VINEYARD MID-ATLANTIC

CONSTRUCTION AND OPERATIONS PLAN

VOLUME II APPENDIX

JANUARY 2025

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PUBLIC VERSION

Vineyard Mid-Atlantic COP

Appendix II-P Sediment Dispersion Modeling

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Prepared for:
Vineyard Mid-Atlantic LLC

January 2025

Revision	Date	Description
0	March 2024	Initial submission.
1	September 2024	Updated to incorporate revisions to the Project Design Envelope (PDE).
2	November 2024	Updated to incorporate revisions to the PDE.
2	January 2025	Resubmitted without revisions.

SEDIMENT DISPERSION MODELING TECHNICAL REPORT

VINEYARD MID-ATLANTIC LEASE 544

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RPS Project: 23-P-221618
Report Version: 6
November 6, 2024

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List of Acronyms

AOI	Area of Interest
ADCIRC	Advanced Circulation
BOEM	Bureau of Ocean Energy Management
C3S	Copernicus Climate Change Service
COP	Construction and Operations Plan
DW	Depth-Weight
EC2015	Western North Atlantic, Caribbean, and Gulf of Mexico ADCIRC Tidal Database
ECMWF	European Centre for Medium-Range Weather Forecasts
ENC	Electronic Navigational Charts
ERA5	ECMWF Reanalysis 5th generation
ESP	Electrical Service Platform
FM	Flexible Mesh
GEBCO	General Bathymetric Chart of the Oceans
GIS	Geographic Information System
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
MAE	Mean Absolute Error
MSL	Mean Sea Level
NDBC	National Data Buoy Center
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
O&M	Operations and Maintenance
OECC	Offshore Export Cable Corridor
PDE	Project Design Envelope
RGFGRID	Deltares Grid Generation software
RMSE	Root-Mean Square Error
SSFATE	Suspended Sediment FATE
SSH	Sea Surface Height
TSHD	Trailing Suction Hopper Dredge
TSS	Total Suspended Solids
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
WTG	Wind Turbine Generator

EXECUTIVE SUMMARY

Background:

Vineyard Mid-Atlantic LLC (the “Proponent”) proposes to develop, construct, and operate offshore renewable wind energy facilities in the Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0544 (the “Lease Area”) along with associated offshore and onshore transmission systems. This proposed development is referred to as “Vineyard Mid-Atlantic.” Vineyard Mid-Atlantic includes wind turbine generator (WTG) and electrical service platform (ESP) positions within the Lease Area. One or two positions will be occupied by ESPs, and the remaining positions will be occupied by WTGs. Offshore export cables installed within an Offshore Export Cable Corridor (OECC) will transmit power from the renewable wind energy facilities to onshore transmission systems on Long Island, New York.

This appendix to the Vineyard Mid-Atlantic COP documents the sediment dispersion modeling assessment of the sediment-disturbing offshore cable installation activities associated with the development of Vineyard Mid-Atlantic. The installation methods are described in detail in the COP (see Section 3.5.4.1 of COP Volume I) and the details of the assumed modeling parameters are documented within this report. Consistent with the Project Design Envelope (PDE), this study has been designed to simulate physical impacts from the anticipated construction activities within the OECC and Lease Area.

Modeling Approach:

RPS applied customized hydrodynamic and sediment dispersion models to assess potential effects from sediment suspension during construction activities. Specifically, this analysis includes two interconnected modeling tasks:

- Development of a three-dimensional (3D) hydrodynamic modeling application of a domain encompassing Vineyard Mid-Atlantic activities using the Deflt3D FM modeling suite; and
- Simulation of suspended sediment fate and transport, including evaluation of seabed deposition and suspended sediment plumes associated with installation activities using an RPS in-house model Suspended Sediment FATE (SSFATE). Velocity field development using the Delft3D FM modeling suite as primary forcing for SSFATE.

To characterize the effects associated with the offshore sediment-disturbing activities,13 total scenarios were developed to conservatively represent the range of anticipated construction activities within the OECC and the Lease Area. Following is a brief overview of the terminology used to describe the methodologies modeled in this study:

- **Horizontal Directional Drilling (HDD):** At the representative landfall locations, HDD will be used to connect the offshore cable to the onshore components, which will require the excavation and subsequent backfill of an exit pit at the seaward end of the HDD.
- **Cable Installation using Jetting Techniques:** Cable installation is accomplished by jetting techniques (e.g., jet plow, jet trenching, or similar) in areas where sand bedforms do not exist or have been cleared.
- **Cable Installation using Vertical Injector:** Cable installation is achieved in areas with or without sand bedforms using a vertical injector tool, which is a high-volume low-pressure water jetting tool that uses directed water jets to fluidize the seabed and lower the cable via the integral depressor to the bottom of the fluidized trench.

The Proponent is considering three potential landfall approaches on Long Island, New York that will interconnect the offshore cables with onshore transmission systems; up to two of the three approaches may be installed. Additionally, the Proponent is proposing to install up to six high voltage alternating current (HVAC) cables, two high voltage direct current (HVDC) cable bundles, or a combination of up to four HVAC cables/HVDC cable bundles within the OECC. To assess potential effects of cable installation, one representative cable installation simulation was performed along each of the three approaches of the OECC to the potential landfall sites. Installation of each cable will take place during separate time periods such that potential effects from installation of one cable will have long since dissipated prior to the start of subsequent cable installations.

The following HDD Exit Pit Excavation and Backfill scenarios were simulated at two tidal stages:

- Representative Landfall Site HDD Exit Pit Construction – Atlantic Beach Approach, Ebb & Flood
- Representative Landfall Site HDD Exit Pit Construction – Jones Beach Approach, Ebb & Flood

The following cable installation simulations were modeled within the OECC and Lease Area:

- Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach
- Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC, within federal waters
- Representative OECC Cable Installation, Vertical Injector – Main OECC, within federal waters
- Representative Lease Area Cable Installation —Typical Jetting
- Representative Lease Area Cable Installation — Maximum Jetting

The effects were quantified in terms of the above-ambient total suspended solids (TSS) concentrations, including the seabed deposition of sediments suspended in the water column during cable installation activities and HDD exit pit excavation and backfill. Results are presented with respect to the thresholds listed below, which were selected either because they are thresholds of biological significance or provide an effective means of demonstrating the physical effects:

- Water column concentrations thresholds: 10, 25, 50, 100, 200, and 650 micrograms per liter (mg/L);
- Water column exposure durations: 1, 2, 3, 4, 6, 12, and 24 hours; and
- Seabed deposition: 1, 5, 10, 20, 50, and 100 millimeters (mm).

Results & Discussion

HDD Exit Pits

The two HDD exit pit construction simulations are representative of the excavation and backfill operations as 100% of the dredged material was released at the water surface over one hour. Backfilled sediment was released during both ebb and flood tides, to capture both environmental extremes. Because 100% of the backfill material was released at the surface, above-ambient TSS concentrations (i.e., ≥10 mg/L) were present throughout the entire water column. The maximum extent to TSS concentrations ≥10 mg/L was predicted to be similar for the Representative Landfall Site HDD Exit Pit Construction - Jones Beach Approach and the Representative Landfall Site HDD Exit Pit Construction – Atlantic Beach modeling scenarios; however, both model scenario concentrations dissipated to less than 10 mg/L within six to 12 hours. Both representative HDD exit pit construction simulations were predicted to exceed the depositional thickness threshold of 100 mm. However, the area associated with these thicknesses was relatively small (0.01 km) and was local to the source. For a more detailed discussion of the HDD exit pit construction simulation results, see Section 3.3.3.

Cable Installation

For the typical jetting simulations, the trench depth in state waters was assumed to be deeper (2.3 m) than was applied in federal waters (1.7 m).[1] Modeling of the Representative OECC Cable Installation using typical jetting techniques was performed for the entire length of the OECC. On average, TSS concentrations ≥10 mg/L were predicted to stay within 0.29 to 0.79 km of the source (with a maximum extent of 1.91 km) for all representative cable installation simulations modeled along the OECC in state and federal waters, assuming typical jetting parameters. Simulations were performed for all potential landfall approaches, starting just prior to the shoreline and traversing to the Lease Area. This provides an additional layer of conservativism as cable installation would not occur to the shoreline. Therefore, this assumption increases the potential areas impacted by suspended sediment concentrations and sediment deposition above the thresholds of concern.

[1] The assumed trench depth is based on the target burial depth plus a 0.5 m allowance to account for the cable diameter, etc.

For the Representative OECC Vertical Injector Cable Installation simulation, the extent to the 10 mg/L concentration contour was predicted to reach farther from the route centerline than for the other cable installation simulations. This result was anticipated because the Representative OECC Vertical Injector Cable Installation simulation was performed within an area containing high fractions of fine material, during a period with very high current velocities, to evaluate a potential worst-case scenario when predicting water column concentrations. For all cable installation scenarios within the OECC and Lease Area, regardless of installation method or parameters applied, above-ambient TSS concentrations substantially dissipated within three hours and fully dissipated between six and 12 hours.

For all cable installation simulations in the OECC and Lease Area, the depositional footprint was predicted to create deposits primarily between 1 mm and 5 mm thick that remained along the cable route (i.e., back into the trench) or adjacent to the cable route. For the typical and maximum jetting simulations in the OECC and Lease Area, the average and maximum extents to the 1 mm thickness threshold was predicted to stay within 0.07 and 0.11 km of the cable route, respectively. The only cable installation scenario predicted to exceed thicknesses >20 mm was the Representative Lease Area Cable Installation — Maximum Jetting simulation. This scenario contained a deeper target trench depth (3 m) and assumed that a higher fraction of the disturbed sediment would be released to the water column than was predicted for the typical jetting parameters. For a more detailed discussion of the OECC and Lease Area cable installation simulation results, see Sections 3.3.4 and 3.3.5, respectively.

Summary

These analyses provide conservative predictions of suspended sediment concentrations above ambient conditions that could result from the HDD exit pit construction and cable installation activities associated with Vineyard Mid-Atlantic. Results from the representative simulations of HDD exit pit construction and cable installation within the OECC and Lease Area show that above-ambient TSS concentrations originating from the source are intermittent, depending on the *in-situ* sediment composition; the vertical distribution of the sediment in the water column; and the hydrodynamic forcing conditions. The models show that the highest concentrations of induced suspended sediment occur in the vicinity of the activity (e.g., cable installation and HDD exit pit construction), as expected; however, these higher concentrations decrease rapidly with distance. All predicted above-ambient TSS concentrations are expected to disperse or settle such that concentrations are below 10 mg/L within three to 12 hours after the construction-related sediment disturbing activity has stopped.

1 INTRODUCTION

Vineyard Mid-Atlantic LLC (the “Proponent”) proposes to develop, construct, and operate offshore renewable wind energy facilities in Bureau of Ocean Energy Management (BOEM) Lease Area OCS-A 0544 (the “Lease Area”) along with associated offshore and onshore transmission systems. This proposed development is referred to as “Vineyard Mid-Atlantic.” Vineyard Mid-Atlantic includes wind turbine generator (WTG) and electrical service platform (ESP) positions within the Lease Area. One or two positions will be occupied by ESPs and the remaining positions will be occupied by WTGs. Offshore export cables installed within an Offshore Export Cable Corridor (OECC) will transmit power from the renewable wind energy facilities to onshore transmission systems on Long Island, New York (NY; Figure 1-1). At the representative landfall location, horizontal directional drilling (HDD) will be used to connect the offshore cable to the onshore components, which will require the excavation and subsequent backfill of an exit pit at the seaward end of the HDD.

This appendix to the Vineyard Mid-Atlantic Construction and Operations Plan (COP) documents the modeling assessment used to simulate potential sediment-disturbing activities associated with the offshore cable installation processes for Vineyard Mid-Atlantic. The resuspension of sediments from the various construction activities may cause a localized sediment plume. A sediment plume is a portion of the water column that experiences a temporary increase in the total suspended solids (TSS) concentration above ambient levels. Over time, the plume settles and deposits sediment on the seabed (i.e., a process referred to as sedimentation), which is estimated as the thickness of sediment accumulated on the seabed above ambient conditions. This report describes the models, modeling approach, inputs, and results used to assess potential construction-related sediment disturbing activities. The Delft3D FM hydrodynamic model and its application to the study area are presented in Section 2. Section 3 provides an overview of the SSFATE sediment dispersion model and its generated results for the 13 modeled scenarios.

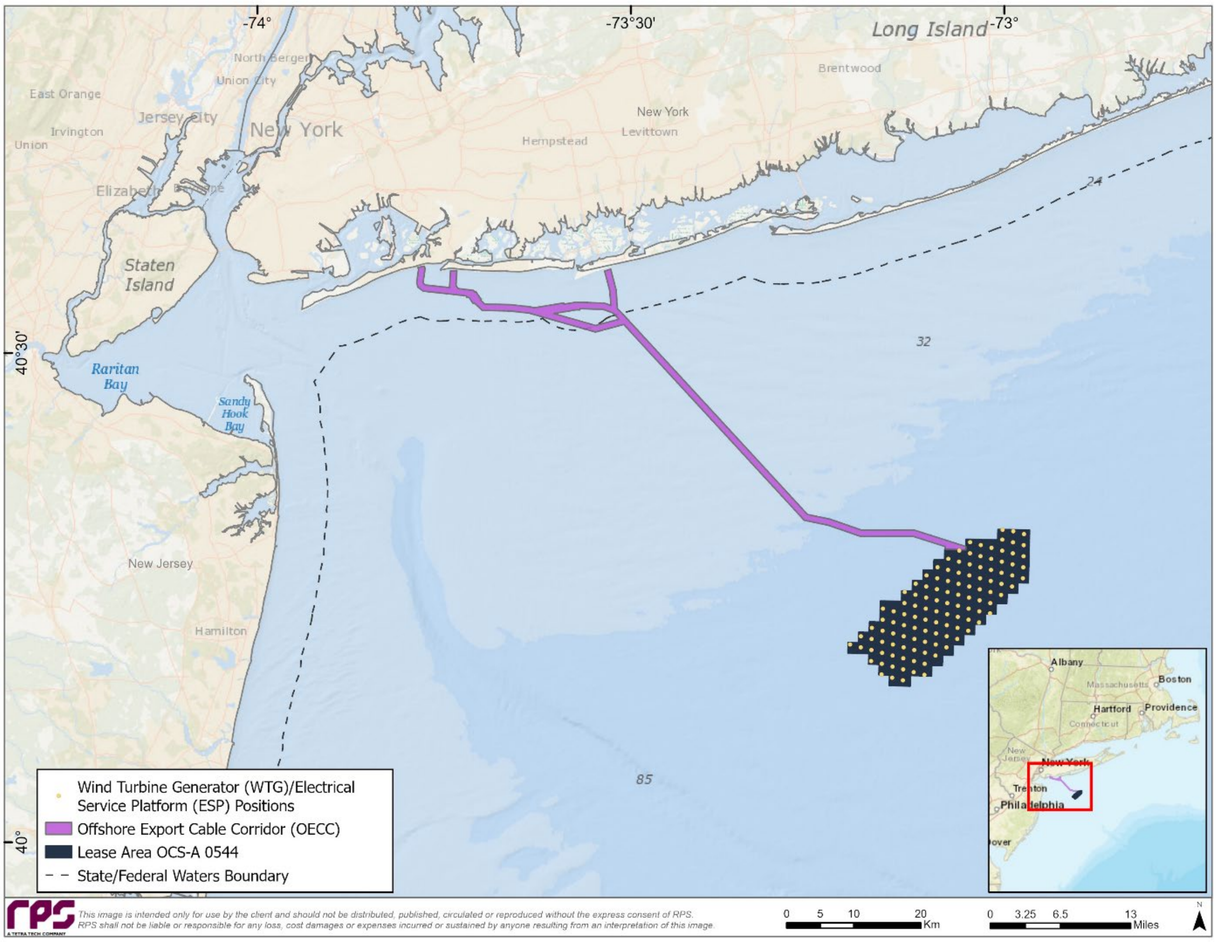


Figure 1-1: Map of the study area with locations for Vineyard Mid-Atlantic’s offshore components.

1.1 Study Scope and Objectives

The installation methods are described in detail in the COP (see Section 3.5.4.1 of COP Volume 1) and the details of the assumed modeling parameters are documented within this report. Consistent with the Project Design Envelope (PDE), this study has been designed to simulate physical impacts from the following activities: (1) cable installation within the OECC and the Lease Area, and (2) excavation and subsequent backfill of an exit pit at the seaward end of the HDD tie-in location.

RPS applied customized hydrodynamic and sediment dispersion models to assess potential effects from sediment suspension during construction activities. Specifically, this analysis includes two interconnected modeling tasks:

1. Development of a three-dimensional (3D) hydrodynamic modeling application of a domain encompassing Vineyard Mid-Atlantic activities using the Deflt3D FM modeling suite; and
2. Simulation of suspended sediment fate and transport, including evaluation of seabed deposition and suspended sediment plumes associated with installation activities using a RPS in-house model Suspended Sediment FATE (SSFATE). Velocity field development using the Delft3D FM modeling suite as primary forcing for SSFATE.

To characterize the effects associated with the offshore cable installation activities and HDD exit pit excavation and backfill, 13 scenarios were developed to conservatively represent the range of anticipated construction activities within the OECC (Table 1-1) and the Lease Area (Table 1-2). The Proponent is proposing to install up to six high voltage alternating current (HVAC) cables, two high voltage direct current (HVDC) cable bundles, or a combination of up to four HVAC cables/HVDC cable bundles within the OECC. To assess potential effects of cable installation, one representative cable installation simulation was performed along each of the three approaches of the OECC to the potential landfall site(s). Up to two of these three approaches may be installed. Installation of each cable will take place during separate time periods such that potential effects from installation of one cable will have long since dissipated prior to the start of subsequent cable installations.

1.2 Project Components

1.2.1 OECC

This section includes a brief overview of the project components analyzed in this assessment, while Section 3.2.3 provides a thorough discussion of the relevant installation details (e.g., the SSFATE model's methodology, underlying assumptions, and results). The OECC travels from the northern portion of Lease Area OCS-A 0544 to the southern shoreline of Long Island, NY. As the OECC approaches shore, it splits into three potential landfall sites (of which, up to two will be used). The two western landfall approaches include the "Atlantic Beach Approach" and the "Rockaway Beach Approach." The eastern approach is the "Jones Beach Approach." An alternative route located further south, "Western Landfall Sites OECC Variant," was evaluated in the sediment dispersion modeling such that results could be compared with the primary route that connects the western landfall approaches to the main OECC (Figure 1-2).

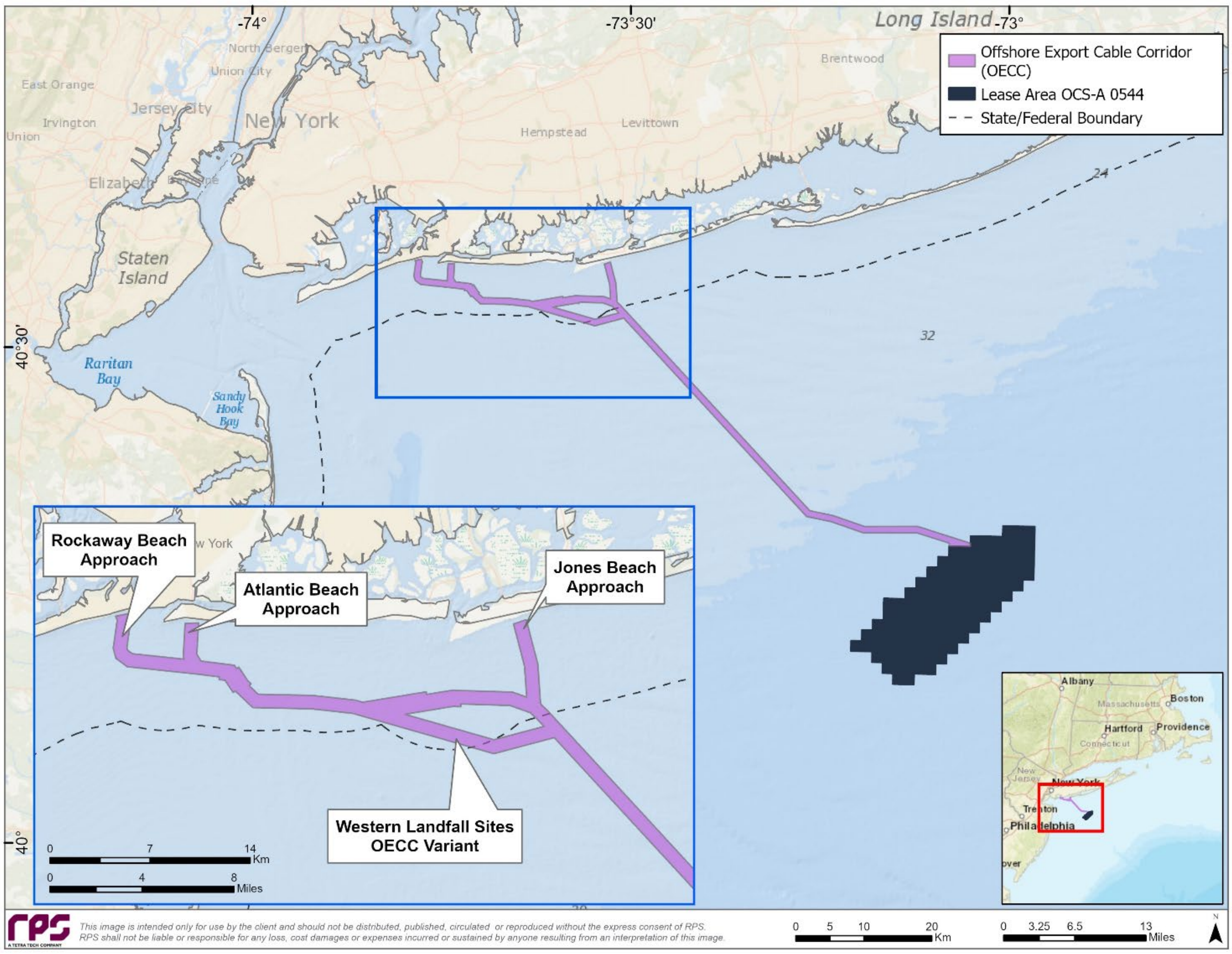


Figure 1-2: Vineyard Mid-Atlantic OECC-related project components and potential landfall site(s).

Cable installation was simulated within the OECC, using its centerline as the representative route (Table 1-1), starting from landfall site and going towards the Lease Area. The route may vary within the corridor depending on *in-situ* conditions and installation constraints, but results produced from this assessment would be of similar magnitude and extent due to its proximity to the modeled route and similar environmental conditions. Cable installation will most likely be accomplished by jetting techniques (e.g., jet plow, jet trenching, etc.) and was modeled to simulate this technique for all sections and variations of the OECC. In areas where jetting techniques may not be adequate (e.g., hard-bottom locations, presence of bedforms), the use of other installation methods may be required depending on the conditions. A sensitivity analysis was performed to capture the potential use of different techniques by simulating cable installation using a vertical injector tool. The vertical injector segment was selected within the main OECC that contained the highest fraction of fine material. This was considered conservative because fine material takes longer to settle and may be transported farther from the release location; produces higher suspended sediment concentrations; and remains suspended in the water column for longer durations.

In addition to cable installation within the OECC, this assessment simulated the excavation and subsequent backfill of an exit pit at the seaward end of the potential HDD path used to connect the offshore export cables and onshore components at the representative landfall location(s). Two proposed landfall sites were modeled: the Atlantic Beach Approach and the Jones Beach Approach. Landfall sites were modeled during a range of environmental conditions (e.g., ebb and flood tides) to encompass the full impact of construction activities on the surrounding areas. Results from these two HDD exit pit excavations and backfill operations are considered representative of the Rockaway Beach Landfall Site because of its proximity and similar hydrodynamic and geologic conditions.

Table 1-1: Description of modeled scenarios for Vineyard Mid-Atlantic, specific to the OECC.

Scenario Name	Description
Representative Landfall Sites HDD Exit Pit Construction	Representative Horizontal Directional Drilling (HDD) exit pit excavation and backfill at Atlantic Beach Landfall Site and Jones Beach Landfall Site.
Representative OECC Cable Installation — Jetting	Offshore export cable installation using jetting techniques and assuming typical installation parameters (1.7-2.3-meter trench depth[2] along the main OECC and landfall approach variations).
Representative OECC Cable Installation — Vertical Injector	Representative offshore export cable installation using a vertical injector along a segment of the main OECC.

1.2.2 Lease Area

The Lease Area will consist of an array of cables (i.e., inter-array cables) that connect the wind turbines to a central location (Figure 1-3). This section includes a brief introduction to the modeling performed for the Lease Area. Section 3.2.3 provides a detailed discussion of the installation parameters applied to SSFATE (e.g., model's methodology, underlying assumptions, and results).

To simulate the installation of the inter-array cables, one representative inter-array cable was selected for modeling. This inter-array cable was selected as a worst-case scenario because it intersects with an area containing one of the highest proportions of fine-grained material and is the longest section of the inter-array cables. The longest route corresponds to the largest volume of sediment being released into the environment during the cable installation process. Installation of each inter-array cable will take place during separate time periods such that potential effects from installation of one inter-array cable will have long since dissipated prior to the start of subsequent cable installations. Therefore, the modeled simulations can be considered representative of the other inter-array cable installations. It was assumed the inter-array cables would be installed via jetting techniques, but to capture variability in jetting parameters (e.g., installation rates and trench depths) two simulations were performed (Table 1-2). One simulation included the use of typical jetting installation parameters (e.g., a slower installation speed and a typical target trench depth) while the other assumed the maximum parameters (e.g., a faster installation rate and a maximum target trench depth).

[2] The assumed trench depth is based on the target burial depth plus a 0.5 m allowance to account for the cable diameter, etc.

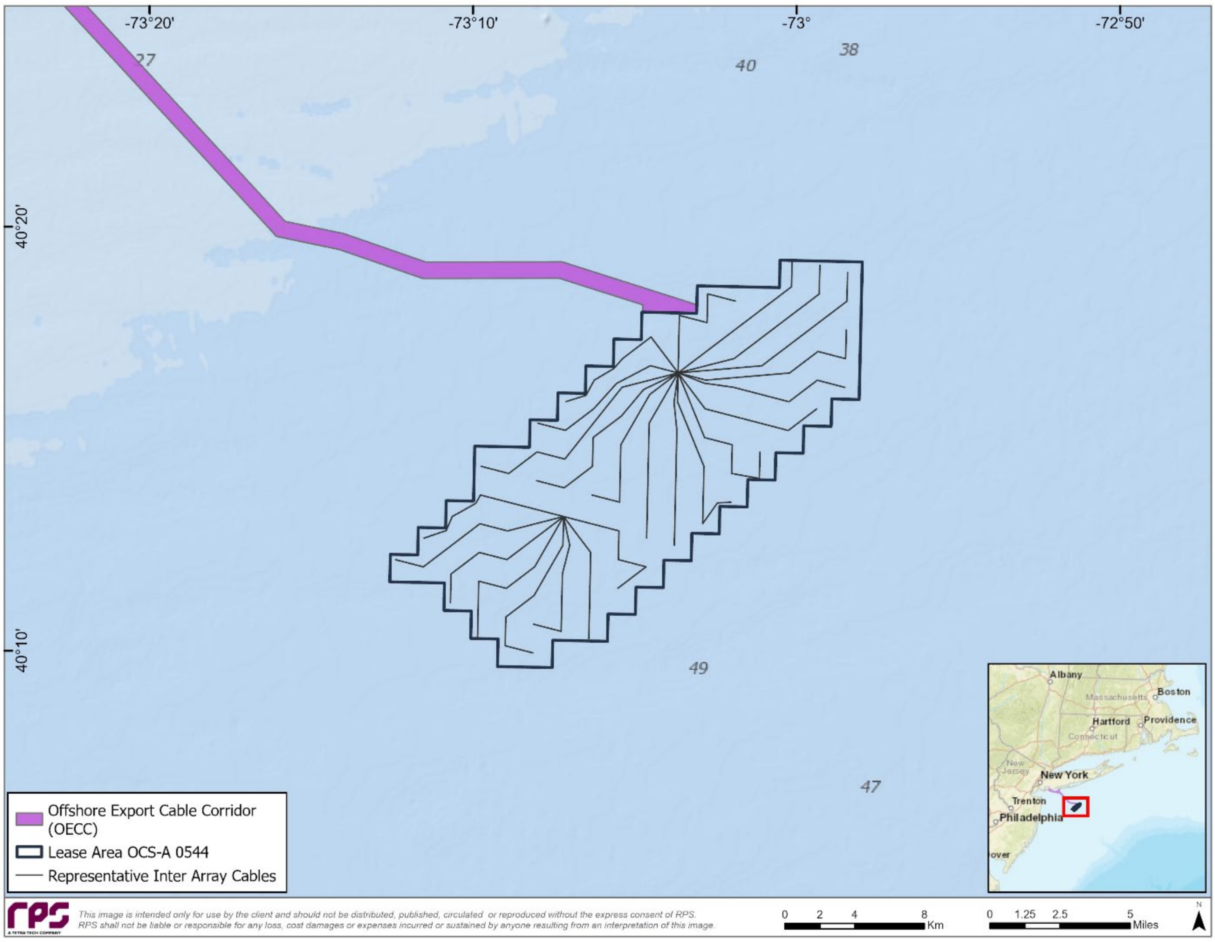


Figure 1-3: Lease Area-related project components.

Table 1-2: Description of modeled scenarios for Vineyard Mid-Atlantic specific to the Lease Area.

Scenario Name	Description
Representative Lease Area Cable Installation — Typical Jetting	Representative inter-array cable installation using jetting techniques and assuming typical installation parameters (a two-meter trench depth and slower installation rate) in the southwest corner of the Lease Area.
Representative Lease Area Cable Installation — Maximum Jetting	Representative inter-array cable installation using jetting techniques and assuming maximum installation parameters (a three-meter trench depth and faster installation rate) in the southwest corner of the Lease Area.

1.3 Thresholds of Concern

The effects were quantified in terms of the above-ambient TSS concentrations, including the seabed deposition of sediments suspended in the water column during cable installation activities and HDD exit pit excavation and backfill. Results are presented with respect to the thresholds listed below, which were selected either because they are thresholds of biological significance (Table 1-3) or provide an effective means of demonstrating the physical effects. Thresholds associated with biological significance are documented in Sections 4.5 and 4.6 of COP Volume II, which are the benthic resources and finfish and invertebrate sections, respectively. The thresholds used in this study include:

- Water column concentrations thresholds: 10, 25, 50, 100, 200, and 650 micrograms per liter (mg/L);
- Water column exposure durations: 1, 2, 3, 4, 6, 12, and 24 hours; and
- Seabed deposition: 1, 5, 10, 20, 50, and 100 millimeters (mm).

Table 1-3: Summary table of minimum effects thresholds for suspended sediment concentrations in the water column and seabed deposition thicknesses.

Organism Group (Life Stage)	Minimum Effects Threshold
Suspended Sediment Concentrations	
Mollusks (eggs) [1]	200 mg/L for 12 hours
Mollusks (juveniles and adults)[2]	100 mg/L for 24 hours
Crustaceans (all life stages)[3]	100 mg/L for 24 hours
Other invertebrates (e.g., worms)[4]	650 mg/L
Corals (eggs)[5]	50 mg/L for 24 hours (preventing fertilization)
Corals (larvae)[5]	10 mg/L for 24 hours (altering larval settlement)
Corals (adults)[5]	25 mg/L for 24 hours (reducing calcification rate)
Seabed Deposition	
Demersal eggs[6]	Deposition greater than 1 mm (0.04 in) can result in the burial and mortality of that life stage.
Subtidal shellfish in the genera *Ostrea* (oysters), *Mytilus* (mussels), *Petricola* (Venus clams), and *Chlamys* (scallops)[7]	Most displayed lethal responses to deposition of either fine sand or mud at thicknesses >50 mm (2 in), with oysters and mussels sensitive to approximately 20 mm (0.8 in) of deposition.
Queen scallops[8]	The highest emergence and survival rates occurred with burials of coarse sediment that are <20 mm (0.8 in) thick, and the highest mortality occurred with fine sediment at thicknesses of 70 mm (2.8 in).

Notes:
1. Based on the concentration and duration at which sublethal effects were observed to the development of eastern oyster eggs (Cake, 1983; Wilber and Clarke, 2001).
2. Based on sublethal effects (i.e., reduced growth and reduced respiration) observed in northern quahog (Murphy, 1985; Turner and Miller, 1991; Wilber and Clarke, 2001).
3. Based on sublethal effects (i.e., reduced growth and reduced respiration) observed in copepods, and euphausiids (Anderson and Mackas, 1986).
4. See Rayment (2002); Read et al. (1982, 1983). For worms, no exposure time was indicated, but tolerate a large range of suspended sediments, as they inhabit areas of high total suspended solids concentrations.
5. See Fabricius (2005); Gilmour (1999); Rogers (1990) for studies investigating tropical species.
6. See Berry et al. (2011).
7. See Essink (1999).
8. See Hendrick et al. (2016).

2 HYDRODYNAMIC MODELING

A three-dimensional (3D) hydrodynamic model was developed in Delft3D Flexible Mesh (FM) Flow encompassing the area of interest (AOI) and surrounding the region to reproduce hydrodynamic conditions during the anticipated construction timeframe of the Project. In addition to capturing the project components (e.g., the Lease Area, OECC, and landfall approaches), the model domain (Figure 2-1) extends from Northern New Jersey to Western Long Island, including New York Harbor as well as major adjoining rivers (e.g., Hudson, Raritan). Depth-varying current fields were simulated in Delft 3D FM to reproduce the forcing conditions in the AOI. The simulated current fields were then implemented into the sediment dispersion model to force the transport of sediment when released to the marine environment. An understanding of the circulation patterns and current fields throughout the water column was necessary to accurately predict the transport and fate of the disturbed sediment because current speed and direction varies spatially and temporally. The following sections describe the environmental data used to develop the hydrodynamic model, including the model set-up, application, and discussion of results.

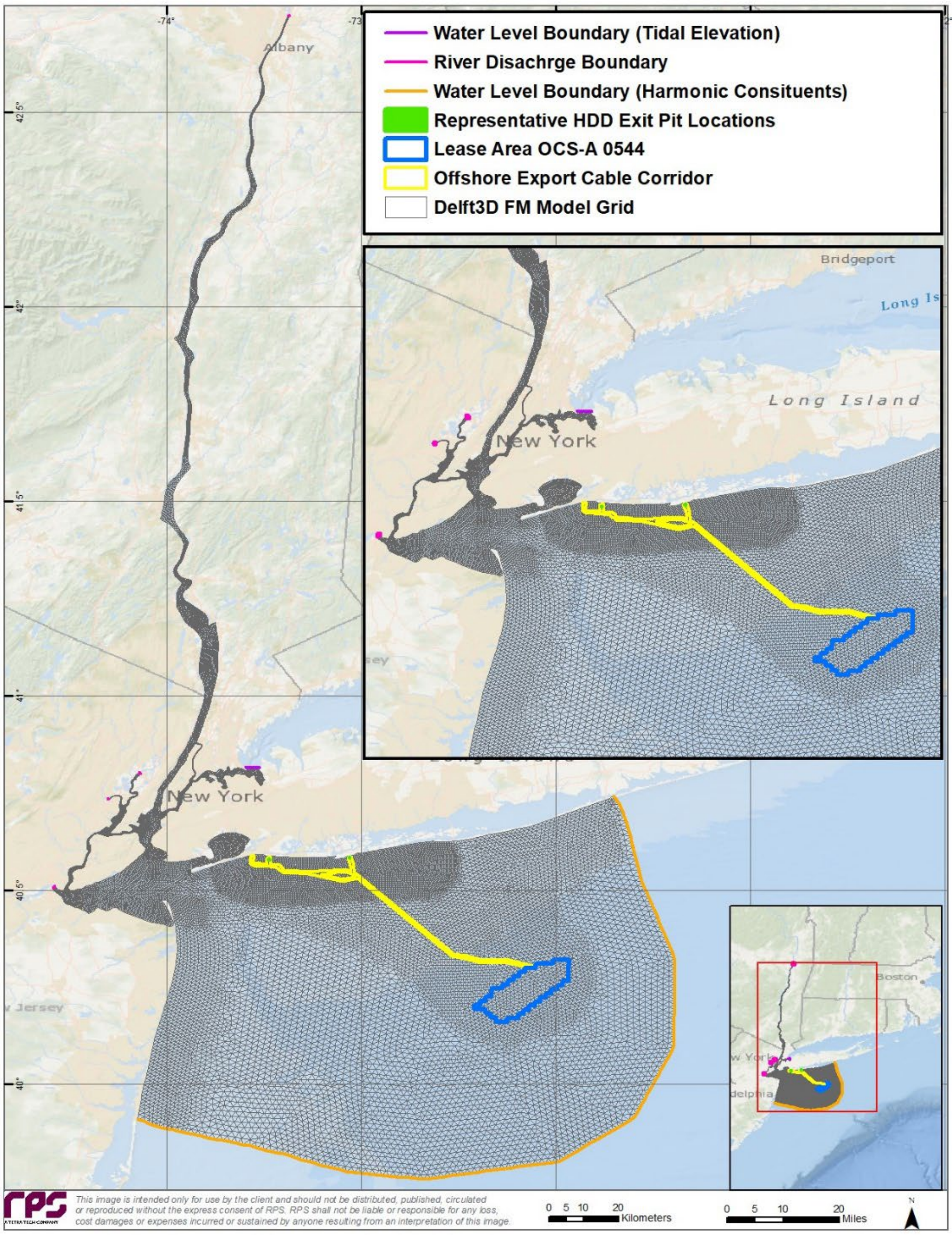


Figure 2-1: Hydrodynamic model grid showing project components and locations of open boundaries.

