



## **Sediment Plume and Deposition Modeling of Removal and Installation of Underwater Electrical Cables on Roberts Bank, Strait of Georgia, British Columbia, Canada**

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### **Abstract**

A three dimensional, integrated numerical model, COCIRM-SED, was applied to predict the sediment plumes and deposition resulting from the removal and installation activities of existing and proposed underwater transmission cables across the Strait of Georgia, British Columbia, Canada. In the model, a total of six sediment categories from fine silt to medium sand were classified and simulated together in terms of sampled sediment characteristics. The model results were obtained with a trenching rate of 300 m/h and two trench sizes, a wide trench of 1.0 m wide × 1.0 m deep and a narrow trench of 0.2 m wide × 1.0 m deep. The amount of sediment that is suspended above the trench was taken to be 30% of the total volume for the wide trench and 25% for the narrow trench. The detailed model results of total suspended sediment values, plumes and depositions are reported in this paper.

### **Introduction**

In order to avoid damage and minimize impacts to the shallow water aquatic environment, the landing portions of submarine electrical cables are usually buried in trenches beneath the seabed using a water-jetting or jet-plow machine. In the case of replacing existing submarine cables, the existing ones have to be removed before installing new ones. During these operations, a fraction of the bottom sediments will be suspended into the water column, and may subsequently be transported and deposited away from the trench areas under the effect of ocean currents. The sediment plumes and siltation associated with these activities are of particular concern to the natural environment, especially potential impacts to fish and aquatic plants, such as eelgrass. In the environmental assessment processes for submarine cable removal and installation, numerical models have become more robust and provide useful tools to quantitatively predict the transport and fate of the suspended sediments, such as total suspended sediment (TSS) concentration, sediment plume expansion, and deposition areas.

A numerical modeling study of the sediment plumes and siltation resulting from the removal and installation activities of existing and proposed submarine transmission cables at landing sites across the Strait of Georgia, British Columbia (BC), Canada, has been carried out by ASL Environmental Sciences Inc. for the British Columbia Transmission Corporation (BCTC) using the three dimensional, integrated numerical model, COCIRM-SED (Fissel, et al., 2006). Due to increasing population and electricity demand on Vancouver Island, BCTC is proposing the

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Vancouver Island Transmission Reinforcement (VITR) Project to upgrade existing 138 kV transmission interconnection circuits between the Arnott Substation in Delta, BC and the Vancouver Island Terminal in North Cowichan, BC (Figure 1). The project consists of replacing one of the two existing 138 kV transmission circuits with a new 230 kV circuit. The proposed new cables will involve four landing sites, including English Bluff Terminal (EBT) at Roberts Bank, Taylor Bay Terminal (TBY) on Galiano Island, Montague Terminal (MTG) on Parker Island, and Maricaibo Terminal (MBO) on Salt Spring Island. To address the environmental assessment requests from the BC Environmental Assessment Office, Fisheries and Oceans Canada (DFO), and other member agencies, BCTC required sediment dispersion modeling for all four landing sites. This paper describes the approach used to model cable removal and installation at these sites, followed by detailed predictions of sediment plumes and depositions associated with the removal and installation of the cables at EBT.

## **Model Approach**

### ***Overview of COCIRM-SED***

COCIRM-SED consists of four integrated modules: circulation, wave, sediment transport and morphodynamics. The circulation module (COCIRM), developed over the past decade (Jiang, 1999; Fissel and Jiang, 2002; Jiang, et al., 2003; Jiang and Fissel, 2004; Jiang and Fissel, 2006), represents a computational fluid dynamics approach to the study of river, estuarine and coastal circulation regimes. The wave module is an adaptation of the third generation, nearshore transformation spectral wave model, SWAN. The sediment transport model involves the dynamics of cohesive and non-cohesive sediment based on multiple size classes. The morphological module solves the bottom elevation variations due to sediment deposition and erosion over different periods. The model explicitly simulates such natural forces as pressure heads, buoyancy or density differences due to salinity, temperature and suspended sediment, river inflow, meteorological forcing, and bottom and shoreline drags. The model applies the fully three-dimensional basic equations of motion and conservative mass transport combined with a second order turbulence closure model (Mellor and Yamada, 1982) for vertical diffusivity and Smagorinsky's formula (Smagorinsky, 1963) for horizontal diffusivity, then solves for time-dependent, three-dimensional velocities ( $u, v, w$ ), salinity ( $s$ ), temperature ( $T$ ), suspended sediment concentrations ( $c_k$ ) and coarse sediment bed-loads ( $q_k$ ) by size category, turbulence kinetic energy ( $k$ ) and mixing length ( $l$ ), horizontal and vertical diffusivities ( $K_h, K_v$ ), water surface elevation ( $\zeta$ ), 2D wave spectra ( $S$ ), wave forces ( $F$ ), and bottom elevation variations ( $\Delta h$ ).

