.

3.2 STFATE Model Results

The STFATE model results show that during the initial 45 minutes of each disposal trip, most of the sand settles out on the seabed, while most of the clay and silt remains suspended in the water column. The suspended sediment is mostly concentrated within 10 m of the bottom and moderately high levels are also predicted at depths around 150 m above the seabed (Figure 12).

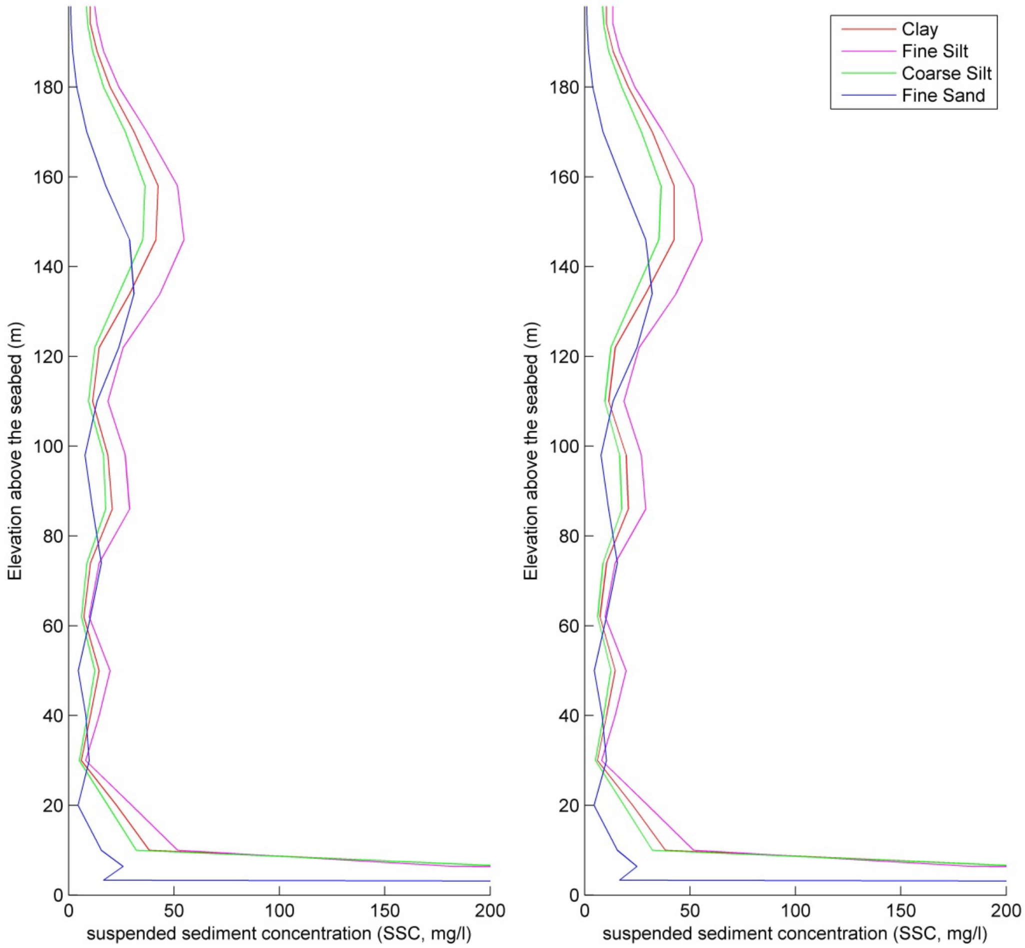


Figure 12: Maximum of SSC profiles after the initial 45 minutes of disposal operations for marine dredging under flood (left panel) and ebb (right panel) current from STFATE model results.

3.3 COCIRM-SED Model TSS Results

The typical COCIRM-SED model results of the TSS plumes at different levels are presented during (Figure 13) and after (Figures 13-14) a disposal operation. Based on the model results, maximum near-bottom (bottom 1% of the water column) TSS values right after a disposal trip can be up to 1103 mg/L above background (Figure 13), which reflects the initial near-bottom TSS as derived from the STFATE model inputs. The high initial near-bottom TSS values are reduced quickly due to sediment settling as well as dilution. A maximum near-bottom TSS value of 45.2 mg/L above background was modeled at about 6 hours after a disposal event (Figure 14). The areas of major TSS plumes are always concentrated near the disposal site for all depths: the maximum TSS values 3 km away from the actual disposal site in any direction are 1.7, 2.5, and 4.3 mg/L at 0, 6, and 12 hours after a disposal operation (below the 25 mg/L water quality guideline for isolated events).