2.1 Environmental Data

Several datasets were obtained to develop model boundary conditions, reproduce predominant forcing in the AOI, and calibrate and validate the hydrodynamic model. These environmental datasets include shoreline, bathymetry, winds, river discharge, tidal elevations, and currents (Figure 2-2 and Table 2-1). The most recent current observations for New York Harbor were captured in the summer of 2019; therefore, river discharge and tidal elevation datasets were also obtained for this period.

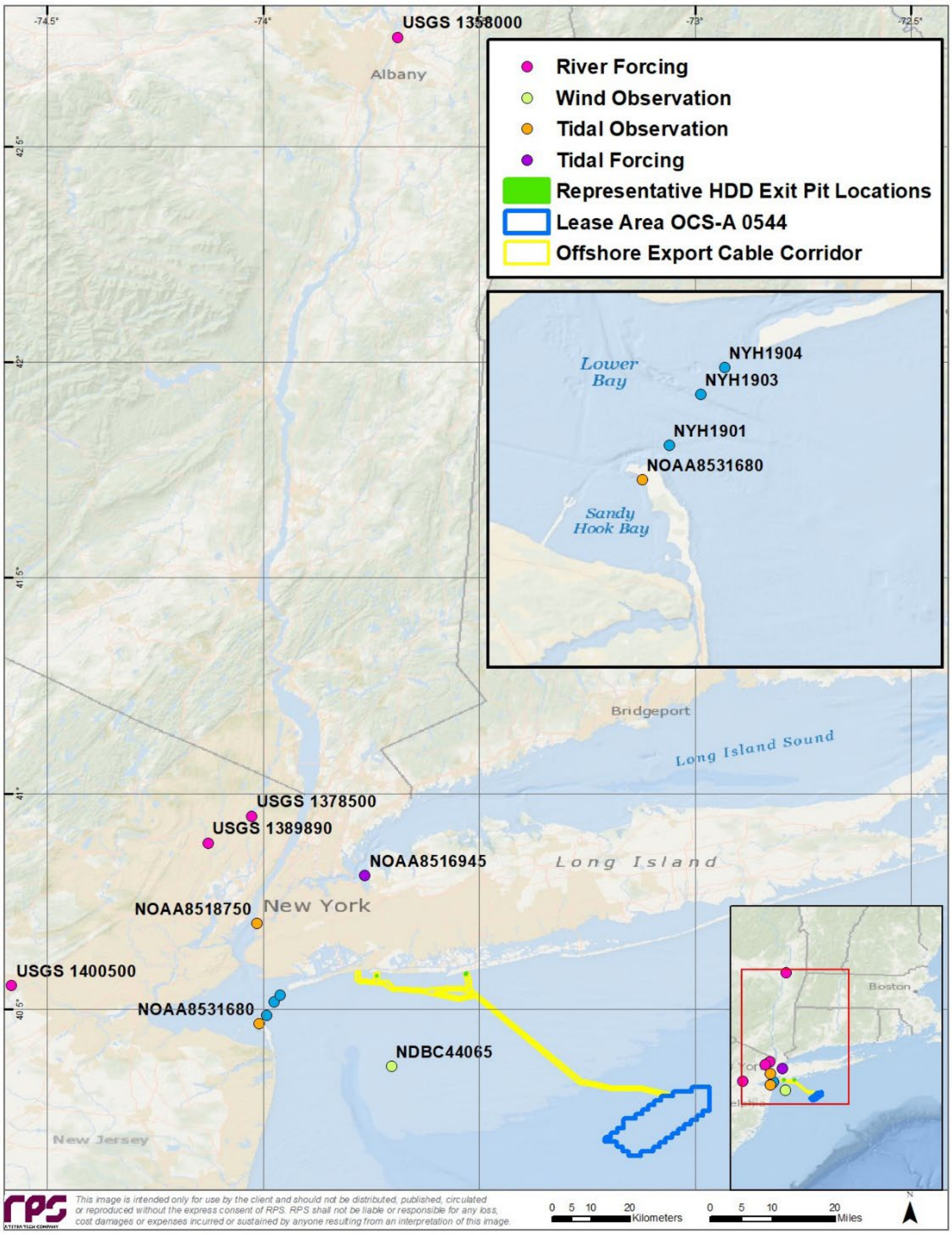


Figure 2-2: Location of project components in relation to the applied environmental datasets.

Table 2-1: Summary of model and 2019 observation data used in the modeling study.

Data Source	Name	Location	Time Step	Longitude (°W)	Latitude (°N)
Wind Model Data (Forcing)	ERA5	10 m height, Global Model	1-hourly	75.2 – 73.0	38.2 – 42.8
Wind Observation (Validation)	NDBC 44065	4.1 m height, New York Bight	1-hourly	73.703	40.369
Tidal Elevation (Forcing)	ADCIRC model	Offshore	-	-	-
	NOAA 8516945	Kings Point	1-hourly	73.765	40.811
Tidal Elevation (Validation)	NOAA 8531680	Sandy Hook	1-hourly	74.009	40.467
	NOAA 8518750	The Battery	1-hourly	74.015	40.700
River Discharge (Forcing)	USGS 1378500	Hackensack River	15-minute	74.027	40.948
	USGS 1358000	Hudson River	15-minute	73.688	42.752
	USGS 1389890	Passaic River	15-minute	74.128	40.885
	USGS 1400500	Raritan River	15-minute	74.583	40.555
Current Observation (Calibration and Validation)	NYH1901	New York Harbor	6-minute	73.993	40.487
	NYH1903	New York Harbor	6-minute	73.975	40.517
	NYH1904	New York Harbor	6-minute	73.961	40.533

2.1.1 Bathymetry and Shoreline

Bathymetric data were gathered from the National Oceanic and Atmospheric Administration (NOAA) Electronic Navigational Charts (ENC) datasets for coastal, offshore, and riverine locations, and the 2021 General Bathymetric Chart of the Oceans (GEBCO) for coastal and offshore waters of New Jersey and New York. The irregularly spaced soundings, referenced to mean sea level (MSL) from both datasets, were interpolated to the hydrodynamic grid to provide complete coverage of water depths over the model domain. The Proponent provided bathymetry data (see Appendix II-B of the COP) that were also interpolated to the hydrodynamic grid (Figure 2-3 and Table 2-2).

The shoreline for the modeling domain was developed using a 2017 Global Self-consistent, Hierarchical, High-resolution Geography Database (Wessel and Smith, 1996) to define the land and water boundary. The shoreline along the Hudson River was developed using the Hudson River Estuary project shapefile (New York State Department of Environmental Conservation, 2016).

Table 2-2: Specifics of bathymetric datasets used for modeling.

Name of Dataset	Owner/Provider	Minimum Horizontal Grid Size
GEBCO (2021)	British Oceanographic Data Centre	~320 m
ENC	NOAA	~10 m
Multibeam Echosounder (MBES) Bathymetry	Vineyard Mid-Atlantic	0.25 m

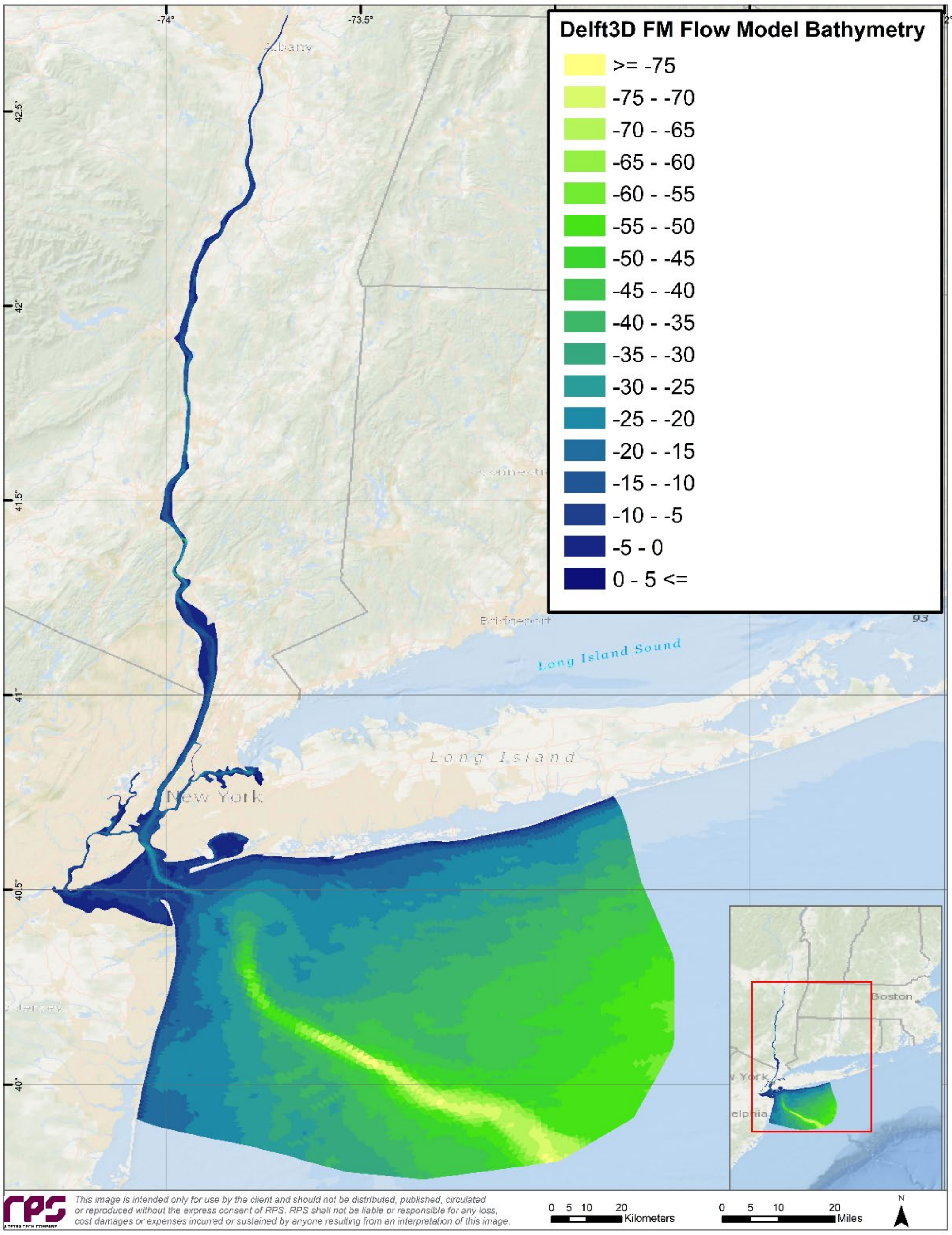


Figure 2-3: Illustration of the bathymetry of the domain interpolated to the D-Flow FM.

2.1.2 Meteorological Observations

Developed by the European Centre for Medium-Range Weather Forecasts (ECMWF), ECMWF Reanalysis 5th generation (ERA5) wind data were obtained from the ERA5 reanalysis product (Hersbach et al., 2020). Global wind data are available on an atmospheric model grid with 0.25° horizontal resolution (C3S, 2018; Hersbach et al., 2020). Gridded U (eastward) and V (northward) velocity components of wind data (at 10 m elevation, 1-hour time step) were applied over the model domain to force the surface boundary of the hydrodynamic model (Table 2-1).

To validate the wind forcing dataset, ERA5 model output was interpolated from the four neighboring grid points to the location of the NDBC buoy 44065 (Figure 2-2 and Table 2-1) from July 1, 2019 through September 1, 2019. To compare the model predicted wind data (i.e., ERA5) with observations, the observed wind speed was adjusted from 4.1 m height to 10 m height using Bratton and Womeldorf (2011) equation:

$$V_2 = V_1 \left(\frac{H_2}{H_1}\right)^{\alpha}$$

where the wind velocity (V_2) at height (H_2) can be estimated using the wind speed velocity (V_1) recorded for a different elevation (H_1), at the same site location. The value of wind shear exponent (α) was set as 0.1 because the NDBC stations are in open water (Bratton and Womeldorf, 2011). The comparison between the NDBC wind measurement and ERA5 model output shows that ERA5 captures the directionality and speed of the wind in the study area (Figure 2-4). Therefore, it is an appropriate wind source for forcing the Delft 3D FM hydrodynamic model.

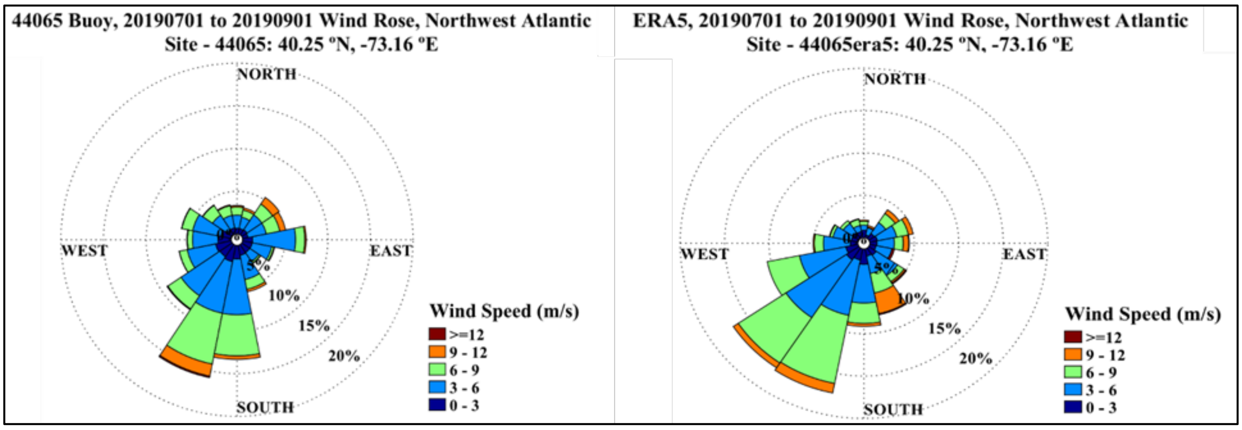


Figure 2-4: Comparison between wind measurement at NDBC buoy 44065 and interpolated data over the same time frame (July 1, 2019 through September 1, 2019) and location from the ERA5 dataset.

2.1.3 Sea Surface Height (Tides)

Tidal data were extracted from an ADCIRC tidal database and NOAA tidal stations for forcing and validating the model. Surface tidal elevations are defined to appropriately model incoming (i.e., flood) and outgoing (i.e., ebb) tidal flow into the domain at the open boundaries of the hydrodynamic model. The specification of the sea surface height (SSH) was forced into the model by defining tidal harmonic (astronomical tide) constituents and applying tidal water level time series at two open boundaries, respectively.

The Western North Atlantic, Caribbean, and Gulf of Mexico ADCIRC Tidal Database (EC2015) provides accurate tidal forcings from a higher resolution Advanced Circulation (ADCIRC) coastal hydrodynamic model of smaller sub-regions within the Atlantic region (Szpilka et al., 2016). The tidal database was used to extract nine harmonic constituents (phase and amplitude of M2, S2, N2, K1, K2, O1, P1, Q1, and M4) at 11 boundary points located along the eastern open boundary of the Delft3D FM model grid used in this project (Figure 2-1).

NOAA National Ocean Service (NOS) tidal stations located within the AOI provided observation data of tidal conditions. Tidal elevation time series from NOAA Stations 8531680 Sandy Hook, 8518750 The Battery, and 8516945 King’s Point were obtained for the entirety of 2019 (Table 2-1). Water level data from King’s Point was applied as forcing at the open boundary between Long Island Sound and the New York Harbor. Data acquired from the other two stations (Sandy Hook and The Battery) were used to validate the model.

2.1.4 River Data

River flux data were collected from four United States Geological Survey (USGS) monitoring stations at the Hackensack, Hudson, Passaic, and Raritan rivers (Figure 2-1 and Table 2-1). Discharges from these four rivers impact the flow and circulation of the estuarine environment, along the coast, and in the New York Harbor near the project components. The 15-minute flow rate data from these stations were specified in the model as discharge open boundary conditions as a function of time (see Section 2.2.1).

2.1.5 Ocean Current Observations

Observations of ocean currents were obtained at three stations within New York Harbor with sensors deployed at different times from June to October 2019 (Figure 2-2 and Table 2-1). The NYH1901 Sandy Hook station was deployed from June 26, 2019 to August 8, 2019; the NYH1903 Ambrose Chanel station was deployed from August 12, 2019 to October 20, 2019; and the NYH1904 Rockaway Inlet Jetty was deployed from June 28, 2019 to August 8, 2019. The current observations were used to calibrate the model, through time series comparisons at observation depths. Current observations from the three stations were also used to predict tidal currents for model validation.

2.2 Delft3D Hydrodynamic Model

The Delft3D FM modeling suite was used to develop a 3D hydrodynamic model of the AOI, capture circulation patterns, and provide the hydrodynamic forcing for the sediment dispersion modeling. The module, D-Flow FM, simulates tidally and/or meteorologically forced two-dimensional (2D, depth-averaged) or 3D unsteady flow and transport phenomena (Deltares, 2022). The model can be run with a rectilinear or flexible mesh grid. The mesh can be constructed using a variety of polygonal elements, with up to six sides, which enables the grid to conform to complex shorelines and sinuous channels as well as include high degrees of mesh resolution in desired areas. The vertical dimension can be specified with boundary-fitted sigma coordinates, Z-grid, or a combination approach.

To appropriately capture the current circulation patterns in the AOI, a flexible mesh grid was developed using the Delft RGFGRID (Deltares Grid Generation Software) tool. The model domain spans from Northern New Jersey to Western Long Island, includes the New York Harbor and major adjoining rivers (Figure 2-1). An iterative process was enacted to ensure sufficient grid resolution throughout the model domain to accurately capture physics and ocean dynamics while optimizing computational modeling time. The computational grid for the entire domain consists of 44,064 cells and 23,228 nodes. Grid resolution varies by area. In the nearshore region, surrounding the landfall connections, the cell edge length is approximately 500 m. Offshore, in proximity to the OECC and Lease Area, the cell edge length is approximately 1000 m. Further offshore, along the eastern open boundary, cell edge lengths range from approximately 1000 m to 1500 m. The highest grid resolutions were applied within the New York Harbor and adjoining tidal straits and rivers to ensure that the rivers, straits, and discharge boundary conditions were adequately modeled and imposed. The vertical layering of the grid is made up of five sigma layers which follow the terrain, equally distributed throughout the water column.

2.2.1 Model Boundary Conditions

The hydrodynamic model applies forcing along its open boundaries and surface. Boundary conditions include specification of wind speed 10 m above the free surface, tidal characteristics, and river discharge (Figure 2-1):

- **Meteorological Boundary Conditions (See Section 2.1.2)**: The wind forcing, as the surface boundary, covers the entire gridded area. Meteorological data was obtained from the ERA5 model dataset and was applied to the entire grid surface as U (Eastward) and V (Northward) velocities.

- **Tidal Boundary Conditions (See Section 2.1.3)**: The D-Flow FM model requires water levels, or tidal phase, and amplitude prescribed along open boundaries. These tidal boundaries allow the transfer of external tidal flow into the domain. For this modeling study, the offshore open boundary of the model domain was in the Atlantic Ocean (Figure 2-1). Spatially-varying tidal amplitude and phases of harmonic constituent were extracted from the EC2015 tidal dataset at each offshore boundary node. Water levels were also prescribed at the boundary between the Long Island Sound and the model domain. This water level boundary condition was prescribed with time series data from a NOAA station at Kings Point (Figure 2-1 and Table 2-1).

- **River Boundary Conditions (See Section 2.1.4):** River discharges were included from four rivers (i.e., Hackensack, Hudson, Passaic, and Raritan Rivers) with significant flows into the model domain (Figure 2-1 and Table 2-1). The boundary conditions were specified by a time series extracted from the corresponding USGS gauge and applied to the Delft3D model at 15-minute intervals.

2.2.2 Model Calibration

Parameters in the DFlow FM model were analyzed for month-long periods at three current observation locations (Figure 2-2) to calibrate the model before validating and applying the model for hindcast simulation. These calibration months were selected based on the availability of observation data near the project components. Parameters that were considered in the calibration process included horizontal resolution of the grid and bottom roughness (e.g., Manning's roughness coefficient, *n*). Comparisons of U and V components of velocity show that the model was able to recreate the semidiurnal nature of the tides and the spring/neap cycle of changing tidal amplitude (Figure 2-5 to Figure 2-7). To reach a better agreement between modeled and measured values, *n* (i.e., Manning's roughness coefficient) was adjusted to calibrate the modeled currents to the observations at the observation station. Statistical analyses were performed to compare model performance with observation of currents (Table 2-3).

The skill of the Delft3D model skill was quantified by statistically comparing simulated currents (U and V) against observations using several statistical metrics, including Root-Mean Square Error (RMSE) and Mean Absolute Error (MAE). These metrics indicate the accuracy of the predictions and the amount of deviation from the actual values and are used in model calibration. Descriptions of these statistical metrics are given below.

The RMSE calculates the average magnitude of deviations between two datasets. For our analyses, RMSE will quantify the deviation between measured data ($Xobs$) and modeled data ($Xmodel$), where both datasets have the same units. Smaller values suggest better agreement between measured and predicted values.

The RMSE is evaluated as follows:

$$RMSE = \sqrt{\frac{1}{N}\sum_{n=1}^{N}(X_{model} - X_{obs})^2}$$

As the errors are squared before they are averaged, RMSE generates a relatively high weight to large errors. The MAE quantifies the average magnitude of deviations between measured data ($Xobs$) and modelled data ($Xmodel$) as follows:

$$MAE = \frac{1}{N}\sum_{n=1}^{N}|X_{model} - X_{obs}|$$

A smaller value of MAE indicates better agreement between measured and calculated values.

Table 2-3: Statistical evaluation of bottom current velocity components (m/s) of the Delft3D application compared with observations at NYH1901, NYH1903, and NYH1904, where *n* is Manning's roughness coefficient.

Station: NYH1901				
Velocity Component	**Statistical measure**	***n* = 0.02**	***n* = 0.025**	***n* = 0.03**
U	RMSE (m/s)	0.28	0.22	0.18
	MAE (m/s)	0.22	0.18	0.15
V	RMSE (m/s)	0.14	0.14	0.15
	MAE (m/s)	0.11	0.12	0.12
Station: NYH1903				
Velocity Component	**Statistical measure**	***n* = 0.02**	***n* = 0.025**	***n* = 0.03**
U	RMSE (m/s)	0.13	0.10	0.10
	MAE (m/s)	0.10	0.08	0.07
V	RMSE (m/s)	0.11	0.09	0.08
	MAE (m/s)	0.09	0.07	0.07
Station: NYH1904				
Velocity Component	**Statistical measure**	***n* = 0.02**	***n* = 0.025**	***n* = 0.03**
U	RMSE (m/s)	0.13	0.10	0.10
	MAE (m/s)	0.10	0.08	0.07
V	RMSE (m/s)	0.11	0.09	0.08
	MAE (m/s)	0.09	0.07	0.07

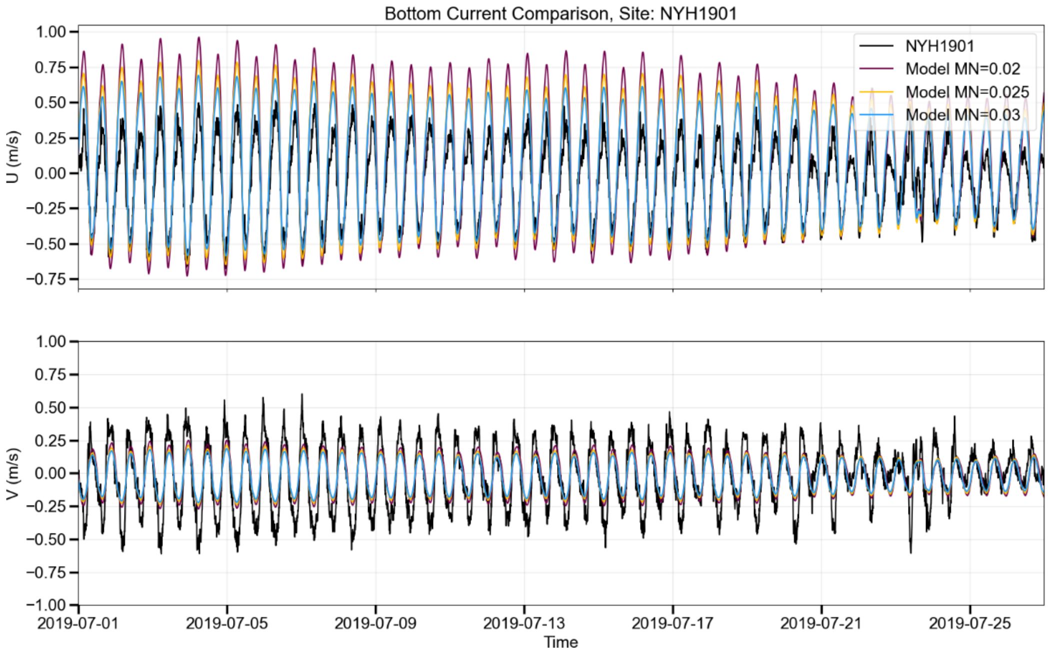


Figure 2-5: Bottom layer current velocity components from NOAA NYH1901 current station compared to hydrodynamic model predictions for the calibration period.

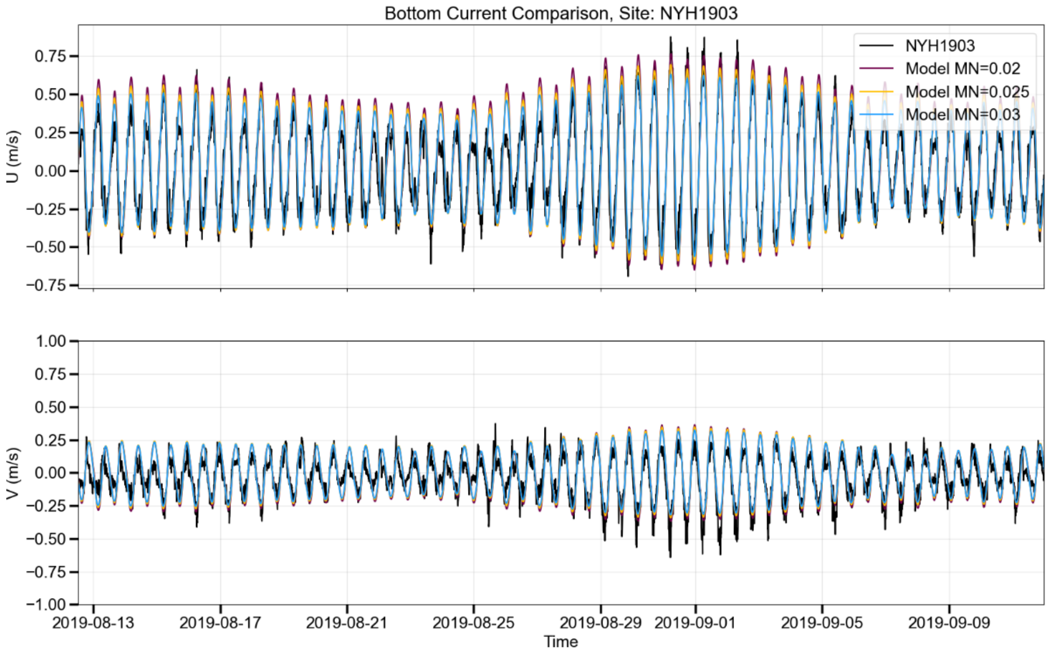


Figure 2-6: Bottom layer current velocity components from NOAA NYH1903 current station compared to hydrodynamic model predictions for the calibration period.

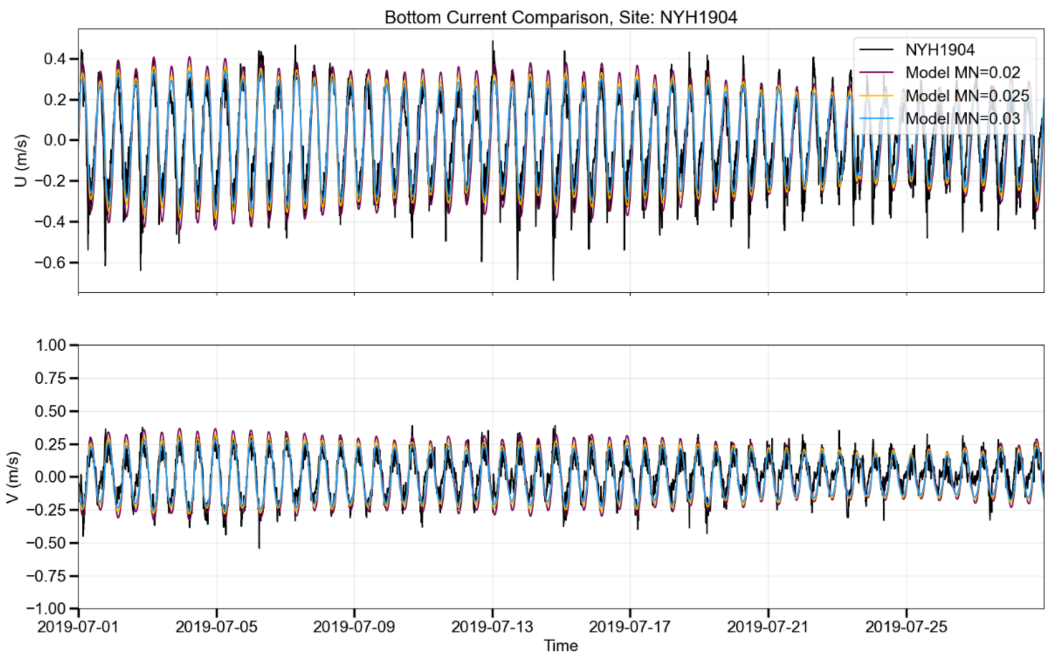


Figure 2-7: Bottom layer current velocity components from NOAA NYH1904 current station compared to hydrodynamic model predictions for the calibration period.

2.2.3 Model Validation

The Delft3D model, calibrated with *n*=0.03, was validated from March 1, 2019 through November 1, 2019 to capture the range of potential tidal current conditions. Model validation included time series comparisons of observed or predicted data to the model as well as a statistical analysis conducted to determine model performance for tidal and hydrodynamic conditions within the model domain. The model recreated tidal conditions during late spring and summer months, as shown by the comparison to observations at the Sandy Hook (Figure 2-8) and the Battery (Figure 2-9) NOAA stations, and related statistical analyses (Table 2-4).

Table 2-4: Statistical evaluation of SSH (m) of the Delft3D application compared with observations at three NOAA Stations.

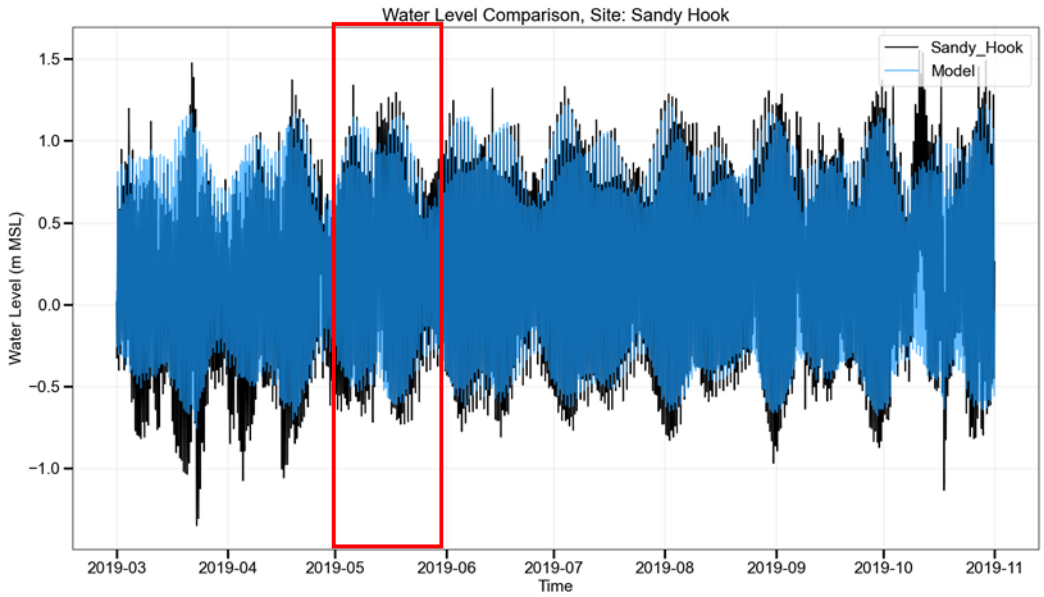
Velocity Component	Statistical Measure	The Battery	Sandy Hook
SSH	RMSE (m)	0.23	0.25
	MAE (m)	0.19	0.22

Table 2-5: Statistical evaluation of bottom current velocity components (m/s) of the Delft3D application compared with observations at three NYH Stations.

Velocity Component	Statistical Measure	NYH1901	NYH1903	NYH1904
U	RMSE (m/s)	0.18	0.08	0.07
	MAE (m/s)	0.14	0.06	0.05
V	RMSE (m/s)	0.12	0.06	0.05
	MAE (m/s)	0.10	0.05	0.04

The model-predicted tidal elevations, over the eight-month time frame, compared well with observations of the semidiurnal tides and reproduced the spring and neap tidal cycles with varying amplitudes. The model accurately predicted water levels at different locations within the domain, especially during times of low tidal residual, as shown in May. Water level forcing and response are primarily dominated by the astronomical tide. The model does not fully capture the smaller fluctuations in the water level related to non-cyclical forcing in the early months of spring and fall.

In addition to plots comparing the model predicted and observed bottom currents (Figure 2-10 through Figure 2-12), statistical analyses were performed for the eastward (U component) and northward (V component) velocities (Table 2-5). Current speeds from the model aligned with predictions from current stations NYH1903 (Figure 2-11) and NYH1904 (Figure 2-12), whereas model predictions diverged slightly from observations at station NYH1901 (Figure 2-10). However, any further adjustments to *n* (i.e., Manning's roughness coefficient) or other parameters would impact the model outputs at the stations with adequate results. Based upon the accurate predictions at NYH1903 and NYH1904 and good agreement to tidal conditions, the model was applied as hydrodynamic forcing for the sediment dispersion modeling.



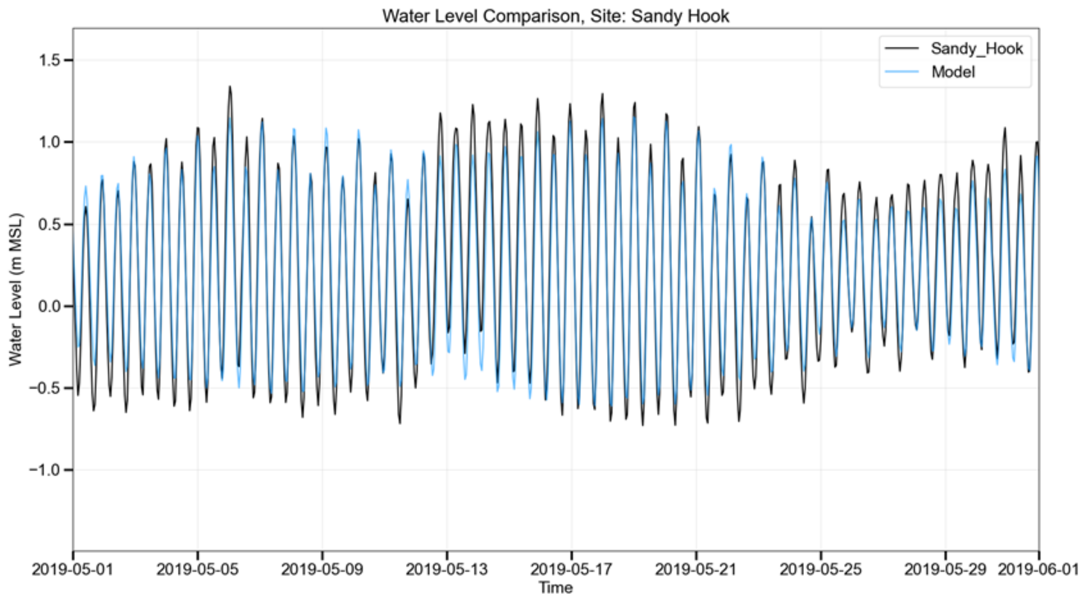
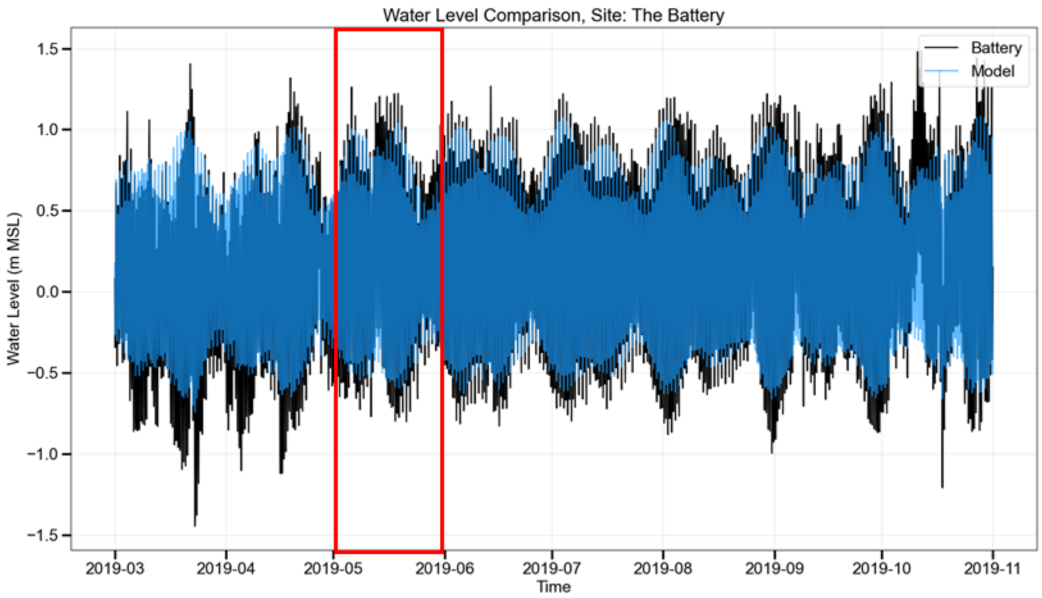


Figure 2-8: Water level of NOAA station, Sandy Hook (black) and hydrodynamic model (blue) during the validation period. The top plot displays the water level time series over the validation time period, March to November 2019, with May outlined in red. The bottom plot displays the water level time series for the month of May, a zoomed in version of the preceding plot.