### ***COCIRM-SED Implementation for VITR Landing Sites Modeling***

The COCIRM-SED model for the VITR project operated on two different spatial scales: the basin and local scales. The basin scale model was required to capture the length and time scales of the basic forcing mechanisms of currents, waves and the large inflow of Fraser River water. The larger, basin scale consists of the Strait of Georgia and western part of Juan de Fuca Strait. In the areas beyond the cable landing sites, a horizontal grid size of 500 m by 500 m was used, while near the

landing sites (within a nested domain of approximately 6 km by 4 km), the horizontal resolution was reduced to 50 m by 50 m. The 500 m and 50 m model grids were 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 (Jiang, et al., 2003). The model results of currents ( $u, v, w$ ), water levels ( $\zeta$ ), and eddy diffusion coefficients ( $K_h, K_v$ ) in the nested grids (with a horizontal resolution of 50 m by 50 m) were saved as inputs for the local scale models.

The smaller, local scale models at four cable landing sites were required to realistically resolve the small scale of cable removal and installation activities and subsequent dispersion of suspended sediments. The local domains (with an area of approximately 6 km by 4 km) thus operated at a much higher horizontal resolution with a grid size of 10 m by 10 m. The 50 m by 50 m basin model results of currents, water levels, and horizontal diffusivities were interpolated to the 10 m by 10 m local scale grids, and the sediment transport module of COCIRM-SED was then used to provide a high resolution representation of the sediment dispersion and deposition for the simulation of sediment releases from the cable removal and installation activities.

Both basin and local scale models used 13 vertical sigma layers with a higher resolution near the surface to account for salinity and temperature stratification effects. High resolution bathymetric survey data, collected for the project along the underway segment of the cable right-of-way by Terra Remote Sensing Inc., was obtained at a resolution of 10 m or better and gridded to provide suitable representation of the water depths in the model.

The basin model was at first validated using available water level and current data (Birch, et al., 2005). In addition to the model calibration and validation carried out by Jiang and Fissel (2006), the model was validated in the areas near each landing site using predictions of tidal water levels and currents based on tidal analyses made available by the Canadian Hydrographic Service of the Department of Fisheries and Oceans (DFO; F. Stephenson, Manager Geomatics Engineering, Canadian Hydrographic Service, pers. comm., 2006).

The basin model was forced at three open boundaries and one major river input (Fraser River). The three open boundaries include western Juan de Fuca Strait, Discovery Passage at Campbell River and Puget Sound at Port Townsend. The model runs were simulations of currents and sediment transport in the latter half of August 2008, when the cable installation is scheduled. Tidal predictions of water levels for August 2008 were derived for the three open boundaries and used for the open boundary conditions. The Fraser River inflow and temperature were taken as the average values for the month of August. The initial water properties (temperatures, salinities and densities) within the model domain and at the boundaries were derived via historical monthly average vertical distributions from Crean and Ages (1968) and from the on-line DFO database for BC coastal waters ([www-sci.pac.dfo-mpo.gc.ca/osap/searchtools/displayrange\\_e.htm](http://www-sci.pac.dfo-mpo.gc.ca/osap/searchtools/displayrange_e.htm)).

### ***Sediment Inputs to Ocean from Project Activities***

Removal of the cable in the shallow subtidal zone will be carried out by raising the cable from a shallow water barge during high tide. The cable will be pulled

upward using an onboard winch and the vertical force applied to the cable should release it from the seabed, in which case the disturbance to bottom sediments will be limited. However, if the cable does not release over the shallow water portions of the route, divers will cut a trench in the bottom to facilitate release of the cables. This could result in a trench about 1.0 m deep by 1.0 m wide. It is assumed that trenching will be required over the total length of the existing cable from the chaseway to -3 m LLW water depth, and 30% of the volume of the sediment in the trench will be released above the seafloor into the water column. This is a very conservative assumption since the disturbance is likely to be minimal where cables are buried only a small distance below the seafloor and can be simply winched off the bottom. The rate of cable removal is taken to be 600 m/h.