In the vertical dimension, TSS values generally decrease towards the surface. Near-surface TSS during disposal is generally less than 2.0 mg/L. Higher TSS values occur only at the center of the dumping site associated directly with a specific disposal trip (Figure 13). Six hours after disposal, the minimum depth with TSS values greater than 25 mg/L (the BC water quality guideline for background levels for an isolated event) will occur at depths greater than 150 m (Figure 14). After 12 hours, TSS values at all depths and for the entire domain are 10.6 mg/L, well below the 25 mg/L guideline value (Figure 15).

After the completion of all disposal operations, TSS levels in Brown Passage decrease to less than 1 mg/L within few days, as the suspended sediment settles out on the seabed and is further diluted.

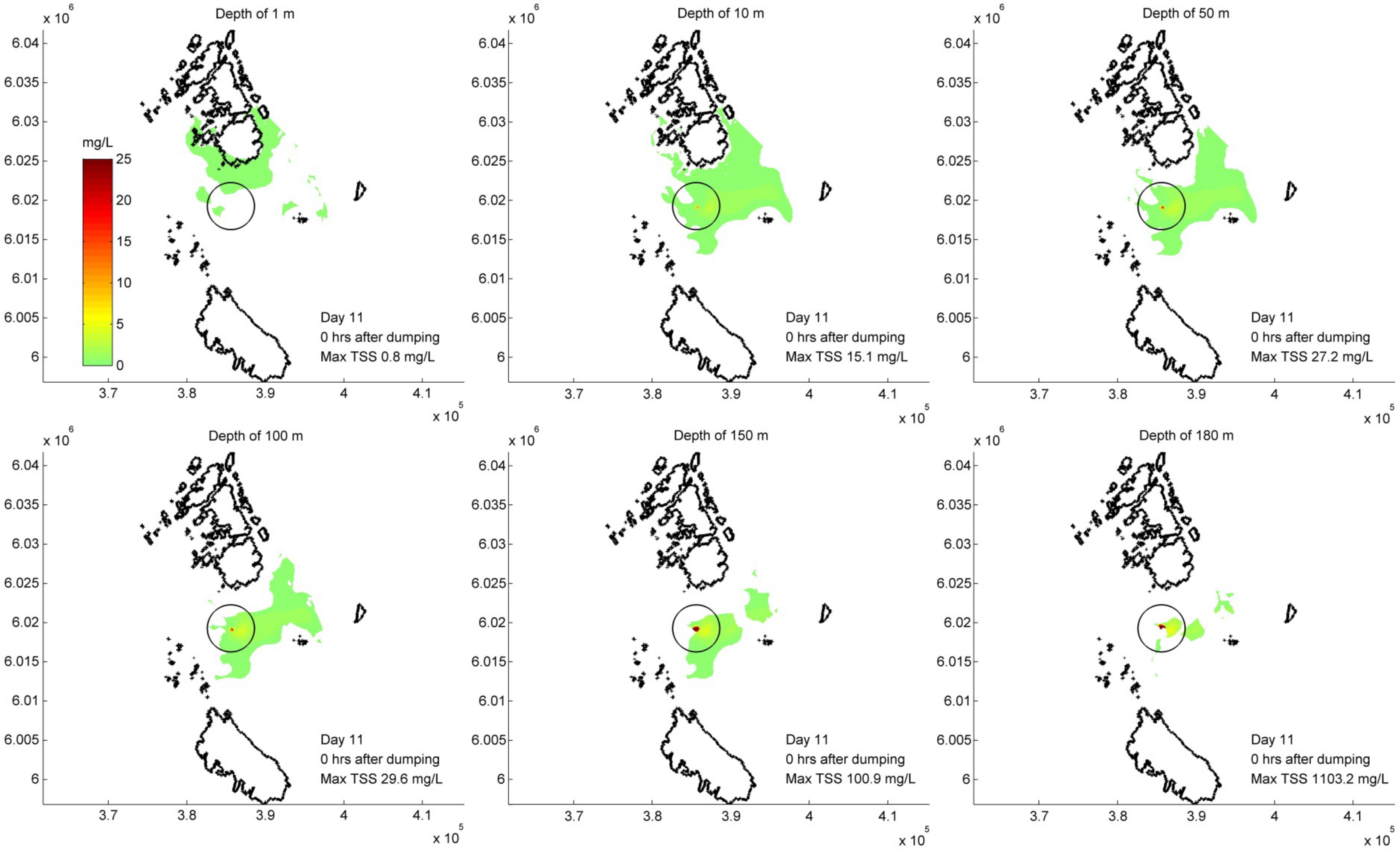


Figure 13: TSS plume at Brown Passage during a disposal trip. The black circle marks the designated disposal area (1 nautical mile in diameter).