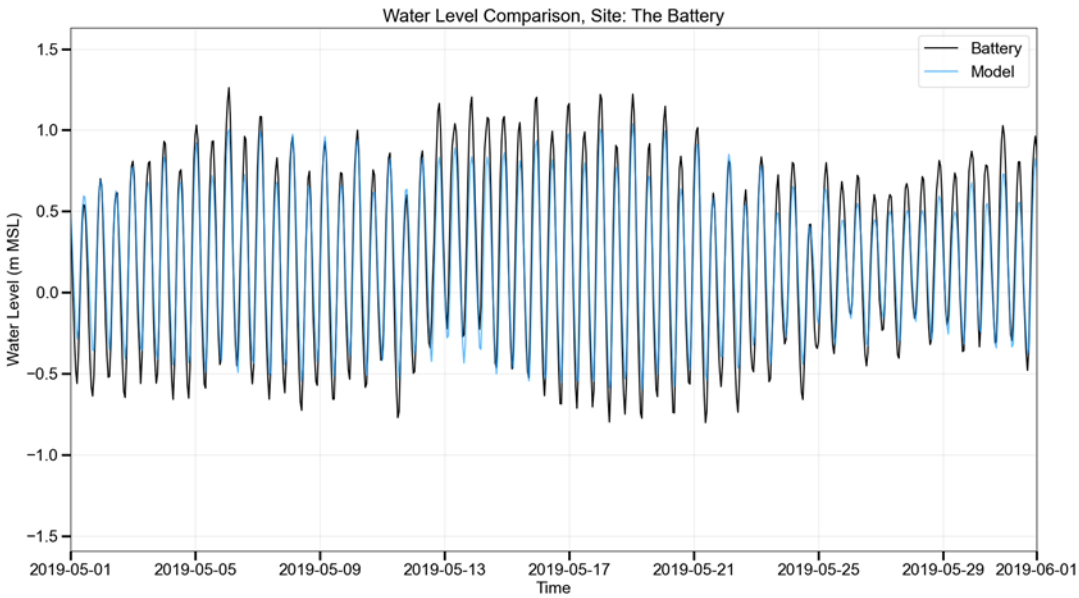
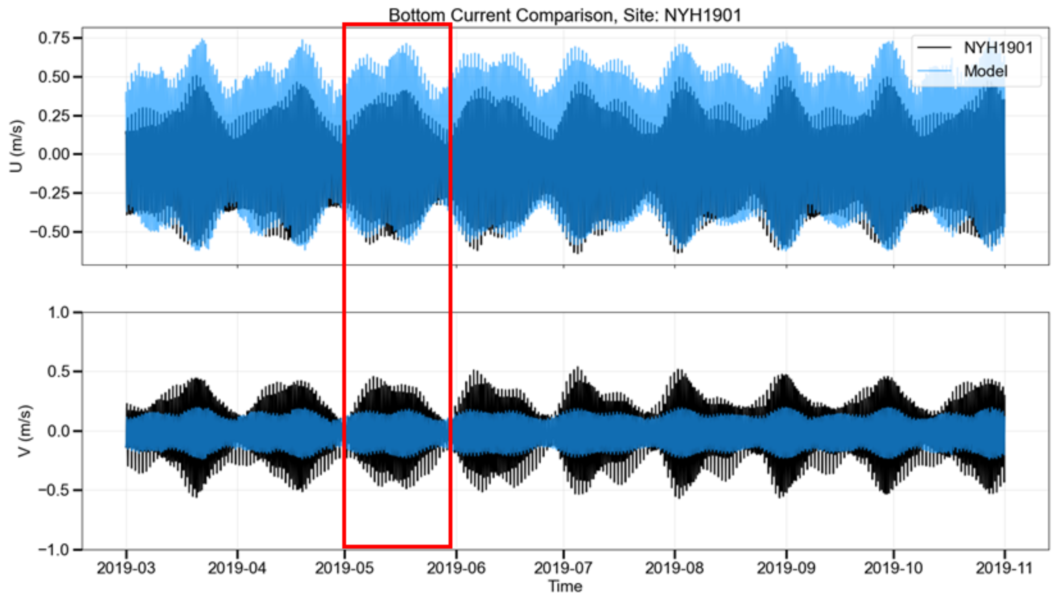


Figure 2-9: Water level of NOAA station, The Battery (black) and hydrodynamic model (blue) during the validation period. The top plot displays the water level time series over the validation time period, March to November 2019, with the month of May outlined in red. The bottom plot displays the water level time series for the month of May, a zoomed in version of the preceding plot.



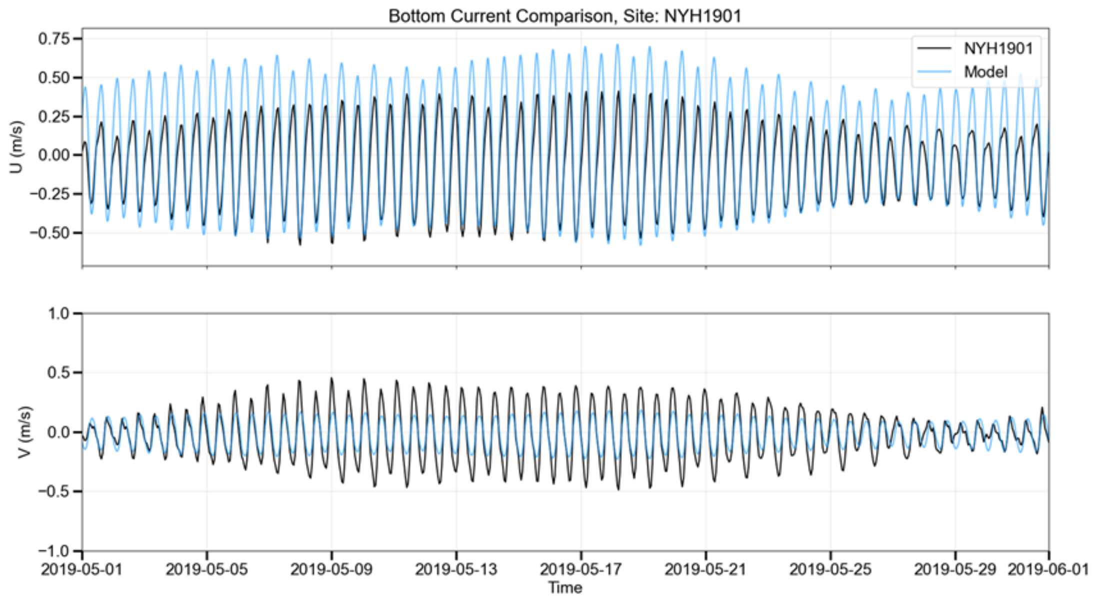
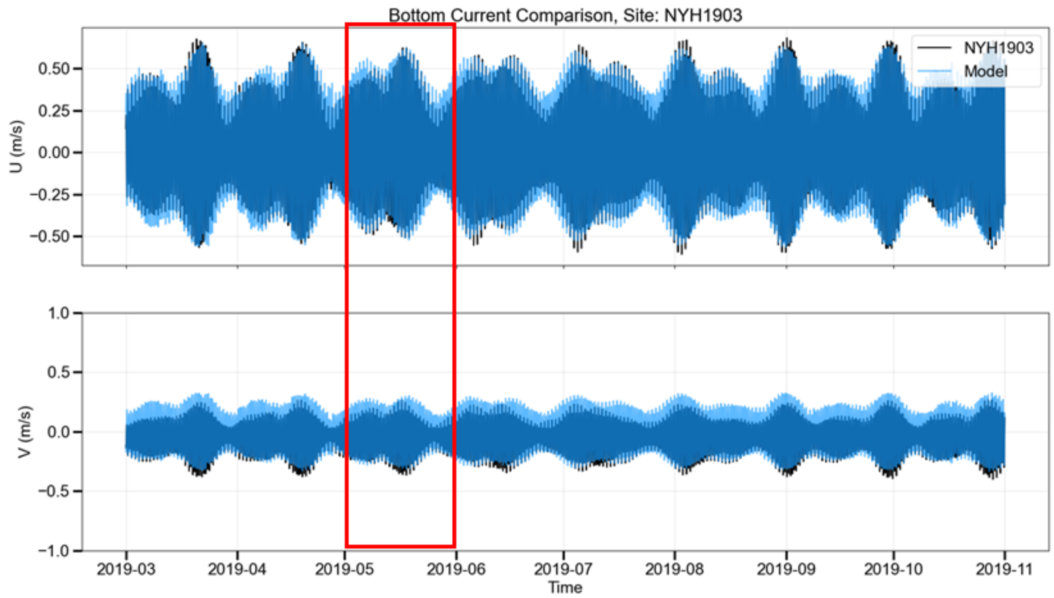


Figure 2-10: Bottom-layer current velocity components of predicted data from NOAA current station, NYH1901 (black) and hydrodynamic model (blue) during the validation period. The top plot displays the current component time series over the validation time period, March to November 2019, with the month of May outlined in red. The bottom plot displays the current component time series for the month of May, a zoomed in version of the preceding plot.



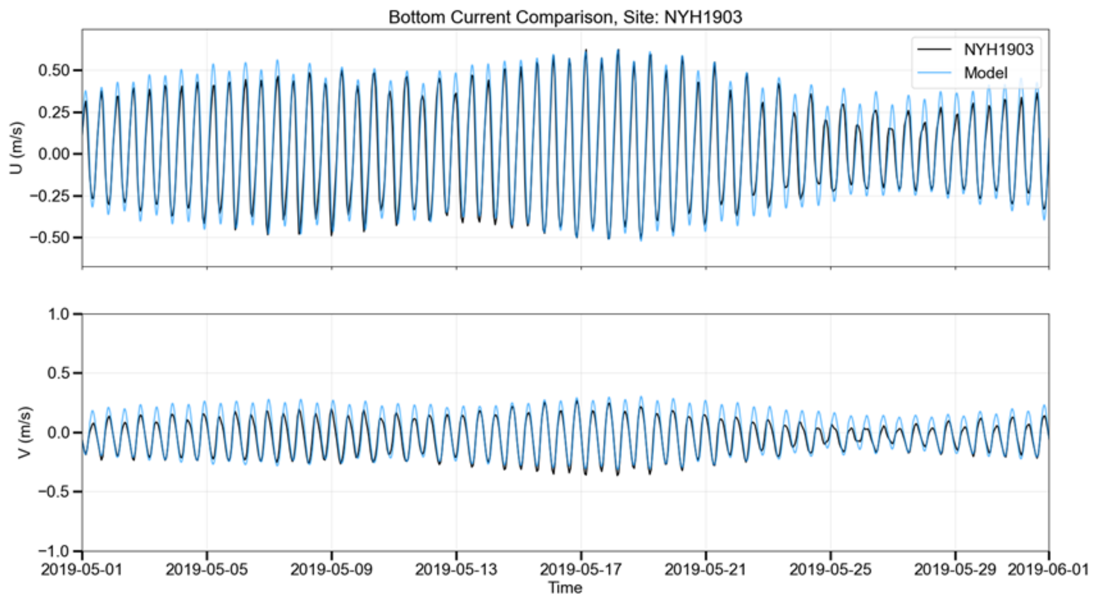


Figure 2-11: Bottom-layer current velocity components of predicted data from NOAA current station, NYH1903 (black) and hydrodynamic model (blue) during the validation period. The top plot displays current component time series over the validation time period, March to November 2019, with the month of May, outlined in red. The bottom plot displays the current component time series for the month of May, a zoomed in version of the preceding plot.

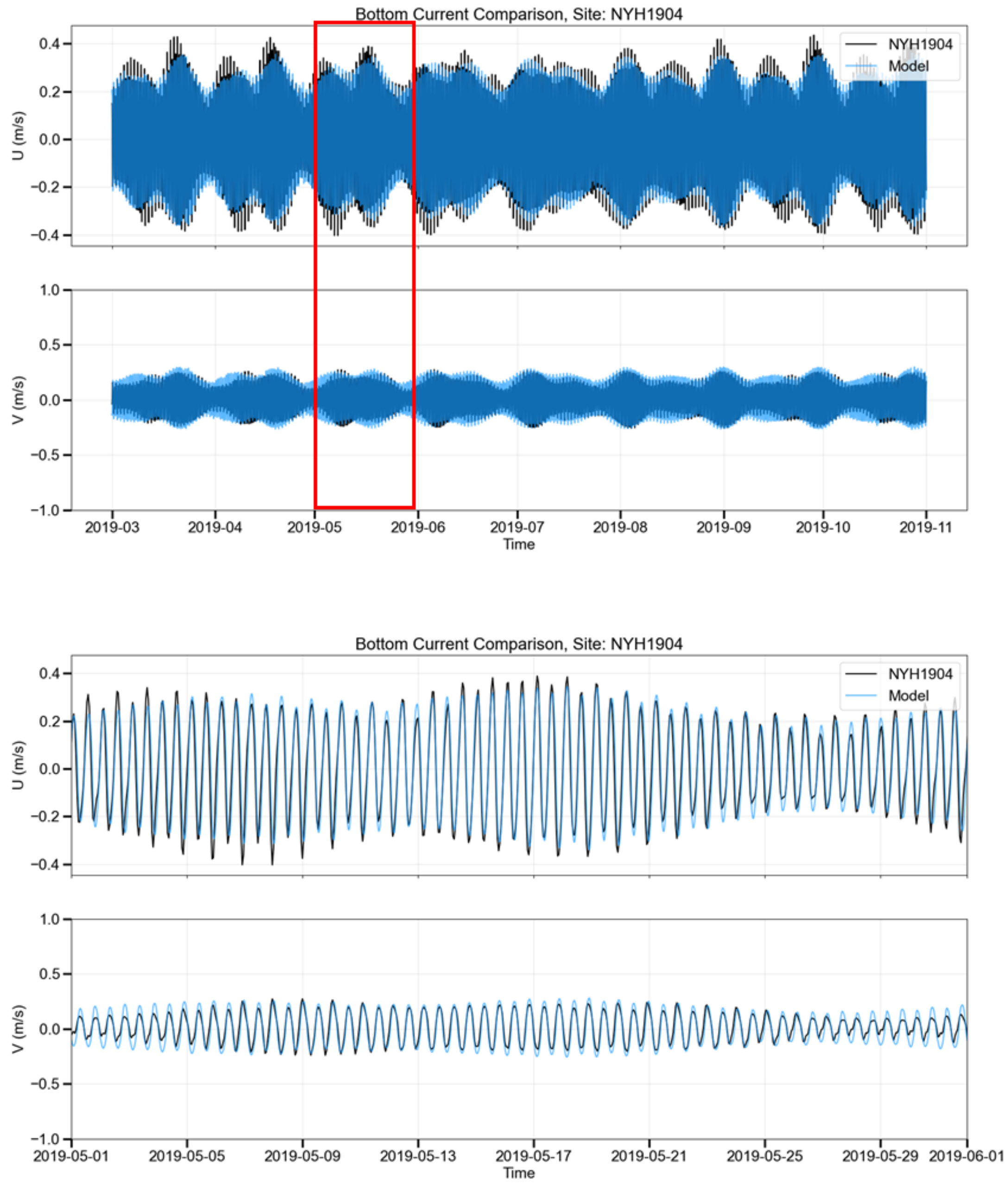


Figure 2-12: Bottom-layer current velocity components of predicted data from NOAA current station, NYH1903 (black) and hydrodynamic model (blue) during the validation period. The top plot displays current component time series over the validation time period, March to November 2019, with the month of May outlined in red. The bottom plot displays the current component time series for the month of May, a zoomed in version of the preceding plot.

2.2.4 Application to Sediment Dispersion Modeling

The time-period for sediment dispersion modeling was conservatively selected based upon the 95th percentile of maximum velocity at the seabed and water surface over tidal cycles during the anticipated eight-month construction window along the OECC within the AOI. The duration between May 1, 2019 and June 1, 2019 contains two spring and neap cycles as well as currents that are close to the 95th percentile of maximum velocity at the bottom and established the time period applied in the sediment dispersion modeling. A snapshot in time of the bottom current speeds within the model domain during a flood time step

(May 13, 2019 04:00 UTC; Figure 2-13) and during an ebb time step (May 13, 2019 12:00 UTC; Figure 2-14) capture spatial and temporal variability in current speed.

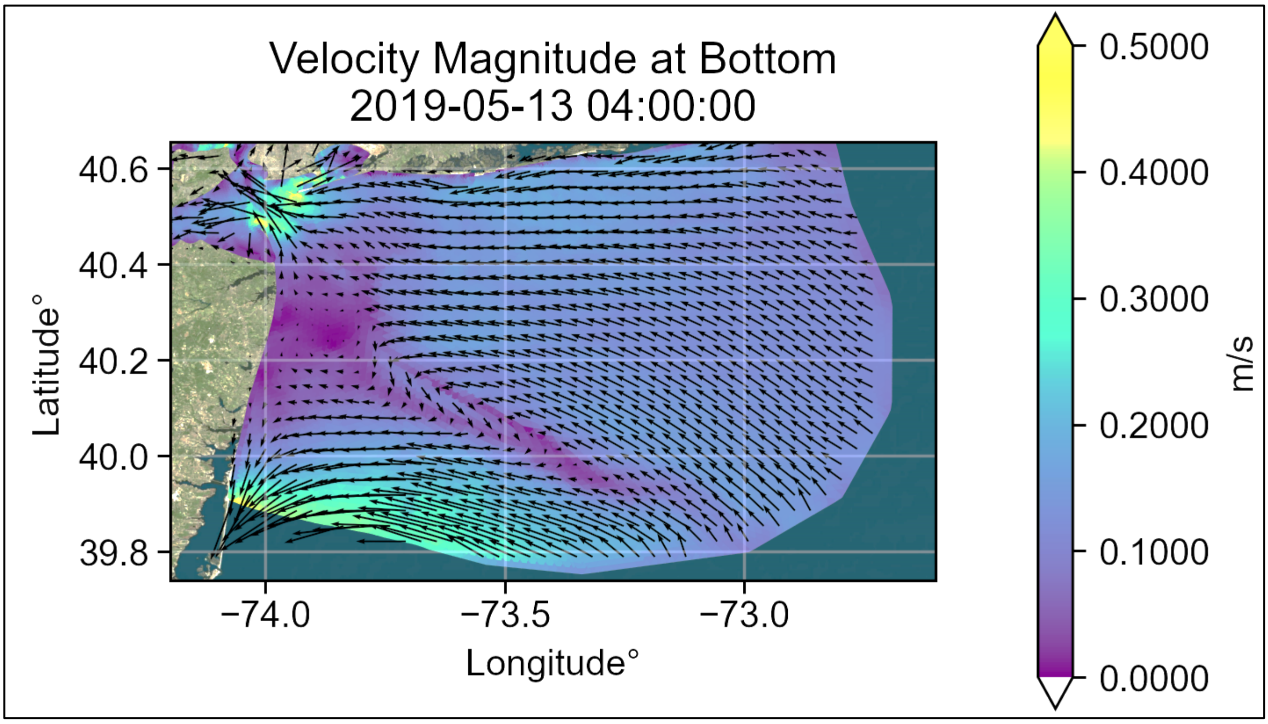


Figure 2-13: Color contour map showing bottom current, overlayed with vectors for a flood time step (May 13, 2019, 04:00 UTC).

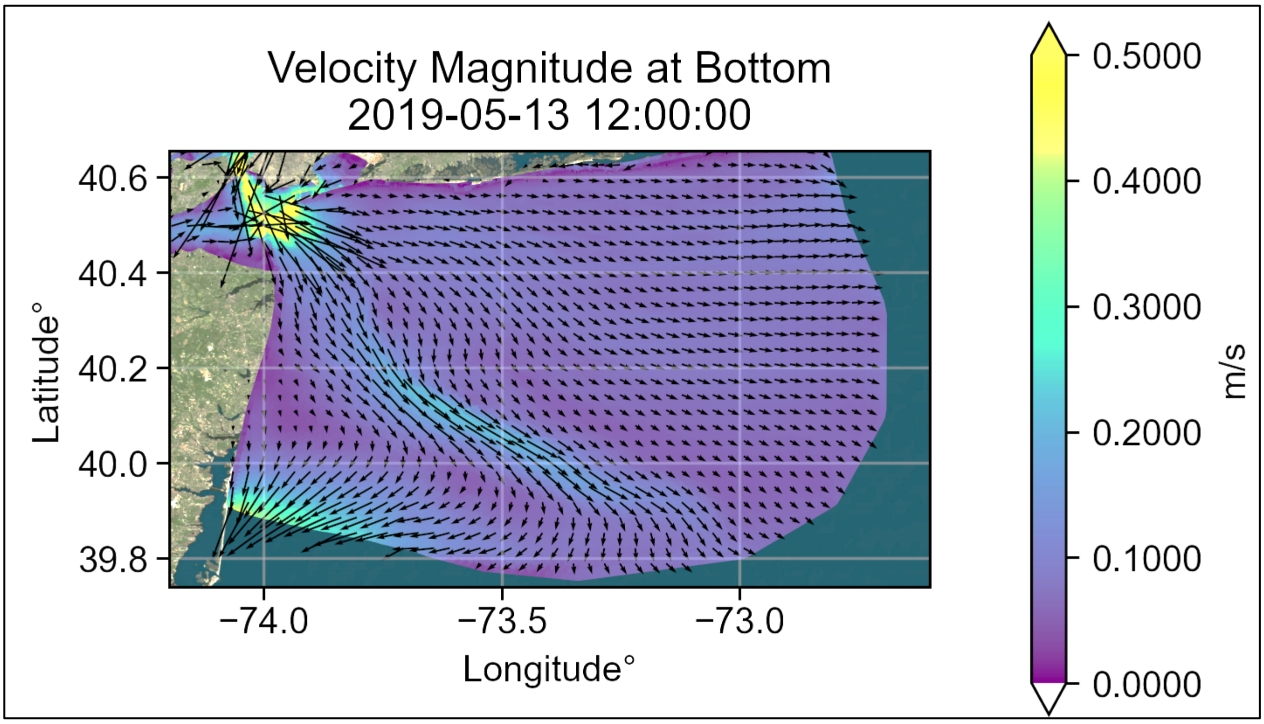


Figure 2-14: Color contour map showing bottom current, overlayed with vectors for an ebb time step (May 13, 2019, 12:00 UTC).

3 SEDIMENT MODELING

3.1 SSFATE Modeling Approach

Sediment dispersion associated with the construction activities was simulated using RPS's SSFATE model. The model requires inputs defining the environment (e.g., water depths, currents) and the construction activity loading (e.g., sediment grain size, resuspended volume) to predict the associated sediment plume and seabed deposition. Details of the model and theory are provided in the following sections.

3.1.1 SSFATE Model Description

SSFATE is a three-dimensional Lagrangian (particle) model developed jointly by the US Army Corps of Engineers' (USACE) Environmental Research and Development Center and Applied Science Associates (now part of RPS, a Tetra Tech Company) to simulate sediment resuspension and deposition originally from marine dredging operations. Model development was documented in a series of USACE' Dredging Operations and Environmental Research Program technical notes (Johnson et al., 2000; Swanson et al., 2000), at previous World Dredging Conferences (Anderson et al., 2001), and at a series of Western Dredging Association Conferences (Swanson et al., 2004; Swanson and Isaji, 2006). Following dozens of technical studies, which demonstrated successful application to dredging, SSFATE was further developed to include simulation of cable and pipeline burial operations using water jet trenchers (Swanson and Isaji, 2006) and mechanical ploughs as well as sediment dumping and dewatering operations. The current modeling system includes a Geographic Information System (GIS)-based interface for visualization and analysis of model output.

SSFATE computes suspended sediment concentrations in the water column and sedimentation patterns on the seabed resulting from sediment-disturbing activities. The model requires a spatial and time-varying circulation field (typically from hydrodynamic model output), definition of the water body bathymetry, and parameterization of the sediment disturbance (source), which includes sediment grain size data and sediment flux description. The model predicts the transport, dispersion, and settling of suspended sediment released to the water column. The focus of the model is on the far-field processes (i.e., beyond the initial disturbance) affecting the dispersion of suspended sediment. The model uses specifications for the suspended sediment source strengths (i.e., mass flux), vertical distributions of sediments, and sediment grain-size distributions to represent loads to the water column from different types of mechanical or hydraulic dredges, sediment dumping practices, or other sediment-disturbing activities, such as jetting or ploughing for cable or pipeline burial. Multiple sediment types or fractions can be simulated simultaneously, as can discharges from moving sources.

SSFATE has been successfully applied to a number of recent modeling studies; these studies have received acceptance from federal and state regulatory agencies.

3.1.2 Model Theory

SSFATE addresses the short-term movement of sediments that are disturbed during mechanical ploughing, hydraulic jetting, dredging, and other processes where sediment is suspended into the water column. The model predicts the three-dimensional path and fate of sediment particles based on sediment properties, sediment loading characteristics, and environmental conditions (e.g., bathymetry and currents). The computational model uses a Lagrangian or particle-based scheme to represent the total mass of sediments suspended over time, which provides a method to track suspended sediment without any loss of mass as compared to Eulerian (continuous) models due to the nature of the numerical approximation used for the conservation equations. Thus, the method is not subject to artificial diffusion near sharp concentration gradients and can easily simulate all types of sediment sources.

Sediment particles in SSFATE are divided into five size classes, each having unique behaviors for transport, dispersion, and settling (Table 3-1). For any given location (segment of the route), the sediment characterization is defined by this set of five classes, with each class representing a portion of the distribution and all five classes summing to 100%. The model determines the number of particles used per time step depending on the model time step and overall duration thereby ensuring an equal number of particles is used to define the source throughout the simulation. While a minimum of one particle per sediment size class per time step is enforced, typically multiple particles are used. The mass per particle varies depending on the total number of particles released, the grain size distribution, and the mass flux per time step.

Table 3-1: Sediment Size Classes used in SSFATE.

Description	Class	Type	Size Range (microns)
Fine	1	Clay	0-7
	2	Fine silt	8-35
	3	Coarse silt	36-74
Coarse	4	Fine sand	75-130
	5	Coarse sand	>130

Horizontal transport, settling, and turbulence-induced suspension of each particle are computed independently by the model for each time step. Particle advection is based on the relationship that a particle moves linearly, in three-dimensions, with a local velocity obtained from the hydrodynamic field, for a specified model time step. Diffusion is assumed to follow a simple random walk process, with the diffusion distance defined as the square root of the product of an input diffusion coefficient, and at each time step is decomposed into X and Y displacements via a random direction function. The vertical Z diffusion distance is scaled by a random positive or negative direction.

Particle settling rates are calculated using Stokes equations and are based on the size and concentration of each particle class. Settling of mixtures of particles is a complex process due to interaction of the different size classes, some of which tend to be cohesive and thus clump together to form larger particles that have different settling rates than would be expected based on their individual sizes. Enhanced settlement rates due to flocculation and scavenging are particularly important for clay and fine-silt sized particles (Swanson et al., 2004; Teeter, 1998), and these processes have been implemented in SSFATE. These processes are bound by upper and lower concentration limits, defined through empirical studies, which contribute to flocculation for each size class of particles. Above and below these limits, particle collisions are either too infrequent to promote aggregation or so numerous that the interactions hinder settling.

Deposition is calculated as a probability function of the prevailing bottom stress and local sediment concentration and size class. The bottom shear stress is based on the combined velocity due to waves (if used) and currents using the parametric approximation by Soulsby (1998). Sediment particles that are deposited may be subsequently resuspended into the lower water column if critical levels of bottom stress are exceeded, and the model employs two different resuspension algorithms. The first applies to material deposited in the last tidal cycle (Lin et al., 2003). This accounts for the fact that newly-deposited material will not have had time to consolidate and will be resuspended with less effort (lower shear force) than consolidated bottom material. The second algorithm is the established Van Rijn (1989) method and applies to all other material that has been deposited prior to the start of the last tidal cycle. Swanson et al. (2007) summarize the justifications and tests for each of these resuspension schemes. Particles initially released by operations are continuously tracked for the length of the simulation, whether in suspension or deposited.

For each model time step, the suspended concentration of each sediment class as well as the total concentration is computed on a concentration grid. The concentration grid is a uniform rectangular grid in the horizontal dimension with user-specified cell size and a uniform thickness in the vertical dimension (z-grid). The concentration grid is independent of the resolution of the hydrodynamic data used to calculate transport, thus supporting finer spatial differentiation of plume concentrations, and avoiding underestimation of concentrations caused by spatial averaging over larger volumes/areas. Model outputs include but are not limited to water-column concentrations in both horizontal and vertical dimensions; time-series plots of suspended sediment concentrations at points of interest; and thickness contours of sediment deposited on the seafloor. Deposition is calculated as the mass of sediment particles that accumulate over a unit area and is calculated on the same grid as concentration. Because the amount of water in the deposited sediment is unknown, by default, SSFATE converts deposition mass to thickness by assuming no water content. For a detailed description of the SSFATE model equations governing sediment transport, settling, deposition, and resuspension, see Swanson et al. (2007).

3.2 SSFATE Data Needs

The sediment modeling was carried out using RPS' in-house model SSFATE. Setup of an SSFATE model scenario consists of defining how each sediment disturbance activity will be parameterized, establishing the sediment source terms, and defining environmental and numerical calculation parameters. For each scenario, the source definition includes:

- Sediment characteristics (e.g., grain size distribution, moisture content) along the route;
- The geographic extent of the activity (point release versus line source [route]);
- Timing and duration of the activity;
- Volumes, cross-sectional areas, and depths of the trench or excavation pit;
- The production rate for each sediment disturbance method;
- Loss (mobilization) rates for each sediment disturbance method; and
- The vertical distribution of sediments as they are initially released to the water column.

The sediment source for cable installation simulations is defined through a load source file, which defines the location of the sources, mass flux of sediment disturbed through operations, loss rate of the disturbed flux resuspended into the water column, vertical position of the mass introduced to the water column, and grain size distribution of the mass introduced to the water column along the route of installation. A component of the sediment grain size distribution is a definition of the percent solids, which is used in the mass flux calculation. Bed sediments contain some water within interstitial pore spaces, and therefore the trench volume consists of both sediment and interstitial water. Therefore, the percent solid of the sediment sample, as based on laboratory measure of moisture content, is used in the calculation of total mass flux. The sediment source can vary spatially, and therefore the line source file is broken into multiple discrete entries, each representing a segment of the route with uniform characteristics. The segments are defined to capture curved route geometry and provide a continuous route aligned with the installation plan.

A model scenario requires characterization of the environment, including a definition of the study area's spatially and time-varying currents (Delft3D output) and water body bathymetry. Model setup includes specification of the concentration and deposition grid, which is the grid at which concentration and deposition calculations are made. The concentration and deposition grid in SSFATE is independent of the resolution of the bathymetric data (Section 2.1.1) or hydrodynamic model grid (Section 2.2); this allows finer resolution which better captures water column concentrations without being biased by numerical diffusion. The concentration and deposition gridding are based on a prescribed square grid resolution in the horizontal plan view and a constant thickness in the vertical. The extent of the concentration is determined dynamically, fit to the extent the sediments travel.

3.2.1 Sediment Characteristics

The sediment characteristics are a key factor of the sediment load definition input to the SSFATE model. The spatially-varying sediment characteristics were developed based on analysis of samples from multiple surveys. The details of the sediment sampling and laboratory analysis are documented in Appendix II-B of the COP; however, an overview of the RPS sediment data analysis as it pertains to the sediment characterization used in the modeling is discussed herein. The objective of the sediment data analysis was to develop the sediment characteristics that represent the sediment composition for the specific target depth which vary by activity type and location. Target depths reflected specific installation activities and represented the depth of sediments that may get resuspended during construction activities.

The objective was to determine the distribution within the five delineated classes used in SSFATE (Table 3-1) and the percentage of the upper seabed that is solid based on the measure of sediment water content, which is a measure of the interstitial pore waters in the sediments. The sampling was comprised of vibracores, which provide a vertical profile of sediments that can be analyzed at multiple depths from the profile. All samples were analyzed by a sieve, which screens out sediments smaller than the specified sieve size. Sieve analysis is performed on multiple sizes to establish a percent finer curve, though it can only resolve the fraction of sands (i.e., coarse sand, fine sand) relative to the SSFATE classifications. Samples also included hydrometer analysis to resolve the fractions in the fine grain size classes (i.e., silts, clay).

For point sources (e.g., HDD Exit Pits), the closest vibracore sample was used for modeling. If the representative HDD Exit Pit was located between two vibracore samples, an interpolation of the two samples was performed and applied in the modeling. All the representative HDD Exit Pit Excavation and Backfill scenarios assumed a target depth of 2.5 m (Figure 3-1). For the line source scenarios (e.g., cable installation), the model interpolated between vibracore data depending on the location of the sediment disturbing activity with respect to the sediment sample. For the OECC cable scenarios, assuming typical jetting parameters, the target trench depth was assumed to be 2.3 m in state waters (Figure 3-1) and 1.7 m in federal waters (Figure 3-2). The vertical injector scenario assumed a deeper target trench depth of 3.4 m, regardless of jurisdiction, but was modeled in federal waters (Figure 3-2). The Lease Area inter-array cable installation simulations were modeled using two conditions. Typical jetting parameters assumed a target trench depth of 2 m and the maximum jetting parameters assumed a target trench depth of 3 m (Figure 3-3).