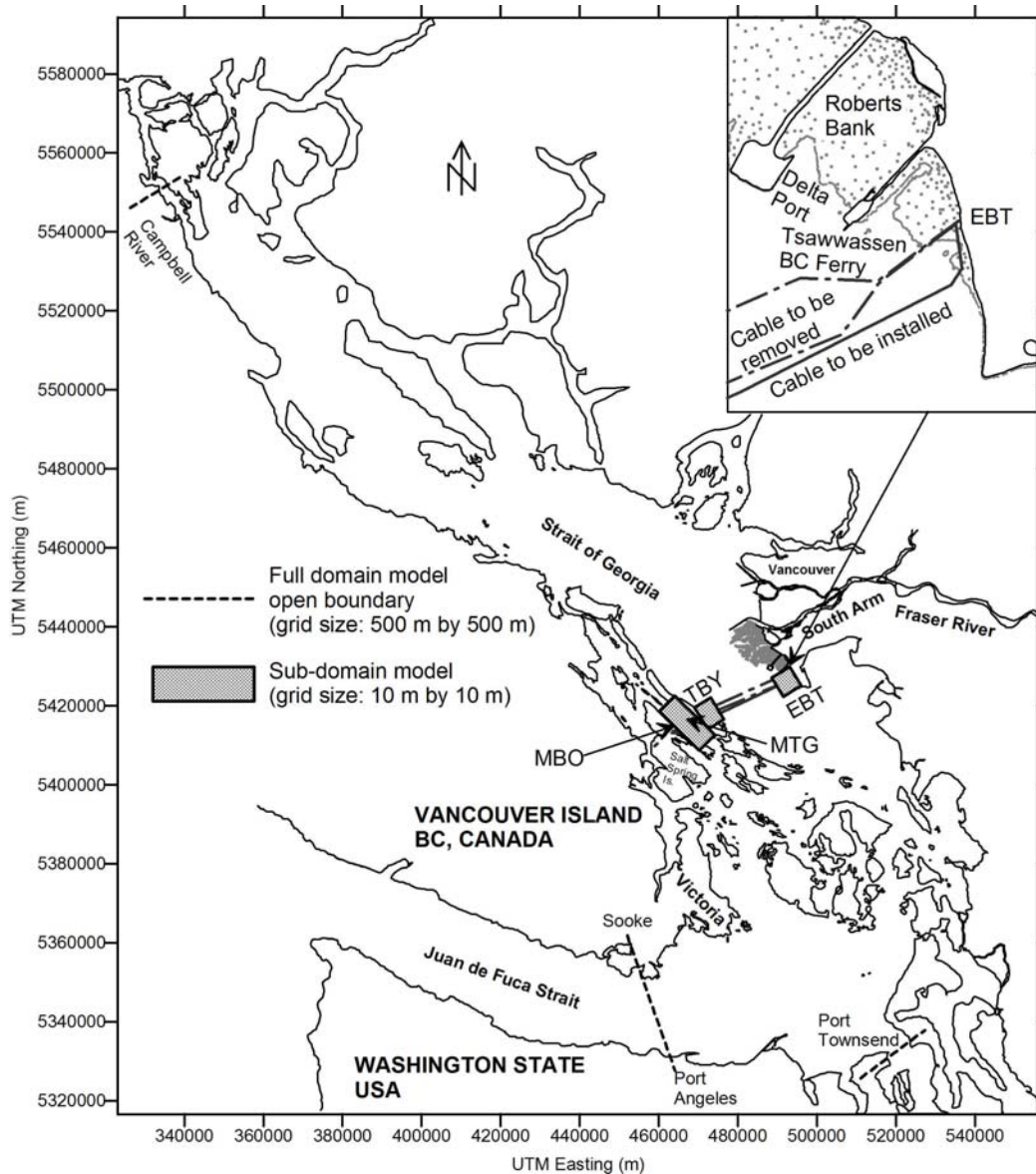


Figure 1. The study area showing existing and proposed new underwater transmission cables, and the COCIRM-SED basin scale domain and the high resolution sub-domains at EBT, TBY, MTG and MBO landing sites.

Installation of the cable between the lower end of the covered chaseway and -3 m LLW involves burial to 1.0 m depth. For this portion of the route, it is proposed to bury the cables using a water-jetting or jet-plow machine. This operation involves creating a trench 1.0 m deep by 0.2 – 1.0 m wide at an installation rate of 300 – 1,200 m/h. The trench would extend from the chaseway to the -3 m LLW water depth, a total length of about 1.8 km at EBT. The model results were obtained with two trenching rates, a fast rate of 1,200 m/h and a slow rate of 300 m/h (only the 300 m/h results are presented in this paper), and two trench sizes, a wide trench of 1.0 m wide  $\times$  1.0 m deep and a narrow trench of 0.2 m wide  $\times$  1.0 m deep. The amount of sediment that is suspended above the trench was taken to be 30% of the total volume for the wide trench and 25% for the narrow trench, which were provided by BCTC.

The fate of the suspended sediments depends on the type of surficial sediments present at each of the four landing sites and ambient flow conditions. Sediment types were identified based on sediment sampling data (Jacques Whitford, 2006) and a literature search (McLaren and Ren, 1995; Barrie and Currie, 2000; Golder Associates, 2005; Barrie et al., 2006). In general, sediment types are dominated by sands with very small amounts of silt and clay, but there is a considerable amount of variability among the landing sites. At the EBT landing site, a total of six sediment categories, with grain sizes ranging from fine silt to medium sand (Table 1), were identified and simulated together in the model. Details of simulating sediment settling, erosion, deposition and particle interaction, etc., were described in Jiang and Fissel (2006).

Table 1. Sediment categories at EBT landing site.

Category No.	1	2	3	4	5	6
Geometric mean size (mm)	0.0060	0.0312	0.0892	0.1261	0.1936	0.3260
Average fraction (%)	4.4	6.1	7.0	18.2	59.4	4.9

Once in suspension, the distribution of the sediment with depth varies according to the sediment type and flow conditions. The initial vertical distribution of suspended sediments in the water column was approximated using the Rouse sediment concentration profile (Rouse, 1939)

$$c_z = c_a \left[ \frac{a(H-z)}{z(H-a)} \right]^{w_s / \beta \kappa u_*} \quad (1)$$

where  $c_z$  is the concentration of the suspended sediments at height  $z$  above the seabed,  $c_a$  is the concentration at the reference height  $a$ ,  $a = \max(0.01H, k_s)$  with  $k_s$  representing the equivalent Nikuradse roughness height,  $H$  is the flow depth,  $w_s$  is the settling velocity,  $\beta$  is a proportionality coefficient taken to be 1,  $\kappa$  is von Karman's constant (assumed to be 0.4), and  $u_*$  is the shear or friction velocity, which is estimated from the water-jetting strength. The shear velocity  $u_*$  was approximately taken as 0.1 m/s based on the experience of turbulence strength driven by the water-jetting activity. The reference sediment concentration  $c_a$  was determined in terms of mass conservation of initially suspended sediment in the water column. The Rouse function eq. (1), used for the initial distribution of the suspended sediments in the water column, is a conservative assumption since in reality the sediments suspended by the water-jetting activities might be more concentrated near the bed and the sediment plume would be consequently dispersed in a smaller area than the model prediction.