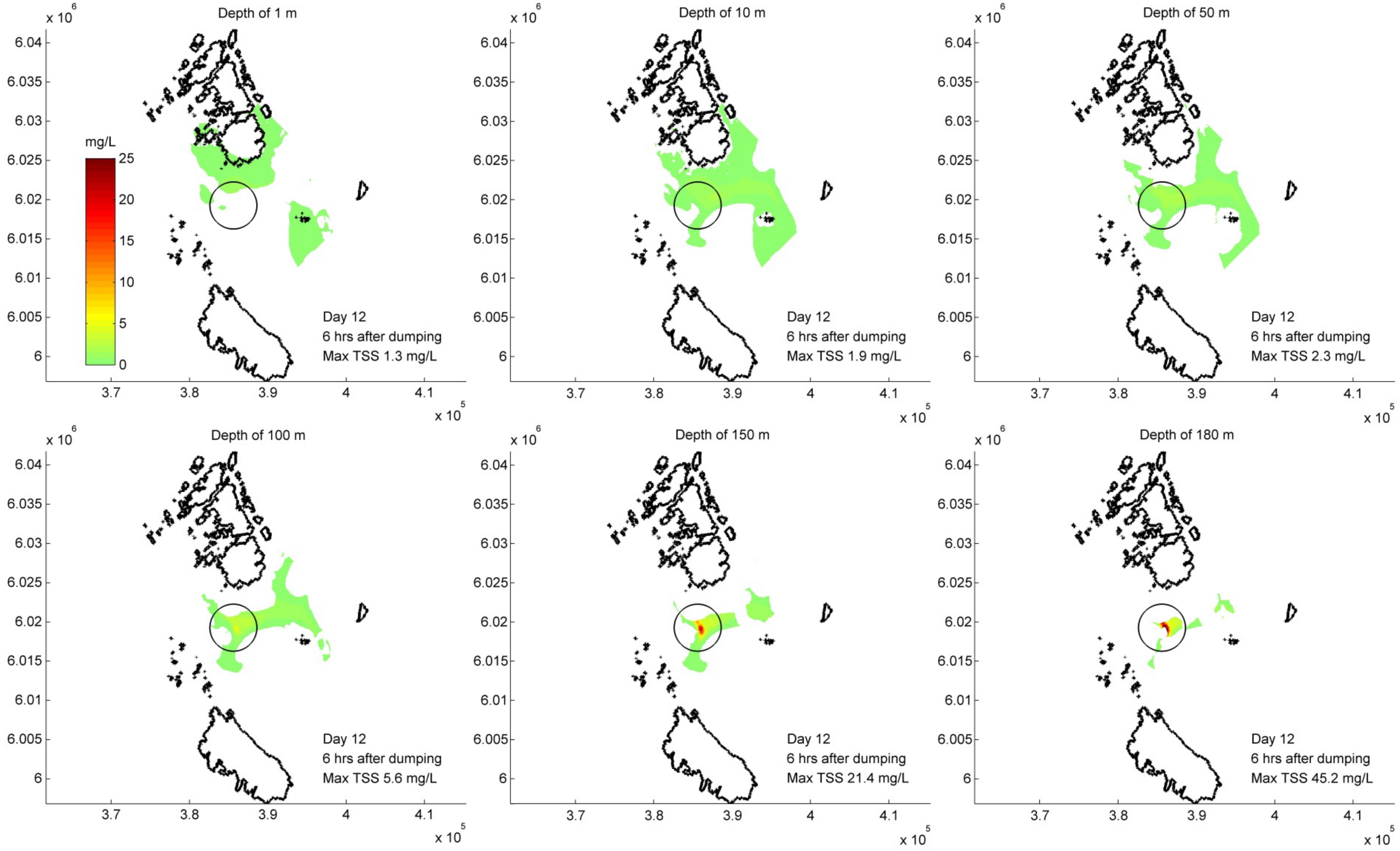


Figure 14: TSS plume at Brown Passage 6 hours after a disposal trip. The black circle marks the designated disposal area (1 nautical mile in diameter).