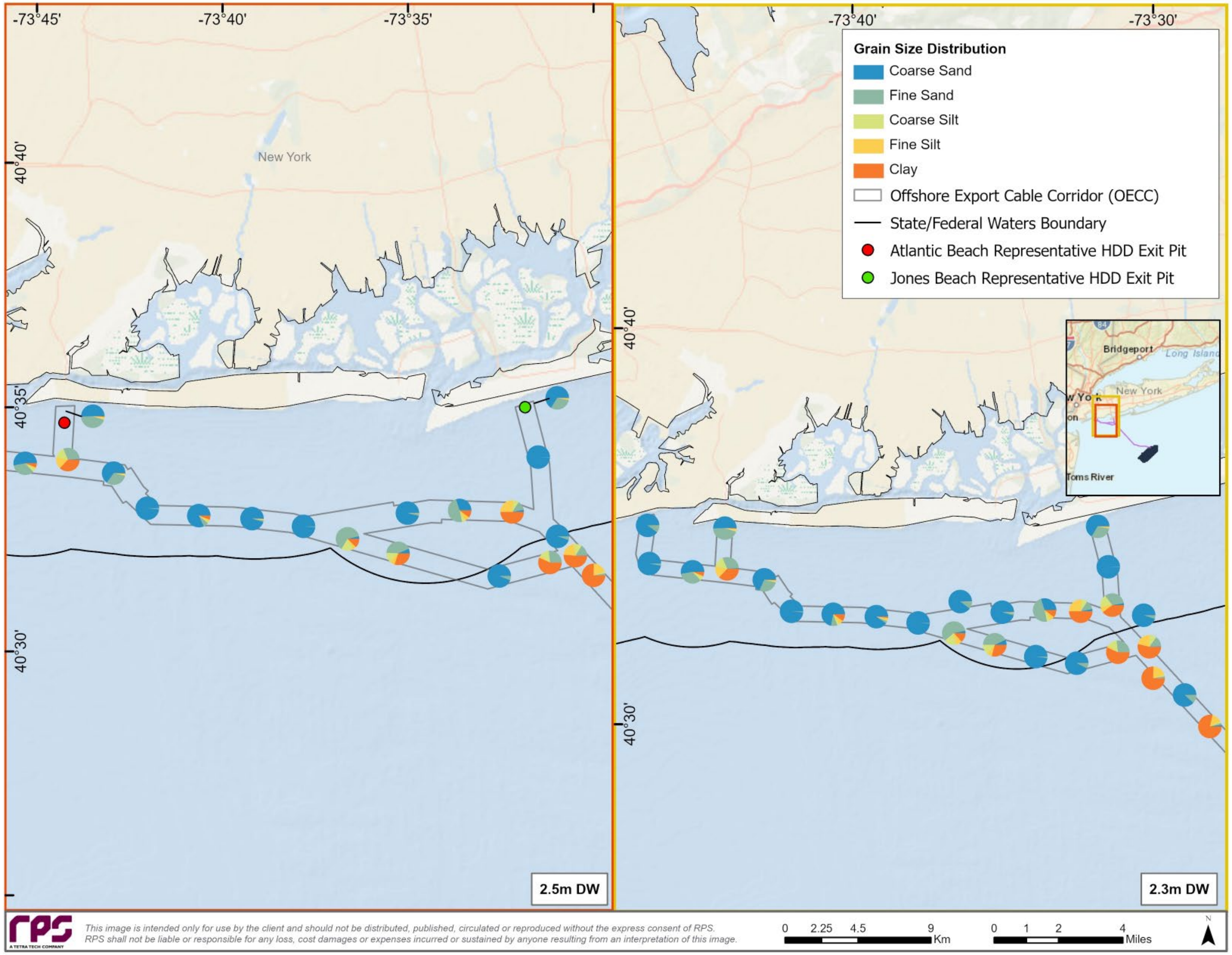


Figure 3-1: Sediment grain size distributions for the state water OECC project components, HDD Exit Pit Construction (2.5 m target depth) and the OECC Cable Installation via Typical Jetting parameters (2.3 m target depth). Note the label in each extent identifies the target depth used to depth-weight (DW) grain size data.

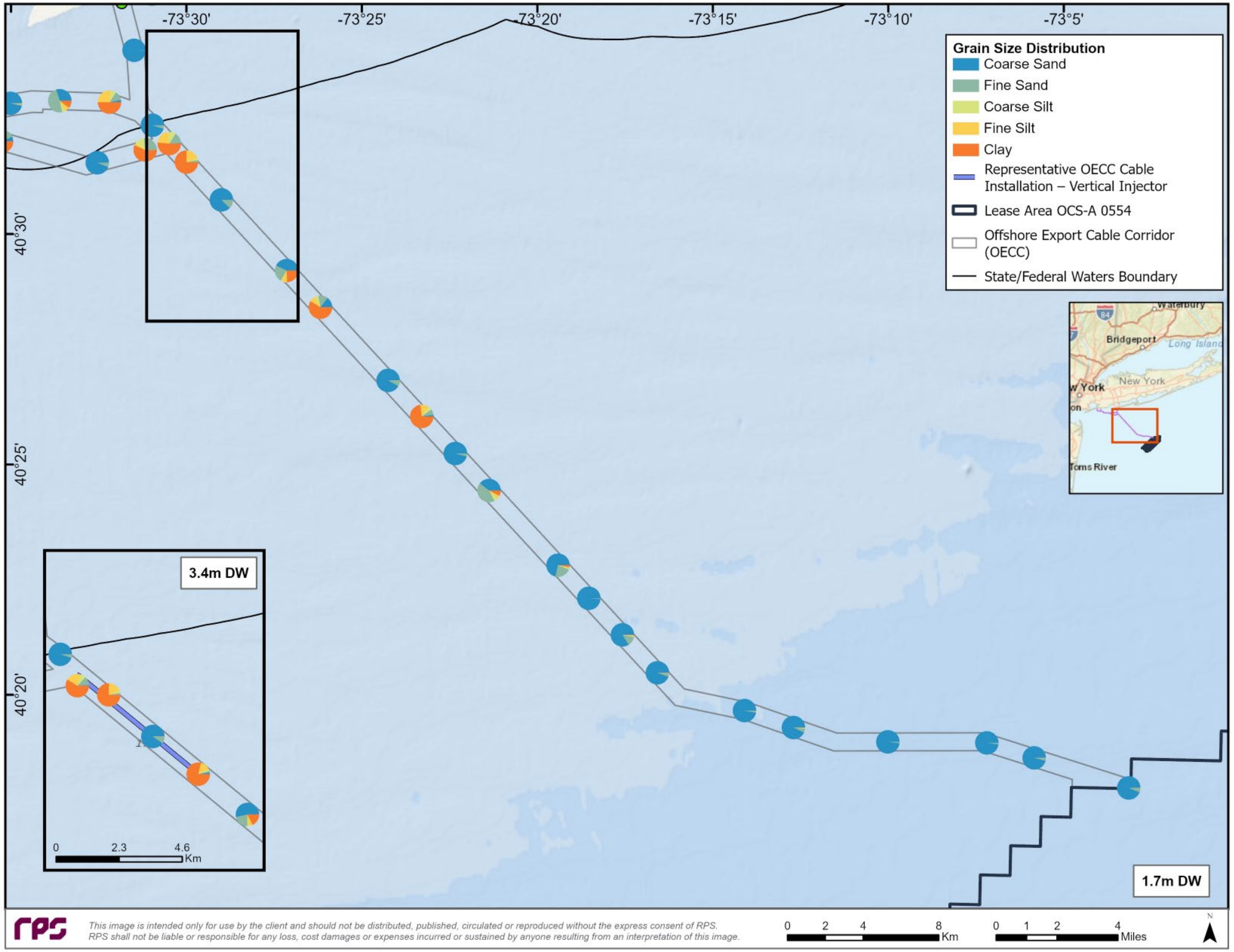


Figure 3-2: Sediment grain size distributions for the federal water OECC cable installation scenarios, depth weighted (DW) for the typical jetting (1.7 m target depth) and vertical injector (3.4 m target depth) simulations. Note the label in each extent identifies the target depth used to DW grain size data.

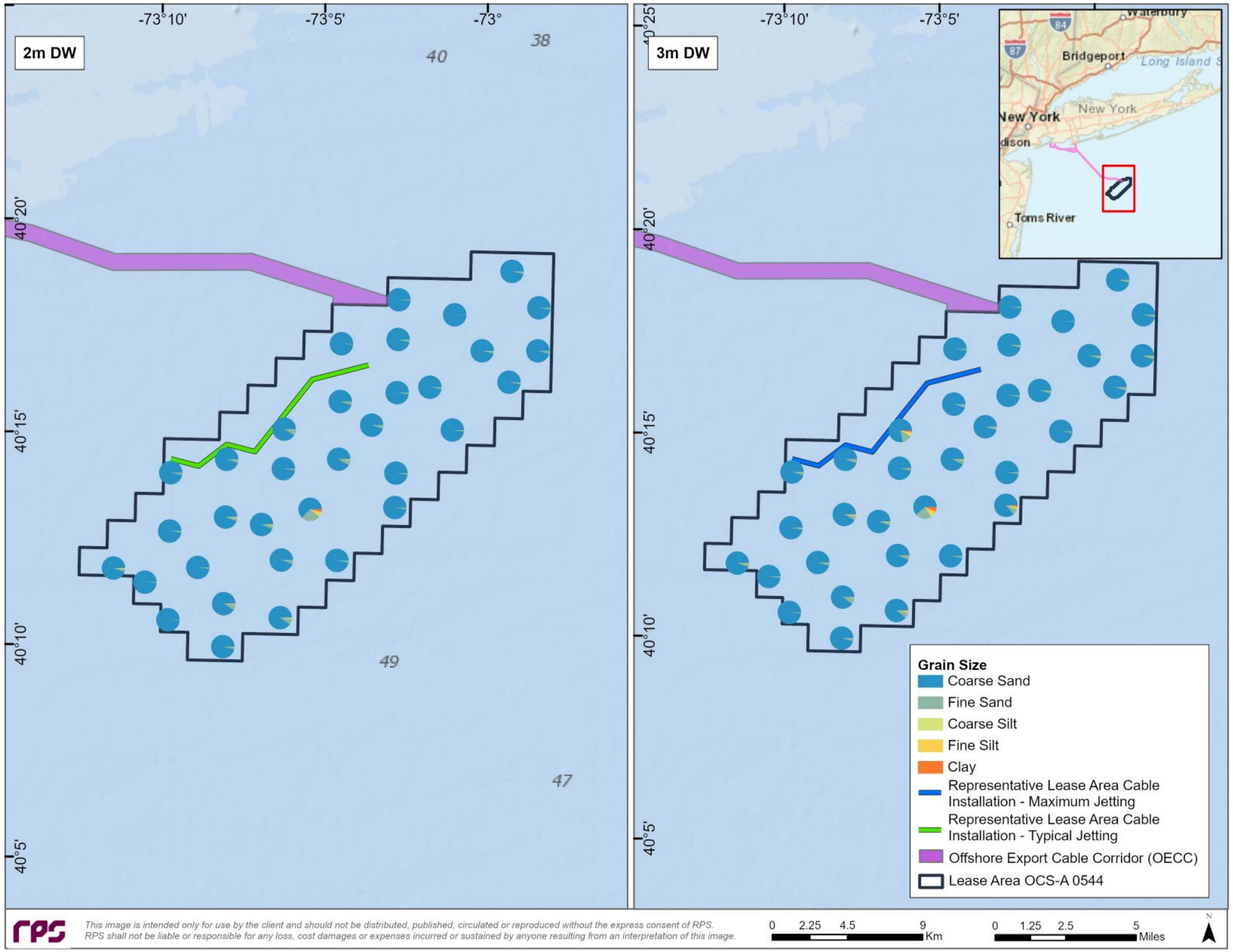


Figure 3-3: Sediment grain size distribution in the Lease Area depth weighted (DW) to the target trench depth for the inter-array cable installation, typical parameters (2 m target depth, left) and maximum parameters (3 m target depth, right). Note the label in each extent identifies the target depth used to DW grain size data.

3.2.2 Hydrodynamic Forcing

Following the model validation, the duration between May 1, 2019 to June 1, 2019 was determined to contain two spring and neap cycles as well as currents that are close to the 95th percentile of maximum velocity at the surface and seabed (Figure 3-4). This period was selected as a conservative representation of potential current speeds as sediment would be transported further from the release site when exposed to fast subsurface currents. Modeling was performed primarily during the first two weeks in May to capture the 95th percentile of maximum current speeds (Figure 3-4).

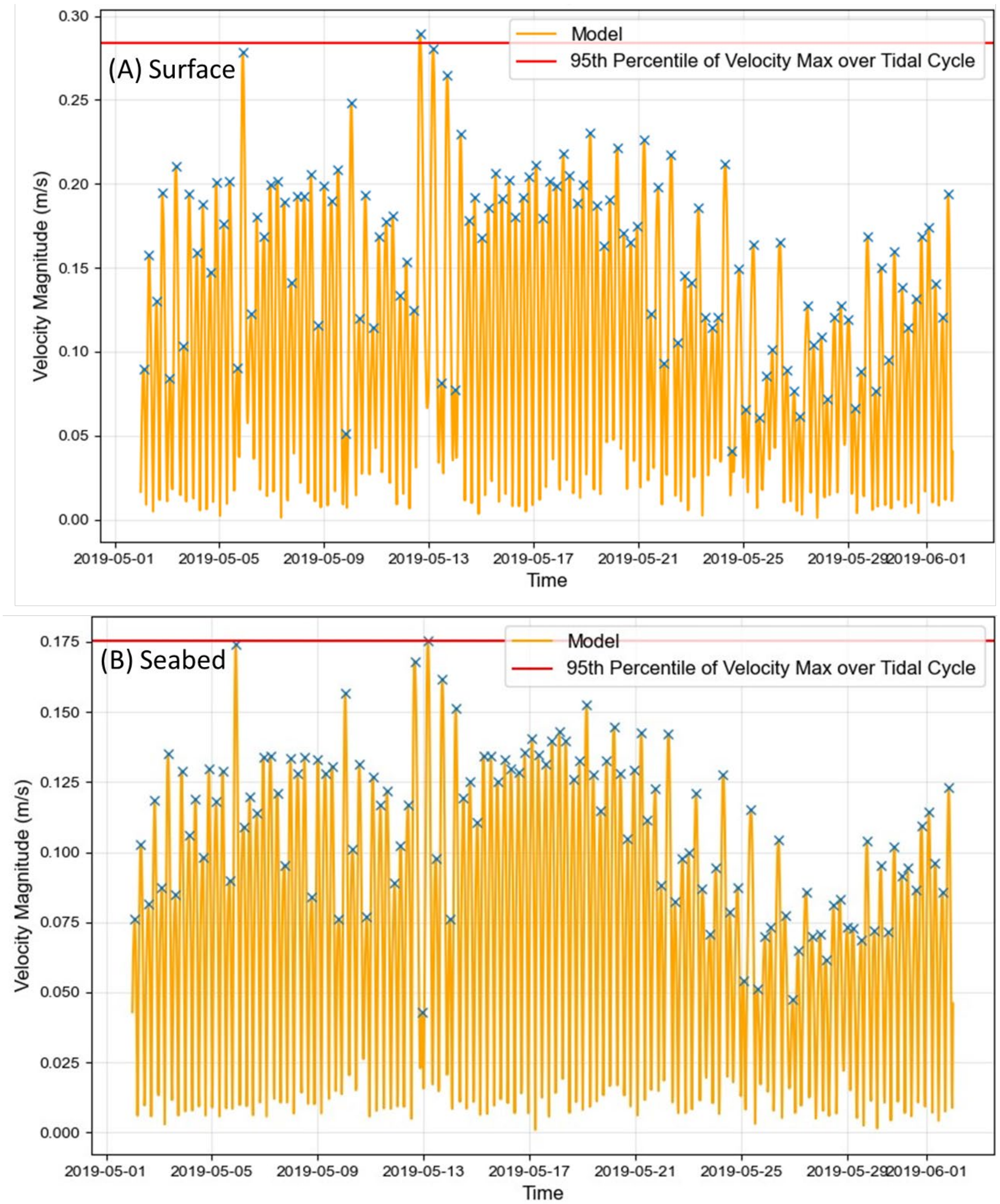


Figure 3-4: The modeled velocity magnitude during the month of May at the (A) surface and (B) seabed, illustrating the 95th percentile of velocity maximum over the tidal cycle.

The start time for the modeling depended on the duration of the sediment disturbing activity. Activities that extended for longer than 12 hours experienced a minimum of one full tidal cycle (i.e., one ebb tide and one flood tide) which allowed sediment plumes to oscillate with the tides. In those instances, the models were initiated on variable dates such that the scenarios overlapped with currents during May 12th and 13th, 2019.

For scenarios when sediment disturbing activities were shorter than 12 hours (i.e., representative HDD exit pit construction), two scenarios were performed, one during an ebb tide and the other during a flood tide. To simplify presentation of the tabular results, the largest affected areas and distances (i.e., worst-case) are reported based on results from the two scenarios (Section 3.3.1 and Section 3.3.2). To illustrate the influence of tidal stage on the transport of the plume, the mapped results are presented for both ebb and flood scenarios and discussed in Section 3.3.3.

3.2.3 Route Definition & Construction Components

Thirteen sediment dispersion simulations were performed to encompass the landfall site construction and cable installation activities included in the PDE (Table 1-1 to Table 1-2). All modeled cable installation simulations within the OECC were selected as the approximate centerline. The modeled inter-array cable installation route within the Lease Area was selected as the centerline of the longest inter-array cable route as this would disturb the most sediment.

To best represent *in-situ* construction activities in the model, the input parameters were selected to reflect the anticipated construction activity based on the equipment type and volume of sediment released to the environment. For line sources (e.g., cable installation), the sediment loading was defined by the route length and the cross-sectional area of the trench, while the point source (e.g., landfall site HDD exit pit construction) depended on the total volume anticipated to be excavated and backfilled. The equipment type defined the production rate (volume per time) and the fraction of the disturbed sediment that will be mobilized to the water column (i.e., resuspension rate or loss rate). The sediment dispersion modeling parameters are summarized below for the various simulations related to the OECC and the Lease Area. A key component of the modeling is the delineated geographical extent of the source (Table 3-2). The Vineyard Mid-Atlantic cable route lengths assessed in this study are broken down in detail below.

Table 3-2: Route definition for the OECC and Lease Area project components.

Description		Modeled Length (km)
Cable Installation – Typical Jetting	Rockaway Beach Approach OECC	State: 25.8 Federal: 1.04
	Western Landfall OECC Variant to Rockaway Beach	State: 22.7 Federal: 3.98
	Atlantic Beach Approach OECC	State: 22.0 Federal: 1.04
	Jones Beach Approach OECC	State: 5.25 Federal: 1.04
	Main OECC	Federal: 49.0
Cable Installation – Vertical Injector	Representative section within OECC	Federal: 4.7
Cable Installation – Typical and Maximum Jetting	Representative Inter-array Cable Lease Area	Federal: 10.6

3.2.3.1 HDD Pit Construction & Cable Installation

HDD Pit Excavation and Backfill were simulated at two of the landfall sites: Atlantic Beach Landfall Approach and Jones Beach Landfall Approach (Figure 3-5; Table 3-3). These were selected as they are potential landfall sites but can also be considered representative of the other landfall site due to the similarity in hydrodynamic and geologic conditions. It was assumed that 100% of the mechanically dredged material would be released at the surface to backfill the excavated pit. The model's results can be considered representative of excavation and backfill activities because adequate time between these two activities would allow any excavation-induced sediment disturbances to disperse back to ambient conditions prior to backfilling.

Cable installation via jetting technique was simulated for the three potential landfall approaches assuming typical installation parameters (Figure 3-6, Figure 3-7, and Figure 3-8). Each landfall approach was independently modeled (Figure 3-7 and Figure 3-8), starting from the landfall site and traversing through state waters just over the federal waters' boundary where the Western Landfall Site Variant connects with the Main portion of the OECC. From this interconnection point, cable installation via typical jetting was simulated to the Lease Area within the OECC (i.e., Main OECC; Figure 3-8). An additional simulation was performed, starting from the Rockaway Beach Approach but traversing through the Western Landfall Sites OECC Variant (Figure 3-8). For all the typical jetting, cable installation simulations in state waters, the modeled trench depth was assumed to be 2.3 m and 1.7 m in federal waters (Table 3-3).

An additional representative scenario was modeled to capture the variability in cable installation technique by simulating installation using a vertical injector tool (Figure 3-8). The vertical injector is a high-volume low-pressure water jetting tool that uses directed water jets to fluidize the seabed and lower the cable via the integral depressor to the bottom of the fluidized trench. The vertical injector is capable of directly installing the cable in areas with sand bedforms, without the need for any separate sand bedform clearing. The vertical injector installation parameters differ from the typical jetting parameters in that the target trench depth is deeper and the production rate is smaller. However, the percent of sediment mobilized and the vertical distribution of sediment in the water column are similar.

Table 3-3: Construction parameters and sediment loading model inputs for Vineyard Mid-Atlantic within the OECC.

Scenario Name	Trench Cross-Section (m^2)	Total Volume[a] (m^3)	Production Rate (m^3/hr)	Duration of Sediment Loading (hours)	Percent Mobilized (%)
Atlantic Beach Landfall Site HDD Exit Pit Construction	N/A	3,750	3,750	1	100
Jones Landfall Site HDD Exit Pit Construction	N/A	3,750	3,750	1	100
Rockaway Beach Approach – Cable Installation along OECC — Typical Jetting Parameters	State: 2.3 Federal: 1.7	61,166	State: 460 Federal: 340	133.4	25
Western Landfall Sites OECC Variant to Rockaway Beach – Cable Installation along OECC — Typical Jetting Parameters	State: 2.3 Federal: 1.7	58,878	State: 460 Federal: 340	132.2	25
Atlantic Beach Approach – Cable Installation along OECC — Typical Jetting Parameters	State: 2.3 Federal: 1.7	52,460	State: 460 Federal: 340	114.7	25
Jones Landfall Approach – Cable Installation along OECC — Typical Jetting Parameters	State: 2.3 Federal: 1.7	13,843	State: 460 Federal: 340	31.2	25
Cable Installation for Main OECC — Typical Jetting Parameters	State: 2.3 Federal: 1.7	83,327	State: 460 Federal: 340	243.1	25
Cable Installation for Representative Export Cable Segment within the Main OECC — Vertical Injector	3.4	15,973	340	39.6	25

[a] Total volume (m^3) does not account for the percent mobilized or percent solids based on sediment moisture content data.

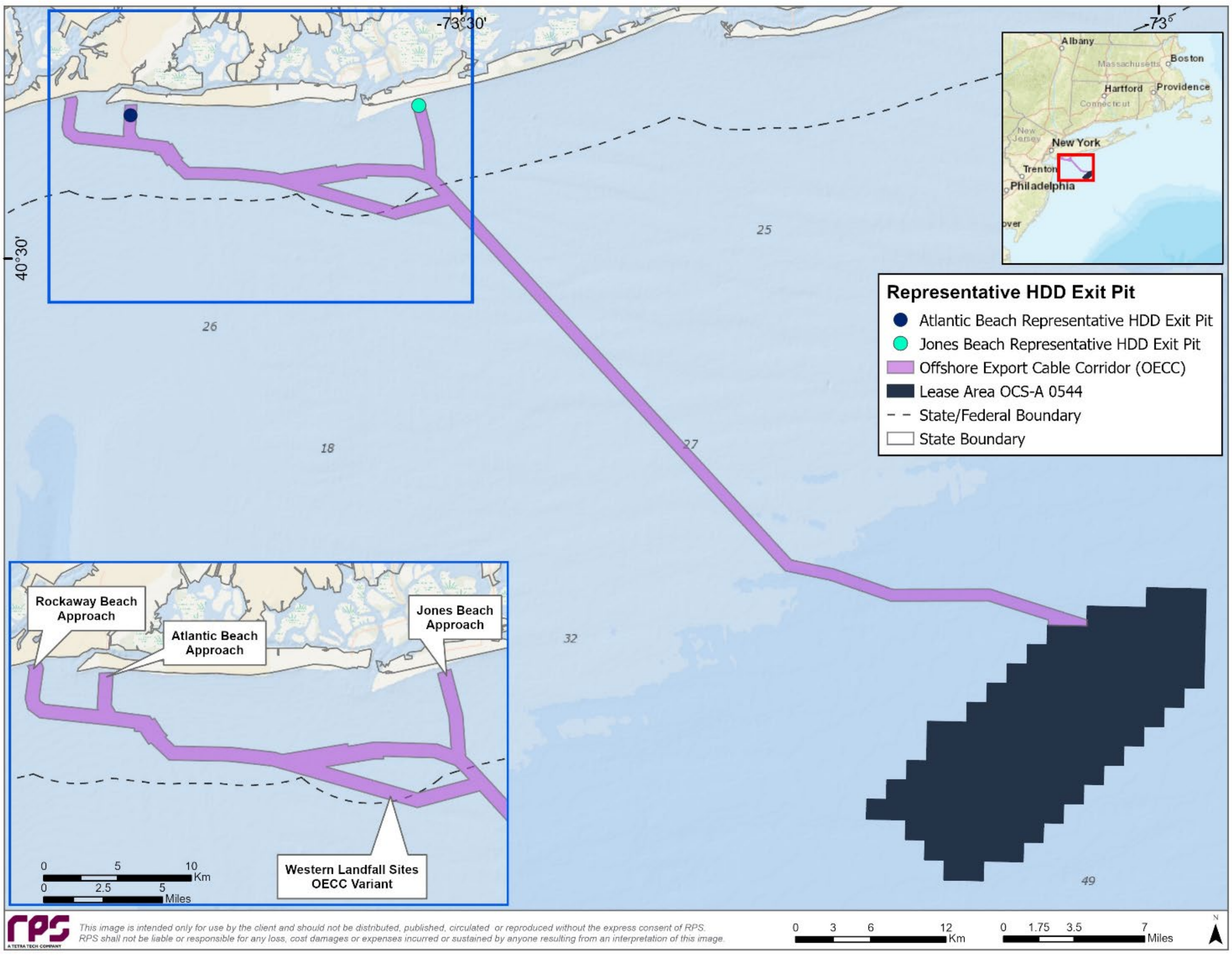


Figure 3-5: Modeled location for the Representative HDD Exit Pit Construction simulations along the Atlantic Beach, and Jones Beach Landfall Approaches.

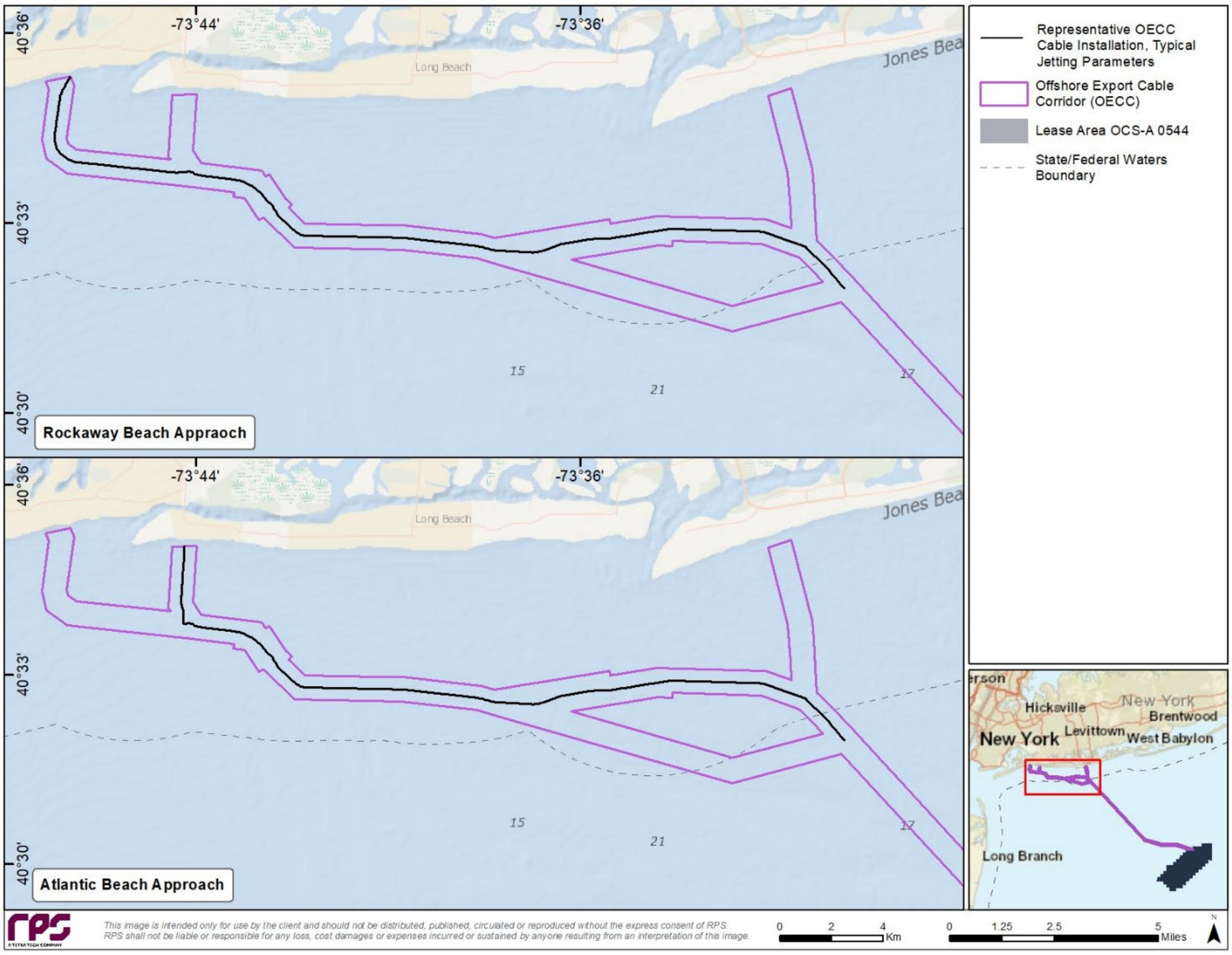


Figure 3-6: Modeled cable installation for the Representative Rockaway Beach (top), and Atlantic Beach (bottom) Landfall Approaches, assuming typical jetting parameters.

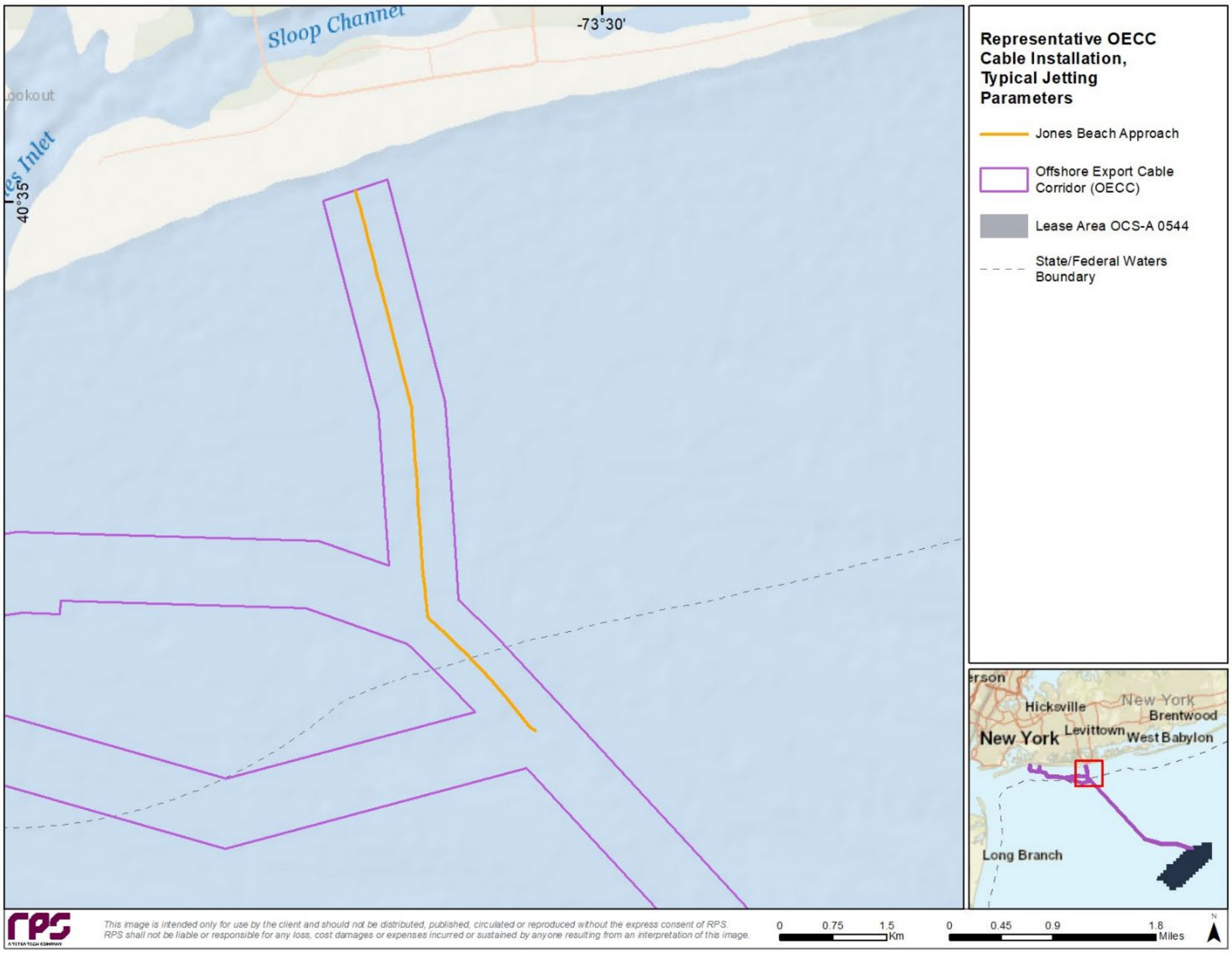


Figure 3-7: Modeled cable installation for the Jones Beach Landfall Approach, assuming typical jetting parameters.

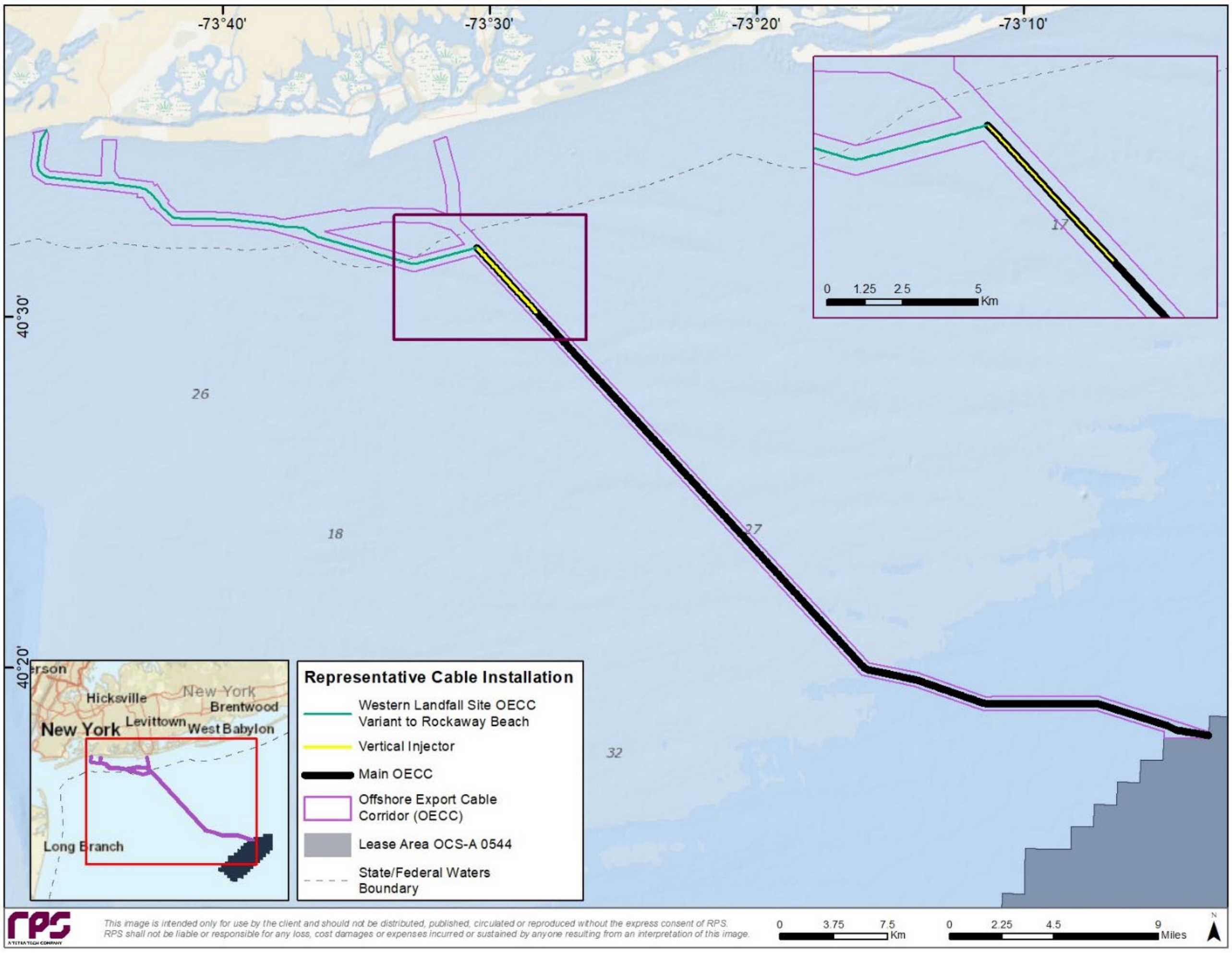


Figure 3-8: Modeled cable installation for the Representative Western Landfall Sites OECC Variant to Rockaway Beach and the Main OECC simulations assuming typical jetting parameters, as well as the Representative Vertical Injector route.

3.2.3.1 Lease Area

Sediment disturbing activities that are anticipated to occur with respect to the Lease Area (Table 3-4) include cable installation by jetting using typical and maximum installation parameters (Figure 3-9). It was assumed the inter-array cables would be installed via jetting techniques. To capture variability in jetting parameters (e.g., installation rates and trench depths) two simulations were performed. The first assumed typical jetting installation parameters (e.g., a slower installation speed and a typical target trench depth) while the other assumed the maximum parameters (e.g., a faster installation rate and a maximum target trench depth).

Inter-array cable installation used a representative cable route to coincide with a conservative modeling approach. The longest inter-array cable was selected as the representative route because it is the longest and therefore would disturb the largest volume of sediment. Additionally, the selected inter-array cable passes through the most diverse vibracore samples, including one sample containing the highest fraction of fine material (Figure 3-3). Assuming the cables are installed sequentially, the modeled inter-array cable installation can be considered a worst-case representation of cable installation in the Lease Area as the predicted impacts would be of lesser or equal extent for the other inter-array cable installations.