## **Model Results**

In this section, the detailed model predictions of sediment plumes and depositions associated with the removal of one existing cable and installation of one new cable at EBT on Roberts Bank (Figure 1) are presented. Simulations of removal and installation start at the time of high tides in August 2008. The modeling of the removal of the existing cable involved a total route length of about 400 m, corresponding to a removal time of 40 minutes at the removal rate of 600 m/h. The installation of the new cables follows a shallow water route parallel to the shoreline over a distance of more than 1 km before turning offshore, as shown in Figure 1, with a total route length of about 1.8 km. The modeled results with a trenching rate of 300 m/h are reported in this paper for the wide and narrow trenches. At this slow trenching rate, the entire cable route could not be installed on a single tidal cycle, and the installation would have to be completed on the following high tide. Installation is carried out for about 3 hours during each of the two tidal cycles.

TSS concentrations are shown at the surface and bottom levels. In the tabulated results, maximum TSS and areas having TSS values exceeding 25 and 75 mg/L are provided. Background levels of 25 to 50 mg/L, and more during freshet (snow melting from May to August), are expected to occur in the Fraser River plume and the shallow portions of the Fraser River delta (Jiang and Fissel, 2006). The 75 mg/L TSS value is used as criteria when considering possible effects of turbidity in freshwater environments (Chilibeck, et al., 1992).

### ***Cable Removal***

While the removal activity is underway, maximum TSS values exceeding 31,000 mg/L are predicted to occur in the immediate vicinity of the trenching activities at the near-bottom level. At the surface level, the maximum TSS values may exceed 1,200 mg/L (Table 2). However, these very high TSS values are limited to distances within 10 m of the activity and the TSS levels rapidly decrease to well below 2,000 mg/L at the bottom level and below 300 mg/L at the surface level within 50 m distance of the instantaneous activity location (Figure 2). Note that the released sediments are initially diluted in the basic 10 m by 10 m model grid. The model may under-predict the maximum TSS value at the instantaneous activity location because the peak concentrations at the 1 m wide trench are averaged over a 10 m model grid cell. The areas having TSS levels above 25 mg/L are small at  $<0.10 \text{ km}^2$  immediately after the completion of the cable removal. Following completion of the removal operation, the maximum TSS concentrations decrease very rapidly, as the dominant sand categories quickly settle out to the bottom. The near-bottom area of TSS values greater than 25 mg/L increases via mixing to  $0.11 \text{ km}^2$  after 2 hours from the initiation of removal; by 3 hours and later after removal, the area with TSS levels above 25 mg/L is essentially zero. The areas having TSS levels above 75 mg/L are very small at  $<0.07 \text{ km}^2$  during the removal operation and quickly drop down to zero after 2 hours and longer.

The deposition thickness from the cable removal process is less than 4.1 cm. Again, the basic 10 m by 10 m model grid resolution essentially spreads the deposition within the entire grid cell, and in reality there could be higher deposition

within the grid cells along the cable route which the model cannot resolve. The total area having a deposition exceeding 1 cm is confined to within 1 – 2 model grid cells, or 10 – 20 m from the center of the removed cable (not shown), amounting to a total area of less than 0.01 km<sup>2</sup>.