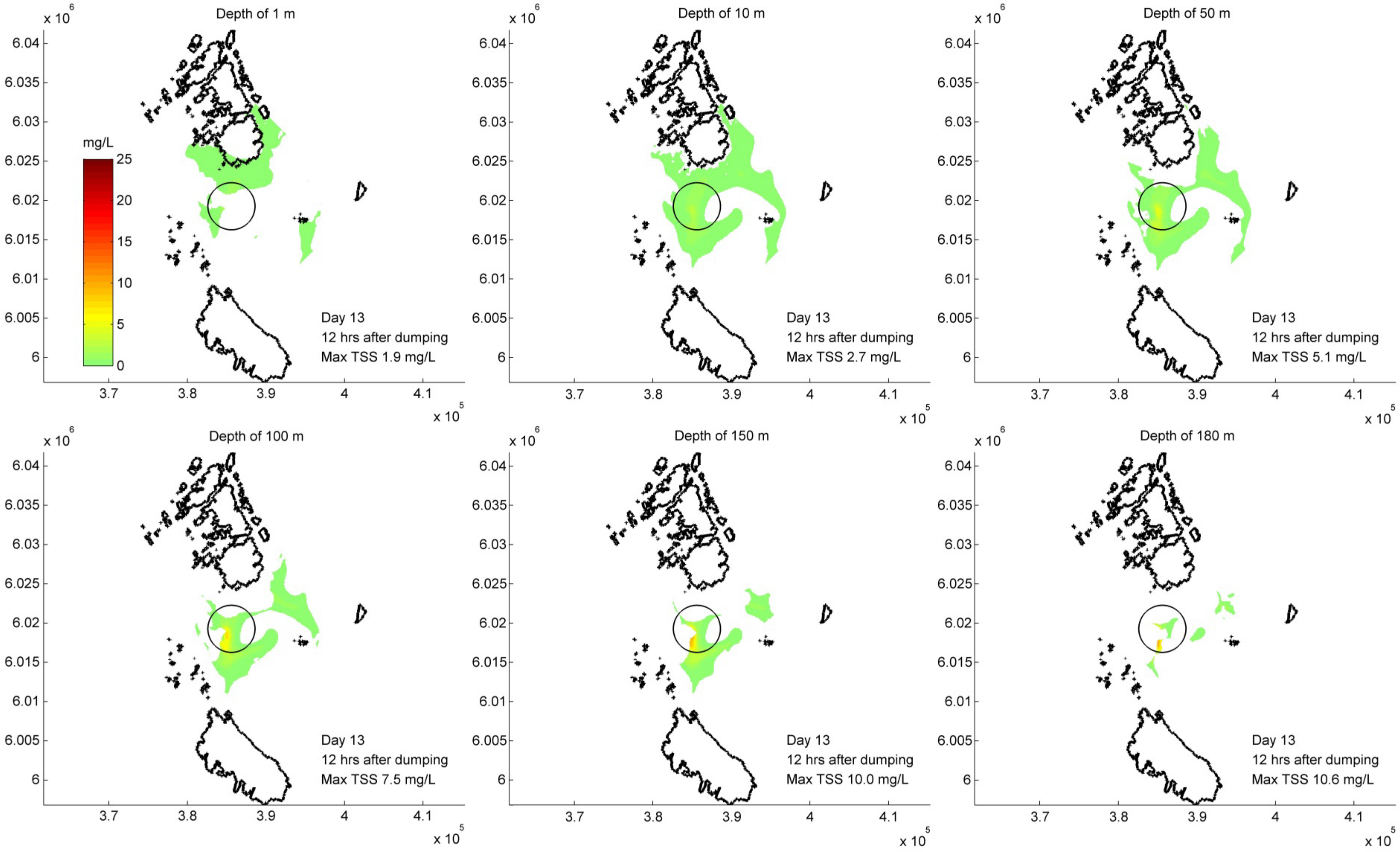


Figure 15: TSS plume at Brown Passage 12 hours after a disposal trip. The black circle marks the designated disposal area (1 nautical mile in diameter).

3.4 COCIRM-SED Model Deposition Results

The total bottom accumulation 20 days following the completion of all dredging disposals is presented in Figure 16. By this time, all suspended disposal sediments will have settled out on the seabed. Most of the dredging materials will be deposited in the deeper water to the southeast of the designated disposal site where