Table 3-4: Construction parameters and sediment loading model inputs for Vineyard Mid-Atlantic specific to the Lease Area.

Scenario Name	Trench Cross-Section (m^2)	Total Volume[a] (m^3)	Production Rate (m^3/hr)	Duration of Sediment Loading (hours)	Percent Mobilized (%)
Cable Installation for Representative Inter-Array Cable —Typical Jetting Parameters	2	21,229	400	52.4	25
Cable Installation for Representative Inter-Array Cable —Maximum Jetting Parameters	3	31,844	900	35.3	35

[a] Total dredge volume (m^3) does not account for the percent mobilized or percent solids based on sediment moisture content data.

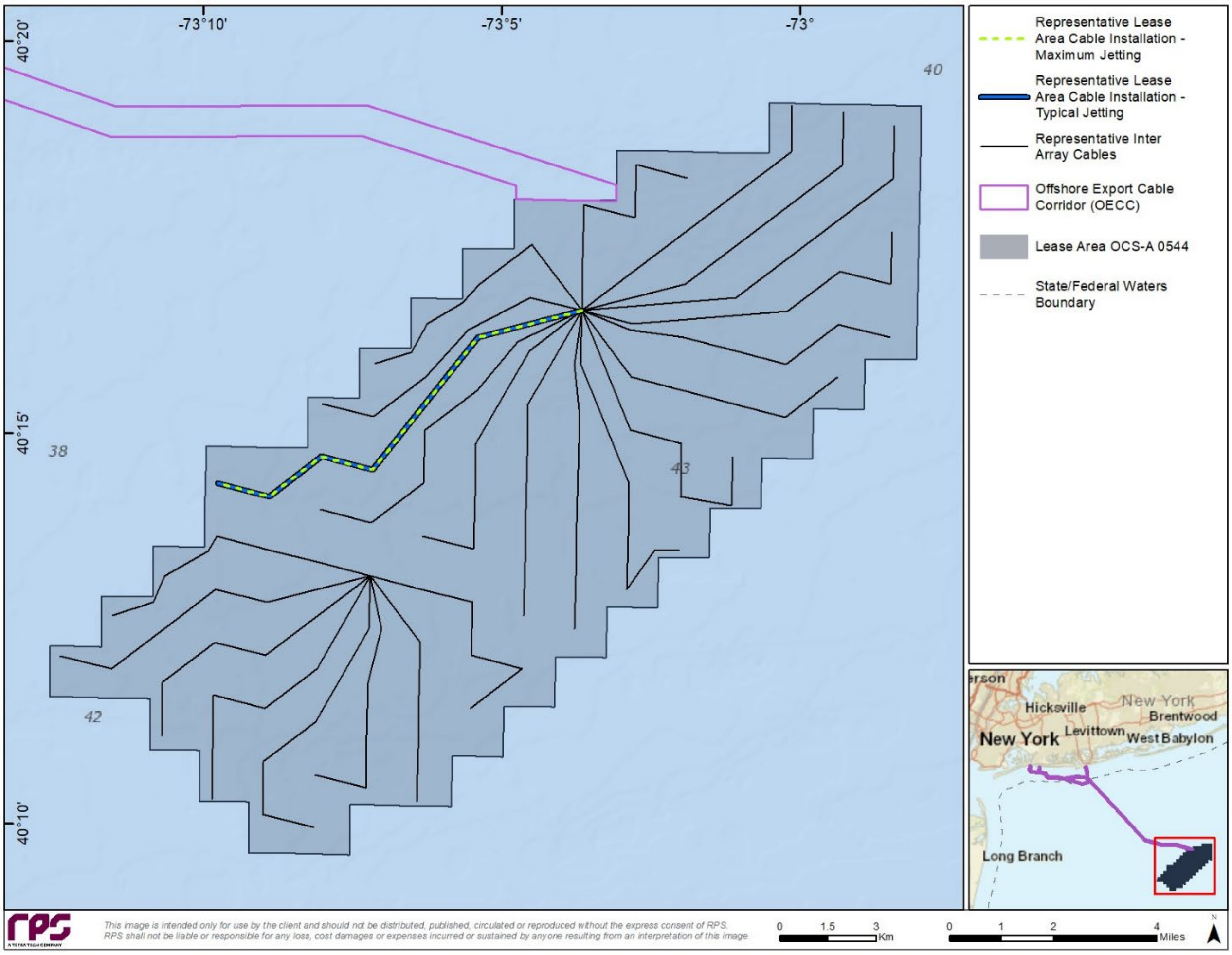


Figure 3-9: Modeled locations of the Lease Area's Representative Inter-array Cable Installation (Typical and Maximum).

3.2.4 Sediment Loading Vertical Initialization

In addition to the sediment loading rate and mobilization fraction, the model requires specification of the vertical location of sediment resuspension, which varied by installation method. Vertical initialization locations and other dredging related parameters are typically estimated empirically on the basis of field measurements of sediment flux through cross-sections of the plume or derived from numerical source models (Mills and Kemps, 2016). The vertical initialization for cable installation techniques (Table 3-5) vary depending on the equipment type.

Table 3-5: Vertical Distribution of Suspended Sediment Mass Associated with Cable Installation Techniques.

Jetting Techniques			Vertical Injector		
Individual Bin Percent	Cumulative Percent	Meters Above Bottom	Individual Bin Percent	Cumulative Percent	Meters Above Bottom
5	100	3	5	100	3
10	95	2	10	95	2
28	85	1	28	85	1
28	57	0.66	28	57	0.66
29	29	0.33	29	29	0.33

3.3 Sediment Modeling Results

SSFATE simulations were performed for each sediment disturbance activity. So that all 13 modeled scenarios could be compared, sediment concentrations were computed on a grid with resolution of 25 m x 25 m in the horizontal and 0.5 m in the vertical. The model time step for all simulations was 5 minutes. Model-predicted concentrations are “excess” concentrations above background (i.e., a concentration of 0 mg/L is assumed for the ambient concentration).

Results from the model runs are presented through a set of figures and tables showing the predictions of suspended sediment concentration and relative thickness of sediment deposition expected to occur along the proposed OECC and Lease Area because of construction activities. Maps of instantaneous above-ambient TSS concentrations; maximum above-ambient TSS concentrations; durations of time for which above-ambient TSS of ≥10 mg/L occur; and seabed deposition (in mm) are provided. Tables quantifying the maximum extent to concentration and depositional thresholds for each installation technique, the modeled area exceeding TSS thresholds for specific durations, as well as areas of seabed deposition exceeding thickness thresholds, are summarized for each scenario.

Additional information about standard graphical outputs for each scenario are provided below:

- **Maps of Instantaneous TSS Concentrations**: These maps show an example snapshot of TSS concentrations at a single moment in time, thus conveying the spatial and temporal variability of the sediment plume in a way that cannot be depicted by cumulative maps. The plan view shows the maximum concentration throughout the water column at that snapshot time, and the vertical cross-section shows the cross-sectional variability of concentrations along a transect. These instantaneous maps show that the plume is not a continuous blanket of sediment, but rather narrow, heterogeneous patches that individually persist for minutes to hours at a single location.
- **Maps of Time-integrated Maximum TSS Concentrations**: Predicted suspended sediment concentrations are presented as a composite of maximum concentrations predicted to always occur during sediment-disturbing activities and locations throughout the model simulation. This map shows the maximum time-integrated water column concentration from the entire water column in scaled plan view, and a non-scaled inset, showing a cross-sectional view of maximum TSS concentrations in the water column. The concentrations are shown as contours using mg/L. The entire area within the contour is at or above the concentration defined by the contour itself. Most importantly, it should be noted that these maps show the maximum TSS concentration that occurred throughout the entire simulation and therefore: (1) these concentrations do not persist throughout the entire simulation and may occur during just one- or several-time steps (time step = 10 minutes); and (2) these concentrations do not occur concurrently throughout the entire modeled area but are the time-integrated spatial views of maximum predicted concentrations. It should be emphasized that the maximum predicted sediment plume concentration or extent will not exist at any one time during the installation.
- **Maps of Duration of TSS Concentrations Greater than 10 mg/L**: These maps show the number of hours that the TSS concentrations are expected to be equal to or greater than 10 mg/L.
- **Maps of Seabed Deposition**: These maps show the predicted deposition on the seabed that would occur once the activity has been completed. The thickness levels are shown as contours (in mm) and the entire area within the contour is at or above the thickness defined by the contour itself. The contours have been delineated at levels either tied to biological significance (i.e., 1 mm and 2 mm) or to facilitate viewing the results.

3.3.1 Results Summary Tables: Suspended Sediment Concentrations

For each modeled scenario, the predicted mean and maximum distance to the 10 mg/L concentration contour was reported (Table 3-6). For the landfall scenarios, this distance was measured from the release location radially to the 10 mg/L contour, while the line source values were measured perpendicular to the route centerline to the 10 mg/L contour.

Based on the release conditions and the tidal stage, TSS concentrations ≥10 mg/L were predicted to extend farthest from the release location for the Representative OECC Cable Installation — Vertical Injector scenario followed by the Representative Jones Beach Landfall Site HDD Exit Pit Construction simulation. The Representative OECC Cable Installation — Vertical Injector scenario produced the largest maximum and average extents to the 10 mg/L concentration contour. The combination between the deepest target trench depth, a relatively high loss rate, a high fraction of fine-grained material, and the orientation of the route being perpendicular to the currents caused the plume to travel away from the route centerline in both directions.

The Representative Jones Beach Landfall Site HDD Exit Pit Construction simulation was also predicted to create a plume with TSS concentrations ≥10 mg/L that extended the farthest. This was likely due to the release of sediments at the surface rather than within the bottom few meters of the water column as was modeled for the cable installation simulations. When sediment is released near the surface, it is transported with the subsurface currents for a longer period, thus causing the finer material to transport farther from the source prior to settling. Additionally, sediments introduced much higher in the water column require more time to settle, causing the 10 mg/L contour to extend farther from the activity.

Although the sediment composition is relatively coarser at the Representative Jones Beach Landfall Site than the other representative landfall site, the Jones Beach Landfall Site is more exposed to incoming tides and currents. The exposure to swift currents caused the suspended sediment to travel farther from the source before dispersing below 10 mg/L or settling to the seabed. The Representative Atlantic Beach Landfall Site is sheltered by the barrier islands such that the magnitude of the currents was diminished during a flood tide, thus minimizing the extent of the predicted plume.

For all representative OECC cable installation scenarios, assuming typical jetting parameters, the maximum and mean predicted extents to the 10 mg/L contour were similar. On average, the TSS concentration ≥10 mg/L was predicted to remain within 0.29 to 0.79 km from the representative cable installation route. Variability in the maximum distance to TSS concentrations ≥10 mg/L can be attributed to the orientation of the route to the prevailing direction of the currents, the timing of the currents, and the sediment composition. For example, the model predicted that the Representative Main OECC Cable Installation – Typical Jetting simulation would produce a plume with suspended sediment concentrations ≥10 mg/L that was transported a maximum distance of approximately 1.58 km. This plume extent was predicted to occur in a region with high fractions of fine-grained material (e.g., clay, silts) and the modeled cable installation was simulated during a period of fast currents. The combination of these factors resulted in a longer plume extent than was predicted closer to the Lease Area. On average, the Representative Main OECC Cable Installation – Typical Jetting simulation, suspended sediment concentrations ≥10 mg/L were predicted to extend 0.5 km. While the direction and timing of currents also impacted model predictions, it is important to note that these simulations, although conservative with respect to potential plume extent, will vary depending on the *in-situ* environmental conditions at the time of the sediment disturbing activities.

The Representative Lease Area Cable Installation — Maximum Jetting simulation was predicted to produce a plume with TSS concentrations ≥10 mg/L that would transport further from the centerline than was predicted for the Representative Lease Area Cable Installation — Typical Jetting. The larger maximum and mean extents to the 10 mg/L concentration contour can be attributed to the larger disturbance volume associated with the maximum jetting parameters (i.e., larger trench depth and higher loss rate).

Table 3-6: Summary of mean and maximum extent to the water column TSS concentration threshold.

Description	TSS Concentration Threshold 10 mg/L
	Mean [Maximum] Distance to Contour (km)
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.61 [0.97]
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.87 [2.00]
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	0.52 [1.34]
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	0.29 [0.62]
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	0.56 [1.58]
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	0.79 [1.91]
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	0.5 [1.58]
Representative OECC Cable Installation — Vertical Injector	0.91 [2.33]
Representative Lease Area Cable Installation — Typical Jetting	0.07 [0.08]
Representative Lease Area Cable Installation — Maximum Jetting	0.19 [0.52]

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

Results from all modeled scenarios were analyzed to determine the spatial area exposed to above-ambient TSS concentrations exceeding specific thresholds for various concentration and duration thresholds. These areas are not always contiguous, but the results provide a sum of all individual concentration grid cells that exceeded a threshold anywhere in the water column for the duration of interest. Results provided in the following tables include areas greater than 0.01 km^2. Post-processing included calculations with respect to duration thresholds of one (Table 3-7), two (Table 3-8), three (Table 3-9), four (Table 3-10), six (Table 3-11), 12, 24, and 48 hours. Although not all scenarios exceeded the various duration thresholds, all scenarios were included for consistency. Additionally, there were no areas over thresholds for the 12-, 24- or 48-hour durations, so tables with those summaries were not included.

In reviewing these tables, it is helpful to keep in mind that the concentration grid resolution used in the modeling was 25 m in the horizontal plane. For a route 49 km long (e.g., Representative Main OECC Cable Installation – Typical Jetting), the area covered by the grid cells along the route is therefore 1.23 km^2 (49,000 m x 25 m = 1.23 km^2).

Areas exposed to above-ambient TSS concentrations are greatest when assessing concentrations above 10 mg/L, and those areas rapidly decrease in size with increasing concentration threshold and increasing duration. For example, as shown in Table 3-7 for the Representative Main OECC Cable Installation – Typical Jetting model scenario, 7.71 km^2 exceeded a TSS concentration of 10 mg/L for more than one hour, but only 0.15 km^2 of this area exceeded 200 mg/L for more than one hour. In the Representative Main OECC Cable Installation – Typical Jetting model scenario, TSS concentrations do not reach 650 mg/L. It is important to note that the listed areas are a summation of potential impacts throughout the entire OECC, such that all the listed areas are not impacted simultaneously. Additionally, for this route, TSS concentrations greater than 100 mg/L do not endure for periods of three hours or greater. Similar trends of rapid decrease in areas with increasing time and/or increasing threshold are noted for all other routes presented.

Table 3-7: Summary of area over threshold concentrations for one hour or longer. Note that the "-" indicates the concentration threshold was not exceeded.

Description	Concentration Thresholds (mg/L)					
	10	25	50	100	200	650
	Areas above Concentration Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.51	0.43	0.38	0.32	0.25	0.14
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.33	0.21	0.13	0.09	0.06	0.03
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	4.94	2.25	1.13	0.49	0.10	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	4.72	2.27	1.14	0.45	0.08	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	4.74	2.19	1.15	0.49	0.11	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	2.46	1.13	0.58	0.16	0.04	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	7.72	3.83	1.96	0.74	0.15	-
Representative OECC Cable Installation — Vertical Injector	3.64	2.07	1.38	0.87	0.44	0.06
Representative Lease Area Cable Installation — Typical Jetting	0.01	-	-	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	0.67	0.08	<0.01	-	-	-

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

Table 3-8: Summary of area over threshold concentrations for two hours or longer. Note that the "-" indicates the concentration threshold was not exceeded.

Description	Concentration Thresholds (mg/L)					
	10	25	50	100	200	650
	Areas above Concentration Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.40	0.34	0.29	0.24	0.18	0.06
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.17	0.12	0.09	0.06	0.03	-
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	2.53	0.75	0.25	0.03	<0.01	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	2.44	0.76	0.22	0.03	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	2.38	0.78	0.21	0.02	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	0.61	0.07	0.01	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	2.78	0.84	0.22	0.01	-	-
Representative OECC Cable Installation — Vertical Injector	1.97	1.06	0.53	0.15	0.01	-
Representative Lease Area Cable Installation — Typical Jetting	-	-	-	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	0.02	-	-	-	-	-

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

Table 3-9: Summary of area over threshold concentrations for three hours or longer. Note that the "-" indicates the concentration threshold was not exceeded.

Description	Concentration Thresholds (mg/L)					
	10	25	50	100	200	650
	Areas above Concentration Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.32	0.27	0.22	0.16	0.10	0.02
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.13	0.09	0.07	0.04	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	1.19	0.29	0.05	<0.01	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	1.21	0.28	0.04	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	1.16	0.27	0.04	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	0.06	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	0.97	0.09	-	-	-	-
Representative OECC Cable Installation — Vertical Injector	0.92	0.31	0.06	<0.01	-	-
Representative Lease Area Cable Installation — Typical Jetting	-	-	-	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	-	-	-	-	-	-

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

Table 3-10: Summary of area over threshold concentrations for four hours or longer. Note that the "-" indicates the concentration threshold was not exceeded.

Description	Concentration Thresholds (mg/L)					
	10	25	50	100	200	650
	Areas above Concentration Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.21	0.17	0.14	0.10	0.05	-
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.08	0.05	0.03	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	0.62	0.09	0.01	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	0.61	0.09	<0.01	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	0.60	0.08	<0.01	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	-	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	0.18	-	-	-	-	-
Representative OECC Cable Installation — Vertical Injector	0.33	0.04	<0.01	-	-	-
Representative Lease Area Cable Installation — Typical Jetting	-	-	-	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	-	-	-	-	-	-

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

Table 3-11: Summary of area over threshold concentrations for six hours or longer. Note that the "-" indicates the concentration threshold was not exceeded.

Description	Concentration Thresholds (mg/L)					
	10	25	50	100	200	650
	Areas above Concentration Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.01	-	-	-	-	-
Representative HDD Exit Pit – Jones Beach Landfall Site*	-	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	0.15	0.01	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	0.19	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	0.09	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	-	-	-	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	-	-	-	-	-	-
Representative OECC Cable Installation — Vertical Injector	<0.01	-	-	-	-	-
Representative Lease Area Cable Installation — Typical Jetting	-	-	-	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	-	-	-	-	-	-

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

3.3.2 Results Summary Tables: Sediment Deposition

Areas greater than 0.01 km^2 are reported herein based on depositional thickness thresholds for all scenarios (Table 3-12). In general, most of the depositional footprints were predicted to have thicknesses between 1 mm and 5 mm for all simulations. The Representative Landfall Site HDD Exit Pit Construction simulations were predicted to produce localized areas with depositional thickness exceeding 100 mm. The Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC scenario was predicted to have the largest area with thicknesses greater than 1 mm because it was the longest route modeled. All the representative cable installation simulations were estimated to have areas, albeit relatively small, with deposition between 10 and 20 mm thick. Regardless of installation technique or parameterization, deposition exceeding a 1 mm thickness remained relatively close (on average less than 0.1 km; Table 3-13) from the representative route centerline for all cable installation simulations in the OECC and Lease Area. The Representative Lease Area Cable Installation — Maximum Jetting scenario was the only cable installation simulation predicted to exceed the 20 mm thickness threshold likely due to the deeper target trench depth, higher loss rate, and relatively high fraction of coarse material present in the Lease Area.

Table 3-12: Summary of depositional area over several thickness thresholds for all scenarios.

Description	Depositional Thresholds (mm)					
	1	5	10	20	50	100
	Areas above Depositional Threshold (km^2)					
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.15	0.05	0.03	0.03	0.01	0.01
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.06	0.03	0.02	0.02	0.01	0.01
Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach	2.11	0.63	0.06	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	2.07	0.60	0.05	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	1.85	0.52	0.06	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	0.53	0.14	0.02	-	-	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	3.45	0.77	<0.01	-	-	-
Representative OECC Cable Installation — Vertical Injector	0.49	0.12	0.02	-	-	-
Representative Lease Area Cable Installation — Typical Jetting	0.75	0.27	0.01	-	-	-
Representative Lease Area Cable Installation — Maximum Jetting	0.88	0.49	0.28	0.01	-	-

Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.

Table 3-13: Summary of mean and maximum extent to depositional thresholds for all routes.

Description	Depositional Thresholds	
	1 mm	20 mm
	Mean [Maximum] Distance to Contour (km)	
Representative HDD Exit Pit – Atlantic Beach Landfall Site*	0.34 [0.61]	0.12 [0.18]
Representative HDD Exit Pit – Jones Beach Landfall Site*	0.19 [0.32]	0.12 [0.14]
Representative OECC Cable Installation, Typical Jetting Parameters –Rockaway Beach Approach	0.05 [0.09]	-
Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach	0.05 [0.07]	-
Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach	0.06 [0.11]	-
Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach	0.07 [0.11]	-
Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC	0.06 [0.09]	-
Representative OECC Cable Installation — Vertical Injector	0.09 [0.17]	-
Representative Lease Area Cable Installation — Typical Jetting	0.05 [0.06]	
Representative Lease Area Cable Installation — Maximum Jetting	0.05 [0.06]	0.02 [0.02]

**Representative HDD Exit Pits were modeled during flood and ebb tides and results were very similar. Of the two modeled Representative HDD Exit Pits (flood & ebb), only results from the maximum effect scenario were reported for simplicity and to be conservative.*

3.3.3 HDD Exit Pit Excavation & Backfill

Depending on the landfall approach, the sediment composition varies from coarse sand to clay, with higher contents of fine-grained material present at the Representative Atlantic Beach Landfall Site. The Representative Jones Beach Landfall Site coincided with areas containing higher fractions of both coarse and fine sand, with smaller fractions of coarse and fine silt present. This section compares results from the simulations of both Representative HDD Exit Pit Excavation and Backfill simulations during both flood and ebb tides. Mapped results for the flood and ebb scenarios are presented together. The following scenarios are presented in sequence:

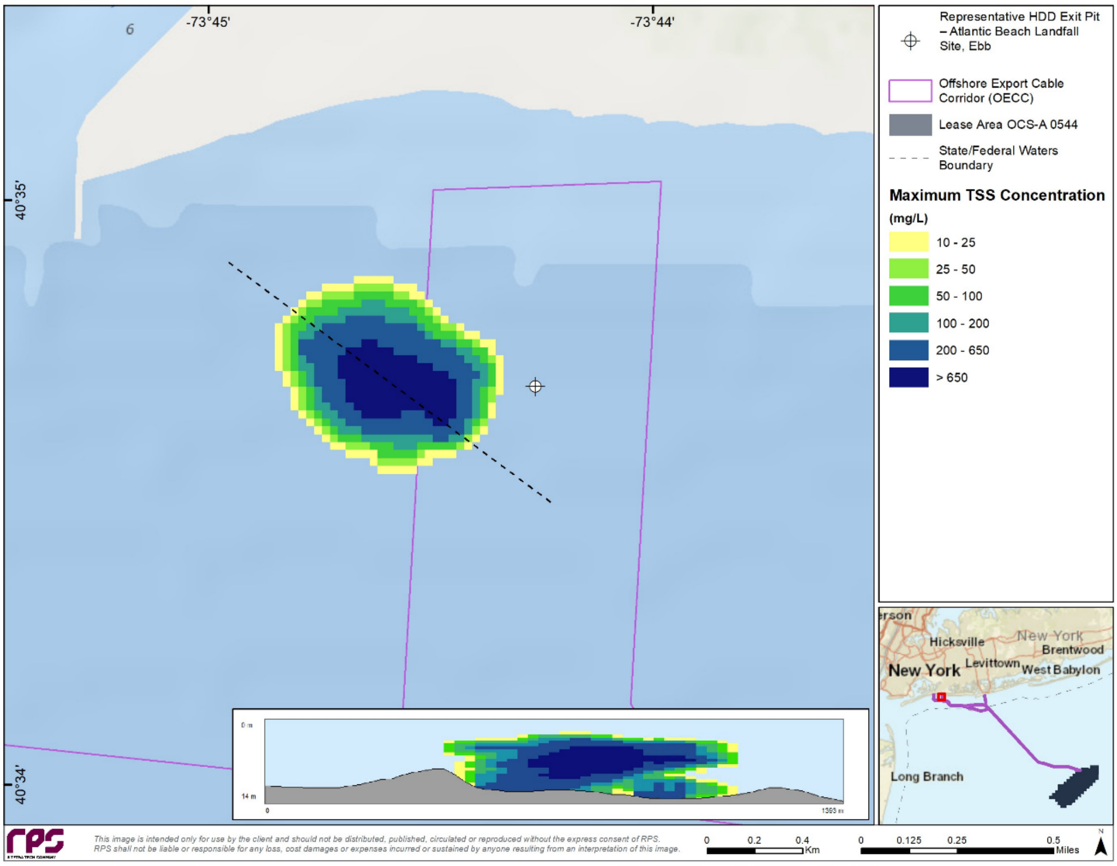
- Representative Landfall Site HDD Exit Pit Construction – Atlantic Beach Approach, Ebb & Flood
- Representative Landfall Site HDD Exit Pit Construction – Jones Beach Approach, Ebb & Flood

These simulations are representative of the excavation and backfill operations as 100% of the dredged material was released at the water surface over one hour. Backfilled sediment was released during both ebb and flood tides, to capture both environmental extremes. As the tide flooded into Lower Bay and Jamaica Bay, the sediment plumes were transported west (i.e., towards Lower Bay and Jamaica Bay). During the ebb tide, the prevailing direction of the sediment plumes were less predictable as local circulation patterns (i.e., river flows, inlets) were more influential.

The instantaneous map illustrates that the overflow and dumping plume is patchy and discontinuous throughout the water column for the Representative Landfall Site HDD Exit Pit Construction – Atlantic Beach Approach, Ebb (Figure 3-10, top), and the Representative Landfall Site HDD Exit Pit Construction – Jones Beach Approach, Ebb (Figure 3-14, top). Alternatively, all of the flood scenarios at each of the Representative Landfall Site HDD Exit Pit Construction scenarios depict an instantaneous plume that was predicted to have higher concentrations in the center of the plume with concentrations diminishing radially in all directions (Figure 3-10, bottom; Figure 3-14, bottom).

As anticipated, the time-integrated maximum water column concentration maps (Figure 3-11, and Figure 3-15) show a footprint that is much larger than those captured by the instantaneous snapshots, extending from the surface to the seabed. The highest concentrations (≥200 mg/L) are shown to stay near the release location and cover a relatively small area (<0.25 km^2; Table 3-7) for both Representative HDD Exit Pit Excavation and Backfill scenarios regardless of tidal stage. As the plume is transported by subsurface currents, the concentrations dissipate and settle. Suspended sediment concentrations ≥200 mg/L are predicted to dissipate within three hours at the Representative HDD Exit Pit – Jones Beach Landfall Site (Table 3-9) and within six hours for the Representative HDD Exit Pit – Atlantic Beach Landfall Site (Table 3-11).

It is interesting to note that longer durations were predicted for the ebb simulations than for the flood simulations regardless of HDD Exit Pit location (Figure 3-12, top; Figure 3-16, top). The faster currents, in a constant direction, during the flood tide dissipated the TSS concentrations to <10 mg/L faster than the ebb tides as those oscillated in variable directions and tended to be slower. It is important to note that the current speed and direction changes during the time it takes for the sediment to disperse and settle. After being released to the surface, the coarse sediment settles first to the seabed, generally forming the thickest deposits (i.e., >100 mm) in proximity to the release location (Figure 3-13, and Figure 3-17). Regardless of Representative HDD Exit Pit location and tidal stage, the maximum extent to the 1 mm and 20 mm thresholds were predicted to be 0.61 km and 0.18 km, respectively (Table 3-13).



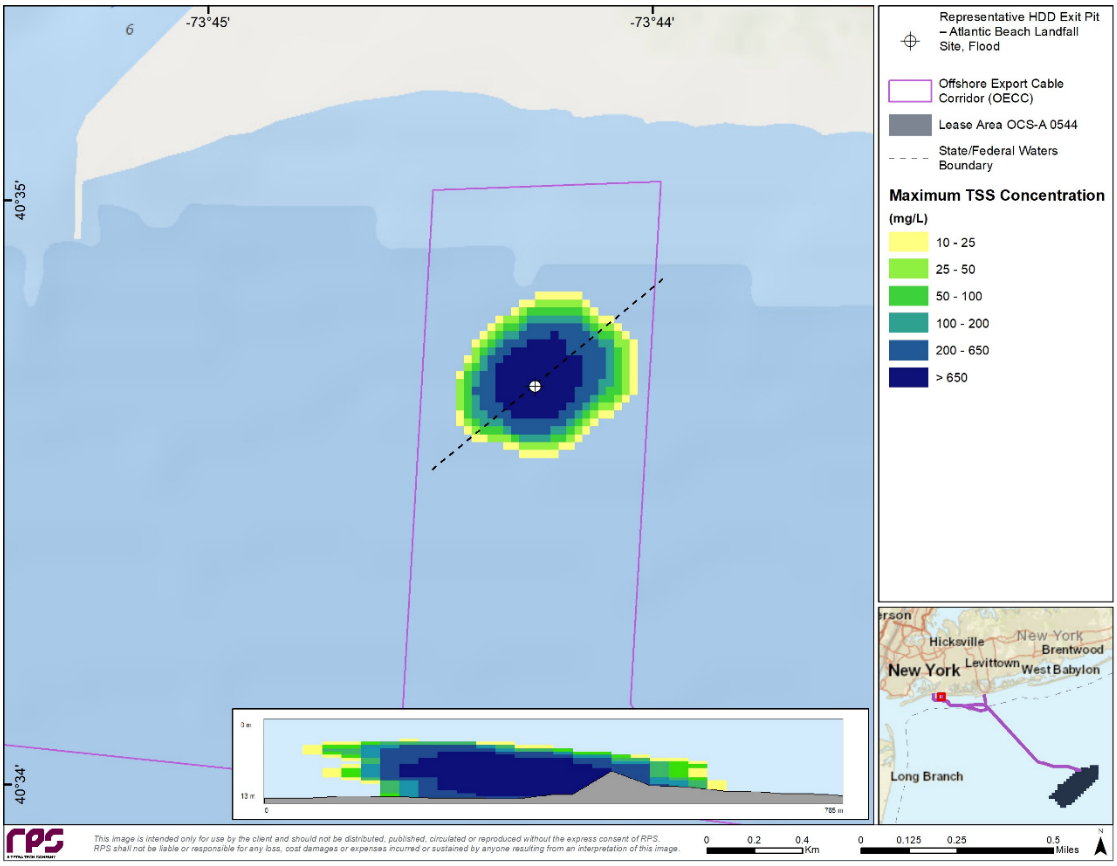


Figure 3-10: Snapshot of instantaneous TSS concentrations for a time step during the Atlantic Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

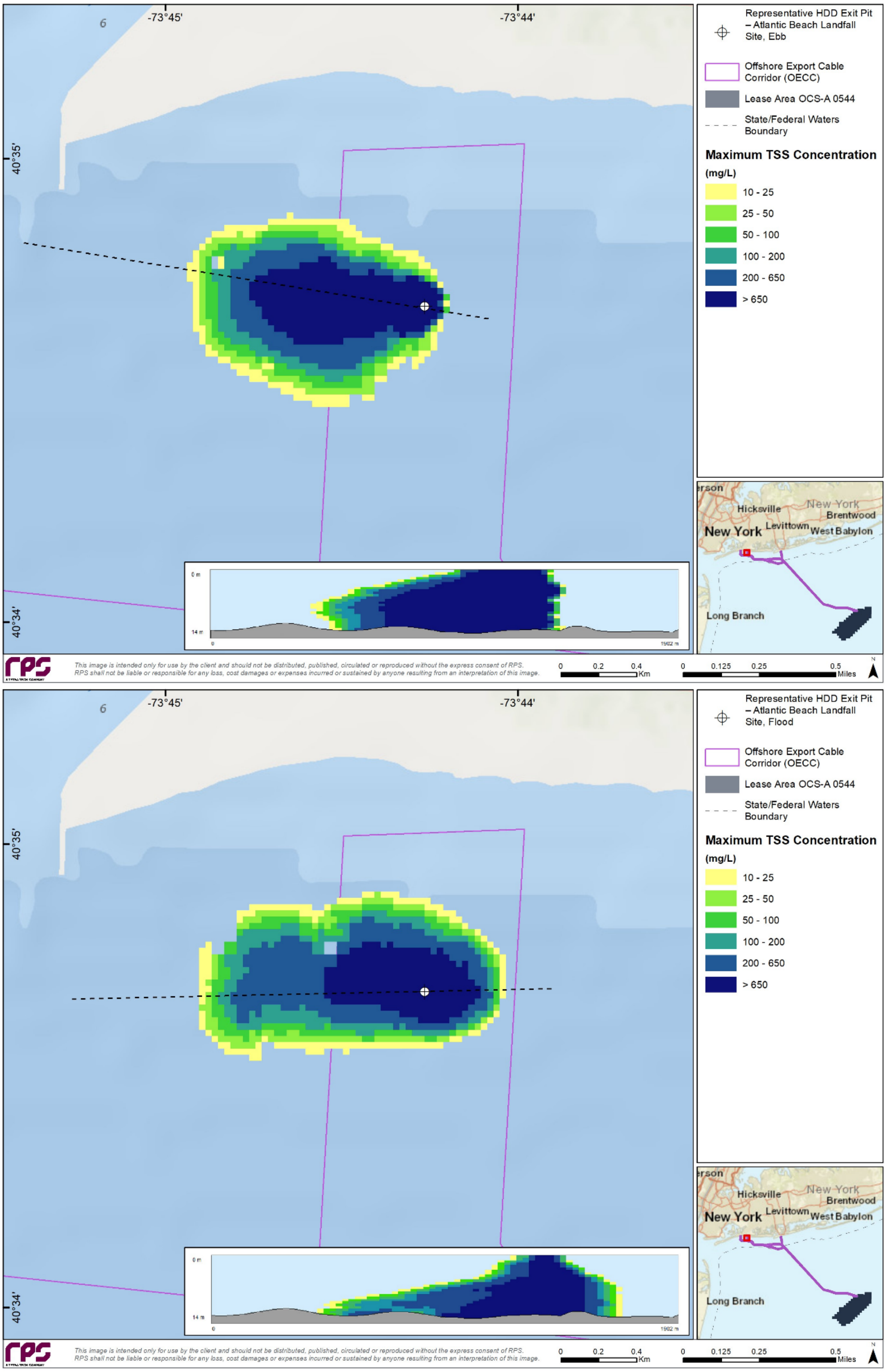


Figure 3-11: Time-integrated maximum concentrations associated with the Atlantic Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

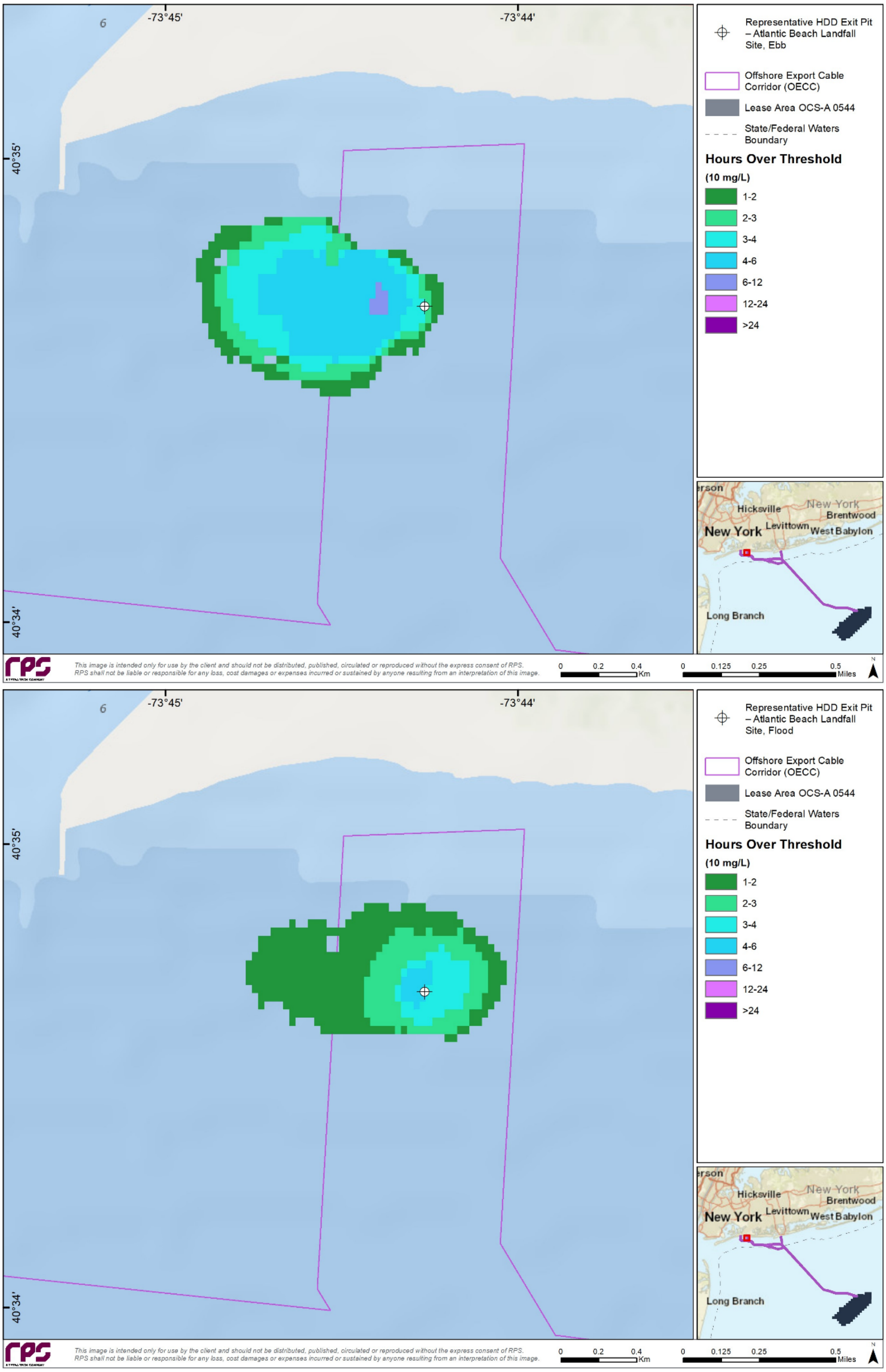


Figure 3-12: Duration of TSS ≥10 mg/L associated with the Atlantic Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