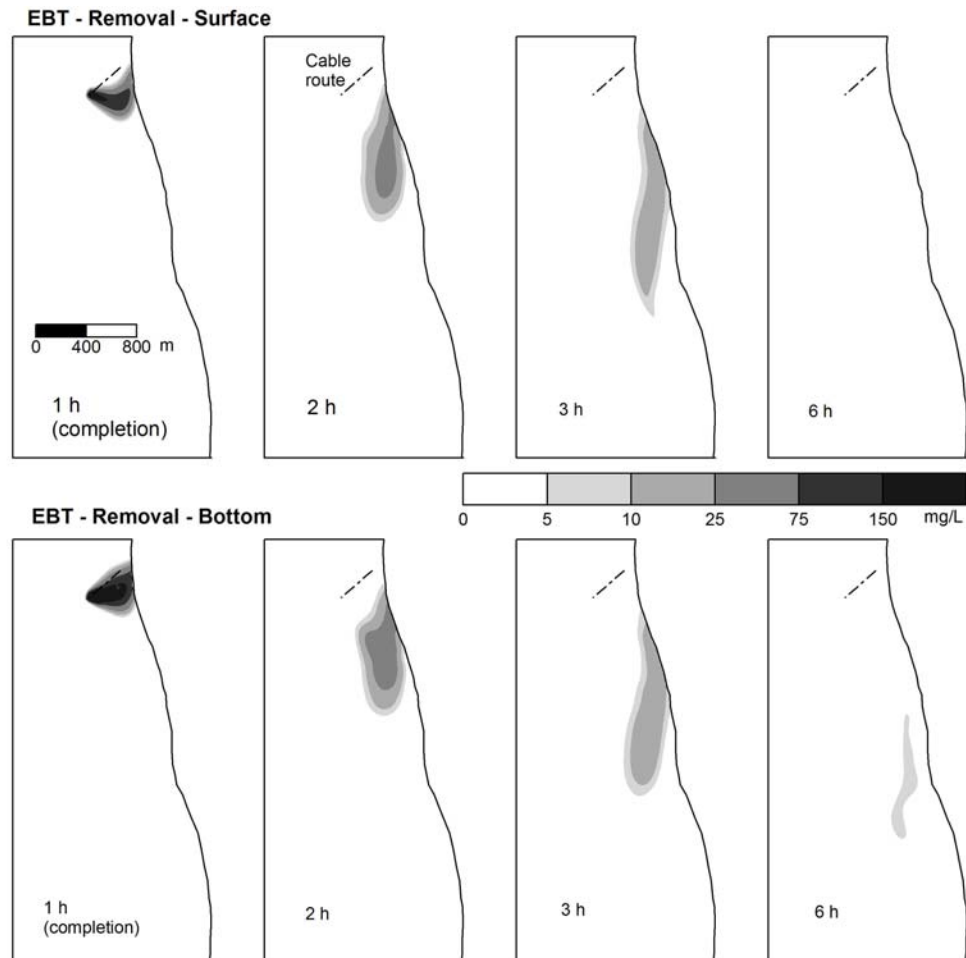


Figure 2. Sediment plumes associated with cable removal at EBT.

Table 2. Summary of TSS and plume areas for cable removal at EBT.

Elapsed time (hours)	Maximum TSS (mg/L)		Area of TSS >25 mg/L (km <sup>2</sup> )		Area of TSS >75 mg/L (km <sup>2</sup> )	
	bottom	surface	bottom	surface	bottom	surface
0.5	31,188.8	1,515.0	0.016	0.013	0.013	0.010
1	27,947.6	1,242.2	0.091	0.071	0.065	0.036
2	51.3	36.7	0.108	0.078	0.000	0.000
3	23.2	20.5	0.000	0.000	0.000	0.000
6	5.9	4.5	0.000	0.000	0.000	0.000
12	1.3	1.2	0.000	0.000	0.000	0.000

***Cable Installation with Wide (1 m) Trench***

On the first day while the installation activity is underway, predicted maximum TSS values range from 10,000 to 20,000 mg/L near the bottom and from 500 – 1,800 mg/L near the surface (Table 3). However, these very high TSS values only occur within 10 m or so of the water jetting activity, and the TSS levels rapidly decrease to well below 1,000 mg/L near the bottom and below 500 mg/L near the surface less than 50 m from the instantaneous activity location (Figure 3). Again within the cable route grids, the model may under-predict the maximum TSS values because sediment concentrations are averaged over a model grid cell. The greatest extent of area having TSS levels above 25 mg/L are again relatively small at <0.26 km<sup>2</sup> at 3 hours after the initiation of installation. Following completion of the installation activity on the first day, the maximum TSS concentrations decrease very rapidly with time, as the dominant sand categories quickly settle to the bottom. The area with TSS values greater than 25 mg/L at the bottom is predicted to be 0.10 km<sup>2</sup> after 6 hours from the onset of installation and down to zero after 12 hours and longer. The areas at the surface with TSS values greater than 25 mg/L are usually smaller than at the bottom, and are essentially zero after 6 hours and longer. The areas having TSS levels above 75 mg/L are very small at <0.12 km<sup>2</sup> during the installation operation on the first day and quickly drop down to zero after 6 hours and longer.

On the second day of installation, the TSS values are expected to decrease as the installation activity moves offshore into deeper water. The predicted maximum TSS values range from 8,000 to 13,000 mg/L near the bottom and from 400 to 1,000 mg/L near the surface (Table 4). Again, these high TSS values are limited in the immediate vicinity of the water jetting activity within 10 m or so (Figure 4). The areas having TSS levels above 25 mg/L are <0.10 km<sup>2</sup> at 3 hours after the resumption of installation. Following completion of the installation activity on the second day, the maximum TSS concentrations decrease very rapidly with time, due to the dominant sand categories quickly settling to the bottom. The model reveals no areas with TSS values greater than 25 mg/L at both bottom and surface after 6 hours and longer. The areas having TSS levels above 75 mg/L are very small at <0.04 km<sup>2</sup> during the installation activity on the second day and drop quickly down to zero after 6 hours and longer.

Table 3. Summary of TSS and plume areas for the first day wide trench installations at EBT.