water depths are greater than 150 m and where the near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. About 71% of the total volume of dredge material is predicted to be deposited within the designated disposal area (1 nautical mile in diameter), to a thickness ranging from 29 mm to 2.1 m. Most of the region with total bottom accumulation greater than 1 mm will occur in water depths exceeding 100 m.

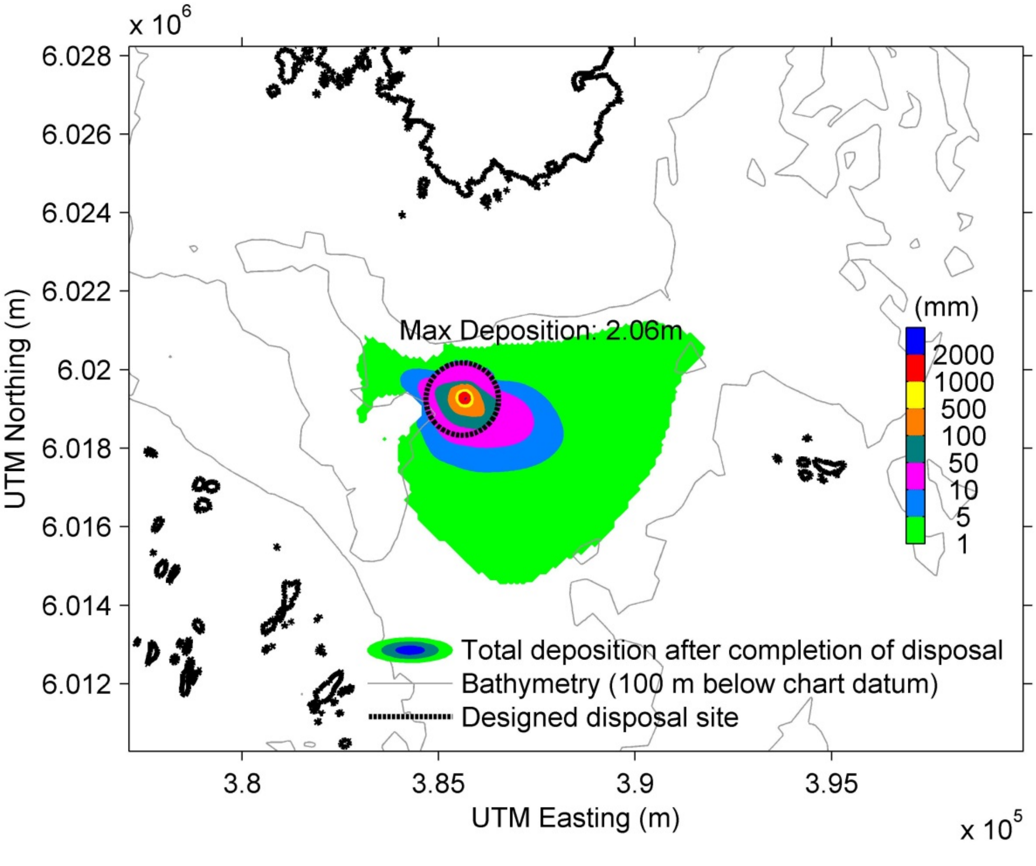


Figure 16: Total bottom accumulation at Brown Passage 20 days after completion of all dredging disposals.