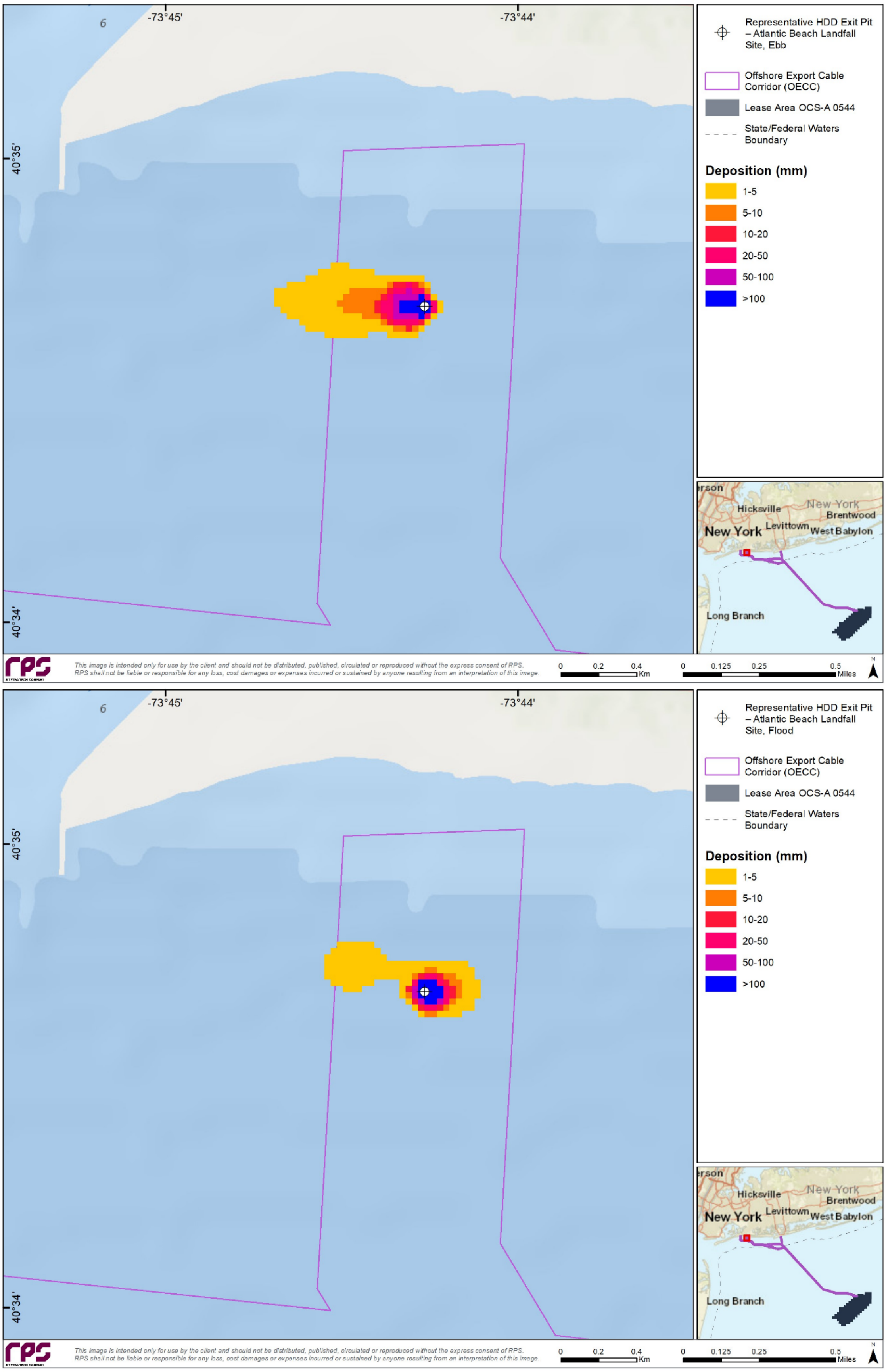


Figure 3-13: Depositional thickness associated with the Atlantic Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

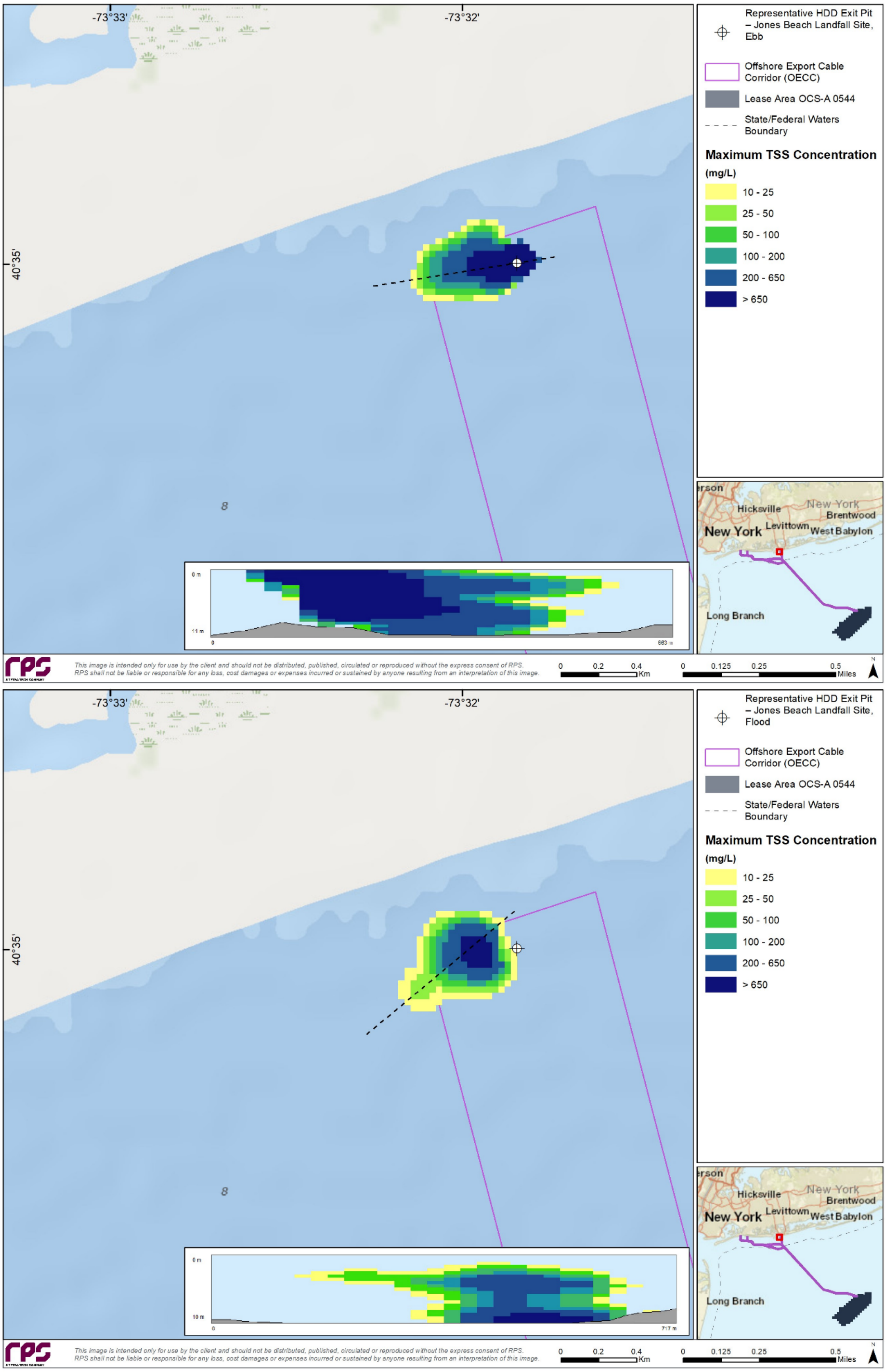


Figure 3-14: Snapshot of instantaneous TSS concentrations for a time step during the Jones Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

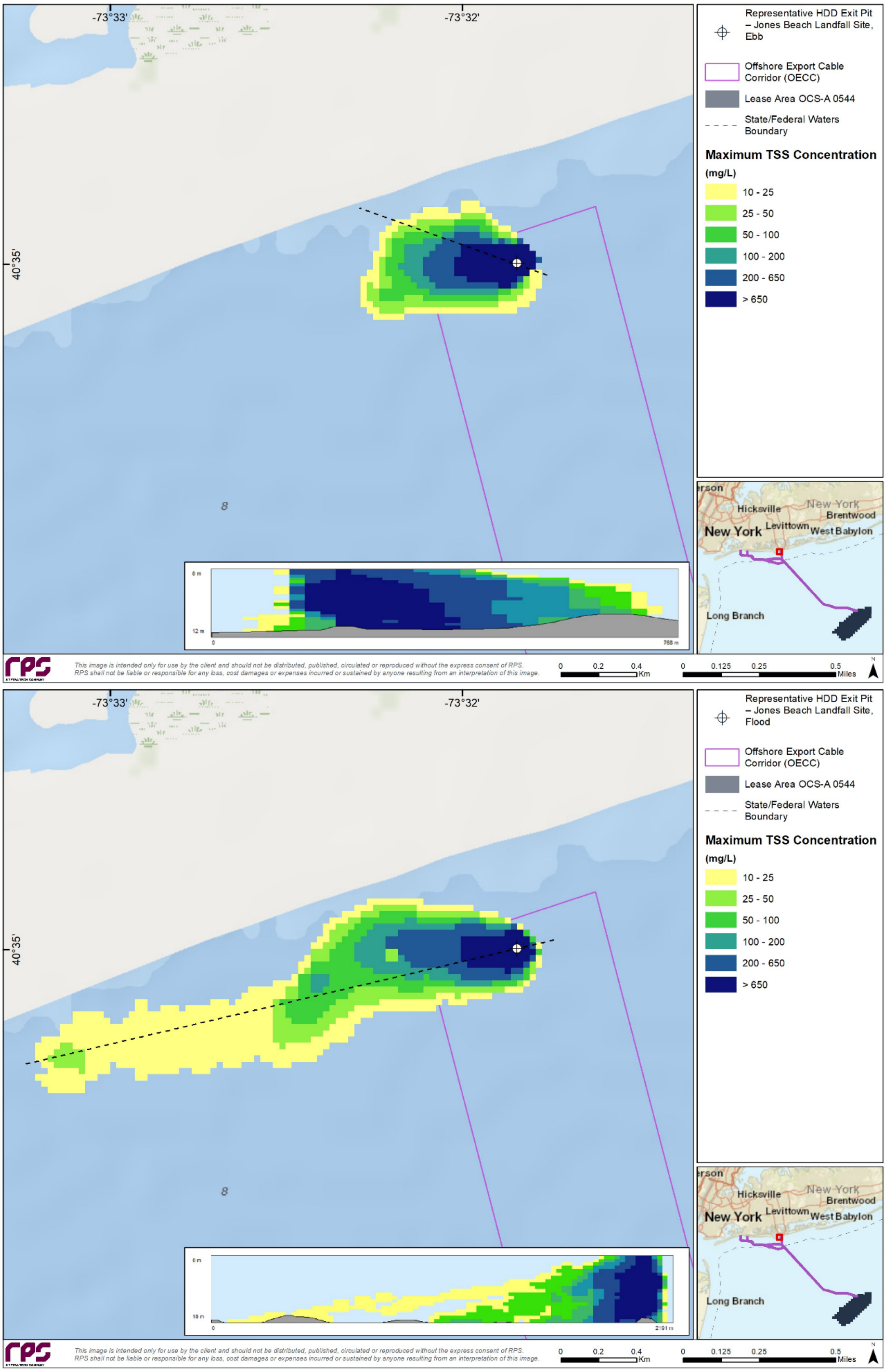
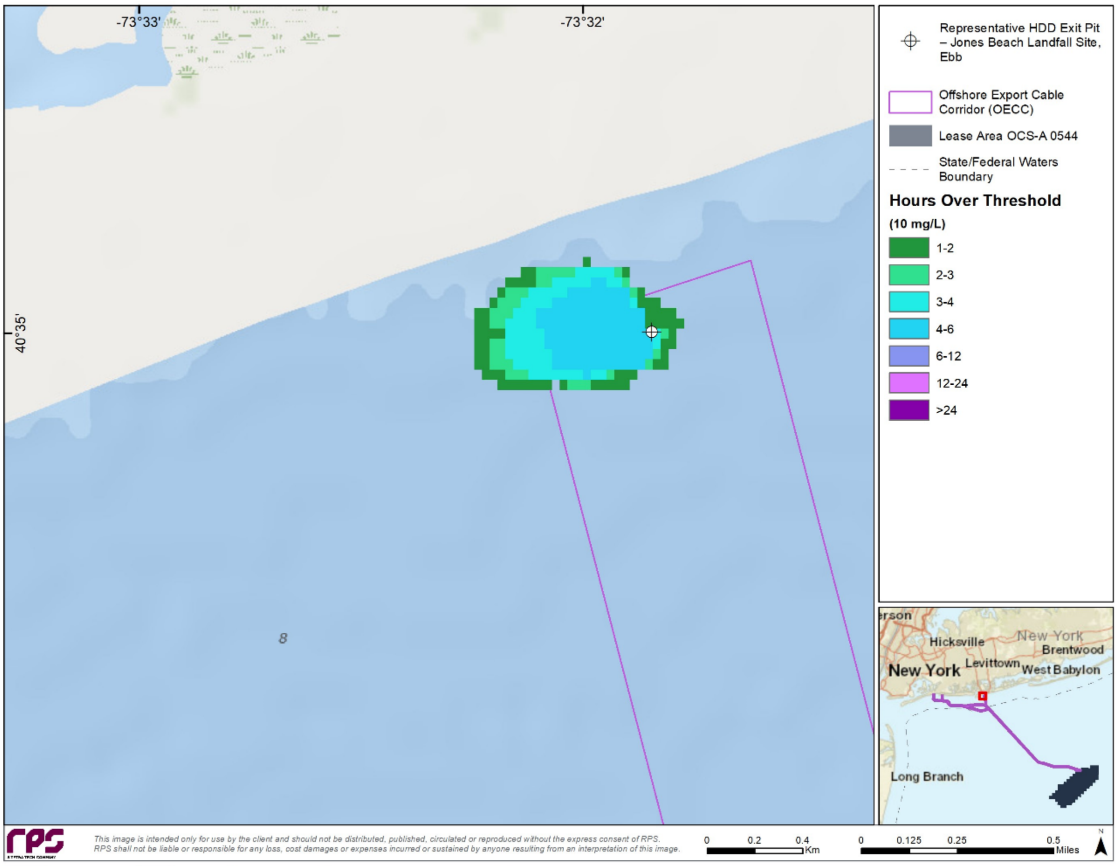


Figure 3-15: Time-integrated maximum concentrations associated with the Jones Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.



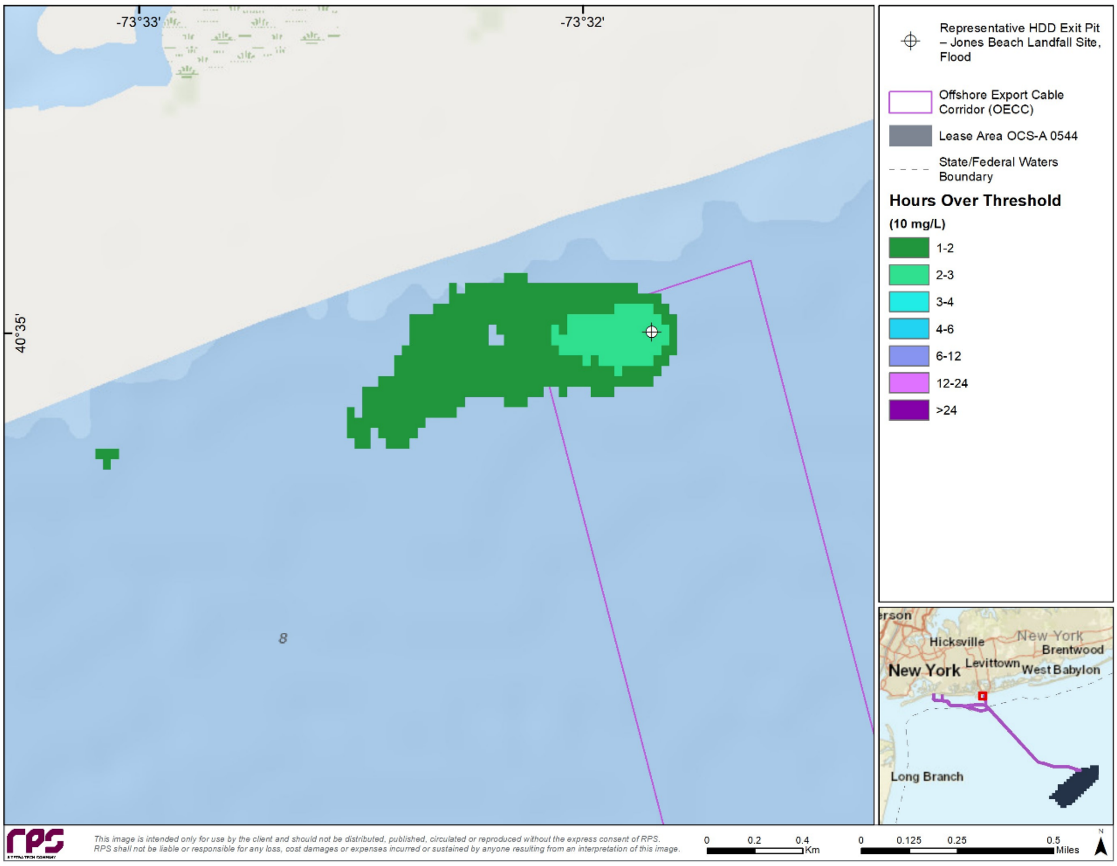
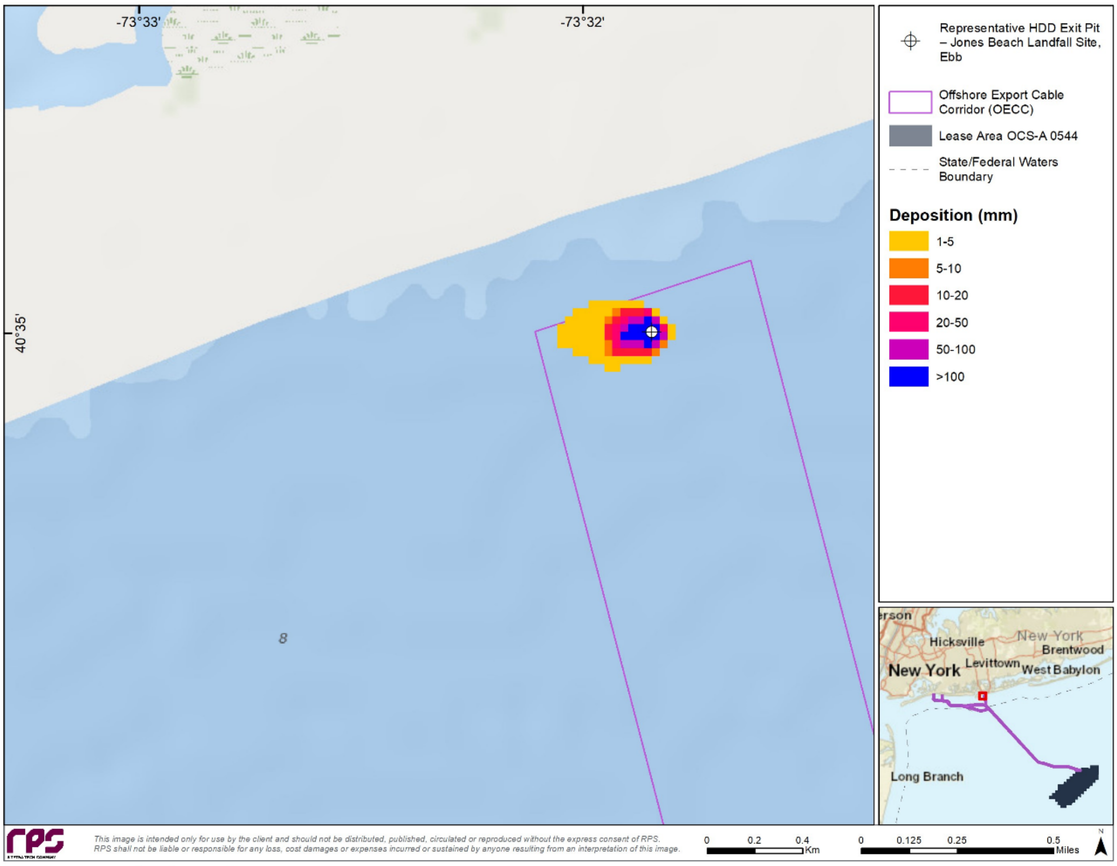


Figure 3-16: Duration of TSS ≥10 mg/L associated with the Jones Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.



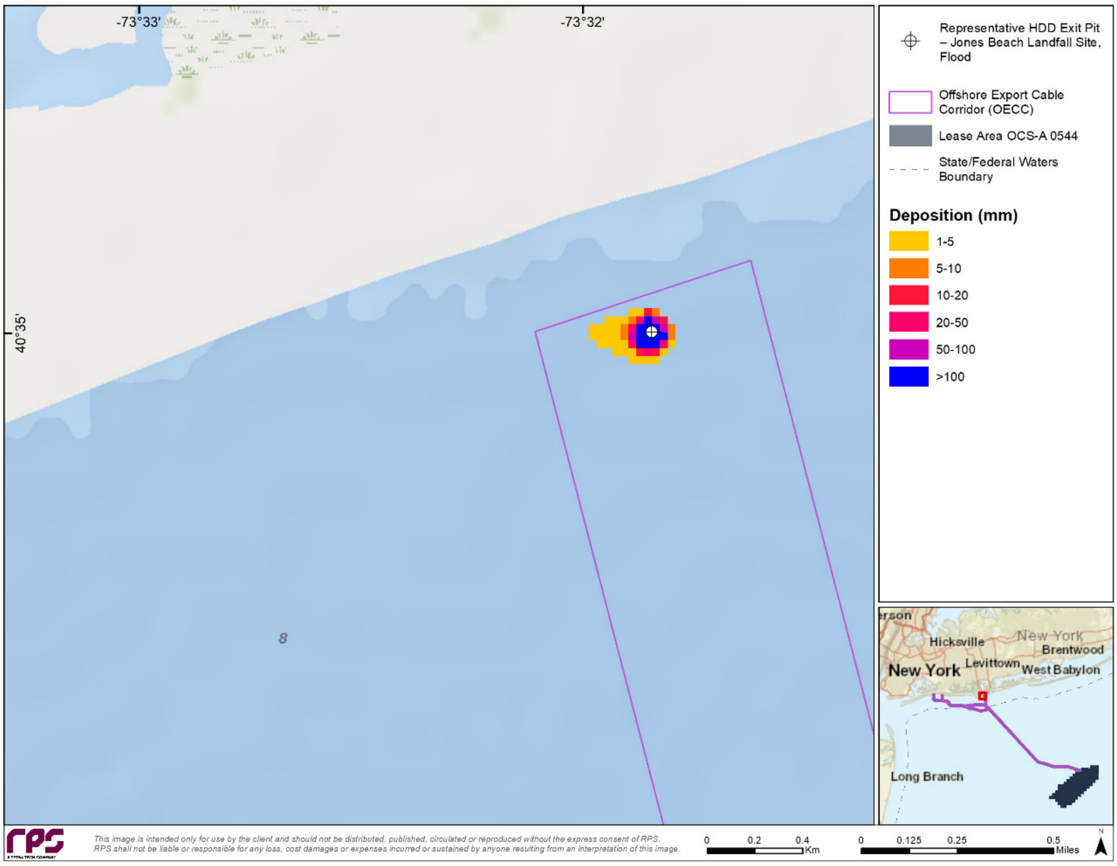


Figure 3-17: Depositional thickness associated with the Jones Beach Landfall Site HDD Exit Pit Construction Ebb (top) and Flood (bottom) simulations.

3.3.4 OECC: Cable Installation

The sediment composition closest to the landfall tends to be primarily coarse and fine sand. As the OECC traverses through state waters, the sediment composition transitions to a combination of fine-grained material (e.g., clays, silts) and coarse material (e.g., coarse sand, fine sand). The proportion of fine material increases as the OECC transitions from state into federal waters, and then back to coarse sand as the OECC approaches the Lease Area.

This section presents results from the simulations of cable installation activities in the state and federal OECC. It is important to note for the typical jetting simulations, that the trench depth in state waters was assumed to be deeper (2.3 m) than was applied in federal waters (1.7 m). Modeling of the Representative OECC Cable Installation using typical jetting techniques was performed for the entire length of the OECC. Simulations were performed from all potential landfall approaches, starting just prior to the shoreline, and traversing to the Lease Area. In reality, cable installation via jetting techniques would not extend to the shoreline, but because the exact locations of the onshore to offshore cable tie-in were unknown at the time of modeling, cable installation was conservatively extended closer to the coastline. This provides an additional layer of conservativism as it increases the potential areas impacted by suspended sediment concentrations and sediment deposition. Note that although all approaches are modeled, up to two approaches will be constructed. Cable installation modeling results for the Representative Rockaway Beach Approach and the Representative Western Landfall Sites OECC Variant to Rockaway Beach simulations are discussed together, however, only one OECC approach connecting the western landfall sites would be constructed, and only if the western landfall sites are selected.

- Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway
- Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach
- Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC
- Representative OECC Cable Installation, Vertical Injector – Main OECC

Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach and the Western Landfall Sites OECC Variant to Rockaway Beach

The instantaneous maps illustrate the transient nature of the plume and how it is influenced by the prevailing current at that moment in time (Figure 3-18, top; Figure 3-20, top). For these two scenarios, the instantaneous snapshots capture a moment when the current is parallel with the route orientation; this causes slightly higher concentrations, for both simulations, within the center of the plume because the suspended sediment concentration is being compounded rather than dispersed in variable directions.

To readily compare the size of the instantaneous snapshot with the extent of the maximum concentration suspended sediment plume, these two maps were plotted together (Figure 3-18 and Figure 3-20). The maximum concentration map captures a much larger footprint than what would occur at any one-time during cable installation because it shows the maximum concentration in the water column over the entire duration of the cable installation simulation (Figure 3-18, bottom; Figure 3-20, bottom). The time-integrated maximum water column concentration cross-section starts near the shoreline and extends through state waters into federal waters where the Western Landfall Sites OECC Variant ends. These cross-sections illustrate that the cable installation via jetting techniques cause a subsurface plume that remains localized to the seabed (Figure 3-18 and Figure 3-20).

Due to the very high content of coarse sediment within the Rockaway Beach Landfall Approach OECC and the relatively slow currents at the time of the simulation, the sediment immediately settles in proximity to the cable installation route with a small portion of the plume being transported west, along the prevailing direction of the currents. As the sediment increases in fine-grained material, the elevated concentration footprints (e.g., 25-100 mg/L as indicated by the green color contours; Figure 3-18 and Figure 3-20) expand. The current direction tended to be parallel with the route which caused both the plume extent to remain relatively close to the route centerline, as well as an increased duration of water column concentrations above 10 mg/L in the presence of clay and silt sediment types (i.e., south of the Atlantic Beach Landfall Approach; Figure 3-19, top; Figure 3-21, top). As discussed in Section 3.3.1, the duration of water column TSS concentrations ≥10 mg/L tended to be higher in areas with fine material because fine sediments (e.g., clays, silts) tend to remain suspended in the water column longer; coarse sediment (e.g., fine sand, coarse sand) settles faster. Increased durations of water column TSS concentrations ≥10 mg/L also occurred because the parallel nature of the currents with the route which compounded the plume as the sediment was continuously disturbed, prior to dispersing. The combination of fine-grained material and a current that is perpendicular to the route orientation also influences the extent of the plume. As previously discussed, actual current conditions during installation will ultimately dictate the fate and behavior of the suspended sediment plume.

Based on these model simulations, the areas above the concentration and deposition thresholds were similar for the Representative Rockaway Beach Approach and the Representative Western Landfall Sites OECC Variant to Rockaway Beach cable installation simulations. Slight variation in the predicted areas was due to the route-specific sediment composition, timing of modeled installation activities, and the orientation of the route with respect to the prevailing currents. Water column concentrations for both simulations were predicted to dissipate below 10 mg/L within six to 12 hours.

For the Representative Rockaway Beach Approach and the Representative Western Landfall Sites OECC Variant to Rockaway Beach cable installation simulations, the depositional footprint followed the route centerline (Table 3-13) and the majority of the depositional footprints contained thicknesses of less than 10 mm for each simulation (Figure 3-19, bottom; Figure 3-21, bottom). Coinciding with areas of coarse sediment, isolated patches of thicknesses between 10 and 20 mm were also predicted for both scenarios.

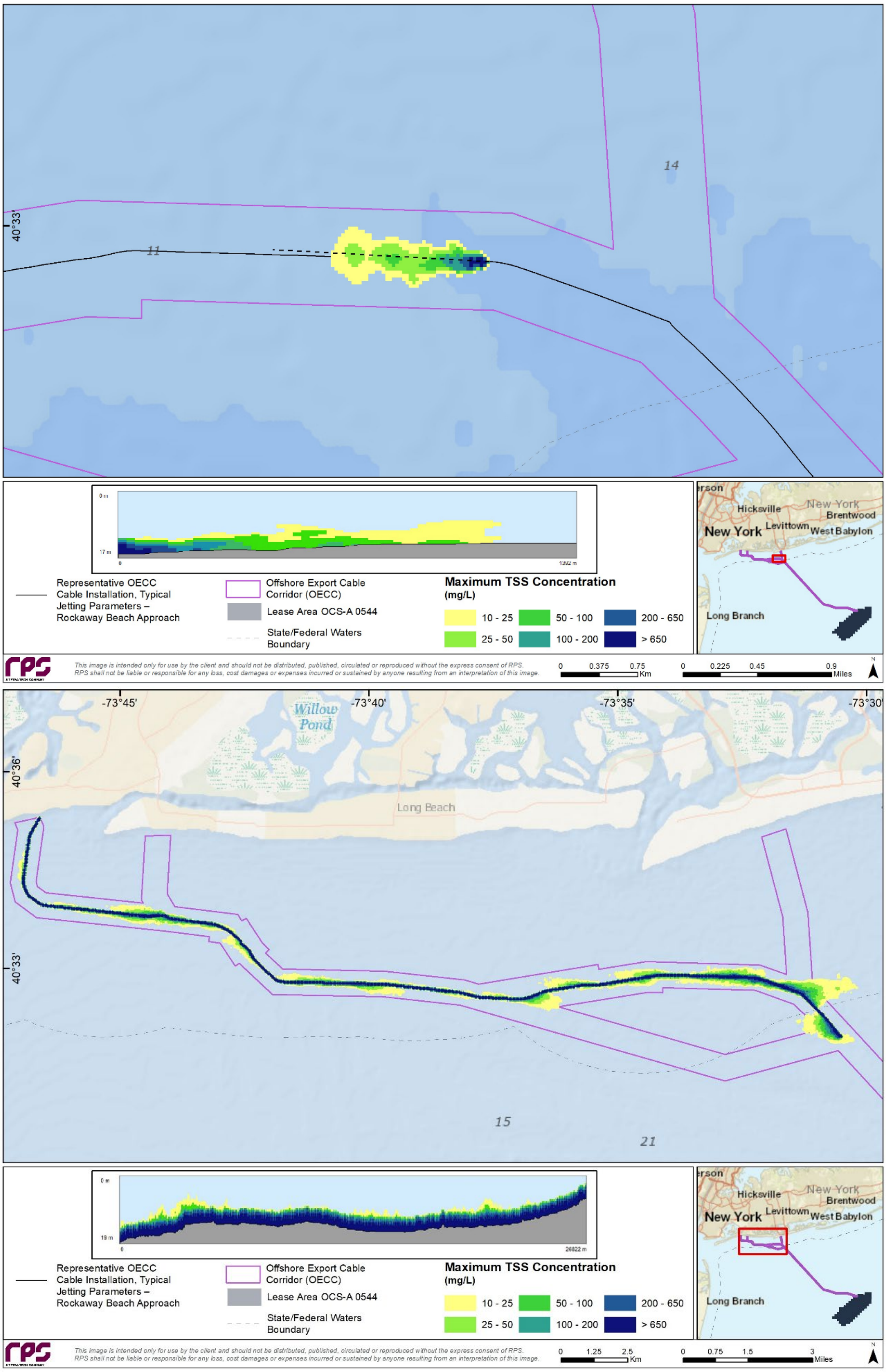


Figure 3-18: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach simulation.

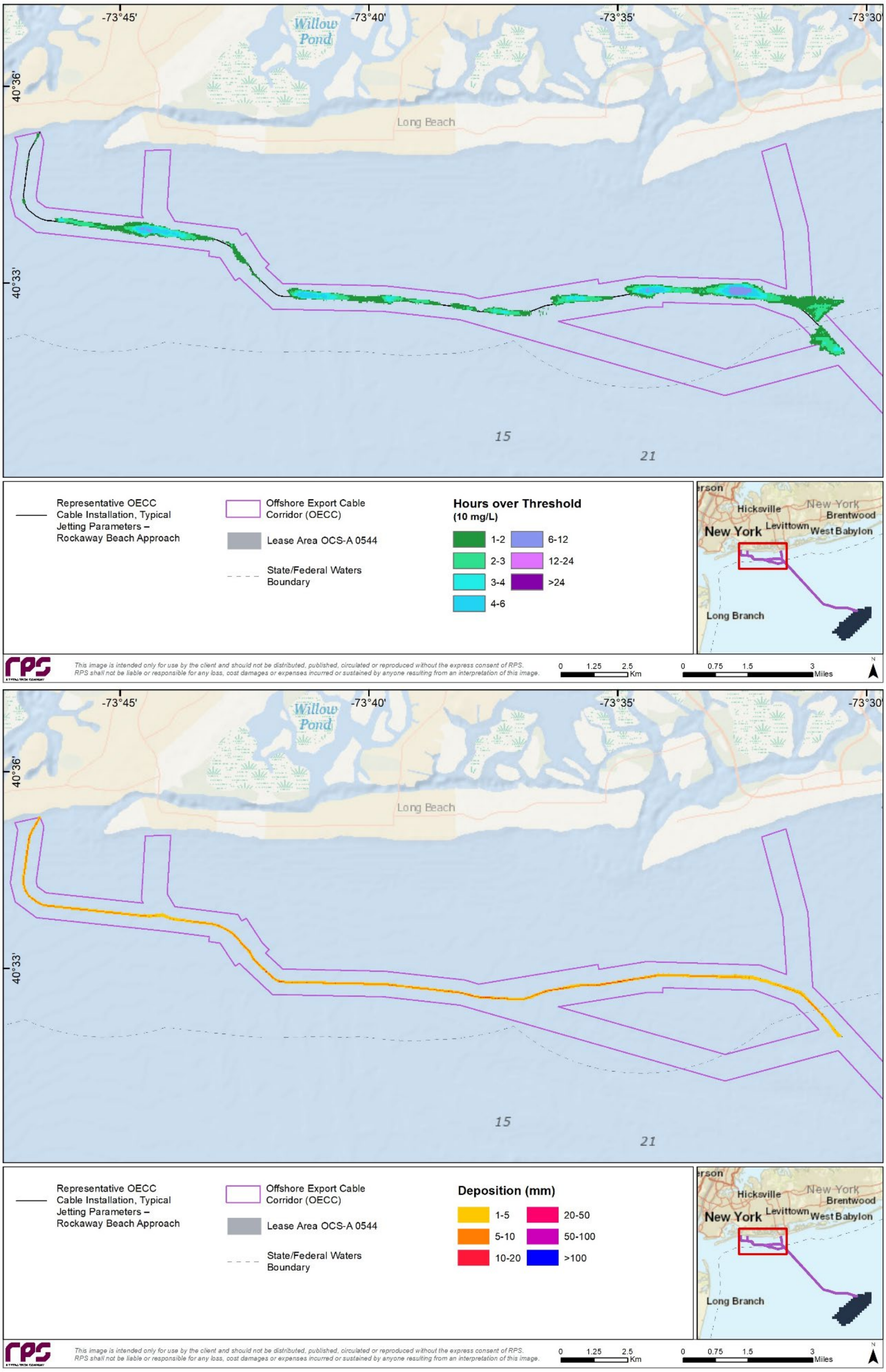


Figure 3-19: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Rockaway Beach Approach simulation.