Elapsed time (hours)	Maximum TSS (mg/L)		Area of TSS >25 mg/L (km <sup>2</sup> )		Area of TSS >75 mg/L (km <sup>2</sup> )	
	bottom	surface	Bottom	surface	bottom	surface
0.5	13,037.0	1,322.7	0.039	0.033	0.030	0.023
1	19,717.4	1,768.9	0.083	0.064	0.055	0.038
2	11,729.5	869.4	0.154	0.163	0.075	0.069
Completion (2 h 58 min)	10,857.6	560.9	0.261	0.255	0.115	0.099
3	762.6	191.5	0.264	0.255	0.115	0.095
6	37.1	23.4	0.097	0.000	0.000	0.000
12	4.9	2.4	0.000	0.000	0.000	0.000

The deposition thickness from the cable installation is less than 5.5 cm. As explained above, in reality there could be higher deposition which the model cannot resolve, within the 10 m model grid immediately along the cable route. The total area



having a deposition exceeding 1 cm is confined to within 1 – 2 model grids of the installed cable, or 10 – 20 m from the center of the trench (Figure 5), amounting to a total area of around 0.03 km<sup>2</sup>. The average deposition thickness within the region where the deposition is greater than 1 cm is about 1.9 cm.

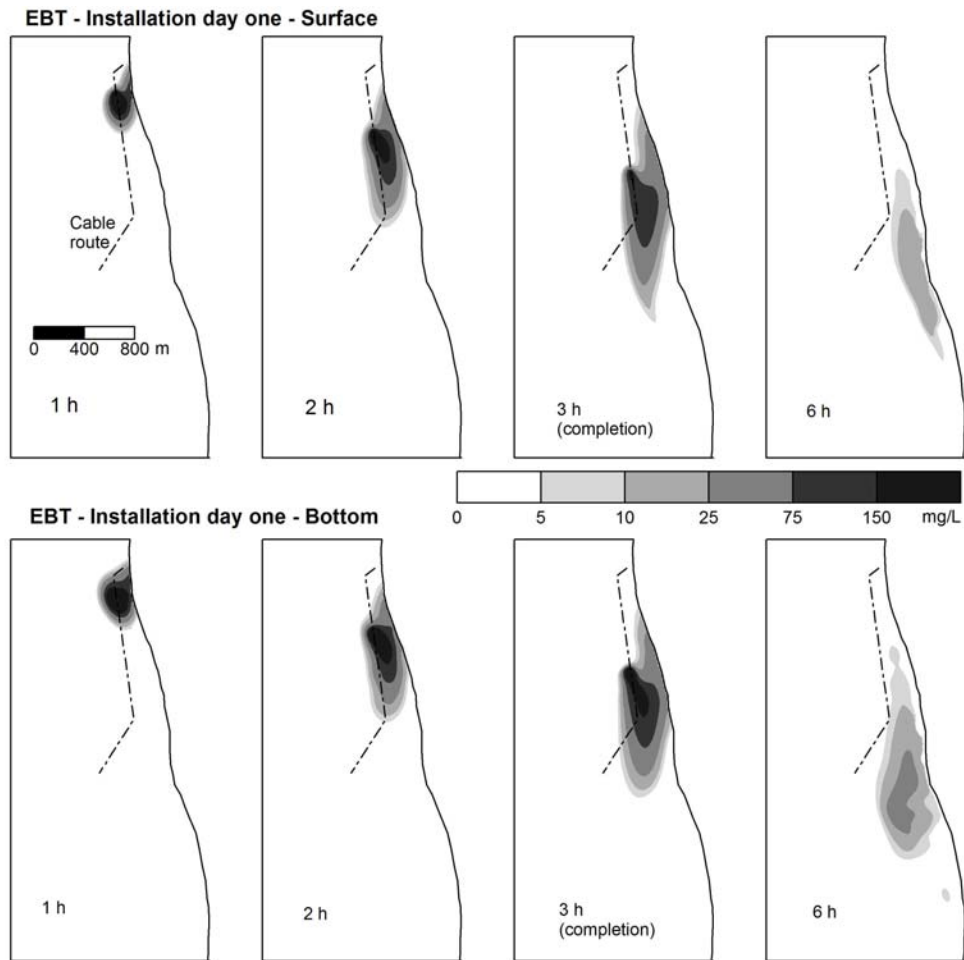


Figure 3. Sediment plumes from the first day of wide trench installations at EBT.

Table 4. Summary of TSS and plume areas for the second day of wide trench installations at EBT.

Elapsed time (hours)	Maximum TSS (mg/L)		Area of TSS >25 mg/L (km <sup>2</sup> )		Area of TSS >75 mg/L (km <sup>2</sup> )	
	bottom	surface	bottom	surface	bottom	surface
0.5	8,154.8	523.6	0.022	0.018	0.011	0.008
1	12,570.0	489.8	0.038	0.039	0.016	0.015
2	9,590.7	399.5	0.056	0.044	0.018	0.003
Completion (2 h 58 min)	9,857.0	1,026.0	0.098	0.055	0.038	0.015
3	1,383.6	230.7	0.100	0.056	0.039	0.014
6	24.4	10.6	0.000	0.000	0.000	0.000
12	4.0	2.2	0.000	0.000	0.000	0.000