4.0 SUMMARY AND CONCLUSIONS

ASL Environmental Sciences Inc. carried out a 3D numerical modeling study for estimation of potential environmental effects in support of the regulatory approval process for the proposed Pacific Northwest LNG project located at Lelu Island, British Columbia, Canada. The ASL highly-integrated circulation and sediment transport model COCIRM-SED was used for estimating total suspended solids (TSS) and deposition of sediments in Porpoise Channel and off the coast of Lelu Island resulting from dredging operations at the material offloading facility (MOF) and turning basin. A separate COCIRM-SED model was developed and applied for studying the transport and fate of the dredging disposal in Brown Passage.

The COCIRM-SED models are forced at the open boundary conditions by tidal levels. The Skeena River discharge is an input to the inshore COCIRM-SED model. Wind forcing is applied through the surface boundary condition and the stratified water properties within the model are determined from historical DFO CTD water properties data sets. Both COCIRM-SED models were calibrated and validated using comparisons to DFO current meter data sets with overall good agreement between the model and observed currents.

For the dredging operations, the model simulations were conducted separately over four one month long periods from winter to late spring, to reflect the different wind and river discharge conditions. The maximum TSS values in the water column are always predicted to be less than 5 mg/L in areas away from the dredging area, and generally less than 1 mg/L. The elevated TSS values extend inland of Porpoise Channel on the flood tide and offshore a few kilometers from the Lelu Island coastline in Chatham Sound.

The maximum thickness of deposited sediments per month during dredging is predicted to be 11 mm or less. Peak values are all located near the dredging area, where the deposition is assumed to be removed by subsequent dredging operations. Outside of this disturbed area, major sediment deposition locations are largely confined to the northwest coast of Lelu Island, the junction of channels at the northeast to Lelu Island, and along the southwest coast of Port Edward. Overall, sediment deposition levels in these areas are predicted to be very low.

Deposition during dredging is also predicted to extend offshore (typically with 1 mm or less of sediment deposited). The sediment would be widely dispersed over an extended offshore area in the windy cases (Winter Run1 and Winter Run3) up to 3 km to the west of Lelu Island.

Modeling of the transport and fate of sediments arising from disposal of materials in Brown Passage was conducted through a separate COCIRM-SED simulation. High initial near-bottom TSS values (500 mg/L or more above background) are predicted in deep water at the disposal location. But levels will be reduced quickly due to sediment settling and dilution. A maximum near-bottom TSS value of 35 mg/L above background was predicted at about 6 hours after a disposal event. In the vertical dimension, TSS values generally decrease towards the surface, with less than 2.5 mg/L above background generally predicted. Higher near-surface TSS values of about 10.0 mg/L above background are predicted only at the center of the dumping site associated with a specific disposal trip. Consequently, the minimum depth with TSS values greater than 25 mg/L above background (the Water Quality Guidelines for British Columbia) is at depths greater than 0.75 of the total water depth, i.e. 150 m, over the entire disposal period. After the completion of all disposal operations, TSS levels in Brown Passage are predicted to decrease to less than 1 mg/L within a few days, as the suspended sediment settles out on the seabed and is further diluted.

The total bottom accumulation 20 days following the completion of all dredging disposals shows that all suspended disposal sediments will have settled out on the seabed. Most of the dredging materials will be deposited in the deeper water within the southeast area of the designated disposal site where water depths are greater than 150 m and where the near-bottom ocean currents are relatively weak, usually less than 0.2 – 0.3 m/s. About 71% of the total volume of dredge material is predicted to be deposited within the designated disposal area (1 nautical mile in diameter), to a thickness ranging from 29 mm to 2.1 m. The deposition spread within an area outside the disposal site occurs from UTM Easting 383000 m to 391500 m and UTM Northing 6014500 m to 6021000 m (8.5 km × 6.5 km). In this area a thickness greater than 5 mm covers the area from UTM Easting 384000 m to 388200 m and UTM Northing 6017500 m to 6020200 m (4.2 km × 2.7 km). Most of the regions with total bottom accumulation greater than 1 mm will occur in water depths exceeding greater than 100 m.

5.0 REFERENCES

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