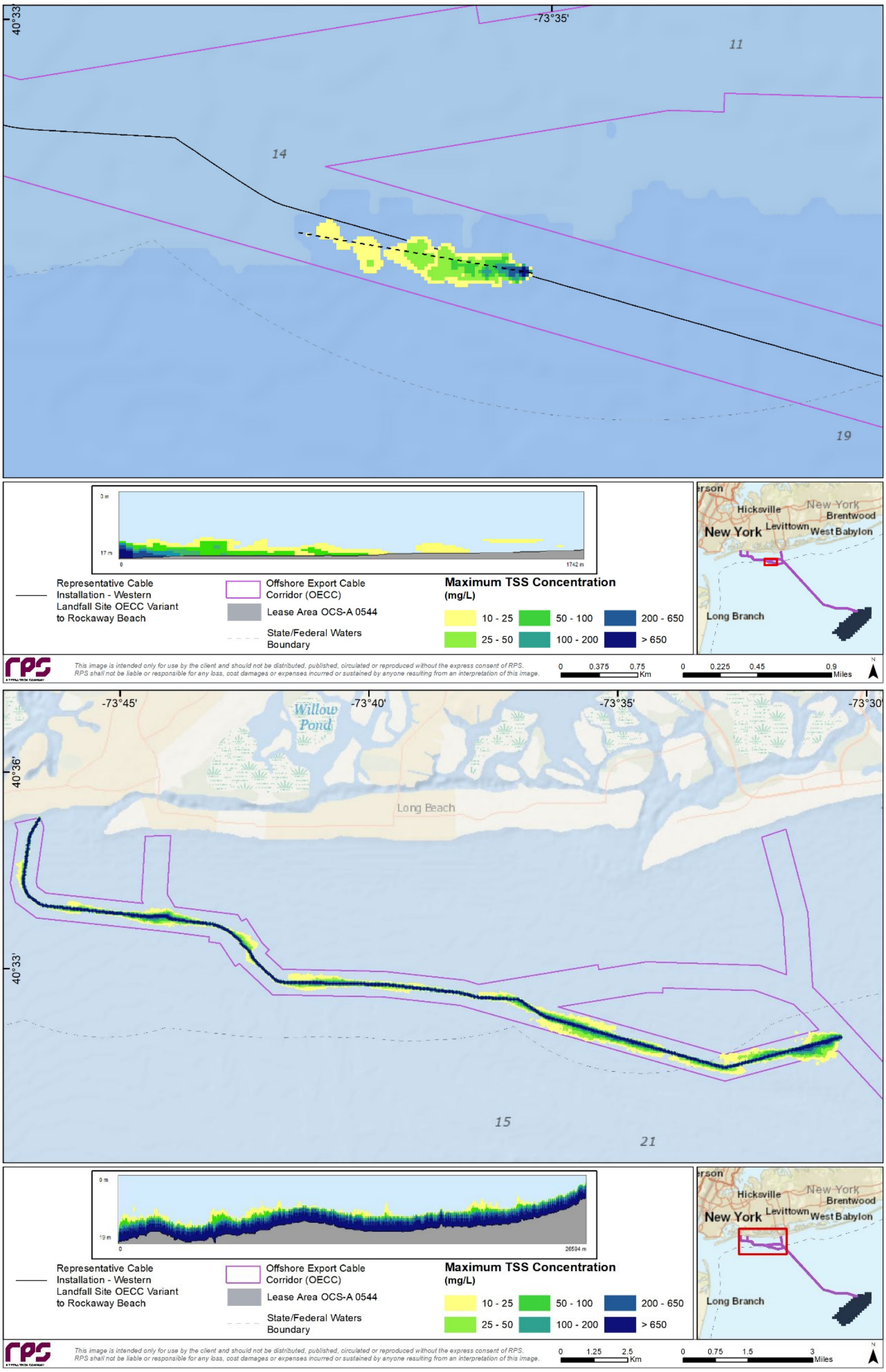


Figure 3-20: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach simulation.

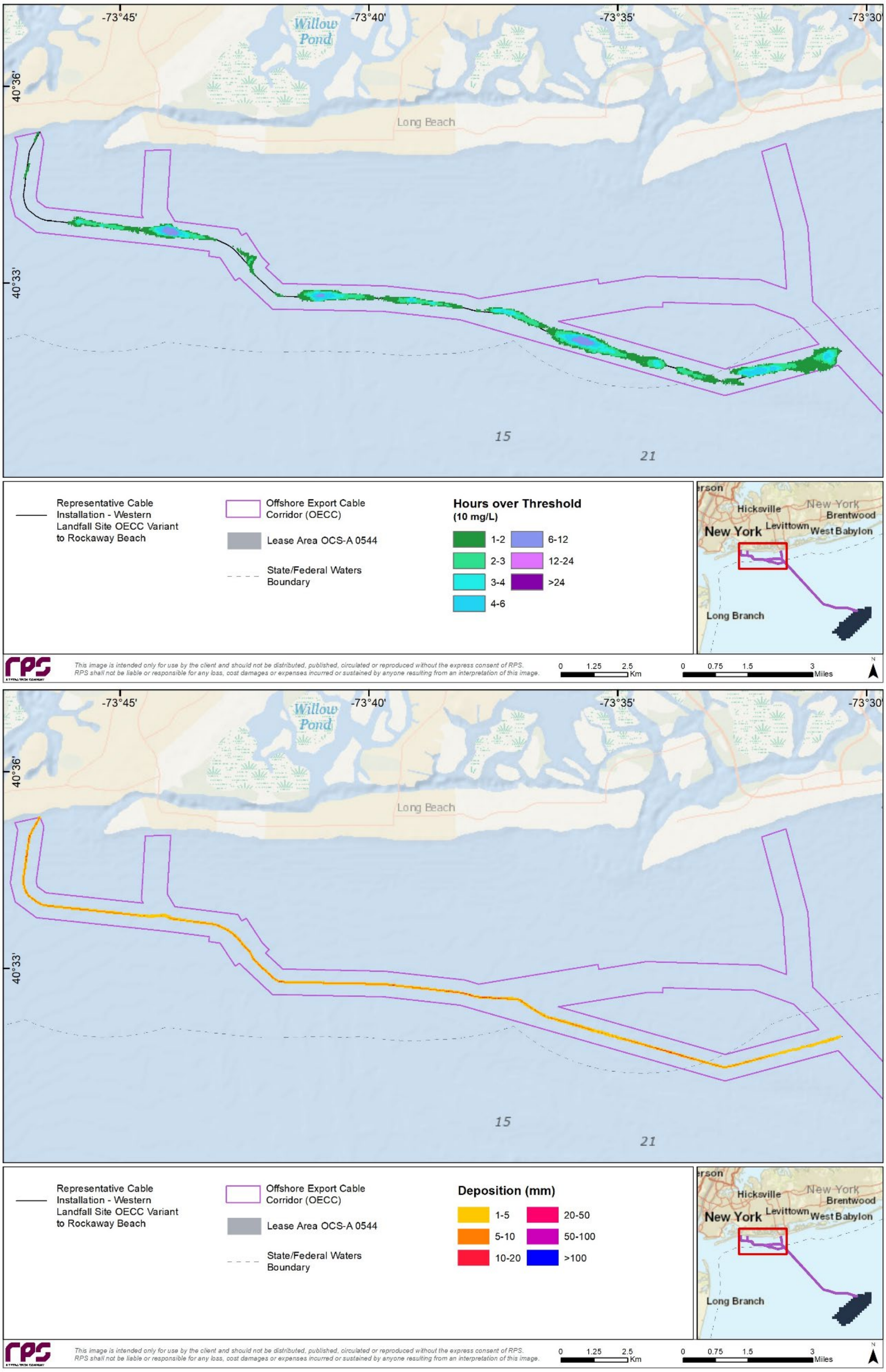


Figure 3-21: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Western Landfall Sites OECC Variant to Rockaway Beach simulation.

Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach

A snapshot of the instantaneous concentrations from the Representative Atlantic Beach Approach cable installation using typical jetting parameters shows the plume remains localized near the seabed and is transient in time and space depending on the local currents (Figure 3-22, top). The prevailing current, at the time of this snapshot, transported the plume northeast, away from the route centerline. This snapshot was taken within an area of relatively high fractions of fine material and was subjected to swift currents. Both the plan-view and the highest concentrations of installation-induced suspended sediment in the vicinity of the installation device, as expected. These higher concentrations then decrease rapidly with distance from the source, as the plume disperses with the currents and settles to the seabed.

The time-integrated maximum water column concentration map (Figure 3-22, bottom) contains an inset that shows the cross-sectional view of the plume throughout the entire length (from the landfall site to the connecting point with the Main OECC). The time-integrated maximum water column concentration map illustrates a much larger footprint than would be expected at one point in time (as compared with the instantaneous snapshot; Figure 3-22, top). Near landfall, the suspended sediment plume oscillated with the tides as this area consists of relatively high fractions of fine-grained sediment (e.g., clay) and the orientation of the route was perpendicular to the currents. In areas where the sediment tended to be coarse sand or fine sand, and the orientation of the currents was parallel with the route, the TSS concentrations tended to remain along the route centerline. The elevated TSS concentrations (>200 mg/L) rapidly dissipated or settled within two hours (Table 3-8) and concentrations dispersed to <10 mg/L within 12 hours (Figure 3-23, top).

Seabed deposition for this scenario ranged between 1 mm and 10 mm for the majority of the cable route, with isolated patches of deposition between 10 mm and 20 mm (Figure 3-23, bottom). Deposition tended to remain along to the route centerline (on average, 0.06 km) with the maximum extent reaching approximately 0.11 km (Table 3-13). In general, the depositional footprint is uniform along the route, with a large portion of the route not exceeding depositional thicknesses of 5 mm.

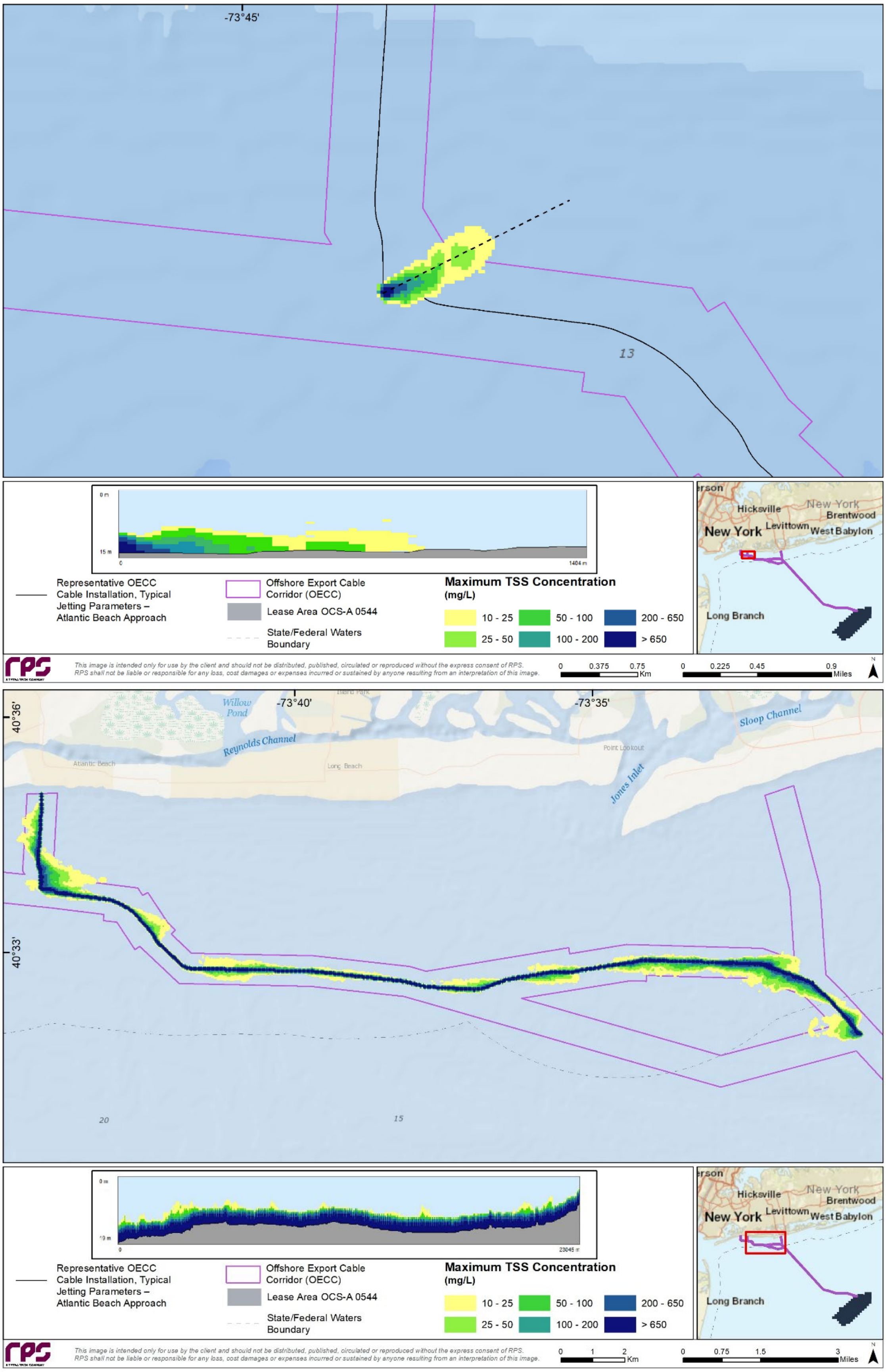


Figure 3-22: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach simulation.

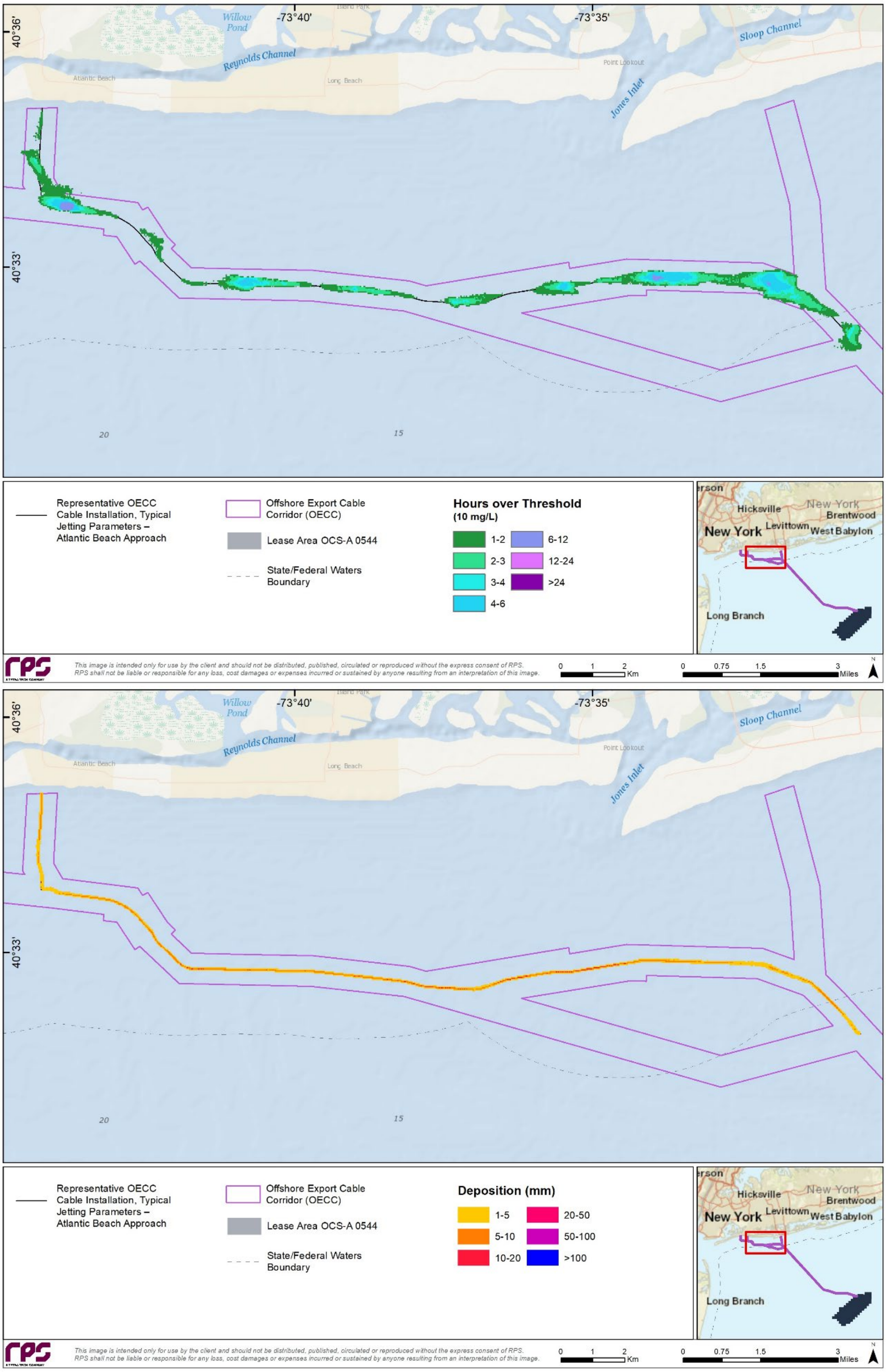


Figure 3-23: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Atlantic Beach Approach simulation.

Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach

The instantaneous snapshot illustrates the west/northwest transport of the subsurface plume by the prevailing currents at that time step (Figure 3-24, top). This instantaneous snapshot corresponds to an area with relatively high fractions of fine-grained material which creates a subsurface plume that is readily dispersible by currents. The instantaneous cross-section captures the patchy, discontinuous nature of the plume as it remains localized to the seabed (Figure 3-24).

The time-integrated maximum water column concentration map clearly captured the oscillatory nature of the plume as it moves east and west with the tides and currents (Figure 3-24, bottom). Based on the timing of the simulation and the direction of the current with respect to the OECC, the plume's behavior and footprint changed along the length of the Jones Beach Approach. The primary factor influencing the suspended sediment concentrations was the forcing of the subsurface currents. In some areas with higher fractions of fine material (i.e., as the installation approached the primary portion of the OECC), the plume tended to extend farther from the source and took longer to settle. TSS concentrations ≥10 mg/L were predicted to remain close to the seabed and dissipate within six hours, at most (Figure 3-25, top).

For the Jones Beach Approach, the sediment deposited along the route centerline consisted of thicknesses mostly between 1 and 10 mm (Figure 3-25, bottom). Patches of deposition along the route were also predicted to range between 10 mm and 20 mm (Figure 3-25). Deposition tended to remain along to the route centerline (on average, <0.07 km) with the maximum extent reaching approximately 0.11 km (Table 3-13).

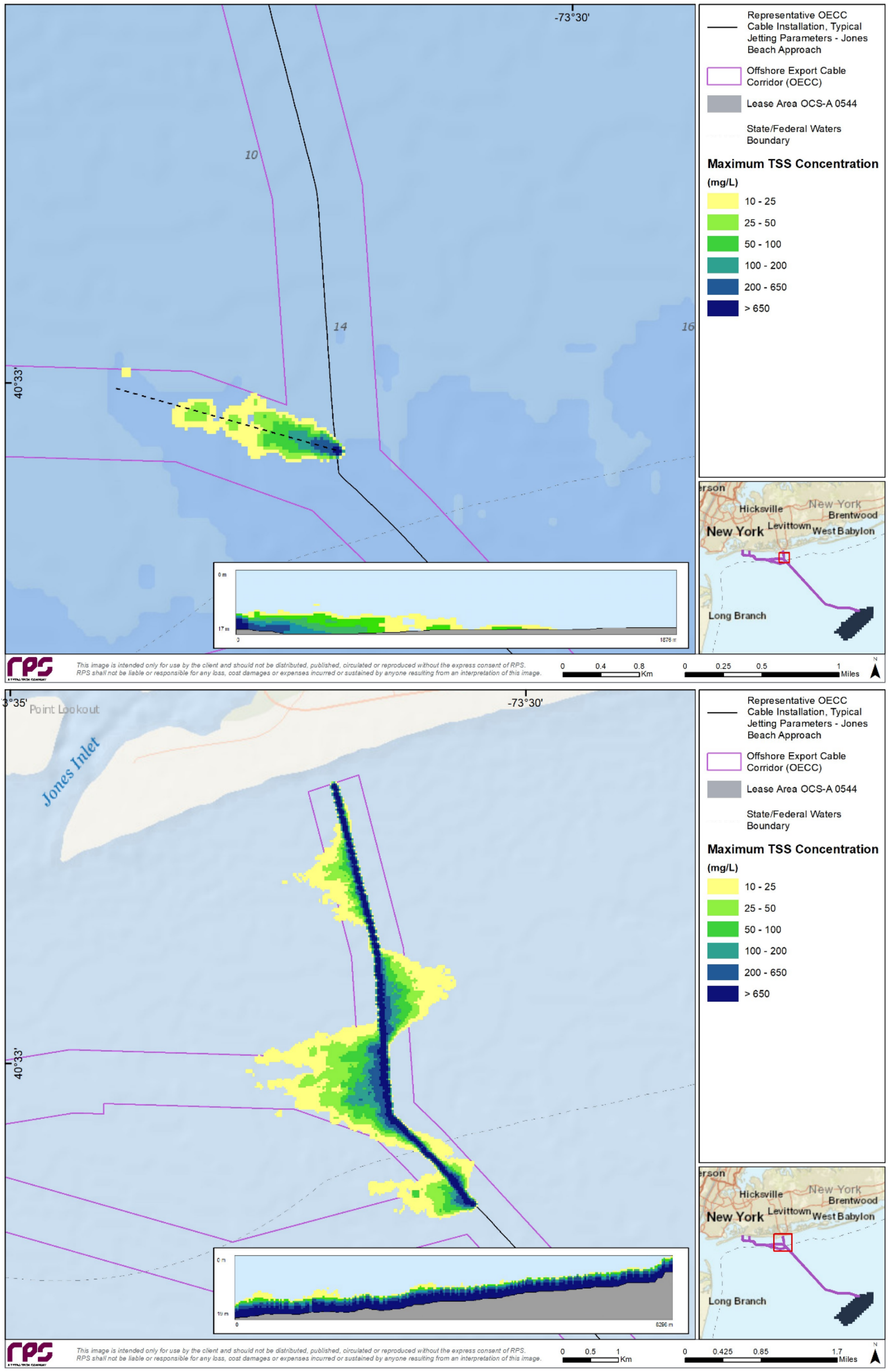


Figure 3-24: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach simulation.

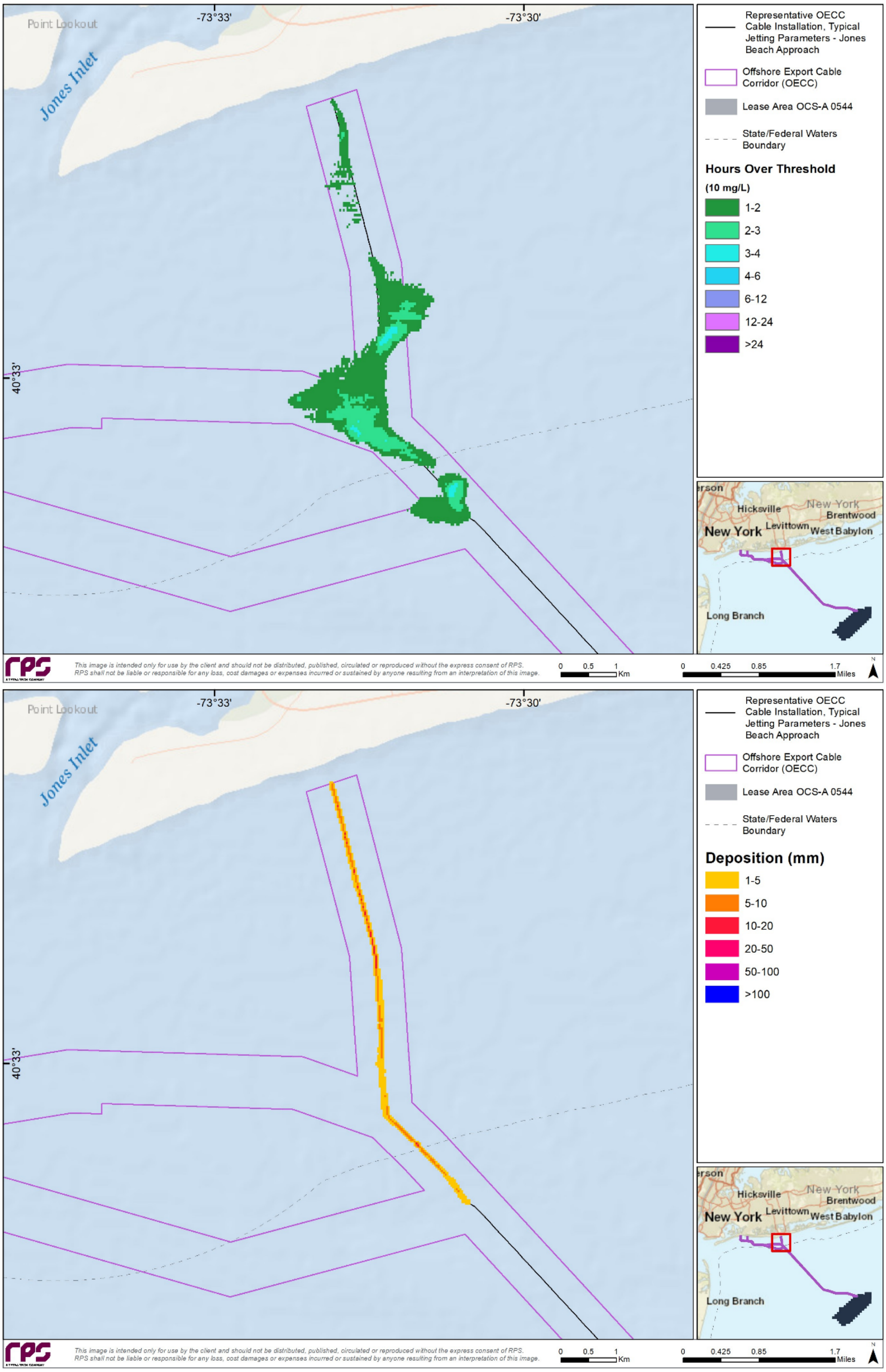


Figure 3-25: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Jones Beach Approach simulation.

Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC

A snapshot of the instantaneous TSS concentrations for a time step for the Representative Main OECC Cable Installation simulation, using typical jetting parameters, was taken near the start of the route in an area with high fractions of fine-grained material (Figure 3-26, top). The snapshot captures the localized plume near the seabed, as well as the patchy nature of the plume in the water column. This was a particularly important example of how the plume was influenced by the sediment type and current magnitude and direction at a moment in time. The highest concentrations near the disturbance location (i.e., at the route centerline) diminished with distance from the source. This snapshot was unique in that there is a central pocket within the plume with elevated concentrations (i.e., >200 mg/L) that did not dissipate as quickly as the surrounding concentrations. Additionally, two small, disparate patches of the plume continued to disperse and settle even though they were not part of the contiguous plume (indicated by the yellow contour in Figure 3-26, top).

The time-integrated maximum concentration map captures the oscillatory nature of the currents at the start of the representative Main OECC as the tail of the plume swings back and forth across the route centerline (Figure 3-26, bottom). This transport pattern was predicted because the orientation of the route is at an angle to the currents, the currents were particularly fast during the modeled time period, and the first segment of the representative Main OECC (closest to the landfall site approaches) coincides with fine-grained sediment. The finer material was readily advected by subsurface currents compared to coarse sand and fine sand, as illustrated in the second half of the representative Main OECC cable installation route. As the OECC approaches the Lease Area, the sediment consists of mostly sand and the orientation of the route changes to be more in-line with the prevailing current.

The first half of the Representative Main OECC cable installation simulation, nearest the shoreline, was predicted to produce suspended sediment plumes with TSS concentrations ≥10 mg/L for more than an hour. The second half of the route, closest to the Lease Area, was only predicted to have small, isolated patches of TSS concentrations ≥10 mg/L that would last one to two hours (Figure 3-27, top). On average, the extent to the 10 mg/L concentration contour was approximately 0.5 km with a maximum extent of 1.58 km (Table 3-6). Elevated concentrations (i.e., >200 mg/L) were predicted to dissipate within two hours, and TSS concentrations ≥10 mg/L were estimated to disperse within six hours.

The depositional footprint followed the route centerline for the entirety of the Representative Main OECC cable installation simulation (Figure 3-27, bottom). Most of the depositional footprint consisted of thicknesses between 1 mm and 5 mm, with isolated patches exceeding thicknesses of 10 mm (<0.01 km^2; Table 3-12). Those patches occurred within the second half of the route, which coincided with areas of coarse sediment and in areas where the current was parallel with the route. Deposition tended to remain along the route centerline (on average, 0.06 km) with the maximum extent reaching approximately 0.09 km (Table 3-13).

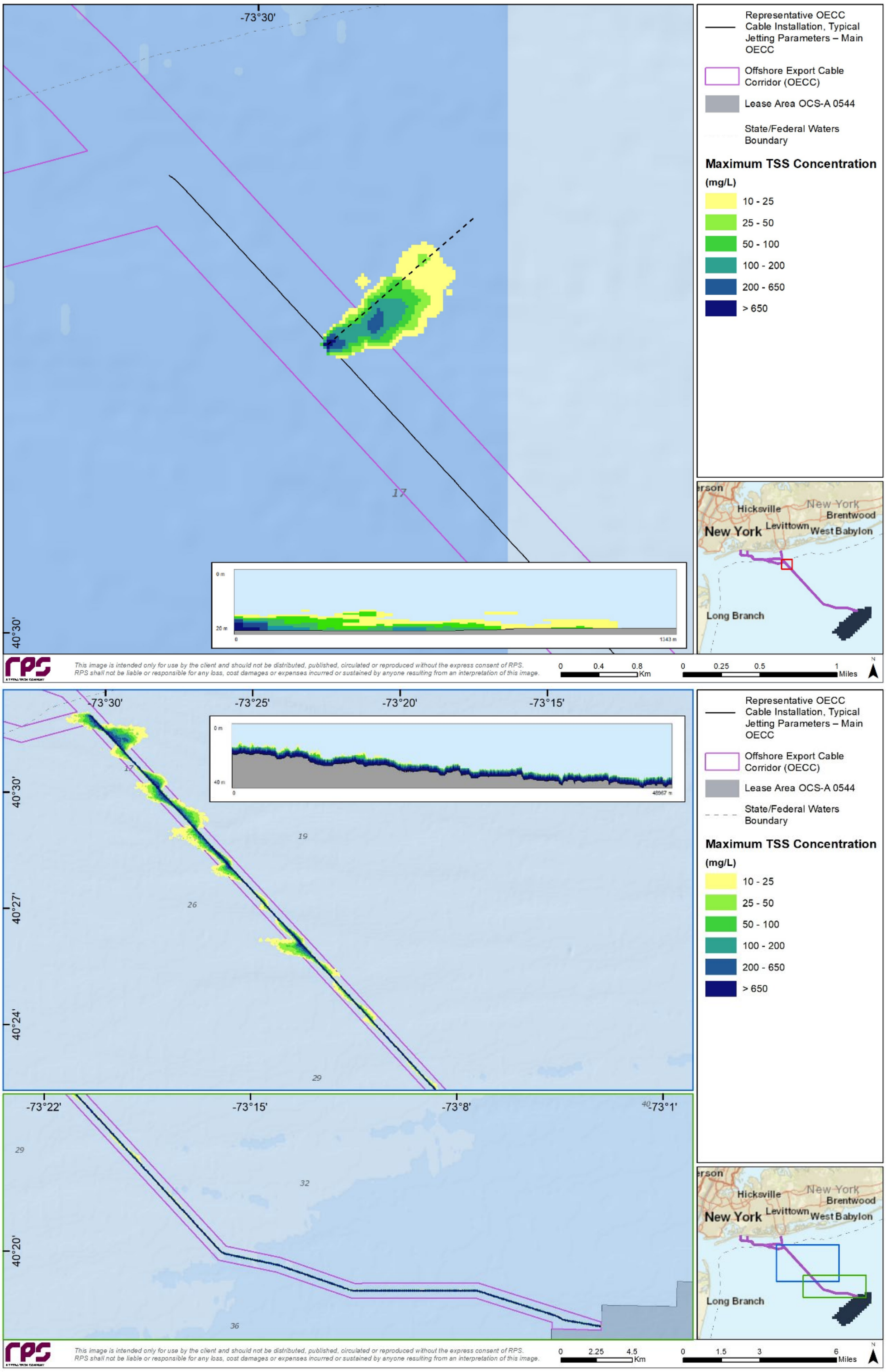


Figure 3-26: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC simulation.

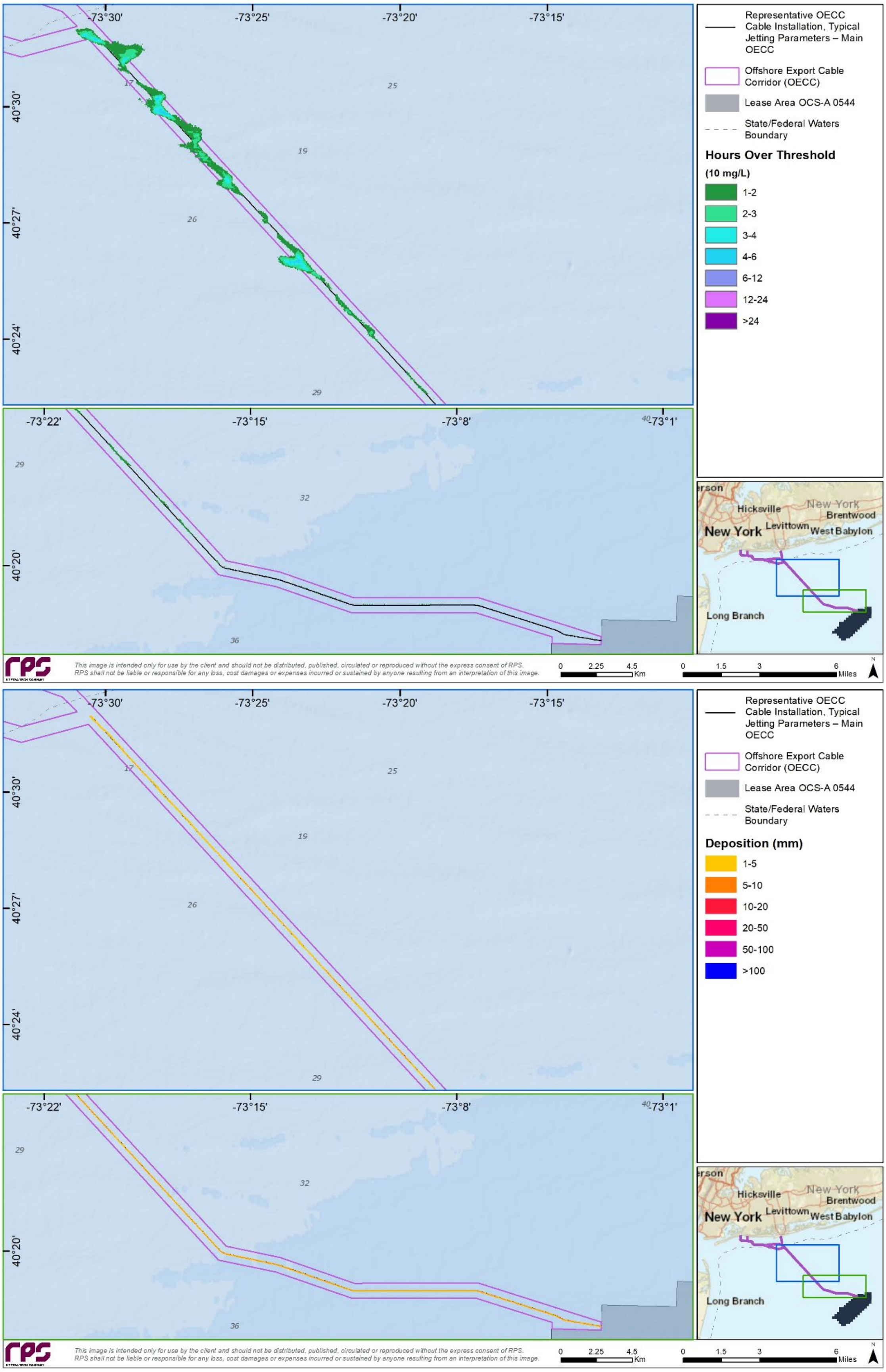


Figure 3-27: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation, Typical Jetting Parameters – Main OECC simulation.