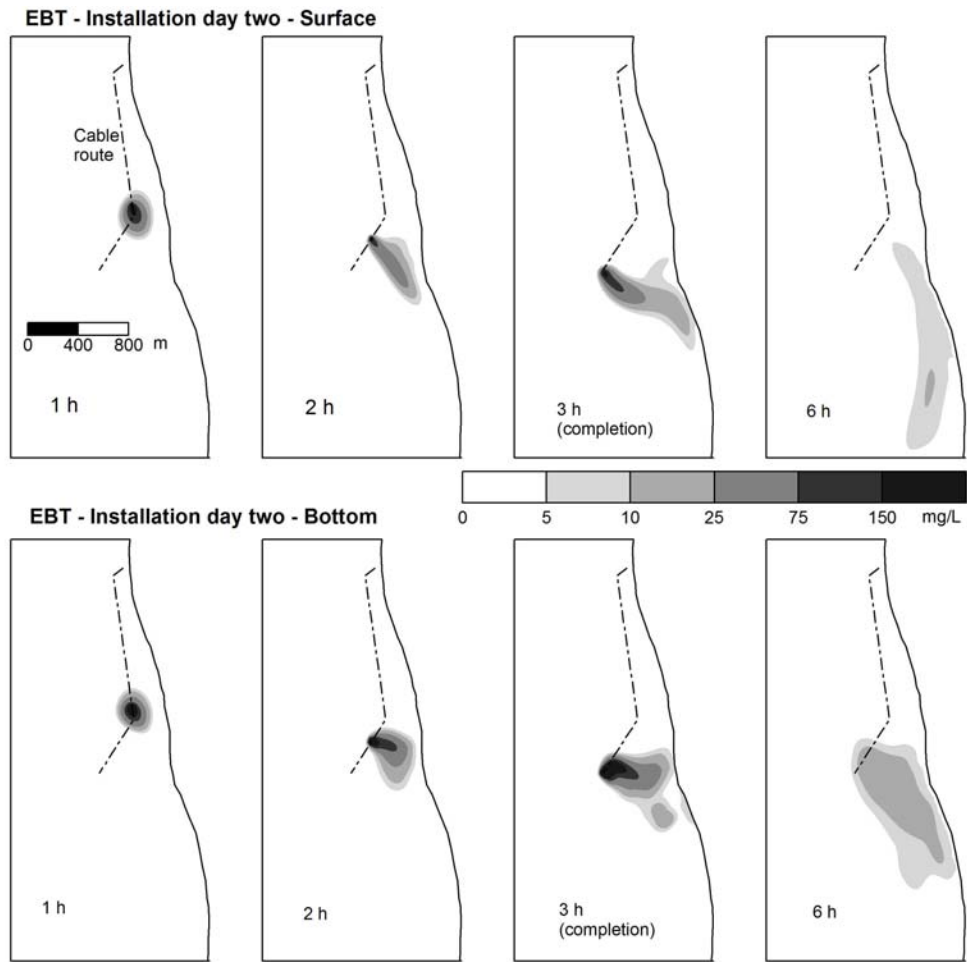


Figure 4. Sediment plumes from second day of wide trench installations at EBT.

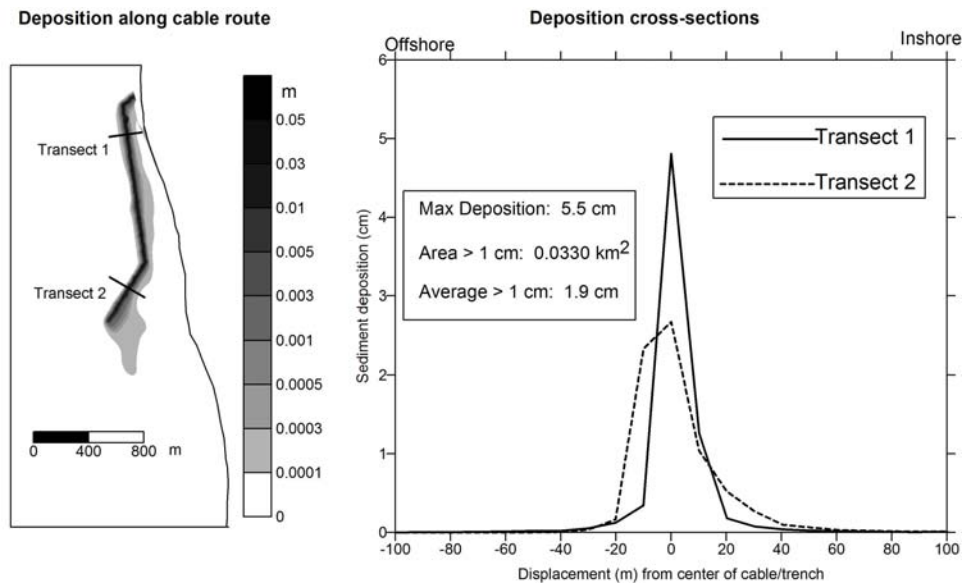


Figure 5. Deposition at EBT after installing over 2 days at a 300 m/h installation rate, including cross sections along the two transects illustrated at left.

### ***Cable Installation with Narrow (0.2 m) Trench***

Compared with the wide trench, the narrow trenching activity reduces the sediment released into the water column by a factor of more than five. Consequently, the TSS levels are expected to decrease significantly from the results presented above. On the first day while the installation activity is underway, predicted maximum TSS values range from 1,800 to 3,300 mg/L near the bottom (compared with 10,000 – 20,000 mg/L for the wide trenching) and from 100 to 300 mg/L near the surface (compared with 500 – 1,800 mg/L for the wide trenching). Within 50 m from the instantaneous activity location, the TSS levels rapidly decrease to well below 100 mg/L near the bottom and below 40 mg/L near the surface (Table 5). The areas having TSS levels above 25 mg/L are small at < 0.04 km<sup>2</sup> at 3 hour after the initiation of installation. Following completion of the installation activity on the first day, the maximum TSS concentrations decrease very rapidly with time. The area with TSS values greater than 25 mg/L at both bottom and surface is predicted to be zero after 6 hours and longer. The areas having TSS levels above 75 mg/L are very small at <0.01 km<sup>2</sup> during the installation activity on the first day and quickly drop down to zero after 6 hours and longer.