Representative OECC Cable Installation — Vertical Injector

A representative simulation was performed to simulate cable installation within the Main OECC using a vertical injector. The simulation was performed within an area containing high fractions of fine material, during a period with very high current velocities, to evaluate a potential worst-case scenario when predicting water column concentrations. The instantaneous snapshot illustrates the influence of the east/northeast prevailing currents at that time step, and the cross-sectional view (inset map) shows the plume was localized to the seabed (Figure 3-28, top). The highest concentrations were predicted near the source and closest to the seabed, with concentrations declining away from the source and vertically in the water column.

The footprint associated with the time-integrated maximum water column concentrations (Figure 3-28, bottom) captures the influence of the fast subsurface currents on the suspended sediment plume. The average and maximum extents of the TSS concentrations ≥10 mg/L was larger for the Representative Vertical Injector scenario than all other scenarios. This was due to the deeper target trench depth which resulted in more sediment being introduced to the water column when compared with the other cable installation simulations. Although the route was shorter compared to the other cable installation simulations, the predicted areas exceeding the concentration threshold for one hour or longer were similar for the smaller thresholds (i.e., <50 mg/L) and larger for the higher concentration thresholds (i.e., >50 mg/L). The elevated levels of suspended sediment (i.e., >50 mg/L) were predicted to dissipate within four hours, while concentrations ≥10 mg/L required 12 hours to dissipate (Figure 3-29, top). The duration of the water column TSS concentrations ≥10 mg/L footprint is similar in extent to the time-integrated maximum water column concentration map and follows a similar pattern of oscillation with the currents.

Due to the simulation being performed in an area of high fine material (e.g., silts, clays), the depositional footprint is centered around the route (Figure 3-29, bottom). Depositional thicknesses were not predicted to exceed 20 mm based on the simulation parameters and the location of the simulation. The maximum extent to the 1 mm deposition contour was approximately 0.17 km, while the extent to that threshold was, on average, 0.09 km (Table 3-13).

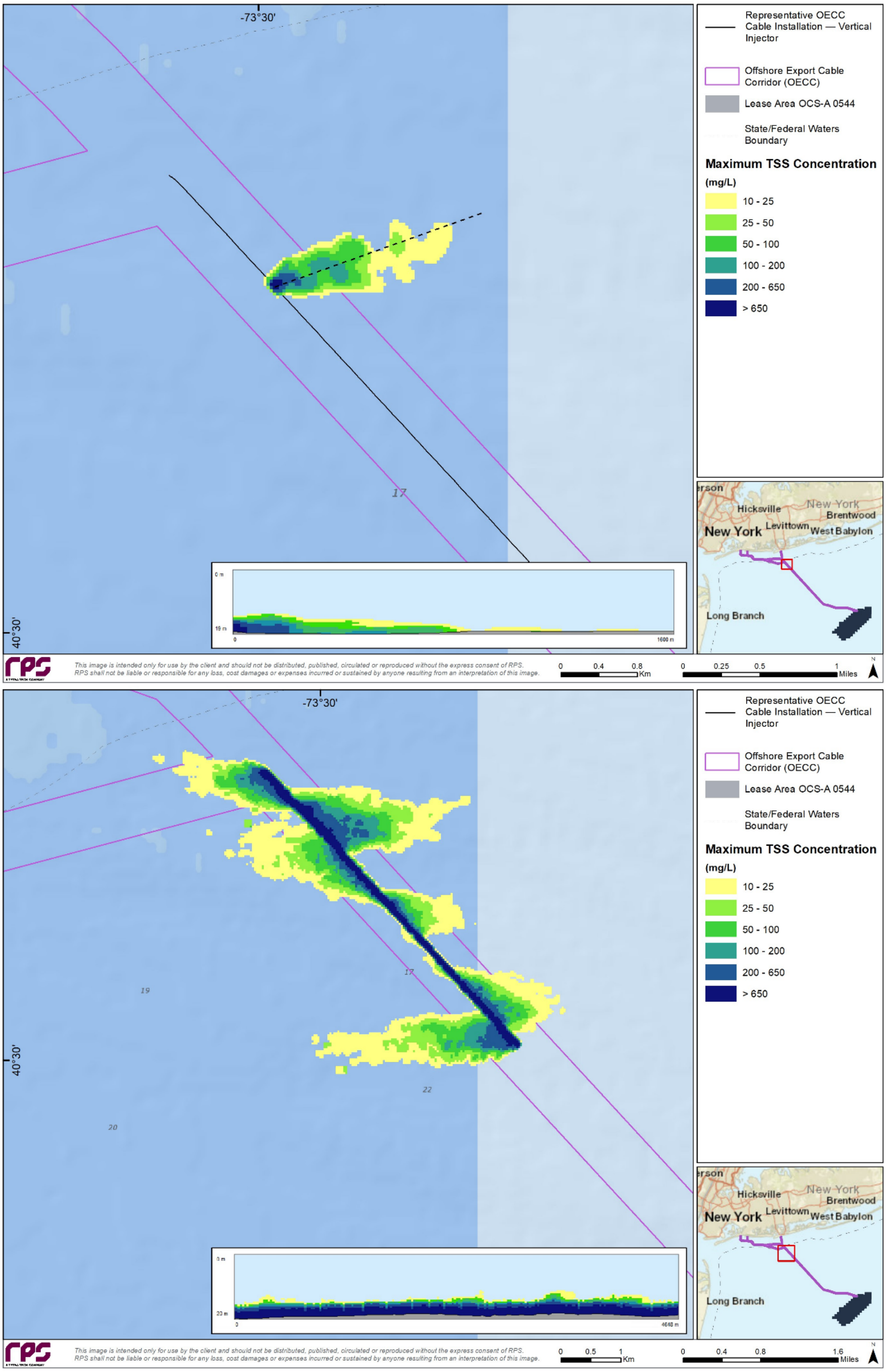


Figure 3-28: Snapshot of instantaneous TSS concentrations for a time step (top) and time-integrated maximum concentrations (bottom) for the Representative OECC Cable Installation – Vertical Injector simulation.

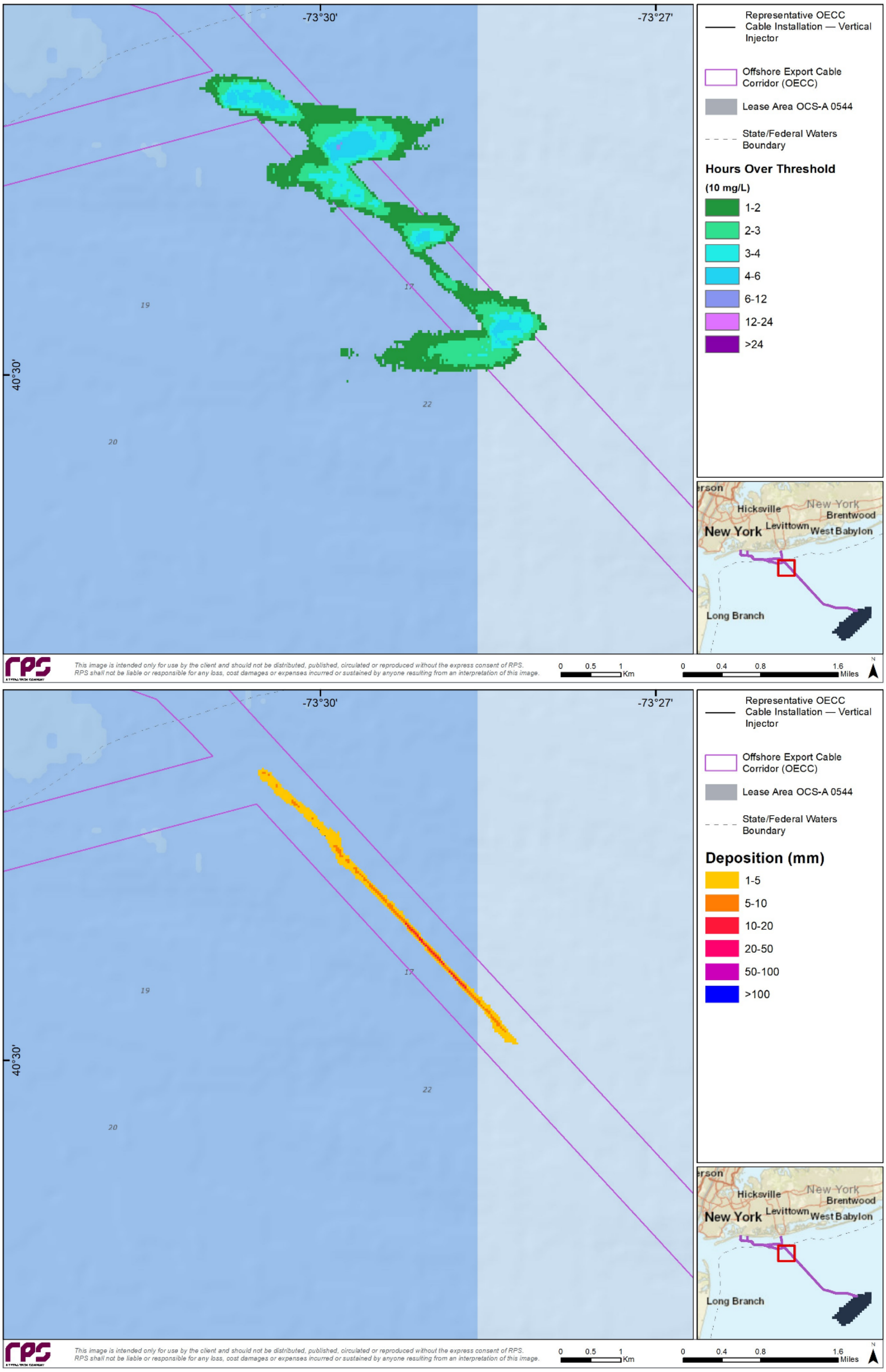


Figure 3-29: Duration of TSS ≥10 mg/L (top) and depositional thickness (bottom) for the Representative OECC Cable Installation — Vertical Injector simulation.

3.3.5 Lease Area

The sediment composition within the Lease Area contains a mixture of sediment types, with small sections containing proportions of coarse silt, fine silt, and clay. Throughout the entirety of the Lease Area, sediment samples primarily consist of coarse sand and fine sand. This section presents results from the simulations of cable installation activities in the Lease Area. Results from these two scenarios are presented together for comparison purposes:

- Representative Lease Area Cable Installation —Typical Jetting
- Representative Lease Area Cable Installation — Maximum Jetting

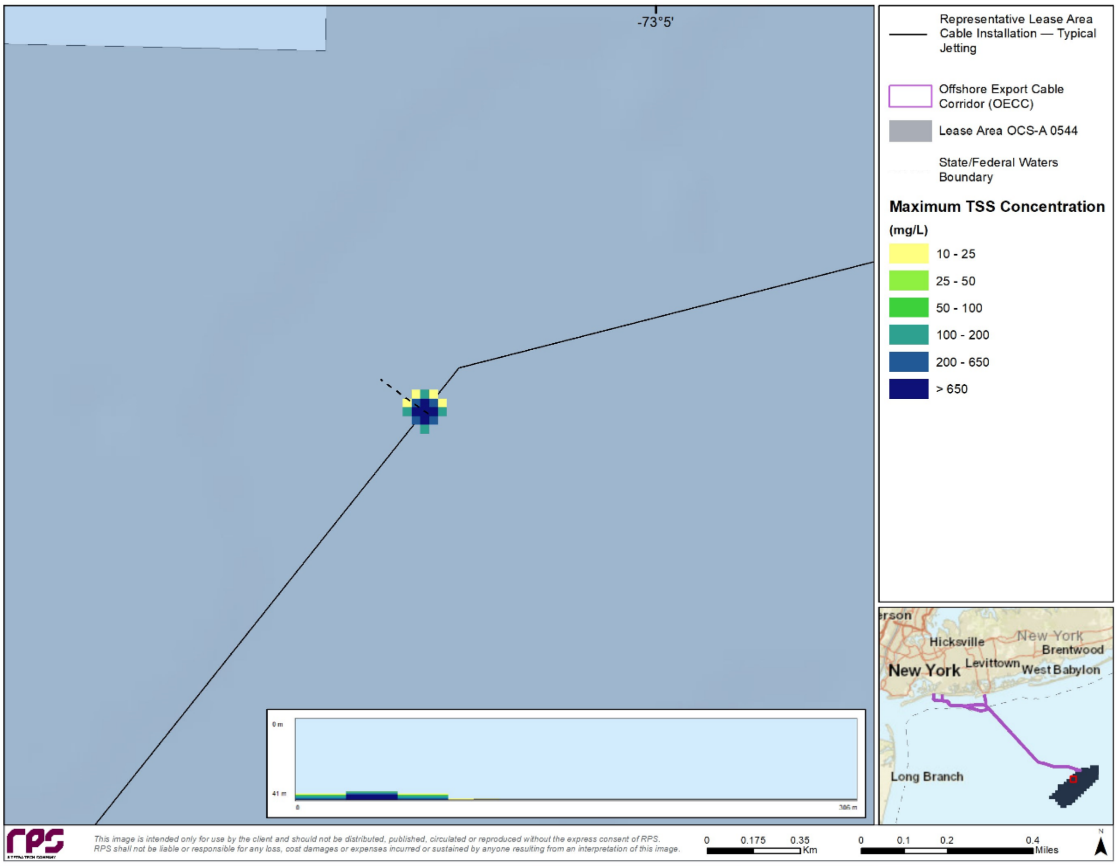
Representative Lease Area Cable Installation —Typical Jetting and Maximum Jetting

As indicated by both the instantaneous snapshot (Figure 3-30) and time-integrated maximum concentration maps (Figure 3-31), the Representative Lease Area cable installation simulations, using typical and maximum parameters, illustrate that higher concentrations are contained around the centerline and remain localized to the bottom of the water column. As with all other OECC cable installation scenarios, the highest concentrations were predicted closest to the bottom (i.e., localized to the source) and dissipated with increasing vertical distance from the seabed. As anticipated, results from the maximum jetting parameter simulation predicted more sediment would be released to the water column which generated a larger plume footprint with higher associated TSS concentrations. Due to the nature of the sediments being exceptionally coarse in the Lease Area, the plumes are small compared to the OECC cable installation simulations. The influence of the currents was only observable in the time-integrated maximum water column concentration maps for the Representative Lease Area Maximum Jetting scenario (Figure 3-31, bottom).

For the Representative Lease Area Typical Jetting scenario, only very small areas (~0.01 km^2; Table 3-7) were predicted to exceed 10 mg/L for an hour or longer (Figure 3-32, top). The Representative Lease Area Maximum Jetting scenario was predicted to have larger areas with TSS concentrations ≥10 mg/L for more than an hour (Figure 3-32, bottom). The areas with TSS concentrations ≥10 mg/L were patchy and discontinuous, and overlapped with the small portion of the Lease Area that contains finer material. TSS concentrations ≥10 mg/L were predicted to return to ambient conditions within two or three hours for the Representative Lease Area Typical Jetting and the Representative Lease Area Maximum Jetting scenarios, respectively.

It is important to note that this scenario was modeled in an area encompassing one of the highest fractions of fine material within the Lease Area. Fine material is easily transported with subsurface currents and inherently takes longer to settle. Additionally, this was the longest inter-array cable installation within the Lease Area and so more sediment was suspended during the simulated installation operations than would occur for the other inter-array cable installations. In areas with less fine material, it would be anticipated that water column concentrations would return to ambient conditions within a shorter time period than those reported for these simulations but would also produce deposits of sediment similar to those predicted in this assessment.

The depositional footprint of the Representative Lease Area Typical Jetting and Representative Lease Area Maximum Jetting scenarios falls along the route centerline (Figure 3-33). For the Representative Lease Area Maximum Jetting scenario, the maximum extents were predicted to be 0.06 km and 0.02 km to the 1 mm and 20 mm thresholds, respectively (Table 3-13). The Representative Lease Area Typical Jetting scenario was predicted to have the same maximum extent to the 1 mm threshold, but was not predicted to exceed depositional thicknesses of 20 mm.



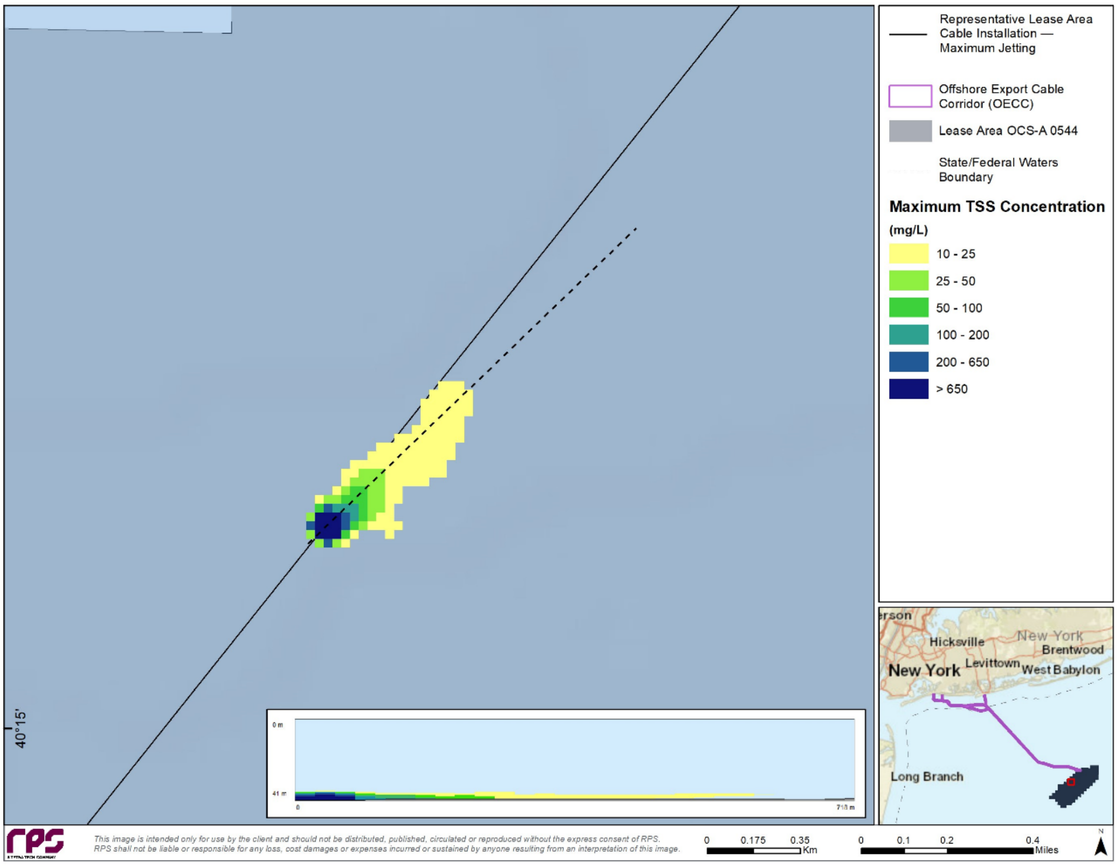


Figure 3-30: Snapshot of instantaneous TSS concentrations for a time step during the Representative Lease Area Cable Installation —Typical Jetting (top) and Maximum Jetting (bottom) simulations.

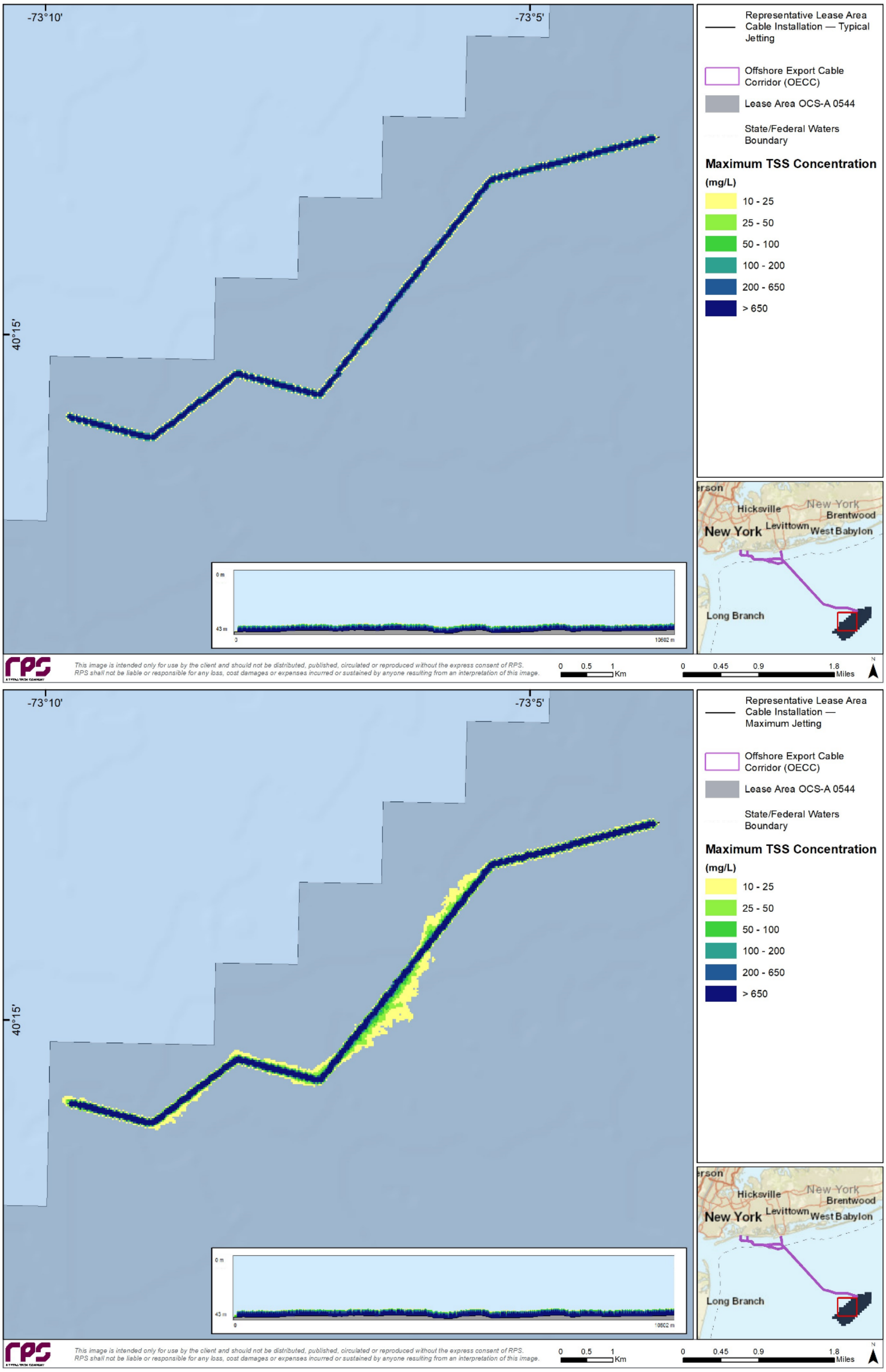
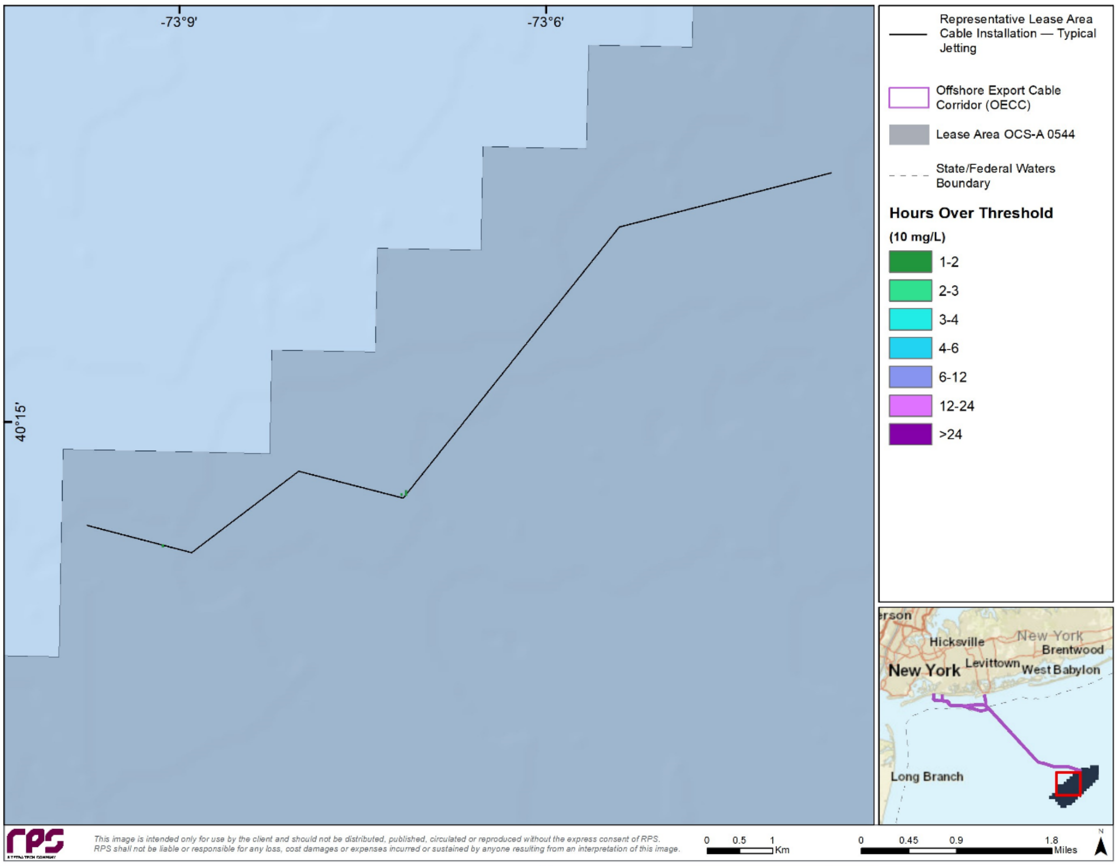


Figure 3-31: Time-integrated maximum concentrations associated with the Representative Lease Area Cable Installation —Typical Jetting (top) and Maximum Jetting (bottom) simulations.



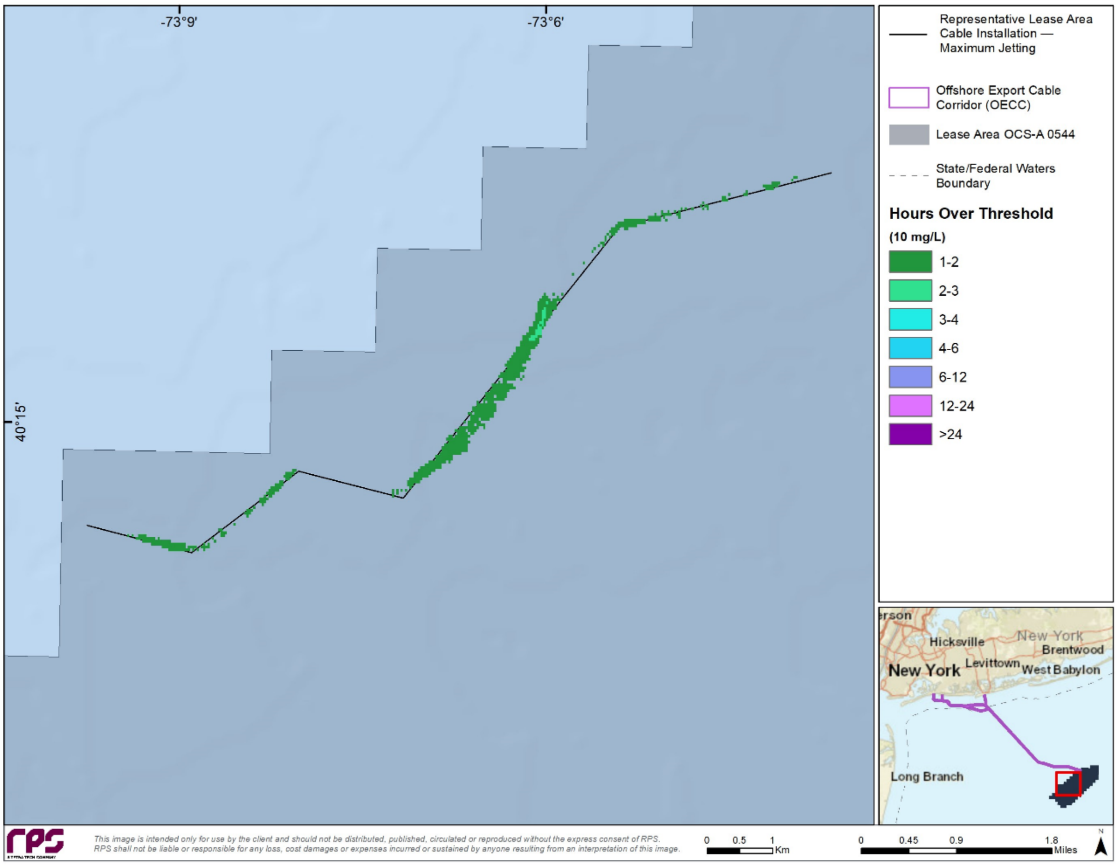


Figure 3-32: Duration of TSS ≥10 mg/L associated with the Representative Lease Area Cable Installation —Typical Jetting (top) and Maximum Jetting (bottom) simulations.

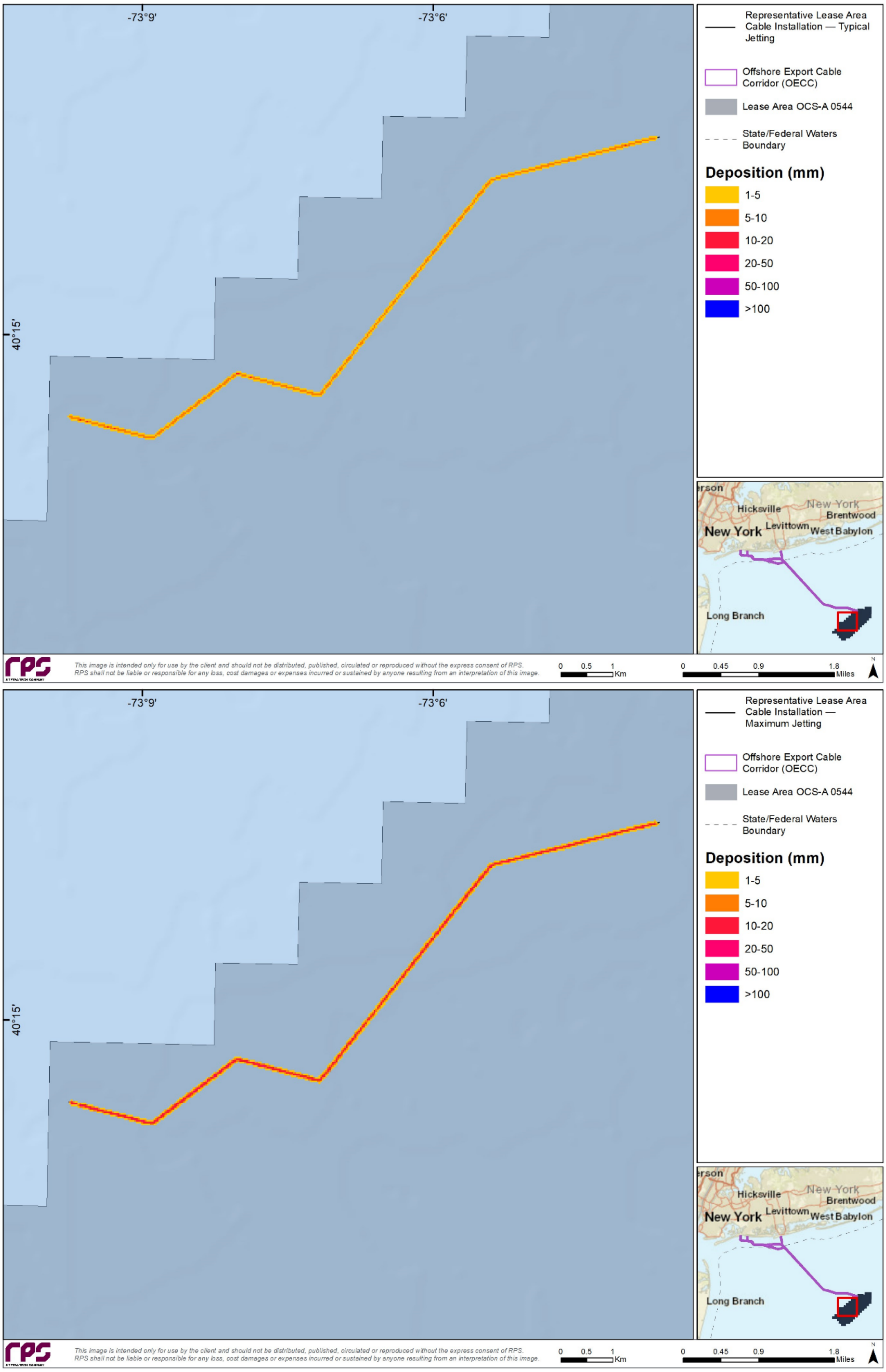


Figure 3-33: Depositional thickness associated with the Representative Lease Area Cable Installation —Typical Jetting (top) and Maximum Jetting (bottom) simulations.

3.3.6 Results Discussion

HDD Exit Pits

The two HDD exit pit construction simulations are representative of the excavation and backfill operations as 100% of the dredged material was released at the water surface over one hour. Backfilled sediment was released during both ebb and flood tides, to capture both environmental extremes. Because 100% of the backfill material was released at the surface, above-ambient TSS concentrations (i.e., ≥10 mg/L) were present throughout the entire water column. The maximum extent to TSS concentrations ≥10 mg/L were predicted to be similar for the Representative HDD Exit Pit -Jones Beach Landfall Site and the Representative HDD Exit Pit – Atlantic Beach Landfall Site modeling scenarios; however, for both model scenarios, concentrations dissipated to less than 10 mg/L within six to 12 hours. Both representative HDD exit pit construction simulations were predicted to exceed the depositional thickness threshold of 100 mm. However, the area associated with these thicknesses were relatively small (0.01 km) and were local to the source. For a more detailed discussion of the HDD exit pit construction simulation, see Section 3.3.3.

Cable Installation

For the typical jetting simulations, the trench depth in state waters was assumed to be deeper (2.3 m) than was applied in federal waters (1.7 m). Modeling of the Representative OECC Cable Installation using typical jetting techniques was performed for the entire length of the OECC. On average, TSS concentrations ≥10 mg/L were predicted to stay within 0.29 to 0.79 km of the source (with a maximum extent of 1.91 km) for all representative cable installation simulations modeled along the OECC in state and federal waters, assuming typical jetting parameters. Simulations were performed for all potential landfall approaches, starting just prior to the shoreline, and traversing to the Lease Area. This provides an additional layer of conservativism as cable installation would not occur to the shoreline. Therefore, this assumption increases the potential areas impacted by suspended sediment concentrations and sediment deposition above the thresholds of concern.

For the Representative OECC Vertical Injector Cable Installation simulation, the extent to the 10 mg/L concentration contour was predicted to reach farther from the route centerline than for the other cable installation simulations. This result was anticipated because the Representative OECC Vertical Injector Cable Installation simulation was performed within an area containing high fractions of fine material, during a period with very high current velocities, to evaluate a potential worst-case scenario when predicting water column concentrations. For all cable installation scenarios within the OECC and Lease Area, regardless of installation method or parameters applied, above-ambient TSS concentrations substantially dissipated within three hours and fully dissipated between six and 12 hours.

For all cable installation simulations (OECC and Lease Area), the depositional footprint was predicted to create deposits primarily between 1 mm and 5 mm thick that remained along the cable route (i.e., back into the trench) or adjacent to the cable route. For the typical and maximum jetting simulations in the OECC and Lease Area, the average and maximum extents to the 1 mm thickness threshold was predicted to stay within 0.07 and 0.11 km of the cable route, respectively. The only cable installation scenario predicted to exceed thicknesses >20 mm was the Representative Lease Area Cable Installation — Maximum Jetting simulation. This scenario contained a deeper target trench depth (3 m) and assumed that a higher fraction of the disturbed sediment would be released to the water column than was predicted for the typical jetting parameters. For a more detailed discussion of the OECC and Lease Area cable installation simulation results, see Sections 3.3.4 and 3.3.5, respectively.

Summary

These analyses provide conservative predictions of suspended sediment concentrations above ambient conditions that could result from the HDD exit pit construction and cable installation activities associated with Vineyard Mid-Atlantic. Results from the representative simulations of HDD exit pit construction and cable installation within the OECC and Lease Area show that above-ambient TSS concentrations originating from the source are intermittent, depending on the *in-situ* sediment composition; the vertical distribution of the sediment in the water column; and the hydrodynamic forcing conditions. The models show that the highest concentrations of induced suspended sediment occur in the vicinity of the activity (e.g., cable installation and HDD exit pit construction), as expected, however, these higher concentrations decrease rapidly with distance. All predicted above-ambient TSS concentrations are expected to disperse or settle such that concentrations are below 10 mg/L within three to12 hours after the construction related sediment-disturbing activity has stopped.

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