On the second day while the installation activity is underway, the TSS levels are predicted to further decrease. Maximum TSS values range from 1,300 to 2,100 mg/L near the bottom (compared with 8,000 – 13,000 mg/L for the wide trenching on day 2) and from 60 to 170 mg/L near the surface (compared with 400 – 1,000 mg/L for the wide trenching on day 2). The areas having TSS levels above 25 mg/L are small at < 0.02 km<sup>2</sup> at 3 hours after the resumption of installation (Table 6). Again, following completion of the installation activity on the second day, the maximum TSS concentrations decrease very rapidly with time, as the dominant sand categories quickly settle to the bottom. The area with TSS values greater than 25 mg/L at both bottom and surface decrease to zero after 6 hours and longer.

The predicted deposition thickness appears to be less than 0.8 cm everywhere (not shown). Again, in reality there could be higher deposition within 10 m of the cable which the model cannot resolve.

Table 5. Summary of TSS and plume areas for the first day of narrow trench installations at EBT.

Elapsed time (hours)	Maximum TSS (mg/L)		Area of TSS >25 mg/L (km <sup>2</sup> )		Area of TSS >75 mg/L (km <sup>2</sup> )	
	bottom	surface	bottom	surface	bottom	surface
0.5	2,147.5	220.3	0.023	0.015	0.010	0.001
1	3,246.7	294.6	0.030	0.020	0.010	0.004
2	1,936.2	144.8	0.034	0.026	0.007	0.001
Completion (2 h 58 min)	1,794.4	93.4	0.037	0.005	0.004	0.000
3	126.6	31.9	0.035	0.003	0.002	0.000
6	6.2	3.9	0.000	0.000	0.000	0.000
12	0.8	0.4	0.000	0.000	0.000	0.000

Table 6. Summary of TSS and plume areas for the second day of narrow trench installations at EBT.

Elapsed time (hours)	Maximum TSS (mg/L)		Area of TSS >25 mg/L (km <sup>2</sup> )		Area of TSS >75 mg/L (km <sup>2</sup> )	
	bottom	surface	bottom	surface	bottom	surface
0.5	1,344.0	87.3	0.006	0.003	0.003	0.000
1	2,067.7	81.6	0.007	0.004	0.002	0.000
2	1,584.4	66.6	0.005	0.001	0.002	0.000
Completion (2 h 58 min)	1,637.3	171.0	0.019	0.003	0.004	0.000
3	229.8	38.5	0.020	0.002	0.003	0.000
6	4.1	1.8	0.000	0.000	0.000	0.000
12	0.7	0.4	0.000	0.000	0.000	0.000

### Summary and Conclusion

The three-dimensional, integrated numerical model, COCIRM-SED was successfully implemented to simulate the dispersal and deposition of suspended sediments resulting from the removal of existing cables and the installation of new submarine transmission cables at four landing sites across the Strait of Georgia. The model predicts TSS values, sediment plume and deposition amounts and areas in detail, providing important inputs to the environmental assessment process requested for the cable removal and installation activities.

From the model results for the removal of one existing cable and the installation of one new cable at EBT, it is shown that during cable removal and installation activities, very high TSS values greater than 10,000 mg/L near the bottom and greater than 1,000 mg/L near the surface are predicted to occur only in the immediate vicinity of the trenching activities within 10 m or so. During the removal and installation operations, the areas having TSS levels above 25 mg/L are usually less than 0.26 km<sup>2</sup>, and the areas with TSS > 75 mg/L are usually less than 0.12 km<sup>2</sup>. Following completion of the removal and installation activities, the maximum TSS concentrations decrease very rapidly with time, as the dominant sand categories quickly settle out to the bottom. In general, the areas having TSS levels above 25 mg/L and 75 mg/L decrease to zero after 3 – 6 hours and longer. The sediment deposition thickness resulting from the removal and installation of one cable is less than 5.5 cm, and the areas with deposition thickness greater than 1 cm occur in a very narrow corridor along the cable route within 10 – 20 m or so.

Because the 10 m model grid size is much larger than the actual trench width of 1.0 m, it is believed that the suspended sediments released from the trenching operation are initially over-diluted. As a result, the model may under-predict the maximum TSS values and deposition thickness at the instantaneous activity location within a few tens of meters of the cable route. To overcome the model resolution limitation, the COCIRM-SED model system has recently been enhanced by incorporating a Lagrangian-based, three-dimensional particle tracking module (PTM), which is capable of simulating dissolved or suspended substances released from coastal development activities in a more realistic manner (Swanson, et al., 2006). Further numerical modeling studies of sediment dispersal and deposition from the cable removal and installation at EBT are underway at ASL Environmental Sciences

Inc. using the newly-developed PTM, in place of the Eulerian-based concentration module.

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